Frederic J.

# THE POPULAR SCIENCE MONTHLY

# THE POPULAR SCIENCE MONTHLY

EDITED BY

J. McKEEN CATTELL

VOL. LXI

NOVEMBER, 1902, TO APRIL, 1903

NEW YORK
THE SCIENCE PRESS
1903

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

# THE POPULAR SCIENCE MONTHLY.

NOVEMBER, 1902.

## SOME REFLECTIONS UPON THE REACTION FROM COEDUCATION.

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THE authorities of many of our great coeducational universities have been of late much perplexed and depressed at the astonishing number of young women who insist on patronizing these institutions. Taken in moderation the coeducational young woman has succeeded in approving herself to a considerable majority of her instructors. But she has recently shown a disposition to outnumber the young men in her classes, and this is resented by certain of her mentors as an obvious impropriety. The occasion has been seized upon by reactionaries here and there to magnify the drawbacks of coeducation, and there can be no question that many members of the faculties of institutions committed to this system are restive under the extant conditions, and apprehensive for the future. A few, especially certain of those educated in eastern non-coeducational institutions or in foreign universities, are severely, not to say bitterly, critical in their attitude, and eager for anything so it be a change. We may therefore expect in the near future much experimentation, and more discussion, upon the coeducational program. As a symptom of the educational development of the country at large, the present agitation possesses an interest and significance quite beyond the limits of the regions immediately affected.

In order to see the present situation in its just perspective one must bear in mind the remarkable educational development which has occurred in recent years in those parts of the country where coeducation is indigenous. The decade from 1890 to 1900 witnessed a growth wholly unprecedented in most of the strong coeducational colleges and universities of the central and western states. Academic standards were raised, equipments were lavishly provided in accordance with modern demands, faculties were enlarged and admirably trained specialists were secured in every department. In many institutions graduate courses of high merit were developed. The increase in the number of students was equally remarkable. The University of Minnesota leaped from 1,183 to over 3,000. The University of California from 763 to 3,024. The University of Wisconsin rose from 966 to 2,619. Cornell had 1,390 students in 1890, and 2,458 in 1900. At the University of Michigan the figures for the same period were 2,420 and 3,482. Moreover, in this same decade two coeducational universities were founded, Leland Stanford, Jr., University and the University of Chicago, which at once took rank with the foremost institutions of the country. In the year 1900 the former reported 1,389 students, the latter 3,520. Many other universities might be cited, such as the State Universities of Iowa, Ohio, Missouri, Kansas, Nebraska and Illinois, but they all tell the same story of the tropical development of higher education throughout this central and western region.

In 1890 there was but one of the large coeducational colleges in which women constituted over a third of the student body. This was true even in the courses grouped under the departments of literature, science and the arts. In institutions possessing schools of law and medicine the percentage of women in the total student body was very small. Even at this early date, however, Oberlin College was enjoying the fruits of its pioneer policy in first opening the doors of a man's college to women by finding 53 per cent. of its students women. It is not without interest to those nervous prophets who foresee a tidal wave of women sweeping the helpless men before it out of the coeducational institutions, that the percentage of women in the department of liberal arts at Oberlin has remained almost stationary for ten years, having, as a matter of fact, fallen somewhat toward the end of the period. Oberlin is in this particular also an exception, however. In all the other important universities the percentage of women has materially increased, and in some instances passed the fifty-per-cent. mark. Thus in 1900 the course in literature, arts and general science showed at the University of California 55 per cent. women; at Minnesota 53 per cent.; at Chicago 47 per cent.; at Michigan 47 per cent; and at Northwestern 44 per cent.*

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* These figures cannot be regarded as absolutely accurate, owing to the method of cataloguing found in the reports of certain institutions. The pe-

If professional schools are included in the computations, the figures take on a very different complexion. Thus at Michigan, for instance, in 1900 the law school with nearly 900 male students and the medical departments with over 600 served, together with the engineering school of 350, to keep the proportion of women to men in the whole institution within 3 per cent. of what it was in 1890, the figures being 16 per cent. and 19 per cent. for the beginning and end of the decade respectively. In almost every case the increase in the percentage of women occurred in the face of an unparalleled increase in the number of male students. Indeed, a recent writer has presented statistics to prove that the increase in the number of men in coeducational institutions has for some years past been relatively more rapid than the increase in the colleges for men alone. This, too, is a hard saying for those who maintain that women are driving men out of the coeducational institutions. But it does not mean, as we shall presently see, that women and men are increasing with equal rapidity in the same courses of study.

One finds his natural anticipations fulfilled in the almost entire absence of women from the courses in law and technology. Medicine attracts a small quota, but to all intents and purposes the serious embarrassments of the present situation may be treated as if the women were all segregated in the department of liberal arts. When one pursues the matter behind the face of the commonly published statistics, he finds that the process of segregation extends much further than these indicate. So far has the process of differentiation gone that certain courses are essentially preempted by women, whereas in others the men reign solitary and supreme. There is, to be sure, no rigid uniformity among the various institutions as regards the particular courses which are thus apportioned. But the phenomena of segregation is practically universal, so that in many classes the spirit of coeducation is buried under the substance of a female seminary or a man's college, as the case may be. Thus it will be found that the classes in English literature have been largely appropriated by women. History, the modern languages and classical studies show in many institutions a large invasion of women, while mathematics, geology and biology, together with the philosophical and social sciences, furnish a transition to the exact sciences and to studies of an advanced character immediately preparatory for law, medicine and technology, in which the men have things almost to themselves. The distribution

culiarities of organization in a few institutions must also be taken into account. Northwestern University, for example, has a large conservatory of music, chiefly patronized by women. This is not taken into account in our figures, which are meant to render comparative statements as nearly as possible reliable and significant. The figures quoted are believed to be entirely trustworthy for this purpose.

of the women as regards the relative numbers pursuing the several subjects offered by the curriculum, seem to be closely similar to that obtaining in the courses in women's colleges, so far as statistics are available and elective conditions comparable. It will be understood of course that these rough classifications refer solely to elective work taken in the broad sense, and not to such courses as are specifically prescribed for every academic degree.

One inevitably questions what this tendency means, what its final outcome is to be, and whether it is to be regarded as a welcome sign or not. It is clear, as regards the first point, that two influences are predominantly responsible for the general result. The first is found in the disposition to mold collegiate work from the earliest possible moment in such a manner as most effectively to assist in the preparation for a professional career. The second is found in the tendency to cultivate established tastes and to foster spontaneous intellectual interests.

The efficacy of the first consideration in the case of men is not open to doubt. In those parts of the country where collegiate coeducation is the prevailing system, the great mass of the young men are expecting immediately after graduation to enter upon a business or professional career, and this intention frequently leads them early in their college course to desert the humanities and the more purely cultural studies, so called, in favor of what they, or the faculties of the professional schools, consider the branches of immediately practical value. Literature and the classics rapidly surrender their claims upon these young men to economics, political science, constitutional history, physics, chemistry, biology, etc. In every large undergraduate body there is naturally always a considerable group of men who conceive of their educational opportunities in a more liberal manner than this, and another group cherishing more or less definite intention of graduate specialization in some of the departments of collegiate work other than those allied with the professional schools. Taken together these groups supply a considerable masculine leaven to what might otherwise in many of the courses in the humanities be a hopelessly feminine lump.

The women taken in mass are also widely controlled by professional considerations. However it may be in the colleges exclusively for women, there can be no reasonable question that up to the present time, at least, large numbers of the women in coeducational institutions have been looking forward to self-support. Or, at all events, if this were not an explicit purpose in their collegiate course, it was a very comforting possible consequence, exercising an indirect influence over their selection of studies. By common consent medicine and teaching are the two professions really open to women. Consequently the average college woman who intends to live by her brains feels that she must choose between the two. The opportunities open to women in a business career have hitherto been too precarious or too purely clerical to attract extensive attention from college-bred women. It is not necessary to point out the reasons which lead the vast majority of college women, who are looking to self-support, to choose the profession of teaching, nor yet to dwell upon the further reasons which practically confine the larger number of them to work in the secondary schools, whose fate is already largely in their hands. Admitting the facts, we at once have a reason why large numbers of women elect the courses they do in college. It is the old familiar process of demand and supply. In no small measure, then, the educational phenomenon from which we started, *i. e.,* the segregation of the sexes in pursuit of different subjects, is attributable to social and economic causes.

Women will probably continue their plethoric patronage of the courses in literature and the humanities at coeducational institutions as long as the secondary schools offer them smaller salaries than are paid to properly trained men, and as long as other vocations requiring a college education are closed to them. It is possible that some relief may be found through the dawning of the halcyon days, so longed for by certain eminent educational reactionaries, when required curricula will supersede the elective system, and the humanities once more come to their own. The wandering male sheep would thus be brought back into the fold. Certainly the progressive suicide of the elective system now going on in many institutions under the influence of professional tendencies is most interesting and suggestive. Moreover, there are reasons for thinking that if the opportunities for women teachers of physics and chemistry were larger, and the collegiate courses in these subjects arranged with less of reference to ulterior professional interests of a technological character, the number of women in such courses would be materially increased. Tradition is in these matters of some consequence, and men have so long conducted this work in the high schools that a rapid change is in no case a probability. There are, of course, exceptions to the rule even now.

When one comes to speak of the influence of native abilities, native tastes and intellectual interests in the election of courses, the available data are altogether less tangible. The prevalent doctrines concerning the mental differences of men and women are matters of dogma readily susceptible of neither proof nor disproof. In polite letters, as in society, woman has long figured as the adorable parent of men, not of ideas; as the repository of delicate sentiment rather than of accurate knowledge and in general, as the residuary legatee of all those interests which men do not care to cultivate. The evidence adducible in support of the correctness of this view is often proclaimed as conclusive; and ranged behind it is the authority of sundry notable physiologists, psychologists, sociologists and gentlemen of fashion. The contrary view in accordance with which women are allowed to possess ideas, some of them even original, is supported by evidence almost as intelligible and by partisans quite as eminent and quite as confident. The fact seems to be that it is extremely difficult to demonstrate how much of a woman's intellectual bent is due to the sexual bias of her mind, and how much to the influences which surround her from cradle to grave. It may be, for example, that literature is intrinsically feminine in its character, and that exact science is dominantly masculine. In the meantime it must certainly be granted that the conditions environing many girls are from childhood on such as tend to cultivate a mild but definite variety of sentimentalism. It has been suggested that some of the methods of studying literature current in these days tend also to sentimentalism, and so appeal to established habits of the feminine mind, while repelling the masculine temper. Courses dealing with the more emotional and esthetic forms of literary criticism and appreciation must necessarily be exposed to some danger from this source. Possibly a slight corrective and palliative for the excessive cultivation of such courses by women might be found in a larger emphasis upon more masculine points of view.

It seems improbable, however, that the relatively small number of men in the courses in belles-lettres in coeducational institutions is due in any considerable degree to this asserted fact regarding native masculine tastes, nor in any indisposition on the part of the men to sit in classes with women. For, as regards the second point, it must be remembered that there are many courses in which both men and women are well represented, and in which the ratio of the sexes to one another has changed but little throughout considerable periods. This is true, for example, of certain courses in history. The first point gains an interesting side light from the observation that in several important eastern institutions for men, where the modes of exposition and instruction in literature do not differ absolutely from those in vogue in western coeducational colleges, the attendance upon such courses shows in recent years no extreme shrinkage, and, as regards certain courses in English, even exhibits a marked development. The most obvious explanation of this difference between the east and the west (over and above the influence of the stimulating personality of certain successful instructors) is unquestionably to be found in the social conditions of which we have already spoken. The appreciation of the educational value of literature is necessarily more circumscribed in new and less wealthy communities than in those which have been long established, and the pressure toward the obviously practical is inevitably far greater. The astonishing development of technological schools in western universities affords striking confirmation of this last named tendency—a tendency by the way which finds a counterpart in the rapid growth of the so-called scientific schools in great eastern universities.

The final explanation which some misogynists would offer for the predominance of women in English courses, *i. e.,* that English literature is ordinarily the easiest of college courses unhappily proves too much. Such statistics as are available tend to show that were this generally conceded, women would rarely preponderate in such classes. On the whole, therefore, it seems probable that although the taste for literature is more largely developed in the women of our coeducational colleges, while the taste for exact science is largely the property of the men, the factor which has produced the most extreme and anomalous conditions of sex segregation, is, especially as regards the men, professional, economic and social in character. Moreover, that which passes as native taste is itself often a mere expression of social and domestic pressure, emphasizing with relentless insistence certain interests as sexually appropriate or practically valuable.

Opinions are somewhat divergent touching the desirability of this educational situation. The instructors of the classes largely dedicated to women are sometimes a trifle violent in the expression of their views. The instructors of the men's sections are, on the other hand, generally complacent. The unbiased spectator is perplexed and baffled. Evidently the advantages and disadvantages of these extreme cases must be weighed in terms of the general educational effects of the system as indicated by its results throughout these institutions as a whole. It is necessary, therefore, to review briefly the current criticisms upon the system, most of which, be it said, are hallowed by age, and many of which are evidently trivial.

A warning hand must be held out at this point against the amiable and ubiquitous inconsequentialist who insists on confusing the problem of coeducation with the problem of the higher education of women. The two are indeed connected, but by no means identical. Collegiate coeducation as a system assumes as a premise that women are to receive collegiate education, if they so desire, and a study of the curricula of women's colleges indicates that women generally wish to pursue those branches offered in the colleges for men. The coeducational problem is not, however, fundamentally one of curricula. It is a problem of determining the conditions under which men and women shall study in any curriculum whatsoever.

The criticisms of the present day upon coeducation dealing in part with strictly educational questions, and in part with general social considerations, differ in a somewhat suggestive manner as concerns one particular from those which were most commonly encountered in the early days of coeducation. The most frequent probably of all criticisms was the hygienic one. Although it was a matter of prehistoric knowledge that women could work all day in the field, many learned persons predicted a speedy decline for the audacious young female who attempted to follow the same collegiate course as her brother. The young person referred to has, however, both in coeducational colleges and in colleges for women, generally insisted on the retention of oppressively good health. And she has done even worse things to discredit the general calling of prophet by discovering numbers of educated men who were willing and eager to attempt matrimony with her assistance. Worst of all, when she has married, she has had a normal number of vigorous children. The irreconcilables on these points generally deny themselves the luxury of the available statistics. This is by no means to call in question the possibility held out to an injudicious girl of ruining her health by social and mental dissipation at a coeducational college. She can in this way undoubtedly emulate some of her sisters at women's colleges and certain of her brothers at men's universities.

But the intelligent contemporary opponent of coeducation has largely lost interest in the health of college women, and he has of late more often turned his attention to the baleful influence of the sex on social and intellectual standards. It is maintained, for instance, by an occasional instructor that women lower the level of scholarship in his classes. He finds it impossible to make such rigorous exactions of them as he would of men, and in consequence the whole tone of his class is contaminated. There seems reason to believe that this opinion is largely subjective in its basis, and it is suggestively rare on the lips of instructors educated in coeducational institutions. The instructor may have allowed himself to secure from his classes what he deemed the best work by the aid of a class room manner which he properly considers incompatible with the presence of ladies. In such cases one may fairly question the propriety of the pedagogical method. He may cherish a purely sentimental attitude toward women. This is a not infrequent circumstance in the case of young men brought up in men's colleges, and exposed for the first time to the ravages of coeducation. In this case time or matrimony or both are likely to cure his complaint. Certainly there are plenty of instructors who have taught in men's colleges without detecting any such decline of standard upon transferring the scene of their labors to coeducational institutions. Indeed, a contrary opinion has been not infrequently expressed, and one even hears the antithetical argument soberly advanced that women inevitably outstrip the men in mere class room exercises, and that the latter should consequently be spared such depressing competition. A few eminent Harvard professors have even gone so far as to rank their students at Radcliffe higher than the men in the corresponding Harvard classes. This may of course be the exception which proves the rule. One may safely surmise that there are no wider differences in point of scholarship between coeducational institutions as a class and men's colleges, than there are among men's colleges themselves. Indeed, in elective courses, in which the men and women are represented in anything like equal numbers, a common verdict of instructors concerning their relative merits is that the women are on the average the better students. They seldom attain the eminence of the ablest men, but the ablest men are excessively rare. There is certainly no palpable proof and not even good circumstantial evidence to convict women of lowering the undergraduate standards of scholarship.

A subtler form of this same criticism aimed at American education in general, but especially applicable to coeducational institutions, is the assertion that women exercise a repressive influence upon the spirit of research for which they have as a sex neither capacity nor appreciation. Inasmuch as a real university must get its highest inspiration from the spirit of investigation it is obviously a matter of paramount importance to prevent women from securing any considerable influence in university life. This argument can be made rhetorically effective, but it begs the whole question and will carry no conviction to one not already convinced.

The disrespect for women's intellectual capacity, indicated in the above criticisms, sometimes takes still another form in the charge that as a class women are not serious-minded in their work. For many of them, it is said, life is a game with matrimony as its principal stake, and college work is but an amusing episode. Coupled with another frequent criticism based upon the professional tendencies of which we have already spoken, *i. e.,* that the intellectual horizon of college women is too often bounded by purely utilitarian considerations of the bread and butter world of pedagogics, this leaves women in possession of few academic virtues. Apparently they are either too strenuous or too flippant, and both characteristics are institutionally undesirable.

It must be remembered that coeducational colleges inconsiderately differ very widely from one another, and so render the task of the generalizer extremely hazardous. Unquestionably one could find institutions where the frivolous society girl is overmuch in evidence, whereas in others the uncomely drudge doth too much abound, and probably neither of these young persons is wholesome in excess. But it is needless to say that in every coeducational university of importance there is a group larger than either of these groups made up of young women who are neither hopelessly flippant nor distressingly utilitarian in their intellectual interests. Moreover, if the venue be changed from the mere fact of sex to the possession of such characteristics as have been described, it would require a buoyant and oblivious nature to deny the counterpart of just such persons in the male portion of any large undergraduate body. It is certainly a cheering thing to think that no considerable number of young men in our colleges for the male sex are ever guilty of frivolity in their attitude toward academic opportunities. But such thinking has no special connection with fact, and is of a speculative rather than of a scientific character. Nor are there lacking in men's colleges those who toil unprofitably and overmuch to the end of attaining some mundane prize not wholly superior to the school teacher's stipend. Even the women's colleges produce these types.

Coeducation is often charged with an insidious suppression of freedom of expression in the class room. *Academische Freiheit* is endangered, therefore, by other enemies than college presidents and boards of trustees. Some subjects are evidently ill qualified for discussion in mixed classes. But it may be doubted whether the restrictions emanating from this source have been unmixed evils. The meritricious and obscene jests of literature, which some eminent scholars in men's colleges delight to dwell upon, can perhaps be spared. Surely there is no serious reason to fear that the male youth of the land will fail to secure outside the class room all the really indispensable development on this side of his appreciation for humor. In the fields of biology, where embarrassments might be supposed most inevitable, the difficulties have by no means proved so serious as anticipated. Nevertheless it must be admitted without scruple that women cause some restraint upon freedom of speech as charged in the indictment.

Although we have had constantly in mind undergraduate conditions, a word may be dropped in passing as regards the criticisms upon graduate work. There is undoubtedly an almost universal willingness among even the most acrimonious critics of coeducation that the few women who desire it shall be allowed the best possible opportunities for graduate work. The only exceptions are found among the small but aggressive group of interesting pre-raphaelite dogmatists who would do away with all collegiate education for women. There are plenty of scholarly men who insist that women will never become investigators of any consequence, but who admit their capacities for assimilation and who feel that as there must under existing conditions be some women teachers in both schools and colleges, it is desirable that they should receive the most thorough possible discipline. Women must expect to find themselves occasionally received on these terms, therefore, if they aspire to scholastic specialization in graduate schools. It will be remembered that the undergraduate courses constitute for many of those who plan to teach in the secondary schools the sole opportunity for specialization. For them the undergraduate curriculum affords essentially a professional training, and subserves exactly the same function as does the graduate school for those who are preparing for collegiate positions.

It behooves us to hurry on to a rehearsal of some of the more seditious social tendencies for which coeducation is held responsible. Foremost among these charges in point of fatuity—for some of them are not fatuous at all—is the asserted blight upon college spirit caused by coeducation. Now college spirit is a capricious plant which blooms profusely in the light of athletic victories and often leads a sickly life of hibernation at other periods. As commonly set forth, it consists in the belief that one's own college is the best on earth, which in some particulars is to an intelligent person always patently untrue, and at times of overwhelming athletic defeat, a thing extremely difficult for even a partisan to formulate with vivacity. Conceived more seriously, it consists in respect and affection for one's alma mater, and in earnest devotion to her welfare. It is unquestionably assisted by the accumulation of institutional legend and tradition. These things come slowly and with age. It is helped into a condition of self-consciousness by all vital student organizations which do not forget their dependence upon the college. Secret societies in many colleges are certainly injurious to college spirit, not because they work consciously against it, but because they absorb wholly into themselves sentimental interests which should include the institution, and because too often they stir up vicious animosities among themselves in a manner which necessarily detracts from the solidarity of interests in the student body at large. The elective system, with its disintegration of classes, has, wherever it has gained an extensive foothold, apparently modified almost to the point of extinction the old-time forms of college spirit. These considerations affect coeducational colleges neither more nor less than other colleges. On the more serious side of respect and affection for one's college, it is certainly difficult to see why coeducation should be disastrous to college spirit in the case of students to whom the system had always seemed the natural thing, unless it can be shown, as it certainly can not, that all coeducational institutions are intrinsically inferior to institutions for the separate sexes. Sufficient insistence upon the shame and ignominy of sitting in classes with the weaker vessels may undoubtedly undermine respect for his college in the mind of a lad brought up in a preparatory school for boys. Other lads could undoubtedly be occasionally influenced in this way. No boy likes to be called effeminate, whether the charge be true or false. In these interesting methods of undermining college spirit, many enthusiastic persons are now engaged. The feeling which they are attempting to arouse and play upon rarely or never occurs spontaneously to a boy brought up in coeducational schools. It is only as one finds a constituency reared in non-coeducational schools that any extensive and sincere antipathy of this sort can be counted upon. Specific instances illustrative of this fact would be easy to mention. Elsewhere the animosity of the men toward the women, if it exists at all, is an evident pose so transparent and unreliable as to deceive no one. In some institutions it has gained a specious prominence through resentment that the women support male student organizations and interests so feebly. Depleted athletic treasuries have been active ferments in this form of anti-woman agitation. Meantime, if one wishes college spirit in its more demonstrative and vocal forms, he must, in young colleges, at least, arrange for athletic victories, and women have not proved a serious impediment to these.

A vaguer form of this same criticism is often met with in the charge that women exercise a deleterious effect on that impalpable something known as academic atmosphere. When this objection is run to ground it is generally found to refer to the depreciation of scholarship already sufficiently mentioned, or to certain social complications of which we shall speak in a moment, or to the fact that the spirit of an institution differs in some other important but unnamable particular from that peculiar to Oxford or Yale or Harvard. Needless to say, the last form of this criticism is quite beyond controversy. It only remains to point out that all attempts to imbue with this spirit the occasional men's colleges found in the coeducational region have failed, in the judgment of competent observers, quite as completely to secure this desired result as have the efforts in coeducational institutions. The difficulties involved are referable much more certainly to the absence of tradition due to the youth of these colleges and to geographically determined social conditions, than to coeducation. Moreover, it is questionable if these difficulties will ever be wholly removed, and still more questionable whether this would be desirable even if it were possible.

The asserted violation of reasonable social proprieties constitutes one of the most frequent and important sources of annoyance to the advocates of coeducation. To behold the campus dotted with couples, billing and cooing their way to an A.B., is a thing, it is said, to rejoice Venus or Pan rather than Minerva, and were it the frequent or necessary outcome of coeducation, the future of the system would certainly be in jeopardy. No university can safely become a matrimonial bureau, nor yet a clearing house for flirtations. With the entire absence of supervision, which characterizes the attitude of many coeducational institutions toward the social life of students, it is not to be wondered at that an occasional silly boy and an occasional silly girl should occasionally do some extremely silly thing. It only remains to remember that the same boy and girl will, with remarkably few exceptions, do equally silly things whatever educational surroundings may be given them. Furthermore, institutions which have attempted to control these matters by fixed rules of deportment seem on the whole to have succeeded in producing rather more risqué escapades than those which eschew restrictions altogether. Public opinion has generally proved a safe guide in this direction. It would be folly to pretend that no social transgressions have occurred, but on the whole judged by any standard reasonably applicable to the situation, the relations of the men and women in the majority of such colleges seem to have been wholesome and unobjectionable. Instances of actual immorality have been so extremely rare as fairly to be considered pathological. That the future has some very serious perplexities in store on this score, however, for some peculiarly situated institutions of which we shall speak presently, seems more than probable. A very little injudicious conduct of the character under consideration goes far to create an atmosphere of a very obnoxious kind, and it is such infrequent but pervasive cases which cause anxiety to the friends and give courage to the foes of coeducation.

Even though actual flirtation is avoided, many critics insist that boys' interests are stimulated in other boys' sisters at a time when it would be quite as well if they could be diverted into entirely different channels, even football. Girls, it is said, are unduly excited by masculine attention at a critical time in their physiological development, when they might better be engaged in storing their minds with useful learning. On the other side of this account it is to be observed that the shock of the class room goes far to shatter the traditional masculine idol in the feminine mind. This destructive process is in the case of most young women in such coeducational colleges begun in the primary schools and carried without interruption up to the academic level. By means of this anti-romantic treatment girls are untionably spared much painful disillusionizing, and they are brought through a difficult period with probably a minimum of silliness and mawkish sentimentality. Moreover, they are often spared certain highly morbid experiences familiar to the authorities of girls' colleges. In the case of the boy there is abundant evidence to warrant the opinion that the grosser forms of vice to which he falls an occasional prey are rendered distinctly less alluring by daily contact with women of refinement and intelligence. That he ordinarily becomes effeminized by such contact is a fantastic theory of some critics which finds absolutely no tangible evidence upon which to rest. Certainly his manners leave much to be desired at times on the side of polite usage and suggest very remotely the adoption of feminine habits, and judged by athletic prowess, which is under the circumstances a very ambiguous index, the facts tell quite another story. At all events, athletic teams of western coeducational colleges have not infrequently defeated the representatives of eastern colleges for men, *e. g.,* Yale, Princeton, Harvard, Brown, etc.

The complementary criticism that women necessarily suffer a loss of refinement and feminine nicety seems equally difficult of proof. It is certainly hard to point out any unavoidable features of coeducation which should inevitably preclude the development or retention of good manners and fine feeling. If the psychologists are correct, the acquirement of what we call manners belongs largely to a period antedating college life, and although a coarsening of the moral and esthetic fiber during this period would unquestionably appear in less refined conduct, it is not obvious that any such change commonly occurs, much less must occur under coeducational conditions. The fact seems rather to be that the college must inevitably expect to reflect in large measure the manners with which its students come already supplied, and these which are often admirable will be determined by the social standards prevailing in the families and communities from which they come. To be sure, the conditions of collegiate life afford an opportunity for throwing into vivid relief acquired social habits. They further afford admirable facilities for the discouragement of extreme variations from the accepted norm. But it is altogether problematic whether they can radically alter the level of the mass, at least this is doubtful under the prevalent conditions in most coeducational institutions where little or no supervision is exercised over students outside the class room. That the general tendency in all such colleges is toward a greater nicety of appreciation for social cultivation, can hardly be questioned. But the process of social leveling up is a slow one. There are no courses in the conventionalities, and no one should confuse the merits of such an institution with those of the young ladies' finishing schools of a great metropolis.

Much was said a few years ago of the certainty that the immediate future in university education belonged to the great urban institutions. It certainly seems probable that some of the most difficult problems in the near future belong to such of these institutions as are coeducational. If there is any serious menace contained in a predominance of the number of women over men in a college, these urban institutions are especially exposed to it. The number of girls in any city of 500,000 people who possess means and leisure sufficient to permit attendance upon a college is very large. If the college opens its doors directly in the faces of these young women, it can arouse no astonishment that many of them should walk in. Moreover, in the western cities which enjoy a practical monopoly of the coeducational system among city institutions, the brothers of these young women will not regularly come with them, or indeed go to any college. They are many of them drafted into the ranks of business life, and the natural balance of the sexes, which is displayed in the lower grades of the coeducational public school, is here entirely to seek. The families which will chiefly serve as recruiting grounds for these young women will be those in which wealth or comfortable means have been acquired in the present generation. In families where college traditions go back a generation or two, both boys and girls, if they go to college at all, will go to institutions determined as a rule by other than merely geographical considerations. But the stronger the local college, the more will it invade the ranks of this latter class, and it will probably draw upon the girls more largely than upon the boys, because of the indisposition to allow girls to leave home and because of the lesser significance for them of collegiate family tradition.

It will be strange if among these city-bred girls of leisure, many of whom will enjoy ample means, there should not be found a goodly number who go to college inspired with the same noble sentiment that now animates a considerable number of young men preparing for college—the disposition to have a good time and do the correct thing. Young women of this variety have already found their way into a number of the coeducational institutions, even those located outside the cities, and their coming even in small numbers has been attended by a distinct change in certain features of the college atmosphere. Judged by its external and most palpable fruits, the condition thus produced suggests at times its counterpart as already recognized in men's colleges—undue leisure unwisely spent, injudicious amusements and too many of them. Seen from the inside, it more often means on its positive side, an ingenuous interest in the more distinctly social phases of college life, and on its negative side, a freedom from the more imperious and sordid cares of the impecunious. We are assured on high authority that in at least one of the great universities for men, the idle and unprofitable class of rich boys has been awakened to a sense of responsibility and opportunity which is bringing splendid returns to the life of the institution. This is a comforting doctrine, and if confirmed in the progress of time, it furnishes ample ground for a confident optimism in the solution by the women themselves of any difficulties which may develop in coeducational institutions from these or similar sources. In any event women have in the century just past shown a disposition to lead, rather than to follow, in the furtherance of social reforms. Meantime it is clear that the urban coeducational university is exposed in larger degree than its rural neighbor to the perplexities mentioned.

It becomes increasingly evident as one surveys the situation that the antagonistic views of coeducation which are at present so conspicuous do not rest upon any radical disagreement as to the facts in the case, but depend almost solely upon the educational ideals and the social creeds which are applied in interpreting the facts. Much of the current discussion of the system is rendered futile by the obliviousness of the protagonists to this obvious consideration. If the life and spirit of Oxford or of Yale or of Harvard constitute one's sole standard of educational excellence, then the average coeducational institution will indeed seem a desolate waste. If one's ideal of social salvation for young women involves matrimony as its only god, and the chaperone as his prophet, then the coeducational regime must generally be condemned as a pagan system marking a barbarian stage of culture. Needless to say, such standards exist tacitly or explicitly in the minds of many cultured men and women who sincerely believe coeducation to be a vulgarizing retrograde influence in both social and intellectual life. It is ridiculous to pretend that the coeducational university can meet satisfactorily the demands laid upon it by such standards. This is not tantamount to admitting that the best coeducational institutions can not cope successfully at any point with Oxonian excellencies, much less is it equivalent to denying the possibility of developing refined and noble men and women under coeducational surroundings. But it is an admission of—nay an insistence upon—the fact that the only standards by which coeducation can pretend to be justified and by which it can be justly judged, are those intrinsic to the social and economic conditions which have produced it, and of which it is an integral part.

One may feel toward these conditions contempt, distrust, hatred—what one will—but one must take them into account if he will pass intelligent judgment upon coeducation. One may deplore the fact sincerely, as every lover of established order does, but he can not gainsay that the development of American social and economic life is rapidly carrying increasing numbers of women out of the beaten path of the domestic treadmill with its everlasting insistence upon the incident of sex into fields where social service is gauged by other standards than those of child-bearing, house-keeping and adorning pink teas. Efficiency is certain to be the touchstone by which women are tried in these new fields, and they will go or stay in proportion as they do better or less well than men. The picture which one learned professor has recently drawn of an uprising of men to force by violence a return of women to their proper sphere, is the product of an inflamed imagination attempting to portray an oriental Utopia. In reality men are chiefly responsible for the changes now going forward, but they are neither the doctrinaires of academic dignity nor yet the leaders of cotillons; they are the seekers after commercial, industrial and professional efficiency. So long as the economic situation remains what it is as regards the principles and motives that control in it, no amount of merely hysterical criticism and opposition is likely seriously to modify the case. And so long, therefore, as many women prefer self-support to marriage on the terms they find the latter offered to them, women will remain primary items in the economic situation, and they cannot be treated in this realm from the merely sexual point of view.

Coeducation is a reflection, often unconscious, of the tendencies which have produced this condition. It represents historically, as well as intrinsically, the democratic disposition to offer equal educational opportunities so far as possible to every human being. The touchstone by which it tests worthiness for such opportunities is social service. So long as women show themselves worthy by this standard to receive the highest forms of education, they will be given opportunity to obtain it, and moreover they will probably, in western institutions at least, obtain it under coeducational auspices. Justly or unjustly the western mind is suspicious of a fallacy lurking in the proclaimed equality of instruction in women's colleges and annexes, with that given in men's colleges. Then, too, if there were no other considerations, the economic waste involved in supporting separate institutions for men and women would tell heavily in favor of coeducation in many western communities. 'Equal but different' is not in educational matters a generally palatable doctrine away from the Atlantic seaboard. If the male is intellectually an altogether superior individual, the female ought on democratic principles to be given a chance for improvement by contact with him.

As a matter of fact coeducation is one of the most characteristic expressions of the social evolution of modern and especially western life. It is not now, and is not likely soon to become, an adequate or satisfactory expression of social and educational ideals in old communities or at all events in the conservative strata of such communities, inheriting as these do directly and easily the traditions of the past, and consequently clinging tenaciously to custom. The few instances in which the system has made its way into New England institutions of collegiate rank are essentially sporadic and serve rather than otherwise to emphasize the truth of this assertion. This fact is still further brought out by the observation that the hostility to the system is greatest in those institutions which are most intimately in contact with older ideals. If one follows the history of the development of the system, one is impressed with the fact that in its inception anyhow the movement possessed the true spirit of robust frontier democracy. It originated in the democratic impulse to give women the highest educational opportunities and to test their fitness for such opportunities by the use made of them, and not by *à priori* notions of the sexually appropriate. Its typical virtues are earnestness, honesty and vigor. It is frequently crude, but it is rarely shallow. It is often obtuse, but it is seldom perverse. It springs from a deep-seated social conviction that men and women are in the first instance human beings, and only secondarily devices for continuing the race. It involves in practice, whatever the theory, a vital scepticism concerning the sexuality of intellect, a position which finds interesting though generally unintentional confirmation in the curricula of women's colleges and annexes. Even under the guidance of learned men and women, it does not seem to have proven possible to better materially the curricula of the men's colleges, to which even the extremest variants are now approximated. Individual preference operating under a liberal elective system has almost everywhere displaced curricula developed under preconceived notions of the sexually fit. Upon the catholic range of these feminine preferences, we have already commented.

Coeducation assumes that if, as is apparently the case, men and women are to be thrown into increasingly intimate contact in relations that do not involve reference to sex, it is desirable that the formal educational process, so often falsely severed from the rest of life, should recognize this fact by bringing boys and girls into contact with one another all their lives.

Like all other influences making for the higher education of women, coeducation is necessarily opposed to the view that woman's only function is maternity, and that her only proper attainments are either of a domestic or sexual character. The condition of women in continental and oriental countries in which this view of woman has prevailed, and the social consequences which have sprung from it, leave no question in the western mind as to the preferable extreme, if one must have an extreme in this matter. On the other hand, the advocates of coeducation regard maternity as a function for which no education is too high nor too broad.

When one brings to bear upon coeducation standards that can fairly be considered intrinsic to it, one can but admit that in the past anyhow its operation has been remarkably successful. The register of graduates from coeducational institutions shows that as a class the young men and women trained under these auspices are filling with honor the functions of the various stations to which life has called them. The beauty and sanctity of domestic life does not appear to have been shattered nor indeed shaken. In public station, to which large numbers of them have been summoned, they appear to have acquitted themselves with eminent credit. There is no great interest of any kind throughout the west in which men and women of this type will not be found important factors. This result may of course be in spite of their education, rather than because of it, and a different form of education might have produced better results. Admitting this, however, it remains to point out the fact, that in any event for the vast majority of these persons coeducation has not resulted in the disastrous fashion which it ought, if its critics were wholly correct. It must in this connection be remembered that there are many thousands of these graduates of coeducational colleges, so that the volume of contamination which disturbs the critics should be considerable and not difficult of recognition.

Coeducation has a monopoly of neither the virtues nor the vices of the educational world. It is a safe assertion that many young men and women would be better off in colleges of some other variety. Experience certainly suggests that a coeducational university is a dangerous place to send certain young men and especially certain young women, brought up in schools for boys or girls severally. The sending of certain girls to such coeducational institutions without providing for guardianship of any kind is often in the highest degree reprehensible. But for the average young person brought up in coeducational nurseries and secondary schools the university of this type is capable of supplying a peculiarly valuable training, and one which could be discarded only at great cost. The system represents so much that is intrinsic to the noblest and best spirit of democracy in the commonwealths where it flourishes, that its immediate overthrow would be hardly feasible even were it thought desirable. The state institutions, which furnish much the larger part of the coeducational constituency, could probably take no extreme measures without legislative endorsement, and this would certainly be very slow in coming. Private institutions are less hampered, and we may look to them for experimental research. Leland Stanford in the west has already discovered that while 500 women in an institution are tolerable and even valuable, 501 are not to be endured. Wesleyan University in the East has also seen a light, but one of a different hue from that seen at Stanford. At Wesleyan twenty per cent. of the student body may be women, but educational propriety draws the line at this point.

Turning to the present and the future, and applying standards properly applicable to the coeducational system, it must be admitted that on the instructional side only one difficulty of serious import appears to exist. This is the tendency toward sex segregation in certain courses of which we have already spoken at length. The most unequivocal advantages of coeducation spring from the fact of joint instruction, and any influences which tend to preclude this are unfortunate. For the various other alleged shortcomings of the system on this side, there is no conclusive evidence and opinion is hopelessly diverse. Furthermore, the criticisms which are advanced, so far as they are capable of satisfactory proof, concern the merely incidental and obviously remediable excrescences of the system, and not its fundamental principles. On the other hand there is almost complete unanimity of opinion regarding the difficulties actual and possible on the social side of coeducational college life.

This fact itself is altogether significant—essential unanimity of opinion regarding one class of difficulties, with radical and complicated differences regarding the other class.

It does not seem chimerical to hope that the first difficulty may at an early date in large measure take care of itself without artificial assistance. Despite the common assertion of the educational rhapsodists that women's native tastes are all in emotional and esthetic lines, even her religious bent included, a study of the elections made by women in the courses of both coeducational and women's colleges suggests, as we have already seen, a much more equitable and catholic distribution of her interests. As wider academic and professional fields open to women, and as the number of women increase who are not obliged to conform their collegiate work to immediate bread and butter interests, there will certainly be a less proportion of them found in the literary courses than at present. And on the other hand, as regards the men, there seems some reason to believe that we may see a reaction from the present extreme tendency to cater to a purely technical preparation for professional life. Certainly it is hard to believe that in the long run the racial confidence in the value of the humanities, shown by educational history, should not secure wider recognition than it often does at present from some of the builders of required curricula for the professions. It seems not improbable, too, that the reconstruction of the work of professional preparation both in school and college with its tendency toward a shortening of the collegiate course, will be accompanied by a disposition to include more of literature in the early part of the training than is now the case. And, as in the case of women just mentioned, there will unquestionably be an increasing number of men in coeducational institutions whose means will permit, and whose tastes will dictate, a less hasty and slavish subserviency to the demands of professional training, and a longer dalliance with arts and letters. This disposition will be rapidly augmented by a wider appreciation of the educational value of these subjects on the part of the communities whence these young men come. Should these various influences cooperate, there can be no question that the present anomalous conditions would be extensively modified. At all events it would set the tide of men back into the humanities. It seems improbable that women will find it tempting or profitable in the near future to attempt extensively entrance upon law or technology or theology. But many of the courses involved in preparation for these careers will undoubtedly appeal to them in increasing measure.

Far and away the most serious problem which coeducation has to face is unquestionably that involved in maintaining proper social relations between the sexes, and this must, if solved permanently, gain its solution from the action of public sentiment in the student body itself. Faculty counsel and administrative suasion will do much, but in the last analysis the suppression of unprofitable and excessive social intercourse on the one hand, and the elimination of irrational sex prejudice on the other, must be accomplished through the force of sincere and enlightened student opinion. This is an altogether hopeful circumstance, although it points to a corrective which is necessarily slow in development and susceptible of temporary error. To distrust its final success is to repudiate the lesson of every liberalizing step which has resulted in making the American college student so completely his own master. Whether the method adopted will involve the social ostracism of women which exists in a mild form at several important coeducational universities, and in a pronounced form at one, it is difficult to say. Certainly the result at this last institution should commend itself to many opponents of the system, for it seems to have materially retarded the increase in the attendance of women such as has been experienced by other coeducational colleges. Evidently this method is calculated to correct only one form of excess in the relations of the sexes. Stupid prejudice is not likely to die under this treatment. Indeed, it will hardly die under any system, for there will probably always be men as there are now, both among faculty and students, who simply dislike personally to have women about. This feeling is moreover warmly reciprocated by some women. Such persons, if in coeducational institutions, should seize an early opportunity to transfer the scene of their labors. Nothing can be socially more unwholesome and more insidious in its effects upon personal dignity than life in a community where such forms of contempt and antisocial sentiment are general and sincere.

The deepest and truest ethical tendencies of the time emphasize not divisions of sex or creed or party, but the unity of social service. And this is social service not in the moralistic, goody-goody sense, but in the sense of actual social function. If men and women are to be fitted for life with this ideal in its broadest implication as a primary determinant of curriculum and method, then coeducation, judged either by its fruits or by its promise, and acknowledging frankly its defects, is unquestionably a hopeful system. When it shows itself clearly disastrous to the solidarity of the highest social interests, it will unquestionably be discarded. But it will not be discarded upon any purely doctrinaire considerations of sexual functions and capacities. Meantime each one of us in the last resort tests it all by his own social creed, and with most of us this is at bottom largely a matter of feeling and not a matter of carefully rationalized judgment, a reflection of our own training and surroundings and not a product of our purely logical processes. Complete agreement, therefore, upon the merits of coeducation is hardly to be looked for in the near future.

# THE PRESENT POSITION OF CHEMICAL PHYSIOLOGY.*

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AN engineer who desires to thoroughly understand how a machine works must necessarily know its construction. If the machine becomes erratic in its action, and he wishes to put it into proper working order, a preliminary acquaintance with its normal structure and function is an obvious necessity.

If we apply this to the more delicate machinery of the animal body we at once see how a knowledge of function (physiology and pathology) is impossible without a preliminary acquaintance with structure or anatomy.

It is therefore not surprising, it is indeed in the nature of things, that physiology originated with the great anatomists of the past. It was not until Vesalius and Harvey by tedious dissections laid bare the broad facts of structure that any theorizing concerning the uses of the constituent organs of the body had any firm foundation.

Important and essential as the knowledge is that can be revealed by the scalpel, the introduction and use of the microscope furnished physiologists with a still more valuable instrument. By it much that was before unseen came into view, and microscopic anatomy and physiology grew in stature and knowledge simultaneously.

The weapons in the armory of the modern physiologist are multitudinous in number and complex in construction, and enable him in the experimental investigation of his subject to accurately measure and record the workings of the different parts of the machinery he has to study. But preeminent among these instruments stands the test-tube and the chemical operations typified by that simple piece of glass.

Herein one sees at once a striking distinction between the mechanism of a living animal and that of a machine like a steam engine or a watch. It is quite possible to be an excellent watchmaker or to drive a steam engine intelligently without any chemical knowledge of the various metals that enter into its composition. In order to set the mechanism right if it goes wrong all the preliminary knowledge which is necessary is of an anatomical nature. The parts of which an engine is composed are stable; the oil that lubricates it and the fuel that feeds

* Presidential address to the Physiological Section at the Belfast Meeting of the British Association for the Advancement of Science.

it never become integral parts of the machinery. But with the living engine all this is different. The parts of which it is made take up the nutriment or fuel and assimilate it, thus building up new living substance to replace that which is destroyed in the wear and tear associated with activity. This condition of unstable chemical equilibrium is usually designated metabolism, and metabolism is the great and essential attribute of a living as compared with a non-living thing.

It seems childish at the present day, and before such an audience as this, to point out how essential it is to know the chemical structure as well as the anatomical structure of the component parts of the body. But the early anatomists to whom I have alluded had no conception of the connection of the two sciences. Speaking of Vesalius, Sir Michael Foster says: "The great anatomist would no doubt have made use of his bitterest sarcasms had some one assured him that the fantastic school which was busy with occult secrets and had hopes of turning dross into gold would one day join hands in the investigation of the problems of life with the exact and clear anatomy so dear to him." Nor did Harvey, any more than Vesalius, pay heed to chemical learning. The scientific men of his time ignored and despised the beginning of that chemical knowledge which in later years was to become one of the foundations of physiology and the mainstay of the art of medicine.

The earliest to recognize this important connection was one whose name is usually associated more with charlatanry than with truth, namely, Paracelsus; and fifty years after the death of that remarkable and curious personality his doctrines were extended and developed by van Helmont. In spite, however, of van Helmont's remarkable insight into the processes of digestion and fermentation, his work was marred by the mysticism of the day which called in the aid of supernatural agencies to explain what could not otherwise be fully comprehended

In the two hundred and fifty years that have intervened between the death of van Helmont and the present day alchemy became a more and more exact science, and changed its name to chemistry, and a few striking names stand out of men who were able to take the new facts of chemistry and apply them to physiological uses. Of these one may mention Mayow, Lower, Boerhaave, Réaumur, Borelli, Spallanzani, and Lavoisier. Mulder and Holland and Liebig in Germany bring us almost to the present time, and I think they may be said to share the honor of being regarded as the father of modern chemical physiology. This branch of science was first placed on a firm basis by Wöhler when he showed that organic compounds can be built out of their elements in the laboratory, and his first successful experiments in connection with the comparatively simple substance urea have been followed by numberless others, which have made organic chemistry the vast subject it is to-day.

Sir Michael Foster's book on the History of Physiology, from which I have already quoted, treats of the older workers who laid the foundations of our science, and whose names I have not done much more than barely mention. Those interested in the giants of the past should consult it. But what I propose to take up this morning is the work of those who have during more recent days been engaged in the later stages of the building. The edifice is far from completion even now. It is one of the charms of physiological endeavor that as the older areas yield their secrets to the explorers new ones are opened out which require equally careful investigation.

If even a superficial survey of modern physiological literature is taken, one is at once struck with the great preponderance of papers and books which have a chemical bearing. In this the physiological journals of to-day contrast very markedly with those of thirty, twenty or even ten years ago. The sister science of chemical pathology is making similar rapid strides. In some universities the importance of biological chemistry is recognized by the foundation of chairs which deal with that subject alone; and though in the United Kingdom, owing mainly to lack of funds, this aspect of the advance of science is not very evident, there are signs that the date cannot be far distant when every well-equipped university or university college will follow the example set us at many seats of learning on the continent and at Liverpool.

With these introductory remarks let me now proceed to describe what appear to me to be the main features of chemical physiology at the present time.

The first point to which I shall direct your attention is the rapid way in which chemical physiology is becoming an exact science. Though it is less than twenty years since I began to teach physiology, I can remember perfectly well a time when those who devoted their work to the chemical side of the science might almost be counted on the fingers of one hand, and when chemists looked with scarcely veiled contempt on what was at that time called physiological chemistry: they stated that physiologists dealt with messes or impure materials, and therefore anything in the nature of correct knowledge was not possible. There was a good deal of truth in these statements, and if physiologists to-day cannot quite say that they have changed all that, they can at any rate assert with truth that they are changing it. This is due to a growing *rapprochement* between chemists and physiologists. Many of our younger physiologists now go through a thorough preliminary chemical training; and, on the other hand, there is a growing number of chemists—of whom Emil Fischer may be taken as a type—who are beginning to recognize the importance of a systematic study of substances of physiological interest. A very striking instance of this is seen in the progress of our knowledge of the carbohydrates, which has culminated in the actual synthesis of several members of the sugar group. Another instance is seen in the accurate information we now possess of the constitution of uric acid. When Miescher began his work on the chemical composition of the nuclei of cells, and separated from them the màterial he called nuclein, he little foresaw the wide practical application of his work. We now know that it is in the metabolism of cell-nuclei that we have to look for the oxidative formation of uric acid and other substances of the purine family. Already the chemical relationships of uric acid and nuclein have taught practical physicians some of the secrets that underlie the occurrence of gout and allied disorders.

With the time at my disposal, it would be impossible to discuss all the chemico-vital problems which the physiologists of the present day are attempting to solve, but there is one subject at which many of them are laboring which seems to me to be of supreme importance —I mean the chemical constitution of proteid or albuminous substances. Proteids are produced only in the living laboratory of plants and animals; proteid metabolism is the main chemical attribute of a living thing; proteid matter is the all-important material present in protoplasm. But in spite of the overwhelming importance of the subject chemists and physiologists alike have far too long fought shy of attempting to unravel the constitution of the proteid molecule. This molecule is the most complex that is known: it always contains five, and often six, or even seven elements. The task of thoroughly understanding its composition is necessarily vast, and advance slow. But little by little the puzzle is being solved, and this final conquest of organic chemistry, when it does arrive, will furnish physiologists with new light on many of the dark places of physiological science.

The revival of the vitalistic conception in physiological work appears to me a retrograde step. To explain anything we are not fully able to understand in the light of physics and chemistry by labeling it as vital or something we can never hope to understand is a confession of ignorance, and, what is still more harmful, a bar to progress. It may be that there is a special force in living things that distinguishes them from the inorganic world. If this is so, the laws that regulate this force must be discovered and measured, and I have no doubt that those laws when discovered will be found to be as immutable and regular as the force of gravitation. I am, however, hopeful that the scientific workers of the future will discover that this so-called vital force is due to certain physical or chemical properties of living matter which have not yet been brought into line with the known chemical and physical laws that operate in the inorganic world, but which as our knowledge of chemistry and physics increases will ultimately be found to be subservient to such laws.

Let me take as an example the subject of osmosis. The laws which regulate this phenomenon through dead membranes are fairly well known and can be experimentally verified; but in the living body there is some other manifestation of force which operates in such a way as to neutralize the known force of osmosis. Is it necessary to suppose that this force is a new one? May it not rather be that our much vaunted knowledge of osmosis is not yet complete? It is quite easy to understand why a dead and a living membrane should behave differently in relation to substances that are passing through them. The molecules of the dead membrane are, comparatively speaking, passive and stable; the molecules in a membrane made of living cells are in a constant state of chemical integration and disintegration; they are the most unstable molecules we know. It is to be expected that such molecules would allow water, or substances dissolved in water, to pass between them and remain entirely inactive? The probability appears to me to be all the other way; the substances passing, or attempting to pass, between the molecules will be called upon to participate in the chemical activities of the molecules themselves, and in the building up and breaking down of the compounds so formed there will be a transformation of chemical energy and a liberation of what looks like a new force. Before a physicist decides that his knowledge of osmosis is final, let him attempt to make a membrane of some material which is in a state of unstable chemical equilibrium, a state in some way comparable to what is called metabolism in living protoplasm. I cannot conceive that such a task is insuperable, and when accomplished, and the behavior of such a membrane in an osmometer or dialyser is studied, I am convinced that we shall find that the laws of osmosis as formulated for such dead substances as we have hitherto used will be found to require revision.

Such an attitude in reference to vital problems appears to be infinitely preferable to that which too many adopt of passive content, saying the phenomenon is vital and there is an end of it.

When a scientific man says this or that vital phenomenon cannot be explained by the laws of chemistry and physics, and therefore must be regulated by laws of some other nature, he most unjustifiably assumes that the laws of chemistry and physics have all been discovered. He forgets, for instance, that such an important detail as the constitution of the proteid molecule has still to be made out.

The recent history of science gives an emphatic denial to such a supposition. All my listeners have within the last few years seen the discovery of the Röntgen rays and the modern development of wireless telegraphy. On the chemical side we have witnessed the discovery of new elements in the atmosphere and the introduction of an entirely new branch of chemistry called physical chemistry. With such examples ready to our hands, who can say what further discoveries will not shortly be made, even in such well-worked fields as chemistry and physics?

The mention of physical chemistry brings me to what I may term the second head of my discourse, the second striking characteristic of modern chemical physiology: this is the increasing importance which physiologists recognize in a study of inorganic chemistry. The materials of which our bodies are composed are mainly organic compounds, among which the proteids stand out as preeminently important; but every one knows there are many substances of the mineral or inorganic kingdom present in addition. I need hardly mention the importance of water, of the oxygen of the air, and of salts like sodium chloride and calcium phosphate.

The new branch of inorganic chemistry called physical chemistry has given us entirely new ideas of the nature of solutions, and the fact that electrolytes in solution are broken up into their constituent ions is one of fundamental importance. One of the many physiological aspects of this subject is seen in a study of the action of mineral salts in solution on living organisms and parts of organisms. Many years ago Dr. Ringer showed that contractile tissues (heart, cilia, etc.) continue to manifest their activity in certain saline solutions. Howell goes so far as to say, and probably correctly say, that the cause of the rhythmical action of the heart is the presence of these inorganic substances in the blood or lymph which usually bathes it. The subject has more recently been taken up by Loeb and his colleagues at Chicago: they confirm Ringer's original statements, but interpret them now as ionic action. Contractile tissues will not contract in pure solutions of non-electrolytes like sugar or albumin. But different contractile tissues differ in the nature of the ions which are their most favorable stimuli. An optimum salt solution is one in which stimulating ions, like those of sodium, are mixed with a certain small amount of those which like calcium restrain activity. Loeb considers that the ions act because they affect either the physical condition of the colloidal substances (proteid, etc.) in protoplasm or the rapidity of chemical processes.

Amœboid movement, ciliary movement, the contraction of muscle, cell division and karyokinesis all fall into the same category as being mainly dependent on the stimulating action of ions.

Loeb has even gone so far as to consider that the process of fertilization is mainly ionic action; he denies that the nuclein of the male cell is essential, but asserts that all it does is to act as the stimulus in the due adjustment of the proportions of the surrounding ions, and supports this view by numerous experiments on ova in which without the presence of spermatozoa he has produced larvæ by merely altering the saline constituents and so the osmotic pressure of the fluid that surrounds them. Whether such a sweeping and almost revolutionary notion will stand the test of further verification must be left to the future; so also must the equally important idea that nervous impulses are to be mainly explained on an electrolytic basis. But whether or not all the details of such work will stand the test of time, the experiments I have briefly alluded to are sufficient to show the importance of physical chemistry to the physiologist, and they also form a useful commentary on what I was saying just now about vitalism. Such eminently vital phenomena as movement and fertilization are to be explained in whole or in part as due to the physical action of inorganic substances. Are not such suggestions indications of the undesirability of postulating the existence of any special mystic vital force?

I have spoken up to this point of physical chemistry as a branch of inorganic chemistry; there are already indications of its importance also in relation to organic chemistry. Many eminent chemists consider that the future advance of organic chemistry will be on the new physical lines. It is impossible to forecast where this will lead us; suffice it to say that not only physiology, but also pathology, pharmacology, and even therapeutics, will receive new accessions to knowledge the importance of which will be enormous.

I have now briefly sketched what appear to me to be the two main features of the chemical physiology of to-day, and the two lines, organic and inorganic, along which I believe it will progress in the future.

Let me now press upon you the importance in physiology, as in all experimental sciences, of the necessity first of bold experimentation, and secondly of bold theorizing from experimental data. Without experiment all theorizing is futile; the discovery of gravitation would never have seen the light if laborious years of work had not convinced Newton that it could be deduced from his observations. The Darwinian theory was similarly based upon data and experiments which occupied the greater part of its author's lifetime to collect and perform. Pasteur in France and Virchow in Germany supply other instances of the same devotion to work which was followed by the promulgation of wide-sweeping generalizations.

And after all it is the general law which is the main object of research; isolated facts may be interesting and are often of value, but it is not until facts are correlated and the discoveries ascertain their interrelationships that anything of epoch-making importance is given to the world.

It is, however, frequently the case that a thinker with keen insight can see the general law even before the facts upon which it rests are fully worked out. Often such bold theorizers are right, but even if they ultimately turn out to be wrong, or only partly right, they have given to their fellows some general idea on which to work; if the general idea is incorrect, it is important to prove it to be so in order to discover what is right later on. No one has ever seen an atom or a molecule, yet who can doubt that the atomic theory is the sheet anchor of chemistry? Mendeleeff formulated his periodic law before many of the elements were discovered; yet the accuracy of this great generalization has been such that it has actually led to the discovery of some of the missing elements.

I propose to illustrate these general remarks by a brief allusion to two typical sets of researches carried out during recent years in the region of chemical physiology. I do not pretend that either of them has the same overwhelming importance as the great discoveries I have alluded to, but I am inclined to think that one of them comes very near to that standard. The investigations in question are those of Ehrlich and of Pawlow. The work of Ehrlich mainly illustrates the useful part played by bold theorizing, the work of Pawlow that played by the introduction of new and bold methods of experiment.

I will take Pawlow first. This energetic and original Russian physiologist has by his new methods succeeded in throwing an entirely new light on the processes of digestion. Ingeniously devised surgical operations have enabled him to obtain the various digestive juices in a state of absolute purity and in large quantity. Their composition and their actions on the various foodstuffs have thus been ascertained in a manner never before accomplished; an apparently unfailing resourcefulness in devising and adapting experimental methods has enabled him and his fellow workers to discover the paths of the various nerve impulses by which secretion in the alimentary canal is regulated and controlled. The importance of the physical element in the process of digestion has been experimentally verified. If I were asked to point out what I considered to be the most important outcome of all this painstaking work, I should begin my answer by a number of negatives, and would say, not the discovery of the secretory nerves of the stomach or pancreas; not the correct analysis of the gastric juice, nor the fact that the intestinal juice has most useful digestive functions; all of these are discoveries of which any one might have been rightly proud; but after all they are more or less isolated facts. The main thing that Pawlow has shown is that digestion is not a succession of isolated acts, but each one is related to its predecessor and to that which follows it; the process of digestion is thus a continuous whole; for example, the acidity of the gastric juice provides for a delivery of pancreatic juice in proper quantity into the intestine; the intestinal juice acts upon the pancreatic, and so enables the latter to perform its powerful actions. I am afraid this example, as I have tersely stated it, presents the subject rather inadequately, but it will serve to show what I mean. Further, the composition of the various juices is admirably adjusted to the needs of the organism; when there is much proteid to be digested, the proteolytic activity of the juices secreted is correspondingly high, and the same is true for the other constituents of the food. It is such general conclusions as these, the correlation of isolated facts leading to the formulation of the law that the digestive process is continuous in the sense I have indicated and adapted to the needs of the work to be done, that constitute the great value of the work from the Russian laboratory. Work of this sort is sure to stimulate others to fill in the gaps and complete the picture, and already has borne fruit in this direction. It has, for instance, in Starling's hands led to the discovery of a chemical stimulus to pancreatic secretion. This is formed in the intestine as the result of the action of the gastric acid, and taken by the blood-stream to the pancreas. Whether this *secretin* as it is called may be one of a group of similar chemical stimuli which operate in other parts of the body has still to be found out.

The other series of researches to which I referred are those of Ehrlich and his colleagues and followers on the subject of immunity. This subject is one of such importance to every one of us that I am inclined to place the discovery on a level with those great discoveries of natural laws to which I alluded at the outset of this portion of my address. I hesitate to do so yet because many of the details of the theory still await verification. But up to the present all is working in that direction, and Ehrlich's ideas illustrate the value of bold theorizing in the hands of clear-sighted and far-seeing individuals.

But when I say that the doctrine is bold, I do not mean to infer that the experimental facts are scanty; they are just the reverse. But in the same way that a chemist has never seen an atom, and yet he believes atoms exist, so no one has yet ever seen a toxin or antitoxin in a state of purity, and yet we know they exist, and this knowledge promises to be of incalculable benefit to suffering humanity.

It may not be uninteresting to state briefly, for the benefit of those to whom the subject is new, the main facts and an outline of the theory which is based upon them.

We are all aware that one attack of many infective maladies protects us against another attack of the same disease. The person is said to be *immune* either partially or completely against that disease. Vaccination produces in a patient an attack of cowpox or vaccinia. This disease is related to smallpox, and some still hold that it is smallpox modified and rendered less malignant by passing through the body of a calf. At any rate an attack of vaccinia renders a person immune to smallpox, or variola, for a certain number of years. Vaccination is an instance of what is called *protective inoculation,* which is now practised with more or less success in reference to other diseases like plague and typhoid fever. The study of immunity has also rendered possible what may be called *curative inoculation,* or the injection of antitoxic material as a cure for diphtheria, tetanus, snake poisoning, etc.

The power the blood possesses of slaying bacteria was first discovered when the effort was made to grow various kinds of bacteria in it; it was looked upon as probable that blood would prove a suitable soil or medium for this purpose. It was found in some instances to have exactly the opposite effect. The chemical characters of the substances which kill the bacteria are not fully known; indeed, the same is true for most of the substances we have to speak of in this connection. Absence of knowledge on this particular point has not, however, prevented important discoveries from being made.

So far as is known at present, the substances in question are proteid in nature. The bactericidal powers of blood are destroyed by heating it for an hour to 56° C. Whether the substances are enzymes is a disputed point. So also is the question whether they are derived from the leucocytes; the balance of evidence appears to me to be in favor of this view in many cases at any rate, and phagocytosis becomes more intelligible if this view is accepted. The substances, whatever be their source or their chemical nature, are sometimes called alexins, but the more usual name now applied to them is that of *bacterio-lysins.*

Closely allied to the bactericidal power of blood, or blood-serum, is its globulicidal power. By this one means that the blood-serum of one animal has the power of dissolving the red blood-corpuscles of another species. If the serum of one animal is injected into the blood-stream of an animal of another species, the result is a destruction of its red corpuscles, which may be so excessive as to lead to the passing of the liberated hæmoglobin into the urine (hæmoglobinuria). The substance or substances in the serum that possess this property are called *hæmolysins,* and though there is some doubt whether bacteriolysins and hæmo-lysins are absolutely identical, there is no doubt that they are closely related substances.

Another interesting chemical point in this connection is the fact that the bactericidal power of the blood is closely related to its alkalinity. Increase of alkalinity means increase of bactericidal power. Venous blood contains more diffusible alkali than arterial blood and is more bactericidal; dropsical effusions are more alkaline than normal lymph and kill bacteria more easily. In a condition like diabetes, when the blood is less alkaline than it should be, the susceptibility to infectious diseases is increased. Alkalinity is probably beneficial because it favors those oxidative processes in the cells of the body which are so essential for the maintenance of healthy life.

Normal blood possesses a certain amount of substances which are inimical to the life of our bacterial foes. But suppose a person gets run down; every one knows he is then liable to 'catch anything.' This coincides with a diminution in the bactericidal power of his blood. But even a perfectly healthy person has not an unlimited supply of bacterio-lysin, and if the bacteria are sufficiently numerous he will fall a victim to the disease they produce. Here, however, comes in the remarkable part of the defence. In this struggle he will produce more and more bacterio-lysin, and if he gets well it means that the bacteria are finally vanquished, and his blood remains rich in the particular bacterio-lysin he has produced, and so will render him immune to further attacks from that particular species of bacterium. Every bacterium seems to cause the development of a specific bacterio-lysin.

Immunity can more conveniently be produced gradually in animals, and this applies, not only to the bacteria, but also to the toxins they form. If, for instance, the bacilli which produce diphtheria are grown in a suitable medium, they produce the diphtheria poison, or toxin, much in the same way that yeast-cells will produce alcohol when grown in a solution of sugar. Diphtheria toxin is associated with a proteose, as is also the case with the poison of snake venom. If a certain small dose called a 'lethal dose' is injected into a guinea-pig the result is death. But if the guinea-pig receive a smaller dose it will recover; a few days after it will stand a rather larger dose; and this may be continued until after many successive gradually increasing doses it will finally stand an amount equal to many lethal doses without any ill effects. The gradual introduction of the toxin has called forth the production of an antitoxin. If this is done in the horse instead of the guinea-pig the production of antitoxin is still more marked, and the serum obtained from the blood of an immunized horse may be used for injecting into human beings suffering from diphtheria, and rapidly cures the disease. The two actions of the blood, antitoxic and antibacterial, are frequently associated, but may be entirely distinct.

The antitoxin is also a proteid probably of the nature of a globulin; at any rate it is a proteid of larger molecular weight than a proteose. This suggests a practical point. In the case of snake-bite the poison gets into the blood rapidly owing to the comparative ease with which it diffuses, and so it is quickly carried all over the body. In treatment with the antitoxin or antivenin, speed is everything if life is to be saved; injection of this material under the skin is not much good, for the diffusion into the blood is too slow. It should be injected straight away into a blood-vessel.

There is no doubt that in these cases the antitoxin neutralizes the toxin much in the same way that an acid neutralizes an alkali. If the toxin and antitoxin are mixed in a test-tube, and time allowed for the interaction to occur, the result is an innocuous mixture. The toxin, however, is merely neutralized, not destroyed; for if the mixture in the test-tube is heated to 68° C. the antitoxin is coagulated and destroyed and the toxin remains as poisonous as ever.

Immunity is distinguished into *active* and *passive*. Active immunity is produced by the development of protective substances in the body; passive immunity by the injection of a protective serum. Of the two the former is the more permanent.

*Ricin*, the poisonous proteid of castor-oil seeds, and *abrin*, that of the Jequirity bean, also produce when gradually given to animals an immunity, due to the production of antiricin and antibrin respectively.

Ehrlich's hypothesis to explain such facts is usually spoken of as the *side-chain theory* of immunity. He considers that the toxins are capable of uniting with the protoplasm of living cells by possessing groups of atoms like those by which nutritive proteids are united to cells during normal assimilation. He terms these *haptophor* groups, and the groups to which these are attached in the cells he terms *receptor* groups. The introduction of a toxin stimulates an excessive production of receptors, which are finally thrown out into the circulation, and the free circulating receptors constitute the antitoxin. The comparison of the process to assimilation is justified by the fact that non-toxic substances like milk introduced gradually by successive doses into the blood-stream cause the formation of anti-substances capable of coagulating them.

Up to this point I have spoken only of the blood, but month by month workers are bringing forward evidence to show that other cells of the body may by similar measures be rendered capable of producing a corresponding protective mechanism.

One further development of the theory I must mention. At least two different substances are necessary to render a serum bactericidal or globulicidal. The bacterio-lysin or hæmolysin consists of these two substances. One of these is called the *immune body*, the other the *complement*. We may illustrate the use of these terms by an example. The repeated injection of the blood of an animal (*e. g.*, the goat) into the blood of another animal (*e. g.*, a sheep) after a time renders the latter animal immune to further injections, and at the same time causes the production of a serum which dissolves readily the red blood-corpuscles of the first animal. The sheep's serum is thus hæmolytic towards goat's blood-corpuscles. This power is destroyed by heating to 56° C. for half an hour, but returns when fresh goat's serum is added. The specific immunizing substance formed in the sheep is called the immune body; the ferment-like substance destroyed by heat is the complement. The latter is not specific, since it is furnished by the blood of non-immunized animals, but it is nevertheless essential for hæmolysis. Ehrlich believes that the immune body has two side groups—one which connects with the receptor of the red corpuscles and one which unites with the haptophor group of the complement, and thus renders possible the ferment-like action of the complement on the red corpuscles. Various antibacterial serums which have not been the success in treating disease they were expected to be are probably too poor in complement, though they may contain plenty of the immune body.

Quite distinct from the bactericidal, globulicidal, and antitoxic properties of blood is its agglutinating action. This is another result of infection with many kinds of bacteria or their toxins. The blood acquires the property of rendering immobile and clumping together the specific bacteria used in the infection. The test applied to the blood in cases of typhoid fever, and generally called Widal's reaction, depends on this fact.

The substances that produce this effect are called *agglutinins*. They also are probably proteid-like in nature, but are more resistant to heat than the lysins. Prolonged heating to over 60° C. is necessary to destroy their activity.

Lastly, we come to a question which more directly appeals to the physiologist than the preceding, because experiments in relation to immunity have furnished us with what has hitherto been lacking, a means of distinguishing human blood from the blood of other animals.

The discovery was made by Tchistovitch (1899), and his original experiment was as follows: Rabbits, dogs, goats, and guinea-pigs were inoculated with eel-serum, which is toxic: he thereby obtained from these animals an antitoxic serum. But the serum was not only antitoxic, but produced a precipitate when added to eel-serum, but not when added to the serum of any other animal. In other words, not only has a specific antitoxin been produced, but also a specific *precipitin*. Numerous observers have since found that this is a general rule throughout the animal kingdom, including man. If, for instance, a rabbit is treated with human blood, the serum ultimately obtained from the rabbit contains a specific precipitin for human blood; that is to say, a precipitate is formed on adding such a rabbit's serum to human blood, but not when added to the blood of any other animal.* The great value of the test is its delicacy: it will detect the specific blood when it is greatly diluted, after it has been dried for weeks, or even when it is mixed with the blood of other animals.

* There may be slight reaction with the blood of allied animals; for instance, with monkey's blood in the case of man.

I have entered into this subject at some length because it so admirably illustrates the kind of research which is now in progress; it is also of interest to others than mere physiologists. I have not by any means exhausted the subject, but for fear I may exhaust my audience let me hasten to a conclusion. I began by eulogizing the progress of the branch of science on which I have elected to speak to you. Let me conclude with a word of warning on the danger of over-specialization. The ultra-specialist is apt to become narrow, to confine himself so closely to his own groove that he forgets to notice what is occurring in the parallel and intercrossing grooves of others. But those who devote themselves to the chemical side of physiology run but little danger of this evil. The subject cannot be studied apart from other branches of physiology, so closely are both branches and roots intertwined. As an illustration of this may I be permitted to speak of some of my own work? During the past few years the energies of my laboratory have been devoted to investigations on the chemical side of nervous activity, and I have had the advantage of cooperating to this end with a number of investigators, of whom I may particularly mention Dr. Mott and Dr. T. G. Brodie. But we soon found that any narrow investigation of the chemical properties of nervous matter and the changes this undergoes during life and after death was impossible. Our work extended in a pathological direction so as to investigate the matter in the brains of those suffering from nervous disease; it extended in a histological direction so as to determine the chemical meaning of various staining reactions presented by normal and abnormal structures in the brain and spinal cord; it extended in an experimental direction in the elucidation of the phenomena of fatigue, and to ascertain whether there was any difference in medullated and non-medullated nerve fibers in this respect; it extended into what one may call a pharmacological direction in the investigation of the action of the poisonous products of the breakdown of nervous tissues. I think I have said enough to show you how intimate are the connections of the chemical with the other aspects of physiology, and although I have given you but one instance, that which is freshest to my mind, the same could be said for almost any other well-planned piece of research work of a bio-chemical nature.

# SCIENTIFIC PALMISTRY.

By Professor HARRIS HAWTHORNE WILDER, Ph.D.,
SMITH COLLEGE.

RISING from the waters of Kejemkoojic Lake in Nova Scotia there stands a series of smooth slaty rocks which appear to one approaching in a canoe so tempting a surface for the scratching of inscriptions that they are completely covered, as far up as one can read, with pictures, names, dates and meaningless scrawls, superimposed upon one another and successively the work of the aboriginal Micmac Indians, the French and the English. The oldest of these are undoubtedly pre-columbian, while at the present day additions are continually being made by vandalistic excursionists.

In spite of the superposition of these varied scrawls, Col. Garrick Mallory, who has made them the subject of special study, was able to separate the genuine Micmac inscriptions from the others and has published many of these in the United States Reports of the Bureau of American Ethnology. Among those he found the accompanying figure of the palmar surface of a human hand (Fig. 1)* which shows a remarkable degree of detail and must have been the result of an unusually careful observation. The figure will be better appreciated, perhaps, if the reader will first scrutinize the palmar surface of his own left hand in a strong light and compare it with his other hand and with the hands of two or three of his friends. It will be noticed, first, that the surface in question is marked by two distinct sets of markings; first, the wrinkles, which form the chief consideration of that means of amusement known as 'palmistry' and which are caused by the movements of the fingers and their muscles, and secondly the papillary ridges, which form the fundamental sculpture of the skin and run in approximately parallel directions across both the palm and the palmar surface of

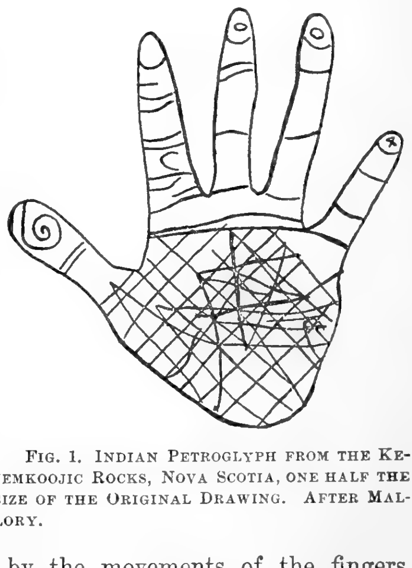


Fig. 1. Indian Petroglyph from the Kejemkoojic Rocks, Nova Scotia, one half the size of the Original Drawing. After Mallory.

* Tenth Annual Report of the Bureau of Ethnology, p. 740, Fig. 1255.

the fingers, their general plan being unaffected by the presence of the wrinkles. By a more careful study of the papillary ridges it will be seen that they are often discontinued, reinforced by new ones, forked or, in a few cases, looped, and that in certain spots the usual course is interrupted by the insertion of a figure or 'pattern,' as it is technically called, in the form of a spiral, a whorl or a loop. Such patterns are of constant occurrence in the balls of the fingers, while the palm usually, though not always, possesses from one to four or five of them, located in certain definite localities, as at the base of the fingers or upon the raised, pad-like outer side of the palm, the hypothenar area. In rare cases such a pattern is met with upon the thenar area, at the base of the thumb (Fig. 6, *a*) but the fine parallel wrinkles almost always found in this region render it difficult to see.

It will be seen, now, by turning to the figure, that each of the above details has been indicated by the Micmac artist, not literally, as we should do it, but symbolically, that is, by something to suggest each detail. Thus in the drawing there are two sets of palmar lines; the foundation or background, consisting of fine lines approximately parallel, and evidently indicative of the papillary ridges, and the superimposed angular ones with little or no system, which represent the wrinkles. As for patterns, it is possible that the little curve near the outer margin may represent the hypothenar pattern, which, though not a constant element, is of frequent occurrence; and, at all events, the patterns at the finger tips are well indicated save in the case of the index finger where the omission is probably accidental. Here also the difference in the form of the separate patterns is well shown; that of the thumb is a spiral, a usual form for that digit, those of the third and fourth fingers are whorls and the curious cross or mark like the Arabic number four, found upon the little finger, may represent certain of the components of that form known as a loop.

Turning from Indian anatomy to Indian morphology, from the observation of facts to the construction of explanatory theories, we have the followng remarkable passage in one of the reports of the *Berliner Gesellschaft für Anthropologie* as cited by Col. Mallory, in connection with the figure of the hand and representing a conversation with one of the Bella Coola Indians of British Columbia.

> The frequency with which partial representation of the eye are met with appeared to me so striking that I requested Mr. Jacobsen to ask the Bella Coola Indians whether they had any special idea in employing the eye so frequently. To my great surprise the person addressed pointed to the palmar surface of his finger tips and to the fine lineaments which the skin there presents; in his opinion a rounded or longitudinal field, such as appears between the converging or parallel lines, also means an eye, and the reason of this is that originally each part of the body terminated in an organ of sense, particu-

larly an eye, and was only afterward made to retrovert into such rudimentary conditions.*

This explanation is, of course, the merest guess-work, resulting from a fancied resemblance between an eye and the shape of a pattern, but by a singular chance, the theory comes nearer the truth than one would at first suspect, since these scrolls and loops, not only of the fingers, but those of the palm as well, are in reality rudiments, not of eyes, but of walking pads; a conclusion which, although it may seem at first a little fanciful, is reached by a simple course of reasoning and rests upon the comparison of easily available data, namely an inspection of the volar, or lower surfaces of the paws of various mammals.

The most typical, that is, the least modified mammalian paw is one with five toes and in which the entire volar surface, from the tips of the digits back to the wrist or heel, comes in contact with the ground during the act of walking. In such paws, as, for example, those found in most rodents and in many of the carnivora, it will be seen that the weight is borne by a series of ten projecting pads or permanent callosities, five of which are situated at the ends of the digits, while the remaining five are placed upon the surface of the palm or sole, and possess the definite arrangement shown in the accompanying diagram, (Fig. 2, *a*) namely, *one each for the thenar and hypothenar areas,* the raised portions associated respectively with the inner and outer margins, and *three placed in a transverse row at the bases of the four fingers and corresponding to the intervals between them.* In accordance with their positions, these pads may be conveniently named the *thenar,* the *hypothenar* and the *first, second* and *third palmar* (or *plantar,* in the case of the hind foot). Those at the ends of the digits may be designated as *apical* and numbered consecutively from *one* to *five.*

In actual cases, owing to the various modifications necessitated by habit and environment, such a diagrammatic arrangement is seldom completely realized, but often in an embryo, before the special modification characteristic of the adult form has been introduced, the condition closely approximates the typical one (Fig. 2, *b*). How these modifications may affect the original plan may be well seen by a comparison of the fore-paws of the mink and the common cat (Fig, 2, *c* and *d*), two carnivores representing different stages in the coalescence of the three palmar pads to form the characteristic cushion adapted for silent progression. In the mink these pads are still semi-distinct and the middle one exceeds the others in size, suggesting that, in the cat, this latter element forms the main bulk of the cushion, a conclusion proved to be the fact from the study of kitten embryos, as,

* *Verhandlungen der Berliner Gesellschaft für Anthropologie,* March 20, 1886, p. 208. (Translated by Col. Mallory.)

in successive stages of these the lateral pads appear at first distinct, then attached to the middle ones as a pair of lateral wings, and finally become completely fused. In the adult cushion the part furnished by each element is still traceable in the irregular contour of the resultant


FIG. 2a.

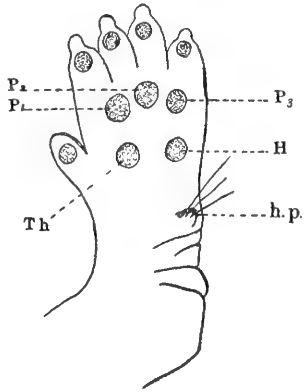



FIG. 2b.

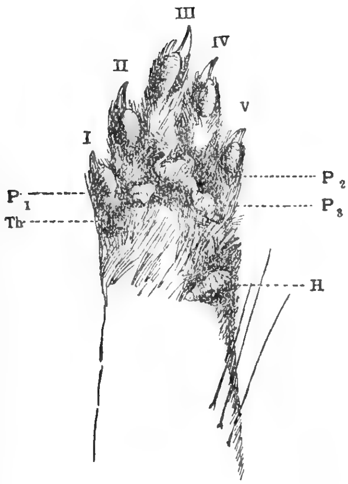



FIG. 2c.

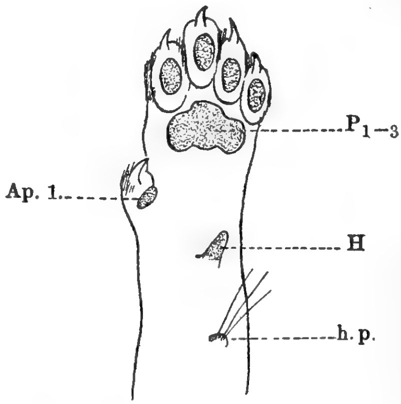



FIG. 2d.

FIG. 2. ARRANGEMENT OF PADS ON MAMMALIAN FOOT. (*a*) Typical arrangement; diagram. (*b*) Typical arrangement; forefoot of rat embryo. (*c*) Forefoot of mink, showing a slight modification of the type. (*d*) Forefoot of cat, showing fusion of palmar pads. Abbreviations: *A*, apical pads; $P_1$–$P_3$, palmar pads; *Th*, thenar pad; *H*, hypothenar pad; *h. p*, hair papilla; *I–V*, the digits.

mass. The noticeable projecting spur near the wrist is a modified hypothenar pad, but the small bristle-bearing papilla still farther up has nothing to do with it and is not a pad.

A singular modification of the type, and one which forms a necessary link in our present inquiry, is seen in monkeys, in which, owing to their arboreal life and the consequent substitution of climbing for walking, the pads have become low, flattened mounds, and the usual hard covering has softened to a soft epidermis marked with curiously disposed ridges, the seat of a highly developed tactile sense. The volar surface of the paws thus forms a delicate organ of touch, specially adapted to perceive the varying conditions of the tree-boughs, a power often of vital importance to the animal (Fig. 3). The epidermic or papillary ridges cover the entire volar surfaces and *designate the position of the typical pads by elaborate patterns in the forms of scrolls, loops and whorls* as may be seen by a comparison of the figures with the typical diagram. It will be noticed, however, that aside from the usual ten pads, there is seen a small accessory hypothenar, situated between the hypothenar and the third palmar, and that upon the fingers, aside from the apical patterns, there are suggestions of loops and other figures placed upon the first and second joints. The morphological significance of these extra parts is not known at present, and it is probable that they have not other meaning than an attempt to increase still farther the sensitiveness of the surface in places not covered by the original pads.

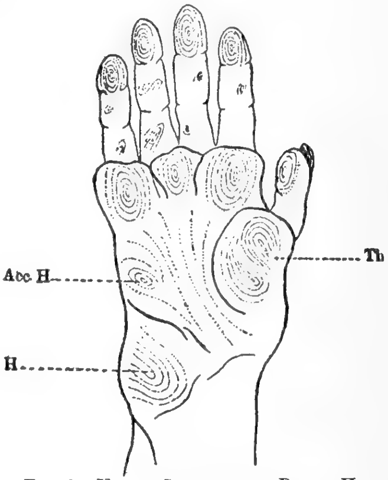



FIG. 3. VOLAR SURFACE OF RIGHT HAND OF LARGE MONKEY (*Inuus*): (from author's illustration in *Anat. Anzeiger*, 1896). *Acc. H*, Accessory hypothenar pad (other abbreviations as in Fig. 2).

To supply the next and final link in our chain of reasoning the reader may be asked to consult his own hand and compare it with Fig. 3. Upon this the apical pads, or patterns, as they may now be called, will be easily seen, much as in the Micmac drawings, and it is probable that one at least of the palmar patterns, and perhaps also the hypothenar, will be in evidence. Individual human hands differ greatly, however, in the patterns represented, the limits in the authors collection of one hundred palm-prints being shown in Fig. 4, both taken from whites of American parentage, yet differing from each other in the matter of patterns more than the first and more atavistic one differs from that of the monkey. In the same way Fig. 5 represents the extremes of a collection of about sixty sole-prints where the differences are as great as in the palms.

The great individual variation of these parts in the human being is not without significance and furnishes an excellent illustration of the biological truth *that the perfection and constancy of an organ are directly proportional to its necessity in the life of the organism.* Thus

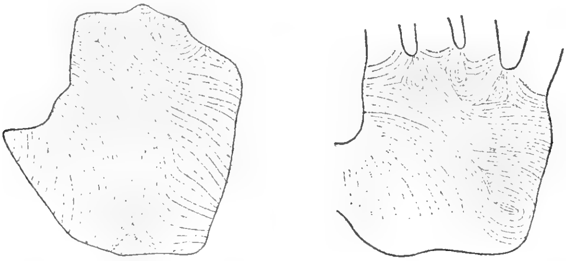


FIG. 4*a*. FIG. 4*b*.

FIG. 4. TRACINGS FROM PALM PRINTS, SHOWING RANGE OF VARIATION.

in an arboreal primate, an exact appreciation of the contact surfaces of the tree-boughs among which it climbs and swings is of vital importance, and the slightest defect or deviation from the standard in the organs furnishing that intelligence would be apt to prove fatal; but

FIG. 5*a*. FIG. 5*b*.

FIG. 5. TRACINGS FROM SOLE PRINTS, SHOWING RANGE OF VARIATION.

when such a being assumes a terrestrial life, so high a degree of sensitiveness in palms and soles is no longer necessary and the organ is allowed to lapse. Individual variations, no longer discouraged, tend to increase, and that which was once a necessary and vital arrangement of the papillary ridges becomes of little importance. The influence of environment becomes entirely removed, and the only reason for the farther continuance of these parts is the conservative power of heredity, which may perpetuate, apparently for a vast period of time, characteristics no longer of necessity to the organism.

Briefly stated, the law described above is this: that only useful and important parts retain a certain normal form in the various individuals of a given species, and that, as they become of less importance, they tend more and more to vary individually, the range of variation increasing with time and the degree of uselessness, if such an expression may be allowed; conversely, an organ that is seen to possess marked individual variation is shown to be of secondary importance, and may be either a rudimentary organ, that is, one on the way towards a greater perfection in the future and in which the variations represent the numerous experiments or attempts to find the form best adapted for a special purpose, or, again, it may be a vestigial organ, or one in which its point of highest usefulness is passed and in which the variations represent various degrees of degeneracy, or stages in its gradual eradication from the organism.

Returning to the case under consideration, a brief mention should be made of another feature of the monkey palm or sole besides that of the patterns, and that is the low but evident mounds upon which the patterns are placed and which more properly represent the elevations or pads themselves. Although these have suffered more in the transition to the human form they are commonly not absent, even in the adult and may be seen with especial clearness in the embryo. In many adult hands the three palmar pads are clearly brought out by simply bending back the fingers and looking across the palmar region, and this notwithstanding the fact that the modern, rather ingenious 'science' of palmistry locates here four 'mounts' rather than three, and associates them with the fingers instead of with the intervals between them; an interesting illustration of what even the most careful observation will do without a rational basis.

The endless variety shown in the disposal of the epidermic ridges as outlined above will suggest several important lines of study, as, for example, the discovery of a system or of laws governing the variation; the possible influence of heredity upon the variation; and through this the possibility of the discovery of characters which may serve as criteria of race; the use of the markings in personal identification, and so on; and, although the simple scrutiny of a few palms may suffice for a preliminary examination, a need will soon be felt of some method by which a permanent and accurate record may be made, something in the form of a print or impression which may be available at all times for purposes of study and comparison. Numerous methods of preparing such records have been elaborated at length by Mr. Francis Galton whose eminent labors upon the comparison and classification of the apical patterns have resulted in an elaborate and accurate system of personal identification, and for these the reader is referred to Chapter III. of his 'Finger Prints.'* The method found by the present author to be the most practicable is a slight modification of Galton's printing-ink method and may be best explained by a quotation from a set of direction prepared for the use of those willing to assist him in the collection of prints.

The method of printing is a simple one, the only needful apparatus being (*a*) a tube of best quality black mimeograph ink, (*b*) a rubber roller six inches long, such as is sold with photographic outfits, and (c) white, unruled paper of a suitable size and quality. A large slate for spreading the ink is a useful accessory, but a smooth sheet of paper pasted upon a flat board or piece of cardboard will fulfil the requirements in this particular.

In printing, a bit of ink should first be squeezed from the tube upon the slate or other surface used and should be spread evenly by rolling the rubber roller back and forth in various directions, until a thin layer of uniform thickness is spread over the flat surface. When the surface is in exactly the right state the palm or sole to be printed should first be wiped dry and applied to it, pressing it down from above and taking care not to move it from its original position. The pressure should be applied especially to all regions which, like the center of the palm, are naturally raised above the level of the other parts, and the fingers should be spread a little apart and pressure applied between them. In removing the member from the inked surface hold the corners of the latter and lift it quickly, beginning at the wrist or heel. By now placing the member in the same position upon a clean piece of paper and by repeating the pressure and other manipulations a print will be obtained. Finally, a little turpentine may be used to clean the roller and the surface of the skin.

Prints formed by the above methods reproduce the exact course of every papillary ridge and may be studied at ease, drawn upon and compared with one another in ways never possible in the case of the actual surfaces; besides which, the contrast of the black ridges with the white interstices (white if the ink has not been used too plentifully) causes the markings to show with far greater distinctness than when presented in the uniform tints of the natural flesh.

In order, however, that such a print should furnish much instruction, it should be interpreted, that is, mapped out morphologically into its natural areas, a proceeding which is always the first step in the study and which causes the prints to appear somewhat as in the examples given in Fig. 6. In the case of the hand, such an interpretation should begin by the determination of five fixed points, or tri-radii, four of which, the *palmar tri-radii,* are below the bases of the four fingers and

* Published by Macmillan & Co., 1892.

the fifth, the *carpal tri-radius,* low down near the wrist and of more uncertain occurrence. These tri-radii are points about each of which three sets of ridges come in contact, their boundaries forming links which radiate from the point at about equal angles from one another. In some cases there will be produced in this way a small triangle of neutral ground from the angles of which the three lines proceed, while in others the three radiating lines proceed from a point.

When these points are determined the palm is marked out into areas by simply continuing the radiating lines until they pass beyond the margin or coalesce with one another, a proceeding best followed at first with a finely pointed hard black pencil, and afterward repeated for the sake of clearness with a colored pencil, preferably red. In tracing these lines it will be noticed that they often follow the interspaces and not the ridges, and that these latter often break or fork, sometimes causing a moment's consideration concerning the best direction to follow. A lens may occasionally be used to advantage, but usually it is better in doubtful cases not to scrutinize the details too minutely, but to let the lines of interpretation follow the general trend of the markings, rather than individual spaces or ridges.

When the interpretation is complete it will be seen that the palm is separated into its elemental areas as in the illustration given in Fig. 6. The two short lines going up between the fingers from each of the palmar tri-radii are termed the *digital lines,* and serve to limit the small triangular *digital areas;* while the third set of lines, usually more extensive, form the *four primary lines* and run across the palm, marking the boundaries of the *three palmar areas.* When a carpal tri-radius is present, its extensions define a *carpal area* adjacent to the wrist and also separate the two largest areas, the *thenar* and the *hypothenar*; in cases where it is wanting, a slight divergence of the lines in about the middle of the wrist at the margin of the palm shows the point from which the line should be drawn that separates the two latter areas. Such a case may be termed a 'parting,' and where this occurs there is no definite carpal area.

These, then, are the elements into which a human palm may be divided, and among these there is the greatest conceivable variation, both of size, arrangement and mutual relationship. If even a small collection of interpreted prints be made and compared (Fig. 6), they will be found to be absolutely individual and distinct, the differences being due to variations in the elementary areas, both in themselves and in their relationships to one another. This variation is so great that it seems at first to be entirely without system, and much like the detailed though purposeless descriptions of the palmist, whose classification of the wrinkles and other features, though worked out into the minutest details, is wholly artificial and arbitrary; yet the exact correspondence of the areas with the patterned mounds of the monkey palm show that we are dealing here with definite morphological parts, and the variations that occur are caused by reduction, hypertrophy, fusions, separations and other principles with which the morphologist is familiar.

Thus, considering the three palmar areas alone, they will be found either all *distinct* (Fig. 6, *a* and *b*) or two of them may be *confluent* (Fig. 6, *c*, $P_2$ and $P_3$), or *semi-confluent* (Fig. 6, *d*, $P_1$ and $P_3$). They may be *open, i. e.*, may extend to the margin (Fig. 6, *b*, $P_1$ and $P_2$) or *closed* (Fig. 6, *c*, $P_2$ and $P_3$). Semi-confluent areas may also be termed

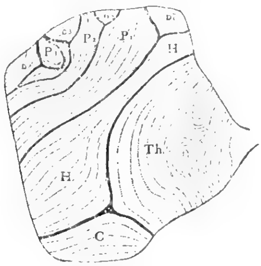



FIG. 6*a*.

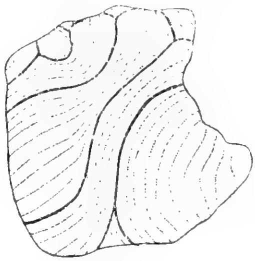


FIG. 6*b*.

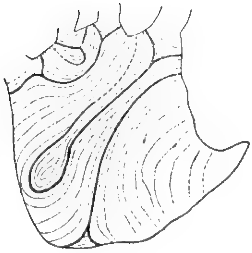


FIG. 6*c*.

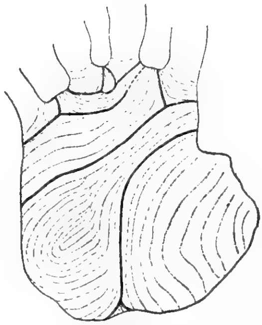


FIG. 6*d*.

FIG. 6. TRACINGS OF FOUR PALM PRINTS, TO ILLUSTRATE VARIOUS MODIFICATIONS.

*divided,* since this condition is brought about by the division of one of the areas by a primary line, and in the same way a single closed area (Fig. 6, *b*, $P_3$) may be termed *circumscribed,* since this condition is brought about by the fusion of the two primary lines which serve as boundaries.

In size an area may vary between a very large one (Fig. 6, *b*, $P_1$) and a greatly reduced one (Fig. 6, *d*, $P_2$), and in the latter case the reduction may become so extreme as to end in the complete loss of an area, a condition which would be obtained if we should consider the second and third palmar tri-radii of Fig. 6, *d,* which are here very near together, to approximate still closer until they became entirely coincident, a condition not infrequent.

These modifications of areas may be readily expressed in terms of the primary lines which determine and bound them, and as each of these four lines possesses a large number of possible positions, they may be made the basis of a classification by which an individual palm not only might have a definite place in a series, but might also be conveniently designated and briefly described; furthermore, the terms constantly occurring in such a description might be expressed by obvious symbols, thus reducing it to a simple formula. To illustrate this the four palms given in Fig. 6 may be described in terms of the primary lines as follows:

(*a*) Line 1, open to margin; line 2, open to margin; line 3, fused with eighth digital line; line 4, recurrent, dividing third palmar area.

(*b*) Line 1, open to margin, low; line 2, open to margin; line 3, fused with line 4; line 4, fused with line 3.

(*c*) Line 1, involved in pattern, returning above; line 2, fused with line 4; line 3, recurrent, dividing third palmar area; line 4, fused with line 2.

(*d*) Line 1, open to margin; line 2, fused with line 3; line 3, fused with line 2; line 4, dividing first palmar area.

By the employment of a few obvious symbols these descriptions might be transformed into formulæ, as, for example:

(*a*) $0 - 0 - d_8 - \frac{P_3}{4}$

(*b*) $0 - 0 - +4 - +3$

(*c*) In H ret. above $- +4 - \frac{P_3}{3} - +2$

(*d*) $0 - +3 - +2 - \frac{P_1}{4}$

This exposition of individual differences in the course of the papillary ridges, and the suggestion of methods of recording, interpreting and describing them, leads us away from the realm of morphology to that of their practical use in establishing personal identity and thus brings us to the work of Mr. Francis Galton, who by the patient observation of a long series of years has elaborated a system by which personal identification may be established by the use of the apical patterns. As a result, primarily, of the suggestions of Sir William Herschel, Galton in his anthropological laboratory at South Kensington, has spent years in collecting data for his work, and to him belongs the entire credit of having established the two essential facts upon which all claim to the value of such markings in the point at issue must rest, namely; (1) their absolutely individual character, and the impossibility of an exact duplicature in two individuals and (2) their permanence throughout life.*

* See for this Galton's numerous publications on the subject and especially his two books on 'Finger Prints' and 'The Decipherment of Blurred and Indistinct Finger Prints.' Macmillan, 1892–94.

That the method of employing the prints of the apical patterns in identification, as advocated by Galton is, in the hands of an expert, an exact one, there can be no doubt, and it has been already accepted by the English government and introduced in the province of Bengal and a few other places, proving a dangerous rival to the more obvious but less accurate system of Bertillon, which depends upon various physical measurements; but the disadvantages occurring from the minuteness of the parts upon which the observation depends and the necessity of a lens, obstacles which would demand in all cases the employment of a trained expert, would necessarily limit the application of such a system to a few places where adequate means could be furnished.

As a practical extension of the Galtonian system; one in which the minute details of the apical patterns are replaced by larger and more definite markings, the present author advocates the use of prints, *not only of the whole palms, but of the soles as well,* a system in which in the vast majority of cases the cursory study of the main lines and areas alone would be sufficient, while only in the almost impossible case of general correspondence in the markings of two individuals in all four members would resort to what Galton terms the 'minutiæ' be necessary. In the collection of one hundred palm prints alluded to above, there are but two or three cases where the general formula is the same in the hands of the same side, and in these the other hands and the two sets of soles are widely different. If this should prove to be about the usual average, then an identity of general plan, that is a similar course in the four primary lines, may be expected to occur once in every 25 left hands. Continuing this line of reasoning, the chance of the coincidence being repeated in the right hand would be but $25^2$, or 625, and if the same figures be true of the soles, then in complete sets the chance of correspondence in the gross details would be $25^4$, or once in 390,625 times. But such 'identity' is by no means a complete one and really means, not an identity at all but a general similarity in the course of the four primary lines and in the areas defined by them. If such very obvious details as the occurrence of patterns, or the condition of the carpal area be also taken into account the chance of coincidence would be many times decreased. Furthermore, as Galton has conclusively proved by careful statistical study of the apical patterns, even in those identical in general plan, the 'minutiæ,' that is, the disposition, number and length of the ridges forming the patterns are always very different.

Aside from this, another line of proof of the impossibility of complete duplicates is furnished by an examination of the hands and palms of so-called 'identical' twins, or twins which are of the same sex and otherwise closely resembling one another. In such cases we have a strong biological warrant to expect a closer resemblance in these and all other parts than could possibly be the case with any other two individuals, but even here, although the correspondence as to the general formulæ is, as a matter of fact, identical or nearly so, the variation in proportions, in the number of ridges forming a given area, and in other similar details, is so great that no one would be deceived into considering them really identical.

If the use and practical application of the system above outlined may be briefly alluded to here, it will be seen that the cases where such a system would be of great importance are numerous and varied. Aside from the case of criminals where the possession of a set of prints by the authorities would be a far better and surer guide than the usual 'Rogues Gallery' photograph or even a set of Bertillon measurements, there are cases of accidents of various sorts in which the bodies may be sufficiently mutilated to render recognition uncertain or impossible; cases of claimants of estates, like the famous Tichbourne claimant; cases of the supposed restoration of lost children, and many others.

With regard to criminals, prints could be made and filed away at headquarters, as is now done with photographs and written descriptions, for in the case of a suspect who has taken refuge under an *alias,* the mere hesitation to submit to the process would increase suspicion, and one could have no just ground for refusal. Should a refractory case occur, the use of chloroform would violate no principle of humanity, and the mere threat of it would be apt to enforce compliance.

In accident cases, as in the classical one of Jezebel, to whom Galton has feelingly alluded, the palms and the soles are apt to be the last external parts to be destroyed, being protected respectively by the involuntary clenching of the hands and by the heavy soles of the shoes. With regard to the durability of the epidermic ridges Galton states that they are still present and plainly seen in many Egyptian mummies and in an experiment made by the author upon the feet of an infant belonging to the prehistoric cliff-dwellers of southern Utah, where the bodies were not even embalmed but simply dried in the rarefied mountain air, the thenar and apical patterns could be definitely traced after a comparatively simple preliminary treatment.

To provide for both accident cases and those involving all forms of claimants, it would be a very simple matter for families to take and preserve a set of prints of each individual, although it would be still better, as in all cases of public versus private supervision, if each community were required by law to add such a set of prints to the birth records of each of its citizens, records which could be easily taken at the entrance to the public schools or at some other definite time when the child is old enough to voluntarily assist in the process. These records could be easily duplicated by photography if wanted for comparison at a distance, but in most cases the sending of the formulæ either alone or with the addition of a few details would suffice, and could be easily telegraphed.

To insure the rapid selection of a given print, especially in a large collection, some method of classification other than by name and family would be requisite and this could be done by filing the actual prints alphabetically and making a card catalogue of the formulæ and descriptions, the arrangement of which would depend upon certain features selected from these.

By such means it would be easily possible to keep even a great number of records in a very compact form, and in the larger towns and in cities this would demand the use of a special room in the municipal building and the maintenance of a clerk to take and file the prints and to be on hand for consultation in case of need, yet the small expense involved in this would be trivial in comparison with the large amounts which would often be saved by a prompt and accurate determination.

It is, then, a matter of certainty that a system of personal identification founded upon the epidermic markings of palms and soles would endure all the tests required of such a system and would be in point of absolute accuracy, rapidity of application, simplicity and convenience in classification much superior to any system now in vogue. Its uses would be as numerous as are the cases in which the identification of a body, living or dead, becomes for any reason a matter of importance and it may be prophesied that the countless cases where doubt, uncertainty and great expense are involved, and which are now of constant occurrence, may be ultimately prevented through its establishment.

## TOWARDS THE NORTH POLE.*

THE collapse of Mr. Baldwin's expedition by Franz Josef Land and the return of Commander Peary and Captain Sverdrup from their abortive attempts to reach the Pole from the American side may make it interesting to give a brief account of the various efforts that have been made to push northwards towards this goal during the last 400 years. Mr. Baldwin's richly-equipped expedition was frankly stated to have as its almost sole object a dash at the Pole, and although both the expeditions of Commander Peary and Captain Sverdrup had other and more substantial objects in view, still, in each case, these were to be combined with an attempt to pass all previous records in this direction. We await details of Captain Sverdrup's proceedings, but it is improbable that he has attained anything like the latitude achieved by Commander Peary.

During the latter half of the sixteenth century and the early years of the seventeenth, when so many stages of the long journey to the North Pole were covered, great progress was made in that section of the north polar area which lies to the north of Europe and includes the extensive land masses of Novaya Zemlya and Spitzbergen. Sir Hugh Willoughby, in the *Bona Esperanza,* 120 tons, Richard Chancellor, in the *Edward Bonaventure,* 160 tons, and Cornelius Durfourth, in the *Bona Confidentia,* 90 tons, first led the way in 1553. The first two vessels reached Kolguev Island, or as some claim even the southwestern shore of Novaya Zemlya, in about 72° N. latitude; but the extent of the voyage is uncertain, as in the following winter all on board, numbering some 62 souls, miserably perished of cold and hunger. There is no doubt, however, that Stephen Burrough in the *Searchthrift* pinnace reached 70°20′ N. latitude in 1556 and sighted the coast of Novaya Zemlya. The next great step northwards in this direction was made by the Dutch mariner, William Barents. Sent by the merchants of Amsterdam in the *Mercury,* 100 tons, to discover a passage to China round the north of the island, he sighted on July 4, 1594, the west coast of Novaya Zemlya in 73°25′ N. latitude. Continuing his journey, he passed the northern limit of the island, finally reaching Orange Island north of the 77th parallel. Two years later another stage in the direction of the Pole was covered. A Dutch expedition comprising two vessels, Barents being chief pilot of the one and Cornelius

* From the London *Times.*

Ryp in command of the other, sailed north past Bear Island to Spitzbergen, and in following its shores, then explored for the first time, reached a latitude of close on 80° N. Even this high northing was surpassed, however, by Henry Hudson in 1607, who, in a little vessel of 80 tons, the *Hopewell,* followed the Spitzbergen coast to a point by dead reckoning 81° N. Land was stated to have been seen as far north as 82°, but either the reckoning must have been erroneous or ice must have been mistaken for land. In 1612, however, Jonas Poole met at Spitzbergen Thomas Marmaduke, of Hull, in the *Hopewell,* who, Poole states, sailed as far north as 82°, two degrees beyond Hakluyt's Headland. If this statement is well founded, no further advance towards the Pole was made in this or any other direction—that is, no well-authenticated advance—for considerably over 200 years. But if Marmaduke's claim is allowed, so must be the claims of the Dutch and other whalers, large numbers of whom for many long years thought nothing of passing 80° N. latitude, and in favorable seasons may possibly have reached a degree or two higher. Confining our attention, however, to authenticated records, and remembering that the highest northing calculated from observations that was reached by Hudson was 80°23′, we may mention, in this brief record of the stages passed in the journey northwards, the expedition sent out by the Admiralty in 1773 under Captain J. C. Phipps (afterwards Lord Mulgrave). Phipps reached 80°48′ N. latitude off the northwest coast of Spitzbergen. It is interesting to note that this was the polar expedition on which Nelson served. A more marked advance was made in 1806, when the famous whaler, William Scoresby, was able to advance good proof that he had reached 81°30′ N. latitude in the Spitzbergen Sea.

But it was reserved for Lieutenant W. E. Parry far to outdistance all his predecessors in the work of north polar exploration. Parry set sail in the *Hecla* in 1827, and making Trureaberg Bay, on the north coast of Spitzbergen, his base of operations, started northwards with two boats, which were fitted with steel-shod runners so that they might serve as sledges. In spite of the toilsome nature of the journey, he and his men pushed over the ice, piled with great blocks and bristling with splinters which pierced through boots and feet, to latitude 82°45′ N. Then it was found that the southerly drift of the ice practically counterbalanced the progress made during the onward march and the expedition was compelled to turn back. Before Dr. Nansen's ever-memorable expedition, Parry's was the highest northing attained in the Eastern Hemisphere. But it may be noted that the Austrian Lieutenant Julius Payer, who, in conjunction with Lieutenant Carl Weyprecht, discovered Franz Josef Land in 1873, reached in the following year the highest point on land yet attained in the Eastern Hemisphere, in 82°05′ N. latitude. Neither Mr. Jackson, Mr. Well-man, nor Mr. Baldwin established a record. Dr. Nansen's famous journey in 1893–96, on which the explorer made so great a stride towards the Pole, is still fresh in the minds of all. Here we will only recall that the *Fram,* after entering the ice near the New Siberian Islands, touched the 86th parallel in the course of her long drift westwards, while Dr. Nansen himself and Lieutenant Johansen, having left the ship in 84° N., finally reached (at least) 86°5′ N., in longitude roughly 90° E. Two years ago this record was surpassed by Captain Cagni, of the Duke of the Abruzzi's expedition, who reached 86°33′ N. latitude, the highest northing yet attained in either the Eastern or the Western Hemisphere.

Hitherto the passage north through Behring Strait has not led any traveller to very high latitudes. Behring himself discovered neither the strait nor the sea that bear his name. His utmost northing was 67°18′, attained on his first expedition in 1728. Exactly 50 years later Captain James Cook, the great navigator, reached 70°44′ north, and in 1826 another British naval officer, Captain F. W. Beechey, who had been told off to cooperate with Franklin in his researches on the mainland of North America, attained the latitude of 71°08′ N. Beechey's mate, Elson, pushed 126 miles beyond Icy Cape to Point Barrow, in 71°24′ N. latitude. In 1849 Captain Kellet reached the first island to the north of Behring Strait, in 71°18′ N., and six years later Commander John Rodgers, of the United States navy, surpassed Elson's latitude, his northing being 72°05′. But the highest latitude recorded in these seas was that attained by Commander G. W. De Long, of the United States navy, to the north of the Liakoff or New Siberian Islands. This group had first been reached from the north coast of Asia in 1770, by a Russian trader named Liakoff, and in 1823 Lieutenant P. F. Anjou, who since 1820 had been exploring among the islands in company with Lieutenant F. von Wrangell, had succeeded in getting as far north as 76°36′. De Long sailed through Behring Strait in the ill-fated *Jeannette* in 1879. The pack-ice was entered near Herald Island in 71°35′ N., and for two years the vessel drifted westward and northwards. Wrangell Land, which De Long had thought was part of a continent, and on which he expected to winter, was passed in the summer of 1779; in June, 1881, Jeannette Island in 76°47′ N. latitude was reached; later in the same month Henrietta Island, in 77°08′ N. was passed, and then the *Jeannette* was crushed in the ice. The survivors drifted north to 77°36′, the highest northing yet attained in those seas. How at last the north coast of Asia was reached, and how all but Chief Engineer Melville and eleven of the crew perished, does not here concern us.

Only a slightly, if at all, higher latitude than that reached by De Long has been attained by travellers following the east coast of Greenland. Hudson sighted this coast in 1607, in about latitude 73° north, and, according to the old Dutch chart of Gerrit van Keulen, as high latitudes were attained during the course of the seventeenth century as have ever since been reached in this direction. In 1654 Gale Hamke found land in 74°30′, in 1670 Lambert touched 78°30′. So difficult is the East Greenland coast of approach, however, and so little was known about it in the early years of last century, that the famous whaler, Captain William Scoresby, son of him whose northing off the coast of Spitzbergen we have already recorded, may well be said to have advanced a stage towards the Pole in this direction when in 1822 he surveyed and charted the coast comprised between latitude 73°30′ north and latitude 75° north. In the following year Captain Clavering, assisting Captain Edward Sabine, in his great pendulum work, reached Shannon Island in 75°12′ north, and saw the coast stretching as far as the 76th parallel. No higher northing was made until the second German North Polar Expedition visited the coast in 1869. After wintering on Pendulum Island, Koldewey and Payer followed the shore northwards in sledges, and in April, 1870, reached the extreme northing along the East Greenland coast—if we except that with which Lambert is credited on the old Dutch chart—of 77°01′. The stretch of coast between this and Peary's furthest on the north coast of Greenland still remains uncharted, though both Peary and Sverdrup professed to have its survey in view as one of their objects. None of these latitudes can compare with those attained by way of the Spitzbergen and Franz Josef Land routes. Indeed, the only route which may be said to rival these latter in the facilities it affords for approaching the Pole is that which runs between the west coast of Greenland and the vast land masses lying to the north of North America. In this direction the first stages of the long journey towards the Pole were covered by the expeditions which began to be despatched towards the close of the fifteenth century in search of a Northwest passage.

Leaving out of account the two uncertain records connected with the names of the two Cabots, as well as the unfortunate enterprise of Frobisher, we come to the brave John Davis, who made a great stride northwards. After twice barely crossing the Arctic circle, in 1585 and 1586, he set out a third time, in 1587, from Dartmouth. The expedition comprised three small vessels, the two larger of which were left near Gilbert Sound, while Davis pushed ahead in the third, a mere pinnace. On June 24 he reached 67°40′ N. latitude, and saw many whales, and on the 28th attained his highest northing, 72°12′, where be found the bold promontory which he named Cape Hope Sanderson. Hudson, of course, was far to the south of this in Hudson Bay, and it was reserved for William Baffin to reach what was, for more than two centuries, the most northerly point attained by this route. Robert Bylot, master, and William Baffin, pilot, set out from Gravesend in 1616, with 15 men on board the *Discovery,* 55 tons. Proceeding along the west coast of Greenland, they reached Cape Hope Sanderson on May 30. As they continued north, Women's Island was found and named in 72°45′. In 73°45′ the expedition was detained for a short time among natives of Horn Sound, but the ice broke up, and on July 1 an open sea lay before the travellers in 75°40′ N. Pushing across this, the expedition reached the entrance to what was named Sir Thomas Smith's Sound, and an extreme northing of 77°45′ was recorded.

When one takes into account all the attendant circumstances, this was really a most remarkable voyage, but, notwithstanding the success which attended it, Davis Strait and Baffin Bay were so neglected by explorers for the next two hundred years that when interest in this section of the north polar field revived, early in the nineteenth century, the narrative of Baffin's discoveries was quite discredited. The accuracy of his observations was soon confirmed, but not until 1852—unless it may have been some whaler—did any one push our knowledge of the Arctic regions in this direction a stage nearer the Pole. In that year Captain E. A. Inglefield, in the *Isabel,* coupled with a summer search for Franklin an attempt to ascertain whether Smith Sound was connected with the Polar Sea. On August 26, the expedition reached Cape Alexander, the most northerly point seen by Baffin, and Inglefield saw the open sea "stretching through seven points of the compass." He started to steam northwards, but twelve hours later, when only forty miles beyond Baffin's furthest, was turned back by the ice. His extreme northing was 78°21′. In the following year the Americans took the field. Elisha Kent Kane, in a vessel fitted out by Grinnell and Peabody, straightway broke the new record and reached and wintered in Rensselaer Harbor, 78°37′ N. In the summer of 1854 the surgeon of the expedition, Isaac I. Hayes, crossed Kane Sea to Grinnell Land, which he traced to Cape Frazer, 79°43′ N. In the meanwhile, on the Greenland side of Kane Sea, two other members of the expedition, William Morton and Hans Hendrik, reached and scaled the south side of Cape Constitution, in 80°35′ N., overlooking Kennedy Channel. These results were the more praiseworthy in that the expedition suffered terribly from scurvey and in other ways, and barely succeeded in reaching the relief expedition that rescued them in 1855. C. F. Hall was the next traveller to push back the line dividing the known from the unknown. Though neither a sailor nor a scientist by profession, he possessed all the qualities of courage and perseverence and endurance which go to the making of a great explorer, and, favored by an exceptionally open season, he succeeded, in 1870, in pushing right through Smith Sound, Kennedy Channel, and Robeson Channel to the polar sea beyond. Heavy pack-ice stopped his advance in 82°11′ N. latitude. His vessel, the *Polaris*, wintered under an enormous floeberg in 81°37′ north. Before winter really set in Hall journeyed by sledge northwards to the 82d parallel, and there saw land on the west side of Robeson Strait, extending north, as far as he could judge—and subsequent observations practically confirmed his estimate—to about 83°05′ N. During the winter Hall died, and the other members of the expedition only escaped after experiencing a succession of disasters.

But the success which had attended the efforts of the expedition to reach a high northern latitude and the other valuable geographical results obtained, roused a spirit of emulation in this country. In 1875 was despatched the famous Nares expedition, in the *Alert* and the *Discovery*. They found all plain sailing as far as Cape Sabine, but beyond that point the ice conditions were as unfavorable to an advance northwards as Hall had found them favorable. By degrees, however, the *Alert* and the *Discovery* made their way along the West Greenland coast past Cape Lieber and across Lady Franklin Bay to Discovery Harbor. Here the *Discovery* wintered, but Nares, pushing north in the *Alert*, managed before the close of the summer to advance a step nearer the Pole than any who had previously followed the Smith Sound route. His winter station on the edge of the Polar Sea was in 82°25′ N. But even this high northing was not to mark the limit of the expedition's success that year. Lieutenant Pelham Aldrich, whilst in command of a sledging party, reached on September 25, 1875, latitude 82°48′ north, on the coast of Grinnell Land, and established what was then a world's record. In the following summer Aldrich was yet more successful, passing round the north end of Grinnell Land from Cape Columbia, in 83°07′ north, to Cape Alfred Ernest, in 82°16′ north. Meanwhile Commander A. H. Markham was attaining still higher latitudes. After following the coast to Cape Henry, in 82°55′ N., Markham struck across the ice-bound Polar Sea in a direct attempt to reach the North Pole. He was accompanied by seventeen men, with two sledges, and after almost superhuman exertions reached a latitude of 83°20′. On the valuable work accomplished in other directions it is not now our purpose to dilate. It is curious to note, however, when one bears subsequent expeditions in mind, that the Nares expedition, successful as it undoubtedly was, was supposed to have closed that particular route to the Pole. "To send another expedition in that direction would," it was declared, "be a waste of money and energy." In spite of this dictum, the Greely Expedition, sent north by the United States Government as a result of the International Polar Conferences of 1879–80, made its way up Smith Sound in 1881. The expedition remained in the polar regions three years, and carried out a series of very important scientific observations. But here we have only to record that it covered yet another stage of the long journey to the Pole. In April, 1882, Lockwood, with eight companions, started north from Newman Bay. Repulse Harbor was reached in five days after great exertions. From this point the conditions of travel were most trying, but the little party pressed on to Cape Bryant, where Lockwood decided to continue the journey with only Brainard and one of the Eskimo. Gradually they crept northwards. Towards the end "floes so high that the sledge was lowered by dog traces," ice so broken that the axe cleared the way, and widening water cracks in increasing numbers impeded progress; but, despite all obstacles, they reached, May 13, 1882, Lockwood Island, 83°24′ N., which remained the highest northing until Nansen made so great an advance towards the Pole.

Commander Peary's magnificent record has already been detailed in these columns. Here we need only recall that Peary set out on his last great expedition in the summer of 1898. Having come to the conclusion that no further advance was to be effected by way of the Greenland inland ice, he determined to push north through the great waterway that lies between the west coast of Greenland and the vast island masses lying to the north of the Dominion of Canada. Peary sailed in the *Hope,* and was followed by the *Windward,* which had been generously presented to him by Mr. Alfred Harmsworth. The two ships obtained some walrus in Whale Sound, between Hakluyt Island and Littleton Island, and then, while the *Hope* returned south, Peary turned the prow of the *Windward* northwards and endeavored to reach Sherard Osborne Fiord in Kennedy Channel. But the season was unfavorable, and Peary was compelled to winter 150 miles south of his objective, near Cape d'Urville. Leaving the ship towards the close of the year, Peary journeyed by land to Fort Conger, the headquarters of Greely's famous expedition, mentioned above. But this attempt to utilize the winter months for travelling delayed rather than advanced the expedition. In a terrible snow storm which overtook the little party, on New Year's Day, Peary suffered badly from frost bite, and on his arrival at Fort Conger it was found necessary to amputate seven of his toes. After this it was, of course, impossible for him to make any serious attempt to reach the Pole in the spring of 1899. Peary, however, had himself drawn about in a sledge, so that he might become accustomed to the conditions of travel in that region, and then, returning to the *Windward,* sailed for the Eskimo encampment at Etah, near Cape York. Here he found the *Diana* awaiting him with supplies. These were landed, and then both the *Diana* and the *Windward* sailed south, leaving Peary to winter at Etah and make an attempt to reach a high northing in the spring of 1900. A start was made from Etah on April 15 of that year. Following, apparently, the west coast of

Greenland, Peary passed Lockwood's farthest north between three and four weeks later. The coast was found to run north some ten miles further to 83°39′ N. latitude, where it turned abruptly to the east. Striking across the great Polar Sea, Peary struggled on to 83°50′ N., where he was turned back by a considerable expanse of open water. Before he returned to headquarters, however, useful work was accomplished along the North Greenland coast, which was surveyed as far as Independence Bay, the point reached by Peary on his two great journeys across the inland ice-cap in 1892 and 1895. The winter months were spent partly at Fort Conger, partly at Meat Caches, 250 miles to the north.

Another attempt to reach the Pole in the spring of 1901 had early to be abandoned, as neither men nor dogs were in a fit condition to make any prolonged march. Peary accordingly made his way south, and on June 6 came across the *Windward* with Mrs. Peary and the explorer's little daughter on board. The *Windward* had gone north in search of Peary in the summer of 1900, and, failing to find him, had wintered in Payer Harbor near Cape Sabine. Here, too, in 1901, came the *Erik* in search of the *Windward*. Disappointment was naturally felt when it was found that Peary has failed to reach the Pole, or even to attain a higher northing than that of Nansen and Cagni in the Western Hemisphere. The strain of so long a sojourn in the Arctic regions had naturally been great upon a man of even Peary's iron physique and dauntless courage, but the explorer determined to make one last effort this year. Both the *Windward* and the *Erik* sailed south in August, 1901. So far as can be made out from the telegrams to hand, Commander Peary has followed, as far as practicable, the plans which he had laid down according to the information brought home by the *Erik*, which left him on August 20, 1901, in his temporary camp on the south side of Herschel Bay, on the west side of Smith Sound, about a dozen miles southwest of his permanent quarters at Payer Harbor, near Cape Sabine, about 78°45′ N. He was then stated to have been well provided with all necessaries, although the difficulty of taking sufficient food for the dogs was regarded as rather a serious one. It was also stated that he intended to take with him a "marine equipment," so as to be able to cross open water wherever it should occur. The telegrams to hand do not refer to a boat as part of the equipment, but, as open leads of water were met with, it is presumed that the expedition had some means of crossing them.

The move northwards began with the advance party of six sledges in charge of Peary's faithful colored companion, Henson, on March 3, followed three days later by the main party with 18 sledges. These parties, no doubt, traveled northwards along the ice foot on the American side, close to the shore, the distance to Fort Conger on the north shore of Lady Franklin Bay, which was the heaquarters of the Greely expedition, being some two hundred miles. Fort Conger lies about 81°50′ N. Apparently little time was spent at Fort Conger, and a fresh start was made for Cape Hecla, which lies a little to the south of the 83d parallel, to the northwest of the northern end of Robeson Channel. If, as is probable, the journey continued to be made along the ice foot, the distance to be covered was not far short of one hunderd miles. Evidently the water right across to Greenland in this channel was remarkably open, while open stretches of water were visible as far as could be seen to the north. From Cape Hecla a start was made on April 1 to face the serious task which Commander Peary had set before him—an advance northwards, if possible, to the Pole. Commander (now Admiral) Markham's furthest north, 83°20′26″, was reached on May 12, 1876, at 64° W. longitude. Markham started from Cape Joseph Henry in 82°55′ N. on April 10, so that he took one month to reach his furthest point about thirty miles to the northwest of his starting point. The difficulties which he met with in trying to surmount the hills of palæocrystic ice which had been thrown up along his route seem to have been greater than even those encountered by Peary. And it should be remembered that Markham had no dogs, and only two sledges and 17 men. The same palæocrystic ice, due to pressure and the piling up of floe upon floe, seems to have been met with by Peary, although he encountered open leads of water and floes in motion. Although he only reached 84°17′ N., about 75 miles to the northwest of his starting point, in order to accomplish this he seems to have been compelled to make long detours. But, as further progress with the means at his disposal was utterly impossible, he had to give up, and was back at Cape Hecla again on April 29, and at his headquarters at Cape Sabine about a fortnight later. Although Commander Peary seems to have met with more open water than did Commander Markham, still the conditions here seem to have been essentially the same as they were in 1876. The vast masses of ice which come down from the north have no adequate exit south of 83° N., so that they are bound to accumulate under the immense pressure that must take place, and so produce those palæocrystic ice ranges which seem to render advance impossible in this direction. It is possible that, had Commander Peary had more abundant means at his disposal, and been able to continue still further to the north, he might have found the conditions more favorable; but the record of this, as of previous attempts in the same direction, seems to confirm the opinion of distinguished Arctic authorities that the Pole is not to be reached by this route. No doubt Commander Peary will have an exciting story to tell, but those interested in the advance of knowledge will anxiously await details of the abundant scientific results which he is reported to have accomplished. Meantime, although he holds the record on the American side of the Polar area, on the other side he has been surpassed by Captain Cagni by over two degrees—about 150 miles.

With regard to Captain Sverdrup, who left Godhavn, in Greenland, on August 8 and has just arrived in Norway, it is evident that he has been quite unable to carry out his somewhat ambitious program, which, besides getting as far north as possible, included a survey of the northeast coast of Greenland. When last seen, in 1899, the *Fram* was making for Jones Sound (misprinted Soner Sound in the telegram) and to that region he seems to have devoted his attention during the past three years. On the north of Jones Sound lies Ellesmere Land, about which we know but little. Captain Sverdrup has apparently surveyed the south and west coasts of that region, and if he has carried his explorations far enough north and west to connect with the results of previous expeditions he will have accomplished a fair amount of good work. But unless he has done much more it can hardly be said that he has fulfilled the expectations of his many admirers and friends. But before expressing any opinion on the results of the expedition, we must await further information. In Jones Sound he certainly selected a region of which our knowledge is slight and defective. In a memorandum on the subject, by Sir Clements Markham, president of the Royal Geographical Society, some interesting information is given as to the progress of our knowledge in this particular region. Jones Sound was discovered by Baffin in 1616, but no other expedition approached it until that under the command of Sir John Ross in 1818. In 1848 a Scotch whaler sailed up the Sound for a hunderd miles, until stopped by ice. In 1851 it was explored by Admiral Sir Horatio Austin who was stopped by ice about 60 miles from the entrance. In 1852 he was followed by Captain Inglefield, and from their explorations it became clear that Jones Sound was a channel leading to the Polar Sea, and not a mere bay or inlet. Possibly that is the reason which induced Captain Sverdrup to make his way into it with the *Fram;* but, as the Polar ice comes crowding down from the north among the numerous islands which seem to stud the sea to the west of Ellesmere Land, it is doubtful if a route in this direction is practicable.

Now that Peary and Sverdrup and Baldwin have all three returned from their abortive attempts to reach the Pole, the only expedition left in the Arctic region is that under Baron Toll, the well-known Russian explorer, who is at work in the direction of the New Siberian Islands, in search of what is known as Sannikoff Land, which is supposed to exist still further to the north. Of Captain Bernier's proposed North Polar expedition nothing has recently been heard.

In conclusion, Commander Peary's work in the interior of Greenland before his last great expedition ought not to be forgotten. His additions to our knowledge of the Greenland ice-cap are very important, seeing how little is known of the interior of the country. Geological investigations carried out by Giesecke in 1806–14 along the west coast of Greenland for 60° N. to 73° N. form the basis of our knowledge of the geology of this vast island. The Danes have done much useful work along the southwest and southeast coasts, and the comparatively narrow strip of territory between the sea and the ice-cap is very well known from the 66th parallel on the east coast round to the 75th parallel on the west. Attempts to cross Greenland from west to east were early made. In 1728 Major Pars even set out at the head of an armed mounted force. But for long all attempts failed. Dalager, Rae, Brown and Whymper were unsuccessful in their efforts to explore the ice-cap. In 1870 Baron A. E. Nordenskiöld could only penetrate some 35 miles inland from the head of Auleitsivik Fiord, to an elevation of 2,200 feet. In 1878 Lieutenant Jensen reached a point 47 miles inland from Frederikshaab, where he found the ice 5,000 feet above sea level. In 1883 Nordenskiöld again visited Greenland, and made fifteen marches on the inland ice from the same point as before. He himself penetrated only a little way, but the Lapp ski-runners whom he had taken with him mounted the ice for 140 miles, reaching an elevation of 6,600 feet. At last Nansen effected the crossing from east to west. Umivik, the starting point, in 64°45′ N. latitude, was reached only after many hardships on August 10, 1888. By August 27 he and his companions, five in number, had ascended 7,000 feet, but only advanced forty miles. The ice-cap, however, was found to terminate in a broad flat plateau from 8,000 feet to 9,000 feet high, and over this such rapid progress was made that the west coast was reached, some fifty miles south of Goothaab, on September 29. Peary's crossings were effected in the reverse direction, and across the northern end of Greenland. After a preliminary journey from Disco Bay in 1886, Peary made his first attempt from McCormick Bay early in 1892, and, striking due northeast, came out on the north coast at Independence Bay. This journey was repeated in 1894, and briefly Peary may be said on these occasions to have determined the relief of an exceptionally large area of the inland ice, to have delineated the northern extension of the great interior ice-cap, to have demonstrated the insularity of Greenland, and to have proved the existence of detached land masses to the north. A valuable account was also obtained of the Smith Sound Eskimo.

# THE DEVELOPMENT OF ECONOMICAL UTILITIES FOR HANDLING RAW MATERIAL.

By WALDON FAWCETT.

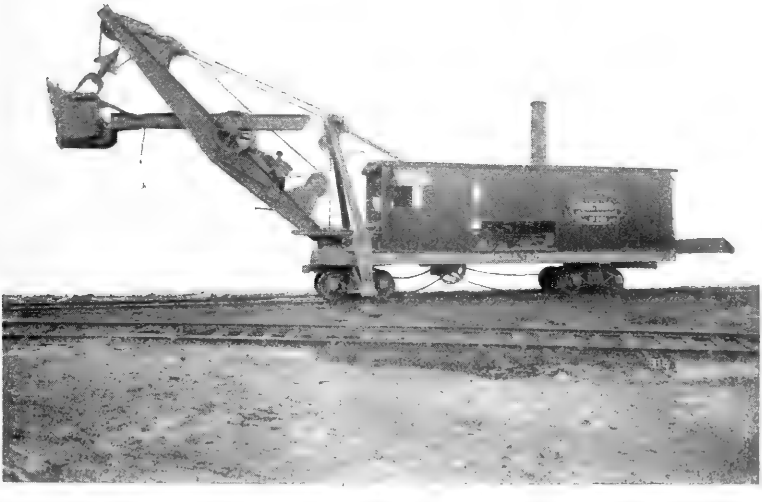
THE existence in crude form of some elementary devices for hoisting or otherwise handling certain classes of raw material, notably stone and logs, dates back many years, but it has been within the past decade and a half that there has taken place that remarkable progression which has constituted one of the most impressive achievements of the modern engineering world. Not only is bulk material, practically without limitation as to weight, hoisted to any height desired, but it has been rendered possible to transfer commodities at high speed for either long or short distances, and thus the mechanical operatives of the modern industrial world secure the trilogy of an economy of time, a saving of labor and the conservation of expenditures.

Easily the most interesting as well as the most significant advancement in this broad field is found in the introduction of improved methods for the handling of those two most important commodities—coal and iron, the latter embracing of course a variety of forms from iron ore to finished steel. Indeed, in the case of the most useful of metals there has been evolved a cordon of mechanical devices, the functions of which so supplement each other that from the time the ore leaves the mine until it has been transformed into marketable iron or steel the factor of manual labor directly applied, is practically eliminated.

The initiatory machine in this chain is found in the steam shovel which takes the iron ore from the 'open pit' mines of the Lake Superior district and later is called into requisition to transfer the ore from the stock piles at the mines to the railroad cars provided to carry it either direct to the blast furnaces or to the vessels wherein it will be given water carriage to the Great Lakes. The steam shovels for the latest approved practice range in weight from fifty-five to ninety-five tons and in this feature alone is afforded ample evidence of progress, for but a few years since the shovels of thirty-five or forty-five tons weight were deemed sufficient for all the exactions imposed by this work. The shovels now in use have dippers ranging in capacity from two and one half to five yards, and something of the celerity of movement with which they are operated may be appreciated from the fact that on many occasions ordinary railroad cars are loaded with ore and pushed out of the way of the machine at the rate of one every two minutes.

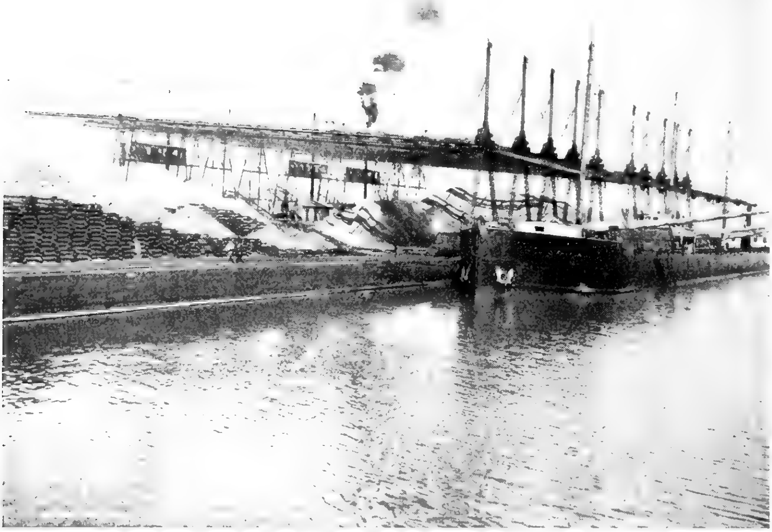
In the unloading of the immense cargo-carrying vessels of the inland seas wherein the iron ore is conveyed from the Lake Superior mining district to the ports adjacent to the blast furnaces of the Middle West are employed the various forms of hoisting and conveying apparatus, all of American origin, which probably constitute the most famous of all the installations for transportation purposes. In this field of activity methods advanced, at a single step, from the old plan of unloading the vessels by means of wheelbarrows and permanent trestles to the bridge tramway structures which are up to the present date in almost universal use.

The conspicuous elements in any such installation embrace the elevated tramway—spanning the dumping ground or railroad yard and

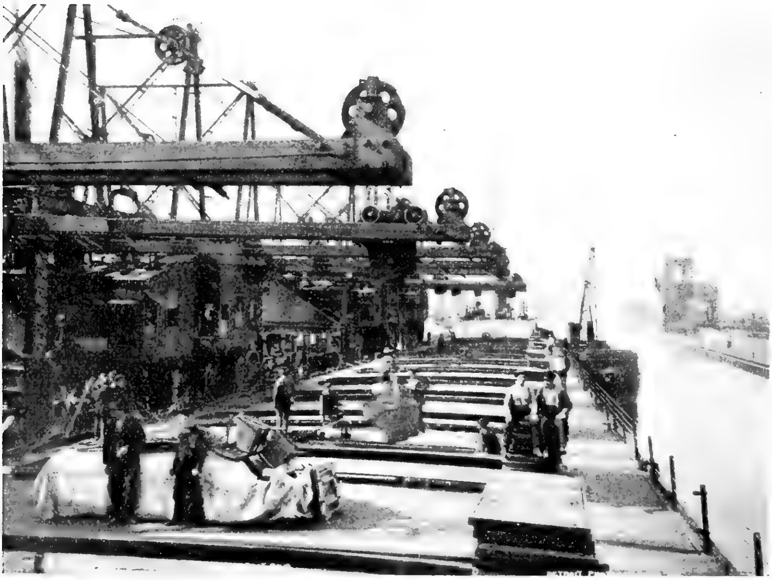


STEAM SHOVEL.

connecting it with the vessels—the trolley or carriage traversing this tramway and the system of mechanism by which the whole is operated and controlled. Such an apparatus is operated, of course, by a motive power located beyond the limit of travel, and while the operation is at every stage subject to the control of an operator, a large proportion of the important functions are automatic, the positive movements of the parts through such operations being derived entirely from the bodily movement of the apparatus itself, while actuated by momentum, gravity or the direct action of the hoist rope. Attached to the trolley of each machine is an automatic dumping-tub or bucket, the discharge of which may be made at the will of the operator, either at the



Bridge Tramways.



Cantilever Aprons Extending over Vessel

full height of the tramway or by an automatic deflection of their motion and with no appreciable loss of speed the buckets may be caused to descend and discharge their contents at any point below the tramway.

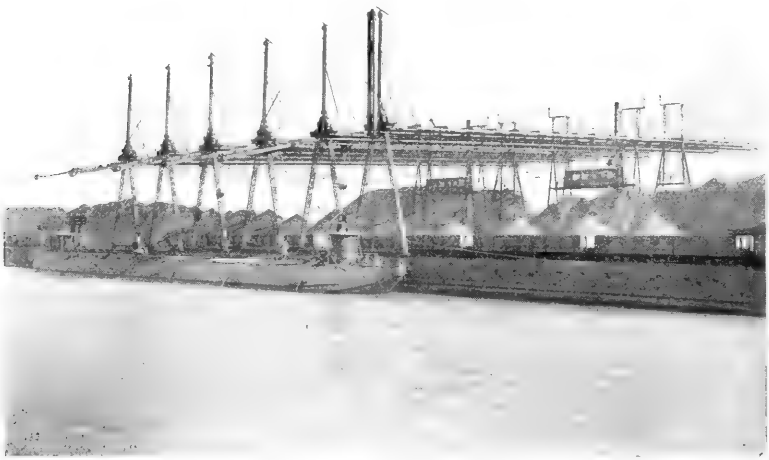
The bridge tramways are usually built in plants or groups of three or four bridges which may be supported on either single or double piers. The tramways are, as a rule, provided with hinged aprons designed to extend over the vessels and very frequently cantilever extensions are provided at the opposite end, so that the buckets are enabled to serve a space of 300 to 350 feet in width. The operation of the tub or bucket is effected by means of a wire cable connected with a drum in the engine room, and the engine is usually of the double cylinder type. The piers supporting a bridge tramway are on wheels, and it is thus possible to skew or move sideways the entire structure, in order to bring the bridges in line with the hatches of the vessel being unloaded. This type of machine hoists the bucket of ore from the hold of the vessel, conveys it to any desirable point on the tramway and automatically dumps the material on the dock or into waiting railroad cars.

As indicating the capacity of the bridge tramway, it may be cited that a plant of three bridges will readily handle 1,200 tons of ore in a day of ten working hours, hoisting the material, conveying it a distance of 100 to 150 feet and dumping automatically. In the case of the bridges of exceptional length a round trip can be made from the hold of the vessel to the extreme end of the cantilever and back again, a distance of 600 feet in one minute, and in actual operations a rate of 45 seconds per trip has been maintained for hours at a time. The buckets or tubs for conveying ore are usually of one ton or a ton and a half capacity. There are several modifications of the bridge tramway system, notably cable tramways in which wire cables are substituted for the bridges and what are technically known as 'fast plants' wherein instead of the long bridges there are extremely short ones with tramway projections over the vessel and cantilever extensions over the railroad tracks on the dock, the effect of this short haul being to reduce tremen-

CLAM-SHELL BUCKET OF AUTOMATIC UNLOADER.

dously the lapse of time necessary for the transference of raw material from vessels to cars.

In the case of all forms of bridge tramway apparatus it is necessary to employ large gangs of men to fill by means of hand shovels the tubs or buckets carried by the trolleys and naturally therefore there is in the transportation world a tendency to regard with favor the latest inventions in the line of machinery for the rapid unloading of iron ore, namely, the automatic unloaders which dispense entirely with human energy directly applied in the unloading operations. The fundamental principle of all the automatic unloaders is found in the operation of some sort of a clam-shell bucket which is let down into the hold of a vessel with its iron jaws extended and, closing them, retains in its grasp



BRIDGE TRAMWAYS FOR HANDLING ORE AND COAL. MENOMINEE DOCK AT ASHTABULA.

one or more tons of ore while it is lifted from the hold and run back to a stock pile or waiting railroad cars after the manner of the bucket of the bridge tramway. The original automatic unloader, introduced only two or three years ago and in active use to-day, weighs several hundred tons, and is equipped with a great mast to be lowered through the vessel hatch and from which depends a clam-shell bucket capable of holding ten tons of ore. The later patterns of unloaders, automatic in their action, are fitted with excavating buckets of only about one ton capacity, and which therefore permit of hoisting and transference by wire cable instead of necessitating the ponderous iron and steel structure required to support the mast and clam-shell in the original design.

Bridge tramways similar to those in use on the ore-unloading docks are employed in the furnace yards to convey the ore from the railroad cars to stock piles, and a patent furnace hoist automatically conveys the ore together with the coke and limestone to the top of the blast furnace and performs the operation of 'charging.' The automatic hoist consists of an inclined iron-trussed bridge reaching from the floor of the stock house to the top of the furnace shell and from thence over the top opening of the furnace. On this bridge is laid a track of T rails on which travels a skip or car, containing the charge of one to three tons as may be desired. The track is so arranged at the top that the contents of the car are automatically dumped into the hopper on the arrival of the car at the top. The skip car is hoisted or hauled to the top by a double engine with a friction clutch drum.

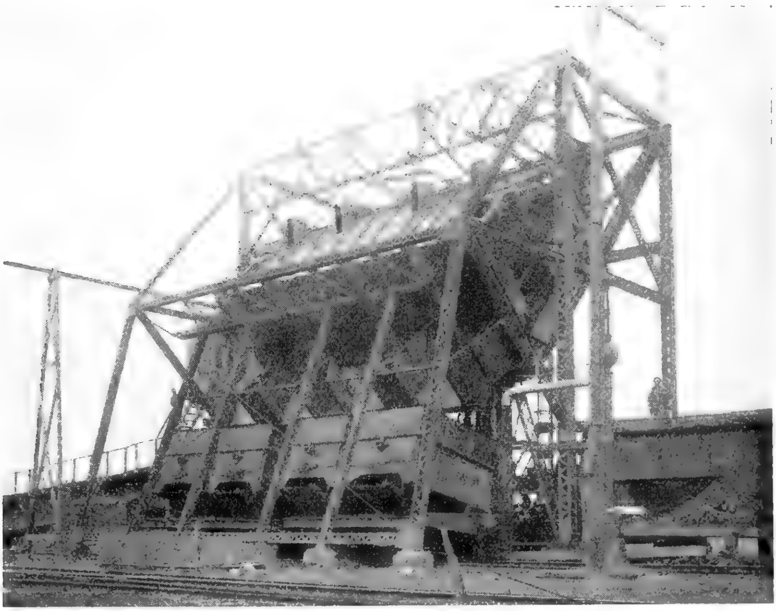
CAR DUMPING MACHINE.

The exigencies of handling great quantities of coal for shipment have been quite as productive of ingenious mechanical devices as have the requirements of the iron industry. Bridge tramways have been employed extensively for both loading and unloading of fuel, and in the case of anthracite coal clam-shell buckets and bucket shovels which scoop up the coal have been introduced in connection with the bridge tramway instead of the ordinary bucket. However, preeminent among all the varied forms of coal-handling apparatus stands the car-dumper, a class of machine, each step in the evolution of which has been marked by a distinct type of apparatus, but which has finally reached a point of development where it is possible for one of these machines to hoist a loaded coal car into position alongside a vessel, pour its contents into chutes communicating with the hold and return the empty car to the track in the elapsed time of one minute. In the case of the most approved styles of car-dumpers the loaded car is clamped to the track in a sort of cradle in such manner that it may be turned completely over and yet by means of a reciprocating movement on the part of a huge pan suspended in the framework of the machine and connected with the chute leading to the hold of the vessel, the coal is transferred with a minimum amount of breakage.

McMyles Car Dump.

A class of coal-handling machinery in which recent years have witnessed great development is found in the various forms of chain elevators and link-belt machinery. This form of equipment is used extensively at railroad coaling stations designed to supply fuel to locomotives. In a representative installation one run of the upper conveyor is for stocking the coal and the other for distributing it into chutes, while the lower conveyor delivers coal from storage. Each conveyor is an endless chain interspersed with metal partitions forming pockets, is 600 feet in length and has a capacity of 120 tons of coal per hour. In many stations an inclined conveyor delivers coal from cars to a distributing conveyor and the latter apportions the fuel among twelve or more chutes. Conveyors of this same general type are also used for transferring coal from mine to storage pile or cars. For such utilization there is selected apparatus of great simplicity of design, namely, a scraper conveyor with steel flights of proper shape attached to the chain and drawing the material along in a steel trough. Some installations of this character have a length of about 300 feet and a capacity of four tons of coal per minute.

Modifications of the belt conveyor are now to be found in use in almost every branch of the industrial domain, being put to a variety

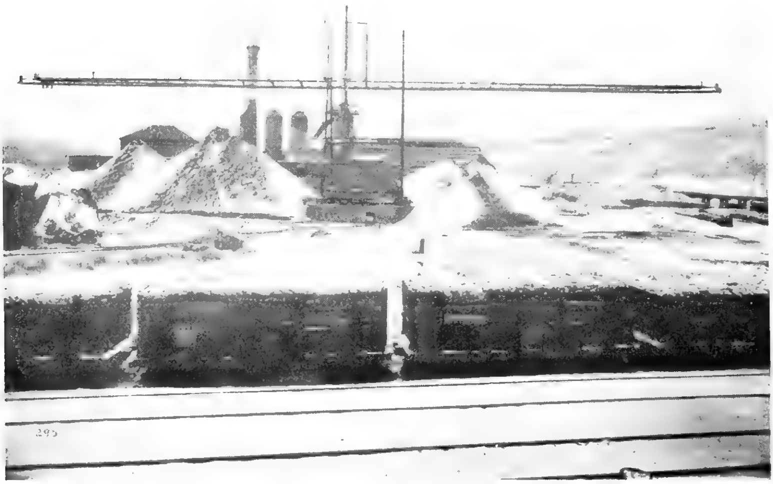


CAR DUMPING MACHINE.

of uses ranging all the way from the movement of grain to the carriage of logs and stone. Moving platforms, constructed on the endless chain plan, also have an important place among the utilities for handling bulk commodities. Likewise is there extensive employment of traveling cableways and aerial ropeways wherein either the impetus of gravity or hauling ropes are depended upon for propulsive power. Some of the recently installed traveling cableways have a span exceeding 700 feet and are adapted for handling loads of from five to ten tons. The most modern of all of these aerial transportation systems is that designated 'telpherage,' whereby electricity is relied upon as an operative force. In this class of installations the overhead trolley system of the ordinary electric railway has simply been adapted to the rope railways, and by the provision of an ingenious device the electric car or telpher is enabled automatically to slacken speed when approaching a curve, resuming the normal rate of travel when the dangerous point has been passed.

The part which cranes of various kinds have played in the solution of the problem of the economical handling of raw material of various kinds is indeed an important one and there has been a steady increase in capabilities until there are now in service in the United States a number of cranes each of which is capable of handling a load of one hundred tons.

Easily the most remarkable of all the cranes yet constructed are the great balanced cantilevers invented by Alexander Brown, an American. The cantilever crane is applicable to a large range of work and is the



CANTILEVER CRANE.

most perfect machine yet devised for use in handling armor plate and other heavy parts in ship-yards and manufacturing establishments generally. The cantilever is divided into two arms, which in some instances have a span of over 350 feet. By means of trolley and hoist block, mounted on the cantilever of the crane, the load can be hoisted from the ground and traversed from one end of the cantilever to the other, the pier or base of the crane being so arranged that the load passes through it. These cantilever cranes have an automatic counterweight running on a track along the bridge and above the hoisting trolley, and connected by ropes to the latter, so that whatever the position of the hoisting trolley on one arm of the crane, the counterweight at all times automatically occupies a similar position on the other arm. The latitude of the operations of the apparatus is further broadened by reason of the fact that the entire crane travels by its own power up and down the track or trestle on which it is mounted. A crane of this type is capable of marvelous speed. A load of fourteen tons may be hoisted at a speed of 200 feet a minute; the trolley travels back and forth along the cantilever arms at a speed of 600 feet a minute; and the entire crane has sufficient propulsive power to enable a speed of 750 feet a minute in traversing the track or trestle.

In conclusion attention must be given to the so-called lifting magnet, the most wonderful of all the new appliances for handling weighty raw material. The electro-magnet, by the aid of electricity, performs on a large scale something of the same function as the toy with which children have long been familiar. One magnet will elevate a mass of metal weighing two tons and it is possible to use several magnets simultaneously in handling a particularly heavy steel plate or bar. This plan of handling material also possesses immense economic advantages, inasmuch as a single mechanic is usually in charge of the crane to which the magnets are attached.

# MENTAL AND MORAL HEREDITY IN ROYALTY. IV.

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## Evidence from Sweden.

### *Gustavus Vasa to Charles XIII.*

THE houses of Vasa, Palatine and Holstein, which held the throne of Sweden from 1527 to 1818, give us the names of 48 related persons in the direct family and cover a period of eleven generations. By including the ancestors to the third degree for each generation of children, we bring in 122 more names, and have in this total of 170 an abundant and interesting field for the study of heredity. These families of Sweden are full of eccentricities, abilities and weaknesses, and the tracing of these peculiarities will be the subject of this section of the work.

Gustavus I. Vasa, 1496–1560, the founder of the celebrated dynasty bearing his name, was a most remarkable and inspiring character. Of a noble though poor and uninfluential family, young Gustavus gave proof even in youth of that striking personality which was destined to deliver Sweden from the terrors of misrule and foreign control, and make his name ever cherished in the hearts of his countrymen. Even as a boy he 'played the king' and declared he would live to drive the Danes out of Sweden.

In 1517 Gustavus was captured by a Danish ship of war and imprisoned for a year in castle Kalloe in North Jutland. Having escaped from prison, he fled to the mountains of Dalencaride, where, after enduring great hardships, he at last succeeded in attaching to himself a powerful party, with which he marched towards Stockholm, which finally surrendered in 1524 after an obstinate defense. The throne of Sweden was now offered to him, but he at first refused. At last, after general solicitation with the interest of the welfare of his country at heart, he accepted and was crowned king in June, 1527.

Born in a private station and bred in the school of adversity, equally great in the public characters of a legislator, warrior and politician, he distinguished himself in every station of life, whether we consider his cool intrepidity and political foresight, his talents for legislation, his propensity to letters and encouragement of learning, his affability to the lowest ranks and his solid and enlightened piety.

All his qualities set off by a majestic and graceful person and still further heightened by the most commanding eloquence, drew the esteem and admiration of all, so that it might justly be said that the most arbitrary monarch never exercised a more unbounded sway over his vassals than Gustavus possessed from the voluntary affection of his free-born subjects. In a word he was a sovereign who was esteemed by foreigners no less than by his own people, by contemporaries as well as by posterity, one of the wisest and best that ever adorned a throne.*

We shall see later how closely he was reproduced in his grandson Gustavus Adolphus the Great.

The father of this founder of the house was Eric Johnson, who is described as an insignificant little man with a violent and uncontrollable temper.† The other ancestors are 'obscure' and, as far as known, were without special gifts of any sort. So Gustavus Vasa must be considered a new variation or a 'sport' in biological terminology. How this genius was transmitted we shall see in the subsequent history of the house.

Of the nine children available for our study, we have very complete accounts concerning five. These are Eric, John, Charles, Magnus and Cecelia. The others did not distinguish themselves in any way as far as known. Of these five, all but one, Charles, were violent or eccentric or both. The mother of all but Eric, Margaret Lejonhufond, was a gentle, beautiful and tactful princess‡ with whom Gustavus lived very happily. Therefore, since the grandfather, Eric, was violent and cruel, and since insanity appeared in Eric and Magnus, the children of both marriages of Gustavus, it seems fair to assume that the lack of mental balance was hereditary, and on the male side. Whatever may have been its origin, the neurosis was a family trait and eccentricities of one sort or another will be found in several of the descendants.

Eric, the eldest son and next king, was suspicious, gloomy and cruel; and finally becoming insane was obliged to abdicate.§ He was nevertheless extremely learned, having a profound acquaintance with the classics and all the sciences of his day, especially the occult branches.

John, the second son, was both passionate and weak.

His tender conscience, though it did not prevent him poisoning his father, Eric, yet induced him to pay a most scrupulous obedience to the ridiculous penance ordered by the pope for commission of the murder. His temper hasty, his disposition selfish, with strong instinctive attachments, so that in domestic life he oscillated between the extreme of indulgence and severity . . . he at last grew to be afraid of his own shadow.‖

Magnus became insane. Cecelia, his sister, brought disgrace on the family even in her youth. Later she went to England with her

* Coxe, 'Travels in Russia, Sweden and Denmark,' IV., 132–134.

† Geijer, 'History of Sweden,' I., 97.

‡ Geijer, I., 127.

§ Coxe, 'Travels,' IV., 126, and 'Ency. Brit.,' 8th ed.

‖ Coxe, *Op. cit.*, IV., 247.

husband, where she got frightfully into debt, and died after leading a rambling and dissolute life.*

Charles IX., by far the flower of the family, inherited much of the genius and character of his father.

> Although the transcendent merits of Charles the Ninth are eclipsed by the superior qualities of his father and son, yet even as the son of Gustavus Vasa and father of Gustavus Adolphus he seems to shine no less with nature than reflected luster. He was enterprising yet cautious in war, sagacious and decisive in the cabinet, a friend to humanity, yet severe in punishment of crimes. Attached by principle to the Protestant cause, he raised it, almost drooping, again to preeminence. Zealous to promote the interest of his people, he built towns, encouraged commerce and agriculture and patronized letters. Of quick and lively feelings, he was subject to violent but short transports of passion, which harassed his frame and finally occasioned his death.†

Another type of Vasa eccentricity is found in the career of Gustavus, the son of the mad Eric XIV. Gustavus had from youth an adventurous and curious existence. Rescued when an infant from the sac in which he was to have been murdered, he was conveyed from Sweden to the Jesuit convents of Thorn and Vienna.

> In these different seminaries he made considerable progress in literature and in particular distinguished himself in so much by his proficiency in chemistry that he was called the second Paracelsus. He was no less remarkable for his knowledge of languages, speaking with fluency, besides his native tongue, French, Italian, German, Polish, Russian and Latin. He was indeed so zealous in the prosecution of his studies, that on account of his indigent circumstances, after attending the schools by day, he used in the evening to play at the inns in the lowest capacity, in order to procure a scanty subsistence.
>
> His literary acquisitions, however, did not advance his future, for he passed a wandering life in the greatest misery; was reduced to such straits that he frequently had recourse to charity and at other times earned his living by the meanest occupations.‡

Here we see a striking instance of a son resembling his father. The literary and scientific one-sidedness so strongly marked appears with equal force even under these trying and humble circumstances, and when no influence of family example could have taken a share in its formation, since Gustavus when an infant was removed from the surroundings in which he was born.

Sigismond III., 1566–1632, the next to be considered, was also in his way a rather unusual character, though the figures 4.5 do not indicate it. This son of the brother, John, and of Catherine, daughter of Sigismond I. of Poland, acquired the throne of Sweden before his uncle, Charles IX. The bigotry of Sigismond, combined with his weakness and peevishness, led to discords and estranged his subjects from

* W. B. Rye, 'England as seen by Foreigners,' 1865, introduction.

† Coxe, V., 175.

‡ Coxe, 'Travels in Russia, Sweden, Denmark,' IV., 251.

him, so that his uncle, Charles, was gladly welcomed as a deliverance to the country, and Sigismond was formally deposed in 1604.

It should be noticed that of all the children of the illustrious Gustavus Vasa, Charles IX. was by far the best, and it was the son of this king who became the brightest light in Swedish history, probably everything considered, the greatest figure in all modern royalty, and one of the most ideal heroes who ever lived, Gustavus Adolphus the Great.

To recount the characteristics of this celebrated champion of the Protestant cause would be but to repeat again the eulogies for the founder of the house, his grandfather. The nobility and genius of Gustavus Adolphus are too well known to need much comment here. It will be sufficient to quote a few extracts from the many works devoted to his life and achievements.

> He ascended to the throne in his seventeenth year and soon gave proof of his extraordinary abilities. The military talents of Gustavus Adolphus were of the highest order, but they were surpassed by his admirable qualities as a man and his virtues as a ruler.* Gustavus was, says Schiller, incontestably the first commander of his century and the bravest soldier in the army which he created. His eye watched over the morals of the soldiers as strictly as over their bravery. In everything their lawgiver was also their example. In the intoxication of his fortune he was still a man and a Christian, and in his devotion still a hero and a king.

Such is the universal testimony of both contemporaries and historians in admiration of the sublime personality of Gustavus Adolphus, the Lion of the North, who like a brilliant comet flashed for a brief time over European affairs, until his course was terminated all too soon while defending the faith for which he gave his life.

Cut off in his thirty-eighth year, when most men are only beginning to assume the full responsibilities for which they are fitted, we do not know what might have been the limit to the manifold acts of benefit and righteousness that would have been conferred by Sweden's greatest king. Let us pause in passing to consider the mysteries of fate that heaped upon this man, sandwiched in between the maniacs and weaklings of his family, all the gifts of mind and heart ever allotted to mortals. If great men are divine, then heredity is, for Gustavus Adolphus is but a perfect repetition of his illustrious grandfather.

After the death of the great king, Sweden passed into the hands of a regency for Christina, his only child. Her sprightly wit and spirit, her energy and taste for learning, all gave her countrymen the greatest hope for a brilliant future for their beloved little queen 'who astonished her guardians by the vigor of her understanding.' In 1644 on her eighteenth birthday, she assumed supreme power and for some

* Lippincott's 'Biog. Dict.'

time fulfilled all the expectations which had been formed for her reign.

The Swedish people were anxious that Christina should marry, but she declined to sacrifice her independence. In 1649, however, she persuaded the Diet to accept as her successor the best of her suitors, Charles Gustavus of Palatine-Deux-Ponts, the son of the only sister of Gustavus Adolphus. In the following year she was crowned with great pomp.

> About this time Christina's character seemed to undergo a remarkable change. She became wayward and restless, neglected her tried counsellors, and followed the advice of self-seeking favorites. So much discontent was aroused by her extravagance and fickleness that she at last announced her determination to abdicate.*

After abdication in 1654 she left for foreign courts, where her eccentricities and daring disregard for conventionalities became the talk of Europe. Upon the whole her character presents a strange combination of faults and foibles, pushed to the most extravagant excess. She says of herself, 'that she was mistrustful, ambitious, passionate, haughty, impatient, contemptuous, satirical, incredulous, undevout, of an ardent and violent temper and extremely amorous.'

The violent temper was common to a large number of her paternal ancestors, but it is especially interesting to note that the change in her character was very similar to that of her uncle, Eric XIV., who began his reign very well, and whose unstable temper did not display itself until he was about twenty-five years old.† Magnus, his brother, likewise became insane at just about the same age. The inconsistencies of character which stand out so strongly in many of the members of this family have not been very common among royalty. They were found to be very common among the relations of Peter the Great, where they were considered related to a family neurosis. Here there is also a neurosis, so we have in the coincidence a very strong proof that much of the *moral* nature here inherited in the form of inconsistencies, as well as the mental, is subject to heredity.

Since Christina abdicated to her cousin, Charles Gustavus, we now take up the Palatine Deux-Pont dynasty of Sweden, which includes the characters numbered from 19 to 27 inclusive.

Charles Gustavus, it is to be remembered, was the best of the many suitors for the hand of the eccentric Christina, and although he, like all the others, failed to change her mind regarding her determination to remain single, her appreciation and regard for him were such that she succeeded in having the succession made in his name. The father to this new heir to the throne was likewise a man of excellent charac-

* 'Ency. Brit.,' 9th ed., art. Sweden.

† Cont. Geijer 'Hist. Sweden,' I., 148.

ter, energy and abilities. Besides, we find Wolfgang of Palatine, 1569, the great grandfather, a man of great distinction in his day. As Catherine, the mother of Charles and sister of the great Gustavus Adolphus, was intellectual and energetic, we have here in starting the new dynasty a selection of by far the better members of the family.

Charles X., himself, was a rather remarkable character, being a man of the greatest enterprise and, as a commander, showed the family brilliancy in a striking degree. His measures were in general entirely just, his only noteworthy weakness being his passionate temper.*

The only child of Charles X. was Charles XI., who became king of Sweden in his turn and began to exercise his power in 1692. He seems to repeat the character of his father almost exactly.

> Charles was chaste, temperate, economical, vigilant and active, a patron of letters, severe yet not implacable, prone to anger but easily softened. If we consider the interior administration of affairs, Charles XI. was one of the wisest monarchs who ever sat upon the throne of this kingdom. To him Sweden stands indebted for many excellent regulations which still subsist.† He promoted manufacture, commerce, science and arts, subverted the power of the senate, and when he died, left a flourishing kingdom to his son Charles XII.‡ He died aged forty-two, lamenting, it is said, upon his death bed, as the only reproach to his memory, the natural violence of his temper, which he had not sufficiently corrected.§

Charles XI. married Ulrica Eleonora, a virtuous and intellectual princess. She was a daughter of Frederick III. of Denmark, and sole representative among six children of that little group of brighter lights forming Denmark's highest intellectual wave, and centered about Christian IV., her greatest king.

From this union sprang two daughters, in no way remarkable, beside one son, born in 1682, who, as Voltaire says, 'became as Charles XII. perhaps the most remarkable man who ever existed upon this earth, who united in himself all the great qualities of his ancestors, and who had no fault or misfortune except in having them too greatly exaggerated.' Invincibly obstinate from childhood, the only way of moving his will was through his sense of honor. Charles was inordinately ambitious from youth, his only desire being to imitate the career of Alexander the Great. When only eighteen years old an opportunity was given him to display his 'extraordinary martial genius' in his unequal contest against three of the most powerful monarchs in Europe. Peter the Great, of Russia; Frederick IV., of Denmark, and Augustus, King of Poland, thinking on account of the youth of Charles to divide his kingdom between them, formed a league against

* Coxe, 'Travels,' IV., 34. 'Ency. Brit.' 9th ed.

† Coxe, 'Travels, IV., 39.

‡ Lippincott's 'Biog. Dict.'

§ Schloetzer's 'Briefwechsel,' I., 147.

him. With only 20,000 Swedes he attacked 80,000 Russians under the Czar Peter who were besieging Narva and then, with only 8,000 men, before the arrival of his main army, gave the Russians such a severe defeat that they were filled with consternation.* A little later when Peter made overtures for peace he replied that he would 'treat with the Czar at Moscow.'

Charles was by no means successful in his subsequent battles, but considering the enormous odds against him, this demibarbarian 'whose ambition was madness and whose valor was ferocity' may justly be considered one of the greatest commanders of modern times, as well as one of the most remarkable men who ever lived. Rude, but chaste, frugal in his dress, food and mode of living, he seems to have had few failings save his impetuosity and inordinate ambition.

Of course such a character as Charles can never be directly derived from any law of heredity like Galton's. A man who has more of certain characteristics than other men can not be produced by adding together in a proportionate way the same characteristics of his ancestors. But if these extreme types like Charles, Peter the Great, Don Carlos, son of Philip II., and Frederick the Great occur most frequently where there is much of the same sort of character in several of the ancestors, we are better satisfied that the types are the product of hereditary influence, than if they frequently occurred in regions where none of the relatives show the character in question. The wave does not flow back towards the mean for every child or even for every generation. It also flows in an upward swell, and it is only to be expected that variations shall occur that show its highest manifestation where there is already some considerable indication of its presence in the neighborhood of the person in whom it appears in such an extreme degree.

In referring back to the ancestry we find the character of Charles XII. almost exactly repeated, though in a lesser degree, in both his father and grandfather. They were both active, vigilant, enterprising and warlike, frugal in daily living, but passionate in their temper. There were ambitions or marked talents in nearly all the other ancestors. His mother was intellectual and virtuous and derived as we have seen from the most able region of Denmark. So, after all, taking into consideration the two sisters of Charles XII., who were nobodies in the intellectual scale, we do not find this fraternity to which he belongs giving us more than is called for.

We are now brought to the dynasty of Holstein, which in the six characters, numbered from 28 to 33 inclusive, gives us no names that amount to anything; nor am I able to find out anything concerning the apparent nonentities who formed the ancestry and relationship of

* Lippincott's.

these. With the exception of Charles Frederick of Holstein, also an inferior character, this new dynasty is in no way related to the former dynasty of Palatine, which, like that of Vasa, we have found so remarkable.

Adolphus Frederick of Holstein, one of the inferior ones above mentioned, married Louisa Ulrica, a sister of Frederick the Great. We find in her a woman of a very different stamp. Among all the richly endowed sisters of Frederick the Great, Louisa Ulrica, Queen of Sweden, stands probably at the head of the list. An idea of her character and attainments can be drawn from several contemporaries here quoted.

> The Queen Dowager to whom we had the honor of being presented, a sister of the King of Prussia . . . a princess who resembled her brother as well in the features of her countenance as in those eminent qualities which characterize the house of Brandenburg.
>
> She was accustomed to rule the cabinet with absolute authority in the reign of her husband.*
>
> A great and inflexible woman of rare endowment and uncommon cultivation. Really merited the appellation of the 'Minerva of the North.'

Since Louisa Ulrica belongs, of course, among the Hohenzollerns, we have passed rather rapidly over the dynasty of Holstein, which to this point has furnished no great names. The next generation, children of Adolphus Frederick and Louisa Ulrica, gives us four, and among them, third in the list, Gustavus Adolphus III., who was destined to shine as another Swedish king of extraordinary ability.

> His ardent mind and fertile genius acted as a perpetual impetus to things that were new, grand and out of the common track. He was so accomplished a gentlemen that there was scarcely a professor of literature or any of the liberal arts but he was able to excel each in his own peculiar study. He was always spoken of as a prodigy of talents.†

Lippincott's 'Biographical Dictionary' says that

> In addition to his talents as a statesman, he was distinguished as a poet and dramatist.

This literary bent was very strong in his mother as well as in many members of her family.

His sister, Sophia Albertina, 'was possessed of a great share of personal virtue and a capacity as vast and varied as her brother, and unsullied by his vices.' The oldest brother amounted to nothing, while the youngest, as Charles XIII., showed in his ambition, wisdom and skill in the management of the country's affairs much of the family genius.

Gustavus IV., the only son of Gustavus III. and the last of the

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* Coxe, 'Travels,' IV., 30.

† J. Brown, 'Northern Courts.'

family, though gifted to a certain extent, carried ambition to madness and folly, and being finally deposed, supported himself by writing, together with a small pension. Since Charles XIII., the uncle of Gustavus IV. who succeeded him on the throne, adopted and made successor, Bernadotte, Napoleon's agent, we have now reached the close of our chapter on modern Sweden.

In the study of this country, from Gustavus Vasa to Gustavus III. Adolphus, we find throughout a most perfect confirmation of the theory of mental and moral heredity. We find that in selecting those who were to become the progenitors of the next generation, twice a choice of the best among them all in Charles IX. and Charles X., and the cause of this selection lay in the fact that their very merits brought to them the throne. In the union of Charles the Tenth's great son with the strongest part of Denmark's dynasty, we have still another point where the genius was not allowed to die. We find no more great names, only the petty Holsteins, until Gustavus III. Adolphus reclaims once more the glory of his ancestors, but this we find to be not the ancient genius but a fresh graft, and from the famous Hohenzollerns taken at the height of their intellectual eminence in the time of Frederick the Great.

In all this Swedish history the lives of these men and women can not be explained by environment. If we adopt this view, why did so many among them who must have had most abundant opportunities, fail entirely to exhibit any of these remarkable mental statures? The only serious failing on the moral side was their violent and ungovernable temper. Since there was also mental unbalance in the family, it seems fair to assume that these violent tempers were a manifestation of the neurosis, and not to be ascribed to their high and arbitrary position.

Also, relative to the moral qualities in this family, there does not seem to be any good reason from the standpoint of environment, why there should be such an absence of that dissolute and licentious type so continually found in Spain, France and Russia during these same centuries. But if we look at it from the standpoint of heredity, we can easily see why this is so, since it was neither there to any great extent in the earlier generations, nor was it in those who became the subsequent ancestors of the different male lines considered. It does not seem as if the example set to princes by their parents should be of more effect than general temptations such as come to all who have abundant means at their disposal; and we know too many examples both in royalty and out, where parental influence has sadly failed to inculcate such desirable lessons.

# HOW TO COLLECT FISHES.

By President DAVID STARR JORDAN,
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IN the collection of fishes, three things are vitally necessary—a keen eye, some skill in adapting means to ends, and some willingness to take pains in the preservation of material.

In coming into a new district the collector should try to preserve the first specimen of every species he sees. It may not come up again. He should watch carefully for specimens which look just a little different from their fellows, especially for those which are duller, less striking or with lower fins. Many species have remained unnoticed through generations of collectors who have chosen the handsomest or most ornate specimens. In some groups, with striking peculiarities, as the Trunk-fishes and Porcupine-fishes, practically all the species were known to the predecessors of Linnæus. No collector could pass them by. On the other hand, new gobies or blennies can be picked up almost every day in the lesser known parts of the world. For these overlooked forms, herrings, anchovies, sculpins, blennies, gobies, scorpion-fishes, the competent collector should be always on the watch. If any specimen looks different from the rest, take it at once and find out the reason why.

In most regions, the chief dependence of the collector is on the markets, and these should be watched most critically. By paying a little more for unusual, neglected or useless fish, the supply of these will rise to the demand. The word passed along among the people of Onomichi, in Japan, that 'Ebisu the fish-god was in the village' and would pay more for Okose (poison Scorpion-fishes) and Umiuma (Sea-horses) than real fishes were worth soon brought (in 1900) all sorts of Okose and Umiuma into the market when they were formerly left neglected on the beach. Thus with a little ingenuity the markets in any country can be greatly extended.

The collector can, if he thinks best, use all kinds of fishing tackle for himself, hooks, flies, bait, seines, traps, anything that will catch fishes. In Japan he can use the 'dabonawa' long lines, and secure the fishes which were otherwise dredged by the *Challenger* and *Albatross*. If dredges or trawls are at his hand he can hire them and use them for scientific purposes. He should neglect no kind of bottom, no conditions of fish life which he can reach. Especially important is the fauna of the tide-pools, neglected by almost all collectors. As the tide goes down, especially on rocky capes which project into the sea, myriads of little fishes will remain in the rock-pools, the algæ and the clefts of rock. In regions like California, where the rocks are buried with kelp, blennies will lie in the kelp as quiescent as the branches of the algæ themselves until the flow of water returns.

A sharp, three-tined fork will help in spearing them. The water in pools can be poisoned on the coast of Mexico, with the milky juice of the 'Hava' tree, a tree which yields strychnine. In default of this, pools can be poisoned by chloride of lime, sulphate of copper, or, if small enough, by formaline. Of these, a solution of commercial chloride of lime, yielding free chlorine gas is cheapest and most serviceable. By such means the contents of the pool can be secured and the next tide carries away the poison. The water in pools can be bailed out, or better emptied by a siphon made of small garden hose or rubber tubing. On rocky shores and about coral reefs dynamite can be used to very great advantage, if the collector or his assistant dare risk it, and if the laws of the country do not prevent. Most effective in rock-pool work is the help of the small boy. In all lands the collector will do well to take him into his pay and confidence. Of the hundred or more new species of rock-pool fishes lately secured by the writer in Japan, fully two thirds were obtained by the Japanese boys. Equally effective is the 'muchacho' on the coasts of Mexico.

Masses of coral, sponges, tunicates and other porous or hollow organisms often contain small fishes and should be carefully examined. On the coral reefs the breaking up of large masses is often most remunerative. The importance of securing the young of pelagic fishes cannot be too strongly emphasized.

Fishes must be permanently preserved in alcohol. Dried skins are far from satisfactory, except as a choice of difficulties in the case of large species. Dr. Gunther thus describes the process of skinning fishes:

> Scaly fishes are skinned thus: with a strong pair of scissors an incision is made along the median line of the abdomen from the foremost part of the throat, passing on one side of the base of the ventral and anal fins, to the root of the caudal fin, the cut being continued upwards to the back of the tail close to the base of the caudal. The skin of one side of the fish is then severed with the scalpel from the underlying muscles to the median line of the back; the bones which support the dorsal and caudal are cut through, so that these fins remain attached to the skin. The removal of the skin of the opposite side is easy. More difficult is the preparation of the head and scapulary region; the two halves of the scapular arch which have been severed from each other by the first incision are pressed towards the right and left, and the spine is severed behind the head, so that now only the head and shoulder bones remain attached to the skin. These parts have to be cleaned from the inside, all soft parts, the branchial and hyoid apparatus, and all smaller bones being cut away

with the scissors or scraped off with the scalpel. In many fishes which are provided with a characteristic dental apparatus in the pharynx (Labroids, Cyprinoids), the pharyngeal bones ought to be preserved, and tied with a thread to their specimen. The skin being now prepared so far, its entire inner surface as well as the inner side of the head are rubbed with arsenical soap; cotton-wool or some other soft material is inserted into any cavities or hollows, and finally a thin layer of the same material is placed between the two flaps of the skin. The specimen is then dried under a slight weight to keep it from shrinking.

The scales of some fishes, as for instance of many kinds of herrings, are so delicate and deciduous that the mere handling causes them to rub off easily. Such fishes may be covered with thin paper (tissue paper is the best) which is allowed to dry on them before skinning. There is no need for removing the paper before the specimen has reached its destination.

Scaleless fishes, as siluroids and sturgeons, are skinned in the same manner, but the skin can be rolled up over the head; such skins can also be preserved in spirits, in which case the traveller may save himself the trouble of cleaning the head.

In the field it is much better to use formalin (formaldehyde) in preference to alcohol. This is an antiseptic fluid dissolved in water, and it at once arrests decay, leaving the specimen as though preserved in water. If left too long in formalin fishes swell, the bones are softened and the specimens become brittle or even worthless. But for ordinary purposes (except use as skeleton) no harm arises from two or three months' saturation in formalin. The commercial formalin can be mixed with about 20 parts of water. On the whole it is better to have the solution too weak rather than too strong. Too much formalin makes the specimens stiff, swollen and intractable, besides too soon destroying the color. Formalin, has the advantage, in collecting, of cheapness and of ease in transportation, as a single small bottle will make a large amount of the fluid. The specimens also require much less attention. An incision should be made in the right side of the abdomen to let in the fluid. The specimen can then be placed in formalin. When saturated, in the course of the day, it can be wrapped in a cloth, packed in an empty petroleum can and at once shipped. The wide use of petroleum in all parts of the world is a great boon to the naturalist. Before preservation, the fishes should be washed, to remove slime and dirt. They should have an incision to let the fluid into the body cavity and an injection with a syringe is a useful help to saturation, especially with large fishes. Even decaying fishes can be saved with formalin.

The collector should mark localities most carefully, with tin-tags and notebook records, if possible. He should, so far as possible, keep records of life colors, and water color sketches are of great assistance in this matter. In spirits or formalin, the life colors soon fade, although the pattern of marking is usually preserved or at least indicated. A mixture of formalin and alcohol is favorable to the preservation of markings. In the museum all specimens should be removed at once from formalin to alcohol. No substitute for alcohol as a permanent preservative has been found. The spirits derived from wine, grain, or sugar is much preferable to the poisonous methyl or wood-alcohol.

In placing specimens directly in alcohol, care should be taken not to crowd them too much. The fish yields water which dilutes the spirit. For the same reason, spirits too dilute are ineffective. On the other hand, delicates fishes put into very strong alcohol are likely to shrivel, a condition which may prevent an accurate study of their fins or other structures. It is usually necessary to change a fish from the first alcohol used as a bath into stronger alcohol in the course of a few days, the time depending on the closeness with which fishes are packed. In the tropics, fishes in alcohol often require attention within a few hours. In formalin, there is much less difficulty with tropical fishes.

Fishes intended for skeletons should never be placed in formalin. A softening of the bones which prevents future exact studies of the bones is sure to take place. Generally alcohol or other spirits, arrack, brandy, cognac, rum, sake, 'vino' can be tested with a match. If sufficiently concentrated to be ignited, they can be safely used for preservation of fishes. The best test is that of the hydrometer. Spirits for permanent use should show on the hydrometer 40 to 60 above proof. Decaying specimens show it by color and smell, and the collector should be alive to their condition. One rotting fish may endanger many others. With alcohol it is necessary to take especial pains to ensure immediate saturation. Deep cuts should be made into the muscles of large fishes as well as into the body cavity. Sometimes a small distilling apparatus is useful to redistil impure or dilute alcohol. The use of formalin avoids this necessity. Small fishes should not be packed with large ones; small bottles are very desirable for their preservation. All spinous or scaly fishes should be so wrapped in cotton muslin as to prevent all friction.

The methods of treating individual groups of fishes and of handling them under different climate and other conditions are matters to be learned by experience. Eternal vigilance is the price of a good collection as it is said to be of some other good things. Mechanical collecting, picking up the thing got without effort and putting it in alcohol without further thought, rarely serves any useful end in science. The best collectors are usually the best naturalists. The collections made by the men who are to study them and who are competent to do so are the ones which most help the progress of ichthyology. The student of a group of fishes misses half the collection teaches if he has made no part of it himself.

# SCIENTIFIC LITERATURE.

*PSYCHOLOGY OF RELIGION.*

'The Varieties of Religious Experience' is the interesting title of Professor William James's most recent volume, 'being the Gifford Lectures on Natural Religion delivered at Edinburgh in 1901–1902.' It is 'a study in human nature,' a contribution to the empirical psychology of man's religious constitution, and as such marks an innovation in the course pursued by Gifford lecturers, who had previously concerned themselves with the philosophy of religion or its history objectively considered. It was a happy thought which set Professor James the difficult and delicate task of analyzing the subjective phenomena of the religious life—or, rather, of religious lives.

In the attempt to classify types of religious experience, the author has laid under extensive contribution autobiographical documents which represent all manner of sects in and out of Christendom. The chapters abound in quotations from the extravagant deliverances of these souls, selected to emphasize the several tendencies in an extreme form.

The scope of the book may be suggested by the titles of some of the chapters: 'Religion and Neurology,' 'The Reality of the Unseen,' 'The Religion of Healthy Mindedness,' 'The Sick Soul,' 'The Divided Self and the Process of its Unification,' 'Conversion,' 'Saintliness,' 'Mysticism,' 'Philosophy,' etc.

While this book is principally occupied with a descriptive account of religious experiences, and a sharp line is drawn between description and valuation, a critical estimate of each type is attempted. Herein the author's wide sympathies come into play, with a capacity for appreciation extreme almost to a fault. Not by its origin, but by its 'fruits for life,' shall a religion be judged, says Professor James, in accordance with his philosophical pragmatism. And the complexity of life provides for the utility of diverse types. The very 'variety' is esteemed significant of possible ranges of unexplored experience. This falls into line with Professor James's individualistic or pluralistic attitude toward the universe, and brings us to the characteristic philosophical considerations which are merely hinted at toward the end of the volume, but which it is intended to marshal systematically in a later work.

Professor James confesses to a leaning toward a vague supernaturalism which he himself characterizes as 'crass,' and which is queer to say the least. It may be said to rest upon the conception of a 'subliminal' region of consciousness, not yet generally admitted into scientific psychology, but which is regarded by Professor James as the more significant part of our human nature, whereby we come into deepest relation with the universe.

No thoughtful reader, least of all a psychologist, can fail to profit by the immense suggestiveness of these lectures, which reveal afresh that psychological insight long since recognized as genius, while they are written in that no less brilliant style so familiar to Professor James's readers for a felicity of phrase unequaled in scientific literature. If one misses something of the scientific vigor of the 'Principles of Psychology,' one finds in compensation much of the mellow wisdom which has marked all of Professor James's later writings.

One of the most remarkable religious movements of the nineteenth century was that inaugurated by Joseph Smith, Jr., from 1820 to 1830. The announcement of the finding of a set of golden plates hidden in a hill in New York state and revealed to the prophet of the Almighty; said plates when interpreted by the prophet proving to be the history of the lost ten tribes of Israel, their journeying to America, their identification with the Indians, their further trials and tribulations, and their ultimate salvation and reconstruction in the Church of the Latter Day Saints,—this is indeed a sufficiently fantastic story. Mr. I. W. Riley devotes a volume (Dodd, Mead & Co.) to an analysis of the character of the founder of this sect. His interest is not in what the man did and the ultimate consequences of his establishment of a peculiar sect, but in the motives and impulses that led to the doing of it and to its successful propagandum. The study is psychological; and in the abnormal mentality of the founder Mr. Riley finds the clue to his actions. The tale is by no means complete, but the author has been most diligent in his search; and circumstantial evidence and arguments by analogy reach a high degree of probability. As a young man, Smith gave evidence of epileptic attacks; he was given to visions and was absorbed in crass forms of religious devotion; the 'Book of Mormons' was dictated while the author was in a semi-hypnotic condition self-induced, and directing his thoughts to the conviction of his own inspiration; his first converts were themselves credulous and suggestible, and the testimony of the witnesses to the vision of the plates was probably the result of a hypnotic suggestion. In brief, a study of abnormal psychological states convinces the author that Joseph Smith was a neurotic degenerate, with an ancestry of like temperament, and that his revelations were the riotous imaginings of his automatic imagination, exhibiting the kind of shrewdness and adaptation to existing conditions often to be found in mental products of such origin. The cumulative evidence for this view can be appreciated only by a direct reading of the book; it forms an interesting example of the application of modern psychological conceptions to the comprehension of a most unusual factor in the religious history of this country.

# THE PROGRESS OF SCIENCE.

## *THE CARNEGIE INSTITUTION.*

Scientific interest this month is focused on the approaching meeting of the trustees of the Carnegie Institution. At the first meeting of the trustees, officers and an executive committee were appointed, and adjournment was taken to November without any decision on matters of policy. During the summer reports have been prepared by advisory committees of scientific men, and the secretary and other members of the executive committee have been engaged in careful consideration of the methods by which the Carnegie Institution can most effectively contribute to the advancement of science. The president of the institution has been abroad in consultation with foreign men of science and studying their institutions. The advisory committees have been selected with care, and it is doubtless proper that their reports should be regarded as confidential until they have been presented to the trustees. Scientific men would, however, be better pleased if the nomination of the members of the advisory committees had been entrusted to the scientific societies of the country and if they were sure that the trustees would take nc action involving the institution in a definite policy until the questions at issue have been more thoroughly discussed. It would not be possible to select more representative trustees than those of the Carnegie Institution, but they are men of affairs, engaged in the conduct of important enterprises, and can not be expected to devote their attention to the policy of the institution. The plan which obtains in this country of entrusting the ownership and control of educational and scientific institutions to a board of business men, who appoint a president with great power, provides an efficient administration. It is not, however, ideal from the point of view of the scientific man—so long as he is an employee or slave he may do his work satisfactorily and economically, but he naturally looks forward to becoming a free man. We all know the difficulties and dangers of a democracy, but we have decided that this is for us the best form of government. Perhaps the greatest service that the Carnegie Institution could perform for science would be to entrust scientific men with its management. They would doubtless make mistakes and perhaps fall into quarrels, but in the end their education would be attained, and thereafter they would be more competent to manage their own affairs than any board of business men placed in authority over them.

As was stated in the September issue of the Monthly, the corporation of the Marine Biological Laboratory has voted to transfer its property to the Carnegie Institution; and this is the only intimation that has been made public in regard to the probable policy of the institution. But while the institution has secured an option on the laboratory, it is by no means certain that it will undertake the ownership. It has been announced by the chairman of the executive committee of the trustees of the laboratory that this will only be done after careful consideration and full discussion, and there is reason to believe that the Carnegie Institution may assist the laboratory without insisting on its becoming a branch or department. This question opens the main problem before the institution, namely, whether it shall conduct several great laboratories for research or shall cooperate with existing institutions. There is doubtless much to be said on both sides. It appears from a series of articles by leading scientific men, published in recent issues of SCIENCE, that opinion is pretty equally divided. Some hold that the resources of the institution can be best utilized in the establishment of laboratories at Washington or elsewhere, while others think that for the present at least assistance should be given where it appears to be most needed. There is in either case some danger of too great centralization of power and of interference with individual initiative, and with agencies supported or likely to be supported from other sources. As a labor saving invention may at first disorganize a trade, though in the end for the benefit of society, so the great resources of the Carnegie Institution must be used with discretion if there is not to be a temporary inhibition of other agencies.

When compared with any similar agency, the funds of the Carnegie Institution are bewilderingly large. Thus in his presidential address before the British Association, Professor Dewar stated that the Carnegie Institution will dispose in a year of as much money as the members of the Royal Institution have expended in a century on its purely scientific work. The other institution most like that endowed by Mr. Carnegie is the Smithsonian, whose endowment was about equal to the annual income of the Carnegie Institution. Compared, however, with certain other agencies, for example, the U. S. Geological Survey, with its appropriation of $1,300,000, the funds of the Carnegie Institution are limited, and it is evident that they must be used economically, without any attempt to rival the government or universities, but doing what can be done only by an institution so unique in its possibilities.

### *THE COLLEGE AND THE UNIVERSITY.*

THE first report of President Butler to the trustees of Columbia University exhibits the benefit of a university president's being from the outset a student of educational problems. The domestic economy of the university is reviewed in a masterly fashion, and questions of wide-reaching importance for the development of the educational institutions of the country are discussed by an acknowledged leader. The most pressing problem is the relation of the college to the university, and here President Butler outlines a policy which while radical appears to be in the line of advance. The plan of Harvard, Johns Hopkins and to a certain extent of Columbia has been to require a college degree for entrance to the professional schools. Students now enter the freshman class of these universities at the age of eighteen or nineteen. If they follow a four years' course at college and a three or four years' course in the professional school, they are on the average twenty-five years of age before they begin actual work with a period of apprenticeship before them. This is wrong both economically and educationally. Only the sons of the rich, who accept parental support when they should themselves be heads of families, are able to enter professional careers. The actual practice essential to professional work is postponed until the age of plasticity is passed.

President Eliot has long advocated a college course of three years, making it at the same time elective, so that a certain amount of work preparatory to the professions can be done at college. Columbia University admits seniors to its schools of medicine and law, permitting them to count part of their professional work toward the bachelor's degree. President Butler now advocates admitting students to the professional schools at the close of the sophomore year, either giving them the degree of A.B. then or after a certain amount of professional work. The newspapers have raised an outcry over this suggestion—they declaim against debasing the bachelor's degree, attracting students by low requirements and the like, confusing the question of the degree as a mere counter with the educational problem. Thirty or forty years ago the A.B. degree did not represent more than the equivalent of the completion of the present sophomore year. It signified rather less than completion of the course of the German gymnasium, of the French lycée or of the English and Scottish universities. Unwise competition for the best students has raised, not lowered, the requirements for the A.B. and for entrance to the professional schools. The A.B. might be abandoned, as in Germany, without any particular loss to the educational system. Its meaning is now vague and unsatisfactory. The real question is: Shall we require students who have completed the high school course to spend four years on so-called liberal studies and athletics before they may begin their real work? This question must be answered in the negative and has been so answered by the logic of events. It is far better to make the professional schools more liberal—that is, more insistent on methods, general principles and research than on mere technique—rather than to require the A.B. degree as a preliminary. A more natural division of studies has been developed in France and Germany than here. The preparatory school and high school should be developed to include all studies that are required and pursued by text-books and recitations. The small denominational college should be placed on the level of the high school, where it can do good work. High schools and colleges should be found in every community. The universities can also conduct colleges for those who wish to go forward to the professional schools and faculties of philosophy or science. The student of the professional school who must complete his work in three years should be permitted to do so, while those who show ability for investigation and independent thought should work both in the professional school and the graduate school, and should be permitted to prepare simultaneously for the professional qualification and for the degree of A.M. or Ph.D., or what they represent.

## *THE BRITISH ASSOCIATION AT BELFAST.*

The seventy-second annual meeting of the British Association will not have the same historical significance as the famous meeting held in Belfast in 1874. At that meeting Tyndall delivered the address which was so widely criticized and discussed. It will be remembered by many that Tyndall there went beyond the limits of science and discussed problems of philosophy and religion. While his remarks were frank and outspoken, it is somewhat difficult for us to realize the objection taken to them thirty years ago. Scientific freedom has since been attained; and this to a certain extent may be said to date from Tyndall's address at the Belfast meeting of the Association. Professor Dewar's address at the present meeting was more nearly what is expected of such an address. After an introduction reviewing scientific organization and the place of Great Britain in science, he described those problems of chemistry on which he is the greatest living authority, namely, the history of cold and the absolute zero; the liquefaction of gases, especially hydrogen and helium; and various low temperature researches.

At the meeting of the sections a great number of important papers were presented, there being, however, an increasing tendency for these to be technical rather than popular in character, as is also the case in our own national association. There is printed above the address by Professor Halliburton on physiology, and we hope to be able to publish subsequently the address by Professor Armstrong before the Section of Education, these being perhaps the two most interesting of the presidential addresses. In the physical section papers were presented by Lord Kelvin and Lord Rayleigh, perhaps the two greatest physicists now living. Lord Rayleigh discussed the question as to whether motion through the ether causes double refraction of light, reviewing the evidence which has led physicists to conclude that the earth in its motion does not drag the ether with it. Lord Rayleigh's experiments have confirmed those of our American physicists, Michelson and Morley, which showed that light travels through a body traversed by a stream of ether with the same speed along it as against or across it. Another paper of considerable interest before the Mathematical and Physical Section was one by Professor Schuster discussing the relative importance of collecting observations in a science such as meteorology and of deducing laws from them. Before the Chemical Section the subjects which seem to have attracted special interest were the action of enzymes and the aromatic compounds. Papers before the Zoological Section were presented by Professor Poulton and others on mimicry, and by Professor Herdman on his expedition to study the pearl oyster beds in the Gulf of Manaar, and on the plans for protecting the North Sea fisheries. The Sections of Economics, Geography and Anthropology usually attract the greatest general interest, but space does not permit reference to the papers and discussions. A word should, however, be said in regard to the Section of Education, established last year, which bids fair to become one of the most attractive departments of the Association, setting a model which the American Association should follow.

The attendance at the meeting was 1,620 as compared with 1,951 at the Belfast meeting twenty-eight years ago. The decrease in attendance was not, however, due to fewer scientific men being present, but to a smaller local interest in the meeting. One of the most interesting features of the general meeting was the invitation presented by Professor Charles S. Minot, last year president of the American Association, asking as many members as possible to attend the Washington meeting of the American Association. Professor Minot described the steps that have been taken in America to secure the reorganization of scientific societies under the auspices of the American Association and the securing of a convocation week in mid-winter for the meetings. President Dewar, in replying on behalf of the Association, emphasized the importance of a visit to America, and expressed the hope that there would be a large attendance of English men of science at the meeting to be held at Washington beginning on the Monday after Christmas.

The meeting of the British Association next year will be at Southport under the presidency of Sir Norman Lockyer, one of the most prominent of living astronomers and editor of *Nature*. The meeting in 1904 will be at Cambridge, where efforts will doubtless be made to rival the important meeting at Oxford in 1894. Plans are being made which may lead to a meeting in South Africa in 1905, the colonies having offered to defray a large part of the expenses of delegates.

### *THE DISTRIBUTION OF ANTHRACITE COAL.*

Anthracite differs from ordinary or bituminous coal in that it contains a small percentage of volatile combustible matter. Commercial anthracite varies from the hard, dry Lehigh with little more than one per cent. to the easily lighted Bernice coals of Sullivan county, Penn., with ten per cent. The Lackawanna and Lykens Valley coals, so much prized for domestic use, are midway between Lehigh and Bernice. The use of hard coal has become so well-nigh universal in the eastern towns and cities that one hardly understands how the community could become accustomed to the use of soft coal; yet the available supply of anthracite in America is so small that, unless some other fuel be discovered, the use of bituminous coal must prevail within seventy-five years at the most. The anthracite fields of Pennsylvania will be exhausted within seventy-five years, even though the annual production should not exceed that of 1901—which is improbable. There is no other deposit of anthracite in the United States, aside from some wholly unimportant patches in North Carolina, New Mexico and Colorado, so unimportant that all combined would yield hardly enough for one year's consumption. Europe has very little anthracite. Most of the Welsh coal is bituminous, the anthracite of the South Wales field being confined to the western end of that field. The Worm basin of Prussia yields perhaps 2,000,000 tons per annum of a semi-anthracite; near Ostrau in the Silesian field and in the Donetz field of south Russia anthracite occurs in moderate quantities; but these are all unimportant. China, however, has vast fields compared with which our Pennsylvania fields are mere dots on the map; there being upward of 40,000 square miles underlain by anthracite coals in Hunan, Honan and East Schansi.

### *BORAX AS A FOOD PRESERVATIVE.*

THE question of the use of borax and boric acid as food preservatives has attracted much attention of late, especially in Germany, where it has been brought forward as a convenient lever to exclude American food products. The results of different investigators are far from uniform, and the conclusions drawn as to its use are correspondingly at variance with each other. It is generally conceded that as far as regards digestion neither borax nor boric acid have any specific influence, but when considerable quantities are present the alkalinity of the former or slight acidity of the latter may be of some effect. In a similar way they may act as mild irritant poisons, occasioning diarrhœa. With continued use most observers find a loss of weight, which seems to be due to loss of fat in the body, and this may occur, without any symptoms of ill health, when small quantities of borax or boric acid are ingested daily. It is possible that this result might attend the regular use of food products which have been preserved by boric acid. While the quantity of the acid present is usually quite small, it is completely eliminated from the system rather slowly. In doses of three grams, one half was eliminated in the first twelve hours, but from five to nine days were required for the disappearance of the remainder. In this way boric acid might have the effect of a cumulative poison. It is said to be a common practice in this country to preserve butter and meat by packing in a mixture of salt with some borax or boric acid. Such a mixture was the 'rex magnum' largely sold fifteen years or so ago. Recent experiments by Polenske show that fat takes up very little of the borax powder, while meats take up no inconsiderable quantity. American pork was found in one case to have absorbed in its outer portion no less than two per cent. of its weight of borax, while in another case four per cent. was taken up in three weeks. This latter amount may, however, be considered extreme. In this connection an observation of von Lippmann's is of interest. On investigating a deposit in a vacuum apparatus for concentrating lemon juice, he found quite a quantity of boric acid, and on further examination discovered that boric acid is present in small quantity in most fruit, as in lemons, apples, etc. As a result it cannot be inferred, because boric acid is found in preserved or dried fruits, that it has been added as a preservative. Altogether it must be said that the whole matter needs further study, and that it must be determined to what limit the use of boric acid and borax is permissible without endangering health.

### *SCIENTIFIC ITEMS.*

We record with great regret the death of John Wesley Powell, director of the Bureau of American Ethnology and formerly director of the U. S. Geological Survey. His death occurred at his summer home in Maine on September 23, he being in his sixty-ninth year. There was published in the Popular Science Monthly for January, 1882, an article reviewing Major Powell's life and work, illustrated by a portrait, and we hope to publish in the next number a further appreciation of his work.—We regret also to record the death of Sir Frederick Abel, known for his important researches on explosives, and of Dr. John Hall Gladstone, known for his researches on chemical combinations.

Dr. Charles S. Minot, professor of histology and embryology in the Harvard Medical School, was given the degree of Doctor of Science at Oxford University, on the occasion of the tercentenary of the Bodleian Library.—Professor W. H. Welch, of the Johns Hopkins University, delivered the Huxley lecture before the Charing Cross Hospital on October first.—Dr. Andrew D. White, Ambassador to Germany, has presented his letters of recall. His successor, Dr. Charlemagne Tower, is also interested in literary and scientific subjects.—An expedition from the Liverpool School of Tropical Medicine under Major Ronald Ross has gone to the Suez Canal to institute preventative measures against malaria.

A committee has been formed for the erection of a public memorial of the late Professor Virchow in Berlin, with Professor Waldeyer as chairman.—A monument, consisting of a pedestal and a bust by the sculptor, Marqueste, is to be erected in the Paris Museum of Natural History, in memory of Alphonse Milne-Edwards.—The eightieth birthday of John Fritz, ironmaster and inventor, of Bethlehem, Pa., will be celebrated by a dinner given in his honor on October 31. The dinner will also signalize the founding of the John Fritz gold medal for achievement in the industrial sciences, the medal to be awarded annually by a committee of members of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers. The organizing committee having the matter in charge on behalf of these societies has already raised $6,000, representing the contributions of some 500 members of the engineering professions in this country and in Europe. The medal has been entrusted to the American sculptor, Victor D. Brenner.

THE POPULAR SCIENCE MONTHLY.

DECEMBER, 1902.

# THE HIGHER EDUCATION OF WOMEN.*

By President DAVID STARR JORDAN,
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THE subject of the higher training of young women may resolve itself into three questions:

1. *Shall a girl receive a college education?*
2. *Shall she receive the same kind of a college education as a boy?*
3. *Shall she be educated in the same college?*

As to the first question: It must depend on the character of the girl. Precisely so with the boy. What we should do with either depends on his or her possibilities. No parent should let either boy or girl enter life with any less preparation than the best he can give. It is true that many college graduates, boys and girls alike, do not amount to much after the schools have done all they can. It is true also that higher education is not a question alone of preparing great men for great things. It must prepare even little men for greater things than they would otherwise have found possible. And so it is with the education of women. The needs of the time are imperative. The highest product of social evolution is the growth of the civilized home, the home that only a wise, cultivated and high-minded woman can make. To furnish such women is one of the worthiest functions of higher education. No young women capable of becoming such should be condemned to anything lower. Even with those who are in appearance too dull or too vacillating to reach any high ideal of wisdom, this may be said—it does no harm to try. A few hundred dollars is not much to spend on an experiment of such moment. Four of the

* Abstract of an address before the Federation of Woman's Clubs, Los Angeles, May 5, 1902.

best years of one's life spent in the company of noble thoughts and high ideals cannot fail to leave their impress. To be wise, and at the same time womanly, is to wield a tremendous influence, which may be felt for good in the lives of generations to come. It is not forms of government by which men are made and unmade. It is the character and influence of their mothers and their wives. The higher education of women means more for the future than all conceivable legislative reforms. And its influence does not stop with the home. It means higher standards of manhood, greater thoroughness of training, and the coming of better men. Therefore let us educate our girls as well as our boys. A generous education should be the birthright of every daughter of the republic as well as of every son.

It is hardly necessary among intelligent men and women to argue that a good woman is a better one for having received a college education. Anything short of this is inadequate for the demands of modern life and modern culture. The college training should give some basis for critical judgment among the various lines of thought and effort which force themselves upon our attention. Untrained cleverness is said to be the most striking characteristic of the American woman. Trained cleverness, a very much more charming thing, is characteristic of the American college woman. And when cleverness stands in the right perspective, when it is so strengthened and organized that it becomes wisdom, then it is the most valuable dowry a bride can bring to her home.

Even if the four K's, 'Kirche, Kinder, Kuchen and Kleider,' are to occupy woman's life as Emperor William would have us believe, the college education is not too serious a preparation for the profession of directing them. A wise son is one who has had a wise mother, and to give alertness, intelligence and wisdom is the chief function of a college education.

### 2. *Shall we give our Girls the Same Education as our Boys?*

Yes, and no. If we mean by the *same,* an equal degree of breadth and thoroughness, an equal fitness for high thinking and wise acting, yes, let it be the same. If we mean this: Shall we reach this end by exactly the *same* course of studies? then the answer must be, No. For the same course of study will not yield the same results with different persons. The ordinary 'college course' which has been handed down from generation to generation is purely conventional. It is a result of a series of compromises in trying to fit the traditional education of clergymen and gentlemen to the needs of a different social era. The old college course met the needs of nobody, and therefore was adapted to all alike. The great educational awakening of the last twenty years in America has lain in breaking the bonds of this old system. The essence of the new education is constructive individualism. Its purpose is to give to each young man that training which will make a man of *him*. Not the training which a century or two ago helped to civilize the mass of boys of that time, but that which will civilize this particular boy. The main reason why the college students of to-day are twenty times as many as twenty years ago is that the college training now given is valuable to twenty times as many men as could be reached or helped by the narrow courses of twenty years ago.

In the university of to-day the largest liberty of choice in study is given to the student. The professor advises, the student chooses, and the flexibility of the courses makes it possible for every form of talent to receive proper culture. Because the college of to-day helps ten times as many men as that of yesterday could hope to reach it is ten times as valuable. This difference lies in the development of special lines of work and in the growth of the elective system. The power of choice carries the duty of choosing rightly. The ability to choose has made a man out of the college boy and has transferred college work from an alternation of tasks and play to its proper relation to the business of life. Meanwhile the old ideals have not risen in value. If our colleges were to go back to the cut-straw of medievalism, to their work of twenty years ago, their professors would speak to empty benches. In those colleges which still cling to these traditions the benches are empty to-day, or filled with idlers.

I do not mean to condemn the study of the ancient classics and mathematics which made almost the whole of the older college course. These studies must always have their place, but no longer an exclusive place. The study of the language and literature of Greece still ranks with the noblest efforts of the human intelligence. For those who can master it Greek gives a help not to be obtained in any other way. As Thoreau once observed, those who would speak of forgetting the Greek are those who never knew it. But without mastery there is no gain of strength. To compel all men and boys of whatever character or ability to study Greek is in itself a degradation of Greek, as it is a hardship to those forced to spend their strength where it is not effective. There are other forms of culture better fitted to other types of man, and the essential feature lies in the strength of mastery.

The best education for a young woman is surely not that which has proved unfit for the young man. She is an individual as well as he, and her work gains as much as his by relating it to her life. But an institution which meets the varied needs of varied men can also meet the varied needs of the varied women. The intellectual needs of the two classes are not very different in many important respects. In so far as these are different the elective system gives full play for the expression of such differences. It is true that most men in college look forward to professional training and that very few women do so. But the college training is not in itself a part of any profession, and it is broad enough in its range of choice to point to men and women alike the way to any profession which may be chosen. Those who have to do with the higher education of women know that the severest demands can be met by them as well as by men. There is no demand for easy or 'goody-goody' courses of study for women except as this demand has been encouraged by men. In this matter the supply has always preceded the demand.

There are, of course, certain average differences between men and women as students. Women have often greater sympathy or greater readiness of memory or apprehension, greater fondness for technique. In the languages and literature, often in mathematics and history, they are found to excel. They lack, on the whole, originality. They are not attracted by unsolved problems and in the inductive or 'inexact' sciences they seldom take the lead. The 'motor' side of their minds and natures is not strongly developed. They do not work for results as much as for the pleasure of study. In the traditional courses of study—traditional for men—they are often very successful. Not that these courses have a fitness for women, but that women are more docile and less critical as to the purposes of education. And to all these statements there are many exceptions. In this, however, those who have taught both men and women must agree; the training of women is just as serious and just as important as the training of men, and no training is adequate for either which falls short of the best.

### 3. *Shall Women be taught in the Same Classes as Men?*

This is partly a matter of taste or personal preference. It does no harm whatever to either men or women to meet those of the other sex in the same class rooms. But if they prefer not to do so, let them do otherwise. No harm is done in either case, nor has the matter more than secondary importance. Much has been said for and against the union in one institution of technical schools and schools of liberal arts. The technical quality is emphasized by its separation from general culture. But I believe that better men are made when the two are brought more closely together. The culture studies and their students gain from the feeling of reality and utility cultivated by technical work. The technical students gain from association with men and influences of which the aggregate tendency is toward greater breadth of sympathy and a higher point of view.

A woman's college is more or less distinctly a technical school. In most cases, its purpose is distinctly stated to be such. It is a school of training for the profession of womanhood. It encourages womanliness of thought as more or less different from the plain thinking which is called manly. The brightest work in woman's colleges is often accompanied by a nervous strain, as though its doer were fearful of falling short of some outside standard. The best work of men is natural, is unconscious, the normal result of the contact of the mind with the problem in question.

In this direction, I think, lies the strongest argument for coeducation. This argument is especially cogent in institutions in which the individuality of the student is recognized and respected. In such schools each man, by his relation to action and realities, becomes a teacher of women in these regards, as, in other ways, each cultivated woman is a teacher of men.

In woman's education, as planned for women alone, the tendency is toward the study of beauty and order. Literature and language take precedence over science. Expression is valued more highly than action. In carrying this to an extreme the necessary relation of thought to action bcomes obscured. The scholarship developed is not effective, because it is not related to success. The educated woman is likely to master technique, rather than art; method, rather than substance. She may know a good deal, but she can do nothing. Often her views of life must undergo painful changes before she can find her place in the world.

In schools for men alone, the reverse condition often obtains. The sense of reality obscures the elements of beauty and fitness. It is of great advantage to both men and women to meet on a plane of equality in education. Women are brought into contact with men who can do things—men in whom the sense of reality is strong, and who have definite views of life. This influence affects them for good. It turns them away from sentimentalism. It gives tone to their religious thoughts and impulses. Above all, it tends to encourage action as governed by ideals, as opposed to that resting on caprice. It gives them better standards of what is possible and impossible when the responsibility for action is thrown upon them.

In like manner, the association with wise, sane and healthy women has its value for young men. This value has never been fully realized, even by the strongest advocates of coeducation. It raises their ideal of womanhood, and the highest manhood must be associated with such an ideal. This fact shows itself in many ways; but to point out its existence must suffice for the present paper.

At the present time the demand for the higher education of women is met in three different ways:

1. In separate colleges for women, with courses of study more or less parallel with those given in colleges for men. In some of these the

teachers are all women, in some mostly men, and in others a more or less equal division obtains. In nearly all these institutions, those old traditions of education and discipline are more prevalent than in colleges for men, and nearly all retain some trace of religious or denominational control. In all, the *Zeitgeist* is producing more or less commotion, and the changes in their evolution are running parallel with those in colleges for men.

2. In annexes for women to colleges for men. In these, part of the instruction to the men is repeated for the women, though in different classes or rooms, and there is more or less opportunity to use the same libraries and museums. In some other institutions, the relations are closer, the privileges of study being similar, the difference being mainly in the rules of conduct by which the young women are hedged in, the young men making their own.

It seems to me that the annex system cannot be a permanent one. The annex student does not get the best of the institution, and the best is none too good for her. Sooner or later she will demand it, or go where the best is to be had. The best students will cease to go to the annex. The institution must then admit women on equal terms, or not admit them at all. There is certainly no educational reason why a woman should prefer the annex of one institution when another equally good throws its doors wide open to her.

3. The third system is that of coeducation. In this system young men and young women are admitted to the same classes, subjected to the same requirements, and governed by the same rules. This system is now fully established in the State institutions of the North and West, and in most other colleges in the same region. Its effectiveness has long since passed beyond question among those familiar with its operation. Other things being equal, the young men are more earnest, better in manners and morals, and in all ways more civilized than under monastic conditions. The women do more work in a more natural way, with better perspective and with saner incentives than when isolated from the influence of society of men. There is less of silliness and folly where a man is not a novelty. In coeducational institutions of high standards, frivolous conduct or scandals of any form are rarely known. The responsibility for decorum is thrown from the school to the woman, and the woman rises to the responsibility. Many professors have entered western colleges with strong prejudices against coeducation. These prejudices have not often endured the test of experience with men who have made an honest effort to form just opinions.

It is not true that the character of the college work has been in any way lowered by coeducation. The reverse is decidedly the case. It is true that untimely zeal of one sort or another has filled the West with a host of so-called colleges. It is true that most of these are weak and doing poor work in poor ways. It is true that most of these are coeducational. It is also true that the great majority of their students are not of college grade at all. In such schools low standards rule, both as to scholarship and as to manners. The student fresh from the country, with no preparatory training, will bring the manners of his home. These are not always good manners, as manners are judged. But none of these defects is derived from coeducation; nor are any of these conditions made worse by it.

Very lately it is urged against coeducation that its social demands cause too much strain both on young men and young women. College men and college women, being mutually attractive, there are developed too many receptions, dances and other functions in which they enjoy each other's company. But this is a matter easily regulated. Furthermore, at the most the average young woman in college spends in social matters less than one tenth the time she would spend at home. With the young man the whole matter represents the difference between high-class and low-class associates and associations. When college men stand in normal relation with college women, meeting them in society as well as in the class room, there is distinctly less of drunkenness, rowdyism and vice than obtains under other conditions. And no harm comes to the young woman through the good influence she exerts. To meet freely the best young men she will ever know, the wisest, cleanest and strongest, can surely do no harm to a young woman. Nor will the association with the brightest and sanest young women of the land work any harm to the young men. This we must always recognize. The best young men and the best young women, all things considered, are in our colleges. And this has been and will always be the case.

It is true that coeducation is often attempted under very adverse conditions. Conditions are adverse when the little girls of preparatory schools and schools of music are mingled with the college students and given the same freedom. This is wrong, whatever the kind of discipline offered, lax or strict; the two classes need a different sort of treatment.

When young women have no residence devoted to their use, and are forced to rent parlors and garrets in private houses of an unsympathetic village, evil results sometimes arise. Not very often to be sure, but still once in a while. These are not to be charged to coeducation but to the unfit conditions which make the pursuit of personal culture difficult or impossible. Women are more readily affected by surroundings than men are, and squalid, ill-regulated, Bohemian conditions should not be part of their higher education.

Another condition very common and very undesirable is that in which young women live at home and traverse a city twice each day on railway or street cars to meet their recitations in some college. The greatest instrument of culture in a college is the 'college atmosphere,' the personal influence exerted by its professors and students. The college atmosphere develops feebly in the rush of a great city. The 'spurstudenten' or railway track students, as the Germans call them, the students who live far from the university, get very little of this atmosphere. The young woman who attends the university under these conditions contributes nothing to the university atmosphere, and therefore receives very little from it. She may attend her recitations and pass her examinations, but she is in all essential respects 'in absentia,' and so far as the best influences of the university are concerned, she is neither 'coeducated' nor 'educated.' The 'spur'-student system is bad enough for young men, virtually wasting half their time. With young women the condition of continuous railroading, attempted study on the trains, the necessary frowsiness of railway travel and the laxness of manners it cultivates, are all elements very undesirable in higher education. If young women enter the colleges, they should demand that suitable place be made for them. Failing to find this, they should look for it somewhere else. Associations which develop vulgarity cannot be used for the promotion of culture either for men or for women. That the influence of cultured women on the whole is opposed to vulgarity is a powerful argument for education, and is the secret basis of much of the agitation against it.

With all this it is necesary for us to recognize actual facts. There is no question that a reaction has set in against coeducation. The number of those who proclaim their unquestioning faith is relatively fewer than would have been the case ten years ago. This change in sentiment is not universal. It will be nowhere revolutionary. Young women will not be excluded from any institution where they are now welcomed, nor will the almost universal rule of coeducation in state institutions be in any way reversed. The reaction shows itself in a little less civility of boys towards their sisters and the sisters of other boys; in a little more hedging on the part of the professors; in a little less pointing with pride on the part of college executive officials. There is nothing tangible in all this. Its existence may be denied or referred to ignorance or prejudice.

But such as it is, we may for a moment inquire into its causes. First as to those least worthy. Here we may place the dislike of the idle boy to have his failures witnessed by women who can do better. I have heard of such feelings, but I have no evidence that they play much actual part in the question at issue. Inferior women do better work than inferior men because they are more docile and have much less to distract their minds. But there exists a strong feeling among rowdyish young men that the preference of women interferes with rowdyish practices. This interference is resented by them, and this resentment shows itself in the use of the offensive term 'coed' and of more offensive words in vogue in more rowdyish places. I have not often heard the term 'coed' used by gentlemen, at least without quotation marks. Where it is prevalent, it is a sign that true coeducation—that is, education in terms of generous and welcome equality—does not exist. I have rarely found opposition to coeducation on the part of really serious students. The majority are strongly in favor of it but the minority in this as in many other cases makes the most noise. The rise of a student movement against coeducation almost always accompanies a general recrudesence of academic vulgarity.

A little more worthy of respect as well as a little more potent is the influence of the athletic spirit. In athletic matters, the young women give very little assistance. They cannot play on the teams, they can not yell, and they are rarely generous with their money in helping those who can. A college of a thousand students, half women, counts for no more athletically than one of five hundred, all men. It is vainly imagined that colleges are ranked by their athletic prowess, and that every woman admitted keeps out a man, and this man a potential punter or sprinter. There is not much truth in all of this, and if there were, it is of no consequence. College athletics is in its essence by-play, most worthy and valuable for many reasons, but nevertheless only an adjunct to the real work of the college, which is education. If a phase of education otherwise desirable interferes with athletics, so much the worse for athletics.

Of like grade is the feeling that men count for more than women, because they are more likely to be heard from in after life. Therefore, their education is of more importance, and the presence of women impedes it.

A certain adverse influence comes from the fact that the oldest and wealthiest of our institutions are for men alone or for women alone. These send out a body of alumni who know nothing of coeducation, and who judge it with the positiveness of ignorance. Most men filled with the time-honored traditions of Harvard and Yale, of which the most permeating is that of Harvard's and Yale's infallibility, are against coeducation on general principles. Similar influences in favor of the separate education of women go out from the sister institutions of the East. The methods of the experimenting, irreverent, idol-breaking West find no favor in their eyes.

The only serious new argument against coeducation is that derived from the fear of the adoption by universities of woman's standards of art and science rather than those of men, the fear that amateurism would take the place of specialization in our higher education. Women take up higher education because they enjoy it; men because their careers depend upon it. Only men, broadly speaking, are capable of objective studies. Only men can learn to face fact without flinching, unswayed by feeling or preference. The reality with woman is the way in which the fact affects her. Original investigation, creative art, the 'resolute facing of the world as it is'—all belong to man's world, not at all to that of the average woman. That women in college do as good work as the men is beyond question. In the university they do not, for this difference exists, the rare exceptions only proving the rule, that women excel in technique, men in actual achievement. If instruction through investigation is the real work of the real university, then in the real university the work of the most gifted women may be only by play.

It has been feared that the admission of women to the university would vitiate the masculinity of its standards, that neatness of technique would replace boldness of conception, and delicacy of taste replace soundness of results.

It is claimed that the preponderance of high-school-educated women in ordinary society is showing some such effects in matters of current opinion. For example, it is claimed that the university extension course is no longer of university nature. It is a lyceum-course designed to please women who enjoy a little poetry, play and music, read the novels of the day, dabble in theosophy, Christian science, or physic psychology, who cultivate their astral bodies and think there is something in palmistry, and are edified by a candy coated ethics of self-realization. There is nothing ruggedly true, nothing masculine left in it. Current literature and history are affected by the same influences. Women pay clever actors to teach them—not Shakespeare or Goethe, but how one ought to feel on reading King Lear or Faust or Saul. If the women of society do not read a book it will scarcely pay to publish it. Science is popularized in the same fashion by ceasing to be science and becoming mere sentiment or pleasing information. This is shown by the number of books on how to study a bird, a flower, a tree, or a star, through an opera glass, and without knowing anything about it. Such studies may be good for the feelings or even for the moral nature, but they have no elements of that 'fanaticism for veracity,' which is the highest attribute of the educated man.

These results of the education of many women and a few men, by which the half-educated woman becomes a controlling social factor have been lately set in strong light by Dr. Münsterberg. But they are used by him, not as an argument against coeducation, but for the purpose of urging the better education of more men. They form likewise an argument for the better education of more women. The remedy for feminine dilettantism is found in more severe training. Current literature as shown in profitable editions reflects the taste of the leisure class. The women with leisure who read and discuss vapid books are not representative of woman's higher education. Most of them have never been educated at all. In any event this gives no argument against coeducation. It is thorough training, not separate training, which is indicated as the need of the times. Where this training is taken is a secondary matter, though I believe, with the fullness of certainty that better results can be obtained, mental, moral and physical in coeducation, than in any monastic form of instruction.

A final question: Does not coeducation lead to marriage? Most certainly it does; and this fact can not be and need not be denied. The wonder is rather that there are not more of such marriages. It is a constant surprise that so many college men turn from their college associates and marry some earlier or later acquaintance of inferior ability, inferior training and often inferior personal charm. The marriages which result from college association are not often premature—college men and college women marry later than other men and women—and it is certainly true that no better marriages can be made than those founded on common interests and intellectual friendships.

A college man who has known college women, as a rule, is not drawn to those of lower ideals and inferior training. His choice is likely to be led toward the best he has known. A college woman is not led by mere propinquity to accept the attentions of inferior men.

Where college men have chosen friends in all cases both men and women are thoroughly satisfied with the outcome of coeducation. It is part of the legitimate function of higher education to prepare women, as well as men, for happy and successful lives.

An Eastern professor, lately visiting a Western State university, asked one of the seniors what he thought of the question of coeducation.

'I beg your pardon,' said the student, 'what question do you mean?'

'Why coeducation,' said the professor, 'the education of women in colleges for men.'

'Oh,' said the student, 'coeducation is not a question here.'

And he was right. Coeducation is never a question where it has been fairly tried.

# THE SIGNIFICANCE OF THE CONDITION OF YOUNG BIRDS AT BIRTH.

By W. P. PYCRAFT, A.L.S., F.Z.S.

IT is a matter of common knowledge that the young of birds are ushered into the world in very different degrees of development, according to the species to which they belong. The helplessness of the callow young of the crow-tribe, for example, stands in strong contrast to the activity displayed by the young of the game-birds. Again the young of birds are remarkable for the very wide degrees of variation which obtain in the matter of clothing on their escape from the shell, variations which range from absolute nakedness to abundant feathering, albeit feathering of a peculiar type.

Out of these commonplace facts the systematic ornithologists, on the one hand, and the philosophical zoologists, on the other, have woven theories which have undergone many changes; but, so far, we venture to think, all have missed the point. A survey of the work of the systematic ornithologist will show that on more than one occasion the condition of the young at birth has been made either the corner-stone of a classification, or one of the main supports thereof.

For the one purpose or the other these young have been duly labeled and classified. In consequence, they may be contemplated from two different points of view: (1) According to their helplessness or otherwise, and (2) according as they are clothed or otherwise. When the young emerge from the shell in a fully active state, they are known as nidifugous or præcocial; those, on the contrary, which are quite blind and helpless on leaving the shell are known as nidicolous or altricial young. The nidicolous young may be, as we have already remarked, absolutely naked, in which case they are said to be psilopædic. If, on the other hand, they are clothed, they are said to be ptilopædic. All nidifugous young are ptilopædic. The nidicolous young, being helpless and often blind, are assiduously fed by the parents, whilst among the nidifugous types, the young either feed themselves under the guidance of their parents, or accompany them in the search for food, and are fed by the way as the food is procured.

Two very different standards of thought have inspired those who selected the condition of the young at birth as a basis of avian classification. The older naturalists, adopting what we now regard as the purely artificial standards of their time, grouped birds according as the young were 'altricial' or 'præcocial,' nidicolous or nidifugous, thus creating an entirely arbitrary system of the same value as those other systems based upon the form of the bill, shape of the wing and so on. The post-Darwinians, working on the lines of evolution, see in these very different conditions, a phylogenetic significance, and regard the nidifugous as more reptilian than the nidicolous young. Consequently, those groups which have nidifugous young are to be regarded as standing comparatively low in the scale, whilst those with nidicolous young must be considered to have risen to a higher plane. This newer view is undoubtedly an improvement on the older, but it must, we think, give place to a yet wider interpretation.

If we turn from the purely systematic point of view to the more philosophical side of the question, as it at present stands, we shall, I think, find an equally unsatisfactory state of affairs. The two most recent text-books of zoology may be cited as authorities.

According to Jordan and Kellogg ('Animal Life,' 1901), 'those animals are highest in development, with best means of holding their own in the struggle for life, that take best care of their young,' and 'among the lower or more coarsely organized birds, such as the chicken, the duck, and the auk, as with reptiles, the young animal is hatched with well-developed muscular system and sense organs, and is capable of feeding itself,' but the offspring of the 'more highly organized forms, such as the thrushes, doves, and song-birds generally' are hatched in a wholly helpless condition, with ineffective muscles, deficient senses, and dependent wholly upon the parent. Similarly Shipley and MacBride write: "The manner the young are cared for is a most important feature. . . . The just-hatched young of the Pheasant and Game-birds are able to run about and look after themselves, whereas those of the Passeres or Songsters, require constant care and attention for a long time. These last are considered . . . to be the most highly developed of all birds, both as to their intellects and their flying powers, so that it is hardly too much to say that the increasing sacrifice of the parents on behalf of the young has had its reward, in the improvement it has brought about in all the faculties of the race."

Those who are responsible for the views just enunciated appear to have forgotten that the cormorants, for example, also bring their young into the world blind, naked and helpless, and not infrequently rear them in a nest of sticks on tree tops; yet the warmest admirer of these birds can not claim for them either a high degree of organization or great intelligence among birds. Their near allies, the darters, gannets, tropic and frigate birds also have helpless young, which in the case of the frigate birds and darters are also reared in nests in trees. We might multiply instances, but these are sufficient for our present purpose. They show at least that 'sacrifice of the parents on behalf of the young' has not been uniformly rewarded 'in the improvement . . . in all the faculties of the race.' More than this, they seem to me to show that this factor has had little or nothing to do with either inclination or structural development.

The real explanation of the matter seems rather to turn upon a question of expediency, designed, so to speak, to reduce infant mortality.

We shall show presently, on evidence well nigh incontrovertible, that the nidifugous condition is indeed a primitive one, but associated with a *strictly arboreal* habitat. This is an important point, as the nidifugous condition is commonly regarded as peculiar to, and possible only in, a terrestrial habitat. Let us assume for the moment that the former is an established fact.

One great disadvantage attendant on precocious development of the young whose nursery is the tree top is obvious—the nestlings would be constantly in danger of falling to the ground, and a large number would indeed meet this fate. Some would fall through weakness, the habit of dispersing themselves among the branches of trees in which the nest was placed resulting in a loss of regular food supply, owing to the difficulty of being on the spot when the parents returned with food. Thus the more sedentary members of the family would stand the best chance of being regularly fed, but among these the danger of falling by accident would be an ever present one. Once on the ground it is probable they would perish speedily, for it is almost certain that the *earliest* birds were entirely arboreal, and either would not or could not seek for lost offspring amid the thick undergrowth.

Now two courses were open whereby this infant mortality could be reduced. Either the eggs could be deposited on the ground, or the activity of the young curtailed. The game-birds, ducks and geese, rails, cranes and plovers may serve for examples of those species which have descended from the trees to the ground for nesting purposes, and although, as a consequence, the young have undergone considerable modifications in adaptation to the new environment, these changes are not so striking as those which have taken place among the young of the tree-dwelling species to be described presently.

The modifications which we should expect to find in the offspring of those species which, instead of curtailing the activity of the young, descended to the ground to breed, would be (1) peculiar habits of concealment aided by protective coloration; and (2) a reduction in the size of the wings and feet, now no longer required solely as grasping organs.

Protective coloration and peculiar habits of concealment are obviously direct responses to the increased need of escaping enemies, and hence we find these devices have been universally adopted. It is possible, however, that protective coloration was preceded by the development of precocious powers of flight, which have since been discarded by all save the game-birds. Probably this rejection was brought about because excessive activity on the ground was found to be as fatal as in the trees; since the young, in escaping from one danger, would be liable to run into another, or to stray too far away to render return possible.

At the present day, though the young of all the game-birds are protectively colored they have yet preserved more or less perfectly their earlier precocial powers of flight, the birds, when escaping danger, using their wings either like the ostrich, as an aid in running, or in actual flight, and there is evidence to show that the broods in consequence suffer. As an example, the observations of Mr. Ogilvie Grant on this subject may be cited. In writing of the common pheasant, he tells us that the mother, on alarm, with a warning note to the young, at once flies off and leaves them to take care of themselves. This they do by scattering in all directions, and then squatting down and trusting to their protective coloration for safety. Quiet restored, the parent returns, often only to recover but three or four of her chicks, the rest having strayed to such a distance that they are left to perish.

Thus, then, the hypothesis of precocious flight seems by no means an improbable one. Its development will be easy to understand when it is remembered that the raw material therefor is furnished by that aberrant member of the game-birds—the hoatzin. The life-history of this bird will be discussed later.

We may pass now to a consideration of those species which, retaining their arboreal nesting habits, have adopted the method of curtailing the activity of the young. This process was accomplished by reducing the food-yolk within the egg, and thus inducing an earlier hatching period. We may approximately measure the extent to which this reduction has been carried by the degree of helplessness displayed by the newly hatched bird, and by the nature and extent of its clothing.

The number of species which have adopted this expedient outnumber those which have not, and this speaks volumes for its success. As examples, we may instance the passerine or song-birds, parrots, cuckoos, birds of prey, cormorants and their allies, and the stork-tribe. The young of these are all born extremely helpless, many perfectly naked, others enveloped in a thick coat of down, whilst in some down is developed soon after hatching, and, in a few, not at all.

Having once however reduced the amount of food-yolk, return to the older fashion of nidifugous young became impossible, and this explains why nidicolous young are still born to those parents which have adopted the practice of depositing their eggs upon the ground. It proves that the arboreal habit has been forsaken since the specialization. Some, like the cormorants, herons and certain of the gull-tribe, for example, build as occasion demands, either on the ground or in trees. Now it is interesting to note that among these birds the young cormorants and herons are completely nidicolous, the young gulls only partially so, whilst the near and less specialized allies of the gulls, the plovers, have nidifugous young. This indicates that in the gulls the food-yolk is in process of reduction. To species breeding in large colonies, or on ledges of precipitous cliffs, the reduction of the food-yolk and helplessness of the young are obviously advantageous.

That this is so may be seen in the case of the colony-breeding species, since it would be impossible for the parents to recognize their own offspring, if nidifugous, when running about amid those of their neighbors. In consequence a large number would almost certainly go unfed and soon starve, whilst great activity among the young of the cliff-breeding species would be accompanied by an enormous mortality, owing to falls from the cliff.

It is contended that the facts so far submitted amply justify the interpretation put upon them, but the following instances should carry conviction. In the aberrant South American game-bird, the hoatzin, we have probably a direct survival of the protoavian type of nestlings. They are, of course, nidifugous, but they differ from all other nidifugous young in the prehensile character of their wings, which are armed with large claws borne upon the thumb and index digit. Claws on the wing are common among birds, and hitherto they have been regarded merely as vestiges—indices of a reptilian ancestry. The part which they play, however, in the life-history of the hoatzin, coupled with certain correlated modifications to be discussed presently, shows that they have a wider significance than this.

The adult hoatzin is an absolutely arboreal bird, inhabiting the dense scrub and trees bordering the lagoons and river banks of British Guiana and the Amazon Valley. Its powers of flight are extremely limited, and it has never been observed to alight upon the ground.

The young, like those of other nidifugous birds, are clothed in down, conspicuous, in the present instance, for its hair-like appearance and sparse distribution. But whilst the locomotion of the nidifugous young of other birds is bipedal that of the hoatzin must be described as quadrupedal, the wings as well as the legs being brought into requisition as the birds make their way along the branches. Even the beak is sometimes used, as in the parrots.

In a wing used as a prehensile organ we should expect to find certain peculiarities which would not be observable in the normal wing. These are not wanting. One of the first points which attract attention in the examination of such a wing is the great length of the hand, which is considerably longer than the forearm. The thumb is found to be unusually long, and to extend beyond the level of the tip of the third digit. Both thumb and finger are armed with large claws. The index finger is furthermore remarkable in that it is produced beyond the fold of skin which runs along the hinder or post-axial border of the wing for the support of the quill-feathers. Examined further, the palmar surface of the thumb and second finger are found to be swollen into little cushions resembling the cushion-like undersurface of the finger-tips of the human hand. Next the budding quill-feathers attract attention, and if a series of young is being examined, probably the first point to be noted is the fact that the development of the quill feathers of the hand were peculiar inasmuch as in the older forms whilst the inner quills are found to have pushed their way some considerable distance beyond the post-axial border of the wing, the outer quills are only represented by simple down-feathers. Thus, a long, free finger-tip is left beyond the quills. The thumb also, as yet, bears only down-feathers, the future quills being conspicuous by their absence. On a little reflection the meaning of this becomes clear.

The arrested development of the quills of the thumb and the tip of the finger is an adaptation to the bird's peculiar needs, albeit a deep-seated character, dating from the dawn of avian development. If all the quills were to grow at an equal rate, a stage would soon arrive when the wing would be useless as a climbing organ, by reason of the developing feathers and so expose the bird to constant danger of falling before the quills had sufficiently developed to break the force of such a fall. Thus then the arrested development of the quills begins to look as if it might have a definite meaning, and this becomes a certainty when still older specimens are examined. In them we find that as soon as the inner quills of the second digit have grown sufficiently long to enable the bird to recover itself in falling the hand begins to shorten, and the claw to diminish, till at the time of puberty the hand has become *shorter* than the forearm, the claws both of the thumb and finger have disappeared, the thumb no longer extends to the level of the third digit, and the second finger no longer projects beyond the hinder wing fold (post patagium).

That the structural peculiarities observable in the wing of the hoatzin are not recently acquired characters can not be doubted. The presence of the claws is almost sufficient to prove this, for having once become vestigial it is unlikely they would reacquire their primitive size.

But we have other evidence affording the strongest confirmation of the contention that the wing of the hoatzin represents an ancient order of things once common to all birds. This evidence is 'writ large' upon the wing of those allies of the hoatzin, the common fowl, the turkey or the pheasants, for example. Herein we find the same developmental stages, but with certain modifications easy to interpret.

In the limb itself—as considered apart from the appendages, the incipient quills or flight-feathers—one of the first things to attract attention is the hand, which although relatively shorter than that of the hoatzin, is still longer than the forearm; next the cushion-like pads of the thumb and second finger are missed, as also are the claws. That of the thumb, however, is generally present though in an extremely reduced condition, and in the index finger it appears only during embryonic life.

The flight feathers again reveal some very interesting features, inasmuch as the inner quills develop at a rate relatively much greater than in the hoatzin, so that they become functional earlier in the life-history, whilst the outer quills, three in number, are still only represented by delicate down feathers, thus, be it noted, leaving a free finger-tip as in the hoatzin. The abrupt changes from quill feathers to nestling down observable in the wing of the chick and turkey seem to show that the quills have undergone a process of forcing or accelerated development, in which the inner quills have developed at an excessively rapid rate, so as to out-distance their fellows at the distal or outer extremity of the wing, which as yet are only represented by nestling down. The rapid development of the inner quills is probably due to the fact that the terrestrial mode of life demanded the aid of the wings for the purposes of flight at an earlier period than would be the case if they dwelt, like the hoatzin, in comparative security among the trees.

The developmental history of the wings of the fowl and its allies seems to leave but little room for doubt that the ancestors of these birds, like the hoatzin, were hatched in trees and crawled about among the branches. Moreover, the change from an arboreal to a terrestrial nursery seems to have taken place comparatively recently. On no other assumption can we explain the free finger-tip and the arrested development of the outer quill feathers. Nevertheless, a sufficient time has elapsed wherein to bring about the suppression of the claws. That of the index digit, being no longer useful, appearing later and later in development, has now entirely ceased to put in an appearance save only during embryonic life; in other forms, separated by a still greater lapse of time from their tree-crawling ancestors, even the embryonic claw has ceased to be.

Of considerable importance is the fact that whilst in the hoatzin and the fowl and its allies the quill feathers appear long before the contour feathers of the body—that is to say, whilst the body is still clothed in down—in the nidifugous young of ground-breeding forms such as the plovers, for example, which seek protection by concealment alone, unaided by flight, the quill feathers appear together with the contour-feathers of the body and at a much later date than in the above. So also with the nidifugous young of aquatic forms.

The accelerated development of the quills is probably a remnant of an earlier phase in the life-history before protective coloration was adopted. As we have already shown, precocious flight is attended by too many perils to prove an effective means of escape from enemies.

In conclusion we may say a word about the young of the megapodes. The eggs of the megapode are, as is well known, hatched in decaying vegetables heaps, or in hot sand, instead of being incubated by the parents. To this end the amount of food-yolk within the egg has been enormously increased, enabling the normal nestling period to be passed within the egg, the young passing through the downy stage during embryonic life, and emerging from the shell, fully fledged.

That the ancestral megapode was originally hatched in trees like the young hoatzin, there can be no doubt, since like the latter the wing of the young shows a free finger-tip and an arrested development of the outer quill feathers, characters which, as we have already seen, are direct adaptations to the peculiar locomotion of tree-climbing nestlings. We may be almost certain that the increase in the food-yolk, just referred to, did not take place until some time after the descent to the ground for breeding purposes, since the wing of the young megapode forms an exact counterpart of that of the young fowl and turkey, and their allies, whilst, had the increase taken place earlier, the wing would have resembled that of the hoatzin in the possession of large claws. The latter are present now only during embryonic life.

The increase in the food-yolk, allowing the earlier nestling stages to be passed within the shell, must be accounted for by supposing the adult megapode to have been obliged to adopt this expedient to avoid perils attendant on normal incubation, perils which may since have passed away leaving no record of their nature. A return to the normal method of incubation is now impossible, the instinct therefor having been replaced by that which induces the birds to bury their eggs and leave them to be hatched by heat other than that of their bodies.

Finally, we may compare the hoatzin with the ancient archæopteryx, and the result of such a comparison will go far to prove that the former represents the most primitive of living birds.

That archæopteryx was strictly arboreal there can be no doubt—the structure of the feet indicates this much; and its long tail is a scarcely less certain index, for such an appendage is undoubtedly but ill-adapted for ground-dwelling habits. The long hand, and the large claws thereon are, so to speak, primitive characters. The period of their greatest functional activity was during the nestling stage when the young clambered about among the branches of the trees like the young hoatzin of to-day. The species was perhaps not phylogenetically old enough to eliminate the traces of nestling-life on reaching puberty, when the quills rendered claws, and climbing, not only needless, but impossible; hence then the retention by the adult of both elongated manus, free finger-tips and claws. It has been suggested, however, that the claws and elongated manus of the adult archæopteryx were periodically functional, the periods being the moulting seasons. It is well known that many existing birds, the anseres to wit, when moulting, shed all the quills at once, and in consequence are for a season flightless. It may well be that this system of losing the quill is a primitive one and obtained in archæopteryx, in which case it is obvious that in a bird so strictly arboreal, the climbing hand of infancy would be of some service. The more usual method of moulting the quills in couples prevailing amongst modern birds so as not to impair the power of flight has probably come about by selection, and hence the reduced and clawless hand of the adult hoatzin, fowl and turkey for example; birds in which, for reasons already explained, the primitive form of manus is still temporarily exhibited by the nestling.

Thus then, through the wing of the hoatzin we have a revelation of a phase of bird-life hitherto unsuspected; inasmuch as its peculiar developmental stages, each with its period of functional activity, enable us to interpret the hitherto meaningless and puzzling characters seen in the wing of the fowl and turkey, and their allies. These constitute wellnigh invincible proofs of an earlier and universal arboreal existence, extending back to the time of the earliest known bird archæopteryx. Certainly the skeleton, especially the wing, lends the strongest support to this view. This carries us further back still, and suggests the conclusion that the reptile stock from which the aves are descended was probably also arboreal.

That too much stress has been laid by systematists on the condition of the young birds at birth is admitted. It is further maintained here that its significance has been misunderstood, and that the facts now brought forward are strong enough, on the one hand, to refute the older views, and on the other, to justify the theory, firstly, that birds were originally arboreal and their young nidifugous; secondly, that nidicolous habits and helplessness of young birds are specialized adaptations to an arboreal or gregarious mode of life; and, thirdly, that the young of gallinaceous birds form a link in the chain of the evolution of nidifugous habits. The free finger-tip and arrested development of the outer quill-feathers point to a prior arboreal habit; whilst the accelerated development of the inner quill-feathers indicates an adaptation to enable the young to escape from the enemies surrounding a terrestrial nursery. The third and last stage is represented by the protective coloration, a device which has been almost universally adopted by nidifugous birds, owing to its greater effectiveness.

# THE MOTIVE POWER OF HEAT.

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MR. ALFRED RUSSEL WALLACE, in his 'Wonderful Century,' describes those great material and intellectual achievements which especially distinguish the nineteenth century from any and all of its predecessors, and shows how fundamental is the change they have effected in our life and civilization. From a comparative estimate of the number and importance of these achievements, he concludes that not only was the century just passed superior to any one that had gone before, but that it must in its results be compared with the whole preceding historical period. It, therefore, marks the beginning of a new era of human progress.

There appears, however, upon looking back through the long, dark vista of human history, one step in material progress that seems to be really comparable with several steps of modern times. It was when fire was first utilized and became the servant and friend rather than the master and enemy of man. From that day to this, fire, in various forms and in ever-widening spheres of action, has been the greatest, the essential factor in that increase of man's power over nature, which has in turn been a chief means of developing what we term civilization. As Mr. Fernald, in his 'Gulf of Fire,'* points out, all men, however widely separated by millenniums of time and by utmost range of space, by mountains, deserts and oceans, by color, language and occupation, by custom and religion, all agree in this—they make fire a servant and a friend. Mr. Fernald shows how the firebrand draws an impassable line between man and the brute creation, and graphically depicts the part played by the ancient element fire in aiding man along that upward path which, having entered, he had only to follow on to make the universe his own.

Steam engines in their infancy were known as 'fire' (*i. e.,* heat) engines; and, in point of fact, the older term is the more correct, because the water or steam is used only as a convenient medium through which the form of energy which we call heat is made to perform the required mechanical operations. The claims of the steam engine (as locomotive, marine and stationary) to the greatest share in the marvelous material progress of the nineteenth century are too

* *Harper's Monthly Magazine,* July, 1902.

well known and acknowledged to need recounting here. We wish merely to call to mind one upon whose theoretical deductions all the advances in the science of thermodynamics since his day have been based: Sadi Carnot, a young French military engineer.

Appreciation of genius is a mark of the civilization and culture of a people, and the world can ill afford to neglect the memory not only of the men who by practical application have helped to make that civilization possible, but also of those who by theoretical deduction have pointed out the way of progress. The world must needs remember those by whose brain power, as Mr. Fernald says, we have been

NICHOLAS LEONARD SADI CARNOT (1796–1832), FATHER OF THE SCIENCE OF THERMODYNAMICS.

enabled to cross the gulf of fire to the paradise of invention and achievement that lies beyond, of which none can see the farther bound. Every schoolboy knows of James Watt, of the Stephensons and their 'Rocket,' but who, save the special student, has ever heard of Sadi Carnot?

Watt made his great improvements in the steam engine (really almost invented it) during the last quarter of the eighteenth century. But for the next fifty years, including those covered by the life of Carnot, the development was seemingly the result of chance. The recognition of this fact led Carnot, when but twenty-eight years old, to undertake to lay the foundation on which all future progress was to rest, by publishing in 1824 a small memoir, 'Reflexions sur la puissance motrice du feu' ('Reflections on the Motive Power of Heat'). George Stephenson made his wonderfully simple, but exceedingly effective, improvements in the locomotive from 1814 to 1829, at a time when the world was still ignorant of the value of Carnot's ideas. To-day, however, when physicists fully realize the importance of his work, the world at large is still ignorant of Carnot's biography; and so it is the purpose of this article to recall the life and character of him whose name must always be intimately associated with the development of the modern 'heat engine' and its influence upon civilization.

Carnot's father, Lazare Nicholas Marguerite Carnot, soldier and statesman, was a member of one of the oldest and most distinguished families in France. Educated as a military engineer, he gained a second lieutenancy at eighteen and in later life won renown as a mathematical writer. Minister of War under Napoleon, he took a prominent part in the French Revolution and was regarded by his countrymen as the genius and organizer of victory, exhibiting the talents later illustrated by the German, Von Moltke. He voted against the extension of the consulate and against the Empire, and was forced into private life in the early days of the latter and died, proscribed, at Magdeburg in 1823. Carnot's brother, Lazare Hippolyte Carnot, was twice a member of the Chamber of Deputies and also Minister of Public Instruction. He died as recently as 1888. A fact which brings Carnot's life still closer to us of to-day is that the late president of France, Sadi Carnot, who was assassinated in 1890, was a grand-nephew of the founder of thermodynamics, the subject of this sketch.

Nicholas-Leonard-Sadi Carnot was born June 1, 1796, in the smaller Luxembourg palace, a part of which was occupied by his father as a member of the Directory. Christened 'Sadi' after the celebrated Persian poet and moralist, he merited the name in that his nature proved to be highly artistic as well as philosophic. Hardly a year after Carnot's birth, in consequence of his father's proscription and enforced exile, his mother took refuge at her homestead in Saint Omer. The boy's delicate constitution was so affected by the vicissitudes of his mother's life that he regained his bodily powers later on only by judicious exercise. He was of medium stature, gifted with extreme sensibility and at the same time with extreme energy, generally reserved, sometimes timid, but singularly quick upon occasion. Whenever he believed that he was encountering injustice, nothing served to restrain him. An incident, which his brother has described, exhibits him in this light even as a child.

The Directory giving place to the Consulate, Carnot senior, after two years of exile, reentered France, being called to the Ministry of War by Bonaparte, who, remembering Carnot's services to him at the beginning of his career, wished to continue the intimate relations that had existed between them during the Directory. Often when the minister came to work with the consul he brought his son, now about four years of age, and left him in the charge of Madame Bonaparte, who was very fond of him. On one such occasion, Madame Bonaparte and some of her ladies, mounted on a little raft, were paddling about upon a pond in the palace court. Napoleon, happening along, began to amuse himself by throwing stones at the raft so as to splash the water over the clean dresses of the would-be sailors. The latter feared to manifest their displeasure, but the little boy, after watching the procedure for a while, suddenly faced the conqueror of Marengo and, shaking a stick at him, cried: 'Animal of a First Consul, are you not ashamed to torment these ladies!'

Lazare Nicholas Marguerite Carnot, Father of Nicholas Leonard Sadi Carnot.

Sadi showed such interest in machinery and applications of physics that his father early directed his studies toward science, and he was just sixteen when he entered the Ecole Polytechnique in 1812. He made rapid progress, graduating the next year with first rank in the artillery. But he was thought too young for the military school at Metz, and was allowed to continue his studies at Paris for another year. Having fought with his gallant fellow-students at Vincennes in March, 1814, he returned when peace was established to his studies at the Polytechnique, but left in October with the rank of sixth-cadet of engineers and repaired to Metz as a sublieutenant in the school of practical fortifications.

The events of 1815 brought Carnot senior again upon the political field during the 'Hundred Days.' This was the occasion for Sadi to make a test of men, of which he never spoke afterwards without disgust. His little quarters of sublieutenant were visited by certain superior officers, who did not hesitate to mount three flights of stairs in order to greet the son of the new minister. Waterloo put an end to all this. The Bourbons reestablished upon the throne, General Carnot was proscribed, and Sadi was sent successively to several forts as engineer, to count bricks, to repair walls and to draw up plans destined to lie buried in the official archives. However, he worked conscientiously, although his name, which but now had won for him so many official pleasantries, served to retard his due advancement for some time. In 1819, desiring greater leisure for private study, Carnot presented himself as a candidate for a new staff-corps then forming, and received an appointment as lieutenant on the general staff. His duties brought him to Paris and the surrounding country, and he led a studious life, interrupted but once by several happy months spent with his brother and exiled father at Magdeburg.

He followed original lines in all his work, and was a constant enemy to the traditional and conventional. Upon his table were found only Pascal, Molière or La Fontaine, and he knew these favorites by heart. With him music was a passion inherited from his mother; not content in attaining a superb execution on the violin, he must needs plunge into the study of theory. His insatiable intelligence led him to follow assiduously courses at the Collège de France, at the Sorbonne and at the École des Mines. He visited manufacturing plants and familiarized himself with the different processes. Mathematical sciences, natural history, industrial arts, political economy, all these were cultivated with ardor. Not only did he indulge in gymnastic exercises, but he investigated the theory of fencing, swimming, dancing and skating.

Toward the end of 1826 he requested and obtained his return to the corps of engineers, receiving by reason of seniority the rank of captain. However, military service was onerous to him, jealous as he was of his liberty, and in 1828 he resigned in order to devote himself more fully to science.

His manuscript notes show that he had perceived the relation which is believed to exist between heat and mechanical work; and after having established the principle which now bears his name, he began researches which would have established with surety the principle of equivalence of mechanical energy and heat had they not been suddenly interrupted by his enthusiastic participation in the revolution of 1830.

An anecdote which shows his impetuous nature as a man, even as we have seen it exhibited as a child, is also given us by his brother. On the day of the funeral of General Lamarque, Carnot was strolling for curiosity's sake in the neighborhood of the insurrection. A cavalier who headed a charge and who appeared intoxicated passed down the street at a gallop, flourishing his saber and striking the pedestrians. Carnot rushed forward nimbly avoiding the soldier's sword, seized him by the leg, threw him to the earth, tumbled him into the gutter and went on his way amid the shouts of the crowd, who were amazed at this exhibition of dexterity and strength.

The hopes of the Democracy, however, appeared to be short-lived, and Carnot returning to his scientific studies applied to them his pent-up political ardor. He undertook important researches upon the physical properties of gases and vapors, especially upon their elastic tensions. Unfortunately his tables were not completed. His excessive application was followed by an attack of scarlet fever in June, 1832, and while convalescing from this attack he was seized on the twenty-fourth of August with the epidemic of cholera and died in a few hours. As if by a sinister presentiment he had been watching the advance of the epidemic very closely, when without previous warning he was carried away upon its tide in the very prime of life, being but thirty-six years of age.

Although the one work that he published is sufficient to keep his name from being forgotten among scientists, yet it is from portions of his note-book that we learn of the activity of his spirit, the variety of his knowledge, his love for humanity and his clear ideas of justice and liberty. In these notes we find rules of practical conduct; observations later embodied in his memoir; some thought that happened especially to strike him, sad or gay; sometimes also, though seldom, an outburst of ill feeling against men and society; thoughts on general political economy or on taxation in particular; and on morals and religion. Some of the ideas contained in these notes remind one not a little of 'Poor Richard's Almanac,' and are so quaintly set that it will doubtless be of interest to quote a few.

> The promptness with which a resolution comes to one generally accords with the justice of it.
>
> Never feign a character that you do not possess, and never assume a personality that you will not be able to sustain.
>
> Speak little of that which you know; not at all of that which you do not know. Why not the more often say: 'I do not know'?
>
> Hope is the greatest of blessings; it is necessary, therefore, in order to be happy, to sacrifice the present to the future.
>
> I do not know why one always confounds the two expressions: 'Good sense' and 'common sense.' Nothing is less common than good sense.
>
> People speak of the laws of war, as if war were not the destruction of all law.
>
> Men attribute to chance that of which they do not know the cause. If they come to divine the cause, the chance disappears. To say that a thing happens by chance is to say that we have not been able to foresee it. What is chance for an ignorant man, may not be chance for a man more instructed.

Carnot possessed a repugnance toward publicity, so that, except in conversation with a small number of intimate friends, those among whom he lived were entirely ignorant of the fund of knowledge he had accumulated. His brother, who was called upon to read the manuscript of his memoir on the motive power of heat in order to see that it was clear enough to be understood by others than scientists, says that he never did understand why Carnot made this one exception. It seems that his solitary life in small garrisons, in the office and in the laboratory served to increase his natural reserve. Yet he was not in the least reticent in a small company; he took part willingly in the gayest joys and abandoned himself to the liveliest conversation. His language was then full of witticism, biting but not malignant, original but not eccentric, sometimes paradoxical, but never with any other pretension than that of an active mind.

It was in 1824 while still an officer on the general staff that Carnot published his 'Reflections on the Motive Power of Heat.' Struck with the fact that chance alone seemed to direct the construction of steam engines, he undertook to raise to the rank of a science the art that was still so imperfect in spite of its importance. He investigated the phenomena of the production of motion by heat from the most general point of view, independent of any particular mechanism and of any particular agent. It was only some years after his death that the value of his work was revealed to his fellow countrymen by an echo from England. However, it did merit the attention of a few French scientists, notably the celebrated engineer, Clapeyron, who in 1834 published in the *Journal École Polytechnique* a paper which was a comment upon and an extension of the ideas of Carnot, in which he called attention to Carnot's reasoning, represented Carnot's processes in an analytical form and arrived at some new results, usefully applying, and for the first time, the principle of Watt's indicator diagram to the geometrical exhibition of the different quantities involved in the cycle of operations by which work is derived from heat by the temporary changes it produces in the volume and molecular state of bodies. It was through this work of Clapeyron that Carnot's ideas became known to Lord Kelvin, who presented them to the world in 1848, pointing out that they enabled us to give for the first time an *absolute* definition of temperature, *i. e.*, a thermodynamic scale of temperature which is independent of the properties of any particular substance. On this scale the absolute values of two temperatures are defined to be in the same ratio as the amounts of heat-energy taken in and rejected by a perfect (*i. e.*, reversible) thermodynamic engine, working with its source and its refrigerator at the higher and lower of these temperatures respectively. Lord Kelvin showed that the ratio between these quantities of heat-energy depends only on these two working temperatures and is independent of the substance used in the engine.

and so the scale of temperature thus defined may be termed absolute. Moreover, such a scale leads at once to the idea of an absolute zero, for no engine could be supposed to convert more heat-energy into work than it received; and, choosing the temperature of the refrigerator (calling it $T$), so that no heat-energy is rejected by the engine, but all the heat-energy taken from the source is turned into work, it is impossible for $T$ to be negative, else the engine would have an efficiency greater than 100 per cent. Therefore zero is the smallest algebraic value the temperature of the refrigerator can have, and temperatures reckoned from this zero are called absolute. The size of the degrees on this scale is arbitrary, and has been conveniently chosen so that there are one hundred degrees between the temperatures of boiling and freezing water. If now a reversible engine be worked between these temperatures and the quantities of heat-energy received and rejected be measured, the temperature of boiling water on the absolute scale may be found. It is not necessary actually to try the experiment, for the work done by the expansion of a substance which obeys the ordinary laws of gases may be calculated by the methods of the infinitesimal calculus. In this way Kelvin's thermodynamic scale has been shown to be practically identical with that of a perfect gas thermometer, which shows the absolute zero of the thermodynamic scale to lie about 273 degrees below the zero of the Centigrade scale.

Professor Tait has said: "Without this work of Carnot, the modern theory of energy, and especially that branch of it which is at present by far the most important in practice, the dynamical theory of heat, could never have attained in so few years its now enormous development. Carnot's claims to recognition are of an exceedingly high order, because they depend not merely upon his method, which is one of startling novelty and originality and is not confined to the subject of heat; but upon the fundamental principle upon which he based his mode of comparing the heat employed with the work procured from it. Every reasoner who has applied himself to the subject of heat since Carnot has gone right so far as he attended to Carnot's principle; but has inevitably gone wrong when he forgot or did not attend to it."

The two things which Carnot introduced, which were entirely original with him and which left his hands in an almost perfect form, were the idea of a 'Cycle of Operations' and the further idea of a 'Reversible Cycle,' giving also the notion of a 'Reversible and Perfect Engine,' showing that the efficiency of such depends only on temperature.

The peculiar merit of Carnot's reasoning consists in the idea of bringing the body back to its initial state as to temperature, density and molecular condition, after a cycle of operations, before making any assertion as to the amount of heat-energy gained or lost. This he accomplished by causing the working substance (a gas in Carnot's case) to pass through two isothermal changes, the first at a higher and the second at a lower temperature, alternated with two adiabatic* changes by which the temperature of the working substance is allowed to fall and then raised again. Each separate step was itself reversible and so the whole cycle was reversible. The great virtue in this is that at the close of the cycle of operations the intrinsic energy of the body is exactly the same that it was at the beginning; and so we make no mistake in saying that the difference between the quantity of heat-energy given out by the body during the isothermal change at the higher temperature and that absorbed by it during the isothermal change at the lower temperature is exactly equal to the amount of external work done by the body in the course of the cycle.

By applying this principle Carnot showed that the production of motive power is possible wherever there is a difference of temperature, the motive power being due to a transfer of heat-energy from the hotter to the colder body, its quantity being independent of the agents employed to develop it, but depending solely upon the temperatures of the bodies between which the transfer occurs, provided the process is reversible.

The most striking fact concerning this memoir is that Carnot used hardly any mathematics at all, but arrived at his conclusions by sheer logical exercise of his mind, expressing the different processes entirely in words and using only such terms as would be clear to one not a scientist. Some of his conclusions are incorrect on account of the erroneous assumption of the materiality of heat, but sometimes he is led to conclusions correct in form, although the deduction is erroneous. Instinct seems to have led him in the right direction.

It may be of interest to go through Carnot's memoir and pick out the various important statements as he himself italicized them. They are in part as follows:

The production of motive power in the steam-engine is not due to a real consumption of the caloric, but to its transfer from a hotter to a colder body.

Wherever there is a difference in temperature the production of motive power is possible, and conversely.

The maximum motive power resulting from the use of steam is also the maximum motive power which can be obtained by any other means.

The motive power of heat is independent of the agents employed to develop it; its quantity is determined solely by the temperature of the bodies between

* By isothermal changes are meant changes in volume and pressure involving changes in the heat-energy of the working substance, but unaccompanied by any changes in temperature.

By adiabatic changes are meant changes in volume and pressure involving changes in temperature, but unaccompanied by any gain or loss of heat-energy of the working substance.

which in the final result (*i. e.*, upon the completion of the cycle) the transfer of caloric occurs.

When a gas passes without change of temperature from one definite volume and pressure to another, the quantity of caloric absorbed or emitted is always the same, irrespective of the nature of the gas chosen for the experiment.

The difference between the specific heat under constant pressure and the specific heat under constant volume is the same for all gases.

When the volume of a gas increases in geometrical progression its specific heat increases in arithmetical progress.

Of course these last two statements are now known to be incorrect, it being established that the difference between $C_p$ and $C_v$ is a constant for any one gas, but not for all gases; and also that the specific heat of permanent gases is independent of pressure and temperature. These conclusions were obtained by Carnot on account of the erroneous assumption of the materiality of heat. Moreover, the assumption of the change of specific heat with volume led him to incorrect conclusions in other cases.

The deductions from Carnot's work made by Clapeyron are correct by reason of the fact that he used differential equations in the extension of Carnot's ideas. For, although Carnot in considering the energy changes of a body subjected to a Carnot's cycle made the mistake of equating the amount of heat-energy ($H$) given out by the body during the isothermal change of volume and pressure at the higher temperature to the heat-energy ($h$) absorbed by the body during the isothermal change at the lower temperature, Clapeyron was correct in his equations because they dealt only with infinitesimal changes in temperature, and hence the difference $H-h$, which is the area included between the two adjacent adiabatics and the two isothermals, is an infinitesimal of the second order as compared with the length of the adiabatic included between the two adjacent isothermals, which was taken itself as an infinitesimal of the first order.

It is fortunate that Clapeyron was mathematician enough to use differential equations in expressing these processes analytically. Indeed, in contrast to Carnot he used such a method wherever he could throughout all his memoirs, and always to good advantage.

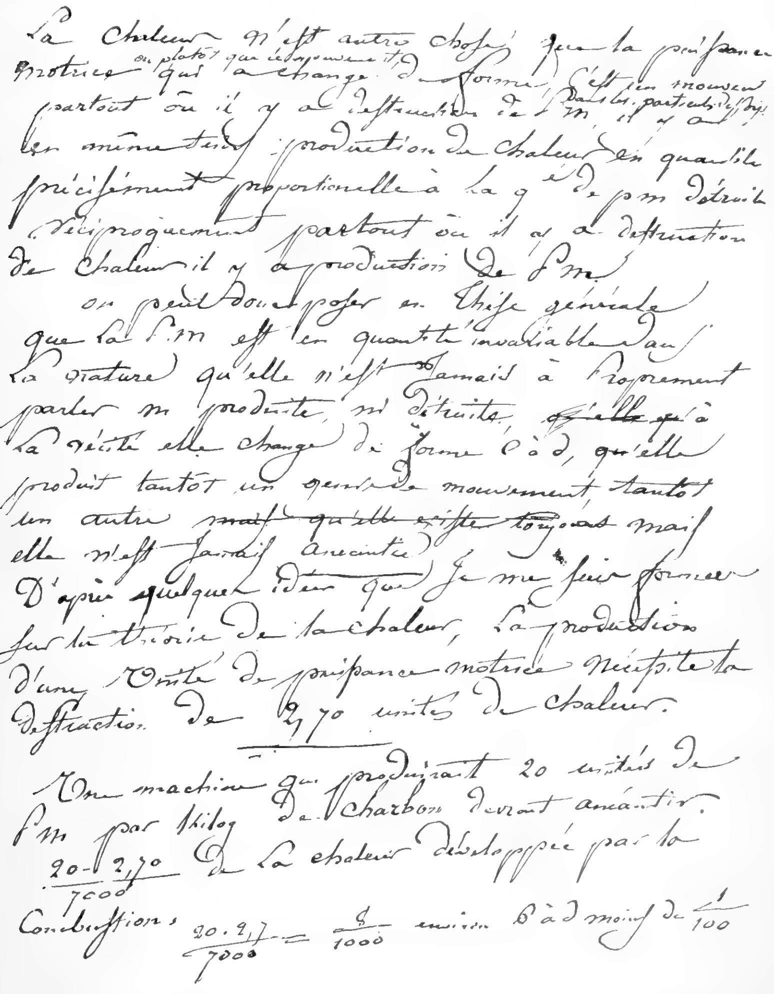
Carnot used the materialistic theory of heat; but it must not be supposed that he was throughout a believer in the same. For even in his memoir as published in 1824 he gives more than a suspicion of its falsity, and in the extracts from his laboratory note-book,* published by his brother after his death, we have direct evidence that he not only foresaw the dynamical theory of heat, but even went so far as to calcu-

* These MS. notes, and also the MS. copy of the 'Reflexions' are on file in the 'Academie des Sciences,' to which body they were presented in 1878 by Carnot's brother, H. Carnot. The notes were entirely unknown to the public until that late date, forty-six years after their author's death.

late the mechanical equivalent and to plan the very experiments since carried out by later workers. To give emphasis to this statement, we have but to consider the following translation of his own words:

Heat is nothing else than motive power, or rather, motion which has changed its form. It is a movement of the particles of a body. Wherever there is a destruction of motive power, there is at the same time the production of a quantity of heat precisely proportional to the quantity of motive power destroyed. Reciprocally, wherever there is destruction of heat, there is the production of motive power.

We can lay down the general proposition that motive power is a quantity


La chaleur n'est autre chose que la puissance motrice ou plutôt que le mouvement qui a changé de forme, c'est un mouvement dans les particules des corps; partout où il y a destruction de p.m. il y a en même temps production de chaleur en quantité précisément proportionnelle à la q.té de p.m. détruite. Réciproquement partout où il y a destruction de chaleur il y a production de p.m.

On peut donc poser en thèse générale que la p.m. est en quantité invariable dans la nature qu'elle n'est jamais à proprement parler ni produite, ni détruite, ~~qu'elle~~ à la vérité elle change de forme c.à.d. qu'elle produit tantôt un genre de mouvement, tantôt un autre ~~mais qu'elle existe toujours~~ mais elle n'est jamais anéantie.

D'après quelques idées que je me suis formées sur la théorie de la chaleur, la production d'une unité de puissance motrice nécessite la destruction de 2,70 unités de chaleur.

Une machine qui produirait 20 unités de p.m. par kilog. de charbon devrait anéantir $\frac{20 \cdot 2,70}{7000}$ de la chaleur développée par la combustion. $\frac{20 \cdot 2,7}{7000} = \frac{8}{1000}$ environ c.à.d. moins de $\frac{1}{100}$

Facsimile of a Page of Carnot's Note-book Relative to the Transformation of Heat into Motive Power, containing a valuation (the first known to be made) of the so-called "mechanical equivalent of heat." This estimate gives for the mechanical equivalent of heat 370 kilogram-meters, which is nearer the correct value (420, Rowland) than Mayer's later determination (365).

invariable in nature, that it is never, properly speaking, either produced or destroyed. In truth, it simply changes form—sometimes producing one kind of motion, sometimes another; but it is never annihilated.

This is a clear and positive statement of the now well-known 'Principle of the Conservation of Energy'; and yet, by reason of the fact that these notes were not published by their author and did not come to light for half a century after his death, the world awaited the enunciation of this universal principle till the day of Mayer, Helmholtz and Joule. Shall all honor be denied Carnot simply because his work remained undiscovered so long? While we ascribe great and merited praise to those philosophers who were fortunate enough first to present the doctrine of energy to the world, we must not forget him who by reason of the much earlier day in which he lived, made a far greater stride in arriving at the same conclusion.

We complete our quotations by giving some of the passages in which Carnot outlines experiments for determining the mechanical equivalent of heat:

Stir vigorously a mass of water in a small barrel or in the cylinder of a double-action pump, the piston of which is pierced with small holes. Experiments of the same kind on the agitation of mercury, of alcohol, of air, and of other gases. Measure the motive power consumed and the heat produced. . . . Allow air to enter a vacuum or a space occupied by air more or less rarefied; the same for other gases or vapors; examine the rise in temperature. Estimate the error of the thermometer by noting the time taken for the temperature of the air to vary a given number of degrees. These experiments will serve to measure the changes of temperature produced in a gas by changes in volume; they will furnish, among other things, the means of comparing these changes with the quantities of motive power produced or consumed. . . . Allow a quantity of air compressed in a larger reservoir to escape therefrom, and check its velocity by having it escape through a large tube containing a number of solid bodies; measure the temperature when it has become uniform. See if it is the same as that in the reservoir. Same experiments with other gases and with vapor formed under various pressures.

How effectually such experiments did accomplish what Carnot expected is fully attested by the subsequent researches of Joule, Kelvin, Hirn, Regnault and others.

Carnot's work was followed up by the epoch-making papers of Sir William Thomson (now Lord Kelvin) in England, and of Rudolph Clausius in Germany.

The science of thermodynamics, founded on the labors of these three illustrious men, has led to the most important development in all departments of physical science. It has pointed out relations among the properties of bodies which could scarcely have been anticipated in any other way; it has laid the foundation for the science of chemical physics; and, taken in connection with the kinetic theory of gases, as developed by Maxwell and Boltzmann, it has furnished a general view of the operations of the universe which is far in advance of any that could have been reached by purely dynamical reasoning.

# SOLOMON'S HOUSE.*

By FRANCIS BACON.

GOD bless thee, my son; I will give thee the greatest jewel I have. For I will impart unto thee, for the love of God and men, a relation of the true state of Salomon's House. Son, to make you know the true state of Salomon's House, I will keep this order. First, I will set forth unto you the end of our foundation. Secondly, the preparations and instruments we have for our works. Thirdly, the several employments and functions whereto our fellows are assigned. And fourthly, the ordinances and rites which we observe.

The End of our Foundation is the knowledge of Causes, and secret motions of things; and the enlarging of the bounds of Human Empire, to the effecting of all things possible.

The Preparations and Instruments are these. We have large and deep caves of several depths: the deepest are sunk six hundred fathom; and some of them are digged and made under great hills and mountains: so that if you reckon together the depth of the hill and the depth of the cave, they are (some of them) above three miles deep. For we find that the depth of a hill, and the depth of a cave from the flat, is the same thing; both remote alike from the sun and heaven's beams, and from the open air. These caves we call the Lower Region. And we use them for all coagulations, indurations, refrigerations, and conservations of bodies. We use them likewise for the imitation of natural mines; and the producing also of new artificial metals, by compositions and materials which we use, and lay there for many years. We use them also sometimes, (which may seem strange,) for curing of some diseases, and for prolongation of life in some hermits that choose to live there, well accommodated of all things necessary; and indeed live very long; by whom also we learn many things.

We have burials in several earths, where we put divers cements, as the Chinese do their porcellain. But we have them in greater variety, and some of them more fine. We have also great variety of composts, and soils, for the making of the earth fruitful.

We have high towers; the highest about half a mile in height; and some of them likewise set upon high mountains; so that the vantage of the hill with the tower is in the highest of them three

* From the 'New Atlantis,' published in 1627. The text of the edition of Ellis and Spedding is followed.

miles at least. And these places we call the Upper Region: accounting the air between the high places and the low, as a Middle Region. We use these towers, according to their several heights and situations, for insolation, refrigeration, conservation; and for the view of divers meteors; as winds, rain, snow, hail; and some of the fiery meteors also. And upon them, in some places, are dwellings of hermits, whom we visit sometimes, and instruct what to observe.

We have great lakes both salt and fresh, whereof we have use for the fish and fowl. We use them also for burials of some natural bodies: for we find a difference in things buried in earth or in air below the earth, and things buried in water. We have also pools, of which some do strain fresh water out of salt; and others by art do turn fresh water into salt. We have also some rocks in the midst of the sea, and some bays upon the shore, for some works wherein is required the air and vapour of the sea. We have likewise violent streams and cataracts, which serve us for many motions: and likewise engines for multiplying and enforcing of winds, to set also on going divers motions.

We have also a number of artificial wells and fountains, made in imitation of the natural sources and baths; as tincted upon vitriol, sulphur, steel, brass, lead, nitre, and other minerals. And again we have little wells for infusions of many things, where the waters take the virtue quicker and better than in vessels or basons. And amongst them we have a water which we call Water of Paradise, being, by that we do to it, made very sovereign for health, and prolongation of life.

We have also great and spacious houses, where we imitate and demonstrate meteors; as snow, hail, rain, some artificial rains of bodies and not of water, thunders, lightnings; also generations of bodies in air; as frogs, flies, and divers others.

We have also certain chambers, which we call Chambers of Health, where we qualify the air as we think good and proper for the cure of divers diseases, and preservation of health.

We have also fair and large baths, of several mixtures, for the cure of diseases, and the restoring of man's body from arefaction: and others for the confirming of it in strength of sinews, vital parts, and the very juice and substance of the body.

We have also large and various orchards and gardens, wherein we do not so much respect beauty, as variety of ground and soil, proper for divers trees and herbs: and some very spacious, where trees and berries are set whereof we make divers kinds of drinks, besides the vineyards. In these we practise likewise all conclusions of grafting and inoculating, as well of wild-trees as fruit-trees, which produceth many effects. And we make (by art) in the same orchards and gardens, trees and flowers to come earlier or later than their seasons; and to come up and bear more speedily than by their natural course they do. We make them also by art greater much than their nature; and their fruit greater and sweeter and of differing taste, smell, colour, and figure, from their nature. And many of them we so order, as they become of medicinal use.

We have also means to make divers plants rise by mixtures of earths without seeds; and likewise to make divers new plants, differing from the vulgar; and to make one tree or plant turn into another.

We have also parks and inclosures of all sorts of beasts and birds, which we use not only for view or rareness, but likewise for dissections and trials; that thereby we may take light what may be wrought upon the body of man. Wherein we find many strange effects; as continuing life in them, though divers parts, which you account vital, be perished and taken forth; resuscitating of some that seem dead in appearance; and the like. We try also all poisons and other medicines upon them, as well of chirurgery as physic. By art likewise, we make them greater or taller than their kind is; and contrariwise dwarf them, and stay their growth: we make them more fruitful and bearing than their kind is; and contrariwise barren and not generative. Also we make them differ in colour, shape, activity, many ways. We find means to make commixtures and copulations of different kinds; which have produced many new kinds, and them not barren, as the general opinion is. We make a number of kinds of serpents, worms, flies, fishes, of putrefaction; whereof some are advanced (in effect) to be perfect creatures, like beasts or birds; and have sexes, and do propagate. Neither do we this by chance, but we know beforehand of what matter and commixture what kind of those creatures will arise.

We have also particular pools, where we make trials upon fishes, as we have said before of beasts and birds.

We have also places for breed and generation of those kinds of worms and flies which are of special use; such as are with you your silk-worms and bees.

I will not hold you long with recounting of our brew-houses, bake-houses, and kitchens, where are made divers drinks, breads, and meats, rare and of special effects. Wines we have of grapes; and drinks of other juice of fruits, of grains, and of roots: and of mixtures with honey, sugar, manna, and fruits dried and decocted. Also of the tears or woundings of trees, and of the pulp of canes. And these drinks are of several ages, some to the age or last of forty years. We have drinks also brewed with several herbs, and roots, and spices; yea with several fleshes, and white meats; whereof some of the drinks are such, as they are in effect meat and drink both: so that divers, especially in age, do desire to live with them, with little or no meat or bread. And above all, we strive to have drinks of extreme thin parts, to insinuate into the body, and yet without all biting, sharpness, or fretting; insomuch as some of them put upon the back of your hand will, with a little stay, pass through to the palm, and yet taste mild to the mouth. We have also waters which we ripen in that fashion, as they become nourishing; so that they are indeed excellent drink; and many will use no other. Breads we have of several grains, roots, and kernels: yea and some of flesh and fish dried; with divers kinds of leavenings and seasonings: so that some do extremely move appetites; some do nourish so, as divers do live of them, without any other meat; who live very long. So for meats, we have some of them so beaten and made tender and mortified, yet without all corrupting, as a weak heat of the stomach will turn them into good chylus, as well as a strong heat would meat otherwise prepared. We have some meats also and breads and drinks, which taken by men enable them to fast long after; and some other, that used make the very flesh of men's bodies sensibly more hard and tough, and their strength far greater than otherwise it would be.

We have dispensatories, or shops of medicines. Wherein you may easily think, if we have such variety of plants and living creatures more than you have in Europe, (for we know what you have,) the simples, drugs, and ingredients of medicines, must likewise be in so much the greater variety. We have them likewise of divers ages, and long fermentations. And for their preparations, we have not only all manner of exquisite distillations and separations, and especially by gentle heats and percolations through divers strainers, yea and substances; but also exact forms of composition, whereby they incorporate almost, as they were natural simples.

We have also divers mechanical arts, which you have not; and stuffs made by them; as papers, linen, silks, tissues; dainty works of feathers of wonderful lustre; excellent dyes, and many others; and shops likewise, as well for such as are not brought into vulgar use amongst us as for those that are. For you must know that of the things before recited, many of them are grown into use throughout the kingdom; but yet if they did flow from our invention, we have of them also for patterns and principals.

We have also furnaces of great diversities, and that keep great diversity of heats; fierce and quick; strong and constant; soft and mild; blown, quiet; dry, moist; and the like. But above all, we have heats in imitation of the sun's and heavenly bodies' heats, that pass divers inequalities and (as it were) orbs, progresses, and returns, whereby we produce admirable effects. Besides, we have heats of dungs, and of bellies and maws of living creatures, and of their bloods and bodies; and of hays and herbs laid up moist; of lime unquenched; and such like. Instruments also which generate heat only by motion. And farther, places for strong insolations; and again, places under the earth, which by nature or art yield heat. These divers heats we use, as the nature of the operation which we intend requireth.

We have also perspective-houses, where we make demonstrations of all lights and radiations; and of all colours; and out of things uncoloured and transparent, we can represent unto you all several colours; not in rain-bows, as it is in gems and prisms, but of themselves single. We represent also all multiplications of light, which we carry to great distance, and make so sharp as to discern small points and lines; also all colorations of light: all delusions and deceits of the sight, in figures, magnitudes, motions, colours: all demonstrations of shadows. We find also divers means, yet unknown to you, of producing of light originally from divers bodies. We procure means of seeing objects afar off; as in the heaven and remote places; and represent things near as afar off, and things afar off as near; making feigned distances. We have also helps for the sight, far above spectacles and glasses in use. We have also glasses and means to see small and minute bodies perfectly and distinctly; as the shapes and colours of small flies and worms, grains and flaws in gems, which cannot otherwise be seen; observations in urine and blood, not otherwise to be seen. We make artificial rain-bows, halos, and circles about light. We represent also all manner of reflexions, refractions, and multiplications of visual beams of objects.

We have also precious stones of all kinds, many of them of great beauty, and to you unknown; crystals likewise; and glasses of divers kinds; and amongst them some of metals vitrificated, and other materials besides those of which you make glass. Also a number of fossils, and imperfect minerals, which you have not. Likewise loadstones of prodigious virtue; and other rare stones, both natural and artificial.

We have also sound-houses, where we practise and demonstrate all sounds, and their generation. We have harmonies which you have not, of quarter-sounds, and lesser slides of sounds. Divers instruments of music likewise to you unknown, some sweeter than any you have; together with bells and rings that are dainty and sweet. We represent small sounds as great and deep; likewise great sounds extenuate and sharp; we make divers tremblings and warblings of sounds, which in their original are entire. We represent and imitate all articulate sounds and letters, and the voices and notes of beasts and birds. We have certain helps which set to the ear do further the hearing greatly. We have also divers strange and artificial echos, reflecting the voice many times, and as it were tossing it: and some that give back the voice louder than it came; some shriller, and some deeper; yea, some rendering the voice differing in the letters or articulate sound from that they receive. We have also means to convey sounds in trunks and pipes, in strange lines and distances.

We have also perfume-houses; wherewith we join also practices of taste. We multiply smells, which may seem strange. We imitate smells, making all smells to breathe out of other mixtures than those that give them. We make divers imitations of taste likewise, so that they will deceive any man's taste. And in this house we contain also a confiture-house; where we make all sweet-meats, dry and moist, and divers pleasant wines, milks, broths, and sallets, far in greater variety than you have.

We have also engine-houses, where are prepared engines and instruments for all sorts of motions. There we imitate and practise to make swifter motions than any you have, either out of your muskets or any engine that you have; and to make them and multiply them more easily, and with small force, by wheels and other means: and to make them stronger, and more violent than yours are; exceeding your greatest cannons and basilisks. We represent also ordnance and instruments of war, and engines of all kinds: and likewise new mixtures and compositions of gun-powder, wildfires burning in water, and unquenchable. Also fire-works of all variety both for pleasure and use. We imitate also flights of birds; we have some degrees of flying in the air; we have ships and boats for going under water, and brooking of seas; also swimming-girdles and supporters. We have divers curious clocks, and other like motions of return, and some perpetual motions. We imitate also motions of living creatures, by images of men, beasts, birds, fishes, and serpents. We have also a great number of other various motions, strange for equality, fineness, and subtilty.

We have also a mathematical house, where are represented all instruments, as well of geometry as astronomy, exquisitely made.

We have also houses of deceits of the senses; where we represent all manner of feats of juggling, false apparitions, impostures, and illusions; and their fallacies. And surely you will easily believe that we that have so many things truly natural which induce admiration, could in a world of particulars deceive the senses, if we would disguise those things and labour to make them seem more miraculous. But we do hate all impostures and lies: insomuch as we have severely forbidden it to all our fellows, under pain of ignominy and fines, that they do not shew any natural work or thing, adorned or swelling; but only pure as it is, and without all affectation or strangeness.

These are (my son) the riches of Salomon's House.

For the several employments and offices of our fellows; we have twelve that sail into foreign countries, under the names of other nations, (for our own we conceal;) who bring us the books, and abstracts, and patterns of experiments of all other parts. These we call Merchants of Light.

We have three that collect the experiments which are in all books. These we call Depredators.

We have three that collect the experiments of all mechanical arts; and also of liberal sciences; and also of practices which are not brought into arts. These we call Mystery-men.

We have three that try new experiments, such as themselves think good. These we call Pioners or Miners.

We have three that draw the experiments of the former four into titles and tables, to give the better light for the drawing of observations and axioms out of them. These we call Compilers.

We have three that bend themselves, looking into the experiments of their fellows, and cast about how to draw out of them things of use and practice for man's life, and knowledge as well for works as for plain demonstration of causes, means of natural divinations, and the easy and clear discovery of the virtues and parts of bodies. These we call Dowry-men or Benefactors.

Then after divers meetings and consults of our whole number, to consider of the former labours and collections, we have three that take care, out of them, to direct new experiments, of a higher light, more penetrating into nature than the former. These we call Lamps.

We have three others that do execute the experiments so directed, and report them. These we call Inoculators.

Lastly, we have three that raise the former discoveries by experiments into greater observations, axioms, and aphorisms. These we call Interpreters of Nature.

We have also, as you must think, novices and apprentices, that the succession of the former employed men do not fail; besides a great number of servants and attendants, men and women. And this we do also: we have consultations, which of the inventions and experiences which we have discovered shall be published, and which not: and take all an oath of secrecy, for the concealing of those which we think fit to keep secret: though some of those we do reveal sometimes to the state, and some not.

For our ordinances and rites: we have two very long and fair galleries: in one of these we place patterns and samples of all manner of the more rare and excellent inventions: in the other we place the statua's of all principal inventors. There we have the statua of your Columbus, that discovered the West Indies: also the inventor of ships:

your monk that was the inventor of ordnance and of gunpowder: the inventor of music: the inventor of letters: the inventor of printing: the inventor of observations of astronomy: the inventor of works in metal: the inventor of glass: the inventor of silk of the worm: the inventor of wine: the inventor of corn and bread: the inventor of sugars: and all these by more certain tradition than you have. Then have we divers inventors of our own, of excellent works; which since you have not seen, it were too long to make descriptions of them; and besides, in the right understanding of those descriptions you might easily err. For upon every invention of value, we erect a statua to the inventor, and give him a liberal and honourable reward. These statua's are some of brass; some of marble and touch-stone; some of cedar and other special woods gilt and adorned: some of iron; some of silver; some of gold.

We have certain hymns and services, which we say daily, of laud and thanks to God for his marvellous works: and forms of prayers, imploring his aid and blessing for the illumination of our labours, and the turning of them into good and holy uses.

Lastly, we have circuits or visits of divers principal cities of the kingdom; where, as it cometh to pass, we do publish such new profitable inventions as we think good. And we do also declare natural divinations of diseases, plagues, swarms of hurtful creatures, scarcity, tempests, earthquakes, great inundations, comets, temperature of the year, and divers other things; and we give counsel thereupon what the people shall do for the prevention and remedy of them.

And when he said this, he stood up; and I, as I had been taught, kneeled down; and he laid his right hand upon my head, and said; "God bless thee, my son, and God bless this relation which I have made. I give thee leave to publish it for the good of other nations; for we here are in God's bosom, a land unknown." And so he left me; having assigned a value of about two thousand ducats, for a bounty to me and my fellows. For they give great largesses where they come upon all occasions.

# NITROGEN-FIXING BACTERIA.

By J. G. Lipman,
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THE soil may truly be regarded as a vast laboratory. The many processes normally taking place in cultivated soils lead to the gradual formation of plant-food, to the solution of the mineral constituents, to the breaking down of the organic molecules into simpler forms, such that are in a condition to furnish the chlorophyl-bearing plants the material for the building up of plant tissue. The cycle of transformation from the simple to the complex and the falling apart of these complex molecules involve the activity of higher plant life, on the one hand, and that of lower organisms, on the other. Primarily it is the energy derived from the sun that, with the cooperation of the living protoplasm, impels the atoms to enter one or another of the innumerable combinations. These atoms are, as Carlyle would put it, 'but the garment of the spirit,' and the atom of carbon or nitrogen, which to-day is in the leaf of the oak or in the brain-cell of man, may on the next day become a structural part of some bacterial spore that is scarcely visible even with magnification of 1,500 or 2,000 diameters. The different kinds of atoms whose presence is essential in order that living tissue may arise, are not many. Among the less than one dozen of these, it is the migration and transmigration of the nitrogen atoms that undoubtedly form the most interesting, as well as the most important, phase of agricultural research. Of all the elements that enter into the composition of vegetable and animal substances, nitrogen is the most expensive, the most evasive, the most difficult to replace. And every person who at all concerns himself with questions as to the origin and the development of the various forms of life, can not be indifferent as to the source of nitrogen in the soil, and the factors that in one way or another affect the store of nitrogen at the disposal of the living world. Whence is the soil nitrogen derived? What conditions are most favorable for the maintenance of an adequate supply of this precious material? What means have we at our disposal for replacing the losses that occur, that in the nature of things *must* occur?

We should remember of all things, that the great aerial ocean, containing as it does more than 78 per cent. by volume of gaseous nitrogen, does not *directly* offer that element to the plant world. In order that this nitrogen may become available, it must be combined with other elements. Like Coleridge's Mariner, floating on the sea, surrounded by the sea, and yet perishing for lack of water, so plants growing on the bottom of the aerial ocean, with four fifths of its bulk consisting of nitrogen, and that to a depth of 200 miles or more, would yet starve for lack of nitrogen if there were not means in nature's workshop to combine that very inert gas. Now, soils of average fertility contain rather more than .1 per cent of nitrogen; in other words, the soil taken to a depth of one foot contains 3,500 pounds of nitrogen to the acre. The quantity is not constant, because of the various factors that lead either to the increase or decrease of that treasure hoard which it had taken ages to accumulate. In the processes of decay and fermentation, due to the activity of molds and bacteria, much of the combined nitrogen is set free and is returned to the atmosphere; in all processes of burning and explosion great quantities of nitrogen are again liberated. This latter fact led Bunge to say that every shot fired kills whether it hits anything or not, for it takes away that much life-giving substance from living things. Then again, as the insoluble proteid molecules are broken down and changed into simple salts, the nitrogen that thus becomes soluble, if not taken up by the crop, is leached out of the soil, and ultimately finds its way to the ocean. Enormous quantities of nitrates are thus carried by the streams to the sea, there to feed its denizens, to return, perhaps, in very slight measure to the land, though changed into other forms. Thus the great swarms of coarse fish caught for fertilizer purposes return in their bodies the nitrogen that had once traveled to the sea; thus, also, the still extensive nitrate beds of arid South America are a fractional return of what the sea had taken to itself. That the dissolved nitrates poured into the sea year after year by streams great and small do not remain there as such is clearly evidenced by the analysis of sea-water which shows but traces of nitrates. And so it appears that the soluble nitrogen salt, greedily taken up by plants in the field, is also quickly consumed in the sea. Of course, the nitrate deposits of South America were not deposited from the ocean as such, but resulted from the decay of great masses of seaweed.

Then there are opposite tendencies. There are agencies which lead to the increase of the nitrogen stock in the soil. It was Cavendish who first showed that when electric sparks are passed through air confined over a solution of caustic potash, small quantities of oxidized nitrogen are formed. In a similar manner, the electric discharges in the atmosphere cause the formation of small quantities of combined nitrogen, and Berthelot had shown that silent electric discharges also cause the combination of gaseous nitrogen. Similarly it has been claimed that in the burning of gas, coal, wax, etc., slight amounts of nitrogen become combined. All these factors, and others not mentioned, are, however, of minor importance as regards the maintaining of the store of combined nitrogen. We should remember that a fair crop of hay will remove from the soil more than 50 pounds of nitrogen, that at times there is removed from the soil 100 to 150 pounds of nitrogen per acre in one season, and remembering that, we can easily appreciate how entirely inadequate the 3 or 4 pounds of nitrogen per acre that are brought down from the atmosphere by dew, rain or snow are for supplying the nitrogen requirements of even a very meager crop.

There must be, then, another factor, or other factors, that are concerned in the supply of the vast quantities of combined nitrogen that are consumed from day to day. The mineral portion of plant food, that portion which constitutes the ash of plants, containing the calcium, magnesium, potassium, sulphur, iron, phosphorus, etc., is derived from the common rocks of the earth's crust. It is otherwise with nitrogen; to be sure, small quantities of it are contained in primitive rocks in iron deposits, in meteoric iron, etc.; yet, speaking generally, nitrogen is not a normal constituent of rocks. It is the atmosphere, and the atmosphere only, which must remain its source for plant and animal life. It is idle to speculate in what condition that nitrogen existed when the earth's crust first began to solidify. It is not likely that it existed as ammonia, for the hydrogen having a greater affinity for oxygen would have combined with the latter. It is not improbable, however, that it existed in combination with oxygen when the temperature of the earth's atmosphere had become sufficiently low. Be it as it may, when the surface rock began to disintegrate and lower plant life first appeared, there was no soil nitrogen. As rock disintegration proceeded, as the rock fragments became finer and offered a more favorable dwelling place for plants and bacteria, the store of nitrogen in the soil began to accumulate. And now we come to those agencies that are of the greatest importance in this gradual increase of the nitrogen store. Small amounts of combined nitrogen formed through electric discharges and brought down to the soil by precipitation would be sufficient in themselves through countless centuries to give rise to vast accumulations, provided that there was a gain only and no loss. But we have already seen that nitrogen is constantly being leached out of the soil. Analytical data at hand show that there is drained away from the land as much as 75 pounds of nitrogen per acre in the form of nitrates, and this certainly is lost to the soil. On some soils the loss is much smaller, on other soils it is even greater, but this, taken together with the amount removed in the crops taken off from year to year, shows clearly that unless there are other means in the economy of nature for drawing upon the great store of atmospheric nitrogen, the present store would soon be exhausted, in fact, it could never have accumulated.

Untiring research by many men and in many places has taught us that it is the mysterious force in living protoplasm that in its aggressive way reaches out and appropriates the restless molecules of atmospheric nitrogen; that though it destroys it also builds up. Practical experience had taught the ancients that crops of the legume family, crops like clover, beans, lupines, etc., do not exhaust the soil to such an extent as do crops not belonging to the same family. They had learned that after a crop of clover they could raise a larger crop of wheat. Why it was so they did not know, nor did the many generations of farmers who followed them; yet not knowing they availed themselves of the advantages that time had pointed out to them. It was reserved for the men of our generation, for men equipped with the methods of our own day, to illuminate the darkness, to unveil for us still another of nature's mysteries, to show us an intelligent way for replacing the unceasing losses of nitrogen. It was scarcely more than fifteen years ago that Hellriegel and Wilfarth published a series of wonderfully conceived and wonderfully exact experiments that decided for all time a much-debated question, which for a century had taxed the ingenuity of the foremost scientists of Europe. What Boussingault with all his mental penetration and clearness of vision had failed to accomplish, what Lawes and Gilbert with all their painstaking care and admirable equipment had failed to achieve, the German investigators had made clear. They showed conclusively that in the root nodules of leguminous plants there are found certain bacteria that in a way still unknown to us enable the host plant to make use of the gaseous atmospheric nitrogen. We do know that there is a continual struggle between the plant and the invading bacteria; we are justified in believing that the bacteria, compelled by the plant, unlock to it the hitherto inaccessible store of nitrogen. It was in this wise, partly, that the nitrogen accumulation in our soils resulted; it was in this wise that the rich prairie soils, containing at times as much as twenty thousand pounds of combined nitrogen per acre to a depth of one foot, had acquired that nitrogen. This dwelling together of two distinct forms of life with mutual benefit resulting is known as symbiosis, and the symbiotic life of leguminous plants and of the organism known as *Bacillus radicicola* has made possible to a great extent the terrestrial life of to-day. Yet there is another phase of the question, a phase that but a few years ago had not been recognized. There are bacteria in the soil that can avail themselves of atmospheric nitrogen without the aid of leguminous plants. Recent work in this field of research indicates that such fixation of atmospheric nitrogen is of vast significance, of greater moment, perhaps, than the fixation of nitrogen by legumes. To understand more clearly the relations existing among the many forms of bacterial life that are concerned with the transformations of the soil nitrogen it is necessary to consider separately some distinct phases of the nitrogen question. The plant tissues from which life had departed hold in them the nitrogen that had once moved in soluble form through the soil. The nitrogen in the dead plant tissue can not, however, again become a part of the food for other plants; not until it has again been changed into simpler soluble forms. This locking up of the nitrogen in forms slowly decaying, and therefore slowly available, is a wise provision, otherwise the nitrogen would soon be washed out of the soil. Thus we see that the soil nitrogen is contained in an insoluble form in the remains of former plants, and, no matter how much of it the soil contains it is inaccessible to the plant growing upon it until it has been first changed into the simpler forms. Now, as to the agents that produce this transformation. Bacteriology, in general, and soil-bacteriology, in particular, are subjects to which the attention of the scientific world has turned very recently. Of the many hundreds of different species of bacteria living in the soil, but few are known. Nevertheless, even at the present time, enough has been learned to enable us to form a conception, at least, of the changes that take place there. The nitrogen of organic substance, whether plant or animal, usually exists in the form of albuminoids, more frequently termed proteids. These proteid molecules are seized by the soil bacteria and are utilized by them for the formation of their own bodies. Being saprophytic by nature, that is, unable to build up organic substance from the simpler materials, as is done by higher plants, they must derive their energy from the tissues that chlorophyl-bearing plants had fashioned with the aid of sunlight. In availing themselves of this potential energy for their own purposes, they break down the complex molecules; to use a popular expression, they cause decay. In order to gain their end, that is, to secure the food contained in the proteid molecules, the bacteria must first change it into a readily diffusible, soluble form. For this purpose the chemical ferments known as enzymes are produced. With the aid of these enzymes, the albuminoid substances are 'peptonized.' In the laboratory such organisms are described as gelatin-liquefying bacteria. A part of the food thus made accessible is appropriated by the microorganisms and in their physiological processes is still further simplified. A part of the carbon is oxidized and escapes into the atmosphere as carbon dioxide, gaseous hydrogen or oxygen is set free, or the two are combined to form water. The nitrogen with which we are here concerned is subject to many changes. In the course of its migration it forms a part of the amid molecules; from these it is split off in the form of ammonia, and this again may be destroyed and gaseous nitrogen set free, or seized by another distinct class of organisms, and oxidized to nitrites and nitrates. The last is the form in which the nitrogen is usually taken up by the plants. On the other hand, the nitrates are themselves subject to the opposite forces of deoxidation. There are species of bacteria in the soil which reduce nitrates to nitrites, to ammonia or even to gaseous nitrogen. To recapitulate, then, there take place in the soil processes of nitrification, denitrification and also the fixation of free nitrogen. It was necessary to consider the former two, in order to understand the third. It would be out of place here to speculate upon the manner in which the soil nitrogen is oxidized; it might not be out of place here to consider the possible ways in which nitrogen is set free from its compounds, on the one hand, or is 'fixed,' on the other hand. Quite recently hypotheses have been advanced which would regard the processes of 'fixation' and of 'denitrification' as being very much related phases of the same physiological activities. The investigators who have labored in this field of research, and to whom we owe most of our knowledge on the subject, are Berthelot, Winogradsky, Beyerink and Stoklasa. Berthelot was among the first to observe that soils free from vegetation can increase their store of nitrogen. Winogradsky, after much painstaking search, isolated from the soil an organism, which, in company with two others, can grow in nitrogen-free media and fix considerable quantities of nitrogen in a short time. Beyrink, also, has isolated within the last few months several organisms that possess a similar power, and Stoklasa has done a great deal of careful work to determine just how the fixation of nitrogen is accomplished. Moreover the subject has assumed more than a mere scientific interest within the last three or four years. The firm of Friedrich Bayer and Co., of Elberfeld, Germany, has placed on the market a bacterial culture bearing the fancy name of 'Alinit.' This alinit they claim can under favorable conditions increase the yield of non-leguminous crops 40 per cent. On examination, the alinit proved to be a pure culture of *B. ellenbachii,* mixed with a starchy material resembling dried and pulverized potatoes. The organism was isolated by a German gentleman-farmer, Caron by name, and named *B. ellenbachii* after his estate, Ellenbach. This bacillus differs but little from the organism isolated by Du Bary some years earlier, and called by him *B. megaterium.* This organism, Stoklasa claims, is not only similar to, but identical with *B. ellenbachii.* The accumulated evidence of several investigators on this point inclines me to the belief that the two are not identical, though very much allied. At any rate, Stoklasa has shown that *B. megaterium* is capable of fixing atmospheric nitrogen in media containing but traces of fixed nitrogen; it develops and adds to the nitrogen content of the medium by drawing upon the nitrogen of the air. This organism has, as it were, a double nature. In the first place, as just noted, it is capable of fixing atmospheric nitrogen; in the second place, it exerts a deoxidizing effect when grown in solutions containing nitrates, with the production of nitrites and ammonia. This double action leads us to inquire into the nature of the physiological processes taking place in either case. His investigations in this field led Stoklasa to assert that there is much in common between the two processes. He believes that the deoxidation of nitrate is due to the action of the bacteria on water, with the liberation of hydrogen and the formation of hydroxyl. Nascent hydrogen is a powerful reducing agent, and would of itself withdraw the oxygen from nitrates to form nitrites, while hydroxyl in contact with ammonia will cause the formation of water and the liberation of nitrogen. Part of this nitrogen is undoubtedly utilized by the bacteria, and the rest is returned to the air. How the inert nitrogen molecule is torn apart and the nascent nitrogen atoms thus formed utilized by the bacteria for their growth is a question that is more difficult of solution. We do know that the amount of nitrogen fixed by *B. megaterium* is affected by the composition of the nutritive medium. The same is true of denitrification. The molecular structure of some carbohydrates or of organic acids and the arrangements of the atoms in the molecule influence the activity of the bacterial cell and its life processes. I have found, for instance, that the more complex citric acid molecule offers a more favorable source of energy to a denitrifying organism that I have isolated than do either succinic, tartaric or lactic acid. And the laboratory work clearly indicates that the amount of organic substance in the soil, as well as its nature, determines the course of development, and the prevalence of the one or the other of the soil organisms. Certain it is that where the fixation of nitrogen takes place in the soil, it occurs only when its store of nitrogen is very meager. This is analogous to the behavior of the legumes. It has been found that these plants when growing in a soil rich in soluble nitrogen do not to any considerable extent draw upon the atmosphere for that element. It is only when the soil offers little or no nitrogen that the atmospheric treasure house is unlocked for it. All experimental evidence thus far accumulated indicates that there is a struggle between the plant and the bacteria invading its roots, that the latter are so modified by the aggressive activity of their host that they form a fine network of tissue in which the atmospheric nitrogen is captured, as it were. That this assumption is not entirely erroneous is shown by the fact that legumes, inoculated with cultures of *B. radicola* that are particularly virulent, although they form root tubercles, show nitrogen hunger when there is none in the soil at their disposal, and the microscopic examination reveals bacteria that are not modified as is the case in vigorous plants. In other words, the bacteria resist the encroachment of their host and would not be compelled to furnish it with the nitrogen that it can not get otherwise. In connection with this, the question naturally arises whether *B. radicola,* the bacteria of the legume tubercles, can fix atmospheric nitrogen independently of its life in the legume tubercles. As a matter of fact, Beyerink and Mazè claim to have proved that this organism can fix elementary nitrogen independently of legumes. We should note here the remarkable fact that although this organism is so universally distributed and common in all soils, all attempts to isolate it from the soil directly have not been successful.

There are probably a half a dozen bacteria capable of fixing atmospheric nitrogen known to-day, and there is little doubt that others will be found before long. As it is, we are fully justified in the claim that soil bacteria are a potent, nay, an indispensable, factor in the creation of the world's food. Though they are to most of us an invisible world, though many of us never suspect their existence, they are yet our staunch friends, living their brief life, contributing to a broader life, making it possible for the finite to dream of the infinite.

# SOME ARACHNIDS AT HANOVER, CAPE COLONY.

BY S. C. CRONWRIGHT SCHREINER,

HANOVER, CAPE COLONY.

WHEN I left Cape Town for Hanover, my friend, Dr. Purcell, of the South African Museum, the leading South African authority on spiders and their kin, asked me to send him any of these creatures I might capture. The district of Hanover, he said, and indeed, practically, the whole high Karoo plateau, was unexplored arachnologically; there had been no collection from the high plateau, and he was particularly anxious to have one to compare with the arachnid fauna of the lower-lying Great Karoo.

I have devoted special attention to spiders, Solifugæ and scorpions, though, naturally, other things have found their way into the collecting bottles. These have all, from time to time, been sent to Dr. Purcell for classification, and the results have been, on the whole, as surprising as interesting.

If the reader will take a map of the Cape Colony and follow the railway from Cape Town to Bloemfontein, he will find the little station of Hanover Road lying about midway between De Aar and Naauw Poort Junctions. Nine miles across the veld, southwest from Hanover Road, is the little dorp or village of Hanover, which lies at the foot of two ijzer (iron-stone) kopjes, on a great Karoo flat, 4,700 feet above the sea level. A superb fountain gushes out from a covered furrow at the foot of the kopjes, furnishing an abundant supply of water for the houses and the fruit gardens; a great vley runs east and west past the dorp; groups of kopjes dot the mighty veld at intervals, and purple hills and mountains fringe the clean-cut and distant horizon. Hanover is bare and at times very cold in the winter; but, in the summer, when the willow trees along the water furrows that line the streets, and the fruit trees in the gardens about the white houses, are green, the little dorp is, of all small towns I have seen, by far the most beautiful. It lies like a great flower on the brown Karoo—not as an excrescence, but as though it were part of the veld. There are old men here who have seen lions in the neighborhood, and younger men who have seen wildebeeste (gnus) career through the streets.

My collecting has been confined practically to the commonage in the immediate neighborhood of the dorp, over which, under martial law, I have had a permit to walk. But fortunately the Dutch farmers have been interested in my work, and both adults and children have gladly taken bottles of spirits and collected on the farms. I have thus received many interesting specimens of spiders and Solifugæ. The farmers are pleased that so many new things have come out of their district, and are eager that it shall hold a front place in the great museum at the capital. A gray-headed old man handed me a bottle of spiders the other day with the remark 'Ik denk Hanover is nou zeker vóór' ('I expect Hanover is in front now'), and was much pleased when I told him how well Hanover was holding its own at Cape Town. The school children too, especially the girls, have done well. I have a couple of charming young friends who, in three weeks, sent me over three hundred specimens, some new and of great interest.

The result of the collecting up to the time of writing is, that, out of over two thousand arachnids I have sent to the museum (and excluding some spiders still undetermined), Dr. Purcell has found some twenty-one families of spiders, comprising more than a hundred species (the great majority of which are new to science), some ten species of Solifugæ (several of which are also new to science), four species of scorpions and one pseudo-scorpion.

One can not speak with any certainty yet, but it would almost seem that the high plateau has, largely, its own peculiar arachnid fauna, which, if it be so, is a very interesting fact.

But the interest does not lie wholly in the finding of an apparently new fauna and many new species of very rare genera; it is perhaps greatest in connection with what has been learned concerning spiders whose habits were thought to be known.

Before passing on to the arachnids, one or two interesting finds in other orders may be noted.

Among snakes, a small rare species (*Prosymna sundevalli*)—speckled, handsome and non-poisonous—is remarkable as having a hard snout for burrowing into the ground. Another snake is interesting from the manner of its capture. I was reading one evening inside the house and my wife was walking up and down the stoep after the heat of the day, when I heard her call anxiously. I went out and found the snake, which I killed two feet from our open door, for which it was making. A beautiful family are the Kous slangen (garter-snakes). They are very poisonous, but fortunately they are smallish and have very small teeth. The best specimen of these snakes I have caught is perhaps the most beautiful of them all. It is circled throughout its whole length with alternate bright red and deep black bands about half an inch wide. I nearly trod on it, and was warned by the most violent short hisses. I looked down at my feet, and there, standing up on a red iron-stone, was this enraged and lovely creature, swaying to and fro with flattened head, ready to fight. It looked like the gay stalk of some beautiful aloe; and its beauty and pluck so appealed to me that I captured it only with great reluctance.

Of course, the kopjes and the flats abound with various lizards, some of the most gaudy colors. For instance, there is one with spiked coat and rough, ringed tail, which has a red head, blue throat, neck and sides, while the back varies from red to brown towards the tail. It sits on a rock and quaintly raises itself up and down on its forelegs. If danger approaches, it slips into a crevice, from whence it can hardly be taken alive, for the spikes catch on the stone so firmly that the lizard is able to resist almost all attempts to take it out. But most interesting, perhaps, are the Geckos (*Pachydactylus mariquensis*), which the Dutch call getjes, also generally found under stones. They are about six inches long and not so quick in their movements as lizards usually are. This and their defencelessness have induced a peculiar method of protection. Their fleshy tails are quite loosely affixed, being deeply constricted all round where they join the body. A slight touch will break them off—so much so that at times the getje seems almost to *throw* them off. Then is seen a strange thing. The tail jumps about in the most lively manner, and thus attracts the attention of the pursuer, while the getje quietly and unobtrusively moves away unobserved—and goes and grows another tail! This is a peculiar and yet very effective method of protection; there are other local lizards that part with their tails with comparative ease, but they are quicker in their movements and their tails are not nearly so lively; the method has reached perfection in the case of the getje only. I am generally accompanied in my walks by my wife's little fox terrier. She seldom catches a getje. When she jumps at one, off flies the tail, which she invariably seizes as it plunges frantically about, and the getje escapes. The getjes are of various colors, some very handsome. Some kinds burrow holes in the sand, and these occasionally take possession of deserted nests of the large trap-door spiders. (I say deserted; they may, however, kill the spiders; but I do not think they do.) They somewhat narrow the opening of the tube just under the lid, to about the size of their body, but they leave the lid intact and keep it in use, opening and shutting it (or allowing it to shut itself) at will. On lifting a lid on one occasion, I found the getje in the hole, peering out from under the slightly-gaping lid, with its head just level with the surface of the ground—a very odd sight. I dug down, and at the bottom of the hole found its egg, which it was evidently guarding. On another occasion I found two at the bottom of a large closed trap-door nest. The lid of a nest, when occupied by the getje, does not close so perfectly as when occupied by the spider, due perhaps to the narrowing of the opening. Though generally held to be poisonous, these charming little lizards are really quite harmless. Hottentots have a great dread of the getje, believing that if it bites them, they will live just long enough to reach home, or at most till sundown.

Among this miscellaneous collection is a wasp (*Mutilla*), of which I have found some twelve or fourteen kinds. The males are winged, as usual with wasps, but the females are wingless. She has a red thorax and a yellow-spotted hairy abdomen. She runs very quickly among the karoo bushes, and, if alarmed, hides under them or buries herself in the loose hot sand at their roots. She has to be handled carefully, as she has a very powerful sting. She also stridulates, no doubt a call to her flying mate who, by the way, cannot sting. I have found only three males (one dead in a *Stegodyphus* nest), but the males are very rare. I do not know why the females are wingless and the sexes so different in appearance. But the same thing occurs with some grasshoppers; I have one kind particularly in my mind, the female of which is dark, huge and heavy, with only rudimentary wings, while the male is small, slight, smart, brick red and a splendid flyer. The variety of grasshoppers and ants here is extraordinary, and the protective shapes and colors are most wonderful. Such protective devices are, of course, quite a feature of the fauna of the bare and stony karoo; but no one who had not seen them could believe how efficacious they are. Even a trained eye may lose an insect while looking at it.

Passing on to scorpions, the four species found here embrace three genera. One kind (*Opisthophthalmus austerus*), a burrower, is very common; one may catch fifty almost any day. They grow to six or seven inches in length and are pugnacious and poisonous. Most *Opisthophthalmi* dig holes from one to two feet deep, sometimes but not generally under stones, with the opening oval-shaped like a human eye; but *O. austerus* here is, as far as my experience goes, invariably found under stones by day, sometimes with only a shallow burrow under the stone, at other times with a burrow ending in a hole which varies in depth, often not being deep enough to hide the scorpion. When you raise the stone you expose the scorpion, which runs to and fro in its now roofless burrow, and, if it has sunk a hole, eventually dives down into that, sometimes tail first. If you irritate these scorpions, they tilt the hind part of the body forward and up by straightening their hind legs under it; then jerking it quickly and stridulating angrily, they rush at you; and most ugly creatures they are—all nippers and sting. The stridulating sound is produced by rubbing the jaws which are lined with short, stiff, yellow hairs against the front edge of the head-plate. The male closely resembles the female up to the last molt, but after that he is longer and slenderer and has longer and slenderer hands (nippers), but he is quicker and more vicious. *O. austerus* is handsomely marked; the back is dark brown, the sides purple sometimes greenish, and the hands often a rich mixture of red and brown. Scorpions have an organ, like two small delicate white wings, attached underneath the body between and in a line with the last pair of legs, which in the male is toothed along the back edge to the base, while in the female the last quarter is not toothed; its functions are unknown, but it is some delicate sense organ presumably.

The other kinds of scorpions found here do not call for special remark, though it may be noted that one of them (*Parabuthus neglectus,* Purc.) was not thought to occur so far east. There is, however, a very interesting pseudo-scorpion, a small tailless creature, otherwise much like a scorpion, found under stones and in sand, which has the curious habit of burying itself in the sand, and then, when it wishes to change its quarters and opportunity offers, it seizes a bee or fly by the leg and is thus strangely transported through the air by the flying insect.

Scorpions are of course viviparous and carry their young when small on their back.

The next group, the Solifugæ, is a very interesting one. The Dutch call them Jacht Spinnekoppen or Haar Scheerders, and, as usual, these are the names by which the Solifugæ are generally known in South Africa. Except that the Solifugæ are not spiders (though, outside of scientific circles, held to be so in South Africa), Jacht Spinnekop (hunting spider) is a very appropriate name, for, to the casual observer, they resemble spiders, and they are mighty hunters. Haar Scheerder (hair shearer) is even more appropriate. They are called Haar Scheerders because of their two enormous 'shears.' Many a person believes that, if they get into your hair, you will not get them out again until they have shorn it all off; others believe that they wait until you are asleep and then come and cut your hair off to build their nests with—imaginery operations, suggested no doubt by the name and the shape of the jaws.

I know of no creature which, for its size, is so terribly armed as the Jacht Spinnekop; practically the whole of its huge head is transformed into two pairs of terrible nippers of quite extraordinary size and power. These nippers run straight forward, the eyes being placed just where they emerge above. Each pair of nippers has its own independent nipping action, and, in addition, each has an independent up-and-down and backward-and-forward motion, giving the jaws an awful tearing power, so that, as soon as the prey is seized, it is ripped into pieces.

The 'Tommies' along the railway sometimes make one of these creatures fight with a scorpion. They place the combatants in some slippery vessel so that they can not run out. The scorpion is nearly always much the larger and heavier and has, in addition to its long arms and powerful nippers, a deadly sting. Yet it not infrequently happens that the Jacht Spinnekop comes off victorious, for it seizes the scorpion in its terrible shears and tears a huge hole in it with a quickness and force against which the scorpion is often powerless.

I have a fine large one before me as I write, nearly three inches long (from tip of jaws to end of abdomen), whose jaws alone are more than a quarter of its length, and are, across in front of the eyes, the broadest and solidest part of the whole creature. It is not poisonous; it needs no poison with such terrible jaws.

Passing from the most obvious feature of the Solifugæ, one remarks several other unique characteristics. In spiders, there are, in front of the first pair of legs, two feelers, one on each side of the head, called palps, shorter than the legs, except in very rare instances; in the scorpion, these palps become long arms with powerful nippers at the ends, and there are no delicate feelers; in the Solifugæ, these palps become long, stout and leg-like, with suckers at the ends for holding or climbing, while there is the very interesting further development that the first pair of legs have ceased to be legs and have become thin, delicate feelers. But there is yet another development, if possible even more interesting still. Along the lower side of the last pair of legs are little white oval plates, supported at regular intervals on short stalks. These delicate little pedestals are sense organs of unknown function; it is possible they are organs of scent, enabling this great hunter to track his prey as he rushes along on the spoor.

Of the Solifugæ I have found some ten or twelve kinds, some belonging to genera hitherto very rare in South Africa. *Dæsia* is the rarest of the known genera here, and the local species is new. The first male found was only the second of the genus in the South African Museum collection. *Dæsia* is smallish and of a light, almost transparent, yellowish tint, and nocturnal in its habits. By day one finds them (if lucky enough to do so) under stones. *Blossia,* of which the species found is also new, is smaller than *Dæsia* and of a delicate pink color; of these I have found several females, but only one male. Another form is a tiny black one, belonging to an undescribed species and genus, and not more than a quarter of an inch long.

But I pass on to the genus *Solpuga,* in which the large kinds, diurnal and nocturnal, are found. When one first sees one of them on the veld, especially the commonest (*S. chelicornis*), one can hardly believe it is not a beautiful karoo flower. This *Solpuga* is about two inches long (exclusive of legs) when full grown, and of a most brilliant yellow, with a heavy black band down the back of the abdomen, while the legs are covered with long yellow hair, which, in the male, becomes a distinct mane and is iridescent. As it lies on the sand on a hot day, sparkling in the sunshine, it is a most exquisite creature. Touch it, and away it darts; catch it—and take care it doesn't catch *you!* The male of this *Solpuga* may be distinguished from the female by two little curved horns, like wires, more than a quarter of an inch long, one on top of each pair of nippers near the points. If you watch a *Solpuga* closely, you may see its sides palpitating rapidly, even violently if you hold it in your hand. Like all active, high-strung, quick-breathing creatures, the Solifugæ perish almost instantaneously when immersed in spirits, while large scorpions and large Harpactiræ will live for two or three hours. Another *Solpuga* has a yellow cephalothorax and a red abdomen, another is wholly yellow with spikes on its legs.* Very little is known with regard to their methods of reproduction and the nurture of their young. They are great burrowers, but do not make regular holes apparently, and they lie dormant underground during the winter. They are a feature of the thirsty veld and the blazing sun.

Coming now to spiders, and dealing first with the four-lunged group, one may remark that the lung plates are very obvious as four yellowish or pinkish discs on the fore part of the lower side of the abdomen (as are the two discs in the two-lunged genera). The largest here are the Theraphosidæ, known in South Africa by the Dutch name, Baviaan Spinnekoppen (baboon spiders). I have been able to discover only one kind here, a new *Harpactira.* The adults, with their legs extended, are roughly as large as a man's hand. Their huge bodies and long powerful legs are covered closely with long hair, which is almost identical in color with the hairy coat of a baboon—hence, perhaps, the appropriate name; putting aside the fact that baboons, who turn stones over in search of scorpions and insects of various kinds, are said to be very partial to them. They are poisonous and have very large and powerful fangs directed backwards and subparallel. When these fangs, which ordinarily lie tucked backwards under the cephalothorax, are shot forward and opened apart, the huge hairy spider has a dreadful appearance. The pads on the legs (extending along the lower side of the two end joints and over the tips) are soft and clingy, like the skin of a monkey's hand, and iridescent. Baviaan Spinnekoppen are nocturnal, living by day under stones in

* These two species, and possibly one or two others, are probably new, but this cannot be determined for certain until the males are caught, and, as yet, I have caught only the females.

burrows, which sometimes end in a hole or a cup-like depression in the ground and are beautifully lined with soft, white silk. Very large spiders are nearly always under large heavy stones; one might almost say that the size of the stone varies as the size of the spider. They prefer the stones on the flats or rands or the boulders at the foot of the kopjes. Occasionally they sink a hole an inch and a half in diameter in the open karoo soil and spin strands of web across its mouth. In one such hole I dug up an adult female with her numerous young, and it was a curious sight to see the young swarming over the great spider. The hole dropped perpendicularly for about six inches and ran at right angles for another foot. The lairs of these spiders are always strewn with bodies of beetles, large and small, eloquent evidences of the sad tragedies that are enacted in insect life. The new *Harpactira* is common at Hanover, though one does not often find really fine examples of adults. The adult males are rarer than the females, from which they may be distinguished by their slighter bodies and longer legs and by a peculiar pear-shaped spine at the ends of the palps.

We now come to the regular trap-door spiders, the Ctenizidæ, that sink a cylindrical silk-lined tube into the earth and affix a hinged lid to the opening. Of these I have found seven species, all of them, I believe, new. Perhaps the greatest interest gathers round a new *Hermachastes.* At Cape Town, the representative of this genus has hitherto invariably been found by Dr. Purcell with a trap-door to its hole, but the Hanover species has made a new departure. I have dug up over a hundred, I should think, and have never yet found one with a door. Some have escape blind side chambers, but I have been unable to find a door, either inside or outside. On the contrary, they have the uniform habit of building up a tube with irregular rim, projecting above the ground and varying in height from being just perceptible to a perpendicular regularly cylindrical funnel about an inch and a half high, the average height being more than half an inch. These projecting tubes are built of leaves, pieces of grass or small sticks, and are bound together and lined inside with white web, which extends throughout the length of the underground hole. This habit, as far as regular trap-door spiders are concerned, was, up to this discovery, quite unknown in South Africa; though I believe there are trap-door spiders in northern Africa which apparently build a similar projecting tube. I have not yet found the adult male of this *Hermachastes,* which probably lives under stones by day—a habit common to the males of this family; but the making of the nest as described has been established with regard to adult females, males up to the last molt, and the young of both sexes.

What has made this spider abandon its trap-door nest and adopt the projecting tube habit? The karoo is dry and dusty and wind swept, and so one can easily understand why an underground, doorless hole should have a projecting funnel; but this will hardly account for the abandoning of the trap-door.

One may note, however, that one of the most common spiders here is a *Lycosa* (*L. subvittata*) which sinks a hole in the ground with projecting tube with irregular rim. A trained eye can generally detect the difference between these two nests at a glance, though sometimes even such an eye will be at fault; but, to the untrained eye, the projecting tubes are so much alike that they are, in the majority of cases, indistinguishable. Now, this *Lycosa* belongs to a wholly different family of spiders, in the two-lunged group; it is a less handsome, smaller spider, pugnacious when handled and remarkably active and wary—unlike *Hermachastes,* which is slow and dull. Can it be a case of imitation, and that *Hermachastes* has adopted the habit of building a nest like *L. subvittata* in a part of the country where this tube-building *Lycosa* is common all over the veld? The interest deepens, as will be seen, when I come to describe the habits of another *Lycosa.*

There is another trap-door spider, *Hermacha* (also a new species), closely allied to *Hermachastes,* which also has a doorless hole but no projecting tube. Its hole, which is sometimes ten inches deep and beautifully lined with white silk, just ends straight off, level with the surface of the ground. Frequently, however, the opening has a delicate, smoke-like web curtain spun across it, which effectually prevents dust getting into it and bars the way to such enemies as do not dig the spider out. Dr. Purcell thinks this habit may be merely the spider's way of shutting itself in when moulting, but it seems to me to occur too frequently and the inmate to be too lively for the acceptance of such an explanation. *Hermacha* builds in stiff clayey (brak) soil, which cakes like a stone when dry. When dug up, it shows fight, rearing itself up, raising its legs, and throwing forward and parting its fangs so that a bright red gap is exposed between them. The nest of *Hermacha* was unknown until I found it here.

Passing by several new and interesting species of this family, we come to perhaps its most representative members, the large spiders that make the largest and strongest doors. Of these I have found three species here, two new *Stasimopus* and one new *Gorgyrella* (a new genus, recently named by Dr. Purcell.) These two forms are closely allied and superficially bear a strong resemblance to each other, except that, generally, *Stasimopus* has a darker cephalothorax and legs. They are slow in their movements, large, with powerful digging teeth and stout, strong, shortish legs. Their silk-lined holes are practically alike, generally dropping almost perpendicularly into the earth for about six to nine inches, with the opening a little larger than the rest of the cylinder; but the doors are different. *Stasimopus* has a thick cork-like door, with bevelled edge, which fits into the hole, being a little larger at the top than at the bottom. The thickness of the door of *Gorgyrella* varies; sometimes it is cork-like (though not so thick as the thickest *Stasimopus* lids), and, at other times, thin and not so firm and solid, in which case its bevelled edge is not so pronounced, and it more overlaps the edge of the hole. The lids of both are always on bare ground, covered with earth, and just flush with the surrounding surface. But there is one essential, and, as far as my experience goes, constant variation in the lids; that of *Stasimopus* is round, with a slighter hinge, which does not apparently break into the outline of the circle, while that of *Gorgyrella* is an incomplete circle, more or less D-shaped, with a broad, strong hinge. In the case of both, the silk that forms the hinge is so arranged as to act as an elastic spring which closes the door automatically. (The nest of *Gorgyrella* was unknown until I found it here, but I have sent some good specimens—as well as many other nests—to the museum, where they may be compared with those of *Stasimopus;* the spider itself is unrepresented—or at any rate unrecorded—in any European museums.)

It is only the females and young that build these nests; the adult males of the whole family are supposed to live under stones. Both sexes are nocturnal in their habits. The females are common but difficult to find; the males, however, are extremely rare; the male of *Gorgyrella* has never yet been found. I found one male *Stasimopus,* which was the second specimen in the South African Museum collection, only one other specimen—that in the British Museum—having been recorded previously. He is hardly recognizable as being what he is, for he is small (about half an inch long), black, with greatly elongated palps. He cuts a very diminutive figure beside his huge and powerful consort.

Among my *Gorgyrella* finds recently have been two with cocoons and one with young. It would seem that, when the eggs are laid and until the young are strong, the female shuts herself up in the hole; for in all three cases I found the lid closed down securely. The hole containing the mother and young was actually so fastened down that I had to tear it open all round the edge. I am not sure that the other two were also stitched down, but the ground had caked round the edges, effectually fastening them down.

These nests are difficult to discover, indeed almost impossible, except after rain, when, if you know where to look and what to look for, you may find a good many; for the holes being hollow, the lids dry before the surrounding earth and show as lighter colored discs.* One needs a little practice, however, even then. The spider is generally at the bottom of the hole, but sometimes, when she hears anything stirring at the lid, she rushes up, digs her claws into it (the lid of *Stasimopus* has a double circle of holes on the inside, into which the claws are inserted), presses her body against one side of the tube and her legs against the other, and holds the door shut with a strength that is simply amazing. Then you may dig her out easily, by removing only a couple of inches of the tube. If you take the piece of earth which contains the spider holding the door shut, and prod her from the back, she will rush partly out of the door and look around, but she generally keeps a claw of a back leg fixed in the lid, by means of which she can, up to the last moment, withdraw herself again like a flash, so that you may occasionally hear the door *slam*, if you have good ears and listen carefully! I once hurriedly tried to drag one away while she had her claw fast in the lid, and she parted with her leg rather than lose her last chance of retreat. When she does let go, the door closes of its own accord by means of its spring hinge.

Their chief enemy here is a burrowing animal, a 'mierkat' (*Suricata tetradactyla*), I think, which destroys a great number of them, discovering them by scent, no doubt.

Some South African trap-door spiders have become climbers. The family Migidæ have, in some instances, become tree trap-door spiders, where they are safe from some of their hereditary enemies and are equally well off for food. They build oval sack-like nests, one to two inches long, under stones or on trees, and cover them externally with moss, lichens, etc., and place a trap-door at one end—a very interesting adaptation. I have found one new species of the genus *Moggridgea* here, but have not yet discovered its nest.

Coming now to the two-lunged spiders, with opposite fangs (which comprise the great majority of spiders), a notable one is *Latrodectus*, which has the most evil reputation in South Africa. It is black with medium long legs and a globular abdomen. (The male is much the smaller and has a thin abdomen.) Fortunately this poisonous spider has a warning color, a red flag showing danger at hand! On the back of the abdomen she has a bright red spot (or spots or stripes). She builds a bell-like nest, about three inches long, in a small bush. At the bottom of the bell, which hangs mouth downwards, the web is very fine and open, and from the mouth radiate web strands. As the webbing approaches the top of the bell, it becomes closer woven, until, for about the last inch or so, it is quite opaque and often cov-

* This method was suggested by Mr. Charles Groom.

ered with small stones, some of them astonishingly large in proportion to the size of the spider, which she has carried up one by one from the ground. There the deadly spider lurks invisible. If you touch the nest, she rushes out, a beautiful creature, with the red patch blazing on her back like fire.

A charming little spider is a *Nemoscolus* (one of the Argiopidæ), which makes a curled nest just like a tiny bugle, within which she lurks. If you walk over the flats, you will see these little bugles suspended upright, mouth downwards, on the karoo bushes, about a foot from the ground. The 'bugle' is kept in position by means of about five powerful strands, tightly strained in different directions, and from its mouth radiates a beautiful little geometric web, hung over the ground like a tiny parasol. If you take hold of the bugle, the spider rushes to its mouth, gives a quick glance round, and then drops to the earth like a plumet, where she lies, feigning death, and is by no means easy to discover.

Another genus of the same family is *Argiope,* which spins a good-sized geometric web with a light pyramidal tangle below it. A favorite site is the open mouth of an ant-bear hole. She sits in the middle of the web, back downwards. The abdomen is large, and somewhat flat with deeply serrated edges, and both it and the cephalothorax, which is slight and to some extent overhung by the abdomen, are whitish or whitish-yellow above and darkly speckled brown and yellow below, while the legs are longish and definitely banded. If she hung back upwards, the white would betray her, but with the lower side up it is wonderful how inconspicuous she is against the ruddy soil of the karoo. If alarmed she shakes the web until it vibrates with astonishing rapidity, so that she becomes merely a haze; and then she drops to the earth, where she either lies still on her back or clings to a small twig low down, presenting the speckled side to the pursuer, remaining motionless and well hidden.

Yet a third genus of this family may be mentioned. *Cyrtophora* is often found in prickly pear (*Opuntia*) hedges. Here she builds a large geometric web with a dense pyramidal tangle below it, both composed of thread of immense strength. The color varies with these spiders and is of considerable beauty. The abdomen is notched above and projects over the cephalothorax to such an extent that the spider has quite a hunch-backed appearance. Like *Argiope,* she hangs back downwards in the middle of the web, with the pyramidal tangle below her. The threads of her web and tangle are so strong and the prickly pear hedges are at times so densely covered with them that the long stick with which one plucks the sweet ripe fruit often becomes so coated with the powerful strands and so impeded thereby that it cannot be used effectively till cleaned.

*Selenops,* one of the Clubionidæ, is notable for the lightning-like rapidity of its movements. It is a singularly flat spider of a speckled reddish-brown color, almost exactly like that of the dolerite rocks on the kopjes where it is found. Its legs are long and distinctly banded, giving the whole spider a mottled appearance. When you turn up a stone under which it is, you will find it, clinging back downwards to the lower side. The moment it becomes alarmed it begins to run, sidewise, with a circular motion, first in one direction, then in another, with such astounding rapidity that it becomes just a blur on the stone; and then it flashes sidewise over the edge.

We come now to perhaps the most interesting finds, which concern two of the Lycosidæ and one of the Eresidæ.

It was long held to be an established fact that no two-lunged spiders were trap-door makers; even up to the present, it seems that only a couple of instances had been observed of two-lunged spiders constructing trap-doors to their nests, and these only in the family Lycosidæ (one in South Africa, one in North Africa and one in Russia). But the finds at Hanover have clearly established the trap-door habit as a regular thing in the case of two species of South African Lycosidæ (one of which may or may not be identical with *L. domicola,* the South African instance above referred to) and one species of Eresidæ. I have found many of these nests and have sent specimens to the South African Museum.*

The Lycosidæ are numerous and common throughout South Africa. One finds them in great numbers under stones, in the projecting tube nests and running about the veld. I have found fourteen species here, varying greatly in color and shape, and in size from one eighth of an inch to about an inch in length. Ten of these are new.

*Lycosa subvittata* has already been mentioned as building the nest with projecting tube, closely resembling that of the new *Hermachastes.* The underground holes of these two nests differ considerably, mainly perhaps in the fact that, whereas that of *Hermachastes* is regularly cylindrical and beautifully white-silk-lined throughout, that of *L. subvittata* is not silk-lined at all but only brown-webbed for about an inch at the top and is not regularly cylindrical. It is not, however, necessary to compare the holes in detail here; the interest is now in connection with the web-lined, irregularly rimmed, projecting tubes, whose essential differences may be briefly noted. The tube of the *Lycosa* is generally shorter, greater in diameter and untidier in appearance than that of the *Hermachastes,* and, while it often slants

* It is remarkable that, while I was laying the facts of the first trap-door *Lycosa* before Dr. Purcell, he should have established at Cape Town the trap-door habit in the case of *Cydrela,* one of the Zodariidæ, another two-lunged family.

and gapes and is not a true cylinder, that of the *Hermachastes* is neat, upright and regularly cylindrical. But the nests frequently occur side by side in the same ground and are almost identical in appearance. For instance, I recently found a nest of the *Lycosa* whose projecting tube was two inches high and so like that of the *Hermachastes* that I had to dig it up to ascertain for certain which spider was the builder.

Thus we have the interesting fact that a true trap-door spider here has abandoned its trap-door making and adopted the projecting tube habit characteristic of a *Lycosa* common to this part of the country; while, on the other hand, we have the equally interesting fact that two species of *Lycosa* have abandoned the habits of their tribe and family and have become regular trap-door makers.

The commoner and smaller of these two trap-door *Lycosæ* is a very alert, often ruddy, spider with banded legs. It makes a hole which is generally a true cylinder and deeper than the hole of *L. subvittata,* and at the opening it always has a door. The doors are thin lids, firm, cup-like in shape, and are attached to the rim of the hole by several almost invisible strands of web. So delicate are these strands (which serve as a hinge, being affixed at several points to the edge of the lid), that I almost invariably move the lid with the point of my knife to ascertain whether it is fixed; for it sometimes comes loose and lies at varying short distances from the mouth of the hole (remaining in use all the time apparently—though of this I am not quite sure). The spider closes the lid in the heat of the day, with the concave, web-lined side down, and opens it late in the afternoon and early in the morning, but so late and so early that it may be said to be open only during the night; though, before the weather became very hot and dry, it was common to see small lids open during the day. Sometimes the lid is attached, on the upper side, to a stone or stick or leaf, but generally it is just covered with earth and lies almost flush with the ground. It is practically undiscoverable when closed. It may be noted that the trap-door *Lycosa* is apparently (perhaps only when young) not wholly nocturnal, and that many have been found under stones, also that the adult male is as much a trap-door maker as the female, and that, when the spider comes from the hole, it opens the door and leaves it lying beside the opening with concave side up—all habits which are certainly not shared by the Ctenizidæ and are apparently peculiar to itself.*

The Lycosidæ are an interesting family in other respects. The female, when about to lay her eggs, makes a neat cup with circular

* I have described the commoner trap-door *Lycosa,* because I have had greater opportunities of observing it; but, as far as my observation goes, the description applies equally to the larger and less common trap-door species.

rim, in which she deposits her eggs, heaped up. She then makes a similar cup which she inverts over them, after which she encloses the eggs between them by soldering them together round the rims. The whole ball of eggs is then spun over with whity-brown silk and attached to the spinners at the end of the abdomen, to be carried about till the young emerge, which crawl out and on to the mother's back, where they remain in a great cluster and are carried about by her for several weeks. She presents an odd spectacle as she rushes about with her numerous progeny on her back.

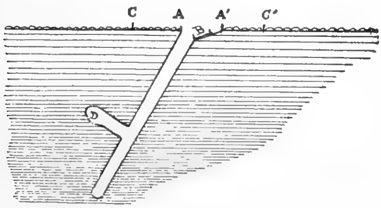
The Lycosidæ as a family are rovers and do not make regular nests, and this is why the females carry first the egg sacks and then the young about with them. But it is interesting to note that the habit of attaching the egg sack to the spinners (and no doubt also of carrying the young about) persists in the projecting-tube builder and in the trap-door species, although the paramount necessity for doing so apparently no longer exists.

The female *Lycosa* is said to be often curiously dainty about the color of the silk she uses for the inner cup; it is frequently of some bright color, say orange, while the rims are cemented with silk of some other gay color, say bright green. Sometimes she uses as many as four different colors. But, after all this trouble, she has to cover up her gaudy and attractive cocoon with some dull-covered silk, so as not to attract the notice of flies and wasps on the lookout for a nest of fat eggs in which to deposit an egg or two of their own.

My finds in Eresidæ cover five species. Several of them, belonging to *Eresus* and *Dresserus,* found under stones in dense tangles of web, are very slow in their movement and feign death when exposed; one of them is a large creature with an abdomen nearly an inch long and half an inch broad, resembling a huge cattle tick in shape and color (a brownish or bluish slate), even to the puncture-like marks on the back. Of the other species, one is *Stegodyphus;* you may see their dense ball-like yellow nests on the karoo bushes, with powerful strands binding them in all directions. At least one species of *Stegodyphus* is social, but the local form lives solitary or in pairs.

Another is perhaps the most interesting Hanover find. A neighboring Dutch farmer (who carefully obtains the Latin name of every species he brings, and who has been a most useful contributor) asked me if I knew of a small 'licht bruin' (light brown) spider that made a double door. Neither I nor any one else, so far as I know, had ever heard of such a thing. But my friend was not far wrong. Where there are ijzer-kopjes (kopjes of dolerite boulders) there are generally, somewhere on the gentle slopes of the flat at the foot, patches of gritty red sand, composed largely of the disintegrated dolerite. The sand is loose and desert-like for about two inches in depth, after which it meets sand finer in grain and baked hard. The larger grit lies on the surface. If you look carefully at these patches, you may see a delicate outline, shaped like a butterfly's wings, traced on the red sand, one pair of 'wings' being generally larger than the other, as is the case with a real butterfly. The impression is very beautiful and fairy-like. These 'wings,' which are covered with gritty red sand and lie flush with the surface of the ground, are generally about an inch and a quarter square, the longest measurement being across the front pair. If you insert the blade of your knife under the smaller wings, you may turn the lid over its hinge, which is on the side of the larger pair. This needs to be done carefully, for the lid is limp and delicate and easily doubles up and loses it shape; the operation is somewhat suggestive of tossing a pancake. You expose a smooth bare spot, shaped like the double wings, nearly in the middle of which is the hole.

Though this butterfly lid is about an inch and a quarter square, the hole is hardly, if anything, more than an eighth of an inch in diameter. It is situated almost under the middle of the lid, just below what corresponds to the thorax of the butterfly. The lid is attached to the side of the hole towards the head of the butterfly, and the attachment is restricted to the width of the thorax, leaving the whole outline of the wings free. The hole, which is from two to three inches deep and beautifully brown-webbed throughout, runs straight into the ground at an acute angle under the hinge. The side of the opening opposite the hinge slants, and on the slant, attached to the web lining of the hole, lies a small, loose, felt-like flap.




MEDIAN SECTION OF NEST OF NEW TRAP-DOOR ERESID. *A–A'*, Extent of lid across hole; *C–C'*, Extent of 'wings' on each side of hole; *A*, Where hinge is affixed; *B*, Flaps; *D*, Blind side chamber.

It must be remembered that the large 'butterfly' lid is never raised—indeed, cannot be raised—by the spider; for she is not strong enough, and, if she were, it would double up and lose its shape. So it always remains flat on the ground, covering the hole and the ground for more than half an inch all around it. The spider creeps in and out underneath, as from under a blanket; you can trace its passage by a little wave rippling along under the sand-covered wings.

The flap, I think, has two purposes. First, it affords the little spider a means of easy ingress and egress to the hole under the lid; it is firm and felt-like to give the spider a good hold for her feet over the loose shifting sand, and it is slanting to enable her gradually to overcome the downward pressure of the large lid; if the hole were perpendicular, the spider would have difficulty in levering herself over the edge against the weight of the lid, and, if the exit were not slanting and there were no flap, the loose, gritty sand would give way under her feet as she strove to get out. The little felt-like flap leads her gradually on to level ground, where she can easily make her way in any direction to the edge of the lid.

Secondly, the flap can, in case of necessity, serve as a make-shift door. If you tear the lid off and wait a little while, you will see the front legs of the spider emerge at *A* and pull at any fragment of hinge left, in order to close the hole temporarily; if she fails at this, she will pull up the flap, which, as I have said, is loose and just long enough to close and conceal the hole admirably. It is interesting to note that the spider always comes up facing *A*, which results in her being pretty well concealed while closing the hole; whereas, if she came up facing *B*, the slant would, to a considerable extent, expose her. This would seem to indicate that the flap is resorted to as a make-shift door only if the spider finds there is not enough web for the purpose left from the torn-off hinge.

Sometimes if you sit and watch an undisturbed nest, you will see the large 'butterfly' lid tremble, and then you will see the points of the little legs appear at the edge as the spider throws out the remains of a small ant or fly or some grains of sand. If you then quickly remove the lid, she will pop round and hide under it on the open ground. If exposed she lies perfectly still with her legs drawn in, feigning death, and may be handled like a dead thing. As she is very much the color of the loose sand, it is quite common to miss her, unless great care be taken.

It will be seen that this wonderful little spider is far ahead of the trap-door *Lycosa* in the complexity of her nest; but we have not yet reached the limit of her intelligence. Often she builds a beautifully webbed blind side-chamber, about half way down the hole, into which she escapes, and which, when the sand is disturbed, collapses over her and enfolds and hides her. I did not find the side chamber till I sought for it carefully. It is a late development, and shows she is no mere brilliant amateur like the *Lycosa*.

The trap-door eresid never, as far as I know, leaves the nest during the day, and certainly never opens the door, but creeps in and out under it, thus always leaving it closed. Neither do the adult males make doors or live under ground. Digging shows females, adult and young in the nests, but males only up to the last molt.

Here again comes a new and very interesting departure on the part of the eresid. The male, which, for all practical purposes, is, up to the last molt, identical with the female in size, color and shape, becomes quite another being in every respect afterwards. The female and immature males and young have a light brown cephalothorax and legs and a smoky abdomen, the colors being not widely different. But, after the last molt, the male is simply unrecognizable. He emerges a handsome, very alert creature, that runs about openly by day—a habit I think unknown in the Ctenizidæ. His magical change is no less radical in character than in appearance. His cephalothorax and legs are black, except that the front pair of legs, which are considerably elongated, have the fore parts white; his abdomen is black underneath, with a thin band of black round the sides, while the upper part is bright yellow. He moves alertly, often in a series of short rushes, and, if interfered with, does not feign death, like the rest of the eresidæ, but fights promptly and viciously, raising his body in front, lifting his forelegs on high and shaking the white parts angrily at you. To anything near his size he must be a most terrifying object.

Now, why this wonderful change in appearance and habits? Why he has adopted the habit of running about by day, I do not know. But, having done so, I cannot help thinking that his changed appearance and habits may have been evolved as a protection to him. At the time of the year when he appears, a very vicious ant (*Camponotus fulvipilosus*) is common over the veld during the day. The adult male eresid closely resembles this ant in color and style of movement. The ant, like the eresid, has a black head, thorax and legs and a yellow abdomen, and it moves in rushes. The resemblance is so close that, when I first saw the eresid, I took it, for a moment, to be the ant, and when I sent it to Dr. Purcell I described it as 'ant-like.'

No such spider as this eresid was previously known in South Africa. Dr. Purcell says it forms a new genus. I have sent several of its nests *in situ* to Cape Town. This could be done sucessfully only by melting hard paraffin and then pouring it into the sand around the nest, letting it soak up to the lid. Then, when the paraffin had hardened in the sand and bound it together, the nest could be removed in perfect order. The paraffin may be removed from the lid by treating it with warm oil of turpentine. Dr. Purcell will some day give detailed descriptions of all the interesting spiders and other things I have chatted about, with sketches of them and the nests *in situ,* and then we shall be able to call them by the names they will receive from him. Meanwhile I have thought a popular account of some Hanover arachnids might prove interesting.

# ZOOLOGY IN AMERICA.

By Professor T. D. A. COCKERELL,

EAST LAS VEGAS, NEW MEXICO.

THE articles in the *North American Review* of January and February on the condition of science in America have naturally aroused a good deal of attention, but no attempt seems to have been made to determine our exact position in any one branch of science. Feeling that the criticisms offered did not apply justly to American zoology, I sought to obtain more exact data upon the subject. Fortunately we have the annual volume of the *Zoological Record,* which enumerates very fully the zoological contributions of each year, omitting only those which are of little or no value. This work, ably edited by Dr. D. Sharp, is published by the Zoological Society of London, and therefore cannot be suspected of enumerating an undue proportion of American articles. As a matter of fact, it errs somewhat in omitting several works published in this country, which cannot easily be obtained in London; while no doubt its list of European writings is very complete.

The latest volume of the *Zoological Record* to hand contains the titles for 1900, including also a small proportion of papers accidentally omitted from previous volumes. I have extracted from this volume the following data:

| Division. | Total titles. | American titles. | Per cent. of American titles |
|---|---|---|---|
| General subject, | 763 | 112 | 14 |
| Mammals, | 346 | 68 | 19.6 |
| Birds, | 580 | 105 | 18 |
| Reptiles and Amphibians, | 239 | 33 | 13 |
| Fishes, | 235 | 32 | 13.6 |
| Mollusca, | 588 | 148 | 25 |
| Brachiopods, | 48 | 13 | 27 |
| Bryozoa, | 30 | 9 | 30 |
| Crustacea, | 192 | 17 | 8.8 |
| Arachnida, | 131 | 13 | 9.9 |
| Myriapoda, | 35 | 1 | 2.8 |
| Prototracheata, | 16 | 1 | 6.2 |
| Insects, | 1431 | 235 | 16 |
| Echinoderms, | 370 | 56 | 15 |
| Worms, | 345 | 50 | 14 |
| Cœlenterates, | 106 | 26 | 24 |
| Sponges, | 83 | 19 | 21 |
| Protozoa, | 167 | 17 | 10 |

I have included among the American titles those published in Europe by residents of America, except when there was reason to believe that they might have been prepared during visits to Europe. I have included papers published in Canada, and one or two from Mexico, but if these were deducted they would not (except in the case of the sponges) materially affect the result. Of course it must be acknowledged that the titles indicate contributions of every size and degree of merit; but as I have looked them over, it has seemed to me that ours were not inferior in quality or size to those of other countries.

The editor of the POPULAR SCIENCE MONTHLY (March, p. 476) has justly remarked that we ought not to expect to equal the rest of the world in our product; and in his opinion if we contribute one seventh we are doing our share. It will be seen from the above list that we actually are contributing approximately this amount in most of the divisions of zoology, while in some groups the proportion is greater. This conclusion agrees well with the impression gained by the writer through his experience of zoology and zoologists both in England and America.

It may be worth while to add some particulars regarding the workers who represent zoology in America to-day.

*General Subject.*—The list for 1900 includes 82 workers, and the names of Alexander Agassiz, Calvert, Davenport, B. Dean, Eigenmann, Eisen, Gill, Hyatt, Kingsley, Loeb, Minot, H. F. Osborn, Peckham, Pilsbry and Wilson are as familiar to European zoologists as they are to us. Many of the papers both here and in other groups are the work of the great body of University students, prepared under the guidance of leading zoologists, of whom C. B. Davenport, of Chicago, is especially conspicuous for his large following.

*Mammalia.*—26 workers, of whom J. A. Allen, D. G. Elliott, C. H. Merriam and H. F. Osborn are perhaps the most widely known. The study of the mammals in this country is being carried on with a zeal and industry which finds no parallel in any previous period; and the careful investigation of the geographical races is giving us material of the greatest value in the study of evolution. The credit for this revival is mainly due to Merriam; and the Europeans, who at first ridiculed his methods, are beginning to follow in his footsteps. American mammalogists have also begun to compete vigorously with Europeans in the study of old-world mammals, and G. S. Miller has even described a number of new ones from Europe.

*Birds.*—66 workers, including J. A. Allen, F. M. Chapman, E. Coues (now dead), R. Ridgway, R. W. Shufeldt and many others well-known in both hemispheres. We have a first-class journal (*The Auk*) devoted to birds, together with a number of minor ones.

*Reptiles and Batrachia.*—29 workers; the titles including the great work on North American reptiles by the late E. D. Cope. Our principal writer now living is Stejneger of the National Museum.

*Fishes.*—22 writers; the titles include a part of the great work on the fishes of North America, by Jordan and Evermann. The American fishes have been and are being very thoroughly studied; and Dr. Jordan, with several helpers, is making known the fish-faunæ of Japan and the Hawaiian Islands.

*Mollusca.*—58 workers, of whom Pilsbry and Dall, in particular, are in the very front rank. H. A. Pilsbry in 1900 published 36 papers, besides three others in cooperation with different workers, and at the same time continued the great Manual of Conchology, which is a monograph of the mollusca of the world. W. H. Dall published 15 papers, and the great value of his work on the bivalves, in particular, is recognized in every country. Other prominent names are those of Beecher, C. T. Simpson, Stearns, Sterki, Verrill, Bush and Whitfield. It must be confessed that there is a lack of good workers on the Pacific coast, though amateur collectors are quite numerous, and are continually discovering wonderful things, which are mostly described by Eastern conchologists.

*Tunicata.*—There is one paper by Verrill, of Yale, but Professor W. E. Ritter, of the University of California, has this group practically to himself in this country. He is preparing an elaborate work on the numerous species of the Pacific coast, which at present are almost wholly unknown.

*Brachiopoda.*—Ten workers; the work relates almost entirely to the fossil forms.

*Bryozoa.*—Eight workers. J. M. Nickles and R. S. Bassler give a synopsis of all the American fossil species, in a work of 663 pages. The principal work on living species is in two papers by Miss Alice Robertson, who has found the Pacific coast prolific in interesting forms.

*Crustacea.*—Thirteen writers, of whom the two most active are both women —Miss M. J. Rathbun and Miss H. Richardson, of the National Museum.

*Arachnida* (Spiders, Scorpions, Mites, etc.).—Only about five workers. This group is much neglected in this country, but Nathan Banks, of the Department of Agriculture, is industrious enough to count for two; while the work of the Peckhams on hunting-spiders is not to be forgotten.

*Myriapoda* (Centipedes).—Only one paper in 1900, and that bibliographic! In former years O. F. Cook has done important work, but his attention is now diverted elsewhere, at least for the time being.

*Insects.*—107 writers, not counting a considerable number of papers on economic entomology not seen by the editor of the *Zoological Record.* The more prominent names include Ashmead, Banks, Beutenmüller, Casey, Coquillett, Chittenden, Dyar, Fernald, Fox, Bruner, Williston, Holland, Howard, Hulst, Needham, H. Osborn, Schwarz, Scudder, Skinner, J. B. Smith, Strecker, Wheeler and Wickham. Much of the work is descriptive; but the economic work of Howard and his associates is the best in the world, if we may accept the opinion of European entomologists; while the new entomology, which combines the study of form with that of habits, finds admirable exponents in Wheeler and Needham. Dyar's work on the immature stages of insects has been freely used and acknowledged in Europe, and parasitic hymenoptera are sent from London and Paris to Ashmead for identification. G. B. King, the janitor of the court-house at Lawrence, Mass., has, with everything against him, made a reputation as a student of scale-insects, and his cooperation has been sought even in Germany.

*Echinoderma* (Star-fishes, Crinoids, etc.).—43 workers, much of the work relating to fossil forms. Prominent names are those of Clarke, Loeb, Springer, Vaughan and Verrill. F. Springer, our best authority on crinoids, has been able to produce the most elaborate and careful works in the intervals of a busy life as a lawyer; works which, it may be remarked, are much better known in London than in New Mexico, where he resides.

*Worms.*—37 writers, but it must be confessed that the papers are mostly of minor importance. Verrill has described a large number of new species. The earthworms and flatworms are greatly in need of more attention.

*Cœlenterata.*—19 writers. The great work of Nutting on hydroids must be mentioned. Professor Nutting has made this subject very much his own, and was even able to go to Plymouth, England, and discover new forms under the eyes of the English zoologists.

*Sponges.*—15 writers, three being Canadian.

*Protozoa.*—15 writers. This group is not receiving a fair share of attention.

So, on the whole, it appears that America is not seriously behind in zoology. Yet, I certainly cannot claim that the position of the science in this country is satisfactory. After all, the real question is, not whether we are doing as much as other people, but whether we are doing what we might, and ought. From this standpoint our deficiencies are serious enough. We are not, as yet, nearly able to cope with the work that lies ready to our hands. When the writer was a boy, he used to read and re-read such works as Wallace's 'Malay Archipelago,' and look forward to the time when he too would travel, and would discover something new. To-day, in New Mexico, he would undertake to find something new every day of the year, if he had no other occupation; and hardly a day passes in the laboratory without the determination of some new fact. But alas, thousands of specimens remain in closed boxes because there is nobody to work upon them; dozens of promising investigations are never undertaken because there is nobody to undertake them. Buildings, apparatus and books are well enough in their way; but the great need is for workers to make use of what is already gathered and ready for use, and to take up the threads of thought which flow from every investigation, and follow them to the end.

While we are seeking to add to the number of workers, something should also be said about their quality. Undoubtedly, there is too much narrowness, and too little general culture, an outward and visible sign of which is the bad Latin published by many of the younger men in the form of zoological names. At the meetings of the American Association for the Advancement of Science, there are sections of zoology, botany, geology, anthropology, etc., all in session simultaneously. The writer found it extremely annoying that he could not be in two or more places at the same time, but very few seemed to see any objection to the arrangement. This indicates limitations which must be regretted, and it is hard to believe that they are inevitable. When the zoologist ceases to know anything about the plants animals eat, or the physical environment in which they live, or even the animals of other groups than his own specialty, the broader ideas of biology will become obscured and evolution itself will cease to be intelligible, just as architecture is nothing to him who studies only single and isolated bricks.

# MENTAL AND MORAL HEREDITY IN ROYALTY, IV.

BY DR. FREDERICK ADAMS WOODS,
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## SPAIN.

THE early history of its great family is coincident with the history of the rise of Spain's greatness as a nation. Whatever value other factors may have had in producing Spain's glory the presence of the long line of great rulers and warriors must have been one of the greatest. This influence of the great leaders could make itself felt then, even more than now.

Within a short time we have had an example in Lord Roberts of what genius for generalship can accomplish in the turn of events. How much greater impress on his times the great man must have made in those medieval days when the masses knew almost nothing!

I know of no other direct line, except the then reigning one in Portugal, where greatness was maintained for so long a period, nor has there appeared any other than these two dynasties, where vigorous and distinguished blood was so continuously introduced into the stock. Portugal was five times united with the best of the stock of Spain to its evident advantage. Spain took wives three times from Portugal. Two of these, the marriage of Ferdinand II. of Leon (d. 1187) and Ferdinand IV. (d. 1317), were of great benefit. The third was valuable as far as the introduction of Portugal's blood was concerned, but happened to be very unwise, because it brought back again in a double way the cruel traits of Sancho IV. which resulted in producing Pedro 'the Cruel' whose tyrannies amounted almost to madness.

There are a few exceptions among the noble characters, such as the cruel tyrants just referred to, whose traits will be seen to be evidently caused by heredity. Still for *twenty-one* generations in the direct male line of Castile from Sancho II. in the tenth century to Charles Quint, the greatest ruler of his time (d. 1558), there were only four who did not possess a high degree of strength and ability. These were Alfonso IX., Ferdinand IV., John I. of Castile and Ferdinand I. of Aragon.

The first two of these were in the early centuries. John I. of Castile and Ferdinand I. of Aragon were father and son, who lived in the period just before the time of Ferdinand and Isabella.

There were two others, also father and son, who ruled over Castile at about this same time, who were exceedingly weak. These were John II. and Henry IV. They are not in the direct line under discussion at present, but it is interesting to see that John II. was a grandson of John I. just noted for his weaknesses and the causes of this temporary running out and subsequent rejuvenation in Ferdinand and Isabella will be discussed later.

During the early centuries of Christian Spain the conditions of the times were such that every sovereign was obliged to defend his right to the throne against the jealousies of his family, so that almost constant wars were being waged among the nearest kin and it was practically impossible that several generations of weak and incompetent kings should not have been wrested from the throne. This factor of natural selection undoubtedly did much to insure the strength of the stock.

The long minorities of the sovereigns of Castile and Aragon which occurred time and again during these centuries have always been considered by all historians as one of her greatest misfortunes, leading to intrigues, civil wars and disasters; affairs being put in a healthy condition again only when the king himself was old enough to take things in his own hands.

This and the fact that the country invariably gained ground under good rulers and just as certainly lost under weak ones make it evident how much more important the king was in those days and under those conditions than he has been in England, for instance, where the progress has been due to the people as a whole, especially her aristocracy and upper classes.*

Such a long line of great rulers as this, such an almost unbroken repetition of great physical and mental strength is almost unparalleled, save by Portugal, in all history. If there is much in heredity it must certainly be necessary here to show that the dynasty was continually maintained by the introduction of just such great qualities either from the best part of its own stock or from outside families.

We can discuss twenty marriages in the direct line. The following fourteen can be seen to have introduced stock equally vigorous and able. These fourteen are those of Sancho II., Ferdinand I. of Leon, Alfonso VI., Ferdinand II., Alfonso IX., Ferdinand IV., Alfonso II., Henry III., Don John II. of Aragon, Ferdinand and Isabella, Johanna 'the Mad.' These were scattered along the course and sufficiently account for the perpetuation of the strain. Many of these unions were remarkably good, being well backed on all sides. Of the other six, four were 'obscure,' tending that much to dilute the distinguished qualities.

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* Conf. Havelock Ellis, 'Study of British Genius,' POPULAR SCIENCE MONTHLY. (Geniuses have come from the upper classes.)

There was one, the marriage of Alfonso VI., that was distinctly bad, as its average value was incapable as well as vicious. The remaining one introduced mostly poor stock but had a small element of goodness in it. I refer to the marriage of John the First of Castile. Half the pedigree of Henry II. of Transtama and of Alfonso VI. are uncertain for different reasons, as will appear.

Beginning now with the most ancient times let us take up the character of each sovereign and discuss the effect on the breed of blood introduced in the marriage of each. Sancho I. by his courage and mental and physical energy extended his dominion in all directions. He reduced important fortresses on both banks of the Ebro, recovered Rioja and conquered the country from Tudela to Najera, Tarragona and Agreda, and the mountain districts surrounding the sources of the Duero. He was also prudent and pious by nature and his conquests were retained throughout his life by the wisdom of his acts. He died in 994.

Sancho married Urraca, daughter of Ferdinand, belonging to the same stock. They had a son Garcias, called 'the Trembler,' about whom little is known with certainty except that he won battles and apparently he was a successful warrior. The name of 'Trembler' was applied to him because before battle, as he himself put it, 'My body trembles before the danger to which my courage is about to expose it.' The pedigree of his wife, Ximenia, is unknown to me, but from this time on to the present, the descent of the female side can be shown with very satisfactory completeness, and it is these pedigrees which show that qualities were infused in the stock all the way down the line, sufficient to keep up the elements of greatness which never ran out in Spain until the death of the Emperor Charles Quint. After this the worst possible unions were made, and then Spain fell.

Sancho III., who died in 1035, was the son of the 'Trembler.' He must have had great ability for war and government, as he made himself the most powerful prince of his age and country. He married Nunnia, the heiress of Castile, who belonged to a powerful family. He held what he got by inheritance and marriage and even extended his dominions by conquest. He was called 'the Major,' or 'the Great.'

Sancho III. was followed by his son, Ferdinand I. He had high abilities and virtues and made himself the most powerful among many monarchs in Spain. He also is called in history 'the Great.' He married a daughter of Alfonso V. of Leon, a successful soldier and ruler and the son of the valiant Bermudo II., who had won distinction by defeating the Moors.

Ferdinand died in 1065. His son, Alfonso VI., was a great warrior and called 'the Valiant.' Alfonso VI. allied himself to an outside stock. He married a daughter of Robert, Duke of Burgundy. It does not appear that her ancestors were especially distinguished, except that her great-grandfather was Hugh Capet. This can not be classed among the brilliant marriages from the present point of view, as the great qualities are so remote.

Their daughter, Urraca, became queen. She was overbearing and tyrannical in her conduct, with morals of very questionable repute. Her mind was of a light and trivial order, though her ambition was as great as it was unprincipled. 'She left to posterity a character darkened by many crimes and scarcely redeemed by a single virtue.' Her reign, 1109–1126, was fortunately for her people a short one, but she succeeded in keeping the country embroiled in family feuds. (Dunham, 'Spain,' II., 162.) Urraca is the first one in the group who had any such traits. On searching for character of her mother's people, who must have introduced these qualities if they came by heredity, I found them amply accounted for in her grandfather and his mother. Robert, Duke of Burgundy, her grandfather, is described in a short column in the 'Biog. Univer.,' most of which tells of his violent temper. His mother, Constance, was a 'wicked intriguer,' and instigated his revolting from his weak and peace-loving father, King Robert of France. 'Robert (the Duke) had a most violent temper and was capable in the excesses of his anger of the most atrocious extremes.' He showed no application to affairs of state and abandoned the government to cruel and incompetent ministers. Queen Urraca married Raymond, Count of Burgundy. He was not at all distinguished, nor were his family.

The successor of the notorious Queen Urraca was Alfonso VII., who luckily did not repeat his mother's character. Unfortunately for our purpose we cannot be sure of his father, owing to the licentiousness of the Queen. The characteristics of this son and his effect on the country may be well shown by quoting Dunham, 'History of Spain and Portugal,' II., 165:

> Alfonso was no common monarch. Though he lost Portugal and was unable to withstand the genius of his namesake of Aragon, whom he imitated in assuming the imperial title, yet with fewer pretensions, though he is undeserving the exaggerated praises of the national historians, it cannot be denied that he exhibited great firmness in circumstances often very difficult, that he caused his territory to be respected by his Christian neighbors and greatly aggrandized it at the expense of the Mohammedans. His talents, however, were inferior to his ambition, and his moderation to both.

If this Alfonso VII. had wedded only average qualities it is probable that the ancient greatness of the race would have run out, but what happened is unusual in the story of families. Just at the time when it is weakened by dilution it is again strengthened by the qualities of a great man. The wife of Alfonso was the daughter of Raymond Berengaria III. (d. 1131), Count of Provence, a prudent sovereign who extended his dominions by inheritance, marriage and victory, ruled fifty years and actually carried his conquests across the sea to the shores of Majorica and made successful wars against the Arabs.

The product of this union was Ferdinand II. (1187) of Leon. He was a very able general and had many estimable and generous personal qualities. He made a marriage calculated to perpetuate the great qualities of his stock, that with Urraca, daughter of Alfonso I., the great founder of Portugal, who by consulting the Portugal chart may be seen to be backed up by distinguished fathers and grandfathers and to have himself derived in part his genius for war from the same stock of Spain already discussed, namely, Alfonso VI. 'the Valiant.'

However, Alfonso IX., his son, was without distinguished qualities or virtues. Coming as he does at the union of greatness he must be counted as an exception. Still the genius of the race does not die here. His marriage was one of the very best. His wife, Berengaria, was a famous heroine of Spanish history. She was a truly great and noble woman. Not only in her own qualities, but by her ancestors she must have brought into Spain one of the best strains that any royal person at that time would have been likely to have represented.

She was the daughter of Alfonso VIII. of Castile, rightly called 'the Noble,' whose reign was of great benefit to the country, himself a son of a successful warrior during a short career and grandson of Alfonso VII. already noted for his success. Her grandfather was Henry II., one of England's most vigorous and able kings, according to Hume 'the greatest prince of his time for wisdom, virtue and abilities.'

After the death of Alfonso IX., the throne was taken up by Ferdinand III. his son. 'He was a just, pious, able and paternal ruler, as well as a valiant soldier.' He triumped over the infidels and considerably extended his domains. His wife was a daughter of the Emperor Philip, a vigorous, warlike character, who, being assassinated when only thirty years old, never had an opportunity to display his real abilities. Philip was the son of Frederick Barbarosa, the greatest man and greatest power of his day. Thus a certain amount of able blood was here introduced. Still we see Isaac Angelus in the pedigree, an abusive and incapable ruler. A little more than half of it all was very beneficial, for Frederick was just and wise as well as extremely able, while the Emperor Philip was up to the standard already established here in Spain. The power of the country was considerably increased under Ferdinand III.

Alfonso X., who was the son of Ferdinand III., had abilities and ambition, but was not at all a man suited to the times. He was weak and irresolute, not obeyed by his subordinates, and his reign was far from successful. His time was devoted to learning and the advancement of science, which alone prospered under his rule. He showed a slight amount of cruelty, but this was not conspicuous compared to others in this age and land. There is no question but that Alfonso X. was a man of great intellect.

His character forms an exception and is the only one of the sort I have met with in this region. It is easily accounted for by a combination of ancestral qualities, but such combinations are apparently far from common. He was a poet, scientist and writer, and through his influence learning was greatly advanced. He is said to have been the first royal personage who was also a man of letters. The marriage of Alfonso X. with Violanta undoubtedly served to a certain extent to perpetuate the strength of the stock, for his wife was a daughter of James, the Giant Conqueror of Aragon. Still James with his great abilities as a warrior was violent, cruel, passionate and licentious, and aside from James there is not much distinguished blood in the characteristics of Violanta's pedigree.

We now come to a period of misfortune for christian Spain, and it is interesting to note how closely the welfare of the country follows the character of the sovereigns, how great the impress of the ruler was on his times in those early days in spite of the theoretical representation of the people in the popular branch of the Cortes.

During the reigns of the next two succeeding monarchs, Sancho IV. and Ferdinand IV., the family feuds and lack of a strong and wise ruler affected the country so disastrously that practically anarchy may be said to have prevailed.

Sancho IV. inherited the cruel, passionate disposition of his grandfather, James of Aragon, without his wisdom. His character was also warlike, vigorous and cruel and the only good fruits of his reign were his conquests against the Moors, whom he defeated in Andalusia and even carried his victories into Tarifa, a town in the very furthest extremity of Spain. The marriage Sancho made, when considered on the grounds of perpetuating greatness, may be considered half or more than half good. His queen, Mary, can be seen on the chart to be descended from largely 'obscure' stock, though she was the great-granddaughter of the famous heroine, Berengaria, already mentioned. She was her worthy descendant, for she repeated her character in every particular. Resolute, calm and devoted, she was an astute diplomatist and politician. Whatever successes there were were due largely to her.

Sancho's reign was short, lasting only eleven years. During the life of the queen mother, she exercised, as we have said, a beneficial influence, but after her death the reign of the feeble Ferdinand IV. was one long list of disasters. Some may wonder why Ferdinand should have been so weak, but as many of his immediate ancestors were far from being endowed with vigorous minds, of course he had a chance to get qualities from the poorer of them. He did repeat the cruel, passionate and tyrannical disposition to perfection, but no one appears to have paid any attention to his wishes.

Now again when the mental qualities are threatened we find them brilliantly restored. Constantine, the wife of Ferdinand, was just the one to effect this, as a glance at the chart will show. It is interesting to see Alfonso X., the scholar and poet, again in his grandson Diniz of Portugal, in another country and in another day where probably no influence of environment could come into play. Alfonso was the first and he was the second royal personage who was also a man of letters. The issue of this union was another one of the heroes of old Castile, Alfonso II., who succeeded to the throne in 1312, when only one year old; grew to be a great warrior against the Moors, and taking after his maternal grandmother possessed a large share of prudence and virtue, some of the rarer characteristics of his tribe. As an example of the respect felt for him even by his enemies the following may suffice: The Moorish king of Granada is said to have exclaimed when he heard of Alfonso's death, 'We have lost the best king in the world—one who knew how to honor the worthy, whether friend or foe.' This eulogy is, however, somewhat offset by the evidence that he was extremely cruel at times.

It is now to be noted that there are an unusual number in the pedigree of Alfonso, who have the adjective cruel or some other designation of depravity attached to them. Now a close intermarriage here will undoubtedly give rise to some of those great and valiant qualities, courage, energy and ability in the leadership of men, which were possessed by some, though not by all these royal lords and dames. There is a fair chance that the literary or possibly the pious and amiable qualities may reappear. But such a close intermarriage would be a hazardous one to say the least.

Let us take a survey of the pedigree of Alfonso XI. in order to see what proportionate amount of cruelty and depravity there is in the ancestry of each succeeding generation.

In five degrees of kinship back of Ferdinand II. (d. 1187) we find three such, among the nine persons whose records were obtainable. In the same degree for Alfonso IX. there were only two among the nine. Ferdinand III. (d. 1252), who represents the next generation, had but three degenerate ancestors among the twelve. In the same degree of kinship for his son Alfonso X., we find five among eighteen. For the next generation (Sancho IV.) the number is two in twelve. Ferdinand IV. (d. 1312), his son, had three in fifteen. So we see that this type of character, though common, was present in Spanish royalty in these early centuries only to the extent of about one in four or five, but in the ancestry of Alfonso XI., on account of a gathering of this cruel type, we find no less than eleven such among the fifteen who could furnish records of any sort. It is simply that about Alfonso XI. there happens to be brought together a number of strains from the four different countries, Aragon, Castile, Hungary and Portugal, each containing an average amount of the qualities in question. However, owing to strange jumping about, which so many characteristics show in the course of hereditary transmission, Alfonso himself shows none of them, but is himself the bridge over which they pass to appear in his son whose actions seemed more like that of a demon than a man—the incarnation of cruelty itself.

A very close intermarriage *was* made by this Alfonso IX. of Castile. His wife was the daughter of Alfonso IV. of Portugal, a brilliant warrior, but withal a cruel tyrant and the one of all rulers in Portugal on whom rests the greatest odium.*

Now let us see what proportion of the passionate and cruel would be found in five degrees of kinship for a child of Alfonso XI. by such a wedlock. Owing to the intermarriage we find but eleven different persons as several names appear twice. There are only three who are free from the characteristics in question, or eight in eleven show the passionate and cruel type. If we take all for six degrees removed we find the number even worse, eleven in fourteen. A son could scarcely escape the worst sort of inheritance, except by the greatest fortune. What did happen was this. Pedro, the only legitimate son of Alfonso XI., known in all history as 'Pedro the Cruel,' amused himself in some such ways as this. He imprisoned and foully treated his first wife, Blanche of Bourbon, and during the first part of his reign had many noblemen, among others Don Juan, his cousin, executed in his presence. Once, it is stated, in the presence of the ladies of the court he commanded a number of gentlemen to be butchered until the Queen, his mother, fell into a dead faint in company with most of the ladies present. "He then caused to be murdered his own aunt, Dona Leonora of Aragon, mother of the above Don Juan, for nothing except that Aragon would not make peace with him—'being compelled to get Moors to do the job, as no Castilian could be induced to undertake it,' says King Pedro IV. of Aragon in his memoirs. A certain priest coming before

* McMurdo's 'History Portugal,' three volumes, London, 1899.

him to say that St. Domingo had appeared to him in a dream and counselled him to tell the king that he would meet his death at the hands of his brother, Henry Pedro insisted that the priest must have been prompted by Don Henry himself, and so ordered the poor dreamer to be burnt alive. One lady, Urraca Osorio, for refusing his address, was burnt alive in the market place of Seville. Another disfigured herself in order to escape his attentions. "He was as devoid of generosity as of pity, as reckless of the truth as of life, as greedy of gain as of blood—a false knight, a perjured husband, a brutal son."*

Thus Pedro 'the Cruel' is amply accounted for by heredity alone, without bringing in the question of the inheritance of any acquired characters, and it does not seem that this brutality could be the result of the environment in which he lived since before his day when times were even rougher we find so many kings and queens possessing every virtue. There were never any before as bad as Pedro nor were there any, on grounds of heredity alone, as likely to be so. It is interesting to note that he was the great-great-grandfather of Richard III. of England, with whom he is often compared. Pedro's actions cost him the loss of most of his subjects, and finally his life at the hands of his bastard brother, Henry, who had somewhat the same characteristics though in a lesser degree.

Henry established a new line under the title of Henry II. His own origin was, probably, without distinction on his mother's side, and this is one of the four successive unions now to be discussed which can not in any way be used to illustrate the perpetuation of genius. It is also at this time that we find four incompetent rulers, three of whom are described as imbeciles. This is very significant, though I do not see that the imbecility of John I. of Castile is at all properly accounted for by heredity. Mere weakness, cruelty and licentiousness might be well expected, but not imbecility in the medical sense of the word, and I do not know that this medical sense is implied by the historians when using this term in connection with these persons. The origin of the well-known insanity in the Spanish and Austrian houses, perpetuated over thirteen generations and involving more than a score of individuals, is a very interesting question. It cannot be traced with certainty prior to Isabella, the Queen of John II. of Castile. This Isabella was out and out insane, according to the celebrated English alienist, Ireland,† and from her, onward, the insanity passed along in one form or another by the very intermarriages which their pride and political motives caused them to arrange, with the intended idea of making permanent their world power, but with the inevitable result of losing that same prestige by placing it in the

* Watts' 'The Christian Recovery of Spain.'

† Ireland, 'Blot on the Brain.'

hands of the unfortunate children whose inheritance was necessarily mental weakness as the result of such unwise wedlocks.

Without taking up the characters separately we need only look at the chart to get a clear idea of the predetermined cause which lead to the peculiar characters who were foremost during this epoch and to see how perfectly natural it was that there should have been some exhibiting the most depraved characteristics while others, like Ferdinand and Isabella, were fortunate enough to inherit the genius which we see is likewise present in a conspicuous degree. The chart shows that Isabella might be expected to be greater than Ferdinand. She had five elements of genius in her pedigree, being through intermarriage twice the great-granddaughter of John of Gaunt, Duke of Lancaster, one of the great men of his day, and John the Great of Portugal appears twice in the pedigree for the same reason. She was also the granddaughter of Henry III. of Castile, who was a model of all that a king should be. Both Ferdinand and Isabella possessed high ability and character, as can be fully confirmed by consulting any history of the times. They were married through personal choice of the queen, as she appreciated in Ferdinand a man worthy of her love. Nothing could be better for the welfare of the country than that two such able rulers should sit upon the throne at once. But Ferdinand was her second cousin and the descendant of weak or perfidious rulers.

We now see that the children of this union have two estimable parents but they have a remarkably bad lot of grandparents, and back of this we find the worst weaknesses in some while in others is much ability of a very high sort. We should not expect a child to be ordinary. On the other hand the most extraordinary is only to be expected. The two descendants whom we have here to consider are Joanna and her son, the Emperor Charles Quint. The former got the insanity and imbecility, the latter the genius and a touch of the neurosis as well. Every one in this region of the chart fills in a link in a way to be expected and is readily and perfectly explained.

The pedigree of Philip the Fair, who married this mad Joanna, contains the great fighting qualities of the old kings, tremendous energy, and great ruling functions without a bit of the insanity and weaknesses shown in Castile and Leon. This was the famous marriage that placed the Hapsburgs on the highest pinnacle of power—a marriage almost certain to produce genius and as certain to produce some descendants whose heritage would be imbecility or weakness, or whose ambition would only lead them to mad extremes. Both the genius and the insanity appear quite as we should expect, and it is to be noted that the neuroses are now seen to appear for the first time in the Hapsburgs, since they are introduced into this family through the blood of Castile and Leon; and furthermore these afflictions appear at once. From this time onward, insanity is rampant. Why should it have remained so and not have diminished through reversion to the mean? Let us look at the subsequent marriages.

The Emperor Charles V. married Isabella, a daughter of Emanuel the First of Portugal, a mediocre king; and an inbred descendant of the great Portugal house. Her mother was a sister of the mad Joanna and granddaughter of John the imbecile, and Isabella, the insane. So this may be called a pretty close intermarriage, as well as an unadvisable one. The Emperor himself was somewhat eccentric. He was cruel as well as inordinately ambitious, but he was withal a great ruler. Towards the latter part of his life he was especially subject to melancholia. The effect of this unwise marriage was of course to perpetuate these traits. We shall see under Austria how the evil qualities were much less conspicuous and how the influence of outside stock made itself felt in counteracting these undesirable perversions. The descendants bred true to kind, and in all regions of the chart we find the vicious qualities appearing in places where we should most expect them, that is, in places where the intermarriages were closest.

It is a matter of common belief that intermarriage alone is a cause of insanity, therefore, it is worth while to consider that here it is merely perpetuating what already exists and cannot be considered the cause of its beginning. In a later chapter this question will be more fully discussed. It was not yet time for the intellectual qualities to entirely disappear, for Charles Quint had two descendants who are celebrated historical characters. These were Don John of Austria and Alexandre Farnese, both of whom so distinguished themselves by virtue of their great abilities that abundant material can be found in any biographical dictionary to confirm the belief that these men were geniuses. His grandson, Albert Archduke of Austria and Governor of the Netherlands (son of Maximilian II.), was a man of high though not the highest talents. There are three others worth mentioning in this connection. The Archduke Charles, his great-grandson, is spoken of in this way:

> He died in the twenty-sixth year of his age of a malignant fever. He was deeply regretted by the nation, being universally considered a prince of extraordinary merit and endowments . . . active and ambitious spirit.*

The Cardinal Ferdinand, his brother, was a man of equal mark and merit, who as Governor of the Netherlands there warded off Spain's impending disasters until his untimely death brought a great

* Dunlop, 'Mem. Spain.'

loss upon his country. He is spoken of in the highest terms by all historians, especially for his bravery, prudence and magnanimity.* Don John, a natural son of Philip IV., also was the possessor of great qualities.

It is noteworthy that three of these six were illegitimate, and that the greatest, Alexandre Farnese and Don John, were of these three. It seems probable that owing to the extremely high-strung and unstable condition of nearly all the members of the family, a union with an entirely different class of people would be of advantage to the health and balance of mind. It was not so much that ability was needed as a toning down of the excessiveness that had been manifesting itself in so many ways.

Of these mentioned, one was a son, two were grandsons, two were great-grandsons and one was a great-great-grandson. The most eminent were the closest related, and it is probable that the number of more distant relationship would not have been so large (as in the case of Galton's tables) but for the close intermarriages, giving the genius a chance to be further perpetuated than would ordinarily have been the case.

The kings of Spain never again had anything of the renowned abilities of Isabella, Charles, or the celebrated warriors of early days like Alfonso VI. (1126), James I. of Aragon, or John the Great of Portugal. It might have been that some of the eldest sons should have inherited the great qualities instead of little ones, but Spain may be said to have been unlucky in this, and as the next three, Philip II., III. and IV., did not get the best, in each succeeding generation the chances of its reappearing become more and more dim until the probabilities of a reversion were entirely unlikely.

Let us now notice the neuroses in this same region. The amount of insanity, or at least marked deviation from the normal, should be strikingly conspicuous owing to the intermarriages. It is so. Philip II. is described in this way by Motley.

> He was believed to be the reverse of the Emperor (his father). Charles sought great enterprises, Philip would avoid them. . . . The son was reserved, cautious, suspicious of all men and capable of sacrificing a realm from hesitation and timidity. The father had a genius for action, the son a predeliction for repose. His talents were in truth very much below mediocrity. A petty passion for contemptible details characterized him from youth . . . diligent with great ambition. . . . He was grossly licentious and cruel.†

Philip II. evidently took after his grandmother, Joanna 'the Mad,' who was weak and melancholic, and perhaps also his grandfather, the feeble Philip 'the Fair' of Austria. He did not resemble either his

* Dunlop, 'Mem. Sp.,' I., 183, also Hume's 'Spain.'

† Motley's 'Rise Dutch Rep.,' Vol. I., p. 142.

father or mother. Both of Philip's marriages were from the biological point of view extremely unwise, the first being worse than the second, as Mary was a daughter of John III. of Portugal, who was weak and bigoted, in fact, a man much like Philip himself. Philip's wife was doubly related to him, being both first and second cousin, and this relation coming by way of the insane ancestors. So what wonder that the child of this union, Don Carlos, should have been one of the most despicable and unfortunate specimens of humanity in modern history?

The following pedigree of Don Carlos shows his chances of inheriting the inbred neurosis:

| | | | |
|---|---|---|---|
| | | John, = Isabel,<br>imbecile. insane. | |
| John, = Isabel,<br>imbecile. insane. | John, = Isabel,<br>imbecile. insane. | | John, = Isabel,<br>imbecile. insane. |
| Isabella. | Isabella. | Isabella. | Isabella = Ferdinand. |
| | Johanna. = Philip,<br>'mad.' weak. | Johanna,<br>'mad.' | Emanuel I., = Mary.<br>weak. |
| Emanuel, = Mary.<br>weak. | Chas. V., = Isabel.<br>melancholic. | Chas. V., = Isabel.<br>melancholic. | |
| John III. = Catherine.<br>weak. | | | |
| | Mary. = Philip II.,<br>morose,<br>cruel. | | |
| | Don Carlos,<br>madly depraved and cruel. | | |

Here if there had been many children instead of one I should say that in a rough way extreme degeneration would be likely to be present in somewhat more than half the number. It is significant to notice that the two worst characters in all modern royalty, Don Carlos and Peter 'the Cruel,' are also the two who have the worst pedigrees.

Don Carlos, it will be observed, though a great-grandson of Joanna 'the Mad' and Philip 'the Weak,' has almost exactly the same blood. Ferdinand and Isabella extend right across the chart. Emanuel I. takes his origin from a root almost identical with both Ferdinand and Isabella, and this root we have seen is the reign in which the insanity must have originated.

I do not see how Philip could have planned it better if he had wanted this son whom he really so much despised.

The son by Philip's only other productive marriage was Philip III. Here again we have a close inbreeding, though through a somewhat better route. Anne was his own niece and even more closely related than a niece, as her father was Philip's own cousin. The only outside blood was distant, by Ladislaus, King of Hungary. This blood was presumably healthy though not distinguished. Philip was a man of very low mental calibre (about grade 2). Hume says he was not a fool, though Prescott calls him the imbecile grandson of Charles V. The melancholic tendency appeared in him, though not to the extent of insanity. Ireland sums the whole situation up thus: "Philip was a man of feeble and indolent character, governed by worthless favorites. The power of Spain declined as rapidly as it had risen."*

This is the same story over again in the history of Spain. We find the condition of the country reflecting the character and strength of the monarch. Many times through the course of the centuries she had been blessed apparently through heredity by great and able rulers and her course had been hampered only here and there by the presence of a weak one; but all this from the great Emperor Charles's day onward was to be just reversed by the same almost unerring law of descent. I do not mean that a weak monarch might not exceptionally, even in those early days, reign over a glorious period. The greatness of Portugal lasted through the reigns of two weak sovereigns, Emanuel I. and John III., though the germs of decay were clearly at work. Likewise Spain's glory had its greatest outward manifestation of splendor in the time of Philip II. whose acts were nearly all injudicious. The increment of one period made itself felt in a later. Still in general the countries prospered only under the great leaders.

Philip was not as bad as Carlos, nor was his pedigree quite as hopeless. The roots from which he sprung were practically all from the weak John II. of Castile and Isabella the insane. In this he is like Carlos. However, it is to be noted that three of his immediate ancestors were excellent characters, though not especially gifted. These are represented as such on the chart. Ferdinand I. and Maximillian II. will be taken up under Austria.

The marriage of Philip III. was no more fortunate. His queen was the daughter of Charles, Duke of Styria, who was evidently not the possessor of great talents, as I have never been able to find a reference to his character or achievements. He was the son of the same Ferdinand I. Charles's wife was of 'obscure' origin. Thus the neurosis was perpetuated and furthermore the genius was not maintained. However, very high ability still cropped out in two of Philip the Third's many children. These were Charles and Ferdinand, already treated. But unfortunately the crown did not fall to either of them, and so we have an artificial election of the worst. The reign of Philip IV., who became king, was a period of great misfortune. His only good qualities were his love of art and literature, and perhaps his best bequests to the world are the famous portraits of himself and family painted by the great Velasquez.

Besides being weak and foolish he was 'far inferior to his prede-

* Ireland, 'Blot on the Brain,' p. 156.

cessor in purity of life.' "Spain might still have regained the lofty station she once held in the rank of kingdoms if at the succession of Philip IV. a wise and energetic monarch had ascended the throne."*

By his marriage with his niece, Maria Anne, he succeeded in having two degenerates, Prosper, who had convulsive fits from his birth and died young, and Charles II., who became king.

> Charles was the last of the Spanish-Austria line and in him all its weaknesses were combined. Feeble in mind and body, he was grossly superstitious and so ignorant that he did not know the names of some of his own towns and provinces.†

By his marriage with Elizabeth, who was a great-granddaughter of Ferdinand I., and consequently partially of the same tainted stock, Philip IV. had one licentious weakling out of three children. This child, Don Balthaza, the subject of the famous Velasquez recently acquired by the Boston Museum of Fine Arts, was so dissipated that he brought himself to his grave before he had reached his seventeenth year.‡ Another of the three, Maria Theresa, who married Louis XIV., was extremely stupid.

Charles V. did not have any posterity and the war of the Spanish succession deluged Europe with blood, but the Austrian House did not reach its end through any sterility caused by inbreeding, for in spite of the inbreeding it is noteworthy that they had large families, quite as large as elsewhere. Many of the children died in infancy, but the wives were not sterile. It can not be argued that inbreeding was a cause of the large percentages of early deaths, since we have also to deal with the question of insanity and neuroses. All sorts of mental and physical defects, such as are known to be frequently found in families with an insane diathesis, may have been the cause.

This completes the study of what may be conveniently classified as two groups. First (*a*) the old Castile, Leon and Aragon, families; second, (*b*) the Hapsburgs in Spain. Let us first review the characteristics of the former. This subgroup (*a*) contains 97 names. The character and ability of the 97 have been found in 63 cases with sufficient fullness for the purpose in hand. The other 34 must be marked 'obscure.' They are valuable in a negative way. There were about 39 of the total who had very marked ability, evidently considerably above the average of kings and queens and such as should place them in grades 7 to 10 of the standard here used. This percentage of over one in three is a high one, but the most striking fact is that out of the thirty actual sovereigns on the thrones of Castile, Leon and Aragon, no less than twenty-two are of this group. This

* Dunlop, 'Mem. Spain,' Vol. I., p. 23.

† Young, 'Hist. Netherlands,' p. 611.

‡ Dunlop, 'Mems. Spain,' Vol. I., p. 378

I attribute in part to the constant struggle between the rival families, between brothers of the same family and other close relatives, in their jealous greed for power and domain, thus keeping up a struggle for existence, capable of showing itself in results, and partly to fortuitous chance endowing the heir to the throne with the qualities of the stronger rather than the weaker of his ancestry. The number of weak or indolent is correspondingly small, though high temper, jealousy and ambition are present in nearly all.

I find about six persons to whom the terms feeble, characterless and indolent, are applied. Two of these, Andrew II., King of Hungary, and Ferdinand IV., of Castile, are apart from the others. The remaining four are very closely related, being father, son, nephew and his son. These are John I., John II., Henry IV. of Castile and Ferdinand I. of Aragon.

The family had already existed twelve generations before these characteristics appeared in it. In the tenth generation one of the greatest names is found in Ferdinand IV., and even in the nineteenth and twenty-first generations some of the best and most vigorous and ambitious appear in Ferdinand, Isabella and the Emperor Charles, all of whom were the descendants of the privileged few with a pedigree practically entirely of this sort extending back through more than twenty generations on all sides, and including many thousands of nobles titles.

These names which close the group are as great as those which opened it. How can this be if the assumption of rank and power is to lead to degeneration? It may be argued that the necessity for action in these times of incessant strife obliged the individuals to be energetic and so the characters were the product of their times, but we have seen that the selection alone would produce this. Furthermore, against the environment explanation we must remember the great number of able and vigorous men who appear much later in history in other countries and the descendants of forty instead of twenty generations of blue-bloods. The modern Saxe-Coburg-Gotha chart is almost entirely free from weaknesses and indolence.

The insanity apparently starts in Peter the Cruel. We have seen how his character might well have been the result of a combination of a large number of cruel persons. This insanity continually reappeared in Spain, where one finds it most rampant. It occasionally appeared in Austria, where it was less often introduced. It probably was also the origin of the Plantagenet neurosis, the full history of which I have not yet had time to study with any completeness.

# THE SIZE OF ALASKA.

By GEORGE B. HOLLISTER,
U. S. GEOLOGICAL SURVEY.

ALASKA, as a portion of our national domain, is at this time justly demanding our interested attention. Its marvelous resources and their probable rapid development are already bringing many to its shores, and will undoubtedly attract many more; hence, new facts regarding it, or old facts placed in a new light, must be of general interest. For many reasons, but chiefly because of its distance from the United States and the present difficulties of travel in its interior the size of the territory has been but little understood and probably much underestimated.

We know that its area has been stated by the geographers to be about 600,000 square miles, but unrelated figures, after all, give to

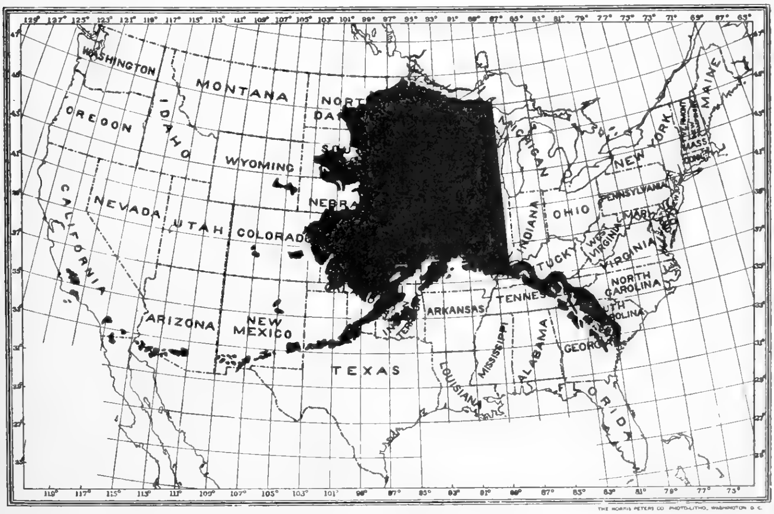



FIG. 1.

the average mind but vague ideas of the extent of territory. When it is said that Alaska has one fifth the area of the whole United States, one begins to have a more intelligent conception of its size, for in a general way the average American readily forms a fairly accurate mental picture of the broad size relations of his country. But so great is the extent of the United States and so difficult is it to judge accurately of the relations of geographical measurements that even this is not a satisfactory comparison. For this reason our practical knowledge would not be much benefited were it stated that the area of Alaska is equal to that of three and one quarter Californias, or ten Iowas, or one hundred and twenty-seven and one half Connecticuts. But if it were possible to take the whole territory of Alaska and its adjoining islands and place them upon the portion of North America occupied by the United States it would be a simple thing to show exactly what the relations of these great possessions to our own country are. Just this, in effect, has been done, as the accompanying illustration shows. The chart was prepared by Mr. Alfred H. Brooks, geologist of the U. S. Geological Survey, in charge of the government work of exploration and geological investigation of the territory, who has drawn upon the map of the United States an outline of Alaska. The scale used in both instances is the same, and the result is most interesting. When Point Barrow, the most northerly extremity of Alaska, is placed upon the Canadian border in northern Minnesota, Mt. St. Elias falls near the Ohio River between western Kentucky and Indiana, and the main portion of the territory covers almost the entire area of the Great Plains and Mississippi Valley as far south as Arkansas. The extreme southeasterly portion of the narrow strip of Alaska, upon which Sitka and Juneau are situated, would extend to the Atlantic Ocean at Georgia; the celebrated Nome District would fall in western South Dakota near the Wyoming line, and the most westerly of the Aleutian Island group would lie upon the Pacific coast line near Los Angeles; the intermediate islands touching the Mexican border in Arizona and New Mexico. In other words, the territory of Alaska is sufficient in geographical extent to reach from the Atlantic to the Pacific and from Canada to Mexico. Placed in this position on the United States Alaska would cover, in whole or in part, twenty-three states and territories, and the western third of Lake Superior.

# DISCUSSION AND CORRESPONDENCE.

## *A BIOGRAPHICAL INDEX OF THE MEN OF SCIENCE OF THE UNITED STATES.*

At the request of the executive committee of the Carnegie Institution I am compiling a biographical index of the men of science of the United States. It is intended in the first instance for the use of the institution, but it will probably also be published. The index should include all those who have carried on research in science, the term, however, being used in its narrower sense so as not to include on the one hand philology, history, economics, etc., nor on the other hand medicine, engineering, education, etc., except in so far as these applied sciences may contribute to pure science.

During the summer I sent to a large list of names (some 8,000) a blank with the request that it be filled in and returned. The blank asked more especially for information in regard to the scientific career and work of those to whom it was addressed. The response has been very gratifying, but as the circular was sent with a one cent stamp, it did not reach immediately some of those absent from home during the summer holidays. I shall be glad if those who have received this blank will fill it in and return it to me. It will be necessary to send a second request by letter postage to those who have not replied; but time and money will be saved if those who see this note will be so kind as to fill in and return the blank in case they have not already done so.

The list of those to whom the blank was sent was compiled with care, and includes the members of the scientific societies of the United States requiring research as a qualification (some fifty), the scientific staffs of the leading institutions of learning (some seventy), the scientific men included in 'Who's Who in America' and others whose names were accessible. There are, however, many connected with smaller institutions and in private life, not members of scientific societies, who have published research work of value, and I shall be glad to have assistance in securing their names and addresses. I shall be under obligations to any readers of this journal who have carried on research in the sciences, but who have not received the blank, if they will send me their names; and I shall be glad to receive the names and addresses of any who have carried on research, but whose names would not be discovered from the lists of societies, larger institutions of learning and existing biographical dictionaries.

J. McKeen Cattell.

Garrison-on-Hudson, N. Y.

# THE PROGRESS OF SCIENCE.

## *THE SMITHSONIAN INSTITUTION AND ITS DEPENDENCIES.*

The lamented death of Major Powell should not affect the work of the two great national institutions for the creation and organization of which he was chiefly responsible. Powell resigned the directorship of the U. S. Geological Survey in 1894, leaving it one of the strongest scientific agencies of the government. During the later years of his life when his health began to fail, he entrusted the administration of the Bureau of American Ethnology to his principal assistant, Dr. W J McGee, who was given the title 'ethnologist in charge.' Such divided control is not usually advisable, but in this case there was perfect sympathy and cooperation, and Major Powell appeared to have provided with remarkable foresight for the continuation of the work that he had inaugurated and successfully conducted. It is a serious blow to scientific work under the government and to anthropology in the country that Powell's plans have failed.

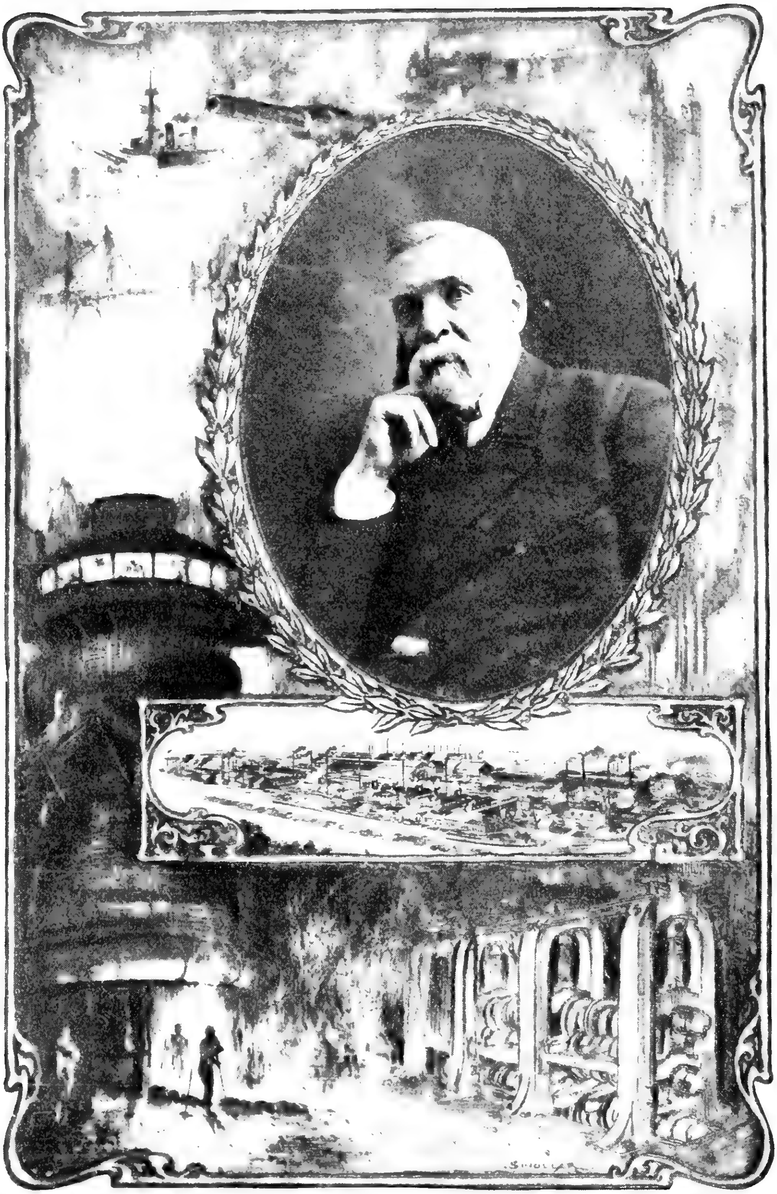
Many do not know that three of the important scientific institutions supported by the government are administered by the Smithsonian Institution—namely, the National Museum, the National Zoological Park and the Bureau of American Ethnology. The two first secretaries of the Smithsonian, Henry and Baird, were always ready to undertake plans for 'the increase and diffusion of knowledge among men,' in accordance with the terms of Smithson's remarkable bequest. When a scientific movement had been inaugurated they were glad to place it under the conditions most favorable to its development. It suffices to mention the weather reports inaugurated by Henry and now conducted as the Weather Bureau under the Department of Agriculture, and the movement for fisheries inaugurated by Baird, which has become the Fish Commission. In accordance with this policy, Henry recommended the separation of the National Museum from the Smithsonian Institution, believing that it would be more liberally supported under direct governmental control and that the institution would be freed for work that it only could do.

The policy of his predecessors has not been followed by the present secretary of the institution. It is generally believed that the miserable building of the museum would long ago have been replaced by a building such as is possessed by the American Museum of Natural History in New York City and that the collections would be far larger and more symmetrical than they are if the museum had been handed over to the Department of Agriculture. The development of the museum under adverse conditions was largely due to the late G. Brown Goode. On the occasion of his death some six years ago, however, the secretary of the institution did not for some time appoint a successor at the museum, but divided the work among three head curators. Now, on the occasion of the death of Major Powell, the secretary has given to one of these curators the directorship of the Bureau of American Ethnology, not, however, giving him the title of 'director,' but that of 'chief,' thus lessening the importance of the position, while subordinating it to the National Museum and to the secretary of the institution. If this were done in order that the secretary might take more direct interest in the work of the bureau it might be excused, but as he is known to have shown lack of sympathy with its work in the past, it is naturally supposed that he purposes to subordinate the research work of the bureau to the collections of the museum. It seems extraordinary that a bureau supported by an appropriation from Congress should be entirely at the mercy of one who is not an officer of the government and whose action is apparently exempt from any control. The office of director of the Bureau of American Ethnology, though not created by Congress, has been officially acknowledged by an act of Congress, and it does not seem possible that this office can be summarily abolished or that Congress will agree to the subversion of the bureau. It is not likely that a physicist, supposed not to be in full sympathy with work in natural history, will be allowed to dictate the policy of the National Museum, the National Zoological Park and the Bureau of American Ethnology, when it is known that his actions are almost unanimously disapproved by the scientific men of the country. It is obvious that the situation is complicated rather than relieved by the fact that the secretary of the Smithsonian Institution and those whom he has placed in charge of its dependencies are men of eminent scientific attainments and of the highest character.

It is probable that the result will be the separation of these institutions from the Smithsonian Institution. The National Zoological Park will then be made not merely a toy for the entertainment of children, but also a laboratory for scientific work. The National Museum will no longer be regarded chiefly as one of the sights for visitors to Washington, but will take its place with the museums of the British, French and German governments. The Bureau of Ethnology will extend its work, so that it will include in its scope the native tribes of our newly acquired possessions, the negroes, the immigrant races and the general ethnology of the people, affording information of the utmost importance for their government. The president of the United States recommended in his first message to congress that the scientific bureaus be concentrated under the Department of Agriculture, and it is to be hoped that Congress will find time to consider the question in the approaching session. If this occurs there is no question but that the institutions supported by the government but administered by the Smithsonian Institution will be transferred to the Department of Agriculture. This will not only give these institutions scope for free development, but will release the Smithsonian Institution from irksome official duties, and will permit it to carry forward more effectively its mission for the increase and diffusion of knowledge.

### *THE UNIVERSITY PRESIDENT.*

Four important institutions of learning have witnessed the inauguration of new administrations during the past month. Hereafter we must speak of President Wilson of Princeton, President Swain of Swarthmore, President James of Northwestern and Chancellor Strong of Kansas. Dr. Carroll D. Wright has also been installed as president of the collegiate department of Clark University. The duties of a university president are so comprehensive and diverse that it is not surprising that men of varying qualifications and types of character are chosen. To run back ten years we find a professor of Semitics at Chicago, a zoologist at Stanford, a philosopher at Cornell, a man of business at Pennsylvania, a student of Greek at California, a clergyman at Brown, an economist at Yale, a chemical investigator at Johns Hopkins, a student of education at Columbia and so on. Those acquainted with these men and even those who have merely seen them together on the stage at one of the inaugural exercises or



J. Fritz

other university functions that have become so numerous in recent years realize that their types of character are as various as their interests. As evolution progresses by variation and survival of the fit we may look for rapid progress in educational administration from the great diversity of college presidents presented for natural selection.

The most striking contrast is evident between the inaugural addresses of the new presidents of Northwestern and Princeton. The Salvation Army captain and the Jesuit priest are not more unlike. President James is full of the spirit of democracy and progress; he overflows with the popularization of the university, technical training, coeducation, university extension, correspondence schools and the like. President Wilson dreads all these things. "In order to learn," he tells us, "men must for a little while withdraw from action, must seek some quiet place of remove from the bustle of affairs." "I believe general training, with no particular occupation in view, to be the very heart and essence of university training." President Wilson here obviously confuses the college with the university, due doubtless to the fact that the college of New Jersey has altered its name to Princeton University, without a corresponding extension of its functions. Whether or not a college for liberal culture, student life and athletics should be maintained apart from a university is still a disputed question. President Hadley in his address at the installation of Chancellor Strong, seems to have struck the correct note when he said:

We should seek for the solution of our university problems, not in the enforced addition of a German course to an English one, but in a combination of the English spirit with the German organization; so that we can teach professional studies without teaching the spirit of professionalism. . . . If our educators can manage to combine the framework of the German university with the spirit of the English university, or of the old-fashioned American college, they will economize the time of the student without sacrificing the educational result to be achieved. They will give to the community, for whose benefit they exist, the trained experts on which the community insists; and they will at the same time provide for the maintenance of that healthful public spirit in the individual and public sentiment in the body politic on which it may sometimes perhaps not so strongly insist, but which it needs all the more for its permanent continuance and prosperity.

## *THE JOHN FRITZ MEDAL.*

The four great American engineering societies—The American Society of Civil Engineers, The American Institute of Mining Engineers, The American Society of Mechanical Engineers and The American Institute of Electrical Engineers—have united to establish a medal in honor of John Fritz, the well-known iron master and mechanical engineer, who has at Bethlehem done so much to forward the engineering interests of the country. Subscriptions of $10 were invited from the members of these societies and the sum of $6,000 was contributed. The design has been executed by Mr. Victor Brenner, and a gold medal will be awarded each year for achievement in the industrial arts and sciences by a joint committee of the societies mentioned above, and it is expected that this medal will have the same representative character as is held by the Bessemer medal conferred by the British Iron and Steel Institution. In addition to the establishment of this medal, a dinner was held in New York City on October 31 to celebrate Mr. Fritz's eightieth birthday. The arrangements were made by the same societies and five hundred members and guests were present. Speeches were made by representatives of the different societies and others, and Mr. Fritz responded. We reproduce the frontispiece of the program—a portrait of Mr. Fritz, the industries with which he has been identified and his signature.

### *GASES IN INTERPLANETARY SPACE.*

The question of whether interplanetary and interstellar space is a vacuum or contains matter in an exceedingly attenuated form is an interesting problem, and one upon which there has long been much speculation. On the one hand the planets give no evidence of an impeding friction, but on the other hand the evidence of such friction in the case of certain comets seems possible. When the earth's atmosphere was supposed to consist solely of oxygen, nitrogen and carbon dioxid, it appeared very improbable that these should pass to any considerable distance away from the surface of the earth, but, with the more recent knowledge of the constituents of the atmosphere, this thesis seems less certain. The discovery of argon by Rayleigh and Ramsay has led to the further discovery of the presence of helium, neon, krypton and xenon, which have enriched chemistry with a new type of chemical element, having no affinity, forming no compounds, and being, as far as has yet been found, perfectly inert. At the same time comes the knowledge that no inconsiderable quantity of hydrogen is a constant constituent of the atmosphere. This has been abundantly proved by Gautier, by Dewar and by Ramsay. Of these gases, hydrogen is the lightest of terrestrially known elements, but helium is not far behind it, and has not yet been changed from its gaseous form to that of a liquid. The methods which have availed to condense hydrogen to a liquid have thus far failed with helium. Turning to the chemistry of the sun, the spectroscope shows the presence of an atmosphere largely of hydrogen, but helium is also present, extending far out from the central mass of the sun. The same instrument reveals lines indicating other elements at still greater heights in the sun's atmosphere, among them one which has been named coronium. From its position far away from the surface of the sun, it seems probable that coronium has a density far less than that of even hydrogen. Again, the evidence of the spectroscope upon the lightest constituents of our atmosphere points to the presence of other gases than helium and hydrogen, and this is reinforced by what the same instrument shows of the aurora. The latter appears to be an electric phenomenon, concerned with elements at least in part now unknown to us, and at a height above the surface of the earth at which it was long supposed there could be no appreciable atmosphere.

It thus appears that the upper strata, both of the sun and of the earth, consist of the lighter constituents which are largely removed from the lower atmosphere by their lightness, and no limit can be placed upon the distance to which these elements would travel from sun or earth into interplanetary space. What is true of sun and earth is doubtless true also of other planets and other suns, and it seems not impossible that even interstellar space may contain these and similar gases in an almost infinitely attenuated condition. What the condition of these gases may be at the temperature of interstellar space, which cannot be far removed from absolute zero, it is difficult to say. On the one hand, at such a temperature they might be expected to be solids, but, on the other hand, the particles would be relatively so few and far apart from each other that they would have the properties of a gas. The great advance in our knowledge of these fields during the last few years gives promise of much new light in the near future.

### *THE DESTRUCTION OF FORESTS BY FIRE.*

A press bulletin from the Bureau of Forestry gives an abstract of a forthcoming paper entitled 'Forest Fires,' by Mr. Alfred Gaskill. By impressing the public with some idea of the peril it suffers from forest fires, and the enormous damage they do, the bureau hopes to induce more effective legislation in suppressing them.

Investigation has shown that, in an average year, 60 human lives are lost in forest fires, $25,000,000 worth of real property is destroyed, 10,274,089 acres of timber land are burned over, and young forest growth worth, at the lowest estimate, $75,000,000, is killed. A special canvass of the country by the Department of Agriculture in 1891 discovered 12,000,000 acres of timber land destroyed by fire. These figures are mere estimates, which fall far short of showing in full the damage done. No account at all is taken of the loss to the country due to the impoverishment of the soil by fire, to the ruin of water courses, and the drying-up of springs. Even the amount of timber burned is very imperfectly calculated, and the actual quantity destroyed is far in excess of that accounted for. Forest fires in this country have grown so common that only those are reported that are of such magnitude as to threaten large communities. The lumbering industry in remote sections of the country may be ruined and people forced to flee for their lives without a mention of the disaster beyond the places near where it occurred.

The fires that burnt this year in Washington and Oregon were uncommon only in the number of lives lost. The burning of logging and mining camps and farm buildings, the loss to the country in the destruction of timber and young tree growth, is of yearly occurrence. Every fall, not only in Washington, Oregon, Colorado and Wyoming, but up and down the Pacific coast and all over the Rocky Mountain country fires burn great holes in the forests and destroy the national wealth. The air of the mountains over hundreds of miles is pungent with the smoke of conflagration, and navigation on Puget Sound has often been impeded by smoke. The following comment by Dr. Henry Gannett, of the U. S. Geological Survey, should convey a fair idea of the damage done in the state of Washington: "In less than a generation two fifths of the standing timber has been destroyed in one of the richest timber regions on the continent, and of the destruction more than half has been caused by fire. Assuming that the timber would, if standing, have the value of 75 cents per thousand feet, not less than $30,000,000 worth has gone up in smoke, a dead loss to the people of the state."

## *SCIENTIFIC ITEMS.*

Ogden Nicholas Rood, since 1863 professor of physics in Columbia University, one of the most eminent American men of science, died on November 12, in his seventy-second year. We hope to publish subsequently some account of Professor Rood's life and work.

Some years ago Mr. Hodgkins left his fortune to the Smithsonian Institution to be used for the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man, the endowment amounting to about $250,000. Part of the fund has been used to establish a Hodgkins gold medal, which in 1899 was awarded to Lord Rayleigh and Professor Ramsay for their discovery of argon. A second award of the medal has now been made to Professor J. J. Thomson, of the University of Cambridge, for his investigations on the conductivity of gases, especially the gases that compose the atmospheric air. An engraving from this medal, made by M. Chaplain, is here given. Professor Thomson has just been appointed the first lecturer at Yale University on the foundation established with a bequest of $85.000 from Benjamin Silliman.

The degree of LL.D. was conferred on Dr. Alexander Graham Bell at St.

Andrew's University on October 23, on the occasion of the installation of Mr. Andrew Carnegie as rector.—Mr. William Sellers has been nominated for the presidency of the American Society of Mechanical Engineers.—Professor Kohlrausch, president of the Reichsanstalt, has been elected a foreign member of the Swedish Academy of Sciences.

Mr. John Morley has given the library of the late Lord Acton to Cambridge University. It will be remembered that this valuable historical library of some 70,000 volumes was purchased some time ago by Andrew Carnegie from Lord Acton, who was allowed to retain it until his death. Upon Lord Acton's death Mr. Carnegie gave the library unconditionally to Mr. Morley.—It is announced that the entomological collection of the late John Ackhurst, of Brooklyn, containing some 50,000 specimens, has been purchased for the zoological department of the University of Chicago.—The collection of the birds of Holland, formed by Baron Snouckaert van Schauburg and mounted by Tar Meer, the celebrated Dutch taxidermist, has been purchased by the Carnegie Museum.


A commemorative tablet has been placed on the house at Favières in which Professor A. A. Liébeault was born. It states that he opened a new era in the medical sciences by his discovery of the systematic application of suggestion and induced sleep in the treatment of disease. The tablet was unveiled in the presence of Professor Liébeault on his seventy-ninth birthday.—An effort is being made by the mayor and municipal council of St.-Just-en-Chaussée, Oise, France, to raise a memorial to two famous men who were born in that town, the brothers Haüy-René Just, founder of mineralogy as an exact science, and Valentin, the philanthropist, who founded the first school for the blind.

THE
POPULAR SCIENCE
MONTHLY.

JANUARY, 1903.

# THE MISSOURI BOTANICAL GARDEN.

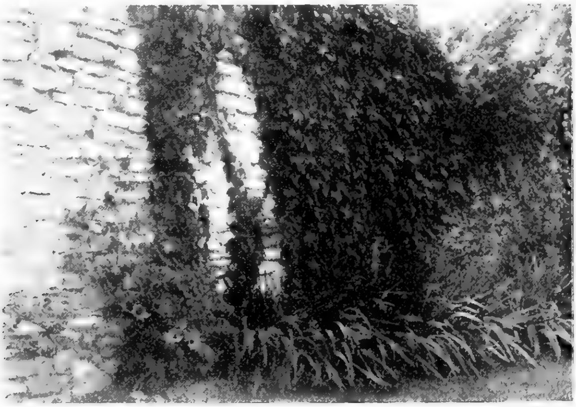
By Professor WILLIAM TRELEASE,
DIRECTOR OF THE GARDEN.

IN 1840, Henry Shaw, an Englishman who had settled in St. Louis in 1819, retired from business with the—for that time—large fortune of a quarter of a million dollars. Revisiting the land of his

Henry Shaw.

birth, he saw how Englishmen enjoy the fruits of labor such as that by which he had acquired this large sum of money. Traveling on the continent, he saw what the world of pleasure offers to those who are able to pay for it. But he returned to the land of his adoption, determined to make for himself there surroundings as nearly as possible comparable with those of his own countrymen; and he so far succeeded that the modest little garden with which he surrounded his country house in the suburbs of St. Louis came in time to be the pleasantest of the resorts of the residents of that city, and the one place to which they were all sure to wish to take their visiting friends.

If he had stopped with this, he would have caused his name to be long remembered by his fellow-citizens, for he did not hold his home as his own exclusively, but admitted to the enjoyment of its beauties any who wished to share them with him. But while his grounds were developing and growing in beauty, he learned, through the helpful acquaintance of Sir William Hooker and of his own fellow townsman,



WALL GARDENING.

Dr. George Engelmann, that it might be possible to perpetuate his name in a surer and more lasting manner, and to cause the garden that he had planned and planted to become of use in the world of science and to grow in such usefulness through the centuries, while losing nothing of its beauty and attractiveness to those who cared to enjoy without using it. In 1859 he secured the passage of an act by the legislature of Missouri which empowered him to deed or will, as he might elect, such of his property as he wished, to trustees for the maintenance of "a botanical garden for the cultivation and propagation of plants, flowers, fruit and forest trees, and for the dissemination of the knowledge thereof among men, by having a collection thereof easily accessible; by the establishment of a museum and library in connection therewith, as also by establishment of public lectures and instruction upon botany and its allied sciences, when it shall be deemed advisable in furtherance of the general objects of said trust; and . . . for the purpose of maintaining a perpetual fund for the support and maintenance of said garden, its care and increase, and the museum, library and instruction connected therewith.''

As the new and larger plans shaped themselves in Mr. Shaw's mind, they began to take form on the grounds, and a flower garden, arboretum, and fruticetum—Loudon's main parts of a garden—were quickly laid out and planted, and separated and fronted by rubble walls in the outermost of which a severe but rather impressive gate-house, bearing the chosen name of the establishment—Missouri Botanical Garden—was built. Not far from his house, Mr. Shaw put a small fireproofed building, over the door of which the inscription 'Botanical Museum

THE MUSEUM BUILDING.

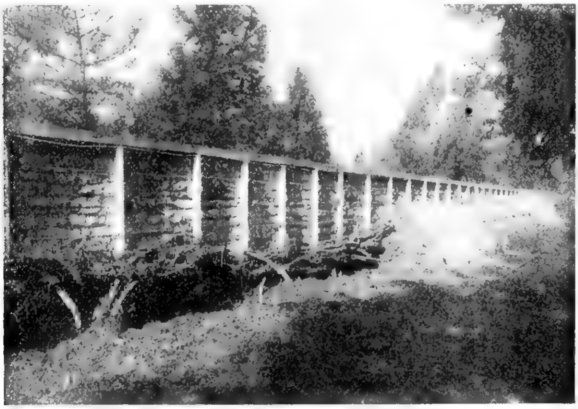
and Library' was cut in the stone, and in which, largely through the interest of Dr. Engelmann, were soon installed a small but well chosen collection of books, and some 60,000 specimens of plants, consisting of the herbarium of the then lately deceased Professor Johann Jakob Bernhardi and a small local collection made by Riehl. The arrangement of these specimens, Mr. Shaw once informed me, was entrusted to 'a young man named Fendler,' whose name was already known as that of an expert collector and destined to be made still better known by subsequent work in the tropics. On the occasion of my introducing to him a gentleman who was making a study of the flora of Missouri and who wished to consult the Riehl collection, Mr. Shaw expressed the regret with which he observed that though the flower garden was visited by thousands of people each year, and the contents of the small and miscellaneous museum attracted them, this was the only request for access to the herbarium or library that had been made by a botanist for years.

From time to time he turned his thoughts toward the fuller realization of his plans, apparently hesitating between leaving their inception to the trustees that he had provided for appointing by will, and making the beginning himself either alone or in conjunction with trustees—a possibility specifically provided for in the enabling act of the legislature. On the occasion of my first visit to him, in the early spring of 1885, he pointed out to me the place, on Flora Avenue, before the main gate of the garden, where he had seriously thought of building lecture rooms, laboratories and residences for a faculty of botany. It was somewhat earlier than this that he called the great botanist, Asa Gray, into his counsels, and largely because of the wise advice of Dr. Gray, who saw that the time was not yet come in St. Louis for an institution such as was contemplated, he decided to let its growth be a normal one from small beginnings—but without in the least modifying his provisions for the final attainment of the largest results he had ever contemplated. Amid the beautiful surroundings of his country home, though also maintaining a city house, Mr. Shaw passed the latter half of a very long life—always coming back to the reconsideration of the coming development of his plans, modifying them in details, but never altering their original breadth as shown in the act that had been passed so many years before. To the garden he welcomed all who cared to visit it, and himself dictated the position of nearly every tree or smaller plant set out.

It was apparently the death of Engelmann, a resident of St. Louis and one of the greatest as perhaps the most accurately painstaking of American botanists, that caused the next step forward to be taken. Shortly after this, in 1884–5, Dr. Gray was once more, and this time rather urgently, called into consultation, that the city in which the plans were laid might not be entirely without a botanist; and the result was that in the spring of 1885 Mr. Shaw proposed to the directors of Washington University to endow in that institution a school of botany, with the understanding that by testamentary provision the best uses of his garden for scientific study and investigation should be ensured to its professor and students. The offer being accepted, the Henry Shaw School of Botany was formally inaugurated on the sixth of November following, and its single professor was thrown into a pleasant and frequent personal intercourse with Mr. Shaw which lasted until the death of the latter. About this time, suggestions were not lacking, from men of judgment, that by rendering the union between the garden and school of botany still closer through placing the former under the care of the directors of the university, it might be possible to ensure a much larger revenue for the needs of the garden since the university enjoys exemption from taxation under an old charter, which the new establishment could scarcely expect to secure with the existing constitutional provisions of the state. The arguments were well considered, but the saving of money—which to-day would amount to over $25,000 annually—did not weigh in Mr. Shaw's mind as contrasted with autonomy, and when he died, in August, 1889, his will was found to provide for the administration of the garden by an independent board of trustees, consisting of fifteen persons; ten named by the testator, and the other five holding office as trustees *ex officio,* in various capacities: The chancellor of Washington University, the bishop of the episcopal diocese of Missouri, the president of the public school board of St. Louis, the president of the Academy of Science of St. Louis, and the mayor of the city. Two additional honorary trustees, whom he evidently hoped to have assist in the inauguration of the establishment on broad lines, were named: Dr. Asa Gray and Professor Spencer F. Baird—neither of whom, unfortunately, survived Mr. Shaw, while it is evident from the phrasing of his will that their places were not intended to be filled. Two other citizens of St. Louis, named as trustees in the will, had died, also, before the testator, and it was held by the courts that their places should not be filled. Except for the members *ex officio,* the board of trustees is a self-perpetuating body, itself filling vacancies as they occur.

GEORGE ENGELMANN.

The testamentary provisions for the carrying out of Mr. Shaw's purposes do not differ in any essential respect from the plan sketched in the enabling act of 1859—passed because there was at that time some uncertainty as to the possibility of otherwise making the provisions that he wished to make in such manner as to ensure their permanence. The purposes of the trust are stated by him in his will to be "having for the use of the public a botanical garden easily accessible, which should be forever kept up and maintained for the cultivation and propagation of plants, flowers, fruit and forest trees, and other productions of the vegetable kingdom; and a museum and library connected therewith, and devoted to the same and to the science of botany, horticulture, and allied objects." Provision is distinctly made for the perpetual maintenance of the establishment on the original site; for holding the endowment in the form of real estate, in which Mr. Shaw, following English custom, had made most of his investments; for the establishment of public lectures on botany and allied sciences; additions to the collections of plants, the museum and the library; exchanges; increase in the means and appliances of instruction; and



A Bit of Horticulture. Figs Prepared for Winter.

the maintenance of the revenue of the school of botany up to a specified point. It is provided that there shall always be a director of the garden, appointed and subject to removal by the board of trustees, by whom his duties are from time to time to be prescribed, but who, "when within the sphere of his duties thus prescribed and while he shall faithfully perform those duties thus prescribed . . . shall not be subject to the interference, management or control of said board," though without such construction of this provision being possible as to take away from the board the permanent control over the garden and the grounds of the institution. The director's residence is indicated as the garden home of its founder, and he is required by the will to devote his entire time and efforts to its interests, and to so employ his energies that from year to year the institution shall grow up in efficiency in promoting the ends in view in its inception.

Provision is made for the cooperation of the garden and the school of botany by the requirement that the professor or professors in the latter shall be the director of the garden or his chief assistant, or both, or that they shall be appointed on nomination of or subject to the approval of the trustees of the garden. The instruction of garden pupils is specifically indicated as a purpose of the institution, and among the subjects that are mentioned as forming a part of the purpose of its founder are horticulture, arboriculture, medicine and the arts, so far as botany enters into them, and scientific investigations in botany proper, vegetable physiology, the diseases of plants, the forms of vegetable life, and of animal life injurious to vegetation, and experimental investigations in horticulture, arboriculture, etc.; but the testator wisely adds: 'I leave details of instruction to those who may have to administer the establishment, and to shape the particular course of things to the condition of the times.'

THE GARDEN HOME.

The intention and obvious need of maintaining the establishment as an ornamental garden are evident in the many references to it as a fundamental idea, and Mr. Shaw very specifically states that he considers it 'an important feature to always keep up the ornamental and floricultural character of the garden.' Direction is given that the yearly net revenue from the endowment shall be applied 'first to the payment of the salaries of the director, assistants, professors and gardeners, and the payment of the wages of the employees and laborers, in keeping up the grounds in good style and providing for the preservation and increase of the plants and trees, and preserving the buildings and inclosures of the grounds, and secondly to the purchase of plants, flowers, and trees, additions to the library, the enlargement and improvement of the garden when necessary or advisable, and such other expenditures as from time to time may be found necessary' in furtherance of the purposes of the testator.

That, in the many specifications of provision for instruction and research, sight should not be lost of his wish that the institution, as a place of beauty, should always afford the pleasure to coming generations that it had given to the people of Mr. Shaw's own day, and that its connection with the outside world might be a pleasing, helpful and broad one, he provides that, though closed on holidays and Sundays as a rule, it shall be opened on the afternoon of the first Sunday each in June and September—dates on which it presents at their best two distinct phases of its attractiveness, the roses and other spring shrubbery on the one, and the decorative bedding on the other; that there shall be preached each year, by a preacher and in a church selected by the episcopal bishop of the diocese of Missouri, a sermon on the wisdom and goodness of God as shown in the growth of flowers, fruits,

SUNDAY VISITORS.

and other products of the vegetable kingdom; that premiums may each year be awarded at a flower show in St. Louis; and that each year there shall be given a banquet to the trustees of the garden and the guests they may invite—literary and scientific men, and friends and patrons of the natural sciences, and a banquet to the gardeners of the institution and invited florists, nurserymen and market gardeners of St. Louis and vicinity.

Immediately after Mr. Shaw's death, the admittance of his will to probate making known the constitution of his board of trustees, the latter organized and appointed as director the professor selected by Mr. Shaw to take charge of the school of botany, defining his duties as 'the duties prescribed for that office in the last will of Henry Shaw, deceased, and such other duties as may from time to time be prescribed by this board in pursuance of the trusts declared in said will.' Under its organization, the board holds monthly meetings for the transaction of business connected with the management of the large endowment property—which at the time of Mr. Shaw's death was appraised at not far from a million and a third dollars, and which is now carried on the books as $1,588,274.60—and the consideration of current administrative details of the Garden. The board consists of some of the most representative citizens of St. Louis, and is possessed of the fullest confidence of the community, as is shown by the attitude of the courts, when, as has several times proved desirable, instructions have been asked on questionable points, or special powers requested. The most notable instance of this is afforded by a request of the board for power to sell certain endowment real estate left by Mr. Shaw and distinctly made inalienable by the terms of both the enabling act and his will, but which was found incapable of utilization for long-term residence leases, as contemplated by him, because of the unwillingness of American home builders to make use of leased ground. Notwithstanding the clear provisions against the alienation of real estate, the courts, being convinced that these provisions brought a detail of the will into conflict with its purpose, granted the desired permission after full consideration of the question in both the lower and supreme court. By the provision of small committees charged with specific duties, the board is able to give remarkably detailed care to the many phases of its trust, and from month to month the plans of the director for the administration of the establishment are passed in review and provided for by suitable appropriation of funds.

A CARNIVOROUS PLANT—*Drosera brevifolia.*

In the development of the Missouri Botanical Garden, two distinct periods are already distinguishable: a first, now drawing to an end, in which, because of the unproductiveness of a very large part of the endowment property, and the need of protecting the latter by the accumulation of a reserve fund sufficient to cover improvement costs that might at any time be assessed against it, little could be hoped for except the bare maintenance of the institution on the lines indicated by its founder, which, having been inaugurated by him only in part, at once increased the expense of maintenance considerably beyond the point at which it had been when the garden was only the home of a private gentleman; and a second, now in sight, in which the realization of his plans to make of the garden a center of research and instruction is to be looked for in greater measure with the passage of every year.

During the first, or maintenance, period, both trustees and director

GENERAL EFFECT—THE GROVE.

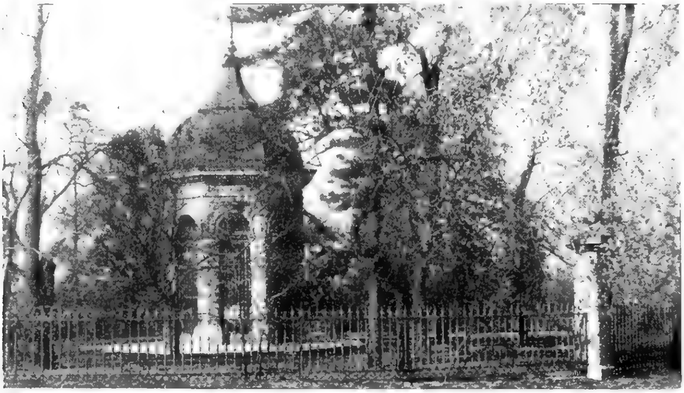
have taken the ground that standing still was impossible—that the institution must either advance or recede—and maintenance, therefore, has really meant slow growth in most of the directions contemplated by its founder. In one single respect, only, has ground seemingly been lost—for the small museum, which, in the later years of

DETAIL—A MOSAIC OF SUCCULENTS.

Mr. Shaw's life, under the care of household servants had deteriorated so far as to be neither useful nor creditable, was closed when his trustees took charge of the establishment; and the need of using the museum building for other purposes has as yet prevented renovating and reopening it. Under the liberal policy of his trustees, the collection of living plants has increased from a scant 2,000 to 10,000 species or varieties; the decorative features have each year grown in variety and attractiveness; the library has increased from less than 1,000 volumes to over 36,000 books and pamphlets; the herbarium has increased from a little over 60,000 sheets of specimens to about 400,000 sheets; a course of instruction for garden pupils has been put in operation, which has trained a number of the best of the young men now engaged in horticulture—in the broad sense—in the country; the school of botany, though it has not had many students, has given botanical instruction to such of the undergraduates of Washington University as wished to take up this study, either as pure botany or in connection with medicine or engineering, and has prepared for the Doctor's degree in the university several candidates whose theses have reflected credit on the institution as well as on themselves; and, during the laying of what must be conceded as a solid foundation for the more rapid development and greater productiveness of the next period of the garden's history, time has been found by the garden staff for the performance of sufficient research work in various departments of botany and horticulture to have caused its recognition as an establishment for this purpose.


A SPECIMEN PLANT—*Martinezia caryotæfolia.*

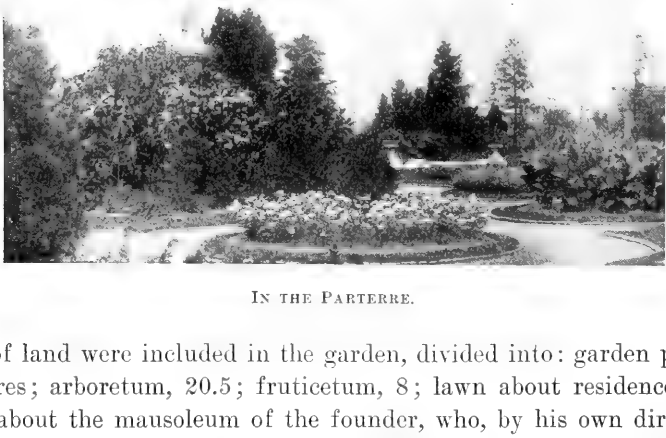
During the laying of the foundation for the greater productiveness of the garden, sight has not been lost for a moment of the desirability of maintaining it as an attractive resort for the lovers of the beautiful, and it may be said that considerably over 100,000 persons visited it last year—some 43,000 on the two open Sundays. As is always the case in large places, detail is often lost in mass effect, or the seeker after detail sees nothing of broad treatment; and in the administration of the institution there is not a day which does not bring to the director more dissatisfaction with either general effect or detail than is made good by contemplation of the best that either offers. And yet the impression that the garden makes on those whose comments reach the office, appears to be that of a place of beauty—and it is often a matter of surprise when I become critical of the dwarfing of individual plants that attends their massing either in the open air or in the



The Mausoleum.

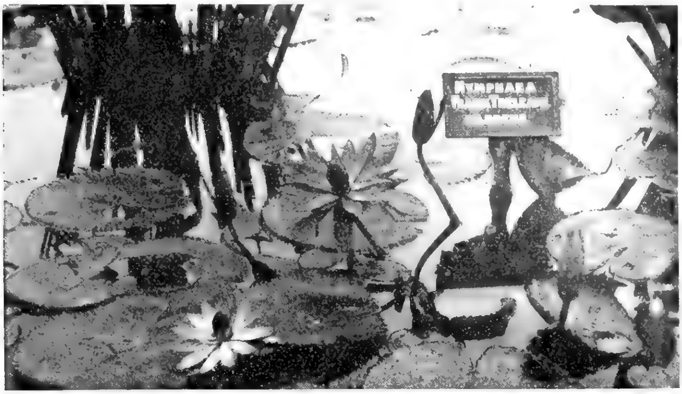
crowded plant houses, to find that excellent specimen plants of hundreds of species are capable of disentanglement whenever they are needed for any particular use or can be allowed adequate space.

At the time of Mr. Shaw's death a fraction less than forty-five



In the Parterre.

acres of land were included in the garden, divided into: garden proper, 9.4 acres; arboretum, 20.5; fruticetum, 8; lawn about residence, 2.7; grove about the mausoleum of the founder, who, by his own direction, is buried on the grounds, 0.6; and vegetable garden—the garden first laid out by Mr. Shaw, at the rear of his house—3.5 acres. Though changes cannot be held off indefinitely, the several parts of the garden as existing at the time of the organization of the board of trustees have thus far been maintained in much the form that they presented during Mr. Shaw's life.



One of Mr. Gurney's Lilies.

The central garden consists of a sunken parterre immediately facing the main gate, through which most visitors enter the grounds; a series of regular beds separated by low hedges, lying to the left and centered about a pavilion from which a bird's-eye view of the whole is had; and a group of plant houses, with lawn and bed surroundings,

Wild Flowers among the Trees.

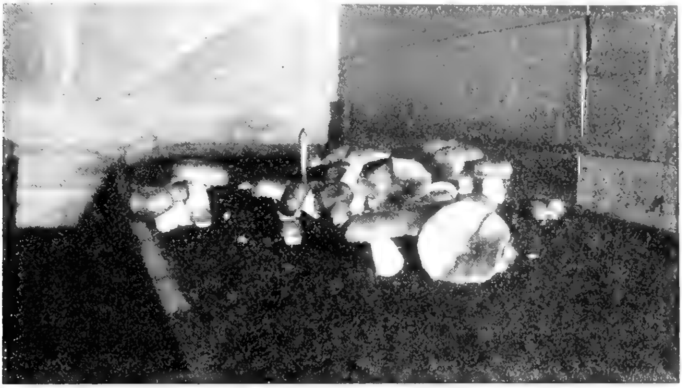
at the right. It is on this part of the garden that the largest annual expenditure for maintenance is made, for there is no class of open-air gardening so expensive as flower-gardening in beds separated by lawns that are kept properly mown. Among the additions that have been made to this part of the garden are ponds for the cultivation of the Royal Lilies (*Victoria Regia* and *V. Cruziana*) and other water plants —a group which is a particular favorite of the head gardener, Mr. James Gurney, who has originated several beautiful and remarkable hybrids and seedlings in it.

The arboretum, which for some reason was planted with the trees in rows, as in a nursery, has always been kept in a less polished condition than the flower garden, affording opportunity for the spontaneous growth of many of the wild plants of the region—indeed, a portion of it has never been plowed, and its prairie vegetation is left undisturbed by the scythe until after the year's growth is finished. It contains a varied collection of trees, many of them now of mature growth, though the tornado which devastated St. Louis in 1896 destroyed some of the choicest of them and mutilated others. In its park-like character, the arboretum affords a restful change from the more formal flower garden, and its studied air of neglect is not the least of its charms. With the growth of the manufacturing interests that have necessarily followed the lines of the great railroads passing not far from the northern and western limits of the garden, has come a considerable change in the possibility of growing perennial plants, and particularly coniferous evergreens, which, intolerant of smoke to a degree scarcely surpassed except among the lichens—which I have never seen growing in the garden—have gradually succumbed, until, notwithstanding constant efforts to replace them, they have all but dropped out of cultivation.

IN THE ARBORETUM.

In the so-called fruticetum, which, from the nature of its present use, is kept closed to the ordinary sight-seer though always opened to those to whom its contents are of real interest, is growing, in addition to the shrubbery properly constituting a fruticetum, a small collection of the fruits best adapted to the climate of St. Louis, replacing the old orchard into which, in the later years of Mr. Shaw's life, this section had grown, but which was almost entirely destroyed by the tornado.

The vegetable garden furnishes to the pupils being taught under the founder's will, the means of practise in vegetable growing, which,



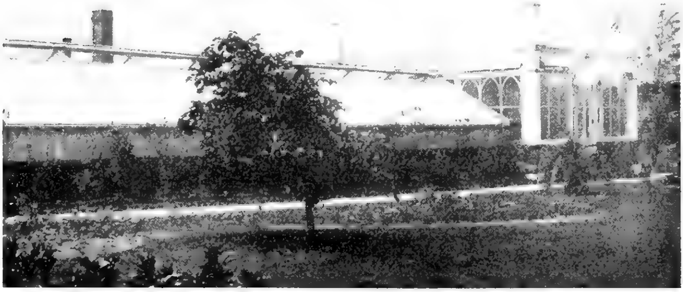
A MUSHROOM BED—*Agaricus amygdalinus*.

by the provision of a small forcing house, is carried through the entire year. About the old residence, which, by direction of Mr. Shaw, is

THE OLD RANGE.

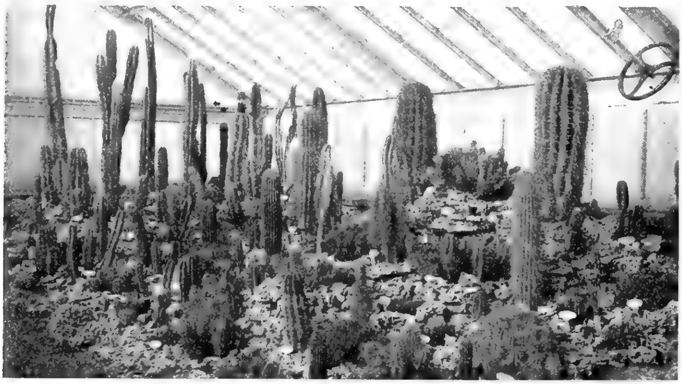
occupied by the director, is still maintained the ample expanse of grass which has always characterized this part of the grounds; this is augmented by a shaded and shrub-planted strip around the vegetable garden, which Mr. Shaw called the pleasure ground, and which has been the scene of some of the pleasantest entertainments of a bygone generation of St. Louisans.

Adjoining the arboretum and vegetable garden is a pasture area of some eighty acres, of which one fourth has recently been graded, drained,



MODERN HOUSES.

supplied with water, and partially planted to a synopsis of North American plants arranged in the familiar sequence of families adopted by Bentham and Hooker, while the remainder will shortly be molded and planted to a general synopsis exemplifying the more modern arrangement of Engler and Prantl, on plans already largely prepared.



A CACTUS HOUSE.

Gardening within doors was not a large part of the art as formerly practised, and the plant houses are far from meeting the wishes of the gardeners, even to-day. The earlier of these were built before the days of light and airy steel construction, and to grow symmetrical and elegant specimen plants, or to bring along through the season a constant succession of flowers, was not and is not possible. In them, however, are to be seen choice or picturesque specimens of a variety of plants best adapted to the conditions that they offer, and of late years they have been supplemented by a range of modern houses, which, though small, is sufficiently large for the growth of many plants that are not seen outside of botanical establishments, as well as of those that possess commercial value because of their ready growth and abundant production of flowers. Among the collections of tender plants that are especially worthy of mention are the cacti and agaves, which, the special subjects of much of the work of Engelmann, have long been well represented in the living collections, and have been added to with the passage of time until there are to-day few collections of these groups which surpass or even approach them in size or importance. One house is devoted to representatives of the Bromeliaceae, of which something over 100 species are cultivated, and to which others are being added at short intervals. One tower is occupied with tender yuccas, which, planted in the ground, are beginning to assume a size and character impossible in the open air in a latitude so far north as that of St. Louis, or in tubbed specimens. In one house are brought together the sago plants, Cycadaceae, of which a fairly good collection is owned by the garden, and added to with every opportunity. In another, are planted out tree-ferns. In others, orchids, already numbering some 600 forms, aroids, in considerable variety, carnivorous plants, acacias and plants of similar foliage, and other groups of particular decorative, economic or biological interest, are displayed, and the provision this season of several new houses for the propagation of plants and for growing those that are needed for

AGAVES.

the embellishment of the houses that are open to the public, makes possible increased beauty of the latter.

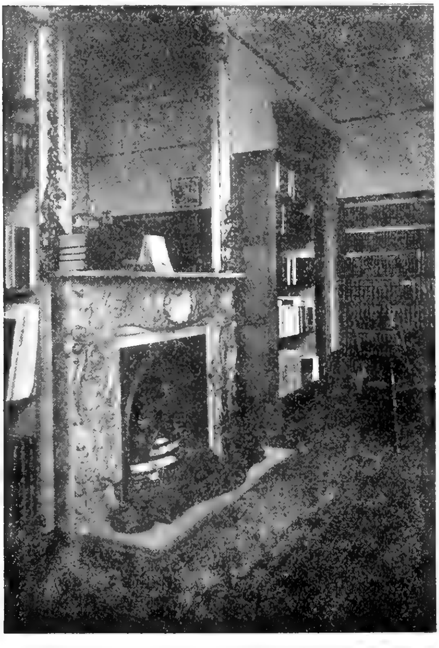
Vegetable gardening is not ordinarily attractive, and a truck garden is usually associated with compost piles, bad smells, and disorder. It is not necessary for this to be true, however, and the little vegetable garden connected with Shaw's Garden is not only not unsightly in itself, but it has from year to year afforded the means of cultivating in the fullest variety a number of kinds of vegetables. Here, for instance, were grown for several seasons all procurable varieties and spontaneous species of chiles, and the monograph on *Capsicum* which the horticulturist of the establishment published as a result of the studies that he was thus enabled to make, takes rank as of value alike to botanists and gardeners. Here, too, have been grown, year after year, the chief varieties of beans that the world's markets afford, and on the plants so cultivated has been based another and equally useful monograph, by the same gentleman, Mr. Irish. Though not classed as vegetables, sweet peas in all procurable sorts have been grown for like purposes of study in this enclosure, its seclusion affording needed protection of the plants while under observation; the thesis of one of the garden pupils, Mr. Rudolph Mohr, on this group of decorative plants, is of more than passing interest.

The New Orchid.

It is the lot of all living and growing institutions which give promise of prolonged existence, to have gifts of greater or less magnitude made to them. The Missouri Botanical Garden has not proved an exception to this rule. Even before the death of its founder, Dr. George J. Engelmann placed in the hands of the present director of the garden the invaluable herbarium of his father, the late Dr. George Engelmann, and shortly after the organization of the board of trustees this was formally transferred to them by Dr. Engelmann, together with the library of his father, which, however, had actually been placed at the garden and in part arranged before the death of Mr. Shaw. One of Dr. Engelmann's biographers expressed the great surprise occasioned by the vast amount of work that he, a busy physician, had found time to do. The number and minute accuracy of his unpublished notes, which form part of this gift from his son, were even more surprising. Over 20,000 of them exist, varying in character from a mere memorandum of the appearance of a plant which he had observed in a foreign garden, or a simple bibliographic reference, to accurate detail sketches of all of the specimens on which his conception of a species in a difficult group rested; and the sixty thick volumes in which they are now contained are counted among the choicest possessions of the institution.

E. Lewis Sturtevant.

It was but a few years after the organization of the garden under its present management that the Director one morning received a letter from the late Dr. E. Lewis Sturtevant, a correspondent for many years, but one whom he never had the privilege of meeting personally, asking if the garden would accept a large collection of specimens, reference cards, sketches, partly in water-colors, and other material illustrative of the genus *Capsicum,* with a view to its ultimate utilization in the preparation of an illustrated monograph such as the donor had for years had in contemplation for his own pen, but which he then saw that he must place in other hands. The gift was accepted, and the resulting publication, which has been referred to above, is now a matter of history and, I am pleased to say, met with Dr. Sturtevant's approval. Some years later, stricken with mortal illness, Dr. Sturtevant once more wrote to ask if the garden would accept as a gift the large and important collection of pre-Linnean books that it had been his pleasure to accumulate through the years of his active study of the origin and modifications of the plants cultivated by man, adding that he wished to attach no conditions to the gift if it would be acceptable, though he offered the suggestion that the best use of the books would be secured if they might be separately shelved from other classes of books and if a catalogue of them and the other pre-Linnean books of the library might be printed, so that persons wishing to make use of them might know where they were to be found. Visitors to the library are more interested in the quaint volumes of this part of its contents than in any other, and investigators have called its treasures into use on many occasions, not infrequently writing from a distance for transcripts of passages that they have needed to use, but have not been able to consult elsewhere. Sometimes, for days at a time, students of particular groups of plants long cultivated, have been occupied with the camera, reducing to unimpeachable form their quotations from these books. Quite recently, it has been found possible to nearly double this collection, by the purchase of a similar collection formed by a gentleman in Europe, and the catalogue of the Sturtevant library—made and printed some years ago in compliance with the suggestion of its donor, which was considered of the greatest importance—will be supplemented by a list of these later acquired works. Very touching was the last thought of Dr. Sturtevant for the garden. Knowing that death was at hand, he took from their cabinet the last and greatest of his treasures, his manuscript card references to the literature of cultivated plants, and himself packed them in a safe manner for shipment, giving instruction that they should be forwarded to the garden immediately after his death. May the institution never be less worthy than it then was of such confidence!



IN THE LIBRARY. A Mantel of the City Home.

To go into details concerning the library at large would be wearisome and useless. Suffice it to say that, based on the small but well selected library bought by Dr. Engelmann for Mr. Shaw many years before his death, and augmented by the gift of the libraries of Engelmann, Sturtevant and the director of the garden as well as many smaller collections, it has been increased by annual purchases of considerable size, selected with discrimination from the libraries of some of the world's greatest botanists, as these, through the death of their owners, have come into the market, until it now comprises over 16,000 volumes and 20,000 pamphlets, valued at over $60,000 and fairly symmetrical in all fields of botany and the sciences that must be taken into consideration in botanical work, as well as in gardening, landscape work, horticulture, forestry, greenhouse construction, and the like. Large as it is, however, it is so far from being satisfactorily complete for the uses it is put to that a sum greater than its present valuation could be spent on it within a few years, if the money were available and the works needed were in the market, without having even then a surfeit of the good things that such a library, destined for research purposes, should offer the busy man who, to use them, must be freed from too great care and delay in searching them out and placing his hand on their contents. Strongest in the library, as would be expected from the fact that the Garden is a garden and possesses a large herbarium and is at present more concerned with the systematic study of flowering plants than with other subjects, are the departments devoted to floras and monographs; those difficult things to have at hand, series of journals and proceedings in whole or in part devoted to botany; and the compendiums of gardening and garden plants; but there are in this country few fuller collections of treatises on plant morphology and physiology, and the works on the ecology of the flower are probably nowhere surpassed in completeness of representation. From the first establishment of the school of botany in the university, it has been the policy to spare no trouble or reasonable expense to make the library as complete as possible in any field in which special work is taken up, and the result is that each piece of research accomplished has been marked by a corresponding growth in the library.

A herbarium is an uninteresting collection to the average person who does not need to use it, whether he be a botanist or not. In envelopes or glued or bandaged down on sheets of paper are thousands of more or less fragmentary plants, sometimes moldy or worm-eaten, for time works havoc with all organic matter, and usually much faded. And yet not even the library is more indispensable for the worker on the species that they represent; for they are the real plants, and not some one's interpretation of them. The choicest part consists always of the original specimens preserved by an author when describing and naming a species or genus, for however his description or figure may have erred, this type persists as a record showing the true generic and specific characters. An herbarium is not always a conclusive source to which to turn for final information, for the author may have and often has had two or more related species under his eye when describing the one to which he gave recognition and a name, and herbarium study calls for some discriminating power; but notwithstanding the inherent difficulties, its value is real and lasting. Though the founder of the Missouri Botanical Garden did not specifically mention a herbarium in his will, his purchase of the Bernhardi collection in the early years of his planning shows his practical appreciation of the need of such a part of the equipment of the institution, and in some manuscript suggestions for his trustees, not made a part of his will, he distinctly states that the correct naming of the plants cultivated in an educational and research garden 'can only be done by a botanist, aided by an herbarium and botanic library'; and one of the world's greatest botanists, in speaking of the relative value of living collections and the *hortus siccus* or herbarium, expresses himself as follows:* "If the collections of dried plants are compared with those of living plants, the advantages of each are more nearly balanced than is usually thought. In a herbarium you see simultaneously specimens of related species and also different localities, different ages or different conditions of the same species. You know the name of the plant, if the herbarium is well determined, and you go at once to the authors who have spoken of it. You learn its origin, which is indicated on the label. On its side, the living plant gives more means for certain anatomical observations. It permits one to better describe certain characters of little importance, such as color, odor, etc., but in the country the plants are not named, and in a botanical garden they are often badly named. . . . The geographic origin of the plants is there almost always uncertain or unknown; the individuals are often modified by cultivation and crossing; fruits are rarely seen with the flowers; rarely several individuals of the same species or several related species; and still more rarely are botanists permitted to gather enough specimens of an exotic plant to examine it to their satisfaction and to preserve the proofs of their work." And he goes so far as to head the chapter devoted to this consideration with the lines: 'Of herbaria in general and of their superiority to every other zoological or botanical collection.' It might have been added, truthfully, that in a garden the representation of any given species is likely to be transient, since the casualties to which living specimens are liable are innumerable; on the other hand, the specimens in the herbarium, though subject to their own particular dangers, are far less likely to suffer, and rarely disappear even in the course of very long periods of time except as a result of gross carelessness.

The principal collections of this class at the Missouri Botanical Garden are, in the first place, the herbarium of Engelmann, which,

* De Candolle, La Phytographie, p. 365.

containing the types of his work on cacti, *Agave, Cuscuta, Yucca,* conifers, and other groups of plants on which he was a recognized authority, and in which he described many species, will long form the most essential resource of students of these plants, for clearing up difficulties in their interpretation. Some years since, one of the young men at the garden was struck by the frequent coincidence of a certain handwriting with species of grasses known to have been collected by Haenke, and to have served for studies by Presl; and investigation showed that the writing was really Presl's, and that in the Bernhardi herbarium, which contains many valuable—but unfortunately inadequately labeled—specimens, was a nearly full set of this important collection of Haenke—the grasses of which were subsequently studied in detail by Professor Lamson-Scribner, to the elucidation of a number of questions concerning the grasses of the United States, which could be answered only by recourse to the original specimens on which Presl's species rested.

It would be even more tiresome to give a minute analysis of the contents of the herbarium than of the library. Suffice it to say that in addition to the Engelmann and Bernhardi herbaria, it contains the herbarium of Sturtevant—purchased after his death from an old friend to whom he had given it, but who desired it to be placed with the other material serving as a record of his friend's work; a pre-Linnean collection formed by the German botanists, Ludwig and Boehmer, on which a Prussian flora was based long since; the cryptogamic herbarium of the director of the garden; a very large and full collection of the plants of Alaska, made on the Harriman Alaska Expedition, and containing, through the Bernhardi herbarium, representatives of a considerable number of the species collected by the early Russian explorers; a good representation of the plants of the West Indies, collected by a former assistant at the institution, who was sent into the Caribbean region on a collecting trip; one of the fullest representations of plants from the Azores, in which, and to a smaller extent in Madeira, the director has spent some time; a very full representation of the flora of Missouri, in which the Riehl collection and a set of specimens many years since put up by Professor G. C. Broadhead, and on which his early notes on the plants of the state rest, are of especial interest; and probably the fullest set of Chinese plants that has yet come to this country. All the more important current collections of the plants of North America, and many of those from foreign lands, have been bought as they have been offered for sale. Not long before his death, Dr. Chapman, long the only authority on the flora of our southern states, asked the director to visit him, in order that arrangements might be made for the ultimate passage to the garden of his personal herbarium. Twice, the Chapman herbarium had been sold—each time the best representatives in it being selected, and supplemented by fragments from his scrap books when these were essential for the representation of a species; but there remained at the time of his death a large amount of material which as he said consisted of the original fragmentary specimens representative of his earlier work on the southern flora, and, therefore, really the types of the species contained in it as he then understood them. For every student of the plants of this region, therefore, this collection is of the greatest value, as showing, so far as

SEED BEDS.

it goes, what he really had in mind when using a particular name—and it was precisely that this record of his work might be permanently preserved, that he was desirous that his collection should find its home in the garden.

In themselves, living plants, books and herbarium specimens are but a burden to those charged with looking after and caring for them. He is a happy botanist who has no care except for the thing that his mind is turned to at any given moment. Happy the gardener with only a bay-window to care for! The need for accumulating more than the use of the moment demands lies in the impossibility of otherwise having at hand facilities when they are needed. The sight-seer finds nothing but a curious scene in half an acre of seed beds, thickly studded with little labels which mark the lines where thousands of kinds of seeds lie awaiting the quickening action of sun and rain; but to the student of morphology its value is untold. The sightseer, too, is impressed with but a small part of the things that he sees in passing through a large collection of even the most beautiful plants. A mass of color, a clump of graceful foliage, repeated in different forms and places by the use of perhaps a scant score of species, is all that the average mind carries away from the greatest botanical establishment. The difference between five hundred and five thousand species in a collection is utterly lost on the casual observer. Let him, however, wish to see some particular plant that he has chanced to read of, and the difference becomes evident. To the botanist, even, the difference between one thousand and ten thousand species is not readily perceptible until he has need of some particular thing, which the larger collection may afford while the smaller is almost certain to offer only disappointment.

However large or small it may chance to be, any collection is useful or valueless according as it does or does not give information as well as please the eye. Curiosity, alone, prompts nearly every

A Named Specimen.

observer to look for the name and native home of a plant that he sees growing in a garden. Much more than this is desired by some, and could be added profitably for all were it not for the fact that more deters the ordinary visitor and so defeats the very object for which it is offered, by keeping him from reading at all. No small part of the usefulness of a botanical garden lies in giving information that is not sought, and that the recipient would not himself think of seeking, but which reaches him through such natural channels that he unconsciously acquires not only it, but the habit of looking for the same kind of information about other things, and for more on the particular one that he has first become interested in. One of the principal objects of the founder of the garden therefore is served by the simple presentation of a named collection of attractive and attractively placed plants, which educates while pleasing those who see it. This is varied by the provision of special collections that are tempting in themselves—such, for instance, as a part of the grounds devoted to plants that are hardy in the city. Thousands of persons each year see in this little collection something that by its beauty or oddity attracts them, and the provision of a general label showing that all are hardy, and of the individual label, telling its name, causes them to wish it for their own garden and enables them to order it of their florist, or, if he does not know how to supply it, puts them in the way of seeking it in the lists of other dealers.

Very frequently, parties of visitors are accompanied through the garden by an employee who points out to them the more important features or aids them in finding things in which they are particularly interested. One portion of the grounds contains, in sequence, the principal families of higher plants, represented by several hundred attractive species chosen with reference to the fullest possible generic representation. Another is set aside for the growth of medicinal plants, and elsewhere are grown representatives of the commoner agricultural crops, of savory herbs, etc. These collections, in particular, are much used by teachers in the public schools, who bring classes to the garden for a part of their nature work, in the open air.

Even surplus and waste material contributes in a way to the same end. It is always necessary to propagate bedding plants in excess of the number actually needed, so that replacements may be possible in case of accidents or inclement weather following their transplanting into the open. While only two or three permanent specimens of a kind are wanted for tender plants, most species grown from seed are sure to be germinated in a greater number of individuals than this. When frost necessitates the clearing of the beds in autumn, many plants that have served their purpose during the growing season are still living, though disfigured. This surplus or refuse material is not thrown away, but by the expenditure on it of a very little care is potted, set aside in frames for recuperation if this is necessary, and distributed to hospitals and schools, where, particularly in the poorer and more densely populated parts of the city, it quietly continues the refining influence that Henry Shaw appreciated as one of the most desirable effects of his garden in his own time.

But the great ultimate purpose of a botanical garden is the fostering of research with the purpose of adding to knowledge. This was recognized by Mr. Shaw, and repeatedly mentioned in his provisions for the future of his establishment. Opportunity for it lies in every plant in the collections, and in every book on the shelves. To get men to use the opportunities offered is the greatest problem of administration. So far, the garden has employed only the most necessary care-takers, and it would have been impossible for a single one of its employees to have been spared from the force without neglect of some essential. Yet, though over-work and a permissible if entirely undesirable neglect of details of convenience in use, but not of preservative care, have been necessary, each of the higher employees has every year found time to do something worth doing in the field of investigation. The achievements, it is true, are neither as many nor as great as the workers or the management of the establishment would have wished them to be, but considering the fact that the garden has been in course of transition from the pleasure grounds of a gentleman to a scientific establishment, and that what has been done has been carefully done, they are not insignificant or unworthy, and each of the thirteen annual reports on the institution thus far printed contains at least one scientific publication of original results, of permanent interest to botanical workers. What will come of the staff of capable investigators that it may shortly be expected to gather together, is a matter of conjecture only—but the conjecture refers rather to the success with which men may be selected than to the opportunities that they will enjoy for the most earnest and serious application of which they are capable.

Research is coming to be recognized as of greater value for the practical development of our natural resources, with the passage of every year. The investigator sometimes sees in his subject only a problem that he must solve whether its solution can ever be of value or not. Sometimes he appears to be so constituted that the suspicion that it can result in anything useful is deterrent to him. Sometimes his chief interest lies in the very possibility of its utilization. But, in any case, no fact well made out and properly correlated is valueless, and the results of the most unpractical of discoveries are often utilized in commerce or in the arts with surprising promptness. While the research thus far carried on at the garden has been dictated largely by consideration of the needs of botanical science alone, or the personal interest of the investigator, I should not like to close this reference to it without mentioning that the studies of one of the intructors in the school of botany, Dr. von Schrenk, have taken the direction of the causes and means of prevention of the decay of timber, on which, under the authority of the National Department of Agriculture, he has done work which has brought him merited scientific recognition, while at the same time its practical results in the saving to railroads and other large users of timber already promise very large financial returns to the community at large.

While its own staff is, therefore, reasonably certain to utilize the facilities of the garden in an ever growing degree for the performance of research work, the results of which are and will always be an ample justification of their acquisition, it is not at all improbable that the passage of time will see their utilization to an even greater extent by investigators not connected with the administration of the establishment. Whatever it possesses is freely placed at the disposal of any one capable of making good use of books or material, and while its own staff, however developed, will always comprise but a small part of the persons capable of making good scientific use of its treasures, it is probable that a recognition will grow with the years, through at least the entire central part of our country, that a visit to the garden is not only possible and practicable, but almost a necessity for all of the botanists outside of the few large universities, who desire to do in its best form the work that lies in the line of their interest and training. Much use has already been made of the garden by men who would not have done their work so well without this help, and much more use of it would doubtless be made were it not for the fact that travel and residence in a city are found more expensive than staying at home, when the isolated worker counts up the cost and consults his limited income. It may be remarked, however, that the man who counts cost too closely through life is often the man who sacrifices future usefulness to present economy, and it may safely be said that few lines of saving are less profitable in the long run than those pursued at the expense of the equipment and wide acquaintance on which professional and financial success usually rests.

Prophecies are always of uncertain value and attended with danger if the prophet seeks a reputation in that field: I shall hardly venture, therefore, to say much about the detailed future of the garden. This much, however, may be said with certainty, that its endowment appears to be so ample and so well founded that, though growth and attainment will be gradual and large immediate undertakings are not within its power, its perpetuity as an important and growing center of study and education are beyond question. The research work already in progress in the garden under the control of the government is suggestive of the continued attainment of better and larger results through cooperation with other establishments than would be possible to either alone. That the grounds will be greatly enlarged, that a supplementary garden of much larger size and more picturesque conformation will some day be opened at a distance from the smoke of the city, which has already sounded the death knell of some of the plants that were formerly cultivated with success in the present garden—which, under the provisions of Mr. Shaw's will is certain to be maintained as the real center and home of the establishment whatever adjuncts it may have—and that there will be erected in the near future a system of large conservatories of modern construction, worthy of a great botanical garden, large additions to the single small plant house now devoted to experimental work in mycology and plant pathology, and a suitable home for its herbarium and library, with ample laboratory facilities, it is easy and safe to predict. That these shall all and always be freely at the disposal of any who wish to make serious use of them in research work of any kind, is an established policy, not likely to change. Finally, it may be said that, as its founder's wish was to make its scope broad, so the purpose of those to whom he has left its administration is to develop it, so far as the means at their disposal admit, on lines which shall better fit it with the passage of each year for the performance of useful work in any part of the field, while strengthening it to the fullest during the progress of each particular study that is taken up—and, throughout, never to let it become anything but a place to which the lover of the beautiful may turn in the full assurance that he will never find it less beautiful than when it was Henry Shaw's home, but rather a place to which wealth of scientific resource has but added greater possibilities for pleasure, when pleasure only is sought.

# THE SAVING OF VANISHING DATA.

By ALFRED C. HADDON, F.R.S.,
CAMBRIDGE UNIVERSITY.

FIVE years ago I pointed out* that it is well from time to time to take stock of our knowledge and our methods of inquiry, to see whether we are working on sound lines. As the business man finds it necessary to go over his stock periodically and to balance his books, so, also, the scientific man, especially the biologist, should perform an analogous operation, lest perchance he finds out too late that he has been entering on a comparatively non-profitable work, or has been neglecting valuable opportunities. While it is impossible to say that any scientific work will be ultimately unprofitable, it is right to point out that particular subjects for investigation may be of more immediate importance than others.

In order not to complicate the question, we will dismiss the practical applications of science by admitting that they are of immediate importance. This leaves the field clear for the consideration of scientific subjects which are studied solely for their own sake.

We can, perhaps, gain a clear view of the question by looking at it from the standpoint of our successors. What will be the opinion of the naturalist of a hundred, or of a thousand years hence of the work now being done? What is the scientific work he would wish us to have undertaken? This question is not a difficult one to answer.

He would not consider it very necessary for us to elucidate the structure, development or physiology of every common animal; these researches can be pursued at any time. The investigation of the life in the oceans—whether on the surface, in shallow water, or in abysmal depths—can be done by him as well as by us.

The naturalist of the future will certainly and most justly complain if we busy ourselves entirely with problems that can wait, which he can solve as well as we, and at the same time neglect that work which we alone can do. Our first and immediate duty is to save for science those data that are vanishing; this should be the watchword of the present day. Those students of botany, zoology and anthropology who have at all considered the matter are impressed with the fact that the present time is a very critical period for the native flora and fauna of many parts of the world. Owing to the spread of commerce, the effects of

* *Nature*, January 28, 1897, p. 305.

colonization, and the intentional or accidental importation of plants and animals, a very rapid change is affecting the character of the indigenous life of numerous districts. This is notably the case in oceanic islands, the area of which is often extremely limited, and whose native forms have been found to be specially liable to be swamped by the immigrants; but it is just those spots which are of especial interest to the naturalist, on account of their isolation from the great land areas. Thus the flora and fauna of many of the most interesting districts for the field-naturalist are in our day becoming largely exterminated before they have been adequately recorded. The investigation of disappearing animals and plants can, in many cases, be undertaken by us alone—and even now much has disappeared and more is fast passing away. Attention has been called to the spread of land species by the agency of man by Mr. L. O. Howard, of Washington. In this very interesting and suggestive article* he deals more especially with insects and most of his illustrations are drawn from America.

In other parts of the world the same dislocation of the indigenous fauna is taking place and even the flora is also becoming modified, for example, Sir Walter Buller, F.R.S., has stated† that all the more interesting birds of New Zealand are passing away. Not a few species have already been exterminated, many more are on the borderland, so to speak, of final extinction; and some even of the commonest birds of thirty years ago have become so scarce that it is difficult to know where to look for them. The saddest part of it is that it seems hopeless now to arrest the evil, owing to the introduction of stoats, weasels and ferrets that are now swarming over every part of the country and defy all attempts to check their increase. The following facts speaks for themselves. No specimen of the once very abundant New Zealand quail (*Coturnix novæ zealandiæ*) has been seen for a quarter of a century: of the celebrated *Notornis mantelli* only three perfect specimens have been obtained; it is probably extinct. Even the extremely abundant woodhens (*Ocydromus* sp.) are on the verge of extinction, as are the various species of kiwi (*Apteryx*), the great ground parrot (*Stingops habroptilus*), the stitch-bird (*Pogonornis cincta*), the bell-bird, the native robin, and many others, not forgetting the beautiful huia or mountain starling (*Heteralocha acutirostris*), celebrated in Maori song and tradition. The huia, which is greatly prized by the Maoris on account of its tail feathers—for personal adornment and as a badge of tribal mourning—has, from time immemorial, been confined to a narrow strip of mostly mountainous wooded country forming part of the old Wellington Province.

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* *Science*, N. S., Vol. VI., September 10, 1897, p. 382.

† 'The Vanishing Forms of Bird-life in New Zealand,' *The Press*, Christchurch, N. Z., January 11, 1897.

It is only just to the New Zealand Government to point out that several years ago the provisions of the 'Wild Birds Protection Acts' were extended so as to include some species that were being destroyed indiscriminately and Little Barrier Island and Resolution Island have been set apart as bird preserves.

Sir Walter goes on to point out that there is just a chance that, in the course of time, some of these vanishing species may learn to adapt themselves to the new conditions of things, and take a fresh lease of life. The tooth-billed pigeon (*Didunculus strigirostris*), a native of the Samoan or Navigator Islands, was supposed to be rapidly becoming extinct, as its terrestrial habits rendered it an easy prey to predatory animals, such as cats and rats, introduced into the islands from European vessels; but late accounts show that it has changed its habits, feeding or resting exclusively on large trees, and that it is now increasing in numbers. Commenting on this, Professor Newton says:

> It is in this way, through the struggle for existence, that habits which have been transmitted from parent to offspring through unknown generations are suddenly abandoned, and entirely opposite ones adopted that give the needed protection to life and continued prosperity, which the inherited methods no longer are able to secure.

Now, singularly enough, the whitehead (*Clitonyx albicapilla*) was forty years ago the commonest bird in the North Island, and at that time a strict inhabitant of low scrubby vegetation, where its habits were gregarious. For many years it seemed to have become extinct, Mr. Reischek, during several years' hunting in the Auckland woods never having met with a single example. During the last few years it has reappeared, but in an entirely new character, as the frequenter of the highest tree-tops, and it appears to be sensibly increasing. On the Little Barrier, however, where it has never been much disturbed, it still continues to frequent the low vegetation.

If so marked a change is apparent on a large land surface like New Zealand, how much more rapid and effectual must be the change in small islands. There is an interesting example of this in the Hawaiian group. In 1890 a committee was appointed by the British Association to investigate the zoology of those islands. The committee secured the services of Mr. R. C. L. Perkins, who has proved himself to be a most efficient collector; his investigations prove that quite a noticeable decrease in the indigenous fauna is taking place each season. The district around Honolulu was perhaps originally the richest in endemic forms, but now introduced forms are in vast preponderance; the distinctive fauna of the plains, if there was one, has quite disappeared. Captain Cook found certain birds, for example, near the shore; of these, some are extinct, and others are to be found only in the mountains.

In a letter to S. D. Sharp, dated Lihue, Kauai, July 21, 1896, Mr. Perkins states:

> This place has been a dead failure. The country where I camped here was a low-lying, densely-covered forest bog-land, at first sight a paradise for Carabidæ (ground beetles), and differing from any other place known to me. Its fauna is entirely lost forever. I turned during my stay thousands of lop, any one of which at 4,000 feet would have yielded Carabidæ. Of all these there was not a single one under which *Pheidole megacephala* had not a nest, and I never beat a tree without this ant coming down in scores.

This is an introduced ant which is overrunning the islands, and which exterminates the native insect fauna. Mr. Perkins finds that earwigs alone can withstand this ant, and his only chance of collection of endemic insects is to get ahead of the ant. In the 'Report' for 1900 it is stated that on his return from a visit to England Mr. Perkins found that great changes had taken place in the islands during his absence, and that the forests were being extensively destroyed and replaced by sugar-cane. The grants by the British Association have been supplemented by grants from the Government Grant Committee administered by the Royal Society, and from the trustees of the Bernice P. Bishop Museum in Honolulu. Eight parts of the three volumes intended to form the 'Fauna Hawaiiensis' have now been published and others are in the press. The inception of this investigation was due to Professor Alfred Newton, and if he had not persisted until he succeeded, comparatively little would ever have been known about the fauna of the Hawaiian islands.

In a communication to *Nature** Mr. Perkins says that few countries have been more plagued by the importation of insect pests than the Hawaiian Islands; in none have such extraordinary results followed the introduction of beneficial species to destroy them, of the effect of which he gives many instances. He goes on to say:

> Why has the success of the imported beneficial insects been so pronounced here, while in other countries it has been attained in a comparatively small measure? The reason, I think, is sufficiently obvious. The same causes which have led to the rapid spread and excessive multiplication of injurious introductions, have operated equally on the beneficial ones that prey upon them. The remote position of the islands and the consequently limited fauna, giving free scope for increase to new arrivals, the general absence of creatures injurious to the introduced beneficial species, and the equality of the climate, allowing of almost continuous breeding, may well afford results which could hardly be attained elsewhere on the globe. The keen struggle for existence of continental lands is comparatively non-existent, and, so far as it exists, is rather brought about by the introduced fauna than by the native one.

To this Mr. Howard adds:

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* *Nature*, March 25, 1897, p. 499.

One prime reason of success is that the most successful of the imported species have come from another portion of the same great faunal region, while others have been received from the region most nearly allied, viz., the Oriental.*

Mr. Perkins then turns to the darker side of the picture for the naturalist's point of view and forecasts what will be the result of all these importations on the endemic fauna. He says sooner or later the greater part of this most interesting native fauna is in all probability doomed to extinction.

Investigations such as those here advocated should be undertaken by a competent naturalist. He should not only be a good collector, but a keen observer, in fact, a naturalist in the true sense of the term; for unless the work is well done it had almost be better left undone. There are many examples of collecting being so imperfectly done as to lead to very erroneous conclusions. It takes time for a naturalist to become acquainted with the local types. The endemics do not show themselves, as usually the conditions of life are such that insects, for example, live retired lives and are not seen, while those that manifest themselves are often foreigners.

It is, perhaps, scarcely necessary to point out that the biological investigation of islands is not a matter of interest to the systematist only, but it is of great importance in connection with the problems of geographical distribution of animals and plants, some of which open up fascinating vistas of the extension of continents in former ages and of their partial submergence, while others relate to the when and how of the peopling of remote islands. Then there are to be considered the bearing of specific and individual varieties on the intricate questions of the origin of species and of evolution in general, and the adaptation of peculiar forms to their particular localities as well as those wonderful inter-relations between plants and plants, plants and animals, animals and animals, and between all and their environment. In a word, all those problems which are to be classed under the term ethology† require painstaking and immediate study; probably no branch of the study of life is of such pressing importance as this, for everywhere 'the old order changeth' and it is that 'old order' which we have to discover.

The extermination of animal life is more rapid and striking than that of plants, but what has been stated for animals applies equally to plants.

More than twenty years ago the late Professor H. N. Moseley raised a note of warning and the concluding sentences of his 'Notes by a Naturalist on H. M. S. *Challenger*' are as follows:

With regard to any future scientific expeditions, it would, however, be well to bear in mind that the deep sea, its physical features and its fauna, will

* *Science, loc. cit.*, p. 396.

† 'Natural History, Œcology or Ethology,' W. M. Wheeler, *Science*, N. S., Vol. XV., June 20, 1902, p. 971.

remain for an indefinite period in the condition in which they now exist and as they have existed for ages past, with little or no change, to be investigated at leisure at any future time. On the surface of the earth, however, animals and plants and races of men are perishing rapidly day by day, and will soon be, like the Dodo, things of the past. The history of these things once gone can never be recovered, but must remain forever a gap in the knowledge of mankind.

The loss will be most deeply felt in the province of anthropology, a science which is of higher importance to us than any other, as treating of the developmental history of our own species. The languages of Polynesia are being rapidly destroyed or mutilated, and the opportunity of obtaining accurate information concerning these and the native habits of culture will soon have passed away.

Many other naturalists besides Moseley have been impressed with the need there is for the study of native races, indeed most of the zoologists who have traveled afield have turned their attention to anthropology, in the broadest sense of the term and not a few have partially, or even entirely, relinquished the study of zoology for that of anthropology. The reason is to be sought not only in the interest of the study of man, but in the conviction that the opportunities for that study are fast slipping away and fastest in those countries where the most important results are likely to be obtained.

In many islands the natives are rapidly dying out, and in more they have become so modified by contact with the white man and by crossings due to deportation by Europeans, that immediate steps are necessary to record the anthropological data that remain. Only those who have a personal acquaintance with Oceania, or those who have carefully followed the recent literature of the subject, can have an idea of the pressing need there is for prompt action. No one can deny that it is our bounden duty to record the physical characteristics, the handicrafts, the psychology, ceremonial observances and religious beliefs of vanishing peoples; this also is a work which in many cases can alone be accomplished by the present generation.

How often have I, when questioning the younger men about their old custom, been told, 'Me young man, me no savvy, old man he savvy,' and so it was. Even a quarter of a century of contact with the white man will cause the attenuation or disappearance of old customs, the memory of which is retained only by a few old men; when these die the full knowledge of the old cults dies too.

I often wonder what the ethnologist of the future will think of us. The Tasmanians have entirely disappeared and we know extremely little about this primitive people. Howitt, Tison, Spencer, Gillen and Walter Roth have done memorable work among the Australians, but if these few men had not labored how much should we really know about the meaning of the social and religious observances of a rapidly vanishing people?

Apart from the work of Codrington and the special investigations of Parkinson, Danks, Fison, Von Pfeil and a few others, how little is known about the practises and beliefs of the varied natives of the Melanesian archipelago. Our knowledge of their physical characteristics is slight; we have collections of many of the objects they make, but of what they do and think our knowledge is as insufficient as it can well be.

The case is not so bad for Polynesia, but even then most of our information is scrappy and many branches of inquiry are practically untouched. Books of travel and missionary records afford ample testimony to the great change that has come over these people. Much is irrevocably lost; but if steps are taken without delay some facts of importance may yet be rescued.

What occurs with almost dramatic rapidity or thoroughness in islands takes place also on the lowland areas where the white man comes into close contact with native races. There are many tracts of Africa which are in need of immediate investigation by trained observers.

Fortunately there is no need to point the moral for North America; although much yet remains to be done, the American anthropologists have not neglected the indigenes whom their civilization is repressing. They, too, recognize that in most cases it is only the fragments of the past that they are able to recover. What they have accomplished has been due mainly to the wise liberality of public-spirited business men.

There is no need to continue, examples could be multiplied indefinitely; our scientific literature is full of laments of the insufficiency of our knowledge of almost every custom or belief in every part of the world. Untrained observers have imperfectly recorded events of which they generally knew little and cared less. Those who have traveled are in universal agreement as to the rapid change that everywhere is taking place, and yet many anthropologists are content to measure skulls or to describe specimens in museums!

A word of warning is not unnecessary. There is still a great danger that travelers will make it their first endeavor to amass extensive collections quite regardless of the fact that a sketch or a photograph of an object about which full particulars have been collected is of much greater scientific value than the possession of the object without the information. The rapid sweeping up of specimens from a locality does great harm to ethnology. As a rule only the makers of an object can give full details respecting it, and no traveler who is here to-day and gone to-morrow can get all the requisite information. This takes time and patience. The rapid collector may get some sort of a story with his specimen, but he has no time to check the information by appeal to other natives, no time to go over the details in order to see that he has secured them all and in a right order. It is probable that many native objects have a deeper significance than would be suspected. This can only be coaxed out of the native by patient sympathy. Some information may be 'rushed,' but the finer flowers of the imagination, the spiritual concepts and sacred aspirations, can only be revealed to those with whom the native is in true sympathy and, quite apart from idiosyncrasy, the time element is most important. No, the rapid collector does positive harm, as, like the unskilled excavator, he destroys the collateral evidence. He may add a unit to a collection, but its instructive value is reduced to a minimum; it is the gravestone of a lost opportunity.

My plea then is for investigators, not for mere collectors, as many of the former as possible and as few of the latter. There is not much difficulty in finding men willing and competent to undertake such investigations if funds were forthcoming. One point is worth mentioning: in most branches of scientific enquiry, later investigations, owing to more minute study, improved methods or a new point of view, are apt to eclipse the earlier investigations. Now this is not the case with ethnological research in the field. The earlier the observations are, provided they are full and accurate, the more liable they are to be of greater importance than later ones. Students continually refer to the oldest books of travel, and they will always do so. From this point of view it is evident that properly qualified investigators should set to work without delay. Every year's delay means that the work will be so much the less perfect. All who are concerned in any field work can have the satisfaction of feeling that students of mankind in future ages will have to consult their publications, and they have the tremendous responsibility that what they write will have to be accepted as correct as there will be no means in the future of checking it.

In order that satisfactory work may be done it ought to be continuous, and two or three good men should be always in the field; to accomplish this an income of at least $5,000 per annum is required. To insure an efficient, economical and fair administration it would be desirable to appoint a small international council of some half dozen members; the council should not be too large, as the business must be carried on by correspondence. This council would decide as to the field work to be undertaken at any particular time and as to the disposal and working out of the material that was collected. Only systematists are aware of the necessity there is that the types of new species should be deposited in the most central institution and regard ought to be paid to the special circumstances of each particular group, independent of country or nationality. Patriotism should not override the practical requirements of science.

# THE AMERICAN'S DISTRUST OF THE IMMIGRANT.

By Dr. A. J. McLAUGHLIN,
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OPPOSITION to immigrants is not new. Even in the convention that framed the Constitution a minority looked with distrust at the alien. A little later came the Alien Act of John Adams's administration. Again, in 1812, the Hartford Convention proclaimed 'The stock population of these states is amply sufficient to render this nation in due time sufficiently great and powerful.' During the discussion of the bill to establish the territorial governments of Kansas and Nebraska, Senator John M. Clayton, of Delaware, introduced in the Senate an amendment confining the elective franchise to native Americans; but, although some prominent statesmen warmly favored the measure, sense of justice and a prudent regard for the national welfare triumphed over narrow race prejudice, and the amendment was lost. In the debate on the bill dealing with preemption rights of settlers on public lands, approved May 29, 1830, Senator Merrick, of Maryland, offered an amendment barring aliens from such rights; but again there were enough clear heads and broad minds to prevent the measure from becoming a law. Finally, in the early fifties, opposition to the alien culminated in the Know-Nothing movement, when misguided fanatics, actuated by insane jealousy of foreigners, not only discriminated against all aliens, but attempted actual persecution.

By 1855, however, the immigrant had proved his usefulness and opposition lessened. He had convinced the intelligent American that he was not a menace, but an indispensable upbuilding force. From this time, therefore, up to a few years ago, he was subject to little or no restriction on entering our ports. It is fortunate for our growth that the immigrant of those early years was of a caliber vastly superior to that of the immigrant of to-day. To-day the immigrants are mostly of other stock than were those who gave us their brawn and muscle and indomitable courage to conquer a wilderness. It was national economy to avail ourselves of their services. They cut down the forests, dug the canals, and built the railroads, thus making our national life possible long before it could have existed without their assistance. These were the days when the immigrants were the German, the Irishman and the Scandinavian.

Of late there has been a rebirth of distrust of the immigrant. That this feeling exists and is even stronger than ever is attested by the numerous magazine and newspaper articles on immigration. Time and again we read protests against the 'horde of illiterates,' or the 'scum of Europe,' or the 'pauper invasion' which is 'swarming into our country.' The articles are usually the feverish output of some enthusiastic patriot who has not come in close contact with the immigrant for any extended length of time, and whose remarks are misleading, though eloquent and readable.

That the writers are as inaccurate as they are intemperate may be seen from a consideration of one of the most frequent errors into which they fall, confusion of race with nativity. For example, observe how they use the term 'Russian.' We receive a great many immigrants, good and bad, from Russia, but very few Russians. So-called Russian immigration is composed (exclusive of real Russians, who form so small a part that they can scarcely be considered a factor) of five distinct races: Hebrews, Poles, Germans, Lithuanians and Finns. The same is true in almost as great a degree of 'Huns.' The immigrants from Austria-Hungary are commonly called Huns; but, while the race line can not be so unerringly drawn as in the case of Russia, the term does not apply racially to the majority of the immigrants. The bulk of the immigration from Austria-Hungary is made up of Hebrews, Slovaks, Poles, Croatians, Magyars (the real Huns) and Germans. This confusion of race and nativity is due to the fact that the statisticians of the past took no cognizance of race, but recorded simply the nativity of the immigrant. Writers in using these statistics jumped at the conclusion that all immigrants born in Russia were Russians, and all born in Hungary were Huns. For the past few years, however, immigrants passing through the Barge Office, or Ellis Island, have been classified according to race as well as nativity. The statistics thus compiled have a scientific value.

If we examine the cause of an American citizen's distrust of the immigrant we find that it varies according to the citizen's point of view. The mechanic fears cheap competition, resulting in low wages; the stirpiculturist, noting the poor physique and low mental caliber of some of the immigrants, fears race degeneration; the reformer, or political purist, increase of crime or pauperism and the influence of a mass of ignorant voters controlled by unscrupulous political bosses; and the law-abiding citizen fears from the immigrant, not only the germ of bodily disease, but the germ of anarchy and also favorable media for its growth.

The great majority of male immigrants are not mechanics, but unskilled laborers. If they possess the qualifications that the early immigrants established as the prime requisites of a desirable immigrant —rugged physique and willingness to work—and if there is a demand for unskilled labor and this demand is not met by Americans, then their admittance or non-admittance resolves itself, to-day as in the past, into a question of national economy. The native American does not engage in the digging of excavations, carrying the hod, or mining. No native American resents that the immigrant has turned him out of the great Pennsylvania mines. The American mechanic's objection is, however, well founded. There is quite a large class of immigrants composed of men of poor physique, with their families, admitted every year, because they are skilled in tailoring, shoemaking, baking or other trades which do not require much physical strength. These people are undesirable immigrants. They enter into direct competition with the American tradesman or mechanic, accepting lower wages and working more hours.

The American mechanic, artisan or tradesman can have no grievance against the poor unskilled laborer, who does not compete with Americans, but with other foreigners who have preceded him and who is able and willing to do work that the American will not do—work that is necessary for our industrial progress. He has, however, cause to complain of the admittance through our ports every year of the thousands of skilled laborers, tailors, shoemakers and all kinds of factory hands who fill the sweat shops and factories and tend to greatly lower the American scale of wages.

The following table gives the relative value of the different races as shown by the percentages of skilled and unskilled laborers. It also shows the percentage of each race coming here between the ages of fifteen and forty-five. It is between the ages of fifteen and forty-five that the economic value of the immigrant to the country is greatest.

Unskilled laborers are absolutely essential for our industrial progress. The demand for the necessary unskilled laborers is not satisfied by native Americans.

Skilled laborers, coming as immigrants, may or may not be advantageous to the country, but they are not necessary for our advancement. The demand for skilled laborers can, with very rare exceptions, be supplied by native Amercan applicants. Therefore, the races having the highest percentages of unskilled laborers and of immigrants between the ages of fifteen and forty-five are the most necessary and the most desirable.

| Race. | Percentage Unskilled. | Percentage Between 15 and 45 Years of Age. |
|---|---|---|
| Lithuanian | 86.5 | 90.5 |
| Slav | 86.9 | 88.2 |
| Magyar | 83.9 | 87.2 |
| Finn | 82.5 | 85.5 |
| Italian | 75.5 | 79.4 |
| Syrian | 48.1 | 75.7 |
| Hebrew | 13.6 | 68.5 |

The reformer's reason for distrust is a grave one. It is a fact that thousands of immigrants receive qualification as voters when under the law they are clearly not entitled to it. There is no doubt that such a mass of ignorant voters constitutes a great power for evil. But the blame can hardly be charged to the immigrant; rather is it due to the unscrupulous ward politicians who thus increase their following and to the judge who grants citizenship papers without proper investigation of the applicant.

So far as the fear of loathsome and contagious disease is concerned the danger is comparatively slight. The immigrants are subjected to a rigid physical examination at Ellis Island by the officers of the United States Public Health and Marine-Hospital Service. The double system of inspection practiced there makes it practically impossible for any immigrant suffering from a loathsome or dangerous contagious disease to pass without detection. The ratio in each race of the number so affected, to the total number of that race landed, during the fiscal year ending June 30, 1901, is here given:

| | | | |
|---|---|---|---|
| Slav (Pole, Slovak, Croatian) | 1 | in every | 7,000 |
| Magyar | 1 | " | 6,500 |
| Italian | 1 | " | 3,450 |
| Lithuanian | 1 | " | 1,250 |
| Hebrew | 1 | " | 1,100 |
| Finn | 1 | " | 1,000 |
| Syrian | 1 | " | 135 |

As far as the fear of increase of crime and pauperism is concerned, it is true that prison statistics usually show a majority of those convicted of crime to be foreign born. But the industrious statistician loses sight of the fact that the 'other half' of the population of a great city, the poor and the needy, the underpaid and the underfed, are almost all foreign born, and it is from this class of course that we expect to fill our jails. It was not, however, his birth, but his poverty, that caused the immigrant to commit crime. We do not expect to find criminals so frequently on Fifth Avenue as on the Bowery.

Hunger may prompt a poor starving wretch to steal, and his act is a criminal offense duly recorded, but when greed of money or position or fondness for good living makes the comparatively rich man commit a 'breach of trust,' his error does not appear in prison statistics. Pauperism is the result of the absence of one or both of the prime requisites of a desirable immigrant. The pauper is either unwilling to work or lacks the physique to stand hard labor. The amount of money brought does not affect greatly an immigrant's chances of becoming a pauper. One immigrant may have little money, but with a rugged physique and willingness to work he will not become a public charge; another immigrant, too lazy for laboring work, or not physically strong, but who is admitted because he claims to be skilled in a trade requiring no great physical strength, may have considerable money and yet be almost certain to become sooner or later dependent upon some one.

There remains the question of race degeneration. On this score the coming of the German, the Irishman, or the Scandinavian no longer causes apprehension. He has demonstrated his capability of making a useful and permanent citizen. His children have attended American schools, and they enter upon life with American ideals in their heads and American patriotism in their hearts. But, as was said before, these races no longer constitute the majority of the immigrants. It is a question whether the Italian, the Jew, or the Slav is willing to merge his identity in that of the nation, and whether such a fusion would not degenerate our race. In order not to deteriorate a race the new elements blended with it should be at least as physically strong as the native race itself.

Some idea of the relative physical condition of the different races from southern and central Europe can be gleaned from the following tables:

TABLE 1.

*Ratio of Immigrants by Race requiring Hospital Treatment on Arrival to the Number of that Race Landed during the Fiscal Year ended June 30, 1901:*

| Race. | Ratio. | | | Total number of Arrivals. |
|---|---|---|---|---|
| Slav (Pole, Slovak, Croatian) | 1 | in every | 300 | 90,888 |
| Magyar | 1 | " | 250 | 13,311 |
| Finn | 1 | " | 200 | 9,999 |
| Italian | 1 | " | 185 | 137,807 |
| Lithuanian | 1 | " | 140 | 8,815 |
| Hebrew | 1 | " | 100 | 58,098 |
| Syrian | 1 | " | 35 | 4,064 |

TABLE 2.

*Ratio of Immigrants Certified as having some Disability grave enough to make them Public Charges, or Dependent upon some one, by Race to the Total Number Landed during the Month of May, 1901:*

| | | | |
|---|---|---|---|
| Lithuanian | 1 | in every | 1,906 |
| Slav (Pole, Slovak, Croat) | 1 | " | 664 |
| Italian | 1 | " | 172 |
| Finn | 1 | " | 163 |
| Magyar | 1 | " | 148 |
| Hebrew | 1 | " | 42 |
| Syrian | 1 | " | 29 |

The average immigrants are of course not only far below the average American in intellect, but are physically inferior. Sensible expectation does not look for race improvement, but rather that before the new element is assimilated the improved surroundings, better food and cleaner habitations will build up physically the immigrant parent

TABLE 3.

*Ratio of Minor Defects in each Race to Number Landed. These were Defects or Conditions not grave enough for Actual Rejection, yet likely to Affect the Immigrant's Chances in making a Living or Usefulness as an Immigrant, such as Poor Physique, Anæmia, Loss of an Eye or Finger, etc. Month of June, 1900:*

| | | | |
|---|---|---|---|
| Finn | 1 | in every | 81 |
| Slav (Croat, Pole, Slovak) | 1 | " | 65 |
| Lithuanian | 1 | " | 64 |
| Magyar | 1 | " | 40 |
| Italian | 1 | " | 26 |
| Syrian | 1 | " | 24 |
| Hebrew | 1 | " | 16 |

stock whose children, brought up in American schools and in American environment can be assimilated without detriment to the native race. It is not the assimilation of the immigrant but of his children we have to consider.

The American's distrust of the immigrant at present is rational and natural. It is the logical sequence of the sweat shop, the increase of crime and pauperism in New York and other great cities, and of the assassin's act at Buffalo. The percentage of undesirable immigrants is no doubt higher to-day than it was twenty, thirty or forty years ago. It may even be admitted that it has been growing higher year by year during the past two decades. But we are no longer unprotected against undesirable immigrants. Restrictions on admittance have been growing more stringent year by year and a great system has been perfected on Ellis Island for sifting the grain from the chaff, that is doing splendid work, not as a dam to keep out good and bad alike, but as a sieve fine enough in the mesh to keep out the diseased, the pauper and the criminal while admitting the immigrant with two strong arms, a sound body and a stout heart.

Amendment of the present immigration laws has been suggested in some important particulars. It has been urged by a great many people that an educational requirement should be added to the law, barring all immigrants who are illiterate. A glance at the following table will show that this restriction would debar many thousands of our most desirable immigrants—would, in fact, be felt most by the races furnishing us with nearly all of the unskilled labor necessary for our industrial progress. It would not, on the other hand, act as a barrier to some of the least desirable immigrants we receive. The passing of this educational amendment would have one good result: It would lessen the total number of immigrants landed and thus permit of an even more rigid examination of the immigrants upon arrival.

Other remedies suggested for the improvement of the immigration laws are raising the head tax and increasing the time of the Govern-

*In the following Table by Illiterates is Meant those who are unable to Read and Write in some Language:*

| Race. | Total number landed year ended June 30, 1901. | Percentage of illiterates. |
|---|---|---|
| Italians | 137,807 | 51.26 |
| Lithuanians | 8,815 | 44.85 |
| Slavs | 90,888 | 34.07 |
| Hebrews | 58,098 | 23.31 |
| Magyars | 13,311 | 7.04 |
| Finn | 9,999 | 1.84 |

ment's jurisdiction over all landed immigrants and increasing the period of liability of the steamship company for return of undesirable immigrants from one year (the present period) to five years. Increasing the head tax from one dollar, the amount imposed at present upon each arriving alien, to five or ten dollars would probably lessen the number of immigrant arrivals. This reduction in number would be due to the fact that many large families, with children and aged dependents, would be obliged to stay in Europe; the extra five or ten dollars per head in a large family would be sufficient in many cases to make the cost of passage prohibitive. Young single men would pay $40 for passage to America almost as readily as $30; consequently the additional head tax would not greatly affect the number of single unskilled laborers. The young laborer would not go back and forth quite so often perhaps if he had to pay the additional five or ten dollars upon landing here each time.

The period of Government jurisdiction over the landed alien and the period of the liability of the steamship companies for return of undesirable aliens for cause should be extended from one year to five years, or better, until the immigrant becomes a citizen. This would enable the immigration authorities to deport within five years after landing many diseased, insane and pauper immigrants, anarchists and other criminals whose undesirability was not manifest upon landing or within one year thereafter. Relatives and interested persons would not be so ready to offer to the boards of special inquiry a guarantee that detained aliens would not become public charges if such guarantee were binding for five years instead of one year, as at present.

The enactment of these amendments into law and the enactment of stringent legislation bearing upon anarchists, together with a rigid enforcement of our naturalization laws, would go far toward dissipating the present popular distrust of the immigrant, and would still further minimize the dangers due to immigration.

# VARIATION IN MAN AND WOMAN.

BY HAVELOCK ELLIS.

ARE variations more common in males than in females? That is a question which has passed through various phases during the past century. John Hunter, who touched on the matter from a biological standpoint, vaguely indicated that males are more variable than females. Meckel, on the contrary, came to the conclusion, on pathological grounds, that in the human species females show a greater degree of variability, and he thought that since man is the superior animal and variation a sign of inferiority the conclusion was justified. " We may state as a principle," Meckel wrote ninety years ago at the outset of his manual of descriptive and pathological anatomy, "that anomalies are more common in the female. This phenomenon seems to depend on the eighth law [Meckel's 'law of development,' according to which woman is more primitive than man] since the organization of the female results from development being arrested at an inferior degree." But while he regards deviations as on the whole more common in woman he admits certain exceptions, and more especially instances the heart and the bladder as more variable in man.

Meckel was a profound student of anatomy, but not a very luminous thinker. Some years later Burdach took up the question in his 'Physiologie.' That great biologist at once raised the problem to a higher level, realized its wider bearings and cleared away the prejudices which had surrounded it. He recognized that in some respects women are more variable than men, but pointed out that, contrary to Meckel's opinion, this was no indication of woman's organic inferiority. He showed from the statistics of the Anatomical Institute of Königsberg that we must distinguish between different kinds of abnormality. Further he referred to the facts that indicate that woman is more childlike than man, but, he added, "it is a very common but a very gross error to consider age as a scale of perfection and to regard the child as absolutely imperfect as compared to the adult. It is not imperfection but simply certain childlike characteristics which women preserve"; and, he points out, it is in decrepitude that women take on the characteristics of the so-called superior sex. His general conclusion was that the nature of man and the nature of woman are both excellent, but there are wider variations in men, more genius and more idiocy, more virtue and more vice.

Darwin turned his attention towards this point and accumulated data. In the 'Descent of Man' he brought together many of the chief facts then known concerning variation in man and woman. All the evidence that he could find pointed in the same direction, and he concluded (Part II., Ch. 8) that there is a 'greater general variability in the male sex.'

Some twenty years later in a summary study of human secondary sexual characters entitled 'Man and Woman,' written as a brief introduction to a more elaborate study of the sexual instinct in man, I devoted a chapter to this question, dealing with it more comprehensively than had previously been done and drawing data from a much wider field, but finding no reason to differ fundamentally from the conclusions of Hunter, Burdach and Darwin. I could not indeed assert that as regards man the greater variability of the male is 'general,' but all the facts available since Darwin's day indicated that a greater variability of the male occurred in the majority of the groups of data investigated. And when I considered that this greater organic variational tendency of men is apparently true of psychic variations also—of genius, of idiocy and other mental anomalies having an organic basis—it seemed to me that in the greater variational tendency of man we are in the presence of a fact that has social and practical consequences of the widest significance, a fact which has affected the whole of our human civilization. Although the greater variational tendency of men is balanced by the more equable level of women, we have to recognize that the existence of the exceptional men who have largely created the lines of our progress is based on natural law. It is a conclusion which does not yet appear to me to be fundamentally affected.

There was, however, one important omission in my statement of this question, and I wish to emphasize the importance of the omission because its significance will subsequently become apparent to the reader. I said little or nothing as to the variability of men and women in *size*, either as regards total stature and weight, or the dimensions of parts of the body.* The reason for that omission is clearly indicated in various parts of the volume and we shall encounter it in due course.

Three years later, in a volume of miscellaneous essays entitled 'The Chances of Death,' Professor Karl Pearson published a lengthy paper entitled 'Variation in Man and Woman.' This writer started with the assertion that in 'Man and Woman' I had 'done much

* I did not consider that such evidence must be absolutely rejected—I admitted it in one or two cases (printed in smaller type)—but simply that as it was liable to a discount of unknown extent it could not be placed in the first rank of evidence.

to perpetuate some of the worst of the pseudo-scientific superstitions, notably that of the greater variability of the male human being,' and that it was the object of his essay 'to lay the axe to the root of this pseudo-scientific superstition.' In fact, as he is careful to tell us at frequent intervals, before he himself entered the field (a field, be it remembered, occupied by some of the world's greatest biologists) all was 'dogma,' 'superstition,' 'nearly all partisan,' at the best 'quite unproven,' I am inclined to think that these terms, which spring so easily to Mr. Pearson's pen, are automatic reminiscences of the ancient controversies he has waged with theologians and metaphysicians. They are certainly a little out of place on the present occasion.

In selecting the material for his demonstration, Professor Pearson tells us he sought to eliminate all those 'organs or characteristics which are themselves characteristic of sex,' such being, in his opinion, gout and color-blindness; he also threw aside all variations which can be regarded as 'pathological,' on the hypothetical ground that such 'pathological' variations may have a totally different sexual distribution from 'normal' variations. He decided that size is the best criterion of variability. As to how a 'variation' may be defined Professor Pearson makes no critical inquiry, though such inquiry would very seriously have modified his final conclusions.*

"What we have to do," he states, "is to take healthy normal populations of men and women, and in these populations measure the size of organs which do not appear to be secondary sexual characters, or from which the sexual character can be eliminated by dealing solely with ratios." Various kinds of size are therefore selected for treatment, such as that of the skull, chiefly as regards its capacity and length-breadth index, stature, span, chest-girth, weight of body and of various internal organs, etc., all these, it is observed, being various aspects of the one factor of size. It is shown by careful treatment of the available data—the so-called coefficient of variation being accepted as a possible or indeed probable measure of significant variation—that, as far as there is any difference at all, women are, on the whole, slightly more variable than men. Having reached this result the author leaps bravely to the conclusion, that 'accordingly, the principle that man is more variable than woman must be put on one side as a pseudo-scientific superstition.'

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* It is true, indeed, that Mr. Pearson remarks that the question 'What are the most suitable organs or characteristics for measuring the relative variability of man and woman?' 'really involves a definition of variability.' But he adds that 'the definition given may be so vague as to beg off-hand the solution of the problem we propose to discuss.' That suspicion, as we shall see, is not altogether unjustified.

If a reply has so far not been forthcoming from the writer against whom this elaborate paper was chiefly directed, this has not been either because I admitted the justice of its conclusions, or complacently accepted a damnation to which I had been consigned in very excellent company. The subject lay only on the outskirts of my own field; I could claim no originality in it; all that I had done was to sift and bring to a focus data which had hitherto been scattered, and to show their significance. At the same time I again placed the subject on my *agenda* paper for reconsideration. In the meanwhile, it scarcely appeared that Mr. Pearson's arguments met with much acceptance, even from those whom they most concerned.*

Almost the only attempt to consider them, indeed, which I have met, is in a review of 'The Chances of Death' by Professor W. F. R. Weldon, in *Natural Science.* This sympathetic critic, with a biologist's instincts, clearly felt that there was something wrong with Mr. Pearson's triumphant demonstration, although as the subject lay outside his own department he was not able to indicate the chief flaws.

There is indeed one initial flaw in Professor Pearson's argument, to which Professor Weldon called attention; it could scarcely fail to attract the notice of a biologist. We are told that we must put aside 'characteristics which are themselves characteristics of sex,' like gout and color-blindness, which 'without being confined to one sex' are yet peculiarly frequent in one sex. Thus, we see, characteristics not confined to one sex may yet be characteristic of one sex, and when we seek to find what characters vary more in one sex than in the other, we must carefully leave out of account all these characters which are most clearly more prevalent in one sex. Professor Pearson thus sets out with an initial confusion which is never cleared up. His object, he tells us, is to seek such degrees of variability as are 'secondary sexual characters of human beings,' and we infer from the course of his argument that the desired characters while not confined to one sex must yet be peculiarly frequent in one sex. *Yet these are precisely the group of characters ruled inadmissible at the outset!* No definition of secondary sexual characters is anywhere given, or on such premises could be given.

Professor Pearson seems to assume that the conception of a sec-

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* Mr. Pearson has endeavored to find an opponent of the greater variational tendency of men in Tennyson, who wrote:

For men at most differ as Heaven and earth,
But women, worst and best, as Heaven and Hell.

This argument, however—whatever it may be worth—had already been answered by anticipation in a chapter of 'Man and Woman' on the affectability of woman in which I pointed out that the 'Heaven and Hell' of woman are both aspects of her greater affectability; not only does one woman differ from another as 'Heaven and Hell' but the *same* woman may so vary at different times.

ondary sexual character is too obvious to need definition. As a matter of fact there is considerable difference of opinion. Since Hunter first spoke of the 'secondary properties' of sex, which he regarded as dependent on the primary, only developing at puberty, and principally, though not entirely, confined to the male, the conception has very much changed; there has been a tendency to throw all sorts of miscellaneous sexual differences into the category. I have suggested that it would be convenient to introduce a group of 'tertiary' sexual characters, keeping the term 'secondary' to its original sense and reserving as 'tertiary' all those minor differences which are not obvious, which can have no direct influence on mating, and only exist as averages; such are the composition of the blood and the shape of the bones.*

It is difficult to correct all the errors and confusions which Professor Pearson falls into at this point. He remarks that we must not regard the greater prevalence of idiocy among men as evidence of greater male variability, unless we count on the other side the greater prevalence of insanity among women. The error here is double. As a matter of fact, although in England and Wales during recent years the incidence of insanity has been as great on women as on men,† nearly everywhere else it is markedly greater in the case of men. Indeed even in England and Wales, at the present time, if we may trust the Commissioners in Lunacy in their latest annual report (1902), the incidence of insanity as indicated by the admissions to asylums, is, *in ratio to the male population,* still slightly greater in the case of men. Professor Pearson has been misled by the greater accumulation of females in asylums, failing to take into consideration the greater longevity of women, which among the insane is specially marked.‡ But even if the facts had been as stated by

* Professor Waldeyer, who has done me the honor of critically examining some of the main points in my book (in the form of an address at one of the annual meetings of the German Anthropological Society) is inclined to doubt the value of this distinction since there is no clear line of demarcation between secondary and tertiary characters. That, however, I had myself pointed out, and the objection cannot logically be held by any one who accepts secondary sexual characters and recognizes that they merge into the primary. There are many natural groups which have nuclei but no definite boundary walls.

† It so happens that I was the first to call attention to the fact that towards the end of the last century the number of women admitted to asylums in England and Wales had for the first time begun to exceed the number of men. (Art: 'Influence of Sex on Insanity,' in Tuke's 'Dictionary of Psychological Medicine.')

‡ How serious this fallacy is may be indicated by an illustration that chances to come to hand almost as I write. I read in a South American medical journal that in the Asylum of Santiago in Chili on the 1st of January, 1901, there were 560 men and 655 women, but, during the year, 539 men were admitted and only 351 women.

Mr. Pearson, his inference would still have been wrong; idiocy is mainly a congenital condition and therefore a fairly good test of organic variational tendency; insanity, though usually on a hereditary basis, is invariably an acquired condition, dependent on all sorts of environmental influences, so that it can not possibly furnish an equally fundamental test. Color-blindness, Mr. Pearson also tells us, is a peculiarly male 'disease,' and must not be used as an argument for greater variability in men unless we use the prevalence of cancer of the breast in women on the other side. Again there is a double error; not only is a congenital anomaly improperly compared to an acquired disease, but a gland like the breast which is only functional in one sex is paired off with an organ like the eye which is equally functional in both sexes. The prevalence of gout among men is, again, paired off against the prevalence of hysteria among women. Here the error is still more complex. Not only is gout not a truly congenital condition, though, like insanity, it frequently has a hereditary basis, but if we take into account conditions of 'suppressed' gout it is by no means more prevalent in men than in women, and even if we do not take such conditions into account, it is still not possible to pair off gout against hysteria, since, although in some countries hysteria is more prevalent in women, in others (as, according to some of the best authorities, in France) it is found more prevalent in men. But it would be tedious to explore further this confused jungle of misstatements.

From the point of view of sexual differences in variational tendency it is not necessary to exclude rigidly either 'tertiary,' 'secondary,' or even 'primary' sexual characters, provided we are careful to avoid fallacies which are fairly obvious, and do not compare organs and characters which are not truly comparable. Even those secondary sexual characters which are almost or entirely confined to one sex may properly be allowed a certain amount of weight as evidence, especially if we grant that such characters are merely the perpetuation of congenital variations. If, therefore, as is generally agreed, such characters more often occur in males, that fact is a presumption on the side of a greater male variational tendency which there is no reason entirely to ignore. It is not conclusive, but it must receive its due weight. To assume, with Professor Pearson, that a variation has no variational significance because it occurs often in one sex and seldom in the other* seems altogether unwarrantable.

If, however, Professor Pearson's attempt to discriminate between different kinds of sexual characters from the point of view of sexual

* In the case of ordinary gout, which Professor Pearson regards as typical of the tests to be excluded, opinions differ considerably as to sexual liability; according to one leading authority it is 68 men to 12 women.

variability fails to work out, and is in any case unnecessary, at another point he falls into the opposite mistake of making no attempt to discriminate when discrimination is of the first importance. As we have already incidentally seen, it seems to him to be of no importance whether the variational tendency is tested by variations having an organic congenital base, or by variations which may be merely due to environmental influences during life.* To him they are all alike 'variations,' and the most important are those that can most conveniently be caught in the mathematical net. Indeed he goes further than this. He actually discriminates *against* the more organic and fundamental kinds of variation. It seems to him 'erroneous' to take into account congenital abnormalities of any kind when we wish to test the relative variability of the sexes. In determining the variational tendencies of the sexes we must leave out of account the majority of variations!

The ground on which Professor Pearson rejects abnormalities is that they are 'pathological,' and that it is conceivable that pathological variation might be greater and normal variation less in the same sex.† He believes that in regarding the 'normal' and the 'abnormal' as two altogether different and possibly opposed groups of phenomena he is warranted by 'current medical science.'

This is very far indeed from being the case. It is quite true that in ordinary clinical work the physician does make such a distinction; it is practically convenient. But it is not science, and if the physician is a genuine pathologist he admits that it is not. This is so well recognized that I had thought it sufficient to quote the remark of the greatest of pathologists, Virchow, to the effect that every deviation from the parental type has its foundation in a pathological accident—a statement which Professor Pearson, on the strength of what is really a verbal quibble, contemptuously puts aside as 'meaningless.' We ought not to say the 'parental type,' he tells us, we ought to say 'a type lying between the parental type and the race type'; let us say it—and the statement remains substantially the same, so far as the question before us is concerned.‡

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* It is scarcely necessary to remark that the two groups cannot be absolutely separated.

† This conception, Mr. Pearson remarks, seems never to have occurred to me. In that shape, happily, it has not. But in 'Man and Woman' and elsewhere I have repeatedly called attention to the fact that, as regards various psychic and nervous conditions, while gross variations are more frequent in men, minor variations are more common in women. This seems to cover whatever truth there may be in Mr. Pearson's supposition.

‡ Virchow repeatedly emphasized the statement in question and by no means always in the form that offends Professor Pearson. Thus he remarked in 1894, at the annual meeting of the German Anthropological Society, that

Virchow is by no means the only pathologist of high authority who has distinctly laid down this principle. Thus, as Ballantyne points out—when remarking that the ancient belief, held even by Simpson, that anomalies and malformations are due to disease has been supplemented by modern research—Mathias Duval has emphatically declared that it is not to be thought that the malformation of any part is a result of disease of that part.*

Even, however, if we go back to the time of Simpson, and earlier, we find that Meckel—who is sometimes regarded as one of the founders of the study of variations—clearly recognized that the simplest anomalies and varieties pass gradually into monstrosities, and that the same laws apply to both.†

Indeed so did Hunter in the previous century. 'Every deviation,' he wrote at the outset of his almost epoch-marking 'Account of an Extraordinary Pheasant,' 'may not improperly be called monstrous,' so that 'the variety of monsters will be almost infinite.'

The tendency of scientific pathology is at once to push the frontiers of the normal into regions popularly regarded as belonging to disease, and at the same time, when actual disease comes into question, to refuse to admit that any new laws are brought into operation. "Between any form of disease and health," one of the founders of modern pathology declared a quarter of a century ago, "there are only differences of degree. No disease is anything more than an exaggeration or disproportion or disharmony of normal phenomena."‡ The notion that disease and health are distinct principles or entities Bernard regarded as a sort of idea belonging to the medical lumber

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whenever 'the physiological norm hitherto subsisting is changed' we are in the presence of an anomaly and that in this sense every departure from the norm is a pathological event, though it is not a disease and may not be harmful, may even be advantageous. In what was perhaps his last utterance on the subject (*Zeitschrift für Ethnologie*, 1901, p. 213) he repeated that pathology as well as physiology is an essential factor in the development of the human race. Pathologists will, I know, agree with me that a conviction of the essential unity of physiology and pathology lay at the foundation of the pathological revolution which Virchow effected.

* With this result Dr. Ballantyne—who may be said to be the chief British authority on pathology in its antenatal aspects—in the main concurs. He even goes so far as to assert ('Manual of Antenatal Pathology,' 1902, p. 35) that natural birth in its effects on the child may almost be regarded as a pathological process; 'it is very certain that the same amount of distortion of parts, occurring at a later period of life, would be termed pathological.'

† 'Handbuch der pathologischen Anatomie,' 1812, Vol. I., p. 9.

‡ Claude Bernard, 'Leçons sur la chaleur animale' (19th Lesson), 1875.

room. These conceptions have been brilliantly developed in the work of recent pathologists.*

And if it is argued that a mathematician cannot be supposed familiar with the principles of pathology, it must be replied that Mr. Pearson has here ventured along a path which leads immediately up to these principles, and, further, that the principle in question is so simple and elementary that it may already be said to have entered general culture. I take up the latest volume of Nietzsche's works ('Der Wille zur Macht')—written more than ten years ago, though only now published—and read: "The value of all morbid conditions is that they show us in magnified form certain conditions that are normal, but in the normal condition not easily visible. . . . *Health* and *disease* are not essentially different, as the old physicians and some modern practitioners have believed. To regard them as distinct principles struggling for the living organism is foolish nonsense and chatter."

On the whole, then, there is no reason for rejecting abnormalities when we are considering the relative variational tendencies of men and women. To the mathematical mind—Professor Pearson forces us to admit—it is possible to conceive that the laws of pathology may reverse the laws of physiology, but such a conception the biologist regards as absurd.

More than this must, however, be said. Not only can we not leave anomalies out of account in dealing with this question, but it is precisely the anomalies which furnish us with the most reliable evidence. The word 'abnormality' is apt to mislead, and Professor Pearson somewhat prejudices the matter in unscientific ears by insisting on its use. It is not a scientific term; the so-called anomaly is not abnormal in the sense that it is morbid; it is only exceptional. It merely indicates the extreme swings of a pendulum whose more frequent oscillations are popularly regarded as 'normal.' What is commonly termed an 'anomaly' might really be regarded as the 'variation' *par excellence.*

Such an assertion would be by no means arbitrary. It does in fact correspond with the usage of most of the writers who have investigated this matter until the present day, and it is possible to justify such usage. If—to return to the image of the pendulum—we wish to find out whether the male or female pendulums swing farthest, we must so far as possible let them swing freely; the more they are restrained by external forces the less the significance of the results we

* To those who may wish to gain an attractive insight into modern conceptions of pathology—according to which disease is a relative term and its study a branch of biology—I would recommend Professor Woods Hutchinson's highly suggestive 'Studies in Human and Comparative Pathology' (1901).

reach. Now the congenital 'anomalies' are precisely the kind of variation that most nearly corresponds to the free swing of the pendulum. It is true that there is no absolute distinction between the initial energy and the subsequent modifying influences, but it is equally true that if we wish to measure and compare the aboriginal energies of the male and female organisms, we must so far as possible disregard those characters which are very considerably influenced by late modifying forces.

Professor Pearson has, however, chosen, as a final and crucial test of the variational tendency in men and women, the single point of difference in size, chiefly in adults. That is to say, he has selected as a final and unimpeachable test one of the most fragile of distinctions, a distinction that has been exposed to a lifetime of modifying influences that are incalculable.

Even if we admit that size at birth constitutes a sound test—and this can not be admitted without qualification, as we shall soon see—it is evident that the comparative variation of the sexes in this respect is liable to be affected by environmental circumstances as age increases. The influences of life differently affecting and exercising the two sexes, the influence of death probably exerting an unequal selective influence—both alike must be allowed for if this kind of evidence is to be regarded as a test of the first rank of importance. Otherwise we are not dealing with the incidence of variations at all, but with the elimination of variations—an altogether different matter. Professor Pearson himself gradually awakes to a realization of this fact as he proceeds with his task, and remarks at last that he strongly suspects that the slightly greater variability of woman which his results show is mainly due to a relatively less severe struggle for existence! Probably he is right, but if so his whole argument falls to the ground. The question of the organic variational tendencies of men and women remains untouched; we have been introduced instead to a problem in selection. So true is it that, as Bacon said, the half of knowledge lies in asking the right question.

We are bound to suppose that when Professor Pearson set out he intended to use the term 'variation' in the same sense as his predecessors had used it—for otherwise his results could not validly be opposed to theirs—but it would appear that as he went on, by an unconscious process of auto-suggestion, he insensibly glided into a familiar field.*

It may seem unnecessary to pursue Professor Pearson any further. It is sufficiently clear that the inquiry he has carried out, however

* It is perhaps significant that while I had dealt with the 'organic variational tendency' Mr. Pearson prefers the vaguer term 'variability,' which enables him to bring in such matters as strength of pull and squeezes of hand, which are merely due to functional exercise.

valuable it may be in other respects, has no decisive bearing on the question he undertook to answer, and can have no very damaging effect on the writers he attacks. But there is considerable interest in driving the point of the discussion still further home.

It may be agreed that since differences in size are probably affected by the influences of life and death to a considerable extent, and perhaps unequally eliminated in the two sexes, they do not form a reliable guide to the sexual incidence of variations. But, it may be argued, this cannot affect measurements made at birth, and we must therefore accept the validity of those of Professor Pearson's measurements which concern the infant at birth. Here, however, we encounter a fact which is of the first importance in its bearing on our subject: the elimination of variations in size has already begun at birth, and there is reason to suppose that that elimination unequally affects males and females. This was duly allowed for in 'Man and Woman,' but there is no hint of it throughout Professor Pearson's long paper. He does not dispute this influence, nor does he realize that until he has disputed it his conclusions can not be brought to bear against mine. Professor Pearson's earlier statistical excursions into the biological field were chiefly concerned with crabs; in passing from crabs to human beings he failed to allow for the fact that human beings do not come into the world under the same conditions. I make no large claim for superior insight in this matter; it was probably a question of training; I was practically familiar with the phenomena of childbirth; he was not. But his ignorance has profoundly affected the validity of his cherished criterion of sex variability, in so far as it is used against his predecessors in this field.

Every child who is born into the world undergoes a severe ordeal, due largely to the limited elasticity of the bony pelvic ring through which it has to pass. Probably as a result of this, a certain proportion perish as they enter the world or very shortly after. Among the number thus eliminated there appears to be a very considerable proportion of the largest infants. Doubtless because male infants tend to be larger than female infants, males suffer most at and shortly after birth. This appears to be the rule everywhere.*

So far as I am aware, the first attempt to explain this matter scientifically was made in 1786 by an English doctor named Clarke, physician to the Lying-in Hospital at Dublin.† By weighing and

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* For the exact proportion of male to female still-born children in most civilized countries, see, *e. g.*, Ploss, 'Das Weib,' 7th edition, 1901, Vol. I., p. 336.

† Joseph Clarke, 'Observations on some Causes of the Excess of the Mortality of Males above that of Females,' *Philosophical Transactions*, 1786. It may be said here that the very first attempt to weigh and measure infants accurately had only been made not so many years previously, by Roederer, in 1753.

measuring 120 newborn infants of both sexes he found that there was a marked tendency for the males to be larger than the females. 'Hence appears,' as he is pleased to put it, 'the merciful dispensations of Providence towards the female sex, for when deviations from the medium standard occur it is remarkable that they are much more frequently below than above this standard.' He considered that the greater mortality of males at and shortly after birth is largely due to the injuries to the head occurring at birth, but also that, since the males are larger and therefore make from the first a larger demand on the nutritive capacity of the mother, they are more likely to suffer from any defect of the mother in this respect. The problem and its possible and probable explanations were thus clearly stated more than a century ago.

As often happens with pioneers, Clarke's little paper was forgotten, and for more than half a century, although a number of workers brought extensive contributions of new data, their attitude was frequently illogical or one-sided, and the progress of scientific knowledge was not great. In 1844 Simpson published a well-known study which brought together a mass of evidence bearing more or less on the question before us. He showed that in male births the mothers suffered excessively as well as the infants; he refused to admit that the greater mortality of males at and shortly after birth could be due to any other cause than the generally recognized larger size of the male head (mainly on the ground that fœtal deaths up to birth are fairly apportioned to the two sexes) and concluded that the greater size of the male head is the cause of a vast annual mortality. A number of later obstetrical inquirers furnished additional contributions to the matter, at one point or another, though not always agreeing that so great a mortality could be due to a difference of size which seemed so small. One authority, indeed, roundly declared that the belief in the larger size of the male head was merely 'a popular prejudice'; this led to fresh measurements, and in this field Stadtfeldt of Copenhagen received credit which really belonged to Clarke of Dublin. Veit showed that even at equal weights more boys than girls die at birth, but, on the other hand, according to Pfannkuch's results, even at equal weights boys' heads are larger than girls'. In any case it certainly seemed probable that the larger size of the male child's head was an important factor in this mortality, and when at length the question began to attract the attention of statistical anthropologists this conclusion was confirmed. The Anthropometric Committee of the British Association, presided over by Mr. Francis Galton, in its final report in 1883 stated its belief that "it would appear that the physical (and most probably the mental) proportions of a race, and their uniformity within certain limits, are largely dependent on the size of the female pelvis, which acts as a gauge, as it were, of the race, and eliminates the largest infants, especially those with large heads (and presumably more brains), by preventing their survival at birth."

It must be added, however, that no direct and final demonstration has been brought forward of the tendency to the elimination of the males (or even infants independently of sex) of the greatest weight or those having the largest heads. For this we require to compare male and female stillborn infants at full term with those who are born living and which subsequently survived for at least a week (a longer period would be more desirable but difficult to secure). Such measurements are not to be found in medical literature, so far as I can discover; at the most we find averages, which are meaningless from the present point of view. I applied to obstetrical and anatomical authorities in various countries and received a number of interesting letters and data, including series of entries from the registers of maternity hospitals. But none of the series so far received contains a sufficient number of stillborn children. So far as they go, they are confirmatory of the belief that it is more especially the large children that are eliminated by the selection of birth. The largest series (with 60 stillborn male babies and 50 stillborn females), for which I am indebted to Dr. C. M. Green, of the Boston Lying-in Hospital, shows that among the stillborn of either sex the range of variation is greater than among the living of the same sex, the absolute range of variation being not only greater as compared with the living babies of the same sex, but there being a greater piling up at each end in the case of the stillborn. The data do not suffice to indicate that there is a greater mortality of the largest sized males than of the largest sized females, when we compare the stillborn with the living of the same sex and weight. Another series, more elaborate in its details but still smaller in number as regards the stillborn—for which I am indebted to Professor Whitridge Williams, of Johns Hopkins Hospital—leads to a similarly incomplete conclusion. I still await more extensive data which have been promised me from a British source.*

There is, however, another test which, while it can by no means be put forward as having any statistical validity, yet furnishes a highly significant indication in this matter. Just as on the psychic side certain very rare individuals appear in the world whose intellectual capacity enormously excels that of their fellows, so, corresponding to

* It seems unnecessary to deal with this point more in detail, not only because of the lack of sufficient data but because the establishment of this point is not necessary for the criticism of Professor Pearson's position. I expect to return to the point elsewhere, and hope that others, who may be more fortunate than I am in obtaining extensive data, will be able to deal with it on the lines I suggest.

'genius,' we have on the physical side certain equally rare individuals who at birth enormously excel their fellows in physical size, while yet remaining normal and well proportioned. Now, we may ask, do these individuals possessing congenital physical 'genius' resemble persons of psychic genius in being more often male than female? Ordinary statistics are not here available, for these cases are so rare that they very seldom fall into an ordinary series. Smellie found one child weighing over 13 pounds in 8,000 cases; in France, a child of 12 pounds was only found in 20,000 cases.* As even a child of 9 pounds is generally considered large, it is clear that when we get beyond 13 pounds we reach a point at which the average difference between males and females is trifling, so that there is almost as great a chance of females as of males reaching the extremely large weights. The only practicable way of obtaining information concerning these cases lay in collecting the scattered records. I have collected all that I can find in medical journals of standing, chiefly English, during the past half century, being aided by the references in Neale's 'Medical Digest.' I have only noted the cases that appear to have been healthy and well developed and weighed over 13 pounds at birth. One unexpected difficulty I encountered: in many cases, even when numerous measurements were given, no reference was made to sex. While such cases were necessarily rejected, I may say that I think it probable that most, and perhaps all, of these rejected cases were males; this was so in the only case in which, by writing to the medical reporter immediately on publication, I was able to repair the omission; the medical mind seems to share in some degree the instinctive conviction that the typical human being is a male, and that in the case of males it is unnecessary to make any reference to sex. My cases were thus reduced to 21. Of these there were only 3 females to 18 males. The females all died at birth, as well as about half the males. However rough this method of estimation may be, it is highly improbable that any more methodical inquiry on children of this size would entirely reverse so large a preponderance of males.

Such a result, it will be seen, can not be considered as absolutely conclusive proof that there exists a selection of birth which in its operation tends to the destruction of the larger male children either at the moment of birth or during the succeeding days and weeks, though it renders such selection probable. This element of doubt, however, by no means makes Professor Pearson's position any stronger. It

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* It must also be said that (as in the case of psychic genius) it is among the well-to-do classes that these very large infants are most usually found, not only because the parents tend to be larger among these classes, but because, as has lately been shown, other things being equal, women who rest during pregnancy tend to have larger children.

is sufficient to show that for more than a century past evidence has accumulated which indicates that the group of data on which Professor Pearson solely and absolutely relies for the foundation of his argument is modified by an influence which renders it tainted for such a purpose. In view of this circumstance, and of the fact that I had rejected this group of evidence on these grounds, the *onus probandi* clearly rested with Professor Pearson. In other words, he had to show either that male children are not larger than female children at birth, or else that large children do not suffer more than smaller children in passing through the maternal pelvis. The fact that Professor Pearson gives no indication that he had realized the necessity of this preliminary step is sufficient proof that he was not adequately equipped for the task he has undertaken.

We now come to a point which is not the less interesting for being entirely hidden from Mr. Pearson. It has been seen that the selection exercised by the pelvis to the detriment of male children is not absolutely proved. But if for the moment we assume that it exists, what are the phenomena that we should expect to find, as regards size, among the survivors? Obviously, a more or less diminished sexual difference during life, *with a maximum of sexual difference immediately after birth.** Now this is exactly what Professor Pearson found! 'Summing up in general our conclusions for weight,' he states, 'it would appear that, except at birth, man is not more variable than woman.' The very great significance of this exception, as affecting any argument on these premises brought against the position maintained in 'Man and Woman,' he undoubtedly failed to see. Still the exception evidently puzzled him. He accumulated series of data on the subject, and indeed initiated an entirely new and very extensive investigation. But the conclusion remained on the whole unaffected. Thus we see that our author, in all innocence, supplies a valuable piece of proof in favor of that very position which he imagines that he is upsetting! If this is the way that the axe is to be laid to the root of 'pseudo-scientific superstitions' they will certainly continue to flourish exceedingly.

We have now reached the climax of Professor Pearson's argument. It is from this giddy height that Mr. Pearson surveys with contempt those foolish persons who still believe that the variational tendency is greater in men than in women, and nothing further remains to be said. If instead of hastening to execute a war-dance on what he vainly imagined was the body of a prostrate foe, Mr. Pearson had pointed out, as he would have been quite warranted in doing, that

* In children dying at or soon after birth, as a result of undue pressure, hemorrhages or congestions are nearly always found in the internal organs, but they are not of necessity immediately fatal.

his conclusions, so far as they rested on a definite basis of fact, confirmed the thesis maintained by Darwin and more fully enforced in 'Man and Woman,' his position would have been unimpeachable. If, again, he had refrained altogether from attempting to interpret his own data—a task for which, it is obvious, he was singularly ill-prepared—and had put them forth simply as a study in natural selection—which is what they really are—his position would, again, have been altogether justifiable. But as the matter stands he has enmeshed himself in a tangle of misapprehensions, confusions and errors from which it must be very difficult to extricate him.

It may be well to summarize briefly the main points set forth in the foregoing pages.

1. In opposition to the doctrine of Darwin, more fully set forth in my 'Man and Woman,' that the variational tendency is, on the whole, more marked in men than in women, Professor Pearson resolved to show that this is one of 'the worst of the pseudo-scientific superstitions.'

2. Unfortunately, however, it never occurred to him to define what he meant by 'variation,' nor to ascertain what the writers whom he was opposing meant by the term.* A very little consideration suffices to show that a typical variation, in what may fairly be called its classic sense, is a congenital organic character *on which selection works,* while, as understood by Professor Pearson, though without definite statement, a typical variation is a character—of almost any kind, occurring at any period of life—*produced by selection.* 'To the biometrician,' Professor Pearson has recently stated, 'variation is a quantity determined by the class or group without reference to its ancestry.' That is to say, it need not be organic or congenital, and it must usually be modified, and sometimes entirely produced, by its environment. This definition may be better than the more classical conception of a variation. But it is certainly very different. To suppose that conclusions reached concerning this kind of variation can be used to overthrow conclusions reached concerning the other kind is obviously unreasonable.

3. Having silently adopted this conception of a variation, Professor Pearson proceeds to inquire what 'different degrees of variability are secondary sexual characters' and not 'characteristics which are themselves characteristics of sex'; and is hereby led into various eccentricities of assertion which it is unnecessary to recapitulate.

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* It is somewhat unusual, Professor Pearson has remarked in a recent controversial paper ('Biometrika,' April, 1902, p. 323), 'in a discussion to give entirely different meanings to the terms originally used, and leaves your adversary to find out with what significance you may be using them.' It seems to occur sometimes however.

'Secondary sexual characters' remain, in his hands, like variation, undefined.

4. All 'abnormalities' are added to the material rejected as unsuitable for investigation, on the ground that they are 'pathological.' It has been easy to show that this notion cannot be maintained, and that in his pious horror of 'pseudo-scientific superstitions' Professor Pearson here lays himself open to retort. Anomalies are not pathological, except in the sense of Virchow, who regarded pathology as simply the science of anomalies. Moreover, scientific pathologists do not admit that even diseases can be regarded as involving any new or different laws. Morbid as well as normal phenomena alike furnish proper material, if intelligently used, for the investigation of this question.

5. Professor Pearson decides that differences in size furnish the best measure of the variability of the sexes. In reaching this decision he makes no reference to the fact that the probabilities accumulated during a century tended to discredit this group of evidence for the purposes he had in view.

6. If, however, we put aside those probabilities which tend to render this evidence tainted, so far as the object of Professor Pearson's special argument is concerned, we still find that the results he reaches are precisely the results we should expect if the position he assails is sound. That is to say that at birth, before the results of the assumed selective action of the pelvis have yet been fully shown, there is greater variability of the males, while later, as a result of that selection, there is a tendency to equality in sexual variability.

7. The net outcome of Professor Pearson's paper is thus found to be a confirmation of that very doctrine of the greater variational tendency of the male which he set out to prove to be 'either a dogma or a superstition.'

It may be as well to state, finally, that nothing I have said can be construed as an attempt to disparage those 'biometrical' methods of advancing biology of which Professor Pearson is to-day the most brilliant and conspicuous champion. I am not competent to judge of the mathematical validity of such methods, but so far as I am able to follow them I gladly recognize that they constitute a very valuable instrument for biological progress. I say nothing against the instrument: I merely point out that, on this occasion, the results obtained by its application have been wrongly interpreted.

# THE ENGINEERING MIND.

By J. C. SUTHERLAND,

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IN a fragment of autobiography written some years before his death, Mr. Huxley said:

> But, though the Institute of Mechanical Engineers would certainly not own me, I am not sure that I have not all along been a sort of mechanical engineer *in partibus infidelium*. I am now occasionally horrified to think how very little I ever knew or cared about medicine as the art of healing. The only part of my professional course which really and deeply interested me was physiology, which is the mechanical engineering of living machines; and notwithstanding that natural science has been my proper business, I am afraid there is very little of the genuine naturalist in me. I never collected anything, and species work was always a burden to me; what I cared for was the architectural and engineering part of the business, the working out the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modifications of similar apparatuses to serve diverse ends.

Those who have read, however, the intensely interesting 'Life and Letters' of Huxley by his son, will recall that at the very close of his career, when driven to the continent in search of health, he took to collecting gentians and determining their species, with great enthusiasm. The physical enjoyments of the search, as well as the pleasure of recognizing each new species that he ran across, were doubtless added to the more direct pleasure he derived from observing the distribution of the genus and the adaptations that the different species had undergone.

At the same time, Huxley's analysis of the foundation of his intellectual pleasure serves to indicate a special 'note' of modern culture; or rather that part of modern culture which has been most profoundly affected by scientific thought. The age, at its best, is the age of the engineering mind. By this is not meant merely that it is an age of vast engineering feats and of a remarkable development of the engineering profession, but that a distinct habit of thought which may be called both with convenience and propriety the 'engineering mind,' is deeply influencing modern culture and is steadily preparing the way for the realization of a better ideal in popular education. The capable engineer computing to a nicety the elements of his bridge structure, the botanist studying the wonderful mechanism for the dispersal of seeds on the withered autumn weeds, the captain of industry organizing his factory, the skilled workman himself, the surgeon, the sea-captain—each and all of these, with many other representatives of human activity, are, at their best, endowed or equipped with a common habit of thought more or less directly connected with what Huxley called 'the architectural or engineering part of the business.' In other words, the more or less distinctly pronounced 'note' of modern culture is a capacity for the recognition of the universal in the particular or the reign of law in nature.

Unquestionably, the intellectual training which leads to the formation of the engineering mind, in its larger sense, affords a larger scope and capacity for pure intellectual pleasure, as well as a more permanent source of such pleasure, than is afforded, for instance, by the popular resort to light fiction. The poetry of common things, disclosed in enormous volume by the science of the nineteenth century, is familiar to many; but it is sealed to many more, not without a certain measure of intellectual culture, by the lack of the special training which forms the scientific habit of thought.

But, apart from the value of the engineering habit of mind regarded from the point of view of intellectual culture for its own sake, the question is at last being recognized with widespread interest as one of importance to nations struggling for industrial supremacy or stability. In Great Britain particularly, thanks in part to the large attention it received at the September meeting of the British Association not only at the hands of the president, Professor Dewar, but from the engineering and educational sections, the question is up for very general discussion in the country and, it is to be hoped, for progressive settlement. The incompetence displayed so often by British officers in South Africa has driven the British people to a severe stock taking, and that stock taking has brought into prominence a fact, more or less fully recognized by a wise minority from the time of Dr. Arnold of Rugby to the present day, namely, that the traditional methods of education in England are not conducive to the formation of trained habits of scientific thought.

Professor Perry, the president of the engineering section of the British Association, has been insisting for some time, and insisted again at the Belfast meeting, that the great fault of the traditional method is the manner in which mathematics is taught. Mensuration is dissociated too sharply from geometry, and geometry too sharply from algebra. That is to say, contrary to the example of Germany and France for nearly a century and to the more recent example of the American universities, the employment of the modern proofs of geometry has been resisted in favor of the more cumbersome and, to the average young mind, the far more difficult proofs employed by

Euclid. The amount of geometrical ground that can be covered by means of the algebraical methods in one year by an average pupil is about equal to that which can be acquired by the same pupil in three years following the Euclidean method. And as there is no loss whatever in rigidity of proof, the natural consequence is surely that of two pupils who have devoted an equal period of time to mathematics during their school training, the one employing in his geometry the modern methods and the other the Euclidean, the former must be more prepared for the intelligent use of mathematical formulæ and reasoning in the university or the technical school than the latter. This consideration, indeed, derives still more strength from the fact that the proving of geometrical propositions by means of operations upon algebraical symbols extends the mental grasp of algebra itself.

Professor Perry appears to have hopes of speedy reform in this respect, the University of Oxford having decided to omit Euclid from the 'locals' of 1903, Oxford being capable of setting the pace for the great schools and the principles of the Society for the Improvement of Geometrical Teaching having made, during the past twenty years, sufficient theoretical headway to ensure the opportunity of the change being welcomed and grasped.

At the same time, it is to be remembered that the mathematical is not the whole or the only training even for the engineering mind. We have the constant reminder of Faraday's example in this respect. Faraday was able to reason most accurately and profoundly upon curves, centers of motion and other phenomena arising from his experiments in electricity and magnetism, although he was obliged to confess in a letter to Professor Clerk Maxwell that although he had tried hard he had never been able to understand even simple equations in algebra—a comforting confession for others to whom mathematical studies have been a great difficulty!—but perhaps more profitably to be regarded simply as a proof that a sufficiently helpful text-book was not placed within his reach at the struggling period when he laid the foundations of his marvelous self-culture.

# POST-GRADUATE DEGREES IN ABSENTIA.

BY A. L. BENEDICT, A.M., M.D.,

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COLLEGE faculties have, within the last few years, conferred post-graduate degrees with conservatism and even reluctance. The time is long past when there was a germ of truth in the assertion that A.M. was a decoration for principals of preparatory schools who sent a sufficient number of students to college, or for young alumni whose interest in their alma mater persisted after graduation. The free distribution of honorary degrees, always a possible source of evil, is especially dangerous in the case of professional degrees, since the latter indicate the completion of an apprenticeship rather than the attainment of learning and confer privileges of practical commercial value and subject to abuse.

Unfortunately, the reaction against the old custom of applying degrees 'honoris causa' and with no very definite requirement of scholarship, has led the majority of colleges to insist that the master's and the doctor's degree shall be reached only by courses of study pursued under the immediate supervision of the faculty and has closed the path to these honors for all who are unable to protract their residence in a college town, except those who have distinguished themselves in the most signal manner. It is, doubtless, presumptuous for criticism of an educational system to emanate from one who has no closer contact with education than the training of a professional student and the practice of a profession, yet the general tendency of colleges to adapt their methods and aims to conform with the demands of practical life, encourages the writer in pleading in behalf of the worker in the great university of the world, who still desires to keep in touch with the scholarship of the college.

Through long custom, we have one degree which is admirably adapted to use as a decoration. This is the title of Doctor of Laws, which has come to be the patent of practical success in any line of activity, not incompatible with a reasonable degree of refinement and intellect. Its significance is executive ability and wide influence of the highest kind. If deservedly applied, it can never add materially to the dignity of the recipient, while any tendency to its abuse is checked by the reflex discredit cast upon the donor.

The master's and doctor's degrees in arts and sciences, on the other hand, represent purely educational attainments, of higher order than the bachelor's, but of the same general scope, and they may be sought with the same propriety as any other reward which represents a performance of a definite task and which is honorary only in the sense that the formal recognition of an accomplished work is an honor. The plea for conferring these degrees *in absentia* might, at first thought, be regarded as in the interests of young men and women, prevented by poverty—actual or relative—from pursuing their studies beyond the usual limits of the college course. On the contrary, few are prevented from continuing their education at college by lack of funds, on account of the generous provision of scholarships and because the experience of undergraduate life renders it comparatively easy for the post-graduate student to be self-supporting, as a tutor, a literary hack or in some other capacity. The real obstacle to post-graduate study *in præsentia* is that every young person of energy and ambition realizes, with the advent of that indefinable condition which we call maturity, that it is time for him to be about the serious business of life, that he must cease to be a consumer, even of scholarship, and that he must become a producer. Some few lines of life work admit of a protraction of residence at a university without interference with the demands which society justly makes on a well-trained intellect, some few are favored by accident of location, but, in the vast majority of all instances, the man or woman who decides to remain at college beyond the usual undergraduate period, must make a sacrifice of the best years of life, years which might better be applied to the preliminary struggle for position which is inevitable to success in every business or profession and which must be undertaken in the arena of actual life. The desire for thorough educational preparation, however laudable, must be recognized as futile in the sense that no scholar can hope to gain the point at which he can consider his past progress as having measurably subtracted from the infinite possibility of the future. On the other hand, all educational systems must frankly recognize that senility begins its inroads before full maturity is reached. The appearance of grey hairs before the beard is fully established is but the symbol of all physical and mental development. The man who waits for his judgment to be fully formed and his knowledge to be completed—even according to human standards—before engaging on his life work, has already lost something of mental flexibility and of the vigor of innervating centers. It is impossible to translate this principle into terms of age and the formulation of standards must be left to the collective experience of educators, sociologists and of that paramount factor in education and social progress which we so often forget—the people. A surprisingly large number of great men have practically completed their work in life at thirty-five. A critical study of most others will demonstrate that, while the recognition of their labors may have been deferred by circumstances—mainly lack of opportunity—till later in life, they were actively engaged in their life work by the twenty-fifth year and had laid the foundation of success by the thirtieth. The late Dr. William Pepper, though one of the most earnest advocates of a liberal education for medical men as well as of thorough medical training, declared at the time of his ripest experience that any educational system was a mistake which would not allow the average man to enter upon actual practice at the age of twenty-three or twenty-four. It would prolong this paper unduly to quote his arguments, none of which however, was so convincing as his own life-history. Business men would, probably, assign a still earlier age. Among educators and scientists, there exists a considerable diversity of opinion; probably the majority would favor a lengthening of the period of preparation but it is questionable whether their personal biographies would support this opinion. On the whole, it would seem that the preparatory period should not occupy more than a third of the maximum duration of active life and that it should not extend much beyond the period of physiologic growth.

As a matter of abstract fairness, it may be argued that the advanced degrees are, at present, open to all college graduates on equal terms—let them accept or reject these terms as they please; if the A.M. or Ph.D. is not worth the sacrifice of a year or two of active life, why complain because one cannot eat his cake and have it too? But is this a wise attitude to assume? Granted that the privileges of the master or doctor and the esteem in which he is held by the community in no practical way exceed those enjoyed by the bachelor, long custom has established the post-graduate degrees, and they should stand for the best, ripest, most practical and wisest scholarship of the times. When the immature critic and student of other men's writings is eligible to a title that is denied to the man who creates literature that is deemed worthy of serious consideration, even though not of epoch-making value; when the laboratory worker who follows the lines laid down by others receives a tangible reward from which the pioneers of such study are often excluded; when field-work in science must radiate from a college rather than from a center which offers equal or greater scientific opportunities; when one museum or library yields not only information but a scholastic degree, while another, as good or better but not incorporated as part of a university, receives no such recognition; when second-hand knowledge of old-world linguistics and anthropology is placed on a higher level than original research, carried on independently, and dealing with similar problems in American fields; when one must be a 'scholar' in the incorrect sense of the grammar school to obtain a scholastic recognition which can not be earned by the slower self-denial and effort of the man who devotes his leisure from the earnest of life to broadening his own intellect and extending the limits of human knowledge—may we not well ask if the reaction against honorary degrees has not carried the colleges too far in the opposite direction?

The necessary regulation of study *in præsentia* may be applied with only literal alterations, to study *in absentia.* There can be the same supervision by a faculty committee, the same minima of time required after the receipt of the bachelor's degree, the same inspection of work or formal examination, the same insistence upon a thesis the same or even higher standard of originality, the same precaution against too great concentration, even the same fees unless the college prefers to guard against the superficial appearance of interested motives. The post-graduate student *in præsentia* is seldom held to a definite schedule of attendance; the student *in absentia* needs only an extension of the same courtesy, and he may be required to report in person at stated intervals. Evidence of adequate resources for the special kind of study undertaken may be required and this could be supplied, so far as museums, libraries, art galleries, laboratories, mechanical workshops, etc., are concerned, by nearly very resident of a large city, while there is scarcely a region of the entire country which does not offer opportunities for one or more kinds of scientific field-work, in which original investigation is urgently needed. A slightly less formal requirement in regard to the customary 'two minor' subjects of study, would probably be wise in most instances and more careful inquiry into the probity and reputation of the candidate would be necessary than in the case of the resident student who is under the immediate and almost constant observation of the faculty, but it would seem that these various modifications of the regulations of study *in præsentia* are feasible, without too great effort on the part of the college authorities.

In conclusion, the writer would again emphasize, as the main plea of this article, that the present custom of limiting the post-graduate degrees to students *in præsentia,* places the intellectual consumer on a higher basis than the producer while it has a corresponding tendency to lower the scholastic value of the titles which ought, par excellence, to represent the highest attainments of the broadest scholarship.

# MENTAL AND MORAL HEREDITY IN ROYALTY, VI.

By Dr. FREDERICK F. WOODS.

## Bourbons in Spain.

### *Philip V. to the present day.*

THE male or Hapsburg line having become extinct on the death of Charles II., the Bourbons came upon the Spanish throne. This group may be subdivided into six smaller groups:

1. Children of first marriage of Philip V.
2. Primogeniture line of Spain.
3. Children of Philip Duke of Parma.
4. Male line in the Two Sicilies.
5. The Carlists.
6. Children of Francesco de Paula.

1–2 I shall start with Philip V. and include in the group with him all his ancestors to the third or great-grandparent degree. This supplies 87½ per cent. of influence according to Galton's law. Next all the children of Philip V. will be included, as well as all their ancestors to the third degree. Then following down the line that corresponds to the throne, I shall treat of each fraternity in turn until the present Alfonso XIII. is reached. After this the other male lines (3–6) will be taken up. The daughters are also included, but not their children, as these are considered under the male lines in other countries—Austria, France, Portugal, etc. There are thirty-four persons in this group who require tracing. As each has fourteen ancestors in the third degree (two parents, four grandparents, eight great-grandparents) the total number of persons concerned is $(14 \times 34) + 34$, or 510. All are of value, even the remote edges, because any striking trait, insanity, genius or moral depravity exhibited in any ancestor should reappear further down; if not in some branch represented in its own country, then perhaps here in Spain. There are many of these second- and third-degree ancestors who have the worst possible epithets bestowed upon them, such as the type of Louis XV. of France, but strange as it may seem to those who discredit heredity, there are only two out of the five hundred and ten who have ever been called great or who could be ranked with the geniuses of a grade as high as 9.

These are Maria Theresa of Austria and her grandson, the celebrated Archduke Charles, who won so much distinction in his battles against Napoleon. Maria Theresa comes in this group no nearer than a grandparent and then only twice, and as a great-grandparent only three times. In none of these does the genius reappear, though over on the part of the chart where most of her descendants are one sees higher marks for intellect. The Arch-duke Charles enters this group merely as a grandfather of the present Queen Regent of Spain, who is no unworthy descendant. The tracing of this higher mental strain, its origin and its reappearance, is to be found under Austria. So as regards genius the results are conclusive. The others are nearly all between 1 and 6, the great majority being below mediocrity, illustrating the intellect of the Bourbons which, as some one has said, never rose above cunning. Although this statement is not absolutely true, there seems to be a certain characteristic in the type of mind most often seen: low craftiness for intrigue, combined with laziness, debauchery, tyranny and often cowardice. This last is the slur we can least frequently bring against royalty. Whatever they are, they are nearly always brave.

The mental qualities are, for the most part, below the mean, while the moral qualities fall as far below the average as any of the worst regions in the older times; as bad as the Romanhofs in the seventeenth and eighteenth centuries. Charts dealing with this group show just how, if heredity be a great force, Spain was brought to her unfortunate fate, how nearly impossible it was that she should have escaped it.

Another important thing to notice is the strong variation in the moral qualities. It is very easy to separate the sheep from the goats. There are only a few about whom we should hesitate to say whether they were good or bad. I have attempted to so classify them in the following list:

*Philip V.
*Ferdinand VI.
†Louis.
Charles III.
Philip, Duke of Parma.
Marie Anne.
Charles IV.
†*Ferdinand I., Two Sicilies.
†*Philip, imbecile son of Charles III.
Maria Louisa, wife of Leopold II. of Austria.
†*Ferdinand VII.
Carlos, first pretender.
Isabella.
†Carlotta, Queen of Portugal.
Francisco de Paula.
†Isabella II. (Queen).
Maria Louisa Montpensier.
Alfonso XII.
Alfonso XIII.
†Ferdinand, D. of Parma.
†Maria Louisa.
*Elizabeth.
†Frances I., Two Sicilies.
Antonia.
†Ferdinand II. ('Bomba').
†Christina.
Carlotta, wife of Francis de Paula.
†Francis II., Two Sicilies.
Don Carlos VI.
*John.
†Don Carlos VII.
Alfonso.
†Elwora.
†Henrique.
Francis d'Assis.

There are thirty-five persons in this list, of whom fifteen were either cruel or dissolute or both. These have the mark † against them. There are at least seven either insane or showing the neurosis in a marked degree. These have the mark * applied to them. This leaves only thirteen free. Of these, four are known to have been indolent almost to point of disease. Thus, only about nine in the thirty-five were normal. This is a remarkably small ratio of normal and is less than found in any other country.

It will be shown that selection of the worst in each generation will account for it without other causes being necessarily introduced. We get some idea here of the extent to which a degeneration can be carried, and it is worthy of note that it may be perpetuated for a great number of generations, even when breeding in. There is no evidence that the in-breeding has led to sterility, as is usually contended by historians and students of the subject. Although the male line by way of the oldest sons ceased once at Charles II., and again at Ferdinand VII., nearly every marriage was prolific of many children, even among the closest blood relations, and one has but to glance at the 'Almanach de Gotha' for the current year to see the number of descendants that are being born to the closely inter-related families of Hapsburg, Bourbon and Orleans.

### Summary of Modern Spain.

The occurrence just where they fall of every one of these modern Spanish Bourbons is compatible with the theory of mental and moral inheritance. There is no greatness springing up where we least expect it; there is no viciousness and imbecility that might not be explained from heredity alone. There is nothing that need be more than pure selection and repetition.

Of course we expect from Galton's law that, on the average, the descendants will show less of any peculiarity than the parents, and here we shall show that averaging all the descendants it is so, but all descendants would include other countries. Portugal, Austria, Italy, France, and including all these it will be shown in a later summary that there is a bettering of affairs from the time of Philip V. onward, but one must notice the artificial selection that took place in Spain. It was as if they were breeding mental monstrosities for a bench show. We see no diminution in either the debauchery or tyranny. The insanity does appear less at the bottom of the chart, but it will also be noticed that the early degenerates, Ferdinand VI. and Philip, son of Charles III., who were avowedly insane, had no children and the worst was consequently eliminated, while the worst moral depravity and laziness were not only perpetuated, but usually drawn from and in a double or triple way. This view of selection alone is important, because this same family is usually considered to have run out through external circumstances and to have followed an easy road from opulence and luxury to indolence and decline.

I shall show that among all the races considered in this book a family never runs out except by selection, no matter what the condition of environment may be. It is far from my wish to assume that environment has done *nothing* in molding these characters, and especially the moral characters that fall under this group of modern Spain. If it has done *much* in order to account for a considerable number of excellent ones, and these often as good as any princes that have ever lived, we must assume that it, like the pedigree, was calculated to bring great variations. This probability will be discussed when all the greater groups are compared one with the other. If environment did have much to do with molding their individual destinies there is no apparent culminated inherited effect from it. After five or six generations the people are practically neither worse nor better than at first.

Nineteenth century estimates had no effect in lessening the cruelty and arrogance of Ferdinand II., 'Bomba.' He was as bad a tyrant as ever lived in the middle ages. His son was a man of the same type. The conditions in Portugal and Spain were not very different from those in Italy where Ferdinand lived, and yet Portugal and Spain show us nothing to be compared with the brutalities of this father and son. Ferdinand II. was no more a tyrant than his grandmother or some others among the Hapsburgs; Francis of Modena, for instance. Carlotta alone of those belonging to the immediate branch of the throne of Spain (occurring in the middle of the chart) would be rightly characterized by the word tyrant. Yet the conditions in Spain for the formation of an autocrat might be justly considered as conducive to this effect as were those of Italy. It will be noticed that the branches in Spain are practically free from this tyrannical type, except that Carlotta, daughter of Charles III., showed something of this character, and one of her sons, Migual, exhibited it in a high degree. She was one among four children to show the violent type. On the other or left side of the chart where the blood of the tyrannical Caroline of Austria is closest, we have Bomba and Carlotta, two of the same type in three children, and also Henrique, one in two, and Francis II., one in one. Imitation may have played a rôle, but then why did a certain definite number imitate and only a certain number do so?

What shall we say here of free-will? How could it have played any appreciable part in molding the characters of these scores of people, each apparently filling a little link in a chain, the destinies of which seem as much the result of birth and breeding as the product of the most carefully conducted racing stable?

### Evidence from Denmark.

The royal house of Oldenburg from which the kings of Denmark are descended covers, from Frederick II. to the daughter of Frederick IV., three centuries and ten generations. Including in each generation not only the reigning sovereign, but also his brothers and sisters, the number of names brought into this family is thirty-seven. In order to get the necessary material for heredity study, there have been added in each generation all the ancestors of every child back to the great-grandparents, so the number brought together in this group is raised by 132, or 169 represents the total.

With the exception of the first two kings, this period of Danish history covers what is known as the 'Age of Absolutism,' 1670–1848. A good idea of the sovereign rights at this time and the general characteristics of the rulers may be gathered from the following quotation:

> Although the Royal Law conferred so absolute a power on the king, a power such as was perhaps not vested in any other sovereign in Europe, the autocrats of the Oldenburg dynasty—good-natured, upright and not more than ordinarily gifted as they were—exercised the prerogative, on the whole, with moderation and leniency, and the country had often reason to be thankful for the advantages secured to it during this period, especially when among the royal councillors were to be found men of talent and capacity.

Good-natured, upright and not more than ordinarily gifted is a fair estimate for our thirty-seven members of the Oldenburg family taken as a whole. There are not more than three or four exceptions to this among them all. In other words, the Oldenburgs show no great mental and moral variations. Do the characteristics of the other 132, who, united with the male line, are the formers of the breed, warrant us in saying that this result is only what we might expect from the direct inheritance of the traits of these progenitors? It will be seen that the characteristics of these outsiders who represent the maternal side amply bear out such a belief.

In the pedigree of the Oldenburgs there is no Hapsburg, Bourbon or Romanhof insanity, or moral depravity. There is no Orange or Hohenzollern genius. In searching out the quality of the maternal blood as it was introduced all down the line, one finds no distinguished ancestry and few peculiar characters of any sort. Two of the queens had brilliant gifts of mind, one being also extremely unprincipled in her political actions. Aside from this there is little of interest in the ancestry. Frederick II., 1534–1588, was a headstrong and arbitrary ruler with too great a fondness for strong drink, but otherwise was not strange in any way and is not a striking figure in Danish history. His consort, Sophia, however, was a woman much praised for her intellectual eminence.* From this union sprang Christian IV., the idol of Danish history and the only sovereign who ranks at all with the more able kings of other countries. There were six other children, but Christian is the only one who has left a distinguished record. Anna, the wife of Christian IV., descended from a comparatively obscure branch of the Brandenburg family, was a mild, sweet-tempered, charitable princess,† but not a conspicuous character in contemporary records. Their son, Frederick III., 1609–70, was a wise and shrewd sovereign, but of languid disposition. His temper was amiable, and his reign popular. The brilliant, haughty and vindictive Sophia Amelia was queen during this reign. It was she who imprisoned the king's half sister for twenty-two years, because, when trying on the crown, it is said, Eleonora Christian dropped it and injured a very fine jewel. The same authority gives us the anecdote that she ordered a noble executed, because he claimed she would fall in love with him. The Brunswick stock from which she came shows at this point no eminence of any kind; still we expect some of her six children to have been mentally gifted. The next generation gives us a rather mediocre showing, with Prince George, husband of Queen Anne of England, almost a fool. Ulrica Elenora, who married Charles XI. of Sweden and became the mother of the remarkable Charles XII., was the only one among the six children to represent the intellectual side of the family.

Christian V. 1646–1699, the eldest son, courageous, enterprising and chivalrous, was no ordinary man, but the strong tendency to ease and pleasure and the weakness he showed in being governed by others forbid us to give him a high rating for intellect when this is judged by the standard of outward achievements. His marriage brought in no mental uplifting, since the Queen Charlotte Amelia was from an 'obscure' region in the family of Hesse Cassel. Neither in the next generation (Frederick IV.) or the two following this (Christian VI. and Frederick V.) do we find any noteworthy mental variations. In all these generations a study of the chart will show the stock good but far from illustrious.

We now come to a very interesting anomaly in Christian VII., the only son of Frederick V. by his first wife Louisa, daughter of George II. of England. Among all modern royalty there is scarcely a feebler specimen of the human race than this poor little, half-mad, debauchee king. His type of mind was so purile and his self-restraint so weak that it seems only charity to consider him among the irresponsibles. From L. Wraxall and Walpole an idea may be obtained

* Allen, 'Hist. de Dannemark,' II., 29.

† L. Flamand, 'Danmarke Dronninger,' 1848, pp. 11, 12.

of his conduct during his visit to England, giving the positive impression that he was a degenerate of the worst type. He would be in just the place we might expect to find him, if he belonged among the older Romanhofs or modern Bourbons, yet there is none of this blood in him, nor is there any other equally bad. Christian VII. was a grandson of George II., and whether he got his bad qualities from him it is impossible to say. If he did he was certainly a great deal worse than George and much feebler intellectually. It is interesting in connection with heredity to note that Christian VII. was a first cousin of George III. who was insane, and also the first cousin, once removed, of the two imbecile sons of Augusta Princess of Brunswick, sister of George III.

Another more convincing bit of evidence in this connection is to be found in the neighboring House of Hesse Cassel; here we find another first cousin, once removed, of Christian VII., who became insane and died in early manhood. The observation that this man Christian, son of Charles of Hesse Cassel, is doubly descended from the suspected strain (Palatine House) makes it almost certain that we are dealing with an inherited insanity in all cases. Both the mother and father of this Christian of Hesse were grandchildren of George II., and consequently from the Palatine House. I almost forgot to mention Frederick William I., of Prussia, about whom Macaulay said, 'His eccentricities were such as had never been seen out of a mad house.' Frederick William was a first cousin of George II. and stands as near the actual Palatine insanity as a nephew.

These six cases would, if occurring in families of ordinary social grades, be sent to asylums and never make their way into the records as showing a congenital tendency. Since they stand apart from the other regions of neurosis such as the Spanish, Russian and modern Bavarian groups, at first we might suspect nothing, but here where we have the family tree and can look up the ancestry, curiously enough we find all related, and through the same source (Palatine) and this the only one of their many lines of descent in which there was insanity.

It should be noticed that the percentages for heredity among the insane run from 20 to 90, according to the observer, and this should make us think that the higher rather than the lower figures are more likely to be correct.

Besides this evidence we may mention the following facts: that the uncle of Christian VII., the Duke of Cumberland, was extremely cruel, and his other uncle, Frederick, Prince of Wales, was a dissolute specimen and William IV. of England was eccentric to say the least. Whatever we may say for hereditary influence, at any rate the bringing up of Christian VII. was pretty bad. He was in the hands of his step-mother, Juliana Maria of Brunswick, who is said to have used every means to corrupt his morals and stunt his education that she might get the more power in her own hands. I only mention this to show a good example of the sort of cases that should make us bend strongly towards the importance of environment in molding the psychical form. It is the relative absence of such cases that has led to the view taken in this book. In spite of the fact that Christian VII. married his first cousin, related on the bad side of the house, since she was a sister of George III., his two children were not of the worst sort by any means, though in general we may say that one took after the father and one the mother. Louisa Augusta, the daughter, had relatively very little intellect, no ambition and a very quick temper, while Frederick VI., the next king, mild, affable and sensible, resembled his mother.

The remaining characters, Christian VIII. and Frederick VII., were merely examples of good normal men, liberal, popular and sufficiently able to fill their positions with honor to their country. There is nothing particularly interesting just here, so we can conclude the chapter of the Oldenburg dynasty with a glance back at the seventeenth century.

It will be noticed that there is one little region where the intellectual ratings are fairly high and that included in this group is Christian IV., the greatest of Danish kings. The only slight error from expected heredity is that the intellectual eminence fails to be perpetuated to quite the extent we might have expected in any of the children of Frederick III. Ulrica Elenora, the only gifted child, was 'distinguished for her knowledge.' She was the mother of Charles XII., of Sweden, and in him the genius was more than rejuvenated.

Aside from this heredity is very well satisfied in the study of this country, there being not more than one or two exceptions at most to what we might expect from the workings of this force. It is also important to note that the age of absolutism entirely failed to produce a type of cruel and arrogant kings. Had such a type been here engendered it would certainly have been ascribed largely to the environment in which they lived.

# MENDEL'S LAW.

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NO discovery in recent years has aroused more interest amongst biologists than that of Mendel's Law. If subsequent investigations confirm it as those thus far made have done it can not be considered less than epoch-making. Its importance to plant breeders seems hardly less than that of the atomic theory to the science of chemistry. Professor Bateson, of Cambridge, says there is reason to believe that the plant breeder may eventually be able, by means of this law, to produce a desired hybrid type with the same degree of accuracy as the chemist now constructs a compound. It is impossible, on the threshold of such a discovery, to state just how far-reaching its importance is; we must wait for further investigation before hoping for too much.

As the history of this discovery is not yet generally known, it may be stated that Mendel's original paper was published in an obscure periodical at Brünn, Austria, in 1865.* This publication received slight notice until De Vries, in March, 1900,† published an exact counterpart of Mendel's theory, including some technical terms proposed by Mendel, and gave some of the results of his own researches to confirm the theory. Shortly after this, Correns of Germany and Bateson of England published results of their own work, showing that each of them had discovered the same law. Meanwhile the writer, working on hybrid wheats in this country, announced the law (but not the theory) in November, 1901.‡ The knowledge of this discovery has become general only during the past few months. It now remains for other investigators to apply it to their own results for confirmation or modification.

As the distinction between varieties and species can not always be drawn with exactness, and particularly since Mendel's law applies alike to crosses and hybrids, it seems justifiable, at least in a discussion such as the present one, to conform to the growing usage of biologists in this country by using the term hybrid to include crosses of all kinds, whether between varieties or distantly related species. I shall, therefore, use the term hybrid in this sense. In the following

* *Verhandl. d. Naturf. Vereines*, Brünn, 1865.

† *Compte Rendus*, March 20, 1900.

‡ Bul. 115, Off. Exper. Sta., U. S. Dept. Agric.

discussion it is to be understood, unless otherwise stated, that the parent forms are all well-established varieties or species (*i. e.,* they come true to type from seed), and that the hybrids are close fertilized (either self-fertilized or fertilized by others like them).

Mendel's law is, briefly stated, as follows: In the second and later generations of a hybrid, every possible combination of the parent characters occurs, and each combination appears in a definite proportion of the individuals.

Mendel did not leave his work unfinished. He proposed a theory, or rather deduced one by a simple course of reasoning that renders the theory almost an established fact as far as results thus far secured are concerned, that explains the facts in the case in a brilliant manner.* As I have shown elsewhere, this theory explains most of the so-called exceptions to the law pointed out by several investigators. It explains so many apparent anomalies in such a simple manner that there is danger of applying it too extensively. This point will be brought up again below.

The theory may be illustrated as follows: Suppose the two parent varieties differ with respect to a single character. For instance, a variety of bearded wheat is crossed with one that is smooth (not bearded). When the hybrid thus produced forms its germ cells (pollen and ovules), the characters of the two parents separate, the beard-producing character passing into part of the pollen grains and part of the ovules, the smooth-head character of the other parent passing into the remaining germ cells. The character passing into any single germ cell being governed by chance, on the average half the pollen and half the ovules will receive the character of one parent, the other half that of the other. The results of this separation of characters may be illustrated by the following diagram, in which $B$ stands for the beard-producing character and $S$ for its opposite. The reason for the use of a small $b$ in designating the hybrid will appear later.

$$\left.\begin{matrix} B \\ \\ S \end{matrix}\right\} \begin{matrix} Sb \\ \text{(hybrid)} \end{matrix} \qquad \begin{matrix} \text{Pollen.} & & \text{Ovules.} \\ \left\{\begin{matrix} B \\ \\ S \end{matrix}\right. & & \left.\begin{matrix} B \\ \\ S \end{matrix}\right\} \end{matrix} \left\{\begin{matrix} B \times B = B \\ S \times B = Sb \\ B \times S = Sb \\ S \times S = S \end{matrix}\right.$$

Since the ovules of each kind are offered both kinds of pollen, half of each, on the average, will be fertilized by one and half by the other kind of pollen, giving the four fertilizations shown at the right. (Abundant experience has shown that $S \times B = B \times S$.) From this it appears that one fourth of the progeny of the hybrid $Sb$ will be like the parent $B$, one fourth like $S$, and one half like the hybrid itself.

* It seems that both Correns and De Vries had arrived at the same theory independently.

Nothing has been said so far concerning the external appearances of the hybrid, whether it is intermediate between the parents, or resembles one or the other of them. The efforts of investigators since the time of Kölreuter have been directed to the futile attempt to find some law which would enable the breeder to predict the appearance of this hybrid. In general, this can not be done, with our present knowledge. There are two cases to consider. In certain instances hybrids are strictly intermediate between the parents. In others they are unlike either parent. These cases will be noticed later. In the more common case the hybrid either shows a parent character fully developed or shows it not at all. A parent character which is fully developed in the hybrid is said to be 'dominant'; if it is apparently absent it is said to be 'recessive.' In my work with hybrid wheats, beards have always been recessive, hence the designation of the hybrid as *Sb*.

It will now be seen that, externally, the progeny of the hybrid will consist of only two types, one type (*B*), constituting one fourth of the progeny, being like one parent, and the other, constituting three fourths of the progeny, resembling the other parent. Of this three fourths, one part (*S*) is actually like one parent, and will produce progeny like itself. The other two parts (*Sb*) are hybrids, and will produce progeny of all the types, exactly as the original hybrid did. Plants of the type *S* may easily be separated from those of the type *Sb* by planting the seed of each plant separately, and noting the character of the progeny.

The above diagram may easily be extended to any desired number of generations. Extended to the third generation it is:

| | | | |
|---|---|---|---|
| *B* | | *B* | *B* |
| | | | *B* |
| | *Sb* | *Sb* | *Sb* |
| | | | *S* |
| *S* | | *S* | *S* |

Assuming that each of the types *S, Sb* and *B* are equally productive, and mixing and sowing all the seed of each generation, the following table shows the percentage of each type in each generation to the sixth:

| Generations. | *S* | *Sb* | *B* |
|---|---|---|---|
| 1 | | 100 | |
| 2 | 25 | 50 | 25 |
| 3 | 37.5 | 25 | 37.5 |
| 4 | 43.75 | 12.5 | 43.75 |
| 5 | 46.87 | 6.25 | 46.87 |
| 6 | 48.44 | 3.12 | 48.44 |

Here it is seen that the hybrid, based on a single pair of antagonistic characters, tends to split up into the two parent types. A hybrid whose parents differ in one respect is called a monohybrid; a dihybrid is one whose parents differ in two respects; and so on. Dihybrids and polyhybrids do not tend to split up into the two parent forms, as will be seen later.

Heretofore, plant breeders have been producing hybrids, and then by selecting to type each year from the progeny, trying to fix new types. Let us see what light Mendel's law throws on this practice. In the illustration given above, if the breeder had selected the type *B* of the progeny of the hybrid, he would have had a fixed type at once. Had he selected for type *S*, he would have had a mixture of the pure type *S* with the mixed type *Sb*. (Professor Bateson proposes the useful terms homozygote for pure types like *S*, and heterozygote for mixed types like *Sb*.) Next year the homozygotes *S* would reproduce their kind only, while the heterozygotes would produce the three types *B*, *Sb* and *S* in the proportion 1:2:1. The second generation would therefore consist of *S*, 62.5 per cent.; *Sb*, 25 per cent.; and *B*, 12.5 per cent. This method of selection would never result in a fixed type unless the breeder should accidentally choose seed of the type *S* only. It has already been shown that the fixed type *S* could have been separated out at once by saving the seed of each selected plant separately, and observing which reproduced true to type. Nature fixes the type whether the breeder selects or not; heretofore, the breeder secured his fixed type by chance selection. With the knowledge of Mendel's law, he now selects his fixed type in a methodical manner, in the third generation.

Dihybrids are much more interesting, since they present the more usual case with which the breeder has to deal. With them, fixed types unlike either parent may be secured in the third generation. It frequently occurs that a breeder finds two characters in different varieties that he wishes to combine in a single variety. This is easily done when the characters obey Mendel's law. To illustrate this case I shall use characters which are of no particular importance, but for which I happen to possess experimental data. The principles are exactly the same for any characters that obey Mendel's law. Suppose we have a variety of wheat that has velvet chaff and another that has smooth heads (is not bearded) and that we wish to combine these two characters in a single variety. It is assumed that neither of the varieties has these two characters already; hence we have to deal with two pairs of opposite characters, namely, beards—no beards, and velvet—glabrous. We may, for brevity's sake, represent these characters by their initial letters, using small letters in cases where they are latent. In my work with wheats, beards have always been recessive, as stated above, and velvet chaff has always been dominant (except in a single individual). Hence the cross *VB* × *GS* gives us the hybrid *VgSb*. When this hybrid produces pollen and ovules, the pair of characters *V* and *G* separate, *V* going to half the pollen grains and ovules, and *G* to the other half. *S* and *B* do the same thing, but without reference to *V* and *G*. Hence we have four kinds of pollen grains and four of ovules, as shown in the following diagram:

| | | Pollen. | Ovules. |
|---|---|---|---|
| *VB* | *VgSb* | *VB* | *VB* |
| | | *VS* | *VS* |
| | | *GB* | *GB* |
| *GS* | | *GS* | *GS* |

Here we have a mixture of four kinds of pollen offered to four kinds of ovules. On the average, one fourth of each kind of ovules will be fertilized by each kind of pollen, giving sixteen equally numerous fertilizations, as follows:

1. *VB* × *VB* = *VB*.
2. *VS* × *VB* = *VSb*.
3. *GB* × *VB* = *VgB*.
4. *GS* × *VB* = *VgSb*.
5. *VB* × *VS* = *VSb*.
6. *VS* × *VS* = *VS*.
7. *GB* × *VS* = *VgSb*.
8. *GS* × *VS* = *VgS*.
9. *VB* × *GB* = *VgB*.
10. *VS* × *GB* = *VgSb*.
11. *GB* × *GB* = *GB*.
12. *GS* × *GB* = *GSb*.
13. *VB* × *GS* = *VgSb*.
14. *VS* × *GS* = *VgS*.
15. *GB* × *GS* = *GSb*.
16. *GS* × *GS* = *GS*.

Here it will be noticed that (2) and (5) give the same result. Similarly, (3) and (9); (8) and (14); (12) and (15); and (4), (7), (10) and (13). We may, therefore, represent the hybrid and its progeny thus:

| | | |
|---|---|---|
| *VB* | *VgSb* | 1 *VS* |
| *GS* | | 2 *VSb* |
| | | 1 *VB* |
| | | 2 *VgS* |
| | | 4 *VgSb* |
| | | 2 *VgB* |
| | | 1 *GS* |
| | | *Sb* |
| | | 1 *GB* |
| | | 16 parts. |

This diagram may easily be extended to later generations. *VS* will produce *VS*. The progeny of the type *VSb* will all have the character *V*, but one fourth of it will have the character *S*, two fourths *Sb*, and one fourth *B*; thus,

| | |
|---|---|
| ***VSb*** | 1 *VS* |
| | 2 *VSb* |
| | 1 *VB* |
| | **4 parts.** |

In like manner the progeny of the other types may be written out.

Of the nine types produced from the hybrid, four of them, *VS*, *VB*, *GS*, *GB*, are pure, and will reproduce true to seed. They have no characters hidden in them to crop out in later generations. It will be noticed that each of these pure types constitute one sixteenth of the progeny of the hybrid. Four other types, *VSb*, *VgS*, *VgB* and *GSb*, have each one latent character, and each constitutes two sixteenths of the whole. The type *VgSb*, having two latent characters, constitutes four sixteenths. In general, a type having $n$ latent characters will be present in the second generation of any hybrid in a proportion $2^n$ times as great as any type having no latent characters.

Suppose now we sow all these nine kinds of seed and secure mature plants from each. Those of the type *GB* can easily be distinguished by their appearance. It can be selected out at once, as a new variety fixed in character. The case is different with *VS*, *VB* and *GS*. For example, if we attempt to select *GS*, we get also *GSb*, which has exactly the same external characters. But if we take all the plants with glabrous chaff and smooth heads (*GS* + *GSb*) and save the seed of each plant separately, we can separate the next generation by noting which plants reproduce true to type; for the seed of *GS* will produce *GS* plants only, while that of *GSb* will produce one fourth *GS*, two fourths *GSb*, and one fourth *GB*, according to Mendel's law. Or, since *GS* and *GSb* appear alike, one fourth of the progeny of *GSb* will be *GB* (glabrous and bearded), the remaining three fourths being glabrous and smooth. In the same way we can separate *VS* from *VSb*, *VgS* and *VgSb*, and *VB* from *VgB*.

Now *VS*, *VB*, *GS* and *GB* are all the possible pure (homozygote) combinations of the parent characters, two of them being identical with the two parents, the others constituting new varieties. The practical plant breeder, therefore, does not need to carry his hybrids beyond the third generation to secure all the possible results of a given cross, as far as new fixed varieties are concerned. It should be remembered that this is true only of characters that obey Mendel's law. It is plain, therefore, that it is a matter of the highest practical importance to ascertain how general this law is.

By the same methods outlined above, it is easy to ascertain what types would result from a trihybrid, and from hybrids of all higher orders. In the case of trihybrids, eight permanent combinations result, one like each parent and six new ones. Quadrihybrids give sixteen types, fourteen of which are new; and so on. In general, the number of new fixed types springing from a hybrid is $2^n - 2$, where $n$ is the order of the hybrid.

The proportion of the various types in later generations of a hybrid is a matter of more than curious interest. We have already seen that, in the case of monohybrids, the later generations tend to split up into the two parent types. It was stated above that this is not so with hybrids of higher order. If we assume that each of the nine types (four homozygote and five heterozygote) resulting from a dihybrid is equally productive, the proportion of each of these types in each generation to the sixth is as follows:

PERCENTAGE OF EACH TYPE IN FIRST SIX GENERATIONS OF THE DIHYBRID $VB \times GS$.

| | First. | Second. | Third. | Fourth. | Fifth. | Sixth Generation. |
|---|---|---|---|---|---|---|
| *VS*, *VB*, *GS*, *GB* | each 0 | 6.25 | 14.06 | 19.10 | 21.97 | 23.46 |
| *VgS*, *VgB*, *VSb*, *GSb* | each 0 | 12.50 | 9.38 | 5.47 | 2.93 | 1.15 |
| *VgSb* | 100 | 25.00 | 6.25 | 1.56 | .39 | .10 |

Hence, if we sow all the seed of each generation, it is seen that each of the homozygote types approaches 25 per cent. of the whole, while all the heterozygote types approach zero, and the larger the number of latent characters in a type, the more rapidly it decreases in proportion. In trihybrids, we should have eight homozygote types, each increasing toward 12½ per cent. of the whole. Hence the generalization, a hybrid of the *n*th order tends to split up into $2^n$ fixed types, all types not fixed tending to disappear. The effect of such a law, in the case of accidental hybrids between species and varieties in the wild state, can not fail to be important in the evolution of species. I leave the discussion of this interesting phase of the subject till the law is more generally confirmed. In this connection it may be well to state that, at the recent international conference of plant breeders in New York, Professor Bateson asserted that Mendel's law has been found to hold in every case where it had been thoroughly tested.* The groups in which these tests have been made are so varied, representing both plants and animals, that the presumption in favor of the generality of the law is strong enough to warrant breeders in searching for it everywhere.

It has been urged by certain breeders that, even if the law is general, it can not be put to practical use by breeders; for it nearly always happens that the varieties crossed differ in an indefinite number of respects, and we should therefore get so vast a number of resulting types that no two individuals could be classed together. This objection is not altogether valid. In the first place, if we take any established variety and examine the individuals closely, we find no two of them alike. Hence, even if the variety we are trying to produce must consist of an indefinite number of types differing only in minor details, we are no more than duplicating the actual conditions existing amongst present useful varieties. In the second place, a very common problem of the breeder is to unite two characters found

* This does not agree with Correns (*l. c.*). I think, however, that the cases to which Correns refers may be explained by means of Mendel's law.

in related varieties, where the remaining characters of both varieties are unimportant. Hence, in practice, we have in reality to deal with dihybrids in many cases. It should also be remembered that, if we treat a hybrid as a dihybrid, neglecting all but the two characters of most concern, the type we select actually splits up into fixed types with reference to all other characters, so that in a few generations we can secure uniformity, even in minor characters, by selection.

There is a very interesting phase of the subject which, for the sake of clearness, has been purposely overlooked in what has been said above. We have dealt only with the case in which a parent character appears in the hybrid in a fully developed state, or is not apparent at all. This is actually the case with the characters discussed above. Cases are known, however, in which both of a pair of opposite characters appear in the hybrid. This may result in a form intermediate between the parents, as I found to be the case when I crossed short-headed club wheats with the ordinary long-headed varieties. The same phenomenon appeared in crosses between varieties with red chaff and those with white chaff. Sometimes, in crosses between white and red flowers, for instance, the heterozygote types are variegated. It is easy to see that this fact may have an important bearing on the flavor and other characters of hybrid fruits, such as apples, peaches, strawberries, etc. It is highly probable that a great majority of these fruits are heterozygote in character, which fact would explain their well-known variability when grown from seed. It would naturally be expected, since flavors are due to the presence, in various proportions, of certain chemical substances, that entirely new flavors should be found in seedlings of this character, for in almost every seedling we should have a new combination of the flavor-giving substances.

One reason why Mendel's law was not discovered long ago is doubtless to be found in the fact that the large majority of seedlings that have come under the breeder's eye have had heterozygote parents of unknown constitution. If all our leading commercial varieties had been commonly close-fertilized, the law would long ago have forced itself upon us. Professor Bailey's remarkable and careful work on hybrid squashes and pumpkins probably came to naught for this very reason. Had he done the same work with varieties that are normally close-fertilized, he would probably have discovered this law. He was on the right road, but he was in the wrong vehicle.

Let us consider what results would follow the growing of apple seed generation after generation with close-fertilization, if the characters of the apple obey Mendel's law. We start with a tree that is already multihybrid. Suppose it to consist of $N$ pairs of opposite character, $A$–$A'$, $B$–$B'$, $\cdots$, $N$–$N'$. The hybrid and the first generation of its progeny would then be, supposing the primed characters to be recessive:

*Aa′ Bb′ Cc′......Nn′* { *ABC......N*, *ABC......Nn′*, *ABC......N′*, etc.
(hybrid.) (progeny.)

The total number of types occurring in the progeny is $3^n$; the number of fixed types (homozygote) is $2^n$. The number of types with $r$ latent characters is $nCr2^{n-r}$, where $nCr$ is the number of combinations of $n$ things taken $r$ at a time. Only one type, namely, $A'B'C' \cdots N'$, consisting entirely of recessive characters, could be selected out without getting with it one or more heterozygote types. But by saving the seed of each tree of this generation separately, and observing which, with close fertilization, would reproduce true to type, we could at once secure, in fixed from, all the 2 homozygote types.

If the tree happened to be of the type *VgSb*, discussed above, in which all the characters of its original parents are present, the above process of analysis would give, not only all its original parents, but all possible combinations of them, and each in a form that would reproduce true to seed, if self-fertilized. If it were of the type *VgB*, in which some of the parent characters are missing, it would give all the original parents whose characters are all present, together with all their combinations with characters that are present from other parents, some of whose characters are missing. Since apples are confessedly many times multihybrids, it is probable that a very large number of seed would have to be used to secure all the types capable of resulting from combinations of the $N$ pairs of characters.

Suppose we neglect all but essential characters; we might, in the case of the apple, reduce the number of types to a point which would make the task a possible one. If this were done, it would mean much to the plant breeder. Having a large number of fixed varieties of apples, supposing, of course, that Mendel's law holds, we could select parents with a view to producing any combination of characters we desire. Did not Downing, many years ago, assert that much better results could be secured in producing new seedling apples by using seed from strains that had already been propagated several generations from seed? And why? Possibly because the continuous propagation from seed tends to produce pure strains. If the seed used were always produced by self-pollination, there certainly would be a tendency to pure strains if Mendel's law applies. This problem is worth working out, both from practical and from theoretical grounds. It could be done more easily with strawberries, or with some of the common ornamentals that do not reproduce true to seed. This method of analysis is one way of testing Mendel's law in such groups.

This subject is too new to permit of any useful generalizations respecting animal breeding. True, Mendel's law has been found to apply with animals so far as the test has been applied, but it will be some time before much use can be made of it in that direction. It will take years to overcome the prevailing prejudices of animal breeders in favor of old-time theories that govern practice in that line.

*Exceptions to the Law.*

Millardet and others have given accounts of hybrids that immediately split up into the two parent forms, having no, or very few, hybrid progeny, and these have been cited as exceptions to Mendel's law. I have elsewhere* shown that Mendel's theory of the separation of parent characters offers a perfectly rational explanation of these cases. If a hybrid is obtained from two varieties each of which prefers its own pollen to that of the other, the resulting hybrid must split up at once into the two parent types, if it obeys the law in question, since each of the two kinds of ovules produced by the hybrid, being offered both kinds of pollen, is fertilized only by its own kind. Yet even in these cases, according to the laws of probability, it ought occasionally to happen that such a hybrid would produce a few hybrids, for it would occasionally happen that an ovule would be offered only one kind of pollen. And this is what actually occurred in hybrids of this class reported by De Vries. A few hybrids occurred along with an excess of both the parent types.

Likewise, when two varieties are crossed, each of which prefers the other's pollen, there will also be an apparent departure from the law; for in this case each of the two kinds of ovules on the hybrid will be fertilized only with the opposite kind of pollen, giving all heterozygotes. Such a hybrid will appear to be fixed in type at once. Such cases have been reported by many observers, including Darwin. In this case it may occasionally happen in later generations of the apparently stable hybrid, that an ovule will be offered only its own kind of pollen and we then get a reversion to one of the parent forms. We may yet find that many sports are to be explained in this manner.

Breeders frequently report entirely new characters in hybrids. If these actually occur we must look further than Mendel's theory for their cause. It must not be overlooked, however, that if the two parents of a hybrid are themselves heterozygote hybrids, Mendel's theory would call for characters unlike any of the visible characters of either parent. In this case, all latent characters in both parents would necessarily crop out in the second generation of the hybrids. We can not dismiss Mendel's theory in such cases until it has been demonstrated that the parents have no latent characters in them.

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* *Science*, October 31, 1902.

It is very probable that many supposed new characters are merely the peculiar result of the blending of opposite characters, neither of which 'dominates' the other; or it may be that the blending of two unrelated dominant characters gives rise to new characters. As an instance of how this might occur, the presence of two chemical substances, one derived from each parent, might give new flavors in fruit, or new colors in flowers. Bateson has demonstrated a case of the latter and shown that the new and radically different color is not a new character at all, but a blending of parent characters which obey Mendel's law perfectly.

Is it not possible that Mendel has also shown to us an explanation of bud sports? These sports are notoriously common on plants known to be hybrids. May not the separation of parent characters occasionally occur at stages of growth other than the formation of germ cells? If such is the case, bud sports at once come under the law.

It does not seem improbable that, once in a while, the parent characters might fail to separate in the usual manner on the formation of germ cells, so that we might have a few cells inheriting both of a pair of opposite characters, and this might extend over a series of generations before the separation finally occurred. Under such conditions, a recessive character might be carried over any number of generations without showing itself, finally cropping out and giving a case of atavism. Perhaps this is the explanation of atavism. It would be interesting in this connection to know if atavic characters are ordinarily recessive.

It is clear that we have before us a working hypothesis that offers a possible explanation of a large number of phenomena heretofore absolutely inexplicable. It will require time to test the hypothesis, even in the limited number of cases suggested above.

The only data thus far published in this country that may be used as a direct test of Mendel's theory are those I secured from hybrid wheats.* At the time these data were arranged for publication similar work in Europe was unknown in this country; they were merely arranged to show that similarly bred hybrids split up into the same types, each type tending to occur in a definite proportion. In all my hybrids characters were present that apparently separated in a manner different from that called for by Mendel's theory. Fortunately, however, the data referred to may easily be arranged to test the applicability of this theory to two characters, namely, beards and velvet chaff. In five out of fourteen crosses one parent was bearded and the other smooth, two of the five being reciprocals. Beards being recessive, theory would call for 25 per cent. of bearded plants

* Bul. 115, Off. Ex. Sta. U. S. Dept. Agr.

in the progeny of the hybrids. The seed of each hybrid plant was kept separate and sown as a plat. In three plats from a cross between Valley (♂), a bearded variety, and Little Club (♀), there was an average of 25.7 per cent. of bearded plants. Eleven plats of the reciprocal cross averaged 25.2 per cent. beards. Six plats of a cross between Little Club and Emporium gave bearded plants to the extent of 24.6 per cent.; three plats of Lehigh × Red Chaff, 25.9 per cent.; and seven plats of Turkey × Little Club, 30.8 per cent. In the last example there were two aberrant cases, the remaining five lying between 25 and 29 per cent.

Much evidence of a similar nature has been brought forward by De Vries, Correns, Bateson and others, in addition to that given by Mendel. These investigators worked with widely different groups of plants and animals.

Thus far, no one has shown definitely that Mendel's theory is inapplicable to a single case. Correns, however, mentions hybrids which do not behave exactly as called for by theory, but I am not sufficiently familiar with the details concerning them to discuss them here. In my own work I found that the color of the chaff and the length of the head behave in a manner most easily explained by a modification of Mendel's theory. Instead of the pair of opposite characters, long heads and short heads, separating completely on the formation of pollen and ovules, they seemed to separate in all possible proportions, giving in the next generation a series of plants having heads of every possible gradation of length between those of the two parents, and even extending in both directions beyond the parents. In my work I arbitrarily separated the hybrids into three groups—long, semi-long and short heads. As this separation was entirely arbitrary, the results are very irregular, and the original figures do not represent very accurately the actual facts with reference to this character. Exactly the same thing occurred with reference to color of chaff. I have not yet had the opportunity of examining the third generation of these hybrids, so that it can not yet be stated definitely that they really form an exception to Mendel's law.

As is the case with any startling discovery, we are apt either to minimize its importance or to extend its application much beyond legitimate bounds. I fear I shall be accused of the latter. But this new thory is so suggestive and offers a rational explanation to so many hitherto enigmatical phenomena, that a few suggestions as to its possible application can do no harm.

# THE PROGRESS OF SCIENCE.

## *THE CONVOCATION OF SCIENTIFIC SOCIETIES*

The American Association for the Advancement of Science and in affiliation with it the American Society of Naturalists and more than twenty special scientific societies will meet in Washington at the end of December and beginning of January. This first of the convocation week meetings of scientific societies will probably always be an important date in the history of science in America. It is a truism to say that the progress of science consists in cooperation among men of science. For such cooperation two main agencies exist which are equally essential—the printing press and personal contact. Books and journals bring the whole world together and make science truly international; but the coming together of the men of science of the country is necessary for a national spirit. This spirit has suffered in the past owing to the dispersion of our scientific workers over an immense area with no one center, such as exists in all foreign countries. A year and a half ago the American Association and its affiliated societies met for the first time west of the banks of the Mississippi, and a year ago the American Society of Naturalists and its affiliated societies met for the first time west of the Atlantic seaboard. Now these two associations and the twenty special societies affiliated with them will for the first time meet together, and we are about to have our first national congress of scientific men.

A convocation week in mid-winter for the meetings of societies has been provided by the action of the leading universities and other institutions, which have extended their Christmas holidays or made other provision by which the week in which the first of January falls is left free from academic exercises. Under these circumstances it is a duty as well as a privilege for all to attend the meetings who are able to do so, and there is no doubt but that the number of scientific men at Washington will be the largest that has ever been gathered together in this country. While the special societies are for scientific experts, it should be remembered that the American Association is concerned with the diffusion as well as with the advancement of science. Its membership is divided into fellows and members. The former class consists of those who are engaged in research, while the latter class contains those who are interested in science. Readers of this journal can obtain information in regard to membership from the permanent secretary, Dr. L. O. Howard, Cosmos Club, Washington, D. C. It may be said here that the dues are only $3 a year, and that members receive free of charge the weekly journal, *Science*. We should be pleased if ten thousand readers of this journal would join the association. They would receive a full return for the small membership fee and would at the same time perform an important service in keeping men of science in contact with the large public from which sympathy, support and recruits must be drawn. Science in the United States has suffered seriously from the fact that there is too great a gulf between the professional man of science and the educated public. In Great Britain there exists a class bridging this gulf, and from it have come men such as Darwin, Rayleigh, Avebury, Huggins and many more. Much would be accomplished for the promotion of such a class here if the membership of the American Association were made twice or ten times what it now is.

Both the scientific man and those only interested in science will be amply repaid by attendance at the Washington meetings. Indeed no scientific man can afford to be absent. Those who wish merely to keep in touch with the forward movement of science will profit much from attendance. They can visit Washington at a favorable time at greatly reduced rates and hotel charges, and there will be much to interest them in the programs. President Roosevelt is honorary president of the local committee and it is expected that he will open the meetings. It would be impossible to quote the titles of the hundreds of papers that will be presented, but their general character is indicated by the names of some of those who will give official addresses: Before the Association President Asaph Hall, and before the sections of the association vice-presidents Hough, Weber, Derby, Culin, Welch, Franklin, Flather, Nutting, Campbell, and Wright; before the Astronomical and Astrophysical Society of America, President Simon Newcomb; before the Chemical Society, President Ira Remsen; before the American Society of Naturalists, President J. McKeen Cattell; before the Botanical Society, President J. C. Arthur; before the Geological Society, President N. H. Winchell; before the Psychological Association, President E. C. Sanford, etc. Public lectures will be given before the Association by Professors Russell and Heilprin on the volcanoes of the West Indies, and before the Naturalists by Dr. Merriam on protective and directive coloration. The discussion before the Naturalists is on 'How can endowments be used most effectively for research?', the speakers including Professors Chamberlin, Welch, Boas, Wheeler, Coulter and Münsterberg. These are only a few of the hundreds of scientific men who will be present and present papers or take part in the discussions of the meetings, which promise to be more interesting and important than any ever before held on this continent.

### *THE CARNEGIE INSTITUTION.*

It might be expected that after the annual meeting of the trustees of the Carnegie Institution on November 25, some statement could be made here in regard to the policy of the institution. Nothing has, however, been made public beyond the news item given to the reporters to the effect that $200,000 had been appropriated for the work to be determined by the executive committee, $40,000 for publication, $50,000 for administration and $100,000 for a reserve fund. The institution will, however, publish a year-book, which will doubtless contain various matters that have hitherto been kept secret, such as the names of members of the advisory committees of scientific men and their reports. Though no official announcement has been made, it appears that certain grants have been approved by the executive committee. Thus the medical papers report that $10,000 a year has been appropriated to revive the 'Index Medicus,' formerly compiled under the direction of Dr. John S. Billings, now vice-president of the institution.

A form of application for grants has been printed and approved by the trustees, to which it seems that men of science are likely to object, if indeed reputable men of science will consent to sign it at all. This form requires scientific men to promise to begin the research 'forthwith and to prosecute it diligently,' not to publish their results elsewhere if the institution wants them and to give all their apparatus, material, collections, etc. to the institution. These and other conditions on the contract seem to be almost an affront to men of science, calculated to profit the Carnegie Institution at the expense of others. It is perhaps premature to criticize the institution when so little is known in regard to its plans. So long, however, as these are not disclosed the institution must be judged by what has been made public. It is known that when the Marine Biological Laboratory at Woods Hole asked for the assistance that it so well deserves, the executive committee replied that they would assist the laboratory if it were given to them, and the corporation actually voted to give the laboratory to the institution.

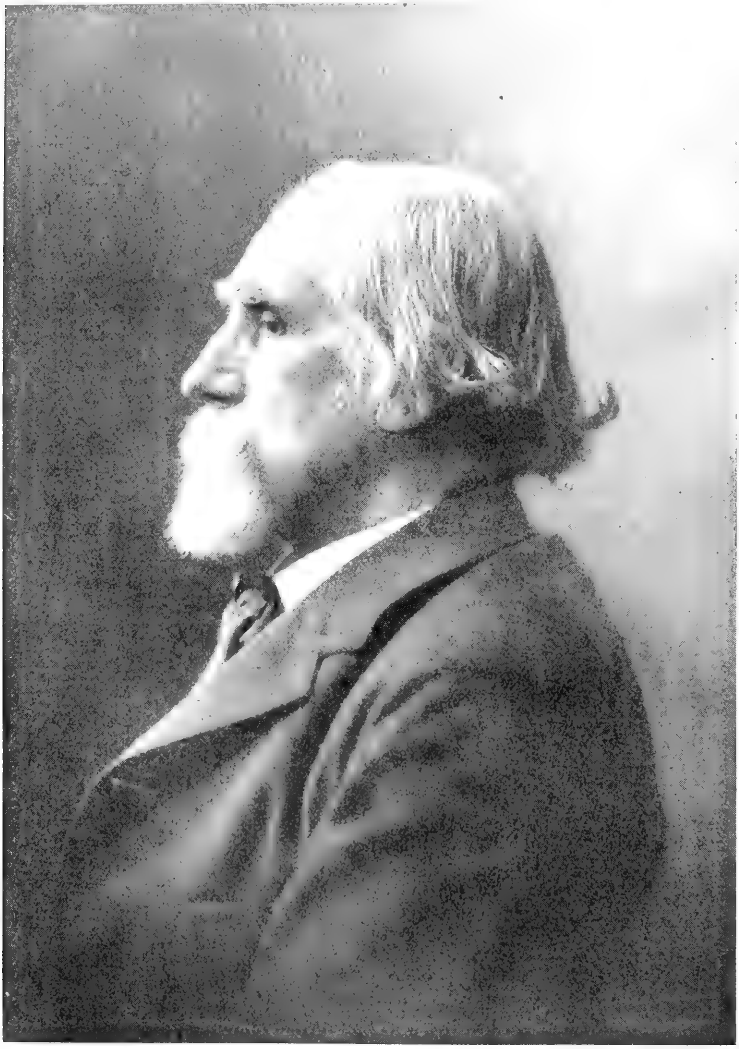
We hope and believe that the appearance of seeking to aggrandize the Carnegie Institution at the cost of other agencies and of men of science, instead of cooperating with them for the advancement of science, is not real, but due only to lack of information in regard to the purposes of the institution. It is, however, but just to men of science that this information be made public at an early day. The lines of Mr. Carnegie's great gift were drawn broadly and generously, and in spite of the apparent mistakes that have been made, there is every reason to believe that the institution will be conducted in the spirit in which it was founded.

### *THE BRITISH EDUCATION BILL.*

It is a striking fact that the British parliament and the British people have in recent months been occupied chiefly with the concerns of primary education; and it is at the same time somewhat depressing to consider that almost no attention is paid to the subject here, the daily papers publishing fuller details of the last divorce case connected with the nobility than of the bill now before parliament. The bill which the House of Commons has sent to the House of Lords is really of very great interest. The affairs of primary education in Great Britain and Ireland have been somewhat anomalous. About half the children who receive free education attend the board schools, supported by the state and by local taxation, and corresponding pretty closely to our public schools. The voluntary schools, controlled chiefly by the church of England, provide for the other half of the children. They do not share in the local taxes, but when they remit tuition fees they receive from the general government a *per capita* grant of $1.25 for each student. The main feature in the bill passed by the House of Commons is the support of the voluntary schools by taxation, local and central, leaving them largely under the control of the church. This is undoubtedly a step in the direction of local and state control, and might be supposed to be acceptable to the liberal and radical parties and distasteful to the conservative and church parties. The exact reverse is the case; the bill has been made the chief measure of the government, and has been bitterly opposed in and out of parliament by liberals and nonconformists. It is claimed that it is a subversion of the principles of free government to tax the community for schools which are conducted by the church and which teach the creed of the church. As a matter of fact the denominational schools are already supported in part by taxation as is also the established church. It, however, appears to be a real hardship that the children of dissenters must be sent to schools where rites are practised that are distasteful to their parents. Our public schools are so completely exempt from denominational control that we can scarcely understand the position of the bishop of London when he says in a public address 'an undenominational education is a rotten system.' The bill will doubtless be passed, and the church will for a while receive from rates what has hitherto been paid by subscription. But it seems almost evident that the voluntary schools will be less subservient to the church than hitherto and that a long step has been taken in the direction of popular control.

### *OGDEN N. ROOD.*

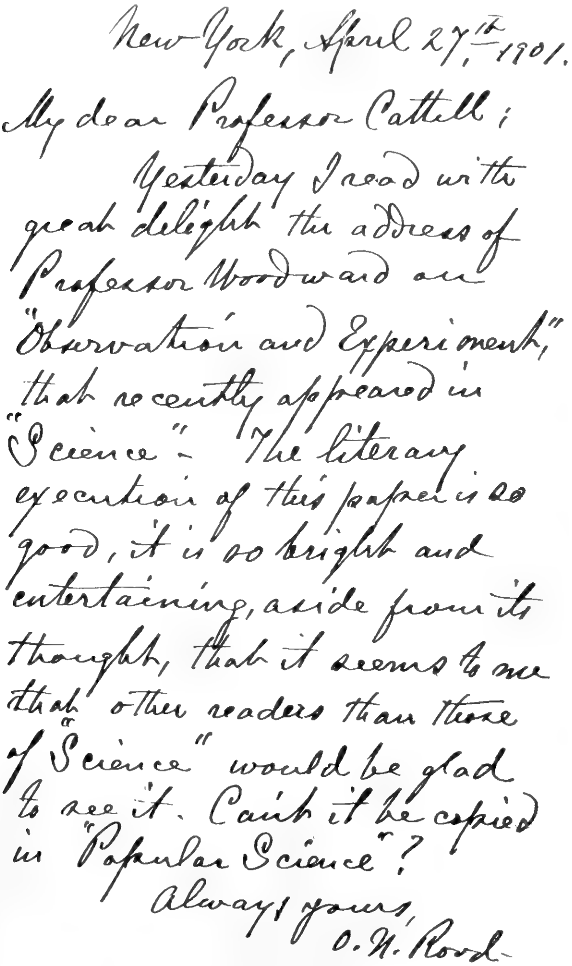
In the death of Professor Ogden N. Rood, America has lost one of its few men of genius. He belonged to a type of the scientific man which seems to be disappearing. Scientific work is becoming in its methods somewhat like any other business and the man of science, the man of letters and the artist no longer belong to distinct types. They take their places in an organized army with generals, petty officers and privates; there is no longer place for the adventurer. But Rood was a man of genius, in the sense in which the word is popularly and perhaps properly used. There was something unexpected and unaccountable



OGDEN N. ROOD.

both in his scientific discoveries and in his personal traits. He was not a mathematician, he was not always familiar with work that had been done in the same direction as his own, he did not have assistants nor use the ordinary machinery of research. But he had ideas, which he worked out with originality and persistence, devising his own methods and making his own instruments.

Rood was born in Connecticut on February 3, 1831, his father being a clergyman. He was dismissed from Yale College for some student escapade—it is said because he stopped chapel by shooting an arrow into the face of the college clock—and it was with some satisfaction that he received the doctorate of laws from Yale University on the occasion of its bicentennial. He graduated at Princeton in 1852, and spent several years in study abroad, a course not common in the fifties. For five years he was professor in a small denominational institution at Troy. Then at the early age of thirty-three he was called to Columbia College and at


New York, April 27th, 1901.
My dear Professor Cattell;
Yesterday I read with great delight the address of Professor Woodward on "Observation and Experiment," that recently appeared in "Science". The literary execution of this paper is so good, it is so bright and entertaining, aside from its thought, that it seems to me that other readers than those of "Science" would be glad to see it. Can't it be copied in "Popular Science"?
Always yours,
O. N. Rood

the same time was made a member of the National Academy of Sciences. For thirty-eight years he held the professorship of physics, while Columbia developed from a small college into a great university, his own work adding much to its fame. His researches in experimental physics are too numerous even for naming, extending as they do over a large part of the science. They include work on photography, projectiles, vacuum pumps, electricity and especially physiological optics. Every one of his papers, perhaps seventy-five in number, embodied a new idea, worked out with ingenuity and persistence. He was also an artist, his water-color sketches being highly esteemed, and was perhaps especially interested in those phases of research that required the knowledge of the physicist, the psychologist and the painter.

Rood was one of the marked men of Columbia University and of New York City. Striking in appearance and in manners, possessing and possibly affecting certain peculiarities, working behind locked doors, sometimes living with his family and sometimes not, in part a recluse, though not averse to congenial company or an evening at the Century Club, he possessed altogether a notable personality. He was a good enemy and a good friend; and the present writer regards it as a special privilege that he was counted a friend.

## *THE PROPOSED ENLARGEMENT OF THE NAPLES STATION.*

The untiring energy of the founder of the Naples Station, Professor Anton Dohrn, has made it possible, with the help of generous friends, to add a new building to the two already existing ones. When first started, in 1873, the station consisted of a single building—the middle one of the three in the accompanying figure. It soon became necessary to add another part, and the building to the left in the figure was tend erected. The station has now outgrown both of these, and another building is about to be added. As shown in the figure the new part will be a duplicate of the oldest building as far as the exterior is concerned. In the interior, however, the arrangement will be entirely different. It is proposed to have a large laboratory on the first floor devoted to physiological research; another on the floor above to physiological chemistry. In addition there will be a large number of private rooms for zoologists and physiologists. A new feature will be rooms in which the

THE NAPLES STATION.

water in the aquaria can be kept at any desired temperature throughout the year. This will give an opportunity, not only for keeping alive a number of different kinds of animals that will not live at ordinary temperatures, but will also give to the investigator a chance to carry out important researches on the effect of different temperatures on marine forms.

The addition to the station will double its working capacity, since the new part will be entirely devoted to investigation, while in the two older buildings there are the public aquaria, the collecting department, and the library. Zoology, botany physiology, physiological-chemistry and psychology will benefit the world over by this enlargement of the Naples Station. Professor Dohrn deserves to be heartily congratulated that his labors have been crowned by success. May the time come before long when the station will be made symmetrical by the addition of a fourth building!

The Proposed Enlargement of the Naples Station.

### *ARE SOLUTIONS MECHANICAL MIXTURES OR NEW SUBSTANCES?*

In a recent volume Duhem sketches the development of our ideas in regard to solutions. If we drop a lump of sugar into a glass of water, the sugar disappears and we have in the tumbler a colorless liquid which looks like water, but which has a different taste. We are all agreed as to the fact, but there has always been a difference of opinion as to what became of the sugar. One view is that the sugar and water are still there, but so finely divided that we do not see the sugar. If we grind a little dry sugar together with a good deal of charcoal, we get a black mixture in which the eye does not detect the sugar though the sugar is unqestionably there. Another view is that we have neither water nor sugar in the tumbler, but a new substance having properties differing more or less completely from those of the sugar and water. This is the view that we take in regard to sugar itself when we speak of it as made up of charcoal and water. The first view, of a mechanical mixture, was held by the Greek atomistic philosophers under Epicurus while the second view was defended by Aristotle and the peripatetic philosophers. Through the Middle Ages, the views of Aristotle prevailed; but Bacon and Descartes brought the atomistic view to the front again, while Newton modified the views of Descartes by substituting assumptions in regard to mutual attractions and repulsions for assumptions as to the shape of the atoms. In the second half of the nineteenth century, the application of thermodynamics to chemistry has led to the discovery of new laws, and these discoveries have been made without assuming anything in regard to atoms. The natural tendency is therefore to reject the atomic theory as a superfluous hypothesis. The only distinction that we can draw between chemical compounds, like sugar or salt, and solutions, such as a mixture of sugar and water, is that the composition of the solutions can vary continuously while the composition of the compounds can not. The natural inference is that solutions are to be looked upon as compounds or new substances with varying composition. The scientific world has thus come back to the view of Aristotle. The matter stands now as it stood centuries ago. One school still holds the views of Epicurus, another stands ready to break a cudgel for Aristotle. Even now we do not know what happens when we put sugar in our coffee though we know why we do so—except where it is merely a matter of habit.

### *SCIENTIFIC ITEMS.*

We regret to record the death of Professor Henry Mitchell, the eminent engineer, and of Major Walter Reed, well known for his researches on the relation of the mosquito to yellow fever.

Dr. W J McGee, ethnologist in charge, Bureau of American Ethnology, has been appointed to represent the United States on the American International Archeological Commission.—Professor J. Willard Gibbs, of Yale University, has been elected a corresponding member of the Munich Academy of Science.

It is reported that the Nobel prizes for this year will be awarded as follows: In chemistry, to Professor Emil Fischer, of Berlin; in physics, to Professor S. A. Arrhenius, of Stockholm; in medicine, to Professor Niels E. Finsen, of Copenhagen, and to Major Ronald Ross, of Liverpool. The value of these prizes, it will be remembered, is about $40,000 each.

DR. CARROLL D. WRIGHT,

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

# THE POPULAR SCIENCE MONTHLY.

FEBRUARY, 1903.


## THE SCIENCE OF ASTRONOMY.*


By Professor ASAPH HALL, U.S.N. (Retired).


I TAKE for the subject of my address the science of astronomy, and propose to give a brief historical sketch of it, to consider its future development, and to speak of the influence of the sciences on civilization.

The science of astronomy is so closely connected with the affairs of life, and is brought into use so continuously and in such a systematic manner, that most people never think of the long labor that has been necessary to bring this science to its present condition. In the early times it was useful to the legislator and the priest, for keeping records, the times of public ceremonies and of religious festivals. It slowly grew into the form of a science, and became able to make predictions with some certainty. This was many centuries ago; Hipparchus, who lived 150 B. C., knew the periods of the six ancient planets with considerable accuracy. His periods are:

| | Period. | Error × 100 / Period |
|---|---|---|
| Mercury | 87d.9698 | + 0d .0007 |
| Venus | 224.7028 | + 0.0009 |
| Earth | 365.2599 | + 0.0010 |
| Mars | 686.9785 | — 0.0002 |
| Jupiter | 4332.3192 | — 0.0061 |
| Saturn | 10758.3222 | — 0.0083 |

These results indicate that more than two thousand years ago there existed recorded observations of astronomy. Hipparchus appears to have been one of those clear-headed men who deduce results from observations with good judgment. There was a time when those ancient

* Address of the President of the American Association for the Advancement of Science, Washington meeting, December 29, 1902.

Greek astronomers had conceived the heliocentric motions of the planets, but this true theory was set aside by the ingenious Ptolemy, who assumed the earth as the center of motion, and explained the apparent motions of the planets by epicycles so well that his theory became the one adopted in the schools of Europe during fourteen centuries. The Ptolemaic theory flattered the egotism of men by making the earth the center of motion, and it corresponded well with old legends and myths, so that it became inwoven with the literature, art and religion of those times. Dante's construction of Hell, Purgatory and Paradise is derived from the Ptolemaic theory of the universe. His ponderous arrangement of ten divisions of Paradise, with ten Purgatories and ten Hells, is said by some critics to furnish convenient places for Dante to put away his friends and his enemies, but it is all derived from the prevailing astronomy. Similar notions will be found in Milton, but modified by the ideas of Copernicus, which Milton had learned in Italy. The Copernican theory won its way slowly, but surely, because it is the system of nature, and all discoveries in theory and practical astronomy helped to show its truth. Kepler's discoveries in astronomy, Galileo's discovery of the laws of motion and Newton's discovery of the law of gravitation, put the Copernican theory on a solid foundation. Yet it was many years before the new theories were fully accepted. Dr. Johnson thought persecution a good thing, since it weeds out false men and false theories. The Copernican and Newtonian theories have stood the test of observation and criticism, and they now form the adopted system of astronomy.

The laws of motion, together with the law of gravitation, enable the astronomer to form the equations of motion for the bodies of our solar system; it remains to solve these equations, to correct the orbits, and to form tables of the Sun, Moon and the planets. This work was begun more than a century ago, and it has been repeated for the principal planets several times, so that now we have good tables of these bodies. In the case of the principal planets the labor of determining their orbits was facilitated by the approximate orbits handed down to us by the ancient astronomers; and also by the peculiar conditions of these orbits. For the most part the orbits are nearly circular; the planets move nearly in the same plane, and their motions are in the same directions. These are the conditions Laplace used as the foundation of the nebular hypothesis. With approximate values of the periods and motions, and under the other favoring conditions, it was not difficult to form tables of the planets. However the general problem of determining an orbit from three observations, which furnish the necessary and sufficient data, was not solved until about a century ago. The orbits of comets were first calculated with some precision. Attention was called to these bodies by their threatening aspects, and by the terror they inspired among people. It was therefore a happy duty of the astronomers to show that the comets also move in orbits around the Sun, and are subject to the same laws as the planets. This work was easier because the comets move nearly in parabolas, which are the simplest of the conic sections. Still the general problem of finding the six elements of an orbit from the six data given by three observations remained to be solved. The solution was given by Gauss a century ago in a very elegant manner. His book is a model, and one of the best ever written on theoretical astronomy. No better experience can be had for a student than to come in contact with such a book and with such an author. The solution of Laplace for the orbit of a comet is general, but demands more labor of computing than the method of Olbers, as arranged by Gauss. It is said by some writers that the method of Laplace is to be preferred because more than three observations can be used. In fact this is necessary in order to get good values of the derivatives of the longitudes and latitudes with respect to the time, but it leads to long and rather uncertain computations. Moreover it employs more data than are necessary, and thus is a departure from the mathematical theory of the problem. This method is ingenious, and by means of the derivatives it gives an interesting rule for judging of the distance of a comet from the earth by the curvature of its apparent path, but a trial shows that the method of Olbers is much shorter. Good preliminary orbits can now be computed for comets and planets without much labor. This, however, is only a beginning of the work of determining their actual motions. The planets act on each other and on the comets, and it is necessary to compute the result of these forces. Here again the conditions of our solar system furnish peculiar advantages. The great mass of the sun exerts such a superior force that the attractions of the planets are relatively small, so that the first orbits, computed by neglecting this interaction, are nearly correct. But the interactions of planets become important with the lapse of time, and the labor of computing these perturbations is very great. This work has been done repeatedly, and we now have good numerical values of the theories of the principal planets, from which tables can be made. Practically, therefore, this question appears to be well toward a final solution. But the whole story has not been told.

The planets, on account of their relative distances being great and because their figures are nearly spherical, can be considered as material particles and then the equations of motion are readily formed. In the case of $n$ material particles acting on each other by the Newtonian law, and free from external action, we shall have $3n$ differential equations of motion, and $6n$ integrations are necessary for the complete solution. Of these only ten can be made, so that in the case of only three bodies there remain eight integrations that cannot be found. The early investigators soon obtained this result, and it is clearly stated by Lagrange and Laplace. The astronomer, therefore, is forced to have recourse to approximate methods. He begins with the problem of two bodies, the sun and a planet, and neglects the actions of the other planets. In this problem of two bodies the motions take place in a plane, and the integrations can all be made. Two constants are needed to fix the position of the plane of motion, and the four other constants pertaining to the equations in this plane are easily found. This solution is the starting point for finding the orbits of all the planets and comets. The mass of the sun is so overpowering that the solution of the problem of two bodies gives a good idea of the real orbits. Then the theory of the variation of the elements is introduced, an idea completely worked out into a practical form by Lagrange. The elements of the orbits are supposed to be continually changed by the attractions of the other planets. By means of this theory, and the mathematical machinery given by Lagrange, which can be applied to a great variety of questions, the observations of the planets can be satisfied over long intervals of time. When this theory of the motions was carried out a century ago it appeared that the great problem of planetary motion was near a complete solution. But this solution depends on the use of series, which undergo integrations that may introduce small divisors. An examination of these series by Hansen, Poincaré and others indicates that some of them are not convergent. Hence the conclusions formerly drawn about the stability of our solar system are not trustworthy, and must be held in abeyance. But looking at the construction of our system, and considering the manner in which it was probably evolved, it appears to be stable. However the mathematical proof is wanting. In finding the general integrals of the motions of $n$ bodies, the assumption that the bodies are particles gets rid of the motions of rotation. These motions are peculiar to each body, and are left for special consideration. In the case of the earth this motion is very important, since the reckoning of time, one of our fundamental conceptions, depends on this motion. Among the ten general integrals that can be found six belong to the progressive motion of the system of bodies. They show that the center of gravity of the system moves in a right line, and with uniform velocity. Accurate observations of the stars now extend over a century and a half, and we are beginning to see this result by the motion of our sun through space. So far the motion appears to be rectilinear and uniform, or the action of the stars is without influence. This is a matter that will be developed in the future. Three of the other general integrals belong to the theory of areas, and Laplace has drawn from them his theory of the invariable plane of the system. The remaining integral gives the equation of living force. The question of relative motion remains, and is the problem of theoretical astronomy.

This has given rise to many beautiful mathematical investigations, and developments into series. But the modern researches have shown that we are not sure of our theoretical results obtained in this way, and we are thrown back on empirical methods. Perhaps the theories may be improved. It is to be hoped that the treatment of the differential equations may be made more general and complete. Efforts have been made in this direction by Newcomb and others, and especially by Glydèn, but so far without much practical result.

The problem of three bodies was encountered by the mathematicians who followed Newton, and many efforts were made to solve it. These efforts continue, although the complete investigations of Lagrange appear to put the matter at rest. The only solutions found are of very special character. Laplace used one of these solutions to ridicule the doctrine of final causes. It was the custom to teach that the moon was made to give us light at night. Laplace showed by one of the special solutions that the actual conditions might be improved, and that we might have a full moon all the time. But his argument failed, since such a system is unstable and cannot exist in nature. But some of the efforts to obtain partial solutions have been more fruitful, and G. W. Hill has obtained elegant and useful results. These methods depend on assumed conditions that do not exist in nature, but are approximately true. The problem of two bodies is a case of this kind, and the partial solutions may illustrate, but will not overcome, the fundamental difficulty.

The arrangement of our solar system is such that the distances of the planets from one another are very great with respect to their dimensions, and this facilitates very much the determination of their motions. Should two bodies approach very near each other the disturbing force might become great, even in the case of small masses. In the case of comets this condition happens in nature, and the comet may become a satellite of a planet, and the sun a disturbing body. In this way it is probable that comets and meteoric streams have been introduced into our solar system. We have here an interesting set of problems. This question is sometimes treated as one of statics, but since the bodies are in motion it belongs to dynamics. Further study may throw light on some relations between the asteroids and the periodical comets.

The great question of astronomy is the complete and rigorous test of the Newtonian law of gravitation. This law has represented observations so well during a century and a half that it is a general belief that the law will prove true for all time, and that it will be found to govern the motions of the stars as well as those of our solar system. The proof is cumulative and strong for this generality. It will be a wonderful result if this law is found rigorously true for all time and throughout the universe. Time is sure to bring severe tests to all theories. We know that the law of gravitation is modified in the motions of the matter that forms the tails of comets. There is an anomaly in the theory of Mercury which the law does not explain, and the motion of our moon is not yet represented by theory. The lunar theory is very complicated and difficult, but it does not seem probable that the defect in Hansen's theory will be found by recomputing the periodical coefficients, that have been already computed by many mathematicians and astronomers, and with good agreement by Hansen and Delaunay, by very different methods. Hansen was a computer of great skill, but he may have forced an agreement with observations, from 1750 to 1850, by using a coefficient of long period with an erroneous value. No doubt the error of this theory will be discovered. Back of all theories, however, remains the difficulty of solving the equations of motion so that the result can be applied with certainty over long periods of time. Until this is done we shall not be able to subject our law to a crucial test.

The constants that enter the theories of the planets and moon must be found from observations. In order to compare observations made at distant epochs, the motions of the planes of reference must be known with accuracy, and also the motion of our solar system in space. As the stars are our points of reference their positions and their proper motions must be studied with great care. This department of astronomy was brought to a high degree of order by the genius of Bessel, whose work forms an epoch in modern astronomy. The recent progress made in determining the positions of the stars in all parts of the heavens will be a great help to the investigations of the future. We must have observatories where accurate and continuous observations are made. Our country is well situated to supplement the work of Europe, and we hope it will never fail to add its contribution to the annals of astronomy. American astronomers should keep pace in the improvements for increasing the ease and accuracy of making observations. The spectroscope has given a new element in the motions of the stars, not to speak of the interesting physical results obtained by its use. Photography will give great aid in determining the relative positions of the stars and in forming maps of the heavens. All new methods, however, will need examination and criticism, since they bring new sources of error. Fifty years ago it was thought the chronograph would increase very much the accuracy of right ascensions. It has not done this directly to any great extent, but it has increased the ease and rapidity of observing. We must remember that astronomical results finally depend on meridian observations, and that it is the duty of astronomers to make these continuous from generation to generation. In this way we shall gain the powerful influence of time to help control and solve our problems. There is one point where a reform may be needed from the dead weight of the large and expanding volumes sent forth by observatories and scientific institutions. The desire for publication is great, but the results should be well discussed and arranged, so that the printing may be shortened. Otherwise our publications may become burdensome, and when they are piled up in libraries some future Caliph Omar may be tempted to burn them. Even mathematics appears to labor under a similar oppression, and much of its printed matter may be destined to molder to useless dust.

In the not distant future stellar astronomy will become a great and interesting field of research. The data for the motions of the stars are becoming better known, but these motions are slow, and the astronomer of to-day looks with envy on the astronomer of a thousand years hence, when time will have developed these motions. Much may be done by the steady and careful work of observation and discussion, and the accumulation of accurate data. Here each one of us can add his mite. But the great steps of progress in science have come from the efforts of individuals. Schools and universities help forward knowledge by giving to many students opportunities to learn the present conditions, and from them some genius like Lagrange or Gauss may come forth to solve hard questions, and to break the paths for future progress. This is about all the schools can do. We need a body of men who can give their lives to quiet and continuous study. When the young Laplace was helped to a position where he could devote his life to research D'Alembert did more for the progress of astronomy than all the universities of Europe.

One needs only to glance at history to see how useful astronomy has been in the life of the world. It has wonderfully enlarged the universe, and widened the views of men. It shows how law and order pervade the world in which we live; and by the knowledge it has disseminated and by its predictions it has banished many superstitions and fears. The sciences will continue to grow; and they will exert the same influence. The erroneous and dogmatic assertions of men will be pushed aside. In our new country the energies of the people are devoted chiefly to commercial and political ends, but wealth is accumulating, leisure and opportunity will come, and we may look forward to a great development of scientific activity. We must be patient. Men do not change much from generation to generation. Nations that have spent centuries in robbery and pillage retain their dispositions and make it necessary for other nations to stand armed. No one knows when a specious plea for extending the area of civilization may be put forth, or when some fanatic may see the hand of God beckoning him to seize a country. The progress of science and invention will render it more difficult for such people to execute their designs. A century hence it may be impossible for brutal power, however rich and great, to destroy a resolute people. It is in this direction that we may look for international harmony and peace, simply because science will make war too dangerous and too costly.

The influence of the sciences in bringing men of different nationalities into harmony is great. This is done largely by the common languages that are formed in each science. In mathematics the language is so well formed and generally adopted that mathematicians all over the world have no trouble in understanding one another. It may be difficult to read Russian, but every one can read the formulas of Tchebitchef and Lobaschewsky. In astronomy the common language is nearly as well established, so that there is little difficulty in understanding the astronomy of different nations. A similar process is going on in chemistry, botany and in the other sciences. When men are striving for the discovery of truth in its various manifestations, they learn that is is by correcting the mistakes of preceding investigators that progress is made, and they have charity for criticism. Hence persecution for difference of opinion becomes an absurdity. The labors of scientific men are forming a great body of doctrine that can be appealed to with confidence in all countries. Such labors bring people together, and tend to break down national barriers and restrictions. The scientific creed is constantly growing and expanding, and we have no fears, but rejoice at its growth. We need no consistory of bishops, nor synod of ministers, to tell us what to believe. Everything is open to investigation and criticism.

In our country we have one of the greatest theaters for national life that the world has ever seen. Stretching three thousand miles from ocean to ocean, and covering the rich valleys of the great rivers, we have a land of immense resources. Here is a vast field for scientific work of various kinds. No doubt the men of the future will be competent to solve the problems that will arise. Let us hope that our national character will be just and humane, and that we may depart from the old custom of robbing and devouring weak peoples. Any one who saw the confusion and waste in this city in 1862 might well have despaired of the Republic; and he who saw the armies of Grant and Sherman pass through the city in 1865 felt that he need fear no foreign foe: neither French emperor, nor English nobleman nor the sneers of Carlyle. To destroy a democracy by external force the blows must be quick and hard, because its power of recuperation is great. The danger will come from internal forces produced by false political and social theories, since we offer such a great field for the action of charlatans. Our schools and colleges send forth every year many educated people, and it is sometimes disheartening to see how little influence these people have in public life. Those who are trained in the humanities and churches ought to be humane in dealing with other people, ready to meet great emergencies and powerful to control bad tendencies in national affairs. But this is rarely the case. On the other hand the most unscrupulous apologists and persecutors have been educated men, and the heroes of humanity have come from the common people. This anomaly points to something wrong in the system of education, which should disappear. The increase and teaching of scientific ideas will be the best means of establishing simple and natural rules of life. Nature, and science her interpreter, teach us to be honest and true, and they lead us to the Golden Rule.

# THE EVOLUTION OF SEX IN PLANTS.

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IN a former paper published in The Popular Science Monthly* we considered the origin of sex in plants, describing the progenitors of the sexual elements or gametes and some of the conditions under which these cells assume sexual characters. No attempt was made to trace the later history of these primitive gametes as they become differentiated into the two extremes of sexual cells, the egg and sperm. This is a subject quite independent of the origin of sex and deserves the separate treatment that we are now to present.

Primitive gametes are sexual cells so similar in size, form and internal structure that they cannot be distinguished as male or female. They are found in a number of the lower groups of algae and have the general appearance and same mode of formation as the zoospores from which they have been derived. Excellent illustrations are presented by *Ulothrix, Cladophora, Hydrodictyon, Ulva* and *Ectocarpus.* In these types the gametes are small motile cells, generally formed numerously in the mother cell or gametangium and discharged into the water where they conjugate in pairs. The principal events of their formation and behavior are illustrated for *Cladophora* and *Ulva* in Fig. 1. In my former paper I described and figured the conditions for *Ulothrix* and *Hydrodictyon.* (Popular Science Monthly, November, 1901, pp. 70–73, figs. 2 and 3.)

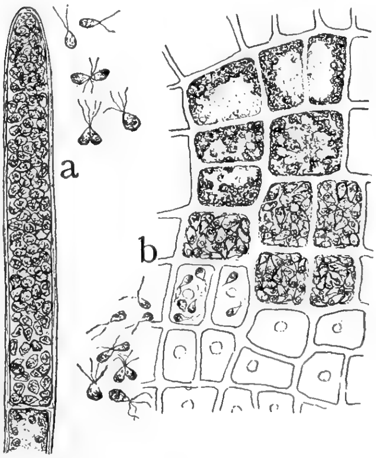


Fig. 1. Gametes and Gametangia of (*a*) *Cladophora*, (*b*) *Ulva*.

Any one familiar with the examples mentioned above will note immediately that they are representatives of diverse groups which are not closely related to one another. On the contrary, most of the forms are associated with very clearly marked divergent lines of development.

* Davis: 'The Origin of Sex in Plants,' Popular Science Monthly, November, 1901, p. 66.

This is important, for it shows that sex did not arise at one period only and at a certain level of the plant kingdom, but, on the contrary, at a number of totally distinct times and in connection with as many independent lines of ascent. We can see no reason why zoospores might not at any time take on the attributes of sex, for the latter conditions are controlled and probably in large measure developed by the chemical and physical environment of the plant. Although sex has arisen a great many times in the plant kingdom and in groups independent of one another, the steps in the process and the structure of the primitive gametes are essentially the same in all cases. There are good reasons for believing that even now certain groups of the algae are developing sexuality, and that this process may be expected to continue wherever the lower algae have the habit of reproducing by zoospores.

With the origin of sex in any group of plants there is immediately presented the possibility of such further evolution as will give the differentiated and highly specialized sexual cells, the eggs and sperms. This evolutionary history is briefly expressed as the development of heterogamy from isogamy or the oosporic type of reproduction from the zygosporic.

Isogamy is the term applied to conditions in which the sexual cells are similar in form, morphologically identical. Heterogamy is the condition in which the female gamete is a motionless cell without cilia and the male gamete generally a ciliated sperm frequently highly specialized in form. Our problem is to understand the steps in the evolution of heterogamy from isogamy and, as far as possible, the factors influential in the process.

Isogamy is a condition very generally distributed among the various groups of algae. We may find it in almost all lines of ascent above the unicellular forms and it is not uncommon among these. Heterogamy always appears at higher levels of development than isogamy and in connection with general advances in vegetative complexity.

It customary to speak of the forms expressing the highest development of evolutionary lines as climax types. Climax types among the algae are almost all heterogamous. There are a few lines in which this level of sexual evolution has not been attained, as for example, the pond scums (Conjugales), the Hydrodictyaceae, Ulvaceae and several smaller groups of the lower algae. On the other hand, there are several heterogamous types standing quite by themselves as the final expression of certain lines of evolution that we can only conjecture because the lower representatives have become extinct. Notable illustrations of this character are the stoneworts (Charales) and the Oedogoniaceae.

Among the remaining groups of algae, and containing by far the greatest portion of this class, are a number of orders and families comprising isogamous and heterogamous forms clearly related in various ways to one another, by vegetative structure and similar life-histories, but offering a wide range of variation in the form and habits of the sexual cells. And it is among these algae that we may find material upon which to base general conclusions on the sexual evolution of plants. These processes are illustrated more or less completely by stages in several groups, but especially so in three lines of development which we shall use as the illustrative basis of this paper. They are the Volvocaceae, certain groups of the brown algae (Phaeophyceae) and the region of the green algae comprising the Ulothricaceae, Chaetophoraceae and Coleochaetaceae.

These three lines are very far removed from one another and must have become separated at an exceedingly early period of development, probably before the origin of sex and certainly before any extended sexual evolution. The Volvocaceae is an extreme side line, by which we mean that its higher members are very far removed from the theoretical main line of ascent that runs through the algae to the next higher group of plants, the Bryophytes. The groups of the Phaeophyceae form a system of side lines very much more highly organized vegetatively than the Volvocaceae. The Ulothricaceae, Chaetophoraceae and Coleochaetaceae are the nearest of all algae to the theoretical main line of ascent, and some of their representatives are very close to this chain of extinct forms; it is, of course, too much to expect that any living alga should be actually one of the links. Each of these three series tells the same story of the general events of sexual evolution as do all other lines of ascent among the algae, fragmentary though some of them are.

We shall take up the Volvocaceae first. This is a peculiar family of plants, remarkable for the fact that the vegetative conditions are motile. Its highest member and a well-defined climax type is *Volvox,* one of the most highly specialized of the algae in its peculiar way. The lowest representatives of the Volvocaceae are unicellular (*Chlamydomonas, Sphaerella,* etc.), and between these simple organisms and the complex *Volvox* there is a series of forms, all cell colonies (*Gonium, Pandorina, Eudorina* and *Pleodorina*), each more complex than the other as to the number, arrangement and degree of specialization of the cells. I know of no family of plants that illustrates so many important evolutionary principles as clearly as the Volvocaceae, and it might be made the subject of an interesting paper. But we are to consider now only the differentiation of the sexual cells.

The lower members of the Volvocaceae are mostly isogamous. In

*Sphaerella* a large number of gametes (32–64) are formed in a mother cell. These sexual cells are quite similar in size and form, and when they conjugate no one could assert a difference in sex. Most species of *Chlamydomonas* resemble *Sphaerella* in having gametes essentially

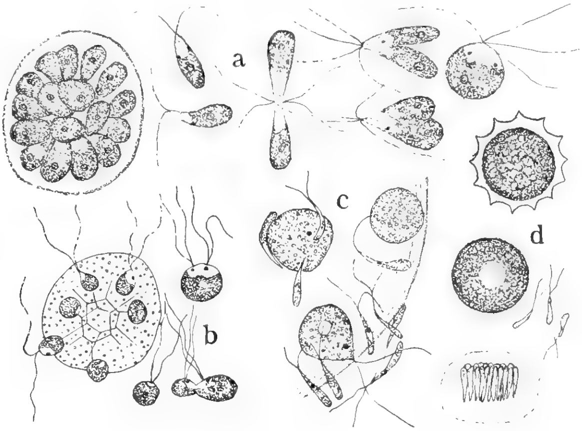


FIG. 2. GAMETES AND GAMETANGIA OF THE VOLVOCACEAE; *a*, *Chlamydomonas Steinii*; *b*, *Pandorina*; *c*, *Eudorina*; *d*, *Volvox*. (*a*, after Goroschankin; *b*, Pringsheim; *c*, Goebel.)

similar (see Fig. 2, *a*), but there are forms in this genus presenting a marked advance. In *Chlamydomonas Braunii** the gametes are of two sizes and the smaller always unite with the larger. However, both are ciliate and consequently motile, so that morphologically they are similar, although there can be no doubt of the sexual differentiation. It is not customary to call the female cell an egg until it has lost its free swimming possibilities and as a passive cell awaits the specialized motile sperm.

*Pandorina,* like *Sphaerella,* produces a large number of gametes, 16–32 in the mother cell, but here there is a considerable range of variation in the size of the sexual elements, although the form is always the same. Sometimes these gametes will pair, a small one with a larger (see Fig. 2, *b*), as in *Chlamydomonas Braunii,* thus showing the tendency towards sexual differentiation. However, there is no rule in this habit of *Pandorina,* for frequently gametes of equal size conjugate, and one can not assert that the larger cells are always destined to be female sought by smaller male elements. What determines the variation in size of the gametes in *Chlamydomonas Braunii* and *Pandorina,* and the consequent differentiation in sex? It depends entirely on the number of gametes formed in the mother cells and on the size of the latter. The larger female gametes are formed less numerously and generally in larger mother cells and conse-

* Figured in POPULAR SCIENCE MONTHLY, November, 1901, p. 67.

quently receive two to four times more protoplasma and food material than the smaller male gametes. This is an important distinction and fundamental to all sexual evolution. The differentiation of one of the gametes as the cell specialized to hold the greater part of the food supply marks the first step in the series of changes that follow.

*Eudorina* and *Volvox* are heterogamous. The eggs are large, the sperms highly specialized (see Fig. 2, *c* and *d*) and in all respects the differentiation of sex seems to be carried about as far as in any group of algae. The eggs are formed singly in the mother cell (oogonium), which means that all the protoplasm and all the food available is reserved for that gamete and this is a great advance over the lower types of the Volvocaceae. The sperms are produced abundantly in each antheridium, 64 in *Eudorina* and sometimes more than 200 in *Volvox*. Naturally one would expect the sperms to be minute and they are proportionally very many times smaller in relation to these eggs than the male gametes of *Chlamydomonas* are to the female.

The condition of heterogamy and its advance over isogamy is the result of several well-defined factors at work wherever sex is present. It is advantageous to specialize one gamete for the purpose of holding as much nourishment as possible, thereby providing well for the vegetative possibilities of the next generation. The most effective way to accomplish this end is to reduce the number of female gametes produced in each oogonium, and the best results will obtain when all the protoplasm from such a mother cell goes to a single female gamete. The absence of motility characteristic of eggs is an accompaniment of the increased food supply. It is a very natural condition and advantageous to the species. In the first place large cells can not move through the water as easily as small cells, and again most of the higher algae have the habit of retaining the eggs in oogonia, protecting them in that way for long periods and of course such eggs must naturally be quiescent. With respect to sperms the evolutionary tendencies are very easily understood. Relieve them of the responsibility of contributing much food material to the egg and it is obviously a great advantage to the organism that sperms be produced as numerously as possible, consistent with economy of energy. This demands the reduction in size of the sperm and also results in that high specialization of form so characteristic of motile male elements.

It is evident that all the factors work for the good of the species and are so vital in their bearings as to fall well within the sphere of natural selection. There are doubtless physiological principles taking part in the developmental processes of gamete formation, and at the higher levels of sexual differentiation important factors of heredity. But these have not been very clearly separated, except that the egg is commonly considered as lacking certain energy which is supplied by the protoplasm (kinoplasm) of the male cell. The sperm, on the other hand, while replete with energy, is ill supplied with nutritive protoplasm (trophoplasm) characteristic of the egg. The phenomenon of parthenogenesis and the recent work on artificial parthenogenesis in animal types show that the energy in the egg may be liberated and the wheels of development set in motion by the proper chemical and physical environment without the intervention of the sperm. But generally the sperm is required to start the egg into activity, and complete and normal development in most organisms probably requires fertilization.

Although most of the stages of sexual evolution are presented in the Volvocaceae, one important stage is there lacking which is especially well illustrated among the brown algae and in the Chaetophoraceae. This is the period of transition from the large free-swimming female gamete to the motionless egg, and covers that evolutionary forward step when the female gamete gives up its motility and the independence of its ancestor the zoospore and becomes the passive receptive egg.

The brown algae (Phaeophyceae) probably developed as an offshoot from the green algae (Chlorophyceae) at a level considerably above the unicellular forms. The lower members of this group are generally well developed filamentous types or more elaborately organized fronds of considerable thickness. Isogamy is general among the lower forms and heterogamy is characteristic of the highest groups (Fucales and Dictyotales). The sexual conditions among the lower groups are especially well exemplified in the genus *Ectocarpus,* whose species present a remarkable series of stages illustrating sexual evolution. The gametes are biciliate cells produced in peculiar types of gametangia which are modified branches whose cells become divided into an immense number of cubical compartments, each of which develops a single gamete. This type of structure is peculiar to the brown algae and is called the plurilocular sporangium or gametangium. It is one of the most interesting organs in the whole group of the Thallophytes because its structure throws light on the difficult problem of the origin of the archegonium.

Some species of *Ectocarpus* have gametes so nearly the same size as to be indistinguishable, but the genus as a whole is remarkable for certain variations in this particular. The plurilocular sporangia are frequently of three distinct sizes, and the zoospores that come from them vary accordingly. It is not always necessary that these zoospores from plurilocular sporangia conjugate in order to grow. There is a great amount of parthenogenetic development depending on environmental conditions that are in part understood. Thus cool temperature and bright illumination tend to suppress sexuality in these zoospores, making them neutral. In other words, sex in *Ectocarpus* is at such a low level of differentiation that its characteristics are still under the potent influence of external factors, and zoospores that will be sexual under certain conditions, *e. g.*, high temperature, will germinate parthenogenetically if this environment is not present. *Ectocarpus* is then another illustration with *Ulothrix* and *Hydrodictyon* of that primitive state, considered in my former paper, when the asexual zoospore became the gamete under the influence of external factors.

But when the zoospores of *Ectocarpus* have sexuality there is a decided tendency for the smaller gametes to seek the larger more slowly swimming elements and fuse with them. The small gametes have, therefore, male characteristics, which is further shown by the fact that they are unable to develop parthenogenetically or, if they do so, grow into small plants much weaker than the normal.

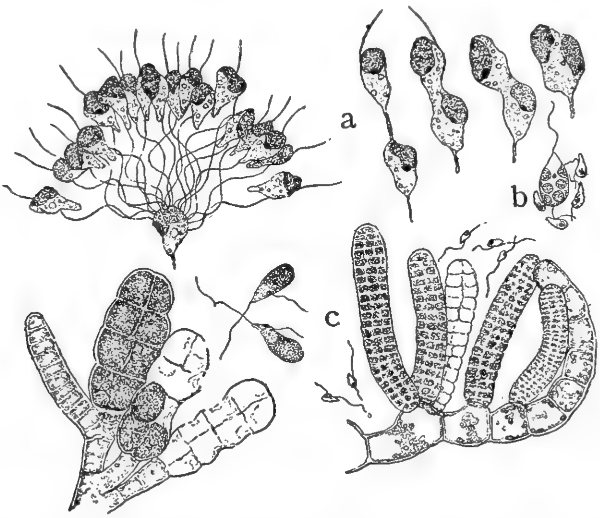


FIG. 3. *a*, *Ectocarpus siliculous*, FEMALE GAMETE SURROUNDED BY MALE, STAGES IN THE FUSION OF GAMETES. *b*, *Ectocarpus secundus*, showing the two sizes of the gametes; *c*, *Cutleria multifida*, male and female gametes and gametangia. (*a*, after Berthold; *b*, Sauvageau; *c* Thuret.)

And now we may consider a habit peculiar to certain species of *Ectocarpus* which is of great interest as an important stage in the process of sexual evolution. It has been most thoroughly studied in *Ectocarpus siliculosus*. The female gametes of this species have a limited period of motility. They swim about slowly and shortly come to rest, attaching themselves. The male gametes are motile for a much longer time. While at rest the female gametes attract the males which hover around (see Fig. 3, *a*), with the result that one fuses with a motionless cell and fertilizes it. This is an exceedingly interesting condition and furnishes the last link in the chain of stages through which gametes pass in their sexual evolution. The gametes of *Ectocarpus siliculosus* are morphologically isogamous, *i. e.*, both are biciliate cells similar in form when first set free from their respective gametangia. At the time of fusion, however, the condition is physiologically that of heterogamy, for the female cell is essentially a quiescent egg sought by motile sperms. There are species of *Ectocarpus* whose gametes have habits similar to *siliculosus* and which are also of two sizes (see Fig. 3, *b*), so that the resemblance to egg and sperm at the time of fertilization is very marked.

Another brown alga should be considered in connection with the forms noted above. *Cutleria* represents a family quite removed from the Ectocarpaceae and much more highly organized. The gametes differ greatly in size as do also the respective gametangia in appearance (see Fig. 3, *c*). The female gamete is exceptionally large and deeply colored, the male small and almost colorless. At certain seasons of the year (late summer and autumn on the coast of France and England) the female gametes germinate parthenogenetically. If sexual it moves about for a short time and then comes to rest, when it is fertilized as a quiescent cell. The conditions are then the same as in the species of *Ectocarpus* previously described.

Before leaving the brown algae, I am tempted to call attention to a very interesting condition in the group of the kelps (Laminariales). These forms are structurally very complex and are unequaled among the algae in size and luxuriance. But the zoospores of the kelps are never sexual, as far as is known, and the group is conspicuous as a wonderfully successful assemblage that has established itself in nature without the advantage of sexuality, which some biologists have supposed to be absolutely necessary for the high development of any group of organisms. The genus *Caulerpa* among the green algae presents a similar illustration.

We are now ready to examine certain groups of the green algae (Chlorophyceae). There are three families above the unicellular algae that are certainly nearer the main line of ascent than any other groups. They are related to one another and present an ascending scale in vegetative and sexual complexity. The Ulothricaceae, typified by *Ulothrix,* is the lowest group. They are isogamous and illustrate especially well the origin of sex as described in my former paper (POPULAR SCIENCE MONTHLY, November, 1901, pp. 70 and 71). The Chaetophoraceae are likewise isogamous, but sex is more firmly established in this group, and structurally its members (*Draparnaldia, Chaetophora, Stigeoclonium,* etc.) are much more elaborate than the forms of the Ulothricaceae. The Coleochaetaceae end the series with an heterogamous type of considerable complexity.

Among the Chaetophoraceae is the genus *Aphanochaete* (see Fig. 4), presenting one of the most interesting stages of sexual evolution and bridging over a very important gap. *Aphanochaete* develops its female gamete singly in a mother cell. It is discharged into the water surrounded by a delicate vesicle. The gamete, although very large, is ciliate. However, it moves about scarcely at all, and does not leave the vesicle. The sperms gather around the dissolving vesicle, and finally one pierces it and fuses with the female gamete. The fertilized egg immediately begins to turn on its axis and moves about in the water for a few moments and then settles down to rest. It is probable that the cilia remain on the egg for this short period of motility, but it is evident that the female gamete has entirely given up the free-swimming habit. But what is more important, the oogonium appears to deliver its gamete with reluctance, for it is not entirely freed from its investing membrane

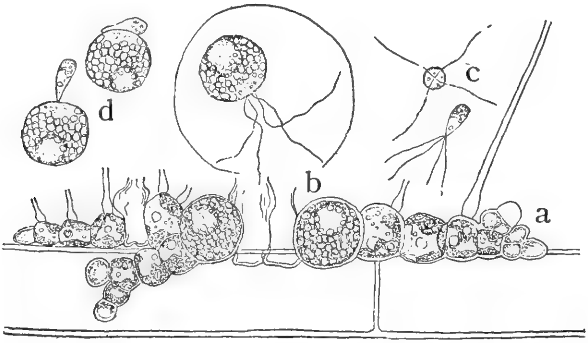


FIG. 4. *Aphanochaete repens; a*, antheridia; *b*, oogonia; *c*, sperms; *d*, eggs. (After Huber.)

until after fertilization. It would be but a small step for *Aphanochaete* to retain this female gamete in the oogonium as a motionless egg and thereby present the furthest extreme of heterogamy. Such a condition would place *Aphanochaete* very close to *Coleochaete,* which it strikingly resembles in some important respects.

The last form in this series of green algae is *Coleochaete,* the sole representative of the family Coleochaetaceae. Of all the algae this type probably stands the closest to the liverworts, not because its sexual organs are similar, but because it presents a sphorophyte generation resembling that of the lowest liverworts (Ricciales). *Coleochaete* is heterogamous, but its sexual organs can scarcely be compared with the archegonia and antheridia of the Bryophytes. These structures are to be related only with the greatest difficulty to the sexual organs of the algae, and probably not through any existing type of structure, unless it be the organ called the plurilocular sporangium.

There are several other groups of algae that confirm and illustrate in various particulars the principles of sexual evolution that we have traced in the three lines of development here described. The Siphonales duplicate the history in most of the stages. Isogamy with variation in the size of the gametes is found in several of the remaining groups. Heterogamy in its most extreme form is presented in such isolated types as the stoneworts (Charales), *Oedogonium, Bulbochaete* and *Sphaeroplea.* All these types stand as representatives of lines of extinct ancestry, whose sexual evolution must have passed through the stages that we have described.

The red algae (Rhodophyceae) do not enter into this discussion. They started with sexuality at an advanced stage of heterogamy.

Let us now briefly summarize with examples the steps in sexual evolution which we have discussed, beginning with isogamy, at the dawning of sex, and ending in heterogamy.

*First Stage.*—Isogamy with exactly similar gametes; the condition at the origin of sex. Exemplified by many of the lower algae, *Hydrodictyon, Ulothrix, Ulva, Cladophora,* etc., certain species of the lower brown algae and unicellular green.

*Second Stage.*—Isogamy with gametes similar in form but of different sizes, the female large and richly nourished, the male relatively small. Illustrated by species of *Chlamydomonas* and *Ectocarpus, Bryopsis* and the forms that also illustrate the third stage. An index to this condition is the differentiation of the gametangia with respect to the number of gametes developed. The female gametangium tends to reduce the number until a single egg takes all the material of the oogonium. The male gametangium increases the number of sexual products, becoming an antheridium that may develop numerous sperms.

*Third Stage.*—Isogamy in that peculiar form when the gametes are similar in form at the time of their discharge from the gametangia, but different at the time of fusion, because the female gamete becomes a motionless cell. Examples: *Ectocarpus siliculosus* and *secundus* and *Cutleria multifida.* This stage is the transition point between isogamy and heterogamy. Morphologically these gametes are isogamous; physiologically they are heterogamous.

*Fourth Stage.*—Heterogamy which has several grades in the degree of differentiation and specialization of the egg and sperm.

*Fifth Stage.*—The retention of the egg in the oogonium (female gametangium), a condition peculiar to but not at all universal among heterogamous higher algae. Illustrated by *Oedogonium, Bulbochaete, Coleochaete, Sphaeroplea, Chara* and *Vaucheria.* This stage would be developed quickly when once started, and a tendency in this direction is probably shown in *Aphanochaete.*

# THE ECONOMIC IMPORTANCE OF FORESTRY.

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EXPERIMENT has already demonstrated the value of practical forestry as a sound business measure. The general application of conservative methods in the handling of public and private forest lands in this country is no longer a remote possibility. Ten years ago, the prevailing attitude towards forestry was one skeptical of its practical advantages. To-day the lumbermen, at one time the strongest opponents of the movement towards conservative forest management, are its staunchest advocates.

Although the application of practical forestry already exerts marked local influence, it is not yet sufficiently extended to form an important factor in our national economy. The time is not far distant, however, when its more general adoption will be felt in all industries dependent upon the forest. Forestry alone can perpetuate lumbering, and the fullest development of the mining industry rests largely upon it. Irrigation, and therefore agriculture upon irrigated lands, can be permanent only through forest preservation.

Mr. Henry Gannett gives the value of the products of the lumber industry for 1900 as about $567,000,000, and $611,000,000 as the invested capital. There were employed, exclusive of those working in dependent logging camps, about 400,000 persons, who received during the year a total of $140,000,000 in wages. Estimating conservatively, the lumber industry gave support in 1900 to 2,000,000 persons, while the number engaged in dependent trades, to whom it indirectly afforded a means of livelihood, was many times greater.

The geographical movement of the lumber industry is significant of a rapidly waning supply of merchantable timber. Fifty years ago, the northeastern states contributed more than one half the total lumber product of the country. They now furnish less than one sixth. In 1880 the Lake states produced one third of the supply, which has already sunk to about one fourth. In the southern and Pacific states, on the other hand, there has been a steady increase in production. These facts show that in the two geographical divisions nearest to the great centers of population, the available supply of timber is rapidly nearing exhaustion. The southern and the Pacific states, therefore, already yielding nearly forty per cent. of the total lumber product, will soon become the chief sources of supply.

In spite of steady improvement in tools, in machinery and in facilities for transportation, the increase in the value of logs and lumber becomes more and more rapid. The American lumberman has always been remarkable for enterprise and effectiveness, while American saw-mills compare favorably with those in any other country. These conditions, which would naturally tend to a sustained decrease in the cost of lumber products, are more than offset by the scarcity of available timber.

To sum up, the lumber industry of this country is approaching the end of its resources with alarming rapidity. It has, by over-production, fostered an abnormal demand, and by methods aimed at present profit alone, hampered the production of a second crop upon the lumbered area. Notwithstanding the growing economy in the harvesting, manufacture and distribution of forest products, their value is each year higher, while there is enormous increase in the importation of softwoods from Canada and of hardwoods from the tropics. Existing data as to the quantity of standing timber in the United States is insufficient for a close estimate of how long it will last at the current rate of consumption. It is inevitable, however, that the present generation will see the exhaustion of our first growth timber. Nor is the supply now standing so secure that it may be counted upon with certainty. Forest fires destroy annually timber aggregating over $50,000,000 in value, and measures to prevent them so far have not proved generally effective. It will be understood, moreover, that the crippling of the lumber trade and of all industries dependent upon it does not await the actual exhaustion of our forests. The geographical distribution of the great timber regions in this country, with relation to the chief sources of demand, is such that the local and not the total available supply is the urgent question. The fact that the heavy forests of the Pacific slope are sufficient to yield for many years an amount equal to the present annual consumption will not prevent a timber famine in the East, when to the price of the bulk of the wood it consumes is added the cost of transportation across the continent. Statistics giving comforting assurance of an abundant yield still at hand do not consider the effect upon wood industries of the substitution of timber of a few kinds only to fill a widely varying demand. The presence of hardwoods in the southern Appalachians and pine in the southern pine belt, in quantity sufficient to replace for some time the waning supply of spruce in the north woods, offers no substitute for the latter species in the manufacture of paper pulp. The redwood, red fir and hemlock of the Pacific coast will in some respects take the place of the longleaf pine, the exhaustion of which, at the present rate of consumption, will soon be accomplished. They can not, however, serve as the source of naval stores, the production of which renders the longleaf pine the most important timber tree of the South. No general statements of large supplies of timber still available can disguise the gravity of the situation which now confronts the lumber industry. The solution of the problem can come only through a change in the policy and in the methods of the lumberman.

The history of lumbering in the United States has not differed essentially from that of the same industry in other countries. In the early days, the chief obstacle of the settler was the forest, while the growing need both of cleared land and of timber kept pace with the advance of colonization. The multiplication of demands for forest products developed feverish activity in the conversion of trees into money, while the methods employed in the harvesting of timber were the natural outcome of existing conditions. Forestry, with its perpetual but conservative returns, offered no financial inducement to the lumberman until the first crop of timber began to fail. With the forest stretched before him, large enough to feed his saw-mill for his lifetime, he had no need to consider the potential value of cut-over lands, often allowing them to revert in default of taxes to the state. His methods of lumbering were significant of his attitude. Skillful and effective in the cutting and transport of logs and the manufacture of lumber, he showed utter obliviousness to the productive capacity of the lumbered areas. Abuse of the lumberman is unmerited and unreasonable. His utilization of natural resources has been accomplished by mistakes similar to those incurred in the development of other industries in this country. The necessity for modification of his methods involves no emotional considerations. The question is one simply of the best business policy.

The attitude of the lumberman towards the source of his industry has so far been generally similar to that of the miner towards the gold mine. He has considered the value of the forest to lie only in the merchantable timber it contains, just as the mine is worthless when the end of the vein is reached. He has cut and burned with complete disregard of the welfare of immature trees, with the result that he has deprived the future of a supply of timber many times the value of the material he has actually utilized. There has been incalculable waste, which in some cases could have been avoided through slight expense, in others simply by the exercise of reasonable care, and which has hastened enormously the approaching exhaustion of the lumber supply. No one realizes more keenly than does the lumberman that the time for forestry has fully arrived.

The influence of the general adoption of practical forestry upon the lumber industry will be felt gradually, but it will eventually accomplish fundamental changes. It will substitute for an enterprise at present aimed only at the utilization of existing resources one embracing also measures for the production of its own supply. There will be steady and fair returns from lumbering, but spectacular opportunities for the investment of capital will cease to exist. The industry will assume normal proportions based upon the actual production of our forests, and will develop soundly with the increase in yield due to the improvement in conservative methods. A steady and sustained output, which may be estimated closely in advance, will tend to the maintenance of a constant scale of values, and to hamper speculation in logs or lumber. The size of the saw-mill will be regulated by the actual annual production of timber in the forest which supplies it. There will be a gradual elimination of enormous milling plants, and the general substitution of the saw-mill of medium size equipped for permanent use and under the same control as an area of forest land yielding a continued supply of timber equal to the capacity of the mill itself.

The general tendency towards wide distribution of the lumber industry will be an important economic feature of its development under conservative methods. The present movements towards centralization in the bodies of merchantable timber still remaining will cease with their consumption. In turning to second growth as a source of supply, the lumberman will establish himself wherever the productive capacity of cut-over lands under conservative handling offers him a fair return for his labor. The final result will be the development in each locality of a permanent class trained to forest work and a favorable geographical allotment of opportunities for the wage earner.

No man can foretell with certainty the value of timber produced under the application of practical forestry, nor the sustained supply which this country is capable of producing. The urgent necessity for the general adoption of conservative methods in lumbering does not rest upon the solution of these questions, but upon the established fact that the present value and the growing scarcity of timber render it profitable to foster the production of a second crop upon cut-over lands. It is to be remembered, also, that the results of forestry follow certainly but gradually. Its immediate adoption throughout the country would serve to shorten the period of decline which is the price the lumber industry must pay for phenomenal but unsound development, but the trees must have time to grow again. The new policy firmly established, the productive capacity of our forests fully utilized, it is believed—and the statement is amply sustained by the record of other countries with a proportionately smaller wooded area and a proportionately equal consumption of forest products—that neither will the value of timber be excessive, nor its supply inadequate to meet the home demand. The establishment of lumbering as a sound and stable industry will be attained only when it reaps, as well as harvests, the crop upon which its existence depends.

Of the indirect returns from conservative forest management, the most valuable is its influence upon the flow of streams. The arid lands comprise two fifths of the area of the United States, and cover nearly all the western half of the continent. Their character varies with the amount of rainfall, ranging from true desert conditions to those capable of supporting a nomadic kind of grazing and a form of farming so low in its production that it promises little in inviting settlement. In his timely and forcible volume, 'Irrigation in the United States,' Mr. Newell states that the utilization of the vacant public lands can come about only through irrigation, or the artificial application of water to the soil, to supplement the scanty rainfall or to supply its absence. The area within the arid region which is irrigable is estimated at not less than 60,000,000 acres. The streams which may be diverted for purposes of irrigation rise in the forests, whose conservation is necessary to the maintenance of an abundant and sustained supply of water.

The passage of the Irrigation Bill, on March 1, 1902, paves the way for the adequate reclamation of the public lands. It sets aside receipts aggregating about $5,000,000 per year, received from the sale of lands within the arid region, and provides that they shall be applied to the construction of works for water conservation. The success of this great undertaking may be assured only through the preservation of the forests which feed the streams available for purposes of irrigation. The careful protection of these forests can be accomplished only by the federal government, through their management as national forest reserves. The exclusion from settlement of forest lands comprising the catchment basin of streams important for irrigation began under President Harrison, and has resulted in the creation of fifty reserves, with a total area of 53,107,685 acres, or 82,981 square miles. These are administered with a view to timber production only in so far as their more valuable function of water conservation is not affected. Their management is still hampered by its distribution among three branches of the government, and by difficulty in the rapid building up of a force of thoroughly trained and effective executive officers. There has, however, been progress in the prevention of timber theft and of fire, and the development of the fullest usefulness of the forest reserves is beset by no insurmountable difficulties. Their extension to include all large bodies of mountainous forest within or tributary to the arid region is essential to the fullest development of the West. There is no more forcible statement of the dependence of irrigation upon forestry than the following extract from the first message of President Roosevelt to Congress:

> In the arid region, it is water, not land, which measures production. The western half of the United States would sustain a population greater than that of our whole country to-day, if the waters that now run to waste were saved and used for irrigation. The forest and water problems are perhaps the most vital internal questions of the United States.
>
> The forests are natural reservoirs. By restraining the floods and by replenishing them in drought, they make possible the use of water otherwise wasted. They prevent the soil from washing, and so protect the storage reservoirs from filling up with silt. Forest conservation is, therefore, an essential condition of water conservation.

Another function of the forest reserves, the regulation of which is at present the most urgent problem of their management, is the use of the grazing lands within their boundaries. Sheep and cattle raising are, and will continue to be, two of the great industries of the arid region. The over-grazing of lands important in the conservation of water supply is harmful in the dying out and hardening of the soil, as a result of the removal of its cover of herbs and grasses, and, in the case of over-grazing by sheep, in the destruction of seedlings and young trees. The purpose of forestry is not to impose unreasonable restrictions upon the development of the grazing industry within the reserves, but to regulate it with due reference to the interests both of the stockman and the irrigator.

The production of timber to fill the increasing needs of the mining industry is another great function of the national forest reserves. The laws governing their management confer upon the Secretary of the Interior power to designate, appraise and sell timber within them. The exercise of this provision under conservative measures can alone continue to permit an adequate supply of timber to the miner and for the home uses of settlers within the arid region.

Wood and water are the chief returns from forested areas. They produce the one and they conserve the other. So far, the treatment of our forests has tended only to impair their usefulness. Preservation without use is required neither of the private owner nor the federal government. Forest preservation by wise use alone can meet the national and the individual need.

# MENTAL AND MORAL HEREDITY IN ROYALTY, VII.

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## Evidence from the House of Nassau.

### *A. Elder Branch of Orange.*

THIS branch of Nassau for five generations from William the Elder (1487–1559) to William, Prince of Orange, who became king of England (1650–1702), includes in the direct line 30 names. Completing the pedigree on the maternal side for each fraternity brings in 83 additional persons, and raises the entire group to 113.

The thirty in the direct line show remarkable characteristics and probably average, among the direct lines already discussed, more genius than all the rest of the countries put together, excepting that little region about Frederick the Great which we believe to have been formed from this. These illustrious names are William the Silent (10), Maurice (9), Frederick Henry (8), William II., Prince of Orange (8), William III., of England (9). These are father, two sons, grandson and great-grandson. If due to heredity, why was it perpetuated through four generations without reverting to the mean? This was largely due, as far as the second generation was concerned, to the fact that the stock was remarkably well maintained on the maternal side. Maurice had, for his mother's father, Maurice, the celebrated Elector of Saxony (9) and for a great-grandfather Philip Landgrave Hesse (7).

Frederick Henry was a grandson of Gaspard de Coligny, the great admiral of France (9), himself of distinguished stock, and the most remarkable member of the Montmorency-Coligny combination. Frederick Henry married Amelia of Sohns, a woman of fine character and high mental endowments; so it is not surprising that his son, William II., who died young, should have been a prince of exceedingly high promise.

In the next generation William II. married Mary, a daughter of Charles I. of England, so that the relatively poor blood of the Stuarts was introduced. He had but one child, William III., one of the greatest of England's kings. That the last of the line took from the paternal rather than the maternal side must be considered good luck, to say the least. Thus besides the remarkable unions we see also a selection inasmuch as the most highly gifted were sons, many of the daughters showing the reversion to mediocrity and balancing up matters in the outside families into which they married, most of whom, if they left descendants at all, left only such as never rose above obscurity.

There were, however, among the other twenty-two grandchildren of William the Silent, three who were distinguished, one of whom, Turenne (10), ranks among the highest. The origin of the genius of William the Silent is not quite clear, since none of his ancestry in several degrees of remoteness were worthy of being called great, although they were of the sterling sort and above mediocrity. So William the Silent himself can not be taken as an instance of heredity, though all his descendants can. The moral tone was very high throughout, and corresponds either with the education or with the blood, since no bad characters were introduced, except Anne, second wife of William the Silent. She was violent, dissolute and finally insane. The later descendants are not from her. She had but two children and no legitimate grandchildren. Except that her daughter Amelia was extremely headstrong, her children appear to have escaped any influence from her.

Thus we see that the branch of Nassau is entirely confirmatory of the theory of heredity, and this should be taken into consideration in studying the causes of the rise of the Dutch Republic, since whatever was due to the personalities of these men finds its inner reason in the pedigrees which lie behind them.

The following is a list of all the grandchildren of William the Silent. This list analyzes the branch of Nassau in another way.

Those who are in (8), (9) or (10) are marked with an asterisk. To be in ranks (9) and (10) the persons must receive high praise in Lippincott's. Those in (8) may not always appear in Lippincott, but must at least receive very high adjectives in other authorities.

*a.* Children by Anne, daughter of Maximilian, Count of Buren:

1. Philip William.
2. Mary.

*b.* Children by Anne, daughter of Maurice, Elector of Saxony:

*3. Maurice of Nassau (9), 'one of the greatest captains of modern times.'
4. Anne.
5. Amelia = Emanuel of Portugal.

*c.* Children of Charlotte, daughter of Lewis, Duke of Montpensier:

6. Louisa Juliana = Palatine.
7. Isabella = de Bouillon.
8. Catherine = Hanau.
9. Flandria, a nun.
10. Charlotte = de la Tremoille.
11. Amelia = Palatine Deux-Ponts.
*12. Frederick Henry (8), celebrated stadtholder.

GRANDCHILDREN.

*a.* Children of Maurice of Nassau (illegitimate):

1. William Lord of Lecke, Vice-Admiral of Holland.
2. Lewis Lord of Lecke, Beverweed and Odyck, a general.

*b.* Children of Amelia of Portugal:

3. Mary Belgica.
4. Emanuel Felix of Portugal.
5. Amelia.
6. Anne.
7. Juliana Catherine.
8. Mauritia Eleonora.
9. Lewis of Portugal.

*c.* Children of Louisa Juliana:
10. Frederick V., Elector Palatine.
11. Elizabeth = Brandenburg.
12. Louisa Juliana = Palatine-Deux-Ponts.
13. Louis Philip = Palatine-Simmern.

*d.* Children of Isabella, Duchess de Bouillon:
14. Frederick Maurice, Lord of Sedan.
*15. Turenne (9), celebrated general.
16. Mary = Henry, Duke Tuars.
17. Juliana Catherine = Francis Count Roye.
18. Elizabeth = Marq. Duras.
19. Henrica Catherine = Goyau de la Moussaye.

*e.* Children of Catherine of Hanau:
*20. Amalia Elizabeth (9) = Hesse Cassel.
21. Philip Maurice, Count of Hanau.
22. Catherine Juliana.
23. Henry Lewis.
24. James John.

*f.* Children of Charlotte de la Tremoille:
25. Henry Duke Thonan Count Laval.
*26. Charlotte Countess Derby (9), a skilful commander and was 'the last person in the three kingdoms who submitted to the parliament.'

*g.* Children of Amelia = Palatine Deux-Ponts:
27. Frederick Louis, Count Palatine Landsberg.

*h.* Children of Frederick Henry:
28. Henrietta.
29. Mary.
30. Louisa.
31. Albertina.
*32. William II., Prince of Orange (8), a youth, of great promise.

Among the twelve children there were two distinguished. There were four distinguished grandchildren, but only four out of thirty-two, so we see a greater proportionate amount near to William the Silent himself; the greatest of the grandchildren, Turenne, occurs where he would most probably fall. He had a brilliant backing on both sides since his father was also 'a distinguished general.'*

### *B. Younger Branch of Nassau Dietz.*

This other branch of the House of Nassau from which the present ruling family of Holland is descended may be well compared with that of Orange since for a number of years they lived and fought side by side in their struggles for liberty, and subsequent to their divergence took their blood largely from the same general sources that produced the geniuses already discussed. Although we find the brilliant branch of the family very largely represented in the pedigree as more remote ancestors, there was no such selection as would require heredity to place genius on the heads of any of the direct descendants.

This, together with the fact that none of the princes had large families of children, seems to sufficiently account for the observation that no great genius subsequently appeared in this branch.

The following is a list of the descendants in the direct line, their maternal pedigree having been looked up in each case, complete to all great-grandparents, and the distinguished ancestors are noted:

Children of John Sr. of Orange (no distinguished maternal ancestors):
1. William Louis, Stadtholder of Friesland—1620.
2. John Count of Siegen—1623.
3. Elizabeth—1611 = Nassau-Saarbruck.
4. Mary—1625 = John Louis Nassau Weisbaden.
5. Machtild—1625 = William Count Mansfeld.

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* Lippincott's.

6. George, Count Nassau Dillenburg—1623.
7. Louis Gunther—1604.
8. Ernst Casimir—1558–1632.
   Children of Ernst Casimir (no distinguished maternal ancestors):
9. Henry Casimir of Nassau Dietz—1640.
10. William Frederic, Count of Nassau Dietz—1664.
   Children of William Frederick (had Henry Frederick (8) as grandparent and William The Silent (10) as great-grandparent):
11. Henry Casimir, Prince of Nassau Dietz—1657–1696.
12. Amelia.
   Children of Henry Casimir (had Henry Frederick (8) as a great-grandparent):
13. John William Frizp—1687–1711.
14. Sophia Hedwig.
15. Isabella Charlotte.
   Children of John William Frizp (had three distinguished great-grandparents, Henry Frederick (8) twice and Amelia of Hesse (9):
16. William, Prince of Nassau Dietz—1711–1757.
17. Anne Charlotte = Baden Durlach.
   Children of William IV (had Caroline, Queen of England (8) as grandmother):
18. William V., Prince of Nassau—1748–1806.
19. Wilhelmina Carolina = Nassau-Wielburg.
   Children of William V. (had Frederick the Great as great-uncle):
20. William I., King of the Netherlands.
21. William George Frederick—1774–1799.
22. Frederica Louisa = Brunswick.
   Children of William I.:
23. William II., King of the Netherlands.
24. Frederick William Charles, Prince of the Netherlands—1792–1881.
   Children of William II. (had Catherine II. as great-grandmother):
25. William III., King of the Netherlands.
26. Henry Prince of the Netherlands—1820.
27. Sophia = Saxe-Weimar.

Among the twenty-seven only three deserve the adjective brilliant. These are William I., king of the Netherlands, 'a captain, a hero, a legislator and a great man,'* and his younger brother, William George Frederick, who lived to be only twenty-five, but won considerable distinction and appears in the 'Biographie Universelle,' 'a rare model of all talents, virtues and precious qualities.' The third is the second son of William I., Frederick William Charles, who 'took a prominent part in the war of the Belgian revolution in 1830.'† These came together, and we suppose their talents came from the high wave about Frederick the Great.

Reviewing the list:

In the first two generations we get what we might well expect, since John Sr. of Orange, a brother of William the Silent, was, although an able man, in no way a genius.

In the third generation, we might not be surprised to see it reappearing, and heredity would demand it in a large number of children, but as there are only two, these may have taken after their parents who were obscure.

* Alphonce Rablee in 'Biographie des Contemporaires.'
† Lippincott's.

The second generation after this is similar, so it seems to me there is nothing in the history of this house to speak against heredity, except that among the three children of William V., we find in two brothers a too large proportion of mental endowment, since there was no eminent relation nearer than great uncles and aunts. Thus about twenty-six of the twenty-seven give us the expected. This is another example of a royal house that did not degenerate through assumption of rank and power.

The moral tone remained good throughout and, although probably explicable on grounds of environment, is also in line with heredity.

## Evidence from the House of Brunswick.

This family may be conveniently taken up next, since it is much like Saxe-Coburg in character, has intermarried with it and taken its tap-roots from much the same sources.

From Henry of Brunswick Danneburg (1546–1598) to William Duke of Brunswick Oels (1806–) we have eight generations with thirty-nine members of the direct house who are available for study. Of these thirty-nine all but Henry, above mentioned, and August (1579–1666) are given a full pedigree to the great-grandparent generation and studied with uncles and aunts as additional material. This brings into the group ninety-five more persons, or 144 in all. Among the thirty-nine we find one in grade (9), Amelia of Saxe Weimar, the distinguished patron of men of learning, and three in grade (8), William Adolphus, an author, and Charles William Frederick, the celebrated general in the Seven Years' War, and Juliana, the very ambitious and unprincipled queen of Frederick V., of Denmark. The gifted ones, Amelia of Saxe-Weimar, Charles William Ferdinand and William Adolphus, are niece and nephews of Frederick the Great and also of Juliana. The generation to which Juliana belongs also contains Ferdinand, a celebrated general, but his fraternity does not average quite as high as the next, which was formed by a union with the Hohenzollerns at the height of their greatness.

The first five generations of the House of Brunswick contain eight as high as grade (7), but none of these were distinguished sufficiently to be mentioned in Lippincott's. Only two, Ferdinand and his father, Ferdinand Albert II., were noted as generals.

The literary activity was very great, there being among the thirty-nine no less than ten who were authors. This authorship ran through five of the eight generations and should have appeared as it did, even setting aside the influence of education and example, since we find a remarkable breeding in of literary qualities somewhat comparable to what was found in the family of Saxe-Coburg-Gotha.

August (1579–1666), the second generation, married an authoress, Sophia Elizabeth; they had four children who were authors, among them Ferdinand Albert I. Ferdinand had several children, but no authors. One of these, Ferdinand Albert II., married Charlotte, not literary, whose father, uncle, aunt and grandfather were all authors. Among their nine children one, Elizabeth, published a number of translations and another, Ernst Ludwig, had literary taste and became the tutor of William of Orange.

The next generation is formed by the union with the literary Hohenzollerns and shows a fair proportion of authors, three in nine. After this none appeared. If these five generations of authors had accrued without any rejuvenation of blood, it would speak strongly for the effects of education. As it is, it could be used for an argument on either side. All that one can say is that heredity is satisfied. On the purely intellectual side there seems to be two rather serious deviations from Galton's law. The generation which contains the nieces and nephews of Frederick the Great is even more brilliant than would be expected. This may have been, as in the case of Frederick's own fraternity, either prepotency or superior opportunities of distinction, one can not tell which.

The next generation gives one of the worst results from the standpoint of heredity found anywhere, and we have quite the unexpected happening.

Two of the children, George William and Charles George, were mentally unfit to rule and consequently disinherited. In this connection it may be stated that a study of Denmark, Hesse Cassel and England has brought the author to the belief that this mental disease in the House of Brunswick was but a cropping out of the old Palatine insanity at the time of James I., of England. Christian VII., of Denmark, who was an uncontrolable imbecile and finally became mad, was a first cousin of George III., of England, who was insane during his later life, and Christian was also a first cousin once removed of the two little imbecile sons above mentioned, of Augusta, princess of Brunswick. Another more convincing bit of evidence in this connection is to be found in the neighboring House of Hesse Cassel. Here we find another who became insane and died in early manhood, and was a first cousin, once removed, of Christian VII. of Denmark. All these are related and only through the same source, the Palatine House, and since this Christian, of Hesse Cassel, is doubly descended from this suspected strain (Palatine House) it seems more than probable that we are dealing with an inherited insanity in all these cases. We may also mention Frederick William I., of Prussia, about whom Macaulay said: 'His eccentricities were such as had never been seen out of a mad house.' Frederick William was a first cousin of George

II., of England, and stands as near the actual Palatine insanity as a nephew.

These six cases would, if occurring in families of ordinary social grade, never make their way into asylum records as exhibiting a congenital tendency, since their close relations were not insane, but here, where we have the family tree and can look up the ancestry, curiously enough we find them all related and through the same source, Palatine, and this moreover the only one of their many lines of descent in which there was insanity. This is to be thought of when regarding the percentage which runs from twenty to 90 for heredity among the insane, according to the observer, and it should make us think that the higher rather than the lower figures are more likely to be correct.

This condition which caused the extinction of the House of Brunswick in the male line is often considered a common one in aristocracy, that is, a degeneration due to the assumption of rank and power, and consequent tendency to ease, dissipation and decline.

Jacobi has tried to show that the majority of royal and powerful families tend to end in degeneration and sterility. Degeneration without a corresponding pollution of blood, a contamination sufficient in itself to explain the condition I believe to be exceedingly rare, and I may say that there are no instances of such a degeneration among all the royal families that I have studied.

Among the 144 included in this group by reason of close relationship, there are two in (10), three in (9) and seven in (8). These are all centered about within two degrees of relationship of Charles William Ferdinand who was probably the most celebrated of any bearing the name of Brunswick. By making him the center of a group of forty-one, including only those more closely related to him, we find two in (10), three in (9), five in (8), eight in (7), that is $\frac{5}{40}$ of genius and of high talent. This is practically the same group of geniuses that centered about Frederick the Great in Prussia. It seems very probable on the grounds of heredity and entirely unlikely on any other.

## THE SMITHSONIAN INSTITUTION.*

"THE advancement of the highest interests of national science and learning and the custody of objects of art and of the valuable results of scientific expeditions conducted by the United States have been committed to the Smithsonian Institution. In furtherance of its declared purpose—for the 'increase and diffusion of knowledge among men'—the congress has from time to time given it other important functions. Such trusts have been executed by the institution with notable fidelity. There should be no halt in the work of the institution, in accordance with the plans which its secretary has presented, for the preservation of the vanishing races of great North American animals in the National Zoological Park. The urgent needs of the National Museum are recommended to the favorable consideration of the congress." (President Roosevelt's first message to Congress.)

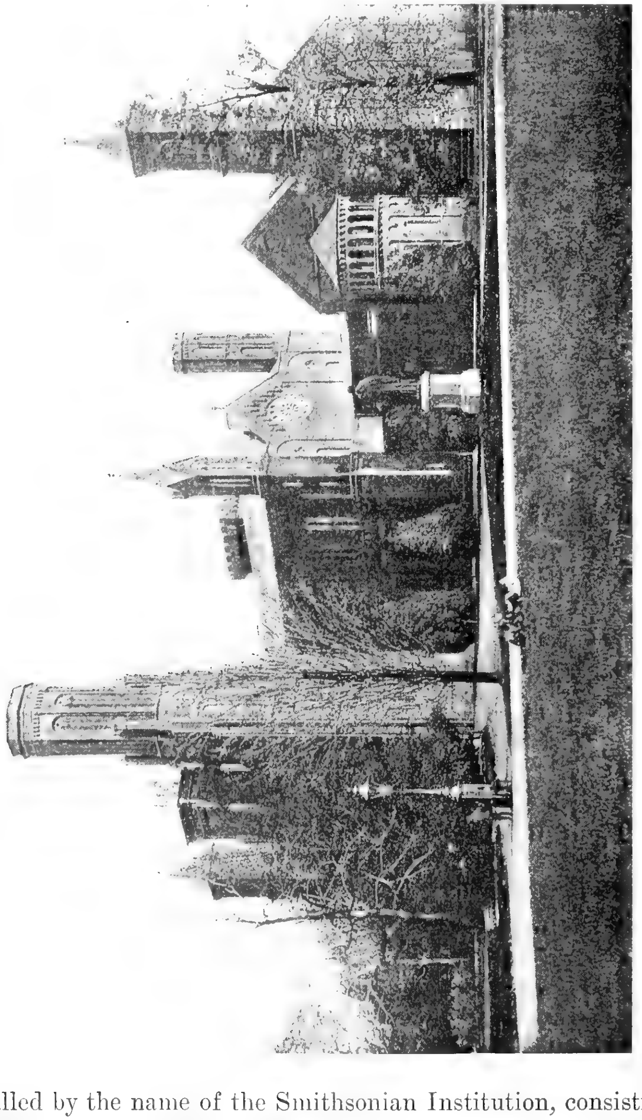
In the first Smithsonian report issued in the twentieth century it may not be amiss to tell the readers of this volume very briefly what the institution is, how it came into being, and how it has fulfilled the purposes for which it was established.

In the popular mind the Smithsonian Institution is a picturesque castellated building of brown stone, situated in a beautiful park at Washington, containing birds and shells and beasts and many other things, with another large adjacent building, often called the Smithsonian National Museum. The institution is likewise supposed to have a large corps of learned men, all of whom are called 'professors' (which they are not), whose time is spent in writing books and making experiments and answering all kinds of questions concerning the things in the heavens above, the earth beneath, and the waters under the earth.

Contrast this popular notion with the facts. The Smithsonian Institution is an 'establishment' created by an act of congress which owes its origin to the bequest of James Smithson, an Englishman, a scientific man, and at one time a vice-president of the Royal Society, who died in Genoa in 1829, leaving his entire estate to the United States of America 'to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men.'

* This article is reprinted from the recent report of the Smithsonian Institution. We have pleasure in reproducing the official account of the foundation and activities of the institution, as we have had occasion to criticize its present management.

After ten years of debate in congress, turning partly on the question whether the government ought to accept such a bequest at all and put itself in the unprecedented position of the guardian of a ward, congress accepted the trust and created by enactment an 'establishment' called by the name of the Smithsonian Institution, consisting of the President of the United States, the Vice-President, the Chief Justice of the United States, and the members of the President's Cabinet. It has also a secretary, with varied functions, among others that of being the keeper of the museum.



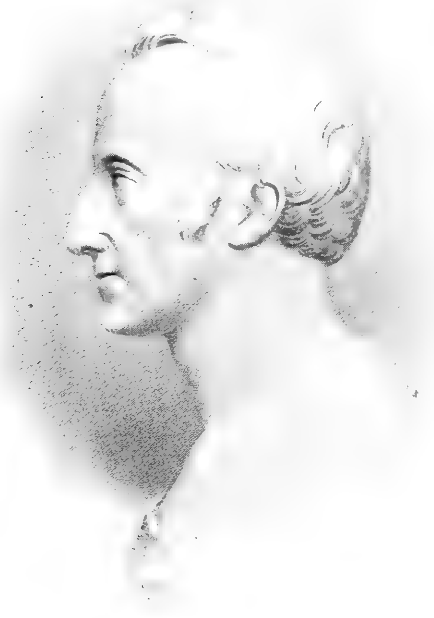
THE SMITHSONIAN BUILDING.

Smithson's money, which amounted to over half a million dollars, and later to three quarters of a million, a great fortune in that day of small things, was deposited in the United States Treasury, the government afterwards agreeing to pay perpetually six per cent. interest upon it.

In the fundamental act creating the institution, congress, as above stated, provided that the President and the members of his cabinet should be members of the institution, that is, should be the institution itself, but that nevertheless it should be governed by a board of regents, composed of the Vice-President and Chief Justice of the United States, three regents to be appointed by the president of the senate (ordinarily the vice-president), three by the speaker of the house of representatives, and six to be selected by congress; two of whom should be residents of the District of Columbia, and the other four from different states, no two being from the same state. The fundamental act further provides that the secretary of the institution already defined shall also be secretary of the board of regents. The museum is primarily to contain objects of art and of foreign and curious research; next, objects of natural history, plants, and geological and mineralogical specimens belonging to the United States. Provision is also made for a library, and the functions of the regents and of the secretary were defined.

The preamble of this bill states that congress has received the property of Smithson and provided 'for the faithful execution of said trust agreeable to the will of the liberal and enlightened donor.' It will thus be seen that the relations of the general government to the Smithsonian Institution are most extraordinary, one may even say unique, since the United States solemnly bound itself to the administration of a trust. Probably never before has any ward found so powerful a guardian.

The first meeting of the regents occurred on September 7, 1846, and in the autumn of the same year they elected as secretary Joseph Henry, then a professor at Princeton, known for his extraordinary experiments on the electromagnet, and other subjects relating to electricity. Under his guidance the institution took shape. Its work at first consisted, in the main, of the publication of original memoirs, containing actual contributions to knowledge, and their free distribution to important libraries throughout the world; to giving popular lectures in Washington, publishing them, and distributing them to libraries and individuals; stimulating scientific work by providing apparatus and by making grants of money to worthy investigators, cooperating with other government departments in the advancement of work useful to the general government, etc. These were the principal methods employed by Henry to carry out the purposes of Smithson, for the increase and diffusion of knowledge. Here, too, were initiated certain studies which afterwards became most fruitful and have resulted in important government work, such as the present Weather Bureau, among others. The beginning of cooperation in library work was at this institution. At the same time many—we might almost say most—of the present scientific activities of the government have grown out of it or been stimulated by it. Experiments in fog signaling, in the acoustics and ventilation of public buildings, and in numerous other subjects, were inaugurated. In fact, in these earlier days, with one or two exceptions,



JAMES SMITHSON.

FOUNDER OF THE SMITHSONIAN INSTITUTION.

the Smithsonian was the sole representative of active scientific work directly or indirectly connected with the United States government. Its influence upon the character of private scientific work, too, was very great, since half a century or more ago the avenues for publishing were few, and the funds for the purpose slender.

Gradually, out of the collections which had been kept in the Patent Office, the private collections of Smithson, and of appropriations of his money made by the regents, and largely also through the results of the great exploring expedition of Captain Wilkes, there grew up a Smithsonian Museum, one which was exclusively cared for from the Smithson fund; but which, partly through the greater activity of the government surveys and partly through the gifts of private individuals, and also through the valuable objects presented to the United States government by foreign nations at the close of the Centennial at Philadelphia in 1876, brought about the establishment of what is now known as the United States National Museum of the Smithsonian Institution, which is under control of the regents of the institution, for which a building was provided, and which now receives direct support from congress. This museum has now the matter belonging to the original institution collected by the Smithsonian's own observers, with much more secured through the general government, making in all over 5,000,000 specimens, and is the foremost collection in the world in everything that relates to the natural history, ethnology, geology, and paleontology of that portion of North America now the United States, besides containing many valuable series from other countries. The collections have been visited by over 7,500,000 persons, and the institution has carried selections of its specimens to every large exhibition held in the United States, and distributed 850,000 specimens to colleges and academies, thus powerfully stimulating the growth of museums large and small in every section of the country.

The publications of the Smithsonian have been in several series, mostly to convey to specialists the results of its original scientific investigations and to thus represent the first half of its fundamental purpose 'for the *increase* of knowledge,' and, subordinately, others to include handbooks and indexes useful to students, and some publications which, while still accurate, contain much information in a style to be understood by any intelligent reader, and thus represent the second half of the founder's purpose for the '*diffusion* of knowledge.' Many valuable publications, too, have been issued by the museum and the Bureau of Ethnology, and recently by the Astrophysical Observatory. In all, 265 volumes in over 2,000,000 copies and parts have been gratuitously distributed to institutions and private individuals, these works forming in themselves a scientific library in all branches.

Partly by purchase, but in the main by exchange for these publications, the institution has assembled a library of over 150,000 volumes, principally of serial publications and the transactions of learned societies, which is one of the notable collections of the world. The major portion of it has been since 1866 deposited in the Library of Congress, with which establishment the most cordial and mutually helpful relations subsist.

In 1850 Spencer Fullerton Baird, a distinguished naturalist, was elected assistant secretary of the institution. To him the great activity in natural history work was due, and by him the museum was fostered, he being greatly aided from 1875 by a young and enthusiastic naturalist, George Brown Goode. Secretary Baird initiated in the Smithsonian Institution those economic studies which led to the establishment of the United States Fish Commission.

JOSEPH HENRY.

FIRST SECRETARY OF THE SMITHSONIAN INSTITUTION, 1846-1878.

As another means of diffusing knowledge there was early established the bureau of international exchanges, originally intended simply for the proper distribution of the Smithsonian's publications, but which gradually assumed very wide proportions, becoming no less than an arrangement with learned societies throughout the world to reciprocally carry free publications of learned societies, or of individual scientific men, intended for gratuitous distribution. This system was afterwards taken up by various governments which, through treaties, bound themselves to exchange their own publications in the same way. Since the inaguration of this service, 5,000,000 pounds weight of books and pamphlets have been carried to every portion of America and of the world. The institution existing not only for America, in which it has over 8,000 correspondents, but for the world, has throughout Europe,

SPENCER FULLERTON BAIRD.

SECOND SECRETARY OF THE SMITHSONIAN INSTITUTION, 1878-1887.

Asia, Africa, and the islands of the sea, nearly 28,000 correspondents—more without the United States than within—justifying the words 'Per Orbem,' as the device on the Smithsonian seal.

Other work has been intrusted to the institution by the government, such as the Bureau of American Ethnology, for studies relating to the aborigines of this continent; the Astrophysical Observatory, which for ten years has been chiefly devoted to the enlargement of Newton's work on the spectrum, and the National Zoological Park. The establishment of the latter was intended primarily to preserve the vanishing races of mammals on the North American continent; but it has also assumed the general features of a zoological park, affording the naturalist the opportunity to study the habits of animals at close range, the painter the possibility of delineating them, and giving pleasure and instruction to hundreds of thousands of the American people.

SAMUEL PIERPONT LANGLEY.

THIRD SECRETARY OF THE SMITHSONIAN INSTITUTION, ELECTED IN 1887.

These two latter establishments are due to the initiative of the present secretary, Mr. S. P. Langley, elected in 1887; a physicist and astronomer, known for his researches on the sun, and more recently for his work in aerodynamics. While the fund has been increased of later years by a number of gifts and bequests, the most notable being that of Mr. Thomas G. Hodgkins of a sum somewhat over $200,000, its original capital, once relatively considerable, has now, in spite of these additions, grown relatively inconsiderable where there are now numerous universities having twenty times its private fund. It threatens now to be insufficient for the varied activities it has undertaken and is pursuing in every direction, among these the support of the higher knowledge by aiding investigators everywhere, which it does by providing apparatus for able investigators for their experiments, etc. Investigations in various countries have been stimulated by grants from the fund. It has been the past, as it is the present, policy of the institution to aid as freely as its means allowed, either by the grant of funds or the manufacture of special apparatus, novel investigations which have not always at the moment seemed of practical value to others, but which subsequently have in many instances justified its discrimination in their favor and have proved of great importance.

The growth of the institution has been great, but it has been more in activity than in mere bigness. The corner-stone was laid fifty years ago. In 1852 the entire staff, including even laborers, was twelve. In 1901 the institution and the bureaus under it employed sixty-four men of science and 277 other persons. These men of science in the institution represent very nearly all the general branches, and even the specialties to some extent of the natural and physical sciences, besides history and the learning of the ancients; and it may perhaps be said that the income of the institution (which, relatively to others, is not one tenth in 1901 what is was in 1851) has been forced to make good, by harder effort on the part of the few, what is done elsewhere in the government service by many.

The private income of the Smithsonian Institution is not quite $60,000, but it controls the disbursement of about $500,000 per annum appropriated by the government for the bureaus under its charge.

Certain other functions difficult to describe are still of prime importance. The Smithsonian is called on by the government to advise in many matters of science, more especially when these have an international aspect. Its help and advice are sought by many thousands of persons every year, learned societies, college professors, journalists, and magazine editors, and thousands of private individuals, seeking information, which is furnished whenever it can be done without too serious a drain, though naturally a percentage of the requests is unreasonable. It has cooperated with scientific societies of national scope, like the American Historical Association, and has stimulated the growth of a number of the Washington scientific societies, and it may be said to teem with other activities.

The regents control the policy of the institution, and the secretary is their executive officer. Since the beginning the regents have been selected from among the most distinguished men in public life and in the educational and scientific world. Their roll contains the names of the most distinguished American citizens for half a century.

An unwritten policy has grown up which, without instructions or regulations, has been of profound influence in the work. The Smithsonian Institution does not undertake work which any existing agency can or will do as well. It does not engage in controversies; it limits its work to observation and the diffusion of ascertained knowledge, not to speculation. It preserves an 'open mind' for all branches of knowledge and considers any phenomena which are the object of serious study within its purview. Its benefits are not confined to Washington nor to the United States, but as far as consistent are extended to all men.

GEORGE BROWN GOODE.
Assistant Secretary of the Smithsonian Institution, 1887-1896.

LOUIS AGASSIZ.
Regent of the Smithsonian Institution. 1863-1873.

ASA GRAY.
Regent of the Smithsonian Institution, 1874-88.

Its secretaries, assistant secretaries, and scientific officers have from the beginning—long before a classified service existed—been elected and appointed for merit, and for that alone. No person has ever been appointed on the scientific staff for any political reason or consideration.

It is impossible to look into the future. The Smithsonian Institution has a remarkable organization for the administration of funds for the promotion of science; yet amidst the great benefactions of the past quarter of a century relatively few have come to it. Its activities could be still further increased if it had greater means under its control, and the regents, because of the peculiarly independent position they hold, can be of great public service in suggesting the channel into which gifts for scientific purposes might be directed, even if they do not see their way clear to accepting such donations for the institution itself.

For the National Museum a great new building is a prime necessity. The museum has practically reached a point where it is physically impossible that it should grow under present conditions.

Secretary Langley has for several years past been urging upon the government the dispatch of several expeditions for capturing the species of large mammals so rapidly being destroyed in the United States and Alaska; but even without this, the National Zoological Park, with its relationships to the other great national parks, is destined to be one of the great collections of the world.

The Bureau of American Ethnology, which since its organization has devoted itself to the aborigines of this continent, may have new work to do in Porto Rico and in Hawaii.

Among still other activities, of which there is now but a premonition, a National Gallery of Art (provided for by Congress in the original charter) may be alluded to.

The past of the Smithsonian Institution is secure, its present is known to all men, and it looks forward to the future in the belief that it will worthily continue under whatever changing conditions to 'increase and diffuse knowledge among men.'

# RECENT JEWISH IMMIGRATION TO THE UNITED STATES.

BY ROGER MITCHELL,
NEW YORK CITY.

FROM a stretch of territory of irregular breadth, and extending from the Baltic Sea to the Levant, there are now coming here in considerable numbers as immigrants a people of unmistakable identity of origin and differentiated from the other inhabitants of the districts whence they come not only by physical appearance, but by the possession of distinctive customs, traits of character and a language of their own. Even though the purity of their blood may be questioned, they stand as the modern representatives of one branch of the ancient Hebrew race. Their language is composite like English, and also like English it has a Germanic basis whose old inflections have been largely lost and to which words and suffixes of other origin, mainly Hebrew and Polish, have been added. This language is invariably expressed in Hebrew characters and read from right to left. Although occasionally efforts are made in certain quarters to disparage its claims to independent recognition, it is to be noted that it has served since ancient times as the medium of a literature, both meritorious and extensive, and is spoken whether in Riga or Constantinople with as little variation as may be found in the case of spoken English within the limits of the United States. In this language, solely by their own efforts, those who use it have lowered the illiteracy among the immigrant class to twenty per cent. while their Slavic neighbors, in spite of some public provision for instruction, show an illiteracy of about forty per cent.

All the people of whom Yiddish is the mother tongue are given special recognition in our Immigration Bureau's classification of arriving immigrants under the term 'Hebrews.' The people thus designated do not constitute the only branch of the Hebrew race in the region above mentioned, nor is Yiddish the mother-tongue of them all, but where the modern Hebrew fails to show this distinctive tongue and has become so merged with the nation in which he lives as to be indistinguishable except by pedigree or religious creed, he is classified with the immigrants of the nationality he has assumed.

By thus removing this one element of so distinctly a national character, not only is a means furnished for differentiating the other national elements included within the same territorial limits, but there is also brought out in stronger relief a racial migration of essentially modern character, due to exceptional influences and one that will go down in history as among the most important in the annals of the Hebrew race.

Jews have been represented among the arrivals to this country since early colonial times. They appeared in considerable numbers as an accompaniment and sequel of our German immigration and were then derived largely from the German Polish provinces, but now the Jewish as well as the Polish immigration from these provinces has practically ceased. The Hungarian Jewish immigrant has likewise disappeared.

The immigration of the Yiddish-speaking Hebrew in the shape of an extensive exodus dates back scarcely twenty years, during which time probably not far from a million have come to this country from the Russian Empire, Galicia and Roumania, not as returning travelers or temporary sojourners, but for the most part as a new and permanent increment to our population.

An important factor in the causation of this movement is to be found in the acute phase which anti-Jewish feeling had assumed in eastern Europe twenty years ago. About 1880 widespread outbreaks of popular fury against the Jews were occurring in Russia. These disorders were followed by attempts on the part of the Russian government to enforce existing though neglected laws relative to the privileges of these people within the empire and to devise new measures for allaying popular clamor and complaint.

The unexaggerated accounts of the violence, robbery and brutality to which the Jews were being subjected by the Russian populace, the tenor of the Russian laws and the harshness with which they were enforced attracted foreign attention to the unfortunate condition of these people and opened to them a refuge in more western countries where the Jew had not been unfavorably known or where, by a similar violent process, he had been eliminated as an important economic factor centuries before.

Exceptional obstacles stood in the way of their emigration. Advance toward the east was forbidden by Russia and the police laws of the continental countries toward the west made a permanent refuge in this direction out of the question. The class to whom emigration would appeal lacked the resources for joining in distant colonial movements as the Germans and Scandinavians had done, and, unlike the Italians, Slovaks and Poles, these Jews were unprepared to supply the sort of labor for which a demand existed in other lands.

Foreign sympathy and organized charitable aid furnished the chief means of overcoming their inertia and starting the stream of migration to England and America. Prominently associated with the earlier aspect of this movement was a Jewish Colonization Association, which had at its disposal a fund of $50,000,000, a donation of the late Baron de Hirsch, but so far as the United States is concerned the new arrivals found in various vocations a sufficient degree of success to establish the immigration on a prepaid ticket basis on which it still continues.

The disabilities imposed upon the Jews in eastern Europe and the events associated with the Russian emigration are wont to be referred to as religious persecution. Tales of the use of the blood of christian children in religious rites and of stolen holy wafers punctured with a knife give a decidedly religious aspect to certain local outbreaks of violence. But the Russian church and the Russian people lack the proselyting spirit so characteristic of western people of whatever faith. While intolerant of dissenting sects from his own church 'because they invent their religions out of their own heads,' the Russian is inclined to respect the diverse religions of alien races as 'received from God.' Neither the Lutheran German nor the Mohammedan Tartar complains of religious persecution. In the case of the Jews, however, the matter of religious faith serves in Russia, Austria and Roumania as it has served in other lands to intensify a deep-seated feeling of popular resentment toward a race alien in speech and customs and closely identified with economic conditions that are commonly regarded as prejudicial to the common good; and it is not in the mere chronicle of clerical invective, political discrimination, violence and murder that the cause of this immigration and the explanation of its character are to be found, but in the economic history of a land where for centuries society was divisible into three classes, nobles, Jews and peasants.

Jews are known to have existed in Hungary and Roumania since Roman times, and within the present limits of Russia at a date almost as remote. But those emigrating to-day owe their presence there to much later migrations, both voluntary and involuntary, from more western Europe to Polish territory. Whenever the political condition of the western states of Medieval Europe became somewhat stable the expulsion of the Jews was almost sure to follow, and the refugees always tended eastward, finding more favorable conditions in those states whose political turmoil and continual squabbles gave little time for the consideration of internal affairs.

Poland offered such favorable conditions long after more western Europe had quieted down. Here the ancient Jewish element was obscured by continual Jewish immigration from the west, of which the wholesale migration from Bohemia near the close of the eleventh century furnishes the first notable example. Later in the fourteenth century this movement was further stimulated by the historical privileges secured for the Jews through the influence of Esther of Opoeno, the Jewess favorite of Kasimir the Great. It is here also that the conception of the civil status of the Jew under Medieval Roman law received its fullest development, determining in a great measure the part which the Jew has played in the economic history of eastern Europe and still surviving as an important factor in the Jewish problem there to-day.

In the Germanic Roman Empire of the middle ages civil rights in a christian state were only for the orthodox Christian. An infidel or a heretic was an anomaly that was not supposed to exist. But, owing to their connection with the Roman empire and the relation of their faith to christianity, the Jews and the Jewish worship received special recognition and were tolerated within certain prescribed limits. In theory the Jews were regarded as being under the personal protection of the king, who accorded them their privileges by virtue of his being the legitimate successor and representative of the Emperor Titus.

In accordance with this status the Jews spread over the Polish kingdom as an alien nation, having a complete organization, a central authority, a system of jurisprudence and a language of their own, owing but a qualified allegiance to Poland and receiving their privileges and the laws determining their relations with the Polish people through bargains with the Polish king.

Moreover, as individuals they brought into eastern Europe, among a people not yet emerged from barbarism, intellects sharpened by centuries of mental training, habits and customs which had stood the test of two thousand years of civilization, and arts for which their race has been famous since the days of Jacob. Tales of their persecution, mingled with the clamoring and complaints of the Poles, are early in evidence. It is needless to undertake a recital of the results that have followed, for they have been no different from what might be imagined and, though superficially the story is one of racial prejudice and religious persecution, the underlying economic problem is always discernible.

In the meantime the Jews have shared the political vicissitudes of the Polish and Lithuanian kingdom, their ancient civil status has been modified, their former privileges abridged or readjusted and repeated attempts have been made to limit their opportunities for coming into competition with the thriftless slow-witted Slav; yet at the end of the nineteenth century we find the Russian government still claiming that the Jews prosper, like our trusts, to the detriment of the country, and that also, like our trusts, they can not be made amenable to existing laws. An imperial circular directed to local officials after the disorders of 1882 reads as follows:

The proceedings at the trial of those charged with rioting and other evidences bear witness to the fact that the main cause of those movements and riots, to which the Russians as a nation are strangers, was but a commercial one, and is as follows:

During the last twenty years the Jews have gradually possessed themselves of not only every trade and business in all its branches, but also of a great part of the land by buying and farming it. With few exceptions they have as a body devoted their attention, not to enriching or benefiting the country, but to defrauding by their wiles its inhabitants, and particularly its poor people. This conduct of theirs has called forth protests on the part of the people, as manifested in acts of violence and robbery. The government, while, on the one hand doing its best to put down the disturbances and to deliver the Jews from oppression and slaughter, have also, on the other hand, thought it a matter of urgency and justice to adopt stringent measures in order to put an end to the oppression practised by the Jews and to free the country from their malpractices which were, as is shown, the cause of the agitation. With this in view, it has appointed a commission (in all towns inhabited by Jews) whose duty it is to inquire into the following matters:

I. What are the trades of the Jews injurious to the inhabitants of the place?

II. What makes it impracticable to put into force the former laws limiting the rights of the Jews in the matter of buying and farming land, the trade in intoxicants and usury?

III. How can these laws be altered so that they shall no longer be enabled to evade them, or what new laws are required to stop their pernicious conduct in business?

Give additional information on:

(*a*) Usury practised by Jews in their dealings.

(*b*) Number of public houses kept by Jews in their own names or in that of a Christian.

(*c*) Number of persons in service with Jews or under their control.

(*d*) The extent (acreage) of the land in their possession by buying or farming.

(*e*) Number of Jewish agriculturists.

Each line of inquiry directed therein had reference to some condition which had been a specific source of trouble. To take one instance which concerned the matter of land tenure, one of the most perplexing problems with which Russia, with its agricultural population, is called on to deal. The fondness of the Pole and Russian for drink served to make the liquor business particularly lucrative, and the Jewish liquor dealer utilized it as a means of involving the peasant in debt, and of finally securing from him the possession of his property rights; and where there was an annual assignment of communal lands the dealer with an eye to his own income saw that his best customers got the most productive parcels.

From old Poland the Jews spread north, east and south. In 1880 they were found to have penetrated the prohibited Russian territory to the east. In southern Russia they have added another failure to the efforts of their race to succeed as agriculturists. A considerable migration found its way to Roumania, and to a lesser extent to the Turkish empire. Since the western migration began numbers have gone into Palestine, though not always to remain, and the resources of the Baron de Hirsch fund have been used liberally in efforts to encourage and sustain a migration to South America, but to judge from the reports of the colonists who may be found coming to the United States by every South American ship, the movement has not yet proved a success.

The migration to Roumania went to increase an existing and practically Roumanized Jewish population of Spagnuoli and more ancient Hebrew stock and served to revive troubles that were believed to be past. At the bottom of the present anti-Jewish agitation in Roumania is an economic problem similar to that in Russia, likewise aggravated by a more or less improvident and shiftless indigenous population, but made still worse by the fact that the bearing of the Jew on the economic ills of the country has become a sort of political issue. Complicating the situation are also certain other elements entirely wanting in Russia.

Roumanian territory in the past has constituted a barrier to westward advance of the Mohammedan Turk, and the keynote of its history is resistance to racial religious aggression. As a dependency of Turkey the treaties and conventions which have determined its autonomy have repeatedly emphasized and affirmed a principle of religious inequality, the propriety of withholding full civil rights from a person of non-christian faith and of making a distinction between nationality and citizenship.

When, therefore, the powers in 1878 recognized the independence of Roumania, they overturned all local precedents in prescribing the principle of religious equality within the new kingdom. Subsequent events proved unfavorable to the popular reception of such a revolutionary idea. Stimulated by anti-Jewish agitation in adjoining foreign countries, an abnormal Jewish immigration poured into Roumania, and the alarm and resentment which this movement caused has been intensified by the new national spirit which independence has awakened among the Roumanians themselves.

Still regarded in accordance with old ideas as aliens whose rights were largely a matter for legislative action, the Jews have been deprived even of privileges which they formerly enjoyed, as have German settlers, Italian workmen, and other foreigners as well.

But to pass from the antecedents of our Jewish immigrants to the immigrants themselves. Except to some extent from portions of Austria and Roumania, they present little evidence of a state of prosperity that would be believed to be sufficient to excite the envy of the Slavic or Roumanian peasant. In general appearance and demeanor, as well as in the degree of their physical deterioration, they are in the main what might be expected from their civil status and immediate environment in the particular locality whence they come. But, in spite of an unprepossessing exterior and apparent contentment in squalid surroundings, the consciousness and pride of belonging to a superior race is always active and personal ambition is seldom extinct. They and their children have given abundant evidence of the qualities which have won distinction for their race in so many fields. Among them may be found the same active and well-balanced minds and the same tendency to concentration of energy for the accomplishment of the task on hand. They have a nervous make-up that is not easily susceptible to the formation of habits of body or thought, and it would often appear that their mental processes were not of the western order, but, after all, the Hebrew is only a more or less modified Oriental still.

So also they seem to possess to a high degree the power of divesting from the bias of prejudice or self-gratification the conclusions by which a course of action is governed, and to be less inclined than western people to be influenced by precedent or convention in making use of visible means for reaching a desired end. Like the southern Italians, they have a reputation for parsimony, but whereas the Italian in stinting himself and his family feels satisfaction in the thought that he has added an infinitesimal amount to the fund that will lead to the accomplishment of some indefinite future object, the Russian Jew only looks on the increments to his assets, like an athlete's medals, as evidence of contests that have been won and as an incentive, not to further efforts to save, but to increase his capacity to gain. To carry the contrast still further, the Hebrew immigrant in the most unaccustomed and bewildering surroundings never abandons his efforts to think for himself, and if compelled to rely upon guidance he will be as likely to repose a limited amount of confidence in a gentile stranger as in an unknown Jew. Instead of settling personal differences 'out of court' like the Italian, he is constantly in litigation, for he can not resist the temptation to utilize the obvious imperfections of our system of jurisprudence as a means of serving some personal end.

By far the majority of these immigrants have prospered. While still represented in the vocations with which they are commonly associated in the public mind, and still exhibiting a predilection for commercial life, they or their children are also to be found in nearly every trade and profession, and are coming into increasing prominence in connection with those positions in the public service which are open to competitive examinations.

This immigration has also another side. The fact that it has been stimulated by pressure from behind rather than a demand in the industrial market here has tended not only to make it possible for the movement to override or evade our immigration laws but also to get beyond the control of the philanthropic organizations which have the best interests of the immigrants at heart.

The tendency of Hebrews to prosper diminishes as they congregate together, and, quite apart from the matter of civil disabilities, there is a proportion above which they are unable to thrive in any given city or town. These conditions have already been realized in certain localities here, and philanthropic effort which was once concerned principally in inducing emigration from unfavorable surroundings in Europe is now attempting to prevent and relieve the equally serious evils of congestion in localities to which it is tending. With reference to the situation in New York city the 27th Annual Report of the United Hebrew Charities (October, 1901) makes the statement 'that a condition of chronic poverty is developing in the Jewish community of New York that is appalling in its immensity.' It goes on to state that, of the applicants to that society for assistance during the year, 45 per cent., 'representing between 20,000 and 25,000 human beings, have been in the United States over five years; have been given the opportunities for economic and industrial improvement which this country affords, yet notwithstanding all this, have not managed to reach a position of economic independence.' It, furthermore, makes the estimate that 'from 75,000 to 100,000 members of the New York Jewish community are unable to supply themselves with the immediate necessaries of life, and who for this reason are dependent, in some form or other, upon the public purse.'

To a degree wholly unlooked for among Jews, the above-mentioned phase of the present Hebrew immigration is accompanied by a moral degradation which has, to some extent, been made familiar through recent events in local municipal politics.

As the report of the society above referred to stated in 1898, 'those who are familiar with the crowded section on the lower east side know that vices are beginning to spring up which heretofore have been strangers to the Jewish people.' Referring to the same conditions, it is asserted in the report for 1901 that 'the vice and crime, the irreligiousness, lack of self-restraint, indifference to social conventions, indulgence in the most degraded and perverted appetites are growing daily more pronounced and more offensive.'

There would seem to be a disposition to regard such moral deterioration as the result of the prevalent squalor and overcrowding, but it is to be noted that the conditions in which these people live in New York at the present day are superior to those to which most of the immigrants were accustomed before they came, and are much better than those which they find in our other large cities or in London. The squalor and overcrowding, though conspicuous because of the extent of the 'Ghetto,' is much less pronounced than in the Italian, Syrian or Greek quarters, and the household régime of the poorest Jews gains by comparison with the family life of other foreigners in the tenement districts.

Moral deterioration may be pointed out in the case of every foreign element that has come to this country, just as it may be among the country-bred youth of our own population who feel in new abodes loss of personal identity and exemption from former moral restraints. In the case of foreigners there is added also a loss of parental control through the greater facility with which children identify themselves with the language and customs of the new environment and by what passes for the process of 'becoming Americanized,' the younger Jews come to look with indifference and even contempt upon the precepts which have safeguarded their race through a troublous past.

After all, when it is considered that the Jews have been estimated as constituting one fourth of the population of Manhattan, it may be questioned whether evidence of moral degradation may not have attracted attention because it was unexpected rather than because it is unproportionally prevalent.

In a great measure the poverty to be found in the 'Ghetto' is due to disease or lack of physical strength. Jewish immigrants of a military age who could pass our army requirements for recruits are comparatively rare, while few of their fellow immigrants, the Poles, would fail to pass such a test. Among the Jews also, senile decay is pronounced at an age when the German, Englishman or Scandinavian is still in his physical and mental prime. Chronic disease is much more prevalent among the Hebrew than among the Slavic immigrants, and common among the former are diseases rarely if ever seen in the case of the latter. The mental standard of the Jewish immigration fails to offset its physical inferiority when brought into active competition with other elements of our cosmopolitan population. Physical breakdown comes sooner or later and the ravages of tuberculosis are in evidence to an extent that is quite at variance with old notions of racial insusceptibility to this disease. This state of affairs is further aggravated by the favorable expectation of life for the Jew, something quite distinct from the matter of health or capacity for work. Temperate habits and the religious factor in the conduct of ordinary matters of diet and life, as well as their absence from hazardous occupations, contribute to this result. An apparent longevity also results from the fact that infant mortality among them is exceedingly low. The centuries through which these people have been associated with the worst phases of civilized life have undoubtedly led to an inherited ability on the part of the children to exist in unfavorable surroundings and an increased power of resistance to certain diseases, but it is also to be noted that in the humblest Jewish household the first symptoms of acute illness will not be overlooked nor neglected, and that the sick child will receive the best available professional attention, together with such a degree of unremitting care and attention on the part of the family, as can seldom be realized among Gentiles of the same station in life.

# THE BEHAVIOUR OF BLIND ANIMALS.

By Professor WESLEY MILLS, M.A., M.D.,
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IN the course of years I have had the opportunity of observing a considerable number of animals totally blind in either one or both eyes and to these only shall I refer in this paper.

*Pigeons.*—All those observed, that were otherwise normal, have been blind on one side only. The defect does not seem to have resulted in any great inconvenience or disadvantage to the individual. Birds do not, it is likely, possess binocular vision, in the sense in which the term may be applied to many mammals; and in consequence of the defect, cutting off the field of vision on one side completely, the bird endeavors to make up for this by adaptive movements of the head, which it can bring about with a facility not possible to the mammal.

It also, through experience, becomes more alert than the average pigeon; nevertheless, when the struggle for existence becomes keen, as for example when a limited quantity of food is strewn about, it is shown to be plainly at a disadvantage, both in securing the food and in the bodily conflicts that are apt to arise between it and its competitors.

*White Rats.*—I have observed several white rats, some of which were blind in only one eye, others in both. The results were in some respects very different from what might have been expected, and in this the difference between the bird and the rabbit, on the one hand, and the rat, on the other, was striking.

Even in the case of total blindness, the rat is not handicapped as one might suppose must be the case. In a very few days the rat blind in only one eye seems to ordinary observation to be in no appreciable degree worse off than his fellows. In a short time the specimen, totally blind, moves about so well that one would need to look carefully to be assured that he gets no assistance from the visual sense. But in his case there are times when it is evident that he is handicapped. In exploring new surroundings he proceeds with special caution, stretching out his neck, sometimes resting on his hind legs, more frequently elevating his fore parts and sniffing in an unusual way, showing an extreme care and plainly making use of his acquired greater facility, or perhaps one should say, his accustomed and habitual greater use of senses that normally are not required to function to such a marked degree.

He is also somewhat more timid and retreats in the way rats do toward their place of exit, with greater readiness. He is of course more at the mercy of his enemies, and yet not to the degree one might have supposed on account of his greater caution as well as the fact that his senses of touch and smell make up so fully for the lack of sight. It must be borne in mind that the olfactory tracts of the central nervous system in the rat are highly developed and their association-paths numerous, so that in an eminent degree the rodent, and especially the rat, is worked, so to speak, as an entire mechanism largely through the reflex paths of smell.

One of the unexpected results of sudden blindness in the case of white rats, whether affecting one or both eyes, was a most marked alteration in disposition. Rats that were perfectly tame became at once ferocious; it was unsafe any longer to attempt to handle them as formerly, or to remove anything from their cage, for in an instant they seemed aware of the approach of one's hand and were not only ready but able to pounce upon it at once; even metal forceps were seized by the teeth. After a considerable period in a rat blind in both eyes this ferocity disappeared, but not so, or to but a slight extent, in those lacking the power of vision on only one side.

In our experience in the breeding of white rats, it is rare for the female to devour her young, but invariably have those blind white rats killed and eaten to a greater or less extent every litter they have had, though placed under circumstances exactly similar to those of the intact rats.

*Rabbits.*—My opportunities to observe this species of rodent when blindness was found on one or both sides, has been almost as good as in the case of the rat. The differences noted in the animals is considerable. A rabbit totally blind behaves in general much like a rat similarly defective, but he shows less tendency on occasion to retreat towards his place of safety, is less alert and apparently less prepared to meet emergencies. But the readiness with which he manages to avoid obstacles in his path is striking. He also, like the rat, stretches out his neck, rises sometimes on his hind legs, but more frequently raises the fore parts of his body into the air, all with the obvious purpose of exploring the nature of his environment to a degree and with a frequency not witnessed in the normal rabbit. Such an animal is, however, more likely to fall under the power of his enemies than is the rat, though so long as food is plenty near his burrow the wild animal would no doubt develop that caution and use his other senses to such an extent that he would generally escape; but that he would in the long run fall a prey to some wily fox seems more than probable.

I have noticed no change in disposition in the case of the rabbit akin to that in the rat and none of the blind specimens has had young.

Neither the rabbits nor the rats ever make the mistake of walking off a place elevated above *terra firma*. As I have elsewhere pointed out, this tendency seems to be a fundamental instinct manifested by even the youngest mammals and is evidently of vital importance for their preservation.

*Cat.*—The cat on which I am able to report was not in good condition after she became suddenly blind in both eyes, and lived but a few days, or I should have been able to note more fully whether her psychic state had been modified by experience.

When put down on the floor she moved about in a slow and apparently cautious way, and, though plainly perfectly blind, when she came near objects she touched them only slightly. In this the whiskers evidently served a good purpose, as was also observed in the rodents. When one made a noise on the floor as by tramping with the feet, puss invariably moved towards the sound, and so perfectly that by walking about one could cause her to describe complicated figures, from which and other observations I conclude that she had become a mere reflex mechanism worked by the most prominent stimuli of the moment from the external world. When she came to a wall, and especially a corner, she stopped and sometimes lay down—showing that the 'puss in the corner' tendency has a deep foundation, for I am inclined to believe that this animal was not conscious in the true sense of the term. This cat had become blind owing to a hemorrhage into the optic thalamus of the brain and lived but a few days afterwards.

I have not reported any other cases in this paper in which there were brain lesions, the discussion being too complicated for my present purpose. That the cat was guided purely reflexly by sounds was evident from the fact that when one stood on a table and tramped as before, puss underneath the table was soon brought to a standstill just below the source of the sounds. Such a remarkable case of guidance reflexly by the ear I had not seen before, and it proved very instructive to me.

*Dog.*—Of the blind dogs I have observed I shall refer to but one. He was a cross-bred skye terrier and formed one of a litter kept in a room in the college basement. He became totally blind when between two and three months old. After this he soon changed greatly in disposition; he, like the rats, seemed to revert to a sort of feral condition. He would on the entrance of any one into the room hide, and when approached would bite savagely at the extended hand; in fact, in order to catch him it was necessary to throw a sack or some such object over him. He had gnawed away the legs on which his cage stood and to which he was chained for a time.

This dog seemed to be at least equal in intelligence to the other members of the litter, his companions. So far as the objects in the room that had a stable situation were concerned, he was perfectly oriented, but if a new object was laid down he would run against it and then attack it as savagely as he would one of his fellows who came in his way.

If any stranger came to the door of the room he seemed to know instantly and would bark fiercely, but he never did this when the regular attendant entered, however silently he approached, being guided probably largely, but by no means wholly, by the sense of smell. He was by far more alert than any of his companions and seemed to be put into a state of high tension by the slightest stimulus.

This dog had a ravenous appetite, and when the vessel containing food for all the dogs of this litter was put down he was generally the first to reach it, though at the moment he might possibly be in the most distant part of the room, and certainly he did not come off second best in the struggle.

He was so like a wild animal, was of so bad a temper, and altogether so undesirable a creature, I thought it best to chloroform him at the end of a few weeks.

# PREVENTIVE MEDICINE.*

By General GEORGE M. STERNBERG, U.S.A.

FROM the earliest times physicians have taken the lead in all that relates to the prevention of disease. In times of epidemic their advice is sought by afflicted communities and they have been instrumental in securing most of the legislation which has been enacted with a view to preventing or restricting the prevalence of infectious diseases. As members of boards of health, they are largely responsible for the enactment and execution of proper sanitary legislation, and as medical officers of the Army and Navy, they are charged with the duty of guarding the health of soldiers and sailors enlisted in the service of their country.

While the principal function of a physician engaged in civil practice is to give proper advice and treatment to the sick, he is constantly called upon to point out the most effectual methods of preventing the extension of infectious diseases in the homes of his patients; to indicate the proper diet and mode of life to be followed by convalescents and other members of families which he regularly attends, etc. All this he does cheerfully, although he rarely receives any compensation for advice of this kind and his professional income is diminished in direct proportion to his success in the prevention of disease among the families constituting his clientele.

The compensation for voluntary work in public or domestic sanitation is to be found in the consciousness of good accomplished and of high and humane motives worthy of the profession to which we belong, and the willingness to perform such voluntary service is one of the most noteworthy distinctions between the educated and honorable physician and the ignorant and mercenary quacks who prey upon the community with no other object in view than that of gain. The beneficent results of preventive medicine are seen in the greatly reduced mortality rates in civilized countries generally, and especially in the fact that certain pestilential maladies which formerly prevailed as wide-spread and devastating epidemics, causing the death of hundreds of thousands of human beings annually, have to a great extent lost their deadly potency as a result of the progress of our knowledge with reference to their etiology and the best methods of combating them.

* Address introductory to the course in preventive medicine, given on January 12, 1903, at the opening of the Washington Post-graduate Medical School.

Smallpox no longer claims its victims in any considerable numbers except in communities where vaccination is neglected; cholera has been excluded from our country during the last two widespread epidemics in Europe and its ravages have been greatly restricted in all civilized countries into which it has been introduced; the deadly plague of the seventeenth and eighteenth centuries is no longer known in Europe and the prevalence of typhus—so-called spotted or 'ship fever'—has been greatly limited. Typhoid fever, tuberculosis and diphtheria are still with us and claim many victims, but we know the specific cause of each of these diseases; we know where to find the bacteria that cause them and the channels by which they gain access to the human body; and we know how to destroy them by disinfecting agents.

The mortality from tuberculosis is constantly diminishing in our large cities and the complete destruction of the infectious sputa of those suffering from pulmonary tuberculosis would no doubt go a long way towards the extermination of this fatal disease.

Perhaps the triumphs of preventive medicine can not be better illustrated than by a brief historical account of the prevalence of bubonic plague during the past three or four centuries. It can scarcely be doubted that the 'black death' of the fourteenth century was the same disease which subsequently prevailed in Europe under the name of 'the plague'—now more generally spoken of as 'bubonic plague.' While modern methods of diagnosis have enabled us to recognize typhoid fever, typhus fever, relapsing fever and bubonic plague as distinct diseases, it must be remembered that up to the end of the fifteenth century no such differentiation had been made and the term 'pest' was applied to any fatal malady which prevailed as an epidemic, and no doubt in some instances included smallpox, which prior to the discovery of Jenner contributed largely to the general mortality of the population of Europe.

Bubonic plague continued to prevail in various parts of Europe at the end of the sixteenth century, and early in the seventeenth century (1603) an epidemic occurred in London which caused the death of 38,000 of its inhabitants. It continued to prevail in this city and in various parts of England, Holland and Germany and six years later caused a mortality of 11,785 in the city of London. During the year 1603 a most disastrous epidemic occurred in Egypt, which is said to have caused a mortality of at least a million. After an interval of ten or fifteen years, during which there was a marked diminution in the number of cases and the extent of its distribution in European countries, it again obtained wide prevalence during the year 1620 and subsequently, especially in Germany, Holland and England. The epidemic in the city of London in 1625 caused a mortality of more than 35,000. In 1630 a severe epidemic occurred in Milan, and in 1636 London again suffered a mortality of over 10,000, while the disease continued to claim numerous victims in other parts of England and on the continent. Later in the century (1656) some of the Italian cities suffered devastating epidemics. The mortality in the city of Naples was in the neighborhood of 300,000, in Genoa 60,000, in Rome 14,000. The smaller mortality in the last-named city has been ascribed to the sanitary measures instituted by Cardinal Gastaldi. Up to this time prayers, processionals, the firing of cannons, etc., had been the chief reliance for the arrest of pestilence, with what success is shown by the brief historical review thus far presented. But this enlightened prelate inaugurated a method of combating the plague and other infectious maladies which, with increasing knowledge and experience in the use of scientific preventive measures, has given us the mastery of these pestilential diseases, and has been the principal factor in the extinction of bubonic plague from the civilized countries of Europe.

But it was long after the time of Cardinal Gastaldi before sanitary science was established upon a scientific basis and had acquired the confidence of the educated classes. Indeed, the golden age of preventive medicine has but recently had its dawn, and sanitarians at the present day often encounter great difficulty in convincing legislators and the public generally of the importance of the measures which have been proved to be adequate, when properly carried out, for the prevention of this and other infectious maladies.

We have now arrived in our review at the period of the 'great plague cf London.' For some years this city had been almost if not entirely free from the scourge, but in the spring of 1665 it again appeared and within a few months caused a mortality of 68,596 in a population estimated at 460,000. This, however, does not fairly represent the percentage of mortality among those exposed, for a large proportion of the population flew from the city to escape infection.

Upon the continent the disease prevailed extensively, especially in Austria, Hungary and Germany. The epidemic in Vienna in 1679 caused a mortality of 76,000. In 1681 the city of Prague lost 83,000 of its inhabitants. During the last quarter of this century the disease disappeared from some of the principal countries of Europe. According to Hirsch it disappeared from England in 1679, from France in 1668, from Holland about the same time, from Germany in 1683 and from Spain in 1681. In Italy it continued to prevail to some extent until the end of the century.

At the beginning of the eighteenth century bubonic plague prevailed in Constantinople and at various points along the Danube; from here it extended in 1704 to Poland, and soon after to Silesia, Lithuania, Germany and the Scandinavian countries. The mortality in Stockholm was about 40,000. The disease also extended westward from Constantinople through Austria and Bohemia.

In 1720 Marseilles suffered a severe epidemic, probably as a result of the introduction of cases on a ship from Leghorn. The mortality was estimated as being between 40,000 and 60,000. From Marseilles as a center it spread through the province of Provence, but did not invade other parts of France. In 1743 a severe outbreak occurred on the island of Sicily. A destructive but brief epidemic, which is estimated to have caused a mortality of 300,000, occurred during the years 1770 and 1771 in Moldavia, Wallachia, Transylvania, Hungary and Poland. At the same time the disease prevailed in Russia, and in 1771 caused the death of about one fourth of the population of the city of Moscow.

Early in the nineteenth century (1802) bubonic plague appeared at Constantinople and in Armenia. It had previously prevailed in the Caucasus, from which province it extended into Russia. In 1808 to 1813 it extended from Constantinople to Odessa, to Smyrna and to various localities in Transylvania. It also prevailed about the same time in Bosnia and Dalmatia. In 1812 to 1814 it prevailed in Egypt, and, as usual, was conveyed from there to European countries. During the same year it prevailed extensively in Moldavia, Wallachia, and Bessarabia. In 1831 it again prevailed as an epidemic in Constantinople and various parts of Roumelia, and again it appeared in Dalmatia in 1840 and in Constantinople in 1841. Egypt, which for centuries had been the principal focus from which plague had been introduced into Europe, continued to suffer from the disease until 1845 when it disappeared from that country.

The last appearance of oriental plague in Europe, until its recent introduction into Portugal, was the outbreak on the banks of the Volga in 1878–79. The disease had previously prevailed in a mild form in the vicinity of Astrakhan and was probably introduced from that locality. An interesting fact in connection with this epidemic is that in Astrakhan the disease was so mild that no deaths occurred, and that the earlier cases on the right bank of the Volga were of the same mild form, but that the disease there increased rapidly in severity and soon became so malignant that scarcely any of those attacked recovered. This is to some extent the history of epidemics elsewhere, and not only of plague, but of other infectious diseases, such as typhus fever, cholera and yellow fever. In all of these diseases the outset of an epidemic may be characterized by cases so mild in character that they are not recognized, and during the progress of the epidemic many such cases may continue to occur. These cases are evidently especially dangerous as regards the propagation of the disease, for when they are not recognized no restrictions are placed upon the infected individuals, although they may be sowing the germs broadcast.

The termination of an epidemic in the pre-sanitary period depended to a considerable extent upon the fact that those who suffered a mild attack acquired thereby an immunity; and that when the more susceptible individuals in a community had succumbed to the prevailing disease there was a necessary termination of the epidemic for want of material.

Another factor which no doubt has an important bearing upon the termination of epidemics is a change in the virulence of the germ as a result of various natural agencies. Time will not permit me to discuss this subject in its scientific and practical aspects, but the general fact may be stated that all known disease germs may vary greatly in their pathogenic virulence, and that in every infectious disease mild cases may occur, not only because of the slight susceptibility of the individual, but also because of the 'attenuated' virulence of the specific germ. In the eighteenth century, the beginning of sanitary science, isolation of the sick and seaboard quarantines came to the aid of these natural agencies, and did much in the way of arresting the progress of this pestilential disease. At the present day these measures, together with disinfection by heat or chemical agents, are relied upon by sanitarians with great confidence as being entirely adequate for the exclusion of this disease or for stamping it out if it should effect a lodgment in localities where an enlightened public sentiment permits the thorough execution of these preventive measures; but when the disease prevails among an ignorant population which strenuously objects to the carrying out of these measures, the contest between the sanitary officer and the deadly germ is an unequal one, and the stamping out of an epidemic becomes a task of great magnitude, if not entirely hopeless. This is illustrated by the experience of the English in their encounter with bubonic plague in their Indian Empire.

Plague seemed to be almost a thing of the past and no longer gave any uneasiness in the countries of Europe which had formerly suffered from its ravages, when in February, 1894, it made its appearance in the city of Canton, China, and three months later in Hong Kong. The disease is known to have been epidemic in the province of Yunnan, which is about 900 miles distant from Canton, since the year 1873, but it attracted little attention until the lives of Europeans living in the city of Hong Kong were threatened by the outbreak of an epidemic among the Chinese residents of that place. Many thousands of deaths occurred in Canton during the three months which elapsed after its introduction to that city before it effected a lodgment in Hong Kong.

Fortunately this outbreak gave the opportunity for competent bacteriologists to make scientific investigations relating to the specific cause of this scourge of the human race and to the demonstration that it is due to a minute bacillus. This discovery was first made by the

Japanese bacteriologist, Kitasato, who had received his training in the laboratory of the famous Professor Robert Koch, of Berlin. This discovery was made in the month of June, 1894, in one of the hospitals established by the English officials in Hong Kong. About the same time the discovery was made, independently, by the French bacteriologist, Yersin. From this time the study of the plague has been established upon a scientific basis and very material additions have been made to our knowledge with reference to the prevention and treatment of the disease.

That the plague bacillus has not lost any of its original virulence is amply demonstrated by the high death-rate among those attacked, and we are justified in ascribing its restricted prevalence to the general improvement in sanitary conditions in civilized countries and to the well-directed efforts of public health officers in the various localities to which it has been introduced during recent years. In the Philippine Islands, where it prevailed to a considerable extent when our troops first took possession of the City of Manila and where the conditions among the natives are extremely favorable for its extension, it has been kept within reasonable bounds and, indeed, the latest reports indicate that it has been practically exterminated by the persistent efforts of the medical officers of our army, charged with the duty of protecting the public health in those Islands.

The monthly report of the Board of Health for the city of Manila for September, 1902, the last at hand, records but one death from plague during that month. During the same period there were ten deaths from typhoid fever, thirty-five deaths from dysentery and seventy-six deaths from 'the great white plague,' pulmonary tuberculosis.

Bubonic plague, cholera and typhoid fever have long been classed as 'filth diseases,' and in a certain sense this is correct, although we now know that the germs of these diseases not only are not generated by filth, but do not multiply in accumulations of filth. They are present, however, in the alvine discharges of the sick, and when this kind of filth is exposed in the vicinity of human habitations or gains access to wells or streams, the water of which is used for drinking, the germs are likely to be conveyed to the alimentary canals of susceptible individuals, and thus the disease is propagated. Until quite recently the attention of sanitarians was so firmly fixed upon the demonstrated transmission of cholera and typhoid fever through the agency of contaminated water or milk that certain other modes of transmission were overlooked, or at least underrated. I refer to the transmission by insects, or as dust by currents of air. I have for many years insisted upon the part played by flies as carriers of infectious material from moist masses of excreta from cases of cholera and typhoid fever. There is good reason to believe that the bacillus of bubonic plague may be transmitted in the same way. The cholera spirillum is quickly killed by desiccation and this disease is probably very rarely, if ever, communicated through the medium of dust. But the germs of typhoid fever and of bubonic plague are more resistant and, without doubt, under certain circumstances, these diseases are extensively propagated by means of dust containing desiccated excreta. There is a good reason to believe that in several of our camps, during the Spanish-American War, this was an important factor in the etiology of typhoid fever epidemics. The average mortality from typhoid fever in our regular army since the Civil War has been, for the first decade (1868–1877) 95 per 100,000 of mean strength; for the second decade (1878–1887) 108 per 100,000, for the third decade (1888–97) 55 per 100,000. This latter rate compares favorably with that of many of our principal cities; for example, it is exceeded by the typhoid death-rate of the city of Washington, which is 78.1 per 100,000 (average of 10 years, 1888–1897), by that of the city of Chicago, which is 64.4 per 100,000; by that of Pittsburgh, which is 88 per 100,000. As a result of insanitary conditions existing in the camps in which our troops were hastily assembled at the outset of the Spanish-American War, the typhoid death-rate in our army of volunteers and regulars during the year ending April 30, 1899, was more than 22 times as great as it had been in our regular army during the decade immediately preceding the war period. As compared with the Civil War, however, there was a decided improvement, the typhoid mortality for the first year of the Civil War having been 1,971 per 100,000 of mean strength and for the Spanish-American War 1,237 per 100,000.

Experience shows that new levies of troops are especially subject to typhoid fever and other infectious 'camp diseases,' not only because of lack of discipline and consequent difficulty in the enforcement of sanitary regulations, but also because the individual soldiers are very susceptible to infection, owing to their age, the abrupt change in their mode of life, the exposure and fatigue incident to camp life, and last, but not least, their own imprudence as regards eating, drinking, exercise, etc. In the absence of sewers or other adequate means of removing excreta, the camp site is likely to become infected by the discharges of unrecognized cases of typhoid and typhoid bacilli are carried by flies to the kitchens and mess-tents and deposited upon food, or as dust are directly deposited upon the mucous membranes of the respiratory passages of those living in the infected camp. That preventive medicine has still serious work before it is shown by the fact that according to the last census return there were 35,379 deaths from typhoid fever in the United States during the census year 1900. The increase in mortality over the number in 1890 (27,056) is out of proportion to the increase in population, notwithstanding the general improvement in the sanitary condition of towns and cities. This is no doubt due to the continued pollution of water supplies and to the extension of this infectious disease in rural districts. It is in fact now an endemic disease in nearly all parts of the United States.

According to the census report of 1900, there were 111,000 deaths from tuberculosis during the year 1900. This does not, however, include the deaths in certain states in which the vital statistics are incomplete or unreliable, and it is probable that there are at least 145,000 victims of the great white plague annually within the limits of the United States. The last census return in those states where registration was approximately correct, including a population of about 21,000,000 people, shows that 12 per cent. of all deaths resulted from pulmonary tuberculosis, 8.5 per cent. from pneumonia, 3 per cent. from typhoid fever and 3 per cent. from diphtheria and croup. These figures indicate to some extent the task which preventive medicine has still to accomplish.

A most interesting and notable example of the beneficent results following the practical application of sanitary measures based upon exact knowledge relating to the etiology of an infectious disease is afforded by the recent extinction of yellow fever in the city of Havana, which for many years had been the principal focus of infection in the West Indies, and the port from which it has been repeatedly carried to the seaport cities of the United States. According to the reports of the health officers in that city, there has not been a case of yellow fever in Havana for more than a year, and the extinction of the disease is ascribed entirely to the vigorous measures enforced to prevent its transmission by mosquitoes of the species proved by the researches of Reed and Carroll to be the immediate hosts of the yellow fever parasite and the active agents in the transmission of the disease from man to man. During the first sixty years of the past century, yellow fever prevailed almost annually in one or more of the southern seaports of the United States and not infrequently it extended its ravages to the interior towns in one or more of the southern states. So frequently did it prevail during the summer months in New Orleans and Charleston that the permanent residents of those cities commonly regarded it as a disease of the climate and a necessary evil which it was folly to attempt to combat by quarantine restrictions.

In the great epidemic of 1853, yellow fever prevailed extensively in the states of Florida, Alabama, Louisiana, Mississippi, Arkansas and Texas. The epidemic of 1867 was limited to the states of Louisiana and Texas. Those states again suffered severely in 1873 and the states of Florida, Alabama and Mississippi were also invaded. A still more extended and deadly epidemic occurred in 1878, causing a mortality of 15,934 out of a total number of cases exceeding 74,000. In this epidemic the disease followed the Mississippi River to the very suburbs of St. Louis, and the state of Tennessee suffered severely as well as the states south of it. The city of Memphis alone had a mortality from the disease of about 5,000. These repeated epidemics not only cost the lives of thousands of citizens and paralyzed business of all kinds during their prevalence, but apprehension with reference to the recurrence of the disease very materially interfered with the growth of many southern cities and retarded greatly the development of those portions of the country most liable to invasion. All this is now changed; public health officials are no longer filled with apprehension upon the approach of summer by the thought that any ship arriving from Havana may introduce the deadly pestilence to our shores; commerce is no longer subjected to the serious restrictions formerly considered necessary for the exclusion of the disease; and the public generally have been made aware that the fangs of this threatening monster have been drawn by the scientific demonstration of its mode of attack and the simple measures which have been proved to be effective in preventing its propagation. Until the recent demonstration of the transmission of yellow fever by mosquitoes, this disease was generally regarded as one of the filth diseases, although there were many facts opposed to this view. In the light of our present knowledge we can no longer class it with typhoid fever, cholera, bubonic plague and dysentery, in which diseases the germ is known to be present in the alvine discharges of the sick and which are, consequently, well named filth diseases.

We now see clearly, however, why in certain particulars relating to its etiology it resembles the malarial fevers. It is limited as regards its prevalence to comparatively warm latitudes or to the summer months in more temperate regions and is dependent, to a certain extent, upon rainfall or the proximity of standing water, because these conditions are necessary for the propagation of mosquitoes. As regards the filth diseases, properly so-called, no single agency is more important for their prevention than the use of properly constructed sewers for the reception of excreta and its removal from the vicinity of human habitations. Sewers had come into use and had the warm endorsement of sanitarians long before the discovery of the germs of the infectious maladies under discussion, and before it was positively known that the infectious agent in these diseases is contained in the discharges from the bowels. But now that we have an exact knowledge of the etiology of these diseases, the reason for the beneficent results attending the use of sewers, in connection with an ample and pure water supply, is apparent. It may be safely asserted that a city or town having a complete and satisfactory sewer system and a pure water supply is practically immune from epidemics of cholera or typhoid fever, provided, of course, that the sewers are used for the purpose for which they are intended, and that streets and back yards no longer serve as receptacles for filth, as was usual during the presanitary period even in great cities like London and Paris. The axiom 'tout a l'égout' now governs the practice not only in Paris, but wherever the fundamental principles of municipal sanitation are understood and sewers have been constructed. Unfortunately, the cost of sewer construction, the reluctance of tax-payers to part with their money and the ignorance or indifference of municipal authorities have conspired to prevent the accomplishment of this fundamental sanitary measure in very many towns in the United States, and our endemic plague—typhoid fever—continues to claim a large annual quota of victims in such localities. Even in the national capital our sewer system is incomplete and in many out-of-the-way places, especially in the densely populated alleys of the city, shallow box privies are in use as receptacles for human excreta and the typhoid fever rate, owing to this and other causes, is disgracefully high.

Mortality rates in towns and cities throughout the civilized world depend to a large extent upon the purity of the water-supply and the efficiency of the system of sewage disposal; and the constant improvement which is shown by the mortality statistics of England and other countries which have made the most progress in this direction is undoubtedly largely due to these two factors. This is well illustrated by the mortality statistics of armies. In the German army the annual death-rate in 1868 was 6.9 per thousand, a decade later it was 4.82, in 1888 it had fallen to 3.24 and in 1896 to 2.6. In our own army, the death-rate during the period of peace just prior to the Mexican War (1848) was about three and one half times as great as during the five years preceding our recent war with Spain, and since the year 1872 there has been a diminution of the death-rate of nearly forty per cent. In the British army at home stations the mortality rate during the decade ending in 1884 was 7.2 per thousand, in 1889 the rate had fallen to 4.57 and in 1897 to 3.42. In the Italian army there has been a gradual and progressive reduction from 13.3 per thousand in 1875 to 4.2 in 1897. The mortality in the French army was a little over 21 per thousand during the five years ending in 1825. In 1890 it had fallen to 5.81 per thousand.

According to the best estimates the average of human life in the sixteenth century was somewhat less than twenty years. At the present time it is more than twice as long and during the past twenty-five years the average duration of life has been lengthened about six years. During the first thirty-five years of the past century the vital statistics of the city of London showed a mortality of about 29 per thousand. At the present time the mortality in that great city has been reduced to from

17 to 19 per thousand. I will not burden you with further statistics, but will simply say that even more notable results have been obtained in many parts of the civilized world as a result of increased knowledge and improved methods for the prevention of infectious diseases and the general improvement in hygienic conditions.

The time at my disposal only permits of a brief general survey of the field which comes within the purview of the department of preventive medicine of the Washington Post-Graduate Medical School. It will be our aim during the course to give detailed information and practical laboratory instruction upon all the more important subjects connected with this branch of medicine. This will be apparent to those who have read our 'circular of information' with reference to the course of instruction. This includes personal and municipal hygiene, a practical knowledge of sanitary chemistry, including food adulterations and pathogenic bacteria, of animal parasites injurious to man, of preventive inoculations, of disinfection, of military and naval hygiene, of national and international quarantine, etc. Fortunately we have among our professors, experts upon all of these subjects and we believe that the city of Washington offers unequaled facilities for a comprehensive and scientific course of instruction in preventive medicine. Such a course as would seem best fitting for preparing graduates in medicine for the responsible duties of health officers in the towns and cities throughout the United States, and as is essential for medical officers in the various branches of the public service. But, while we have many special advantages for giving a comprehensive and practical course in the department of preventive medicine, it must not be thought that clinical medicine and surgery are to be neglected. On the contrary, we have ample advantages for clinical instruction in the various hospitals of the city and a corps of competent and experienced professors who are prepared to give practical instruction in all branches of medicine and surgery. Those physicians who enroll themselves as students in the Washington Post-Graduate Medical School and faithfully follow the course of instruction which is open to them, can not fail to return to their professional work with broader and more exact information on many subjects relating to scientific medicine, with increased skill in the diagnosis and treatment of disease and with greater confidence in the resources of the noble profession to which they have devoted their lives.

# A STATISTICAL STUDY OF EMINENT MEN.

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THE accounts of great men in biographies and histories belong to literature rather than to science. Modern science is either genetic or quantitative. It seeks to discover those uniformities which we call causes and to use that method of description which we call measurement. It is now time that great men should be studied as part of social evolution and by the methods of exact and statistical science.

History is only the last chapter of organic evolution, and both where similar causes are at work and where new factors have arisen, the parallel between social and organic evolution is instructive. While the Darwinian principle of natural selection as an explanation of the origin of species has an aspect which makes it almost as naïve as the doctrine of special creations, it has given an extraordinary stimulus to modern thought. Natural selection is no cause of the origin of species or of anything else, but the environment is the condition of the survival of species and of individuals. Evolution has progressed through the occurrence of variations sanctioned by the environment. We are, it is true, not only ignorant of the causes of variations, but even of their nature. We do not know whether one species has been derived from another by gradual variations in many individuals or by sudden jumps in a few. We do not know whether the type prescribes the individual, or whether the individual forms the type. Yet in spite of our ignorance not only of the causes but even of the nature of organic evolution the distinctions formulated by the naturalist are fruitful when applied to social evolution.

It is evident that there are two leading factors in producing a man and making him what he is—one the endowment given at birth, the other the environment into which he comes. The main lines are certainly laid down by heredity—a man is born a man and not an ape. A savage brought up in cultivated society will not only retain his dark skin, but is likely to have also the incoherent mind of his race. On the other hand, environment has at least an absolute veto. Had the infant Newton been cast among Hottentots he could have announced no laws of motion. But were those differences—small from the point of view of organism, great from the point of view of function—which distinguished Dante from his Florentine fellow townsmen innate or due to the circumstances of his life? Here the biological parallel may be serviceable. Are those variations which produce new species caused by the environment? Can life be regarded as the resultant of physical forces? Many zoologists and physiologists answer in the affirmative, but it appears rather that life develops not on account of, but in large measure in spite of, physical forces—these tend to the dissipation of energy, they are the causes of death rather than of life. So in like manner it seems that the environment would tend to reduce the great man to its level rather than to lift him above it—Dante wrote in spite of his surroundings, not on account of them. Still the environment counts for much. If the seed of the white pine is dropped among New England rocks it will grow into a small bush, if planted in the rich soil of the south it will become a great tree. We have the 'Divine Comedy' because Dante had 'the steep stairs and bitter bread' in place of Beatrice.

As the environment tends to reduce all things to its level, so heredity tends to maintain the type. Whence then the great man who brings something new into the world? Carlyle had the same heredity and the same initial environment as his brothers. Why should he write of heroes and become one, while they remained peasants? Why, we may ask the theory of organic evolution, should certain individuals of a species possess variations tending to greater complexity, which lay down the lines of evolution? Perhaps all we can say is that the question 'why' is more in place in the nursery than in the laboratory. Why heredity should maintain the type is as obscure as why new types should arise. If the world were a chaos, no questions would be asked, as it is a cosmos it must have a certain definite order. But if when we ask 'why' we really mean 'how,' then we have the plain way of science before us. We can investigate the stability and variability of the type, we can study the effects of the environment on the individual. We know perhaps in a general way that any great war will find the material at hand for the making of a Grant and a Lee, and, on the other hand, that a Shelley may be what he is in spite of heredity and environment. More exact knowledge can only come from an inductive study of facts.

As in organic evolution the effects of variations are less obscure than their causes, so in social evolution we can trace more easily the influence of great men than we can account for their origin. As we ascend the scale of animal life and human development the rôle of social tradition becomes increasingly potent. A new trait in a single individual among lower animals, even though it may be both useful and stable, can have but an infinitesimal effect in altering the species. In man a new advance made by a single individual becomes quickly the common property of all. Let fire be discovered and we have a trait that endows every one. Let the printing press be invented and each can speak with a thousand tongues. Let Dante see the ideal of romantic love and every boy and girl in Christendom has his life altered thereby. What we now are—as men—depends chiefly on social tradition; withhold it for a generation and we should revert to savagery and further. It is also true that social tradition sets the course of organic development. Individuals who are unfit for their social environment can not survive in it; those who possess variations, however slight, making adjustment to social conditions and social ideals more easy are more likely to survive and to transmit their traits. If we depended only on social tradition, progress would be limited by the extreme range of individual adaptations. But by the preservation of stable variations in the line of social evolution, we secure a new type from which new forward variations are more likely.

Whether great men really lay down the line of social evolution or only anticipate and hasten its necessary course is an unsolved question. Are great men, as Carlyle maintains, divinely inspired leaders, or are they, as Spencer tells us, necessary products of given physical and social conditions? If Dante had not set the ideal of romantic love, would it not have come from other sources? Did Darwin do more than express what was 'in the air' and hasten by a dozen years the necessary course of science? We can only answer such questions by an actual study of facts.

When we regard the noteworthy men that have appeared in the world, it is evident that they have but little in common. 'Some are born great, some achieve greatness, and some have greatness thrust upon them.' We have men of genius, great men and men merely eminent. Thus many a genius has been a 'mute inglorious Milton' lacking the character or the circumstance for the accomplishment of his task. Washington was scarcely a genius, but was a truly great man. Napoleon III. was neither a genius nor a great man, but was eminent to an unusual degree. But if we simply take those men who have most attracted the eyes and ears of the world, who have most set its tongues and printing presses in motion, we have a definite group. Beginning with this we can analyse and classify; we can study these individuals, their causes and their effects; we can regard them as types of a given age and race; we can use them to measure interests and tendencies.

For these purposes our first need is a definite list of the most eminent men, sufficiently large for statistical study.* The method I followed to discover the 1,000 men who are preeminent was this: I

* The statistics of this paper were presented to the American Psychological Association in December, 1894, and an abstract was published in *The Psychological Review* for March, 1895. It was read in its present form as a lecture before the Philosophical Club of Yale University in 1897.

took six biographical dictionaries or encyclopædias*—two English, two French, one German and one American and found the two thousand men (approximately) in each who were allowed the longest articles. In this way some 6,000 men were found. I then selected the men who appeared in the lists of at least three of the dictionaries, and from these (some 1,600) selected the thousand who were allowed the greatest average space, the value of the separate dictionaries being reduced to a common standard. Thus was obtained not only the thousand men esteemed the most eminent, but also the order in which they stand.

This list represents the point of view of these dictionaries, and would be somewhat different had other works been selected. Mathematical science can indeed assign a probable error to each name on the list, and tell us how likely it is that the man should be there, and within what limits his place on the list is likely to be correct. But the greater men of the thousand would remain whatever the authorities collated; and although the personal names of the lesser men might vary, this would affect but little the statistics sought. The preparation of this list required more work than may be supposed, but it has an objective impartiality and value, which it would not have if the names had been selected by an easier method.

According to this list the ten most eminent men are Napoleon, Shakespeare, Mahommed, Voltaire, Bacon, Aristotle, Goethe, Cæsar, Luther, Plato. There is no doubt but that Napoleon is the most eminent man who has lived. Yet it should give us pause to think that this Titan of anarchy stands first in the thoughts of most men. It is curious that these ten preeminent men are so widely separated in race and age—two Greeks, two Frenchmen, two Germans, two Englishmen, one Roman and one Arab: two in the fifth century and one in the first century before Christ, one in the sixth, one in the fifteenth, two in the sixteenth and three in the eighteenth century. The ten names last on the list are Otho, Sertorius, Macpherson, Claudian, Domitian, Bugeaud, Charles I. of Naples, Fauriel, Enfantin and Babeuf. These are scarcely great men, yet they fairly represent the lower limits of the thousand who are most eminent. Each hundred in the list shows a nice gradation in eminence. There are indeed many cases where each of us would shift a man up or down, but further examination will show that the opinion in such cases is usually individual, not having the objective validity of this series. I give for reference the thousand preeminent men of the world in the order of eminence, divided into groups of one hundred.

* 'Lippincott's Biographical Dictionary,' 'The Encyclopædia Britannica,' Rose's 'Biographical Dictionary,' 'Le dictionnaire de biographie générale,' Beaujean's 'Dictionnaire biographique' and Brockhaus's 'Conversationslexicon.' There is no biographical dictionary in German nor any encyclopedia as satisfactory as the Britannica, neither do such works exist in Italian, Dutch or Scandinavian, otherwise it would have been desirable to have used them.

Napoleon, Shakespeare, Mohammed, Voltaire, Bacon, Aristotle, Goethe, Julius Cæsar, Luther, Plato, Napoleon III., Burke, Homer, Newton, Cicero, Milton, Alexander the Great, Pitt, Washington, Augustus, Wellington, Raphael, Descartes, Columbus, Confucius, Penn, Scott, Michelangelo, Socrates, Byron, Cromwell, Gautama, Kant, Leibnitz, Locke, Demosthenes, *Mary Stuart*, Calvin, Molière, Lincoln, Louis Philippe, Dante, Rousseau, Nero, Franklin, Galileo, Johnson, Robespierre, Frederick the Great, Aurelius, Hegel, Petrarch, Horace, Charles V. (Germany), Mirabeau, Erasmus, Virgil, Hume, Guizot, Gibbon, Pascal, Bossuet, Hobbes, Swift, Thiers, Louis XIV., Wordsworth, Louis XVI., Nelson, Henry VIII., Addison, Thucydides, Fox, Racine, Schiller, Henry IV. (France), W. Herschel, Tasso, Jefferson, Ptolemy Claudius, Augustine, Pope, Machiavelli, Swedenborg, Philip II., Leonardo da Vinci, George III., Julian, Pythagoras, Macaulay, Rubens, Burns, Mozart, Humboldt, Comte, Cousin, Cuvier, Justinian, Euripides, Camoens.

Talleyrand, Fénelon, Carlyle, Pius IX., Pitt, More, Hannibal, Spinoza, Chateaubriand, Abelard, Grant, Charles I. (England), Darwin, Mazarin, Bolingbroke, *Elizabeth* (England), Ovid, *Joan d' Arc*, Livy, Corneille, Rabelais, Huss, a' Becket, d' Alembert, Grotius, Peter I., Polo, Linnæus, Raleigh, Palmerston, Lamartine, Jos. Bonaparte, Tennyson, Plutarch, Charlemagne, Aristophanes, Melanchthon, St. Ambrose, Richelieu, James I., Hunter, Hugo, Disraeli, Dryden, Origen, Titian, Boccaccio, Alberoni, Lessing, Fichte, Condillac, Dickens, Wallenstein, Schelling, Dürer, Charles XII., Kepler, Trajan, Knox, Constantine, La Fontaine, Van Dyck, Cervantes, *Stael*, Hippocrates, Louis XVIII., Clive, Rembrandt, Diderot, Chaucer, Montaigne, Napier, *Sand*, Marmont, Tiberius, Peel, Francis I. (France), Nicholas I., William I., J. S. Mill, Sophocles, J. Adams, Webster, Athanasius, Bentley, Savonarola, Marlborough, J. Cook, Seneca, Zwingle, Cavour, Buffon, Goldsmith, Brougham, Alexander VI., Gerson, Alexander I. (Russia), Louis XV., R. Bacon, Pericles.

Herodotus, Hadrian, Davy, Frederick II. (Germany), *Catherine II.*, Condé, B. Jonson, Antony, Lucretius, Pompey, James II. (England), Canning, Strafford, Mencius, La Fayette, A. Hamilton, Alfred the Great, Gassendi, Cortez, Beethoven, L. Bonaparte, *Sévigné*, Xenophon, Wycliffe, Alfieri, Charles X. (France), Harvey, Marius, Juvenal, Firdousee, Gutenberg, Lope de Vega Carpio, La Place, Garibaldi, Necker, Froissart, Arius, Æschylus, Etienne, Epicurus, Mithridates, Isocrates, Jerome, A. Jackson, Canova, Atterbury, Bulwer, Gay-Lussac, Wilhelm I. (Prussia), Niebuhr, Fielding, George IV., Haller, Schleiermacher, J. Watt, St. Bernard, William III., Joinville, Arago, Fouché, Handel, Spenser, Lagrange, Herder, Velasquez, Bunsen, Alcibiades, De Foe, Hastings, Colbert, Metternich, Richard I., Tertullian, Lamennais, Leo X., Cobden, Gustavus Adolphus, Wieland, Berkeley, Law, *Maintenon*, Cranmer, Coleridge, Chrysostom, Beza, Murat, Mazzini, Condorcet, Polybius, Ariosto, Chatterton, Pliny (Elder), Turgot, Tacitus, Malebranche, John of England, Danton, Chalmers, Germanicus, Haydn.

St. Basil, William of Orange, Longfellow, Philip IV., Sully, Huygens, Louis XI., Montesquieu, Eugene, Charles II. (England), Bernadotte, A. Severus, Klopstock, Innocent III., Zoroaster, Attila, G. Monk, A. Smith, Ney, Victor Emmanuel, Prescott, Pindar, Béranger, Gregory VII., Beaumarchais, Rossini, Bentham, Drake, Moreau, Faraday, Boetius, T. Moore, S. Clarke, Channing, Alexander II. (Russia), *Maria Theresa*, Wagner, Priestley, *Josephine*, Thackeray, Copernicus, Blücher, Soult, Maximilian, Carnot, Philo, Averroes, Calderon, Bolivar, Sulla, Ali-weli-zade, Le Sage, Heine, Boyle, Loyola, *Marie Antoinette*, Wesley, Poussin, Winckelmann, Turenne, R. B. B. Sheridan, Weber, W. Hamilton, Avicenna, Shaftesbury, Bright, Catullus, Boerhaave, C. Grey, Leopold I. (Germany), W. Irving, Henry IV. (Germany), Tamerlane, Masséna, Retz, B. Constant, Reuchlin, Sainte-Beuve, Baxter, K. W. Humboldt, Jenner, Liebig, Philip II. (Germany), Aquinas, Dumouriez, Murillo, Lucian, Agassiz, Mehemet Ali, Wolsey, Solon, Jansen, Lavoisier, R. Walpole, Hogarth, Derby, Bichat, Sherman, Frederick W. III. (Prussia), St. Simon.

Wilkes, Phidias, Philip Augustus, Mendelssohn, Boniface VIII., Cobbett, Bailley, Emerson, Joseph II. (Germany), Russell, Vauban, Ferdinand V. (Spain), Bayle, Archimedes, *Christina*, Scipio, Thou, T. Fairfax, Metastasio, Louis IX., L' Hôpital, Marat, Guicciardini, Berzelius, Akbar, Sarpi, Varro, Armenius, Vergniaud, Bayard, Gregory I. (Pope), Louis XIII., Beaton, Wilberforce, Tieck, Andrews, Lycurgus, O'Connell, Burnet, Reynolds, Seward, J. Franklin, Galen, A. Dumas, Alaric, Campanella, Arnauld, Balzac, Plautus, a' Kempis, Richelieu, Pius VI., Terence, Charles VII. (France), Rénan, Pizarro, Henry II. (England), Martial, Theodosius, R. Blake, J. J. Scaliger, Cardan, Cowper, Musset, Pius II., Villars, Helvétius, Belisarius, Candolle, W. Temple, Palestrina, Robertson, Strauss, Kotzebue, Bach, Madison, Hesiod, George I. (England), Dupin, F. A. Wolf, St. Hilaire, Farragut, J. Q. Adams, Cato (Elder), Gluck, Grote, Cyrus, Bunyan, J. L. Grimm, L. Bonaparte, Antoninus Pius, Chesterfield, Pius VII., Leopardi, L. de Medici, Richard II., Gouvion St. Cyr, Gregory Naz., Warburton, Strabo.

Euclid, Desmoulins, *Genlis*, Clarendon, De Witt, Essex, Brahé, Eusebius, Mahmud II., Ferdinand VII. (Spain), Frederick I. (Germany), Euler, G. Howard, Reid, Gambetta, Ledru-Rollin, Lulli, Michaelis, Mahmud, Southey, Monge, Lucullus, Oersted, Hutten, Selden, Henry VI., Hawthorne, Villemain, Gall, Goldoni, Beaumont, Aguesseau, Beauharnais, J. F. Cooper, Catilina, Clement, J. B. Rousseau, Castlereagh, Fontanelle, Casaubon, Cellini, Charles VI. (France), L. R. St. Simon, Lavater, Jacobi, Herod, *Margaret of Anjou*, Philip VI. (France), Richter, Voss, Mackintosh, Lâo-Tsze, Paracelsus, Persius, Themistocles, J. C. Wolf, Ampère, George II. (England), Huskisson, Æschines, Albuquerque, Bruyère, Dalhousie, Suwaroff, Hampden, Coligni, Photius, Cudworth, Alva, Pufendorf, Rumford, Anderson, de Malherbe, *Mary*, J. B. Jourdan, Louis XII., Theodoric, Barrère, Titus, Ranke, Aurelian, *Gaskell*, T. Paine, Herbart, Lee, Phocion, *Mme. Roland*, Henry III. (France), St. Pierre, Ingres, Warwick, Garrison, Erskine, Halley, Cato (younger), Gustavus I., Vasco da Gama, Maupertuis, Guyon, Courier.

Albertus Magnus, Boehme, E. T. W. Hoffmann, T. E. Hook, Marot, Henry I. (England), Massillon, Quintilian, Monmouth, Mæcenas, Philip V., Michelet, Luxembourg, Tintoretto, Vespucci, Saladin, G. Buchannan, Henry V. (England), Butler, Anselm, Rochefoucauld, Charles the Bold, Manutius, Gustavus III., Cornelius, John of Austria, Delille, Adanson, Cherubini, Champollion, Mornay, Sieyès, H. Walpole, Jenghiz Khan, Magellan, William IV. (England), *Boleyn*, Ronsard, Meyerbeer, Ramus, Steele, Servetus, Orleans d' P., Gray, Josephus, Royer-Collard, F. C. M. Fourier, St. Francis, H. Clay, Gioberti, Desaix de Voygoux, Grattan, Montecuculi, Sacy, Bruno, Paley, Jerome Bonaparte, Barras, Maury, De la Vigne, Ali (Ibn abi talib), Cavaignac, Cromwell, Charles d' Orleans, Sterne, Malesherbes, Middleton, Vico, Berthollet, *Jane Grey*, A. Sidney, Salmasius, Pliny (younger), MacDonald, Sallust, Saxe, Marmontel, Clarendon, Sylvester II., J. Taylor, Lamarck, Holbein, Henry VIII., Volta, Rosa, Whiston, Haüy, Cyprian, A. Chénier, Diocletian, *Pompadour*, J. Herschel, Kaulbach, Poggio, Holberg, Miller, Henry IV. (England), Oehlenschläger, Boden, Manes.

*Sappho*, Sarto, Anaxagoras, *Isabella of Castile*, A. W. Schlegel, Justin, Godoy, Epaminondas, P. Henry, Fulton, Dumont d' Urville, Garrick, Andrieu, Ginguené, Regnard, Du Guesclin, Wellesley, H. Vernet, *George Eliot*, Fuller, Heraclitus, Newman, Struensee, Thorwaldsen, *Cleopatra*, Zeno, Poushkin, E. Coke, Augereau, *Brontë*, Jerome of Prag., Aurungzebe, Vespasian, Philopœman, Vane, Jouffroy, Bonnet, Giotto, Agrippa, Alcuin, Gregory of Nyssa, Proudhon, Politian, Arndt, Fréret, R. Hall, Charles IX. (France), *Anne*, Smollett, Demetrius Polior, Democritus, Gay, Cabanis, J. Flaxman, Gallatin, Fouquet, Cujas Guido Reni, C. S. Gracchus, Jeffreys, Gardiner, Oxenstierna, Kléber, Scipio, Mabillon, Lacépède, Stewart, Lyell, Rameau, Cassini, Lalande, Sumner, Parker, Plotinus, Cagliari, Lacordaire, *Marguerite d' Angoulême*, Kosciusko, P. H. Sheridan, Tocqueville, Hipparchus, Henry III. (England), Whitegift, Rudolph I., de Volney, Jugurtha, Prior, Ménage, Oken, Murray, Bellarmino, Churchill, Laffitte, Henry II. (France), W. Jones, J. Owen, Cecil, Darius I., Charles Edward Stuart, Donizetti.

Hammer-Purgstall, J. L. David, Propertius, Boileau, Leighton, Correggio, Grouchy, Francke, Lysias, Lannes, Bonner, Pichegru, Erigena, Casanova, C. de Medici, Nadir (Shah), Whitefield, J. P. J. d'Orleans, Lucan, Teniers, Richard III., Apelles, Meckiewitz, Ximines, Sobieski, E. Irving, Stein, Hoche, Louvois, Saadi, *Montague*, Alfonso X., Scribe, Oudinot, Livingston, E. Herbert, K. W. F. Schlegel, Mariana, Rienzi, Sixtus V., Hahnemann, Celsus, von Gentz, Deák, Pym, Gustavus IV., Monroe, Gauss, Keats, C. Bell, Godwin, De la Croix, Charles VI. (Germany), Edward IV., Ennius, Epictetus, Ferdinand II., Harold II., Zeno, Fiesole, Pestalozzi, Dundonald, Tippoo Sahib, Clovis, Huet, Maistre, Cagliostro, Ray, Malthus, Atticus, Barrow, Somers, Arkwright, Wren, Quinet, Nodier, Krüdener, Bede, Claude of Lorraine, Theocritus, L. Stanislaus, Hooker, P. Sidney, Müller, Maimonides, Odoacer, Hénault, *Theresa*, Barthez, Espartero, Decazes, *Martineau*, T. Brown, Fermat, Agathocles, Empedocles, Charles V., Banks, Zinzendorf, Thierry.

T. S. Gracchus, Delambre, Caligula, Edward III. (England), Richardson, Porphyry, Nicole, Waller, Balboa, Solyman, *Catherine de Medici*, La Harpe, Pole, Thales, *Marie de Medici*, Procopius, Lactantius, Borgia, Berengarius de Tours, Tallien, Camden, Armstrong, Jeffrey, Capo, Sismondi, R. Owen, Apuleius, St. Just, Spontini, W. Laud, Irenæus, Lacretelle, J. B. Lulli, Paul I. (Russia), Stilicho, Arbuthnot, Dampier, Auber, Grégoire, Dolet, La Chaise, Francis II. (Germany), Dolomieu, Æsop, F. M. Grimm, Dupuytren, M. J. Brutus, Feuerbach, Barnaveldt, Farel, Akenside, Prince Albert, Bouillon, Hauser, Frederick Wilhelm II. (Prussia), Gerando, W. Wallace, Chamfort, Agrippa, Garat, Audubon, A. Doria, Hareeree, Cowley, Heyne, Martinez, Petronius, *Hortense*, Mahommed II., Mai, Sue, J. Barry, Marivaux, Sebastian, Rotrou, W. Russell, Suchet, Paoli, Bopp, Romilly, Montalembert, John XXII., Rohan, Iamblicus, Bernhard, Simonides, Baggesen, Raspail, Thomson, Louis I., Otho, Sertorius, Macpherson, Claudianus, Domitian, Bugeaud, Charles I. (Naples), Fauriel, Enfantin, Babeuf.

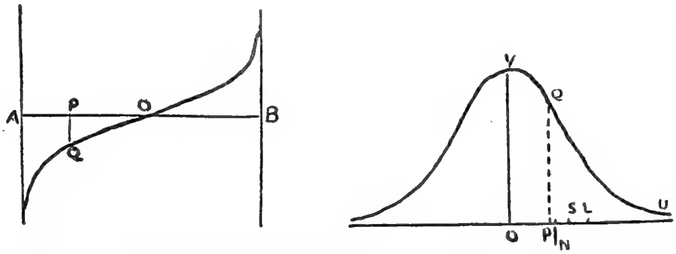
The preparation of this list was incidental to the main purpose of my research, and I do not wish to lay undue stress upon it. Still it is of interest to find that we can compare and even measure a thing as intangible as the eminence of great men. We should not need to refer to such a list to decide whether Homer or Virgil is the more eminent; but it may satisfy that curiosity which is the beginning of science to know that there are to the best of our present knowledge twelve men more eminent than Homer and fifty-six men more eminent than Virgil. Further by reckoning the probable errors it is found that the chances are even that Homer's place on the list is between 10 and 26 and Virgil's between 42 and 98.

But while our general knowledge apart from any such list as this may suffice to compare Homer with Virgil as accurately as is needful, this does not hold for men whose work is not readily comparable. Is Raphael, Descartes or Columbus the more eminent? As a matter of fact they stand respectively 22d, 23d and 24th on the list, and are equally eminent. I do not see how this result could have been reached from any general knowledge we may have of the work and fame of these men. Or again, Newton follows Homer and Hume follows Virgil on the list, consequently Newton is as much more eminent than Hume as Homer is than Virgil.

Things can be arranged in order more easily than they can be measured. We know that one sound is louder than another, though we may be unable to say whether it is more or less than twice as loud. We can arrange without much difficulty the examination papers of our students in the order of excellence, though unable to decide that one paper is twice as good as another. But the theory of probability makes even the measurement of the eminence of great men possible.

If all the men of the races and ages with which we are concerned were arranged in order, we might divide them into quarters. Supposing there to be one hundred million individuals in all from whom these men might have arisen, taking the adult male population of the countries and periods producing nearly all of them, we should have at the end the 25 million least deserving of credit, including the defective and delinquent classes. Then we should have two groups each containing 25 million, one falling below and one rising above the average. These are the ordinary men who depart from the median by an amount less than the probable error. Then at the upper end we have the group of 25 million individuals who through some special trait or through a combination of traits rise above the others. At the extreme end of this group are the thousand preeminent men of our list.

What a man is and does is the result of innumerable influences, chiefly small and independent, some pulling him down and some lifting him up. In so far as this is the case, the men will be grouped together and depart from each other in a certain definite fashion. The matter can most readily be illustrated by taking a single trait such as height. If these men were placed in a row arranged according to height, the tops of their heads would form a curve of which an exaggerated form is given. In a general way the middle man would be of the average height, say 5 ft. 8 in., and a great part of all the men would be of nearly this height, one quarter being not more than 1½ inches shorter and one quarter not more than 1½ inches taller. The line of the heads would be nearly horizontal, but would gradually slope more and more, until at one end we should have the comparatively few dwarfs and at the other the few giants. These relations can be illustrated by the bell-shaped curve, whose properties are well known.

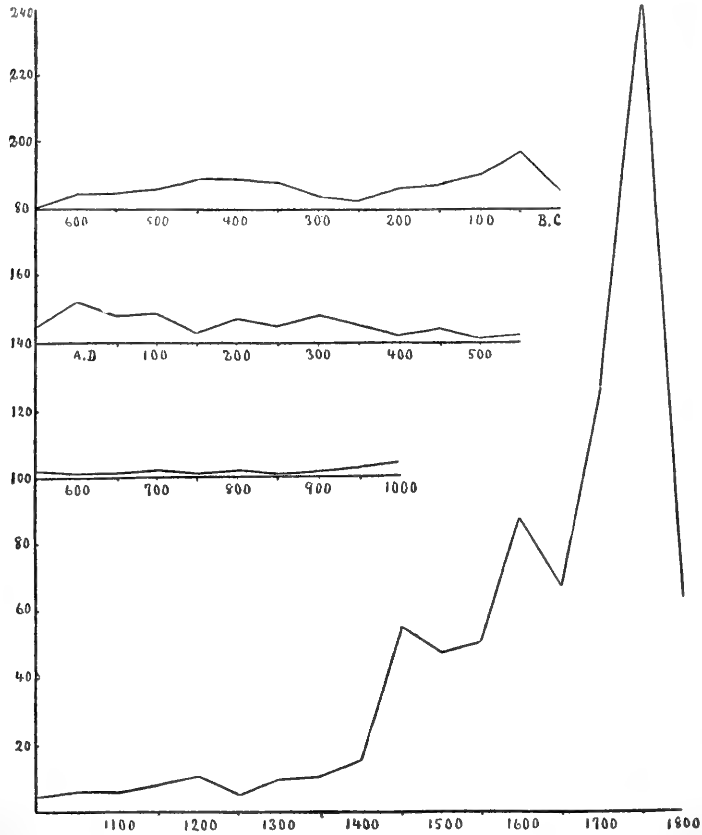



Ogive and Bell-shaped Curves Showing the Distribution of Traits.

Five feet eight inches is the average height of men, and the number of men of that height (within say 1/10 in.) is proportional to the line *OY*. The number of men say 1½ inches (within 1/10 in.) larger than the average by an amount equal to the probable error or 1½ in. is proportional to the line *PQ*, and the number of men within these limits, one quarter of all the men, is proportional to the area *OYQP* which is one quarter the area of the curve. The number of men 6 ft. 2 in. in height—who depart from the mean by 6 in., or four times the probable error—would be *OU*, only 1/50 as many as are 5 ft. 9½ in. in height, and but three in a thousand of all men would be taller than 6 ft. 2 in.

Now applying this to the collective traits giving efficiency, we have one half of all men coming within the limit *OP* which may be taken as a unit of measure. The total number of men surpassing the average by four times the amount of the average departure would be about 300,000. Most of us may hope to fall within this group. The thousand preeminent men filling the extreme area of the curve would begin at a point six times the average departure, and the relative excellence of the greater men on the list can also be expressed numerically.

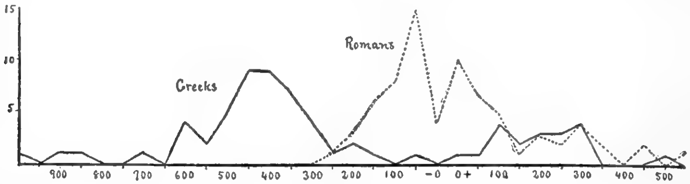
Turning now to the distribution of these eminent men in time and race we may review statistics not wholly devoid of interest. The number of great men born in each half century since the beginning of history is shown in the accompanying curve. In still more remote ages there were leaders of men, gods, prophets and heroes, whose names are forgotten or obscured, and at the beginning we have four names, representing rather work than persons—Zoroaster, Homer, Hesiod, Lycurgus—followed by the rise of Greek civilization and culture—the most notable event in the world's history. Here we have a race as superior to us as we are to the negroes—a great race, for whose origin we can no more account than we can explain the birth of Shakespeare at Stratford-on-Avon. The curve shows the progress of the Greek race as represented by its great men—leaders then and now in war, in




The Curve Represents the Distribution of the Thousand Most Eminent Men of History from 600 B. C. to the First Half of the Nineteenth Century. The numbers are given on the left side, the ordinates or height of the curve above the base line representing the number of eminent men born in each half century. Thus there were five preeminent men born between 600 and 550 B. C. and 241 in the second half of the eighteenth century. As men attain eminence about fifty years later than they are born, the periods of productivity are one place further to the right.

statesmanship, in philosophy, in literature, in art—and its more sudden decline in the third and second centuries before Christ. But the supremacy relinquished by the Greeks was grasped by the iron hand of the Romans, who in the centuries just before Christ rise rapidly and then fall. The relation of Greek to Roman civilization is shown in a separate figure.

These curves—which of course give only a graphic representation of quantitative relations whose general character we all know—indicate that heredity, including under the term both stability and variability of the stock, is more potent than social tradition or physical environment. We have these races forming by their own inherent genius a social environment far beyond anything the world had ever witnessed, but when this was at its maximum it had not power to counteract the weakening influence of race admixture and exhaustion of the stock. The physical environment also remained the same, and those who would account for Greek and Roman culture by the favorable position of the two Mediterranean peninsulas—their climate, soil, coast line




THE CURVES SHOW THE DISTRIBUTION OF EMINENT MEN IN THE GRECO-ROMAN PERIOD.

and the like—should tell us why these could not maintain what they had formed. Why should the Greeks then have resisted the countless hordes of Persia, while recently on the same ground they fled before a few thousand Turks? Physical environment and social tradition may be conditions of development, but they are not its efficient causes.

Following the extraordinary development of the two nations of classical antiquity we have a decline, not sudden, for Rome still produced soldiers and writers, the Christian Church had its leaders and theologians, and the Greeks witnessed their Indian summer in Alexandria. But the light fails toward the fifth century—never, however, to be quenched, for there were always one or two to pass on the torch until the fire was rekindled in newer races. In Britain, in Germany and in France there developed centers of civilization. The mixed races of Italy gave birth to an art and a literature rivaling that of Greece. The Roman Catholic Church fairly established its authority by the great men it produced. It was a strange time, all Europe was in turmoil, but universities were established and the arts of peace flourished in the midst of wars.

The curve shows a rise from the tenth century increasing in rapidity as it proceeds. As the list includes only men no longer living, and as many of those born during the first half of the nineteenth century were still living and had not even attained eminence when the books of reference on which the list is based were compiled, the absolute numbers of those born since 1800 have no value, but they serve for comparison

The increase in eminent men as we approach our own day may be partly a matter of perspective. Still the numbers should normally increase with larger population and multiplication of opportunity and interests. It is unfortunately very difficult to compare the number of great men with the total population from which they arose. Were a curve of this sort drawn, however, it would be very dfferent from that here exhibited. The rise in modern times would be much less; and the Greek and Roman periods would surpass that of the end of the eighteenth century.

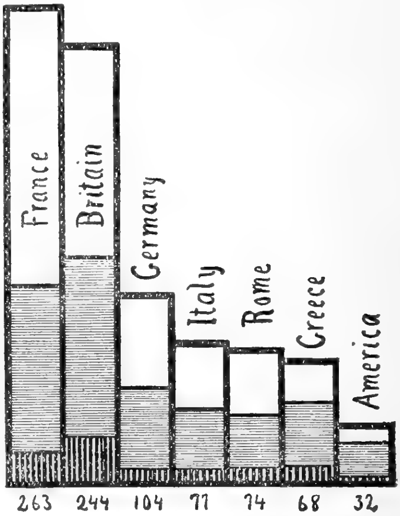
In our curve there are three noticeable breaks. Perhaps nothing could serve better than such a curve to impress on the minds of school children, or even on our own, the eddies in the stream. It must be remembered that the curves give the numbers of men born in each half century, while the period in which they flourished is about fifty years later. Thus in the fourteenth century there was a pause followed by a gradual improvement and an extraordinary fruition at the end of the fifteenth century. Painting is represented in Italy by Raphael, Angelo, Leonardo, Titian, Correggio and Sarto, in Germany by Holbein and Dürer. Savonarola failed, while Luther led a reformation. Columbus discovered a new world and Copernicus discovered innumerable worlds. There was then a pause in progress, until a century later England and France took the lead. Spenser was quickly followed by Shakespeare, who did not stand alone among English dramatists. A little later Molière, Racine and Corneille represented the drama in a group of eminent French men of letters. Descartes and Bacon revived philosophy and science; while Italy, failing in art, produced Galileo.

The latter part of the seventeenth century was a sterile period, followed by a revival culminating in the French revolution. Here, as in other periods, it is difficult to decide how far men were made eminent by circumstance and how far great men were leaders in new movements. The social upheaval in France gave eminence to political and military leaders who otherwise would have remained in obscurity, and given a Napoleon his complement is a Wellington. The progress of science may in part be an answer to the demands of increasing population. But philosophy and art also witnessed a renaissance. In Germany we have Kant, Goethe and the development of music, in England, poets speaking a new language. Here great men seem not so much the creatures as the creators of their environment.

As we come nearer to our own times it becomes increasingly difficult to measure tendencies by the methods we are using. The positions of men on the list are subject to larger probable and constant errors. Byron may be a household word on the continent and Shelley unknown, while the best criticism may place Shelley above Byron. Our list places Mendelssohn above Bach and ignores Schumann altogether—

while the last thirty years have altered not only critical opinion, but also popular taste.

If we regard now more especially the racial distribution of our great men, we get results conveniently exhibited in the accompanying figure. The heights of the rectangles are proportional to the numbers of great men produced by several nations. France leads, followed pretty closely by Great Britain. Then there is a considerable fall to Germany and Italy. Rome and Greece are nearly alike. America has produced one more eminent man than Spain (not on the chart) which is followed by Switzerland, Holland and Sweden. We then reach the nations headed by Russia, which have produced fewer than 10 preeminent men. The shaded rectangles show the distribution of the 500 men who are the most eminent and the heavily shaded rectangles the hundred who are the greatest of all. Here the relations are somewhat altered. Great Britain surpasses France, and Greece has produced more exceptionally great men than Germany.*

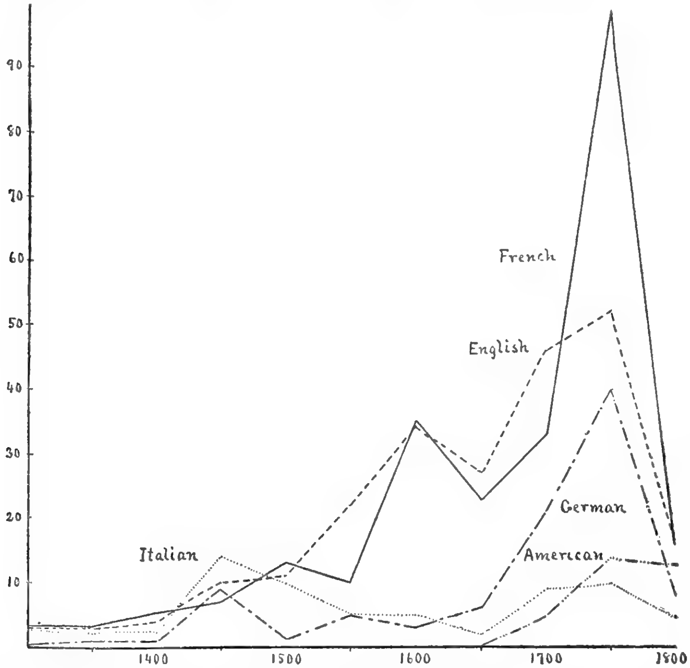



THE RECTANGLES ARE PROPORTIONAL TO THE NUMBERS OF THE MOST EMINENT MEN PRODUCED BY DIFFERENT NATIONS. The shaded parts represent the more eminent five hundred, and the heavily shaded parts the hundred most eminent of all.

We have already noticed the curves showing separately the Greek and Roman periods. Similar curves for the leading modern nations are given in the chart. The Italian renaissance is followed by its decadence with a partial revival in recent times. Germany for one short period in the fifteenth century rivaled France and England, but in the two following centuries lagged far behind, to rise with great rapidity in the eighteenth century. France and Great Britain, as we have seen, have produced nearly the same number of great men, and their curves during the centuries cross and recross. The British curve is somewhat more regular than the French, exhibiting perhaps certain racial characteristics. As has been already stated, the French revolution brought into prominence many men not truly great, and the position then attained by France is not held in the nineteenth century. In so far as the curves

* These relations are somewhat dependent on the authorities collated; their validity may be assigned by the calculation of probable errors, but there may be a constant error due to the fact that the collation of names depends chiefly on French and Anglo-Saxon standards.

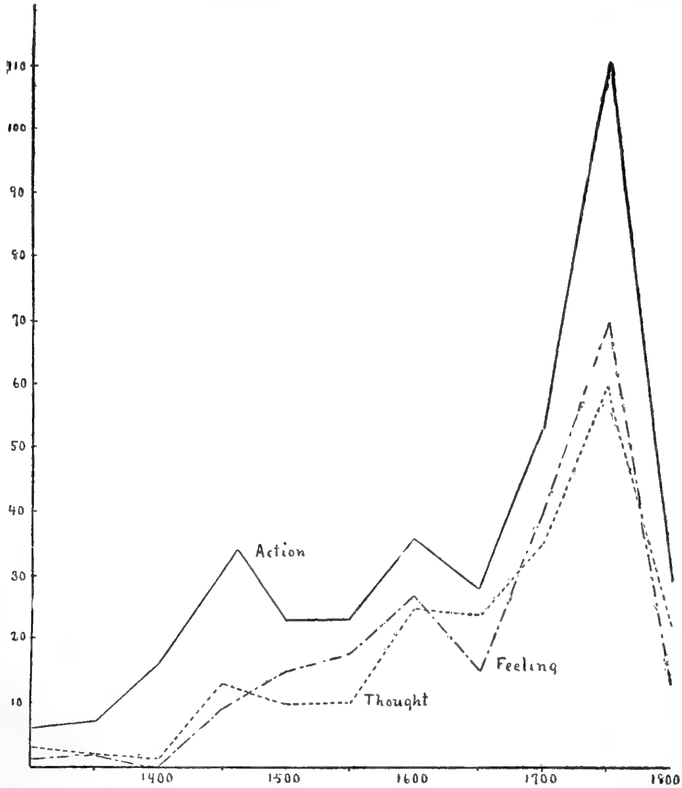
for the nineteenth century are valid, the promise for America is large. We should during the twentieth century produce more notable men than any other nation. It is ill for us, having the largest population and the richest resources, if we do not keep this promise.




THE CURVES SHOW THE PRODUCTION OF GREAT MEN AT DIFFERENT PERIODS BY SEVERAL OF THE LEADING NATIONS.

Our racial divisions are given to us ready made. The subject becomes more difficult when we try to class eminent men in accordance with their traits. We can, however, perhaps use the tripartite subdivision current in psychology. There we are apt to treat separately cognitions, feelings and volitions. This classification proves useful when applied to the traits of great men. Some excel because they have strong wills, are quick and sure in action. These become leaders in war and in political affairs. Others have strong feelings—artists, poets, men of letters. Others surpass in pure thought—philosophers, scholars, men of science. Distinguishing then men of action, men of feeling, and men of thought, we secure the curves shown on the accompanying chart. It is seen that more men are eminent for action than for either thought or feeling, though if the latter two classes are combined it is found that the quiet work of the student has after all produced more eminent men than war and politics. Each class shows an increase as we approach our own time and the secular variations affect them together, though it is noticeable that men of thought have been much more constant in their appearance and bid fair to surpass the others in the twentieth century.

In passing I may state that modern psychology does not admit that we can divide mental processes into such as are cognitions, such as are feelings and such as are volitions, any more than we can divide physical bodies into such as have size, such as have color and such as have weight, but must rather regard these as aspects of all mental processes. So

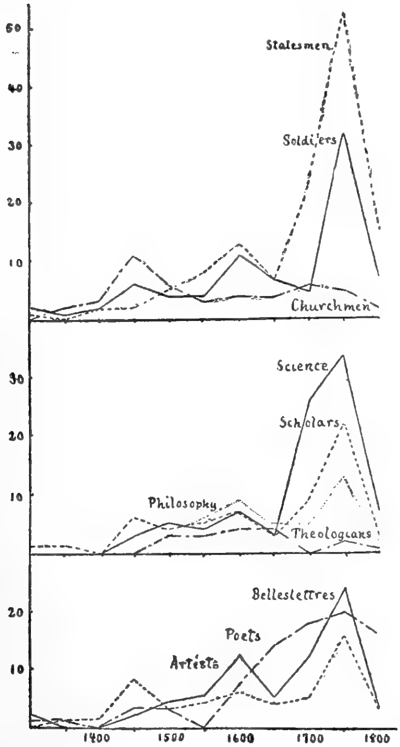



THE CURVES SHOW THE RELATIVE NUMBERS OF MEN OF ACTION, MEN OF THOUGHT, AND MEN OF FEELING AT DIFFERENT PERIODS.

with our great men—if a man excels in action he probably is not deficient in feeling and judgment—on the contrary these are probably strong. My statistics show, contrary perhaps to the current opinion, that a man who excels in one direction is likely also to excel in others. An artist is much more likely to be a poet than is an ordinary man and is, though in a less degree, more likely to be a soldier or a man of science.

Curves showing further subdivisions are also given. From the upper chart it is clear that there have been more eminent statesmen than soldiers, especially since the beginning of the eighteenth century.

Soldiers are also surpassed in numbers by men of science and our curves foretell the gradual cessation of wars. Churchmen and theologians are of decreasing importance in human affairs. It is interesting to note that the sterility at the end of the seventeenth century and the subsequent revival hold for nearly every separate department. Fiction and belleslettres make the only exception, their growth in the seventeenth and eighteenth centuries continued in the nineteenth century, and the number of prose writers, novelists, essayists and the like, who attained eminence in the past century, surpasses that in any other department. Any librarian can confirm this by telling what books are most read. Poetry and art seem to be failing. Next to politics and belleslettres, science occupies the most important place.



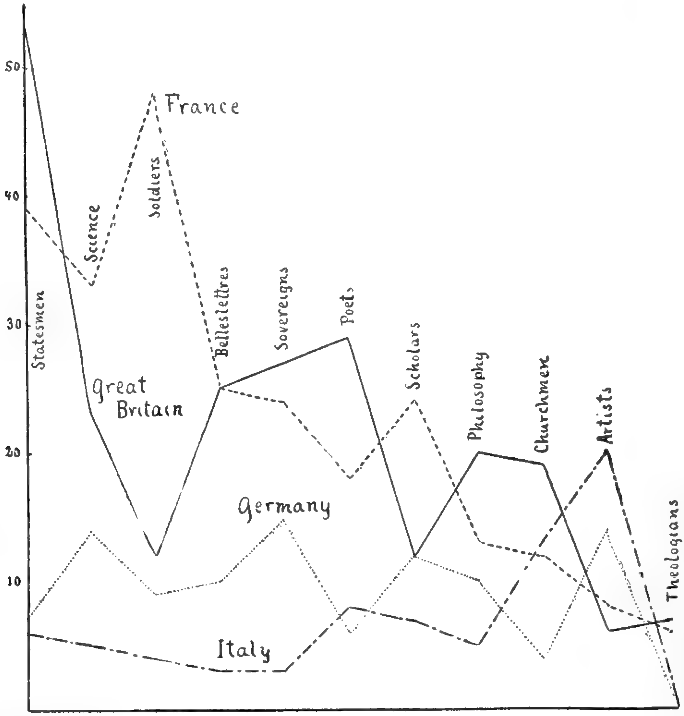

THE CURVES SHOW THE DISTRIBUTION OF MEN OF ACTION, MEN OF THOUGHT AND MEN OF FEELING, SEPARATED INTO GROUPS FOR DIFFERENT LINES OF ACTIVITY.

The first five hundred were separated from the five hundred less eminent men, but they were found to be nearly equally divided in the different classes, except that there are more very great poets and fewer very great men of letters.

The accompanying chart shows the contributions of different nations to different departments. It is evident that France has excelled in war, in belleslettres and in science—England in politics, in poetry and in philosophy—Italy in art. Germany has produced ten and Italy six of the eighteen great musicians. Of the fourteen great explorers England has produced five and Spain four.

There are two somewhat anomalous classes of eminent men which I have not as yet mentioned. Hereditary sovereigns and those made eminent purely by circumstance. The hereditary sovereigns included are of course only the more eminent, 102 in all, but they can not be compared with the other classes. Only eight have been included under the class of those eminent by circumstance, of whom Casper Hauser is typical—but several others, especially the wives of kings, might be placed there.

I have spoken throughout of eminent men as we lack in English words including both men and women, but as a matter of fact women do not have an important place on the list. They have in all 32 representatives in the thousand. Of these eleven are hereditary sovereigns and eight are eminent through misfortunes, beauty or other circumstances. Belleslettres and fiction—the only department in which woman has accomplished much—give ten names (of which three are in the first 500) as compared with 72 men. Sappho and Joan d'Arc are




THE CURVES SHOW THE RELATIVE CONTRIBUTION OF DIFFERENT NATIONS TO DIFFERENT LINES OF ACTIVITY.

the only other women on the list. It is noticeable that with the exception of Sappho—a name associated with certain fine fragments—women have not excelled in poetry or art. Yet these are the departments least dependent on environment and at the same time those in which the environment has been perhaps as favorable for women as for men. Women depart less from the normal than man—a fact that usually holds for the female throughout the animal series; in many closely related species only the males can be readily distinguished. The distribution of women is represented by a narrower bell-shaped curve.*

* Since the above was written Professor Karl Pearson has questioned the lesser variability of woman. The matter can only be decided by facts; these statistics certainly show greater variability for the male.

This paper is only preliminary to the real object of my research. We have many books and articles on great men, their genius, their heredity, their insanity, their precocity, their versatility and the like, but, whether these are collections of anecdotes such as Professor Lombroso's or scientific investigations such as Dr. Galton's, they are lacking in exact and quantitative deductions. Admitting that genius is hereditary, or, what is more doubtful, that it is likely to be associated with insanity, we have only the 'yes' or 'no' as our answer. But this is only the beginning of science. Science asks how much? We can only answer when we have an objective series of observations, sufficient to eliminate chance errors, such as this list of a thousand preeminent men.

When we have such a series we can use what psychological insight we possess to classify our material. We can seek to distinguish genius from talent, and, having given these terms a more exact signification, can secure quantitative data regarding their relative frequency under varying conditions. We can determine how the man of unusual endowment in its various manifestations differs from his fellow men, both in those traits which distinguish him from them and in those traits which he shares with them. With traits that can be measured such as length of life, height, etc., we can readily compare the several classes of eminent men with other classes in the community. In the case of other traits, insanity for example, we must first determine its prevalence, according to a proper definition, in the various classes of eminent men and can then give a definite statement as to its relative frequency among them and a comparison with other classes. Other more intangible traits I am also endeavoring to measure. Qualities such as originality or kindliness are graded on a scale of eight, mistakes are eliminated by the numbers and we secure fairly reliable averages. The different classes of eminent men can then be compared *inter se,* and with other classes of the community, when the data for these are at hand. Then we have the distinctions on which I have already dwelt. We can only determine the causes of great men and their effects by a careful study of a number sufficiently large to eliminate accidental causes and errors in our estimate; but having done this, our results can be expressed in the definite measures of exact science.

In conclusion attention may be called to the practical importance of such determinations. Science must precede the applications of science. The father must discover the laws of the pendulum before the son can apply them to the clock. A Faraday and a Henry must investigate the phenomena of electricity before we can have the electric motor. It is evident that applications of psychology and sociology are not as yet numerous or important. But may not this be chiefly because the scientific principles are wanting? Education and government are carried on by the rule of thumb, not because this is the best way, but because we lack the knowledge to prescribe a better way. The struggle for existence, careless of the individual, proceeds with reckless waste of life, and it is only the fit that survives, and not what we regard as the best. The Chinese civilization of the age of Confucius was more stable than that of classical Greece. The progress to our present civilization may have depended largely on the comparatively few men who have guided it, and the civilization we hope to have may depend on a few men. Can we not with the knowledge we have and with the knowledge we should acquire do more to produce such men, to select them, to train them and to use them?

We can not perhaps apply the methods of horticulture to society, nor carry Plato's Republic into effect. But great men tend to be proportional in numbers to the total populations producing them and to the average of the stock. If we can improve the stock by eliminating the unfit or by favoring the endowed—if we give to those who have and take away from those who have not even that which they have—we can greatly accelerate and direct the course of evolution. If the total population, especially of the well endowed, is larger, we increase the number of great men. We should make sure that all are given such preliminary education and opportunity that none fail through lack of these. Lastly great men and also the well endowed should be so placed that their abilities are not spent on trivial or selfish ends.

We may have still stocks that are immature—the Slavs, the Czechs and the Scandinavians—and there is a possibility of vitality in the negroes. But we have finally broken the links between us and the lower animals. When our stock is exhausted, when there are no longer variations towards what we regard as advance, then for thousands of years the human race may be dependent on the social tradition now set. We are perhaps beginning to fail in art and in poetry, but for a century or more science and its applications will probably be at their maximum. What is accomplished during this short period must be either the foundation for a new stock or the endowment policy for a long old age.

# SCIENTIFIC LITERATURE.

## *BIOGRAPHIES OF EMINENT CHEMISTS.*

Besides the individual works named in recent numbers of The Popular Science Monthly, the collected works, or dictionaries, of biography, particularly those treating specially of scientific men, contain valuable information of the lives and labors of the chemists. So far as known to the writer there is only one book devoted to chemists exclusively, and that one is so full of mistakes and so weak through its omissions of conspicuous men of all nationalities, especially Americans, that it could only be named for the purpose of condemning it. Suffice it to say the book is of German origin, yet it does not include all the honorary members of the German Chemical Society. The fact that it is of recent origin and is issued by a prominent publisher does but strengthen its weakness.

The most valuable of all biographical dictionaries dealing solely with men of science is also of German origin, and owing to its unwieldly title is usually designated by the words: 'Poggendorff's Dictionary.' The 'Biographisch-literarisches Handwörterbuch zur Geschichte der exakten Wissenschaften,' begun in 1858 by J. C. Poggendorff, and continued to 1900 by Feddersen and von Oettingen, now comprises three large volumes, and another is promised; it is most comprehensive, including all nationalities, all epochs of history and all branches of *exact* science. Under the last heading, however, as interpreted by its originator, the dictionary does not include biology, so that with few exceptions, botanists and zoologists, as well as physicians, are omitted; otherwise for mathematicians, astronomers, geologists, physicists and chemists it is most valuable. This dictionary not only gives very brief outlines of the lives of those catalogued, but in addition, fairly full lists of their scientific publications both in independent books and in periodicals. To the historian, and the student of the literature of sciences within the categories named, these volumes are indispensable; together with 'Who's Who in America' they form a *vade mecum* with reference to the dead and the living actors in science. If a personal remark may be here permitted, the writer will venture to add that his copy of 'Poggendorff's Dictionary' has been enhanced in value by the insertion of more than six hundred engraved portraits of savants, each one adjoining the appropriate biography, thereby doubling the number of volumes and increasing the interest of the reader.

Several works are particularly admirable for the abundance of the portraits of scientists within their covers; among these may be mentioned the four volumes published in 1833–40 by the Philanthropic Society, 'Montyon et Franklin,' containing likenesses not easily found elsewhere, and Figuier's 'Vie des savants' in five volumes, containing many portraits and illustrations in which imagination has been of great assistance to the artist. Hofmann's 'Erinnerungen an vorangegangene Freunde' (three volumes, 1889) embraces sketches of the lives of chemists only, illustrated by portraits, which unfortunately are not well engraved, though the text is that of a master as well as a sympathetic friend appreciative of the scientific work of those he portrays. The biographies by Hofmann include Graham, Liebig, Buff, von Fehling, Wöhler, Dumas, Quintino Sella, Kirchoff and Wurtz, as well as some of his own pupils; besides portraits of these chemists the volumes contain facsimiles and other illustrations.

Of English scientists living at the beginning of the nineteenth century there exists a very large, handsomely engraved print, which represents the men assembled in the Royal Institution; this was designed by Gilbert and drawn by Skill and W. Walker, the latter of whom being also the engraver; it was published in June, 1862. It contains fifty portraits, including twelve distinguished chemists, Cavendish, Dalton, Davy, Rumford, Watt, Wollaston, Rutherford and others; and is accompanied by a key and a volume giving biographies of all the scientists whose portraits are given. The book is edited by William Walker, junior, and with the print forms a most valuable publication of artistic merit.

Of American scientists the chief treasury for portraits and biographies are the volumes of The Popular Science Monthly as is well known to our readers. From the pages of this journal the late editor compiled a handsome book of over five hundred pages, entitled 'Pioneers of Science in America' (New York, 1896), and embracing sketches of forty-nine eminent men; the excellent portraits in this work were in large measure drawn and engraved expressly for it, and some of them can scarcely be found elsewhere.

In concluding these desultory comments on biographies of eminent chemists, begun in the April number, mention must be made of two more volumes of interest; 'Essays in Historical Chemistry,' by T. E. Thorpe (London, 1894), might be more accurately entitled essays in chemical biography, for the volume consists of addresses and lectures dealing with the lives and scientific labors of twelve distinguished chemists, from Hon. Robert Boyle, the 'Father of Chemistry and Brother to the Earl of Cork,' to Dimitri Ivanowitsh Mendeléeff, the Russian whose name is memorably linked to the periodic law. Dr. Thorpe's essays are gracefully written and read well, but he has not always taken pains to verify his statements. The assertion, for example, that Claudio Bereguardi made experiments with the barometer on the leaning tower of Pisa (prior to Torricelli's invention) is a myth.

The second work to be named in conclusion is entitled 'Memorial Lectures delivered before the Chemical Society [of London]' (London, 1901), to which allusion has already been made; it contains masterly sketches of the lives and labors of twelve of the most eminent chemists who have died within the last decade, each written by a sympathetic friend or by one whose investigations were analogous. This work can be cordially commended as the most recent, authoritative and comprehensive volume published on the subject. Fine portraits embellish the valuable contribution to chemical biography.

# THE PROGRESS OF SCIENCE.

## *THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

The first convocation week meeting of the American Association and its affiliated societies was a notable event in the progress of science in America. We have on several occasions called attention to the circumstances that led up to this meeting. The American Association with its affiliated societies has hitherto held its meetings in the summer, when the dispersal of men of science and the heat have been disturbing factors. The American Society of Naturalists with its affiliated societies has met during Christmas week when the time was too short, especially for those who traveled from a distance. The American Association was successful in securing a short extension of the Christmas holidays from all our leading institutions of learning, some seventy in number, leaving free for the meetings of scientific and learned societies the week in which the first of January falls. The American Association and the American Society of Naturalists and most of the national societies devoted to the special sciences then united to hold the great congress which met at Washington from December 29 to January 3.

There were at the meetings more scientific men than had ever before assembled on this continent. The enrolment of members of the association was 989, which was increased to 1,352 by the registration of those attending the meeting of affiliated societies, but not members of the association. The attendance was larger than the registration, and may be estimated at considerably more than 1,500. The addresses, papers and discussions were truly bewildering in their number and range. There were about thirty-five special societies and sections of the association meeting nearly or quite simultaneously. Under these circumstances conflicts and inconveniences were not entirely absent, but on the whole the complicated machinery worked with remarkable smoothness. Such a great meeting accomplished much in promoting solidarity among men of science, and in demonstrating their activity and power of organization to the world. It was especially fortunate that this meeting should have been held at Washington, which is now the scientific, as well as the political, capital of the country. Men of science from all parts must have been greatly impressed by the immense quantity and admirable quality of scientific work being done under the national government, whereas the government officers must have been encouraged in their research by the visitors.

A number or even a volume of the MONTHLY would go but a small way toward publishing the addresses and papers presented at the Washington meeting. We print elsewhere the address of the retiring president, Professor Asaph Hall, one of the world's great astronomers. Other addresses and abstracts of the proceedings will be found in *Science;* the real scientific work of the meeting, however, must be looked for in the special journals and series of publications.

Dr. Carroll D. Wright, U. S. Commissioner of Labor, was chosen as the next president, and St. Louis as the next place of meeting. The range of the association and its affiliated societies was demonstrated by both selections.

For the first time social and economic science was recognized in the election to the presidency, whereas the place of meeting acknowledged the middle west as coordinate with the east in its scientific activity.

### *THE RECOGNITION OF THE IMPORTANCE OF PREVENTIVE MEDICINE.*

While it is quite impossible to give an account of the multifarious activities of the association, what may be accomplished by organized science may be illustrated by two resolutions passed by the council. One of these recognized the service of the late Major Walter Reed in exterminating yellow fever at Havana, the other emphasized the need of expert medical supervision in the construction of the Isthmian Canal.

The first resolution reads:

Resolved, That the American Association for the Advancement of Science hereby records its sense of the great loss sustained by science in the death of Major Walter Reed, surgeon in the United States Army, and its appreciation of the far-reaching and invaluable services which he has rendered to humanity. By solving the problem of the mode of spread of yellow fever, Major Reed not only made a great contribution to science, but at the same time conferred inestimable benefits upon his country and upon mankind. To have discovered and demonstrated the methods, which have already been successfully tested in Cuba, of eradicating a wide-spread and terrible pestilence, is a benefaction of imperishable renown, of incalculable value in the saving of human lives, of vast importance to commercial interests, and deserving of the highest rewards in the power of his countrymen to bestow. This association earnestly urges upon the attention of Congress the duty of making full provision for the support of his family.

Resolved, That the President designate a committee of nine members of this Association, with power to increase its number, which shall be authorized and requested to devise and carry out a plan, or aid in similar efforts elsewhere instituted, by which a suitable and permanent memorial of this great benefactor of his race may be secured. This committee shall be authorized to prepare and publish a statement of the services of the late Major Reed in discovering the mode by which yellow fever may be exterminated.

The members appointed to serve as such committee are: Dr. D. C. Gilman, Dr. A. Graham Bell, General George M. Sternberg, Mayor Seth Low, Hon. Abram S. Hewitt, President J. G. Schurman, Dr. S. E. Chaillé, Dr. W. H. Welch, Dr. Charles S. Minot.

The second resolution was as follows:

Inasmuch as the construction of the Isthmian Canal is through a region in which without energetic sanitary control there is sure to be enormous loss of human life from preventable diseases, particularly from pernicious malaria and yellow fever, as well as great waste of energy and of money from disabilities caused by such diseases, and

Inasmuch as the measures for the restraint of these diseases, which have already achieved even their extermination in Cuba under American administration, require expert knowledge based upon practical familiarity with tropical diseases, experience in the application of these measures, and large authority in their administration,

Resolved, That the American Association for the Advancement of Science begs most respectfully and earnestly to call to the attention of the President of the United States the importance of appointing as a member of the Isthmian Canal Commission a medical man possessed of the qualifications indicated. The association is convinced that the mere employment of such a sanitary expert by the commission will not be likely to secure the desired results.

Resolved, That the permanent secretary of the association transmit a copy of these resolutions to the President of the United States.

### *A NEWLY RECOGNIZED FACTOR IN AMERICAN ANEMIAS—'THE GERM OF LAZINESS.'*

Under the sensational heading of 'the germ of laziness,' the daily press has been endeavoring to tell the public something about a new discovery made by the U. S. Public Health and Marine Hospital Service. Owing to the wording of the first report, by the New York *Sun*, many newspapers have not known whether this alleged discovery should be taken seriously or in jest, and the editorial remarks upon the subject have, therefore, varied from the serious to the sarcastic. The following are the facts of the case, as learned by the POPULAR SCIENCE MONTHLY from a reliable source.

The Eber's Papyrus, an Egyptian manuscript, about 3,500 years old, described a tropical malady as the 'A A A' or the 'U H A' disease, which is characterized by an extreme anemia, pains in the abdomen, palpitation of the heart, and certain other symptoms. This same disease is described by various authors in the eighteenth century, but its cause was not discovered until 1843, when Dubini, of Milan, found a parasitic, roundworm which inhabits the intestine and which he named *Anchylostoma duodenale.* This worm belongs to the strongyles and is closely related to the 'hookworm,' *Uncinaria vulpis,* described by Frölich in 1789.

It has been thoroughly established that Dubini's hookworm sucks the blood and produces a poison; also that it causes the conditions known under the various names of St. Gothard anemia, miner's anemia, brickmaker's anemia, Egyptian chlorosis, uncinariasis, anchylostomiasis, etc. This disease is known to be very prevalent in tropical countries, but curiously enough no positive case in the United States was recognized as such until 1893, when Dr. Blickman, of St. Louis, found a German who had brought the infection with him from Europe. Dr. Stiles, zoologist of the Public Health and Marine Hospital Service, has maintained for eight or ten years that this disease must be more or less common in the southern portion of this country, and that physicians have undoubtedly confused it with malaria. This view, which he has repeatedly defended before medical and scientific audiences, has been looked upon as extreme and has not been adopted by the American practitioners. Isolated cases of the disease were reported occasionally, but between 1892 and 1902 only about 35 cases were found in the United States, and most of these were imported. Dr. Ashford had, however, shown that the disease is common in Porto Rico. In May, 1902, Dr. Stiles obtained the parasites from three cases which occurred respectively in Virginia, Galveston and Porto Rico, and he showed that they were not identical with the parasite which causes miner's anemia in the Old World. He described this new worm as *Uncinaria americana,* and using Virginia, Galveston and Porto Rico as the three angles of a triangle, he maintained that this area must harbor a more or less common disease caused by the new parasite. In September, 1902, he started out to demonstrate the correctness of this view and in eight weeks time he proved his point.

The extreme and in some cases nonsensical statements made by the daily press have been startling, but not more so than the more serious and conservative statements Dr. Stiles made before the medical society to which he presented his results. The press has, however, misquoted his statements in more than one particular. His results briefly stated are these:

If we go south from Virginia to the gulf we meet two totally different kinds of anemia, which can be distinguished by the soils on which they occur, the parasites which cause them, the symptoms which result, and the treatment which is necessary. One of these anemias follows the more impervious soils such as clay and is due to malaria, which, as is well known, is caused by a minute parasite which lives in the blood and which may be cured by a proper use of quinine. The other anemia, preeminently a disease of the sandy regions, is caused by a parsitic 'hookworm' (*Uncinaria americana*) which lives in the intestine and which is not affected by quinine but can be killed by the use of thymol. These two anemias have heretofore been confused by most physicians, hence this new discovery clears up a matter of great importance from the standpoint of the practising physician, and it is not an exaggeration to state that it means a revolution in the treatment of fully half of the sick people found in the southern sand areas.

One of the most important symptoms of 'hookworm' disease is an extreme lassitude, both mental and physical; this condition is due to the emaciation and to the thin watery character of the blood, which does not properly nourish either the brain or the muscles. Now, curiously enough, it is especially in the sand areas of the south that the poorer whites, known as the 'poor white trash,' are found, and Dr. Stiles, who has been living among these people for a number of weeks, positively states that it is among these people that hookworm disease is especially common and especially severe. He found entire families and entire neighborhoods affected, and owing to the symptoms which the disease causes, he asserts that this malady is very largely responsible for the present condition of these people. He states in fact that if we were to place the strongest class of men and women in the country in the conditions of infection under which these poorer whites are living, they would within a generation or two deteriorate to the same poverty of mind, body and worldly goods, which is proverbial for the 'poor white trash.'

It is true that the poorer whites are found on clay soils as well as on sand, but Dr. Stiles maintains that on clay soil these people are healthier, stronger and more intelligent, hence that they are better fitted for the competition in life, from which the hookworm disease practically excludes the poorer whites of the sand farms. He has further traced families from sand to clay or to the cities and proved their improvement under the new conditions; and conversely he has traced families from clay to sand and proved their deterioration.

An important point claimed in these investigations is that hookworm disease is especially prevalent among children, and that it not only interferes with their school attendance, but that children who are afflicted with the malady and who have gone from sandy districts to a city have the reputation among their teachers of being more or less backward and even stupid in their studies. All this agrees with well-established symptoms of the disease, for it is thoroughly established, not only by Dr. Stiles's investigations, but by observations in Europe and Africa, that hookworm diseases stunts both the physical and the mental development. Dr. Stiles states in fact that he has found patients of twenty to twenty-three years of age who both mentally and physically were not developed beyond the average boy or girl of eleven to sixteen years old.

There are other points in connection with this work, such as the perverted habit of dirt-eating, the presence of the disease among factory hands who formerly lived in the country, the financial loss involved, etc., into which we can not enter here at present. The happiest part of the entire work is that the disease can be easily prevented and that it can be cured. Under these circumstances, we may look for decided improvement among the poorer whites in the sand districts of the south, although this remark is not to be interpreted as meaning that we consider that 'hookworm disease' gives us a complete explanation of all ills in the southern states.

The full report of these investigations will be in the printers' hands this month and will be issued as a bulletin of the Hygienic Laboratory, U. S. Public Health and Marine Hospital Service.

## *CARNEGIE INSTITUTION OF WASHINGTON.*

It is the purpose of the Carnegie Institution of Washington, among other plans, to encourage exceptional talent by appointing a certain number of research assistants.

These positions will not be those commonly known as fellowships or scholarships; nor is the object of this provision to contribute to the payment of mechanical helpers or of assistants in the work of the institution. It is rather to discover and develop, under competent scrutiny and under favorable conditions, such persons as have unusual ability. It is not intended to provide means by which a student may complete his courses of study, nor to give assistance in the preparation of dissertations for academic degrees. Work of a more advanced and special character is expected of all who receive appointment.

The annual emolument will vary according to circumstances. As a rule, it will not exceed $1,000 per annum. No limitations are prescribed as to age, sex, nationality, graduation or residence. Appointments will at first be made for one year, but may be continued.

It is desirable that a person thus appointed should work under the supervision of an investigator who is known to the authorities of the Carnegie Institution to be engaged in an important field of scientific research, and in a place where there is easy access to libraries and apparatus—but there may be exceptions to this.

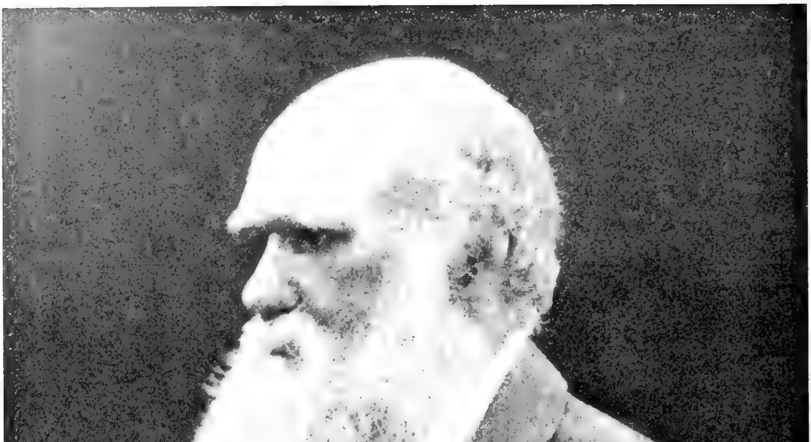
Applications for appointments may be presented by the head of, or by a professor in, an institution of learning, or by the candidate. They should be accompanied by a statement of the qualifications of the candidate, of the research work he has done, and of that which he desires to follow, and of the time for which an allowance is desired. If he has already printed or written anything of interest, a copy of this should be enclosed with the application.

Communications upon this subject should be distinctly marked on the outside envelope, and on the inside, Research Assistant, and should be addressed to the Carnegie Institution of Washington, 1439 K Street, Washington, D. C.

The Carnegie Institution has made a grant to the Marine Biological Laboratory and now has at its disposal twenty tables in the Laboratory at Woods Hole, Mass., for the season of 1903. These tables are intended for the use of persons engaged in original research in biology, and carry with them the right to be furnished with the ordinary supplies and material of the Laboratory. Applications for the use of one of these tables should be addressed to the Secretary of the Carnegie Institution, Washington, D. C., stating the period for which the use of the table is desired, and the general character of the work which the applicant proposes to do.

## *SCIENTIFIC ITEMS.*

Dr. Carroll D. Wright, U. S. Commissioner of Labor, was elected president of the American Association for the Advancement of Science at the recent Washington meeting. The vice-presidents for the sections are: Section A, Mathematics and Astronomy, O. H. Tittmann, U. S. Coast and Geodetic Survey; B, Physics, E. H. Hall, Harvard University; C, Chemistry, W. D. Bancroft, Cornell University; D, Mechanical Science and Engineering, C. M. Woodward, Washington University; E, Geology and Geography, I. C. Russell, University of Michigan; F, Zoology, E. L. Mark, Harvard University; G, Botany, T. H. Macbride, University of Iowa; H, Anthropology, M. H. Saville, American Museum of Natural History; I, Social and Economic Science, S. E. Baldwin, New Haven; K, Physiology and Experimental Medicine, H. P. Bowditch, Harvard University.



# THE POPULAR SCIENCE MONTHLY.

MARCH, 1903.


## HITHERTO UNPUBLISHED LETTERS OF CHARLES DARWIN.*

### To A. R. Wallace.

Down, April 6th, 1859.

I this morning received your pleasant and friendly note of November 30th. The first part of my MS.† is in Murray's hands to see if he likes to publish it. There is no preface, but a short introduction, which must be read by every one who reads my book. The second paragraph in the introduction I have had copied verbatim from my foul copy, and you will, I hope, think that I have fairly noticed your paper in the *Linn. Journal*. You must remember that I am now publishing only an abstract, and I give no references. I shall, of course, allude to your paper on distribution; and I have added that I know from correspondence that your explanation of your law is the same as that which I offer. You are right, that I came to the conclusion that selection was the principle of change from the study of domesticated productions; and then, reading Malthus, I saw at once how to apply this principle. Geographical distribution and geological relations of extinct to recent inhabitants of South America

* 'The Life and Letters of Charles Darwin,' edited by his son, Professor Francis Darwin, and published in this country in 1887 by Messrs. D. Appleton and Company, is not surpassed in interest by any similar records, and for the man of science it is of unparalleled importance. From unused material and additional letters, Professor Francis Darwin and Mr. A. C. Seward have compiled a second series, entitled 'More Letters of Charles Darwin: A record of his work in a series of hitherto unpublished letters,' which will be published shortly in two volumes by Messrs. D. Appleton and Company. By their courtesy we are enabled to print here a number of letters which show the surpassing interest of the work.—Editor.

† 'Origin of Species.'

*Rawlinson pinx.* *Haughton sculp*

*Erasmus Darwin . M.D.*

first led me to the subject: especially the case of the Galapagos Islands. I hope to go to press in the early part of next month. It will be a small volume of about five hundred pages or so. I will of course send you a copy. I forget whether I told you that Hooker, who is our best British botanist and perhaps the best in the world, is a full convert, and is now going immediately to publish his confession of faith; and I expect daily to see proof-sheets. Huxley is changed, and believes in mutation of species: whether a convert to us, I do not quite know. We shall live to see all the younger men converts. My neighbour and an excellent naturalist, J. Lubbock, is an enthusiastic convert. I see that you are doing great work in the Archipelago; and most heartily do I sympathise with you. For God's sake take care of your health. There have been few such noble labourers in the cause of Natural Science as you are.

P. S. You cannot tell how I admire your spirit, in the manner in which you have taken all that was done about publishing all our papers. I had actually written a letter to you, stating that I would not publish anything before you had published. I had not sent that letter to the post when I received one from Lyell and Hooker, urging me to send some MS. to them, and allow them to act as they thought fair and honestly to both of us; and I did so.

To T. H. Huxley.

July 20th [1860].

Many thanks for your pleasant letter. I agree to every word you say about *Fraser* and the *Quarterly*. I have had some really admirable letters from Hopkins. I do not suppose he has ever troubled his head about geographical distribution, classification, morphologies, etc., and it is only those who have that will feel any relief in having some sort of rational explanation of such facts. Is it not grand the way in which the Bishop asserts that all such facts are explained by ideas in God's mind? The *Quarterly* is uncommonly clever; and I chuckled much at the way my grandfather and self are quizzed. I could here and there see Owen's hand. By the way, how comes it that you were not attacked? Does Owen begin to find it more prudent to leave you alone? I would give five shillings to know what tremendous blunder the Bishop made; for I see that a page has been cancelled and a new page gummed in.

I am indeed most thoroughly contented with the progress of opinion. From all that I hear from several quarters, it seems that Oxford did the subject great good. It is of enormous importance the showing the world that a few first-rate men are not afraid of expressing their opinion. I see daily more and more plainly that my unaided book would have done absolutely nothing. Asa Gray is fighting admirably in the United States. He is thorough master of the subject, which cannot be said by any means of such men as even Hopkins.

T. H. HUXLEY.

I have been thinking over what you allude to about a natural history review. I suppose you mean really a *review* and not a journal for original communications in Natural History. Of the latter there is now superabundance. With

ASA GRAY.

J. D. HOOKER.

respect to a good review, there can be no doubt of its value and utility; nevertheless, if not too late, I hope you will consider deliberately before you decide. Remember what a deal of work you have on your shoulders, and though you can do much, yet there is a limit to even the hardest worker's power of working. I should deeply regret to see you sacrificing much time which could be given to original research. I fear, to one who can review as well as you do, there would be the same temptation to waste time, as there notoriously is for those who can speak well.

A review is only temporary; your work should be perennial. I know well that you may say that unless good men will review there will be no good reviews. And this is true. Would you not do more good by an occasional review in some well-established review, than by giving up much time to the editing, or largely aiding, if not editing, a review which from being confined to one subject would not have a very large circulation? But I must return to the chief idea which strikes me—viz., that it would lessen the amount of original and perennial work which you could do. Reflect how few men there are in England who can do original work in the several lines in which you are excellently fitted. Lyell, I remember, on analogous grounds many years ago resolved he would write no more reviews. I am an old slow-coach, and your scheme makes me tremble. God knows in one sense I am about the last man in England who ought to throw cold water on any review in which you would be concerned, as I have so immensely profited by your labours in this line.

With respect to reviewing myself, I never tried: any work of that kind stops me doing anything else, as I cannot possibly work at odds and ends of time. I have, moreover, an insane hatred of stopping my regular current of work. I have now materials for a little paper or two, but I know I shall never work them up. So I will not promise to help; though not to help, if I could, would make me feel very ungrateful to you. You have no idea during how short a time daily I am able to work. If I had any regular duties, like you and Hooker, I should do absolutely nothing in science.

I am heartily glad to hear that you are better; but how such labour as volunteer-soldiering (all honour to you) does not kill you, I cannot understand.

For God's sake remember that your field of labour is original research in the highest and most difficult branches of Natural History. Not that I wish to underrate the importance of clever and solid reviews.

To J. D. Hooker.

Down, Feb. 14th [1860].

I succeeded in persuading myself for twenty-four hours that Huxley's lecture* was a success. Parts were eloquent and good, and all very bold; and I heard strangers say, 'What a good lecture!' I told Huxley so; but I demurred much to the time wasted in introductory remarks, especially to his making it appear that sterility was a clear and manifest distinction of species, and to his not having even alluded

* At the Royal Institution.

to the more important parts of the subject. He said that he had much more written out, but time failed. After conversation with others and more reflection, I must confess that as an exposition of the doctrine the lecture seems to me an entire failure. I thank God I did not think so when I saw Huxley; for he spoke so kindly and magnificently of me, that I could hardly have endured to say what I now think. He gave no just idea of Natural Selection. I have always looked at the doctrine of Natural Selection as an hypothesis, which, if it explained several large classes of facts, would deserve to be ranked as a theory deserving acceptance; and this, of course, is my own opinion. But, as Huxley has never alluded to my explanation of classification, morphology, embryology, etc., I thought he was thoroughly dissatisfied with all this part of my book. But to my joy I find it is not so, and that he agrees with my manner of looking at the subject; only that he rates higher than I do the necessity of Natural Selection being shown to be a *vera causa* always in action. He tells me he is writing a long review in the *Westminster*. It was really provoking how he wasted time over the idea of a species as exemplified in the horse, and over Sir J. Hall's old experiment on marble. Murchison was very civil to me over my book after the lecture, in which he was disappointed. I have quite made up my mind to a savage onslaught; but with Lyell, you, and Huxley, I feel confident we are right, and in the long run shall prevail. I do not think Asa Gray has quite done you justice in the beginning of the review of me. The review seemed to me very good, but I read it very hastily.

To J. D. Hooker.

Down, Nov. 20th [1862].

Your last letter has interested me to an extraordinary degree, and your truly parsonic advice, 'some other wise and discreet person,' etc., etc., amused us not a little. I will put a concrete case to show what I think A. Gray believes about crossing and what I believe. If 1,000 pigeons were bred together in a cage for 10,000 years their number not being allowed to increase by chance killing, then from mutual intercrossing no varieties would arise; but, if each pigeon were a self-fertilising hermaphrodite, a multitude of varieties would arise. This, I believe, is the common effect of crossing, viz., the obliteration of incipient varieties. I do not deny that when two marked varieties have been produced, their crossing will produce a third or more intermediate varieties. Possibly, or probably, with domestic varieties, with a strong tendency to vary, the act of crossing tends to give rise to new characters; and thus a third or more races, not strictly intermediate, may be produced. But there is heavy evidence against new characters arising from crossing wild forms; only intermediate races are then produced. Now, do you agree thus far? if not, it is no use arguing; we must come to swearing, and I am convinced I can swear harder than you, ∴ I am right. Q.E.D.

If the number of 1,000 pigeons were prevented increasing not by chance killing, but by, say, all the shorter-beaked birds being killed, then the *whole* body would come to have longer beaks. Do you agree?

Thirdly, if 1,000 pigeons were kept in a hot country, and another 1,000 in a cold country, and fed on different food, and confined in different-size aviary, and kept constant in number by chance killing, then I should expect as rather probable that after 10,000 years the two bodies would differ slightly in size, colour, and perhaps other trifling characters; this I should call the direct action of physical conditions. By this action I wish to imply that the innate vital forces are somehow led to act rather differently in the two cases, just as heat will allow or cause two elements to combine, which otherwise would not have combined. I should be especially obliged if you would tell me what you think on this head.

But the part of your letter which fairly pitched me head over heels with astonishment, is that where you state that every single difference which we see might have occurred without any selection. I do and have always fully agreed; but you have got right round the subject, and viewed it from an entirely opposite and new side, and when you took me there I was astounded. When I say I agree, I must make the proviso, that under your view, as now, each form long remains adapted to certain fixed conditions, and that the conditions of life are in the long run changeable; and second, which is more important, that each individual form is a self-fertilising hermaphrodite, so that each hair-breadth variation is not lost by intercrossing. Your manner of putting the case would be even more striking than it is if the mind could grapple with such numbers—it is grappling with eternity—think of each of a thousand seeds bringing forth its plant, and then each a thousand. A globe stretching to the furthest fixed star would very soon be covered. I cannot even grapple with the idea, even with races of dogs, cattle, pigeons, or fowls; and here all admit and see the accurate strictness of your illustration.

Such men as you and Lyell thinking that I make too much of a Deus of Natural Selection is a conclusive argument against me. Yet I hardly know how I could have put in, in all parts of my book, stronger sentences. The title, as you once pointed out, might have been better. No one ever objects to agriculturists using the strongest language about their selection, yet every breeder knows that he does not produce the modification which he selects. My enormous difficulty for years was to understand adaptation, and this made me, I cannot but think, rightly, insist so much on Natural Selection. God forgive me for writing at such length; but you cannot tell how much your letter has interested me, and how important it is for me with my present book in hand to try and get clear ideas. Do think a bit about what is meant by direct action of physical conditions. I do not mean whether they act; my facts will throw some light on this. I am collecting all cases of bud-variations, in contradistinction to seed-variations (do you like this term, for what some gardeners call 'sports'?); these eliminate all effects of crossing. Pray remember how much I value your opinion as the clearest and most original I ever get.

I see plainly that *Welwitschia* will be a case of Barnacles.

I have another plant to beg, but I write on separate paper as more convenient for you to keep. I meant to have said before, as an excuse for asking for so much from Kew, that I have now lost *two* seasons, by accursed nurserymen not having right plants, and sending me the wrong instead of saying that they did not possess.

### To J. D. Hooker.

Freshwater, Isle of Wight, July 28th [1868].

I am glad to hear that you are going to touch on the statement that the belief in Natural Selection is passing away. I do not suppose that even the *Athenæum* would pretend that the belief in the common descent of species is passing away, and this is the more important point. This now almost universal belief in the evolution (somehow) of species, I think may be fairly attributed in large part to the *Origin.* It would be well for you to look at the short Introduction of Owen's *Anat. of Invertebrates,* and see how fully he admits the descent of species.

Of the *Origin,* four English editions, one or two American, two French, two German, one Dutch, one Italian, and several (as I was told) Russian editions. The translations of my book on *Variation under Domestication* are the results of the *Origin;* and of these two English, one American, one German, one French, one Italian, and one Russian have appeared, or will soon appear. Ernst Häckel wrote to me a week or two ago, that new discussions and reviews of the *Origin* are continually still coming out in Germany, where the interest on the subject certainly does not diminish. I have seen some of these discussions, and they are good ones. I apprehend that the interest on the subject has not died out in North America, from observing in Professor and Mrs. Agassiz's Book on Brazil how excessively anxious he is to destroy me. In regard to this country, every one can judge for himself, but you would not say interest was dying out if you were to look at the last number of the *Anthropological Review,* in which I am incessantly sneered at. I think Lyell's *Principles* will produce a considerable effect. I hope I have given you the sort of information which you want. My head is rather unsteady, which makes my handwriting worse than usual.

If you argue about the non-acceptance of Natural Selection, it seems to me a very striking fact that the Newtonian theory of gravitation, which seems to every one now so certain and plain, was rejected by a man so extraordinarily able as Leibnitz. The truth will not penetrate a preoccupied mind.

Wallace, in the *Westminster Review,* in an article on Protection has a good passage, contrasting the success of Natural Selection and its growth with the comprehension of new classes of facts, with false theories, such as the Quinarian Theory, and that of Polarity, by poor Forbes, both of which were promulgated with high advantages and the first temporarily accepted.

To C. Lyell.

15, Marine Parade, Eastbourne, Oct. 3rd [1860].

Your last letter has interested me much in many ways.

I enclose a letter of Wyman's which touches on brains. Wyman is mistaken in supposing that I did not know that the Cave-rat was an American form; I made special enquiries. He does not know that the eye of the Tucutuco was carefully dissected.

With respect to reviews by A. Gray. I thought of sending the Dialogue to the *Saturday Review* in a week's time or so, as they have lately discussed Design. I have sent the second, or August, *Atlantic* article to the *Annals and Mag. of Nat. History.* The copy which you have I want to send to Pictet, as I told A. Gray I would, thinking from what he said he would like this to be done. I doubt whether it would be possible to get the October number reprinted in this country; so that I am in no hurry at all for this.

I had a letter a few weeks ago from Symonds on the imperfection of the Geological Record, less clear and forcible than I expected. I answered him at length and very civilly, though I could hardly make out what he was driving at. He spoke about you in a way which it did me good to read.

I am extremely glad that you like A. Gray's reviews. How generous and unselfish he has been in all his labour! Are you not struck by his metaphors and similes? I have told him he is a poet and not a lawyer.

I should altogether doubt on turtles being converted into land tortoises on any one island. Remember how closely similar tortoises are on all continents, as well as islands; they must have all descended from one ancient progenitor, including the gigantic tortoise of the Himalaya.

I think you must be cautious in not running the convenient doctrine that only one species out of very many ever varies. Reflect on such cases as the fauna and flora of Europe, North America, and Japan, which are so similar, and yet which have a great majority of their species either specifically distinct, or forming well-marked races. We must in such cases incline to the belief that a multitude of species were once identically the same in all the three countries when under a warmer climate and more in connection; and have varied in all the three countries. I am inclined to believe that almost every species (as we see with nearly all our domestic productions) varies sufficiently for Natural Selection to pick out and accumulate new specific differences, under new organic and inorganic conditions of life, whenever a place is open in the polity of nature. But looking to a long lapse of time and to the whole world, or to large parts of the world, I believe only one or a few species of each large genus ultimately becomes victorious, and leaves modified descendants. To give an imaginary instance: the jay has become modified in the three countries into (I believe) three or four species; but the jay genus is not, apparently, so dominant a group as the crows; and in the long run probably all the jays will be exterminated and be replaced perhaps by some modified crows.

I merely give this illustration to show what seems to me probable.

But oh! what work there is before we shall understand the genealogy of organic beings!

With respect to the *Apteryx,* I know not enough of anatomy; but ask Dr. F. whether the clavicle, etc., do not give attachment to some of the muscles of respiration. If my views are at all correct, the wing of the *Apteryx* cannot be (p. 452 of the *Origin*) a nascent organ, as these wings are useless. I dare not trust to memory, but I know I found the whole sternum always reduced in size in all the fancy and confined pigeons relatively to the same bones in the wild Rock-pigeon: the keel was generally still further reduced relatively to the reduced length of the sternum; but in some breeds it was in a most anomalous manner more prominent. I have got a lot of facts on the reduction of the organs of flight in the pigeon, which took me weeks to work out, and which Huxley thought curious.

I am utterly ashamed, and groan over my handwriting. It was 'Natural Preservation.' Natural persecution is what the author ought to suffer. It rejoices me that you do not object to the term. Hooker made the same remark that it ought to have been 'Variation and Natural Selection.' Yet with domestic productions, when selection is spoken of, variation is always implied. But I entirely agree with your and Hooker's remark.

Have you begun regularly to write your book on the antiquity of man?

I do *not* agree with your remark that I make Natural Selection do too much work. You will perhaps reply that every man rides his hobby-horse to death; and that I am in the galloping state.

### To C. Lyell.

Torquay, Aug. 21st [1861].

I am pleased that you approve of Hutton's review. It seemed to me to take a more philosophical view of the manner of judging the question than any other review. The sentence you quote from it seems very true, but I do not agree with the theological conclusion. I think he quotes from Asa Gray, certainly not from me; but I have neither A. Gray nor *Origin* with me. Indeed, I have over and over again said in the *Origin* that Natural Selection does nothing without variability; I have given a whole chapter on laws, and used the strongest language how ignorant we are on these laws. But I agree that I have somehow (Hooker says it is owing to my title) not made the great and manifest importance of previous variability plain enough. Breeders constantly speak of Selection as the one great means of improvement; but of course they imply individual differences, and this I should have thought would have been obvious to all in Natural Selection; but it has not been so.

I have just said that I cannot agree with 'which variations are the effects of an unknown law, ordained and guided without doubt by an intelligent cause on a preconceived and definite plan.' Will you honestly tell me (and I should be really much obliged) whether you believe that the shape of my nose (eheu!) was ordained and 'guided by an intelligent cause?' By the selection of analogous and less differences fanciers make almost generic differences in their pigeons; and can you see any good reason why the Natural Selection of analogous individual differences should not make new species? If you say that God ordained that at some time and place a dozen slight variations should arise, and that one of them alone should be preserved in the struggle for life and the other eleven should perish in the first or few first generations, then the saying seems to me mere verbiage. It comes to merely saying that everything that is, is ordained.

Let me add another sentence. Why should you or I speak of variation as having been ordained and guided, more than does an astronomer, in discussing the fall of a meteoric stone? He would simply say that it was drawn to our earth by the attraction of gravity, having been displaced in its course by the action of some quite unknown laws. Would you have him say that its fall at some particular place and time was 'ordained and guided without doubt by an intelligent cause on a preconceived and definite plan?' Would you not call this theological pedantry or display? I believe it is not pedantry in the case of species, simply because their formation has hitherto been viewed as beyond law; in fact, this branch of science is still with most people under its theological phase of development. The conclusion which I always come to after thinking of such questions is that they are beyond the human intellect; and the less one thinks on them the better. You may say, Then why trouble me? But I should very much like to know clearly what you think.

### To Asa Gray.

Down, Nov. 29th [1859].

This shall be such an extraordinary note as you have never received from me, for it shall not contain one single question or request. I thank you for your impression on my views. Every criticism from a good man is of value to me. What you hint at generally is very, very true: that my work will be grievously hypothetical, and large parts by no means worthy of being called induction, my commonest error being probably induction from too few facts. I had not thought of your objection of my using the term 'natural selection' as an agent. I use it much as a geologist does the word denudation—for an agent, expressing the result of several combined actions. I will take care to explain, not merely by inference, what I mean by the term; for I must use it, otherwise I should incessantly have to expand it into some such (here miserably expressed) formula as the following: "The tendency to the preservation (owing to the severe struggle for life to which all organic beings at some time or generation are exposed) of any, the slightest, variation in any part, which is of the slightest use or favourable to the life of the individual which has thus varied; together with the tendency to its inheritance." Any variation, which was of no use whatever to the individual, would not be preserved by this process of 'natural selection.' But I will not weary you by going on, as I do not suppose I could make my meaning clearer without large expansion. I will only add one other sentence: several varieties of sheep have been turned out together on the Cumberland mountains, and one particular breed is found to succeed so much better than all the others that it fairly starves the others to death. I should here say that natural selection picks out this breed, and would tend to improve it, or aboriginally to have formed it. . . .

You speak of species not having any material base to rest on, but is this any greater hardship than deciding what deserves to be called a variety, and be designated by a Greek letter? When I was at systematic work I know I longed to have no other difficulty (great enough) than deciding whether the form was distinct enough to deserve a name, and not to be haunted with undefined and unanswerable questions whether it was a true species. What a jump it is from a well-marked variety, produced by natural cause, to a species produced by the separate act of the hand of God! But I am running on foolishly. By the way, I met the other day Phillips, the palæontologist, and he asked me, 'How do you define a species?' I answered, 'I can not.' Whereupon he said, 'At last I have found out the only true definition—any form which has ever had a specific name! . . .'

### To Asa Gray.

Down, June 8th [1860].

I have to thank you for two notes, one through Hooker, and one with some letters to be posted, which was done. I anticipated your request by making a few remarks on Owen's review. Hooker is so weary of reviews that I do not think you will get any hints from him. I have lately had many more 'kicks than halfpence.' A review in the last Dublin *Nat. Hist. Review* is the most unfair thing which has appeared,—one mass of misrepresentation. It is evidently by Haughton, the geologist, chemist and mathematician. It shows immeasurable conceit and contempt of all who are not mathematicians. He discusses bees' cells, and puts a series which I have never alluded to, and wholly ignores the intermediate comb of *Melipona,* which alone led me to my notions. The article is a curiosity of unfairness and arrogance; but, as he sneers at Malthus, I am content, for it is clear he can not reason. He is a friend of Harvey, with whom I have had some correspondence. Your article has clearly, as he admits, influenced him. He admits to a certain extent Natural Selection, yet I am sure does not understand me. It is strange that very few do, and I am become quite convinced that I must be an extremely bad explainer. To recur for a moment to Owen: he grossly misrepresents and is very unfair to Huxley. You say that you think the article must be by a pupil of Owen; but no one fact tells so strongly against Owen, considering his former position at the College of Surgeons, as that he has never reared one pupil or follower. In the number just out of *Fraser's Magazine* there is an article or review on Lamarck and me by W. Hopkins, the mathematician, who, like Haughton, despises the reasoning power of all naturalists. Personally he is extremely kind towards me; but he evidently in the following number means to blow me into atoms. He does not in the least appreciate the difference in my views and Lamarck's, as explaining adaptation, the principle of divergence, the increase of dominant groups, and the almost necessary extinction of the less dominant and smaller groups, etc.

To Asa Gray.

Down, July 23rd [1862].

I received several days ago two large packets, but have as yet read only your letter; for we have been in fearful distress, and I could attend to nothing. Our poor boy had the rare case of second rash and sore throat . . .; and, as if this was not enough, a most serious attack of erysipelas, with typhoid symptoms. I despaired of his life; but this evening he has eaten one mouthful, and I think has passed the crisis. He has lived on port wine every three-quarters of an hour, day and night. This evening, to our astonishment, he asked whether his stamps were safe, and I told him of one sent by you, and that he should see it to-morrow. He answered, 'I should awfully like to see it now'; so with difficulty he opened his eyelids and glanced at it, and, with a sigh of satisfaction, said, 'All right.' Children are one's greatest happiness, but often and often a still greater misery. A man of science ought to have none—perhaps not a wife; for then there would be nothing in this wide world worth caring for, and a man might (whether he could is another question) work away like a Trojan. I hope in a few days to get my brains in order, and then I will pick out all your orchid letters, and return them in hopes of your making use of them. . . .

Of all the carpenters for knocking the right nail on the head, you are the very best; no one else has perceived that my chief interest in my orchid book has been that it was a 'flank movement' on the enemy. I live in such solitude that I hear nothing, and have no idea to what you allude about Bentham and the orchids and species. But I must enquire.

By the way, one of my chief enemies (the sole one who has annoyed me), namely Owen, I hear has been lecturing on birds; and admits that all have descended from one, and advances as his own idea that the oceanic wingless birds have lost their wings by gradual disuse. He never alludes to me, or only with bitter sneers, and coupled with Buffon and the *Vestiges*.

Well, it has been an amusement to me this first evening, scribbling as egotistically as usual about myself and my doings; so you must forgive me, as I know well your kind heart will do. I have managed to skim the newspaper, but had not heart to read all the bloody details. Good God! what will the end be? Perhaps we are too despondent here; but I must think you are too hopeful on your side of the water. I never believed the 'canards' of the army of the Potomac having capitulated. My good dear wife and self are come to wish for peace at any price. Good night, my good friend. I will scribble on no more.

One more word. I should like to hear what you think about what I say in the last chapter of the orchid book on the meaning and cause of the endless diversity of means for the same general purpose. It bears on design, that endless question. Good night, good night!

## To J. D. Dana.

Down, Dec. 5th, 1849.

I have not for some years been so much pleased as I have just been by reading your most able discussion on coral reefs. I thank you most sincerely for the very honourable mention you make of me. This day I heard that the atlas has arrived, and this completes your munificent present to me. I have not yet come to the chapter on subsidence, and in that I fancy we shall disagree, but in the descriptive part our agreement has been eminently satisfactory to me, and far more than I ever ventured to anticipate. I consider that now the subsidence theory is established. I have read about half through the descriptive part of the *Volcanic Geology* (last night I ascended the peaks of Tahiti with you, and what I saw in my short excursion was most vividly brought before me by your descriptions), and have been most deeply interested by it. Your observations on the Sandwich craters strike me as the most important and original of any that I have read for a long time. Now that I have read yours, I believe I saw at the Galapagos, at a distance, instances of those most curious fissures of eruption. There are many points of resemblance between the Galapagos and Sandwich Islands (even to the shape of the mound-like hills)—viz., in the liquidity of the lavas, absence of scoriæ, and tuff-craters, Many of your scattered remarks on denudation have particularly interested me; but I see that you attribute less to sea and more to running water than I have been accustomed to do. After your remarks in your last very kind letter I could not help skipping on to the Australian valleys, on which your remarks strike me as exceedingly ingenious and novel, but they have not converted me. I can not conceive how the great lateral bays could have been scooped out, and their sides rendered precipitous by running water. I shall go on and read every word of your excellent volume.

If you look over my *Geological Instructions* you will be amused to see that I urge attention to several points which you have elaborately discussed. I lately read a paper of yours on Chambers' book, and was interested by it. I really believe the facts of the order described by Chambers, in S. America, which I have described in my Geolog. volume. This leads me to ask you (as I can not doubt that you will have much geological weight in N. America) to look to a discussion at p. 135 in that volume on the importance of subsidence to the formation of deposits, which are to last to a distant age. This view strikes me as of some importance.

When I meet a very good-natured man I have that degree of badness of disposition in me that I always endeavour to take advantage of him; therefore I am going to mention some desiderata, which if you can supply I shall be very grateful, but if not no answer will be required.

Thank you for your *Conspectus Crust.*, but I am sorry to say I am not worthy of it, though I have always thought the Crustacea a beautiful subject.

To J. D. Dana.

Down, July 30th (1860).

I received several weeks ago your note telling me that you could not visit England, which I sincerely regretted, as I should most heartily have liked to have made your personal acquaintance. You gave me an improved, but not very good, account of your health. I should at some time be grateful for a line to tell me how you are. We have had a miserable summer, owing to a terribly long and severe illness of my eldest girl, who improves slightly but is still in a precarious condition. I have been able to do nothing in science of late. My kind friend Asa Gray often writes to me and tells me of the warm discussions on the *Origin of Species* in the United States. Whenever you are strong enough to read it, I know you will be dead against me, but I know equally well that your opposition will be liberal and philosophical. And this is a good deal more than I can say of all my opponents in this country. I have not yet seen Agassiz's attack, but I hope to find it at home when I return in a few days, for I have been for several weeks away from home on my daughter's account. Prof. Silliman sent me an extremely kind message by Asa Gray that your Journal would be open to a reply by me. I cannot decide till I see it, but on principle I have resolved to avoid answering anything, as it consumes much time, often temper, and I have said my say in the *Origin*. No one person understands my views and has defended them so well as A. Gray, though he does not by any means go all the way with me. There was much discussion on the subject at the British Association at Oxford, and I had many defenders, and my side seems (for I was not there) almost to have got the best of the battle. Your correspondent and my neighbour, J. Lubbock, goes on working at such spare time as he has.

This is an egotistical note, but I have not seen a naturalist for months. Most sincerely and deeply do I hope that this note may find you almost recovered.

### To A. Hyatt.

Down, Dec. 4th, 1872.

I thank you sincerely for your most interesting letter. You refer much too modestly to your own knowledge and judgment, as you are much better fitted to throw light on your own difficult problems than I am.

It has quite annoyed me that I do not clearly understand yours and Prof. Cope's views; and the fault lies in some slight degree, I think, with Prof. Cope, who does not write very clearly. I think I now understand the terms 'acceleration' and 'retardation'; but will you grudge the trouble of telling me, by the aid of the following illustration, whether I do understand rightly? When a fresh-water decapod crustacean is born with an almost mature structure, and therefore does not pass, like other decapods, through the Zoea stage, is this not a case of acceleration? Again, if an imaginary decapod retained, when adult, many Zoea characters, would this not be case of retardation? If these illustrations are correct, I can perceive why I have been so dull in understanding your views. I looked for something else, being familiar with such cases, and classing them in my own mind as simply due to the obliteration of certain larval or embryonic stages. This obliteration I imagined resulted sometimes entirely from that law of inheritance to which you allude; but that it in many cases was aided by Natural Selection, as I inferred from such cases occurring so frequently in terrestrial and fresh-water members of groups, which retain their several embryonic stages in the sea, as long as fitting conditions are present.

Another cause of my misunderstanding was the assumption that in your series

a—ab—abd—ae,<br>
ad

the differences between the successive species, expressed by the terminal letter, was due to acceleration: now, if I understand rightly, this is not the case; and such characters must have been independently acquired by some means.

The two newest and most interesting points in your letter (and in, as far as I think, your former paper) seem to me to be about senile characteristics in one species appearing in succeeding species during maturity; and secondly about certain degraded characters appearing in the last species of a series. You ask for my opinion: I can only send the conjectured impressions which have occurred to me and which are not worth writing. (It ought to be known whether the senile character appears before or after the period of active reproduction.) I should be inclined to attribute the character in both your cases to the laws of growth and descent, secondarily to Natural Selection. It has been an error on my part, and a misfortune to me, that I did not largely discuss what I mean by laws of growth at an early period in some of my books. I have said something on this head in two new chapters in the last edition of the *Origin.* I should be happy to send you a copy of this edition, if you do not possess it and care to have it. A man in extreme old age differs much from a young man, and I presume every one would account for this by failing powers of growth. On the other hand the skulls of some mammals go on altering during maturity into advancing years; as do the horns of the stag, the tail-feathers of some birds, the size of fishes, etc.; and all such differences I should attribute simply to the laws of growth, as long as full vigour was retained. Endless other changes of structure in successive species may, I believe, be accounted for by various complex laws of growth. Now, any change of character thus induced with advancing years in the individual might easily be inherited at an earlier age than that at which it first supervened, and thus become characteristic of the mature species; or again, such changes would be apt to follow from variation, independently of inheritance, under proper conditions. Therefore I should expect that characters of this kind would often appear in later-formed species without the aid of Natural Selection, or with its aid if the characters were of any advantage. The longer I live, the more I become convinced how ignorant we are of the extent to which all sorts of structures are serviceable to each species. But that characters supervening during maturity in one species should appear so regularly, as you state to be the case, in succeeding species, seems to me very surprising and inexplicable.

With respect to degradation in species towards the close of a series, I have nothing to say, except that before I arrived at the end of your letter, it occurred to me that the earlier and simpler ammonites must have been well adapted to their conditions, and that when the species were verging towards extinction (owing probably to the presence of some more successful competitors) they would naturally become re-adapted to simpler conditions. Before I had read your final remarks I thought also that unfavourable conditions might cause, through the law of growth, aided perhaps by reversion, degradation of character. No doubt many new laws remain to be discovered. Permit me to add that I have never been so foolish as to imagine that I have succeeded in doing more than to lay down some of the broad outlines of the origin of species.

After long reflection I cannot avoid the conviction that no innate tendency to progressive development exists, as is now held by so many able naturalists, and perhaps by yourself. It is curious how seldom writers define what they mean by progressive development; but this is a point which I have briefly discussed in the *Origin.* I earnestly hope that you may visit Hilgendorf's famous deposit. Have you seen Weismann's pamphlet *Einfluss der Isolirung,* Leipzig, 1872? He makes splendid use of Hilgendorf's admirable observations. I have no strength to spare, being much out of health; otherwise I would have endeavoured to have made this letter better worth sending. I most sincerely wish you success in your valuable and difficult researches.

I have received, and thank you, for your three pamphlets. As far as I can judge, your views seem very probable; but what a fearfully intricate subject is this of the succession of ammonites.

To B. D. Walsh.

Down, Dec. 4th [1864].

I have been greatly interested by your account of your American life. What an extraordinary and self-contained life you have led! and what vigour of mind you must possess to follow science with so much ardour after all that you have undergone! I am very much obliged to you for your pamphlet on Geographical Distribution, on Agassiz, etc. I am delighted at the manner in which you have bearded this lion in his den. I agree most entirely with all that you have written. What I meant when I wrote to Agassiz to thank him for a bundle of his publications, was exactly what you suppose. I confess, however, I did not fully perceive how he had misstated my views; but I only skimmed through his *Methods of Study,* and thought it a very poor book. I am so much accustomed to be utterly misrepresented that it hardly excites my attention. But you really have hit the nail on the head capitally. All the younger good naturalists whom I know think of Agassiz as you do; but he did grand service about glaciers and fish. About the succession of forms, Pictet has given up his whole views, and no geologist now agrees with Agassiz. I am glad that you have attacked Dana's wild notions; [though] I have a great respect for Dana. . . . If you have an opportunity, read in *Trans. Linn. Soc.* Bates on 'Mimetic Lepidoptera of Amazons.' I was delighted with his paper.

I have got a notice of your views about the female *Cynips* inserted in the *Natural History Review:* whether the notice will be favourable, I do not know; but anyhow it will call attention to your views. . . .

As you allude in your paper to the believers in change of species, you will be glad to hear that very many of the very best men are coming round in Germany. I have lately heard of Häckel, Gegenbauer, F.

Müller, Leuckart, Claparède, Alex. Braun, Schleiden, etc. So it is, I hear, with the younger Frenchmen.

To C. V. Riley.

Down, June 1st [1871].

I received some little time ago your report on noxious insects, and have now read the whole with the greatest interest. There are a vast number of facts and generalisations of value to me, and I am struck with admiration at your powers of observation.

The discussion on mimetic insects seems to me particularly good and original. Pray accept my cordial thanks for the instruction and interest which I have received.

What a loss to Natural Science our poor mutual friend Walsh has been; it is a loss ever to be deplored. . . .

Your country is far ahead of ours in some respects; our Parliament would think any man mad who should propose to appoint a State Entomologist.

To E. S. Morse.

Down, Oct. 21st, 1879.

Although you are so kind as to tell me not to write, I must just thank you for the proofs of your paper,* which has interested me greatly. The increase in the number of ridges in the three species of *Arca* seems to be a very noteworthy fact, as does the increase of size in so many, yet not all, the species. What a constant state of fluctuation the whole organic world seems to be in! It is interesting to hear that everywhere the first change apparently is in the proportional numbers of the species. I was much struck with the fact in the upraised shells of Coquimbo, in Chili, as mentioned in my *Geological Observations on South America.*

Of all the wonders in the world, the progress of Japan, in which you have been aiding, seems to me about the most wonderful.

To A. Agassiz.

Down, May 5th, 1881.

It was very good of you to write to me from Tortugas, as I always feel much interested in hearing what you are about, and in reading your many discoveries. It is a surprising fact that the peninsula of Florida should have remained at the same level for the immense period requisite for the accumulation of so vast a pile of débris.

You will have seen Mr. Murray's views on the formation of atolls and barrier reefs. Before publishing my book, I thought long over the same view, but only as far as ordinary marine organisms are concerned, for at that time little was known of the multitude of minute

* 'The Shell Mounds of Omori.'

oceanic organisms. I rejected this view, as from the few dredgings made in the *Beagle* in the S. Temperate regions, I concluded that shells, the smaller corals, etc., etc., decayed and were dissolved when not protected by the deposition of sediment; and sediment could not accumulate in the open ocean. Certainly shells, etc., were in several cases completely rotten, and crumbled into mud between my fingers; but you will know well whether this is in any degree common. I have expressly said that a bank at the proper depth would give rise to an atoll, which could not be distinguished from one formed during subsidence. I can, however, hardly believe, in the former presence of as many banks (there having been no subsidence) as there are atolls in the great oceans, within a reasonable depth, on which minute oceanic organisms could have accumulated to the thickness of many hundred feet. I think that it has been shown that the oscillations from great waves extend down to a considerable depth, and if so the oscillating water would tend to lift up (according to an old doctrine propounded by Playfair) minute particles lying at the bottom, and allow them to be slowly drifted away from the submarine bank by the slightest current. Lastly, I can not understand Mr. Murray, who admits that small calcareous organisms are dissolved by the carbonic acid in the water at great depths, and that coral reefs, etc., etc., are likewise dissolved near the surface, but that this does not occur at intermediate depths, where he believes that the minute oceanic calcareous organisms accumulate until the bank reaches within the reef-building depth. But I suppose that I must have misunderstood him.

Pray forgive me for troubling you at such length, but it has occurred to me that you might be disposed to give, after your wide experience, your judgment. If I am wrong, the sooner I am knocked on the head and annihilated so much the better. It still seems to me a marvelous thing that there should not have been much and long-continued subsidence in the beds of the great oceans. I wish that some doubly rich millionaire would take it into his head to have borings made in some of the Pacific and Indian atolls, and bring home cores for slicing from a depth of 500 or 600 feet.

TO MRS. EMILY TALBOT, BOSTON.

DOWN, July 19th, [1881?].

In response to your wish, I have much pleasure in expressing the interest which I feel in your proposed investigation on the mental and bodily development of infants. Very little is at present accurately known on this subject, and I believe that isolated observations will add but little to our knowledge, whereas tabulated results from a very large number of observations, systematically made, would probably throw much light on the sequence and period of development of the several faculties. This knowledge would probably give a foundation for some improvement in our education of young children, and would show us whether the system ought to be followed in all cases.

I will venture to specify a few points of inquiry which, as it seems to me, possess some scientific interest. For instance, does the education of the parents influence the mental powers of their children at any age, either at a very early or somewhat more advanced stage? This could perhaps be learned by schoolmasters and mistresses if a large number of children were first classed according to age and their mental attainments, and afterwards in accordance with the education of their parents, as far as this could be discovered. As observation is one of the earliest faculties developed in young children, and as this power would probably be exercised in an equal degree by the children of educated and uneducated persons, it seems not impossible that any transmitted effect from education could be displayed only at a somewhat advanced age. It would be desirable to test statistically, in a similar manner, the truth of the oft-repeated statement that coloured children at first learn as quickly as white children, but that they afterwards fall off in progress. If it could be proved that education acts not only on the individual, but, by transmission, on the race, this would be a great encouragement to all working on this all-important subject. It is well known that children sometimes exhibit, at a very early age, strong special tastes, for which no cause can be assigned, although occasionally they may be accounted for by reversion to the taste or occupation of some progenitor; and it would be interesting to learn how far such early tastes are persistent and influence the future career of the individual. In some instances such tastes die away without apparently leaving any after effect, but it would be desirable to know how far this is commonly the case, as we should then know whether it were important to direct as far as this is possible the early tastes of our children. It may be more beneficial that a child should follow energetically some pursuit, of however trifling a nature, and thus acquire perseverance, than that he should be turned from it because of no future advantage to him. I will mention one other small point of inquiry in relation to very young children, which may possibly prove important with respect to the origin of language; but it could be investigated only by persons possessing an accurate musical ear. Children, even before they can articulate, express some of their feelings and desires by noises uttered in different notes. For instance, they make an interrogative noise, and others of assent and dissent, in different tones; and it would, I think, be worth while to ascertain whether there is any uniformity in different children in the pitch of their voices under various frames of mind.

I fear that this letter can be of no use to you, but it will serve to show my sympathy and good wishes in your researches.

To A. R. Wallace.

Down, April 29th [1867].

I have been greatly interested by your letter, but your view is not new to me. If you will look at p. 240 of the fourth edition of the *Origin* you will find it very briefly given with two extreme examples of the peacock and black grouse. A more general statement is given at p. 101, or at p. 89 of the first edition, for I have long entertained this view, though I have never had space to develop it. But I had not sufficient knowledge to generalise as far as you do about colouring and nesting. In your paper perhaps you will just allude to my scanty remark in the fourth edition, because in my Essay on Man I intend to discuss the whole subject of sexual selection, explaining as I believe it does much with respect to man. I have collected all my old notes, and partly written my discussion, and it would be flat work for me to give the leading idea as exclusively from you. But, as I am sure from your greater knowledge of Ornithology and Entomology that you will write a much better discussion than I could, your paper will be of great use to me. Nevertheless I must discuss the subject fully in my Essay on Man. When we met at the Zoological Society, and I asked you about the sexual differences in kingfishers, I had this subject in view; as I had when I suggested to Bates the difficulty about gaudy caterpillars, which you have so admirably (as I believe it will prove) explained. I have got one capital case (genus forgotten) of a [Australian] bird in which the female has long tail-plumes, and which consequently builds a different nest from all her allies. With respect to certain female birds being more brightly coloured than the males, and the latter incubating, I have gone a little into the subject, and can not say that I am fully satisfied. I remember mentioning to you the case of *Rhynchœa,* but its nesting seems unknown. In some other cases the difference in brightness seemed to me hardly sufficiently accounted for by the principle of protection. At the Falkland Islands there is a carrion hawk in which the female (as I ascertained by dissection) is the brightest coloured, and I doubt whether protection will here apply; but I wrote several months ago to the Falklands to make enquiries. The conclusion to which I have been leaning is that in some of these abnormal cases the colour happened to vary in the female alone, and was transmitted to females alone, and that her variations have been selected through the admiration of the male.

It is a very interesting subject, but I shall not be able to go on with it for the next five or six months, as I am fully employed in correcting dull proof-sheets. When I return to the work I shall find it much better done by you than I could have succeeded in doing.

It is curious how we hit on the same ideas. I have endeavoured to show in my MS. discussion that nearly the same principles account for young birds not being gaily coloured in many cases, but this is too complex a point for a note.

On reading over your letter again, and on further reflection, I do not think (as far as I remember my words) that I expressed myself nearly strongly enough on the value and beauty of your generalisation, viz., that all birds in which the female is conspicuously or brightly coloured build in holes or under domes. I thought that this was the explanation in many, perhaps most cases, but do not think I should ever have extended my view to your generalisation. Forgive me troubling you with this P.S.

To A. R. Wallace.

Down, May 5th [1867].

The offer of your valuable notes is most generous, but it would vex me to take so much from you, as it is certain that you could work up the subject very much better than I could. Therefore I earnestly, and without any reservation, hope that you will proceed with your paper, so that I return your notes. You seem already to have well investigated the subject. I confess on receiving your note that I felt rather flat at my recent work being almost thrown away, but I did not intend to show this feeling. As a proof how little advance I had made on the subject, I may mention that though I had been collecting facts on the colouring, and other sexual differences in mammals, your explanation with respect to the females had not occurred to me. I am surprised at my own stupidity, but I have long recognised how much clearer and deeper your insight into matters is than mine. I do not know how far you have attended to the laws of inheritance, so what follows may be obvious to you. I have begun my discussion on sexual selection by showing that new characters often appear in one sex and are transmitted to that sex alone, and that from some unknown cause such characters apparently appear oftener in the male than in the female. Secondly, characters may be developed and be confined to the male, and long afterwards be transferred to the female. Thirdly, characters may arise in either sex and be transmitted to both sexes, either in an equal or unequal degree. In this latter case I have supposed that the survival of the fittest has come into play with female birds and kept the female dull-coloured. With respect to the absence of spurs in the female gallinaceous birds, I presume that they would be in the way during incubation; at least I have got the case of a German breed of fowls in which the hens were spurred, and were found to disturb and break their eggs much. With respect to the females of deer not having horns, I presume it is to save the loss of organised matter. In your note you speak of sexual selection and protection as sufficient to account for the colouring of all animals, but it seems to me doubtful how far this will come into play with some of the lower animals, such as sea anemones, some corals, etc., etc. On the other hand Häckel has recently well shown that the transparency and absence of colour in the lower oceanic animals, belonging to the most different classes, may be well accounted for on the principle of protection.

Some time or other I should like much to know where your paper on the nests of birds has appeared, and I shall be extremely anxious to read your paper in the *Westminster Review.* Your paper on the sexual colouring of birds will, I have no doubt, be very striking. Forgive me, if you can, for a touch of illiberality about your paper.

To Aug. Weismann.

Down, Feb. 29th, 1872.

I am rejoiced to hear that your eyesight is somewhat better; but I fear that work with the microscope is still out of your power. I have often thought with sincere sympathy how much you must have suffered from your grand line of embryological research having been stopped. It was very good of you to use your eyes in writing to me. I have just received your essay; but as I am now staying in London for the sake of rest, and as German is at all times very difficult to me, I shall not be able to read your essay for some little time. I am, however, very curious to learn what you have to say on isolation and on periods of variation. I thought much about isolation when I wrote in Chapter IV. on the circumstances favourable to Natural Selection. No doubt there remains an immense deal of work to do on 'Artbildung.' I have only opened a path for others to enter, and in the course of time to make a broad and clear high-road. I am especially glad that you are turning your attention to sexual selection. I have in this country hardly found any naturalists who agree with me on this subject, even to a moderate extent. They think it absurd that a female bird should be able to appreciate the splendid plumage of the male; but it would take much to persuade me that the peacock does not spread his gorgeous tail in the presence of the female in order to fascinate or excite her. The case, no doubt, is much more difficult with insects. I fear that you will find it difficult to experiment on diurnal lepidoptera in confinement, for I have never heard of any of these breeding in this state. I was extremely pleased at hearing from Fritz Müller that he liked my chapter on lepidoptera in the *Descent of Man* more than any other part, excepting the chapter on morals.

To T. H. Huxley.

Worthing, Sept. 9th, 1881.

We have been paying Mr. Rich* a little visit, and he has often spoken of you, and I think he enjoyed much your and Mrs. Huxley's visit here. But my object in writing now is to tell you something, which I am very doubtful whether it is worth while for you to hear, because it is uncertain. My brother Erasmus has left me half his fortune, which is very considerable. Therefore, I thought myself bound to tell Mr. Rich of this, stating the large amount, as far as the executors as yet know it roughly. I then added that my wife and self thought that, under these new circumstances, he was most fully justified in altering his will and leaving his property in some other way. I begged him to take a week to consider what I had told him, and then by letter to inform me of the result. But he would not, however, hardly allow me to finish what I had to say, and expressed a firm determination not to alter his will, adding that I had five sons to provide for. After a short pause he implied (but unfortunately he here became very confused and forgot a word, which on subsequent reflection I think was probably 'reversionary')—he implied that there was a chance, whether good or bad I know not, of his becoming possessed of some other property, and he finished by saying distinctly, 'I will bequeath this to Huxley.' What the amount may be (I fear not large), and what the chance may be, God only knows; and one can not cross-examine a man about his will. He did not bind me to secrecy, so I think I am justified in telling you what passed, but whether it is wise on my part to send so vague a story, I am not at all sure; but as a general rule it is best to tell everything. As I know that you hate writing letters, do not trouble yourself to answer this.

P. S.—On further reflection I should like to hear that you receive this note safely. I have used up all my black-edged paper.

To Anthony Rich.

Down, Feb. 4th, 1882.

It is always a pleasure to me to receive a letter from you. I am very sorry to hear that you have been more troubled than usual with your old complaint. Any one who looked at you would think that you

* Anthony Rich (1804?–1891). Educated at Caius College, Cambridge, of which he was afterwards an Honorary Fellow. Author of *Illustrated Companion to the Latin Dictionary and Greek Lexicon*, 1849, said to be a useful book on classical antiquities. Mr. Darwin made his acquaintance in a curious way—namely, by Mr. Rich writing to inform him that he intended to leave him his fortune, in token of his admiration for his work. Mr. Rich was the survivor, but left his property to Mr. Darwin's children, with the exception of his house at Worthing, bequeathed to Mr. Huxley.

had passed through life with few evils, and yet you have had an unusual amount of suffering. As a turnkey remarked in one of Dickens' novels, 'Life is a rum thing.' As for myself, I have been better than usual until about a fortnight ago, when I had a cough, and this pulled me down and made me miserable to a strange degree; but my dear old wife insisted on my taking quinine, and, though I have very little faith in medicine, this, I think, has done me much good. Well, we are both so old that we must expect some troubles: I shall be seventy-three on Feb. 12th. I have been glad to hear about the pine-leaves, and you are the first man who has confirmed my account that they are drawn in by the base, with a very few exceptions. With respect to your Wandsworth case, I think that if I had heard of it before publishing, I would have said nothing about the ledges; for the Grisedale case, mentioned in my book and observed whilst I was correcting the proof-sheets, made me feel rather doubtful. Yet the Corniche case shows that worms at least aid in making the ledges. Nevertheless, I wish I had said nothing about the confounded ledges. The success of this worm book has been almost laughable. I have, however, been plagued with an endless stream of letters on the subject; most of them very foolish and enthusiastic, but some containing good facts, which I have used in correcting yesterday the 'sixth Thousand.'

Your friend George's work about the viscous state of the earth and tides and the moon has lately been attracting much attention, and all the great judges think highly of the work. He intends to try for the Plumian Professorship of Mathematics and Natural Philosophy at Cambridge, which is a good and honourable post of about £800 a year. I think that he will get it when Challis is dead, and he is very near his end. He has all the great men—Sir W. Thomson, Adams, Stokes, etc.—on his side. He has lately been chief examiner for the Mathematical Tripos, which was tremendous work; and the day before yesterday he started for Southampton for a five-weeks' tour to Jamaica for complete rest, to see the Blue Mountains, and escape the rigour of the early spring. I believe that George will some day be a great scientific swell. The War Office has just offered Leonard a post in the Government Survey at Southampton, and very civilly told him to go down and inspect the place, and accept or not as he liked. So he went down, but has decided that it would not be worth his while to accept, as it would entail his giving up his expedition (on which he had been ordered) to Queensland, in Australia, to observe the Transit of Venus. Dear old William at Southampton has not been very well, but is now better. He has had too much work—a willing horse is always overworked—and all the arrangements for receiving the British Association there this summer have been thrown on his shoulders.

But good Heavens! what a deal I have written about my sons. I have had some hard work this autumn with the microscope; but this is over, and I have only to write out the papers for the Linnean Society. We have had a good many visitors; but none who would have interested you, except perhaps Mrs. Ritchie, the daughter of Thackeray, who is a most amusing and pleasant person. I have not seen Huxley for some time, but my wife heard this morning from Mrs. Huxley, who wrote from her bed, with a bad account of herself and several of her children; but none, I hope, are at all dangerously ill. Farewell, my kind, good friend.

Many thanks about the picture, which if I survive you, and this I do not expect, shall be hung in my study as a perpetual memento of you.*

* Charles Darwin died on April 19, 1882, in his seventy-fourth year.

# THE VIENNA ACADEMY OF SCIENCE.

By EDWARD F. WILLIAMS,

CHICAGO, ILL.

EARLY in the fifteenth century scholars on the continent of Europe began to discuss questions in little companies out of which grew what are now known as academies of science. At first these societies were made up of thoughtful men who met to compare their ideas on questions and discoveries which were exciting universal interest. The Academia Pontaniana in Naples was organized in 1433; the Academia Platonica in Florence in 1474. The proceedings in these academies were for the most part open to the public, and the work accomplished through them became the means of the formation of the academies of science, which, in most of the capitals of Europe, have filled so prominent a place the past century and have done so much to utilize and spread abroad historical, philosophical and scientific knowledge.

The history and the work of one of these academies, that in Vienna, will, it is believed, be of interest.

A private academy, the Literaria Sodalitas Danubia, started in Ofen in 1490 by Konrad Pickle, a Frenchman known as Celtes, was moved to Vienna in 1497, where it received into its membership philosophers, jurists, doctors of medicine and privy councillors. Its prime object was declared to be to broaden out 'the Humanism' of the time. It continued to prosper while Celtes was its directing spirit, but after his death in 1508 its influence gradually declined.

Early in the eighteenth century Leibnitz was anxious that an academy should be established in the Austrian capital, similar to the one which in 1700 he had persuaded the King of Prussia to organize in Berlin.

The central position of Vienna, the prestige of the Austrian government and the low estate into which universities all over Europe had fallen led him to visit the city and seek aid from those in authority in carrying out his project. Although his plans received favorable attention, wars with the Turks, opposition from Roman Catholics, especially from the Jesuits, and the difficulty of obtaining means for the support of an academy prevented their execution. Still Leibnitz persisted in urging his plans, and on his fifth visit in 1712 began to be confident that the greatly needed academy would soon be organized. His death the following year led to the abandonment of the project for the time. A Leipzig professor, by the name of Gottsched, in 1749 sought to revive the plan of Leibnitz, but although courteously received nothing came from his efforts. He wanted to be a professor in the university and president of the academy, but the fact that he was a protestant undoubtedly stood in his way. Still others than he were interested in the establishment of an academy. A plan presented by Baron von Petrasch in 1746 at the request of Count Haugnitz was laid before the government in 1750 and carefully considered. Under the terms science and the fine arts it proposed to cover the whole field of knowledge. Nothing came of this effort nor of another put forth in 1774, perhaps because the government feared the influence of the union of men so prominent for learning and ability, and perhaps because it did not see whence the means for its support were to come. The project for an Academy was not taken up again in earnest till 1837, when twelve men met in Vienna to talk the matter over. They recognized and emphasized the fact that in most of the large cities on the continent academies had been founded not only to the benefit of their members but to the credit of the cities in which they had their seat. Patriotism, they insisted, required the union of the scholarship of Vienna in an academy as a channel of communication with the learned world. As all who met to discuss the formation of an academy were of one mind as to its necessity, they formulated a plan of work, suggested means for its support and signed a petition to the government for its immediate organization. A small stamp tax on certain articles and the right of the academy to publish a calendar would, they thought, produce the necessary funds. The petition was seriously discussed. Men high in office, of noble birth and near the emperor were in favor of granting the request. The plan now presented was compared with that drawn up in 1750. Public sentiment as represented by the learned class was tested. The professors in the university were asked for their opinion. Some thought there were already too many institutions in the city and that there was neither room nor place for another. The medical faculty as a whole was not in favor of an academy. Some thought its work could not fail to come into conflict with that of the university. But the dean of the faculty of arts, Professor J. J. von Luttrow, wrote that the two could not come into conflict, that a university is a place for imparting knowledge already acquired and tested, while an academy seeks to increase knowledge by investigations and discoveries and furnishes a place where scientific men may compare their theories, criticize them and weigh carefully and judicially the evidence upon which they have been formed. For years the discussions about the forming of an academy continued. The matter was referred, in May, 1838, to a special commission formed by the court. This commission reported favorably in June of the following year. Nothing however was really done till 1847, although several commissions had meanwhile been appointed and without exception had reported that they looked upon the project of an academy with approval. Tired of waiting the movements of the government, a private academy was organized in January, 1846. Its members favored an academy with two classes, historical philosophical, and mathematical scientific, and did their work along these lines. When the petition for the formation of an academy reached the prime minister, Metternich, he simply said that it was unnecessary as he had long since determined to found an academy and had secured a plan for it. From its discussions he proposed to exclude theology, literature, politics and ethics, and limit them to the subjects connected with positive science. In presenting his plan to the emperor, which received his approval, the minister said that the conservatism of the academy would counteract prevailing disturbances in thought, especially in politics, and furnish a center around which monarchical ideas would crystallize. It was decided that a prince of the reigning house should be curator, that the president should be a nobleman, that there should be 48 active members, as many corresponding members, and one public meeting a year; that the cost should be borne by the government, but must be limited to 40,000 gulden annually; that for each of the two classes a secretary should be chosen, to whom, with the dean and the president, small salaries should be paid, but that ordinary members should receive nothing, inasmuch as many of them, professors in the university and in other offices, were already in the service of the government. Final and favorable action was taken in November, 1847, though the formation of the academy had been officially announced in May of that year. The Academy consisted of 40 active members, 18 of them resident in Vienna, the others representing various sections of the realm. Many reasons prevented the curator, Archduke John, from issuing a call for the meeting of the academy till February, 1848. It had been agreed that in addition to the forty members named by the emperor out of the lists furnished him, these forty should have the privilege of choosing eight more members and, subject to the emperor's approval, of electing its president, its secretaries and its dean. The cost of printing the papers presented to the academy was to be met by the government, but to the request that these papers be free from police supervision a negative answer was returned. This was in the revolutionary year 1848. The day after the request for freedom of publication had been denied a mob gathered in Vienna, the emperor surrendered his absolute power and granted the academy the liberty it desired. He also permitted the academy to increase its membership, by 12 in each class, and to elect an equal number of corresponding members. Though providing amply for the study of history and philosophy, the first place was given to science. Hammer Purgstall was chosen the first president. "An academy," said he, "is a union of spiritual forces for the advance of knowledge in its highest development and power. It does not busy itself with the instruction of youth but with protecting and stimulating men of learning. It is a sort of judgment seat to which scientific attainments are brought and at which their real value is appraised.''

Though hesitating so long over the establishment of an academy, having permitted its organization, the government did not fail to favor it in every possible way and to provide handsomely for its support. Rooms were set aside for its sessions and its work, in the Polytechnic Institute. Since 1857, it has had a home of its own in a building long used as barracks for soldiers, but designed, according to tradition, by the Empress Maria Theresa for the academy which she herself intended to found. Here the general secretary resides, and as the building is very large, several scientific societies have courteously been granted shelter. The correspondence of the members of the academy within the realm goes free. Save in the summer months, sessions are held every week and, with the exception of a single meeting each month, the different sections of the academy meet by themselves. The proceedings of the meetings fill many volumes and form a collection of scientific, historical, philosophical and archeological papers of almost inestimable value. Twenty-four active members now reside in Vienna. Strangers properly introduced are permitted to attend the sessions of the academy, though none of these sessions are open to women.

The means at the disposal of the academy, though they cannot be given with absolute accuracy, are for an institution of the kind quite large. They make it clear that its members have the confidence of the public and that the work they are doing appeals to men of wealth and lovers of learning. From the sale of an almanac which contains brief reports of the proceedings of the academy the profits are not inconsiderable. Extraordinary grants from the government and gifts from rich men have from time to time been made for special purposes. That infirm officers of the academy may receive pensions, since 1898 the government has given 50,000 gulden annually, instead of the 40,000 previously received. To this sum are added 20,000 gulden for printing, and 7,000 gulden to each class for pressing needs. Property left to the academy for prizes, or to be used in any way which in the judgment of its members will increase knowledge and promote its diffusion, now produces a large income. Since 1890, Prince John of Lichtenstein has given 5,000 gulden annually for excavations in Asia Minor, and since 1900 has doubled the amount.

Experience has convinced the academy that the giving of prizes is not the best way to use money. Only such are awarded as are made necessary by the terms of a bequest. The offer of prizes, it is affirmed, only stimulates a man who has work in hand to complete it, but rarely induces one to begin new work or to enter upon investigations which may result in important discoveries and valuable additions to human knowledge. So far as possible the income of the academy, which is now between forty and fifty thousand dollars a year from its own funds, is employed in subventions, to aid in printing important treatises, for travel, for excavations or special work. A brief reference to what has been accomplished will justify the demands of the friends of the academy for its establishment. It has provided for the publication of the 'Corpus Scriptorum Ecclesiasticarum Rerum' in many volumes and of many volumes of reports of the excavations of the prehistoric commission for whose work it furnished the means. It has nearly completed the petrographic study of the central chain of the Eastern Alps, and has made a map of the region. In 1894 it joined in an international enterprise to discover the weight of the earth. In 1897 it sent, at a cost of more than 20,000 gulden, an expedition to Bombay to study the bubonic plague. Its bacillus was discovered, but the young man in charge of the expedition lost his life. In 1898 and 1899, it had a commission at work in southern Arabia, and on the island of Socotra. In 1897 it completed deep sea soundings in the Mediterranean, especially in what is called the Adriatic Sea. In 1899 it sent a double expedition to India to study meteors and the eclipse and in 1891 it sent a botanic expedition to Brazil. The results of all these expeditions and of others almost as important have been carefully edited and given to the world through the press.

In 1901 36 annual 'advertisers' had appeared and 49 'almanacs.' These were filled with information not elsewhere to be obtained. At that time the philosophical class had published 48 volumes of works prepared under its direction and 141 volumes of 'Proceedings.' The scientific class had published 68 volumes of special treatises and 108 volumes of 'Proceedings.' Five parts of the 'Report of the Prehistoric Commission' had also appeared. For twenty years and more monthly reports of the condition of chemistry in Europe and throughout the world have been printed and circulated. Of the 'Archives for Austrian History' 88 volumes have appeared, of the 'Sources (Fontes) for Austrian Affairs,' 8 volumes in the First Part, 51 in the Second Part; of 'Announcements from the National Archives,' 2 volumes, of the 'Monumenta Concilliorum,' 2 volumes, and 4 volumes of Part III. Of the 'Hapsburg Memorials,' divisions two and three of Vol. I. have been printed and one part of Vol. II. Ten volumes of the 'Tables of Codices' have appeared, three of the 'Venetian Dispatches' and the second division of Vol. II.

The Academy claims to have suggested and obtained the appointment of a committee to consider the sources of Indian lexicography; to investigate the condition of the Corpus Scriptorum of Oriental knowledge; to look after Grecian grave inscriptions and to create a commission for the study of oceanography. It shares with the Berlin Academy and with the academies of Munich, Göttingen and Leipzig in the preparation of a Latin dictionary. The work is done in Munich and on a scale which may require twenty years to complete. Together with the academies of Munich, Göttingen and Leipzig, it has carried through and nearly completed an 'Encyclopedia of Mathematics and Related Knowledge,' and has agreed to join with them in the future in any work which ought to be undertaken, but which is too large for the resources of a single academy. It joined the international association of academies in 1900, and is taking part in the publication of the international catalogue of scientific literature. Statements by the secretary of what was done during the year 1899–1900 show the great place the academy now fills. The Prehistoric Commission, he says, continued its investigations at Töplitz near Krain, and discovered in graves which had never been opened many articles belonging to a prehistoric race. The work is nearly complete and full reports of it will soon be published. Successful efforts have been made to obtain a complete collection of objects needed for the 'Phonographic Archives' of the academy. The third part has been published of the report of the Austrian Plague Commission on the morphology and biology of the bacillus, and on the means to be used for the disinfection of man and beast and their future protection against danger from this source. A report of the visit to India to photograph meteors and observe the eclipse has been printed. Opportunity was taken during this visit to secure measurements of the intensity of the sun's heat and to collect twenty specimens of orchids. The petrographic survey of the Alps has been continued and provision made for publishing part A of Vol. VI. of the 'Mathematical Encyclopedia.' The material is in hand for nearly all the work. The Earthquake Commission has made observations in Istria and Dalmatia, in Krain and Görz. The number of earthquakes studied is 190, in the previous year 209. Reports from several hundred meteorological stations have been received and tabulated for use not only in the study of meteorology but for the study of terrestrial magnetism.

Under the patronage of the 'historical class' of the academy important publications have been brought out on the early history of Austria-Hungary. Some new historical facts have been discovered during the year. Work on the edition of the Latin church fathers has continued, and the writings of Arnobius Minor have been worked over by J. Schnarnagl, those of Cæsar Arelatorius by G. Morris, those of Prudentius by J. Bergmann. It is hoped to get these writings into such shape as to make them valuable. The collection of manuscripts belonging to the library, through the aid of other libraries and by purchase, has been greatly increased. As the result of an archeological journey to Permesos in Pisidia nine graves, differing in type from any yet opened, were carefully examined. Vol. I. of this report has now been published.

The Academy is trying to obtain for its 'Phonographic Archives': (1) Exact representations of the sounds of European languages and dialects at the beginning of the twentieth century, (2) representations of the best musical accomplishments of the present time and of the musical productions of peoples of different degrees of culture as a basis for comparison, (3) representations of the tones of the voices of distinguished men. These tones the phonograph will preserve. The results of the expedition to southern Arabia and Socotra will soon appear in a large number of volumes, giving an account of reptiles, fishes, insects, lepidoptera, diptera, coleoptera, neuroptera, etc. The gains for linguistics and epigraphy are said to be very great.

The study of the results of the commission to India to gather information in regard to the cause of the bubonic plague has discovered its bacillus and made it possible to prevent the spread of the plague in the future. An essay on 'Die Porcia von Socotra,' published by the academy, has pointed out the possible relation of this Porcia to the Portia of Shakespeare. Several tales current among the people of Socotra and on the coast were carefully written down and will not only show how stories of this character travel from country to country, but will add to our knowledge of folk-lore. Work which promises to be of importance has been done in the study of the syntax and philology of the Slavic languages, and several publications have appeared on the political history and philosophy of the Slavic peoples. The Academy is attempting to investigate and study accurately the history, archeology, philology and ethnology of the entire Balkan peninsula.

The archeological work of the academy proved to be of such importance and extent that a special society was formed to carry it forward. Explorations in Ephesus were made in 1897, preliminary reports of which have appeared, and also of work done in Cilicia. In the spring of 1898 measurements were made in Luxor, Egypt, to determine the influence of winter climate on atmospheric electricity, in Siberia to discover the influence of extreme cold, and in a balloon at the height of 4,000 meters. The Academy has taken part with the German academies in preparing an Encyclopedia of Mohammedanism and it shares with the academies of Berlin and Munich the income of the Savigny bequest for the study of Law, German and Roman, and the law of all nations. The subventions, which cover almost every department of scientific research, and those made for historical and philosophical purposes, over fifty in number, now exceed in amount 75,000 florins annually. They indicate an activity in research equaled by no other academy save that of Berlin on the continent and are producing results in which the members of the academy may justly take great pride.

In closing this brief account of what a single academy of science on the continent of Europe has done, it may not be out of place to add that, as the work of the academy has expanded, other societies, chiefly scientific or archeological, have grown out of it, thus proving it to be, as was predicted long before its formation that it would be, the mother of scientific and historical learning in Austria. The academy in Buda Pesth has larger resources of its own than the Vienna Academy and has pushed its work with untiring zeal. Barriers of language render the results of its work less accessible than those of the German academies. Two academies in Prague, one for the Germans of the city and of Bohemia, and one for the Czechs, both under the protection of the government and in receipt of grants from it year by year, have done excellent work, but on a smaller scale than at Vienna. Of lesser academies in various cities in the empire, or of learned societies it is unnecessary to speak, inasmuch as the Vienna Academy is the model which, so far as possible, all of them try to follow.

# MENTAL AND MORAL HEREDITY IN ROYALTY, VIII.

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## *Evidence from Lehr's Genealogy.*

If there is any one still unconvinced that heredity is by far the most important of all causes leading to high mental activity resulting in what we call eminence or distinction, he need only carefully study the great book of pedigrees compiled by Paul Ernst Lehr. If he will follow these charts of relationship and, at the same time, use any general biographical dictionary, he will find how seldom has distinction, as judged by achievements, fallen to those not close blood relations of others of the same stamp. And this consanguinity of distinction is in spite of the varying degrees of education and opportunity that must have been presented to these different princes even when living in the same age or the same family. If we find, as we do on certain pages of the book, great barren regions containing dozens of titles of the highest social rank, the bearers of which lived in different countries and eras, there is no reason to suppose that these undistinguished princes did not average just as much opportunity as the average of dozens on some other page where clustered together are the names of those whose achievements have been the themes of biographers and historians.

For instance, there does not seem to be any reason why the kings and princes of Denmark should not have averaged just about the same opportunity as the princes of Prussia; education of varying degrees of perfection, stirring times and chances to display ability in war and government fell to the lot of a certain number in each country, certainly to no more in Prussia than in Denmark, yet Denmark is barren of genius, and Prussia at the same time is full of it. At that time not only do we find great men and women in Prussia, but also their relations in Brunswick and Sweden, engaged in vigorous activity, while the princes of nine tenths of the other countries of Europe are doing nothing really worthy of any mention at all, although education and events must certainly be favorable to a great many of them.

It is not that education is of no moment, for it must be, as we all know, of conspicuous influence in mental development. Even those 'self-made' men who have had no education worth mentioning in the ordinary sense of the word, have nevertheless educated themselves by observation and experience. It is not that education is of no moment, but it must be that the determining factor in the production of the more important man, is not his education or his opportunities, but the inherent desire for knowledge and power that makes him *seek* an education in one way or another, while the mediocre man is not willing to have more thrust upon him than his native attention can stand.

Lehr's 'Genealogy' is a book compiled for purely heraldric purposes and traces to the twelfth degree of remoteness eight of the principal reigning families of northern Europe. Since in going back twelve generations every person has 4,096 ancestral quarterings, the total value of the material brought together in this way is $8 \times 4{,}096 = 32{,}768$, an immense field for the study of heredity. Owing to intermarriages the total number of different persons is considerably less than this, being 3,312, but it makes no difference from the standpoint of science whether we repeat the same person several times in the pedigree or whether another of the same characteristics is introduced in his stead, the scientific value of this book is represented by the larger number, 32,768. This is of course ignoring the possibility that inbreeding of itself creates a different value for the stock; but since inbreeding in these families is never very close, and since it is the best scientific opinion that inbreeding *per se* as usually carried on among human beings is of no consequence, other things being equal,* this error, if it be one, may be neglected.

A group of 32,768 persons, such as we have in the pages of Lehr, possesses several peculiar advantages for the study of the origin of genius. First, it is gathered together in an entirely impersonal way, Lehr having no scientific theory in view. Second, it contains also mediocrities, so that we may see how many times mediocrity has produced its like before any genius appears. Third, the exact relationship of every person to every other person is known, and the pedigrees are perfectly complete. Fourth, nearly all are of royal or noble birth, very few being below the rank of a count, so that although their environments are very different, their social position is always much the same.

Among all these 3,312 I found only sixteen worthy of the nine or ten grades here employed. These are given in the list below, the word (new) being appended to those whose immediate ancestry is devoid of others of equal intellectual worth.

1. (new) Anhalt: Catherine II., Empress of Russia.

    Catherine must be considered as a 'sport' in more than the popular use of the term, since her ancestry was in no way remarkable. She did not leave any descendants nearly as capable as herself.

2. Brunswick: Amelia, Duchess of Saxe-Weimar.

    'Distinguished patron of genius and learning.' Friend of Goethe. She was an excellent student, in which she showed 'wonderful perseverance' and also composed considerable music. Amelia was a niece of Frederick the Great and consequently closely related to about a dozen of the most brilliant of modern royalty.

* Conf. Huth, 'Marriage of Near Kin.' 8vo. London, 1887.

3. Castile: Isabella, the Catholic, wife of Ferdinand of Aragon.
Isabella was probably a reversion due to the remarkable and repeated inbreeding from John of Gaunt, Duke of Lancaster and John the Great of Portugal. Her illustrious descendants were numerous. Among others may be mentioned the emperor Charles Quint, Don John of Austria and Alexander Farnese.
4. Coligny: Caspard, the great admiral.
The great admiral was the product of the union of the Colignys with the Montmorencys when both families possessed illustrious names. He also left great descendants (Maurice of Nassau and others).
5. Henriette: poetess, a grand niece of the admiral.
6. (new) Douglas: Archibald Earl of Angus.
Not a conspicuous example of heredity. His son Gavin was distinguished as a poet.
7. (new) Egmont: Lamoral, –1558.
Had two sons of some distinction.
8. Hanau: Amelia, married William V. of Hesse-Cassel.
As regent, 'extraordinary energy, wisdom and virtue.' William the Silent, the illustrious founder of the Dutch Republic, had thirty-two grandchildren, four of whom were distinguished. Amelia was one of these four.
9. Hohenzollern: Frederick William, the Great Elector of Brandenburg.
True founder of the eminence of the Hohenzollerns and greatest man in Germany in his day. He was one of the numerous great grandchildren of William the Silent.
10. Lorraine: René II., Duke of, –1508.
Defeated Charles the Bold. Mother was a daughter of René, Duke of Aragon (distinguished).
11. Lorraine: Claude, first Duke of Guise, son of the above. He served in the army with distinction at Marignano and other places, and was created Duke of Guise by Francis I. His fame was exceeded by his son, Francis, who became 'one of the greatest commanders of his time,' and also by his grandson, Henry, the bitter opponent of the Protestants.
12. (new) Orange: William the Silent, illustrious founder of the Dutch Republic. Sprang from comparatively mediocre stock, but his genius was wonderfully well perpetuated owing to his remarkably brilliant alliances.
13. Palatine: Sophia, Electress of Hanover, an undoubted example of hereditary talent, owing to her many brilliant relations, and one of the connecting links between the genius in the families of Orange and Hohenzollern.
14. Parthenay: Catherine, Vicomtesse de Rohan, –1631.
"A spirited and gifted French lady, was a Huguenot. She distinguished herself at the siege of La Rochelle in 1627, and later published some poems." The famous Duke of Rohan was her son. He was called 'the perfect captain,' also wrote valuable memoirs and a treatise on war. The father and aunt were both distinguished.
15. (new) Romanhof: Peter the Great of Russia.
It is a question whether Peter is to be regarded as a new variation or a reversion to his great grandfather, Feodor, who was the greatest man in Russia in his day. His only other very brilliant relation was Sophia, his half sister.

16. (new) Vasa: Gustavus I., illustrious founder of the dynasty. Certainly a new variation. Genius amply inherited in Gustavus Adolphus and others.

These are all the great names found among 3,312. All the quotations are taken from Lippincott's 'Dictionary,' so the work has an entirely impersonal basis. In considering the remaining, 3,296, who, as far as Lippincott's great dictionary is concerned, have left no lives worthy of distinguished merit, we gain an insight into the rarity of such men and women as the Great Elector of Brandenburg or Catherine Parthenay. What of these 3,296? Can it be possible that, living in the highest social position as they did, a very large majority of them did not have abundant opportunities to exercise ability had they been the possessors of it.

What is to be said on the side of heredity? It will be seen that at least seven of these sixteen numbers (2, 4, 5, 8, 9, 12, 13) belong in what may be called the great main mountain chain of royalty, composed of the families Condé, Coligny, Montmorency, Orange, Palatine and Hohenzollern, whose course can be traced from Anne de Montmorency 1493–1562, as far as one generation beyond Frederick the Great in the beginning of the nineteenth century.

Of the other nine, Catherine II. of Russia, alone gives no striking proof of heredity. It is examples of this sort that should be most frequent were environment the main cause. Since wars have been going on during most of the period covered in this book, and since the majority of princes have had positions in the army and cabinet, and have been given fair educations, and since the effects of environment must have been mostly questions of chance, apart from family influence, there does not seem to be any reason why environment should group the great ones together in any way except as regards time or place. But these sixteen are not grouped as regards time or place, but are scattered over the centuries and in various countries. If more than ninety per cent. of them are compatible with all that can be expected from heredity, and the chances are tremendously against such an occurrence owing to the large preponderance of mediocrity, then we must conclude that heredity is far more important than environment in the causation of the above facts.

About half the number are new variations. This is pretty well in line with results in the study of genius in general. That is, the vast horde of mediocrities is just about as likely to produce a great man as the relatively small number of great are likely to perpetuate their own kind. The reason why genius for war and government was maintained through more generations than scientific or literary genius ever has been is probably simply this: leading families in science and art do not in general intermarry in the way that these great governing families have done. Some exceptions to this may occur, as among the descendants of Jonathan Edwards and the famous musician, Bach, but in these cases the mental qualities were perpetuated.

In the lower forms of animal life we know by actual experimentation that slight changes in the environment occasion the greatest difference in results, still in spite of the strange modifications that may be occasioned in the developing fish or frog by external mechanical or chemical means, the question resolves itself under ordinary conditions to the nature of the primary germ-cells.

If a naturalist were stocking two tanks, one for fishes and one for frogs, and had eggs of both to use for that purpose, the first practical question for him would be—which are the eggs of fishes and which are the eggs of frogs?

It is just so in the development of the human mind. As far as the practical results are concerned, the one bit of knowledge, the possession of which will best enable us to predict the fully developed adult, is an answer to the same sort of question as that we would first wish to know in the case of the fishes and the frogs. What is the nature of the primary germ-cells? Since for obvious reasons we can not know this nature, the next best thing to know is its theoretical probabilities as derived from a proper study of the ancestry.

It would seem from the facts here studied that the probabilities will be roughly as given below. Quality possessed by entire ancestry is almost sure to appear. Quality possessed by one parent and half the ancestry is likely to appear with almost equal force, in one out of every two descendants. Quality possessed by one parent only, and not present in the ancestry, has one chance in about four for its appearance in the progeny. Quality not possessed by either parent, but present in all the grandparents and most of the remaining ancestry, would also have about one chance in two for its appearance in one of the children. If only one of the great grandparents possessed the quality in question, then the chances of its appearance in any one of the grandchildren of this ancestor would be only about one chance in sixteen. It would be, however, very unlikely that some of the remote ancestry had not also the quality in question, so the chances would be raised in a greater or less degree according to the proportionate amount of this remote influence.

There does not seem to be the least reason for assuming that the male side is any more or less potent than the female side in the transmission of family characteristics, nor does there seem to be any grounds for the fancied belief that sons tend to resemble their mothers and daughters their fathers, or the more generally accepted scientific belief to the contrary. No figures have been compiled on this subject because it has seemed to the author to be profitless in view of the approximate equality of the instances *pro* and *con*.

The above estimates for the characteristics of offspring are in accordance with Galton's law of ancestral heredity, except that provision is made for the fact that *mental and moral qualities do not freely blend, so that a child is apt to 'take after' pretty completely some one of his ancestors, more often the near one, less and less often the remote one,* until the chances of reversion to a very distant one are exceedingly slight.

Once in a large number of times occurs one of those fortuitous* combinations of ancestral qualities that is destined to make a person inheriting them vary much from any of his kind, and in fortunate instances shine as a genius, springing from a mediocre stock. The figures drawn from Lehr's 'Genealogy' were about one in five hundred for this sort of occurrence.

At this point it may be well to consider a popular misconception concerning the value of hereditary influence—a mistake very frequently made. Many people argue that great geniuses, coming as they frequently do from humble families, Franklin and Lincoln for instance, discount our belief in mental heredity; when, on the other hand, these men should only strengthen our reliance in this same force. We should consider the thousands, indeed millions, of mediocrities, who have to be born from mediocrities, before one mind of the type of Franklin's is produced.

That they rise superior to their circumstances is in itself a proof of the inborn nature of their minds and characters. A man of this sort represesents just the combination of the best from many ancestors. It would be possible in a great many throws to cast a large number of dice so that they would all fall aces. But here in certain regions of royalty as among the Montmorencys and Hohenzollerns where the dice are loaded, such a result may be expected in a large percentage of throws.

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* It is to be remembered that when we speak of chance as a cause of the combinations of characteristics, that even the throwing of dice or pitching of pennies is entirely subject to the laws of mathematics, as has been abundantly proved by experiments. (Conf., K. Pearson, 'Chances of Death,' etc.)

# HIGH-GRADE MEN: IN COLLEGE AND OUT.

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THE American college graduate has often been called upon to face the accusation of impracticability. From time to time men of wide influence and broad experience have censured not only his ideals, but his fitness for participation in those affairs which count for most in a modern civilization. The burden of their complaint is that he is a dreamer of dreams, not a doer of deeds, and that there is little place for him in the strenuous competition of the life of to-day. Such accusations are gradually becoming less and less frequent. Enough has been written upon the subject to prove the general falsity of the position, and no further defense is needed of college men as a class. It can not, however, be denied that as individuals college graduates meet, with very different degrees of perfection, the demands of life. Some take first rank in their chosen callings; others see their efforts crowned only with moderate success, while another, and we believe a smaller class, make partial or total shipwreck of their hopes. But this differentiation and stratification which is so noticeable in the struggle for honors in the various competitions of business and professional life was equally true for them during their undergraduate courses. In the student body of every institution of learning we find the high-grade men, the moderate successes, from the standpoint of college education, and the rear guard. A question of no little importance, and one with which the present paper deals is this: Is the high-grade man of his college days high-grade still when put to the severer tests of active life? Is the level to which he rose or sank in competition for college honors his level for life, or is there a general shifting of strata for the changed conditions? The answer to these questions is of broad educational significance. It has to do with ideals: those of the college and of life. The high-grade man in college has realized most nearly the ideal of his alma mater. He is its best product according to its criterion of success and is given its highest stamp of approval. If he fails in life, it means that judged by another criterion—that of society in its broadest sense—he is not a success; that the two criteria are different, based upon different ideals, and, as a corollary, since life is the final test, that the college ideal is not a practical one and that the aim of higher academic education is false. If, however, he holds first place in life, as he did in the preparation for it, we must conclude that the two ideals, that of the college and that of the civilization of which it forms a part, are coincident; that, in terms of the ultimate test, the college ideal is a good one.

The present study is an attempt to follow the subsequent careers of high-grade college men in order to determine their evaluation by the world at large. It presupposes two criteria, each of which must be arbitrarily chosen, one for high grade or success in college, and the other for achievement of the same character in after life. As the former criterion, I have taken membership in Phi Beta Kappa, the honorary, college Greek letter fraternity; as the latter, mention in 'Who's Who in America' the annual biographical cyclopedia published in Chicago.

There can be, I believe, little question as to the validity of the first criterion. Election to Phi Beta Kappa is based upon marks given in course, only the high-grade men (and women) being admitted, and so far as I know, no complaint has ever been made as to the justice of election on this basis. There are at present fifty chapters of the fraternity in the colleges and universities of our country. Only students matriculated for the bachelor's degree are elected and of the entire membership 85 per cent. or more have received it in arts; the remainder in science or philosophy. This eliminates from our study the professional, technical and graduate schools and reduces it practically to the academic institutions of higher grade: in fact, the typical American college whose *raison d'être* has been more boldly questioned than has almost any other part of our educational machinery. The percentage of graduates elected to Phi Beta Kappa by the different chapters varies, being as low as 8 per cent. for Harvard and as high as 33 per cent. for several other colleges, with an average of about 16 per cent., or one graduate in six, for the whole. It is, then, this upper stratum of college men which we are considering in this study.

The criterion of success in after life which I have made use of is perhaps not so free from valid criticism. It is possible that not all would wish to accept mention in 'Who's Who' as indicative of high grade in life, yet with all its shortcomings, I know of no better criterion of success that can be applied to large numbers of living Americans. Although the names of many men and women of eminence fail to find place on its pages, it is nevertheless probably true that each who is there mentioned has achieved more than an ordinary degree of success in the chosen calling and is, therefore, entitled to be classed as high grade.

The volume chosen for the purpose of the present study was that for 1900, since it was contemporary with the 'Handbook and General Address Catalog of Phi Beta Kappa,' compiled by the Secretary, Reverend E. B. Parsons, of Williamstown, Mass., which is used in connection with it. The volume referred to contains the names of 8,602 living Americans, from every calling and profession. Of this number 3,237 are college graduates, with degrees from more than 200 institutions.

A classification of the names in it, in terms of the various professions and vocations, gives us the following numbers for the twenty-four which seem to form the most natural divisions. *Actor:* male 54, female 40. *Artist,* including illustrators: male 260, female 21. *Author,* including writer, historian, novelist and poet: male 528, female 272. *Business,* including the various mercantile pursuits: male 200. *Clergyman,* including bishop, rabbi, missionary, priest, salvation army and monk: male, 655, female 7. *College professor,* including president, dean and chancellor: male 1,090 female 11. *Congressman* (both senate and house), 446. *Editor,* including journalist, critic, correspondent and reporter: male 509, female 13. *Educator,* including superintendent, teacher, philanthropist and reformer: male 188, female 30. *Engineer,* including architect and miner: male 284. *Financier,* including capitalist and banker: male 215. *Inventor:* male 26. *Lawyer,* including justice, judge, and jurist: male 857, female 4. *Lecturer:* male 21, female 6. *Librarian:* male 362, female 9. *Musician,* including singer: male 111, female 21. *Physician:* male 540, female 7. *Railroad official:* male 102. *Sailor:* 103. *Scientist,* including naturalist: male 416, female 7. *Soldier:* 205. *Statesman,* including governor, diplomat, politician and mayor: 202. *U. S. official:* male 98, female 1. *Miscellaneous,* running all the way from farmer to insurance president: male 53, female 2. This classification is given in order to show that there is nothing in the nature of the work to make it draw more largely from the class of high-grade college men than from the low because of any limitation of calling.

The method of the present study is as follows: First, those colleges were selected which have had a chapter of Phi Beta Kappa for at least twenty years previous to 1900; and graduates only of those colleges are considered. This selection was made because of the fact that very few young men find place in 'Who's Who,' and recent graduates are practically excluded because of a virtual age limit. We have then as the basis, the twenty-two colleges mentioned in the table (*a*). Next, by reference to the 'Phi Beta Kappa Handbook,' the exact number of living members of each chapter were ascertained (*b*), 8,122 for all. Then by means of a comparison of these names in the 'Phi Beta Kappa Handbook,' with those in 'Who's Who,' the number for each chapter found in both was determined (*c*), *i. e.*, the number of Phi Beta Kappa men in 'Who's Who,' or the number of high-grade college men who maintained a high grade in after life, according to our criterion. The next column of the table (*d*) shows the percentage of such for each college, which percentages form one term of a comparison. The other term was determined as follows: By various means, though largely through the use of the 'World's Almanac for 1901' (figures for 1900), the total number of living alumni for each of the twenty-two colleges of our list was determined and then, by a complete tabulation of all the names in 'Who's Who,' the number from each college who found mention there, ascertained, *i. e.*, the number of the rank and file—high-grade and low—who were high grade in the ultimate evaluation. These numbers are not given upon the table, but the percentage of such for each college is in column *e*. In the two columns, *d* and *e*, we have the basis of what seems to me an important comparison, the first representing the percentages of high-grade college men who were successful in life according to our criterion, and the second the percentage of good, bad and indifferent college men who achieved success in terms of the same criterion. The averages at the bottom of these columns are very expressive: 5.9 per cent. for the former to 2.1 per cent. for the latter. If we are to accept these figures, our conclusion must be that the Phi Beta Kappa man's chances of success are nearly three times those of his classmates as a whole; that the upper stratum of college life is the upper stratum still when put to the test and, to borrow further from the nomenclature of the geologist, the cataclysm of graduation does not produce a subversion of strata. An examination of the table shows that for only five of the colleges studied was the percentage of success for

| Colleges. | Living $\phi\beta\kappa$ Graduates. | $\phi\beta\kappa$ Graduates in 'Who's Who.' | Per cent. $\phi\beta\kappa$ Graduates in 'Who's Who.' | Per cent. Living Graduates in 'Who's Who.' | Per cent. Elected to $\phi\beta\kappa$. | Per cent. of 'Who's Who' Men Elected to $\phi\beta\kappa$. |
|---|---|---|---|---|---|---|
| *a.* | *b.* | *c.* | *d.* | *e.* | *f.* | *g.* |
| Amherst | 630 | 29 | 4.6 | 2.6 | 20 | 40.3 |
| Bowdoin | 358 | 36 | 10 | 2.2 | 25 | 59.8 |
| Brown | 658 | 22 | 3.3 | 1.8 | 25 | 52.4 |
| Colgate | 184 | 4 | 2.1 | 1.7 | 25 | 57.1 |
| Columbia | 310 | 21 | 6.7 | .8 | 20 | 39.6 |
| Cornell | 212 | 11 | 5.2 | 1.6 | 12 | 30 |
| Dartmouth | 650 | 38 | 5.8 | 2.4 | 16 | 45.2 |
| Hamilton | 366 | 9 | 2.4 | 3 | | 45 |
| Harvard | 1110 | 139 | 12.5 | 2.7 | 8 | 40.8 |
| Hobart | 135 | 2 | 1.5 | 2.6 | 25 | 40 |
| Kenyon | 140 | 3 | 2.1 | 3.6 | | 33 |
| Marietta | 175 | 1 | .6 | 1.1 | 33 | 33 |
| Middlebury | 135 | 3 | 2.3 | 3.3 | 33 | 30 |
| N. Y. City Col. | 185 | 2 | 1.1 | .8 | 12 | 10 |
| N. Y. Univ | 190 | 6 | 3.1 | .4 | | 42 |
| Rutgers | 285 | 5 | 1.7 | 1.6 | 25 | 83 |
| Trinity | 225 | 12 | 5.3 | 4.1 | 33 | 40 |
| Union | 360 | 23 | 6.4 | 3 | 25 | 34.3 |
| Wesleyan (Conn.) | 375 | 21 | 5.6 | 3.4 | 25 | 47.7 |
| Western Res | 140 | 5 | 3.6 | .4 | | 45.5 |
| Williams | 435 | 33 | 7.6 | 2.8 | 20 | 54.1 |
| Yale | 864 | 56 | 6.5 | 2.3 | 12 | 24.5 |
| | 8122 | Tot. 481 | Av. 5.9 | Av. 2.1 | Av. 15.7 | Av. 39.3 |

the graduates as a whole (*e*) greater than for their high grade men (*d*), and these colleges had so few alumni mentioned in 'Who's Who' as to give their figures but little weight in a statistical study of this nature.

The names in the two books furnishing our data, considered in still another relation, tend to corroborate the conclusion already arrived at. In column *f* of the table is shown the percentage of graduates which each college, so far as I have been able to secure the figures, elects to Phi Beta Kappa. It will be seen that there is no common custom and that the variation is considerable. Each represents, however, the proportion of high-grade men, according to our criterion, among its living alumni, and, consequently, the proportion we might expect to find among its representatives in 'Who's Who,' if high grade in college has nothing to do with one's expectancy of place in that book. The average percentage of such for all the colleges considered, as shown at the foot of the column, is 15.7.* The next column, however (*g*), shows the percentages of such men who have actually received such honorable mention, and in the two we have the basis for another comparison: that between representation based upon the numerical expectancy of the high-grade college men (an average of 15.7 for all the colleges) and upon their actual achievement (39.3 per cent.). The comparison is certainly an encouraging one to the high-grade men, showing as it does that they have surpassed their mathematically computed expectancy by more than 150 per cent.

I have been able, through the courtesy of officers connected with two of the larger New England colleges, to supplement this study of Phi Beta Kappa graduates by one based upon the exact standing in class, of each one of their alumni mentioned in 'Who's Who.' This enables us to determine not only the percentage of high-grade men receiving mention, but also the distribution of the rest through the lower grades of the class. I had hoped to make this study cover a larger number of institutions, but have been unable to secure the data. The figures for the two are as follows:

| | |
|---|---|
| Total number of living alumni | 13,705 |
| Total number mentioned in 'Who's Who' | 303 |
| Percentage mentioned in 'Who's Who' | 2.2 |
| Percentage mentioned, of those who graduated in first tenth of class | 5.4 |
| Percentage mentioned, of those who graduated in second tenth of class | 2.9 |
| Percentage mentioned, of those who graduated in third tenth of class | 2.5 |
| Percentage mentioned, of those who graduated in fourth tenth of class | 1.8 |

* Percentages in the column 'weighted' in terms of living graduates.

| | |
|---|---|
| Percentage mentioned, of those who graduated in fifth tenth of class | 1.8 |
| Percentage mentioned, of those who graduated in last half of class | 1.9 |

As may be seen from these figures, 2.2 per cent. of the rank and file of the living graduates of these two institutions achieved 'Who's Who' success, and we might with reason expect this percentage to hold true for each tenth of the classes, provided scholarship has nothing to do with honors subsequent to graduation. What we do actually find for the separate tenths is shown lower down in the column of percentages; for the first tenth of the class, considerably more than double the expected number; for the second and third tenths, slightly more than expectancy, and for the remainder of the class, considerably less. These percentages are based upon the supposition that mortality has been equal throughout the class and that one tenth of the living alumni were graduated in each tenth of the class, based upon scholarship. It will be seen from the figures that the percentage of success is a little greater for the last half of the class, based upon marks, than for the tenths just preceding it. This fact is even more pronounced for those who graduated practically at the foot of the class, although my figures covering that portion are not sufficiently accurate to form the basis of percentages for the tenths considered separately. I know of no way to account for this, unless it be that those students who were able to keep a foothold among their classmates only with the greatest difficulty, gave up all hope of success in those pursuits ordinarily chosen by the college graduates, following others for which they were fitted by nature rather than by training, but in which competition would be with a weaker class; while those who had made a moderate success of college work continued in a losing competition with their classmates. If this be valid hypothesis it would account for the relative success of the lowest tenth of the class.

Supplementary still to this minor study of the two colleges, I have figures for one—the larger of the two—showing the success, according to our criterion, of the men who have received first, second, third and fourth places at graduation; that is, not simply of high grade, but those who have most nearly fulfilled the ideals of their alma mater. Of the living alumni of this institution 2.3 per cent. were mentioned in 'Who's Who' and the law of probability would lead us to expect that the percentage would hold good for the men of any given place in the class. We find that eight men of the first place were mentioned; nine of second place, and six each of third and fourth places. Since, however, the class of 1832 was the oldest contributing to 'Who's Who' for 1900, we are safe in assuming that not more than seventy men of each of these places can possibly be alive and this assumption is based upon the supposition that not one has died in all these years. Even upon this generous supposition we find that of the *possibly* living first-place men, 11.4 per cent. have gained that renown which we have taken as an indication of high grade in life: 12.8 per cent. of those of second college place and 8.6 per cent. for the next two places of honor. If, however, we apply the figures for the mortality tables of life insurance to the honor men of the last seventy college classes, we find that in all probability but forty-one of them have survived the three-score and ten years of baccalaureate life, and that our percentages are 19, 22 and 15 respectively. These, when compared with the 2.3 per cent. which represents the success of the alumni of the institution as a whole, should, it seems to me, go some way toward refuting the widely accepted belief that the college salutatorian and valedictorian are doomed to obliquity.

The statistical evidences that the high-grade college man maintains his status in after life, which are here presented, though open to all the criticisms of the statistical method, are nevertheless in accord with our general belief of what should be. If the college course is a true preparation for life, it is but natural to expect that he who best fulfils the requirements of the former is best fitted for the latter. Were this not so, we must pronounce the preparation a failure. But the educational career is more than a mere preparation for life; it is a sample of it, cut in such a way as to show as much as possible of the figure. The elementary school course, cut small as it is, can give but little of the design of the whole piece, yet it does suggest at least its general color tone. In the secondary school one may hope to discover some few of the tracings, to gain some general idea of the figure as a whole. But in the college course, taking one as it does to the period of manhood, we may expect a sample of sufficient breadth to disclose the bolder shades and the more general designs of the whole pattern. If it does not, the trouble is with the cutting, and we should cut it differently. Seemingly the work with the educational scissors is well done, and it is a matter of no surprise that the man who matches the sample best cut matches the whole piece.

# THE SOURCE OF NITROGEN IN FOREST SOIL.

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NORMAL development and growth of forest plants is possible only when the plants are able to obtain a sufficient amount of nutritive substances from their medium.

Among the substances indispensable for the nutrition of plants nitrogen occupies a conspicuous place. On an average, sixteen per cent. of this element is included in the composition of albuminous matter. Nitrogen is necessary for the formation of protoplasm of vegetative cells, and when it is absent no formation of protoplasm can take place; hence, no development of organic life in general is possible. Plants derive nitrogen from the soil, where it is found in a free state (air), or combined in the form of nitrogenous compounds.

If plants had the capacity of absorbing atmospheric nitrogen and assimilating it like carbon, the question as to the presence of nitrogen in the soil would have no interest, since the air would be a sufficient source of nitrogen. While some plants have the capacity of absorbing atmospheric nitrogen, the majority draw their supply from the salts of nitrogen found in the soil.

The consumption of atmospheric nitrogen has been fully determined for the wild acacia (black locust) and for the white and black alders. Thus in quartz sand completely free from nitrogen, seeds of black locust, while developing into seedlings, increased their contents of nitrogen from 0.0024 gr. to 0.092 gr., or more than 38 times, between May 1 and September 10. The locust in this respect resembles all the other leguminosæ, which have long been known to agriculturists as accumulators of nitrogen. On examining plants which absorb the free nitrogen contained in the soil, it was found that the roots of these plants have tubercles inhabited by organisms. These organisms are bacteria, which, attracted by the excretions of the roots, immigrate from the soil and cause the formation of root-tubercles which are invariably present in the papilionaceæ. The bacteria absorb the atmospheric nitrogen and transmit it to the plant. A great many bacteria cause tubercles on the roots; they can be classified according to the species which they choose as their host, more conveniently than by their external appearance. Each species of the leguminosæ seems to possess its own race of bacteria, which can be made serviceable to other species only by gradual adaptation. Leguminosæ which lack proper bacteria are backward in development.

If, for instance, black locusts are grown in soil which contains no bacteria or only bacteria taken from the tubercles of leguminosæ somewhat less closely allied to them, they thrive only moderately; whereas under the influence of the locust bacteria they develop luxuriantly. The organism living in the root tubercles of the alder is also, according to Hiltner, instrumental in the absorption of nitrogen. It displays its activity particularly whenever the available nitrogen of the soil begins to be exhausted on account of its vigorous consumption by the tree. The fungi which cover the suction rootlets of oaks, beeches, birches, and other cupuliferæ, as well as conifers and many other woody plants, probably also assist the trees in the taking up of nitrogen. They do not, however, absorb the atmospheric nitrogen, but only decompose, among other organic substances, the nitrogenous compounds of humus, and thus convert them into chemical combinations more accessible to the tree.

Thus, excepting the leguminosæ and a few species of other families, plants depend for their supply of nitrogen upon the nitrogenous compounds in the soil. And it is with these plants that the question as to the source of nitrogen in the soil becomes important, inasmuch as there are no minerals containing nitrogen so widely distributed as to satisfy the demand of trees for this element. Atmospheric precipitations and the product of the decay of animal and vegetable refuse are usually supposed to be the sources of nitrogenous compounds in the soil. The chemical compounds in which nitrogen occurs in the soil are chiefly nitrates, ammonia, and organic nitrogenous compounds resulting from the decomposition of organic substances. The best sources of nitrogen for green vegetation are generally supposed to be the nitrates; but for forest trees, at least, these seem to be of small account, because, as Ebermayer says, in forest and marshy soils nitrates are present, if at all, only in small traces. Also, in the interior of stems nitrogen is found in the form of nitric acid only when they are grown on a soil containing nitrates; for instance, on cultivated land. Among the compounds of nitrogen which are supplied to the soil through atmospheric precipitation, some nitric acid is found, but two to five times as much ammonia is present. The whole amount of nitrogen which is held in combination and supplied to the soil in this manner through snow and rain amounts, according to Ramann, to nine pounds per year per acre, and even less. This is insufficient to supply the demands of trees for nitrogen, as they store up a much greater quantity. Ebermayer states the average amount of nitrogen taken up by various kinds of trees per year and acre as follows:

| | | | | | |
|---|---|---|---|---|---|
| Beech forest, | about | 44 | lbs. | of | nitrogen; |
| Silver fir forest, | " | 35 | " | " | " |
| Spruce forest, | " | 33 | " | " | " |
| Scotch pine forest, | " | 30 | " | " | " |

Thus, only the ammonium salts and the organic compounds of nitrogen formed in the process of decay are available for the roots as sources of nitrogen. The amount of nitrogen supplied to the soil through atmospheric precipitation, either in the form of nitrates or ammonia, is not sufficient to supply the needs of trees for nitrogen.

There remains still another source, and this is the organic compounds of nitrogen formed in the process of decay of litter. In fact, Ebermayer has recorded strongly developed roots of spruces and firs on the Bavarian Alps that grew in pure humus one meter thick, from which he concludes that the dark forest humus furnishes all the nitrogen and other mineral nourishment required by trees.

If, therefore, the source of nitrogen in forest soil is nitrogenous compounds resulting from the decay of the litter, one would expect in a forest which is managed on a business basis (that is, in which trees are removed when ripe), a gradual decrease of the contents of nitrogen in the soil, as occurs on a larger scale in agriculture. In agriculture, where the annual harvesting of crops deprives the soil of almost all the nitrogen which is assimilated by the plants, and returns to the soil only a small part of it by the decay of the roots of the plants, and where the easily soluble nitrates are washed out by rains and carried away from the fields, or deposited in layers inaccessible to the roots, the exhaustion of nitrogen in the soil sets in soon, and the artificial introduction of nitrogen becomes a necessity.

One of the most common ways of replenishing the nitrogen taken up by crops is manuring and the growing of leguminous plants which have the capacity of absorbing atmospheric nitrogen. These plants are plowed under during the period of blooming, and when they decompose they give their nitrogen to the soil. In the forest, it is true, a considerable part of the nitrogen is returned to the soil in the form of shed leaves, and only part of it, which is contained in the trunk of the tree, is removed. The washing out of nitrates from forest soil does not occur, because no nitrates are formed in it, and those which are brought in by atmospheric precipitation are decomposed under the influence of a special microorganism known as *Bacillus dentrificans,* which is formed in soils with acid reaction.

But forest soil, though it loses less nitrogen than does arable land, nevertheless loses it; and more remarkable yet, forest soils not only do not become poorer in nitrogen, but, on the contrary, become enriched with it, a fact readily demonstrated in poor soils planted to forests.

How this loss is compensated by nature was not known until recently. The introduction of nitrogen into forest soils artificially is not practicable, and therefore the enrichment of the soil with nitrogen must go on under the influence of other causes. A certain number of leguminous plants grow in forests, but these are by no means sufficient to compensate for the loss of nitrogen through the felling and removal of forest trees. In some arborescent species, as *Alnus glutinosa, Robinia pseudacacia,* and others, tubercles which stimulate assimilation of free nitrogen are found on the roots. It may happen that such species do not occur in the forest, or that the necessary bacteria do not develop in the soil, when the loss of nitrogen would not be replenished at all. This replenishing, however, always occurs, and some sources must be found to account for it.

Recently, E. Henry, professor in the forest academy at Nancy, France, discovered a new source of enrichment of the soil with nitrogen, which is of great interest to foresters. Professor Henry has proved by experiments that the loss of nitrogen in forest soil is constantly repaired by means of absorption of atmospheric nitrogen by fresh forest litter.

In November, 1894, Professor Henry collected leaves only recently dead and still hanging on oaks and hornbeams (*Carpinus betulus*). The amount of nitrogen in these leaves was determined in per cent. of the dry substance. In this way it was found that the leaves of oaks contained 1.108 per cent. of nitrogen, and the leaves of the hornbeams 0.747 per cent. The oak leaves were placed in two zinc boxes. The bottom of one of the boxes was covered with limestone, that of the other with sandstone not containing lime. Both boxes were covered with a netting of galvanized wire. The leaves were dried in the laboratory, and 48.16 grams of their dry substance were placed in the first box, and 53.54 grams in the second. The leaves of the hornbeams were distributed in the same way. All four boxes were exposed to air, with necessary precautions against enriching the leaves with nitrogenous compounds. In December, 1895, the following year, Professor Henry determined the contents of nitrogen in the leaves taken from two boxes, whereby it was found that the oak leaves taken from the box with the limestone bottom contained 1.923 per cent. of nitrogen, and the leaves of hornbeam taken from the box with the sand bottom, 2.246 per cent. After making the necessary allowance for loss in weight of oak and hornbeam leaves owing to decomposition, Professor Henry computed the increase of nitrogen in the oak leaves at 4 per cent., in the hornbeams at .78

per cent. Thus it was proved by him that fresh leaves fallen from trees absorb atmospheric nitrogen in the process of decomposition.

The two other boxes remained exposed to the air for another year, and in May, 1896, fifty grams of fine forest soil were added to each box. On subjecting the leaves contained in them to a chemical analysis, Professor Henry found almost the same contents of nitrogen that had been found in the leaves of the first two boxes which were exposed to the air during only one year. From these results he concluded that the capacity of fallen leaves to absorb nitrogen from the air is retained only in leaves freshly fallen on old litter.

The capacity of forest litter to absorb nitrogen develops probably under the influence of special microorganisms, active only at the beginning of the process of decomposition of fallen leaves; later, however, when the process of decomposition of leaves goes on under the influence of exclusively inorganic agents, no increase of nitrogen is observed; on the contrary, a loss is shown.

It is thus scientifically proved that forest litter is capable of enriching the soil with nitrogen, but only under the condition that the decomposition of freshly fallen leaves goes on. As to the assumption that bacteria are developed in freshly fallen leaves, which, like *Rhizobium leguminosarum* Frk., possess the capacity of absorbing atmospheric nitrogen, it can only be said that as yet no bacteria have been found in forest litter.

A practical deduction from Professor Henry's scientific investigation is the advisability of planting cut-over areas as soon as possible, so that the young seedlings may find in the soil a quantity of nitrogen sufficient for their nourishment. The longer cut over areas remain unplanted, the less is success to be expected from planting, as the young trees develop poorly because of insufficient nourishment.

Thus, the forest not only furnishes timber and other products, prevents snow- and land-slides, and regulates the flow of rivers, but enriches the soil with nitrogen, one of the most essential nutritive elements of plants, and in this way transforms poor soils, fit only for tree growth, into rich agricultural lands.

# EDUCATION FOR PROFESSIONS.*

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THE preparation of the man who has chosen to enter a profession involves, properly, suitability for the profession chosen, in character, ability and a special talent, if not a genius, as a basis and an excuse for that preparation. It should include a general education sufficient to give the individual the knowledge and culture demanded, in this generation, of all who aspire to enroll themselves in the ranks of the leaders of the professions, broad enough and deep enough to command respect and to justify confidence both in the man's attainments and in their utilization. It must involve training, both gymnastic and 'practical,' and development of that strength and maturity without which the professional apprenticeship of the special school can not be appreciated or its best results attained. Education, in the commonly accepted meaning of the term, should be carried as far and as high as the time, the means and the ability of the man permit and continued, if possible, until he has acquired maturity, earnestness, intelligent ambition and thorough assurance that he has chosen the right field of work for his life's long endeavors. Yet, from the day when it becomes certain that his field of work may be safely selected, a thread of special preparation may run through all the sequence of his studies without injury to their value in the development of the man.

Mathematics may be taught by examples selected from the practical problems of the coming days of professional work; modern languages may be given large place in the curriculum; the sciences may be studied in a serious manner and intensively; these latter studies may be made to conspire for his advantage in the reading of scientific matter in foreign literatures. In many and very various ways, the bent of the child, the youth, the man, may be favored without loss of culture and with the great advantage of stimulating and maintaining his interest throughout. But, in the earlier stage, it would be a mistake to sacrifice culture and gymnastic training, true education, to professional training. Quite enough can usually be accomplished in the manner just indicated without observable distortion of the general education which every youth should rightfully claim. As secondary education and collegiate work in the 'liberal' arts are to-day conducted, it is probably always possible to secure a large part of the needed sci-

* Read before the N. Y. State Science Teachers' Association, Syracuse meeting, December 30, 1902.

entific and linguistic preparation for professional study before entrance into the professional school and, as in law, for example, it is seldom wise to attempt to incorporate such work in the curriculum of the school.

It is becoming more and more common to exact of the candidate for admission into professional study the preparatory work which brings with it the diploma of a reputable college giving a liberal A.B. course. In the professional school, it is sometimes sought to arrange a system of electives for the A.B. course in the university or the college, such as will best combine its work with the requirements of the professional school, and will thus permit the accomplishment of the two lines of work in a reduced period, as, for example, at Cornell, in the Colleges of Arts and Sciences and of Engineering, in six years.

It is progress such as this which justifies the comment of Wendell Phillips regarding the value of modern education and that of Andrew Carnegie respecting the changes which have justified the words of that great orator, in our day as never before:

> 'Education,' says the orator, 'is the only interest worthy the deep, controlling anxiety of thoughtful men.' Says the business man and philanthropist: "The changes and the advances made in education, in deference to modern ideas, have almost transformed our universities. These now give degrees for scientific instruction upon the same footing as for classics. . . . No university could stand to-day which had not changed its methods and realized, at last, that its duty was to make our young men fit to be American citizens and not to waste their time trying to make poor imitations of Greeks and Romans."

Now, as never before, education is coming to represent the ideal of John Milton, so often quoted and so rarely disputed, an ideal that can not be too often or too impressively placed before the youth of our own day: "I call a complete and generous education that which fits a man to perform, justly, skilfully, and magnanimously, all the offices, both public and private, of peace and war." This ideal was embodied in the plan of Cowley for a 'Philosophic College' more perfectly than in the curriculum of any modern institution until, in fact, that aspiration began to find expression in the liberalized and enriched elective system inaugurated by President Wayland, and until, in the last generation, Ezra Cornell proclaimed his aspiration to 'found an institution in which any man can find instruction in any study.' This modern, and now almost universally accepted, Miltonian curriculum is based upon principles well-stated by Forel:

> Education should promote comprehension and combination, but discharge the vast work of memorizing as much as possible upon books, which should be merely consulted, not learned. Make haste to forget useless trash. It obstructs your own thoughts, paralyzes your artistic sense, and dries up your emotions. Read only the choice books from among the thousands with which we are flooded.
>
> Man must seek to improve his brain 'by a sane, voluntary and rational selection, rather negative than positive, by instructing both sexes, and by urging

the most highly organized brains and bodies to reproduce themselves as much as possible, while forcing the inferior and incompetent ones to the opposite direction.' This reform secures evolutional perfectibility, while the educational reform meets the conditions of superadded perfectibility; and only thus can the greatest of human problems be solved.*

The same idea is expressed in somewhat different words, and as viewed by Huxley's different type of mind, from a different standpoint, thus:

That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic-engine, with all its parts of equal strength and in smooth working order, ready, like the steam-engine, to be turned to any kind of work and spin the gossamers, as well as forge the anchors, of the mind; whose mind is stored with knowledge of the great and fundamental truths of nature and of the laws of her operations; who, no stunted ascetic, is full of life and fire but whose passions are trained to come to heel by a vigorous will; the servant of a tender conscience who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to respect others as himself.†

The right sort of a liberal education obviously begins in childhood with the growth of the observational faculties, continues through youth with the development of the power of comprehension and reflection, is finally terminated, so far as formal education goes, with those studies which are the expression of the thoughts or of the discoveries or of the deductions of great minds and which demand the employment of mature, acute, powerful and trained talent.

This is the university period, and if this can be prefaced to the professional training the man is indeed fortunate. It is the modern incorporation of the Miltonian ideal into our educational work that makes it possible for one of our ablest business men to say:

It used to be assumed that education was a hindrance to 'success in life.' The great merchant was to begin by sweeping out the store. The weakling was the proper candidate for college, whence a living might be assured him in the church or other 'learned profession.' A college education was thought a handicap against 'practical' achievement. This superstition is one of the husks the world has thrown off.‡

In an ideal university, as I conceive it, says Huxley, almost in the words of Cornell, a man should be able to obtain instruction in all forms of knowledge and discipline in the use of all the methods by which knowledge is obtained. In such a university, the force of living example should fire the student with a noble ambition to emulate the learning of learned men and to follow in the footsteps of the explorers of new fields of knowledge. And the very air he breathes should be charged with that enthusiasm for truth, that fanaticism of veracity, which is a greater possession than much learning, a nobler gift than the power of increasing knowledge; by so much greater and nobler than these

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* August Forel, University of Zurich.—'Current Encyclopedia,' November, 1901.

† Huxley, Vol. II., p. 320.

‡ 'Of Business,' R. R. Bowker, 1901.

**as the moral nature of man is greater than the intellectual; for veracity is the heart of morality.***

This declaration should be accepted as the fundamental principle, and the very inner spirit, of true education in all departments and as being as truly characteristic of the right form of culture as of the correct method of seeking professional knowledge. It is a characteristic of every correct form of study or of aspiration.

The 'ladder' which, in our country, leads 'from the gutter to the university' for every man who, possessing brain and physical vigor. wills it, includes the successive rounds of the public-school system. The purpose of that organization is to fit, as well as may be, 'all sorts and conditions' of youth for the life of the average citizen of our republic. It properly includes in its curriculum only those subjects which are of most value to the average citizen and it can not, and should not be expected to, provide either those luxuries of education rightfully desired by the well-to-do, or the special forms of training demanded by those proposing to enter on special lines of work, as into either of the professions. If it offers manual training, it is because that is found, on the whole, advantageous to all citizens, and sufficiently so to justify its insertion into an already crowded curriculum. Should, here and there, as in Europe, often, a trade-school be established, it should be justified by the general demand, among the people of the vicinity, for such a training; being a requirement of the place as a seat of the special manufacture, or, as with the common trades, by its systematic teaching of principles and methods that meet the needs of all and which can not be as readily, perfectly, completely and economically taught by other systems.

That 'ladder' includes our secondary schools, in which a selected body of youth are collected who have been found, by a sort of evolutionary selection, to be exceptionally well fitted to receive that higher sort of instruction. Here it is often possible for a determination of the choice of vocation intelligently and safely to be made. The pole-star may be discovered and the course may be laid directly for the desired haven. But this course must be steered, as best possible, through available and safe channels and the youth seeking ultimately to enter a great profession may be compelled—often indeed, greatly to his advantage—to follow the courses set for him by the school which is intended to promote the education of other sorts of minds. It is commonly the fact, however, that the studies here offered include those fundamentals of professional preliminary work which should always be acquired previous to entrance upon purely professional study and hence time is not wasted in securing this, which is also, fortunately, always desirable culture.

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* Huxley, 'Coll. Essays,' III., 189.

The preparation of the aspirant for entrance into a profession involves the provision of a fundamental knowledge of means of acquirement of professional knowledge and this means acquaintance with the languages in which the literatures of the profession are to be found. In the case of the law school, this means Latin; with the theologist it includes Greek and Hebrew; with the medical man, it means mainly Latin, as with the others, so far as affecting early history; while, with all, this means the necessary acquirement of the modern languages, French or German, or more commonly both, and sometimes Italian and others. In engineering, it involves the acquisition of the modern languages, the sciences of the physicist and the chemist, of the mathematician, sometimes of the geologist and of the mineralogist; and it supplements these with special studies furnishing the peculiar, 'expert,' knowledge constituting preparation for the characteristic branches of the professional course.

When the whole course of preparatory work is surveyed, from primary to secondary and special, and when its relation to the strictly professional course is noted, it will be found that the latter involves so much of the admittedly educational, as distinguished from the professional, work that it thus becomes practicable for the aspirant to give all the years which his individual means and his time may allow, and most profitably, to liberally educating his faculties and to the storing of his mind with useful knowledge.

Says Dr. W. T. Harris, the philosophic educator and psychologist:*

> Specialization in science leads to the division of aggregates of knowledge into narrow fields for closer observation. This is all right. But, in the course of study in the common school, it is proper and necessary that the human interest should always be kept somewhat in advance of the physical.

This is simply a statement of the fact, admitted by all, that professional training in the special school is the application, in a restricted field, of principles which should be applied in every field and in all studies, whether those characteristic of a profession or those which constitute divisions of a broad, liberal and cultural education. But it is also true that, before specialization can be properly commenced, the scholar must have terminated that division of his education which is intended to give him general preparation for 'the future of his life.' It is true that a certain amount of specialization may be practicable in the preparatory years; but it is none the less true that, in preparation for the latest stage, the student must give main attention to the educational side and leave the professional to be given main attention in years following those of growth and of development of character and of intellectual power.

The guiding hands of parent and teacher may do much in the

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* *The Forum*, January, 1901.

adjustment and regulation of the educational life and progress of the young in securing that correct perspective and that direct course from haven to haven which, only, can give the highest possible result in training, in education, and, finally, in professional life. The best disposition of time, the best choice of subjects of study, the best adjustment of hours and the most satisfactory appropriation of time to work, to play, to gymnastics, and to practically fruitful exercises of mind and body, can only be determined by wise and experienced advisers.

Referring to industrial and professional training, Dr. Lyman Abbott says:

> Industrial education, in the broad sense of the term, is a function of the state; not because it is the duty of the state to give to every, or to any, man a training in his profession, but because it is the function of the state to prepare man for self-support. One difficulty with our system of education thus far seems to me to be that we have paid too much attention to the higher education and too little to the broader education. We need to broaden it at the base even if we have to trim a little at the top.*

The importance of the provision of every citizen, of either sex, with systematic and scientific preparation for the duties of life is thus a most essential provision for the future of the State. Even were we not compelled, in providing for the individual, to make provision for systematic education and training in subjects that relate to the useful arts and the duties of every-day life, it would be none the less imperative, as being vital in the maintenance of the highest interests of the people as a whole. We can not escape this duty, either individually or as a nation, and it is supremely important that we go about our work in a systematic and intelligent manner.

Regarding methods: It is interesting to observe how completely educational processes have changed, in the last generation, in every department and in every division. The old methods, which reminded one of the stuffing of the Strasbourg goose, have largely disappeared and, while it must be admitted that work under high pressure is now too generally the rule, it may be claimed that a very great gain has been effected in finding reasonable ways of teaching, and especially of importing into the study of serious, and perhaps intrinsically difficult and uninteresting, subjects methods of treatment which render the task far more attractive than formerly.

> The system of instruction by didactic methods still exists in places, but only because the machinery for carrying on the work on more rational principles has not been obtained. Wherever the object is education, the methods of research have been introduced and it is recognized that real scientific knowledge can only be gained by individual experience.†

This is as true of other subjects than those which, like physics and

* Lyman Abbott, 'The Rights of Man,' p. 161.

† Sir John Gorst at the Glasgow meeting of British Association, 1901.

chemistry, like all the naturalist's subjects, the observational and experimental, seem necessarily to carry with them the paraphernalia of the laboratory. In every department of study there is some method apposite to that line of work which permits an appeal to the sense of inquisitiveness—a fundamental element of human nature and a most admirable and desirable one—and gives thus a means of approaching the mind by a direct and pleasant path. This is a principle now coming to be accepted as axiomatic, in education, in all its branches, and the once 'dry-as-dust' subjects are taking on new life and assuming lovely and engaging forms.

Thus we may steadily keep in mind, through the whole career of the youth intended to ultimately take part in the constructive work of the world, the fact that he must after a time take up technical studies and that, the more the work of the later years can be facilitated in the earlier, the better and the more profitable the earlier as well as the later work. The courses of instruction may perfectly well be made to include work in literature and in the pure sciences which is both valuable in the early gymnastic branches of education and useful in the later professional work. The earlier courses, in the case of the pupil, for example, who is proposing to fit himself for entrance into engineering or architecture, may perfectly well, and wisely should, be made to include just as much pure mathematics as can be had, just as much of chemistry and physics as the schools can provide and the modern languages in liberal amount.

Assuming that the aspirant for admission to the professional school, in this department, may follow his own bent, and that he desires to be educated and cultured as well as professionally expert, he will continue his work into the higher education, and there will elect advanced mathematics, will secure opportunities for experimental work in the physical laboratory, for work in analysis and synthesis in the chemical laboratory and for the study of the technical, as well as of the literary, works of modern writers in French and German and possibly in Italian and Spanish. If he is preparing himself to take up ultimately law or medicine or theology, he will similarly find in the college and university curricula various branches of study which will be of service either in shortening or in supplementing his work in the professional school. All such opportunities being taken advantage of, it will be found that the total time required to secure first an education and then a professional training will be greatly abridged without sensible loss in final results.

There are often subjects obtainable in the educational curriculum, or at least obtainable in connection therewith, which will be found either to constitute a part of the required work of the technical course, or to be likely to prove of special interest and advantage in connection with it, and which may be incorporated with advantage to the former course, also. There are many subjects, outside the liberal courses as usually prescribed, which, nevertheless, will be found quite as valuable, as cultural and as educational, as are some subjects which are the usual elements of that older scheme. The wise man will look for opportunities to secure a good hold upon these, in substitution, if needs be, for more usual electives.

It will also be sometimes found that, to the earnest, competent and ambitious man, the commonly prescribed courses of instruction are by no means sufficient to provide a good day's work, each day, and that he may, with great advantage and without the slightest difficulty or sacrifice, increase the prescribed time and number of subjects by perhaps a third. He can not afford, in fact, to forego the opportunities which present themselves in such numbers and such wealth, up to the natural limit of his powers of safe and healthful exertion. He has but one such opportunity in his lifetime and only the man lacking in intelligence or in moral fiber will waste one hour of such precious time. In the large universities and the leading colleges of our time, the student is perplexed and embarrassed by the wealth of opportunity which is presented him. He will usually find that it will require very great care and deliberate thought to make a wise choice of subjects, to adjust himself to a wise limitation of time, so to adjust and schedule his work and his play as to make each day and each college-year in maximum degree profitable. This he should do, having in view the coming life, private as well as professional, and contemplating the utilization of that life most perfectly in the promotion of the highest interests of self, family, friends, country.

Thus, in summary, the ideal preparation of the aspirant, professionally, involves even a supervision of the child in its earliest efforts to obtain a knowledge of the outside world into which it has been introduced, a guidance of kindergartner and of the pupil in the elementary schools in the acquirement of those fundamental knowledges which furnish the means of acquirement of all knowledge, a discreet steering of the course of the older student in the preparatory schools and the finishing school or the college, and deliberate, earnest and careful choice of subjects of study and investigation in higher learning; all to the purpose of insuring that no hour of work shall be wasted by misappropriation to studies which have a less value for the ultimate purpose of the individual life than others equally available.

The preparation of the aspirant to professional standing and distinction, or even to the most modest success, thus involves wise counsel from older and more experienced minds, from the earliest to the latest years of this long apprenticeship.

Francis of Verulam thought thus, and such is the method which he determined within himself, and which he thought it concerned the living and posterity to know.

Being convinced, by a careful observation, that the human understanding perplexes itself, or makes not a sober and advantageous use of the real helps within its reach, whence manifold ignorance and inconveniences arise, he was determined to employ his utmost endeavors towards restoring or cultivating a just and legitimate familiarity betwixt the mind and things.

Bacon says, also:

And whilst men agree to admire and magnify the false powers of the mind, and neglect or destroy those that might be rendered true, there is no other course left but, with better assistance, to begin the work anew, and raise or rebuild the sciences, arts, and all human knowledge from a firm and solid basis.

Nor is he ignorant that he stands alone in an experiment almost too bold and astonishing to obtain credit; yet he thought it not right to desert either the cause or himself, but to boldly enter on the way and explore the only path which is pervious to the human mind. For it is wiser to engage in an undertaking that admits of some termination than to involve oneself in perpetual exertion and anxiety about what is interminable.

In the mechanic arts, the case is otherwise—these commonly advancing towards perfection in a course of daily improvement, from a rough unpolished state, sometimes prejudicial to the first inventors; whilst philosophy and the intellectual sciences are, like statues, celebrated and adored, but never advanced; nay, they sometimes appear most perfect in the original author, and afterwards degenerate. For since men have gone over in crowds to the opinion of their leader, like those silent senators of Rome, they add nothing to the extent of learning themselves, but perform the servile duty of waiting upon particular authors, and repeating their doctrines.

The end of our new logic is to find, not arguments, but arts; not what agrees with principles, but principles themselves; not probable reasons, but plans and designs of works—a different intention producing a different effect.*

Finally: The preparation of the physical man, like the preparation of the foundations of any great architectural structure, is a first and a last essential. Of little value is a noble conception or a high aspiration, the noblest work of the greatest architect or the highest attainments of the greatest human genius, without a solid and safe substructure, capable of supporting it at all times, in all weathers and in all contingencies, throughout a long and constantly satisfying life. Health, strength, vigor, ambition and high spirits are essential strata in this foundation of every human structure of character and value. The human mind, the human intellect, the spiritual and the moral man, can only survive and properly flourish within a wholesome and vigorous body. So closely are the mind and body related that the failure of the one carries with it, inevitably, loss of efficiency and ultimate failure of the other. Every minutest defect of body and brain of the physical man detracts from the possibilities of accomplishment of the highest and best in the profession, in the home, in the house of one's

* 'Novum Organum.'

friend. No man can do his very best as an intellectual, moral, spiritual, being without employing his physical part in its very best estate in the work. Defect of body means, always, defect in the work of the man, either in quality or in quantity.

The physical frame is a machine, a transformer of natural energies. It is at once a home for the soul and a wonderful, an intricate and mysterious prime mover, an engine of which the motive forces are as yet undetermined and unmeasured. We know that its perfection is essential to the perfection of the humanity which it encloses and of which it is the vehicle; we know that the display of the intellectual and the spiritual power, the genius, of humanity is dependent upon the provision of ample stored physical energy and of efficient means of kinetizing and applying it to the purposes of the mind as well as of the body; we know that the animal machine is not a heat-engine; we think it is not an electrical generator; we are coming to believe that it is some form of chemical motor—possibly one in which the vital, the physical, and especially the chemical and electrical, energies find common source and origin in a common point of emanation. We know that, whatever its nature as a motor, it has an inherent efficiency far superior to that of any heat-engine yet devised and constructed by man. We know that it requires certain well-ascertained elements as its fuel—or food—that it must be kept well within the requirements of certain well-established physical laws; that, to maintain and promote its best and highest work, it must be cared for with scrupulous attention to certain definite hygienic laws. We know that the best possible, the highest possible, can only be attained by man when this curious and mysterious and inseparable vehicle of the soul is thus maintained in its best estate.

The building of the body—which means the building of the brain, always, and just as absolutely—the construction of the physical side of the man, is actually a problem in architecture and engineering and one, like all such problems, capable of a good or a bad or an indifferent, but never of a perfect, solution in any actual case. The building is carried on by mysterious and unknown forces within it and we can never touch them or their work without embarrassment or injury to both. We do, however, know positively certain laws and their action and certain rules of procedure in the adjustment of exterior conditions, favorably or unfavorably, and in supplying the necessaries of wholesome life. We know, in a general way, what should be the methods of life, of diet, of exercise, of use of powers of body and of mind. We know enough to make the difference, in most cases, between health and disease, success and failure of the physical man, and, in consequence, thus largely to determine the success or the failure of the real, the intellectual and spiritual, man.

The materials of the builder and their preparation for use are, on the whole, well known, for best construction, and it is well established that a frugal yet ample supply is essential of those substances which furnish in potential form the energy which is demanded by the animal machine. Especially should we avoid such kinds as will clog the machine and impede the evolution of the potential energies in kinetic form. These constitute main conditions of production and of maintenance of the maximum efficiency of the machine, and also of its passenger, the inner man, with whom, even in our individual selves, we have so uncertain and so mysterious an acquaintance.

Man has learned by scientific methods to identify and utilize a vast number of materials distributed amongst the various kingdoms of nature and the physician and the surgeon are able to perform wonders in the maintenance and repair of this mysterious motor. Plainness and simplicity of diet, frugality and maintained efficiency of the apparatus of preparation, are thus requisites for highest attainments, whether in physical or in intellectual and moral and spiritual realms, whether in gymnastics, in learning, or in imagination and in spiritual life. The famous athlete, the great man of science, the philosopher, the poet or the divine, each and all live a better life and are more perfect men in proportion as they perfect the physical side.

Methods of life and habits of body and mind exercise an enormous influence upon the health, happiness, capacity and achievement of the man. It is the daily experience of every one that only when the body is at its best can the mind and the soul rise to highest levels. Keep the animal machine in good order and the highest efficiency of the being dwelling within it is maintained—and only thus can efficiency be attained or maintained.

The teachings of comparative physiology, indicating what are the desirable and what the undesirable materials of construction, and the teachings of the natural instincts which, in the child as in the animal, reject harmful substances, give ample instructions to him who seeks, honestly and earnestly, for such knowledge. Guided by these precepts, an ambitious and intelligent man can usually find his way safely and successfully through the snares of this world which everywhere trap the foolish and unwary.

With ordinarily good physical health and a good body within which to dwell, at the outset, the way by which to an approximation of the ideal perfection of Agassiz, the 'soul of the sage in the body of the athlete,' is open to every man. No aspiring and earnest youth need doubt which is the proper course. The way toward the ideal, the perfect, man, is open to him.

The prerequisites of a successful life are health, strength, intelligence; power of self-control and of self-direction; selection of that profession, or that vocation, which gives largest opportunity for the peculiar talents and ambitions of the aspirant; a good general education; a complete professional training; habits of work and play in due proportion; ability to keep abreast of the times, socially, professionally and generally; capability of meeting and of making mutually helpful all people with whom the accidents of life bring one in contact in social or in professional life, and a good-tempered persistence in making a record that shall, with its steadily lengthening and strengthening chain, become a constantly more and more helpful factor of all success.

Professional success attained, the greatest problem, that of making that success in highest degree valuable and productive, is one which appeals to the thoughtful man more importunately than ever could the problem of gaining a triumphant success in any division of the great world of humanity. It is not so much the acquirement of wealth, whether of money or of wisdom or of fame, which must compel thought and anxious sleeplessness, as it is the problem of investment and of securing safe and satisfactory returns on the accumulated and invested capital. If the capital consists of material wealth, the question how to use it for the highest and best purposes becomes a serious one and the example of the great philanthropist is studied to ascertain the outcome of his endeavor to do most and best with his surplus, to learn how far such attempts have hitherto proved successful and how far they have proved unfruitful or harmful. If the capital is personal fame and power and influence, the same question comes up in a modified form and the successful man is fortunate, or unfortunate, after all, proportionally as he is able to make his fame and power and influence felt for good in the great world's movements.

The ultimate measure of the man, of the woman, is the degree of final approximation to the success of a Peabody in promoting education, of a Carnegie in giving men opportunity to learn and to develop, of a Booker Washington in promoting the advance of a race, of a Roosevelt in advancing the standard of honest and patriotic politics, of a Rockefeller in discreetly seeking out the greatest needs of humanity and providing for their effective supply, of a Vassar in promoting the special care of women in their intellectual life, of any approximation gained for self and others to a higher life in wisdom and learning, in knowledge and culture.

The prerequisites of success are the perfect training of the body, brain and soul; the methods are scientific, in education, in training and in practice. The resultant form is a specific type, a species. The results of the work are as specific, in every profession; usually measured, crudely, by accumulated capital, in form of learning, of skill, of property; but its use is ever the same, its abuse usually common to all forms. Its use is the elevation and upbuilding of humanity, its abuse self-gratification; its glory is seen in the progress of mankind.

# SCIENCE VERSUS ART-APPRECIATION.

BY JOHN QUINCY ADAMS,
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A PERSON traveling for the first time in a foreign land is often puzzled by its customs and institutions. He can not understand why people lay so much stress on forms which seem to him trivial, and, with good intentions, habitually do so many things which he considers immoral and vicious. These will remain incomprehensible to him as long as he attempts to judge them by the laws and habits of his own land—the common mistake of travelers.

In like manner, an inhabitant of the realm of science, entering the domain of art, misconceives its character, because he does not understand its language, methods nor traditions. The scientist carries with him into the field of art the mental habits and standards peculiar to his native soil, and whatever can not be measured by scientific methods escapes his notice.

We know that the botanist, the housewife and the farmer see a different set of properties in the common dandelion, and would classify it respectively as compositæ, food or weed. In the same way, one sees in each object what one looks for, and this is determined by one's mental habits. It is but logical that the scientists should seek in environment the leading characteristics of science, and should expect to arrive at truth by analysis and generalization.

Scientific ideas rule not only the scientists—they dominate also our science-trained age. Evidence of this confronts us whichever way we turn.

We see nearly every field of human effort controlled by specialization. It is no less clear that the aim of the manufacturer, as of the investigator, is to set forth 'the latest thing out.' Every province of human interest has been brought under scientific classification, so that nearly all thought is now cast in 'general ideas.' This mode of thinking ignores individuality and sees in men and things only units of a class. For this reason, man is content with countless repetitions of the same form because his class idea is realized if it find in each object the few characteristics common to the group. Therefore, in general many of man's needs are satisfied with mere form, and if he sees objects possessing these formal features sitting in art's accustomed seats, he does not call in question their titles, but allows articles of furniture, forms of ornament and styles of architecture to retain their historic names, and though their beauty has departed like the glory of some ancient family, he renders homage to their silly and meaningless descendants because of their name and position. The world has been filled with these ugly forms made in the name of art, but they only bear witness that science has subdued the earth and now holds undisputed sway.

Not only has it driven art into the background, but it has misrepresented its character.*

Science has led man to expect art to set forth phenomena, to illustrate events, to communicate knowledge with absolute exactness. It has taught us to believe a work of art worthless unless it give precise information which can be verified by an appeal to facts. But man turns to art for the fulfilment of these expectations only to be sadly disappointed. Weary and cast down, crowds leave the museums with curiosity unsatisfied, with small addition to their learning, but denouncing art for failing to keep the promises of science. As well condemn the law of gravitation for the death caused by a falling rock.

Accustomed, as we are, to the precise and unequivocal terms of science, we expect the language of art to be equally explicit, and just at this point we are led astray by supposing that the artist—like the scientist—has something definite to communicate. Like the pioneer, the artist does not know what is ahead of him, but, driven by his creative impulse, beset by all sorts of perplexities, he struggles on over unknown regions until he reaches a point which satisfies him. What he produces is the outcome of his creative power, which picks and chooses its material from nature, breaks up and recombines again, and this process is continued until an effect is produced which his esthetic judgment pronounces good. The very terms which the artist uses are vague and indefinite, each one having an infinite number of meanings, determined not by any inherent quality, but by its relation to other terms in the same work of art. For example, a straight line has little esthetic value in itself; nevertheless, it is of great importance in one picture and almost indispensable in another. In like manner, the meaning of every bit of color varies with each change in its combination with other colors; or a musical tone may be a commonplace noise in itself, but as a part of Lohengrin's Wedding March it thrills one with delight. For this reason, a dictionary of artistic language is impossible. Not a line, a form, a color nor a rhythm stands for a definite idea, the meaning of each one depending not only upon its relative position as expressed by the artist, but also as appreciated by the spectator or listener.

* The reader must keep in mind that we are not contesting the great value of science and its methods, but that we object to these methods being applied to art.

I think we all agree that for each learner, science consists essentially of definite, objective facts which must be acquired in much the same way that one gets possession of other external objects. Upon demand, the student must show the amount of stock on hand, and this is taken as the index of his success. When the teacher wants to mark progress, he requires each one to open his mental storehouse and exhibit the sum of its contents.* It naturally follows as a corollary that the chief aim of science-teaching is to stimulate the pupil to gain possession of scientific realities, and thus add to his stock of knowledge. Each fact acquired is an addition to his mental possessions. Therefore, he must dispassionately learn what actually exists, never forgetting that he is nature's witness and that his testimony is valuable only in so far as he tells the whole truth and nothing but the truth.

On the other hand, art can not be analyzed into equal units, nor its composition expressed by a formula. Neither can its character be determined by the application of rules and measurements, for each work of art is a new thing in the world, and is, in fact, a law unto itself. To attempt to measure art by these quantitative and objective standards is like taking a sieve to fetch water. Art being a degree of harmony, an expression of feeling, a way of doing, it can be estimated only by one who has sufficient capacity of feeling. There is no yard-stick which can indicate to every person the exact amount of art in any given production. The only way to estimate it is by a direct appeal to one's own internal measure, called appreciation. As Plotinus long ago said, 'The kingdom of Art is within us.' We are misled into thinking that there exists a common objective standard, because we so often find many competent judges agreeing as to the merits of a work of art. Undoubtedly, there may be a great similarity in personal standards due to a common artistic environment and a similar social heritage, which have formed our conceptions of art as of all other objects depending on personal valuation. The main object of art-teaching therefore should be to build up within each pupil the highest possible standard of esthetic appreciation. He must be incited to make esthetic judgments as to the quality of objects, and in this way he develops his capacity to appreciate. Each decision made is a distinct mental growth.

However, to meet the demands of our examination system for a definite quantity of knowledge, we teach only a body of collateral facts so closely related to art as to deceive us into thinking that it is art. We are satisfied to obtain results which can be measured by a definite,

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* As the pupil finds that courses of study, systems of examinations, methods of promotions, and in fact, the phenomena of science itself, are all based on the quantitative and external standard of measurement, it is but natural that the one idea that takes possession of and dominates his intellectual life is that quantity is the sole criterion of success.

objective standard. For example, as literature, we teach analytical grammar, philology, history and events. As a regular exercise in English literature in many schools, students are required to put a beautiful passage of Shakespeare into English! Now, in reality, such a process never carries one beyond the mere incidents of a literary masterpiece, and the one element which makes it a work of art, namely, its power to infect the reader, with the emotion of the writer eludes all such analytical pursuit. Many of us after leaving college, take up Shakespeare, Lowell, Wordsworth or Hawthorne, and are astonished to find them interesting and inspiring. Our apparent purpose in teaching music is to develop dexterity, as though every child were to be a musician.

The plastic arts are taught as parts of an external body of knowledge which the pupil may take in and then give out again, as though his nervous system were glass with the power of transmitting, with more or less accuracy, forms, colors and sounds. Such strong emphasis on the acquisition of technical skill reduces the study of art almost to the level of learning a trade. Those teachers and pupils who pursue higher ideals find themselves in conflict with the accepted educational canons. These, as I said above, demand measurable results which are most easily secured in the plastic arts by devoting the time to training all the faculties to bear upon production. While the appreciation of art may be learned, incidentally, by this method, the index of progress is the amount of dexterity acquired so that all the faculties become set towards making something. This, no doubt, is an excellent way to learn a handicraft, but a questionable method of cultivating understanding and appreciation. Although it can not be denied that a thorough knowledge of how a work of art is produced, of the skill displayed in overcoming special difficulties, affords a peculiar pleasure, we must not forget that the same pleasure comes from seeing, for the first time, anything skilfully done, the difficulties of which one understands. And this is true whether it be artistic or purely mechanical. Whether it be the production of a tone on the violin or the ingenuity of a knitting or type-setting machine. Such ephemeral pleasure comes not from esthetic emotion but from scientific knowledge.

In the days when manufacturing was by handicraft and every workshop was a school of art, there was less need for teaching art in any other way. But since the factory has displaced the workshop, and the operative the handicraftsman, there is no chance in industry for the application of art, except in a few cases. Art is no longer a quality of the product of every-day work as formerly, and it is hopeless for us to expect it to be. And with its departure from industry, art has vanished from the daily life of men. This is not surprising, because, although the long and toilsome road to art by way of production is closed up by the advent of machinery, we still insist on teaching all pupils to approach by this route. The result is that few ever emerge from the drudgery to enjoy the beauty in the world, because in school they learn only the a, b, c of drawing, painting or modeling and such meager skill is a very poor guide to the great domain of art. In fact it has restricted the attention to a very small part only of the artistic field and so narrowed our conception of art that to-day very few, even intelligent persons, think of art as a possible quality of nearly every human act as well as of its expression in the concrete. I have heard eminent professional men denounce art in language too strong to print, declaring it to be only an absurdity. I once asked one of these art-haters if he thought the room in which we were sitting would be as comfortable and pleasant if it were four times as long and one fourth as wide? I followed his emphatic 'No, of course not!' with the remark that proportion is the corner stone of decorative art.

A short time ago, in conversation with a very successful worker (an Oxford man) in one of the great social settlements of London, I was emphasizing the importance of art in social work. He interrupted me with: "Oh, yes, we don't go in for art here, but they do at Toynbee Hall. We go in for music, acting plays, literature and dancing." He seemed very much taken aback when I exclaimed; 'But I include all those under art.'

This testimony of these two typical witnesses, I have selected from a large amount of evidence which shows, that to most persons art is a small book written in a strange tongue. It seems incredible that the intelligent world should limit art to pictures and statues. Even Mr. Whistler, when he says: 'There never was an art-loving nation,' evidently has in mind only the plastic arts; for there never was a people who did not love art in some form. Ever since man began to reshape the external world; to employ his leisure to give pleasure to himself and others, art has been the one universal mode of communicating feeling. There is not, and there has never been, a group of people which has not expressed its emotions in some form of art.

As I have said above, science is largely responsible for the widespread misconceptions and indifference to art. It has dug a new channel into which it has turned the current of our thought. Out of these conditions naturally arise methods of teaching art which reinforce our wrong notions and increase our apathy; for the results approved by science are produced by pupils and teachers devoid of all appreciation for art.

In art, as in all forms of human activity, to produce and to consume are diverse operations which call into play different sets of intellectual faculties. Why, then, are not both producers and consumers legitimate claimants to recognition in education? In the nature of things, is there any reason for granting the claims of production, only, and teaching art in all our schools as though all children were to be nothing but producers? Is it not as important to use wisely as to make well? In art, should not children be taught to appreciate, independently of the use of tools? Certainly, no one will maintain that appreciation depends upon ability to do, but on the capacity to understand. One may enjoy the beauty of a house although one lack the skill to drive a nail; great pleasure may be had from the splendors of a gothic cathedral without knowing how to build one; and even the primrose may fill one with esthetic delight.

Here, then, we have two educational ideals. While I do not wish to minimize the great value of technical training in handicrafts as a means of developing character, I wish to insist that learning to do and learning to enjoy are independent and totally different functions. Every writer on economics dwells upon the important distinctions between makers and users, and the common experience of every-day life teaches that it is possible for man to make what he detests and thoroughly enjoy what he can not do.

There is no doubt of our ability as producers, and this vast power has been obtained by sacrificing our artistic instincts on the altar of production. Our modern society, like some great oak, has put forth all its vitality to extend one mighty branch, but to do this, it has sacrificed its symmetry and beauty.

The pleasure derived from an object of art—as from any object of enjoyment—does not depend upon an external standard, for, though a work of art may be pronounced perfect by competent judges, I may derive no pleasure, whatever, from it. In order to enjoy, I must be able to join hands with the artist and partake of his feelings. Every artistic conception is surrounded by an atmosphere of pleasurable emotion, and the art consists in giving expression to this. To be infected with this feeling, the mind of the spectator, like the sensitive plate in a camera, must be prepared to receive it, that is, it must possess the requisite capacity. Let us keep clearly before us that our goal, now, is not the acquisition of facts and opinions; it is not learning esthetic rules, nor relying upon some authority; these may assist, but no amount of such collateral truths can add aught to one's standard of appreciation—this can be done only by the action of the mind itself. The power to enjoy art, like the strength of the blacksmith's arm, is developed only through use. As a meteor entering the earth's atmosphere is set on fire by friction, so the feelings are enkindled by vital contact with art. Now this does not come alone from visiting picture galleries; attending grand operas, or reading the poets. These are favorable conditions, but in order to increase the power of appreciation, one's esthetic sense must find a place to rest its foot—where it may pause with delight.

This implies the perception of art. In this we have the process of growth, for the standard of appreciation is built up out of a countless number of these esthetic judgments—judgments rendered by the joint action of the emotion and the intellect. Hence the art-teacher is typified by the horticulturist who trims, buds and nourishes, making all conditions as favorable as possible, but recognizing that here his power ends, and that all growth must come from within. As all plant culture requires essentially the same methods, so the cultivation of appreciation rests on a few identical principles, no matter what branch of art is studied. Beneath the apparent diversity, art is a unity.—When the pupils of Angelo asked: 'Master, which is the greatest art?' he replied: 'I know of but one art.' So that our art instruction must rest on the great fact that art is not something done in a corner, but is as broad as human life. Not a nook nor cranny of human activity which does not hold some gem of joyous workmanship. Art shuns no medium, but clothes alike the Parthenon and the humblest object of daily use with dignity and beauty. As it forms some part of the environment of every child we naturally begin to build its standard of appreciation with the material nearest to hand. In literature, we do not begin with Wordsworth and Emerson, nor in music with the Ninth Symphony; why should we begin the study of plastic art with its most exalted forms? Life's interest centers in its immediate environment, and as it is with this that all rational education begins, we commence our instruction by teaching children to appreciate the art in the common and familiar objects which they touch and handle every day. In spite of the most rigid demands of utility, a big percentage of man's toil is devoted to the ornamentation of practical objects. The concrete world takes on every whimsical shape or color that can be thought of to solicit favor, and we pick out objects chiefly for the attributes which please the eye. Few will deny that very much of this is in bad taste and does not satisfy the esthetic sense, but gratifies some merely transitory feeling. Notwithstanding, we surround ourselves with these tawdry objects, because in the bewildering flood of forms and colors in which human effort takes shape we must direct our course by the chart with which we are most familiar, and this as the world goes is a price-list. Trusting too much to this, and urged on by fickle motives, it is not strange that in our search for art we lose all bearings, like the sailors perishing from thirst who hailed a distant ship for a little fresh water: 'Dip down! You're in the Amazon!' was signaled back.

Though few are aware of it, in every neighborhood are some works of art in daily use, and more hidden away in garrets, such as articles of table service, embroideries, household furniture, toys, kitchen utensils and workmen's tools. Nearly every kind of article has at times been made by artists. What a surprise to most young people to find out that art is not something afar off; to discover, as well, that every object made by man is full of meaning, having not only a character of its own, but being also an epitome of its maker's biography and a page of the history of his time. In fact it is a truer record of human action than printed page or spoken word.

With such a wide range of objects, the choice must be left to the teacher who can guide only where his love and appreciation light the way. As any object will do for a sign-post to beginners in this field, let us take a good specimen of a Chippendale chair which we place before the pupils. We call attention to its simplicity; lead the pupils to see the sincerity shown in its workmanship; to feel the dainty touches of originality in working out a pattern; help them to see the sufficiency of clean wood, free from ostentatious ornament, sham graining, and specious varnish; point out that the carving does not vaunt itself but artlessly adds to the charm of the whole; aid them to find out that no small curve could have been left off without loss of beauty; lead them up to appreciate its symmetry and unity—the highest notes in a work of art.

To place beside this a costly and gaudy chair, and to contrast it point for point with the Chippendale, will clarify many hazy esthetic perceptions. A mere hint will persuade most pupils of the futile attempt to make an ugly object beautiful by excessive ornamentation; that the chief end of varnish seems to be to fill cracks and cover up faulty workmanship; and that a chair filled with twistings and turnings is not unlike the fool who thinks he will be heard for his much speaking.

Let the young people but look at and think of the two chairs, and the simple dignity of the one will soon bring to view the braying vulgarity of the other. Their character will come out strongly if the pupils are prompted to strip off, in thought, as much as they can from each chair, without marring its beauty or taking from its utility. The Chippendale will bear the loss of very little, if any; whereas the other can give up a large heap of rings, warts, grooves, paint and contortions without taking from its usefulness, but, on the contrary, adding much to its beauty. Now as a better chair rises out of this rubbish, an economic truth will come into view: that a large amount of labor is spent to produce ugliness—to debase raw material. As one by one the artistic objects of common life are examined in this way and approved by this quickened power of appreciation, the non-artistic, also, will be forced to stand before the bar of the esthetic judgment to give an account of their purpose in the household. In most houses, the great number that will have to plead 'guilty' to the charge of worthless, defective or faulty must lead to an inquiry as to the function and relation of articles in the home, and an added zest will be given to this study of decoration by the discovery that the choice and arrangement of furniture are fingerposts to character. We see, in turn, the homes of the loquacious, the conventional, the shallow, the vain, the sincere, the refined, the deceitful, the vulgar; in fact most human virtues and weaknesses are unconsciously stamped on man's chosen surroundings. Such a study of decorative art will fit the student to take up, in the same way, other branches of art, and finally painting and sculpture.

Although now recognized by a few people that these two subjects may be intelligently studied without learning to paint or model, their true educational value is lost through the manner of teaching them. Either they are taught as purely sentimental subjects with which rude facts have nothing to do—as though they possessed some mysterious essence of beauty too ethereal to touch or think on; or else, like chemical substances, they are analyzed into their elements, the relation of their parts determined mathematically and the mannerisms of the artists pointed out and carefully noted down. Now while certain attributes of a painting and the balance of its parts are curious, and, for certain purposes, important items of knowledge, to single them out and teach them for their own sake, supposing it to be the study of art, is not unlike the mistake of the foolish virgins. The few features of a painting made use of to build up appreciation must be judiciously selected as witnesses to testify to the character of the art and thus assist the student to arrive at a just esthetic decision. The choice of facts for teaching art is determined by the capacity of the learners and like the pawns on a chess board, their value lies in the way they are used. Every choice that man makes illustrates the truth that all appreciation roots in experience; it therefore follows that a work of art is a sealed book to the spectator unless it deals with phenomena which are related to his mental world. For this reason, it is unwise to place before pupils paintings and statues which lead them into a foreign world of ideas and customs. The subject-matter should be explainable by the pupil's experience, leaving the art as the only new thing. As the character of pictures should be determined by the age and understanding of the pupils, rather than by the glory of the work of art, it naturally follows that for young people it is wise to select those works which portray familiar features of their known world. Our cities contain first-rate collections of modern art which can be thoroughly studied instead of making use of photographs of old masters, so foreign to the pupils. This will not seem so difficult if once recognized that a museum is not a storehouse, but a laboratory.

All art instruction, however good it may be, is bound to remain incomplete unless the school-room, its background, is brought into harmony with it. This can not be done by merely hanging the walls with pictures, as is clearly shown by the attempts in two of our large cities. The class-rooms in at least one public school in each of these cities have been 'decorated' with large and beautiful photographs of famous works of art. But the want of harmony in the proportions of the rooms, the ugly color of the walls and woodwork, the hopelessly commonplace paneling, and the inartistic seats, make the pictures as much out of place as mailed knights in a modern regiment. While such incongruity may make the vulgar stare, it can not but make the judicious grieve.

During recent years the cause of art has been espoused by professional esthetes with whom art is merely a fad. They use it as a means of self-advertisement. Such persons have no feeling for art and are blind leaders of the blind with the well-known result. As Mr. Whistler says in 'Ten O'clock': 'The voice of the æsthete is heard in the land and catastrophe is upon us.' For only he can teach, in whom the spirit of the artist dwells.

Considered and taught from the standpoint of appreciation, art becomes a vital force in the lives of men and forms an important factor of their effective environment. Each person, gratified at his growing powers of appreciating art at first-hand, is led to re-survey the surrounding world with this new artistic standard. This quality of expressing its maker's delight, which many objects possess—and nearly all may possess—is sought for without any other stimulus than the pleasure derived from gratifying the esthetic sense. Each object is made to stand a new trial and respond to a new set of demands. All the elements of environment are scrutinized, then condemned or approved; for, contrary to the popular notion, the majority of mankind have a latent power of appreciation for art, but like the water hidden in the rocks in Cyprus, it will come forth only when struck in the right place and manner.

If a woman, with a good esthetic standard, goes forth to buy furniture, she is no longer in a mood to be persuaded to buy an object, unless it comes up to her conception of beauty. Neither gilded ugliness, expensive tawdriness, nor the 'latest thing out' is wanted, but a character which she can live with and enjoy. Such a demand on the part of a goodly portion of purchasers would materially change the character of our manufactured product and leaven our social and industrial life.

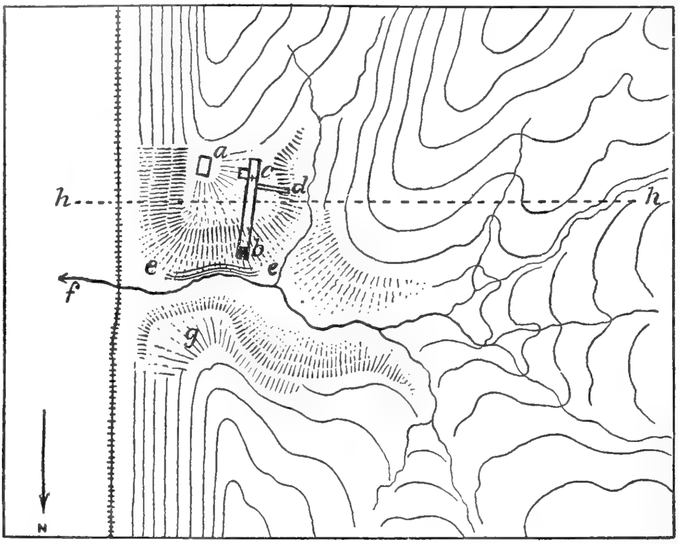
# THE FOSSIL MAN OF LANSING, KANSAS.

By Professor S. W. WILLISTON,
UNIVERSITY OF CHICAGO.

CLOSE by the mouth of a small but deep ravine opening into the valley of the Missouri River eighteen or nineteen miles northwest of Kansas City, and two and a half miles east of Lansing, Kansas, a farmer and his two sons, some two or three years ago, began the excavation of a cave to be used for the storage of their farm and dairy products. In the intervals of their more active farm work, this excavation was carried further into the side of the hill, until it had reached a length of nearly seventy feet. In February, 1902, a human skeleton was exhumed at the end of this cave or tunnel, but it excited no great surprise, since many fragments of bones had been found in the progress of their work. Fortunately, however, most of the bones were saved, though some were broken up and removed with the excavated material, from which not a few were recovered later. In the latter part of March, Mr. Michael Concannon, the elder son, took with him to Kansas City a fragment of one of the jaws and showed it to a reporter of one of the daily papers, by whom a brief account of the discovery was published.

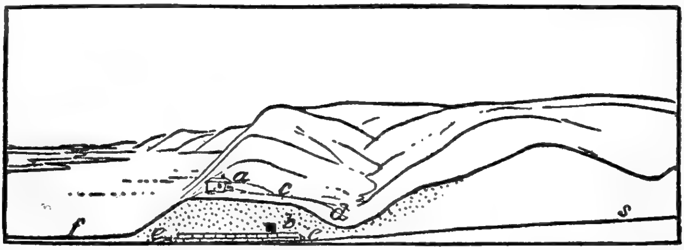
This notice attracted the attention of Mr. M. C. Long, the curator of the Kansas City Museum, a gentleman who has long been interested in things archeological. Mr. Long immediately visited the place of the discovery in company with Mr. F. Butts, and secured such parts of the skeleton as had been saved. They recognized the importance of the discovery, and, from Mr. Long's description, a more extended account was widely published by the newspapers, with more or less embellishment, as that of a glacial man. On July 18, the present writer, in company with Mr. Long, made as thorough an examination of the place of the discovery and the accessible remains as was possible at the time, the results of which were briefly published in *Science* of August 1. In this paper he affirmed his belief in the post-glacial age of the remains, attributing their inhumation to a time when the Missouri River flowed at an elevation of forty to fifty feet above its present bed.

Very soon thereafter the subject received the attention of a number of eminent geologists and anthropologists, those most competent to express an opinion upon the age of the deposits in which the bones were found and the character of the remains, who thoroughly examined the excavation and the bones. Among these were Professors Winchell and Upham, of Minnesota, Haworth, of Kansas, Chamberlin




SKETCH MAP OF THE LANSING SITE. *a*, Concannon dwelling and point of contact of limestone river bluff and recent bench. *b*, Entrance to cellar-tunnel. *c*, Inner end of tunnel where skeleton was found. *d*, Trench opened by Bureau of American Ethnology. *e–e*, Outcrop of limestone of floor of excavation. *f*, Entrance of rivulet to Missouri river flood-plain. *g*, Contact of limestone spur and bench remnant on north side. After Holmes.

and Salisbury, of Chicago, Calvin, of Iowa, and Drs. Dorsey, of Chicago, Holmes, of Washington, and Hrdlicka, of New York, all of




SECTION OF THE LANSING SITE SHOWING BLUFFS AND RIVER BEYOND, LOOKING SOUTH. *a*, Concannon dwelling and point of contact of limestone river bluff and recent bench. *b*, Entrance to cellar-tunnel. *c*, Inner end of tunnel where skeleton was found. *d*, Trench opened by Bureau of American Ethnology. *e–e*, Outcrop of limestone in rivulet bed. *f*, Entrance of rivulet to Missouri river flood-plain. *s*, Grade of steam bed. After Holmes.

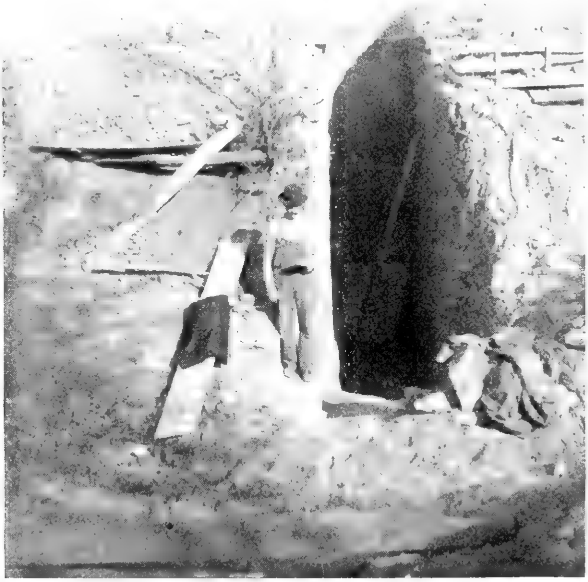
whom agree upon the essential facts concerning the discovery and the genuineness of the remains themselves.

While, however, the authenticity of the find has never been questioned, save by a Kansas City newspaper, the nature of the deposits in which the bones were found, and, in consequence thereof, the age of the bones themselves has been the subject of not a little discussion, and of wide differences of opinion. Already the literature of the subject is considerable, and the reader who chooses may find it in the discussions by Professors Winchell and Upham, in *Science* and the *American Geologist,* by Professor Chamberlin, in the *Journal of Geology,* and, more recently, by Dr. Holmes, in the *American Anthropologist.* The subject, too, has been fully discussed at the Congress of Americanists in New York, and at the various meetings in Washington during the session of the American Association for the Advancement of Science.

It is fortunate that the conditions were such that there can be no

View looking Northward across the Mouth of the Tributary Valley, showing Concannon's house at the left and the truncated slope under it, the mouth of the valley just beyond, and in the center the north bluff with its truncated face overlooking the Missouri bottoms, on the edge of which the railroad lies. The bluff is about 160 feet high. From a photograph by Mr. Chamberlin.

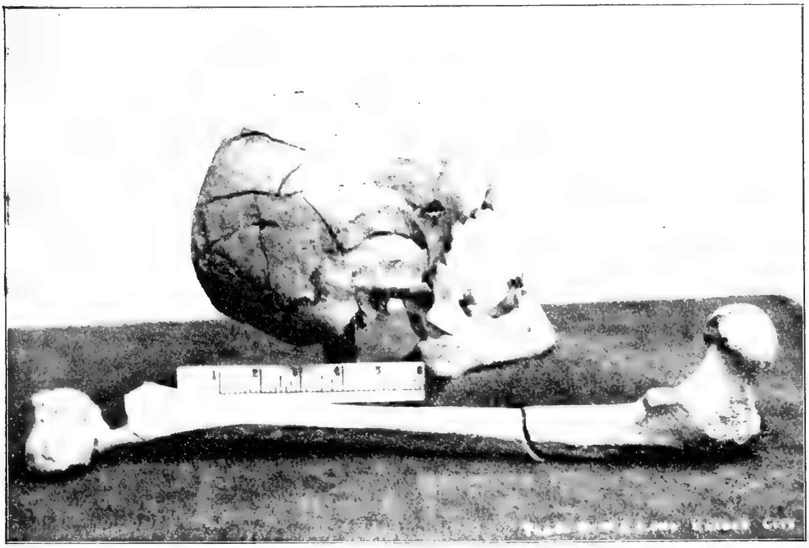
serious doubt concerning either the discovery itself or the nature of the remains. The small ravine, near the mouth of which the bones were discovered, opens upon the flood-plain of the Missouri River from the west. The ravine is less than a mile in length, with a fall of more than one hundred feet, and has no running stream, save perhaps for a short time in wet weather. Very near its mouth it has a tributary branch, perhaps a quarter of a mile in length, coming from the south, nearly parallel with the river bank. It is at the extremity of the intervening spur that the excavation was made, beginning a few feet above the bed of the ravine and extending southward nearly horizontally for a distance of seventy feet. The cave itself has for its floor in its whole length, a thick, nearly horizontal stratum of carboniferous limestone, but the material excavated is believed, in most part at least, to have been deposited by either the river or the recurrent freshets in the tributary ravine. The excavation has a width of about ten feet, and a height of seven or eight, the roof being slightly arched, which, with the walls, have retained their shape without support. Upon the floor, for a thickness of one or two, or in some places perhaps more, feet, there are many broken pieces of limestone, and shales, for the most part worn and disintegrated, that were evidently the talus from the adjacent hillside of carboniferous rocks. With these, however, and sometimes at higher altitudes there are not a few larger masses of



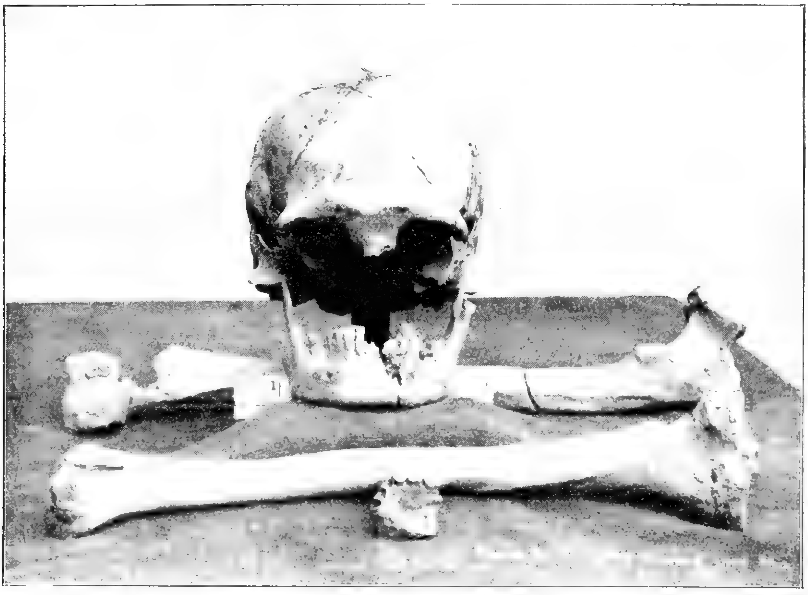
Entrance to the Excavation, Looking South.

sharp-angled limestone masses, lying horizontally. In this talus material a number of fragments of water shells were found. About three feet above the floor, on the west side of the tunnel, and extending nearly horizontally inward, there is a stratified layer of finer material. At places this stratum is pinched out and scarcely distinguishable, and later excavations show that it does not extend further than the end of the tunnel as first excavated.

Its material is not unlike that of the walls of the tunnel elsewhere, though less coarse. Above this stratum, evidences of water stratification are indistinct or wanting. In some places there are whitish horizontal streaks of limited extent, and some observers believe that distinct indications of stratification are shown in the disposition of the occasional masses or small nodules of limestone and pebbles. However that may be, there are not a few fragments of worn limestone and

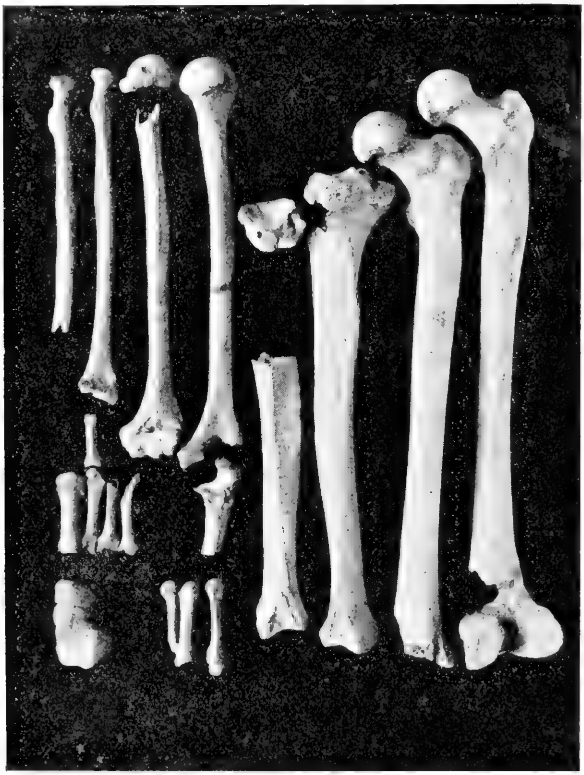


SIDE VIEW OF SKULL AND FEMUR FOUND IN THE TUNNEL. From a photograph by Mr. M. C. Long.



FRONT VIEW OF THE SKULL, TIBIA AND FEMUR OF ADULT SKELETON, with Maxilla of Child in foreground. From a photograph by Mr. M. C. Long.

occasional pebbles, for the most part of local origin. Otherwise the material of the walls and roof everywhere is a fine, siliceous, sharp angled silt, firm and lumpy when dry, but a soft mud when wet. It contains some, but not much, carbonate of lime disseminated through it, and is of a yellowish brownish color. At the edge of the roof, near the outer extremity of the tunnel, the writer dug from the wall a complete cast of a river clam. The original shell had entirely dis-



Limb Bones of the Lansing Skeleton.

appeared, leaving, however, the external markings sharp and clear. No other similar specimen has been discovered in the later excavations. Land shells, of three or four species, are abundant everywhere in the material. Fragments of bones of other animals than man have been discovered in the excavation, but they are indecisive in character,—a part of a bison vertebra, a mere fragment of a small artiodactyl metapodial, etc.

Additional excavations at the end of the tunnel, and a cross-section, undertaken at the instigation of Mr. Holmes, have disclosed the projecting point of carboniferous shales underlying the superincumbent drift material, between the end of the tunnel and the near-by bank of the river. Above the skeleton, the thickness of this silty material is about twenty feet, and the elevation of the terrace or knoll, between the tunnel and river bank, is about ten feet greater.

The present course of the Missouri River is at the opposite side of the flood plain a mile or more distant. Until within a few years, however, the river flowed within a few hundred yards of the entrance of the cave. In 1881, the year of the highest water known in the river at this place since 1844, the water reached to within about seventy-five feet of the cave entrance, and to within twelve and a half feet of the

VIEW IN THE MOUTH OF THE TRIBUTARY VALLEY LOOKING OUT UPON THE MISSOURI BOTTOMS AND SHOWING THE ENTRANCE TO THE TUNNEL AT THE EXTREME RIGHT. **From a photograph by Professor Chamberlin.**

horizon of the skeleton, as determined from Mr. Martin Concannon's testimony.

The bones discovered in the excavation belong to two different skeletons. One of these skeletons is represented by a single bone, the left upper maxilla, belonging to a child about nine years of age, as determined by the teeth, of which the permanent incisors and first molar were fully erupted, while the deciduous molars were much worn. This bone was found about sixty feet from the entrance of the cave, nearly upon the floor of the tunnel. The other skeleton was evidently complete, or nearly so, and but little disturbed. It was found about ten feet further away from the entrance, lying upon the limestone talus, though wholly covered by the silty material characteristic of the tunnel throughout. This skeleton is that of an adult between forty and fifty years of age, about five feet two inches in height, of slight build and, in much probability, of a female. The bones were firm, and as fully fossilized as could be expected in such material as enclosed them. The bones show in places an incrustation of a stony matrix commonly observed about bones of pleistocene animals preserved in river deposits in the west. I may also add that some of the bones of the leg show pathological deposits, probably rheumatoid. The young man who exhumed the skeleton stated that it was irregularly placed. As the specimen came under my observation it was largely enclosed in its original matrix. Very clearly it had not been covered by the limestone talus upon the floor of the cave. Portions of the encrusting matrix enabled one to determine that the bones had been in large part, if not wholly, articulated when discovered. Every collector of vertebrate fossils knows how rarely so large a skeleton as that of a man is found preserved entire and with the bones in position. The right femur was lying in its socket, but reversed; the left femur had been partly dislocated from its acetabulum, and was lying obliquely across the pelvis. Various other bones showed connections, and some of the bones of the feet are still united. Altogether, sufficient fragments were recovered to show that nearly every bone in the skeleton had been present. The femur measures a little more than seventeen inches in length (430 mm.), the tibia fourteen inches (350 mm.), the humerus twelve inches (302 mm.), the radius ten inches (250 mm.), and the forearm, from olecranon to wrist, eleven inches (277 mm.).

It seems very probable that the skeleton had been immersed in water while yet held together by the flesh. It is impossible that it could have been subjected to strong currents of water after the decomposition of the ligaments had occurred, nor could it have been exposed to the atmosphere for any length of time, nor even for a short time to the depredations of predatory animals while yet enclosed in the flesh. In other words, it seems almost beyond dispute that the person had either been thrown into the water very soon after death, or had been drowned, and that the body had remained immersed in comparatively quiet water until covered so deeply by the soil that it could no longer suffer the vicissitudes of exposure to the atmosphere and predatory animals. Evidences of artificial or accidental burial beneath the silt are wanting and are improbable. So far as any theory of the age of the skeleton is contradictory to this evidence it may be rejected.

Two chief views as to the age of the remains are now held: the one by Professors Winchell and Upham: the other by Professor Chamberlin, with the assent of Professors Salisbury and Calvin. To give all the reasons upon which these views are based is to repeat the already voluminous discussion, and we must content ourselves with the conclusions only.

According to Professors Winchell and Upham, the material covering the skeletons was deposited during the time of the fourth recrudescence or southward extension of the glaciers in the United States, in that stage known as the Iowan, that is, during the next to the last glacial extension which reached as far south as central Iowa. Under

VIEW FROM THE WEST SHOWING INTERSECTING TRENCH DUG TO JOIN THE ORIGINAL TUNNEL, with the Concannon residence in background. The skeleton was found nearly below the place indicated by the larger light spot at the right of the trees. From a photograph by Professor Chamberlin.

this view, the valley of the Missouri River was at this time filled to a depth of a hundred feet or more, but has since been excavated to its present level, and the material covering the Lansing skeleton is a part which has not since been carried away. In support of this view, it is claimed that the material covering the skeleton is of the character of glacial loess; that it shows evidence of water stratification; and that there is no evidence to prove that there has been any subsidence of the valley subsequent to glacial time.

The other view is that presented by Professor Chamberlin. He believes that the inhumation of the remains dates from a time when the river bed was from fifteen to twenty-five feet above its present level, that is, when the waters of the river eroded the surface of the limestone upon which the bones were lying, and that the bones themselves were covered by the action of the river, or by the wash from the adjacent uplands. The material above the stratum already described, Professor Chamberlin believes to be without evidence of water stratification; that it was built up chiefly by the action of the tributary, which deposited its washed down silt from the uplands upon the comparatively low gradient of the end of its valley, while the river itself was flowing at the opposite side of its flood-plain. He admits as possible, though less probable, that the whole of the material covering the skeleton may have been deposited by the action of the river while flowing at a high elevation. Whether his views are finally accepted or not, they are supported by valid arguments, and are conservative. By this explanation a considerable antiquity is accorded to our Lansing man, but one far short of the glacial times. If the other explanation is accepted, the one first offered by the present writer, and the one suggested as possible by Professor Chamberlin, the age of the skeleton would be considerably greater, though still much short of the glacial times.

Yet another opinion is held by certain able geologists—that the whole of the material covering the skeleton, and to the top of the knoll, full forty feet above the flood-plain, has been built up, for the most part at least, by the action of the tributary. This explanation might permit the inhumation of the skeleton within very recent times, since the settlement of the valley by white men, indeed. But, this view seems incompatible, not only with the physical conditions presented, but also with the evidence afforded by the skeleton itself, and is, I believe, untenable. This explanation would require the covering of the skeleton while yet in the flesh, by some sudden freshet in the ravine, so deeply as to be beyond the effects of the atmosphere, and the reach of the many prowling wolves and other predatory animals—a requirement that seems quite improbable, considering the position and condition of the skeleton. Such a freshet would be far more likely to wash the body or skeleton far out into the valley of the river.

Dr. Holmes has somewhat modified Professor Chamberlin's views, in that he believes that a change of level in the altitude of the river of five or ten feet would be sufficient to have met the conditions presented. However, Mr. Holmes frankly says that the decision must finally rest with the glacial geologists, none of whom has so far published anything to sustain the lessened estimate. Furthermore, Mr. Holmes' views are open to the same objections as those just given. It seems to me that nothing short of Professor Chamberlin's estimate will meet the paleontological requirements.

As to the character of the remains themselves, both Dr. Hrdlicka and Dr. Dorsey, to whom may confidently be left the final decision, assert that they are of modern type, and might well belong to an Indian inhabiting the plains region within quite recent times, so far as anthropological evidence goes. Nor does this verdict as to the character of the remains have much to do with either of the views presented. It is certainly not improbable that the widespread races of American Indians date back for thousands of years in their history. Mr. Upham's estimate of the time since the death of the Lansing man is about twelve thousand years, a not unreasonable time for the evolution of the American Indian.

Evidences of the high antiquity of man in America have hitherto been wanting, or doubtful, and the Lansing man, whichever age is assigned to him, can claim but little greater age than might be given him from *à priori* reasoning. One must frankly admit that proofs of man's contemporaneity with the many extinct animals of the pleistocene times in North America have been few, and perhaps in some cases doubtful. But, that man has existed with some of the large extinct animals of North America, the present writer, in company with other vertebrate paleontologists, believes. But this belief does not carry with it, necessarily, a belief in any very great antiquity. It seems very probable that some of these large animals, such as the elephant, mastodon and certain species of bison, have lived on this continent within comparatively recent times.

Furthermore, if the evidences of the commingling of human and extinct animal remains in South America are to be accepted, and such evidences seem almost beyond dispute, it must necessarily follow that man has existed on our own continent for a yet longer time, since there could have been no other way for him to reach the southern continent than through the Isthmus of Panama. In additional support of the evidence of man's high antiquity in South America, I am permitted to quote the following from a recent letter by Professor W. B. Scott, the distinguished paleontologist of Princeton University, who has recently spent some time in those regions in the study of the extinct vertebrate fauna: "I am convinced, from personal examination, that man existed in South America contemporaneously with the great, extinct mammals. To be more explicit, human remains have been found in the Pampean beds in association with large numbers of extinct mammalian genera." Is it not reasonable to suppose that we must seek for the earliest indications of man's habitation on our continent in the Pacific regions?

# THE PROGRESS OF SCIENCE.

## *THE SMITHSONIAN AND CARNEGIE INSTITUTIONS.*

THE regents of the Smithsonian Institution held their annual meeting on January 28, and the report of the secretary for the year ending June 30, 1902, has been made public. The first year-book of the Carnegie Institution is nearly ready, and will probably be distributed at about the same time as the present number of the MONTHLY. Those who are interested in science have, therefore, an opportunity to judge the work of these institutions, so unique in their objects and so great in their possibilities. The two institutions have many points of similarity in their organization and aims. The original bequest of Smithson, approximately $500,000, was about the same as the average endowment of the leading colleges at the time, and the $10,000,000 given by Mr. Carnegie is now about equal to the average endowment of our great universities. Each institution is managed by a board, which meets once a year at Washington and is composed of eminent citizens of the country. Each institution has an executive head, but lacks any body corresponding to the faculty of a university. There are, however, several points of difference. The Smithsonian Institution is concerned with the diffusion as well as with the increase of knowledge, and its activities are supposed to extend 'per orbem.' The Carnegie Institution is confined to the advancement of knowledge by research, and the founder has stated: 'That his chief purpose is to secure, if possible, for the United States of America leadership in the domain of discovery.'

The Smithsonian Institution has performed a service of immense importance, though probably not on the lines expected by the founder. What should be done with Smithson's bequest was for years a matter of debate in congress and elsewhere. When the institution was finally organized in 1846, it was the main center of scientific work in the country. Its 'establishment' was the president of the United States with his cabinet, the vice-president and the chief justice. The regents represented the executive, the supreme court, the senate, the house, the District of Columbia and different states. The secretary was keeper of the museum, librarian and practically the head of all the scientific work done at Washington. But in fifty years the scientific activity of the country has developed in a way that is without precedent. The incomes of our leading universities are twice the original endowment of the Smithsonian, and the national government spends annually on the geological survey or the weather bureau twice this endowment.

The Smithsonian Institution might conceivably have become a branch of the government coordinate with the executive, legislative and judicial branches, but the reverse of this has happened; its functions have become increasingly unimportant, and it probably now is a drag on the government agencies that it still administers. The establishment is a mere name; the regents meet annually for an hour or two to listen to the report of the secretary; there is no more reason why the secretary should continue as keeper of the national museum than as librarian of the national library. The last report of the secretary is certainly disappointing. So far from recommending that the National Museum and the Bureau of Ethnology should be given greater autonomy, he proposes to administer at the expense of the government a national gallery of art and has abolished the office of director of the Bureau of Ethnology. The researches done by the institution proper are described in four lines. One memoir of an outsider and three compilations have been published. The only attempt to do anything for the diffusion of science is the reprinting (at the cost of the government) in the annual report of scientific articles from this and other journals, the sales of which in the preceding year amounted to $16.41. The international exchanges are supported by the government to the profit of the institution and, so far as they concern science at all, belong to the age of barter. It is of course easier to criticize than to outline a constructive policy. The regents will hold an adjourned meeting on March 11, when there will be opportunity for discussion of the administration of the institution. Most men of science would agree, if invited to give their opinion, that the National Museum and the Bureau of Ethnology should be given greater autonomy and that the Smithsonian Institution should be brought into closer touch with the scientific interests of the country.

Appreciation is far pleasanter than criticism, but we can not express unqualified admiration for the work of the Carnegie Institution as related in its first year-book. The trustees passed a resolution requesting the executive committee to prepare a report on the work that should be undertaken by the institution, but apparently no definite policy has been adopted. Advisory committees of scientific men were appointed, and their reports, as published in the year-book, give interesting suggestions as to the needs of science. The members of these committees were, we understand, paid from $100 to $200 and then discharged. Were eminent lawyers, engineers or physicians retained for services so important, their fees would be from $1,000 to $10,000. Under these circumstances it is not surprising that the reports are somewhat unequal, and no attempt seems to have been made to coordinate them. There were no general meetings to consider the policy of the institution. Thus the committees on physics and on geophysics recommended an annual expenditure of $400,000, apart from buildings, publications, etc.; yet they probably do not expect the entire income of the institution to be spent as they recommend. If there is any one point on which the various committees tend to agree it is that the scientific work and policy of the institution should be directed by experts, but no provision has been made for such direction. In place of any large plans for the advancement of science, the trustees have appropriated $200,000 for subsidies which have been allotted by the executive committee. The details of these subsidies have not been published, but, in so far as they have become known, they appear to be rather obvious. Grants for the Harvard, Lick and Yerkes Observatories are safe investments, but do not appeal to the imagination. The revival of the *Index Medicus* is a worthy undertaking, but such a drag-net of medical literature should be supported by the physicians whose cases it further advertises. Fortunately the institution has avoided any serious errors such as the assumption of ownership of the Marine Biological Laboratory on which an option was purchased by the executive committee. The well-meaning but rather colorless policy of the institution is adequately shown by the report of the president which we reproduce.

### PRESIDENT GILMAN'S SUMMARY OF THE PLANS AND METHODS OF THE CARNEGIE INSTITUTION.

As a convenient summary of the plans and methods thus far agreed upon the following minute is approved:

The methods of administration of the Carnegie Institution thus far developed are general rather than specific.

The encouragement of any branch of science comes within the possible scope of this foundation, but as the fund, munificient as it is, is inadequate to meet the requests for aid already presented, not to mention others which are foreseen though not yet formulated, attention has been concentrated upon a selection of those objects which, at this time and in our country, seem to require immediate assistance.

Efforts have been and will be made to secure cooperation with other agencies established for the advancement of knowledge, while care will be exercised to refrain from interference or rivalry with them. Accordingly, ground already occupied will be avoided. For example, if medical research is provided for by other agencies, as it appears to be, the Carnegie Institution will not enter that field. Systematic education, abundantly provided for in this country by universities, colleges, professional schools, and schools of technology, will not be undertaken. Nor will the assistance of meritorious students in the early stages of their studies come within the scope of this foundation. Sites or buildings for other institutions will not be provided.

Specific grants have been and will be made, for definite purposes, to individual investigators, young or old, of marked ability, and for assistance, books, instruments, apparatus and materials. It is understood that such purchases are the property of the Carnegie Institution and subject to its control. The persons thus aided will be expected to report upon the methods followed and the results obtained. In the publication of results it is expected that the writer will say that he was aided by the Carnegie Institution of Washington, unless it be requested that this fact be not made known.

In order to carry out the founder's instructions in respect to bringing to Washington highly qualified persons who wish to profit by the opportunities for observation and research afforded by the various scientific bureaus of the United States Government, a certain sum is set apart for this purpose.

In addition, the Carnegie Institution will appoint from time to time a number of persons to be known as research assistants, who may or may not reside in Washington, and who shall undertake to carry on such special investigations as may be entrusted to them by the institution. The appointments will be made for a year, and may be renewed in any case where it seems desirable. Permission may be given to go abroad, if special advantages not accessible in this country can thus be secured.

Publication is regarded by the founder as of special importance. Accordingly, appropriations will be made for this purpose, especially for the printing of papers of acknowledged importance, so abstruse, so extended or so costly that without the aid of this fund they may not see the light.

With respect to certain large undertakings involving much expense, which have been or may be suggested, careful preliminary inquiries have been and will be made.

In order to secure the counsel of experts in various departments of knowledge, special advisers have been and will be invited from time to time for consultation. Valuable suggestions and counsel have already been received from such advisers.

## SIR GEORGE GABRIEL STOKES.

In the death, on February 1, 1903, of Sir George Gabriel Stokes, the mathematico-physical sciences have lost one of their most eminent representatives. For sixty years he has been a leader in the British school of mathematical physicists, a school including as peers and contemporaries George Green, Sir William R. Hamilton, Sir George Airy, James Clerke Maxwell, Lord Kelvin and Lord Rayleigh.

Stokes was born at Skreen, County Sligo, Ireland, in 1819. He was educated at Bristol College, and at Pembroke College, Cambridge, where he was senior wrangler in 1841. He was elected a fellow of Pembroke the same year. In 1849 he became Lucasian professor of mathematics at Cambridge, and he held this position up to the time of his death. He served his college and university also in numerous other positions of honor, having been master of Pembroke for many years and a member of parliament for Cambridge from 1887 to 1892.

SIR GEORGE GABRIEL STOKES.

The fields of work to which Stokes devoted his attention chiefly are those of hydromechanics, including the theories of fluid motion and sound; the undulatory theory of light, including among his more recent papers researches on the X-rays; and physical geodesy, including investigations on the figure and constitution of the earth and the variation of the acceleration of gravity at its surface. Taking up the work in these fields at the stage of advancement attained in the early part of the last century, mainly through the labors of the distinguished French investigators, among whom Lagrange, Laplace, Poisson and Fresnel were preeminent, Stokes contributed a large part of the decided progress gained during the past sixty years. He shares with Helmholtz the credit for the important advances in hydromechanics since the epoch of Lagrange; he did more than any other writer to extend the brilliant work of Fresnel; and his additions to the theory of geodesy are the most noteworthy since the epoch of Laplace.

His long and active career was crowned with recognition such as falls to few men of science. Universities and learned societies of his own and foreign countries conferred upon him the highest marks of distinction; while at the 'Stokes Jubilee,' celebrated at Cambridge in the summer of 1899, the whole scientific world united in presenting the heartiest tribute of appreciation of his laborious and fruitful life.

### *THE NEW YORK ZOOLOGICAL PARK*

The New York Zoological Park and Society have made important progress during the past year. We have already called attention to the fact that the New York Aquarium has been placed under the charge of the Zoological Society. The city appropriates $45,000 for the maintenance of the aquarium, while the society undertakes the scientific control. The importance of the aquarium as an educational institution is borne witness to by the fact that the average daily attendance is 5,000 persons. The new director, Dr. C. H. Townsend, has made a number of improvements in the aquarium. He has planned a fish-hatching exhibit, which will be in operation throughout the year, and alterations that will greatly improve the illumination and ventilation. He also proposes to bring the aquarium in closer touch with the

Cage showing Bengal Tigers.

school system of New York by providing material for biological classes and in other ways.

The Zoological Park has during the year greatly enlarged its buildings and its collections. The city provided $85,000 for maintenance, which is this year increased to about $105,000. The board of estimate and apportionment last year made a special appropriation of $250,000 for the improvement and extension of the park, which was used for the making of paths, etc., and for the construction of several buildings. The most important of these is the lion house, erected at a cost of $150,000. We give views of the interior of the main hall, which is 192 feet in length, and of one of the cages, which is 18 x 22 feet in size. It will be noticed that the cages are enclosed with netting instead of with bars. The cages are covered with glass tiling of a dull jungle green color, which forms an excellent background for the display of the animals and has many sanitary advantages. A unique feature of the building is a studio for artists, which will encourage painters and sculptors to make studies of animal life.

The lion house was opened in February; a new antelope house, costing $50,000, will soon be ready. The sum of $25,000 has been subscribed chiefly for the increase of the collections and valuable gifts have been received. The society pays special attention to scientific work, having established a pathological laboratory and appointed scientific curators in place of the usual keepers. The park was visited last year by 731,515 persons, in spite of its present inaccessible position; when the rapid transit system is completed, the attendance will doubtless be doubled or trebled.

MAIN HALL OF LION HOUSE.

## SCIENTIFIC ITEMS.

WE record with regret the deaths of Dr. H. E. Schunk, F.R.S., the British chemist; of the Rev. Dr. Henry W. Watson, F.R.S., known for his contributions to mathematics and physics; of

Mr. James Winshurst, F.R.S., known for his work in electricity; of Dr. John Young, lately professor of natural history at Glasgow University; of M. Pierre Lafitte, professor of the history of science in the Collège de France; of Professor Leonard Landois, professor of physiology at Greifswald, and of Dr. Morrill Wyman, one of the best known American physicians.

The Nobel prizes for 1902 were formally awarded on December 10—the prize in chemistry to Professor Emil Fischer, of Berlin; the prize in medicine to Professor Ronald Ross, of Liverpool University, and the prize in physics to Professor H. A. Lorentz, of Leiden, and Professor P. Zeeman, of Amsterdam. The value of each of the prizes is about $40,000.—The Desmazières prize of the Paris Academy of Sciences has been awarded to Professor Roland Thaxter, of Harvard University, for his study on the parasitic fungi of American insects.

Professor F. W. Clarke, of the U. S. Geological Survey, has been invited to deliver the Wilde lecture before the Manchester Literary and Philosophical Society next year on the occasion of the celebration of the hundredth anniversary of the propounding of the atomic theory at Manchester by Dalton.—Dr. Edgar Smith, professor of chemistry in the University of Pennsylvania, has been elected president of the American Philosophical Society.—Commander Robert E. Peary, U.S.N., was elected president of the American Geographical Society, New York, at its annual meeting on January 27.—Sir William Turner, professor of anatomy, has been appointed principal of the University of Edinburgh.—Professor G. N. Stewart, of Western Reserve University, has been appointed professor of physiology at the University of Chicago, to fill the vacancy caused by the removal of Dr. Jacques Loeb to the University of California.

The hundredth anniversary of the birth of Heinrich Daniel Rhumkorff was celebrated at Hanover on January 15. A tablet was placed on the house in which he was born and a new street was given his name. Professor W. Kohlrausch made an address on Rhumkorff's scientific work.—Mr. Carnegie has intimated to the provost of Greenock that he is prepared to present to a properly authorized authority in the town the sum of $50,000 to defray the cost of the erection of a memorial to James Watt.

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# THE POPULAR SCIENCE MONTHLY.

APRIL, 1903.

## ON THE ORIGIN OF SPECIES.*

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WHAT are species? To answer this question is as difficult now as it was in the days of Linnaeus. Formerly it was supposed that a certain number of forms had been created, and that these, obeying natural laws as yet undiscovered, had split up and so given rise to groups, which afterwards were called genera. Such genera were clover, rose and buttercup, plums, apples and pears. Among them, by the addition of a name, certain species were distinguished, such as red clover, white clover, etc.

Linnaeus, in his first publications, adopted the above view. 'Each genus is created as such,' is one of his best known theses. Later he changed this in so far as to declare species created, *i. e.*, those species which he recognized as such, and which he had endowed with binomials. In this manner, the power to split up, to produce new forms, and thus to form groups, was transferred to the species, which offered the great advantage, that, since species greatly surpassed the genera in number, the necessary number of splittings was correspondingly reduced.

Next to the disciples of Linnaeus and a few others who still adhered to the old doctrine, there soon arose a group of botanists and zoologists who went much farther in applying the principle of Linnaeus than was intended by him. The former continued to consider

* Translated from 'Album der Natur,' by H. T. A. Hus, Assistant in Botany, University of Amsterdam, and revised by the author. Cf. 'Die Mutationstheorie, Versuche und Beobachtungen über die Entstehung von Arten im Pflanzenreich.' Bd. I., Entstehung der Arten durch Mutation, Leipzig, Veit & Co., 1901.

genera as created, and species to have originated from them. When the number of known species increased and soon assumed undreamed of proportions, it seemed but natural not to accept for each species a separate creation. But the others denied the possibility of a transition from an old form to a new one by natural means. Each actually existing form, constant from seed, must, according to their idea, have been created as such. They denied the right to collect groups of forms under one specific name, as did Linnaeus and, after him, his disciples, especially when, owing to constant research, an exceedingly large number of forms became known. Instead, they recognized each form as a unity—unities which could be collected under a generic name only.

But Linnaeus, guided more by the talents of a lawyer than by those of an investigator, had once for all connected his conception of a species with the use of the binomials introduced by him. Whatever bears two names is a species. This is the law which all must obey. Genera bear simple names, subdivisions of species tri- or quadrinomials. Whoever wishes to have a form recognized as a species, must give it two names. Unless this be done he will not attain his object. But the number of simple forms, constant from seed, increased year by year and, even for Europe alone, threatened to become ten times greater than it had been.

Since the validity of the theory of descent has been generally recognized, these questions have lost much of their importance.

The work of Darwin embraces two main theses which as a rule are not sufficiently distinguished and which even by him were frequently collated. The one was to ascertain the common descent of plants and animals, the other, to find how one species could have originated from another. These two points are mutually independent, and were especially so at the time of publication of Darwin's 'Origin of Species.'

The doctrine of the common descent of all organisms holds that genera, families and even the larger divisions of the plant- and animal-kingdoms originated in a manner identical with the one which, before the days of Linnæus, was largely accepted for the splitting of genera into species and afterwards for the formation of subspecies from species. The common origin of groups of smaller types was recognized; but how large these groups were no one knew exactly. Darwin extended their limits so as to enclose all living organisms, practically collecting them into a single genus.

For this purpose it was not even necessary to know how the simple forms themselves originated. What was conceded for these by every one, had only to be applied to the larger groups. Yet Darwin attached considerable weight to this question and threw much light upon it.

That the smaller species are created as such is the view now held by a comparatively small group of scientists. It is a contention, the truth of which has never been generally recognized, and at the present time has of course lost all right of existence. Before and after Linnaeus, before and after Darwin, the formation of the smaller species, the one from the other, has, except by the few above mentioned, been generally recognized, a recognition based upon experience as well as on tradition.

The smaller species are called subspecies or, as in horticulture, varieties, and are therefore considered as subdivisions of the species of Linnaeus.

Their descent from other species was conceded even before the days of Darwin, but nothing was known regarding the manner of their origin. It was generally deemed sufficient to attribute it to environmental influence. In agriculture and in horticulture it occurred from time to time that new forms originated from older ones; it always happened unexpectedly and without gradual transitions, always by skips and jumps. The new forms were called sports; whether in nature the same thing occurred was unknown.

Both in agriculture and horticulture these sudden changes were very rare and always shrouded in mystery. They occurred without any apparent preparation, the new form appeared unexpectedly, and once its presence had become apparent it was impossible to trace its origin. One could but state the fact, which, for cultivation- and trade-purposes, was deemed quite sufficient; but its nature remained wrapped in darkness. Truly no tempting basis on which to found a grand theory.

It was for this reason that Darwin preferred to turn to more generally known, or, at least, more tangible, facts. He laid much stress on over-production, on the struggle for life which must be the consequence, and on the greater chances of success possessed by the strongest individuals or by those best adapted to their surroundings.

He pointed to the dissimilarity, the so-called variability of individuals, and showed it might be met with everywhere and at all times, in all organs and in all characters. This dissimilarity is decisive in the struggle for life; not in every individual case of course, for here chance plays too prominent a part, but in the majority of cases and in the long run. That which is not fitted for the surroundings must succumb; each species adapts itself more or less to its environment; each species is different in nature from what it would be in the absence of all disturbing influences and were its reproduction unhampered.

How far can variability extend its influence? Has variability its limits? May variability proceed for centuries in the same direction or must it necessarily return to the starting point? Can variability bring about the formation of new characters or new organs or is it limited to differences in the degree of development of those already extant? Most of these questions were left unanswered at the time and, for the greater part, have remained so. And, as long as no answer was forthcoming, imagination had free play as regards the manner in which one species originated from another.

A stop was put to this when Quetelet discovered his famous law. Variability obeys certain rules; nothing outside the compass of these rules can be attributed to it. Variability is not unlimited and always returns to its starting point. There may be various causes for a prolonged deviation of variability from the mean, of which continued selection of individuals, strongly developed in any particular direction, is the most important; but as soon as these causes cease to exist or this selection ceases to be practiced, it must return to the mean. Variability is nothing but a more or less, a plus-variation or a minus-variation; it does not go in any direction other than the greater or lesser development of a character already present. Variability merely causes a decrease or an increase; it does not create.

It remained for the disciples of Quetelet to draw attention to the consequences of his discovery, which are among the most recent results of scientific research. Darwin and Wallace were not acquainted with these objections to their theory, it was only long after the publication of their works, that science became aware of the existence of these objections and of their importance.

The theory of variability, such as we know it at the present day, does not lead to conclusions favorable to the theory of the gradual origin of species, the theory which assumes that species originated by a gradual increase in the degree of variability. Hence many writers have at various times declared more or less openly against this theory. Others again have tried to reconcile it with the newly discovered facts. But Darwin's explanation is a most plausible one, which, apparently at least, solves all difficulties. And the voice of his antagonists is as yet not so powerful but that the great majority should remain faithful to the old banner.

Besides, Darwin never expressed himself so definitely upon this point as some would have us believe. Openly in one passage, less so in a second one, he acknowledges the possibility of another explanation. It might very well be possible that the changes of the species in nature might occur suddenly, as had been observed to be the case in agriculture and horticulture. This would, as satisfactorily as the theory of gradual change, explain the relationship existing between smaller species in nature and more especially between those agricultural plants which systematic botany unites into a single species. Without a doubt, the formation of the various kinds of beets, of oats or of barley, would have required many centuries, but the results are accounted for as easily by accepting exceedingly slow changes as the causes of the formation of species, as they would be were we to consider them due to shocks occurring but once in a protracted period. Darwin fully realized this and considered the doubt upon this subject as one of the weakest points of his theory.

Darwin, as did many since, compared the origin of species in nature to the methods, ordinarily used in agriculture, to obtain improved races of plants and animals. On this subject much confusion exists. Horses, for instance, are improved principally by crossing with specimens of a superior race, which specimens more or less fully transfer the good qualities of the race to the descendants. But it is certain that in nature the species did not originate in this manner, at least not as a general rule. Improved races are obtained only by careful and constant selection in one direction. This bears a great resemblance to the origin of species, but there is this objection, that such a race would never be independent of selection; as soon as selection ceases, the good qualities disappear. Species and subspecies, even true varieties, on the other hand, are totally independent of the mother species; neither in nature nor in cultivation do they return to the old type, either by a change in environmental conditions or by the cessation of a selection; always provided of course, that accidental crossing is impossible.

The experience yielded by agriculture would lead one to consider a gradual transition from one species into another improbable. They point to a distinct difference between gradually improved races and those suddenly formed, so-called varieties. The former bear no resemblance, the others a resemblance in all respects to wild species.

During the last few decades several writers have expressed themselves more or less strongly against the conception of a gradual origin of species. In America Cope was the one to set the example. Among paleontologists Dollo, among zoologists Bateson, and recently among botanists Korschinsky declared themselves in favor of the doctrine of the discontinuity of the natural ancestral trees. But their opinions have not been sharply defined and formulated and are based upon an acquaintance with facts not much larger than that commanded by Darwin himself. Hence their small influence and the small progress made by their convictions. Hence the American paleontologist Scott, a devoted adherent of Cope's doctrine, deemed it necessary to defend this doctrine against Bateson's book. For his conception of discontinuity is entirely different from that of Bateson. They are both dissatisfied with the reigning views on the origin of species by gradual variability, but in its place each wishes to put an entirely different conception.

It would lead too far were I to enter here upon the various points on which their theories differ; let it be sufficient to note some parts of Scott's treatise, since this gives the sharpest and clearest contrast to the reigning view. In the long ancestral trees which have been brought to light by the study of prehistoric animals, one form leads gradually to another. When the strata are sufficiently known there remain no breaks in the pedigree. Breaks are met with only where the strata are wanting or where it has as yet been impossible to study them thoroughly. Each ancestral tree consists of an uninterrupted series of forms. Between two adjacent ones there exists no greater difference than between the two most closely related species of the present day. And in the successive strata they follow each other up in such a manner as corresponds to the gradual development of the ancestral tree.

But how did each form originate from the one immediately preceding it? Gradually or suddenly? Directly, paleontology can of course not teach us anything upon this subject. Did the species originate suddenly, then there can have been no intermediate forms, but even if they originated gradually the chances that such intermediate forms would have become fossilized, are exceedingly slight. For how small is the proportion of fossilized specimens to those which once must have existed! In any case, no such intermediate forms have been found, and it is for this reason that many paleontologists accept a sudden formation of new forms from the older ones. The transition is slight, as slight for instance as the well-known differences between the local races of slugs; but as these races are constant, so in paleontology are the closest related forms sharply separated from one another.

The contrast between the views of Scott and those of the majority of botanists and zoologists has, I believe, been sufficiently shown here. According to Scott species did not originate gradually, but by small jumps. By each jump a limit was passed, but after that the species remained constant until, perhaps many centuries later, a new shock produced a new form. Each species, each subspecies, or even each variety, is constant in all its characters; they remain the same from the beginning till the end, until, later on, either after having produced other species, or without having done so, they succumb in the struggle for life.

This theory restores the doctrine of the invariability of species to its old place. And this invariability is so general a matter of experience that it has always remained an exceedingly weak point of Darwin's theory of descent. The continual, slow, even inappreciable changes of species, which Darwin, but more especially Wallace and his disciples, accepted, and which are so lineally opposed to every-day experience, do not exist for Scott. Each species remains unchanged as long as its period of existence lasts. All its characters vary more or less according to the law of Quetelet, but the type, to which all variations return, remains the same through centuries.

A species changes only when it produces others. Or rather, it does not change, but continues to exist next to the species newly formed. It may be compared to a tree, which, though it produces branches, does not cease growing in length. Only when among its descendants there are types better fitted for the battle of life, a species may locally succumb. But it would require a long time before the new species had entirely taken the place of the old.

It is clear that one must distinguish by some simple term variation by jumps from variation obeying the law of Quetelet. It is not practical to use the terms, sport, discontinuous variation or spontaneous variation, since they tend to produce the impression of something incomprehensible. Scott did not use these terms. He speaks of 'mutations.' A mutation occurs when one species is formed from another. As it is, 'mutation' is the expression in general use before the days of Darwin, and at first used by Darwin himself. Since it has apparently fallen into disuse, except in paleontology, where it is met with in various authors, always conveying the same meaning, it seems best to continue to use this term. Hence as long as species produce others they are called mutable, and this part of the doctrine of variability is known as mutability.

Once it has been conceded that species originate from others by mutation, one can go on to investigate what deductions must be made in regard to this process from the facts with which we are acquainted. And as long as an empirical investigation was impossible it was of the utmost importance to be able, even in this manner, to form an opinion about it.

First of all, we can come to the conclusion that mutations must be the smallest changes which can produce a difference between two species or rather between two constant types. Ordinarily the estimation of the differences existing between two related species is too great. Differences as between a horse and a donkey are of course not the result of a single mutation; there must have been a series of transition forms, at present extinct. Nobody will expect to see so great a change occur at once. Even much slighter differences, for instance those existing between our native violets, are still too large; here also there must have existed transition forms. And indeed a comparison with the floras of other countries actually does show a number of forms which bridge over these differences.

Yet differences between species are often so small that only a very careful study can make us acquainted with them. Among our native plants I have but to mention *Cochlearia Anglica* and *C. danica, Lepigonum* [*Spergularia*] *salinum* and *L. medium, Chrysanthemum maritimum* and *C. inodorum, Carex Oederi* and *C. flava.* These are differences which one would rather neglect. Other examples can be met with in the genera *Rosa, Rubus, Salix, Hieracium* and many others; each botanist is acquainted with them, they are the common stumbling-blocks on botanical excursions. Yet in systematic botany they are regularly recognized as *bona fide* species.

It sometimes occurs that two of these species which closely resemble each other grow side by side, as in the instances above-mentioned. In this case one can as a rule compare them when fresh, and in this manner fully realize the differences existing between them. But it happens far more frequently that the two plants, or three or four members of a small group, occur in different countries, often at great distances from one another. Then the differences are far less apparent. To this must be added that by the drying process necessary for herbarium purposes, many characters are lost. In that case the plants are no longer clearly distinguished, and are ordinarily considered as a single species, united under one name. This happens with *Draba verna, Viola tricolor, Helianthemum vulgare* and numerous other plants. It is only when we obtain them from different countries and grow them next to each other in the garden that the differences become apparent, and it is only then that these differences prove to be as great as those existing between the members of the above-mentioned couples of species.

One must therefore consider each mutation a step not greater than the differences between *Chrysanthemum inodorum* and *C. maritimum* for instance. I choose this example because the first species, the double form, with entirely filled, pure white, exceedingly graceful heads, is a well-known component of bridal bouquets. Besides, both are native species and of common occurrence, but generally not distinguished on botanical excursions. Where the differences between related species are greater, the lack of transition forms must be attributed to the fact that these live in other countries, or to their having become extinct.

In the second place, various investigators have come to the conclusion that mutations must occur periodically. For it is only in this manner that we can make the theory of descent agree with the undeniable fact that the species, such as we know them at present, have remained unchanged for centuries. In certain localities, on islands for instance, or places so situated that for centuries no transportation of plants or seeds can have taken place, the individuals of any one species do not show any or, at least, no constant differences, the above-mentioned couples of species, and compound species excepted. Spruces form a compound species, consisting of numerous types, but the common fir which without doubt is older than our era has remained the same everywhere. It is ever thus; the species do not undergo any gradual change, but each species is constant and remains so until others take its place. It never or but rarely occurs that new species make their appearance in fully investigated countries, unless indeed they happen to have been introduced from elsewhere. Yet it is probable that new species are formed quite frequently, but that, being too weak, they succumb before one becomes aware of their existence.

The numerous small species which are united under the name *Draba verna* are constant to seed, they do not change, besides they are distributed throughout Europe. It is therefore considered probable that there was a time during which they were formed, probably in a comparatively small region in the central part of Europe [at the present day they are most frequent along the Rhine and the Loire], and that in this locality flourished one or more species from which the present forms originated. At the end of this mutation-period the species would again have become constant. In this manner mutable and immutable periods in the development of species would have alternated more or less regularly.

There is a great tendency to consider a rapid increase in number as one of the reasons which cause a species to become temporarily mutable. Many species multiply exceedingly rapidly when they are transported to a new region where the conditions are favorable. Many European plants did this in America, likewise many American plants in Europe, as is only too well known through the waterpest, *Elodea canadensis*. As a matter of fact, we did not see them 'mutate,' but this may have been due to insufficient observation. It would be of great importance to pay close attention to this point when draining lakes, clearing waste lands, after forest fires and in similar cases.

Whether the mutations, during the mutable period, have been one-sided or many-sided, is a most important question and one frequently discussed by the adherents of the mutation theory. The case of *Draba verna,* just mentioned, certainly speaks in favor of many-sided variability; the 200 'subspecies' known, vary in all organs and in all possible ways. Numerous other instances might be quoted. But opposed to them are the results obtained by paleontology. The progress in zoological times, more particularly in the animal kingdom, has always followed definite lines; by a straight line nature tried to reach her goal, not by zigzag lines, feeling her way. The main line has of course numerous small side branches, but branches which do not lead to still living types are rare. Scott and others deduce from this that mutability is one-sided, only progressing in the desired direction. Yet it might as well be possible that the mutations were many-sided, but that of them only those survived which excelled their ancestors in a particular direction, better fitting them for the existing conditions.

Finally one can come to a very important conclusion in regards the manner in which plants and animals mutate. It is this, that new species did not originate in a single individual, but in a number of individuals, either at the same time or during a number of years. Delboeuf was the first to formulate this idea, and Scott and others agree with him on this point.

This is a quite simple and natural view to take. A single individual would, among all the members of his former species, practically have no chance of life and reproduction, even if it were a hermaphrodite plant and much better adapted to local conditions than the others. For this chance plays too prominent a part in the struggle for life. There are a thousand chances that a seed does not germinate or is killed in its prime, independent of any qualities it may possess. Once the young plant has passed this period, the chances certainly are better, but even then many succumb because they occupy an unfavorable place. But when a plant produces a number of individuals of the new species at the same time, and repeats this for a number of years, then the chances of the new species are sufficient; and this even if it is weaker or in some regards inferior, and certainly if it is as good as the mother species. It is not at all necessary that the new species be stronger, or be at once offered the opportunity to make use of its superior qualities. Delboeuf carefully calculated the chances, but even without these calculations one can see the truth of his remarks. For the larger the number of mutating individuals, and the more generations this mutating lasts, the greater will become the chance of the new species to maintain itself among the old one, always supposing the former is not so weak as to be crowded out each time. To be better equipped than others before entering upon the struggle for life is certainly a great advantage, but not a *sine quâ non* for ultimate success.

Reviewing the above, we find that the mutation theory comprises the following theses. Species originated from others by sudden but small changes, often so small as to be hardly visible to the neophyte. They are constant and true to seed from the first; neither are they connected with the mother species by a series of intermediate forms, nor do they have to pass in their prime, a stage of gradual development. This formation of new forms does not take place continually, but it is only from time to time that a species enters a period of mutability; in this case it produces, during a certain number of years, one or more, perhaps an exceedingly large number of new species. The mother species itself remains unchanged; it may persist after the mutable period is passed, and in that case retains its old characters. The new species make their appearance in several, probably in numerous, individuals, and during each year of the mutation period. If they do not do this, their chances of life are exceedingly small, but in the other case their chances are sufficient, even if the new species are not in any regard superior to the mother species. The weaker ones among the new forms disappear of course very early.

The real struggle for life, in which natural selection must decide whether the young types shall continue to exist or not, only comes later on; it is not a war between species, but against other organisms, and against climate and soil.

In 1886, when I was preparing to write my *Intracellular Pangenesis,* the above mentioned considerations were only partly known to me. De Bary's studies on *Draba verna* only appeared in 1889, Bateson's book in 1894, Scott's article a little later, etc. But what was known at this time was sufficient to convince me that the formation of species should lend itself to experimental investigation. This was certainly directly opposed to the *reigning* opinion and especially the conception of a slow and gradual origin was not in favor of my view. It was thought that sudden transitions were limited to the so-called varieties, that they occurred in agriculture and horticulture only, and besides so rarely that an actual study of the problem was not to be thought of.

I then began a more systematic study of the variability of plants, a subject which always had possessed a great attraction for me. It very soon became apparent that observations in nature and in the garden could not lead to the desired goal. Even if one pays constant attention to the same individuals and the same localities, visiting them in various seasons and in different years, the observations remain too incomplete. This is but natural, since mutability commences with the seed and in nature but comparatively little seed, after germinating, attains its full development. I therefore decided to have recourse to sowing-experiments and for this purpose collected as much seed as possible from wild growing plants.

This seed was sown in my experimental garden, in some cases on quite a large scale. Besides I sowed seed gathered from some specimens of wild plants growing isolated in the garden. It was of course my aim to try to find among them one or more species which were passing through a mutation period. Among the seed sown was for instance that of *Verbascum thapsiforme, Thrincia hirta, Crepis biennis, Centaurea nigra, Capsella Bursa pastoris, Bidens cernua, Aster Tripolium, Cynoglossum officinale, Sisymbrium Alliaria, Daucus Carota,* and a number of other wild plants. As far as possible I allowed myself to be guided by symptoms of a particular tendency to variability, and hence chose by preference seed from plants with fasciated stems, split leaves or other variations. I also sowed, as far as room permitted, seed of annual garden plants, bought in shops.

It is clear that, notwithstanding the immense amount of work involved, the chances of success were exceedingly small. Yet I was lucky enough to find the very thing wanted. Among a hundred species there was a single one which proved to be mutable, at first but in a small degree, but sufficiently to decide me to abandon nearly all other experiments and to study this one plant as thoroughly as possible. Of the other species I had in the meantime obtained a number of monstrous races; these I continued to cultivate, but not the others.

The plant referred to was *Oenothera Lamarckiana,* a species of American origin, which has here escaped from cultivation, as did formerly both the evening primroses, *Oenothera biennis* and *Oenothera muricata,* which at the present time are quite common on our sand dunes. *Oenothera Lamarckiana,* the large evening primrose, surpasses both other species in size of flowers, but for the rest is very much like them. This plant was first described by Lamarck as *Oenothera grandiflora,* but by this name a number of other species of *Oenothera* are known. Seringe changed the name to *Oenothera Lamarckiana,* which name has been retained.

In 1886 I collected a quantity of seed from wild plants of *Oenothera Lamarckiana* and also transported a number of rosettes of biennial specimens to the botanical garden at Amsterdam. The next year they flowered profusely and produced a large quantity of seed.

The seed obtained from wild plants was sown in 1887 and yielded at once what we desired. For among the plants obtained from it, there were three which, though agreeing among each other, possessed characters entirely deviating from those of the rest. This species was, therefore, able to produce at least one new form. The new form differed more from the mother species than the three species above mentioned did among each other. The leaves were broader, rounder and more obtuse, the buds swollen and the fruits small. The stems were small, weak and remained brittle even in autumn. At the tips of the branches the young leaves and buds were collected in crowded rosettes, so that at first the plants were denoted 'roundheads.' In a number of other particulars they differed more or less from the ordinary form, in fact they did not entirely agree with it in a single point. The most important difference, however, was the inability to produce good pollen. The anthers of the mother species are, when open, thickly covered with a sticky powder, which is entirely lacking in the case of the roundheads. The anthers of the new form are dry, what little pollen there is is shriveled, for the greater part unfertile and entirely unfit for fertilization. The plant is purely feminine. Male or hermaphrodite specimens I never saw, though I have often cultivated hundreds of roundheads. On account of the broad leaves, and thick buds, *Oenothera lata* was chosen as the systematic name.

Encouraged by these results, I continued my investigation, partly, during the same year, by a closer study of the locality where the seed was collected, partly by sowing experiments on a large scale in the spring of the year following. The former made me acquainted with two new types, which had remained unobserved in 1886, but which, as rosettes of root-leaves, must have been present at the time, since *Oenothera Lamarckiana* is, in that locality, biennial, with hardly any exception. The one was glabrous, more delicate and more graceful, but as robust as the common form, the other had so short a style that the stigma, instead of protruding far above the stamens, was situated at the base of the flower. Both forms were formerly absolutely unknown, and, later on, in the sowing-experiments, proved to be as constant and true to seed as the mother species. That they originated in the locality where they were found may be considered as certain, but how this happened could not be investigated.

The seed, sown in the spring of the following year, again yielded two new forms. The one was a dwarf form, such a one as occurs from time to time among all kinds of culture plants—but a few decimeters high, whereas the mother species attains a height of 1½ to 2 meters and more. The other was a form with shiny leaves, about half the size of *Oenothera Lamarckiana,* narrow, dark green, and very graceful. Both were quite fertile and produced a large quantity of seed.

Dwarf forms are ordinarily described along with the species to which they belong, as *varietas nana* or *nanella,* and my dwarf forms agree with them in every respect. They offer a good contrast with the other types, which cannot be termed varieties in the ordinary sense. For, in the first place, they deviate from the parent species not in a single character, but in all, and, in the second, they do not have their parallel in other genera. For repetition, such as appearance of white flowers, glabrous leaves, thornless stems and fruits, unbranched stems, variegated leaves, double flowers, etc., is one of the most common characteristics of true varieties.

Later the dwarfs proved to be constant to seed. Not so the shiny variety. Though I did not sow the latter each year, I did it frequently; its characters reappeared as a rule in but about one third of the individuals.

By sowing I obtained in 1888 nearly 15,000 plants, among which there were five dwarfs and five *latas,* that is to say, of each about 1 on every 3,000. In later years, when I became familiar with the most favorable methods of treatment, the percentage increased considerably, until at last there appeared approximately one new form on every 100 individuals.

The *latas* were, as we have seen, obtained partly from seed collected from wild plants and partly from seed yielded by wild plants transported to and cultivated in the botanic garden. Yet they agreed entirely in all respects, forming but a single well-defined type. Later in 1889 and in 1894, I also found them in the original locality.* In my garden they made their appearance nearly every year. Each *lata*-plant which, without similar ancestors, originated from the *Oenothera Lamarckiana,* bears always exactly the same characters; one can always recognize it shortly after germination, and predict at the time all characters which it will exhibit later on. The same is true for the dwarfs, for the shiny forms, etc.

Once the certainty obtained of having found a mutating plant, I of course applied myself as closely as possible to a study of this phenomenon. Naturally this was at first connected with great difficulties, especially because I did not have an exact idea of what I was to look for. It was only in 1895 that I succeeded in surmounting these difficulties. I had by that time realized how small were the differences to which I had to pay attention, and that these differences, at least for the greater part, are apparent in the earliest stages of development. I therefore sowed on a large scale, reviewed my plants nearly daily, and changed each clearly deviating form to another bed, where it was given plenty of room and tended with great care.

That year I obtained about 14,000 plants from seed. Dwarfs and roundheads made their appearance in large numbers, 60 of the former and 73 of the latter. Their parents had been ordinary *Lamarckianas,* carefully pollinated with each other's pollen, as had been their ancestors of the last two generations and therefore of pure descent, as were probably all their ancestors of the original locality. The shiny form also made its appearance, again in but a single specimen. Besides there appeared five entirely new forms; three of these were separated as rosettes, one only showed itself to be a new form, when flowering, and the other only during the next year after hibernating.

The last two were rare, the one, *O. leptocarpa,* appeared in two specimens, the other, *O. gigas,* in a single individual. Both are at present constant to seed, absolutely unchangeable. The former is not beautiful, but ranker and taller than *O. Lamarckiana,* and flowers later in the season. *Oenothera gigas,* on the other hand, is a splendid, exceedingly robust plant, which, with a rich crown of very large flowers, easily excels the mother species.

The three others I denoted as 'red-nerved,' *O. rubrinervis,* 'white,' *O. albida,* and *O. oblonga.* They appeared respectively in 8, 15 and

* Likewise this year [1902].

176 specimens. The whites were very weak, and all of them died without flowering. But they reappeared each year, and in 1897 I succeeded in getting them to blossom. After that they proved to be constant and true to seed. The same is true for the red-nerved ones and for the *oblongas,* which are very typical and easily cultivated species.

Since 1895 I have each year sown *Oenothera Lamarckiana,* always taking care that the seed was pure. Fertilization was always artificial, with their own pollen, and with the exclusion of all insects. Yearly I had a thousand or more seedlings and regularly found among them a number of mutations. The new forms with which I already was acquainted reappeared each time; with a single exception no others have been added. The percentage of mutants remained the same each year, of course with slight variations.

Repeatedly I saw new species originate which either did not flower or were sterile or which on account of general weakness succumbed early in life. Some of these clearly originated several times, others so rarely that it was practically impossible to make a diagnosis. A few of these I also found in the original locality. Hence nature evidently makes besides species capable of existence also those which are not so. The latter disappear very soon and hence are hardly ever seen; the former persist for a greater or smaller number of years.

The above may be considered sufficient to prove that the origin of species is a phenomenon falling entirely within the limits of ordinary observation. One has but to search his surroundings for a plant which happens to be passing through a mutation period to be able to study the entire process. Transportation to the garden only serves to make isolation of the plant possible; it but shows what happens in nature, but which there, on account of unfavorable conditions, is but seldom or imperfectly observed.

At the same time one sees that experiment, in this first example, confirms the deductions made a long time since from paleontological and biological data.

Delboeuf, as well as Scott, requires that each new species does not appear in a single specimen, but in a number of specimens, and not once but during a number of years. For only under these conditions are their chances sufficient. It is exactly this which happens with the *Oenotheras.* They are formed each year, 1 per 1,000 or 1 per 100, in any case in a sufficiently large number to fall within the requirements formulated by the savants just mentioned. They are with a single exception at once constant from seed, without ever returning to the type of the mother species; they would, by sufficient isolation, at once form groups of uniform individuals. Nothing indicates their appearance in advance, there is not even a hint of transition; once formed they are perfect, and retain, even after several generations, their original characters. They originate with a shock or jump and then are constant.

They are formed from the mother species as side issues, and not because the mother species undergoes a gradual change. On the contrary in nearly all mutations, the species continues unchanged, and to it belongs the great mass of individuals, until one day the struggle for life shall turn the scales.

Mutability is not one-sided, as many paleontological series would lead one to expect, but many-sided as must be deduced from the principles laid down by Darwin. And the new *Oenotheras* vary in different organs and in various directions; most frequently the new characters are injurious, sometimes indifferent, occasionally beneficial, probably at least. Next to strong new species there occur weak ones, next to these, those so weak as never to reach the flowering period; and finally sterile forms. From this array of forms nature, in the struggle for life, later on makes its choice; only those most fit continue to exist. Even here experiment confirms theory.

What is the duration of a mutation period? Geology answers: probably very long, for otherwise the chances of life of the new species would be too small. And it seems to me that in the case of *Oenothera Lamarckiana* I have seen neither the beginning nor the end. The fifteen years during which I studied the species comprises probably but a very small part of that period.

# MENTAL AND MORAL HEREDITY IN ROYALTY. IX.

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## *Regression to the Mean.*

BY taking each country separately and analyzing it minutely, we have seen how almost perfect heredity appears to be as a cause of the mental and moral peculiarities wherever found. In order to ascertain if talent is properly related to genius in point of consanguinity, so that we have a progressive falling off in relationship to 9, 10 grades as we descend from the high ranks to the mediocrities, a count has been made of the number of geniuses (9, 10 grades) which each person possesses as a blood relation both in the first degree of consanguinity and in the second. By the first degree is meant the number of geniuses who are as closely related as father, mother, brother, sister, son or daughter.

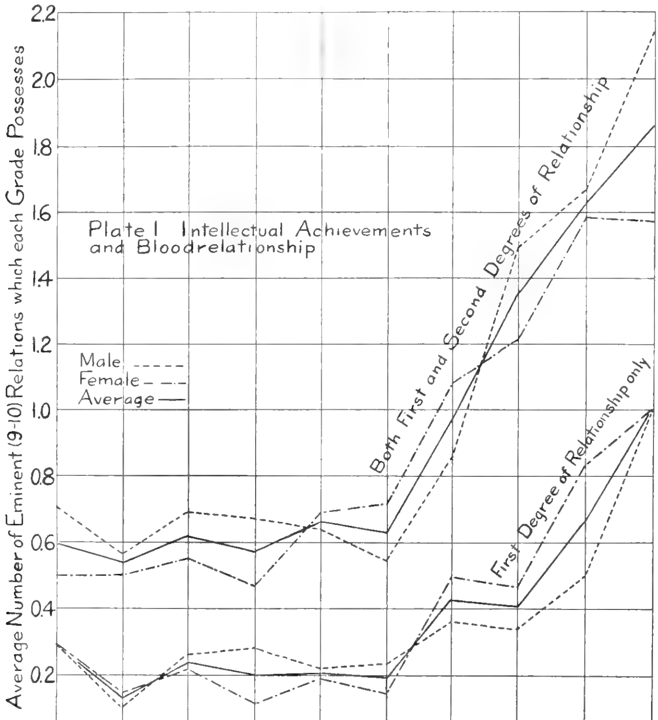
The second degree includes also grandparents, uncles, aunts, grandchildren, nephews and nieces. If the proportionate relationship of geniuses to men and women of their own type is greater for the first degree of relationship than for the second, we shall see the principle of heredity satisfied, especially if the ratio is the same as found by other observers for physical traits.

The curves show that such is the case, and we have an almost perfect rise in eminent relationship as we ascend from mediocrity to the highest scale. This is true for both the males and females. The average of both sexes smoothes out the curve and gives an even more regular rise than is given by each sex separately. It is to be remembered that such facts mean a great deal since were the geniuses scattered over the entire number, without any law of distribution in regard to blood—as I claim they should be from the effect of environment on the intellectual side at least—there would be instead a reverse of the facts, or an actual falling off in percentage of eminent relations among the higher grades.

This can be made clear by considering any one instance. Take the case of Catherine II. of Russia. All her near relations receive one count for being related to her, yet she herself receives no count, since none of her near relations stand in a 9 or 10 grade. The same would be true of Frederick the Great were he the only one in his immediate family who belonged to 9 or 10 grade. As a matter of fact he counts 6 such relations.

The accompanying curves (Plate I.) show the percentage of eminent (or 9, 10) relations which each grade possesses. The lower lines show the considerable falling off for mediocrity when only the first degree of relationship is considered, but it will be seen that the falling off is relatively greater when we consider the eminent relations of mediocrities than when we regard the eminent relations of geniuses.

In the second degree of relationship the average of the 9, 10 have about 1.7 eminent relations while the mediocrities have about .6. In the first degree the average of the 9, 10 have about .85 eminent relations while the mediocrities have but about .2. In other words, in




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grades | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Males | 7 | 21 | 36 | 48 | 69 | 62 | 64 | 41 | 18 | 7 | |
| Females | 2 | 6 | 9 | 38 | 78 | 48 | 36 | 24 | 12 | 7 | |
| Totals | 9 | 27 | 45 | 86 | 147 | 110 | 100 | 65 | 30 | 14 | 633 |

the second degree the geniuses have about 2.83 times as many relations in the genius grades as the mediocrities have, while in the first degree they have about 4.25 or the regression from the first to the second degree is .6659. This is strikingly close to Galton's first estimate for filial and fraternal regression given in 'Natural Inheritance,' p. 133, as ⅔.

With regard to the relationship between genius and insanity, it is to be observed that the line does not fall off as we go from the mediocre to the lowest grades. This would confirm the results obtained by Havelock Ellis in his study of British genius that there is a slight relationship between genius and insanity, though nothing like as much as is claimed by Lombroso.

Grade 10 for intellect contains, as Plate I. shows, only fourteen persons. The names of the men are here given as a sample: also the eighteen who belong to grade 9. Probably few will question the right of the following to enter these elect grades, though some might place one or two a grade higher or lower. The number of relations in the 9 or 10 grades which each person possesses is placed on the left, the first figure being for the first and second degree, the second figure being the number in the first degree alone or the number of (9, 10) relations as close as father or son.

GRADE 10 (NAMES ALPHABETICALLY).

1,1, Bourbon, Condé, Louis II., 'The Great Condé.'
4,1, Orange, William the Silent.
1,1, Portugal, John I., 'The Great.'
0,0, Prussia, Hohenzollern, Frederick William the 'Great Elector.'
6,3, Prussia, Frederick the Great.
1,0, Sweden, Gustavus Vasa, Founder of the Dynasty.
2,1, Sweden, Gustavus Adolphus, 'The Great.'

15,7

The fractions 15/7 and 7/7 give us the averages 2.14 and 1.00 found on Plate I. (See dotted line for males.)

GRADE 9.

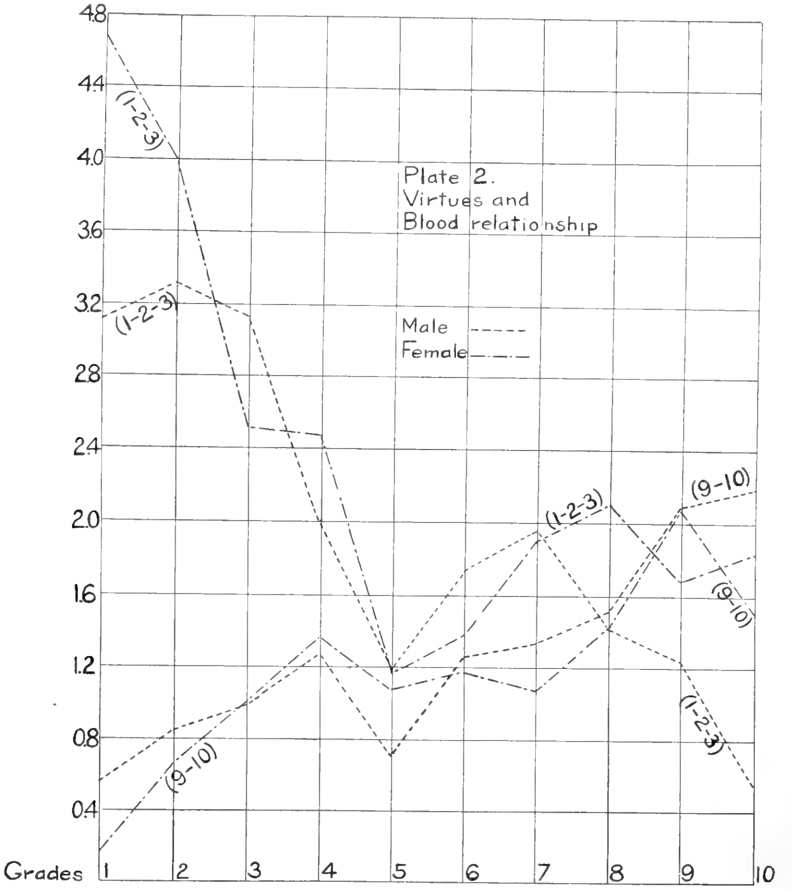
1,0, Austria, The Archduke Charles, who commanded against Napoleon, b. 1771.
1,0, Don John of Austria. Celebrated naval commander.
1,1, Austria, Maximilian I., Emperor, b. 1459.
3,1, Bourbon, Henry IV., King of France.
0,0, Caspard de Coligny. The great admiral of France.
1,0, Alexander Farnese.
6,3, Hohenzollern. Henry, brother of Frederick the Great. Considered by many to be the equal of Frederick.
4,1, Orange, Maurice of Nassau. One of the greatest captains of modern times.
1,0, Orange, William III., King of England.
0,0, Portugal, Alfonso I., Founder of the Kingdom.
1,0, " Diniz, 'Father of his Country.'
1,1, " Henry 'the Navigator' celebrated as a mathematician. Son of John 'The Great.'
1,1, Romanhof, Peter the Great of Russia.
0,0, Savoy, Prince Eugene, celebrated general.
1,0, Saxony, Maurice Elector of, celebrated general.
0,0, Sweden, Charles XII., military genius.

5,1, Sweden, Gustavus III., extraordinary mind. His large eminent relationship is Hohenzollern due to his being a nephew of Frederick the Great.
3,0, Tour. Great Turenne, celebrated commander.
30,9

Since there are eighteen persons in this group, the fractions 30/18 and 9/18 give us the averages 1.67 and .50 seen in Plate I. to be the figures for grade 9.

*The Inheritance of Moral Qualities.*

The reasons for the belief that heredity is almost the entire cause for the mental achievements of these men and women and that environ-



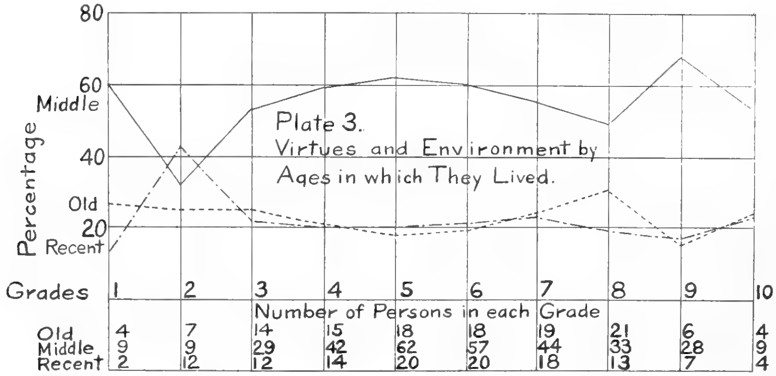

ment must consequently play a very minor rôle, have already been given. The reasons are of a twofold nature. First, the practically perfect results derived from what might be expected of heredity, both from the internal study of the families separately and from the curves of correlated relationships in the first and second degree. Second, the belief of the author that environment would not cause the great names to be associated in blood.

If a great king succeeds in building up an extended empire, it does not appear to the writer that his son would have an easier task in becoming famous as a great governor. The importance which Prussia assumed under the Great Elector did not make his son, Frederick I., rank any higher than 3 in our scale. Still the genius has always been properly perpetuated somewhere, in some of the descendants. Also the times have continually 'called for great men.' Never did a dying country call more urgently than Spain in her last three centuries; yet none appeared. Italy had to wait fifty years for Cavour, Garibaldi and Victor Emanuel. England could not get a good Stuart, but in a descendant of William the Silent she found a hero in William III.

When we come to analyzing the moral qualities we find more difficulty than in the mental. First, because good parentage would tend to bring a better environment; and, second, because the curves of distribution, though in general entirely compatible with hereditary influence, are less perfect. Still it has come to be the belief of the author that even on the moral side heredity is more important than surroundings for the following reasons: First let us consider the curves of relationship. It will be seen (Plate II.) that the men and women in the high grades have some three times as many relations of their own kind as the bad characters have in the way of relationship to these best ranks. The degenerates (grades 1, 2, 3,) have between two or three times as many relations of their own ilk as the best have in these lower grades, while the best have actually more in their own 9, 10 grades than they have in the three lower grades put together. A second reason is drawn from a count of the different grades relative to the period in which they lived. We might expect that in the old days, when the standard of morality was rough, lawlessness and licentiousness would be found in a greater percentage than during more recent times. Three divisions have been made.

The period prior to the year 1600 is here called 'old'; from 1600 to 1800, 'middle'; from 1800 onward, 'recent.' It will be seen in the chart (Plate III.) that the proportionate distinction of characters according to this method arranges them in each rank, almost perfectly according to the law of 'deviation from an average,' each group old, middle and recent, falling off equally from the mediocrities, so that when we attempt to make curves for old, middle and recent, according to the percentage in each rank, we get no curves at all, but lines almost flat. The only irregularities are at the edges 1, 2 and 9, 10 grades, and mean only that here the instances are too few to make them group themselves in perfect harmony.

I was somewhat surprised that the recent royalty should not give a better showing than the more ancient members, but this is because modern royalty, that is, from 1600 up to 1850, has such a large percentage of badly selected Bourbon blood in it. If we took royalty as it exists to-day we should undoubtedly find a much higher tone, but this is to be ascribed to the fact that most of the existing members are derived from Saxe-Coburg and other excellent German families. Up to 1850 France, Spain, Portugal and Italy were full of Bourbon blood, and we have seen that nineteenth century demands or the awful example of predecessors had no effect on it.




Another way of attacking the problem is the study of each country separately. Spain, France and Russia give us most of the moral degenerates. In all these the individuals are closely associated in blood with a marked mental neurosis. This is of itself a coincidence to be explained by those who doubt the inherited nature of morality, and besides this we have to consider the fact that prior to the appearance of the moral depravity and mental unbalance as well, there was a period when these countries were relatively free from such degenerate types.

Why did the three rulers of the Romanhof dynasty who lived before Peter the Great, in whose generation the neurosis first appeared, exhibit such mild and amiable characteristics, although arbitrary rulers of an ignorant people, and living in the rudest epochs? Then suddenly, with the appearance of the epilepsy and imbecility, we find such examples of moral depravity as the Empress Elizabeth. Strangely among the degenerates we find her sister Anne 'serious, cultivated and virtuous.' Some might contend that rude conditions brought out both good and bad, but then they would have to explain why in Germany

(Saxe-Coburg, etc.) even in the earliest times here traced, we find practically no such variation in characters. They also would have to explain why in Spain and Italy in the nineteenth century, we also find a variation in moral characters exactly like that found in Russia in the early eighteenth or in Spain in the sixteenth centuries.

Another aspect of the question, that is more in line with heredity than environment, is the fact that variations among the children are always duplicated by corresponding variations in the ancestry. This is equally true of both mental and moral and indeed facial characteristics. Children born of the same parents and reared in the same court must usually have pretty nearly the same surroundings, yet instead of their being molded to any standard type, we find that when the blood is diverse in character, just about the proper proportion of children show these same peculiarities both for good and bad. It is only when the blood is uniformly good as in the families of Brunswick, Saxe-Coburg and Sallefeld that we find unanimity in the morality of the descendants.

So that heredity appears to the writer to have exercised in mental life a factor not far from nine tenths, while from the moral side it is something over one half. As to anything in the nature of 'soul' or 'free-will' in the sense of a motive power lying outside of natural laws, such evidence can not, of course, exclude its existence. It does, however, show that such a power, if it exists at all, has only a very minor influence, and even the arch argument of theology, the heroic soul who tries and tries again, is found to be but the reduplication of another. So it appears that the three possible factors in mental and moral life are to be expressed in the following order: Heredity, Environment, and finally, printed with the same old question mark. Free-will.

THE GREAT AUK.

# THE GREAT AUK IN ART.

BY FRANK BOND,
U. S. DEPARTMENT OF AGRICULTURE.

A CAREFUL examination and comparison of the available illustrations of the great auk leaves the mind in some doubt as to the appearance of this extinct, flightless bird. Some of these illustrations are found in recent publications, while others illuminate descriptive articles written over a century ago. A few voyagers, notably Richard Hakluyt, sometime preacher, and M. Martin, Gent., undoubtedly saw the bird in great abundance on certain islands of the north Atlantic which were notorious as the home of the auk—Hakluyt on the American side and Martin off the coast of Scotland. But neither of these travelers left even a rough sketch of what his eyes saw. Zoologists, naturalists, taxidermists and ornithologists have, however, given us their conception of the bird in black and white, and a number of their illustrations are reproduced and accompany this article.

Undoubtedly the only sources of inspiration for the earlier drawings are the written descriptions of the bird, or the attempts to reconcile several divergent descriptions by a plate which would strike a happy mean, the dried skin coming in later as a desirable artists' accessory. The mounted skin also has had a baneful influence upon the pencil of the artist, for in no other way can the differences in form and outline be understood or the reckless indifference to details be satisfactorily explained. Turning to the sources of inspiration which are chiefly responsible for the erroneous, visual evidence of extinction of as many species of great auk as there are drawings of the bird extant, we find that descriptions in detail force a most charitable view of the shortcomings of the pencil and brush. One would not be justified in charging superlative imaginative powers upon the artists, until the apparent mendacities of the writers had been explained. However, to careless observation and lack of familiarity with birds may be charged the majority of the mistakes of both pen and brush. A careful sifting of the available evidence seems to warrant the conclusion that the pictures of the great auk, heretofore published, are defective in many important particulars. These will be considered later in detail.

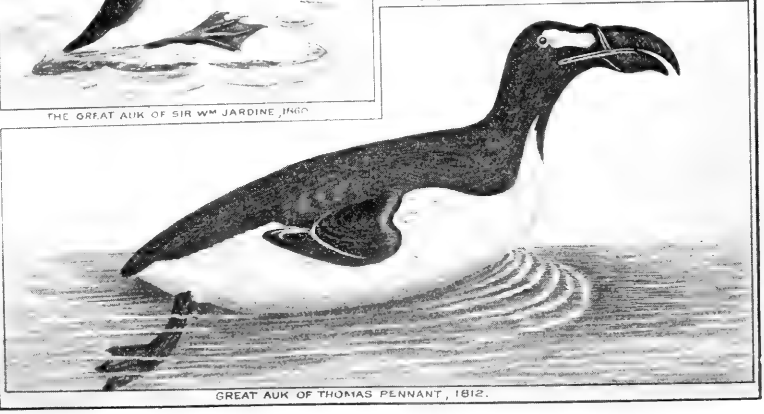
In the following paragraphs descriptions of similar parts of the great auk, furnished by writers of the past 320 years, are grouped together making comparison easy and the fact that the quotations from some of these authors cover but a point or two does not render the information given by them any the less interesting. That but three

THE GREAT AUK OF BUFFON 1812

NORTHERN PENGUIN BROOKES, 1771.

THE GREAT AUK OF SIR Wm JARDINE, 1860

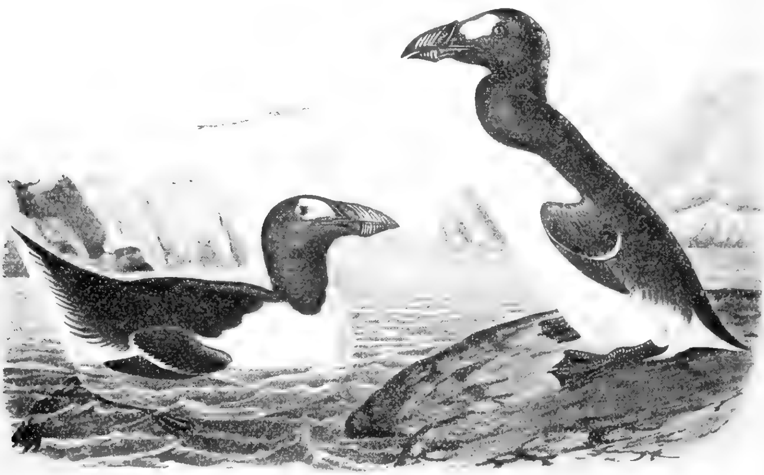
GREAT AUK OF Wm B. CARPENTER, 1866.



GREAT AUK OF THOMAS PENNANT, 1812.

of the authors quoted below, Hakluyt 1583, Wormius 1655, and Martin 1697, ever saw the great auk alive or in the flesh is an item of more than passing interest.

*Size of the Great Auk.*—Very large, not much less than a goose—Hakluyt, 1583. Did not much exceed the bigness of a goose—Wormius, 1655. Above the size of a Solan goose—Martin, 1697. Size of a goose—Brookes, 1771. Three feet to the end of the toes—Pennant, 1812. Three feet long, size of a goose but slender—Buffon, 1812. Approaches that of a goose—Cuvier, 1817. Approaches a goose—Willoughby. Length to end of tail, 29 ins., 31½ ins. to end of feet—Audubon, 1840. Thirty inches to three feet—Jardine, 1860. About 3 feet long —Dallas, 1867. Size of a goose—Seebohm, 1886. Twenty-seven and a half inches to tail—Duchaussoy, 1897.



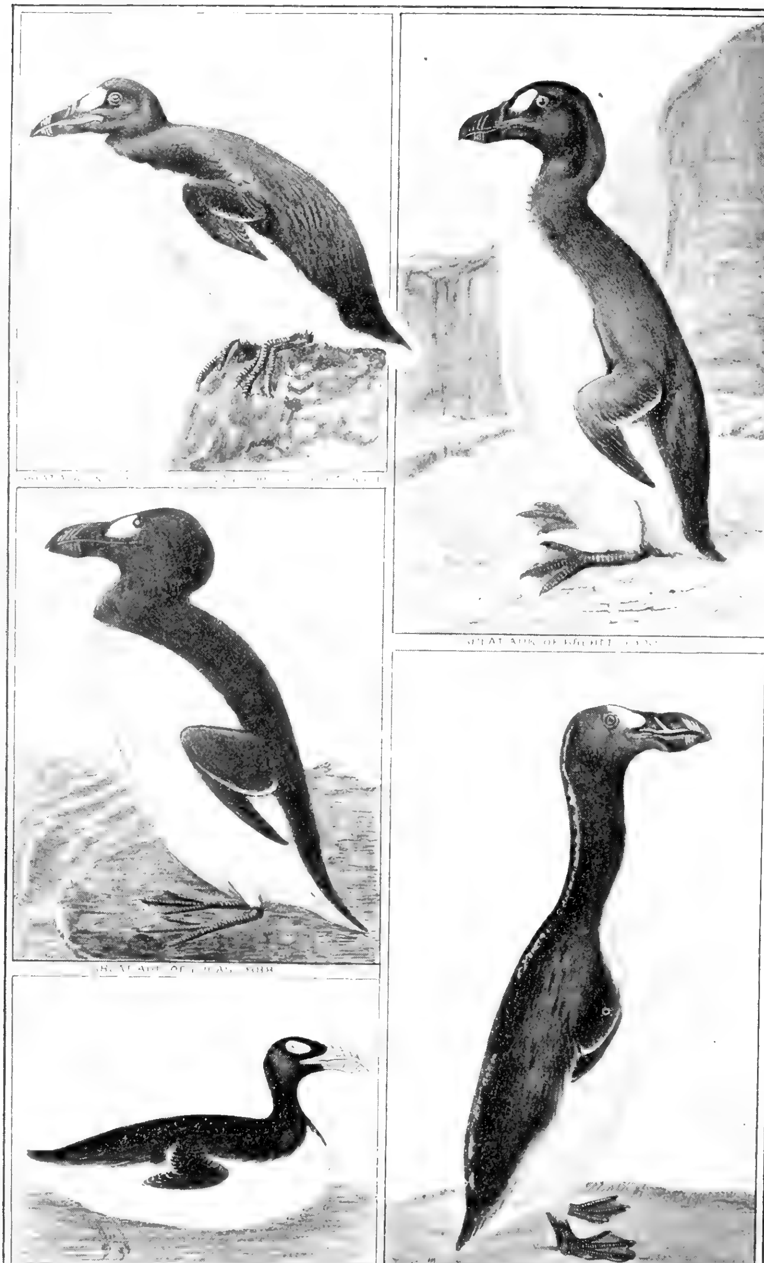
THE GREAT AUK OF AUDUBON.

*Bill of the Auk.*—A long broad bill—Martin, 1697. Like a broad cutlass, sides flat and hollowed with notches—Buffon, 1812. Marked with several furrows—Pennant, 1812. Black, with 8 or 10 grooves, long and broad—Cuvier, 1817. Black with grooves between transverse ridges white—Audubon, 1840. Black with transverse furrows, the grooves white—Jardine, 1860. White grooves less conspicuous than in Razorbills—Seebohm, 1886. Bill black with 7 or 8 whitish grooves on upper, 10 or 11 on lower—Duchaussoy, 1897.

*White Marks on Head.*—Large white spot *under* each eye, red about the eyes—Martin, 1697. White oval spot before the eye—Linnaeus, 1761. Large white spot between eye and bill—Pennant, 1812. Great oval white spot between bill and eye, margin rising like a rim on each side of the head, which is very flat—Buffon, 1812. Oval white patch between the eye and bill—Cuvier, 1817. Large oblong white patch before each eye—Audubon, 1840. In front and *around the eyes* is a large oval patch of white—Jardine, 1860. White oval patch from eye to bill—Seebohm, 1886. In front of eyes oval white spot on side of head from base of bill—Duchaussoy, 1897.

*Description of Neck.*—Short and thick—Audubon, 1840.

*Character of Wing.*—Cannot flie, their wings not able to carry them—Hakluyt, 1583. Its wings short, it flies not at all—Martin, 1697. So small as to



GREAT AUK OF DALLAS 1867

GREAT AUK OF TEMMINCK 1848.

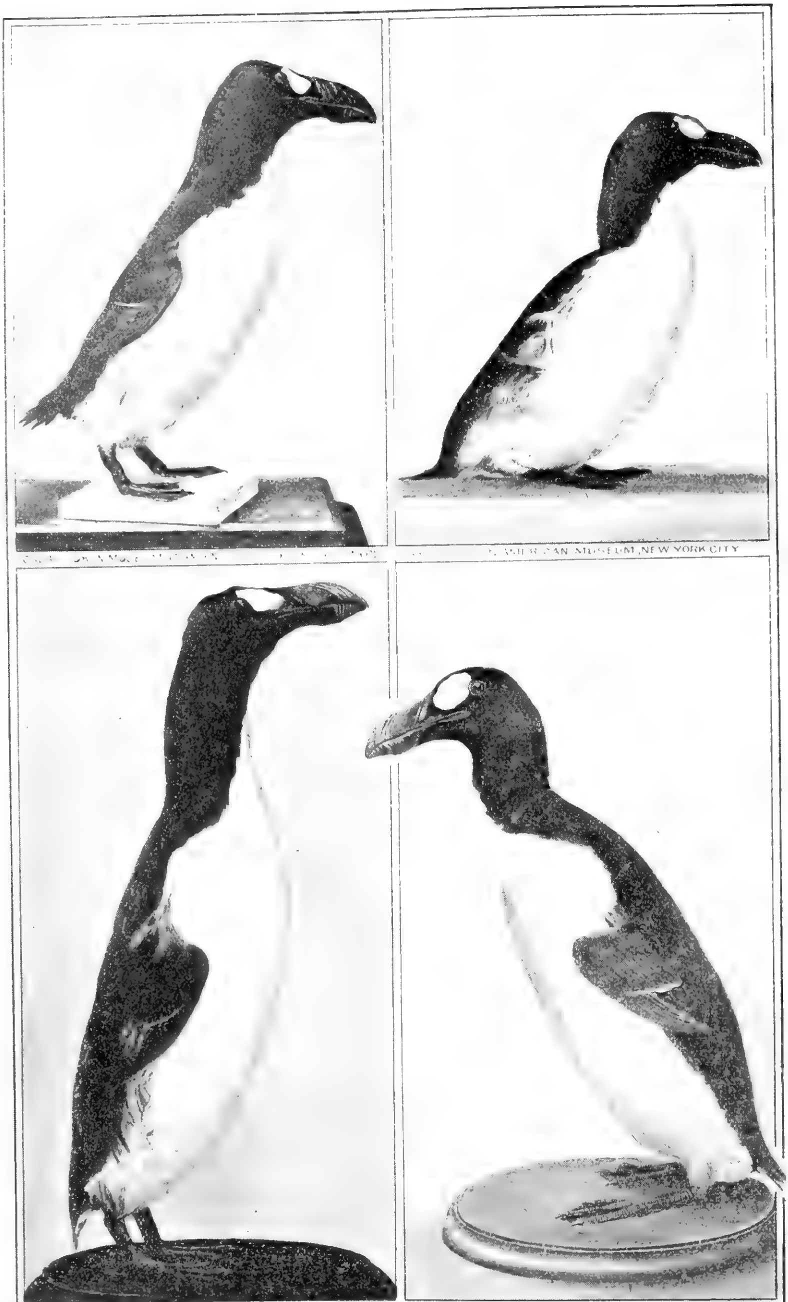
be useless in flight, four inches from tip to first joint—Pennant, 1812. Great feathers exceed not 3 inches in length, cannot raise into the air—Buffon, 1812. Very small in proportion to other birds, for subaquatic progression—Cuvier, 1817. Extremely small but perfectly formed—Audubon, 1840. Very small although formed of regular feathers, serve as fins when diving—Dallas, 1867. Like small duck—Seebohm, 1886. Rudimentary, useless for flight; used in swimming and diving—Duchaussoy, 1897.

*Feet.*—She is whole-footed—Martin, 1697. Placed far behind, but very strong—Audubon, 1840.

SMITHSONIAN GREAT AUK SKELETON.

*Attitude and Mode of Progression.*—Stands stately, its whole body erected—Martin, 1697. Can scarcely even walk; pace heavy and sluggish; lies stretched out on rocks and ice; erect attitude is painful—Buffon, 1812. Stood very erect, never flapped along water surface—Wooley, 1858. Only shuffled along—Seebohm, 1886.

After having compared the above descriptions, one is not inclined to criticize harshly the illustrations based upon them, except in cases where the author, after having carefully noted an important specific marking, entirely omits it in his drawing. The white spots on either side of the head of the great auk seem to have been a most serious stumbling-block to writers and artists alike. Martin, in 1697, states that the white spot is *under* the eye. No other description agrees with this, and the photographs of mounted skins show no such phenomenon



[illegible]

[illegible] AMERICAN MUSEUM, NEW YORK CITY.

[illegible] GREAT AUK BEFORE RE[illegible]

[illegible] GREAT AUK AFTER REMOUNTING.

—but Martin saw the birds. Sir William Jardine, in 1860, says the white spot is in front and around the eye, but his drawing shows he had not the courage of his conviction. However, Carpenter, in 1866, and Dallas, in 1867, took Jardine at his word, as appears from their illustrations of the bird. It is noteworthy that while nearly all the authors quoted describe the form of this spot as 'oval,' the photographs of mounted birds rarely show such an outline. This is owing to faulty taxidermy. A sub-triangular spot seems to have been the popular form with the majority, both of artists and taxidermists, in spite of the practical uniformity in description as to the oval shape. From the time of Brookes, in 1771, until a comparatively recent date, there has existed a strong desire to continue the spot under the eye, thus in a degree conforming to Martin's description in 1697. Audubon aimed to satisfy everybody, for in his swimming bird a white triangular spot continues under the eye while the 'large oblong white patch before each eye' of his standing bird conforms to his description.* Referring to the illustration of the Smithsonian auk, after remounting, it will be noted that the white spot is oval or elliptical in shape, with a comparatively even and regular outline, and this is believed to represent this characteristic marking of the species in its correct form and position. Any taxidermist can understand how a dried skin which has been softened unevenly might be stretched in such manner as to extend the margin of the spot outward in any direction, even under the eye, as in Audubon's swimming bird, or how an indentation could be produced such as appears on the front margin of the spot in his standing bird. Neither of these outlines, however, is tenable in the light of the evidence offered. The oval spot surrounding the eye can only be supported by an appeal to the offhand statement of Sir William Jardine, a statement which is disputed by every available fact.

Little need be said concerning the illustrations of the bill of the great auk, except that the outline in the majority is fairly good, although the representation of the grooves and their location on the bill appears to have been subject to speculative influences. The 'white grooves' of several authors should not be confounded with the white lines which appear crossing both maxilla and mandible in all published photographs. These lines are high-light lines due to light reflected from the elevated ridges above the grooves. An examination of the bills of mounted great auks shows that the grooves are a horn-white or whitish in the bottom, a shade much darker than the reflected light from the polished ridge would appear.

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* The auks of Audubon accompanying this article were copied from the plate in the Library Edition of 1840 in which he says, regarding the illustrations—'the drawings on stone and the colouring, have also been well done and the former are almost all superior to the first numbers of the work, which I considered very good.'

# THE MAKING OF BIOLOGISTS.

By Professor T. D. A. COCKERELL,
EAST LAS VEGAS, N. MEX.

IT is doubtless true that biologists are 'born' rather than 'made,' but it is probably no less true that they may be and are nipped in the bud in many instances by the frost of adverse circumstances. I speak of the making of biologists by the same right and in the same sense that the farmer speaks of raising crops, although as a matter of fact the crops raise themselves by their own inherent vitality. Encouraged by a lively conviction that the infant mortality of biological talent is much greater than is commonly supposed, I have sought to ascertain the conditions which permitted the survival of so much as we actually have, thinking that ways might be found to increase the crop. While neither expecting nor desiring that every one should become a specialist in biology, one may be pardoned for ardently wishing that the existing native talent should be more fully utilized, in view of the innumerable biological investigations lacking investigators.

In the United States to-day there are about four hundred publishing zoologists, exclusive of those whose writings are of little or no importance as contributing to the advancement of the science. The botanists are probably about as numerous, but I have not yet attempted to catalogue them. Of the zoologists about 140 are enumerated in 'Who's Who,' and these include most of those who have done any considerable amount of work, although there are some surprising omissions, and a few nearly as surprising inclusions. It would be a useful thing to publish at some future time a biographical index of all American biologists, living or dead, who have really contributed to the subject. In the meanwhile I have extracted a good deal of interesting information from 'Who's Who,' and a few other sources.

Starting with the idea that 'nature' counts for at least as much as 'nurture,' I looked for racial distinctions. Unfortunately it is impossible to ascertain the exact influence of race upon the development of talent, because those of different races are not subject to the same environment. It is well understood that the Germans, as a people, are inclined to be scientific, and considering the enormous influx of Germans into America, one would look for a large body of German-born biologists. There are, indeed, many German amateurs; but in our list of prominent American biologists the German-born are less than half-a-dozen, the best-known being Loeb, Ortmann and Eigenmann. Similarly, the English-born are scarcely worth mentioning; while Norway, Hungary, Switzerland and Canada have single representatives in Stejneger, Heilprin, A. Agassiz and McMurrich. On the whole, the foreign-born element in American biology is insignificant, and as it were accidental.

Such facts as these make us doubt the validity of the opinion that talent will always come to the front, whatever the conditions. Among those who have immigrated from Germany and the British Islands there must have been a larger number capable of biological research than the figures show; but as a matter of fact the conditions surrounding these people were not commonly favorable to scientific work. The same must be true of the French immigrants who settled long ago in the south; they have never yet shown anything like the scientific talent which their origin would lead us to expect.

Dr. G. B. Halsted told me last year that he believed that about one in two hundred persons in this country possessed some sort of mathematical genius. Being afterwards uncertain whether he meant university students or the general population, I wrote to him and received the following interesting reply:

> One in two hundred *university students* has markèd mathematical ability. Of those who do not get to any university the percentage may be just as high, since only *race*, and not caste, is necessary for this gift. A Hindoo has just been senior wrangler at Cambridge, England; and Gauss was a bricklayer's son. No one with a drop of African blood has ever given us a theorem in mathematics. Shaler accounts for the stupidity of the Romans in mathematics by supposing that the primitive basal race in Italy was from Africa. There is a marked difference between ability in geometry and ability in arithmetic and algebra. The Jews give us more great mathematicians than any other race, but never a geometer. Geometry is hindered by a *necessity* for visualization. Todhunter said with penetrating wisdom that the person who had to see the relations definitely on a figure could not go on in the higher mathematics. Non-Euclidean geometry, my subject, cannot be visualized. Calculating prodigies are usually idiots, absolutely lacking in power of visualization. I enclose you a long account of one such [Jacques Inaudi] which is very definite on this point [*i. e.*, the absence of visualization]. Most eminent mathematicians are deficient as calculators, some do not know their multiplication table. . . . I have never in my life had to extract a root of a number. The thing which seems most to *foster* mathematical ability is use in very early youth, strong stimulation in early youth. (Litt., December 24, 1901.)

With respect to the negro race unfavorable conditions may have had more to do with unproductiveness than is supposed. The Tuskegee Institute under Professor Booker T. Washington has lately obtained the means of carrying on original research in science, and it will be extremely interesting to watch the results. I ventured to ask Professor Washington whether he had observed any scientific talent among his people, and he referred me to Dr. Roscoe Conkling Bruce, who wrote as follows on the subject of talented negroes:

Scientific aptitudes have to my knowledge appeared among the negroes not infrequently. Among negroes who have actually achieved a degree of eminence in scientific research are the late L. A. Willson, of Cleveland, Ohio; T. McC. Stewart, Jr., of New York city; Frederick Hemmings, of Boston; and Dr. S. C. Fuller, of Westboro', Mass. Dr. W. E. B. DuBois, of Atlanta University, has made two solid contributions to descriptive sociology, 'The Supression of the Slave Trade' and 'The Philadelphia Negro.' Dr. Kelly Miller, of Howard University, has made important mathematical researches. Professor Hugh M. Browne, of Baltimore, is an eminent physicist. Professor George A. Towns, of Atlanta, has written a valuable theory of æsthetics; Professor Ferris, of Cambridge, is now engaged in writing a book on metaphysics. Our Professor Carver, of Tuskegee, has done something in biology. There is frequently noticeable among our students at Tuskegee the scientific attitude and spirit. (Litt., April 6, 1902.)

It should be added that Professor C. H. Turner has done important work on fresh-water Crustacea.

Of course the custom of classing as 'colored' all those who have any negro blood makes it difficult to ascertain the possibilities of talent resident in the negro blood itself. I suppose that most of those above mentioned are of mixed blood, but I have no exact information.

Returning to our birth-statistics of zoologists, we may proceed to discuss the native-born. These people are the descendants of early immigrants who showed little or no scientific ability, doubtless for such reasons as we have already discussed. The tremendous increase of intellectual activity in Europe and America during the last century and a half shows what possibilities may lie unsuspected in a people; for no biologist can suppose that the stock itself has greatly changed in so short a period. The same may be said concerning the recent intellectual awakening of the Japanese, though no doubt these people formerly employed their minds in ways overlooked because unintelligible to Europeans. It seems wonderful to us to-day to receive monthly an entomological journal printed in Japanese and to find some of the best work in biology coming from natives of that country. Who knows but that we ourselves, great as has been our progress, are capable like the Japanese of yet other new births, into fields of intellectual activity hardly yet suspected to exist?

I have classified the native-born zoologists by the states of their birth. New York is easily in the lead, with Massachusetts a good second, Illinois third, Ohio fourth, Connecticut fifth. The more prominent names are as follows:

*New York.*—Beecher, Bigelow, Birge, Call, Casey, J. M. Clarke, O. F. Cook, B. Dean, J. Dwight, Dyar, Elliot, Gill, D. S. Jordan, Mearns, Merriam, G. S. Miller, Miss Rathbun, Shufeldt, Slingerland, J. B. Smith, Walcott, Ward, Whitfield, Winchell, J. B. Woodworth.

*Massachusetts.*—J. A. Allen, Beal, Brewster, Dall, Felt, Hitchcock, Lucas, C. D. Marsh, Minot, Scudder, Thayer, Thorndike, Williston. How few of these are to-day identified with Massachusetts!

*Illinois.*—Coquillett, Gilbert, Hatcher, L. O. Howard, Kofoid, Nutting, Ridgway, Simpson, Stanton, E. B. Wilson, Walcott.

*Ohio.*—Chittenden, Girty, Pratt, Schuchert, C. H. T. Townsend, Ulrich, C. M. Weed.

*Connecticut.*—Benedict, Blatchley, Davenport, C. L. Franklin, H. F. Osborn, Mrs. Slosson.

*Pennsylvania* has given us Ashmead, Bruner, H. C. Chapman, Garman, W. Stone and the late H. Strecker. From *New Jersey* we have Beutenmüller and F. M. Chapman; from *Maine,* Fernald, Verrill and C. B. Wilson; from *New Hampshire,* Nelson; from *Maryland,* Uhler. *Iowa* is the birth-place of Eastman, Evermann, McGee, Springer and Pilsbry; *Michigan* of V. Bailey; *Minnesota* of C. L. and C. J. Herrick; *Wisconsin* of H. Osborn, Ritter and W. M. Wheeler. The South is hardly represented at all; from *South Carolina* come J. A. Holmes and J. P. Smith; from *Kentucky,* Morgan and Miss Sadie Price; *Florida, Georgia, Louisiana, Arkansas, Mississippi, North Carolina* and *Virginia* do not appear on my list at all! There are, I hope, some zoologists born in these states of whom I have no statistics, but in any event the zoological output of the southern states is wholly insignificant. This fact suggests again the great influence of environment, whatever the blood; and one may add that the tropical English colonies have deprived us of the services of many a good man, who under more stimulating social and climatic conditions promised much.

The civilization of the West is so young that perhaps we ought not to expect much of the native-born therein. As a matter of fact, the showing is small indeed; my records give only these names: *Kansas,* V. L. Kellogg, Marlatt; *Texas,* Vaughan; *California,* T. S. Palmer. Of course there are many others less well known; indeed a very good crop of young men and women, who will be prominent enough in the next twenty years. Everything shows that California, in particular, will be the center of great biological activity; but so far Colorado is by no means doing her part. About fifteen years ago a small body of naturalists founded the Colorado Biological Association, of which the present writer was secretary; but the movement died in 1890, and to-day there are not enough biologists in the state to revive it or found a new society on similar lines. Even the professors in the state university seem to be permitted rather than encouraged to engage in research. However, Colorado has too much natural vigor to tolerate this inertia indefinitely; the time cannot be far distant when there will be an awakening.

I have also catalogued the prominent zoologists under the names of the schools, colleges and universities they attended; but the results are perhaps not very significant. Of course every one knows that many of our leading men (*e. g.,* Jordan, Dall, Uhler, J. A. Allen, Scudder) studied under Agassiz, but it may be doubted whether their interest in biology was not fully determined before they went to him. I think it will be possible to show in due time, that the critical period for the biologist is much earlier than some of us have supposed, is, in fact, during the years of childhood. This would agree with Dr. Halsted's opinion, expressed above, about mathematicians. The list of those who received no university training is significantly long, including Ashmead, Beutenmüller, W. Brewster, F. M. Chapman, Cockerell, Coquillett, D. G. Elliott, Gill, Lucas, McGee, Miss Rathbun, Ridgway, Schuchert, Simpson, J. B. Smith, Thayer, C. D. Walcott, Whitfield and Uhler. On the other hand, Harvard, Johns Hopkins, Yale, Cornell, Amherst, Michigan and a few others have long lists of prominent graduates, and the list of those who studied in Germany is surprisingly large. In all, 56 institutions in the United States are represented in my list, mostly by only one or two names. There is plenty of evidence that first-class men may come from institutions which do not ordinarily turn out zoologists of any sort, or perhaps ordinarily do turn them out, in a different sense.

Dr. D. S. Jordan is the man who comes first into our mind as a gift from Agassiz. He himself is always ready to insist upon his obligations to that great naturalist; but the following information, kindly supplied to me by Dr. Jordan, shows that he was a good biologist before he ever saw the master.

When a boy I lived on a farm in western New York. I was very early interested in the local botany and had made a collection of the local fauna before I entered college. At college I developed this as a thesis, called 'The Fauna of Wyoming County, New York,' for a master's degree. I was also very much interested in the breeding of sheep, and from my twelfth year to the time I went to college I gave considerable attention to this, having a pretty fair knowledge of all matters pertaining to a flock of sheep. Very soon after entering Cornell I was made laboratory assistant in botany, and was ultimately promoted to an instructorship. I did not take up zoology as a serious matter until after I had left Cornell. At Penikese I was instructor in marine botany. Agassiz thought that I ought to do some work of an entirely different sort, and placed me in charge of the work of collecting fishes, asking me to study the habits of the different forms. On going to Wisconsin—where marine botany is scanty—I was advised by him to take up the anatomy of fishes and especially of the ganoid forms. I did a good deal of work on birds, but deliberately chose fishes because the group was comparatively little known and apparently offered a wide field. The influence of Agassiz was a great element in my scientific progress. Not less great was that of Agassiz's student, Charles F. Hartt, several years ago professor of geology at Cornell—a subject in which I did a good deal of work. (Litt., October 25, 1901.)

It is perhaps by his general influence upon the country that Agassiz did most to promote the study of biology in America. Such a man always attracts to his person the enthusiastic young men who are able to benefit most by his teaching, but who would probably have made good biologists in any case. For most of these, the turning point had been long ago reached and passed; but Agassiz was able to indirectly influence the young people of the whole country, and though he is now dead, he is not gone, and we are all in some sense his pupils.

Dr. Alfred R. Wallace, writing from Parkstone, Dorset, November 7, 1901, has given me the following most interesting account of his early experiences:

As to my interest in biology, I can trace it I think to two very trifling facts. I doubt if I had or have any *special* aptitude for it, but I have a natural love for *classification* and an inherent desire to *explain things*;—also a great love of beauty of form and colour. The two slight facts are these. When a boy at school I heard a Quaker lady say that she and some friend had found the 'Monotropa,' which was quite a discovery as being before unknown in the district. This, and hearing the names of other flowers referred to as rare, made me think it would be very interesting to know the names of all the plants that grew wild,* but as I had no botanical friends the wish remained dormant, till I was about 15, when I purchased for a shilling (I think) a little book on botany published by the *Society for the Diffusion of Christian Knowledge*, and which contained the characters of about a dozen of the commonest natural orders in Britain. This was a revelation to me, and kept me employed for a year or two determining the flowers I met with if they belonged to any of these few orders. I then bought Lindley's 'Elements of Botany,' I think it was, but was disappointed in finding no more 'orders' described, but details of structure which did not much interest me. When recovering from a serious illness I met with Loudon's 'Encyclopædia of Plants,' and finding that this contained brief characters of all British plants, I amused myself by copying them *all*, except I think the grasses and sedges, on sheets of note paper, which I interleaved in Lindley's volume, and by means of these I was able to determine most of the species I met with, and made a considerable herbarium. The other incident was, meeting H. W. Bates at Leicester and being started by him as a beetle and butterfly collector. The enormous *variety* of form and structure in the beetles attracted me, and I think during all my tropical experiences the collection of these gave as much enjoyment as even the gorgeous birds and butterflies. Classification then began to fascinate me, through Swainson, and the 'Vestiges of Creation,' with the works of Herbert Spencer, started me on the problem of the origin of species; and thus my various mental tendencies had full occupation in the contemplation and study of natural objects. I also, very early, became interested in geology, in mechanics, in physics and in astronomy, and this breadth of scientific interest, though with no direct education in any one of them, has been of great service to me in preventing a too exclusive attention to any one aspect of nature.

With reference to Dr. Wallace's disclaimer at the beginning of his letter, it may be questioned whether there is such a thing as a special aptitude for biology, aside from the combination of just such tastes and aptitudes as he describes. I have always fancied that the same qualities which would make a good historian would make also a good biologist—the interest in living things, the love of detail and of classification, the fidelity to truth, the perseverance in inquiry, the lively imagination, and

* I also heard, to my astonishment, that every minutest *weed* had been described and had a name.

so forth. It is interesting in this connection to note that the ornithologist Coues became a historian during the last years of his life. The love of beauty is also undoubtedly a strong factor in the making of biologists, although there are some good workers who seem to be singularly deficient in this respect.* Many years ago the present writer went with Dr. and Mrs. Wallace to find the daffodils in an English meadow. When we arrived at the place, we found the flowers in profusion, and it was inspiring to see the child-like pleasure the veteran naturalist took in their beauty. Here was a man who could never grow old, to whom nature was a perpetual delight. As I heard Professor C. L. Herrick say in an address to some students, the love of nature is the secret of perpetual youth.

In the first issue of *The Hibbert Journal,* Sir Oliver Lodge writes as follows:

> Take a scientific man who is not something more than a scientific man, one who is not a poet, or a philosopher, or a saint, and place him in the atmosphere habitual to the churches—and he must starve. He requires solid food, and he finds himself in air. . . . Take a religious man, who has not a multitude of other aptitudes overlaid upon his religion, into the cold dry workings, the gropings and tunnellings of science, where everything must be scrutinized and proved, distinctly conceived and precisely formulated,—and he cannot breathe.

I think this antithesis is not altogether a natural one, but that, on the contrary, the scientific man *must* be something of 'a poet, or a philosopher, or a saint,' to be completely a scientific man. It will be a sad day for the world when we cease to have men who can live freely in the enjoyment of the universe, and each one is permitted to know only this or that. Let us be free to think and enjoy, even though our thoughts wander far afield, and our enjoyment is not always that of a connoisseur.

Sometimes science suffers greatly in the opinion of those who do not claim to be scientific, just because her proper character is not understood, and it is assumed that she must be cold, hard and unimaginative. I have heard the late William Morris speak contemptuously of science, and in his admirable lecture on 'The Aims of Art' (1887) he says that if socialism does not prevail 'science will grow more and more one-sided, more incomplete, more wordy and useless, till at last she will pile herself up into such a mass of superstition, that beside it the theologies of old time will seem mere reason and enlightenment.' Yet Morris was himself an admirable observer of nature, and possessed many of the best qualities of a naturalist. I suppose the name of psychology would have

* I heard the other day a perfectly authentic story of a teacher in one of our best universities, a man who has done wonderful work in classification, and is far ahead of all others in his particular specialty. One of his students, looking through the microscope, exclaimed at the beauty of some object. The professor immediately shut him up with the remark: 'I should think that by this time you would know that you don't come here to look at pretty things!'

made him shudder, and yet the very lecture cited is really an important contribution to that subject, with its theory of the moods of energy and idleness. The views just expressed seem to be confirmed by the history of one of the most distinguished biologists of this country, Dr. A. S. Packard, who writes me as follows:

> I may say that the love of flowers, animals and natural scenery was inborn in me. My ancestry on both sides were ministers, we never had a naturalist in the family, but my father was extremely fond of and appreciative of natural scenery, and was interested in history and archæology. As a child I was very fond of flowers, as were my parents, and as early as I can remember had a flower-garden of my own. When about 14–15 I began to collect minerals, and then shells. My zeal for collecting and forming a museum led an older brother, who also had such tastes, to give me his cabinet, containing curiosities, shells and minerals. I was also an omnivorous reader,—devoured all the books on natural science in the library of Bowdoin College, where I was kindly allowed to browse, long before entering college. When about 16–17 I collected insects in considerable numbers. I was also aided by a maiden lady in Brunswick, Maine, who told me about shells, and aided me in naming my native plants. I formed a herbarium before entering college. From Miss Ann Jackson when a boy I first heard of Lamarck, and of his classification of shells, and of the Lamarckian genera of shells. With, then, an inborn taste for natural history, an aversion to business, and a fondness for books, my deep interest in animal life was sustained and I was impelled to devote my life to biological study. All through college I corresponded with Professor Baird, assistant secretary of the Smithsonian Institution, also with conchologists and entomologists, and this was a constant stimulus to the natural zeal and interest, or passion, for biology which has influenced my life. Also I was a born collector, though I have now no large collections. I trust this will show how I became interested in natural history. Had I been brought up in a city, the result might have been different. (Litt., October 28, 1901.)

It is interesting to think that Packard might have been our leading conchologist, Jordan our first authority on seaweeds. In nearly every case of which I have full information, some other branch of biology was studied than that which afterwards became the specialty. The interest was almost always at first a general one, afterwards limited by circumstances or choice. Of course one has to remember here that nearly all children in rural districts are interested in nature, though so few become biologists. The writer spent part of his childhood on a farm in Sussex, England, and well remembers the interest taken by the children in the first primroses or daffodils of the year, the arrival of the birds, the occurrence of efts (newts) in certain ponds, and such matters. It seems probable that most children are potential biologists, to some extent, but only a few are able to break through the crust of indifference and opposition which surrounds them a little later, and remain naturalists to the end. If this is true, and it is also true that stimulation at an early age is very important, the nature study movement in the schools may yet produce great results for science. However, in the absence of suitable teachers, and in view of the crowded curriculum and consequent weariness of the pupils, one fears that in many instances the effects of a nature study course may be the reverse of those desired. There may be fatigue and disgust with the whole subject.*

Most of the naturalists who have kindly written me about their early life state that their interest began in the woods and fields—anywhere but in the town. It would seem that the chances are very much against a naturalist born in the city, notwithstanding certain presumed advantages in the way of education.† A good typical instance of the influence of country life is given by Dr. John M. Coulter, the well-known botanist, who writes:

> I was brought up in a village and had a strong out-of-door tendency. This took me into the ravines, and woods, and along the streams in the neighborhood almost constantly. My interest for collecting things runs back to a time I cannot recall. The actual selection of botany among other out-of-door subjects was probably determined by the lines of least resistance, in the form of opportunities presented. (Litt., October 24, 1901.)

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* Many an English boy has acquired a distaste for the Bible from having to learn chapters by heart, lists of the kings of Israel, and so forth; and this often on Sundays, depriving him of the rest and recreation to which he feels entitled.

† One thing in favor of the city is the museum, where it exists. It is undoubtedly a factor of great importance, as will be shown later on.

# THE RELATION OF MALARIA TO AGRICULTURE AND OTHER INDUSTRIES OF THE SOUTH.

BY PROFESSOR GLENN W. HERRICK,

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IN a paper on 'Measures for the Decrease of Malaria in the South,' read in Nashville, Tenn., in August of the past summer before the Southern Commissioners of Agriculture, I very briefly called attention to the important rôle of malaria in agriculture. It was an inadequate attempt to demonstrate the practical bearing of this disease upon the wealth-producing powers of a commonwealth, with the hope that it might prove an added inducement for putting into practice the measures which had been recommended for the decrease of malaria. For to induce a people to use a remedy it must first be shown that a remedy is very much needed. We trust that this further treatment of the same question will result in more widespread and serious discussions and investigations of the profound influence of this most insidious disease upon the industries and wealth-producing powers of the southern people.

The south as a whole has given little thought to the tremendous rôle malaria plays in her industries, especially in agriculture. We have no idea of the loss occasioned by malaria in unfitting men for long or energetic hours of labor. The loss of energy and enthusiasm, the loss of interest in one's own efforts and successes, all of which contribute enormously to the inefficiency of labor and cause the wealth-producing power, especially in agriculture, to fall far short of its normal capacity, is due in a marvelous and undreamed of degree to that life-sapping disease, malaria. The man that is just able to 'crawl out of bed and drag around' is certainly not the man to accomplish an efficient and full day's labor. Because a man is at work is not necessarily a proof that he is actually adding to the sum total of his own wealth or to that of the state, and in a lesser degree does it prove that he is adding to the sum total of wealth, all of which he is capable. A man's general state of health has quite as much relation to his producing powers as the amount and kind of food he eats. And certainly there is no disease known to man that more insidiously undermines his constitution and lessens his ability to produce his full measure of wealth than malaria. Moreover, looking at malaria from another point of view, namely its relation to other diseases, let us hear what the eminent Dr. Patrick Manson, of England, says. In speaking of the importance of our knowledge concerning the relation of mosquitoes to malaria he says: 'This is a piece of knowledge of the utmost importance to mankind, for we know that malarial disease in tropical countries . . . *causes more deaths and more disposition to death* by inducing cachectic states, predisposing to other affections than *all the other parasites affecting mankind together.*' The italics are our own. This is a most startling statement to the ordinary layman, yet it comes from one who knows whereof he speaks.

Celli, the celebrated Italian authority on malaria, tells us that the mean mortality statistics give about 15,000 deaths yearly from malaria in Italy. He further says that, "calculating from the number of deaths the number of patients, we arrive approximately at about two million cases a year." "The loss of labor and of production, and the expenses entailed in dealing with this disease consequently amount to several millions of francs." About five million acres of land go uncultivated or very improperly cultivated, which represents an enormous loss. One railway company spends on account of malaria one million fifty thousand francs ($200,000) a year. He sums up by saying, 'one can positively assert that *malaria annually costs Italy incalculable treasure.*'

Our own statistics on malaria are meager and not so clear cut as one could wish. Yet the figures of the twelfth and last census which is just now appearing are enlightening, as the following table taken from that census will show. I have selected the six diseases that cause the most deaths in the states considered. There are no other diseases that approach near enough to these in their death rate to demand serious consideration or comparison.

Number of Deaths for Year ending May 31, 1900.

| | Total. | Consumption. | Heart Disease. | Pneumonia. | Typhoid. | Dysentery. | Malaria. |
|---|---|---|---|---|---|---|---|
| Louisiana | 20,955 | 2,016 | 1,149 | 1,945 | 1,077 | 385 | 1,030 |
| Mississippi | 20,251 | 2,129 | 876 | 2,168 | 1,370 | 380 | 983 |
| Alabama | 25,699 | 2,666 | 1,111 | 2,459 | 1,713 | 864 | 1,005 |
| Georgia | 26,941 | 2,651 | 1,350 | 2,598 | 1,585 | 781 | 1,011 |
| South Carolina | 17,166 | 2,133 | 843 | 1,324 | 970 | 578 | 749 |

It must be borne in mind that these figures concern only those deaths that were reported. Scores of deaths occurred in these states that were never reported. But it no doubt is safe to assume that the deaths from one disease were reported as fully as those from another, hence we can with fairness use these figures for making comparisons.

In the first place then, considering malaria by itself in relation to the total number of deaths in each of the five states mentioned, we find the following generalizations to be true. The total number of deaths in Louisiana for the year ending May 31, 1900, was 20,955, of which 1,030 or very nearly one twentieth were from malaria fevers. In

Mississippi for the same year there were 20,251 deaths, of which 983 or a trifle less than one twentieth were from malaria fevers. In Georgia, Alabama and South Carolina, taking these three states as a whole, a trifle less than one twenty-fifth of the whole number of deaths was due to malaria. Evidently then malaria is responsible for a surprisingly large part of the whole number of deaths in these five states.

But there is another and much more significant fact to be drawn from the afore-mentioned table. It is seen that, in general, consumption, heart disease, pneumonia and typhoid fever caused more deaths than malaria and these were the only diseases that did. But these diseases are much more fatal than malaria. That is, where one person sick with either of these four diseases recovers, dozens are sick with malarial chills and fevers and recover. In other words, malaria causes much more sickness than any one or all of those four diseases rolled in one. Taking Celli's own basis of estimate, we shall find that there were in the five states mentioned, approximately 635,000 cases of malaria in the year ending May 31, 1900, a factor truly appalling in its influence against the wealth-producing power of a people.

Again we must just here take into consideration the fact that the census figures do not give an accurate and full report of all the deaths by malaria. This is an important point because where one death from malaria is not taken into account a dozen or more cases of sickness from chills and fevers are not accounted for, whereas when one death by consumption is not reported, it is simply one death not reported and nothing more. The same is largely true of the other three diseases used in our comparison. There is not a doubt that the cases of sickness as a result of malaria would easily number a round million could we obtain full and accurate reports.

Finally by taking all the foregoing facts and deductions into consideration, we are forced to but one rather startling conclusion, namely, that *malaria is responsible for more sickness among the white population of the south than any disease to which it is now subject.*

We must now consider briefly what six hundred and thirty-five thousand or a million cases of chills and fevers in one year mean. It is a self-evident truth that it means well for the physicians. But for laboring men it means an immense loss of their time together with the doctor's fees in many instances. If members of their families other than themselves be affected it may also mean a loss of time together with the doctor's fees. For the employer it means the loss of labor at a time perhaps when it would be of greatest value. If it does not mean the actual loss of labor to the employer, it will mean a loss in the efficiency of his labor. To the farmers it may mean the loss of their crops by want of cultivation. It will always mean the non-cultivation or improper cultivation of thousands of acres of valuable land. It means a listless activity in the world's work that counts mightily against the wealth-producing power of a people. Finally, it means from two to five million or more days of sickness, with all its attendant distress, pain of body and mental depression to some unfortunate individuals of those five states.

While the above statistics are meager and inconclusive, and while our estimates may be open to question, yet we may be sure that malaria detracts enormously from the full wealth-producing power of the south. To substantiate this statement one has but to reflect, from his own personal knowledge, upon the number of working days that are lost in a year by white men because of chills and fevers. The writer recalls to mind many such cases within the year. Only the past summer I saw a whole family forced to leave a farm on account of malaria. While living there some one or all of them were sick the major portion of the time, and although the farm was a productive one they were scarcely able to make a living, because of their unfitness for work. In a certain railroad town with which I am familiar it is invariably the rule that some employee is 'laying off' because of chills and fever or because of some indisposition at the bottom of which is malaria.

In my summer vacation which was spent in North Carolina I had an opportunity of observing a laboring man and his family that lived near a brook in the quiet pools of which were the malarial mosquitoes, *Anopheles*. During my sojourn of about three weeks the head of the family 'laid off' four days from chills and fevers, and no doubt he has lost many days since during the autumn. He is a man with a delicate, pale skin and, while conversing with him, I have noted as many as two *Anopheles* mosquitoes on one hand at the same time. The question has often occurred to me since, whether these mosquitoes prefer to attack people with delicate skin. My own face and hands were not troubled by them, although we stood within hand-shaking distance of each other and the mosquitoes were fairly abundant. The mother and children of the family were great sufferers from malaria, especially the former, on account of which much of their earnings was used to pay doctor's fees.

In looking for a concrete effect of malaria upon agriculture, we have only to turn our attention to one of the most fertile regions of the United States if not of the world, namely, the so-called Delta region of Mississippi. It lies along the Mississippi River in the western part of the state and extends from the mouth of the Yazoo River north, nearly to the Tennessee line. It is the second best farming land in the world, having only one rival, and that is the valley of the Nile. Still this land to-day, at least much of it, can be bought at ten to twenty dollars an acre. Thousands of acres in this region are still covered with the primeval forest, and the bears and deer still roaming there offer splendid opportunities for the chase, as evidenced by the late visit of our chief executive to those regions for the purpose of hunting. Why is not this land thickly settled and why is it not worth from two to five hundred dollars an acre? If it produces from one to two or more bales of cotton on an acre, and it does, it ought to be worth the above named figures. A bale of cotton to the acre can be produced for thirteen dollars, leaving a net profit of twenty to forty dollars for each bale or forty to eighty or more dollars for each acre of land cultivated. Moreover, this land has been doing that for years and will do it for years to come without the addition of one dollar's worth of fertilizer. Land that will produce a net profit of forty to eighty dollars an acre is a splendid investment at one, two or even three hundred dollars an acre. Yet this land does not sell in the market for anything like so much, because the demand is not sufficient, for white people positively object to living in the 'Delta' on account of malarial chills and fevers. A man said to me not long ago that he would go to the 'Delta' that day if he were sure that his own life or the lives of the members of his family would not be shortened thereby. There are thousands exactly like him, and the only reason that these thousands do not go there to buy lands and make homes is on account of chills and fevers. But there is a time coming, and that not far distant, when malaria in the 'Delta' will not menace the would-be inhabitants. When that time comes it will be the richest and most populous region in the United States.

There can be no doubt that many people are kept away from the sunny southern skies because of the dangers of malaria, sometimes fancied 'tis true, but quite as often real. It behooves us to remove this danger entirely. I feel sure the day is soon coming when chills and fevers will have lost their terrors because we shall surely learn how to avoid them. It is most propitious that these wonderful discoveries in regard to malaria and yellow fever were made on the eve of the south's great awakening along industrial and educational lines.

If the experiments of Ross, Manson, Celli, Sambon, Low and others demonstrate that malaria can be avoided; and if the experiments of Carroll, Reed, Lazear and Agramonte demonstrate that quarantine and fumigation are useless and that yellow fever can be controlled by controlling mosquitoes or by keeping inside of a wire screen out of their way, then I venture to predict that those experiments will go down in the annals of the south as the most important of the nineteenth century.

# THE HABITS OF THE GIANT SALAMANDER.

BY DR. ALBERT M. REESE,

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CRYPTOBRANCHUS (*Menopoma* of the earlier text-books) *Alleghaniensis* or hellbender, the American representative of the giant salamanders, although only too familiar to the fishermen of the Ohio valley is, to most people, rather a curiosity and its habits, therefor are worthy of some attention.

Its distribution, according to most authors, is limited to the tributaries of the Ohio River, but whether or not this is strictly true I am unable to state. I have investigated several cases of the supposed occurrence of *Cryptobranchus* in waters far distant from the Ohio, but in each instance the animal in question proved to be *Necturus*. By the natives of the regions it inhabits, the hellbender is called 'alligator' or, occasionally, 'waterdog': it is easy to imagine how the former name might have originated, but why it should be called a 'dog' is as hard to imagine as the reason for calling *Necturusa* 'mud-*puppy.*' The hellbender is said to reach a length of more than 60 cm., the largest specimen that I obtained, from a considerable number of individuals, was 55 cm. in length. It is a most unprepossessing animal, and, probably on that account, has the reputation, among fisherman, of being poisonous, although it is really a most inoffensive and harmless creature. I have handled many dozen individuals, some of which were just from their native stream and some of which I have had in captivity for more than eight months, but in no instance has any attempt been made to bite. Its jaws are very wide and strong, however, and being armed with numerous small, sharp teeth, are probably capable of inflicting a painful wound. Its repulsive appearance seems to be largely due to the curious flatness of the head, the tiny, almost invisible, lidless eyes and the lateral folds of skin which extend for the greater part of its length.

The tips of the toes, of which there are four on the anterior and five on the posterior feet, are nearly white and are thus in curious contrast to the dark color of the rest of the animal.

The adult hellbender breathes by means of well-developed lungs, but there is a gill opening in each side of the throat, from which bubbles of air occasionally escape. The nostrils are two very small openings situated at the extreme tip of the broad snout, so that when the animal comes to the surface to breathe, it need expose but the tip of its snout above water. The process of inspiration, if it may be so called, is practically one of swallowing air. When it becomes necessary for the hellbender to take in a fresh supply of air, it swims towards the surface of the water until the tip of the snout is exposed; then, by swelling downward the skin of the floor of the mouth, a huge mouthful of air is drawn in, and the animal, now arching upward its neck and back, slowly sinks to the bottom, the swallowed air passing back to the lungs either by its own buoyancy, the lungs now being higher than the throat, or by a sort of peristaltic action of the throat. As the animal sinks, a considerable portion of the air that was taken into the mouth escapes through the nostrils or through the gill openings. After reaching the bottom, the animal frequently retains, for some time, the strongly arched position, as though the region of the lungs were buoyed up by the air that had just been taken in. The air is gotten rid of partly by a quick expiration when the animal comes to the surface, and partly by an occasional bubble sent up from the bottom. If the animal be alarmed as by a sudden approach to the tank in which it is contained, it frequently sets free one or more large bubbles of air, perhaps by the involuntary relaxation of certain muscles, perhaps by a voluntary expulsion of superfluous air, to enable it better to escape the supposed danger. The length of time that the hellbender remains under water seems, in captivity at least, to be quite variable. I made a series of observations on three individuals, a very large one, a very small one and a medium-sized one, and the average interval between inspirations was about fifteen minutes. The longest time that any individual was actually observed to remain below the surface was forty-three minutes.

In motion the hellbender is usually slow and awkward. On a smooth dry surface, as the top of a table, it is almost helpless, because the slime secreted by the skin soon dries and becomes so sticky as almost to prevent motion. Even in its native element its motions are usually awkward, though when swimming rapidly this is not apparent. In crawling over the bottom, the diagonally opposite legs very nearly 'keep step,' *i. e.,* the left front leg and the right hind leg move forward at the same time. In active swimming the tail is the most effective organ, as in the alligators. If an individual, which is lying quietly on the bottom, be watched carefully it will frequently be noticed that it has a slight rocking or swaying motion, caused by the alternate straightening or relaxing of the legs, similar, perhaps, to the swaying motion of elephants. In captivity they usually congregate in the darkest portions of their tank, crawling under boards or stones if these be present, or under each other if there be no better hiding place. If not lifted above the surface of the water, they may be handled with scarcely a struggle, but if taken from the water they struggle to regain their native element. As a rule the smaller specimens were more active than the larger.

As my chief object in collecting the hellbenders was to obtain eggs fcr embryological work (my hope being that the animals would spawn in captivity) and as I had at first no idea as to when the spawning season occurred, I started in pursuit of the creatures about the first of February, tramping many weary miles through three feet of snow and chopping numerous holes through the thick ice that covered French Creek in which the hellbenders abound. Hand-lines, night-lines and traps were tried again and again, but, though several specimens of *Necturus* were caught, not a single *Cryptobranchus* was obtained until the twenty-eighth of March, after the ice and snow had all disappeared and several days of warm weather had slightly warmed the water. Fishermen, generally, stated that 'alligators' could not be caught until the ice had melted and the water had had time to warm slightly.

Although the first specimens were caught during the last days of March, it was not until nearly a month later that they could be obtained in any numbers, and it was during May that they were most abundant. About June 7, desiring to obtain a few more specimens, I applied to the boys from whom I had been buying them, but, after fishing for a week or more, they told me that the 'alligators' had stopped biting, and I was unable to obtain the additional specimens that I wanted. Whether they usually cease taking food at this time I am unable to say, but Mr. Chas. H. Townsend, of the New York Aquarium, says* that they were caught by him in August, on hooks baited with pieces of meat or fish heads. Most of the specimens I obtained were caught in traps that had been set for fish, though many were caught with hook and line, the disadvantage in the latter method being that the hook was often caught so far down in the digestive tract that it could not be extracted without seriously injuring the animal.

The color of all the hellbenders, when first caught, was a more or less uniform dirty black or greenish-brown with numerous irregular dark spots on the dorsal side. Fishermen were occasionally heard to speak of 'red alligators' but I never saw a hellbender that could, in truth, be called red, though after they had been in captivity for a couple of months many of them changed color very perceptibly, becoming a more decided brown, sometimes with a decided greenish tinge and sometimes with the dark spots, mentioned above, very pronounced. It is possible that this change in color, in a state of nature, may be very much more marked and that when the breeding season arrives it may become an actual red, and serve as a sexual character. Judging from analogy, it would be supposed that these more brilliantly colored individuals would be males, but such was not the case. Of the specimens that I had under observation, nearly all were females; if this were true in a state of nature, it might be possible

* *American Naturalist*, February, 1882.

that the females had acquired this brighter coloring, as a secondary sexual character, for the attraction of the males.

The hellbender has the reputation of being an exceeding voracious animal, and in his native stream this is probably true, though in captivity his appetite is very moderate. The contents of the stomach of a number of individuals were examined, and it was found that the most common article of food was apparently crayfish, though earthworms, small fish and, in one case, the mandibles and a foot of a small mammal, probably a mouse, were found. Fish as much as 8 cm. in length were sometimes found in the stomachs of large individuals. As it seemed impossible to catch the hellbenders until comparatively late in the spring, it is probable that they lie dormant through the winter, and hence do not take any food until they renew their activity at the appearance of warm weather.

A number of animals that I obtained one morning in a fish-trap seemed very much distended, as with eggs; on being put into a tub of water they disgorged a great mass of material consisting chiefly of a number of small fish that had been caught in the same trap and had thus fallen easy prey to the appetite of the hellbenders. It almost always happened that when hellbenders were put into an ordinary vessel of water they disgorged, within a few hours, the contents of their stomachs, while if put into a tank of *running* water they seldom, if ever, disgorged.

Although it seems certain that they catch and eat living fish and crayfish, under natural conditions, they never ate these animals alive in captivity nor, as far as I could see, ever attempted to catch them when they were put into the tank and left there for days. The fact, however, that the crayfish were frequently found on top of a floating piece of board that was in the tank would seem to indicate either that the hellbenders had attempted to catch them or that they had an instinctive fear of the salamanders, founded on racial experience. A couple of small hellbenders were kept for a short time in a glass aquarium jar for close study. These two individuals were the only ones that were actually *seen* in the act of taking food. If earthworms were lowered into the water just in front of them, they would seize them by a quick, lateral jerk of the head and then swallow them by a series of quick forward jerks, the tongue being, apparently, of very little use in drawing food into the mouth. The quickness of this seizing motion was quite surprising in so sluggish an animal, and showed how a fish or crayfish that ventured within reach might easily be captured. From the beginning of their captivity the hellbenders were fed on raw liver, chopped into pieces as large as the end of a man's thumb. During the first few weeks they ate very little and were fed about once a week, but towards the last of July their appetites seemed to increase, and they were fed every two days. They would never eat, as has been said, while they were watched, but if the liver were left in the tank over night, most of it would be eaten before morning.

The extreme slowness of their digestion is shown by the fact that liver eaten seventy hours before, on being disgorged showed very little change, the pieces being of about the same size and consistency as when swallowed.

After about the middle of September, the hellbenders refused to eat during a period of more than two months, though pieces of liver were put into their tank at intervals. One morning at the end of this period, on looking into the tank, something black was seen projecting from the mouth of one of the largest hellbenders, which on close examination proved to be the end of the tail of the smallest of the hellbenders, which had been swallowed head-first. By means of a pair of forceps the smaller individual was withdrawn from within the larger, and both immediately swam away, none the worse apparently for their remarkable experience. The smaller hellbender was a little more than half as long as the one by which it was swallowed. In spite of this apparent return of appetite, the hellbenders ate but little of the fresh supply of liver that was immediately given them.

The remarkable vitality of the hellbender is well known by those who have had any opportunity of studying the living animal. Mr. Townsend in the article mentioned above says: "They are remarkably tenacious of life. I carried my specimens six miles in a bag behind me on horseback, under a blazing hot sun, and kept them five weeks in a tub of water without a morsel to eat, and when I came to put them in alcohol they seemed almost as fresh as ever."

I had several illustrations of their tenacity of life. One of the first specimens I obtained, a large one, more than 50 cm. in length, escaped from the tank into which it had been placed and hid itself under a lot of lumber and rubbish that was piled near by. After a long search it was given up for lost, but one morning, just a week later, on going into the cellar where the tank was kept, there lay the escaped hellbender, dry and dusty but as well as ever, and the same animal is living at the present time. Some months later, while they were living in a tank of running water in the back yard of a city house, another hellbender escaped and could not be found. Exactly three weeks later it was found lying on the pavement outside of the yard. It was still living, though extremely thin and weak, but it died a few hours after being put back into the tank, possibly because it was too weak to swim to the surface for air. During the three weeks it was lost it changed color very decidedly, becoming a reddish-brown, with the dark spots showing in sharp contrast. During the latter part of June sixteen hellbenders, nearly all of large size, were put into a wooden box (12 in. × 9 in. × 6 in. in size) in which numerous small holes had been bored and were taken from western Pennsylvania to Baltimore, Maryland. Although confined in such small space for a continuous period of nineteen hours, they reached the end of their journey in perfect condition. On another occasion fifteen of these same animals were put into the same box and taken by rail to a distant city; on this occasion they were in the box continuously for twenty-five hours, and one individual died on the journey, apparently suffocated by the mass of disgorged liver that filled its mouth. I had purposely refrained from feeding them for several days previous to the journey, but their fast had not been sufficiently long and the undigested liver was all disgorged, apparently causing, as has been said, the death of one individual.

Although possessed of such tenacity of life their recovery from wounds is apparently slow, a wound in the head of one large specimen remaining raw and open for several months. Possibly in its natural environment recovery would have been more rapid.

My chief aim, as I have said, in working with *Cryptobranchus,* being to obtain embryological material, I enquired of every fisherman and countryman I met, and of many other people as well, concerning the breeding habits of this little-studied animal. The only facts of any sort that I could learn were obtained from Mr. C. H. Townsend, whom I shall again quote. He says in the article mentioned above: "During their confinement in the tub two of the females deposited a large amount of spawn. This spawn was something similar to frog spawn in its general appearance, but the mass had not the dark colors of the latter. The ova were exuded in strings and were much farther apart than frog eggs. They were of a yellow color, while the glutinous mass which connected them had a grayish appearance." This deposition of spawn, he says, took place in August. Had I had this information earlier in the season it would have saved me many fruitless attempts to capture the hellbenders, and possibly my efforts to obtain their eggs might have been successful. As it was I did not get a single egg, the animals refusing to spawn in captivity, though they were kept in a large tank of running water under conditions as near like their natural habitat as I could make them.

Ovaries examined during the first two months showed a gradual development, but those examined during the early part of September showed evident signs of degeneration. All of the individuals killed, except one or two, were females. It would seem that hellbenders, like some other amphibia, will not spawn in captivity if removed from their natural environment too long before their natural breeding season.*

* The author has in preparation a paper on the anatomy and histology of *Cryptobranchus,* which he hopes to have ready for publication in a few months.

# THE CARNEGIE INSTITUTION AND THE NATIONAL UNIVERSITY.

By Professor JAMES HOWARD GORE,

COLUMBIAN UNIVERSITY.

THE recent gift of Mr. Carnegie for the founding 'in the city of Washington, in the spirit of Washington, an institution which, with the cooperation of institutions now or hereafter established, there or elsewhere, shall, in the broadest and most liberal manner, encourage investigation, research and discovery, encourage the application of knowledge to the improvement of mankind; provide such buildings, laboratories, books and apparatus as may be needed, and afford instruction of an advanced character to students whenever and wherever found, inside or outside of schools, properly qualified to profit thereby' has awakened unprecedented interest in the educational world.

There has been no lack of persons ready to criticize the purpose of the institution and the methods by which the avowed purpose is to be carried out. And this criticism has not always been favorable.

That it should be located in Washington, is acceptable to all; that the 'spirit of Washington' should be observed in formulating the lines of activity meets with universal approval. But there are many who feel competent to expound the 'spirit of Washington' and stand ready to measure the new institution by the standard derived from their interpretation of this spirit.

Those who have dreamed of a national university, who have looked upon education as a function of the general government and saw in such a university the culmination of a general educational system—ignoring the anomalous condition of state supervision of the schools up to the state university and in some instances only including the state university, with a higher institution over and above all—such persons declared that the directing forces of the Carnegie Institution have not caught the 'spirit of Washington.'

The workers for a national university have appealed to our patriotic affection for Washington by quoting from his will these words:

I proceed after this recital, for the more correct understanding of the case, to declare; that, as it has always been a source of serious regret with me, to see the youth of these United States sent to foreign countries for the purpose of an education, often before their minds are formed, or they had imbibed any adequate ideas of the happiness of their own; contracting too frequently, not only habits of dissipation and extravagance, but principles unfriendly to republican government, and to the true and genuine liberties of mankind, which thereafter are rarely overcome; for these reasons it has been my ardent wish to see a plan devised on a liberal scale, which would have a tendency to spread systematic ideas through all parts of this rising empire, thereby to do away local attachments and State prejudices, as far as the nature of things would, or indeed ought to admit, from our national councils. Looking anxiously forward to the accomplishment of so desirable an object as this is (in my estimation), my mind has not been able to contemplate any plan more likely to effect the measure, than the establishment of a University in a central part of the United States, to which the youths of fortune and talents from all parts thereof may be sent for the completion of their education, in all the branches of polite literature, in arts and science in acquiring knowledge in the principles of politics and good government, and as a matter of infinite importance in my judgment, by associating with each other and forming friendships in juvenile years, be enabled to free themselves in a proper degree from those local prejudices and habitual jealousies which have just been mentioned, and which, when carried to excess, are never-failing sources of disquietude to the public mind, and pregnant of mischievous consequences to this country. Under these impressions so fully dilated,

*Item.*—I give and bequeath in perpetuity, the fifty shares which I hold in the Potomac Company (under the aforesaid acts of the Legislature of Virginia) towards the endowment of a University, to be established within the limits of the District of Columbia, under the auspices of the general government, if that government should incline to extend a fostering hand towards it.

(Signed July 9, 1790.)

An analysis of this will shows that its author advocated the breaking down of local attachments and prejudices by stimulating a love for the nation and bringing together youths from all sections; that he wished to keep the young men in this country instead of encouraging them to go abroad—two propositions that are somewhat antagonistic, since the one seeks to broaden students by eliminating state lines, the other to keep them narrow by erecting national barriers. Furthermore, this eradicating of 'habitual jealousies' was to be accomplished by 'the establishment of a University in a central part of the United States,' and it will be noticed that later on, by implication, he defines this central part to be 'within the limits of the District of Columbia.' It therefore seems that the correct standpoint from which to appreciate the 'spirit of Washington' is the date when the 'District of Columbia' was the 'central part of the United States,' and the welfare of the nation depended upon isolation and intellectual training by domestic talent rather than foreign culture. At this date, what could have been Washington's ideal of a university course of study? Could it have been far beyond the curricula of the colleges then in existence? An examination of the courses of study at that time available would determine what a national university should offer unless it be asserted that this spirit, so frequently referred to, could grow with the country while the arguments for intellectual unification inwardly and insularity outwardly should continue in force.

At the date when this will was signed, July 9, 1790, the following colleges were in operation in the United States:

Harvard (1636).
Yale (1701).
College of William and Mary (1692).
University of Pennsylvania (1749).
Columbia (1754).
Princeton (1746).
Brown University (1764).
Dartmouth (1769).
Rutgers (1770).
Hampden-Sidney (1776).
Washington and Lee (1782).
Washington University (1782).
Dickinson (1783).
St. Johns (1784).
Nashville (1785).
Georgetown (1789).
University of North Carolina (1789).

In Yale College we find the following courses offered for the session of 1702:

(1) Latin, five or six orations of Cicero; five or six books of Virgil; talking college Latin; (2) Greek, reading a portion of the New Testament; (3) Hebrew, Psalter; (4) Some instruction in mathematics and surveying; (5) Physics (Pierson); (6) Logic (Ramus).

In Dartmouth College, for the session of 1811, the following courses were offered:

*Freshmen*—Latin and Greek classics; arithmetic; English grammar; rhetoric.

*Sophomore*—Latin and Greek classics; logic; geography; arithmetic; geometry; trigonometry; algebra; conic sections; surveying; belles-lettres; criticism.

*Junior*—Latin and Greek classics; geometry; natural and moral philosophy; astronomy.

*Senior*—Metaphysics; theology; natural and political law.

The following courses were offered at Harvard for the session of 1825:

*Freshmen*—Livy, five books; plane geometry; Graeca Majora; Horace, algebra; English grammar.

*Sophomore*—Solid geometry; English history; Cicero; analytic geometry; rhetoric.

*Junior*—Logic; moral philosophy; chemistry; Tacitus; Homer; calculus; mechanics; electricity.

*Senior*—Intellectual philosophy; astronomy; Butler's analogy; political economy; chemistry; natural philosophy.

By comparing even the latest and most advanced of these courses of study, one will see that the best high schools of the present day are nearly the equivalent of the institutions from which Washington could have drawn his ideals, and that a university that now begins where the best colleges of his time left off, would surely be the equal of all that he could have hoped to see in his national university. Such institutions we now have in every state and in almost every city.

During the early years of our national existence it might have been possible to bring into one institution the greater part of the young men desiring higher training by offering superior courses of study, but later, when college graduates began sending their sons, the *alma mater* was the first choice and was the college finally selected unless the opportunities were *far* greater at some other institution or else for economic reasons a near-by or home college was chosen. Now, when great efforts are put forth by the authorities of a university to keep pace with its foremost rival, this 'going away to college' is very great as may be seen in the accompanying table.

| | Harvard. | University of Pennsylvania. | Yale. | University of Chicago. | Columbia. | Totals. |
|---|---|---|---|---|---|---|
| Chicago students at | 74 | 3 | 82 | | 8 | 167 |
| Boston students at | | 3 | 5 | 2 | 5 | 15 |
| New York students at | 205 | 10 | 205 | 4 | | 425 |
| Connecticut students at | 46 | 27 | | 6 | 83 | 162 |
| Philadelphia students at | 47 | | 27 | 4 | 5 | 83 |
| Washington students at | 33 | 7 | 25 | 2 | 9 | 76 |

The small number of Boston students who do not attend Harvard suggests the fact that there is in this city a preponderance of Harvard alumni, and the large number of students from New York at Harvard and Yale illustrates a similar condition, as does also the small number of Boston, New York, Connecticut and Philadelphia students at Chicago, though in this last instance distance doubtless exerts some influence.

It is evident that in the manifold centers of instruction with students from practically all the states, the process of 'freeing themselves from local prejudices and jealousies' is more effectual than if there were congregated at one place numbers so great that state associations would be formed for social reasons.

In Germany the migration of students is encouraged, and in this country the Association of American Universities is endeavoring to formulate a plan by which students may pass from one institution to another, receive credit for work wherever done and return for his degree to the university at which he matriculated.

In 1790 state capitals were as far apart in time as national capitals are to-day, and the prejudices and jealousies that now differentiate people of different nationalities are no greater than those that in Washington's time separated the citizens of the various states of the Union. And though the nations of the world will never be brought under a single government, the desirability of removing national prejudices is as great now as was a century ago the elimination of state jealousies. The logical conclusion therefore would be that the 'spirit of Washington,' moved forward a hundred years, would call for an international or world university.

Suppose Mr. Carnegie had responded to the invitation to found a national university and had given ten million dollars for that purpose, in what respect could it have been greater than the institutions now in existence?

The assets of a university are: (1) the endowment and educational plant *per se,* (2) the faculty, (3) the felicity of its situation.

The entire Carnegie bequest would be exhausted before Harvard or Columbia could be reached, and the University of Pennsylvania would be barely passed. It is thus apparent that even when supplemented by the opportunities for study which Washington affords, the advantages in a material way would not exceed existing institutions by an amount sufficient to overcome sentimental or other reasons that attract students elsewhere.

A superior faculty can be secured, in general, only by offering salaries in excess of those now paid, and if the new faculty is to be greater in point of numbers and superior in attainments to all other faculties, the income on the entire amount given would not suffice to meet this charge alone.

Again, such men could be found, in general, only in existing institutions, unless the risky experiment of taking untried persons should be followed, and the withdrawal of each superior man from a university would weaken it or the institution that was called upon to fill the vacancy thus created.

Washington unquestionably possesses material educational advantages, but the institutions already located there are living up to them at least in as complete a degree as could be reached by a new institution, unless it should become merely a competitor. To be more than a rival, it would require an endowment sufficiently great to procure an equipment and faculty surpassing those now in existence.

The advocates of a national university declare that it should not be a rival to existing institutions, and Mr. Carnegie asserts that the aim of his institution is 'To increase the efficiency of the universities and other institutions of learning throughout the country, by utilizing and adding to their existing facilities, and by aiding teachers in the various institutions for experimental and other work, in these institutions as far as may be advisable.' The purpose of one is to destroy existing institutions—the intention of the other is to build them up.

Assuming that the plan of operation of the Carnegie Institution to be along the lines announced in the daily press, it is easy to see that the work of no institution will be duplicated but supplemented, that students will be sent to the universities rather than drawn from them, and that the ablest professors will be left under conditions where they can do the greatest good to the greatest number.

If a great specialist were called from his present position to Washington to conduct work more advanced than he now performs, the number of persons annually benefited by his instruction would be lessened. Suppose he should remain where he is, and these advanced workers be sent to him, he would be able to carry on the greater part, if not all, of his regular work and direct these special investigators as well. No institution would be crippled by the loss of its strongest men, but on the contrary it would be strengthened by the coming of exceptional students.

The Carnegie Institution might also reach a class that could not be benefited by a national university intended for graduate students only, for it could assist and encourage the exceptional man even if, through force of circumstances, he had been unable to obtain a degree. This surely is in the spirit of the man who became the commander in chief of an army without having passed through a military academy.

The fear that the humanities will be neglected in this institution is not well founded. For, though emphasis has been laid upon the opportunities Washington affords for scientific investigation, there is no implication that the sciences alone will receive attention. The advanced student in linguistics or philosophy needs direction and access to libraries and museums, and since it is impossible to bring into one place the ablest directors and the richest collections of books and original material, the very best that can be done is to send the investigator to the expert for direction and leave him free to pass from one city to another while searching the sources from which his knowledge must be drawn. Such workers are beyond the need of recitation drill and daily contact with an instructor, and it is very sure that while one guide might suffice, there would be no one locality where his work could be carried on to the best advantage.

It is likely that the Carnegie Institution will concern itself first of all in obtaining authentic and complete information regarding the great specialists of the world, the extent and scope of all libraries, museums, workshops, laboratories and special facilities for advanced work of every sort and character. It has secured groups of advisers in the various branches of art, science and philosophy, and thus doubly equipped, is able to direct intelligently the student where to go and how to proceed in order to complete the task which he had undertaken. If, in addition to this advice, the institution should find it possible to give financial aid to the worthy investigator the fondest hope of Washington will be more than reached and a grander spirit than his will become a thing of life.

# BIOGRAPHY IN THE SCHOOLS.

By Professor DAVID R. MAJOR and T. H. HAINES,

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THE study described in the following pages was suggested by Professor E. Ray Lankester's tribute to Huxley which concludes, 'Ever since I was a little boy he (Huxley) has been my ideal and hero.'* An instance of a scientist in the rôle of 'ideal and hero' to the boyish imagination is rare enough to attract attention. How rare it is, and how low a rank the scientist takes in the scale of heroes, because of our faulty methods of education, will be indicated roughly by the figures which follow.

The study was planned originally to find out in a general way the relative degree of familiarity which a given number of students (high school and university) have with the names of military leaders, on the one hand, and the names of great scientists, on the other. Or rather, the aim was to get a quantitative statement of the degree to which familiarity with the names of the world's great military leaders surpasses familiarity with the names of its great scientists. For it is an every-day observation that the names of the former are on everybody's lips and that those of the latter class of men are not widely known.

When the tests reported here were actually given, the original plan, which included only the two classes just named, was extended so as to include eight other categories giving ten in all, as follows:

1. English and American poets.
2. Statesmen.
3. Inventors.
4. Scientists.
5. Orators.
6. Military leaders.
7. Occupations and industries fundamental to modern life.
8. Novelists.
9. Artists, including painters, sculptors and musicians.
10. Greek and Roman writers.

It will be noticed that with the exception of the first and last groups there is no limitation as to time or place.

The method followed was to ask the students to begin at a given signal, *e. g.*, the tap of a pencil, and write in three minutes the names of all the English and American poets they could recall. At the end of the first three minutes the second group, statesmen, was given, and so on to the end of the list. In all, six hundred and fifty high school and university students were tested on the ten classes named above.

Table I. gives the number of students belonging to each high school and university class tested, and the average number of each of the ten

* L. Huxley, 'Life and Letters of Thomas Huxley,' II., p. 447.

groups named by each class. For example, 216 pupils in the first year of high school were tested. The average number of poets named by the 216 pupils was 5.5; statesmen, 4.1, etc.

Tables II. and III. give the same items for boys and girls separately. It will be noticed that the university students tested belonged, in the main, to the third and fourth years.

### TABLE I.

AVERAGE NUMBER NAMED BY BOTH BOYS AND GIRLS.

| | High School. | | | | University. | | | |
|---|---|---|---|---|---|---|---|---|
| Year. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| *Number of Students*........... | 216 | 148 | 94 | 54 | | 26 | 88 | 24 |
| 1. English and American poets. | 5.5 | 7.0 | 7.2 | 7.4 | | | 13.2 | 14.8 |
| 2. Statesmen................. | 4.1 | 4.7 | 5.5 | 5.7 | | | 11.0 | 12.5 |
| 3. Inventors.................. | 3.4 | 3.6 | 3.8 | 3.4 | | | 5.9 | 7.3 |
| 4. Scientists.................. | 0.15 | 0.32 | 0.66 | 0.66 | | | 4.1 | 5.9 |
| 5. Orators.................... | 1.9 | 2.6 | 3.4 | 3.5 | | | 6.8 | 7.1 |
| 6. Military leaders............ | 5.7 | 6.5 | 7.0 | 6.0 | | | 10.6 | 11.2 |
| 7. Occupations................ | 4.7 | 4.7 | 6.7 | 7.5 | | | 8.9 | 9.7 |
| 8. Novelists.................. | 1.7 | 2.0 | 3.0 | 3.5 | | | 7.2 | 8.1 |
| 9. Artists.................... | 1.5 | 2.5 | 3.3 | 2.7 | | | 6.9 | 8.1 |
| 10. Greek and Roman writers.... | 1.2 | 2.7 | 3.5 | 3.0 | | | 10.2 | 9.4 |

### TABLE II.

AVERAGE NUMBER NAMED BY BOYS.

| | High School. | | | | University. | | | |
|---|---|---|---|---|---|---|---|---|
| Year. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| *Number of Boys.* | 102 | 70 | 46 | 28 | | 26 | 41 | 14 |
| 1. English and American poets. | 5.2 | 7.1 | 6.6 | 7.2 | | 12.6 | 13.7 | 14.2 |
| 2, Statesmen................. | 4.5 | 6.0 | 5.7 | 5.8 | | 12.1 | 13.0 | 13.6 |
| 3. Inventors.................. | 3.7 | 4.1 | 4.8 | 4.2 | | 6.9 | 7.9 | 8.6 |
| 4. Scientists.................. | 0.5 | 0.3 | 0.8 | 1.0 | | 5.3 | 5.4 | 6.5 |
| 5. Orators.................... | 2.3 | 3.2 | 3.7 | 4.0 | | 8.5 | 9.1 | 8.1 |
| 6. Military leaders............ | 6.7 | 7.5 | 7.7 | 6.1 | | 11.6 | 13.1 | 12.3 |
| 7. Occupations................ | 5.3 | 5.4 | 7.2 | 8.0 | | 9.5 | 10.0 | 9.9 |
| 8. Novelists.................. | 1.4 | 2.0 | 2.7 | 2.9 | | 6.0 | 7.6 | 7.8 |
| 9. Artists.................... | 0.9 | 2.5 | 2.5 | 2.1 | | 5.1 | 6.5 | 6.5 |
| 10. Greek and Roman writers... | 1.1 | 3.4 | 3.3 | 2.9 | | 7.3 | 10.5 | 9.7 |

### TABLE III.

AVERAGE NUMBER NAMED BY GIRLS.

| | High School. | | | | University. | | | |
|---|---|---|---|---|---|---|---|---|
| Year. | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| *Number of Girls.* | 114 | 78 | 48 | 26 | | | 47 | 10 |
| 1. English and American poets. | 5.8 | 7.0 | 7.8 | 7.6 | | | 12.8 | 15.7 |
| 2. Statesmen................. | 3.7 | 3.5 | 5.4 | 5.6 | | | 9.2 | 10.7 |
| 3. Inventors.................. | 3.3 | 3.1 | 2.8 | 2.6 | | | 4.1 | 5.4 |
| 4. Scientists.................. | 0.2 | 0.3 | 0.5 | 0.2 | | | 3.0 | 4.5 |
| 5. Orators.................... | 1.6 | 2.1 | 3.1 | 2.9 | | | 4.9 | 5.5 |
| 6. Military leaders............ | 4.8 | 5.7 | 6.3 | 5.6 | | | 8.5 | 9.4 |
| 7. Occupations................ | 4.1 | 4.1 | 6.1 | 7.3 | | | 8.0 | 9.5 |
| 8. Novelists.................. | 1.9 | 2.0 | 3.2 | 4.1 | | | 6.9 | 8.7 |
| 9. Artists.................... | 2.0 | 2.5 | 4.1 | 3.4 | | | 7.2 | 10.5 |
| 10. Greek and Roman writers... | 1.2 | 2.1 | 3.6 | 3.2 | | | 9.9 | 9.0 |

It is not the intention to attempt an exhaustive treatment of the foregoing tables. They tell their own story, and the reader will draw his own conclusions on points which may happen to interest him. A few conclusions, however, of pedagogical and popular interest will be stated briefly.

Passing at once to a consideration of the tables there appears, as one naturally would expect, an increasing familiarity with the names in all the groups as we go from the first year in the high school to the senior year in the university. The largest percentages of gain are shown in the increased familiarity with the names of scientists, ancient classical writers and artists. The smallest gain is shown in the cases of military leaders and inventors. That is, the boy or girl in passing from the first year in the high school to the last year in the university will learn relatively vastly more names of scientists, ancient classical writers, and artists than he will of military men and inventors. As a university senior he will know forty times as many scientists' names as he knew as a first-year high school pupil; he will know eight times as many artists' names, and twice as many military names.

TABLE IV.

| Rank. | High School. | Av. Number for all Grades. | Rank. | University. | Av. Number for all Classes. |
|---|---|---|---|---|---|
| 1 | Poets | 6.5 | 1 | Poets | 13.5 |
| 2 | Military leaders | 6.2 | 2 | Statesmen | 11.3 |
| 3 | Occupations | 5.3 | 3 | Military leaders | 10.7 |
| 4 | Statesmen | 4.7 | 4 | Greek and Roman writers | 10.0 |
| 5 | Inventors | 3.6 | 5 | Occupations | 9.0 |
| 6 | Orators | 2.6 | 6 | Novelists | 7.3 |
| 7 | Greek and Roman writers | 2.29 | 7 | Artists | 7.0 |
| 8 | Novelists | 2.28 | 8 | Orators | 6.8 |
| 9 | Artists | 2.27 | 9 | Inventors | 6.2 |
| 10 | Scientists | 0.35 | 10 | Scientists | 4.4 |

If one examines Table IV. one finds that in the high school in order of familiarity, the names of English and American poets rank first, with military leaders as a close second. Statesmen stand third, inventors fourth, orators fifth, Greek and Roman writers sixth, novelists seventh, artists eighth, scientists tenth. It should be observed that the ranks of novelists, artists and Greek and Roman writers are nearly the same.

When we pass to the junior and senior years of the university, we find this order considerably changed. Poets rank first, statesmen second, military leaders third, Greek and Roman writers fourth, occupations fifth, novelists sixth, artists seventh, orators eighth, inventors ninth and scientists tenth.

If the two sets of figures are compared, it is found that the university students are relatively—as well as absolutely—more familiar than the high school pupils with the names of statesmen, novelists, artists and ancient classical writers. They are relatively, though not absolutely, less familiar with the names of inventors, orators and military leaders.

It appears further that the three highest groups, omitting occupations, for both high school and university students are poets, statesmen and military men, and that scientists are least known by both classes of students. This is explained partly by the fact that students hear more about men in the first named classes and partly by the further fact that the careers of statesmen, orators and military leaders appeal strongly to the imagination of the young. The great deeds of men belonging to these groups are concrete, and have form, color and tone, easily grasped by young minds. The achievements of the man of science have few of these characteristics, and so people generally, young and old alike, think of the scientist much as Heine said, in substance, of Kant, 'He was a philosopher, and so has no biography.'

The figures probably will have no surprises for those who have thought about the matter. But it is of interest to dwell briefly on their bearing upon certain questions which are of perennial interest to educators, and to students of the broader aspects of social tendencies. Any one who has been through our public schools will remember a number of studies which are rich in biographical material, hero worship, and suggestions as to personal ideals, while others are entirely devoid of them. It is hoped that this study will throw some light upon the questions of what kinds of personal ideals are fostered by the school, and what kinds of school work receive most emphasis.

To the writers the results indicate pretty clearly where modern education, in this country at least, lays greatest stress, on what things it drills, wherein are the main lines of interest and study, and, possibly, what sort of ideals are held up to school children. The far-reaching social and ethical significance of these influences needs only to be suggested in this connection. Boys and girls dream of becoming like persons whose lives and achievements they are led to admire. The boy reads of the military man's victories and longs to follow in his footsteps. He hears of the statesman's laurels won in legislative halls, or on the stump, and so pictures himself likewise the admired of all admirers. It is not an exaggeration to say that nine of every ten of the boys who graduate from our high schools count it a greater thing to be a member of the state legislature, or to be captain of the local militia, than to be a Pasteur, Virchow, Huxley, Wagner or Phidias.

Of course the ability to run off a long list of names of scientists, or of artists is not necessarily accompanied by a knowledge of science, on the one hand, or by a knowledge of art, on the other. But it is evidence, even though slight, of interest in the achievements of the scientists and artists and probably some degree of respect, even admiration, for the great names in those two fields. On the other hand, it is safe to say that pupils will not become zealous in the study of either science or art without, at the same time, becoming deeply interested in the heroes in those subjects. It is likely, for example, that a person who knows something of music and is interested in it will be familiar with a number of names of the world's great musicians. And it is also highly probable that if one does not know these great names in music one has little knowledge of, or interest in, that art. In a word, the presumption is strong that if a pupil is interested in a given field of activity he will also know the great names in that field. It is also true that one of the surest and quickest ways to get pupils interested in a given line of study is to arouse their interest in the lives of persons distinguished in that line. President Stanley Hall puts the matter admirably in his article on 'Criticisms of High School Physics.'* What Dr. Hall says with reference to physics, holds true of the other sciences. "Boys in their teens," he writes, "have a veritable passion for the stories of great men, and the heroology of physics, which, if rightly applied, might generate a momentum of interest that would even take them through the course as laid out, should find a place. . . . Physics has its saints and martyrs and devotees, its dramatic incidents and epochs, its struggles with superstition, its glorious triumphs, and a judicious seasoning perhaps of the whole course with a few references and reports by choice with material from this field would, I think, do much." The practical point in mind is—teachers of science should do more in the way of acquainting pupils with the lives of scientists, first from a sense of justice to the memory of those who have wrought so vastly for the good of mankind, and for the further purpose of inspiring young persons to take up science as a life work.

The bearing of our figures upon the fact of the general neglect of art in the public schools of America is worth noticing briefly. President Butler of Columbia University defines education as a gradual adjustment to the spiritual possessions or inheritances of the race, these inheritances being literary, scientific, esthetic, institutional and religious. With reference to the importance of the esthetic inheritance and its place in a well-rounded education he says, "We should no longer think of applying the word cultivated to a man or woman who had no esthetic sense, no feeling for the beautiful, no appreciation of the sub-

* *Pedagogical Seminary*, IX., p. 194.

lime, because we should be justified in saying, on psychological grounds, that that nature was deficient and defective. This great aspect of civilization . . . is a necessary factor in adjusting ourselves to the full richness of human conquest and human acquisition . . . we should see to it that the esthetic inheritance is placed side by side with the scientific and the literary in the education of the human child."* Among the humanizing elements of education as it should be organized esthetic insight and appreciation rank high. Yet our figures bear testimony to what every one knows without tables of statistics, that art is neglected in the education of the American youth so far as the schools are concerned. The fact that high school seniors who can name on an average 5.7 statesmen know only 2.7 painters, sculptors and musicians in all the world's history is too significant to require comment. Is it a fair showing? Does it not indicate an over emphasis of certain lines of school work to the neglect of others, and to the permanent injury of pupils? Does it not indicate an overdoing of the literary side? Are we not too much enslaved to letters and books even in our humanizing? One may even ask, has the poet any just claim to so much more of the pupil's time and interest, as indicated by the figures, than the artist who bodies forth his ideals on canvas or in stone?

Finally a word regarding a by-product of the investigation. An examination of the individual papers brings home to one anew that much even of the university student's knowledge is a vague, jumbled patch-work of shadows and blurs. A few instances from a vast number will illustrate the point. We are told that Victor Hugo was a military leader; that Aristotle and Virgil were great orators; that Isosceles was a great orator; that Emerson and Bryant and Lowell were English poets, and Bismarck an English statesman; that Romeo was a Roman writer; that Shakespeare was a Latin author and wrote Julius Cæsar; that Macaulay was a Roman writer and wrote Lays of Ancient Rome. Confusion and haziness are the banes of the university student as they are of all grades of learners. We are in constant danger of over estimating the number of clear-cut live facts or principles in the possession of any pupil or student. The question naturally arises, is it not possible that modern education with its wealth of material which it pours forth on students with such lavish hands does not smother and confuse rather than enliven and illumine?

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* Butler, 'The Meaning of Education,' Ch. I.

# A VISIT TO THE QUARRY-CAVES OF JERUSALEM.

By CHARLES A. WHITE,
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THE hill-country of Judea consists chiefly of one great anticlinal fold of a thick series of Upper Cretaceous strata, mostly limestones, the axis of the fold having a nearly due north and south trend. This series rises from beneath the slightly elevated and comparatively narrow Tertiary plain which borders the Mediterranean Sea, is broken by erosion into rugged hills and deep ravines, reaches, even in its present condition of great denudation, an elevation of about 2,500 feet, and then dips eastward. The angle of dip being greater upon the eastern than upon the western side of the axis, the whole series of strata is carried beneath the surface of the Dead Sea, which is only ten or twelve miles east of the axis in a straight line and more than 1,200 feet below ocean level. East of the western shore of the Dead Sea the geological structure is complicated by faults, but that matter need not be discussed. Jerusalem is situated upon the east side of, but very near to, the axis, and because of the presence of the great depression in the land surface called the 'Ghor' one gets good views from the hilltops that rise around the city upon and near the axis. Within range of distinct vision are the Wilderness of Judea, the Hills of Edom, and especially the Mountains of Moab with the Dead Sea and the lower end of the Jordan valley lying near their base. The great series of strata thus folded, consisting, as it does, largely of compact limestone, has furnished only a scanty, although fertile, soil by the natural process of disintegration, and that memorable land is, therefore, preeminently a region of stony ground.

The lithological character of those strata is favorable for the production of natural caves, and many such exist there as is well known from references to them in both sacred and profane history. All the drainage lines of the region, however, being short and most of them declivitous, none of those caves is of large size compared with the great caverns of other regions. Many of those small Judean caves have been artificially enlarged and adapted to use as store-houses, stables, tombs and even as human dwellings. Numerous rock excavations which are wholly artificial have also been made from time immemorial and for various purposes, but I shall refer only to those which have resulted from the quarrying of stone for building purposes, and especially mention only those which now exist at Jerusalem, and which are among the most important of their kind.

Much of the limestone of the Judean fold is suitable for common masonry and it is everywhere so used, but one stratum which comes to the surface at Jerusalem is especially valuable. Its superior quality seems to be limited to the vicinity of that ancient city, for that quality has not been found in the equivalent stratum of the series elsewhere. It is a light gray limestone sometimes, and, not improperly, called marble, but locally it is known as Malaké or the Royal stone. It is of good appearance, great durability and of uniform texture, and is worked with comparative ease. The place of surface outcrop of this stratum within the city walls is now covered with compactly built houses, but all the good stone was doubtless removed from there long before the present city and its walls were built and its place filled with the accumulated débris of centuries. The first surface quarries of this fine stone must have been very ancient, and the condition of the ground surface just north of the present north wall of the city shows that they were extensive. But even in ancient times, the exposures at the surface of this valuable stone were inadequate to the demand, and the quarries were extended underground, following the dip of the strata, which is there about ten degrees. In this way the quarry caves were formed, the firm stratum above the Malaké making a good roof and the equally firm one beneath making a good floor. The so-called Grotto of Jeremiah, just north of the present north wall of the city, is one of those quarry caves. It is accessible to travelers for an entrance fee and attracts considerable attention because tradition says the 'Lamentations' were written there. But the most extensive cave of this kind exists beneath the Mohammedan quarter, or northeastern part of the city itself, and is not accessible except by official permission. From its location and historical references to it, I have no doubt that it was this cave which furnished at least the greater part of the fine stone for Solomon's temple and other great buildings of ancient Jerusalem. I do not know by what distinctive name it may have been called in ancient times, but it is now locally called by a name that signifies 'The Cotton Grotto.'

Through our American consul, a small party of us got permission from the Turkish governor of Jerusalem to visit this cave, and he detailed a very courteous officer to accompany us. We passed out of the city by the north, or Damascus gate, turned eastward and went about one hundred yards along the trail which encircles the city near the walls and came to a place opposite the 'Grotto of Jeremiah,' where a rock escarpment or low cliff forms the base of the city wall. The entrance to the cave is in the face of this escarpment, and it is so inconspicuous that I did not specially notice it when passing the place on former occasions. Though not originally large, the entrance has been narrowed by rude masonry and a wooden door placed therein. Our officer-guide opened the door by means of an ordinary key which he brought with him, an attendant furnished each of us with a lighted taper, and we began our march into the darkness.

The artificial character of the cave was at once apparent from the presence of numerous rude piers of the original stone which were left by the quarrymen to support the roof and that part of the city which rests upon it. The floor has the general eastward dip of the strata and, although not very even, it was nowhere difficult to traverse. The height of the roof above the floor differs considerably at different places, probably because of the varying thickness of the fine part of the Royal stratum. In some places it is hardly more than ten feet, but in others I estimated the height at twenty feet or more. We walked through the long rude corridors, mostly in a southerly and south-easterly direction, reaching a distance from the entrance that I estimated to be not less than a quarter of a mile. I made no estimate of the cubic contents of the cave, but its great size gave me a distinct impression that it is large enough to have furnished all the fine stone that was required for the grand buildings of the ancient city and of its successive rehabilitations.

As we progressed southward from the entrance the west limiting wall came occasionally into view. It appeared to be quite uneven and I detected there no conditions of the rock which I thought attributable to systematic quarrying such as those which I soon afterward observed in other parts of the cave. For that, and the other reasons already mentioned, I think all the Malaké stone which originally existed on the west side and extended to the surface in reverse direction of the dip, was long ago removed and its place supplied with rejected and inferior stone. When we reached the south and east limiting walls of the cave, we found them perpendicular and bearing abundant marks made by the quarrymen. The character of the great excavation and the peculiar quarry-marks which we found upon its walls left no room for doubt as to its great antiquity nor of the fact that it was wholly the work of human hands. What we saw also agreed with numerous well-known legends and with trustworthy historical references to quarry caves of this kind. The surfaces, which bear the marks referred to having never been exposed to the weather nor to extremes of heat and cold, have remained unchanged, and even those marks which were made by the cutting tools of the workmen are still plainly visible. Fragments of their burnt-clay lamps and water bottles are also occasionally found in the scanty débris, which was produced by their peculiar methods of quarrying. Dr. Cyrus Adler, of the Smithsonian Institution, upon the occasion of his visit there, was so fortunate as to discover a perfect lamp and a damaged water bottle, which he has deposited in the U. S. National Museum. The little niches cut out of the face of the rock to receive the lamps are still there, and far within the cave there is a small spring, the clear water of which now fills the little basin which was cut in the rocky floor centuries ago to receive it. Although it is not probable that any stone has been quarried in this cave since a period at least as remote as the beginning of the Christian era, so little has time affected the wrought surfaces of the rock since the last quarrying was done there, one might almost expect to see the old masons return to their work at any time, to hear at high noon the call from labor to refreshment and, in the dim light of their tiny lamps, to see them gather around the spring for their mid-day meal. Perhaps it was just here that, according to the legend, the grand master was murdered when he came to inspect the quarry work. The thought startled me, and I looked around half expecting to see hostile faces peering at us out of the darkness.

The principal method of quarrying that was practised in this cave was laborious but effective, and the same method is known to have been practised in other ancient quarries. It is a hand method, the effect of which is much like that of one now employed by aid of machinery in quarrying marble and massive limestones. A perpendicular face of the rock was prepared and the outlines of the desired ashlars drawn upon it. The principal tool used for the shaping and removal of such stones was a long slender chisel, a little more than an inch wide, which was struck on end with a hammer or mallet. A narrow groove or slot was thus cut on all the drawn lines and of sufficient depth for the full thickness of the ashlar. The latter was then removed by driving wooden wedges into the slots, the impact of which split the ashlar off at its back face and allowed it to fall upon the quarry floor. The split face was usually nearly even, because of the uniform texture of the stone, but any defect in that part of it would cause it to split unevenly. We saw one large ashlar lying where it had fallen, 'rejected of the builders,' because its back face had broken off obliquely.

In most places the quarrying of the Royal stratum appears to have been prosecuted as far as was intended, and the stones were all removed, but in one place, at least, the work was for same reason left unfinished. Some of the ashlars were only outlined and some partially cut out, the great stones still remaining in their original places. Perhaps the work was interrupted by a strike of the quarrymen and never resumed because of failure to obtain compliance with their demands. But workmen had few rights in those days, and that suspension of quarry work was more probably due to some deed of violence for, unfortunately, we now know that this cave has repeatedly been the scene of horrors that make the heart sick to contemplate. This method of cutting out ashlars was economical of material and it produced very little débris in the quarry. The stones were also cut so nearly of the desired shape that they required little dressing before taking their places in the building. This method of quarrying also agrees with the scriptural account of the precision with which the stones of Solomon's temple were prepared in the quarry.

Although we have now so much evidence of the true nature and great antiquity of this cave, from and after the destruction of Jerusalem by Titus it remained unknown for centuries. Its entrance became so covered with the débris which accumulated in the destruction and rebuilding of the city that all knowledge of its position, and even of its existence, became lost until the year 1852, when its only now known entrance was discovered by Dr. J. T. Barclay, an American missionary. Dr. Barclay gives a brief account of his discovery and exploration in his book, 'The City of the Great King,' wherein he estimates the length of the cave at rather more than a quarter of a mile, and its greatest breadth at less than half that distance. His estimate of its length agrees with my own, but Dr. Adler, in the *Jewish Quarterly Review,* for April, 1896, estimates it at about 1,000 feet. Its position is approximately indicated upon some lately published maps by an outline which shows a length of only about 500 feet, but this representation is too far from the truth to deserve consideration. The distance from the entrance of the cave in the north wall of the city to the south wall of the same is barely 3,000 feet, and by my estimate of the length of the cave it extends considerably more than one third the distance across the city. I am, therefore, of the opinion that it extends beneath the northwest corner of the temple area and consequently beneath the governor's residence, which is closely adjacent.

Sir J. W. Dawson, in his book 'Egypt and Syria' suggests that there was formerly a ramp or sloping tramway, leading from the quarry into the temple area by which stones were taken up to the building site of the temple. Nothing of that kind, however, has ever been discovered and the suggestion does not agree with the statements made by Professor H. Graetz in his 'History of the Jews.' Professor Graetz states that the stones used in the building of the temple were obtained from underground quarries by men who were compelled to labor there. He says that "Eighty thousand of these unhappy beings worked in the stone quarries day and night by the light of lamps. They were under the direction of a man from Biblos (Giblem), who understood the art of hewing heavy blocks from rocks and of giving them the necessary shape for dove-tailing. Twenty thousand slaves removed the heavy blocks from the mouth of the quarry and carried them to the building site.''

Hard as was the lot of the workmen in the quarry-caves in times of so-called peace, it was not comparable in horror with that of the beseiged inhabitant who resorted to those underground retreats in time of war. The following paragraph from Josephus's account of what took place in the quarry-caves of Jerusalem at the time of its seige and destruction by Titus is frightfully descriptive of those terrible scenes. ''The Romans slew some of them, some they carried captives and others they made search for underground, and when they found where they were they broke up the ground and slew all they met with. There were also found slain there above two thousand persons, partly by their own hands and party by one another, but chiefly destroyed by the famine; but then the ill savor of their bodies was most offensive to those who lighted upon them, insomuch that some were obliged to get away immediately, while others were so greedy of gain that they would go in among the dead bodies that lay on heaps and tread upon them, for a great deal of treasure was found in these caverns and the hope of gain made every way of getting it to be esteemed lawful.''

As the centuries have passed away decay has so completely done its work there upon all organic matter that not even a bone of all that multitude of the dead has been found with the floor-dust of the cave. Even the air is not now oppressive, although there is apparently no other aperture or entrance than the one by which we entered. I also saw no appearance of fouling of the cave by seepage from the city water-pools nor from the surface drainage of the unsanitary streets and alleys overhead. As we turned to retrace our steps all was so peaceful and untainted it was difficult to realize that man's inhumanity to man was ever so terribly demonstrated there as credible historians have compelled us to believe.

Because of the great difference between the methods of modern and ancient warfare, the scenes which accompanied the various sieges and captures which Jerusalem has suffered can never be repeated; but if a hostile army should ever again camp before the city with intent to destroy it, an effort would doubtless be made to place a few tons of dynamite at the farther end of that anciently constructed mine. In the twinkling of an eye a more complete destruction would follow than that which was inflicted by Titus in his six months of siege and spoliation. Indeed, considering the present possibility of smuggling high explosives into that mine, and the wide prevalence of wanton anarchism, it would be prudent to guard it with special care.

# THE NILE DAMS AND RESERVOIR.*

By SIR BENJAMIN BAKER, F.R.S.,
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THE Nile Reservoir at Aswân will contain over 1,000 million tons of water. This statement will probably convey little meaning to most people; and in truth the quantity may be made to appear either small or large at will by a judicious selection of illustrations. Thus the absolute insignificance to Egypt of 1,000 million tons of water in a reservoir, as compared with a reasonable rainfall, will be apparent at once when it is considered that the annual rainfall on the area included within the four-mile cab radius from Charing Cross is about 100 million tons, and that the rainfall on London and its suburbs within a thirteen-mile radius would, therefore, about suffice to fill the Nile Reservoir. On the other hand, we may, by choosing other illustrations, restore the Nile Reservoir to the dignity of its just position of one of the greatest engineering works of the day. Thus the question of the water supply of London, and its prospective population of 11¼ millions, has been prominently before the public for some years; and many will remember what was termed the colossal project of our member, Sir Alexander Binnie, late Engineeer of the London County Council, for constructing reservoirs in every reasonably available valley in Wales, to store up water for London, and to supply compensation water to the Welsh rivers affected thereby. Well, the united contents of the whole of those reservoirs would be less than half that of the great Nile Reservoir. Again, the Nile Reservoir would hold more than enough water for one year's full domestic supply to every city, town and village in the United Kingdom with its 42 million inhabitants. But possibly the best way of giving an idea of the magnitude of the work, and its utility to cultivation in a thirsty land, is by considering the volume of the water issuing from the reservoir during the three or four summer months, when scarcity of supply prevails in the river and the needs of the cultivators are greatest. At that time the flow from the reservoir will be equivalent to a river double the size of the Thames in mean annual flood condition. It will be recognized at once that a good many buckets would have to be set at work to bale out a river like that, and yet the scarcity of water in the Nile itself, and in the canals, during the months of April, May and June, is such that even dipping the water out of the channels in buckets has to be con-

* Address given before the Royal Institution of Great Britain.

trolled by strict regulations. Thus, two years ago, when the Nile was below the average in summer discharge, it was decreed in Upper Egypt that the 'lifting machines,' which include the shadoof, or bucket-and-pole system, and the sakieh, or oxen-driven chain of buckets, should be worked not more than from five to eleven consecutive days, and stop the following nine to thirteen days, between the middle of April and the middle of July; and the order in which the different districts were to receive a supply was carefully specified, so that, as far as possible, every crop should get watered once in about three weeks. When it is remembered that a single watering of an acre of land means, where shadoofs are concerned, raising by manual power about 400 tons of water to varying heights up to 25 feet, and that four or five waterings

FIG. 1. THE DAM AT ASWÂN, VISITED BY THE LATE CECIL RHODES AND HIS PARTY.

are required to raise a summer crop, it will be seen what a vast amount of human labor is saved throughout the world by the providential circumstance that in ordinary cases water tumbles down from the clouds, and has not, as in Egypt, to be dragged up from channels and wells. Shadoof work, under average conditions, involves one man's labor for at least one hundred days for each acre of summer crop; so that even at 6d. per day for labor, the extra cost of cultivation due to the absence of rain would amount to 50s. per acre.

The great Nile Reservoir and Dam at Aswân, the Barrage at Asyût, and various supplementary works in the way of distributing canals and regulators, are designed with the object of mitigating the evils enumerated above, by supplying in summer a larger volume of water at a higher level in the canals, so that not only can more land be irrigated, but that labor in lifting water will be saved. When the International Commission, eight years ago, recommended the construction of a large reservoir somewhere in the Nile valley, I was desirous of knowing what would be the opinion of a real old-fashioned native landowner on the subject; and was introduced to one whose qualifications were considered to be of no mean order, as he was a descendant of the Prophet, very rich, and had been twice warned by the government that he would probably be hanged if any more bodies of servants he had quarrelled with were found floating in the Nile. He was a very stout old man, and, between paroxysms of bronchial coughing, he assured me that there could be nothing in the project of a Nile reservoir, or it would have been done at least 4,000 years ago. In contrast with this I may mention that, a few months ago, the most modern and enlightened of all the rulers of Egypt, the present Khedive, when visiting the dam, said he was proud that the great work was being carried out during his reign, and that the good services rendered by his British engineers was evidenced by the London County Council coming to his Public Works Staff for their chief engineer.

The old system of irrigation, which the descendant of the Prophet looked back upon with regret, was little more than a high Nile flooding of different areas of land or basins surrounded by embankments. Less than a hundred years ago, perennial irrigation was first attempted to be introduced, by cutting deep canals to convey the water to the lands when the Nile was at its low summer level. When the Nile rose, these canals had to be blocked by temporary earthen dams, or the current would have wrought destruction. As a result, they silted up, and had to be cleared of many millions of tons of mud each year by enforced labor, much misery and extortion resulting therefrom. About half a century ago, the first serious attempt to improve matters was made by the construction of the celebrated barrage at the apex of the Delta. This work consists, in effect, of two brick arched viaducts crossing the Rosetta and Damietta branches of the Nile, having together 132 arches of 16 feet 4 inches span, which were entirely closed by iron sluices during the summer months, thus heading up the water some 15 feet, and throwing it at a high level into the main irrigation canals below Cairo. The latter are six in number, the largest being the central canal at the apex of the Delta, which, even in the exceptionally dry time of June, 1900, was carrying a volume of water one-fourth greater than the Thames in mean flood, whilst the two canals right and left of the two branches of the river carried together one half more than the Thames, and the Ismailieh Canal, running down to the Suez Canal, though starved in supply, was still a river twice the size of the Thames at the same time of the year. At flood times the discharges of all the canals are, of course, enormously increased. It will be recognized at once, therefore, that, as in the summer months the whole flow of the Nile is arrested and thrown into the aforesaid canals, the old barrage will always remain the most important work connected with the irrigation of Egypt. It was constructed under great difficulties by French engineers, subject to the passing whims of their Oriental chiefs. About fifteen years elapsed between the commencement of the work and the closing of all the sluices, and another twenty years before the structure was sufficiently strengthened by British engineers to fulfil the duties for which it was originally designed. All the difficulties arose from the nature of the foundations, as the timber sheet piling wholly failed to prevent the substructure from being undermined by the head of water carrying away the fine sand and silt upon which the barrage was built. At Asyût, cast-iron sheet piling was used, as will hereafter be described. It is impossible to say what the cost of the old barrage has been from first to last, but probably nearly ten times that of the recently-completed Asyût Barrage. Forced labor was largely employed in its construction, and at one time 12,000 soldiers, 3,000 marines, 2,000 laborers, and 1,000 masons were at work at the old barrage.

In connection with the Nile Reservoir, subsidiary weirs have been constructed below the old barrage to reduce the stress on that structure. The system adopted was a novel one, reflecting great credit on Major Brown, Inspector-General of Irrigation in Lower Egypt. His aim was to dispense almost entirely with plant and skilled labor; and so, without attempting to dry the bed of the river, he made solid masonry blocks under water, by grouting rubble dropped by natives into a movable timber caisson. Both branches of the Nile were thus dammed in three seasons, at a cost, including navigation locks, of about half a million sterling. Many other subsidiary works have been and will be constructed, including regulators, such as that on the Bahr Yusuf Canal.

### *Asyût Barrage.*

By far the most important of the works constructed to enable the water stored up in the great reservoir to be utilized to the greatest advantage is the Barrage across the Nile at Asyût, about 250 miles above Cairo, which was commenced by Sir John Aird and Co. in the winter of 1898, and completed this spring. As already stated, in general principle this work resembles the old barrage at the apex of the Delta; but in details of construction there is no similarity, nor in material, as the old work is of brick and the new one of stone.

The total length of the structure is 2,750 feet, or rather more than half a mile, and it includes 111 arched openings of 16 feet 4 inches span, capable of being closed by steel sluice gates 16 feet in height. The object of the work is to improve the present perennial irrigation of lands in Middle Egypt and the Fayoum, and to bring an additional area of about 300,000 acres under such irrigation, by throwing more water at a higher level into the great Ibrahimiyah Canal, whose intake is immediately above the Barrage (Fig. 2).

The piers and arches are founded upon a platform of masonry 87 feet wide and 10 feet thick, protected up and down by a continuous and impermeable line of cast-iron grooved and tongued sheet piling, with cemented joints. This piling extends into the sand bed of the river to a depth of 23 feet below the upper surface of the floor, and thus cuts off the water and prevents the undermining action which caused so much trouble and expense in the case of the old barrage. The height of the roadway above the floor is 41 feet, and the length of the piers up and down stream 51 feet. The river bed is protected against erosion for a width of 67 feet up stream by stone pitching, with clay

FIG. 2. ASYÛT LOCK.

puddle underneath to check infiltration, and down stream for a similar width by stone pitching, with an inverted filter-bed underneath, so that any springs which may arise from the head of water above the sluices shall not carry sand with them from underneath the pitching.

It is easy enough to construct dams and barrages on paper, but wherever water is concerned the real difficulty and interest is in the practical execution of the works, for water never sleeps, but day and night is stealthily seeking to defeat your plans. On the Nile the conditions are very special, and in some respects advantageous. There is only one flood in the year, and within small limits the time of its occurrence can be foretold, and arrangements made accordingly. It would have been impossible to have carried out the Nile works on the system adopted had the river been subject to frequent floods. The working season for below-water work on the Nile lies practically between November and July, for nothing would be gained by starting the temporary enclosing embankments, or sudds, when the river was at a higher level than it is in November; nor would it be possible at any reasonable cost to prevent the sudds from being swept away by the flood in July. At Asyût the mode of procedure was to enclose the site of the proposed season's work by temporary dams or sudds of sandbags and earthwork, then to pump out and keep the water down by powerful centrifugal pumps, crowd on the men, excavate, drive the cast-iron sheet piling, build the masonry platform and piers, lay the aprons of puddle and pitching, and get the work some height above low Nile level before the end of June, so that the temporary dams should not require reconstruction after being swept away by the flood. The busiest months were May and June, when in the year 1900 the average daily number of men was 13,000. It is also then the hottest; the shade temperature rising to 118 degrees. To keep the water down, seventeen 12-inch centrifugal pumps, throwing enough water for the supply of a city of two million inhabitants, had to be kept going, and in a single season as many as one and a half million sandbags were used in these temporary dams. The bed of the river being of extremely mobile sand, the constant working of the pumps occasionally drew away sand from under the adjoining completed portions of the foundations, necessitating the drilling of many holes through the 10-foot thick masonry platform, and grouting under pressure with liquid cement. About 1,000 springs also burst up through the sand, each one of which required special treatment. A new regulator had to be constructed for the Ibrahimiyah Canal, with nine arches and sluices, to control the high floods and prevent damage to the Canal and the works connected therewith.

*Aswân.*

Asyût, as already observed, is about 250 miles above Cairo. The great dam at Aswân is 600 miles above the same point. Between Asyût and Aswân the remains of many temples exist, of far greater interest and importance than those at Philæ. The latter ruins, however, have attracted more attention in recent days, because, being situated immediately above the Dam, the filling of the reservoir will partially flood Philæ Island during the tourist season.

It would be idle to speculate as to who first thought of constructing a reservoir in the Nile valley, or who first arrived at the conclusion that the site of the present dam above Aswân was the best one. Mr. Willcocks, one of the ablest engineers of the Public Works Department of Egypt, who was instructed by Sir William Garstin to survey various suggested sites for a dam between Cairo and Wady Halfa, unhesitatingly decided that the Aswân site was the best, and the majority of the International Committee, who visited the sites in 1894, came to the same conclusion. This conclusion had, however, been anticipated by Sir Samuel Baker more than forty years ago, from mere inspection of the site without surveys. In suggesting a series of dams across the Nile to form reservoirs from Khartoum downwards, he wrote: "The great work might be commenced by a single dam above the first cataract at Aswân, at a spot where the river is walled in by granite hills. By raising the level of the Nile 60 feet, obstructions would be buried in the depths of the river, and sluice-gates and canals would conduct the shipping up and down stream." This single dam, proposed by Sir Samuel Baker forty years ago, is in effect the one which is now on the point of completion. Mr. Willcocks' original design consisted practically of a group of independent dams, curved on plan, and the arrangement of sluices and dimensions of the dam differed considerably from those of the executed work. There is no doubt that the single dam, 1¼ miles in length, constitutes a more imposing monumental work than a series of detached dams, and that it also offered greater facilities to a contractor for the organization of his work and rapid construction; and, further, the straight dam is better able to resist temperature stresses from extreme heat without cracking. Two dams across the Nile, the old barrage and the Asyût Barrage, have already been described; and it will be hardly necessary to say, therefore, that the Aswân Dam is not a solid wall, but is pierced with sluice openings of sufficient area for the flood discharge of the river, which may amount to 15,000 tons of water per second. There are 180 such openings, mostly 23 feet high by 6 feet 6 inches wide; and where subject to heavy pressure, when being moved, they are of the well-known Stoney roller pattern.

Although the preliminary studies of Mr. Willcocks and the other government engineers occupied some four years, there was neither time nor money to sink shafts in the bed of the river, to ascertain the real character of what was called in the engineer's report 'an extensive outcrop of syenite and quartz diorite clean across the valley of the Nile,' giving 'sound rock everywhere at a very convenient level.' Unfortunately, the rock proved to be unsound in many places to a considerable depth, with schistous micaceous masses of a very friable nature, which necessitated carrying down the foundations of the dam sometimes more than 40 feet deeper than was originally anticipated or provided for in the contract. As the thickness of the dam is nearly 100 feet at the base, this misapprehension as to the character of the rock involved a very large increase in the contract quantity and cost of the granite masonry of the dam. The total length of the dam is about 1¼ miles; the maximum height from foundation, about 130 feet; the difference of level of water above and below, 67 feet; and the total weight of masonry over one million tons. Navigation is provided for by a 'ladder' of four locks, each 260 feet long by 32 feet wide.

As remarked in the case of Asyût, the difficulties in dam construction are not in design, but in the carrying out of the works. It would not be too much to say that any practical man standing on the verge of one of the cataract channels, hearing and seeing the apparently irresistible torrents of foaming water thundering down, would regard the putting in of foundations to a depth of 40 feet below the bed of the cataract in the short season available each year as an appalling undertaking. When the rotten rock in the bed was first discovered, I told Lord Cromer frankly that I could not say what the extra cost or time involved by this and other unforeseen conditions would be, and that all I could say was that, however bad the conditions, the job could be done. He replied that he must be satisfied with this assurance, and

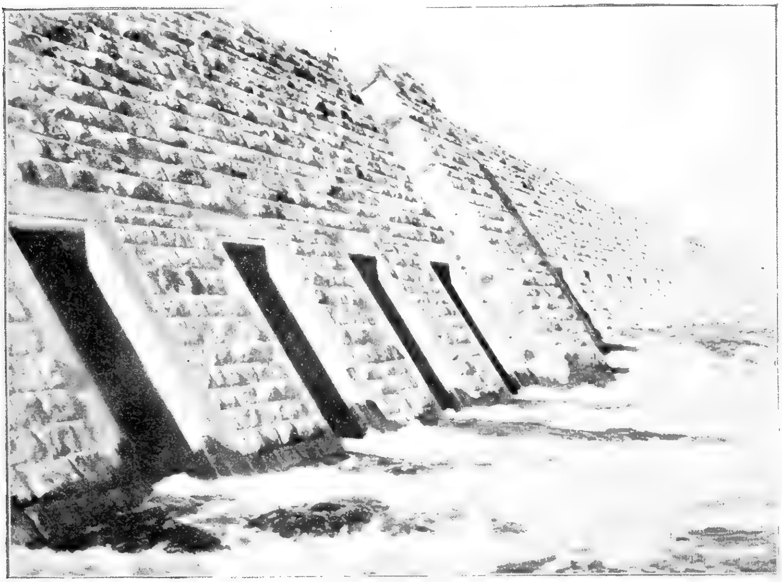


FIG. 3. NORTH SIDE OF DAM, LOOKING WEST.

say that the dam had to be completed whatever the time and cost. With a strong man at the head of affairs, both engineers and contractors—who often are suffering more anxiety than they care to show—are encouraged, and works, however difficult, have a habit of getting completed, and sometimes, as in the present case, in less than the original contract time.

The contract was let to Sir John Aird and Co., with Messrs. Ransomes and Rapier as subcontractors for the steelwork, in February, 1898, and they at once commenced to take possession of the site of the works, and of as much of the adjoining desert as they desired in order to construct railways, build dwellings, offices, machine shops, stores and hospitals, and provide sanitary arrangements, water supply, and the multitudinous things incidental to the transformation of a remote desert tract into a busy manufacturing town. Two months after signing the contract the permanent works were commenced, and before the end of the year thousands of native laborers and hundreds of Italian granite masons were hard at work. On February 12, 1899, the foundation stone of the dam was laid by H.R.H. the Duke of Connaught. Many plans were considered by the engineers and contractors for putting in the foundations of the dam across the roaring cataract channels, and it was finally decided to form temporary rubble dams across three of the channels below the site of the great dam, so as to break the force of the torrent and get a pond of comparatively still water up stream to work in. Stones of from one ton to twelve tons in

FIG. 4. SOUTH SIDE OF DAM, FROM WEST BANK.

weight were tipped into the cataract, and this was persevered with until finally a rubble mound appeared above the surface of the water. The first channel was successfully closed on May 17, 1899, the depth being about 30 feet and the velocity of current nearly fifteen miles an hour. In the case of another channel, the closing had to be helped by tipping railway wagons themselves, loaded with heavy stones, and bound together with wire ropes, making a mass of about 50 tons, to resist displacement by the torrent.

These rubble dams were well tested when the high Nile ran over them; and on work being resumed in November, after the fall of the river, water-tight sandbag dams or sudds were made around the site of the Dam foundation in the still waters above the rubble dams, and pumps were fixed to lay dry the bed of the river. This was the most exciting time in the whole stage of the operations, for no one could predict whether it would be possible to dry the bed, or whether the water would not pour through the fissured rock in altogether overwhelming volumes. Twenty-four 12-inch centrifugal pumps were provided to deal if necessary with one small channel; but happily the sandbags and gravel and sand embankments staunched the fissures in the rock and interstices between the great boulders covering the bottom of this channel, and a couple of 12-inch pumps sufficed. The open rubble dam itself, strange to say, checked the flow sufficiently to cause a difference of nearly 10 feet in the level of the water above and below;

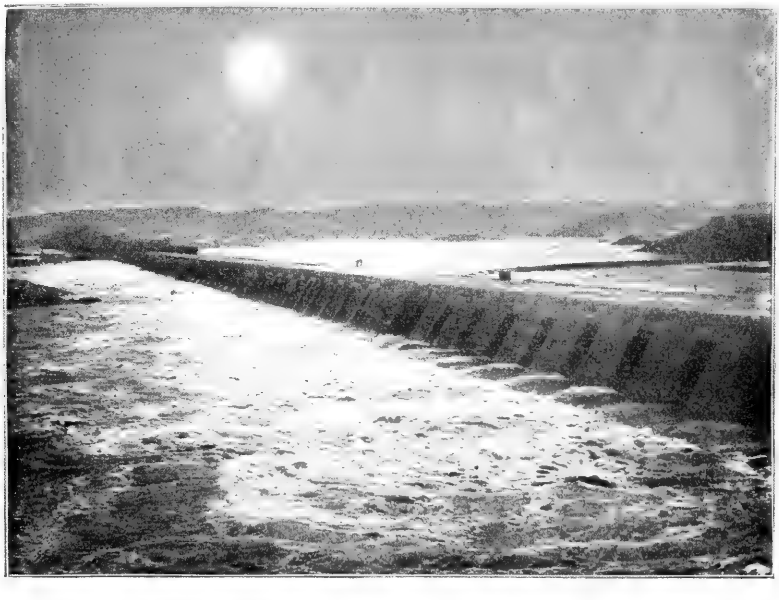


FIG. 5. FROM WEST BANK, LOOKING EAST, DURING ECLIPSE OF NOVEMBER 11, 1901.

but when the up-stream sandbag dam was constructed the difference was 20 feet, so that the down-stream sandbag dam was a very small one compared with the other.

The masonry of the dam is of local granite, set in British Portland cement mortar. The interior is of rubble, set by hand, with about 40 per cent. of the bulk in cement mortar, four sand to one of cement. All the face-work is of coursed rock-faced ashlar, except the sluice linings, which are finely dressed. This was steam-crane and Italian masons' work. There was a great pressure at times to get a section completed before the inevitable rise of the Nile, and as much as 3,600 tons of masonry were executed per day, chiefly at one point in the dam. A triple line of railway, and numerous trucks and locomotives, were provided to convey the materials from quarries and stores to every part of the work. The maximum number of men employed was 11,000, of whom 1,000 were European masons and other skilled men (Figs. 3, 4 and 5).

Mr. Wilfred Stokes, chief engineer and managing director of Messrs. Ransomes and Rapier, was responsible for the detailed designing and manufacture of the sluices and lock-gates; 140 of the sluices are 23 feet high by 6 feet 6 inches wide, and 40 of them half that height; 130 of the sluices are on the 'Stoney' principle, with rollers, and the remainder move on sliding surfaces. The larger of the Stoney sluices weigh 14 tons, and are capable of being moved by hand under a head of water producing a pressure of 450 tons against the sluice.

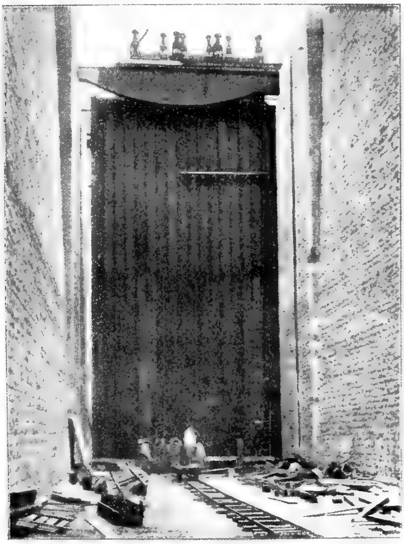


FIG. 6. NAVIGATION CANAL. FIRST LOCK-GATE FROM NORTH.

There are five lock-gates, 32 feet wide, and varying in height up to 60 feet. They are of an entirely different type to ordinary folding lock-gates, being hung from the top on rollers, and moving like a sliding coach-house door. This arrangement was adopted for safety, as 1,000 million tons of water are stored up above the lock-gates, and each of the two upper gates is made strong enough to hold up the water, assuming the four other gates were destroyed (Fig. 6).

When the river is rising, the sluices will all be open, and the red water will pass freely through, without depositing the fertilizing silt. After the flood, when the water has become clear, and the discharge of the Nile has fallen to about 2,000 tons per second, the gates without rollers will be closed, and then some of those with rolllers; so that between December and March the reservoir will be gradually filled. The reopening of the sluices will take place between May and July, according to the state of the Nile and the requirements of the crops.

Between December and May, when the reservoir is full, the island of Philæ will in places be slightly flooded. As the temples are founded partly on loose silt and sand, the saturation of the hitherto dry soil would cause settlement, and no doubt injury to the ruins. To obviate this risk, all the important parts, including the well-known Kiosk, or

'Pharaoh's bed,' have been either carried on steel girders or underpinned down to rock, or, failing that, to the present saturation level. It need hardly be said that, having regard to the shattered condition of the columns and entablatures, the friability of the stone, and the running sand foundation, the process of underpinning was an exceptionally difficult and anxious task. There were few men to whom I would have entrusted the task, but amongst those was Mat Talbot—one of the well-known Talbots who have done such splendid service as non-commissioned officers in the army of workmen employed by contractors during the past forty years; and well has he justified his reputation at home—where his last job was the most difficult part of the Central London Railway—and the commendation of Dr. Ball, who had charge of the works at Philæ.

It would be invidious to single out for special acknowledgment the services of members of a staff, where all have enthusiastically done their best for the accomplishment of the great work projected and patiently persisted in against all opposition, by Lord Cromer and his trusty lieutenant, Sir William Garstin, Under Secretary of State for Public Works. The successive Director-Generals of the Reservoirs were Mr. Willcocks, Mr. Wilson, and Mr. Webb; the chief engineers at Aswân, Mr. Fitzmaurice and Mr. May, and at Asyût, Mr. Stephens. The almost unprecedented labor and anxiety of arranging all the practical contractors' details of supply of labor, materials, and execution of the work fell upon the shoulders of Mr. Blue, except as regards Asyût, where Mr. McClure relieved him of a part of his responsibility.

As regards the initial stages of the project, I may say that when the Egyptian Government informed me that they wanted the works carried out for a lump sum, and no payment to be made to the contractor until the works were completed, I felt it would be idle to invite tenders until some arrangement had been made as to finance. As in other cases of doubt and difficulty, therefore, I went to my friend, Sir Ernest Cassel, and the difficulties vanished. The way was then clear for getting offers for the work. Sir John Aird and Co. were the successful competitors, and they have completed a largely increased quantity of work in less than the contract time, to the entire satisfaction of the Egyptian Government and of every one with whom they have been associated. The same recognition is due to Messrs. Ransomes and Rapier, and their able engineer and manager, Mr. Wilfred Stokes, who was unexpectedly called upon to complete all the complicated machinery of the sluices and gates in one year under the contract time, and did it.

# SCIENTIFIC LITERATURE.

## *CHEMISTRY.*

Three Presidential addresses, delivered recently in this country and abroad, give admirable surveys of the present status, of past growth and of the future needs of chemistry. The address of Professor F. W. Clarke to the American Chemical Society, given December 30, 1901, on 'The Development of Chemistry' deals with the four principal agencies that have been instrumental in building the chemical structure of to-day; these are: private enterprise, the commercial demand, governmental requirements, and university teaching. At the beginning all these agencies had not been established, the two great stimuli to chemical research were the intellectual interest of the problem to be solved, and practical utility; these still have great influence, but the most important need at the present time, says Professor Clarke, is a well equipped and endowed research laboratory, in which to conduct systematic and thorough investigations.

Dr. Ira Remsen chose for his address to the same society, given a year later, 'The Life History of a Doctrine.' In a scholarly and witty way he sketched the early history, development and modern phases of the atomic theory, saying that in the light of late advances we must enlarge our conception of atoms. He pointed out that the many obituaries on the electrochemical theory of Berzelius were probably premature, since in the latest conception of atoms electrical charges play an important part. An atom charged with electricity is called an ion, and only then is it ready for action. At the same time President Remsen refers to physicists the explanation of some of the features of the theory of ions.

Professor James Dewar, in his address as president of the British Association for the Advancement of Science, delivered September 10, 1902, was of a more comprehensive nature, reviewing many aspects of science. Incidentally he compared the chemical equipments of England and Germany to the decided disadvantage of the former, stating that Germany possessed a professional staff one third larger in numbers and superior in quality. One firm in Germany, employing 5,000 workmen, has a staff of 160 chemists, 260 mechanics and engineers, besides 680 clerks. Owing to the high education and practical character of their chemists German manufacturers enjoy a monopoly. Passing from this theme, Professor Dewar gave some of the interesting results obtained in his researches on low temperatures, especially in liquefying hydrogen and helium. The whole address, which is very readable, can be found in the October numbers of *Science*. Besides these addresses another one by Dewar must not be overlooked, the 'Centenary Commemoration Lecture' at the Royal Institution.

The Bi-Centennial of Yale University, celebrated in 1901, was appropriately marked by the publication of several superb volumes containing chemical research conducted by professors and instructors in that institution. Two of these are from the Kent Chemical Laboratory, and embody the labors of Professor F. A. Gooch, and of some of his assistants; the other two are from the Sheffield Scientific School, and contain chiefly the labors of Professor Horace L. Wells. The papers are limited to the ten years preceding their publication and reflect great credit on their authors. To attempt any synopsis of the contents of these volumes would lead to technical details beyond the scope of these columns.

Text-books in English and in other languages continue to flow from the press in undiminished numbers; some are very elementary, giving no novelty in treatment nor other advantages over the host of those preceding them, but others are on a higher plane, endeavoring to embody the most recent theories and to adapt them for the purposes of instruction. One of the most praiseworthy of the latter group first appeared in Holland in 1898, was soon translated into German, and two years later into English. Its author is Dr. A. F. Holleman, professor at the University of Groningen, its translator is Dr. Harmon C. Cooper, of Syracuse University, and it bears the imprint of John Wiley and Sons, New York City. Holleman's text-book combines the new achievements of physical chemistry with the mass of long-established facts of inorganic chemistry so as to form a unified whole; it makes it unnecessary for beginners to get acquainted with the common phenomena of elementary chemistry by the study of one book written on the old plan, and then to take up the independent study of those laws of physical chemistry established by Ostwald, van't Hoff, Arrhenius, and their disciples, as set forth in some other manual devoted to those subjects. All these features are combined by Holleman in a single graded course, making it a superior, up-to-date work. The translation by Dr. Cooper is satisfactory and free from ambiguity.

Another book of very high grade is that by Dr. Mellor, of Manchester, England, entitled: 'Higher Mathematics for Students of Chemistry and Physics.' Chemistry is developing along mathematical lines, and it is evident that its students must hereafter be practical mathematicians. Of several books applying mathematics to the scientific evolution of chemistry, Mellor's book is very complete and satisfactory, and can be warmly recommended.

# THE PROGRESS OF SCIENCE.

## *THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH.*

Scientific medicine in the United States is to be congratulated on the establishment of a laboratory for research that may be compared with those of the great European capitals. There are in this country more than a hundred thousand practising physicians, somewhat over two hundred medical journals and a large number of medical schools, and many important advances in technical medicine are due to American practise. Opportunity for systematic research has, however, been hitherto lacking. This will be supplied by the laboratory to be built in New York City on the foundation of Mr. John D. Rockefeller. It will be remembered that two years ago Mr. Rockefeller gave $200,000 for the establishment of an institute for medical research and placed the endowment in the hands of a strong and compact board of directors, consisting of Dr. William H. Welch, Baltimore; Dr. T. Mitchell Prudden, New York; Dr. Theobald Smith, Boston; Dr. Simon Flexner, Philadelphia; Dr. Hermann M. Biggs, New York; Dr. C. A. Herter, New York; Dr. L. Emmett Holt, New York.

The fund could be used for current expenses, and with it grants have been made, varying in amount from $200 to $1,500, to over twenty investigators who have carried forward their work at American and foreign universities. The directors, however, believed that, in addition to such individual studies, there was needed a central institution for certain lines of research with an adequate equipment and permanent endowment. Towards this purpose Mr. Rockefeller has given $1,000,000, which will be used for the purchase of land, the erection of buildings and the organization of the work, and it is understood that Mr. Rockefeller is prepared to give an additional endowment when needed. A site has been secured in New York City overlooking the East river, and it is hoped that the laboratory will be completed and ready for the commencement of work in the autumn of 1904. The buildings will include a small hospital which will be maintained in close association with the experimental work. The institute has assumed the publication of *The Journal of Experimental Medicine,* which will remain under the editorial supervision of Dr. W. H. Welch, professor of pathology in the Johns Hopkins University and president of the board of directors of the institute. The directors will also undertake the diffusion of knowledge by the means of lectures, publications and hygienic museums that will tend to the prevention and cure of disease. Dr. Simon Flexner, professor of pathology in the University of Pennsylvania, has been appointed scientific director of the laboratories, and there will be associated with him the heads of the different departments that will be established.

## *THE SMITHSONIAN INSTITUTION.*

The board of regents of the Smithsonian Institution held an adjourned meeting on March 12, at which matters of much importance for the institution and for the progress of science in America were discussed. It was decided that in addition to the annual meeting in January for the transaction of routine business, there shall hereafter be held two additional meetings, one in December and one in March, when the affairs of the institution may be discussed fully and freely. A committee that had been appointed to consider the powers and duties of the executive committee did not make a final report, but it was the general opinion that this committee should have regular and stated meetings. Dr. A. Graham Bell introduced a series of resolutions and moved that they be referred to the committee appointed to consider the powers of the executive committee. They will be reported on and fully discussed at the meeting in December. The resolutions are as follows:

The secretary shall nominate, and by and with the advice and consent of the board of regents, shall appoint the heads of the various bureaus supported by congress under the direction of the Smithsonian Institution—*to wit*—the National Museum, the Bureau of American Ethnology, The National Zoological Park, the Bureau of International Exchanges, and the Astrophysical Observatory.

The secretary shall have power to fill up all vacancies that may happen in these offices during the intervals between meetings of the board, by granting commissions which shall expire at the next meeting of the board of regents.

The head of each bureau shall nominate, and, by and with the advice and consent of the secretary, shall appoint the subordinates in the bureau under his charge.

The heads of the bureaus shall be termed directors; and the board of regents hereby creates the offices of director of the National Museum, director of the Bureau of American Ethnology, director of the National Zoological Park, director of the Bureau of International Exchanges, and director of the Astrophysical Observatory, and instructs the secretary to fill these offices by temporary appointment to expire at the next meeting of the board, when nominations shall be presented for confirmation by the board.

It will thus be seen that the entire question of the organization of the Smithsonian Institution and its relations to the government bureaus is under consideration by the regents. At the meeting two other matters of general interest were discussed. Congress has made an appropriation of three and a half million dollars for a new building for the U. S. National Museum, the construction of which has been placed in the hands of Mr. Bernard R. Green. The secretary, with the advice and consent of the chancellor and the chairman of the executive committee was designated to cooperate with Mr. Green.

Owing to the need of moving the body of James Smithson from the grave in which it rests at Genoa, it was proposed last year by Dr. Bell that the remains be brought to this country, where congress would doubtless erect over them a suitable monument in the grounds of the Smithsonian Institution. This suggestion was not adopted at the time, but Dr. Bell has now offered to have the remains removed at his expense, which offer the regents will doubtless be glad to accept.

## *THE DEPARTMENT OF AGRICULTURE.*

The appropriation for the United States Department of Agriculture provided by the recent session of congress covers a total of practically six million dollars, an increase over that for the current year of $769,140, including an emergency appropriation of a half a million dollars. The increased funds are for the most part to enable an extension of the work of the department along its present lines, rather than to take up new special features. The largest increases are for the Bureaus of Animal Industry, Plant Industry, Forestry and Soils.

The Bureau of Animal Industry receives $1,287,380, an increase of $100,000 for the extension of its meat and other inspection work, and an emergency appropriation of $500,000 is placed at the disposal of the secretary of agriculture to stamp out the foot-and-mouth disease, which has recently raged in several of the New England states, and other contagious diseases of animals which may appear.

The total appropriation for the Bureau of Plant Industry is $674,930, an increase of $62,200 for its work in vegetable pathology and physiology, botanical investigations, studies of the pomaceous fruits and their preservation, and experiments with grasses and forage plants. These increases will enable carrying on the plant breeding work on a somewhat larger scale to secure crops resistant to alkali, disease-resistant beets, and the improvement of Indian corn. More extensive investigations and field trials will be made of the nitrogen-fixing organisms in growing leguminous plants; and among the plant diseases the Texas root-rot of cotton and the California vine disease will receive special attention. The increase for botanical investigations will be used for developing the studies of poisonous plants, particularly on the western ranges. The fund for the purchase of seeds for congressional distribution is increased by $20,000, being now $290,000, but an additional $10,000 is allowed to be expended out of this fund for the introduction of seeds and plants from foreign countries, making the fund for that purpose $30,000.

The amount for the Bureau of Forestry is increased to $350,000, which is $58,140 more than the current appropriation, and will enable an extension of its forestry and timber investigations and the preparation of working plans for owners of woodlands.

The Bureau of Soils receives $212,-480, $42,800 more than the present year. The increase will be used in expanding the soil survey and the tobacco work, which is in charge of this bureau. Surveys will be made the coming year in thirty-two states, which shows the wide distribution of this work. The tobacco investigations will be confined principally to experiments with the Cuban filler tobacco in Alabama, middle South Carolina, and eastern Texas, where soils have been located similar to those on which it is successfully grown.

The scientific staff of the Weather Bureau is increased somewhat, an assistant chief being added, and the bureau is authorized to erect five new observatories and to establish cable communication between Block Island and Narragansett Pier, with terminal buildings and equipment at each place. Its total appropriation amounts to $1,248,520.

The appropriations for the experiment stations in Hawaii and Porto Rico are increased to $15,000, making them uniform with the stations in other states and territories, and $5,000 is appropriated for taking up the farmers' institute work with a view to assisting the organizations in the different states and territories and making them more effective means for the dissemination of the results obtained at the department and at the agricultural experiment stations. These increases bring the total amount for the agricultural experiment stations and the Office of Experiment Stations (including irrigation investigations and investigation in human nutrition) up to $895,000.

The Division of Statistics is raised to the grade of a bureau and given an increased appropriation of $15,500 for general maintenance, making a total of $156,660.

Other items carried by the act are $85,300 for the Bureau of Chemistry, an increase of $11,600; $77,450 for the Division of Entomology, an increase of $10,000; $51,850 for the Division of Biological Survey, an increase of $6,000; $229,320 for the Division of Publications, $105,000 of which is to be used for the preparation and printing of Farmers' Bulletins; $16,000 for the Division of Foreign Markets; $35,-000 for Public Road Inquiries, an increase of $5,000; $20,000 for the Library; and $138,210 for administrative, contingent and general expenses.

The growth of the department is indicated in a general way by the amounts authorized for the rent of office and laboratory buildings. Starting some twelve years ago with an item of $900, the amount authorized for rent of buildings has steadily increased year by year until in the present bill it amounts to $27,500. This shows conclusively the inadequacy of the present buildings, which led the last session of congress to appropriate $1,500,000 for a new agricultural building, plans for which are now in course of preparation.

The agricultural appropriation act does not carry the appropriation for printing the publications of the department, except in the case of the popular series known as 'Farmers' Bulletins.' The department's allotment out of the general printing fund is $185,000, an increase of $10,000, and $300,000 is provided for printing and binding a half million copies of the 'Year-book.' Adding to this the cost of the regular and special reports, which are printed by order of congress, brings the amount for printing the department publications up to approximately three quarters of a million dollars. In the last fiscal year 757 separate publications were issued in an aggregate edition of over ten million copies, some six million of which were 'Farmers' Bulletins.' This is a larger number of separate publications and of total copies than are issued by any other department of the government, and stamps the Department of Agriculture as the greatest agency in the world for the dissemination of popular and technical information on agriculture and agricultural science.

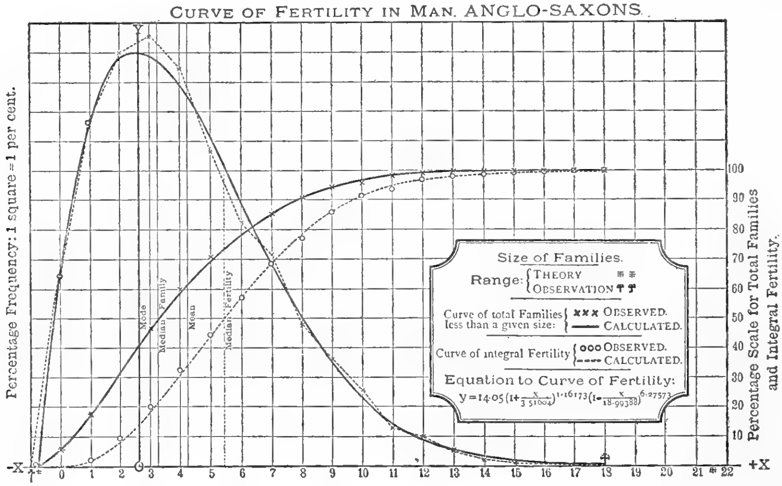
### *THE QUESTION OF THE BIRTH RATE.*

Just one hundred years ago, in 1803, was published the edition of Malthus's 'Essay on Population' which has had a considerable influence on economic theory and aided Darwin in thinking out his principle of the origin of species by natural selection. Malthusianism has become a current word with somewhat sinister implications, quite foreign to the spirit of the kindly clergyman, who announced the theory that population tends to increase more rapidly than the means of subsistence. If this were true population must be limited by moral restraint, vice or misery, and Malthus urged people not to marry until they had a fair prospect of supporting a family. Owing to the applications of science during the past century the means of subsistence in civilized nations have increased far more rapidly than the population. Malthus's proposition has become inverted; the production of goods increases in geometrical ratio, whereas the production of people occurs with an ever decreasing increment. It is no longer an economic question of starvation, but a sociological question of race suicide.

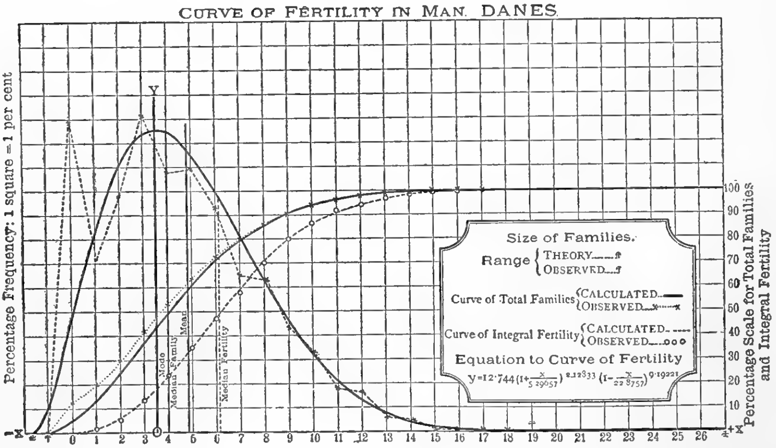
The subject has during the past month become prominent in newspaper discussions owing to statements made by the president of the United States and by the president of Harvard University. President Eliot has shown that graduates of Harvard do not reproduce themselves. Statistics from the colleges for women have also been compiled which prove that the graduates are not self-perpetuating. From the point of view of social evolution there would be certain advantages in the need of recruiting the ruling classes from a larger group, as this would give room for natural selection. As a matter of fact President Eliot's conclusions are contradicted by the only large study of the subject at hand, that by Rubin and Westergaard of Copenhagen marriages. It appears from some thousands of cases that while the birth rate is slightly smaller for the professional and upper classes than for artisans, the average number of surviving children is greater for the former, being about 3.31 as compared with 3.14. It may be that Harvard graduates have as large surviving families as those of the same race, but of lower social class.

It is unfortunate that statistics are not at hand on the marriage rate and is 29, in Germany 35 and in Russia 52. In Massachusetts the birth rate was last year 25.07 and the marriage rate 8.67. Even if all illegitimate children are attributed to the married, the average size of family would be less than three. The foreign born have a much larger fertility than the natives, and

CURVE OF FERTILITY IN MAN. ANGLO-SAXONS.




CURVE OF FERTILITY IN MAN. DANES.




birth rate in relation to the conditions on which they depend. The questions involved are of the utmost practical importance and should be taken up at once by the national and state governments. The birth rate in France where the population is stationary, is about 22 per thousand. In Great Britain it it is quite possible that the New England stock has a mean family of only two, as President Eliot finds to be the case with Harvard graduates. President Eliot appears to be mistaken in attributing the small families of Harvard graduates in part to postponement of marriage due to protracted education. The age of marriage of men of the upper classes in Copenhagen, with mean families of 4.5 was over 32, whereas it appears that the professional classes in the United States marry at an earlier age than this.

It is surely a serious problem when the more civilized races tend not to reproduce themselves. It is difficult of explanation by the laws of heredity and natural selection. We may assume that in the lower animals the number of offspring is most favorable for the survival of the race. In man there may be a selective death rate tending to reduce large families, but it does not appear to be an important factor. One quarter of the married population produces one half of the next generation, and if fertility is inheritable or correlated with inheritable traits the size of families should increase rapidly. If there were a complete correlation between fertility in mother and daughter, the size of families would be doubled in the fifth generation. It appears that physiological fertility is held in check by prudential restraint, but it is not clear why the psychological factors are not subject to natural selection and social tradition. Those who would have large families should supplant those who would not.

We reproduce from Professor Pearson's 'Chances of Death' two diagrams. The first is based largely on 2,279 marriages of a Connecticut quaker family, to which a skew frequency curve is fitted. The modal family, or most frequent family, falls between two and three; the median family, or the family of such size that there are as many larger as smaller, is 3.29; the mean or average family is 4.22, and the range or maximum family is 22.5. The second curve, for 1842 families of the professional and upper classes in Denmark, shows a somewhat higher fertility. Both curves indicate an artificial limitation in the deficiency, as compared with the theoretical curve, of families of five and six; and this would probably be much more marked in French or in recent Anglo-Saxon families. There is indeed urgent need of further investigation into the facts of the birth rate. Applied science may have at the end of the present century problems more pressing than the increase of the means of subsistence; there must be people to subsist.

### *THE RHODES SCHOLARSHIPS.*

THE scholars to be appointed under the terms of the will of the late Cecil Rhodes will go into residence at Oxford next year, and the best methods for selecting them are now being considered. The Prussian ministry of education has addressed a letter to the Oxford colleges asking information as to the reception of the fifteen scholars to be nominated by the German emperor. It is assumed that students will go to Oxford direct from the gymnasium, and it is asked whether the *Abiturienten-Zeugnis* which admits to the German universities will be accepted. Among other things information is wanted as to whether students may pursue studies preparatory to the professions and whether scholars may be appointed for a shorter period than three years.

Dr. Parkin, of the Toronto Grammar School, who was himself a colonial student at Oxford, has been commissioned to secure information for the use of the executors in framing a workable plan for American and colonial students. He has visited Oxford to learn the sentiments of the educational authorities and finds that most of the colleges will be glad to welcome the scholars. He is now in America holding conferences with educators and others, and will proceed to the different British colonies. The chief practical questions seem to concern the methods by which the scholars shall be appointed and the stage in their education at which they shall go to Oxford. The appointing authority is complicated in this country owing to the existence of state and private institutions with no machinery for correlation, and some question has already arisen in one or two of the western states as to the part to be taken by the board of education, the state university and the private institutions. In several conferences that have been held in the East the question has arisen as to whether the boy should go to Oxford to begin his college work or after he has taken his A.B. degree here.

We see no reason why the intentions of Mr. Rhodes should not be followed. These were certainly that the scholars should spend the three years in residence at one of the Oxford colleges preparing for the B.A. degree, and that they should be selected by the schools, not by the universities. Mr. Rhodes proposed that the qualifications should be rated on a scale of ten, one point for leadership in manly outdoor sports and three for qualities of manhood, these to be determined by fellow students, then two points for force of character to be assigned by teachers, and lastly four points for scholarship to be determined by examination. Mr. Rhodes does not seem to have considered the difficulty of comparing the claims of students from different schools, but if a candidate is nominated by each school wishing to do so, the central state authority could give the competitive examination and select the scholar as the result of this and of his school record. It seems proper that Mr. Rhodes's intention should at least be given a trial, even though the presidents of American universities think it better that B.A.'s should be sent to Oxford for research work. There is indeed much to be said for Mr. Rhodes's plan of selecting the scholars and for his intention that they be undergraduates. Oxford is not a particularly good place for graduate work, but its college life has certain admirable aspects not to be found in American or continental institutions. It would not do to educate all American boys by the Oxford method, but much gain will accrue to the educational, political and social life of the country by sending thirty each year thither.

There appears to be some opposition to the Rhodes scholarships. The students of Göttingen are said to have voted not to accept them, and some American newspapers print editorial criticisms not always well informed. The New York *Sun*, for example, says 'The Rhodes bequest was based upon a flagrant misconception of facts, and inspired by an ill-considered purpose.' This opposition seems to be based on the assumption that Harvard and Berlin are better universities than Oxford, and that the student will be anglicized to the advantage of Great Britain. Harvard and Berlin are of course better universities than Oxford, but the Oxford College is *sui generis*, and its influence on the students is great and on the whole beneficial. It would doubtless be an excellent economic investment for Great Britain to send one hundred students to study at Berlin and Harvard, and it certainly seems to be an advantage for the United States to send one hundred students to Oxford to be educated at the cost of Great Britain.

## *CENSORSHIP OF THE PRESS IN RUSSIA.*

The issue of The Popular Science Monthly for October, which contained an article by Dr. F. A. Woods reviewing heredity in the Romanofs prior to 1762, was censured by the Russian government in a curious manner. The leaves containing the article were cut out from the number and the title on the table of contents was so inked that it could not be read. This seems to show a considerable degree of conscientiousness on the part of the censor, as it would have been easier and less exciting to the curiosity of subscribers to have simply destroyed the numbers. The incident recalls, however, the in-tolerable state of affairs to which the Russian press and people must submit. Russian newspapers are of two classes, censored and uncensored. The former must show everything that is printed to a local censor beforehand, the latter are subject to the minister of the interior, who suppresses or punishes them as he sees fit. It is said that the conditions are not quite so bad as they were, but a 'confidential' letter of instructions sent to the uncensored papers from the ministry of the interior on the twenty-second of last July gives striking information as to the limitation imposed on freedom of speech. Among the large number of subjects regarding which it is forbidden to publish news or criticism we quote the following coming within the scope of this journal:

> Information and articles concerning disorders in the higher educational establishments, whether secular or clerical, and disciplinary punishments inflicted on those taking part in such disorders, . . . and, in general, all news relating to the internal life of these institutions, except when the competent educational authority has consented to such publication.
>
> Information concerning disorders, in our factories and industrial works, or any other breaches of public order and tranquility, except when permission for publication has been given by the higher police authorities.
>
> Information concerning the appearance of epidemic diseases among the population, or the spread of the plague in Russia and the adjacent countries, except when permission for publication has been given by the medical department of the Ministry of the Interior.
>
> Historical and critical disquisitions, articles and documents, printed in specialist or strictly scientific journals or other works, in cases where such articles, etc., serve an exclusively scientific purpose, and where, by reason of their contents, their distribution among a wide circle of readers might lead to undesirable results.

We shall look forward with interest to learn whether the censor discovers this note and cuts it out of the copies of the MONTHLY going to subscribers in Russia.

### *MILEY'S COLOR PHOTOGRAPHY.*

PROFESSOR W. G. BROWN, of the University of Missouri, brought to the attention of the Chemical Section of the American Association for the Advancement of Science, at the recent Washington meeting, a new method of color photography of considerable interest, due to M. and H. M. Miley, of Lexington, Va. Two photographs were shown—a copy of Rembrandt Peale's Washington in the uniform of a colonial officer, and a plate of peaches. The process is a three-color film one, in which the essential modification of existing processes is the use of pigmented gelatine films in place of stained ones.

In making photographs by this method, three negatives are taken in colored light, the light being obtained by passing ordinary light through a medium of proper color interposed between the lens and the plate, usually a screen of colored glass or some coloring matter placed between sheets of thin glass. One negative is taken through a red screen, a second through a green screen and a third through a violet screen. The colors, red, green and violet, used for the screens should be such as transmit rays falling within a limited portion of the spectrum. The photographic plates used for the negatives must be adapted to the color of the light to which they are exposed; for the negative exposed to the red light an orthochromatic plate stained with cyanin solution, for that to the green light an unmodified orthochromatic plate and for violet light an ordinary gelatin-silver-bromid plate is used. From the negatives obtained positives are made of carbon tissue (bichromated gelatin pigment paper). The carbon tissue, perhaps better, pigment tissue, used with the red light negative is charged with an inalterable blue pigment, the blue being the complementary of the red used in the production of the negative. The pigment tissue for the red and yellow positives, that is, the tissue used with the green and violet-light negatives is charged with the complementary inalterable red and yellow pigments. The pigment tissue, of whatever color, is sensitized, exposed and developed in the usual way with some modifications made to facilitate the manipulation during the development, transference and subsequent superposition of the films.

The yellow positive is made first and transferred to gelatine-coated paper which forms the final support of the photograph, the red positive is next made and before drying is superposed on the yellow positive, finally the blue positive is superposed on the other two. The resulting photograph, if the negatives have been of the right density, the pigments of the proper colors and the technique right, is one of which it can be safely said that none made by any other process can be compared with it. The photographs are superior to three-color prints, just as a carbon photograph is superior to a half-tone print, and are superior to an ordinary photograph in the same measure that a carbon print is. Miley's color photographs possess all the richness, depth and permanence of carbon photographs with the addition of color. Unlike the three-color half-tone prints, there is no break in the continuity of the color. The texture and minute details of the subject are faithfully reproduced with a naturalness that can only be compared with the originals.

So far the process has been used for still life, landscapes and paintings, but it is possible to take portraits by it, as the time of exposure through the red screen is about fifteen seconds and, with a suitable plate-holder and screen-holder, all three plates could be exposed easily in less than thirty seconds. It is hardly necessary to say that the method can be used for the production of transparencies and lantern slides. These, however, have not yet been made.

## *SCIENTIFIC ITEMS.*

We regret to record the deaths of Professor William Harkness, the eminent astronomer, past president of the American Association for the Advancement of Science; of Dr. Norman Macleod Ferrers, F.R.S., the mathematician, master of Gonville and Caius College, Cambridge, and of Mr. James Glaisher, F.R.S., known for his work in meteorology and aeronautics.

Mr. Joseph Larmor, fellow of St. John's College, Cambridge, has been elected Lucasian professor of mathematics in succession to the late Sir George Gabriel Stokes.—Professor E. F. Nichols, of Dartmouth College, has been elected to a chair of physics in Columbia University.—Mr. Stewart Culin, recently curator of the Museum of Science and Art of the University of Pennsylvania, has become curator of ethnology to the Museum of the Brooklyn Institute of Arts and Sciences.—The Lucy Wharton Drexel medal of the University of Pennsylvania was presented to Professor F. W. Putnam at the Founder's Day celebration on February 21.—Dr. Albert B. Prescott, professor of chemistry in the University of Michigan, has been given the degree of LL.D. by Northwestern University.

# INDEX.

THE NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS.