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THE POPULAR SCIENCE MONTHLY VOLUME LXXXVI JULY TO SEPTEMBER, 1915

THE SCIENTIFIC MONTHLY VOLUME I OCTOBER TO DECEMBER, 1915

EDITED BY J. McKEEN CATTELL

THE SCIENTIFIC MONTHLY ——— OCTOBER, 1915 ————————-

THE EVOLUTION OF THE STARS AND THE FORMATION OF THE EARTH. II

BY DR. WILLIAM WALLACE CAMPBELL

DIRECTOR OF THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

THE PRINCIPLES OF SPECTROSCOPY

THUS far our description of the stellar universe has been confined to its geometrical properties. A serious study of the evolution of the stars must seek to determine, first of all, what the stars really are, what their chemical constitutions and physical conditions are; and how they are related to each other as to their physical properties. The application of the spectroscope has advanced our knowledge of the subject by leaps and bounds. This wonderful instrument, assisted by the photographic plate, enables every visible celestial body to write its own record of the conditions existing in itself, within limits set principally by the brightness of the body. Such records physicists have succeeded to some extent in duplicating in their laboratories; and the known conditions under which the laboratory experiments have been conducted are the Rosetta Stones which are enabling us to interpret, with more or less success, the records written by the stars.

It is well known that the ordinary image of a star, whether formed by the eye alone, or by the achromatic telescope and the eye combined, contains light of an infinite variety of colors corresponding, speaking according to the mechanical theory of light, to waves of energy of an infinite variety of lengths which have traveled to us from the star. In the point image of a star, these radiations fall in a confused heap. and the observer is unable to say that radiations corresponding to any given wave-lengths are present or absent. When the star's light has been passed through the prism, or diffracted from the grating of a spectroscope, these rays are separated one from another and arranged side by side in perfect order, ready for the observer to survey them and to determine which ones are present in superabundance and which other ones are lacking wholly or in part. The following comparison is a fair one: the ordinary point image of a star is as if all the books in the university library were thrown together in a disorderly but compact pile in the center of the reading room: we could say little concerning the contents and characteristics of that library; whether it is strong in certain fields of human endeavor, or weak in other fields. The spectrum of a star is as the same library when the books are arranged on the shelves in complete perfection and simplicity, so that he who looks may appraise its contents at any or all points. Let us consider the fundamental principles of spectroscopy.

1. When a solid body, a liquid, or a highly-condensed gas is heated to incandescence, its light when passed through a spectroscope forms a continuous spectrum: that is, a band of light, red at one end and violet at the other, uninterrupted by either dark or bright lines.

2. The light from the incandescent gas or vapor of a chemical element, passed through a spectroscope, forms a bright-line spectrum; that is, one consisting entirely of isolated bright lines,

distributed differently throughout the spectrum for the different elements, or of bright lines superimposed upon a relatively faint continuous spectrum.

3. If radiations from a continuous-spectrum source pass through cooler gases or vapors before entering the spectroscope, a dark-line spectrum results: that is, the positions which the bright lines in the spectra of the vapors and gases would have are occupied by dark or absorption lines. These are frequently spoken of as Fraunhofer lines.

To illustrate: the gases and vapors forming the outer strata of the Sun's atmosphere would in themselves produce bright-line spectra of the elements involved. If these gases and vapors could in effect be removed, without changing underlying conditions, the remaining condensed body of the Sun should have a continuous spectrum. The cooler overlying gases and vapors absorb those radiations from the deeper and hotter sources which the gases and vapors would themselves emit, and thus form the dark-line spectrum of the Sun. The stretches of spectrum between the dark lines are of course continuous-spectrum radiations.

These principles are illustrated in Fig. 12. The essential parts of a spectroscope are the slit—an opening perhaps 1/100th of an inch wide and 1/10th of an inch long—to admit the light properly; a lens to render the light rays parallel before they fall upon the prism or grating; a prism or grating; a lens to receive the rays after they have been dispersed by the prism or grating and to form an image of the spectrum a short distance in front of the eye, where the eye will see the spectrum or a sensitive dry-plate will photograph it. If we place an alcohol lamp immediately in front of the slit and sprinkle some common salt in the flame the two orange bright lines of sodium will be seen in the eyepiece, close together, as in the upper of the two spectra in the illustration. If we sprinkle thallium salt in the flame the green line of that element will be visible in the spectrum. If we take the lamp away and place a lime light or a piece of white-hot iron in front of the slit we shall get a brilliant continuous spectrum not crossed by any lines, either bright or dark. Insert now the alcohol-sodium-thallium lamp between the lime light and the slit, and the observer will see the two sodium lines and one thallium line in the same places as before, but as dark lines on a background of bright continuous spectrum, as: illustrated in the lower of the two spectra. Let us insert a screen between the lamp and the lime light so as to cut out the latter, and we shall see the bright lines of sodium and thallium reappear as in the upper of the two spectra. These simple facts illustrate Kirchhoff's immortal discovery of certain fundamental principles of spectroscopy, in 1859. The gases and vapors in the lamp flame are at a lower temperature than the lime source. The cooler vapors of sodium and thallium have the power of absorbing exactly those rays from the hotter lime or other similar source which the vapors by themselves would emit to form bright lines.

When we apply the spectroscope to celestial objects we find apparently an endless variety of spectra. We shall illustrate some of the leading characteristics of these spectra as in Figs. 13 to 18, inclusive, and Figs. 21, 22, 23 and 24. The spectra of some nebulae consist almost exclusively of isolated bright lines, indicating that these bodies consist of luminous gases, as Huggins determined in 1864; but a very faint continuous band of light frequently forms a background for the brilliant bright lines. Many of the nebular lines are due to hydrogen, others are due to helium; but the majority, including the two on the extreme right in Fig. 13, which we attribute to the hypothetical element nebulium, and the close pair on the extreme left, have not been matched in our laboratories and, therefore, are of unknown origin. Most of the irregular nebulae whose spectra have been observed, the ring nebulae, the planetary and stellar nebulae, have very similar spectra, though with many differences in the details.[1]

[1] My colleague, Wright, who has been making a study of the nebular spectra, has determined the accurate positions of about 67 bright nebular lines.

The great spiral nebula in Andromeda has a continuous spectrum crossed by a multitude of absorption lines. The spectrum is a very close approach to the spectrum of our Sun. It is clear that this spiral nebula is widely different from the bright-line or gaseous nebulae in physical condition. The spiral may be a great cluster of stars which are approximate duplicates of our Sun, or there is a chance that it consists, as Slipher has suggested, of a great central sun, or group of suns, and of a multitude of small bodies or particles, such as meteoric matter, revolving around the nucleus; this finely divided matter being visible by reflected light which originates in the center of the system.

There is an occasional star, like chi Carinae, whose spectrum consists almost wholly of bright lines, in general bearing no apparent relationship to the bright lines in the spectra of the gaseous nebulae except that the hydrogen lines are there, as they are almost everywhere. There is reason to believe that such a spectrum indicates the existence of a very extensive and very hot atmosphere surrounding the main body, or core, of the star in question. This particular star is remarkable in that it has undergone great changes in brilliancy and is located upon a background of nebulosity. The chances are strong that the star has rushed through the nebulosity with high rate of speed and that the resulting bombardment of the star has expanded and intensely heated its atmosphere.

There are the Wolf-Rayet stars, named from the French astronomers who discovered the first three of this class, whose spectra show a great variety of combinations of continuous spectrum and bright bands. We believe that the continuous spectrum in such a star comes from the more condensed central part, or core, and that the bright-line light proceeds from a hot atmosphere extending far out from the core.

The great majority of the stars have spectra which are continuous, except for the presence of dark or absorption lines: a few lines in the very blue stars, and an increasing number of lines as we pass from the blue through the yellow and red stars to those which are extremely red.

Secchi in the late 60's classified the spectra of the brighter stars, according to the absorption lines in their spectra, into Types I, II III and IV, which correspond: Type I, to the very blue stars, such as Spica and Sirius; Type II, to the yellow stars similar to our Sun; Type III, to the red stars such as Aldebaran; and Type IV, to the extremely red stars, of which the brightest representatives are near the limit of naked-eye vision. Secchi knew little or nothing concerning stars whose spectra contain bright lines, except as to the isolated bright-line spectra of a few nebulae, and as to the bright hydrogen lines in gamma Cassiopeia, and his system did not include these.

One of the most comprehensive investigations ever undertaken by a single institution was that of classifying the stars as to their spectra, over the entire sky, substantially down to and including the stars of eighth magnitude, by the Harvard College Observatory, as a memorial to the lamented Henry Draper. Professor Pickering and his associates have formulated a classification system which is now in universal use. It starts with the bright-line nebulae, passes to the bright-line stars, and then to the stars in which the helium absorption lines are prominent. The latter are called the helium stars, or technically the Class B stars. The next main division includes the stars in which hydrogen absorption is prominent, called Class A. Classes B and A are blue stars. Then follows in succession Class F, composed of bluish-yellow stars, which is in a sense a transition class between the hydrogen stars and those resembling our Sun, the latter called Class G. The Class G stars are yellow. Class K stars are the yellowish-red; Class M, the red; and Class N, the extremely red. Each of these classes has several subdivisions which make the transition from one main class to the next main class fairly gradual, and not per saltum; though it should be said that the relationship of Class N to Class M spectra is not clear. The illustration, Fig. 17, brings out the principal features of the spectra of Classes B to M. The spectrum becomes more complicated as we pass from Class B to the Class M, and the color changes from blue to extreme red, because the violet and blue radiations become rapidly weaker as we pass through the various classes.

GENERAL COURSE OF EVOLUTIONARY PROCESS

The general course of the evolutionary processes as applied to the principal classes of celestial bodies is thought to be fairly well known. With very few exceptions astronomers are agreed as to the main trend of this order, but this must not be interpreted to mean that there are no outstanding differences of opinion. There are, in fact, some items of knowledge which seem to run counter to every order of evolution that has been proposed.

The large irregular nebulae, such as the great nebula in Orion, the Trifid nebula, and the background of nebulosity which embraces a large part of the constellation of Orion, are thought to represent the earliest form of inorganic life known to us. The material appears to be in a chaotic state. There is no suggestion of order or system. The spectroscope shows that in many cases the substance consists of glowing gases or vapors; but whether they are glowing from the incandescence resulting from high temperature, or electrical condition, or otherwise, is unknown, though heat origin of their light is the simplest hypothesis now available. Whether such nebulae are originally hot or cold, we must believe that they are endowed with gravitational power, and that their molecules or particles are, or will ultimately be, in motion. It will happen that there are regions of greater density, or nuclei, here and there throughout the structure which will act as centers of condensation, drawing surrounding materials into combination with them. The processes of growth from nuclei originally small to volumes and masses ultimately stupendous must be slow at first, relatively more rapid after the masses have grown to moderate dimensions and the supplies of outlying materials are still plentiful, and again slow after the supplies shall have been largely exhausted. By virtue of motions prevailing within the original nebular structure, or because of inrushing materials which strike the central masses, not centrally but obliquely, low rotations of the condensed nebulous masses will occur. Stupendous quantities of heat will be generated in the building-up process. This heat will radiate rapidly into space because the gaseous masses are highly rarefied and their radiating surfaces are large in proportion to the masses. With loss of heat the nebulous masses will contract in volume and gradually assume forms more and more spherical. When the forms become approximately spherical, the first stage of stellar life may be said to have been reached.

It was Herschel's belief that by processes of condensation, following the loss of heat by radiation into surrounding space, formless nebulae gravitated into nebula of smaller and smaller volumes until finally the planetary form was reached, and that planetaries were the ancestors of stars in general. That the planetaries do develop into stars, we have every reason to believe; but that all nebulae, or relatively many nebulae, pass through the planetary stage, or that many of our stars have developed from planetaries, we shall later find good reason for doubting. The probabilities are immensely stronger that the stars in general have been formed directly from the irregular nebulae, without the intervention of the planetaries. The planetary nebula seem to be exceptional cases, but to this point we shall return later.

It is quite possible, and even probable, that gaseous masses have not in all cases passed directly to the stellar state. The materials in a gaseous nebula may be so highly attenuated, or be distributed so irregularly throughout a vast volume of space, that they will condense into solids, small meteoric particles for example, before they combine to form stars. Such masses or clouds of non-shining or invisible matter are thought to exist in considerable profusion within the stellar system. The nebulosity connected more or less closely with the brighter Pleiades stars may be a case in illustration. Slipher has recently found that the spectra of two small regions observed in this nebula are continuous, with absorption lines of hydrogen and helium. This spectrum is apparently the same as that of the bright Pleiades stars. Slipher's interpretation is that the nebula is not shining by its own light, but is reflecting to us the light of the Pleiades stars. That this material will eventually be drawn into the stars already existing in the neighborhood, or be condensed into new centers and form other stars, we can scarcely doubt. The condensation of such materials to form stars large enough to be seen from the great distance of the Pleiades cluster must generate heat in the process, and cause these stars in their earliest youth to be substantially as hot as other stars formed directly from gaseous materials. It is possible, also, that the spiral nebulae will develop into stars, perhaps each such object into many, or some of the larger ones into multitudes, of stars.

Let us attempt to visualize the conditions which we think exist in a newly-formed star of average mass. It should be essentially spherical, with surface fairly sharply defined. Our Sun has average specific gravity of 1.4, as compared with that of water. The average density of the very young star must certainly be vastly lower; perhaps no greater than the density of our atmosphere at the Earth's surface; it may even be considerably lower than this estimate. The diameter of our Sun is 1,400,000 kilometers. The diameter of the average young star may be ten or twenty or forty times as great. The central volume or core of the star is undoubtedly a great deal denser than the surface strata, on account of pressure due to the star's own gravitational forces. The conditions in the outer strata should bear some resemblance to those existing in the gaseous nebula. The star may or may not have a corona closely or remotely similar to our Sun's corona. The deep interior of the star must be very hot, though not nearly so hot as the interiors of older stars; but the surface strata of the young star should be remarkably hot; for, being composed of highly attenuated gases, any lowering of the temperature by radiation into surrounding space will be compensated promptly through the medium of highly-heated convection currents which can travel more rapidly from the interior to the surface than in the case of stars in middle or old age. Even though the star, as observed in our most powerful telescopes, is a point of light, without apparent diameter, its outer strata should supply some bright lines in the spectrum, because these strata project out beyond what we may call the core of the star and themselves act as sources of light. The spectrum should, therefore, consist of some of the bright lines which were observed in the nebular spectrum, these proceeding from the outer strata of the star; and of a continuous spectrum made up of radiations proceeding from the deeper strata or core of the star, in which a few dark lines may be introduced by the absorption from those parts of the outer gaseous strata which lie between us and the core.

A few hundred stellar spectra resembling this description are well known, discovered mostly at the Harvard Observatory. Their details differ greatly, but they have certain features in common. The bright lines of helium are extremely rare in stars, but they have been observed in a few stellar spectra. The bright lines of nebulium have never been observed in a true star: they and the radiations in the ultra-violet known as at 3726A, seem to be confined to the nebular state; and the absorption lines of nebulium have never been observed in any spectrum. As soon as the stellar state is reached nebulium is no longer in evidence. Stellar spectra containing bright lines seem always to include hydrogen bright lines. This is as we should expect; hydrogen is the lightest known gas, and it is probably the substance which can best exist in the outer strata of stars in general. The extensive outer strata of very young stars seem to be composed largely of hydrogen, though other elements are in some cases present, as indicated by the weaker bright lines in a few cases. This preference of hydrogen for the outermost strata is illustrated by several very interesting observations of the nebulae. The nebulium lines are relatively strong in the central denser parts of the Orion and Trifid nebulae, but the hydrogen bright-lines are relatively very strong in the faint outlying parts of these nebulae. The planetary nebula B.D.—12 degrees.1172 is seen in the ordinary telescope to consist of a circular disc (probably a sphere or spheroid) of light and a faint star in its center. When this nebula is observed with a slitless spectrograph the hydrogen and nebulium components are seen as circular discs, but the hydrogen discs are larger than the nebulium discs. In other words, the hydrogen forms an atmosphere about the central star which extends out into space in all directions a great deal farther than the nebulium discs extend. The Wolf-Rayet star-planetary nebula D. M. + 30 degrees.3639 looks hazy in a powerful telescope, and when examined in a spectroscope the haziness is seen to be due to a sharply defined globe of hydrogen 5 seconds of arc in diameter surrounding the star in its center. Wolf and Burns have shown that in the Ring Nebula in Lyra the 3726A and the hydrogen images are larger as to outer diameter than the nebulium images, but that the latter are the more condensed on the inner edge of the ring. Wright has in the present year examined these and other nebulae with special reference to the distribution of the principal ingredients. He finds in general that the radiations at 4363A and 4686A, of unknown or possibly helium origin, are most closely compressed around the central nuclei of nebulae; that the matter definitely known to be helium is more extended in size; that the nebulium structure is still larger; and that the hydrogen uniformly extends out farther than the nebulium; and that the ultra violet radiation at 3726A seems to proceed from the largest volume of all. The 37726A line, like the nebulium line, is unknown in stellar spectra; it seems also to be confined to true nebulosity. Neglecting the elements which have never been observed in true stars, we may say that all these observations are in harmony with the view that hydrogen should be and is the principal element in the outer stratum of the very young star. A few of the stars whose spectra contain bright hydrogen lines have also a number of bright lines whose chemical origin is not known. They appear to exist exactly at this state of stellar life: several of them have not been found in the spectra of the gaseous nebulae, and they are not represented in the later types of stellar spectra. The strata which produce these bright lines are thought to be a little deeper in the stars than the outer hydrogen stratum.

A slightly older stage of stellar existence is indicated by the type of spectrum in which some of the lines of hydrogen, always those at the violet end, are dark, and the remaining hydrogen lines, always those toward the red end, are bright. The brightest star in the Pleiades group, Alcyone, presents apparently the last of this series, for all of the hydrogen lines are dark except H alpha, in the red. In some of the bright-line stars which we have described, technically known as Oe5, Harvard College Observatory found that the dark helium and hydrogen lines exist, and apparently increase in intensity, on the average, as the bright lines become fainter. Wright has observed the absorption lines of helium and hydrogen in the spectra of the nuclei of some planetary nebulae, although the helium and hydrogen lines are bright in the nebulosity surrounding the nuclei. We may say that when all of the bright lines have disappeared from the spectra of stars, the helium lines, and likewise the hydrogen lines, have in general become fairly conspicuous. These stars are known as the helium stars, or stars of Class B. Proceeding through the subdivisions of Class B, the helium lines increase to a maximum of intensity and then decrease. The dark hydrogen lines are more and more in evidence, with intensities increasing slowly. In the middle and later subdivisions of the helium stars silicon, oxygen and nitrogen are usually represented by a few absorption lines.

Just as the gaseous nebulae radiate heat into space and condense, so must the stars, with this difference: the nebulae are highly rarified bodies, with surfaces enormously large in proportion to the heat contents; and the radiation from them must be relatively rapid. In fact, some of the nebulae seem to be so highly rarified that radiation may take place from their interiors almost as well as from their surfaces. The radiation from a star just formed must occur at a much slower rate. The continued condensation of the star, following the loss of heat, must lead to a change of physical condition, which will be apparent in the spectrum. It should pass from the so-called helium group, to the hydrogen, or Class A group, not suddenly but by insensible gradations of spectrum. In the Class A stars the hydrogen lines are the most prominent features. The helium lines have disappeared, except in a few stars where faint helium remnants are in evidence. The magnesium lines have become prominent and the calcium lines are growing rapidly in strength. The so-called metallic lines, usually beginning with iron and titanium lines, which have a few extremely faint representatives in the last of the helium stars, become visible here and there in the Class A spectra, but they are not conspicuous.

In the next main division, the Class F spectra, the metallic lines increase rapidly in prominence, and the hydrogen lines decrease slightly in strength. These stars are not so blue as the helium and hydrogen stars. They are intermediate between the blue stars and the yellow stars, which begin with the next class, G, of which our Sun is a representative.

The metallic lines are in Class G spectra in great number and intensity, and the hydrogen lines are greatly reduced in prominence. The calcium bands are very wide and intense.

Another step brings us to the very yellow and the slightly-reddish stars, known as Class K. These stars are weak in violet light, the hydrogen lines are substantially of the same intensity as the most prominent metallic lines, and the metallic lines are more and more in evidence.

Stars in the last subdivisions of the Class K and all of the Class M stars are decidedly red. In these the hydrogen lines are still further weakened and the metallic lines are even more prominent. Their spectra are further marked by absorption bands of titanium oxide, which reach their maximum strength in the later subdivisions of Class M.

The extremely red stars compose Class N on the Harvard scale. Their spectra are almost totally lacking in violet light, the metallic absorption is very strong, and there are conspicuous absorption bands of carbon.

Deep absorbing strata of titanium and carbon oxides seem to exist in the atmospheres of the Class M and N stars, respectively. The presence of these oxides indicates a relatively low temperature, and this is what we should expect from stars so far advanced in life.

The period of existence succeeding the very red stars has illustrations near at hand, we think, in Jupiter, Saturn, Uranus and Neptune, and in the Earth and the other small planets and the Moon: bodies which still contain much heat, but which are invisible save by means of reflected light.

The progression of stellar development, which we have described, has been based upon the radiation of heat. This is necessarily gradual, and the corresponding changes of spectrum should likewise be gradual and continuous. It is not intended to give the impression that only a few types of spectra are in evidence: the variety is very great. The labels, Class B, Class A, and so on to Class N, are intended to mark the miles in the evolutionary journey. The Harvard experts have put up other labels to mark the tenths of miles, so to speak, and some day we shall expect to see the hundredths labeled. Further, it is not here proposed that heat radiation is the only vital factor in the processes of evolution. The mass of a star may be an important item, and the electrical conditions may be concerned. A very small star and a very massive star may develop differently, and it is conceivable that there may be actual differences of composition. But heat-radiation is doubtless the most important factor.

The evolutionary processes must proceed with extreme deliberation. The radiation of the heat actually present at any moment in a large helium star would probably not require many tens of thousands of years, but this quantity of heat is negligible in comparison with the quantity generated within the star during and by the processes of condensation from the helium age down to the Class M state. We know that the compression of any body against resistance generates or releases heat. Now a gaseous star at any instant is in a state of equilibrium. Its internal heat and the centrifugal force due to its rotation about an axis are trying to expand it. Its own gravitational power is trying to draw all of its materials to the center. Until there is a loss of heat no contraction can occur; but just as soon as there is such a loss gravity proceeds to diminish the stellar volume. Contraction will proceed more slowly than we should at first thought expect, because in the process of contraction additional heat is generated and this becomes a factor in resisting further compression. Contraction is resisted vastly more by the heat generated in the process of contraction than it is by the store of heat already in evidence. The quantity of heat in our Sun, now existing as heat, would suffice to maintain its present rate of outflow only a few thousands of years. The heat generated in the process of the Sun's shrinkage under gravity, however, is so extensive as to maintain the supply during millions of years to come. Helmholtz has shown that the reduction of the Sun's radius at the rate of 45 meters per year would generate as much heat within the Sun as is now radiated. This rate of shrinkage is so slow that our most refined instruments could not detect a change in the solar diameter until after the lapse of 4,000 or 5,000 years. Again, there are reasons for suspecting that the processes of evolution in our Sun, and in other stars as well, may be enormously prolonged through the influence of energy within the atoms or molecules of matter composing them. The subatomic forces residing in the radioactive elements represent the most condensed form of energy of which we have any conception. It is believed that the subatomic energy in a mass of radium is at least a million-fold greater than the energy represented in the combustion or other chemical transformation of any ordinary substance having the same mass. These radioactive forces are released with extreme slowness, in the form of heat or the equivalent; and if these substances exist moderately in the Sun and stars, as they do in the Earth, they may well be important factors in prolonging the lives of these bodies.

Speaking somewhat loosely, I think we may say that the processes of evolution from an extended nebula to a condensed nebula and from the latter to a spherical star, are comparatively rapid, perhaps normally confined to a few tens of millions of years; but that the further we proceed in the development process, from the blue star to the yellow, and possibly but not certainly on to the red star, the slower is the progress made, for the radiating surface through which all the energy from the interior must pass becomes smaller and smaller in proportion to the mass, and the convection currents which carry heat from the interior to the surface must slow down in speed.

A HISTORY OF FIJI.

BY DR. ALFRED GOLDSBOROUGH MAYER

IV

THE Fijians had a well-organized social system which recognized six classes of society. (1) Kings and queens (Tuis and Andis). (2) Chiefs of districts (Rokos). (3) Chiefs of villages, priests (Betes), and land owners (Mata-ni-vanuas). (4) Distinguished warriors of low birth, chiefs of the carpenter caste (Rokolas), and chiefs of the turtle fishermen. (5) Common people (Kai-si). (6) Slaves taken in battle.

The high chiefs still inspire great respect, and indeed it has been the policy of the British government to maintain a large measure of their former authority. Thus of the 17 provinces into which the group was divided, 11 are governed by high chiefs entitled Roko Tui, and there are about 176 inferior chiefs who are the head men of districts, and 31 native magistrates. In so far as may be consistent with order and civilization these chiefs are permitted to govern in the old paternal manner, and they are veritably patriarchs of their people. The district chiefs are still elected by the land owners, mata-ni-vanuas, by a showing of hands as of old.

Independent of respect paid to those in authority, rank is still reverenced in Fiji. Once acting under the kind permission and advice of our generous friend Mr. Allardyce, the colonial secretary, and accompanied by my ship-mates Drs. Charles H. Townsend, and H. F. Moore, I went upon a journey of some days into the interior of Viti Levu, our guide and companion being Ratu Pope Seniloli, a grandson of king Thakombau, and one of the high chiefs of Mbau. Upon meeting Ratu Pope every native dropped his burdens, stepped to the side of the wood-path and crouched down, softly chanting the words of the tame, muduo! wo! No one ever stepped upon his shadow, and if desirous of crossing his path they passed in front, never behind him. Clubs were lowered in his presence, and no man stood fully erect when he was near. The very language addressed to high chiefs is different from that used in conversation between ordinary men, these customs being such that the inferior places himself in a defenceless position with respect to his superior.

It is a chief's privilege to demand service from his subjects; which was fortunate for us, for when we started down the Waidina River from Nabukaluka our canoes were so small and overloaded that the ripples were constantly lapping in over the gunwale, threatening momentarily to swamp us. Soon, however, we came upon a party of natives in a fine large canoe, and after receiving their tama Ratu Pope demanded: "Where are you going"? The men, who seemed somewhat awestricken, answered that it had been their intention to travel up the river. Whereupon Ratu Pope told them that this they might do, but we would take their canoe and permit them to continue in ours. To this they acceded with the utmost cheerfulness, although our noble guide would neither heed our protests nor permit us to reward them for their service, saying simply, "I am a chief. You may if you choose pay me." In this manner we continued to improve our situation by "exchanging" with every canoe we met which happened to be better than our own, until finally our princely friend ordered a gay party of merry-makers out of a fine large skiff, which they cheerfully "exchanged" for our leaky canoes and departed singing happily, feeling honored indeed that this opportunity had come to them to serve the great chief Ratu Pope Seniloli; and thus suffering qualms of conscience, we sailed to our destination leaving a wake of confusion behind us. Moreover I forgot to mention that many natives had by Ratu Pope's orders been diverted from their intended paths and sent forward to announce the coming of himself and the "American chiefs." Thus does one of the Royal house of Mbau proceed through Fiji.

At first sight such behavior must appear autocratic, to say the least, but it should be remembered that a high chief has it in his power fully to recompense those about him, and this without the payment of a penny. Indeed, many intelligent natives still regret the introduction of money into their land, saying that all the white man's selfishness had been developed through its omnipotence. In Fiji to-day there are no poor, for such would be fed and given a house by those who lived beside them. The white man's callous brutality in ignoring the appeal of misery is incomprehensible to the natives of Fiji. "Progress" they have not in the sense that one man possesses vast wealth and many around him struggle helplessly, doomed to life-long poverty; nor have they ambition to toil beyond that occasional employment required to satisfy immediate wants. Yet if life be happy in proportion as the summation of its moments be contented, the Fijians are far happier than we. Old men and women rest beneath the shade of cocoa-palms and sing with the youths and maidens, and the care-worn faces and bent bodies of "civilization" are still unknown in Fiji. They still have something we have lost and never can regain.

It is impossible to draw a line between personal service such as was rendered to Ratu Pope and a regular tax (lala) for the benefit of the entire community or the support of the communal government; and the recognition of this fact actuated the English to preserve much of the old system and to command the payment of taxes in produce, rather than in money.

Land tenure in Fiji is a subject so complex that heavy volumes might be written upon it. In general it may be said that the chief can sell no land without the consent of his tribe. Cultivated land belonged to the man who originally farmed it, and is passed undivided to all his heirs. Waste land is held in common. Native settlers who have been taken into the tribes from time to time have been permitted to farm some of the waste land, and for this privilege they and their heirs must pay a yearly tribute to the chief either in produce or in service. Thus this form of personal lala is simply rent. The whole subject of land-ownership has given the poor English a world of trouble, as one may see who cares to read the official reports of the numerous intricate cases that have come before the courts.

For example, one party based their claims to land on the historic fact that their ancestors had eaten the chief of the original owners, and the solemn British court allowed the claim.

Basil Thomson in his interesting work upon "The Fijians; a Study of the Decline of Custom," has given an authoritative summary of the present status of taxation and land tenure, land being registered under a modification of the Australian Torrens system.

In order to protect these child-like people from the avarice of our own race they are not permitted to sell their lands, and the greater portion of the area of Fiji is still held by the natives. The Hawaiian Islands now under our own rule furnish a sad contrast, for here the natives are reduced by poverty to a degraded state but little above that of peonage. The Fijians. on the other hand, may not sell, but may with the consent of the commissioner of native affairs lease their lands for a period of not more than twenty years.

The Fijians appear never to have been wholly without a medium of exchange, for sperm-whale's teeth have always had a recognized purchasing power, but are more especially regarded as a means of expressing good will and honesty of purpose. A whale's tooth is as effective to secure compliance with the terms of a bargain as an elaborately engraved bond would be with us. More commonly, however, exchanges are direct, each man bringing to the village green his taro, yaqona, yams or fish and exchanging with his neighbors; the rare disputes being settled by the village chief.

In traveling you will discover no hotels, but will be entertained in the stranger's houses, and in return for your host's hospitality you should make presents to the chief. Indeed to journey in good fashion you should be accompanied by a train of bearers carrying heavy bags full of purposed gifts, and nowhere in the world is the "rate per mile" higher than in Polynesia.

As in all communities, including our own world of finance, a man's wealth consists not only in what he possesses but even more so in the number of people from whom he can beg or borrow. Wilkes records an interesting example of this, for he found that the rifle and other costly presents he had presented to King Tanoa were being seized upon by his (Tanoa's) nephew who as his vasu had a right to take whatever he might select from the king's possessions. Indeed, in order to keep his property in sight, Tanoa was forced to give it to his own sons, thus escaping the rapacity of his nephew. The construction of the British law is such that a vasu who thus appropriates property to himself could be sued and forced to restore it, but not a single Fijian has yet been so mean as to bring such a matter into court.

An individual as such can hardly be said to own property, for nearly all things belong to his family or clan, and are shared among cousins. This condition is responsible for that absence of personal ambition and that fatal contentment with existing conditions, which strikes the white man as so illogical, but which is nevertheless the dominant feature of the social fabric of the Polynesians, and which has hitherto prevented the introduction of "ideals of modern progress." The natives are happy; why work when every reasonable want is already supplied? None are rich in material things, but none are beggars excepting in the sense that all are such. No one can be a miser, a capitalist, a banker, or a "promoter" in such a community, and thieves are almost unknown. Indeed, the honesty of the Fijians is one of those virtues which has excited the comment of travelers. Wilkes, who loathed them as "condor-eyed savages," admits that the only thing which any native attempted to steal from the Peacock was a hatchet, and upon being detected the chief requested the privilege of taking the man ashore in order that he might be roasted and eaten. Theft was always severely punished by the chief; Maafu beating a thief with the stout stalk of a cocoanut leaf until the culprit's life was despaired of, and Tui Thakau wrapping one in a tightly wound rope so that not a muscle could move while the wretch remained exposed for an entire day to the heat of the sun.

During Professor Alexander Agassiz's cruises in which he visited nearly every island of the Fijis, and the natives came on board by hundreds, not a single object was stolen, although things almost priceless in native estimation lay loosely upon the deck. Once, indeed, when the deck was deserted by both officers and crew and fully a hundred natives were on board, we found a man who had been gazing wistfully for half an hour at a bottle which lay upon the laboratory table. Somehow he had managed to acquire a shilling, a large coin in Fiji, and this he offered in exchange for the coveted bottle. One can never forget his shout of joy and the radiance of his honest face as he leaped into his canoe after having received it as a gift.

Even the great chief Ratu Epele of Mbau beamed with joy when presented with a screw-capped glass tobacco jar, and Tui Thakau of Somo somo had a veritable weakness for bottles and possessed a large collection of these treasures.

Intelligent and well-educated natives who know whereof they speak have told me that they desire not the white man's system, entailing as it does untold privation and heart-burnings to the many that the few may enjoy a surfeit of mere material things. As the natives say, "The white man possesses more than we, but his life is full of toil and sorrow, while our days are happy as they pass."

Thus in the Pacific life is of to-day; the past is dead, and the future when it comes will pass as to-day is passing. Life is a dream, an evanescent thing, all but meaningless, and real only as is the murmur of the surf when the sea-breeze comes in the morning, and man awakens from the oblivion of night.

Hoarded wealth inspires no respect in the Pacific, and indeed, were it discovered, its possession would justify immediate confiscation. Yet man must raise idols to satisfy his instinct to worship things above his acquisition, and thus rank is the more reverenced because respect for property is low. Even to-day there is something god-like in the presence of the high chiefs, and none will cross the shadow of the king's house. Even in war did a common man kill a chief he himself was killed by men of his own tribe.

As it is with property so with relationships. The family ties seem loosened; every child has two sets of parents, the adopted and the real, and relationships founded upon adoption are more respected than the real. Rank descends mainly through the mother. The son of a high chief by a common woman is a low chief, or even a commoner, but the son of a chieftainess by a common man is a chief. Curiously, there are no words in Fijian which are the exact equivalent of widow and widower. In the Marshall group the chief is actually the husband of all the women of his tribe, and as Lorimer Fison has said in his "Tales from Old Fiji," their designation and understanding of relationships suggests that there was once a time when "all the women were the wives of every man, and all the men were the husbands of every woman," as indeed was almost the case in Tahiti at the time of Captain Cook's visit to this island.

The social customs of Fiji are rarely peculiar to Fiji itself, but commonly show their relationship or identity with those of the Polynesians or Papuans. Curiously indeed, while the original stock of the Fijians was probably pure Papuan, their social and economic systems are now dominated by Polynesian ideas, and only among the mountain tribes do we find a clear expression of the crude Papuan systems of life and thought. This in itself shows that under stimulation the Fijians are capable of advancement in cultural ideals.

This superposition of a Polynesian admixture upon a barbarous negroid stock may account for the anomalous character of the Fijians, for in the arts they equalled or in some things excelled the other island peoples of the Pacific, and some of their customs approached closely to the cultural level of the Polynesians, but in certain fundamental things they remained the most fiendish savages upon earth. Indeed we should expect that contact with a somewhat high culture would introduce new wants, and thus affect their arts more profoundly than their customs.

In common with all primitive peoples, their names of men and women are descriptive of some peculiarity or circumstance associated with the person named. Indeed, names were often changed after important events in a person's life, thus our old friend Thakombau began life as Seru, then after the coup d'etat in which he slaughtered his father's enemies and reestablished Tanoa's rule in Mbau he was called Thakombau (evil to Mbau). At the time he also received another name Thikinovu (centipede) in allusion to his stealthiness in approaching to bite his enemy, but this designation, together with his "missionary" name "Ebenezer," did not survive the test of usage. Miss Gordon Cumming gives an interesting list of Fijian names translated into English. For women they were such as Spray of the Coral Reef, Queen of Parrot's Land, Queen of Strangers, Smooth Water, Wife of the Morning Star, Mother of Her Grandchildren, Ten Whale's Teeth, Mother of Cockroaches, Lady Nettle, Drinker of Blood, Waited For, Rose of Rewa, Lady Thakombau, Lady Flag, etc. The men's names were such as The Stone (eternal) God, Great Shark, Bad Earth, Bad Stranger, New Child, More Dead Man's Flesh, Abode of Treachery, Not Quite Cooked, Die Out of Doors, Empty Fire, Fire in the Bush, Eats Like a God, King of Gluttony, Ill Cooked, Dead Man, Revenge, etc.

In the religion of a people we have the most reliable clue to the history of their progress in culture and intelligence, for religions even when unwritten are potent to conserve old conceptions, and thus their followers advance beyond them, as does the intelligence of the twentieth century look pityingly upon the conception of the cruel and jealous God of the Old Testament, whose praises are nevertheless still sung in every Christian church. Thus in Tahiti the people were not cannibals, but the gods still appeared in the forms of birds that fed upon the bodies of the sacrificed. The eye of the victim was, indeed, offered to the chief, who raised it to his lips but did not eat it. In Samoa also where the practice of cannabalism was very rare and indulged in only under great provocation, some of the gods remained cannibals, and the surest way of appeasing any god was to be laid upon the stones of a cold oven. In Tahiti and Samoa, while most of the gods were malevolent, a few were kindly disposed towards mortals; in Fiji, however, they were all dreaded as the most powerful, sordid, cruel and vicious cannibal ghosts that have ever been conjured into being in the realm of thought.

All over the Pacific from New Zealand to Japan, and from New Guinea to Hawaii, ancestor-worship forms the backbone of every religion as clearly as it did in Greece or Rome. There are everywhere one or more very ancient gods who may always have existed and from whom all others are descended. Next in order of reverence, although not always in power, come their children, and finally the much more numerous grandchildren and remote descendants of these oldest and highest gods. Finally, after many generations, men of chieftain's rank were born to the gods. Thus a common man could never attain the rank of a high chief, for such were the descendants of the gods, while commoners were created out of other clay and designed to be servants to the chiefs.

But the process of god-making did not end with the appearance of men, for great chiefs and warriors after death became kalou yalo, or spirits, and often remained upon earth a menace to the unwary who might offend them. Curiously, these deified mortals might suffer a second death which would result in their utter annihilation, and while in Fiji we heard a tale of an old chief who had met with the ghost of his dead enemy and had killed him for the second and last time; the club which served in this miraculous victory having been hung up in the Mbure as an object of veneration.

Of a still lower order were the ghosts of common men or of animals, and most dreaded of all was the vengeful spirit of the man who had been devoured. The ghosts of savage Fiji appear all to have been malevolent and fearful beings, whereas those of the more cultured Polynesians were some of them benevolent. As Ellis says of the Tahitian mythology:

Each lovely island was made a sort of fairyland and the spells of enchantment were thrown over its varied scenes. The sentiment of the poet that

"Millions of spiritual creatures walk the earth,
Unseen, both when we wake, and when we sleep"

was one familiar to their minds, and it is impossible not to feel interested in a people who were accustomed to consider themselves surrounded by invisible intelligences, anti who recognized in the rising sun, the mild and silver moon, the shooting star, the meteor's transient flame, the ocean's roar, the tempest's blast, or the evening breeze the movements of mighty spirits.

The gods and ghosts of Fiji often entered into the bodies of animals or men, especially idiots.

Thus when the Carnegie Institution Expedition arrived at the Murray Islands in Torres Straits, the scientific staff were much pleased at the decided evidences of respect shown by the natives until it came out that the Islanders considered their white guests to be semi-idiots, and hence powerful sorcerers to be placated. Fijian religion had developed into the oracular stage, and the priest after receiving prayers and offerings would on occasions be entered into by the god. Tremors would overspread his body, the flesh of which would creep horribly. His veins would swell, his eyeballs protrude with excitement and his voice, becoming quavering and unnatural, would whine out strange words, words spoken by the god himself and unknown to the priest who as his unconscious agent was overcome by violent convulsions. Slowly the contortions grew less and with a start the priest would awaken, dash his club upon the ground and the god would leave him. It may well be imagined that the priests were the most powerful agents of the chiefs in forwarding the interests of their masters, for, as in ancient Greece or Rome, nothing of importance was undertaken without first consulting the oracle.

Surrounded by multitudes of demons, ghosts, and genii who were personified in everything about him, religion was the most powerful factor in controlling Fijian life and politics. In fact, it entered deeply into every act the native performed. The gods were more monstrous in every way than man, but in all attributes only the exaggerated counterparts of Fijian chiefs.

War was constantly occurring among these gods and spirits, and even high gods could die by accident or be killed by those of equal rank so that at least one god, Samu, was thus dropped out of the mythology in 1847.

Ndengei was the oldest and greatest, but not the most universally reverenced god. He lived in a cavern in the northeastern end of Viti Levu, and usually appeared as a snake, or as a snake's head with a body of stone symbolizing eternal life. Among the sons and grandsons of Ndengei were Roko Mbati-ndua, the one-toothed lord; a fiend with a huge tooth projecting from his lower jaw and curving over the top of his head. He had bat's wings armed with claws and was usually regarded as a harbinger of pestilence. The mechanic's god was eight-handed, gluttony had eighty stomachs, wisdom possessed eight eyes. Other gods were the adulterer, the abductor of women of rank and beauty, the rioter, the brain-eater, the killer of men, the slaughter god, the god of leprosy, the giant, the spitter of miracles, the gods of fishermen and of carpenters, etc. One god hated mosquitoes and drove them away from the place where he lived. The names and stations of the gods are described by Thomas Williams, who has given the most detailed account of the old religion.

As with all peoples whose religion is barbarous, there were ways of obtaining sanctuary and many a man has saved his life by taking advantage of the tabus which secured their operation. No matter how desirous your host might be of murdering you, as long as you remained a guest under his roof you were safe, although were you only a few yards away from his door he would eagerly attack you.

But not only did the Fijians live in a world peopled by witches, wizards, prophets, seers and fortune-tellers, but there was a perfect army of fairies which overran the whole land, and the myths concerning which would have filled volumes could they ever have been gathered. The gnome-like spirits of the mountains had peaked heads, and were of a vicious, impish disposition, but were powerless to injure any one who carried a fern leaf in his hand.

Sacred relics such as famous clubs, stones possessing miraculous powers, etc., were sometimes kept in Fijian temples, but there were no idols such as were prayed to by the Polynesians.

The fearful alternatives of heaven and hell were unknown to the Fijians. They believed in an eternal existence for men, animals, and even canoes and other inanimate things, but the future life held forth no prospect either of reward for virtues or punishment for evil acts committed while alive. So certain were they of a future life that they always referred to the dead as "the absent ones," and their land of shades (Mbulu) was not essentially different from the world they lived in. Indeed, their chief idea of death was that of rest, for as William's states, they have an adage: "Death is easy: Of what use is life? To die is rest."

There were, however, certain precautions the Fijian felt it advisable to take before entering the world to come. If he had been so unfortunate as not to have killed a man, woman or child, his duty would be the dismal one of pounding filth throughout eternity, and disgraceful careers awaited those whose ears were not bored or women who were not tatooed upon parts covered by the liku. Moreover, should a wife not accompany him (be strangled at the time of his death) his condition would be the dismal one of a spirit without a cook. Thirdly, as one was at the time of death so would the spirit be in the next world. It was therefore an advantage to die young, and people often preferred to be buried alive, or strangled, than to survive into old age. Lastly and most important, one must not die a bachelor, for such are invariably dashed to pieces by Nangganangga, even if they should succeed in elud- ing the grasp of the Great Woman, Lewa-levu, who flaunts the path of the departed spirits and searches for the ghosts of good-looking men. Let us imagine, however, that our shade departs this life in the best of form, young, married, with the lobes of his ears pierced, not dangerously handsome and a slayer of at least one human being. He starts upon the long journey to the Valhalla of Fiji. Soon he comes to a spiritual Pandanus at which he must throw the ghost of the whale's tooth which was placed in his hand at time of burial. If he succeeds in hitting the Pandanus, he may then wait until the spirit of his strangled wife comes to join him, after which he boards the canoe of the Fijian Charon and proceeds to Nambanggatai, where until 1847 there dwelt the god Samu, and after his death Samuyalo "the killer of souls."

This god remains in ambush in some spiritual mangrove bushes and thrusts a reed within the ground upon the path of the ghost as a warning not to pass the spot. Should the ghost be brave he raises his club in defiance, whereupon Samuyalo appears, club in hand, and gives battle. If killed in this combat, the ghost is cooked and eaten by the soul killer, and if wounded he must wander forever among the mountains, but if the ghost be victorious over the god he may pass on to be questioned by Ndengei, who may consign him either to Mburotu, the highest heaven, or drop him over a precipice into a somewhat inferior but still tolerable abode, Murimuria. This Ndengei does in accordance with the caprice of the moment and without reference either to the virtues or the faults of the deceased. Thus of those who die only a few can enter the higher heaven for the Great Woman and the Soul destroyer overcome the greater number of those who dare to face them. As for the victims of cannibal feasts, their souls are devoured by the gods when their bodies are eaten by man.

In temperament and ambitions the spirits of the dead remained as they were upon earth, but of more monstrous growth in all respects, resembling giants greater and more vicious than man. War and cannibalism still prevailed in heaven, and the character of the inhabitants seems to have been fiendish or contemptible as on earth; for the spirits of women who were not tattooed were unceasingly pursued by their more fortunate sisters, who tore their bodies with sharp shells, often making mince-meat of them for the gods to eat. Also the shade of any one whose ears had not been pierced was condemned to carry a masi log over his shoulder and submit to the eternal ridicule of his fellow spirits.

Altogether, this religion seems to have been as sordid, brutal and vicious as was the ancestral negroid stock of the Fijians. Connected with it there was, however, a rude mythology, clumsy but romantic, too much of which has been lost; for the natives of to-day have largely forgotten its stories or are ashamed to repeat it to the whites. In recent times the natives have tended to make their folk-lore conform to Biblical stories, or to adapt them to conditions of the present day. The interesting subject of the lingering influence of old beliefs upon the life of the natives of to-day has engaged the attention of Basil Thomson in "The Fijians, a Study of the Decay of Custom."

As in every British colony, the people are taught to respect the law. Sentences of imprisonment are meted out to natives for personal offences which if committed by white men would be punished by small fines, but the reason for this is that in the old native days such acts were avenged by murder, and it is to prevent crime that a prison term has been ordained. The natives take their imprisonment precisely as boys in boarding school regard a flogging, the victim commonly becoming quite a hero and losing no caste among his fellows. Indeed it is a common sight to see bands of from four to eight stalwart "convicts" a mile or more from the prison marching unguarded through the woods as they sing merrily on their way "home" to the jail. Once I recall seeing two hundred prisoners, all armed with long knives, engaged in cutting weeds along the roadside, chanting happily as they slashed, while a solitary native dressed only in a waist-cloth and armed only with a club stood guard at one end of the line, and this not near the prison, but in a lonely wood fully a mile from the nearest house.

In 1874, the British undertook the unique task of civilizing without exploiting a barbarous and degraded race which was drifting hopelessly into ruin. They began the solution of this complex problem by arresting the entire race and immuring them within the protecting walls of a system which recognized as its cardinal principle that the natives were unfit to think or act for themselves. For a generation the Fijians have been in a prison wherein they have become the happiest and best behaved captives upon earth. During this time they have become reconciled to a life of peace, and have forgotten the taste of human flesh; and while they cherish no love for the white man, they feel the might of his law and know that his decrees are as finalities of fate. All are serving life sentences to the white man's will, and the fire of their old ambition has cooled into the dull embers of resignation and then died into the apathy of contentment with things that are. Worse still, they have grown fond of their prison world, and the most pessimistic feature in the Fijian situation of to-day is the evident fact that there is almost no discontent among the natives. Old things have withered and decayed, but new ambition has not been born.

It is in no spirit of criticism of British policy that I have written the above paragraph for it was absolutely necessary that the race should "calm down" for a generation at least before it could be trusted to arise. Now, however, there are no more old chiefs whose memories hark back to days of savagery, and now for the first and only time has come the critical period in the unique governmental experiment the British have undertaken to perform, for now is the time when the child must learn to walk alone and the support of guardian arms must in kindness be withdrawn, else there must be nurtured but a cripple, not a man.

Among the generation of to-day the light of a new ambition must appear in Fiji or the race shall dwindle to its death. No real progress has been made by the Fijians; they have received much from their teachers, but have given nothing in return. They are in the position of a youth whose schooling has just been finished, life and action lie before him; will he awaken to his responsibility, develop his latent talent, character and power, and recompense his teachers by achievement, or will he sink into the apathy of a vile content?

The situation in Fiji is one of peculiar delicacy for the desire for better things must arise among the Fijians themselves, and should it once appear, the paternalism of the present government must be wisely withdrawn to permit of more and more freedom in proportion as the natives may become competent to think and act rightly for themselves. A cardinal difficulty is the unfortunate fact that the natives DESIRE no change, and even if individually discontented and ambitious, they know of no profession, arts or trades to which they might turn with hope of fortune. The establishment of manual training schools wherein money-making trades should be taught, if possible BY NATIVE teachers, is sorely needed in Fiji.

At present there is too little freedom of thought in Fiji; fear of the chief and of Samuyalo's club has been replaced by fear of the European and his hell. Free, fearless thought is the father of high action, and while their minds remain steeped in an apathy of dread there can be no soil in which the seed of independence can germinate.

Yet it is still possible that the Fijians may attain civilization. Of all the archipelagoes of Polynesia, Fiji alone may still be called the "Isles of Hope." As one who has known and grown to love these honest, hospitable, simple people, I can only hope that the day is not far distant when a leader may arise among them who will turn their faces toward the light of a brighter sky, and their hands to a worthier task than has ever yet been performed in Polynesia.

Yet why civilize them? Often does one ask oneself this question, but the answer comes as the voice of fate, "they must attain civilization or they must die." Should the population continue to decline at its present rate, the time is imminent when the dark-skinned men of Fiji will be not the natives, but the swarming progeny of the coolies of Calcutta.

Nowhere over all the wide Pacific have the natives been more wisely or unselfishly ruled than in Fiji, yet even here native life seems to be growing less and less purposeful year by year. In time it is hoped a reaction may set in and that with the decline of communism new ambitions may replace the old, but then will come the problem of the rich and the poor—a thing unknown in Fijian life to-day.

Hardly the first lessons in civilization have been taught in Polynesia, yet who can predict the noon day, should even the faintest glow appear in native hope. In former ages the Japanese were a barbarous insular people, and as in our own civilization the traditions and habits of rude Aryan ancestors still color our fundamental thoughts so in Japan we find evidences of a culture essentially similar to that of the Pacific Islands of to-day. The ancient ancestor worship of Japan is strangely like that of the tropical Pacific with its gods, the ghosts of long departed chiefs, and its high chief a living god to-day. Moreover in the Pacific Islands the house consists of but a single room, and such to-day is essentially the case in Japan, save only that delicate paper screens divide its originally unitary floor-space into temporary compartments. As in the South Seas, matting still covers the floor of the Japanese house, its roof is thatched, and is constructed before the sides are made, there is no chimney, the fire-place is an earthen space upon the floor or is sustained within an artistically molded bronze brazier, the refined descendant of the cruder hearth. In Polynesia as in Japan one seats oneself anywhere in tailor-fashion upon the floor, and upon this floor the meals are served, and here one sleeps at night, nor will the women partake of food in the presence of the men. In essential fundamental things of life the Japanese show their kinship in custom and tradition to the insular peoples of Asiatic origin now occupying the Pacific, and if Japan has attained to so great a height in culture and civilization, why may we not hope for better days for the South Sea Islanders?

WAR SELECTION IN THE ANCIENT WORLD

BY CHANCELLOR DAVID STARR JORDAN

LELAND STANFORD JUNIOR UNIVERSITY

"The human harvest was bad!" Thus the historian sums up the conditions in Rome in the days of the good emperor, Marcus Aurelius. By this he meant that while population and wealth were increasing, manhood had failed. There were men enough in the streets, men enough in the camps, menial laborers enough and idlers enough, but of good soldiers there were too few. For the business of the state, which in those days was mainly war, its men were inadequate.

In recognition of this condition we touch again the overshadowing fact in the history of Europe, the effect of "military selection" on the human breed.

In rapid survey of the evidence brought from history one must paint the picture, such as it is, with a broad brush, not attempting to treat exceptions and qualifications, for which this article has no space and concerning which records yield no data. Such exceptions, if fully understood, would only prove the rule. The evil effects of military selection and its associated influences have long been recognized in theory by certain students of social evolution. But the ideas derived from the sane application of our knowledge of Darwinism to history are even now just beginning to penetrate the current literature of war and peace. In public affairs most nations have followed the principle of opportunism, "striking while the iron is hot," without regard to future results, whether of financial exhaustion or of race impoverishment.

The recorded history of Rome begins with small and vigorous tribes inhabiting the flanks of the Apennines and the valleys down to the sea, and blending together to form the Roman republic. They were men of courage and men of action, virile, austere, severe and dominant.[1] They were men who "looked on none as their superior and none as their inferior." For this reason, Rome was long a republic. Free-born men control their own destinies. "The fault," says Cassius, "is not in our stars, but in ourselves that we are underlings." Thus in freedom, when Rome was small without glory, without riches, without colonies and without slaves, she laid the foundations of greatness.

[1] Virilis, austerus, severus, dominous, good old words applied by Romans to themselves.

But little by little the spirit of freedom gave way to that of domination. Conscious of power, men sought to exercise it, not on themselves but on one another. Little by little this meant aggression, suppression, plunder, struggle, glory and all that goes with the pomp and circumstance of war. So the individuality in the mass was lost in the aggrandizement of the few. Independence was swallowed up in ambition and patriotism came to have a new meaning, being transferred from hearth and home to the camp and the army.

In the subsequent history of Rome, we have now to consider only a single factor, the reversal of selection." In Rome's conquests, Vir, the real man, went forth to battle and foreign invasion; Homo, the human being, remained on the farm and in the workshop and begat the new generations. "Vir gave place to Homo," says the Latin author. Men of good stock were replaced by the sons of slaves and camp-followers, the riff-raff of those the army sucked in but could not use.

The Fall of Rome was due not to luxury, effeminacy or corruption, not to Nero's or Caligula's wickedness, nor to the futility of Constantine's descendants. It began at Philippi, where the spirit of domination overcame the spirit of freedom. It was forecast still earlier in the rise of consuls and triumvirs incident to the thinning out of the sturdy and self-sufficient strains who brooked no arbitrary rule. While the best men were falling in war, civil or foreign, or remained behind in faraway colonies, the stock at home went on repeating its weakling parentage. A condition significant in Roman history is marked by the gradual swelling of the mob, with the rise in authority of the Emperor who was the mob's exponent. Increase of arbitrary power went with the growing weakness of the Romans themselves. Always the "Emperor" serves as a sort of historical barometer by which to measure the abasement of the people. The concentrated power of Julius Caesar, resting on his own tremendous personality, showed that the days of Cincinnatus and of Junius Brutus were past. The strength of Augustus rested likewise in personality. The rising authority of later emperors had its roots in the ineffectiveness of the mob, until it came to pass that "the little finger of Constantine was thicker than the loins of Augustus." This was due not to Constantine's force, but to the continued reversal of selection among the people over whom he ruled. The emperor, no longer the strong man holding in check all lesser men and organizations, became the creature of the mob; and "the mob, intoxicated with its own work, worshipped him as divine." Doubtless the last emperor, Augustulus Romulus, before the Goths threw him into the scrap-heap of history, was regarded by the mob and himself as the most god-like of the whole succession.

The Romans of the Republic might perhaps have made a history very different. Had they held aloof from world-conquering schemes Rome might have remained a republic, enduring even down to our day. The seeds of Rome's fall lay not in race nor in form of government, nor in wealth nor in senility, but in the influences by which the best men were cut off from parenthood, leaving its own weaker strains and strains of lower races to be fathers of coming generations.

"The Roman Empire," says Professor Seely, "perished for want of men." Even Julius Caesar notes the dire scarcity of men, while at the same time there were people enough. The population steadily grew; Rome was filling up like an overflowing marsh. Men of a certain type were plenty, but self-reliant farmers, "the hardy dwellers on the flanks of the Apennines," men of the early Roman days, these were fast going, and with the change in type of population came the turn in Roman history.

The mainspring of the Roman army for centuries has been the patient strength and courage, capacity for enduring hardships, instinctive submission to military discipline of the population that lined the Apennines.

"The effect of the wars was that the ranks of the small farmers were decimated, while the number of slaves who did not serve in the army multiplied," says Professor Bury. Thus "Vir gave place to Homo," thus the mob filled Rome and the mob-hero rose to the imperial throne. No wonder that Constantine seemed greater than Augustus. No wonder that "if Tiberius chastised his subjects with whips, Valentinian chastised them with scorpions."[2]

[2] The point of this is that the cruel Tiberius was less severe on the Romans of his day than was the relatively benevolent Valentinian on his decadent people.

With Marcus Aurelius and the Antonines came a "period of sterility and barrenness in human beings." Bounties were offered for marriage. Penalties were devised against race-suicide. "Marriage," says Metellus, "is a duty which, however painful, every citizen ought manfully to discharge." Wars were conducted in the face of a declining birth-rate, and the decline in quality and quantity in the human breed engaged very early the attention of Roman statesmen. Deficiencies of numbers were made up by immigration, willing or enforced. Failure in quality was beyond remedy.

Says Professor Zumpt:

'Government having assumed godhead, took at the same time the appurtenances of it. Officials multiplied. Subjects lost their rights. Abject fear paralyzed the people and those that ruled were intoxicated with insolence and cruelty.... The worst government is that which is most worshipped as divine. . . . The emperor possessed in the army an overwhelming force over which citizens had no influence, which was totally deaf to reason or eloquence, which had no patriotism because it had no country, which had no humanity because it had no domestic ties. . . . There runs through Roman literature a brigand's and barbarian's contempt for honest industry. . . . Roman civilization was not a creative kind, it was military, that is, destructive.'

What was the end of it all? The nation bred Romans no more. To cultivate the Roman fields "whole tribes were borrowed." The man with quick eye and strong arm gave place to the slave, the scullion, the pariah, whose lot is fixed because in him there lies no power to alter it. So at last the Roman world, devoid of power to resist, was overwhelmed by the swarming Ostrogoths.

The barbarian settled and peopled the empire rather than conquered it. It was the weakness of war-worn Rome that gave the Germanic races their first opportunity.

"The nation is like a bee," wisely observes Bernard Shaw, "as it stings it dies."

In his monumental history of the "Downfall of the Ancient World" (Der Untergang der Antikenwelt) Dr. Otto Seeck of the University of Munster in Westphalia, treats in detail the causes of such decline. He first calls attention to the intellectual stagnation which came over the Roman Empire about the beginning of the Christian Era. This manifested itself in all fields of intellectual activity. No new idea of any importance was advanced in science nor in technical and political studies. In the realm of literature and art also one finds a complete lack of originality and a tendency to imitate older models. All this Seeck asserts, was brought about by the continuous "rooting out (Ausrottung) of the best"[3] through war.

[3] "Die Ausrottung der Besten, die jenen schwacheren Volken die Vernichtung brachte, hat die starken Germanen erst befahigt, auf den Trummern der antiken Welt neue dauerende Gemeinschaften zu errichten." Seeck.

Such extermination which took place in Greece as well as in Rome, was due to persistent internal conflicts, the constant murderous struggle going on between political parties, in which, in rapid succession, first one and then the other was victorious. The custom of the victors being to kill and banish the leaders and all prominent men in the defeated party, often destroying their children as well, it is evident that in time every strain distinguished for moral courage, initiative or intellectual strength was exterminated. By such a systematic killing off of men of initiative and brains, the intellectual level of a nation must necessarily be lowered more and more. In Rome as in Greece observes Seeck:

'A wealth of force of spirit went down in the suicidal wars. . . . In Rome, Marius and Cinna slew the aristocrats by hundreds and thousands. Sulla destroyed the democrats, and not less thoroughly. Whatever of strong blood survived, fell as an offering to the proscription of the Triumvirate. . . . The Romans had less of spontaneous force to lose than the Greeks. Thus desolation came sooner to them. Whoever was bold enough to rise politically in Rome was almost without exception thrown to the ground. ONLY COWARDS REMAINED, AND FROM THEIR BLOOD CAME FORWARD THE NEW GENERATIONS.[4] Cowardice showed itself in lack of originality and in slavish following of masters and traditions.'

[4] Author's italics.

Certain authors, following Varro, have maintained that Rome died a "natural death," the normal result of old age. It is mere fancy to suppose that nations have their birth, their maturity and their decline under an inexorable law like that which determines the life history of the individual. A nation is a body of living men. It may be broken up if wrongly led or attacked by a superior force. When its proportion of men of initiative or character is reduced, its future will necessarily be a resultant of the forces that are left.

Dr. Seeck speaks with especial scorn of the idea that Rome died of "old age." He also repudiates the theory that her fall was due to the corruption of luxury, neglect of military tactics or over-diffusion of culture.

'It is inconceivable that the mass of Romans suffered from over-culture.[5] In condemning the sinful luxury of wealthy Romans we forget that the trade-lords of the fifteenth and sixteenth centuries were scarcely inferior in this regard to Lucullus and Apicius, their waste and luxury not constituting the slightest check to the advance of the nations to which these men belonged. The people who lived in luxury in Rome were scattered more thinly than in any modern state of Europe. The masses lived at all times more poorly and frugally because they could do nothing else. Can we conceive that a war force of untold millions of people is rendered effeminate by the luxury of a few hundreds? . . . Too long have historians looked on the rich and noble as marking the fate of the world. Half the Roman Empire was made up of rough barbarians untouched by Greek or Roman culture.

Whatever the remote and ultimate cause may have been, the immediate cause to which the fall of the empire can be traced is a physical, not a moral decay. In valor, discipline and science the Roman armies remained what they had always been, and the peasant emperors of Illyricum were worthy successors of Cincinnatus and Calus Marius. But the problem was, how to replenish those armies. Men were wanting. The empire perished for want of men.'

[5] "Damitsprechend hat man das Wort `Ueberkultur' uberhaupt erfunden, als wenn ein zu grosses Maass von Kultur uberhaupt denkbar ware."

In a volume entitled "Race or Mongrel" published as I write these pages, Dr. Alfred P. Schultz of New York, author of "The End of Darwinism," takes essentially the same series of facts as to the fall of Rome and draws from them a somewhat different conclusion. In his judgment the cause was due to "bastardy," to the mixing of Roman blood with that of neighboring and subjective races. To my mind, bastardy was the result and not the cause of Rome's decline, inferior and subject races having been sucked into Rome to fill the vacuum left as the Romans themselves perished in war. The continuous killing of the best left room for the "post-Roman herd," who once sold the imperial throne at auction to the highest bidder. As the Romans vanished through warfare at home and abroad, came an inrush of foreign blood from all regions roundabout. As Schultz graphically states:

'The degeneration and depravity of the mongrels was so great that they deified the emperors. And many of the emperors were of a character so vile that their deification proves that the post-Roman soul must have been more depraved than that of the Egyptian mongrel, who deified nothing lower than dogs, cats, crocodiles, bugs and vegetables.'

It must not be overlooked, however, that the Roman race was never a pure race. It was a union of strong elements of frontier democratic peoples, Sabines, Umbrians, Sicilians, Etruscans, Greeks, being blended in republican Rome. Whatever the origins, the worst outlived the best, mingling at last with the odds and ends of Imperial slavery, the "Sewage of Races" ("cloaca gentium") left at the Fall.

Gibbon says:

'This diminutive stature of mankind was daily sinking below the old standard and the Roman world was indeed peopled by a race of pygmies when the fierce giants of the north broke in and mended the puny breed. They restored the manly spirit of freedom and after the revolutions of ten centuries, freedom became the parent of taste and science.'

But again, the redeemed Italian was of no purer blood than the post-Roman-Ostrogoth ancestry from which he sprang. The "puny Roman" of the days of Theodoric owed his inheritance to the cross of Roman weaklings with Roman slaves. He was not weak because he was "mongrel" but because he sprang from bad stock on both sides. The Ostrogoth and the Lombard who tyrannized over him brought in a great strain of sterner stuff, followed by crosses with captive and slave such as always accompany conquest. To understand the fall of Rome one must consider the disastrous effects of crossings of this sort. Neither can one overlook the waste of war which made them inevitable through the wholesale influx of inferior tribes. Neither can one speak of the Roman, the Italian, the Spaniard, the French, the Roumanian, nor of any of the so-called "Latin" peoples as representing a simple pure stock, or as being, except in language, direct descendants of those ancient Latins who constituted the Roman Republic. The failure of Rome arose not from hybridization, but from the wretched quality on both sides of its mongrel stock, descendants of Romans unfit for war and of base immigrants that had filled the vacancies.

Greece.—Once Greece led the world in intellectual pursuits, in art, in poetry, in philosophy. A large and vital part of European culture is rooted directly in the language and thought of Athens. The most beautiful edifice in the world was the Peace Palace of the Parthenon, erected by Pericles, to celebrate the end of Greece's suicidal wars. This endured 2,187 years, to be wrecked at last (1687) in Turkish hands by the Christian bombs of the Venetian Republic.

But the glory of Greece had passed away long before the fall of the Parthenon. Its cause was the one cause of all such downfalls—the extinction of strong men by war. At the best, the civilization of Greece was built on slavery, one freeman to ten slaves. And when the freemen were destroyed, the slaves, an original Mediterranean stock, overspread the territory of Hellas along with the Bulgarians, Albanians and Vlachs, barbarians crowding down from the north.

The Grecian language still lives, the tongue of a spirited and rising modern people. But the Greeks of the classic period—the Hellenes of literature, art and philosophy—will never be known again. Says Mr. W. H. Ireland:

'Most of the old Greek race has been swept away, and the country is now inhabited by persons of Slavonic descent. Indeed, there is a strong ground for the statement that there was more of the old heroic blood of Hellas in the Turkish army of Edhem Pasha than in the soldiers of King George.'

The modern Greek has been called a "Byzantinized Slav." King George himself and Constantine his son are only aliens placed on the Grecian throne to suit the convenience of outer powers, being in fact descendants of tribes which to the ancient Greeks were merely barbarians.

It is maintained that the modern Greeks are in the main the descendants of the population that inhabited Greece in the earlier centuries of Byzantine rule. Owing to the operation of various causes, historical, social and economic, that population was composed of many heterogeneous elements and represented in very limited degree the race which repulsed the Persians and built the Parthenon. The internecine conflicts of the Greek communities, wars with foreign powers, and the deadly struggles of factions in the various cities had to a large extent obliterated the old race of free citizens by the beginning of Roman period. The extermination of the Plataeans by the Spartans and of the Melians by the Athenians during the Peloponnesian war, the proscription of the Athenian citizens after the war, the massacre of the Coreyrean oligarchs by the democratic party, the slaughter of the Thebans by Alexander and of the Corinthians by Mummius are among the more familiar instances of the catastrophes which overtook the civic element in the Greek cities. The void can only have been filled from the ranks of the metics or resident aliens and of the descendants of the far more numerous slave population. In the classic period four fifths of the population of Attica were slaves; of the remainder, half were meties In A.D. 100 only three thousand free arm-bearing men were in Greece. (James D. Bourchier.)

The constant little struggles of the Greeks among themselves made no great showing as to numbers compared to other wars, but they wiped out the most valuable people, the best blood, the most promising heredity on earth. This cost the world more than the killing of millions of barbarians. In two centuries there were born under the shadow of the Parthenon more men of genius than the Roman Empire had in its whole existence. Yet this empire included all the civilized world, even Greece herself. (La Pouge.)

The downfall of Greece,[6] like that of Rome, has been ascribed by Schultz to the crossing of the Greeks with the barbaric races which flocked into Hellas from every side. These resident aliens, or metics, steadily increased in number as the free Greeks disappeared. Selected slaves or helots were then made free in order to furnish fighting men, and again as these fell their places were taken by immigrants.

[6] Certain recent writers who find in environment the causes of the rise and fall of nations, ascribe the failure of Greece to the introduction in Athens and Sparta of the malaria-bearing mosquito. As to the facts in question, we have little evidence. But while the prevalence of malaria may have affected the general activity of the people, it could in no way have obliterated the mental leadership which made the strength of classic Hellas, nor could it have injected its poison into the stream of Greek heredity.

It is doubtless true at this day that "no race inhabits Greece," and the main difference between Greeks and other Balkan peoples is that, inhabiting the mountains and valleys of Hellas, they speak in dialects of the ancient tongue. Environment, except through selection and segregation, can not alter race inheritance and the modern "Greeks" have not been changed by it. Schultz observes:

'We are told that the Hellenes owed their greatness largely to the country it was their fortune to dwell in. To that same country, with the same wonderful coast line and harbors, mountains and brooks, and the same sun of Homer, the modern Greeks owe their nothingness.'

In other words, it is quite true that the Greece of Pericles owed its strength to Greek blood, not to Hellenic scenery. When all the good Greek blood was spent in suicidal wars, only slaves and foreign-born were left. " 'Tis Greece, but living Greece no more."[7]

[7] In contrasting a new race with the old—as the modern Greeks with the incomparable Hellenes—we must not be unjust to the men of to-day whose limitations are evident, contrasted with a race we know mainly by its finest examples. In spite of poverty, touchiness and vanity characteristic of the modern Greek, there is good stuff in him. He is frank, hopeful, enthusiastic. The mountain Greek, at least, knows the value of freedom, and has more than once put up a brave fight for it. The valleys breed subserviency, and the Greeks of Thessaly are said to be less independent than the mountain-born.

Furthermore, we do not know that even the first Hellenes of Mycenae were an unmixed race, or that any unmixed races ever rose to such prominence as to command the world's attention. We do know that when war depletes a nation slaves and foreigners come in to fill the vacuum, and that the decline of a great race in history has always been accompanied by a debasing of its blood.

Yet out of this decadence natural selection may in time bring forward better strains, and with normal conditions of security and peace nature may begin again her work of recuperation.

In the fall of Greece we have another count against war, scarcely realized until the facts of Louvain and Malines, of Rheims and Ypres, have brought it again so vividly before us. War respects nothing, while the human soul increasingly demands veneration for its own noble and beautiful achievements. As I write this, there rise before me the paintings in the "Neue Pinakothek" at Munich, representing the twenty-one Cities of Ancient Greece, from Sparta to Salamis, from Eleusis to Corinth, not as they were, "in the glory which was Greece," not as they are now, largely fishing hamlets by the blue Aegean Sea, but as ruined arches and broken columns half hid in the ashes of war, wars which blotted out Greece from world history.

ANTI-SUFFRAGISTS AND WAR

BY ELSIE CLEWS PARSONS

NEW YORK CITY

ONE of the most curious of those misstatements of fact and confusions of thought the conservative seems even more prone to make than the radical has to do with a certain suppositiously historical relation between women and war. It is assumed[1] that early society is ever militant and that because of its militarism it excludes women, women not being fighters, not only from its government, but from all its privileges, even making of them its drudges and its beasts of burden. And so, argues the conservative, women are for the same reasons disfranchised, and properly disfranchised, to-day. Whether more or less militant than it was, society is still founded on force, and because women are not as strong as men, men will not give them the vote. Besides it is only right, since they can not fight, they should not vote. It has always been so, and so it should continue to be, at any rate until war becomes a thing of the past, and that will never be, you can't change human nature, etc., etc.

[1] And, let us admit, not merely by the conservative anti-feminist. As radical and discerning a feminist as Thomas Wentworth Higginson, after asserting that physical strength was once "sole ruler," cites in agreement Walter Bagehot's reference to "the contempt for physical weakness and for women which marks early society." ("Women and the Alphabet," p. 49. Boston and New York, 1900.)

There are of course various answers to this militarist anti-suffrage argument, answers which in spite of the logic of current events are still likely to be satisfactory or not according to previous convictions, but the only point I wish to challenge is the appeal in this connection to the past. Let the militarist anti-suffragist assert his belief in government by force if he likes, but let him not try to justify it by the precedents of primitive life. Nor may he—or she—explain the exclusion of women to-day as a survival of their subjection in primitive society to brute force. The government of primitive society is not based on physical prowess, and although modern woman is excluded from men's activities for the same reason as primitive woman was excluded, the reason is not muscular inferiority.

It is a pity in the feminist controversies of the last hundred years or so that the "exclusion of women" did not become a more popular phrase than the "subjection of women." That term gave a fallacious twist both to observation and analysis. Primitive and modern men alike commonly EXCLUDE women, they seldom subject them. Similarly, in some societies, children and young people, all in fact but the elderly, are treated to methods of exclusion rather than of subjection.

Early society is dominated by the elders; its practices and customs have been determined by them and, in the most primitive society, government is nothing but a gerontocracy, a government of old men. Even with chieftaincy the council of the elders is weighty and the heads of households have considerable influence. Are the elders the fighters or raiders of the tribe? No, they are its judges, its legislators and, most important of all, its magicians. Nor is the chief or king the fighter par excellence of the tribe. But he too may be and often is the tribal magician. Through their powers of magic elders and chiefs are responsible for the weather, for the reproduction of plants and animals, for the success of the crops, of hunts and catches, for the health and general welfare of the people. And in war? In war they are the most important personages too. Because they fight? No, because in war too they make magic; they charm the approaches to the village, they "doctor" the trails or the weapons or the canoes, they make war medicine, they invoke and propitiate the war gods. The warriors are the younger men, men whose efforts would be vain without the backing of their magic-working seniors or chiefs. The elders make peace and declare war. And it is at their dictate that the young men take to head-hunting or to raiding or even to stealing women.

As to the subjection of women, what exists of it the elders are responsible for. It is they who scare a girl or shame her into being docile. It is they who marry her off against her will, it is they who set her unending tasks or shut her up in idleness. It is they who make her undergo the discomforts or miseries of what we call conventional life or bully her into exile or death.

With this control of girls or women the warriors, the "standing army," have little or nothing to do, even less in primitive life than in modern. It is the old people, the old women at times as well as the old men. Again it is the old men who are leaders in the exclusion of the women. In control of the initiation of the youths, they separate them from their mothers or sisters and often decree for the initiates a ceremonial avoidance of all women for a set time. The penalties they threaten—sickness, decrepitude, effeminacy—are too dire to pass unheeded. This "avoidance" has been explained as due to the monopolistic spirit of the elders. With their women they want no interference by the youths. But a far more plausible explanation, I think, takes the avoidance as a concentration rite, so to speak, a symbol, if you like, of the life ahead, the life in which the boys, "made" men, are going to have little to do in public with women. For even after the special avoidance of the initiation period ends, the segregation of the sexes continues. Men keep together and away from women in their club-houses, and in all the places of assembly which are differentiated from the primitive club-house—the church, the council, the workshop, the gymnasium, the university, the play-house. And from all the interests which center in these places men have from time to time excluded women, they have excluded them from magic and religion, from arts and letters, from games, from politics and, let me add, from war.

Why are men so exclusive? Because—the reason will seem almost too simple, I fear, for acceptance—because now and always men do not want to be bothered by women. Women get in our way, they say, women are a nuisance. Almost anywhere away from home women are a nuisance—in church organization, in the university, in business, etc. Of course if women can be kept apart from us in these activities and will stay in their place, if they join an order of nuns or deaconesses, if they go to a separate college in the university, if they will become good stenographers, we don't mind having their cooperation, we welcome it. Women may even go to war—as an absolutely separate division of the army, said the men of Dahomi, as non-combatant pahia women or workers of magic, said the Roro-speaking tribesmen of New Guinea, or as Red (dross nurses, say the men of Europe and America. If we men can be sure women will not interfere with us, we really do not mind. Women have only to give us that assurance of non-interference to make us doubt the assertion we sometimes make that in going to war they are interfering with the order of nature.

AN INTERPRETATION OF SLAVOPHILISM

BY ARTHUR D. REES

PHILADELPHIA, PA.

THERE are good reasons for believing that the Russians are practically the greatest peace people in Christendom. They are the least commercial in the competitive sense, the least capitalistic also, and as a people, the least combative in Europe, despite the wrecks of warring dynasties that ten centuries have left upon their plains and the miscellaneous strifes and calamities of all kinds that have beset them.

Always expanding along lines of least resistance; absorbing by comparatively petty conquests, decaying or scanty peoples; reaching Kamchatka in the Far East with more ease than she reached the shores of the Baltic; never flinging her legions far and wide victoriously as did Rome, Spain, France or Great Britain—Russia remains to-day, for the most part, humble, and, in reality, a conquered people, living, dreaming and preaching a morality born both of this humility and of the physical environment that has helped to foster it. All Muscovy can not be judged by those few who live in the saddle—the Cossack population, men and women, numbers only about two million—nor by the pitiable pageant of despotism the observer beholds in their land: pogroms, poverty, disease, distress, militarism, orthodoxy and Pan-Slavism. Russia has a soul in spite of these; a gentle and beautiful soul, only half revealed, and too much concealed by her dilapidation and her dilemma; a peaceful soul, abnormally humble and devout, and in respect to these qualities unequalled in Christendom.

Since the age of Vladimir the Holy, "The Beautiful Sun of Kief," in the tenth century, Russia has had the tradition of international peace. Vladimir wandered over the country, sword and battle ax in hand, like a reincarnation of Thor, armed with his mighty and wondrous hammer. Then came his yearning for a new religion—something to inspire his life better than Perun—Russia's old god of thunder—and the other idols, and a little later, the picturesque investigation of his peripatetic commissioners having been completed, he became a Christian of the Greek church, was baptized with many fine and grand ceremonies, compelled his docile people to do likewise, and, like a true Northman that he was—the great grandson of Rurik of the Baltic wilds—he so impressed his frowsy hordes, half Scythian and half Slav, that now in the hearts of their descendants, in their popular songs and legends, in those concerning Kief especially—a beautiful and pathetic strain of music eight centuries old—he, Vladimir, is still the central heroic figure; once a man, but now a kind of god, sent from Heaven to rule, enlighten and bring peace to his people and be known in story and song as "Vladimir the Holy, the Beautiful Sun of Kief."

An old chronicle describes for us how his hordes drank their cup of trembling at his hands. There, around about the low hills of the southern Dnieper River, probably on the crumbling sandstone cliffs of Kief—the city, studded with jewel-like legends and famed for its "golden palaces," stood his candidates for baptism; near by were priests from Constantinople, gorgeously arrayed, chanting, in strains unknown to the populace, the Greek church baptismal service. Then the democratic immersion!—rich man, poor man and all, at Vladimir's command, wade into the baptismal waters, some up to their knees, some to their waists, some to their necks, and, thus finding a new faith from Heaven, they crossed themselves for the first time as the thunder rolled on high! Here is Russia remembering her Creator in the days of her youth—and forgetting Him ever since; from then on, Holy Russia! Possibly Holy Vladimir, at any rate, for becoming, with that ceremony, peaceable, except for self-defence, he gave up all of his idols and his aggressive sword. The former he scourged and cast into the river, the latter he sheathed in its scabbard. And all this about 988—the first peace movement of Holy Russia. The faith of it, and its vision and dream came early in her history and have not yet gone out or been extinguished.

Before the next such movement, time enough passed by to give the seasons and the winds and rains full opportunity to whittle down old Kief's storied sandstone hills. In 1815, the much-expanded realm of Muscovy, then a partner in the holy alliance, proclaimed under Alexander the First, the ideal of peace. This Czar declared he would rule as a father over his children and in the interest of "justice, charity and peace," and, in so doing, created the leading precedent for the peace program of Nicolas the Second.

Alexander, who in the first half of his reign ruled liberally for the days of Napoleonic supremacy, no doubt was sincere in his desire to govern in the "spirit of brotherhood," but in the latter years of his power, he fell sadly short of this standard.

Alexander the Second, the emancipator of forty-six million serfs, may have had some world peace ideal in mind when he in 1874 promoted a conference in Brussels to codify the usages of war, but the reaction from his earlier liberalism was setting in about this time and, growing worse, led to his assassination in 1881.

The next move in the direction of peace came, as the world rather well knows, through the present Czar, Nicolas the Second, who on ascending the throne in 1894, proclaimed that Russia would rule in the interests of peace and would cultivate the arts of it. In 1898 followed the first call for a World Peace Conference, and in 1899 came another circular with a similar object.

But it is out of the kind heart of Muscovy, and from the troubled, humble and penitent soul of Russia that the real peace movement of her land has arisen. For many centuries calamities have been pouring upon her plains, profusely pouring—drought, famine and invasions without number; now Rurik and his Northmen to start the empire out of its prehistoric lethargy; their dynasty of conquering blood still sharing in the rulership of the land to-day; now the Tartars, remnants of whom with their high cheek bones are still visible in the Baltic provinces; particularly and always and ever poverty beyond description; poverty, disaster and conquest, like triple demons to humiliate the soul of Russia and keep her dumb for many centuries, except for the beauty of her unending song.

And out of these conditions of life has grown the peace morality that is native to the Russian people; out of their sorrows and their conquered plains, out of their broken hearts too, although the economic genesis of it all is very apparent.

The Russian people's Russia has ever been under the overlords heel, downtrodden years without number, and yet it is a land which has never produced a system of military tactics and training—forever dependent for these creations upon her neighbors; a land which has produced scarcely one great naval or military commander who to-day holds a place in history as do those of other nations; a land whose people have been usually led to slaughter like sheep by Northman or Teutonic or Polish generals; whose armies have never been noted for their great campaigns, and always have been poorly drilled, managed and fed, and never yet successful in any foreign wars. Surely from such a land as this, no widespread war-morality or world-conquering legions could come.

In fact the very reverse has come to pass: the philosophy of Slavophilism has arisen in Muscovy, yet not so much arisen as it has developed with the Russian soul, not as a thing apart, but as a quality thereof, blossoming somehow with all other Russian things, out of the primitive Scythian darkness. The rebellious spirit having been crushed out of the generations since, what is left but non-resistance? Yet in these latter years a resisting spirit, nursed and suckled largely in western Europe, has falsely made it appear that all Russia was in arms, storming with chaotic unity at the church, the state and the army, deluging their ancient customs with the destructive and re-creative might of radicalism. Far and wide of the truth is this! Let no one think the vast heart of Russia has changed! Only the few have cast away the ancient quiet; only the few have the modern consciousness instead of the medieval, theocratic one; only the few are not at heart Slavophiles in feeling and in morality.

This philosophy existed long in the national or social mind before it was crystallized into public doctrines, and exists even yet largely in its more primitive unworded or instinctive form, although it was Peter the Great who unconsciously awoke the latent and then unexpressed Slavophilic feelings and moralities when he, like a civilizing Pied Piper, charmed the chieftains of industry of Western Europe to follow his trail into Muscovy, his "Empire of Little Villages," and there regenerate them.

Therefore at about the end of the seventeenth century in Russia, the "dumb silent centuries" gradually became articulate in expressing their opposition to all things western. This is the heart of Slavophilism, and no one can truly fathom the Russian soul before understanding its philosophy. It is the Muscovite theory of the simple life, still crying out against the Great Peter's work and recalling the devotees of western culture to its idealization of medieval, theocratic, autocratic Russia.

Despite this reaction, however, it has a great meaning, a tender beauty, and a message of depth and power for our western world. Primarily Russia is a peasant and an agricultural land, and there is a colorless monotony in her vast plains. Indeed land and people are alike; as in the average peasant there is patience, resignation and submission, so there is in the very land itself. Open and prostrate it lies beneath the torrid sun of the south, and the arctic winds of the north; subdued and downtrodden for centuries, it and its people have always been at the mercy of ruthless men and rainless winds.

Thus passive endurance has become one of the saving qualities of the Russian's soul. The peasant's nature is one that has few wants and little rebellious power. The Greek church of the simple gospel is his and a government of the Czar's will. His power of self renunciation is one which in Slavophilic thought gives him true liberty. Therefore ask the followers of this doctrine, what need is there of the constitutional liberties of the west, or its republics or limited monarchies, or its differences in ecclesiastical faith and structure? Slavophilism declares that Russia has the only true freedom, faith and brotherhood, which other lands sadly lack. In addition she has the ancient and splendid heritage of the communal land system, wherein the inherent justice of the Russian peasant's heart is shown by his voluntary division and re-division of the land among his brothers at stated times.

What need therefore, Slavophilism asks, for the degenerate justice of the west? None! Away with Europe then!—the Europe of competition and gruesome factories! The Europe of destructive forces, of greedy land grabbers, of capital and labor wars, where society is held together, not as in Russia by the ties of affection, brotherhood and communal interest, but only by money and greed, and where free thinkers, atheists and materialists abound, whose lives and thoughts would unsettle the holy, orthodox feelings of Russia, disturb her ancient conscience and poison her humility with murmurings of discontent and rebellion.

Away with the books of the west, too! And its agricultural implements! Wooden ploughs instead of chilled steel! Outdoor work and not indoor prisons called factories! Peasants working for centuries beneath the uncanopied sun, and on the floors without walls, will not let doors and brickwork thumbscrew their souls in confinement thus! Indoors awhile in winter will they labor, but spring airs shatter the moralities of the time-clock and away to the fields they rush; in the spring to sow and sing, in the summer to sing again and at the harvest time too, and then to plait the bearded stalks into wreaths and crown the maidens with sheaths of corn; the hymns for the "death of winter" and the "birth of spring," marriage songs and funeral dirges and chants of olden times well intermingled with the labor of their hands.

Herein the poetry of agricultural, peaceable Russia clashes with the prosaic efficiency of the west, the efficiency of commercial wars, strikes and class struggles which peasant Muscovy has known so little.

And again, Slavophilism, with its theory of successive civilizations, culled perhaps from the philosophy of Hegel, each civilization superior to its forerunner, comes to show us a vision: the gradual displacement of one type of society by another, but continuing what is best in the preceding until nothing except what is good remains and universal peace results, thus portraying the displacement of national civilizations by universal ones, from which ultimately an idealistic world policy will result, and the federation and peace of men.

Some Slavophiles saw even in Peter's work a process of progressing from nationality to universality. In his time there was the same yearning toward its peaceful ideal. The "Old Russia" party wanted Peter to renounce war and conquest. Alexis, his own murdered son, worked with this element which was very largely representative of the nation. To them, St. Petersburg, then a new and growing capitol, was typical of change, unrest and falsity; Moscow was in their hearts the only capital, typical of Russia's old comfort and quiet. Many nobles antagonized Peter, but he swept them aside, imprisoning them or sending them to the gallows. Like Russia's slight resistance to Rurik and others, and to the Tartars, so was her feebleness before Peter the Great, who was himself, however, by no means an accomplished military leader, but an enlightened barbarian, dealing with a people whom writers and observers declare to be endowed with conspicuous traits of humility, scarcely found in the Christian nations of the western world.

Russian fiction represents its people in the same way. Unaggressive characters, who talk and think but do not act, fill its novels; they dream of the great age of the "Universal Idea" that shall come for all and regenerate the "rotten west," where "rationalism is the original sin"; the typical west that Slavophilism condemns—the west of the struggles between the rulers and the ruled; between Scripture and tradition and the upper and lower classes. The Slavophile idea, in theory at least, leaves no room for this. Christian love and humility and peasant communes, where rationalism, strife and rebellion are unknown, must be instituted in the west; then the "Universal Idea" of Russia will create Millennial times. This was the "Messianic hope of Slavophilism," and perhaps is yet to a great degree destined in the minds of its devotees to give the last feature to the development of the world, so that the love and feeling of the east would appease the discord of the west, diluting its discipline and its logic with true religious intuition and humility, and eventually the idealized relationship of autocracy for the Czar and self-government for the people—the old system so rudely strained by Peter the Great—would permeate the ruled and rulers of the world.

Here then is Slavophilism! And pacific Russia—the heart and soul of her, claiming this to be the true ethical and spiritual ideal for her people, and censoring her upper class, with its foreign culture, materialism, and infidelity, as being the only real traitor to this saving morality of the ancient regime.

Among the prominent advocates of this philosophy might be mentioned, first, Constantine Aksakoff, Russia's Rousseau, who in the middle of the nineteenth century, was a virtuous propagandist of the doctrine. He earnestly, even religiously, preached the return of Russia from the allurements of western Europe, unto her own theory of national salvation, declaring that "the social order of the west is on a false foundation" and that Slavophilism would offset its degeneracy, if only Russia would free herself from the false class leadership for whose origin the Great Peter stands the convicted sponsor! Thus Slavophilism, under the leadership of Aksakoff, instead of leading forward with the great liberal movement that came after the Crimean War, resulting finally in the emancipation of the serfs, would lead backward to the stagnant hours of medieval Russia. Then there were no German words to disfigure the Russian language! Then there were no German divisions of rank among the officials to strangle life by their formality. No, none of these, nor the disturbing importations of Peter; in Aksakoff's variation of the gospel, the Russians are the "beyond men" and need them not. Thus before Peter's reign all was Slavophilic!—a religion of the simple Christian gospel, a church considering itself the only true ecclesia, a government of the Czar's will, a life of passive humility; creating freedom of conscience and speech for the peasants, and freedom of activity and legislation for the rulers, unknown in modern corrupted Russia!

And thus was old peaceable-hearted Muscovy of the past centuries pictured as the metropolis of true political and individual morality.

Herzen, too, an able pamphleteer in revolutionary things, preached something similar, crying from his pulpit at home or in exile, that Russia would solve all her problems and lead the human race by the simplicity of the Slavophile ideal. His early and rabid westernism was greatly tempered on contact with the west. Disillusion and disgust overcame him. The mercantilism of the bourgeoisie there drove him into Aksakoff's fold, and he too thereafter found faith alone in the "regenerative power of Russia," and her system of the mir, the central sun of the Slavophilic state, the village commune, self-governing and self-contained. And then from that, this was to ensue: the whole world made of village communes as in Russia, perhaps even their log cabins too, and fresh mud to go with them on their walls! But this did not deter the vision of these evangelists. The commune was to be indefinitely extended; national and international ones were to be organized, all self- governing, and then would follow as the night the day, universal peace wherever these communes were found.

This is the Utopia Russia has given to the world to stand beside Plato's, or Sir Thomas More's or Morris's or Bellamy's. This was the dream of pacific Pan-Slavism.

Dostoievsky himself is of it, and is luminous not with a mere facet flash of its philosophy but with the whole orb of it. To him the Russians "are more than human, they are pan-human."

Count Tolstoi too must be listed with these preachers. He, making his own shoes and cutting his own and the peasants' grain, lived it, showing how he thought the world's work ought to be done. What were factories or the culture of the west to him in later years—Shakespeare or no Shakespeare? Destructive ideals of life. Competition, money and land greed, self-assertion—all things that are the anthitheses of Slavophilism—he shunned; mocking the palsied heart and poisoned ideals of the west, and indeed of the "upper class" section of his own land as no other Slavophile did. And following its teaching, he journeyed through self-renunciation to freedom and communal life, after repentance for his wanderings, expiation and regeneration.

Dostoievsky, on the other hand, reached this philosophy largely by being born to it among the humble people who lived it. Melancholy-minded by nature—a sort of a Russian Dante but living in actual infernos and purgatorios, Siberia and prison cells, he came at last to worship his fellow countrymen and their ideals as almost nothing else in heaven or earth, and bowed down before them "as the only remnant left of Christian humility, destined by Providence to regenerate the world." Here is Slavophilism in a fervid extreme. "The Down-trodden and Offended," "Memoirs of a Dead House," "Crime and Punishment," "Poor People,"—these, the titles of his novels, show the predilections of his own soul. He died in the mystic frenzy of this enthusiasm.

Here then, in this philosophy and in the lives of these men, is something of the soul of Russia, beautiful in its humility, yet not so humble that it is not ambitious to embrace the world in the folding arms of its peace, its communal government and its morality. Pan-Slavism of this nature is the only kind that in truth can ever come from Russia. Pan-Slavism of the military sort, with musketry, bribery and all other diabolic black arts, miscalled government, rests on such a slim foundation that it need be but little apprehended.

It was this brotherly humble soul of Russia that greatly helped to put an end to the Russo-Japanese war: not merely failing finances and lack of transportation. The feeling of a kindly people for their own and a neighboring race caused widespread mismanagement, opposition and wholesale desertions from the army, among both the officers and the men. The Romanoff family and official Russia caused the conflict, but human Russia, humble and poor, was a great factor in its conclusion.

There is no doubt, however, that a certain number of Slavophiles are addicted to the military mania, and this form of their belief is more dangerously reactionary than its ordinary phase. Many of these belong to the bureaucratic caste. Official Russia holds aloft the eagle; human Russia the dove. Official Russia leads the anti-Jewish massacres; human Russia is very little responsible for pogroms. Ignatieff, "Father of Lies," a bureaucrat of the military Pan-Slavic breed, about 1882, began the worst persecutions against the Jews in the last generation, and possibly Pobiedonosteff, the late procurator of the Holy Synod, was the worst offender in this one. The peaceful feelings of the masses of the people, however, do not sanction these outbreaks, and Slavophilism of such a sort is not the philosophy of the Russian heart, no matter how many pogroms may be enumerated.

It is therefore to human Russia that one must look for the true feelings of the people; to their faith and deeds, to the humility of their devotions, and prostrations before their numberless shrines and ikons, to their religious ceremonies in the open fields for huge detachments of the army, to the thousands of their yearly pilgrims to Jerusalem, to their superstitions, their poverty and long-suffering, all of which attest innate passive endurance and non-resistance, and show their kind of Slavophilism, which all in all, is much more than "mere reverence for barbarism."

The war-time excitement in their cities seemed characteristic of this national soul: "Russia is the

Mother of Servia" was the street cry of the marching throngs. It might be added that the word mother, "matushka," is a prevalent one in expressing their feelings. They call their greatest river the "Mother Volga." Conquering Rome said "Father Tiber" and the native warriors of this continent called the Mississippi the "Father of Waters." The difference in these appellations shows the tender quality of the Russian soul, whose ardent sympathies in July, 1914, were greatly aroused by the spectacle of a large nation attacking a small one, notwithstanding whatever may be said to justify that deed.

Finally, however, let it be added, that the one thing that will recreate Russia in the image of the west, is capital. Once let the vast sums that have invaded Muscovy be put, not to the autocratic purpose of the official rulers, but into factories, mines, city subways and transportation of all kinds, irrigation, canals, agricultural implements and to other productive uses, then capitalistic Russia will stand forth shorn of the Slavophilic simplicities of non-resistance and humility. Labor wars, practically unknown hitherto, yet now beginning, will occur in much greater number and the peasant class, still unified, will be torn asunder by differences in wealth and interests; the middle class, now very small, will grow to large proportions, and many destructive forces will come upon the land which has hitherto mocked western Europe because of their presence there.

The many centuries of peasant unity, with its beauty of brotherhood, affection and communal interests, will come to an end under such a new regime. Already competitive forces are dissolving communism in land, and many of the old beauties of Russia are disappearing. Capitalism will bring with it much turmoil and strife, unhappiness and death, but also the dawn of brighter hours; newer and better cities, cleaner water, better food, houses and clothes, and after the stress of its first attack is over, and Russia has evolved laws and means to control and socialize the invader, it may be that the old simplicities and beauties of life will return, and a greater and holier Russia will arise, still able to teach and aid in the regeneration of the rest of the world.

PHYSICAL TRAINING AS MENTAL TRAINING

BY DR. J. H. McBRIDE

PASADENA, CALIFORNIA

THE first duty of a people is to provide for the health of its children. The possible human value of any country fifty years ahead depends chiefly upon what is done by and for its children. They are the future in the making.

History seems to justify the statement of Professor Tyler[1] that conquering races have been physically strong races, and that nations have failed when they became degenerate.

[1] Growth and Education," J. M. Tyler.

Dionysius, speaking of the advantage of virility in a nation, said,

It is a law of Nature common to all mankind, which no time shall annul or destroy, that those who have more strength and excellence shall bear rule over those who have less.

This law applies equally to individuals. Skill, cunning and reason play their part, but the animal quality of endurance is always back of these and is often decisive in a contest.

Darwin said he had difficulty in applying the law of the survival of the fittest to the facts of the destruction of Greece until it occurred to him that in this instance the strongest was the fittest. Civilized people's have been destroyed by ruder races that were physically superior.

The children that are now in our schools will take to adult life such foundation as heredity has furnished, with the equipment that society may care to add. We of this day have no greater obligation than to prepare these children mentally and physically for the duties that maturity may bring. Man did not escape the physical necessities of the body when he became civilized; the advantages of health are as great to-day as when our forebears lived in tents. Very few of the primitive man's activities are left; what he did regularly and from necessity we do incidentally, and usually for sport, and yet the demands upon the energies of man have not been lessened, they have only been changed in form.

Our educational authorities, though in many instances interested in physical development of the young, have not given the subject the important place in their program that it deserves. This is not wholly due to indifference, but largely to their ideals that were derived from classical-ascetic standards.

In the medieval ideal the human body was animal and sinful, to be despised and repressed. The mind was said to be the spiritual element in man, representing the immortal part of his nature, and therefore was the only part worthy of attention in an educational system. From the fall of the Roman empire to the later nineteenth century this ideal dominated education.

The medieval universities, including Oxford and Cambridge, provided only for mental training. Their education was intended for those who were to follow the professions or to become scholars or gentlemen of leisure. Education was not intended to prepare the great mass of men for the every-day work of life.

While only indirectly related to my subject, it is interesting to recall that there was in this country in the early nineteenth century much opposition to the establishment of common schools for the masses. It was claimed that those who belonged to the working classes did not need to be educated. Our own colleges and universities were originally founded on the old classical-ascetic model, so that the spirit of the medieval period survived in the educational plan of this country. It is only in recent decades that these institutions have begun to depart from the older, formal, classical methods that made education a privilege of the few, the average man being deprived of the advantages of the training that he needed. Because of this the humble millions of men and women who wove and spun, and fed and housed the world were left out of the educational scheme.

Some years ago a London weekly paper, which speaks for the conservative class of England, in discussing certain suggested innovations in English higher education, said that the great merit of education at Oxford and Cambridge was that it was "absolutely useless." By this it was probably meant that the education was for a chosen few, was not intended to prepare men for the practical work of life and was essentially and only an intellectual and cultural training.

The change of attitude that is seen in our day is due chiefly to two great discoveries: the re-discovery of the human body and its relation to our mentality and the discovery of the mind of the child and youth. We have found that man is an animal who graduated from caves and dugouts and to whom even barbarism was a lade and great achievement. That the human body was made by the experiences of that rude life, and that since then we have made no change in it except to stand on two feet. Neither have we added one nerve cell or fiber to our brains since the day when the cave was home and uncooked food the daily diet.

The conception of man as an animal has led to a study of him as such. Educators as a class now concede that the physical man must be considered as an essential part of their scheme, that the brain is an organ of the body among other organs, and is subject to the same laws and influenced by similar conditions.

The influence of the mind upon the body is a commonplace of psychology, but the influence of the body upon the mind is of equal importance, though less frequently emphasized.

Whatever one's theory of the nature of mind, it must be considered in relation to the brain as the organ of its expression. The mind has, too, a broader base than the brain, for every organ of the body has some share in the mental functions. Every physician knows that physical disease lowers the quality of the thinking and, with the exception of a few geniuses like Darwin and Leopardi, it makes impossible intellectual work of a high order. Disorders of the internal organs rob the brain of nourishment and weaken it, and by obtruding their morbidness upon it they batter down its resistances and lower the thinking power.

Though we can never know the history of man's origin, the lives of the child and of the wild man help us to understand something of the order of racial development. All the higher mental faculties grow in the child as they grew in the race—out of impulse, instinct, feeling; and from infancy to maturity we recapitulate mentally and physically the early human-making stages, short circuiting in twenty years the race-process.

The life of physical activity that the child leads develops and coordinates the brain and the muscular system. In this way the great motor functions are organized in the brain and become part of the physical basis of mind.

The older education that trained the intellect exclusively, without reference to the practical demands of life or the needs of the body, was inadequate in that it ignored the law of thinking and doing. It is true that there is much to its credit, as many fine spirits have testified. They at least survived it.

Stanley Hall says "we think in terms of muscular movement," and this expresses the most important single fact in the mature mentality. That the mind is largely constituted of memories of muscular movements is basic in development.

The muscles are the special organs of volition, the one part of the body that the mind can directly command and act on. The muscles are preeminently the mind's instruments, the visible and moving part of its machinery. They are thought carriers, and during the growth period their functional activities are organized into the mental life. This is why "we think in terms of muscular movement," and why muscular training supplies a natural need of the developing mind.

The normal boy says little or nothing of what he thinks, but much of what he is doing or intends to do. He has the motor mind, the instinct for doing things by which he builds the brain and body. It is nature's way of laying the foundation in the individual as by the more tedious process of evolution she laid it in the race. The mental development of the normal infant is indicated by the increasing accuracy and delicacy of muscular coordination. The feeble-minded child very early shows its mental defect in the clumsy use of its muscles. Because of the functional relation of the voluntary muscles and the mentality, physical training is in a large degree mental training. When by such training we give dexterity to muscles of the growing person we are making possible better mental development; that is, because of this relation of the mind to action there is a direct mental discipline in the thought-out processes of physical activity. If, then, we make physical development a part of our educational process, we are taking advantage of race tendencies, we are starting the individual as nature started the race; we are laying the foundation in the individual as it was originally laid in the race; we are building as the race built.

Exclusively intellectual training may be sufficient for the genius or for the few who have great initiative and intellectual self-confidence, but for the great mass of boys and girls this training is not sufficient. It does not prepare the young for the kind of work that three fourths of them will have to do. We are now beginning to recognize this and through manual training, vocational guidance, etc., we are teaching boys and girls how to do things, and this, too, has the additional merit of being, in a measure, physical training.

Educators, until recently, have, in emphasizing the paramount importance of mental training, lost sight of the needs of the body. Their classical ideals and formal methods made dead languages, mathematics, philosophy etc., the school diet of boys whose normal hunger was for action, and for learning by doing.

Sir William Hamilton, who wrote fairy tales in metaphysics for a generation of Scotchmen, placed these lines over the doorway of his lecture room.

In earth there 's nothing great but Man;
In Man there 's nothing great but Mind.

This sounds well, but it is poor philosophy. There is much in earth that is great besides man and much in man that is great besides his mind. The older type of metaphysician with his staggering vocabulary and his bag of "categories" has now chiefly a historic interest. In the modern view the interdependence of mind and body is a fundamental fact of life. As science reveals the physiologic marvels of the once despised body, the latter grows in our respect, for we find that its seeming humble functions are intimately related to our highest powers. Sir William's couplet gives a hint of the dominance of the classical method of his day. It overemphasized the importance of reason and too often converted the youthful mind into a rag bag of useless information. The educators of that time and since have thought more highly of human reason than experience justifies. With their medieval bias for a world of will and reason, they drove the young with the whip and spur of emulation toward what to them seemed the one possible goal, intellectual achievement.

We exaggerate the share that reason has in conduct. In the history of the race, which is epitomized in the life of every individual, reason was a late outgrowth of feeling, passion, impulse, instinct. It was these older faculties that ruled the life of the primitive man who made the race, and it was through them that the race gradually rose to reason by what Emerson would call the "spiral stairway of development."

These functions of impulse and instinct dominate the life of the child and they are only a little less potent in the conduct of us grownups. Much of what we call reason is feeling, and much of our life activities are due to desire, sentiment, instinct and habit, which, under the illusion of reason, determine our decisions and conduct. Some one has said that reason is the light that nature has placed at the tip of instinct, and it is certainly true that without these earlier, basal faculties reason would be a feeble light. During the growing period these are specially strong, and the important thing is that they be guided and organized in relation to the needs of maturity. In combining mental and physical training we are in some measure furnishing this guidance, doing intentionally what nature did originally without design.

In the uncivilized state the stress of life was chiefly physical. The civilized man has to a large degree reversed this old order, in that the use of the body is incidental in his work, the stress being placed upon the brain. He piles his life high with complexities and in place of life being for necessities, and they few and simple, it is largely for comforts which we call necessities, and Professor Huxley has said that the struggle for comforts is more cruel than the struggle for existence.

This stress which is put upon conscious effort in civilization places a new and severe tax upon the brain. It intensifies and narrows the range of man's activities; it causes him to specialize and localize the strain to a degree that may be dangerous. It is certainly true that every man has his breaking strain, and there is nothing that will raise the limit of endurance like a strong and well-developed body.

The Italian physiologist, Mosso, showed by an ingenious device that when a person lying quite still was required to add a column of figures, blood left the extremities and flowed toward the brain. Any emotional state or effort of thought produces the same result. This demonstration that we think to our fingers' ends suggests the importance of a strong body as a prompt support in mental work.

All our work, mental as well as physical, is a test of endurance, not a test that is spiritual and non-material, but even in the sphere of the mind it is plainly animal and physical. Thinking is primarily a physical process and draws upon the vital stores of every organ. The energy that makes clear thinking possible depends largely upon the vigor of the body, and to the extent that this fails, the brain functions suffer. Therefore, any work, mental or physical, will be better done and more easily done if the body is strong. Other things being equal, the intellectual work of the strong man will be better done than similar work by one of equal talent, but who is not strong.

Big muscles are not necessary in physical development. Many people are not designed for big muscles, and any attempt by them to produce a heavy, massive development may do harm. What is wanted is vigor, skill, muscular readiness and a reawakening of the old associations of thought and action. Such training goes further than thought and action, for it reaches all the organs and adds immensely to the vital capacity and working power of the individual.

The play instinct of the child is as old as the race, or older, and is a vitally important factor, not only in physical development, but also in mental development. In its destructive and disorderly activities the child shows the later adult forces in the formative stage. Old instincts and movements that were once self-preservative and of serious meaning to a wild ancestor reappear in the play of children, and, utilized wisely, may under new form become a valuable possession of the adult. There is a great big man, in fact, several possible men, inside every boy. Through his running, jumping, fighting, swimming, through impulse, instincts and emotions he is seeking the man that is in him, and it is by this turbulent and experimental course that he finally comes to the order of maturity.

Every boy is a vitally coiled up set of springs pressing to be released. Race-old energies are struggling in him for expression, and play is the normal way to satisfy the great demand. The child may miss some important things and yet get on, but it can not, without severe and lasting harm miss the instinctive activities of play.

In play and games the young are re-enacting these old muscular coordinations and developing mind and body on the old foundation. The boy's love of outdoor sports and the adventures of hunting are significant. Those ancestors of ours who hunted and fished and shaped with care their arrow heads were developing a manual skill and thinking power that we inherit. We use our muscles for more varied and possibly more finished purposes, but it is through the patience and practise of their rude lives that we possess the delicate uses of the hands and the finer dexterities of the mind.

The boy who goes whistling to the fields, or hunts, or fishes, or swims, is unconsciously reaching out toward later life and is preparing for serious and bigger things.

The growing formative period of life is the time for good physical development. Whatever is gained and fixed then is permanent, as it becomes a part of the physiological habits of the individual. The years before twenty decide the future energy stores, and the capacity to endure. Every function enlarged, every gain of power, is additional storage room for energy, to be drawn upon in the coming days of adult stress.

Good physical development not only gives strength and skill in the use of the body, but develops a physiological habit of surplus power that may be called quantity of energy. Life is not alone in quality, in delicacy of adjustment, in accuracy, in fineness of feeling; it is also in quantity. The poet who, with frail physique and feeble pulse, sits in his quiet retreat and puts his fine fancies into the rhythms of verse has quality. But in the stress and rivalry of life that awaits the majority of men, there is a need for quantity of energy, such as enabled a Washington or a Caesar or a Napoleon or a Wellington to shoulder his way through difficulties. These men combined quality with quantity and this combination may make, and often does make, the life of masterful achievement. The quantity of energy in us average men may make the difference between success and failure.

Many men fail in life for lack of staying power, for lack of that kind of endurance that is furnished by having power in reserve.

The strong, confident person who has strength to spare, reserves of energy, does his work easily and without friction. Half the timidities and indecisions of men are chargeable less to lack of ability than to lack of the physical vigor, the QUANTITY of energy, which is the driving power of character. In all the contests of life an important element in success is the ability to endure prolonged stress, to have the reserve energy that can be drawn upon and utilized as a driving force. This power is not alone necessary in the emergencies, the "short hauls" of life, but also in the long hauls that spread the strain through greater periods. Many of the failures of life are due as much to lack of ability to meet prolonged stress as to lack of experience or intelligence. Men of moderate ability but with great powers of endurance often succeed, while men of greater talent fail for lack of the ability to endure strain.

The man with a weak body and without the self-confidence that surplus energy gives is liable to be of uncertain judgment. Such a man in the presence of a problem requiring quick decision, doubts and hesitates and stands shivering on the brink of action while hastening opportunities pass him by.

Much of the loose thinking of our time is undoubtedly due to poor educational drill. In fact the failure of the schools to teach pupils how to apply the mind and how to think is one of their common reproaches. Inability to use the mind effectively is also frequently due to a lack of vigor and physical stamina. A person with poor digestion, or under-developed body, or weak circulation has of necessity a badly nourished brain. Such a brain, unless it belongs to a genius, will do poor thinking.

The mentally trained person who is also physically strong has the combination that puts his powers at easy command. He can be joyously busy doing the impossible because the doing of it has been made easy by training.

How much native power there is in all of us that for want of proper training or sympathetic encouragement never comes to maturity! How many of the finer qualities of character that, for want of a kindlier climate of cheerful companionship and wise direction, failed to mature and now lie dead in us! Very many people are only partly alive. A large part, and in some, the best part, is dead. The capacity they show is probably only a small share of a fine inheritance which, not knowing how to use, they allowed to die.

We have an instinctive liking for people who are strong and healthy. They appeal to us by their robustness and their confident display of energy. We do not now need the big muscles that were once necessary in wielding spear and battle-axe. We need, however, as much as the race ever needed well-developed bodies and habits of health.

It is not difficult for us to see that sports and games and play help to physical development, but it is not so plain that they may be made to develop the best qualities of character.

It is a fact, however, that all the important elements of character are tried out in games and sports. Enthusiasm, self-confidence, the adventurous spirit, alertness, promptness, unselfishness, cooperation, quick judgment—all these have their training and discipline on the game field. They comprise those fundamental native qualities that have gone to make humanity what it is. The young should have this training, and, if of the right kind, it may be made to contribute to the making of the best kind of character. The same quickness and accuracy of judgment that enable a boy to win a point in football may in later life be used to win a battle or save a business venture. Beyond this, there is of course gained the strong body that makes work easy and stress less difficult to bear.

Hall calls attention to the fact that two generations ago, Jahn, the great builder of German physique, roused the then despairing German nation by preaching the gospel of strong bodies. He created a new spirit in Germany, and the whole nation was aroused and seized with an enthusiasm for outdoor games and sports, and there arose a new cult for the body. His pupils sang of a united fatherland and of a stronger race. The Germans are in the habit of reminding us that it was about one generation after Jahn that the German Empire was founded and Germany became a world power.

Every argument for the physical training of boys applies with equal force to girls. Women need to be physically as strong as men. No race will remain virile and progressive unless both the fathers and mothers have the physical stamina that produces healthy, vigorous offspring. In this age, when women are going out into the world to compete with men it is highly important that they be physically strong if they are to stand the stress successfully. It was from rough barbarians, the rude war-loving Teutonic men and women described by Tacitus, that the Anglo-Saxon race inherited those splendid qualities of mind and body that have made their descendants masters of seas and continents.

It has been objected that gymnastics and field sports make girls coarse and mannish. The exact opposite has been found to be the case. It has been observed in colleges that when young women are properly led, their sports, in place of making them mannish, have a marked refining influence. They care more for correct posture because this is made one of their tests in athletic sports. They develop better manners and a new sense of pride in their appearance. They soon learn to avoid slang, loud talking and boisterous behavior. In the University of Chicago where they have excellent training, many of the girls have said that they came to have a new sense of dignity and to care more for their personal appearance.

They also develop the finer elements of character, a cooperative spirit, obedience to commands, patience, self-confidence, a spirit of comradeship, a democratic attitude and an appreciation of good qualities in others wherever found. All of these esthetic, social and moral qualities, woven into the texture of the growing character, and with the vigorous health that the physical training brings, are the best contribution to the making of the most effective type of the womanly woman. All games and sports and athletics for the young should therefore make for refinement and esthetic development.

The state needs now, and will always need, men and women who have sound bodies and abounding energy.

The harsher phases of the human struggle may pass and wars may cease, but the old contests of races, nations and individuals will continue under other forms.

As the race grows older life will become more largely mental. The increasing complexity of human relations and the more delicate adjustments that these relations require will bring a new and finer social order that will make higher demands upon reason.

While there is no evidence that experience or time or training will ever change the structure of the brain, it is probable that we have as yet but imperfectly utilized our mental possibilities. Stratton says:

> Out of the depths of the mind new powers are always emerging.[2]

[2] "Experimental Psychology and Culture," George M. Stratton.

Back of the mental life, and making it possible, are the energies of the body, the functioning of the animal in man, which in the brain are changed to the higher uses of the mind. The ability to execute, to act effectively, to do and keep doing, to do the work of the professional man, the banker, or the scientist, all this is primarily physical, and from top to bottom of man's activities the physical test is applied. With the mental and emotional strain of civilized life goes the physical strain which is the other half of the struggle, and which now and always is both mental and physical. The Greeks recognized this unity of mind and body twenty-five hundred years ago and their results remain unmatched by any race.

They saw that the thought-out movements of physical training resulted in mental training and this law of mental development through physical training was a fundamental principle in their educational plan.

The nation that will again make this an ideal will produce a finer race of men, and other things equal, will excel in all that makes a people great.

EDWARD JENNER AND VACCINATION

BY PROFESSOR D. FRASER HARRIS, M.D., D.Sc.

DALHOUSIE UNIVERSITY, HALIFAX, N. S.

WE are so exceedingly apt to take our blessings as a matter of course that at the present time a large number of us have quite forgotten, and some of us have never known, what a terrible disease smallpox is and from how much suffering national vaccination has saved us. But even many of us, who may not be included amongst those who know nothing of smallpox, do come within the group of those who know next to nothing of the life and work of Dr. Edward Jenner. A number of persons think he was Sir William Jenner, physician to Queen Victoria.

An infectious or communicable disease is one caused by the admission of some form of living matter into the body of a human being or of a lower animal. All diseases are clearly not communicable in the sense that they are due to the presence of living things. Indigestion, for instance, I can not communicate to my neighbor, however serious my dietetic indiscretions.

Now, while the actual microorganisms causing many of the infectious diseases have been discovered in these recent days through the agency of the microscope—one of science's most valuable gifts to suffering humanity—a few diseases undoubtedly infectious have, even up to the present time, not had their microorganic causes discovered. Smallpox or variola is one of these. The term variola is from the Latin varus, a pimple.

The name Small Pox, which first occurs in Holinshead's "Chronicle" (1571), was given to this disease to distinguish it from the Great Pox or syphilis, the French disease, or Morbus Gallicus which attained the proportions of an epidemic in Europe about 1494. The expression "The Pox" in the older medical literature always refers to the Lues Venereal The word "pox" is the plural form of pock; the spelling "pox" is phonetic; "pocks" is the correct form.[1]

[1] Thus the following expression in Galt's "Annals of the Parish" is justified—"My son Gilbert was seized with the smallpox and was blinded by THEM for seventeen days."

Smallpox is unquestionably a highly infectious or communicable disease, and in the language of a past day, there is a virus or poison which can pass from the sick to the unaffected; when this transference occurs on a large scale we speak of an epidemic of smallpox. As Sir William Osler truly says, "It is not a little remarkable that in a disease, which is rightly regarded as the type of all infectious maladies, the specific virus still remains unknown." The same, however, is true of the common diseases of scarlatina, measles and chickenpox. Of some diseases, the virus is a bacillus or coccus, excessively minute fungi recognizable only under the microscope; but the bacteriologists are now beginning to speak of viruses so impalpable that they, unlike ordinary bacteria, can go through the pores of a clay filter, are filter-passers, that is are of ultra-microscopic dimensions. Some authorities conjecture that the virus of variola belongs to the group of filter-passers. The virus of smallpox, however, is very resistant and can be carried through the air for considerable distances; it clings for long periods to clothes, books, furniture, etc.

I shall not now digress to give the clinical details of a case of smallpox; the eruption may be slight or it may be very extensive. It occurs in three forms, discrete, confluent and hemorrhagic. The most dangerous form of smallpox is the confluent, in which the face and arms particularly are covered with large pustular areas of a most disfiguring appearance.

The disease called chickenpox, or varicella, has no relationship to smallpox and does not protect from it, nor does smallpox protect from chickenpox.

HISTORY OF SMALLPOX

There seems very little doubt that the home of smallpox was somewhere on the continent of Africa, although it is true that there are traditions pointing to its existence in Hindustan at least 1000 B.C. One Hindu account alludes to an ointment for removing the cicatrices of eruption. Africa has certainly for long been a prolific source of it: every time a fresh batch of slaves was brought over to the United States of America there was a fresh outbreak of smallpox.[2] It seems that the first outbreak in Europe in the Christian era was in the latter half of the sixth century, when it traveled from Arabia, visiting Egypt on the way. The earliest definite statements about it come from Arabia and are contained in an Arabic manuscript now in the University of Leyden, which refers to the years A.D. 570 and 571. There is a good deal of evidence that the Arabs introduced smallpox into Egypt at the sacking of Alexandria in A.D. 640. Pilgrims and merchants distributed it throughout Syria and Palestine and along the north of Africa; then, crossing the Mediterranean, they took it over to Italy. The Moors introduced it into Spain whence, via Portugal, Navarre, Languedoc and Guienne it was carried into western and northern Europe. The earliest physician to describe smallpox is Ahrun, a Christian Egyptian, who wrote in Greek. He lived in Alexandria from A.D. 610 to 641. The first independent treatise on the disease was by the famous Arabian physician, Rhazes, who wrote in Syriac in 920 A.D., but his book has been translated into both Greek and Latin. The first allusion to smallpox in English is in an Anglo-Saxon manuscript of the early part of the tenth century; the passage is interesting—"Against pockes: very much shall one let blood and drink a bowl full of melted butter; if they [pustules] strike out, one should dig each with a thorn and then drop one-year alder drink in, then they will not be seen," this was evidently to prevent the pitting dreaded even at so early a date. Smallpox was first described in Germany in 1493, and appeared in Sweden first in 1578.

[2] Osler thinks the pesta magna of Galen was smallpox; Marcus Aurelius died of it.

The contributions of Sydenham, the English Hippocrates, to the knowledge of smallpox, are classical.

Throughout the Middle Ages, owing to the very crowded and unsanitary state of the cities of Europe, smallpox was one of the various plagues from which the inhabitants were never free for any length of time.[3] Leprosy, influenza, smallpox, cholera, typhus fever and bubonic plague constituted the dreadful group. In most countries, including England, smallpox was practically endemic; an attack of it was accepted as a thing inevitable, in children even more inevitable than whooping-cough, measles, mumps or chickenpox is regarded at the present time. There was a common saying—"Few escape love or smallpox." In the eighteenth century so many faces were pitted from severe smallpox that it is said any woman who had no smallpox marks was straightway accounted beautiful. Very few persons escaped it in either the mild or the severe form in childhood or in later life.

[3] England was by no means exempt, but it was not infection in the modern sense that Shakespeare meant when he wrote—

"This England,
This fortress, built by Nature for herself
Against infection and the hand of war."

Now it is characteristic of a microorganic disease that a person who has recovered from an attack of it is immune from that disease for a longer or shorter time, in some cases for the remainder of life. This is, luckily, as true of smallpox as of any of the other acute infections. We do not now need to enquire into the theory of how this comes about; it is a well-recognized natural phenomenon. The modern explanation is in terms of antigens and anti-bodies and is fast passing from the stage of pure biochemical hypothesis into that of concrete realization. Persons who have recovered from smallpox rarely take it a second time; the few who do, have it in a mild form. It follows, then, that if smallpox is purposely inoculated into a human being he will for a long time be resistant to the subsequent infection of smallpox. The fact of smallpox protecting from smallpox is by no means without analogy in other diseases. Thus in Switzerland, in Africa, in Senegambia, it has been the custom for a long time, in order to protect the cattle from pleuro-pneumonia, to inoculate them with the fluid from the lung of an animal recently dead of pleuro-pneumonia. Of course since the time of Pasteur we have been quite familiar with the inoculation of attenuated virus to protect from the natural diseases in their fully virulent form, for instance, anthrax, rabies, plague and typhoid fever.

As it was, then, known to mankind from a very early period that a person could be protected from smallpox by being inoculated with it, inoculation grew up as a practice in widely distant parts of the globe. The purpose of intentional inoculation was to go through a mild attack of the disease in order to acquire protection from the much more serious natural form of the disease—to have had it so as not to have it. A very high antiquity is claimed for this smallpox inoculation, some even asserting that the earliest known Hindu physician (Dhanwantari) supposed to have lived about 1500 B.C., was the first to practice it. Bruce in his "Voyages to the Sources of the Nile" (1790) tells us that he found Nubian and Arabian women inoculating their children against smallpox, and that the custom had been observed from time immemorial. Records of it indeed are found all over the world; in Ashantee, amongst the Arabs of North Africa, in Tripoli, Tunis and Algeria, in Senegal, in China, in Persia, in Thibet, in Bengal, in Siam, in Tartary and in Turkey. In Siam the method of inoculation is very curious; material from a dried pustule is blown up into the nostrils; but in most other parts of the world the inoculation is by the ordinary method of superficial incision or what is called scarification. By the latter part of the seventeenth century inoculation for smallpox was an established practise in several European countries into which it had traveled by the coasts of the Bosphorus, via Constantinople. In 1701 a medical man, Timoni, described the process as he saw it in Constantinople. Material was taken from the pustules of a case on the twelfth or thirteenth day of the illness. As early as 1673 the practice was a common one in Denmark, Bartholinus tells us. In France inoculation had been widely practiced; on June 18, 1774, the young king Louis XVI., was inoculated for smallpox, and the fashionable ladies of the day wore in their hair a miniature rising sun and olive tree entwined by a serpent supporting a club, the "pouf a l'inoculation" of Mademoiselle Rose Bertin, the court milliner to Marie Antoinette. In Germany inoculation was in vogue all through the seventeenth century, as also in Holland, Switzerland, Italy and Circassia. In England the well-known Dr. Mead, honored, by the way, with a grave in Westminster Abbey, was a firm believer in inoculation, as was also Dr. Dimsdale, who was sent for by the Empress Catherine II. to introduce it into Russia. Dr. Dimsdale inoculated a number of persons in Petrograd, and finally the Grand Duke and the Empress herself. The lymph he took from the arm of a child ill of natural smallpox. For his services to the Russian court Dr. Dimsdale was made a Baron of the Russian Empire, a councillor of state and physician to the Empress. He was presented with the sum of 1,000 pounds and voted an annuity of 500 pounds a year. At the request of Catherine, Dr. Dimsdale went to Moscow, where thousands were clamoring for inoculation. The mortality from smallpox in Russia seems to have been still higher than in the rest of Europe. The annual average death rate on the Continent at the end of the eighteenth century was 210 per 1,000 deaths from all causes, while in Russia in one year two million persons perished from smallpox alone. In England in 1796, the deaths from smallpox were 18.6 per cent. of deaths from all causes.

A great impetus was given to inoculation in England by the letters of Lady Mary Wortley Montague, the wife of our ambassador to Turkey, Edward Wortley Montague, and daughter of the Duke of Kingston. In 1717 Lady Mary wrote a letter to her friend Miss Chiswell, in which she explained the process and promised to introduce it to the notice of the English physicians. So convinced was Lady Mary of the safety of smallpox inoculation and its efficacy in preserving from subsequent smallpox, that in March, 1717, she had her little boy inoculated at the English embassy by an old Greek woman in the presence of Dr. Maitland, surgeon to the embassy. In 1722 some criminals under sentence of death in Newgate were offered a full pardon if they would undergo inoculation. Six men agreed to this, and none of them suffered at all severely from the inoculated smallpox. Towards the close of the same year two children of the Princess of Wales were successfully inoculated; and in 1746 an Inoculation Hospital was actually opened in London, but not without much opposition. As early as 1721 the Rev. Cotton Mather, of Boston (U. S. A.), introduced inoculation to the notice of the American physicians, and in 1722 Dr. Boylston, of Brooklyn, inoculated 247 persons, of whom about 2 per cent. died of the acquired smallpox as compared with 14 per cent. of deaths amongst 6,000 uninoculated persons who caught the natural smallpox. There was, however, great popular opposition to the practice of inoculation, and Dr. Boylston on one occasion was nearly lynched.

While successful inoculation undoubtedly protected the person from smallpox, sometimes the inoculated form of the disease was virulent, and certainly all cases of inoculated variola were as infectious as the natural variety. Inoculated persons were therefore a danger to the community; and there is no doubt that such persons had occasionally introduced smallpox into towns which had been free from the natural disease. At the end of the eighteenth century, just about the time of Jenner's discovery, public opinion was strongly against the continuance of the practice of inoculation, and as natural smallpox had not at all abated its epidemic character, the times were ripe for "some new thing."

Now there is a disease of cows know as cowpox or vaccinia (from the Latin vacca, a cow) which is communicable to human beings. It is thought to be due to the same virus which in pigs is called swinepox and in horses "grease." Jenner believed vaccinia to be the same pathological entity as human smallpox, modified, however, by its transmission through the cow. For a long time this view was stoutly resisted, but it has now been accepted as probably representing the truth. The identity of vaccinia and "grease" is certainly much more doubtful.

To many of Jenner's contemporaries the view that vaccinia had at one time been a disease of human beings seemed unlikely; but we are now in a far better position to admit its probability than were those of Jenner's time. We have since then learned that man shares many diseases with the lower animals, tuberculosis, plague, rabies, diphtheria and pleuro-pneumonia, to mention only a few. We have also learned that certain lower animals, insects for instance, are intermediary hosts in the life-cycle of many minute parasites which cause serious diseases in the human being, amongst which malaria, yellow fever and the sleeping sickness are the most familiar.

It appears to have been understood before Jenner's time that persons who had acquired cowpox by handling cattle, but especially by milking cows, were immune from smallpox. In the reign of Charles II. it is well known that the court beauties envied the dairy-maids because having had cowpox, they could not take smallpox which all women so dreaded. Dr. Corlett tells us that the Duchess of Cleveland, one of the King's mistresses, on being told that she might lose her place in the royal favor if she were disfigured by smallpox, replied that she had nothing to fear as she had had cowpox. In 1769 a German, Bose, wrote on the subject of cowpox protecting from smallpox. In the year 1774 a cattle dealer, Benjamin Jesty, at Yetminster, in Dorset, inoculated his wife and three children with cowpox. None of them ever took smallpox during the rest of their lives although frequently exposed to its infection. Jesty died in 1816, and it is recorded on his tombstone that he was the first person who inoculated cowpox to protect from smallpox. Cowpox, or vaccinia, though infectious for cows, is not transmissible among human beings, in other words, as a disease of man it is not infectious. Edward Jenner, the Englishman of Berkeley in Gloucestershire, was the first person to think scientifically on the fact that cowpox protected from smallpox. John Hunter had said to him, "Jenner, don't think, try." Luckily, however, he did both. Thinking alone avails little, experimentation alone avails not much, but the one along with the other has removed mountains. Just as Newton thought scientifically about that falling apple and reduced our conceptions of the universe to order, just as Watt thought scientifically about that kettle-lid lifted by the steam and so introduced the modern era of mechanical power brought under man's control, so Jenner thought about and experimented with cowpox until he had satisfied himself that he had discovered something which would rid the human race forever of the incubus of an intolerable pestilence.

It was in 1780 that Jenner set himself to study cowpox in a way that had never before been attempted, for he was convinced that in the having had an attack of the disease lay the secret of the conquest of that world-scourge. He confided in his fried Edward Gardner about "a most important matter . . . which I firmly believe will prove of essential benefit to the human race . . . should anything untoward turn up in my experiments, I should be made, particularly by my medical brethren, the subject of ridicule." Luckily he was quite prepared for both ridicule and opposition; for has not everything new been ridiculed and opposed? Galileo was opposed, Bruno was opposed, Copernicus was opposed, Harvey was opposed, George Stevenson was opposed, Pasteur was ridiculed and opposed, and so were Darwin, Simpson and even Lister. The physiological inertia even of the educated has too often blocked the path of advancement: but Jenner is in illustrious company, a prince amongst the hierarchy of the misunderstood.

The facts or surmises before Jenner at this date, then, were—(a) Cowpox produces an eruption extremely like that of mild smallpox, it is, therefore, probably a form of smallpox modified by transmission through the cow; (b) And an attack of cowpox protects from smallpox. To test these things experimentally some one must first be inoculated with cowpox, and, having recovered from the vaccinia, that same person must, secondly, be inoculated with the virus of smallpox or be exposed to the infection, and, thirdly, this person ought not to take the disease.

In 1788 Jenner had a careful drawing made of the hand of a milkmaid suffering from cowpox to demonstrate to Sir Everard Home how exceedingly similar were vaccinia and variola. Home agreed it was "interesting and curious," and the subject began to attract some attention in medical circles.

In November, 1789, Dr. Jenner inoculated his eldest child Edward, aged 18 months, with some swinepox virus, and as nothing untoward happened, he inoculated him again with swinepox on April 7, 1791. The child had a slight illness, very like vaccinia, from which he rapidly recovered. The moment for the crucial experiment was not yet; it came in due time, but Jenner had to wait five years for it, and five years are a long time to a man who is yearning to perform his crucial experiment. Happily for suffering humanity, in the early summer of 1796 the opportunity came; the hour and the man were there together.

Cowpox had broken out on a farm near Berkeley and a dairy maid called Sarah Neames contracted the disease. On May 14, 1796, Dr. Jenner took some fluid from a sore on this woman's hand and inoculated it by slight scratching into the arm of a healthy boy eight years old, by name James Phipps. The boy had the usual "reaction" or attack of vaccinia, a disorder indistinguishable from the mildest form of smallpox. After an interval of six weeks, on July 1, Jenner made the most momentous but justifiable experiment, for he inoculated James Phipps with smallpox by lymph taken from a sore on a case of genuine, well-marked, human smallpox, AND THE BOY DID NOT TAKE THE DISEASE AT ALL. Jenner waited till the nineteenth of the month, and finding that the boy had still not developed variola, he could hardly write for joy. "Listen," he wrote to Gardner, "to the most delightful part of my story. The boy has since been inoculated for the smallpox which, aS I VERNTURED TO PREDICT, produced no effect. I shall now pursue my experiments with redoubled ardor."

Here we are behind the scenes at a great discovery; "as I ventured to predict"; prediction is part of scientific theorizing; there is a place for legitimate prediction as there is for experimentation. All discoverers have made predictions; Harvey predicted the existence of the capillaries, Halley predicted the return of his comet, Adams predicted the place of the planet Neptune, the missing link in the evolutionary series of the fossil horses had been predicted long before it was actually found by Professor Marsh. Pasteur predicted that the sheep inoculated with the weak anthrax virus would be alive in the anthrax-infected field, while those not so protected would all be dead. A prediction verified is a conclusion corroborated, an investigator encouraged.

Early in 1797, through another outbreak of cowpox, Jenner was able to inoculate three persons with variola, only to find as before that they were immune from smallpox. He now felt himself justified in preparing a paper for the Royal Society, the highest scientific tribunal in England. The council, however, returned him his paper with the remark that in their opinion the amount of evidence was not strong enough to warrant its publication in the Transactions. Jenner was wise enough not to be discouraged, and so in June, 1798, he published the paper himself under the title, "Inquiry into the causes and effects of the Variolae-Vacciniae, a disease discovered in some of the western counties of England, particularly Gloucestershire, and known by the name of cowpox." This historic pamphlet, which ranks with the great classics of medicine, was dedicated to Dr. O. H. Parry, of Bath. Later on the Royal Society was sagacious enough to elect the very man whose paper it had previously refused.

While in London attending to the publication of his pamphlet, Dr. Jenner called on the great surgeon Mr. Cline, and left some cowpox virus with him for trial. Cline inoculated a young tubercular patient with vaccinia and later with smallpox in no less than three places. In due time this patient did not show a sign of smallpox. So impressed was Cline with this remarkable result that he wrote to Jenner thus: "I think the substitution of cowpox poison for smallpox one of the greatest improvements that has ever been made in medicine. The more I think on the subject, the more I am impressed with its importance."

The word "vaccination" was coined by the French, so remarkable for the aptness of their descriptive terms, and it has ever since remained with us as a convenient expression for the inoculation of vaccinia as protecting from variola.[4]

[4] It is certainly not necessary to point out that the principle of vaccination has been one of wide application in modern medicine. Our word "vaccine" testifies to this. A vaccine is a liquid, the result of bacterial growth, injected into a patient in order to render him immune from that particular disease which is caused by sufficient infection with the microorganisms in question, e. g., of typhoid fever or of plague.

Dr. Jenner's views were now becoming known, and the critics and the doubters had appeared: St. Thomas has always had a large following. The most formidable of the early objectors was Dr. Igenhouz, who had come to London to study inoculation for variola, and had already inoculated, among other notable persons, the Archduchess Theresa Elizabeth of Vienna. The careless vaccinations of Doctors Pearson and Woodville at the London Smallpox Hospital brought much apparent discredit on Jenner's work. In all his early work Jenner used lymph obtained directly from papules on the cow or calf, but Woodville in 1799 showed that excellent results could be got from arm-to-arm vaccination. As this latter method is a very convenient one, the technique was widely adopted. We have to remember that we are speaking of a period about sixty years before Lister gave to suffering humanity that other great gift, antisepsis: and so many arms "went wrong," not because of being vaccinated, but because the scratches were afterwards infected by the microorganisms of dirt. Jenner knew well the difference between the reaction of clean vaccination and that of an infected arm, but a great many medical men of his time did not, and so he was constantly plagued with reports of vaccinations "going wrong" when it was septic infection of uncleansed skin that had occurred. The explanation of these things by letter consumed a very great deal of his valuable time. By the end of 1799 a large number of persons had, however, been successfully vaccinated. As one Pearson proved troublesome by starting an institution for public vaccination on principles which Jenner knew to be wrong, and as Jenner found himself virtually supplanted and misrepresented, he came up to London in 1800 to vindicate his position. The King, the Queen and the Prince of Wales, to whom he was presented, materially helped on the cause by countenancing the practice of vaccination. Lord Berkeley, his Lord of the Manor, was in this as in all things a kind and wise patron. In the United States of America vaccination made rapid progress, having been introduced there under the good auspices of Dr. Waterhouse, professor of medicine at Cambridge, Mass. The discovery was announced with true American informality as "Something curious in the medical line," on March 12, 1799.

Things went even better on the continent of Europe; deCarro, of Vienna, inaugurated vaccination with such zeal and discrimination that it spread to Switzerland, France, Italy and Spain. From Spain it passed over to Latin America. In Sicily and Naples, "the blessed vaccine" was received by religious processions. Sacco, of Milan, commenced vaccinating in 1801, and in a few years had vaccinated 20,000. In Paris, a Vaccine Institute was established; and Napoleon ordered all his soldiers who had not had smallpox to be vaccinated. On Jenner's application, the Emperor liberated several English prisoners remarking—"What that man asks is not to be refused." Napoleon voted 100,000 francs for the propagation of vaccination. Lord Elgin introduced it into Turkey and Greece. The Empress of Russia, Catherine II., was one of the greatest supporters of Jennerian vaccination. She decreed that the first child vaccinated in Russia should be called "Vaccinoff," should be conveyed to Petrograd in an imperial coach, educated at the expense of the state and receive a pension for life. The Emperor of Austria and the King of Spain released English prisoners at Jenner's request. There were statues of Jenner erected abroad, at Boulogne and at Brunn, in Moravia, before any in England. Thus the European countries showed their gratitude to the Englishman whose patience, genius and absence of self-seeking had rid them of the detestable world-plague of smallpox. Vaccination was made compulsory by law in no less than five European countries before it was so in the United Kingdom in 1853. In eight countries vaccination is provided free at the expense of the government. The clergy of Geneva and of Holland from their pulpits recommended their people to be vaccinated. In Germany, Jenner's birthday (May 17) was celebrated as a holiday. Within six years, Jenner's gift to humanity had been accepted with that readiness with which the drowning clutch at straws. The most diverse climes, races, tongues and religions were united in blessing vaccination and its discoverer. The North American Indians forwarded to Dr. Jenner a quaintly worded address full of the deepest gratitude for what he had saved them from: "We shall not fail," said these simple people, "to teach our children to speak the name of Jenner, and to thank the Great Spirit for bestowing upon him so much wisdom and so much benevolence."

There are two allusions to smallpox in "Don Juan," which was published in 1819, showing to what an extent Jennerian teachings were in the air. The first is:

The doctor paid off an old pox
By borrowing a new one from an ox.
(Canto I., stanza 129.)

The second is:

I said the smallpox has gone out of late,
Perhaps it may be followed by the great.
(Stanza 130.)

Before 1812, Jenner had been made an honorary member of nearly every scientific society in Europe, and had received the freedom of the cities of London, Edinburgh, Dublin and Glasgow. The Medical Society of London presented him with a gold medal struck in his honor; in Berlin in 1812 there was a Jennerian festival on the anniversary of Phipps's vaccination. Addresses and diplomas were showered on him, and in 1813 the University of Oxford conferred on him the degree of M.D. honoris causa. As he refused point blank to pass the examination in Latin and Greek required by the Royal College of Physicians of London, Jenner never obtained admission into that learned body. When some one recommended him to revise his classics so that he might become an F.R.C.P. he replied, "I would not do it for a diadem"; and then, thinking of a far better reward, added: "I would not do it for John Hunter's museum."

But while the pure in heart were thus receiving the blessing offered them by the benovelent man of science, the pests of society, those discontented and jaundiced ones who are always to be found in the dark recesses of the cave of Adullam, were not idle. Many of his medical colleagues did indeed sneer, as some are always apt to do at any new thing however good. To all these Jenner replied, and a very great deal of his valuable time was consumed in arguing with them. But the sect of the anti-vaccinators had arisen, and was to some extent organized. Caricatures, lampoons, scurrilities, vulgarities and misrepresentations, the mean, were scattered on all sides. Nothing was too absurd to be stated or believed—that vaccinated persons had their faces grow like oxen, that they coughed like cows, bellowed like bulls and became hairy on the body. One omniscient objector declared that, "vaccination was the most degrading relapse of philosophy that had ever disgraced the civilized world." A Dr. Rowley, evidently imagining himself honored by a special participation in the Divine counsels, declared that "smallpox is a visitation from God, but cowpox is produced by presumptuous man. The former was what Heaven had ordained, the latter is a daring violation of our holy religion." It was rather hard to blame Dr. Jenner for the origin of cowpox. It took much forbearance to endure this sort of thing; but Jenner's was a first-class mind and he evidently dealt leniently even with fools. It was not for the first time in the world's history that a lover of mankind had been spurned with the words—"He hath a devil and is mad."

Besides enduring all these mental and physical worries, and the annoyance that the Royal Jennerian Society established in 1802 was so mismanaged that it collapsed in 1808, Jenner had spent a very large sum of private money on the introduction of vaccination. He had been, as he himself expressed it, "Vaccine clerk to the whole world." Parliament, it is true, in 1801, voted him a sum of 10,000 pounds which was not paid for three years afterwards and was diminished by 1,000 pounds deducted for fees, so that it barely recompensed him for his outlays. By 1806, the immensity of the benefit conferred upon his diseased fellow-creatures having been recognized more perfectly in every other country than his own, the British Parliament woke up, and voted him a sum of 20,000 pounds, only one member representing the anti-vaccinators opposing the grant. Parliament, which had previously received from the Colleges of Physicians of London, Edinburgh and Dublin the most favorable reports of the efficacy of vaccination, decided to reestablish the Royal Jennerian Institute. A subscription of 7,383 pounds from grateful India reached Jenner in 1812. In 1814 he was in London for the last time, when he was presented to the Emperor of Russia, Alexander I., who told him that he had very nearly subdued smallpox throughout that vast Empire. Jenner refused a Russian order on the ground that he was not a man of independent means.

The management of the Institute caused him much concern in his later years; he disapproved of the personnel and of many of the details of its working. One of the last worries of his life was an article in the November number for 1822 of the famous Edinburgh Review. Although it contained a good deal of praise, it was not favorable to Jenner, who said of it, "I put it down at 100,000 deaths at least." I have ascertained that this article was not written by the celebrated Francis Jeffrey, although he was editor of the Review until 1829.

Jenner's life, apart from his great discovery and his developing the practice of vaccination, has not much incident in it. He was born on May 17, 1749, the son of the Rev. Stephen Jenner, vicar of Berkeley, Gloucestershire, England, the same Berkeley in whose castle, Edward II., the vanquished at Banockburn, was murdered in 1327. Jenner's mother's name was Head. Edward went to school at Wotton-under-Edge and at Cirencester, and began to study medicine with a Mr. Ludlow, a surgeon at Sodbury near Bristol. In his twenty-first year, Jenner went to London as a pupil of the great John Hunter, in whose house, he lived two years, during which time he was entered as a medical student at St. George's Hospital. It is interesting to know that while still a student he was asked by Sir Joseph Banks to arrange and catalogue the zoological specimens brought home by the circumnavigator Captain Cook in his first voyage of 1771. Jenner devoted considerable attention to natural history, to geology and to the study of fossils, on which topics he kept up correspondence with Hunter long after he left London. In the year 1788 he married a Miss Kingscote, and settled down to practice in his native place. Mrs. Jenner died in 1815, after which date Jenner never left Berkeley again.

Curiously enough, it was not until 1792 that Jenner obtained the degree of M.D., and it was not from an English university at all, but from the University of St. Andrews in Scotland. This university, the smallest although the oldest of the Scottish universities, has therefore the honor of being the Alma Mater to the epoch-making Englishman. I have seen the entry of the name in the list of graduates for the year 1792; it has evidently been misspelled, for the name is corrected. The first foreign university to recognize Jenner's eminence was Gottingen. In 1794 Jenner had an attack of typhus fever. Jenner never cared for London or a city life, and although in 1808 he was persuaded to take a house in town, he soon gave it up and went back to his beautiful Gloucestershire. For many years he practiced during the season in the pleasant health-resort of Cheltenham. He loved the country, he studied lovingly the living things around him there: many are familiar with a piece of verse he wrote on "The signs of rain."

The year 1810 was a sad one for Jenner: his eldest son died, and that noticeably depressed his health. In 1823 he presented a paper to the Royal Society on the migration of birds, a subject not even yet fully cleared up. On January 26, in the same year, he was stricken with paralysis on the right side and died within twenty-four hours. His body was buried in the chancel of the parish church of Berkeley, where there is a memorial window placed by public subscription. In person, Edward Jenner was short and rather heavily built; his expression of face was pleasant with a touch of sadness. All reports agree that in dress he was conspicuously neat, looking more like a gentleman-farmer than a physician, with his blue coat, yellow buttons, red waistcoat, buff breeches and top-boots.[5]

[5] He was painted by Sir Thomas Lawrence, by Northcote and by Vigneron.

There is no disguising the fact that during his lifetime Dr. Jenner was much more appreciated in foreign countries than in England. The medico-social club of Alverton, near where he lived, would not listen to him when he addressed them on vaccination. The effort to collect enough money from the medical men of England in order to place a marble statue to Jenner in the nave of Gloucester Cathedral, was successful only after a long delay. An attempt to erect a statue in London died of apathy; but in 1858, 32 years after he died, a statue was erected in Trafalgar Square. In 1862 it was removed to a quiet corner of Kensington gardens; and perhaps its surroundings, the trees, the flowers and the birds he loved are more suitable than the effigies of those national heroes who served their country by taking, not by saving life. No, Nelson the hero is hardly the suitable companion for Jenner the hero.

There is no doubt that Jenner's medical contemporaries, at least in England, failed to appreciate the magnitude of the gift their colleague had presented not merely to his own country, but to the world at large. The discovery had, of course, been led up to by several different lines of indication, but this in no way detracts from the genius of Jenner in drawing his memorable inductions from the few facts which others had known before his time. The fame of Newton is no whit diminished because Copernicus, Kepler and Galileo lived and worked before him, the credit due to Harvey is none the less because many before his time had worked on the problem of the heart and vessels, and because some of them, notably Cesalpinus, came within a very little of the discovery of the circulation; the achievements of Darwin are not to be belittled because Lamarck, Malthus or Monboddo had notions in accordance with the tenor of his great generalization of evolution among living beings. Certainly Jenner had precursors; but it was his genius and his genius alone which, putting together the various fragments of knowledge already possessed, gave us the grand but simple induction based on his own experiments that vaccinia prevents from variola. It was too simple and too new to be appreciated in all its bearings either by the medical men or the laity of his own day. Its impressiveness is not inherent in it, as it is in the mathematical demonstration of universal gravitation, as it is in the atomic theory or in that of the survival of the fittest through natural selection. The English country doctor merely said in essence—"let me give you cowpox and you will not get smallpox." Unless the fact of this immunity is regarded as possessed by all the nations of the world for ever more there is nothing particularly impressive in it; and so it failed to impress his contemporaries. It is only when we contrast the loathsomeness and danger of smallpox with the mildness and safety of vaccinia and varioloid that we grasp the greatness of the work which Jenner did for mankind. The very simplicity of vaccination detracts from its impressiveness unless its results are viewed through the vista of the centuries. We need the proper historical perspective in this as in all else. Thus viewed, however, the simplicity of the procedure and the universality of its application are most imposing. Vaccination does not, indeed, dazzle the scientific imagination like some of the other generalizations of biology, but it is one that has been gloriously vindicated by the subsequent history of the world's hygiene.

Jenner knew himself to be a benefactor of the human race; he would have been insincere if he had pretended otherwise; he finished his first paper with these words: "I shall endeavor still farther to prosecute this enquiry, an enquiry, I trust, not merely speculative, but of sufficient moment to inspire the pleasing hope of its becoming essentially useful to mankind"; and on his death-bed he said, "I do not marvel that men are not grateful to me, but I am surprised that they do not feel grateful to God for making me a medium of good."

In private life Dr. Jenner was amiable and kind-hearted. Dibden said of him: "I never knew a man of simpler mind or of warmer heart." He was particularly kind to the poor. Dr. Matthew Baillie said of him: "Jenner might have been immensely rich if he had not published his discovery."

We may in conclusion examine some of the objections to and criticisms of vaccination. The objections can be classified as those entertained (a) by medical men and (b) those by the public generally.

The objections raised by medical men are now a matter of ancient history. Each generation of medical men has refused at first to admit any new teaching promulgated in its time; physiological inertia is not at once overcome. The most enlightened of Jenner's critics did really believe that he was drawing too extensive an induction from insufficient data; this was the position of the Royal Society in 1788; but the Edinburgh reviewer of 1822 should have known better. The purely technical criticisms of Jenner's work have by this time been fully assessed and replied to. It is true that at one time it was not clear what were the relationships of chickenpox and smallpox, of vaccinia and variola, of vaccinia and varioloid, of the various forms of pox in animals—cowpox, swinepox, horsepox or grease—either inter se or to human smallpox. But I do not suppose that in this year of grace 1914 there can be found one properly trained medical man, acquainted with the history of Jennerian vaccination, familiar with the ravages of smallpox and with the protective power of vaccinia, who could be induced, by no matter how large a bribe, to say that he disapproved of vaccination or that he believed it did not protect from smallpox. There are cranks in all walks of life, but the medical crank who is also an anti-vaccinationist is happily the rarest of them all.

The lay objectors—the professed anti-vaccinators—are with us yet in spite of some very serious lessons which have been taught them. We may pass by the objectors of the class who believe that vaccinated persons cough like cows and bellow like bulls; these objections go into the limbo of old wives' fables or into the category of wilful misrepresentation. Unfortunately there is a large class of persons who can believe the absurdest nonsense about any subject which is particularly distasteful to them.[6] Another class of objection is the sentimental repugnance to the idea of being given one of the diseases of "the lower animals." Now the fact is that already we share a great many diseases with the lower animals, a few of them being tuberculosis, anthrax, rabies, tetanus, cancer, pleuro-pneumonia, certain insect-borne diseases, some parasitic worm diseases and some skin diseases like favus. As the knowledge of the lowly origin of many of our diseases is more widespread, this sort of objection will die out.

[6] Antivaccinators constantly allude to calf-lymph as "filth"; if lymph is filth, then I am able to assure them that each one of them has about three liters of it in his own body.

An objection which is worthy of more consideration is that in being vaccinated a child is apt to contract some infectious disease such as tuberculosis or syphilis which are the two most dreaded. Now so long as arm-to-arm vaccination was the routine practice, there was a remote probability that this sort of accident might occur. It appears to be true that a few accidents of this kind have occurred, just as a few arms have become septic or had erysipelas develop in them. But when the few such cases are compared with the millions and millions of uncomplicated vaccinations, their importance becomes very insignificant. Now that arm-to-arm vaccination is no longer practiced, but fresh calf-lymph used for each child, these accidental inoculations are a thing of the past. The ignorance of cause and effect is responsible for a great deal of the most childish objections to vaccination as to much else. One woman lately told me that she could not have her child vaccinated because a child in the same street was made a cripple for life by being vaccinated. Could we have a better example of the "post hoc sed non propter hoc."[7]

[7] Now and again, however, we have the sad spectacle of some one really well educated but apparently either ignorant of logic or desirous of wilfully misrepresenting facts. The Hon. Stephen Coleridge has an article in the June (1914) number of the Contemporary Review which is, to say the least of it, highly immoral in ethics and statistics.

I shall examine only that part of it bearing on vaccination. The statements are that in the last five recorded years, 58 persons died from smallpox vaccination (he means vaccination against smallpox), whereas in the same five years, 85 persons died from smallpox itself. The inference we are intended to draw from these figures is that to be vaccinated is nearly as fatal as to have smallpox itself.

Now this kind of argument is a very common one with statistically immoral persons, and is known as the suppression of the ratio. Before we can appreciate the fact that in five years 58 persons died after being vaccinated, we at least need to know the total number of persons who were vaccinated. If only 58 persons were vaccinated and they all died, then the mortality was 100 per cent., but if, as was practically the case, thousands of infants in Great Britain were vaccinated in five years, then if only 58 died after vaccination (although not necessarily in consequence of it) the mortality falls some thousands of a per cent. The suppression of the ratio, i. e., 58/many thousands is the deceit that is practiced.

Fifty-eight per year for five years, is 11.6 deaths per year of persons vaccinated: presumably these were infants: taking the birth-rate in England as 30 per 1,000 living, we may say that 900,000 infants were born; deduct 100,000 as not vaccinated, we have 800,000 infants vaccinated, of these 11.6 died after being vaccinated, which is 0.0014 per cent. This is not much of a mortality from any cause; but using Mr. Coleridge's own figures, it is a splendid demonstration of the safety of infant-vaccination, the opposite of what he pretends it shows.

Mr. Coleridge proceeds to tell us that in five years 85 persons died of smallpox in Great Britain, i. e., an average of 17 persons per year. In other words 17 persons died of smallpox in a country with 30 million inhabitants, or 0.000056 per cent. of persons living, not a high mortality. And we strongly suspect, may we hope, that those 17 were persons who had not been vaccinated.

But in Pre-Jennerian days, 17 persons died of smallpox out of every 100 persons dying from all causes.

Mr. Coleridge's figures, properly and honestly interpreted, testify loudly to conclusions exactly the opposite of what he desires to insinuate; he has no doubt taken the statistics of the Registrar-General, but he has prostituted them.

Mr. Coleridge's paper could not be a better example of the art of concealing the causes of phenomena.

He exhibits the following table:

Deaths from smallpox per annum per a million living:

1862-1870	172.2
1871-1880	244.6
1881-1890	45.8
1891-1900	13.3
1901-1910	12.8

So that the table shows that since 1880 in Great Britain the deaths from smallpox per million per year have declined until they are only about 1/14th of their original number.

The natural inference from these figures, viewed in the light of the history of smallpox in Great Britain, is that compulsory vaccination has been steadily eradicating the disease; but this is not Mr. Coleridge's conclusion: He says it is due to the large number of persons who have refused to be vaccinated! This would be laughable if it were not really serious; it is sad and serious that a man of Mr. Coleridge's education and social position should so consistently mislead the uncritical readers of the Contemporary Review to whose pages he has unfortunately very free access. If Mr. Coleridge really believes these things he is either very stupid or very ignorant; if he knows them to be otherwise, but wilfully deceives the public, he is immoral. He suffers from the worst form of bias, the anti-scientific. {the end of long footnote}

There is still that group of persons who object to everything—anti-vivisection, anti-meat eating, anti-breakfast, anti-hats and of course also anti-vaccination. They are anti the usual and the normal that are quite good enough for the most of people. They generally also believe that the earth is flat; they are past praying for, all we can do with them is to look them, like the difficulty of Jonah and the whale, "full in the face and pass on."

Many people at the present time allow themselves to be persuaded into being anti-vaccinators because neither they nor their deluders have ever known what an epidemic of smallpox is, have never seen with their own eyes the awful spectacle of a person suffering from smallpox in any of its forms—discrete, confluent or hemorrhagic. Thanks to this very Jenner, the world has now for 100 years been almost free from epidemic, virulent smallpox and most perfectly so in the vaccinated countries, so that millions, the majority, of Englishmen, have never seen a case of smallpox at all. Not knowing the awful danger they have escaped, through Great Britain having had compulsory vaccination since 1853, they have become lax in their belief in the necessity for the continuance of that precaution. "They jest at scars that never felt a wound." Towns such as Gloucester in England, in which a large number of children have been allowed to grow up unvaccinated, have always been visited sooner or later by a serious outbreak of smallpox. It must be so; the laws of natural phenomena can not be changed to suit the taste of those persons who are mentally incapable of understanding them. They can not be evaded; ignorance of the law is no more an excuse in the realm of natural than of man-made law.

We now come to that undesirable product of present-day, grandmotherly legislation, the conscientious objector. As I am not a politician, I shall not say anything for or against the policy of inserting in a bill which makes vaccination compulsory a clause giving to the conscientious objector the power or right to refuse to have his child vaccinated, but as a medical man who knows a little of the history of medicine, I can only describe it as gratuitous folly. I am one of those who believe that the laity should have no say in the matter of whether any given procedure is or is not advantageous for the public health. The efficacy of universal inoculation of vaccinia as a prophylactic against variola is a question of scientific medicine to be decided on technical grounds and ought not to be a matter open to debate by the public at all. It is perfectly monstrous to suppose that the ordinary person, quite untrained to weigh evidence for or against the advisability of the carrying out of a particular form of national immunization against a horrid disease, is qualified to form any opinion. He might as well be consulted on the advisability of making the channel tunnel or on the safest type of aeroplane or on any other subject involving the technical training of the engineer. To permit the so-called "man in the street" to say whether he shall or shall not permit the carrying out of some important piece of civic hygiene is to introduce a principle subversive of all system and obstructive of all progress in the science of public health. It is absurd that in a case like this the pronouncements of the judges are to be submitted to the criticisms of the jury. England has already had one or two pretty severe lessons through allowing such places as Gloucester and Leicester to exercise their right of private judgment on the question of vaccination. In Gloucester where there was at one time a vigorous anti-vaccination movement, a serious epidemic overtook the city a few years ago (1896). What science pronounces to be beneficial, the layman must submit to. What we want in these days is less superstition and more faith—in science. I am informed that there are more than 2,000 unvaccinated children in the schools of this city at the present moment, and all because a piece of legislation allows any unintelligent, prejudiced or credulous parent to decide on the momentous question of the vaccination of his children.

Our quarantine regulations are extremely strict, and rightly so, on the subject of smallpox; but is it not a farce to take so much trouble about the health of our immigrants when inside the city we are all the time encouraging a high degree of receptivity towards this very disease? I should call this a very clear case of straining at the international gnat and swallowing the municipal camel. The community at present is at the mercy of its least instructed members. A most sensible suggestion is that if an outbreak of smallpox occurs in Halifax, the cost of it should be borne by the unvaccinated and by the anti-vaccinators. The fact is we have forgotten what smallpox is like. In 1796 before Jennerian vaccination, the death-rate from smallpox in England was 18.5 per cent. of deaths from all causes; in London between 1838 and 1869 it was 1.4 per cent., while in 1871—the worst year for smallpox since vaccination became compulsory—the deaths from smallpox were barely 4.5 per cent. of deaths from all causes, a proportion which was exceeded 93 times in the eighteenth century. At the present moment the deaths from smallpox in London constitute a little under 0.24 per cent. of deaths from all causes, or 77 times less than in pre-Jennerian times.

According to MacVail, in the pre-vaccination period smallpox was nine times as fatal as measles and seven and one half times as fatal as whooping cough. To-day in the vaccinated community its fatality is negligable, in the unvaccinated it is as high as it was in the Middle Ages. In the city of Berlin, where vaccination is absolutely compulsory, there is no smallpox hospital at all; the cases of smallpox in that city being only a few unvaccinated foreigners. In 1912 the deaths in New York City were as follow: 671 from measles, 614 from scarlatina, 500 from typhoid fever, 187 from whooping cough and 2 from smallpox.

In London there were in 48 years of the seventeenth century no less than 10 epidemics of smallpox; in the whole of the eighteenth, 19; and in the nineteenth no epidemic at all during which smallpox was responsible for more than one tenth of the deaths from all causes in any one year.

In Sweden, the highest death-rate before vaccination was 7.23 per 1,000 persons, the lowest 0.30;

under permissive vaccination the highest was 2.57, the lowest 0.12; under compulsory vaccination the highest was 0.94, the lowest 0.0005.

It is so frequently said that the disappearance of smallpox is due not to vaccination, but to improved general hygiene, that we must look into this criticism with some care. In the first place, a large diminution in the mortality from smallpox occurred before there was any great change in the unsanitary conditions of the English towns, before there was any enforcing of the isolation of patients either in hospitals or in their own homes. Since the introduction of vaccination, measles and whooping cough still remain in the status quo ante, while smallpox has been exterminated in all fully vaccinated communities, these two diseases of children are as prevalent as ever in England even although the general sanitary conditions have been immensely improved in that country. Of course the effects of vaccination wear out in time, and that is why it is well to be revaccinated once or twice. Now there has been a remarkable progressive change in the age-incidence of smallpox "which can only be explained," says Dr. Newsholme, "on the assumption that vaccination protects children from smallpox and that the protection diminishes, though it never entirely disappears, as age advances.

The "conscience clause" should be immediately removed from the act in which it was inserted on the grounds that it is weak and reactionary in principle, not in the interests of the development of the legislative aspect of the science of public health, and that it permits in certain unintelligent communities quite a considerable number of unvaccinated children to grow up as a permanent menace to their town and district.

When the history of medicine becomes more widely known, when the principles of prophylactic inoculation are more generally understood, when respect for science is the rule rather than the exception, when great achievements in the saving rather than the destroying of life are objects of national veneration, then we may hope to see the day when it will be unhesitatingly admitted that the discovery by Dr. Edward Jenner, the Englishman, was one of the most momentous in the history of the human race, and that his life was one of the noblest, most unselfish and, in its far-reaching effects, most important that has ever been lived on this planet.

THE VALUE OF INDUSTRIAL RESEARCH

BY W. A. HAMOR

MELLON INSTITUTE OF INDUSTRIAL RESEARCH, UNIVERSITY OF PITTSBURGH

THE aim of all industrial operations is toward perfection, both in process and mechanical equipment, and every development in manufacturing creates new problems. It is only to be expected, therefore, that the industrial researcher is becoming less and less regarded as a burden unwarranted by returns. Industrialists have, in fact, learned to recognize chemistry as the intelligence department of industry, and manufacturing is accordingly becoming more and more a system of scientific processes. The accruement of technical improvements in particularly the great chemical industry is primarily dependent upon systematic industrial research, and this is being increasingly fostered by American manufacturers.

Ten thousand American chemists are at present engaged in pursuits which affect over 1,000,000 wage-earners and produce over $5,000,000,000 worth of manufactured products each year. These trained men have actively and effectively collaborated in bringing about stupendous results in American industry. There are, in fact, at least nineteen American industries in which the chemist has been of great assistance, either in founding the industry, in developing it, or in refining the methods of control or of manufacture, thus ensuring profits, lower costs and uniform outputs.

At the recent symposium on the contributions of the chemist to American industries, at the fiftieth meeting of the American Chemical Society in New Orleans, the industrial achievements of that scientific scout, the chemist, were brought out clearly.[1]

[1] In this connection, see Hesse, J. Ind. Eng. Chem., 7 (1915), 293.

The chemist has made the wine industry reasonably independent of climatic conditions; he has enabled it to produce substantially the same wine, year in and year out, no matter what the weather; he has reduced the spoilage from 25 per cent. to 0.46 per cent. of the total; he has increased the shipping radius of the goods and has made preservatives unnecessary. In the copper industry he has learned and has taught how to make operations so constant and so continuous that in the manufacture of blister copper valuations are less than $1.00 apart on every $10,000 worth of product and in refined copper the valuations of the product do not differ by more than $1.00 in every $50,000 worth of product. The quality of output is maintained constant within microscopic differences. Without the chemist the corn-products industry would never have arisen and in 1914 this industry consumed as much corn as was grown in that year by the nine states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Delaware combined; this amount is equal to the entire production of the state of North Carolina and about 80 per cent. of the production of each of the states of Georgia, Michigan and Wisconsin; the chemist has produced over 100 useful commercial products from corn, which, without him, would never have been produced. In the asphalt industry the chemist has taught how to lay a road surface that will always be good, and he has learned and taught how to construct a suitable road surface for different conditions of service. In the cottonseed oil industry, the chemist standardized methods of production, reduced losses, increased yields, made new use of wastes and by-products, and has added somewhere between $10 and $12 to the value of each bale of cotton grown. In the cement industry, the chemist has ascertained new ingredients, has utilized theretofore waste products for this purpose, has reduced the waste heaps of many industries and made them his starting material; he has standardized methods of manufacture, introduced methods of chemical control and has insured constancy and permanency of quality and quantity of output. In the sugar industry, the chemist has been active for so long a time that "the memory of man runneth not to the contrary." The sugar industry without the chemist is unthinkable. The Welsbach mantle is distinctly a chemist's invention and its successful and economical manufacture depends largely upon chemical methods. It would be difficult to give a just estimate of the economic effect of this device upon illumination, so great and valuable is it. In the textile industry, he has substituted uniform, rational, well-thought out and simple methods of treatment of all the various textile fabrics and fibers where mystery, empiricism, "rule-of-thumb" and their accompanying uncertainties reigned. In the fertilizer industry, it was the chemist who learned and who taught how to make our immense beds of phosphate rock useful and serviceable to man in the enrichment of the soil; he has taught how to make waste products of other industries useful and available for fertilization and he has shown how to make the gas works contribute to the fertility of the soil. In the soda industry, the chemist can successfully claim that he has founded it, developed it and brought it to its present state of perfection and utility, but not without the help of other technical men; the fundamental ideas were and are chemical. In the leather industry, the chemist has given us all of the modern methods of mineral tanning, and without them the modern leather industry is unthinkable. In the case of vegetable-tanned leather he has also stepped in, standardized the quality of incoming material and of outgoing product. In the flour industry the chemist has learned and taught how to select the proper grain for specific purposes, to standardize the product, and how to make flour available for certain specific culinary and food purposes. In the brewing industry, the chemist has standardized the methods of determining the quality of incoming material and of outgoing products, and has assisted in the development of a product of a quality far beyond that obtaining prior to his entry into that industry. In the preservation of foods, the chemist made the fundamental discoveries; up to twenty years ago, however, he took little or no part in the commercial operations, but now is almost indispensable to commercial success. In the water supply of cities, the chemist has put certainty in the place of uncertainty; he has learned and has shown how, by chemical methods of treatment and control, raw water of varying quality can be made to yield potable water of substantially uniform composition and quality. The celluloid industry and the nitro-cellulose industry owe their very existence and much of their development to the chemist. In the glass industry the chemist has learned and taught how to prepare glasses suitable for the widest ranges of uses and to control the quality and quantity of the output. In the pulp and paper industry, the chemist made the fundamental observations, inventions and operations and to-day he is in control of all the operations of the plant itself; to the chemist also is due the cheap production of many of the materials entering into this industry, as well as the increased and expanding market for the product itself.

Sufficient has been presented to show that certain industries of the United States have been elevated by an infusion of scientific spirit through the medium of the chemist, and that manufacturing, at one time entirely a matter of empirical judgment and individual skill, is more and more becoming a system of scientific processes. The result is that American manufacturers are growing increasingly appreciative of scientific research, and are depending upon industrial researchers—"those who catalyze raw materials by brains"—as their pathfinders. It is now appropriate to consider just how industrialists are taking advantage of the universities and the products of these.

THE METHODS EMPLOYED IN THE ATTACK OF INDUSTRIAL PROBLEMS[2]

[2] See also Bacon, Science, N. S., 40 (1914), 871.

When an industry has problems requiring solution, these problems can be attacked either inside or outside of the plant. If the policy of the industrialist is that all problems are to be investigated only within the establishment, a research laboratory must be provided for the plant or for the company. At present, in the United States, probably not more than one hundred chemical manufacturing establishments have research laboratories or employ research chemists, although at least five companies are spending over $100,000 per year in research. In Germany, and perhaps also in England, such research laboratories in connection with chemical industries have been much more common. The great laboratories of the Badische Anilin und Soda Fabrik and of the Elberfeld Company are striking examples of the importance attached to such research work in Germany, and it would be difficult to adduce any stronger argument in support of its value than the marvelous achievements of these great firms.

A frequent difficulty encountered in the employment of researchers or in the establishment of a research laboratory, is that many manufacturers have been unable to grasp the importance of such work, or know how to treat the men in charge so as to secure the best results. The industrialist may not even fully understand just what is the cause of his manufacturing losses or to whom to turn for aid. If he eventually engages a researcher, he is sometimes likely to regard him as a sort of master of mysteries who should be able to accomplish wonders, and, if he can not see definite results in the course of a few months, is occasionally apt to consider the investment a bad one and to regard researchers, as a class, as a useless lot. It has not been unusual for the chemist to be told to remain in his laboratory, and not to go in or about the works, and he must also face the natural opposition of workmen to any innovations, and reckon with the jealousies of foremen and of various officials.

From the standpoint of the manufacturer, one decided advantage of the policy of having all problems worked out within the plant is that the results secured are not divulged, but are stored away in the laboratory archives and become part of the assets and working capital of the corporation which has paid for them; and it is usually not until patent applications are filed that this knowledge, generally only partially and imperfectly, becomes publicly known. When it is not deemed necessary to take out patents, such knowledge is often permanently buried.

In this matter of the dissemination of knowledge concerning industrial practice, it must be evident to all that there is but little cooperation between manufacturers and the universities. Manufacturers, and especially chemical manufacturers, have been quite naturally opposed to publishing any discoveries made in their plants, since "knowledge is power" in manufacturing as elsewhere, and new knowledge gained in the laboratories of a company may often very properly be regarded as among the most valuable assets of the concern. The universities and the scientific societies, on the other hand, exist for the diffusion of knowledge, and from their standpoint the great disadvantage of the above policy is this concealment of knowledge, for it results in a serious retardation of the general growth and development of science in its broader aspects, and renders it much more difficult for the universities to train men properly for such industries, since all the text-books and general knowledge available would in all probability be far behind the actual manufacturing practice. Fortunately, the policy of industrial secrecy is becoming more generally regarded in the light of reason, and there is a growing inclination among manufacturers to disclose the details of investigations, which, according to tradition, would be carefully guarded. These manufacturers appreciate the facts that public interest in chemical achievements is stimulating to further fruitful research, that helpful suggestions and information may come from other investigators upon the publication of any results, and that the exchange of knowledge prevents many costly repetitions.

INDUSTRIAL FELLOWSHIPS

If the manufacturer elects to refer his problem to the university or technical school—and because of the facilities for research to be had in certain institutions, industrialists are following this plan in constantly increasing numbers—such reference may take the form of an industrial fellowship and much has been said and may be said in favor of these fellowships. They allow the donor to keep secret for three years the results secured, after which they may be published with the donor's permission. They also secure to him patent rights. They give highly specialized training to properly qualified men, and often secure for them permanent positions and shares in the profits of their discoveries. It should be obvious at the outset that a fellowship of this character can be successful only when there are close confidential relations obtaining between the manufacturer and the officer in charge of the research; for no such cooperation can be really effective unless based upon a thorough mutual familiarity with the conditions and an abiding faith in the integrity and sincerity of purpose of each other. It is likely to prove a poor investment for a manufacturer to seek the aid of an investigator if he is unwilling to take such expert into his confidence and to familiarize him with all the local and other factors which enter into the problem from a manufacturing standpoint.

THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH[3]

[3] For a detailed description of the Mellon Institute and its work, see Bacon and Hamor, J. Ind. Eng. Chem., 7 (1915), 326-48.

According to the system of industrial research in operation at the Mellon Institute of Industrial Research of the University of Pittsburgh, which is not, in any sense of the word, a commercial institution, a manufacturer having a problem requiring solution may become the donor of a fellowship; the said manufacturer provides the salary of the researcher selected to conduct the investigation desired, the institute furnishing such facilities as are necessary for the conduct of the work.

The money paid in to found a fellowship is paid over by the institute in salary to the investigator doing the work. In every case, this researcher is most carefully selected for the problem in hand. The institute supplies free laboratory space and the use of all ordinary chemicals and equipment. The chemist or engineer who is studying the problem works under the immediate supervision of men who are thoroughly trained and experienced in conducting industrial research.

At the present time, the Mellon Institute, which, while an integral part of the University of Pittsburgh, has its own endowment, is expending over $150,000 annually for salaries and maintenance. A manufacturer secures for a small expenditure—just sufficient to pay the salary of the fellow, as the man engaged on the investigation is called—all the benefits of an organization of this size, and many have availed themselves of the advantages, twenty-eight companies maintaining fellowships at the present time.

Each fellow has the benefit of the institute's very excellent apparatus, chemical and library equipment—facilities which are so essential in modern research; and because of these opportunities and that of being able to pursue post-graduate work for higher degrees, it has been demonstrated that a higher type of researcher can be obtained by the institute for a certain remuneration than can be generally secured by manufacturers themselves. There is a scarcity of men gifted with the genius for research, and it requires much experience in selecting suitable men and in training them to the desirable degree of efficiency, after having determined the special qualities required. Important qualifications in industrial researchers are keenness, inspiration and confidence; these are often unconsidered by manufacturers, who in endeavoring to select, say, a research chemist, are likely to regard every chemist as a qualified scientific scout.

All researches conducted at the Mellon Institute are surrounded with the necessary secrecy, and any and all discoveries made by the fellow during the term of his fellowship become the property of the donor.

When the Mellon Institute moved into its $350,000 home in February, 1915, the industrial fellowship system in operation therein passed out of its experimental stage. During the years of its development no inherent sign of weakness on the part of any one of its constituent factors appeared; in fact, the results of the fellowships have been uniformly successful. While problems have been presented by companies which, upon preliminary investigation, have proved to be so difficult as to be practically impossible of solution, there have been so many other problems confronting these companies that important ones were found which lent themselves to solution; and often the companies did not realize, until after investigations were started, just what the exact nature of their problems was and just what improvements and savings could be made in their manufacturing processes.

Fellowships at the Mellon Institute are constantly increasing in the amounts subscribed by industrialists for their maintenance and, as well, in their importance. The renewal, year after year, of such fellowships, as those on baking, petroleum and ores, goes to show the confidence which industrialists have in the Mellon Institute. Again, the large sums of money which are being spent by companies in bringing small unit plants to develop the processes which have been worked out in the laboratory, demonstrate that practical results are being secured.

Where there have been sympathy and hearty cooperation between the Mellon Institute and the company concerned, the institute has been able to push through to a successful conclusion large scale experiments in the factory of the company, which in the beginning of the fellowship seemed almost impossible: it may be said that the results of the fellowships at the Mellon Institute indicate that a form of service to industry has been established, the possibilities of which no man can say.

A FEW CLASSIC UNKNOWNS IN MATHEMATICS

BY PROFESSOR G. A. MILLER

UNIVERSITY OF ILLINOIS

KING HIERO is said to have remarked, in view of the marvelous mechanical devices of Archimedes, that he would henceforth doubt nothing that had been asserted by Archimedes. This spirit of unbounded confidence in those who have exhibited unusual mathematical ability is still extant. Even our large city papers sometimes speak of a mathematical genius who could solve every mathematical problem that was proposed to him. The numerous unexpected and far-reaching results contained in the elementary mathematical text-books, and the ease with which the skilful mathematics teachers often cleared away what appeared to be great difficulties to the students have filled many with a kind of awe for unusual mathematical ability.

In recent years the unbounded confidence in mathematical results has been somewhat shaken by a wave of mathematical skepticism which gained momentum through some of the popular writings of H. Poincare and Bertrand Russell. As instances of expressions which might at first tend to diminish such confidence we may refer to Poincare's contention that geometrical axioms are conventions guided by experimental facts and limited by the necessity to avoid all contradictions, and to Russell's statement that "mathematics may be defined as the subject in which we never know what we are talking about nor whether what we are saying is true."

The mathematical skepticism which such statements may awaken is usually mitigated by reflection, since it soon appears that philosophical difficulties abound in all domains of knowledge, and that mathematical results continue to inspire relatively the highest degrees of confidence. The unknowns in mathematics to which we aim to direct attention here are not of this philosophical type but relate to questions of the most simple nature. It is perhaps unfortunate that in the teaching of elementary mathematics the unknowns receive so little attention. In fact, it seems to be customary to direct no attention whatever to the unsolved mathematical difficulties until the students begin to specialize in mathematics in the colleges or universities.

One of the earliest opportunities to impress on the student the fact that mathematical knowledge is very limited in certain directions presents itself in connection with the study of prime numbers. Among the small prime numbers there appear many which differ only by 2. For instance, 3 and 5, 5 and 7, 11 and 13, 17 and 19, 29 and 31, constitute such pairs of prime numbers. The question arises whether there is a limit to such pairs of primes, or whether beyond each such pair of prime numbers there must exist another such pair.

This question can be understood by all and might at first appear to be easy to answer, yet no one has succeeded up to the present time in finding which of the two possible answers is correct. It is interesting to note that in 1911 E. Poincare transmitted a note written by M. Merlin to the Paris Academy of Sciences in which a theorem was announced from which its author deduced that there actually is an infinite number of such prime number pairs, but this result has not been accepted because no definite proof of the theorem in question was produced.

Another unanswered question which can be understood by all is whether every even number is the sum of two prime numbers. It is very easy to verify that each one of the small even numbers is the sum of a pair of prime numbers, if we include unity among the prime numbers; and, in 1742, C. Goldbach expressed the theorem, without proof, that every possible even number is actually the sum of at least one pair of prime numbers. Hence this theorem is known as Goldbach's theorem, but no one has as yet succeeded in either proving or disproving it.

Although the proof or the disproof of such theorems may not appear to be of great consequence, yet the interdependence of mathematical theorems is most marvelous, and the mathematical investigator is attracted by such difficulties of long standing. These particular difficulties are mentioned here mainly because they seem to be among the simplest illustrations of the fact that mathematics is teeming with classic unknowns as well as with knowns. By classic unknowns we mean here those things which are not yet known to any one, but which have been objects of study on the part of mathematicians for some time. As our elementary mathematical text-books usually confine themselves to an exposition of what has been fully established, and hence is known, the average educated man is led to believe too frequently that modern mathematical investigations relate entirely to things which lie far beyond his training.

It seems very unfortunate that there should be, on the part of educated people, a feeling of total isolation from the investigations in any important field of knowledge. The modern mathematical investigator seems to be in special danger of isolation, and this may be unavoidable in many cases, but it can be materially lessened by directing attention to some of the unsolved mathematical problems which can be most easily understood. Moreover, these unsolved problems should have an educational value since they serve to exhibit boundaries of modern scientific achievements, and hence they throw some light on the extent of these achievements in certain directions.

Both of the given instances of unanswered classic questions relate to prime numbers. As an instance of one which does not relate to prime numbers we may refer to the question whether there exists an odd perfect number. A perfect number is a natural number which is equal to the sum of its aliquot parts. Thus 6 is perfect because it is equal to 1 + 2 + 3, and 28 is perfect because it is equal to 1 + 2 + 4 + 7 + 14. Euclid stated a formula which gives all the even perfect numbers, but no one has ever succeeded in proving either the existence or the non-existence of an odd perfect number. A considerable number of properties of odd perfect numbers are known in case such numbers exist.

In fact, a very noted professor in Berlin University developed a series of properties of odd perfect numbers in his lectures on the theory of numbers, and then followed these developments with the statement that it is not known whether any such numbers exist. This raises the interesting philosophical question whether one can know things about what is not known to exist; but the main interest from our present point of view relates to the fact that the meaning of odd perfect number is so very elementary that all can easily grasp it, and yet no one has ever succeeded in proving either the existence or the non-existence of such numbers.

It would not be difficult to increase greatly the number of the given illustrations of unsolved questions relating directly to the natural numbers. In fact, the well-known greater Fermat theorem is a question of this type, which does not appear more important intrinsically than many others but has received unusual attention in recent years on account of a very large prize offered for its solution. In view of the fact that those who have become interested in this theorem often experience difficulty in finding the desired information in any English publication, we proceed to give some details about this theorem and the offered prize. The following is a free translation of a part of the announcement made in regard to this prize by the Konigliche Gesellschaft der Wissenschaften, Gottingen, Germany:

On the basis of the bequest left to us by the deceased Dr. Paul Wolskehl, of Darmstadt, a prize of 100,000 mk., in words, one hundred thousand marks, is hereby offered to the one who will first succeed to produce a proof of the great Fermat theorem. Dr. Wolfskehl remarks in his will that Fermat had maintained that the equation

x <superscript Greek 1> + y <superscript Greek 1> = z <superscript Greek 1>

could not be satisfied by integers whenever <Greek l> is an odd prime number. This Fermat theorem is to be proved either generally in the sense of Fermat, or, in supplementing the investigations by Kummer, published in Crelle's Journal, volume 40, it is to be proved for all values of <Grrek 1> for which it is actually true. For further literature consult Hibert's report on the theory of algebraic number realms, published in volume 4 of the Jahreshericht der Deutschen Mathernatiker-Vereinigung, and volume 1 of the Encyklopadie der mathematischen Wissenschaften.

The prize is offered under the following more particular conditions.

The Konigliche Gesellschaft der Wissenschaften in Gottingen decides independently on the question to whom the prize shall be awarded. Manuscripts intended to compete for the prize will not be received, but, in awarding the prize only such mathematical papers will be considered as have appeared either in the regular periodicals or have been published in the form of monographs or books which were for sale in the book-stores. The Gesellschaft leaves it to the option of the author of such a paper to send to it about five printed copies.

Among the additional stipulations it may be of interest to note that the prize will not be awarded before at least two years have elapsed since the first publication of the paper which is adjudged as worthy of the prize. In the meantime the mathematicians of various countries are invited to express their opinion as regards the correctness of this paper. The secretary of the Gesellschaft will write to the person to whom the prize is awarded and will also publish in various places the fact that the award has been made. If the prize has not been awarded before September 13, 2007, no further applications will be considered.

While this prize is open to the people of all countries it has become especially well known in Germany, and hundreds of Germans from a very noted university professor of mathematics to engineers, pastors, teachers, students, bankers, officers, etc., have published supposed proofs. These publications are frequently very brief, covering only a few pages, and usually they disclose the fact that the author had no idea in regard to the real nature of the problem or the meaning of a mathematical proof. In a few cases the authors were fully aware of the requirements but were misled by errors in their work. Although the prize was formally announced more than seven years ago no paper has as yet been adjudged as fulfilling the conditions.

It may be of interest to note in this connection that a mathematical proof implies a marshalling of mathematical results, or accepted assumptions, in such a manner that the thing to be proved is a NECESSARY consequence. The non-mathematician is often inclined to think that if he makes statements which can not be successfully refuted he has carried his point. In mathematics such statements have no real significance in an attempted proof. Unknowns must be labeled as such and must retain these labels until they become knowns in view of the conditions which they can be proved to satisfy. The pure mathematician accepts only necessary conclusions with the exception that basal postulates have to be assumed by common agreement.

The mathematical subject in which the student usually has to contend most frequently with unknowns at the beginning of his studies is the history of mathematics. The ancient Greeks had already attempted to trace the development of every known concept, but the work along this line appears still in its infancy. Even the development of our common numerals is surrounded with many perplexing questions, as may be seen by consulting the little volume entitled "The Hindu-Arabic Numerals," by D. E. Smith and L. C. Karpinski.

The few mathematical unknowns explicitly noted above may suffice to illustrate the fact that the path of the mathematical student often leads around difficulties which are left behind. Sometimes the later developments have enabled the mathematicians to overcome some of these difficulties which had stood in the way for more than a thousand years. This was done, for instance, by Gauss when he found a necessary and sufficient condition that a regular polygon of a prime number of sides can be constructed by elementary methods. It was also done by Hermite, Lindemann and others by proving that epsilon and rho are transcendental numbers. While such obstructions are thus being gradually removed some of the most ancient ones still remain, and new ones are rising rapidly in view of modern developments along the lines of least resistance.

These obstructions have different effects on different people. Some fix their attention almost wholly on them and are thus impressed by the lack of progress in mathematics, while others overlook them almost entirely and fix their attention on the routes into new fields which avoid these difficulties. A correct view of mathematics seems to be the one which looks at both, receiving inspiration from the real advances but not forgetting the desirability of making the developments as continuous as possible. At any rate the average educated man ought to know that there is no mathematician who is able to solve all the mathematical questions which could be proposed even by those having only slight attainments along this line.

THE ABORIGINAL ROCK-STENCILLINGS OF NEW SOUTH WALES

BY DR. CHAS. B. DAVENPORT

COLD SPRING HARBOR, N. Y.

IN a number of places in eastern Australia curious aboriginal markings are found on the faces of the sandstone cliffs. A good idea of them is given by the photographs. These came from Wolgan Gap near Wallerang in the Blue Mountain region of New South Wales. They are found on overhanging rocks that have served as shelters or camping places for the aborigines and which doubtless have protected their works of art.

These stencillings are made by a sort of spatter work, something like that in vogue a generation ago in this country, using leaves, etc., as forms. The rocks at Wolgan Gap are a coarse sandstone stained almost black by an iron oxide derived from included bands of ironstone. These black surfaces were selected by the artists. Nearby in the rock is a band of shale which had disintegrated at its exposed edge to a white powder. The native artist put some of this white powder in his mouth, placed his hand or foot upon the rock, and blew the moistened powder upon and around his outstretched fingers or toes. When he removed them they were outlined on the rock. Since the sandstone is coarse and deeply pitted, the moist powder was blown into minute cavities where it has remained despite the erosive activities of some generations. The presence of the powder is shown on the photographs as a sort of halo around the object. The hands are either right or left, and, in some cases, both hands seem to have been stencilled at once. Sometimes the whole arm and hand are stencilled together, and in one of the photographs a boomerang is shown. The age of these stencils is not known. They were first discovered at Wolgan Gap about sixty years ago, but others have been known for a longer time, for instance, those at Greenwich, Parametta River, near Sydney.

The significance of these stencillings has been the subject of some controversy. The natives may have been induced to make them as boys carve their names on benches or even rocks. The materials for making the stencillings were present and, the example once having been set, others would emulate it. It is interesting that similar stencillings of the hands were made by cave men on the walls of some of the European caves, as, for instance, those of Aurignac in southern France. Evidently spatter work is no modern pastime.

SUBSTITUTES FOR WAR

THIS war, beyond measure disastrous to civilization, is a trial also of our democracy. We may hope that it is an old-world war and an old-men's war, repugnant to the genius of our newer life. The statements of some of our public men and the contents of some of our newspapers can not be read without discouragement. But it is also true that there has perhaps not appeared a cartoon in any American newspaper tending to glorify war, and no legislation has so far been enacted in preparation for war. There is good reason to believe that the people have not been infected by the contagion of blood.

As Professor Patrick argued in a recent issue of the Monthly, man is by genetic inheritance a fighting and a playing animal, not an animal delighting in steady work. The ape and the tiger will be exterminated elsewhere in nature before they will be suppressed in man. It is a slow process, but surely proceeding.

The writer of this note has determined the proportion of each century in which the leading nations have been engaged in war. The curve thus found has no great reliability; for it does not take into account the percentages of the peoples concerned, but its course clearly indicates that even under circumstances as they have been, wars will come to an end. And there is good reason to believe that the newer condition—universal education and universal suffrage, democratic control, improved economic conditions of living for the people, the scientific attitude—will tend to bend the curve more rapidly toward the base line of permanent "peace on earth and good will to men."

While man has inherited instincts which exhibit themselves in playing and fighting, the same instincts may by social control be diverted to playing the games of art or science, to fighting disease and vice. It is rarely wise or feasible to attempt to suppress instincts; they should be directed so as to provide desirable conduct. Loyalty to family, to group, to neighborhood and to nation can not be lightly cast away for an abstract cosmopolitanism. But it can be expressed otherwise than by seizing everything in sight by cunning or by violence.

William James, the great psychologist, in one of his brilliant essays published in The Popular Science Monthly for October, 1910, tells us that history is a bath of blood; we inherit the war-like type; our ancestors have bred pugnacity into our bone and marrow; showing the irrationality and horror of war does not prevent it; but a moral equivalent can be found by enlisting an army to toil and suffer pain in doing the hard and routine work of the world. It is doubtful, however, if the "gilded youths" to whom James refers would accept "dish-washing, clothes-washing and window-washing, road-building and tunnel-making, foundries and stoke-holes," as a substitute for war, and for the great mass of the people there is more than enough of these things. It is to escape from them that we seek excitement and adventure, intoxication by drugs and war.

Professor Cannon, of Harvard University, proposes international football and other athletic contests as substitutes for war. The adrenal glands, whose secretions excite the combative and martial emotions, must function, and their activity, he argues, can be directed in this way. Mr. Bryan has just now made the proposal that we build six great national roads by which armies might be collected for defence; the secretary of the navy has founded a Naval Inventions Board; the postmaster general has suggested that aeroplanes be used to deliver mail in order that we may have an aerial corps ready for service. There may be an element of the absurd in some of these proposals, as there would be in using submarines to catch cod fish, so that there might be practise in building and managing such crafts for peaceful pursuits. There is, however, psychological justification for aiming to direct the emotions so that their discharge is not destructive, but of benefit to the nation and to the world. Such would be the development of our national resources, the construction of railways, roads, waterworks and the like; social and political reforms; progress in the care of public health, in education and in scientific research. It is proposed that the next congress should spend half a billion dollars on the army and navy. It is possible that on a plebiscite vote, exactly under existing conditions, a majority would vote to make the department of war a department of public works, military defence being only one of its functions, and to spend the sum proposed on public works useful in case of war, but not an incitement to war.

NATIONAL WEALTH AND PUBLIC INDEBTEDNESS

WHILE the lives and the wealth of the European nations are being sacrificed on a scale hitherto unparalleled, it is well in the interests of those nations, as well as of our own, that we conserve the lives and wealth of our own people. The greatest wealth of a nation is its children, its productive workers, its scientific men and other leaders, its accumulated knowledge and social traditions. These are immeasurable, but the Bureau of the Census has recently prepared a report on the material wealth and indebtedness, according to which it is estimated that the total value of all classes of property in the United States, exclusive of Alaska and the insular possessions, in 1912, was $187,739,000,000, or $1,965 per capita. This estimate is presented merely as the best approximation which can be made from the data available and as being fairly comparable with that published eight years ago. The increase between 1904 and 1912 was 75 per cent., for the total amount and 49 per cent. for the per capita. Real estate and improvements, including public property, alone constituted $110,677,000,000, or 59 per cent. of the total, in 1912. The next greatest item, $16,149,000,000, was contributed by the railroads; and the third, $14,694,000,000, represented the value of manufactured products, other than clothing and personal adornments, furniture, vehicles and kindred property.

The net public-indebtedness in 1913 amounted to $4,850,461,000. This amount was made up as follows: National debt, $1,028,564,000, or $10.59 per capita; state debt, $345,942,000, or $3.57 per capita; county debt, $371,528,000, or $4.33 per capita; and municipal debt, $2,884,883,000, or $54.27 per capita. Thus the average urban citizen's share of the net federal, state, county and municipal debt combined was $72.76; and the average rural citizen's share of the net federal, state and county debt combined was $18.49.

The total federal debt in 1910 was $2,916,205,000, of which amount $967,366,000 was represented by bonds, $375,682,000 by non-interest-bearing debt (principally United States notes or "greenbacks"), and $1,573,157,000 by certificates and notes issued on deposits of coin and bullion. Against this indebtedness there was in the treasury $1,887,641,000 in cash available for payment of debt, leaving the net national indebtedness at $1,028,564,000, or $10.59 per capita. The increase in the net indebtedness between 1902 and 1913 amounted to 6 per cent., but for the per capita figure there was a decrease of 13 per cent. The burden due to the national debt is thus very light in comparison with that imposed by the indebtedness of other great nations.

The state debt, however, rests still more easily on the shoulders of the average citizen, being only one third as great as that of the nation. The total state indebtedness in 1913 was $422,797,000, and the net debt—that is, the total debt less sinking-fund assets—was $345,942,000, or $3.57 per capita. The net debt increased by 44.5 per cent. between 1902 and 1913, and the per capita net debt by 18 per cent.

The total county debt in 1913 amounted to $393,207,000, of which amount $371,528,000, or $4.33 per capita, was net debt. The net indebtedness increased by 89 per cent. between 1902 and 1913, and the per capita net indebtedness by 55 per cent. By far the greatest item of indebtedness in this country is that of municipalities. This amounted in 1913 to an aggregate of $3,460,000,000, of which $2,884,883,000, or $54.27 per capita, represented net indebtedness. The rate of increase in net indebtedness between 1902 and 1913 was 114 per cent.

While the nations of Europe are involving themselves in the toils of debts, we should use our vast surplus wealth to pay the national, state and municipal debts, even those contracted for public improvements. We save every year about $100 for each adult and child of the country and waste about an equal sum. It would be well if this wealth could be invested for the benefit of each, and education and scientific research are the most productive of all investments.

SCIENTIFIC ITEMS

WE record with regret the death of Karl Eugen Guthe, professor of physics in the University of Michigan and dean of the Graduate School, in Hanover, Germany; of John Howard Van Amringe, long dean of Columbia College and professor of mathematics; of Carlos J. Finlay, known for his advocacy of the theory that yellow fever is transmitted by mosquitoes; of A. J. Herbertson, of Wadham College, Oxford, professor of geography in the university; of Julius von Payer, the distinguished polar explorer and artist, of Vienna, and of Guido Goldsehmiedt, professor of chemistry in the University of Vienna.

DR. JACQUES LORE, of the Rockefeller Institute for Medical Research, has been elected a foreign fellow of the Linnean Society, London.—Dr. David Bancroft Johnson, president of Winthrop Normal and Industrial College, of Rockhill, S. C., has been elected president of the National Education Association, in succession to Dr. David Starr Jordan, chancellor of Stanford University.

A MEMORIAL to Johann C. Reil, the anatomist, has been erected in Halle. It stands in front of the university clinic, the seat of his labors until called to Berlin in 1810. He died in 1813, aged fifty-five years.—A bronze bas-relief—the work of Mr. S. N. Babb—is about to be erected in St. Paul's Cathedral in memory of Captain Scott and his companions who perished in the Antarctic. At the request of the committee responsible for the memorial an inscription has been written by Lord Curzon, which reads as follows: "In memory of Captain Robert Falcon Scott, C.V.O., R.N., Dr. Edward Adrian Wilson, Captain Lawrence E. G. Oates, Lieut. Henry R. Bowers and Petty Officer Edgar Evans, who died on their return journey from the South Pole in February and March, 1912. Inflexible of purpose, steadfast in courage, resolute in endurance in the face of unparalleled misfortune. Their bodies are lost in the Antarctic ice. But the memory of their deeds is an everlasting monument."

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PAPUA, WHERE THE STONE-AGE LINGERS

BY DR. ALFRED GOLDSBOROUGH MAYER

WITH their undaunted spirit for braving the wilds, the English entered New Guinea in 1885. For centuries the great island had remained a mere outline upon the map the fever-haunted glades of its vast swamps and the broken precipices of its mountain ranges having defied exploration, more than the morose and savage character of its inhabitants. Even in the summer of 1913, Massy Baker the explorer, discovered a lake probably 100 miles or more in shore-line, which had remained hidden in the midst of the dark forests of the Fly and Strickland River regions, and here savages still in the stone age, who had never seen a white man, measured the potency of their weapons against the modern rifle.

To-day there are vast areas upon which the foot of the white man has not yet trodden, and of all the regions in the tropical world New Guinea beckons with most alluring fascination to him to whom adventure is dearer than life.

Far back in the dawn of European exploration, the Portuguese voyager Antonio de Abreu, may have seen the low shores of western New Guinea, but it is quite certain that sixteen years later, in 1527, Don Jorge de Meneses cruised along the coast and observed the wooly-headed natives whom he called "Papuas." The name "New Guinea" was bestowed upon the island by the Spanish captain, Ynigo Ortz de Retes, in 1515, when he saw the negroid natives of its northern shores.

Then there came and passed some of the world's greatest navigators. Torres wandering from far Peru, to unknowingly discover the strait which bears his name; Dampier, the buccancer-adventurer, and, in 1768, the cultured, esthetic Bougainville, who was enraptured by the beauty of the deep forest-fringed fjords of the northeastern coast. Cook, greatest of all geographers, mapped the principal islands and shoals of the intricate Torres Strait in 1770; and a few years later came Captain Bligh, the resourceful leader of his faithful few, crouching in their frail sail boat that had survived many a tempest; since the mutineers of the Bounty had cast them adrift in the mid-Pacific. In the early years of the nineteenth century the scientifically directed Astrolabe arrived, under the command of Dumont D'Urville, and, later, Captain Owen Stanley in the Rattlesnake, with Huxley as his zoologist, Then, in 1858, came Alfred Russel Wallace, the codiscoverer of Darwinism, who, by the way, is said to have been the first Englishman who ever actually resided in New Guinea.

The daring explorers and painstaking surveyors came and went, but the great island remained a land of dread and mystery, guarded by the jagged reefs of its eastern shores, and the shallow mud flats, stretching far to sea-ward beyond the mouths of the great rivers of its southern coast. So inaccessible was Papua that even the excellent harbor of Port Moresby, the site: of the present capital, was not discovered until 1873. One has but to stifle for a while in the heavy air that flows lifeless and fetid over the lowlands as if from a steaming furnace, or to scent the rank odors of the dark swamps, where for centuries malaria must linger, to appreciate the reason for the long-delayed European settlement of the country. But those who blaze the path of colonial progress are not to be deterred by temperatures or smells; let us remember that Batavia, "the white man's graveyard," is now one of the world's great commercial centers; and Jamaica, the old fever camp of the British army, is now a health resort for tourists.

Papua, the land of the tired eyes and the earnest face, of the willing spirit and the weary body, waning as strength fails year by year in malaria and heat, the land wherein the heart aches for the severed ties of wife and home; its history has hardly yet begun, but the reward of generations of heroism will be the conquest of another empire where England's high standards of freedom are to he raised anew. A victory of peace it is to be, as noble as any yet achieved in war; and great through its death roll, and forgotten though the workers be, the fruits of their labors will bless that better world Great Britain is preparing for those of ages yet to come.

There are great resources in Papua with its area of 90,500 square miles. Untrodden forests where the dark soil moulders beneath the everlasting shade; swamps bearing a harvest of thousands of sago and nipa palms, and mountains in a riot of contorted peaks rising to a height of 13,200 feet in the Owen

Stanley range.

It is still a country of surprises, as when petroleum fields, probably 1,000 square miles in area, were discovered only about four years ago along the Vailala River, the natives having concealed their knowledge of the bubbling gas springs through fear of offending the evil spirits of the place. It is evident that although the country has been merely glanced over, there are both agricultural and mineral resources of a promising nature in Papua. It remains but for modern medicine to over-come the infections of the tropics for the region to rise into prominence as one of the self-supporting colonies of the British empire.

The early history of British occupation centers around the striking personality of James Chalmers, the great-hearted, broad-minded, missionary, one of the most courageous who ever devoted his life to extending the brotherhood of the white man's ideals. Chafing, as a young man, under the petty limitations of his mission in the Cook Islands, he sought New Guinea, as being the wildest and most dangerous field in the tropical Pacific. Here, for twenty-five years, he devoted his mighty soul to the work of introducing the rudiments of civilization and Christianity to the most sullen and dangerous savages upon earth. Scores of times his life hung in the balance of native caprice; wives and friends died by his side, victims to the malignant climate and to native spears, while he seemed to possess a charmed life; until, true to his prediction, he was murdered by the cannibals of Dopina at the mouth of the Fly River in 1901.

Hundreds of scattered tribes had learned to revere their great leader "Tamate," as they called him, who brought peace and prosperity to his followers. Yet a danger to Papua that he himself foresaw and did all in his power to avert came as a result of the introduction of the very civilization of which he was the champion, for with peace came new wants that the most unscrupulous of traders at once sought to supply at prices ruinous to the social and moral welfare of the natives.

Also, the proximity of Queensland threatened to become a menace; for Chalmers himself was well aware of the dark history of the "blackbird trade" wherein practical slavery was forced upon the indentured laborers, lured from their island homes to toil as hopeless debtors upon the Australian plantations. A government of the natives for the native interests he desired; not one administered from the Australian mainland in the interest of alien whites. The hopes of Chalmers were only partially realized, for Papua is still only a territory of Australia.

In most respects this condition appears to be unfortunate. The crying needs of a new country are usually peculiarly local and not likely to be appreciated by a distant ruling power. Moreover, Australia is itself an undeveloped land and requires too large a proportion of its own capital for expansion at home to be a competent protector of a colony across the sea. One feels that Papuan development might have proceeded with greater smoothness had the colony been more directly under the British empire, rather shall an Australian dependency.

The strategic necessity that Australia should command both the northern and the southern shores of Torres Straits might still have been secured without the sacrifice of any important initiative in matters of government upon the part of Papua.

The cardinal evil that Chalmers feared has, however, been averted. The natives still own 97 1/2 per cent. of the entire land area, and wise laws guard them in this precious possession, and aim to protect them from all manner of unjust exploitation. It is much to the credit of the government that the cleanest native villages and the most healthy, ambitious and industrious tribes, are those nearest the white settlements. Contact between the races has resulted in the betterment, not in the degradation, of the Papuan natives.

The touch of a master hand is apparent in a multitude of details in managing the natives of Papua; and it is of interest to see that in broad essentials the plan of government is adapted from that which the English have put to the test of practice in Fiji; the modifications being of a character designed to meet the conditions peculiar to Melanesia, wherein the chiefs are relatively unimportant in comparison with their role in the social systems of the Polynesians and Fijians. Foremost in the shaping of the destiny of Papua stands the commanding figure of Sir William Macgregor, administrator and lieutenant governor from 1888 to 1898. As a young man Macgregor was government physician in Fiji, where he became prominent not only as a competent guardian of the health of the natives, but as a leader in the suppression of the last stronghold of cannibalism along the Singatoka River. In Papua his tireless spirit found a wide field for high endeavor, and upon every department of the government one finds to-day the stamp of his powerful personality. Nor did he remain closeted in Port Moresby, a stranger to the races of his vast domains, for over the highest mountains and through the densest swamps his expeditions forced their way; the Great Governor always in the van. It was thus that he conquered the fierce Tugeri of the Dutch border, who for generations had been the terror of the coasts; and wherever his expeditions passed, peace followed, and the law of the British magistrate supplanted the caprice of the sorcerer.

But his hardest fight was not with the mountain wilds or the malarious morasses. It was to secure from the powerful ones of his own race the privileges of freemen for the natives of Papua.

In his youth he had seen the blessings that came with the advent of British rule in Fiji; and here, in broad New Guinea, upon a vaster scale, he strove to make fair play the dominant note in the white man's treatment of a savage race.

Arrayed against Chalmers and Macgregor were conservatism and suspicion founded in ancient precedent, and a commercial avarice that saw in native exploitation the readiest means to convert New Guinea into a "white man's country." Aversion there was also in high places to embarking upon a possibly fruitless experiment, involving generations of labor and expense for a remote and uncertain harvest. Chalmers and Macgregor, however, through the force of their high convictions and the wisdom of their wide experience, won the great fight for fairness; for civilization's cardinal victories are those, not of the soldier, but of the civil servant who dares risk his reputation and his all for those things he deems just and generous; and when Papua comes to erect statues to her great leaders, those of these two patriots must surely occupy the highest places, as champions of the liberties of the weak. The noble policy of Macgregor is still, and let us hope it long may be, the keynote of the administration in Papua, which to-day is being ably carried forward under the great governor's disciple, the Honorable John H. P. Murray.

The proclamation given by Captain Erskine in 1884 declared that a British Protectorate had become essential for the safeguarding of the lives and property of the natives of New Guinea and for the purpose of preventing the occupation of the country by persons whose proceedings might lead to injustice, strife and bloodshed, or whose illegitimate trade might endanger the liberties and alienate the lands of the natives.

It is, however, one thing for a government to declare its altruistic intentions, but often quite another to carry them into effect.

In Papua, every effort has been made to prevent robbery of the natives by unscrupulous whites. The natives are firmly secured in the possession of their lands, which they can neither sell, lease nor dispose of, except to the government itself. Thus the natives and the government are the only two landlords in the country. To acquire land in Papua, the European settler must rent it from the government, for he is not permitted to acquire fee simple rights. The whites are thus tenants of the government, and are subject to such rules and regulations as their landlord may decree. The tenant is, however, recognized as the creator and owner of any improvements he may erect upon the land, and, at the expiration of his lease, the government undertakes to pay him a fair compensation for such improvements, provided he has lived up to the letter of regulations respecting his tenure.

For agricultural land a merely nominal rental is demanded, ranging from nothing for the first ten years to a final maximum of six pence per acre; yet this system has had the effect of retarding European settlement, for, although its area is twice that of Cuba, Papua had but 1,064 whites in 1912, and only one one hundred and seventy-fourth of the territory is held under lease.

Men of the type who can conquer the primeval forests and create industries prefer to own their land outright, and are apt to resent the restrictions of complex government regulations, however wisely administered. Socialism, while it may in some measure be desirable in old and settled communities, serves but to dull that sense of personal freedom which above all spurs the pioneer onward to success in a wild and dangerous region.

Possibly in the end, the government may find it advantageous to permit certain lands to be acquired by Europeans, in fee simple; for until this is done the settlement of the country must proceed with extreme slowness. Moreover, mere tenants owning nothing but their improvements, and even these being subject to government appraisement, may be unduly tempted to drain, rather than to develop, the resources of the land they occupy.

But the chief aim of the Papuan government is to introduce civilization among the natives, and a slow increase in the European population is of primary necessity to the accomplishment of this result.

At present the natives are not taxed, the chief sources of revenue being derived from the customs duties upon imports, the bulk of which are consumed by the Europeans, and this source of income is supplemented by an annual grant of about 25,000 pounds from the Australian Commonwealth, but, due to the duties upon food and necessities, the cost of living is higher than it should be in a new country.

Judging, however, from the experience of the English in Fiji and of the Dutch in Java, the natives would be benefited rather than oppressed by a moderate poll tax to be paid in produce, thus developing habits of industry, and in some measure offsetting the evil effects of that insidious apathy which follows upon the sudden abolition of native warfare.

Every effort should also he made to encourage and educate the Papuans in the production and sale of manufactured articles. One must regret the loss of many arts and crafts among the primitive peoples of the Pacific, which, if properly fostered under European protection to insure a market and an adequate payment for their wares, would have been a source of revenue and a factor of immeasurable import in developing that self respect and confidence in themselves which the too sudden modification of their social and religious Systems is certain to destroy. The ordinary mission schools are deficient in this respect, devoting their major energies to the "three R's" and to religious instruction, and, while it is pleasing to observe a boy whose father was a cannibal extracting cube roots, one can not but conclude that the acquisition of some money-making trade would be more conducive to his happiness in after life.

It is not too much to say that the chief problem in dealing with an erstwhile savage race is to overcome the universal loss of interest and decline in energy which inevitably follows upon the development of that semblance of civilization which is enforced with the advent of the white man. The establishment of manual training schools wherein arts and crafts which may be profitably practiced by the natives as life-professions, is a first essential to the salvation of the race. These schools should and would in no manner interfere with the religious teaching received from missionaries, but would indeed be a most potent factor in the spread of true Christianity among the natives. Whether Christianity be true or false does not affect the case, for the natives are destined to be dominated by Christian peoples, and it primarily essential that they should understand at least the rudiments of Christian ideals and behavior.

The realization of the importance of training them to the pursuit of useful arts and trades, which would enable the natives to become self-supporting in the European sense, has been perceived by certain thinkers among the missionaries themselves, and in certain regions efforts are being made the success of which should revolutionize our whole method of dealing with the problem of introducing civilization among a primitive people.

Keep their minds active and their hands employed in self-supporting work and their morals and religion will safely fall into accord with Christian standards.

Up to the present native education has been left to the devoted efforts of the missionaries, who have more than 10,000 pupils under their charge, but the time is coming when the government should cooperate in establishing trade schools wherein crafts, providing life-vocations to the natives, may be taught.

There may be more than 275,000 natives in Papua, but, due to lack of knowledge of the country, the actual number is unknown.

Among the mountain fastnesses, defending themselves in tree-houses, one finds a frizzly-headed black negrito-like race hardly more than five feet in height. These are probably remnants of the "pigmy" pre-Dravidian or Negrito-Papuan element, which constituted the most ancient inhabitants of the island and who long ago were driven inland from the coveted coast.

The burly negroid Papuans of the Great River deltas of western Papua differ widely from the lithe, active, brown-skinned, mop-headed natives of the eastern half of the southern coast; and Professors Haddon and Seligmann have decided that in eastern New Guinea many Proto-Polynesian, Melanesian and Malayan immigrants have mingled their blood with that of the more primitive Papuans. Thus there are many complexly associated ethnic elements in New Guinea, and often people living less than a hundred miles apart can not understand one another; in fact, each village has its peculiar dialect. Social customs and cultural standards in art and manufacture vary greatly from the same cause, and each tribe has some remarkable individual characteristics. In the Fly-River region, the village consists of a few huge houses with mere stalls for the families, which crowd for defence under the shelter of a single roof. Along the southern side of the eastern end of the island, however, each family has its own little thatched hut, and these are often built for defense upon piling over the sea, reminding one of the manner of life of the prehistoric Swiss-lake dwellers.

Nearly 12,000 natives are at present employed by the whites as indentured laborers in Papua, their terms of service ranging from three years, upon agricultural work, to not more than eighteen months in mining. Their wages range from about $1.50 to $5.00 per month, and all payments must be made in the presence of a magistrate and in coin or approved bank notes.

At every turn both employer and employed are wisely safeguarded; the native suffering imprisonment for desertion, and the employer being prohibited from getting the blacks into debt, or from treating them harshly or unjustly. Their enlistment must be voluntary and executed in the presence of a magistrate, and, after their term of service, the employer is obliged to return them to their homes.

One is impressed with the many manifestations of a fair degree of efficiency on the part of the native laborers, who are really good plantation hands and resourceful sailors. In fact, trade has always been practiced to a considerable extent by the shore tribes, the pottery of the eastern end of the coast being annually exchanged for the sago produced by the natives of the Fly River Delta. It is a picturesque sight to see the large lakatois, or trading canoes, creeping along in the shadow of the palm-fringed shores under the great wall of the mountains, the lakatoi consisting of a raft composed of six or more canoes lashed together side by side, and covered by a platform which bears a thatched hut serving to house the sailors and their wares. The craft is propelled by graceful crescent-shaped lateen sails of pandanus matting and steered by sweeps from the stern. Trading voyages of hundreds of miles are often undertaken, the lakatois starting from the east at the waning of the southeast trade wind in early November and returning a month or two later in the season of the northwest monsoon.

The Papuan is both ingenious and industrious when working in his own interest, and with tactful management he becomes a faithful and fairly efficient laborer. Perhaps the most serious defect in the present system of employment in Papua is the usually long interval between payments. The natives are not paid at intervals of less than one month and, often, not until the expiration of their three-year term of service. With almost no knowledge of arithmetic and possessed of a fund which seems large beyond the dreams of avarice, he is practically certain to be cheated by the dishonest tradesmen who flock vulture-like to centers of commercial activity. This evil might be in large measure prevented were the natives to be paid at monthly intervals, for they would then gradually become accustomed to the handling of money and would gain an appreciation of its actual value.

Generations must elapse before more than a moderate degree of civilization is developed in Papua, but the foundations are being surely and conservatively laid, and already in the civilized centers natives respect and loyally serve their British friends and masters.

In common with many another British colony, the safeguard of Papua lies not in the rifles of the whites, but in the loyal hearts of the natives themselves, and in Papua, as in Fiji, the native constabulary under the leadership of a mere handful of Europeans may be trusted to maintain order in any emergency. As Governor Murray truly states in his interesting book "Papua, or British New Guinea," the most valuable asset the colony possesses is not its all but unexplored mineral wealth or the potential value of its splendid forests and rich soil, but it is the Papuans themselves, and let us add that under the leadership of the high-minded, self-sacrificing and well-trained civil servants of Great Britain the dawn of Papuan civilization is fast breaking into the sunlight of a happiness such as has come to but few of the erstwhile savage races of the earth.

Without belittling the nobility of purpose or disregarding the self-sacrificing devotion of the missionary for his task, let us also grant to the civil servant his due share of praise. His duty he also performs in the dangerous wilds of the earth; beset with insidious disease, stifling in unending heat, exiled from home and friends, with suspicious savages around him, he labors with waning strength in that struggle against climate wherein the ultimate ruin of his body is assured. Yet in his heart there lives, growing as years elapse, the English gentleman's ideal of service, and for him it is sufficient that, though he is to be invalided and forgotten even before he dies, yet his will have been one of those rare spirits who have extended to the outer world his mother country's ideal of justice and fair play.

CONTACT ELECTRIFICATION AND THE ELECTRIC CURRENT

BY PROFESSOR FERNANDO SANFORD

STANFORD UNIVERSITY

IN a previous paper in this journal, entitled "The Discovery of Contact Electrification" (November, 1913), it was shown that the production of electric charges by the mere contact of two dissimilar metals was first discovered by Rev. Abraham Bennett, in 1789, and that it was verified by a different method by Tiberius Cavallo, in 1795. Meantime, in 1791, Dr. Galvani discovered the twitching of a frog's muscle, due to electrical stimulus. Galvani's discovery was described by himself as follows:[1]

[1] Translation from "Makers of Electricity," p 143.

'I had dissected a frog and had prepared it, as in Figure 2 of the fifth plate, and had placed it upon a table on which there was an electric machine, while I set about doing certain other things. The frog was entirely separated from the conductor of the machine, and indeed was at no small distance away from it. While one of those who were assisting me touched lightly and by chance the point of his scalpel to the internal crural nerves of the frog, suddenly all the muscles of its limbs were seen to be so contracted that they seemed to have fallen into tonic convulsions. Another of my assistants, who was making ready to take up certain experiments in electricity with me, seemed to notice that this happened only at the moment when a spark came from the conductor of the machine. He was struck by the novelty of the phenomenon, and immediately spoke to me about it, for I was at the moment occupied with other things and mentally preoccupied. I was at once tempted to repeat the experiment, so as to make clear whatever might be obscure in it. For this purpose I took up the scalpel and moved its point close to one or the other of the crural nerves of the frog, while at the same time one of my assistants elicited sparks from the electric machine. The phenomenon happened exactly as before. Strong contractions took place in every muscle of the limb, and at the very moment when the sparks appeared, the animal was seized as it were with tetanus.'

Following this original observation, Galvani made a great many experiments on the effect of electric stimulus upon the nerves of frogs and other animals. He found that the twitching of the frog's muscles could be produced by atmospheric electricity, both at the time of lightning and at other times when no lightning was visible. During these investigations he observed that when the legs of the frog were suspended from an iron railing by a hook through the spinal cord, and when this hook was of some other metal than iron, the muscles would twitch whenever the feet touched the iron railing. He tried out a number of pairs of metals, and found that when the nerve was touched by one metal and the muscle or another point on the nerve was touched by another metal and the two metals were then brought into contact or were connected through another metal or through the human body, the muscles would contract as they would when stimulated by electricity.

Galvani concluded that the contraction in this case, as in the earlier experiments, was produced by an electric stimulation, and since the metals seemed to him to serve merely as the conductors of the electric discharge, he concluded that the source of the electricity must be in the tissues of the animal body. This seemed all the more probable since it was known that certain fishes and an electric eel were capable of giving violent electric shocks. This electricity of the eels and fishes had been named animal electricity, and Galvani concluded that all animals were capable of producing this electricity in the tissues of their bodies.

He believed this electricity was to be found in various parts of the body, but that it was especially collected in the nerves and muscles. The especial property of this animal electricity seemed to be that it discharged from the nerves into the muscles, or in the contrary direction, and that to effect this discharge it would take the path of least resistance through the metal conductor or through the human body. Since during this discharge the muscle was caused to contract, Galvani concluded that the purpose of this animal electricity was to produce muscular contractions.

Galvani seems to have concerned himself principally with the physiological processes which he believed gave rise to the electric charges, but physicists began immediately to seek for other sources of the electricity. The one observation which seemed to offer a definite suggestion as to the possible source of the electrical charge was the fact that, in general two different metals must be used to connect the muscle and nerve before a discharge would take place from the one to the other. This made Galvani's theory that the metals served merely as conductors seem improbable. On the other hand, it was sometimes possible to get the muscular contractions by using a single bent wire or rod to connect the nerve and muscle, especially if the two ends were of different degrees of polish, or if one end was warmer than the other.

Volta was apparently the first to suggest that the electricity which seemed to be generated in Galvani's experiments might have its source in the contact of the two metals. Several writers called attention to an apparent relation between Galvani's experiments and a phenomenon announced by J. G. Sulzer, in 1760. Sulzer found that if pieces of lead and silver were placed upon the tongue separately no marked taste was produced by either, but that if while both were on the tongue the metals were brought into contact a strong taste was produced which he compared to the taste of iron vitriol. Here was a case of undoubted stimulation of the nerves of taste by the contact of two metals, and it seemed not improbable that other nerves might be stimulated in the same manner. In the meantime Mr. John Robison had increased the Sulzer effect greatly by building up a pile of pieces of zinc with silver shillings and placing these in contact with the tongue and the cheek.

It was the question as to the possibility of producing the electric charge by mere metallic contact which led Cavallo to make his experiments upon contact electrification. Thus Cavallo says in Volume III. of "A Complete Treatise on Electricity," published in 1795:

'The above mentioned singular properties, together with some other facts, which will be mentioned in the sequel induced Mr. Volta, to suspect that possibly in many cases the motions are occasioned by a small quantity of electricity produced by the mere contact of two different metals; though he acknowledges that he by no means comprehends in what manner this can happen. This suspicion being entertained by so eminent a philosopher as Mr. Volta, induced Dr. Lind and myself to attempt some experiment which might verify it; and with this in view we connected together a variety of metallic substances in diverse quantities, and that by means of insulated or not insulated communications; we used Mr Volta's condenser, and likewise a condenser of a new sort; the electrometer employed was of the most sensible sort; and various other contrivances were used, which it will be needless to describe in this place; but we could never obtain the smallest appearance of electricity from those metallic combinations. Yet we can infer to no other conclusion, but that if the mere combination, or contact, of the two metals produces any electricity, the quantity of it in our experiments was too small to he manifested by our instruments.'

Later, on page 111 of the same volume, he says:

'After many fruitless attempts, and after having sent to the press the preceding part of this volume, I at last hit upon a method of producing electricity by the action of metallic substances upon one another, and apparently without the interference of electric bodies. I say apparently so, because the air seems to be in a great measure concerned in those experiments, and perhaps the whole effect may be produced by that surrounding medium. But, though the irregular, contradictory, and unaccountable effects observed in these experiments do not as yet furnish any satisfactory theory, and though much is to be attributed to the circumambient air, yet the metallic substances themselves seem to be endowed with properties peculiar to each of them, and it is principally in consequence of those properties that the produced electricity is sometimes positive, at other times negative, and various in its intensity.'

Cavallo then proceeds to describe the experiments on contact electrification which were described in the previous paper referred to at the beginning of the article.

Cavallo's experiments were evidently made in 1795. In the following year Volta announced the discovery of the electrical current. In a letter written to Gren's Neues Journal der Physik, August, 1796, Volta says:

'The contact of different conductors, particularly the metallic, including pyrites and other minerals as well as charcoal, which I call dry conductors, or of the first class with moist conductors, or conductors of the second class, agitates or disturbs the electric fluid, or gives it a certain impulse. Do not ask in what manner: it is enough that it is a principle and a great principle.'

It will be seen that at this stage of his discovery Volta was inclined to attribute tho origin of the current to the contact between the metals and his moist "conductors of the second class," though later in the same article he says it is impossible to tell whether the impulse which sets the current in motion is to be attributed to the contact between the metals themselves or between the two metals and the moist conductor, since either supposition would lead to the same results.

Later, as was shown in the previous paper by the present writer Volta came to regard the metallic contact as the cause of the electromotive force. In a letter written to Gren in 1797 and published as a postscript to his letter of August, 1796, Volta says:

'Some new facts, lately discovered, seem to show that the immediate cause which excites the electric fluid, and puts it in motion, whether it be an attraction or a repulsive power, is to be ascribed much rather to the mutual contact of two different metals, than to their contact with moist conductors.'

The new facts, "lately discovered," to which Volta attributes his change of view were his repetitions of Bennett's experiments of 1789.

Volta apparently thought that the current was not only set up by the contact of the two metals of a pair, but that it was kept up by the mutual action of the metals on each other. He accordingly made no attempt to discover whether any changes took place in his circuit while the current was being generated. The chemical action on his metals and the dissociation in his electrolyte seem to have entirely escaped his attention. At least, he did not attach enough importance to them to mention them anywhere in his description of his apparatus.

In the meantime a chemical explanation of the phenomena observed by Galvani had been proposed in 1792 by Fabroni, a physicist of Florence. After discussing the Sulzer phenomenon already mentioned in this paper, Fabroni argues that the peculiar taste caused by bringing the two metals into contact while on the tongue is due to a chemical, rather than to an electrical, action. He then discusses the different chemical behavior of metals when taken singly and when placed in contact with other metals. He says: [2]

[2] The following quotations from Fabroni have been translated by the present writer from the

German of Ostwald's "Elektrochemie," pp. 103, ff.

I have already frequently observed that fluid mercury retains its beautiful metallic luster for a long time when by itself; but as soon as it is amalgamated with any other metal it becomes rapidly dim or oxidized, and in consequence of its continuous oxidation increases in weight.

I have preserved pure tin for many years without its changing its silvery luster, while different alloys of this metal which I have prepared for technical purposes have behaved quite otherwise.

I have seen in the museum at Cortonne Etrusean inscriptions upon plates of pure lead which are perfectly preserved to this day' although they date from very ancient times; on the other hand, I have found with astonishment in the gallery of Florence that the so-called "piombi" or leaden medallions of different popes, in which tin and possibly some arsenic have been mixed to make them harder and more beautiful, have fallen completely to white powder, or have changed to their oxides, though they were wrapped in paper and preserved in drawers.

In the same way I have observed that the alloy which was used for soldering the copper plates upon the movable roof of the observatory at Florence has changed rapidly and in places of contact with the copper plates has gone over into a white oxide.

I have heard also in England that the iron nails which were formerly used for fastening the copper plates of the sheathing of ships were attacked on account of contact, and that the holes became enlarged until they would slip over the heads of the nails which held them in position.

It seems to me that this is sufficient to show that the metals in these cases exert a mutual influence upon each other, and that to this must be ascribed the cause of the phenomena which they show by their combination or contact.

After discussing some of the experiments on nerve stimulation which had been made by Galvani and others, Fabroni argues that these are principally, if not wholly, due to chemical action, and that the undoubted electrical phenomena which sometimes accompany them are not the cause of the muscular contractions.

In discussing the nature of the chemical changes produced in two metals by their mutual contact, Fabroni says:

'Since the metals have relationships with each other, the molecules must mutually attract each other as soon as they come into contact. One can not determine the force of this attraction, but I believe it is sufficient to weaken their cohesion so that they become inclined to go into new combinations and to more easily yield to the influence of the weakest solvents.'

In order to further show the weakening of cohesion by the contact of two metals, Fabroni describes the results of some experiments which he has made. He says:

'In order to assure myself of the truth of my assumptions, I put into different vessels filled with water:

(1) Separate pieces, for example, of gold in one, silver in another, copper in the third, likewise tin, lead, etc.

(2) In other similar vessels I put pieces of the same metals in pairs, a more oxidizable and a less oxidizable metal in each pair' but separated from each other by strips of glass

(3) Finally, I put in other vessels pairs of different metals which were placed in immediate contact with each other.

The first two series suffered no marked change, while in the latter series the more oxidizable metal became visibly covered with oxide in a few instants after the contact was made.'

Fabroni found that under the above circumstances his oxidizable metals dissolved in the water, and in some cases salts were formed which crystallized out. He then compares the metals in contact with each other in water with the metals on the tongue when brought into contact, as in Sulzer's experiment, and the two metals touching each other by which different points on a nerve were touched to produce the muscular twitchings in Galvani's experiments, and concludes that the chemical action upon the metals was the same in each case, and that the other phenomena observed must have resulted from this chemical action. It is not strange that when Volta showed later that an electric current passed between the metals in all of tho above cases Fabroni should regard the chemical action which he had previously observed as the cause of this current.

Ten years after the publication of Fabroni's original paper, Volta wrote a letter to J. C. Delamethrie which was published in Vol. I of Nicholson's Journal. This letter was written after the chemical changes in the voltaic cell had received a great deal of attention by many experimenters, the most prominent of whom was Davy. To show that Volta's theory as to the source of the current was not affected by these investigations, a quotation from this letter is given below.

'You have requested me to give you an account of the experiments by which I demonstrate, in a convincing manner, what I have always maintained, namely, that the pretended agent, or GALVANIC FLUID, is nothing but common electrical FLUID, and that this fluid is incited and moved by the simple MUTUAL CONTACT OF DIFFERENT CONDUCTORS, particularly the metallic; strewing that two metals of different kinds, connected together, produce already a small quantity of true electricity, the force and kind of which I have determined; that the effects of my new apparatus (which might be termed electromotors), whether consisting of a pile, or in a row of glasses, which have so much excited the attention of philosophers, chemists, and physicians; that these so powerful and marvelous effects are absolutely no more than the sum total of the effects of a series of several similar metallic couples or pairs; and that the chemical phenomena themselves, which are obtained by them, of the decomposition of water and other liquids, the oxidation of metals, &c., are secondary effects; effects, I mean, of this electricity, of this continual current of electrical fluid, which by the above mentioned action of the connected metals, establishes itself as soon as we form a communication between the two extremities of the apparatus, by means of a conducting bow; and when once established, maintains itself, and continues as long as the circuit remains interrupted.'[3]

[3] This seems to be a misprint for uninterrupted.

Further along in the same letter Volta reiterates his conviction that the contact of the two metals furnishes the true motive power of the current. Thus he says (p. 138):

'As to the rest, the action which excites and gives motion to the electric fluid does not exert itself, as has been erroneously thought, at the contact of the wet substance with the metal, where it exerts so very small an action, that it may be disregarded in comparison with that which takes place, as all my experiments prove, at the place of contact of different metals with each other. Consequently the true element of my electromotive apparatus, of the pile, of cups, and others that may be constructed according to the same principles, is the simple metallic couple, or pair, composed of two different metals, and not a moist substance applied to a metallic one, or inclosed between two different metals, as most philosophers have pretended. The humid strata employed in these complicated apparatus are applied therefore for no other purpose than to effect a mutual communication between all the metallic pairs, each to each, ranged in such a manner as to impel the electric fluid in one direction, or in order to make them communicate, so that there may be no action in a direction contrary to the others.'

At the end of the above letter as published in Nicholson's Journal, the editor, William Nicholson, comments at length on Volta's theory of the source of current in the cell and calls attention to the fact that Davy had already made cells by the use of a single metal and two different liquids. At the conclusion of his comments he calls attention to the fact that Bennett and Cavallo had performed experiments with contact electrification prior to Volta's experiments, and says in conclusion, after referring to Bennett,

'This last philosopher, as well as Cavallo, appears to think that different bodies have different attractions or capacities for electricity; but the singular hypothesis of electromotion, or a perpetual current of electricity being produced, by the contact of two metals is, I apprehend, peculiar to Volta.'

This peculiar theory of Volta's probably never gained many adherents and was necessarily abandoned as soon as the energy relations of the current were considered, but the controversy as to whether the electrical current or the accompanying chemical changes was the primary phenomenon soon became transferred to a quite different field, viz., to the origin of the electrical charges which Bennett had shown resulted from the contact of different metals. Bennett attempted to account for the phenomena which he had observed on the hypothesis that different substances "have a greater or less affinity with the electric fluid," and Cavallo says:

'I am inclined to suspect that different bodies have different capacities for holding the electric fluid.'

Volta reaches a similar conclusion after repeating some of Bennett's experiments. In referring to this decision of Volta as to the origin of the electric charge in contact electrification, Ostwald says:

'We stand here at a point where the most prolific error of Electrochemistry begins, the combating of which has from that time on occupied almost the greater part of the scientific work in this field.'

The error, from Ostwald's point of view, lies in the assumption that the transference of electricity from the one metal to the other is a primary phenomenon of metallic contact. He, with many others, including some of the most distinguished physicists and chemists of the past century, regard the electrical transference as a secondary phenomenon resulting from the previous oxidation of one of the metals. Thus Lodge, in discussing the opposite electrification of plates of zinc and copper when brought into contact says:

'The effective cause of the whole phenomenon in either case is the greater affinity of oxygen for zinc rather than copper.'

The apparent conflict of opinion between those who hold that the different affinities of the metals for oxygen is the cause of the rearrangement of their electrical charges when brought into contact and those who hold with Bennett and Cavallo that the metals in their natural state have different affinities for the electrical fluid must disappear when we recognize that all affinity, and consequently the affinity for oxygen, must be an electrical attraction. If zinc has an affinity for oxygen, it must be because the zinc is either electropositive or electronegative to oxygen. If it has a greater affinity for oxygen than copper has, then the zinc must be either electropositive or electronegative to copper. This being the case, and both being conductors, it is not surprising that some electricity will flow from one to the other when the two metals are brought into contact.

Those writers who attribute the oxidation theory of contact electrification to Fabroni apparently overlook the fact that not oxidation, but the weakening of the cohesion of at least one of the metals due to their contact, was the primary phenomenon in Fabroni's theory. When this is remembered, it is seen that the observations of Bennett and Fabroni, instead of furnishing arguments for two conflicting theories, actually serve, as all true scientific observations must, to supplement each other.

Thus we now know that cohesion or affinity is an electrical attraction between the atoms or molecules of a body. The only known methods of changing the electrical attraction between two bodies whose distances and directions from other bodies remain constant is by varying the magnitude of their charges or by changing the specific inductive capacity of the medium between them. Bennett observed that when two pieces of different metal in their normal electrical condition are placed in contact, there is a redistribution of the charges of their surface atoms. Fabroni observed under the same conditions a change in the surface cohesion of the two metals.

To the present writer this seems the actual sequence of phenomena, viz., a redistribution of the charges of the surface atoms of the metals, a consequent change in surface cohesion and a resultant oxidation of one of the metals.

ON CERTAIN RESEMBLANCES BETWEEN THE EARTH AND A BUTTERNUT

BY PROFESSOR A, C. LANE

TUFTS COLLEGE

THE drama of the earth's history consists in the struggle between the forces of uplift and the forces of degradation. The forces of uplift are mainly the outward expression of the inner energy and heat of the earth, whether they be the volcano belching its ashes thousands of meters into the air, or the earthquake, with the attendant crack or fault in the earth's crust, leading to a sudden displacement, and sending, far and wide, a death-dealing shock, or those mountain-building actions, which, though they may be as gentle and gradual as might be produced by the breathing of mother earth and the uplifting of her bosom thereby, nevertheless, end in the huge folds of our mountain ranges.

Against these, there are always working the forces of degradation—the slow rotting of weathering caused by the direct chemical action of the moist atmosphere or the alternation of hot and cold which crumbles rocks far above the line where rain never falls. Once the rock is rotten and decayed, it yields readily to the forces of degradation, which drag it down—the beating of the rain, the rush of the avalanche or of the landslide, the tumult of the torrent, the quieter action of the muddy river in its lower reaches or the mighty glacier which transfers fine and coarse material alike toward the sea.

These actions are always going on. Are they always equally balanced, or are there periods when the forces of elevation are more active, the forces of degradation not so powerful, as against other times in which the forces of degradation alone are at work? If there is inequality in the balance and struggle of these contending forces, the great periods or acts in the geologic drama might thus be marked off as Chamberlin suggests. Newbery, Schuchert and others have pointed out that there seem to have been great cycles of sedimentation which may be interpreted as due to the alternate success, first of the factors of elevation, then of those of degradation.

Suppose, for instance, that there has been an epoch of elevation, that mountain chains have been lifted far into the sky and volcanoes have sent their floods of lava forth, and fault-scarped cliffs run across the landscape and that then, for a while, the forces of elevation cease their work. Little by little, the mountains will be worn down to a surface of less and less relief, approaching a plain as a hyperbola approaches its asymptote—a surface which W. M. Davis has called peneplain.

But where will the material thus worn go? Into the sea. Going into the ocean it will raise the level of the sea slowly but surely. At present, for every four feet of elevation taken off the land, there will be something like one foot rise of the ocean level, and this rise may take only thirty thousand years—a long time in human history, but not so long in the history of the earth. All the time, then, that the forces of the atmosphere are wearing down the surface of the earth to the sea level the sea is rising and its waves are producing a plain of marine denudation which rises slowly to meet the peneplain which is produced by degradation. In the beginning of this cycle, where the forces of degradation have their own way, coarse material may be brought down by torrents from the mountains, and the glaciers, which find their breeding place in these high elevations, may drag down and deposit huge masses of boulder clay. But, little by little as the mountains are lowered, the sediments derived from them will become finer and finer and glaciers will find fewer and fewer sources.

Not only that, but the growth of seas extending over the continents will tend to change the climate, we shall have a moister, more insular climate, we shall have a greater surface of evaporation, and thus, on the whole, a more equable temperature throughout the world. We know that, at present, the extremes of cold and hot are found far within the interior of the continents. Continental climates are the climates of extremes, and on the whole extremes are hurtful to life. So then as the forces of degradation tend to lower the continents beneath the sea level glaciers and deserts and desert deposits alike must also disappear. Vegetation will clothe the earth, and marine life swarm in the shallow seas of the broadening continental shelf. Under the mantle of vegetation, mechanical erosion will be less, that is, the breaking up of rocks into small pieces without any very great change, but the rich soil will be charged with carbon dioxide, and chemical activity will still go on. Rivers will still contain carbonates, even though they carry very little mud, and in the oceans the corals and similar living forms will deposit the burden of lime brought into the sea by the rivers. Thus, if forces of degradation have their own way, in time there will be a gradual change in dominant character, from coarse sediments to fine, from rocks which are simply crumbled debris to rocks that are the product of chemical decay and sorting, so that we have the lime deposited as limestone in one place and the alumina and silica, in another. We shall have a change from local deposits, marine on the edges of large continents, or land deposits, very often coarse, with fossils few and far between, to rocks in which marine deposits will spread far over the present land in which will appear more traces of that life that crowded in the shallow warm seas which form on the flooded continents. We shall have a transition from deposits which may be largely formed on the surface of the continents. lakes, rivers, salt beds and gypsum beds, due to the drying up of such lakes and the wind-blown deposits of the steppes, to deposits which are almost wholly marine.

Now, I need not say (to those who are familiar with geology) that we have indications of just such alternations in times passed. There are limestones abounding in fossils, with a cosmopolitan life very wide spread to be recognized in every continent, such as used to be known as the Trenton limestone, the mountain limestone, the chalk. Perhaps every proper system and period should be marked by such a limestone in the middle. The time classed as late Permian and Triassic on the other hand was one of uplift, disturbance, volcanic action and extreme climates, which gave us the traps of Mt. Tom, the Palisades of the Hudson, the bold scenery of the Bay of Fundy and the gypsum and red beds which are generally supposed to be quite largely formed beneath the air and beds of tillite formed beneath glaciers. Then in the times succeeding, in many parts of the world, degrading forces were more effective than uplifting so that the mountains became lower, and the seas extended farther over the continents. Then the prevalence of lime sediments was so great that the "chalk" was thought to be characteristic everywhere. And about the time the "chalk" the land was reduced to a peneplain. A similar cycle may be traced from the Keweenawan rocks to the group of limestones so widespread over the North American continent and so full of fossils, which to older geologists and oil drillers have been known, in a broad way, as Trenton.

All this introduces a question—to which I wish to suggest an answer—How is it that these cycles came to be? Were the outer rock crust of the earth perfectly smooth the oceans would cover it to the depths of thousands of feet and it is only by the wrinkling of such a crust that any part of it appears above the ocean. If the earth had a cool thin crust upon a hot fluid interior, and that thin crust were able to sustain itself during geologic ages so that the shrinkage should accumulate within, until finally collapse came, giving an era of uplift, it is obvious that we could account for such cycles. There is very clear evidence that the outermost layer of the earth's crust is but a thin shell like the outer shuck or exocarp of a butternut, so thin that it is not at all possible that it can sustain itself for more than a hundred miles or so, or for more than a very few years at the outside. Hayford's[1] investigations are the latest that show that the continents project because, on the whole, they are lighter, they float, that is, above the level of the oceans because there is a mass of lighter rock below, like an iceberg in the sea. Here the likeness between nut and earth fails and it would be more like the earth if the outer shuck were thicker in certain large areas. If this extra lightness or "isostatic compensation" is equally distributed, Hayford finds[2] that the most probable value of the limiting depth is 70 (113 km.) miles, and practically certain that it is somewhere between 50 (80 km.) and 100 (150 km.) miles; if, on the other hand, this compensation is uniformly distributed through a stratum 10 (16 km.) miles thick at the bottom of the crust so that there is a bulging of the crust down into a heavier layer below to balance the projection of the mountains above, as I think much more likely, then the most probable depth for the bottom of the outer layer is 37 (60 km.) miles. This layer is much thinner than the outer layer of the figure and is supposed to yield to weight placed as, though more slowly than, new thin ice bends beneath the skater.

[1] The figure of the earth and isostasy from measurements in the U.S. Dept. of Commerce and Labor, 1909, p. 175.

[2] loc. cit., p. 175.

There are a number of facts which support this so-called theory of isostasy, according to which the crust of the earth is not capable of sustaining any very great weight, though it may be at the outside rigid, but is itself essentially like a flexible membrane resting on a layer of viscous fluid. However viscous this fluid may be and rigid to transitory quickly shifting strains like those produced by the earth's rotation, it does NOT REMAIN AT REST in a state of strain (at any rate if this strain passes limits which are relatively quite low). Not only are, according to Hayford's observations, the inequalities of the North American continent compensated for by lighter material below, so that the plumb- bob deflections are only one twentieth what they would be if they rested upon a rigid substratum of uniform density, but other facts that lead to the same conclusion are the apparent tendency of areas of sedimentation to slowly settle under their load, the apparent settling of the Great Lake region under a load of ice and springing up again since the removal of the ice. But if the theory of isostasy is true, one would at first say that there could be no great accumulation through a geologic period of stresses which would finally yield in the shape of folded mountain ranges. It has, in fact, been suggested that mountain ranges have been slowly folded and lifted as the stress which produced them accumulated and this would seem to be true if one considers only the outer crust, but on the other hand, as we have pointed out, there are indications in the history of the earth of periods of relative quiescence followed by periods of relatively considerable disturbance.

How can these two theories be reconciled in accordance with what we know of the laws of physics and chemistry and those of the earth's interior? It seems to me they can by making suppositions which are perfectly natural regarding the state of the earth's interior.

We are at liberty to suppose if the facts point that way that there are the following layers in the earth's masses:—First, the external, rigid and brittle layer; second, a layer under such temperature and pressure that it is above its plastic yield point and may be considered as a viscous fluid. The pressure must continue to increase toward the center. We do not know what is the temperature, but it is perfectly possible that at a greater depth the earth may become rigid once more if the effect of pressure in promoting solidity and rigidity continues, as Bridgman tells me he thinks probable. We do not even have to assume a change in the chemical composition of the earth's substance, though it is perfectly allowable. This, then, will be a third layer, once more rigid, perhaps extending to the center and of very considerable thickness and capable of accumulating strain from long periods. Blanketed as it would be by thousands of meters of the first two layers, any change must be relatively slow.

Kelvin in his computation of the age of the earth from cooling assumed for the interior of the earth constant conditions. It is now generally accepted that this is not probable, and that whether it cooled from a gas or coagulated from planetesimals, it became solid first at the center which then would be hottest, and both Becker[3] and A. Holmes[4] assume an initial temperature gradient. If that gradient were greater than the gradient of steady flow the conditions of steady flow would be approached most rapidly at the exterior, the loss of heat and energy would be altogether from within and it is easy to arrange for conditions mathematically in which almost all the loss of energy would come from the very interior, near the center. What will be the effect? A paradoxical one, if the part outside the center is rigid enough to be self-sustaining. The central core will become a gas!

[3] Bull. Geol. Soc. Am., Vol. 26, 1915, p. 197, etc. [4] Geological Magazine, March and April, 1913.

This is so contrary to our ordinary experience and ideas, in which loss of heat tends to change from gas to fluid and solid, that we must look into it a little to make it sound reasonable. The recent brilliant work of P. W. Bridgman (contrary to the earlier speculations of Tammann) indicates that the effect of increased pressure, at high temperature, makes a substance solid and crystalline. Crowd any atoms close enough together, and no matter how fast they expand or contract under the influence of heat the crystalline atomic forces will get to work when they are crowded within their range, and the closest packing, hence that which will yield most to the pressure, hence that which is likely to take place, is when they are all regularly arranged facing the same way. Such an arrangement we call crystalline. Just so when they want to pack the most people into the car of an elevator they ask them to all face to the front. Keep this metaphor a moment. Any one who should try to penetrate such a crowd would find it a hard job. They would offer a very effective rigidity. Now suppose them to sweat in those confined quarters their fat away, their phlogiston, their caloric. If the walls of the car remained rigid while the individuals therein shrunk they might after a while be able to turn around or even move around in a car. Such is then the supposed condition of the atoms in the FOURTH, the central, layer of the earth's crust. This assumes that the middle layer is rigid and sustains itself, like the shell of a nut, as in the figure, while within the atoms are in a less rigid condition. That such a shell might be self-sustaining is suggested by an experiment of Bridgman, who put a marble with a gas bubble in it under a pressure of something like 150,000 pounds to the square inch without producing any perceptible change.

As loss of energy from the earth's interior went on this central core of gas would enlarge until the middle shell was hardly self-supporting. Then, probably at some time of astronomic strain when the earth's, orbit was extra elliptical, it would collapse, in collapsing generate heat, and so stop the process. The collapse would be transmitted to the viscous layer which might be increased, motions set up in it, and so a wrinkling of the outer thin crust on which we live.

Then there would be four layers to the earth like the butternut of the figure. First, the inner kernel of gas; second, the hard shell or endocarp; third, a viscous layer like the sarcocarp or pulp, and outside of all the wrinkled crust of exocarp. If such is the structure of the earth we may have in the very structure of the earth itself a reason why from time to time there are collapses of the middle layer leading to elevations of portions of the outer rind, and marking off the chapters in geological history, the lines between geological systems.

There are reasons in facts of observation for believing that such is the structure of the earth, of which I have as yet said nothing. We see the interior of a glass marble, I saw the bubble in the interior of Bridgman's glass marble, how? By waves, vibrations, which start from the sun or some other source, and going through it reach my eye. Though the earth is not penetrated by sunlight it is penetrated by the waves and vibrations that start from that jar produced by a crack which we call an earthquake. These vibrations can be received by that eye of the geologist called a seismograph. The seismologist tells us there are three kinds of waves sent out in an earthquake. If you notice the explosion of a blast at a little too close distance you will notice that you see it first, then hear it, and then perhaps a little later a few chips of rock may come flying past your ears. These three things correspond somewhat to the three kinds of waves which spread forth from an earthquake. But in the case of the explosion we see the blast first, then hear later. The waves which produce the sensation of sight are, we know, lateral disturbances, the waves which produce the sensation of sound are waves of condensation, whose motion is in the direction of their propagation and they come later. In the case of the jars of earth, the reverse is true. The first set of waves to arrive are the waves which are due to compression—vibrations in the direction in which the waves are produced—and correspond to sound waves. Later come waves which are transverse sidewise disturbances of the solid mass of the earth. As we can easily see, in an earthquake jar traveling from the opposite end of the earth, there should be no insurmountable difficulty in recognizing the jar, which is a direct upthrow from one which would tilt it to the right or left. Now there is a law of Laplace by which the velocity of spread of sound waves through gas may be calculated. That this law should hold at temperatures and pressures so high as those that must exist in the middle of the earth is, of course, a question, but it will be interesting to see how nearly the actual velocity of about 10 kilometers a second compares with the velocity which such waves should have in gas of a density and under a pressure such as a gas near the center of the earth must have. Using Oldham's figures (and they seem to be confirmed by the recent investigations of E. Rudolph and S. Szirtes[18]), we find that the time of transmission of these first and fastest preliminary compression tremors is about twice the velocity of such a jar according to Laplace's law in as dense a mass of gas, provided the ratio of the specific heat of a gas at constant pressure to that of a gas at constant volume remains 1.4, which is for many substances. But as it is 1.6 for mercury the discrepancy is not more than I had expected.

[5] Gerlands, "Beitrage zur Geophysik," XI., Band, 1 Heft, 1911, p. 132. "Das kolumbianische Erdbeben am 31 January, 1906."

The second preliminary tremors arriving later are due to the lateral disturbance. Their propagation is much less rapid when the point of origin is nearly opposite the point of receival. In other words there is a core within the earth about 0.4 of the radius in radius, in which according to Oldham, these lateral waves have much less velocity. Now in a gas there is less resistance to lateral displacement than in a solid, and the less the resistance the less the velocity, so that this fact fits in with the idea of a gaseous core perfectly. If there is such n core, moreover, of less rigidity it would have less refraction. Consequently waves not striking the border above the angle of total reflection would be totally reflected, and just as around a bubble there is a dark border where the light does not get through so at a certain distance from the source of an earthquake there would be a circle (it is really about 140 degrees of arc away), where no second tremors would be felt. Here again, though seismograph stations are as yet few, fact and theory are apparently going to correspond.

The last type of earthquake waves follow around the outer layer of the crust.

There is one farther line of verification to which I had addressed myself. Is it likely that the loss of heat and energy from the central nucleus, at the rate which we know at the surface from a central nucleus of anything like 0.4 the radius of the earth, would give a shrinkage of anything like the amount indicated by the mountain ranges, in anything like the time which we are led to assign on other grounds to the geologic periods?

Rudski has also attempted to connect the shrinkage and age of the earth. Both these methods depend on how fast the earth is losing heat, that is on the geothermal gradient. Since at present, owing to the apparently large but unknown contribution of radioactivity to that gradient we know very little about what the other portion is, it seems unwise to give any figures, especially as almost all the numerical data are largely guess work. It will, however, be fair to say that very long times for the age of the earth seem to be indicated, nearer millions of millions than millions unless the radius of the gaseous core was mainly small or its rate of contraction with loss of temperature high.

THE CASH VALUE OF SCIENTIFIC RESEARCH

BY PROFESSOR T. BRAILSFORD ROBERTSON

UNIVERSITY OF CALIFORNIA

THERE can be no doubt that the average man and woman in Europe and America to-day professes a more or less nebulous feeling of respect and admiration for the scientific investigator. This feeling is not logical, for very few have ever met or seen a scientist, fewer still have ever seen the inside of a scientific laboratory, and hardly any have ever seen scientific research in the making.

The average man in the street or man of affairs has no very clear conception of what manner of man a "scientist" may be. No especial significance attaches in his mind to the term. No picture of a personality or his work arises in the imagination when the word "scientist" is pronounced. More or less indefinitely, I suppose, it is conceded by all that a scientist is a man of vast erudition (an impression by the way which is often strikingly incorrect) who leads a dreary life with his head buried in a book or his eye glued to telescope or microscope, or perfumed with those disagreeable odors which, as everybody knows, are inseparably associated with chemicals. The purpose of this life is not very clear, but doubtless a vague feeling exists in the minds of most of us that people who are willing to pursue such an unattractive career must be worthy of admiration, for despite all the triumphs of commercialism, humanity still loves idealism, even idealism which seems objectless because it is incomprehensible.

From time to time the existence of the scientific man is recalled to the popular mind by some extravagant headlines in the daily press, announcing some utterly impossible "discovery" or some extravagantly nonsensical dictum made by an alleged "scientist." The "discovery" was never made, the dictum never uttered, but no matter; to-morrow its place will be taken by the latest political or matrimonial scandal, and the public, with excellent good sense, will forget all about it.

From time to time, also, there creeps gradually into the public consciousness a sense that SOMETHING HAS HAPPENED. Brief notices appear in the press, at first infrequently and then more frequently, and an article or two in the popular monthlies. The public becomes languidly interested in a new possibility and even discusses it, sceptically. Then of a sudden we are awakened to the realization of a new power in being. The X-ray, wireless telegraphy or the aeroplane has become the latest "marvel of science," only to develop in a very brief period into a commonplace of existence.

Many indeed are aware that we owe these "marvels" to scientific research, but very few indeed, to the shame of our schools be it spoken, have attained to the faintest realization of the indubitable fact that we owe almost the entirety of our material environment, and no small proportion of our social and spiritual environment, to the labors of scientists or of their spiritual brethren.

Long ago, in ages so remote that no record of them survives save our heritage of labor well achieved, some pastoral savage, more reflective and less practical than his brethren, took to star-gazing and noting in his memory certain strange coincidences. Doubtless he was chidden by his tribal leaders who were hard-headed men of affairs, skilled in the questionable art of imposing conventional behavior upon unruly tribesmen. But he was an inveterate dreamer, this prehistoric Newton and the fascination of the thing had gripped his mind. In due time he was gathered to his fathers, but not before he had passed on to a few chosen ones the peculiar coincidences he had observed. And thus, from age to age coincidence was added to coincidence and the result of all this "unpractical" labor was, at long last, a calendar. Let who will attempt to estimate the cash value of this discovery; I will not attempt the impossible. I will merely ask you to picture to yourselves humanity in the condition of the Australian Aboriginal or of the South African Bushman; devoid of any means of estimating time or season save by the daily passage of the sun, and I ask you, "supposing that through some vast calamity, a calamity greater even than the present war, humanity could at a stroke evolve a calendar, would it be worth while?" I for one think it would.

The evolution of the calendar is not an inapt illustration of the methods of science, and of the part which it has played in shaping the destiny of man. Out of the unregarded labors of thousands of forgotten men, and a few whom we now remember, has sprung every detail of that vast complex of machinery, method and measurement in which to-day we live and move and have our being. In all ages scientific curiosity guided by the scientific discipline of thought has forced man into new and more complex paths of progress. Lacking the spirit of research, a nation or community is merely parasitic, living upon the vital achievements of others, as Rome based her civilization upon the civilization of the Greeks. Only an indefinite and sterile refinement of the existing environment is possible under such circumstances, and humanity stays stationary or sinks back into the semibarbarism of the middle ages.

The few scattered students of nature of that day picked up the clue to her secrets exactly as it fell from the hands of the Greeks a thousand years before. The foundations of mathematics were so well laid by them that our children learn their geometry from a book written for the schools of Alexandria two thousand years ago. Modern astronomy is the natural continuation and development of the work of Hipparchus and of Ptolemy; modern physics of that of Democritus and of Archimedes; it was long before biological science outgrew the knowledge bequeathed to us by Aristotle, by Theophrastus and by Galen.[1]

[1] T. H. Huxley, "Science and Culture."

If, therefore, we ask ourselves what has been the value of science to man, the answer is that its value is practically the value of the whole world in which we find ourselves to-day, or, at any rate, the difference between the value of our world and that of a world inhabited by Neolithic savages.

The sweeping nature of this deduction may from its very comprehensiveness fail to carry conviction to the reader. But concrete illustrations of the value which scientific research may add to our environment are not far to seek. They are afforded in abundance by the dramatic achievements of the past century of human progress, in which science has begun painfully and haltingly to creep into its true place and achieve its true function.

In the year 1813 many important events occurred. The power of Napoleon was crumbling in that year and countless historians have written countless pages describing innumerable events, great and small, which accompanied that colossal downfall. But one event of that year, of which we do not read in our historical memoirs and school books was the discovery by Sir Humphry Davy, in the humble person of a bookbinder's apprentice, of the man who will probably stand out forever in the history of science as the ideal scientific man—Michael Faraday. The manner of this discovery is revealed by the following conversation between Sir Humphry Davy and his friend Pepys. "Pepys, what am I to do, here is a letter from a young man named Faraday; he has been attending my lectures, and wants me to give him employment at the Royal Institution—what can I do?" "Do?" replied Pepys, "put him to wash bottles; if he refuses he is good for nothing." "No, no," replied Davy; "we must try him with something better than that." The result was, that Davy engaged him to assist in the laboratory at weekly wages.[2]

[2] J. Tyndall, "Faraday as a Discoverer."

Davy made many important discoveries, but none of his discoveries was more important than his discovery of Faraday, and of all the events which occurred in the year 1813, the entry of Faraday into the Royal Institution was not the least significant for humanity.

On the morning of Christmas day, 1821, Faraday called his wife into his laboratory to witness, for the first time in the history of man, the revolution of a magnet around an electric current. The foundations of electromagnetics were laid and the edifice was built by Faraday upon this foundation in the fourteen succeeding years. In those years and from those labors, the electro-motor, the motor generator, the electrical utilization of water power, the electric car, electric lighting, the telephone and telegraph, in short all that is comprised in modern electrical machinery came actually or potentially into being. The little rotating magnet which Faraday showed his wife was, in fact, the first electric motor.

What was the cash value to humanity of those fourteen years of labor in a laboratory?

According to the thirteenth census of the United States, the value of the electrical machinery, apparatus and supplies produced in this country alone, in 1909 was $221,000,000. In 1907, the value of the electric light and power stations in the United States was $1,097,000,000, of the telephones $820,000,000, and the combined income from these two sources was $360,000,000. Nor does this represent a tithe of the values, as yet barely realized, which these researches placed at our disposal. Thus in its waterfalls, the United States is estimated to possess 150,000,000 available horse-power, which can only be realized through the employment of Faraday's electro-motor. This corresponds, at the conservative figure of $20 per horse-power per annum to a yearly income of $3,000,000,000, corresponding at 4 per cent. interest to a capital value of $75,000,000,0000.[3]

[3] M. T. Bogert, "The Function of Chemistry in the Conservation of our National Resources," Journal of the American Chemical Society, February, 1909.

Such was the Christmas gift which Michael Faraday presented to the world in 1821.

Faraday died a poor man in 1867, neither for lack of opportunity nor for lack of ability to grasp his opportunities, but because as his pupil Tyndall tells us, he found it necessary to choose between the pursuit of wealth and the pursuit of science, and he deliberately chose the latter. This is not a bad thing. It is perhaps as it should be, and as it has been in the vast majority of cases. But another fact which can not be viewed with like equanimity is that of all the inexhaustible wealth which Faraday poured into the lap of the world, not one millionth, not a discernible fraction, has ever been returned to science for the furtherance of its aims and its achievements, for the continuance of research.

There is no regular machinery for securing the permanent endowment of research, and it is always and everywhere a barely tolerated intruder. In the universities it crouches under the shadow of pedagogy, and snatches its time and its materials from the fragments which are left over when the all-important business of teaching the young what others have accomplished has been done. In commercial institutions it occasionally pursues a stunted career, subject to all the caprices of momentary commercial advantage and the cramped outlook of the "practical man." The investigator in the employ of a commercial undertaking is encouraged to be original, it is true, but not to be too original. He must never transcend the "practical," that is to say, the infinitesimal rearrangement of the preexisting. The institutions existing in the world which are devoted to research and, research alone can almost be counted on the fingers. The Solvay Institute in Brussels, the Nobel Institute in Stockholm, the Pasteur Institute in France, the Institute for Experimental Therapy at Frankfort, The Kaiser Wilhelm Institutes at Berlin, The Imperial Institute for Medical Research at Petrograd, the Biologisches Versuchsanstalt at Vienna, the Biological Station at Naples, the Royal Institution in London, the Wellcome Laboratories in England and at Khartoum, the Smithsonian, Wistar, Carnegie and Rockefeller Institutes in the United States; the list of research institutes of important dimensions (excluding astronomical observatories) is, I believe, practically exhausted by the above enumeration, and many of them are woefully undermanned and underequipped. At least two of them, the Solvay Institute wholly, and the Frankfort Institute for Experimental Therapy in part, owe their existence and continuance to scientific men, Solvay and Ehrlich, who have contrived to combine the pursuit of wealth and of science, and have dedicated the wealth thus procured to the science that gave it birth.

In 1900 the value of the manufacturing industries in the United States which had been developed from patented scientific inventions was no less than $395,663,958 per annum,[4] corresponding to a capital value of about $10,000,000,000. It is impossible to arrive at any accurate estimate of the proportion of this wealth which finds its way back to science to provide equipment and subsistence for the investigator, who is creating the wealth of the future. But the capital endowment of the Rockefeller and Carnegie Institutes, the two wealthiest institutes of research in the world is, according to the 1914 issue of Minerva, only $29,000,000. The total income (exclusive of additions to endowments) of all the higher institutions of learning in the United States in 1913, was only $90,000,000, of which a minute percentage was expended in research.

[4] 12th census, Vol. 10, Part 4.

If science produces so much wealth, is there no contrivance whereby we can cause a small fraction of this wealth to return automatically to science and to furnish munitions of war for fresh conquests of nature? A very small investment in research often produces colossal returns. In 1911 the income of the Kaiser Wilhelm Institute for Physical Chemistry was only $21,000. In 1913 the income of the Institute for Experimental Therapy at Frankfort, where "606" was discovered, was only $20,000; that of the Imperial Institute for Medical Research at Petrograd was $95,000, and that of the National Physical Laboratory in England (not exclusively devoted to research) was $40,000. Yet these are among the most famous research institutions in the world and have achieved results of world-wide fame and inestimable value both from a financial standpoint and from the standpoint of the physical, moral and spiritual welfare of mankind.

In 1856, Perkin, an English chemist, discovered the coal-tar (anilin) dyes. The cost of this investigation, which was carried out in an improvised, private laboratory was negligible. Yet, in 1905, the United States imported $5,635,164 worth of these dyes from Europe, and Germany exported $24,065,500 worth to all parts of the world.[5] To-day we read that great industries in this country are paralyzed because these dyes temporarily can not be imported from Germany. All of these vast results sprang from a modest little laboratory, a meager equipment and the genius and patience of one man.

[5] U. S. Census Bureau Bull. 92.

W. R. Whitney, director of the research laboratory of the General Electric Company, points out that the collective improvements in the manufacture of filaments for electric lamps, from 1901 to 1911, have saved the consumer and producer no less than $240,000,000 annually. He adds with apparently unconscious naivete that the expenses of the research laboratory in his charge aggregate more than $100,000 annually![6] A handsome investment, this, which brings in some two hundred million for an outlay of one hundred thousand.

[6] "Technology and Industrial Efficiency," McGraw-Hill Book Co., 1911.

According to Huxley the discovery by Pasteur of the means of preventing or curing anthrax, silkworm disease and chicken cholera, a fraction of that great man's life work, added annually to the wealth of France a sum equivalent to the entire indemnity paid by France to Germany after the war of 1870.

Humanity has not finished its conquest of nature; on the contrary, it has barely begun. The discipline of thought which has carried humanity so far is destined to carry it further yet. Business enterprise and politics, the all-absorbing interests of the majority of mankind, work in an endless circle. Scientific research communicates a thrust to this rotation which converts the circle into a spiral; the apex of that spiral lies far beyond our vision. We have, not decades, not centuries, not thousands of years before us; but, as astronomy assures us, in all probability, humanity has millions of years of earthly destiny to realize. Barely three thousand years of PURPOSEFUL scientific research have brought the uttermost ends of the earth to our doors; have made civilization and excluded much of the most brutal and brutalizing in life. Not more than two hundred years of research have made us masters where we were slaves; masters of distance, of the air, of the water, of the bowels of the earth, of many of the most dreaded aspects of disease and suffering. Only for forty years have we practiced antisepsis; only for sixty years have we had anesthetics; yet life to-day is well-nigh inconceivable without them. And all of this has been accomplished without any forethought on the part of the acknowledged rulers and leaders of mankind or any save the most trumpery and uncertain provision for research. What will the millions of years which stretch in front of us bring of power to mankind? We can barely foreshadow things too vast to grasp; things that will make the imaginings of Jules Verne and H. G. Wells seem puny by comparison. The future, with the uncanny control which it will bring over things that seem to us almost sacred—over life and death and development and thought itself—might well seem to us a terrifying prospect were it not for one great saving clause. Through all that may happen to man, of this we may be sure, that he will remain human; and because of that we can face the future unafraid and confident that because it will be greater, it will also be better than the present.

What can we do to accelerate the coming of this future? Not very much, it is true, but we can surely do something. We can not create geniuses, often we can not discern them, but having discerned, surely we can use them to the best advantage. It is true that all scientific research has depended and will depend upon individuals; Simon Newcomb expresses the matter thus:

'It is impressive to think how few men we should have to remove from the earth during the past three centuries to have stopped the advance of our civilization. In the seventeenth century there would only have been Galileo, Newton and a few other contemporaries, in the eighteenth they could almost have been counted on the fingers, and they have not crowded the nineteenth.'[7]

[7] "Inventors at Work," Iles, Doubleday Page, 1906.

The first thing we have to do is to discover such men, to learn to know them or suspect them when we meet them or their works. The next is to give them moral and financial recognition, and the means of doing their work. Our procedure in the past has been the reverse of this. I quote from a letter of Kepler to his friend Moestlen:

'I supplicate you, if there is a situation vacant at Tubingen, do what you can to obtain it for me, and let me know the prices of bread, wine and other necessaries of life, for my wife is not accustomed to live on beans.'

The founder of comparative psychology, J. H. Fabre, that "incomparable observer" as Darwin characterized him, is now over ninety years of age, and until very recently was actually suffering from poverty. All his life his work was stunted and crippled by poverty, and countless researches which he was the one human being qualified by genius and experience to undertake, remain to this day unperformed because he never could command the meager necessary equipment of apparatus.

Once again, what can we do?

No small proportion of the population of a modern community are alumni of some institution of higher learning, and one thing that these can do is to see to it by every means in their power that some measure of the spirit of academic freedom is preserved in their alma mater. That the spirit of inquiry and research is not merely tolerated therein but fostered and substantially supported, morally and financially.

As members of the body politic, we can assist the development of science in two ways. Firstly, by doing each our individual part towards ensuring that endowment for the university must provide not only for "teaching adolescents the rudiments of Greek and Latin" and erecting imposing buildings, but also for the furtherance of scientific research. The public readily appreciates a great educational mill for the manufacture of mediocre learning, and it always appreciates a showy building, but it is slow to realize that that which urgently and at all times needs endowment is experimental research.

Secondly, it is vital that public sentiment should be educated to the point of providing the legal machinery whereby some proportion, no matter how small, of the wealth which science pours into the lap of the community, shall return automatically to the support and expansion of scientific research. The collection of a tax upon the profits accruing from inventions (which are all ultimately if indirectly results of scientific advances) and the devotion of the proceeds from this tax to the furtherance of research would not only be a policy of wisdom in the most material sense, but it would also be a policy of bare justice.

THE PHYSICAL MICHELANGELO

BY JAMES FREDERICK ROGERS, M.D.

NEW HAVEN, CONN.

You will say that I am old and mad, but I answer that there is no better way of keeping sane and free from anxiety than by being mad.

HAD Michelangelo been less poetic and more explicit in his language, he might have said there is nothing so conducive to mental and physical wholeness as saturation of body and mind with work. The great artist was so prone to over-anxiety and met (whether needlessly or not) with so many rebuffs and disappointments, that only constant absorption in manual labor prevented spirit from fretting itself free from flesh. He toiled "furiously" in all his mighty undertakings and body and mind remained one and in superior harmony—in abundant health—for nearly four score and ten years.

This Titan got his start in life in the rugged country three miles outside Florence: a place of quarries, where stone cutters and sculptors lived and worked. His mother's health was failing and it was to the wife of one of these artisans that her baby was given to nurse. Half in jest, half in earnest, Michelangelo said one day to Vasari:

'If I have anything good in me, that comes from my birth in the pure air of your country of Arezzo, and perhaps also from the feet that with the milk of my nurse, I sucked in the chisels and hammers wherewith I make my figures.'

He began his serious study of art (and with it his course in "physical training") at fourteen, when he became apprenticed to a painter. He was not vigorous as a child, but his bodily powers unfolded and were intensified through their active expression of his imagination.

His life was devoted with passion to art. He had from the start no time for frivolity. Art became his religion—and required of him the sacrifice of all that might keep him below his highest level of power for work. His father early warned him to have a care for his health, "for," said he, "in your profession, if once you were to fall ill you would be a ruined man." To one so intent on perfection and so keenly alive to imperfection such advice must have been nearly superfluous, for the artist could not but observe the effect upon his work of any depression of his bodily well-being. He was, besides, too thrifty in all respects to think of lapsing into bodily neglect or abuse. He was severely temperate, but not ascetic, save in those times when devotion to work caused him to sleep with his clothes on, that he might not lose time in seizing the chisel when he awoke. He ate to live and to labor, and was pleased with a present of "fifteen marzolino cheeses and fourteen pounds of sausage—the latter very welcome, as was also the cheese." Over a gift of choice wines he is not so enthusiastic and the bottles found their way mostly to the tables of his friends and patrons. When intent on some work he usually "confined his diet to a piece of bread which he ate in the middle of his labors." Few hours (we have no accurate statement in the matter) were devoted to sleep. He ate comparatively little because he worked better: he slept less than many men because he worked better in consequence. Partly for protection against cold, partly perhaps for economy of time, he sometimes left his high dog-skin boots on for so long that when he removed them the scarf skin came away like the skin of a moulting serpent.

He dressed for comfort and not to mortify the flesh. Upon the receipt of a present of some shirts from his nephew he writes:

'I am very much surprised ye should have sent them to me, for they are so coarse that there is not a farm laborer here who would not be ashamed to wear them.'

He is much pleased with a finer lot selected later by his nephew's new wife. Perhaps he did not come up to modern notions of cleanliness (he was early advised by his father never to bathe but to have his body rubbed instead) but he was clean inside, which can not be said of all who make much of a well-washed skin.

His intensity of purpose and fiery energy expressed themselves in his features and form. "His face was round, his brow square, ample," and deeply furrowed: "the temples projected much beyond the ears"; his eyes were "small rather than large," of a dark (some said horn) color and peered, piercingly, from under heavy brows. The flattened nose was the result of a blow from a rival apprentice. He evidently looked the part, though for such mental powers one of his colossal statues would seem a more fitting mold.

Michelangelo experienced some illnesses, all but two of them of minor moment. In 1531 he "became alarmingly ill, and the Pope ordered him to quit most of his work and to take better care of his health." That the illness was a storm merely of the surface is evidenced sufficiently in that his fresco of the "Last Judgment," probably the most famous single picture in the world, was begun years later and completed in his sixty-sixth year. In the work of this epoch there is more than ever the evidence of a pouring forth of energy amounting almost to what the critics call violence—to terribleness of action. It was not until the age of seventy that an illness which seemed to mark any weakening of his bodily powers came upon him. At seventy-five, symptoms of calculus (a disease common in that day at fifty) appeared, but, though naturally pessimistic, he writes, "In all other respects I am pretty much as I was at thirty years." He improved under careful medical treatment, but the illness and his age were sufficient to cause him to "think of putting his spiritual and temporal affairs in better order than he had hitherto done."

He wielded the brush and the chisel with consummate skill in his seventy-fifth year. With the later loss of cunning his energy found vent more in the planning and supervising of architectural works, culminating in the building of St. Peter's, but even in these later years he took up the chisel as an outlet for superfluous energy and to induce sleep. Though the product of his hand was not good, his health was the better for this mutual exercise of mind and body. In his eighty-sixth year he is said to have sat drawing for three consecutive hours until pains and cramps in his limbs warned him that he had not the endurance of youth. For exercise, when manual labor proved a disappointment, he often took horseback rides. There was no invalidism about this great spirit, and it was not until the day before his death that he would consent to go to bed.

In a poem of his last years he burlesques his infirmities in his usual vigorous manner.

'I live alone and wretched, confined like the pith within the bark of the tree.... My voice is like a wasp imprisoned within a sack of skin and bone. ... My teeth rattle like the keys of an old musical instrument.... My face is a scarecrow.... There is a ceaseless buzzing in my ears—in one a spider spins his web, in the other a cricket chirps all night.... My catarrh, which causes a rattle in my throat, will not allow me to sleep.—Fatigue has quite broken me, and the hostlery which awaits me is Death.'

Few men at his age have had less reason to find in themselves other than the changes to be expected with the passing of years and in prose he acknowledged that he had no more affections of the flesh than were to be expected at his age. Codiva pictures him in his last years as "of good complexion; more muscular and bony than fat or fleshy in his person: healthy above all things, as well by reason of his natural constitution as of the exercise he takes, and habitual continence in food and sexual indulgence." His temperance and manual industry and his "extraordinary blamelessness in life and in every action" had been his source of preservation. He was miserly, suspicious, quarrelsome and pessimistic, but the effects of these faults were balanced by his better habits of thought and action. That he, like most great men, felt keenly the value of health, is evidenced not only by his own practice, but by his oft repeated warnings to his nephew when choosing a wife to see that whatever other qualities she might have she be healthy. The blemish of nearsight he considered a no small defect and sufficient to render a young woman unworthy of entry into the proud family of the Buonarroti. To his own father he wrote: "Look to your life and health, for a man does not come back again to patch up things ill done."

One of those who look beneath unusual human phenomena for signs of the pathologic finds Michelangelo "affected by a degree of neuropathy bordering closely upon hysterical disease." What a pity that more of us do not suffer from such degrees of neuropathy—and how much better for most of us if we had such enthusiasm for perfection, and such mania for work, at least of that health-bringing sort in which there is absorbing colabor of brain and hand. True it is that "there is no better way of keeping sane and free from anxiety than by being mad."

THE CONSERVATION OF TALENT THROUGH UTILIZATION

BY PROFESSOR JOHN M. GILLETTE

STATE UNIVERSITY OF NORTH DAKOTA

TO raise the question of how to conserve talent is not an idle inquiry. We are in no immediate danger of famine. Yet there is an enormous interest being devoted to what is known as the conservation of soil. Our forests contain an abundance of timber for near purposes, and when they are gone we shall probably find a better substitute in the direction of concrete. Still agitation and discussion proceed relative to the conservation of our timber supply. We hear of conservation of childhood, of conservation of health, of conservation of natural scenery. It is a period of agitation for conservation of resources all along the line. This is all good. Real intelligent foresight is manifesting itself. Civilized man demonstrates his superiority over uncivilized man most in the exercise of anticipation and prescience.

As compared with other natural resources, genius and talent are relatively scarce articles. This is at least the popular impression as to their quantity. Even scientific men, for the most part, incline to this opinion. Unless we are able to demonstrate that they are quite abundant this opinion must be accepted. I shall seek to show that the estimate of the amount of talent in existence which is usually accepted is too small. However, we are in no peril of so inflating the potential supply of talent and genius in the course of our remarks that they may be regarded as universal. Nor are we likely to discover such a rich lode of this commodity that the world may run riot in its consumption of the visible supply. Talent promises to remain so scarce that, granting for the moment that it is a useful agent, its supply must be conserved.

I shall use the term talent so as to include genius. Both talent and genius are of the same kind. Their essential difference consists in degree. Increase what is commonly called talent in the direction of its manifestation and it would develop into genius. Genius is commonly thought of as something abnormal, in the sense that it is essentially eccentric. A genius is generally spoken of as an eccentric, erratic, unbalanced, person. The eccentricity is then taken as constituting the substance of the quality of genius. This is undoubtedly a mistake. Because some geniuses have been erratic, the popular imagination has formed its picture of all genius as unbalanced. The majority of the world's men of genius have been as balanced and normal in their judgments as the average man. We may think of a genius as like the ordinary man in his constitution. He has the same mental faculties, the same emotions, the same kind of determinizing ability. What makes him a genius is his power of concentration in his given field of work. The moral quality, or zeal to accomplish, or energy directed toward intellectual operations stands enormously above that of the average individual. If we could confer this quality of moral will on the common normal man possibly we would raise him to that degree which we term genius.

In order to determine the worth of conserving talent we must estimate its value as a commodity, as a world asset. I shall, therefore, turn my attention first to discovering a method of reckoning the value of eminent men.

One method open to us is what may be called the individualistic test. Under this method we think of the individual as individual or of his work as a concrete case of production. One phase of this is the individual's estimate of his own powers. We may inquire what is the man's appreciation of his own worth. This is precarious because of two difficulties. There is an egotistical element in individuals. It is inherent as a historical agent of self-preservation. Most of us are like primitive groups. The ethnologist expects to find every tribe or horde of savages claiming to be THE PEOPLE. They ascribe superior qualities to their group. In their names for their group they call themselves the people, the men, and so on, indicating their point of view.

Again, an individual, however honestly he might try, could not estimate his own worth accurately. Let any of us attempt to see ourselves as others see us and we shall discover the difficulty of the undertaking. We are not able to get the perspective because our personal feelings, our necessary selfish self-appreciation, puts our judgments awry. Others close to us may do little better. They are likely to either underrate us or to exaggerate our qualities and powers. In the United States we are called on to evaluate Mr. Taft and Mr. Roosevelt. Is either of them a great man? Has either of them been a great president? Opinions differ. We are too close to them. We do not know. We give them credit, perhaps, for doing things which the age would have worked out in spite of them. Or we think things would have come inevitably which their personal efforts, it will be found, were responsible for establishing. We have not yet been able to determine accurately just how great Abraham Lincoln was. It is almost half a century since he did his work. But we live in the presence of the personal relative to him yet. Sentiment enters in and obfuscates judgment.

If we turn to the product itself as mere product we are at a loss. Unless we ask what is the import of the work we confess we do not know. A man in Connecticut has made a manikin. It walks, talks, does many of the things which human beings do. But it is not alive, it is not serviceable, it can accomplish nothing. Suppose the maker passes his life in making probably the most intricate and perfect mechanism which has been made. Is he a genius? We may admit that the products manifest great ingenuity on the part of their creator, yet we feel repelled when we think of calling the maker a genius.

The community method of rating talent is far more satisfactory. The inventor is related to his time or to human society by means of the usefulness of his invention. The statesman is rated by means of the deep-seated influence for improvement he has had on his age. The educator finds his evaluation in the constructive spirit and method he displays in bringing useful spirit and methods to light. The scientist is measured by the uplift his discovery gives to the sum and substance of human welfare. If a product which some individual creates can not be utilized by society, its creator is not regarded as having made a contribution to human progress. As a consequence he does not get a rating as genius. To get the appraisal of mankind the product of the man of talent must get generally accepted, must fill the want of society generally or of some clientele. If a man produces something merely ingenious, something which does not serve a considerable portion of humanity in the way of satisfying a want, if his creation does not pass into use, he does not step into the current of the world's history as a fruitful factor, he fails to attain to the rank of talent.

This objective measure of the value of the producer puts talent into direct relation to the concept of social evolution and progress. Society has been an evolution. Collective humanity has gone through distinctive metamorphoses. Distinct strides in advance have been made, tendencies have manifested themselves, conditions have changed so that larger satisfactions have ensued, democracy in the essential wants of mankind has been wrought out. Society is more complex in its quantitative aspect. It is more serviceable by reason of its greater specialization. Since progress stands for improvement it has come to be regarded as a desirable thing.

In the sociological conception of things the genius possesses a specific social function. He is not a passing curiosity. He is not produced for amusement. He does not stand unrelated. He is the product of his age, is articulated with its life, performs an office which is of consequence to it. He is the connecting link between the past and the future. He takes what was and so combines it anew as to produce what is to be. He is the innovator, the initiator, the agent of transformation, the creator of a new order. Hence he is the exceptional man. The masses of men are imitators. They make nothing new, add nothing to the mechanism of social structure, introduce no new functions, produce no achievements, do nothing which changes the order of things. The common people are quite as important for the purposes of society as are the talented. Society must be conserved most of the time or we should all float down the stream of change too rapidly for comfort. Hence the function of the great mass of individuals is to seize and use the achievements which the creators, the talented have brought into existence. We may conclude, therefore, that if society is to be improved and if the lives of the great body of human beings are to be endowed with more and more blessings, material and spiritual, we must look to the men of talent, the men of achievement, and to them 'alone, for the initiation of these results.

We may say, then, that we have discovered not only the method of estimating the value of talent, but also in what its value consists. If progress is desirable, talent by means of which that progress is secured is likewise valuable. And, like other things, its value is measured by its scarcity. It is now incumbent on us to attempt to discover the extent of the supply of this commodity, both actual and possible.

I shall refer to two estimates of the amount of talent in existence which have been made because they differ so much in their conclusions as to the extent of talent, and because they exhibit quite different view-points and methods.

The great English scientist and benefactor of the race, Sir Francis Galton, in his work entitled "Hereditary Genius" made a computation of the number of men of eminence in the British Isles. This estimate was made nearly a half-century ago and has generally been accepted as representing actual conditions. One means of discovering the number was by taking a catalogue of "Men of The Times" which contained about 2,500 names, one half of which were Americans and Europeans. He found that most of the men were past fifty years of age. Relative to this he states:

'It appears that in the cases of high (but by no means in that of the highest) merit, a man must outlive the age of fifty to be sure of being widely appreciated. It takes time for an able man, born in the humbler ranks of life, to emerge from them and to take his natural position.'[1]

[1] Cattell's investigations of American men of science disproves this statement for Americans. He finds that only a few men enter the ranks of that class of men after the age of fifty, and that none of that age reach the highest place. The fecund age is from 35 to 45; ("American Men of Science," p. 575.)

After eliminating the non-British individuals he compared the number of celebrities above fifty with males of the same age for the whole British population. He found about 850 who were above fifty. Of this age there were about 2,000,000 males in the British Isles. Hence the meritorious were as 425 to 1,000,000, and the more select were as 250 to 1,000,000. He stated what he considered the qualifications of the more select as follows:

'The qualifications for belonging to what I call the more select part are, in my mind, that a man should have distinguished himself pretty frequently either by purely original work, or as a leader of opinion. I wholly exclude notoriety obtained by a single act. This is a fairly well defined line, because there is not room for many men to become eminent.'

Mr. Galton made another estimate by studying an obituary list published in The Times in 1868. This contained 50 men of the select class. He considered it broader than his former estimate because it excluded men dying before they attained their broadest reputation, and more rigorous because it excluded old men who had previously attained a reputation which they were not able to sustain. He consequently lowered the age to 45. In Great Britain there were 210,000 males who died yearly of that age. This gave a result of 50 men of exceptional merit to 210,000 of the population, or 238 to the million.

His third estimate was made by the study of obituaries of many years back. This led to similar conclusions, namely, that about 250 to the million is an ample estimate of the number of eminent men. He says:

'When I speak of an eminent man, I mean one who has achieved a position that is attained by only 250 persons in each million of men, or by one person in each 4,000.'

The other estimate of the amount of talent in existence has been made by one of our most eminent American sociologists, the late Lester F. Ward. The elaborate treatment of this matter is found in his "Applied Sociology," and offers an illustration of a most rigorous and thorough application of the scientific method to the subject in question. The essential facts for the study were furnished by Odin in his work on the genesis of the literary men of France, although Candole, Jacoby and others are laid under contribution for data. Maps, tables and diagrams are used whenever they can be made to secure results. Odin's study covered the period of over five hundred years of France and French regions, or from 1300 to 1825. Out of over thirteen thousand literary names he chose some 6,200 as representing men of genius, talent or merit, the former constituting much the smaller and the latter much the larger of the total number.

The object of Ward's investigation is to discover the factor or factors in the situation which are responsible for the production of genius. In the course of examination it was seen that certain communities were very much more prolific than others in producing talent. Paris, for instance, produced 123 per 100,000; Geneva, Switzerland, 196; certain chateaux as many as 200, and some communities none at all or very few. After considering the various factors which account for the high rate in certain localities and the low rate or absence of merit in others the conclusion is reached that we should expect the presence of the meritorious class generally in even greater numbers than it has existed in the most fruitful regions of the French people.

Mr. Ward's studies have led him to conclude that talent is latent in society, that it exists in greater abundance than we have ever dared to expect, that all classes possess it equally and would manifest it equally if obstacles were removed or opportunities offered for its development. Education is the key to the situation in his estimation. It affords the opportunity which latent talent requires for its promotion, and if this were intelligently applied to all classes and to both sexes alike instead of securing one man of talent for each 4,000 persons as Mr. Galton held, we would be able to mature one for every 500 of our population. This would represent an eight-hundred-per-cent. increase of the talented class, an eight-fold multiplication. It is an estimate of not the number of the talented who are known to be such, but of society's potential or latent talent.[2]

[2] Investigations made on school children by the Binet test indicate Ward's estimate is conservative. It has been found that from two to three out of every hundred children are of exceptional ability, thus belonging to the talented, or at least merit class.

Because these estimates are so divergent, it may be worth while to consider the reason for the difference. And in taking this up we come to the fundamentally distinct point of view of the two investigators. Mr. Galton's work is an illustration of the view which regards talent as a product of the hereditary factors. Mr. Galton believed that heredity accounts for talent and that it is so dominant in the lives of the talented that it is bound to express itself as talent. In his estimation there is no such thing as latent genius, because it is in the nature of genius that it surmounts all obstacles. He says:

'By natural ability, I mean those qualities of intellect and disposition, which urge and qualify a man to perform acts which lead to reputation. I do not mean capacity without zeal, nor zeal without capacity, nor even a combination of both of them, without an adequate power of doing a great deal of very laborious work. But I mean a nature which, when left to itself, will, urged by an inherent stimulus, climb the path that leads to eminence, and has strength to reach the summit—one which, if hindered or thwarted, will fret and strive until the hindrance is overcome, and it is again free to follow its labor-saving instinct.'[2]

[3] "Hereditary Genius," pp. 37-8.

This in reality amounts to saying that the genius is omnipotent. Nothing can prevent the development of the genius. He is master of all difficulties by the very fact that he is a genius. It is also equivalent, by implication, to saying that obstacles can have no qualifying effect on the course of such an individual. A great difficulty is no more to him than a small one. Hence no matter in what circumstances he lives he is always bound to gain the maximum of his development. He could not be either greater or less than he is, notwithstanding the force of circumstances, whether obstructive or propitious. The energy of a genius is thus differentiated from all other forms of energy. Other forms of energy are modified in their course and effects by preventing obstacles. Add to or subtract from the impediments and the effect of the energy is changed by the amount of the impediments. But this doctrine completely emancipates human energy, when manifested in the form of genius, from the working of the law of cause and effect.

It is especially noteworthy that it is not what we should expect in view of the place and function of the environment in the course of evolution. To say the least environment enjoys a very respectable influence in selecting and directing the forces of development. Some men have gone so far as to make the external factors account for everything in society. Discounting this claim, the minimum biological statement is that the environment exercises a selective function relative to organic forms and variations. It opposes itself to the transmission strain, and if unfavorable to it, may eliminate it entirely.

To be able to accomplish this it must be regarded as having an influence on all forms. And as there are all grades of environment from the most unfavorable to the most propitious, similarly constituted organisms living in those various environments must perforce fare differently, some being hindered others being promoted in varying degrees. That is, should the most able by birth appear in the most unfavorable environment they could not be expected to make the same gains in life as similar congenitally able who appear in the most favorable conditions.

Mr. Ward, on the contrary, holds that genius, like all other forms of human ability, is the product of circumstances. It is determined in its raw form by heredity, to be sure. In similar circumstances it will affect more than the average man. But like all other forms of energy it is subject to the law of causality. It is not omnipotent so that it is able to set at naught the effects of opposing forces. Nor can it develop in the absence of nourishing circumstances. Deprive it of cultural opportunities and it is like the sprout of the majestic tree which is deprived of moisture, or the great river cut off from the supply of snow and rain. In other words, it is a product of all the factors at work in its being and environment, and the internal can not manifest itself or its powers without the presence of the external. Modify the external factors to a perceptible degree and the individual is modified to the same degree.

In seeking to find the factors which are accountable for the development of talent Mr. Ward takes into consideration those of the physical environment, the ethnological, the religious, the local, the economic, the social, and the educational. Each one of these items is given a searching examination as to its force. I shall briefly deal with each of these in turn, giving the import of the findings in each case and as many of the basic facts as possible in a small space.

By a consideration of French regions by departments, provinces, and principal sections, as to their yield of talent, the physical environment was found to have had no perceptible influence. The mountain-situated Geneva and the lowland Paris produced alike prolifically talented men. The valley of the Seine and that of the Loire competed for hegemony in fecundity. The facts contradicted the highland theory, the lowland theory, the coast theory, and every other theory of the dominance of physical environment.

To get at the influence of the ethnological factor the Gaulic, Cimbrian, Iberian, Ligurian and Belgic elements of the population were examined as to their fecundity in talent. Odin confesses to being unable to discover "the least connection between races and fecundity in men of letters." Attention was paid likewise to races speaking other than French language. Again there was a conflict of facts. Inside of France ethnological elements exerted "no appreciable influence upon literary productivity." In Belgium and Lorraine, where the German language dominated, it was found that French literature mastered the situation, thus indicating that a common language does not necessitate a common literature. The conclusion ethnologically is that races possess an equality in yielding talent.

The religious factor was found to have been more influential formerly in bringing to light talent than at the close of the five-hundred-year period. From 1300 to 1700 the church furnished on the average 37.8 per cent. of all literary talent. Its fecundity dropped to 29 in the period from 1700 to 1750. Between 1750 and 1825 it produced but 6.5 of the talent. As Galton has shown, eminent men were killed or driven out during the period of religious persecution in Spain, France and Italy. The celibacy of the clergy which gave undisturbed leisure may have been an element in making the church productive in the earlier years. On the other hand, the quieting effect of family life of the protestant ministry seems to have had a propitious influence in later times, as there appeared a relative increase among protestant clergy of talent, while the output among the catholic clergy continued to decline.

In this investigation the local environment appeared to have the most influence in the production of talent. Odin gave witness to having a suspicion that somewhere there was a neglected factor. The facts connected talent with the cities in an overwhelming manner. The statement that genius is the product of the rural regions seems to have had no legs to stand on. The majority of the talented were born in the cities and practically all of them were connected with city life.

In proportion to population the cities produced 12.77, almost thirteen times as many men of talent as rural regions. The whole of France produced 6,382, the number selected by Odin as the more meritorious of the men of letters. If all France had been as productive as Paris it would have yielded 53,640; if as fecund as the other chief cities, it would have produced 22,060; but if only as fertile as the country the number would have fallen to 1,522.

It would seem that the matter of population has something to do with the production of talent. Aggregations of population offer frequent contact of persons, division of labor, competition between individuals, a better coordination of society for cooperative results, neutralization of physical qualities, and the ascendancy of innovation over the conservative attitude. It is not the mere density of population which is the effective element. It is rather the dynamic density which is productive, that is, the manifestation of the common life and spirit. City life is specialized in structure and function, rendering men more interdependent and cooperative. Specialization means moral coalescence

The chateaux of France are very prolific in producing talent. They yielded 2 per cent. of all the talent of the period, seemingly out of proportion to their importance.

Why are certain of the cities and the chateaux more fertile than most cities and the country in producing the talented? We have a general reply in the statement as to the dynamic density of cities. A further analysis finds those communities are possessed of elements which the country does not have. Odin calls them "properties." They are the location of the political, administrative and judicial agencies of society; they are in possession of great wealth and talent; they are depositories of learning and the tools of information. The avenues which open upon talent and the tools and agencies by means of which the passage to it is to be made segregate themselves in cities and towns

As the result of his investigation into the distribution of men of science in the United States, Professor Cattell arrives at nearly the same conclusion. He writes:

'The main factors in producing scientific and other forms of intellectual performance seem to be density of population, institutions and social traditions and ideals. All these may be ultimately due to race, but, given the existing race, the scientific productivity of the nation can be increased in quantity, though not in quality, almost to the extent that we wish to increase it.'[4]

[4] "American Men of Science," Second edition, p. 654.

It is interesting to note that nearly all of the women of talent have been born in cities and chateaux. This means that women had to be born where the means of development were to be had, as they were not free to move about in society, as were men.

Periods Rich Poor 1300-1500 24 1 1500-1550 39 4 1551-1600 42 — 1601-1650 84 5 1651-1700 73 4 1701-1725 36 3 1726-1750 53 7 1751-1775 86 8 1776-1800 52 12 1801-1825 73 11 —— —— Total 562 57, or 9 per cent.

The economic factor has been an important one in offering the leisure which is necessary for the development of talent. Men who have to use their time and energy wholly in the support of themselves and families are deprived of the leisure which productivity and creativeness in work demands. Of the French men of letters 35 per cent. belonged to the wealthy or noble class, 42 per cent. to the middle class, and 23 per cent. to the working class. Odin was able to discover the economic environment of 619 men of talent. They were distributed by periods between the rich and poor as shown in the table on page 169.

Of one hundred foreign associates of the French Academy the membership of the wealthy, middle and working classes were 41, 52 and 7. A combination of two other of Candole's tables yields for those classes in per cents 35, 42 and 23. In ancient and medieval times practically all of the talented came from the wealthy class. On the whole, but about one eleventh of the men of talent had to fight with economic adversity. But when we remember that the wealthy class formed but a small portion of the population in each period, probably not more than one fourth, this means that as compared with members of the working class individuals of the wealthy class had forty or fifty times as good a chance of rising to a position of eminence. The contrast is so sharp that Odin is led to exclaim, "Genius is in things, not in man."

The social and the economic factors are so closely intertwined that the influence of the social environment is already seen in treating the economic. The social deals with matter of classes and callings. The upper classes are of course the wealthier classes so that the social and economic measures largely agree. In Mr. Galton's inquiry into the callings of English men of science which he made in 1873, it appears that out of 96 investigated 9 were noblemen or gentlemen, 18 government officials, 34 professional men, 43 business men, 2 farmers and 1 other. Unless the one other was a working man the workers produced none of these 96 men of science. Odin's classification of the French men of letters gives to the nobility 25.5 per cent., to government officials 20.0, liberal professions 23.0, bourgeoise 11.6, manual laborers 9.8. Only a little over one fifth of the talented were produced by the two lower classes. Yet in numerical weight those classes constituted 90 per cent. of the population. Data from four other European countries show very much the same results, except that the workers and bourgeoise classes make a better showing. It is unquestionable, therefore, that the opportunities for developing talent or genius are largely withheld from the working class and bestowed on the upper classes.

We have yet one other factor to treat in the production of talent, namely, the educational. The facts relative to the education of the talented contradicts the assumption usually made that genius depends on education and opportunity for none of its success, but rises to its heights in spite of or without them.

Of 827 men of talent (not merit class) Odin was able to investigate as to their education he found that only 1.8 per cent. had no education or a poor education, while 98.2 per cent. had a good education. This number investigated was 73 per cent. of all men of that class, and it is fair to assume that about the same proportion of educated existed in the other 27 per cent. whose education was not known. Of the 16 of poor or no education 13 were born in Paris, other large cities, or chateaux, and three in other localities. Thus they had the opportunities presented by the cities. Facts as to talented men in Spain, Italy, England and Germany indicate that anywhere from 92 to 98 per cent. have been highly educated, and probably the latter per cent. is correct.

These figures can have but one meaning. They indicate that talent and genius are dependent on educational and conventional agencies of the cultural kind, as are other human beings for their evolution. Otherwise we should expect the figures to be reversed. If education and cultural opportunities count for naught, then we should expect that, at a time when education was by no means universal, the 90 or 98 per cent. Of genius would mount on their eagle wings and soar to the summits of eminence, clearing completely the conventional educational devices which society had established.

Our conclusion, therefore, is that social and economic opportunities afford the leisure as well as cultural advantages for the improvement of talent; that the local environment is of vital importance, offering as it does the cultural advantages of cities of certain kinds and of chateaux, and that of the local environment the educational facilities are of the supremest importance. Consequently, it appears that Mr. Ward's estimate of one person of talent to the 500 instead of Mr. Galton's estimate of one to the 4,000 does not seem strained. Produce in society generally the opportunities and advantages which Geneva, Paris and the chateaux possessed and which gave them their great fecundity in talent, and all regions and places will yield up their potential or latent genius to development and the ratio will be obtained.

This position is likely to be criticized, unless it is remembered that we admit that there is a hereditary difference at birth, and that all we seek to establish is that, given these differences, what conditions are likely to mature and develop the men of born talent. Thus after the appearance of my "Vocational Education" I received a letter from Professor Eugene Davenport in which he makes this statement:

'Ward's arguments as here employed seem to show that environment is a powerful factor in bringing out talent even to the exclusion of heredity. I doubt if you would care to be understood to this limit, and yet where you enumerate on page 61 the reasons why certain cities are fecund in respective talents, you seem to have overlooked the fact that if these cities have been for many generations centers of talent to such an extent as to provide exceptional environmental influences, the same conditions would also provide exceptional parentage, so that the birthrate of talent would be much higher in such a region than the normal. In other words, the very same conditions which would provide exceptional opportunities for development also and at the same time provide an exceptional birth condition. This is the rock on which very many arguments tending to compare heredity and environment wreck themselves.'[5]

[5] This is a criticism that needs to be met. Mr. George R. Davies of this institution has submitted facts in a paper which appeared in the March number of the Quarterly Journal of the University of North Dakota, which fills in the gap. He shows relative to American cities that there has been little or no segregation of talented parentage.

We have arrived at a point where we are able to consider the question of the conservation of talent. A position of advantage has been gained from which to view this question. For we have seen that talent has a decidedly important and indispensable social function to perform. It is the creative and contributive agency, the cause of achievement, and a vital factor in progress. Its conservation is consequently devoutly to be desired. We have also discovered the fact that, while a rare commodity, it is present in society in a larger measure than we have commonly believed. If progress is desirable in a measure it is likely to be desirable in a large measure. If talent is able to carry us forward at a certain rate with the development of a minimum of the quantity that is in existence we should be able to greatly accelerate our progress if all that is latent could be developed and put into active operation. Further, we have obtained some insight into the conditions which favor the development of talent and likewise some of the obstacles to its manifestation. If it abounds where certain conditions are present in the situation and fails to appear where those conditions are absent, we have a fertile suggestion as to the method of social control and direction which will bring the latent talent to fertility.

We must undoubtedly hold that if a larger supply of talent exists than is discovered, developed and put to use that, since, as we have seen, it is so valuable when estimated in terms of social progress, we are dealing wastefully with talent. We are allowing great ability to go to waste since we are leaving it lie in its undeveloped form. Therefore one of the problems of the proper conservation of talent consists in finding a method of discovering and releasing this valuable form of social energy.

When we come to inquire how this may be done, how this discovery is to take place, we must take for our guide the facts which were found to bear on the maturing of talent in the above studies. We discovered that the local environment seemed to contain the influential element in bringing forth talent. When that local environment was analyzed it turned out that the items of opportunity for leisure and the facilities for education were the most fruitful factors. Leisure is absolutely essential to afford that opportunity for self-development which is required even of the most talented. This can only be had when the income of the individual is sufficient to give him a considerable part of his active time for carrying out his intellectual aspirations. We have great numbers of people whom we have reason to believe are as able on the average, have as large a proportion of talent as the well-to-do, whose poverty is so crushing and whose days of toil are so long and so consuming of energy that the element of leisure is lacking. It is only an occasional individual of this class of people who is able to secure the wealth which means a measure of leisure by which he is able to mount out of obscurity. An improvement in the physical conditions of life of these people, together with an increase in their economic possibilities is a necessary means to the proper conservation of the talent of this group.

The cultural factor is one which must be made more omnipresent than it is now before we shall be able to awake the latent talent of the masses of people. There are certain sections of all nations, and more especially of such nations as the United States, where the population is widely scattered over vast areas of farming regions in which the opportunities for education and stimulative enterprises and institutions are lacking or meager. The same is true of very large sections of the populations of the cities. In both cases large neighborhoods exist in which the lives of the people move in a humdrum rut, never disturbed by matters which arouse the creative element in human nature. Especially is this important in the early years of life where the outlook for the whole future of the individual is so strongly stamped. To come into contact with no stimulus and arousing agent in the home, or the neighborhood in the earliest years is to become settled into a life-long habit of inert dullness.

When we revert to the schools which so generally abound, we fail to find the stimulating element in them which might be regarded as the necessary opportunity to develop talent. The vast majority of elementary teachers are persons whose intellectual natures have never been aroused. Their imaginative and sympathetic capacities lie undeveloped. Their work in the school is conducted on the basis of memory. It is parrot work and ends in making parrots of the pupils. The rational and causal as agencies in education are hardly ever appealed to. Until our teaching force is itself developed in the directions and capacities which alone characterize the intellectual we can not hope for much in the way of recovering the rich field of latent talent from its infertility.

Something remains to be said about the proper utilization of talent which has been developed. Did all genius depend on the hereditary factor and consequently we had developed all individuals possessing exceptional ability into contributors and creators, the question of their complete utilization by society remains. That all able men and women are working at the exact thing and in the exact place and under the exact methods which will yield the greatest and most fruitful results for society only the superficial could believe. Herbert Spencer used up a very large part of his superb ability during the larger portion of his life in the drudgery of making a living. The work of the national eugenics laboratory of England is carried on by a man of great talent, Professor Carl Pearson, in cramped quarters and with insufficient equipment and support. The enterprise is as important as any in England, that of discovering the conditions and means of improving the human race. The laboratory was built up in the first instance by the sacrifice of Sir Francis Galton, and it is maintained by means of the bequest of his personal fortune.

These are but instances of the many which exist where talented individuals are working under great handicaps which neither promote their talent nor secure fecundity of results to collective man. In nearly every line of human endeavor gifted individuals are consuming in an unnecessarily wasteful manner, from the point of view of social improvement, their splendid abilities. In educational institutions trained experts and specialists are doing the work which very ordinary ability of a merely clerical kind could conduct, sacrificing the higher and more fruitful attainments thereby. I have known a faculty of some forty members who were compelled to register the term standings by sitting in a circle and calling off the grades of several hundred students student by student and class by class for each student as it came their turn, while a clerk recorded the grades. The process consumed about ten hours per member each term, or something over a thousand hours a year for the whole faculty. Both economically and socially it was expensive and wasteful because a cheap clerk could have done the whole far better and have released the talent for productive purposes.

We shall be wise when we realize the worth of our workable talent and so establish its working conditions that it may secure the full measure of its productiveness. If scientific management for the mass of laborers of a nation is worth while how much more serviceable would it be to extend its fructifying influence to the most able members of the community.

But how to proceed in order to make the discovery of the latent talent is the pressing problem. For a long time our methods promise to be as empirical as are those we employ for the advancement of science. Relative to the latter, after enumerating a large list of conditions for promoting science of which we are ignorant, Professor Cattell says:

'In the face of endless problems of this character we are as empirical in our methods as the doctor of physic a hundred years ago or the agricultural laborer to-day. It is surely time for scientific men to apply scientific methods to determine the circumstances that promote or hinder the advancement of science.'[6]

[6] "American Men of Science," p. 565.

Since the discovery and utilization of genius and talent in general are so closely related to the problem of the promotion of science, his statement may be adopted to express the demand existing in those directions.

WAR, BUSINESS AND INSURANCE[1]

[1] Chairman's address on Peace Day of the Insurance Congress, Panama-Pacific International Exposition, San Francisco, October 11, 1915.

BY CHANCELLOR DAVID STARR JORDAN

STANFORD UNIVERSITY

THE complications behind the war in Europe are very many, ruthless exploitation, heartless and brainless diplomacy, futile dreams of national expansion (the "Mirage of the Map"), of national enrichment through the use of force (the "Great Illusion"), and withal a widespread vulgar belief in indemnities or highway robberies as a means of enriching a nation.

All these would represent only the unavoidable collision, unrest and ambition of human nature, were it not that every element involved in it was armed to the teeth. "When blood is their argument" in matters of business or politics, all rational interests are imperilled. The gray old strategists to whom the control of armament was assigned saw the nations moving towards peaceful solution of their real and imaginary difficulties. The young men of Europe had visions of a broader world, one cleared of lies and hate and the poison of an ingrowing patriotism. After a generation of doubt and pessimism in which world progress seemed to end in a blind sack, there was rising a vision of continental cooperation, a glimpse of the time when science, always international, should also internationalize the art of living.

Clearly the close season for war was near at hand. The old men found means to bring it on and in so doing to exploit the patriotism, enthusiasm, devotion and love of adventure of the young men of the whole world.

The use of fear and force as an argument in politics or in business—this is war. It is a futile argument because of itself it settles nothing. Its conclusion bears no certain relation to its initial aim. It must end where it should begin, with an agreement among the parties concerned. War is only the blind negation, the denial of all law, and only the recognition of the supremacy of some law can bring war to an end. In time of war all laws are silent as are all efforts for progress, for justice, for the betterment of human kind. If history were written truthfully every page in the story of war would be left blank, or printed black, with only fine white letters in the darkness to mark the efforts for humanity, which war can never wholly suppress.

In this paper I propose to consider only economic effects of this war and with special reference to the great industry which brings most of this audience together, the business of insurance.

The great war debts of the nations of Europe began with representative government. Kings borrowed money when they could, bankrupting themselves at intervals and sometimes wrecking their nations. Kings have always been uncertain pay. Not many loaned money to them willingly and only in small amounts and at usurious rates of interest. To float a "patriotic loan," it was often necessary to make use of the prison or the rack. With the advent of parliaments and chambers of deputies, the credit of nations improved and it became easy to borrow money. There was developed a special class of financiers, the Rothschilds at their head, pawnbrokers rather than bankers, men able and willing to take a whole nation into pawn. And with the advent of great loans, as Goldwin Smith wisely observed, "there was removed the last check on war."

With better social and business adjustments, and especially with the progress of railways and steam navigation with other applications of science to personal and national interests, the process of borrowing became easier, as also the payment of interest on which borrowing depends. Hence more borrowing, always the easiest solution of any financial complication or embarrassment. Through the substitution of regular methods of taxation for the collection of tribute, the nations became solidified. Only a solidified nation can borrow money. The loose and lawless regions called Kingdoms and Empires under feudalism were not nations at all. A nation is a region in which the people are normally at peace among themselves. In civil war, a nation's existence may be dissolved.

In all the ages war costs all that it can. All that can be extorted or borrowed is cast into the melting pot, for the sake of self-preservation or for the sake of victory. If the nations had any more to give war would demand it. The king could extort, but there are limits to extortion. The nation could borrow, and to borrowing there is but one limit, that of actual exhaustion.

Mr. H. Bell, cashier of Lloyd's Bank in London, said in 1913:

'The London bankers are not lending on the continent any more. We can see already the handwriting on the wall and that spells REPUDIATION. The people of Europe will say: "We know that we have had all this money and that we ought to pay interest on it. But we must live; and we can not live and pay."'

The chief motive for borrowing on the part of every nation has been war or preparation for war. If it were not for war no nation on earth need ever have borrowed a dollar. If provinces and municipalities could use all the taxes their people pay, for purposes of peace, they could pay off all their debts and start free. In Europe, for the last hundred years, in time of so-called peace, nations have paid more for war than for anything else. It is not strange therefore that this armed peace has "found its verification in war." It has been the "Dry War," the "Race for the Abyss," which the gray old strategists of the general staff have brought to final culmination.

The debt of Great Britain began with the revolution of 1869, with about $1,250,000. This unpopular move, known as Dutch finance, was the work of William of Orange. Other loans followed, based on customs duties with "taxes on bachelors, widows, marriages and funerals," and the profits on lotteries. At the end of the war of the revolution the debt reached $1,250,000,000, and with the gigantic borrowings of Pitt, in the interest of the overthrow of Napoleon, the debt reached its highest point, $4,430,000,000. The savings of peace duly reduced this debt, but the Boer war, for which about $800,000,000 was borrowed, swept these savings away. When the present war began the national debt had been reduced to a little less than $400,000,000 which sum a year of world war has brought up to $10,000,000,000.

The debt of France dates from the French Revolution. Through reckless management it soon rose to $700,000,000, which sum was cut by paper money, confiscation and other repudiations to $160,000,000. This process of easing the government at the expense of the people spread consternation and bankruptcy far and wide. A great program of public expenditure following the costly war and its soon repaid indemnity raised the debt of France to over $6,000,000,000. The interest alone amounted to nearly $1,000,000,000. A year of the present war has brought this debt to the unheard of figure of about $11,000,000,000. Thus nearly two million bondholders and their families in and out of France have become annual pensioners on the public purse, in addition to all the pensioners produced by war.

Germany is still a very young nation and as an empire more thrifty than her largest state. The imperial debt was in 1908 a little over $1,000,000,000. The total debt of the empire and the states combined was about $4,000,000,000 at the outbreak of the war. It is now stated at about $9,000,000,000, a large part of the increase being in the form of "patriotic" loans from helpless corporations.

The small debt of the United States rose after the Civil War to $2,773,000,000. It has been reduced to about $915,000,000, proportionately less than in any other civilized nation. The local debts of states and municipalities in this and other countries are, however, very large and are steadily rising. As Mr. E. S. Martin observes,

'We have long since passed the simple stage of living beyond our incomes. We are engaged in living beyond the incomes of generations to come.'

Let me illustrate by a supposititious example. A nation has an expenditure of $100,000,000 a year. It raises the sum by taxation of some sort and thus lives within its means. But $100,000,000 is the interest on a much larger sum, let us say $2,500,000,000. If instead of paying out a hundred million year by year for expenses, we capitalize it, we may have immediately at hand a sum twenty-five times as great. The interest on this sum is the same as the annual expense account. Let us then borrow $2,500,000,000 on which the interest charges are $100,000,000 a year. But while paying these charges the nation has the principal to live on for a generation. Half of it will meet current expenses for a dozen years, and the other half is at once available for public purposes, for dockyards, for wharves, for fortresses, for public buildings and, above all, for the ever-growing demands of military conscription and of naval power. Meanwhile the nation is not standing still. In these twelve years the progress of invention and of commerce may have doubled the national income. There is then still another $100,000,000 yearly to be added to the sum available for running expenses. This again can be capitalized, another $2,500,000,000 can be borrowed, not all at once perhaps, but with due regard to the exigencies of banking and the temper of the people. With repeated borrowings the rate of taxation rises. Living on the principal sets a new fashion in expenditure. The same fashion extends throughout the body politic. Individuals, corporations, municipalities all live on their principal.

The purchase of railways and other public utilities by the government tends further to complicate the problems of national debt. It is clear that this system of buying without paying can not go on forever. The growth of wealth and population can not keep step with borrowing, even though all funds were expended for the actual needs of society. Of late years, war preparation has come to take the lion's share of all funds, however gathered, "consuming the fruits of progress." What the end shall be, and by what forces it will be brought about, no one can now say. This is still a very rich world, even though insolvent and under control of its creditors. There is a growing unrest among taxpayers. There would be a still greater unrest if posterity could be heard from, for it can only save itself by new inventions and new exploitations or by frugality of administration of which no nation gives an example to-day.

Nevertheless, this burden of past debt, with all its many ramifications and its interest charges, is not the heaviest the nations have placed on themselves. The annual cost of army and navy in the world before the war was about double the sum of interest paid on the bonded debt. This annual sum represented preparation for future war, because in the intricacies of modern warfare "hostilities must be begun" long before the materialization of any enemy. In estimating the annual cost of war, to the original interest of upwards of $1,500,000,000 we must add yearly about $2,500,000,000 of actual expenditure for fighters, guns and ships. We must further consider the generous allowance some nations make for pensions. A large and unestimated sum may also be added to the account from loss of military conscription, again not counting the losses to society through those forms of poverty which have their primal cause in war. For in the words of Bastiat, "War is an ogre that devours as much when he sleeps as when he is awake." It was Gambetta who foretold that the final end of armament rivalry must be "a beggar crouching by a barrack door."

When the great war began, the nations of Europe were thus waist deep in debt, the total amount of national bonded indebtedness being about $30,000,000,000, or nearly three times the total sum of actual gold and silver, coined or not in all the world. A year of war at the rate of $50,000,000 to $70,000,000 per day has increased this indebtedness to nearly $50,000,000,000, the bonds themselves rated at half or less their normal value, while the actual financial loss through destruction of life and property has been estimated at upwards of $40,000,000,000.

In "The Unseen Empire," the forceful and prophetic drama of Mr. Atherton Brownell, the American ambassador, Stephan Channing, tries to show the chancellor of Germany that war with Great Britain is not a "good business proposition." He says:

'Our Civil War has cost us to date, if you count pensions for the wrecks it left—mental and physical—nearly twenty billions of dollars. And that doesn't include property losses, nor destruction of trade, nor broken hearts and desolate homes—that's just cold hard cash that we have actually paid out. You can't even think it. There have been only about one billion minutes since Christ was born. Now if there had been four million slaves and we had bought every one of them at an average of one thousand dollars apiece, set them free and had no war, we should have been in pocket to day just sixteen billion dollars. That one crime cost us in cash just about the equal of sixteen dollars a minute from the beginning of the Christian era.'

The war as forecast in the play is now on in fact, and one certain truth in regard to it is that it is assuredly not "a good business proposition" for anybody in any nation, excepting of course, the makers of the instruments of death.

DAILY COST OF GREAT EUROPEAN WAR (Charles Richet, 1912)

Feed of men. $12,600,000
Feed of horses 1,000,000
Pay (European rates) 4,250,000
Pay of workmen in the arsenals and ports (100 per day)1,000,000
Transportation (60 miles in 10 days) 2,100,000
Transportation for provisions. 4,200,000
Munitions: Infantry 10 cartridges a day. 4,200,000
Artillery: 10 shots per day. 1,200,000
Marine: 2 shots per day. 400,000
Equipment. 4,200,000
Ambulances: 500,000 wounded or ill ($1 per day). . 500,000
War ships. 500,000
Reduction of imports 5,000,000
Help to the poor (20 cents per day to 1 in 10) . 6,800,000
Destruction of towns, etc. 2,000,000
Total per day $49,950,000

The actual war began, in accord with Professor Richet's calculation, at a cost of $50,000,000 per day. Previous to this the "dry war" or "armed peace" cost only $10,000,000 per day. This is Richet's calculation in 1912, an underestimate as to expenses on the sea and in the air. These with the growing scarcity of bread and shrapnel, the equipment of automobiles, and the unparalleled ruin of cities have raised this cost to $70,000,000 per day.

This again takes no account of the waste of men and horses, less costly than the other material of war and not necessarily replaced. All this is piled on top of "the endless caravan of ciphers" ($30,000,000,000), which represents the accumulated and unpaid war debt of the nineteenth century.

War is indeed the sport for kings, but it is no sport for the people who pay and die, and in the long run the workers of the world must pay the cost of it. As Benjamin Franklin observed:

'War is not paid for in war time) the bill comes later.'

And what a bill!

Yves Guyot, the French economist, estimates that the first six months of war cost western Europe in cash $5,400,000,000, to which should be added further destruction estimated at $11,600,000,000, making a total of $17,000,000,000. The entire amount of coin in the world is less than $12,000,000,000. Edgar Crammond, secretary of the Liverpool Stock Exchange, another high authority, estimates the cash cost of a year of war, to August 1, 1915, at $17,000,000,000, while other losses will mount up to make a grand total of $46,000,000,000. Mr. Crammond estimates that the cost to Great Britain for a year of war will reach $3,500,000,000. This sum is about equivalent to the accumulated war debt of Great Britain for a hundred years before the war. The war debt of Germany (including Prussia) is now about the same.

No one can have any conception of what $46,000,000,000 may be. It is four times all the gold and silver in the world. It represents, it is stated, about 100,000 tons of gold, and would probably outweigh the Washington monument. We have no data as to what monuments weigh, but we may try a few other calculations. If this sum were measured out in $20 gold pieces and they were placed side by side on the railway track, on each rail, they would line with gold every line from New York to the Pacific Ocean, and there would be enough left to cover each rail of the Siberian railway from Vladivostock to Petrograd. There would still be enough left to rehabilitate Belgium and to buy the whole of Turkey, at her own valuation, wiping her finally from the map.

Or we may figure in some other fashion. The average working man in America earns $518 per year. It would take ninety million years' work to pay the cost of the war; or ninety million American laborers might pay it off in one year, if all their living expenses were paid. The working men of Europe receive from half to a third the wages in America. They are the ones who have this bill to pay.

The cost of a year of the great war is a little greater than the estimated value of all the property of the United States west of Chicago. It is nearly equal to the total value of all the property in Germany ($48,000,000,000) as figured in 1906. The whole Russian Empire ($35,000,000,000) could have been bought for a less sum before the war began. It could be had on a cash sale for half that now. It would have paid for all the property in Italy ($13,000,000,000); Japan ($10,000,000,000); Holland ($5,000,000,000); Belgium ($7,000,000,000); Spain ($6,000,000,000) and Portugal ($2,500,000,000). It is three times the entire yearly earnings in wages and salaries of the people of the United States

($15,500,000,000).

We could go on indefinitely with this, playing with figures which nobody can understand, for the greatest fortune ever accumulated by man, in whatever fashion, would not pay for three days of this war.

The cost of this war would pay the national debts of all the nations in the world at the time the war broke out, and this aggregate sum of $45,000,000,000 for the world was all accumulated in the criminal stupidity of the wars of the nineteenth century. If all the farms, farming lands, and factories of the United States were wiped out of existence, the cost of this war would more than replace them. If all the personal and real property of half our nation were destroyed, or if an earthquake of incredible dimensions should shake down every house from the Atlantic to the Pacific, the waste would be less than that involved in this war. And an elemental catastrophe leaves behind it no costly legacy of hate; even the financial troubles are not ended with the treaty of peace. The credit of Europe is gone for one does not know how long. Before the war, it is said, there were $200,000,000,000 in bonds and stocks in circulation in Europe. Much of this has been sold for whatever it would bring. Some of the rest is worth its face value Some of it is worth nothing. In the final adjustment who can know whether he is a banker or a beggar?

The American Ambassador was quite within bounds when he said: "There isn't so much money in the world; you can't even think it!"

Or we may calculate (with Dr. Edward T. Devine) in a totally different way. The cost of this war would have covered every moral social, economic and sanitary reform ever asked for in the civilized world, in so far as money properly expended can compass such results. It could eliminate infectious disease, feeble-mindedness, the slums and the centers of vice. It could provide adequate housing, continuity of labor, insurance against accident; in other words it could abolish almost every kind of suffering due to outside influences and not inherent in the character of the person concerned.

A Russian writer, quoted by Dr. John H. Finley, puts this idea in a different form:

'Our most awful enemies, the elements and germs and insect destroyers, attack us every minute without cease, yet we murder one another as if we were out of our senses. Death is ever on the watch for us, and we think of nothing but to snatch a few patches of land! About 5,000,000,000 days of work go every year to the displacement of boundary lines. Think of what humanity could obtain if that prodigious effort were devoted to fighting our real enemies, the noxious species and our hostile environment. We should conquer them in a few years. The entire globe would turn into a model farm. Every plant would grow for our use. The savage animals would disappear, and the infinitely tiny animals would be reduced to impotence by hygiene and cleanliness. The earth would be conducted according to our convenience. In short, the day men realize who their worst enemies are, they will form an alliance against them, they will cease to murder one another like wild beasts from sheer folly. Then they will be the true rulers of the planet, the lords of creation.'

Says Robert L. Duffus:

'Money spent in warfare is not like spending money in other industries. It will bring far more beastliness, far more injustice, far more tyranny, far more danger to all that is honorable, generous and noble in the world, far more grief and rage than money spent in any other way. Not one per cent. of the amount devoted to these purposes, is, for the end aimed at, wasted.'

It is said that the main cause of the war lay in the envy of German commerce by British rivals. This is assuredly not true. But if it were, let us look at the business side of it. Taking the net profits of over-seas trade as stated two years ago by the Hamburg-American Company, the strongest in the world, and estimating the rest, we have something like this:

During the "Dry War" the net earnings of the German Mercantile fleet was about one third the cost of the navy supposed to protect it. It would take seventy years of trade, on the scale of the last year before the war, to repay Germany's expenses for a year of war. To make good all the losses of Europe would require more than one hundred years of the over-seas trading profits of all the world. War is therefore death to trade, as it is to every other agency of civilization.

At the beginning of the war the value of stocks and bonds in circulation in Europe amounted to about $200,000,000,000. What is the present value of all these certificates of ownership? What is the present value of any particular industrial plant or commercial venture?

A friend in London had inherited through his German wife a large aniline dye plant on the Rhine. He told me recently that he had not heard one word from it for six months. What will be its value when he hears from it? And what certainty has he as to its ownership?

Is it true that this war is the outcome of commercial jealousy? Let us look at this for a moment. The two greatest shipping companies in the world before the war were the Hamburg-American Company and the Nord-Deutscher Lloyd of Bremen. These companies had grown strong because they deserved to grow. They had attended to their affairs both in shipment of freight and transportation of passengers with that minute attention to details which is so large an element in German success. The growth of these companies arose through American trade and especially through trade with Great Britain and the British possessions. Did they clamor for war—a war, whatever else might result, sure to cripple their trade for a generation. It is said that Ballin, of the Hamburg Company, unable to prevent Great Britain from rising to the defense of Belgium "went home broken-hearted." Did Ballin build the great Imperator, costing nine million—six million of it borrowed money—with a view of laying her off after a few trips for an indefinite period in Hamburg? Did the Nord-Deutscher Lloyd contemplate leaving the Vaterland and the George Washington to lie in Hoboken till they were sold for harbor dues?

Nor was the jealousy on the other side. The growth of German commerce concerned mainly Great Britain. Presumably it was profitable on both sides, for all trade is barter. In any event, Great Britain has never raised a tariff wall against it, never protected her traders by a single differential duty. She has risen above the idea that by tariff exactions the foreigners can be made to pay the sages. As for envy of German commerce, who ever heard of an Englishman who envied anybody anything?

Again, did the Cunard Company build her three great steamships, the Mauretania, the Lusitania, the Aquitania for the fate which has come to them? In 1914 I saw the great Aquitania, finest of all floating palaces, tied by the nose to the wharf at Liverpool, the most sheepish-looking steamship I ever saw anywhere. Out of her had been taken $1,250,000 worth of plate glass and plush velvet, elevators and lounging rooms, the requirements of the tender rich in their six days upon the sea. The whole ship was painted black, filled with coal—to be sent out to help the warships at sea. And for this humble service I am told she proved unfitted.

No, commercial envy is not a reason, rivalry in business is not a reason, need of expansion is not a reason. These are excuses only, not causes of war. There is no money in war. There is no chance of highway robbery in the byways of history which can repay anything tangible of the expense of the expedition. The gray old strategists do not care for this. It is fair to them to say they are not sordid. They care no more for the financial exhaustion of a nation than for the slaughter of its young men. "An old soldier like me," said Napoleon, "does not care a tinker's damn for the death of a million men." Neither does he care for the collapse of a million industrial corporations.

Of the many forms of business and financial relation among men, none is more important than those included under the name of insurance. Insurance is a form of mutual help. By its influence the effects of calamity are spread so widely that they cease to be felt as calamity. The fact of death can not be set aside, but through insurance it need not appear as economic disaster, only as personal loss. Its essential nature is that of social cooperation and it furnishes some of the most effective of bonds which knit society together. As insurance has become already an international function, its influence should be felt continuously on the side of peace. That it is so felt is the justification of our meeting together to-day, as underwriters of insurance and as workers for peace. The essence of insurance, as Professor Royce observes, is that

'it is a principle at once peace-making in its general tendency and business-like in its practicable special application.... As a result of insurance, men gradually find themselves involved in a social network of complicated but beneficent relations of which individuals are usually very imperfectly aware but by means of which modern society has been profoundly transformed.'

For life insurance, in general, is not personally selfish in its motive. It is essentially altruistic, the effort of the benefit of some person beloved who is designated as the beneficiary. For the benefit of this surviving person, the efforts involved in the payment of premiums are put forth, and the insurance companies and their underwriters constitute the machinery by which this unification is given to society.

To all the interests of insurance, the lawlessness of war is wholly adverse and destructive. Insurance involves mutual trust and trust thrives under security of person and property. Insurance demands steadiness of purpose and continuity of law. In war, all laws are silent. War is the brutish, blind, denial of law, only admissible when all other honorable alternatives have been withdrawn—the last resort of "murdered, mangled liberty."

In its direct relation, war destroys those who to the underwriter represent the "best risks," the men most valuable to themselves and thus most valuable to the community. Those whom war leaves behind, to slip along the lines of least resistance into the city slums, are the people insurance rarely reaches. War confuses administration of insurance. Policies, in war time, can be written only on a sliding scale. This greatly increases the premium by reducing the final payments. Increase of rate of premium must decrease business. War means financial anarchy, inflated currency and depreciation of bonds. A currency which fluctuates demoralizes all business and war leaves no alternative. The slogan "business as usual" in war time deceives nobody. If it did, nobody would gain by the deception. Enforced loans from the reserve fund of insurance companies to the state mean the depreciation of reserves. The substitution of unstable government bonds means robbery of the bond holders. The yielding to the state, by enforced "voluntary action," of reserves of savings banks and insurance companies represents a form of state robbery. This is now in practice on the continent of Europe. Such funds are probably never actually confiscated but held in abeyance until the close of the war. This is another form of the everpresent "military necessity," which seizes men's property with little more compunction than it shows in seizing men's bodies. War conditions mean insecurity of investment. In war, all bonds are liable to become "scraps of paper," and no fund can be made safe. The insurance investments in Europe have been enormously depleted in worth, a reduction in market value estimated at 50 per cent.

Experts in insurance tell me that in war time certain policies are written so as to be scaled down automatically when the holder goes under the colors. Some are invalid in time of war, and some have the clause of free travel greatly abridged. A few are written to apply to all conditions, but on these the rates of premiums would naturally increase. Companies generally refuse to pay under conditions not nominated in the bond, and in general all policies are automatically reduced to level of war policies when war begins.

I am told that some American companies issue group policies as for any or all of a thousand men, these not subject to a physical examination. The war claims in Great Britain have been very heavy, because such a large proportion of clerks, artisans, students and other insurable or well-paid men have been first to volunteer. Some insurance companies have been much embarrassed by the general enlistment of their employees.

In fire insurance, conditions are much the same. All contracts in foreign nations are held in abeyance until the close of war. Such companies doing business in America are now mostly incorporated as American.

In every regard, the business of insurance is naturally allied with the forces that make for peace. War brings ruin, through increase of loans, through the exhaustion of reserves and the precarious nature of investment. The same remark applies in some degree to every honorable or constructive business. If any other form of danger threatened a great industry, its leaders would be on the alert. They would spare no money and leave no stone unturned for their own protection.

Towards war, business has always shown a stupid fatalism. War has been thought "inevitable," coming of itself at intervals with nobody responsible.

There could not be a greater error. War does not come of itself, nor without great and persistent preparation. A few hundred resolute men, bent on war, led by unscrupulous leaders brought on this war. The military group of one nation plays into the hands of like groups in other nations. To keep up war agitation long enough, whether the cause be real or imaginary, seems to hypnotize the public mind. The horrors of war fascinate rather than repel, and thousands of men in this land of peace are ready to fight in Europe to one who dreamed of such a line of action a year or two ago.

"Eternal vigilance is the price of liberty." The interests involved should put honest business on its guard. The insurance men could afford to maintain a thousand observers, men wise in business as well as in International Law, and in the manners and customs of the people of the world. A few dozen skilful politico-military detectives—men like W. J. Burns for example employed in the interest of finance might save finance a billion dollars. These should watch the standing incentives to war. Such men should stand guard against the influences that work toward conflict. Those who work for peace should be not "firemen to be called in to put out the fire" already started through the negligence of business men but agents for "fireproof building material" in our national edifice, to stand at all times for the security of business, the sanctity of law, order and peace. This kind of "preparedness for war" would involve no risks of conflict, of victory or defeat.

THE EVOLUTION OF THE STARS AND THE FORMATION OF THE EARTH. II

BY WILLIAM WALLACE CAMPBELL

DIRECTOR OF THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

EVIDENCE IN SUPPORT OF SEQUENCE PROPOSED

THERE are several lines of evidence in support of the order of evolution which we have outlined.

1. The close relationship of the bright-line nebular spectrum, the bright-line stellar spectrum and the spectra of the simplest helium stars; the practically continuous sequence of spectra from the helium stars to the red stars.

2. In the long run, we must expect the stars to grow colder, at least as to the surface strata. What the average interior temperatures are is another question; the highest interior temperatures are thought to be reached at an intermediate or quite late stage in the process, in accordance with principles investigated by Lane and others; but the temperatures existing in the deep interiors seem to have little direct influence in defining the spectral characters of the stars, which are concerned more directly with the surface strata.[1] We should therefore expect the simpler types of spectra, such as we find in the helium and hydrogen stars, in the early stages of the evolutionary process. The complicated spectra of the metals, and particularly the oxides of the metals, should be in evidence late in stellar life, when the atmospheres of the stars have become denser and colder.

[1] This important point seems not to have been realized by all theorists.

3. The velocities of the Orion nebula, the Trifid nebula, the Carina nebula, and of several other irregular nebulae, have been measured with the spectroscope. These bodies seem to be nearly at rest with reference to the stellar system. The helium stars have the lowest-known stellar velocities, and the average velocities of the stars are higher and higher as we pass from the helium stars, through the hydrogen and solar stars, up to the red stars. The average velocities of the brighter stars of the different spectral classes, as determined with the D. O. Mills spectrographs at Mount Hamilton and in Chile, are as in the following table:

Spectral Class	No. of Stars	Average Velocity in Space
B	225	12.9 km. per Sec.
A	177	21.9
F	185	28.7
G	128	29.9
E	382	33.6
M	73	34.3

We can not place the irregular nebulae after the red stars: their velocities are too small, and their spectra have no resemblances to the red-star spectra.

4. Wherever we find large irregular gaseous nebulae we find stars in the early subdivisions of the helium group. They are closely related in position. This is true of the Orion and other similar regions. The irregular, gaseous nebulae are in general found in and near the Milky Way, and so are the helium stars. The yellow and red stars, at least the brighter ones, do not cluster in nebulous regions.

5. The stars are more and more uniformly distributed over the sphere as one goes from the helium stars through the hydrogen and solar stars, to the red stars. The Class M stars show little or no preference for the Milky Way. Of course, I am speaking here of the brighter and nearer stars which we have been able to study by means of the spectroscope, and not at all of the faint stars which form the unstudied distant parts of the Milky Way structure. The helium stars are young, their motions are slow, and they have not wandered far from the place of their birth. Not so with the older stars.

6. The visual double stars afford strong evidence that the order of evolution described is correct. The 36-inch refractor has shown that one star in 18, on the average, brighter than the ninth visual magnitude, consists of two or more suns which we can not doubt are in slow revolution around each other. The number of double stars observable would be very much greater than this if they were not so far away. Of the 20 stars which we say are our nearest neighbors, 8 are well known double stars; one double in each two and one half, on the average. Aitken has made a specialty of observing the double stars whose components in each case are very close together and are in comparatively rapid revolution. His program includes 164 such systems whose types of spectra are known, as in the following table:

Spectrum	Number of Double Stars
Bright-line	0
Class B	4
Class A-F	131
Class G-N	28
Class M-N?	1

The message which this table brings is clear. The double stars whose spectra are of the Bright-Line and Class B varieties have their components so close together that only 4, of Class B, are visible. The great majority fall in Classes A to K; 159 out of 164. The component stars in these classes are far enough apart to be visible in the telescopes, and yet are close enough to be revolving in periods reasonably short. In the Class M double stars, this program contains not more than one star, and I believe the explanation is this: double stars of Class M are in general so far apart, and therefore their periods of revolution are so long, that they do not get upon programs of rapidly revolving stars. Also, the fainter components in many red stars must have cooled off so far that they are invisible. The distances between the components of visual double stars are in general the greater as we proceed from the helium stars through the various spectral classes up to Class M. There are reasons for believing that two stars revolving around their center of mass have gradually increased their distance apart, and therefore their revolution period. If this is true, the Classes G and K; double stars are effectively older than Classes A and F double stars, and these in turn are effectively older than Class B double stars.

7. The spectrograph has great advantages over the telescope in discovering and observing double stars whose components are very close together, by virtue of the facts that the spectrograph measures, velocities of approach and recession in absolute units—so many kilometers per second—and that the speeds of rotation in binary systems are higher the closer together the two components are. The observations of the brighter helium stars, especially those made at the Yerkes Observatory by Frost and Adams, have shown that one helium star in every two and one half on the average is a very close double. In beta Cephei, an early Class B star, the components are so close that they revolve around each other in 4 1/2 hours; many systems have periods in the neighborhood of a day, of two days, of three days, and so on. Similar observations made with the D. O. Mills spectrographs in both hemispheres have shown that about one star in every four of the bright stars, on the average, is a double star. In general, the proportion of spectroscopic doubles discovered to date is greatest in Class B and decreases as we proceed toward Class M. The explanation is simple: in the Class B doubles the components are close together, their orbital velocities are very high and change rapidly, and the spectrograph is able to discover the variations with little loss of time. As we pass toward the yellow and red spectroscopic binaries we find the components separated more and more, the orbital velocities are smaller and the periods longer, the variations of velocity are more difficult to discover, and in the wider pairs we must wait many years before the variations become appreciable. There is a very marked progression of the average lengths of periods of the spectrographic double stars as we pass from the Class B to the Class M pairs. Similarly, the eccentricities of the orbits of the binaries increase as we proceed in the same direction. Accumulating evidence is to the effect that the proportion of double stars to single stars may be as great in the Classes A to K as in Class B.

8. Kapteyn believes that he is able to divide the individual stars—those whose proper motions are known—into the two star streams which he has described; and he finds that the first stream is rich in the early blue stars, less rich relatively in yellow stars, and poor in red stars, whereas the second stream is very poor in early blue stars, rich in yellows, and relatively very rich in reds. His interpretation is that the stream-one stars are effectively younger than the stream-two stars, on the whole. Stream one still abounds in youthful stars: they grow older and the yellow and red stars will then predominate. Stream two abounds in stars which were once young, but are now middle-aged and old.

The eight lines of argument outlined are in harmony to the effect that there is a sequence of development from nebulae to red stars.

The extremely red stars are all faint, only a very few being visible to the naked eye, and these near the limit of vision. Our knowledge concerning them is relatively limited. That these, and all stars, will become invisible to our telescopes, and ultimately be dark unshining bodies, is the logical conclusion to which the evolutionary processes will lead. As I have already stated, both Newcomb and Kelvin were inclined to believe that the major part of gravitational matter in the universe is already invisible.

It should be said that a few astronomers doubt whether the order of evolution is so clearly defined as I have outlined it; in fact, whether we know even the main trend of the evolutionary process. We occasionally encounter the opinion that the subject is still so unsettled as not to let us say whether the helium stars are effectively young or the red stars are effectively old. Lockyer and Russell have proposed hypotheses in which the order of evolutionary sequence begins with comparatively cool red stars and proceeds through the yellow stars to the very hot blue stars, and thence back through the yellow stars to cool red stars.

I think the essentially unanimous view of astronomers is to the effect that the great mass of accumulated evidence favors the order of evolution which I have described. We are all ready to admit that there are apparent exceptions to the simple course laid down, but that these exceptions are revolutionary in effect, and not hopeless of removal, has not yet, in my opinion, been established.

PHYSICAL CONDITIONS GOVERN APPEARANCES OF SPECTRA

A question frequently asked is this: if the yellow and red stars have been developed from the blue stars, why do not the thousands of lines in the spectra of the yellow and red stars show in the spectra of the blue stars? Indeed, why do not the elements so conspicuously present in the atmosphere of the red stars show in the spectra of the gaseous nebulae? The answer is that the conditions in the nebulae and in the youngest stars are such that only the SIMPLEST ELEMENTS, like hydrogen and helium, and in the nebulae nebulium, which we think are nearest to the elemental state of matter, seem to be able to form or exist in them; and the temperature must lower, or other conditions change to the conditions existing in the older stars, before what we may call the more complicated elements can construct themselves out of the more elemental forms of matter. The oxides of titanium and of carbon found in the red stars, where the surface temperatures must be relatively low, would dissociate themselves into more elemental components and lose their identity if the temperature and other conditions were changed back to those of the early helium stars. Lockyer's name is closely connected with this phenomenon of dissociation. There is no evidence, to the best of my knowledge, that the elements known in our Earth are not essentially universal in distribution, either in the forms which the elements have in the Earth, or dissociated into simpler forms wherever the temperatures or other conditions make dissociations possible and unavoidable.

The meteorites, which have come through the atmosphere to the Earth's surface, contain at least 25 known terrestrial elements. That they have not been found thus far to contain all of our elements is not surprising, for we should have difficulty in finding a piece of our Earth weighing a few kilograms which would contain 25 of our elements. We have not found any elements in meteorites which are unknown to our chemists. Our comets, which ordinarily show the presence of not more than three elements, carbon, nitrogen and oxygen, give certain evidence of sodium in their composition when they approach fairly near to the Sun; and the great comet of 1882, when very close to the Sun, developed in its spectrum many bright lines not previously seen in comet spectra, which Copeland said were due to iron. That the comets do not show a greater number of elements is not in the least surprising: they are not condensed bodies, and we think that their average temperature is low, too low generally to develop the luminous vapors of the more refractory elements. If their temperatures, approximated those which exist in the stars, their spectra would probably reveal the presence of many of the elements which exist in the meteorites. Of course the proof of this is lacking.

DESTINY OF THE STELLAR SYSTEM

We have said that the evolutionary processes depend primarily upon the loss of heat. This is to the best of our knowledge a genuine loss, except as some of the heat rays happen to strike other celestial bodies. The flow of heat energy from a star must be essentially continuous, always in one direction from hotter bodies to colder bodies, or into so-called unending and heatless space. Temperatures throughout the universe are apparently moving toward uniformity, at the level of absolute zero. Now, this uniformity would mean universal stagnation and death. It is possible to have life and to do work only when there are differences of temperature between the bodies concerned: work is done or accompanied by a flow of heat, always from the hotter to the colder body. We are not aware that any compensating principle exists. Several students of the subject, notably Arrhenius, have searched for such a principle, a fountain of youth so to speak, in accordance with which the vigor of stellar life should maintain itself from the beginning of time to the end of time; but I think that nothing approaching a satisfactory theory has yet been formulated. The stellar universe seems, from our present point of view, to be slowly "running down." The processes will not end, however, when all the heat generable WITHIN the stars shall have been radiated into an endless space. Every body within the universe, it is conceivable, could have cooled down to absolute zero, but the system might still be in its youth. So long as the stars, whether intensely hot or free from all heat, are rotating rapidly on their axes or are rushing through space with high speeds, the system will remain VERY MUCH ALIVE. Collisions or very close approaches of two stars are bound to occur sooner or later, whether the stars are hot or cold, and in all such cases a large share of the kinetic energy—the energy of motion—of the two bodies will be converted into heat. A collision, under average stellar conditions, should convert the two stars into a luminous gaseous nebula, or two or more nebulae, which would require hundreds or thousands of millions of years to evolve again into young stars, middle-aged stars, old stars, and stars absolutely cold. So long as any of these bodies retain motion with reference to other bodies, they retain the power of rebirth and another life. Not to go too far into speculative detail, the general effect of these processes would be the destruction of relative motions and the gradual decrease in the number of separate bodies, through coalescence. Assume further, however, that all existing bodies, widely scattered through the stellar system, are absolutely cold and absolutely at rest with reference to each other: the system might even then be only middle-aged. The mutual gravitations of the bodies would still be operative. They would pass each other closely, or collide, under high generated velocities: there would be new nebulae, and new and vigorous stellar life to continue through other long ages. The system would not run down until all the kinetic energy had been converted into heat, and all the heat generable had been dissipated. This would not occur until all material in the universe had been combined into one body, or into two bodies in mutual revolution. However, if there are those who say that the universe in action is eternal, through the operation of compensating principles as yet undiscovered, no man of science is at present equipped to prove the contrary.

THE NOVAE

The so-called new stars, otherwise known as temporary stars or novae, present interesting considerations. These are stars which suddenly flash out at points where previously no star was known to exist; or, in a few cases, where a faint existing star has in a few days become immensely brighter. Twenty-nine new stars have been observed from the year 1572 to date; 19 of them since 1886, when the photographic dry plate was applied systematically to the mapping of the heavens, and 15 of the 19 stand to the credit of the Harvard observers. This is an average of one new star in two years; and as some novae must come and go unseen it is evident that they are by no means rare objects. Novae pass through a series of evolutions which have many points in common; in fact, the ones which have been extensively studied by photometer and spectrograph have had histories with so many identities that we are coming to look upon them as standard products of evolutionary processes. These stars usually rise to maximum brilliancy in a few days: some of the most noted ones increased in brightness ten-thousand-fold in two or three days. All of them fluctuate in brightness irregularly, and usually in short periods of time. Several novae have become invisible to the naked eye at the end of a few weeks. With two or three exceptions, all have become invisible in moderate-sized telescopes, or have become very faint, within a few months. Two novae, found very early in their development, had at first dark line spectra, a night later bright lines appeared, and a night or two later the spectra contained the broad radiation and absorption bands characteristic of all recent novae. After the novae become fairly faint, the bright lines of the gaseous nebula spectrum are seen for the first time. These lines increase in relative brilliancy until the spectra are essentially the same as those of well-known nebulae, except that the novae lines are broad whereas the lines of the nebulae are narrow. In a few months or years the nebular lines diminish in brightness, and the continuous spectrum develops. Hartmann at Potsdam, and Adams and Pease with the 60-inch Mount Wilson reflector, have shown that the spectra of the faint remnants of four originally brilliant novae now contain some of the bright lines which are characteristic of Wolf-Rayet stars.[2]

[2] After this lecture was delivered Adams of Mount Wilson reported that in November, 1914, the chief nebular line (5007A) and another prominent nebular line (4363A) had entirely disappeared from the spectrum of Nova Geminorum No. 2, whereas the second nebular line in the green (4959A) remained strong; probably a step in progress from the nebular to the Wolf-Rayet spectrum.

Why the novae suddenly flare up, and what their relations to other celestial bodies may be, are questions which can not be regarded as settled. Their distribution on the celestial sphere is indicated in Figure 25 by the open circles. In this figure the densest parts of the Milky Way are drawn in outline. All of the novae have appeared in the Milky Way, with the exception of five: and these exceptions are worthy of note. One of the five appeared in the condensed nucleus of the great Andromeda nebula, not far from its center; another (zeta Centauri) was located close to the edge of a spiral nebula and quite possibly in a faint outlying part of the nebula; a third (tau Coronae) was observed to have a nebulous halo about it at the earliest stage of its observed existence; a fourth (tau Scorpii) appeared in a nebula; and the fifth (Nova Ophiuchi No. 2) in 1848 was not extensively observed. The other 24 novae appeared within the structure of the Milky Way. Keeping the story as short as possible, a nova is seemingly best explained on the theory that a dark or relatively dark star, traveling rapidly through space, has encountered resistance, such as a great nebula or cloud of particles would afford. While passing through the cloud the forward face of the star is bombarded at high velocities by the resisting materials. The surface strata become heated, the luminosity of the star increases rapidly. The effect of the bombardment by small particles can be only skin deep, and the brightness of the star should diminish rapidly and therefore the spectrum change speedily from one type to another. The new star of February, 1901, in Perseus, afforded evidence of great strength on this question. Wolf at Heidelberg photographed in August an irregular nebulous object near the nova. Ritchey's photograph of September showed extensive areas of nebulosity around the star. In October Perrine and Ritchey discovered that the nebular structure had apparently moved outward from the nova, from September to October. Going back to a March 29th photograph taken for a different purpose, Perrine found an irregular ring of nebulosity closely surrounding the star. Apparently, the region was full f nebulosity which is normally invisible to us. The rushing of the star through this resisting medium made the star the brightest one in the northern sky for two or three days. The great wave of light going out from the star when at its brightest traveled in five weeks as far as the ring of nebulosity, where, falling upon non-luminous nebulous materials, it made the ring visible. Continuing its progress, the wave of light illuminated the material which Wolf photographed in August, the materials which Ritchey photographed still farther away in September, and the still more distant materials which Perrine and Ritchey photographed in October, November, and later. We were able to see this material only as the very strong wave of light which left the star at maximum brightness made the material luminous in passing. That 24 novae should occur in the Milky Way, where the stars are most numerous, and where the resisting materials may preferably prevail, is not surprising; and it should be repeated that at least three of the five occurring outside of the Milky Way were located in nebulous surroundings.

The actual collision of two stars would necessarily be too violent in its effect to let the reduction of brilliancy occur so rapidly as to cause the disappearance of the nova in a few weeks or months. The close approach of two stars might conceivably produce the observed facts, but even this process seems too violent in its probable results. The chances for the collision of a rapidly traveling star with an enormously extended nebulous cloud are vastly greater, and the apparent mildness of the phenomenon observed is in better harmony with expectation.

RELATION OF NOVAE, PLANETARY NEBULAE AND WOLF-RAYET STARS

Although all recent novae have been observed to become planetary or stellar nebulae, they seem not to remain nebular for any length of time; they have gone further and become Wolf-Rayet stars. Whether any or all of the planetary nebulae that have been known since Herschel's day, and have remained apparently unchanged in form, have developed from new stars, is uncertain and doubtful. If they have, the disturbances which gave them their character must have been violent, such as would result from full or glancing collisions of two stars, in order to produce deep-seated effects which change slowly, rather than surface effects which change rapidly.

Whether the Wolf-Rayet stars have in general been formed from planetary nebulae is a different question: some of them certainly have. Wright has recently shown that the stellar nuclei of planetary nebulae are Wolf-Rayet stars, and he has formulated several steps in the process whereby the nebulosity in a planetary eventually condenses into the central star. The distribution of the planetaries and the Wolf-Rayet stars on the sphere affords further evidence of a connection. We saw. that the novae are nearly all in the Milky Way. The irregular, ring, planetary and stellar nebulae, plotted in Fig. 27, prefer the Milky Way, but not so markedly. The Wolf-Rayets, without exception, are located in the Milky Way and in the Magellanic Clouds, and those in the Milky Way are remarkably near to its central plane. 107 of these objects are known, 1 is in the Lesser Magellanic Cloud, and 21 are in the Greater Magellanic Cloud. The remaining 85 average less than 2 3/4 degrees from the central plane of the Milky Way.

We are obliged to say that the places of the novae, of the planetary and stellar nebulae, and of the Wolf-Rayets in the evolutionary process are not certainly known. If the Wolf-Rayet stars have developed from the planetaries, the planetaries from the novae, and the novae have resulted from the close approach or collision of two stars, or from the rushing of a dark or faint star through a resisting medium, then the novae, planetaries and Wolf-Rayets belong to a new and second generation: they were born under exceptional conditions. The velocities of the planetary nebulae seem to be an insuperable difficulty in the way of placing them between the irregular nebulae and the helium stars. The average radial velocity of 47 planetary nebulae is about 45 km. per second; and, if the motions of the planetaries are somewhat at random, their average velocities in space are twice as great, or 90 km. per second. This is fully seven times the average velocity of the helium stars, and the helium stars in general, therefore, could not have come from planetary nebulae. The radial velocities of only three Wolf-Rayet stars have been observed, and this number is too small to have statistical value, but the average for the three is several times as high as the average for the helium stars. We can not say, I think, that the velocities of any novae are certainly known.

If the planetaries have been formed from novae, especially the novae which encountered the fiercest resistance, the high velocities are in a sense not surprising, for those stars which travel with abnormally high speeds are the ones whose chances for collisions with resisting media are best; and, further, the higher the speeds of collision the more violent the disturbance. This line of argument also leads to the conclusion that the novae, planetaries and Wolf-Rayets belong not in general before the helium stars, but to another generation of stars. They may, and I think will, develop into a small class of helium stars having special characteristics; for example, high velocities.

KANT'S HYPOTHESIS

Immanuel Kant's writings, published principally in 1755, are in many ways the most remarkable contributions to the literature of stellar evolution yet made. Curiously, Kant's papers have not been read by the text-book makers, except in a few cases. We have already referred to his ideas on the Milky Way and on comets. In his hypothesis of the origin of the solar system, he laid emphasis upon the facts that the six known planets revolve around the Sun from west to east, nearly in the same plane and nearly in the plane of the Sun's equator; that the then four known moons of Jupiter, the five known moons of Saturn, and our moon revolve around these planets from west to east, and nearly in the same general plane; and that the Sun, our moon and the planets, so far as known, rotate in the same direction. These facts, he said, indicate indisputably a common origin for all the members of the solar system. He expressed the belief that the materials now composing the solar system were originally scattered widely throughout the system, and in an elemental state. This was a half century before Herschel's extensive observations of nebuae. Kant thought of this elemental matter as cold, endowed with gravitational power, and endowed necessarily with some repulsive power, such as exists in gases. He started his solar system from materials at rest. Most of the matter, he said, drifted to the center to form the Sun. He believed that nuclei or centers of attraction formed here and there throughout the chaotic structure, and that in the course of ages these centers grew by accretion of surrounding matter into the present planets and their satellites; and that in some manner motion in one direction prevailed throughout the whole system. Kant's explanation of the origin of the ROTATION of the solar system is unsound and worthless. We now know that such a cloud of matter, free from rotation, could not of itself generate rotation; it must get the start from outside forces. Kant's false reasoning was due in part to the fact that some of our most important dynamical laws were not yet discovered, in part to his faulty comprehension of certain dynamical principles already known, and probably in part to the unsatisfactory state of chemical knowledge existing at that date. This was half a century before Dalton's atomic theory of matter was proposed.

Kant asserted that the processes of combination of surrounding cold materials would generate heat, and, therefore, that the resulting planetary masses would assume the liquid form; that Jupiter and Saturn are now in the liquid state; and that all the planets will ultimately become cold and solid. This is in fair agreement with present-day opinion as to the planets, save that modern astronomers go further in holding that the outer strata of Jupiter and Saturn, likewise of Uranus and Neptune, down to a great depth, must still be gaseous. In 1785, after the principle of heat liberation attending the compression of a gas had been announced, Kant supplemented his statement of 1755 as to the origin of the Sun's heat. He attributed this to gravitational action of the Sun upon its own matter, causing it to contract in size: he said the quantity of heat generated in a given time would be a function of the Sun's volumes at the beginning and at the ending of that period of time. This is substantially the principle which Helmholtz rediscovered and announced in 1854, and which is now universally accepted—with the reservation of the past ten years, that radioactive substances in the Sun may be an additional factor in the problem.

Kant's paper of 1754 enunciated the theory that the Moon always turns the same face to the Earth because of tidal retardation of the Moon's rotation by the Earth's gravitational attraction; and that our Earth tides produced by the Moon will slow down the Earth's rotation until the Earth will finally turn one hemisphere constantly to the Moon. This principle was in part reannounced by Laplace a half century later, and likewise investigated by Helmholtz in 1854, before Kant's work was recognized.

Kant's speculations on a possible destruction and re-birth of the solar system, on the nature of Saturn's ring, and on the nature of the zodiacal light are similar in several regards to present-day beliefs.

Kant wrote:

'I seek to evolve the present state of the universe from the simplest condition of nature by means of mechanical laws alone.'

In 1869 Sir William Thomson, afterwards Lord Kelvin, commented that Kant's

'attempt to account for the constitution and mechanical origin of the universe on Newtonian principles only wanted the knowledge of thermodynamics, which the subsequent experiments of Davy, Rumford and Joule supplied, to lead to thoroughly definite explanation of all that is known regarding the present actions and temperatures of the Earth and of the Sun and all other heavenly bodies.'

These are, apparently, the enthusiastic comments resulting from the re-discovery of Kant's papers. A present-day writer would not speak so decisively of them, but we must all bow in acknowledgment of Kant's remarkable contributions to our subject, published when he was but 31 years old.

LAPLACE'S HYPOTHESIS

In 1796, 41 years following Kant's principal contributions, Laplace published an extensive untechnical volume on general astronomy. At the end of the volume he appended seven short notes. The final note, to which he gave the curious title "Note VII and last," proposed a theory of the origin and evolution of the solar system which soon came to be known as Laplace's Nebular Hypothesis. There are several circumstances which indicate pretty clearly that Laplace was not deeply serious in proposing this hypothesis:

1. Its method of publication as the final short appendix to a large volume on general astronomy.

2. He himself said in his note that the hypothesis must be received "with the distrust with which everything should be regarded that is not the result of observation or calculation."

3. So far as we know he did not submit the theory to the test of well-known mathematical principles involved, although this was his habit in essentially every other branch of astronomy.

4. Laplace, in common with Kant, laid great stress upon the fact that the satellites all revolve around their planets from west to east, nearly in the common plane of the solar system; yet 6 or 7 years before Laplace's publication, Herschel had shown and published that the two recently discovered satellites of Uranus were revolving about Uranus in a plane making an angle of 98 degrees with the common plane of the solar system. While Laplace might not have known of Uranus's satellites in 1796, on account of existing political conditions, there is no evidence that he considered or took note of the fact when making minor changes in his published papers up to the time of his death in 1827. It is a further interesting comment on international scientific literature that Laplace died without learning that Kant had worked in the same field.

Laplace and his contemporary, Sir William Herschel, had been the most fruitful contributors to astronomical knowledge since the days of Sir Isaac Newton. Herschel's observations had led him to speculate as to the evolution of the stars from nebulae, and as a result interest in the subject was widespread. This fact, coupled with Laplace's commanding position, caused the nebular hypothesis to be received with great favor. During an entire century it was the central idea about which astronomical thought revolved.

Laplace conceived that the solar system has been evolved from a gaseous and hot nebula; that the nebulosity extended out farther than the known planets; and that the entire nebulous mass was endowed with a slow rotation that was UNIFORM IN ANGULAR RATE, as in the case of a rotating solid. This gaseous mass was in equilibrium under the expanding forces of heat and rotation and the contracting force of gravitation. Loss of heat by radiation permitted corresponding contraction in size, and increased speed of rotation. A time came, according to Laplace, when the nebula was rotating so rapidly that an outer ring of nebulosity was in equilibrium under centrifugal and gravitational forces and refused to be drawn closer in toward the center. This ring, ROTATING AS A SOLID, maintained its position, while the inner mass contracted farther. Later another ring was abandoned in the same manner; and so on, ring after ring, until only the central nucleus was left. Inasmuch as the nebulosity in the rings was not uniformly distributed, each ring broke into pieces, and the pieces of each ring, in the progress of time, condensed into a gaseous mass. The several large masses formed from the abandoned rings, respectively, became the planets and satellites of the solar system. These gaseous masses rotated faster and faster as their heat radiated into space, they abandoned rings of gaseous matter just as the original mass had done, and these secondary rings condensed to form the satellites; save that, in one case, the ring of gas nearest to Saturn for some reason formed a solid (!) ring about that planet, instead of condensing into one or more satellites. Thus, in outline, according to Laplace, the solar system was formed.

The first half of the nineteenth century found the nebular hypothesis accepted almost without question, but a tearing-down process began in the second half of the century, and at present not much of the original structure remains standing. This is due in small part to discoveries since Laplace's time, but chiefly to a more careful consideration of the fundamental principles involved. We have space to present only a few of the more salient objections.

1. If the materials of the solar system existed as a gas, uniformly distributed throughout what we may call the volume of the system, the density of the gas would be exceedingly low: at the most, several hundred million times less dense than the air we breath. Conditions of equilibrium in so rare a medium would require that the abandonment of the outer parts by the contracting and more rapidly rotating inner mass should be a continuous process. Each abandoned element would be abandoned individually; it would not be vitally affected by the elements slightly farther out in the structure, nor by the elements slightly nearer to the center. Successive abandonment of nine gaseous rings of matter, EACH RING ROTATING AS IF IT WERE A SOLID STRUCTURE, is unthinkable. The real product of the cooling process in such a nebula would undoubtedly be something in the nature of a spiral nebula, in which the matter would revolve around the nucleus the more rapidly the nearer it was to the nucleus. If the matter were originally distributed uniformly throughout the rotating structure, the spiral lines might not be visible. If it were distributed irregularly, the spiral form here and there could scarcely fail to be in evidence to a distant observer.

2. Laplace held that the condensation of each ring would result in one planet, rotating on its axis from

west to east; this apparently by virtue of the fact that in a ring rotating AS A SOLID the outer edge travels more rapidly than the inner edge does, and therefore, the west to east direction of rotation must prevail in the planetary product. If now, as we firmly believe, each constituent of such an attenuated ring must rotate substantially independently of other constituents, those nearer the inner edge of the ring will possess the higher speeds of rotation, and the preponderance of kinetic energy in the inner parts of the ring should give the resulting planetary condensation a retrograde direction of rotation.

3. According to Laplace the satellites should all revolve around their primaries from west to east. Eight of the satellites do not follow this rule.

4. If the materials composing the inner ring of Saturn were abandoned by the parent planet, as this planet contracted in size and rotated ever more and more rapidly, then the ring should revolve about the planet in a period considerably longer than the planet period. The reverse is the fact. The rotation period of the equatorial region of the planet itself is 10 h. 14 m., whereas the inner edge of the ring system revolves about the planet once in about five hours.

5. The inner satellite of Mars revolves once in 7 h. 39 m., whereas Mars requires 24 h. 37 m. for one rotation. According to the Nebular Hypothesis, the period of the satellite should be the longer.

6. Laplace's hypothesis would seem to require that the orbits of the planets be circular or very nearly so. The orbits of all except Venus and Neptune are quite eccentric, and Mercury's orbit, which should have the nearest approach to circularity, is by far the most eccentric.

7. If the planetary rings were abandoned by centrifugal action, we should expect the Sun to be rotating in the principal plane of the planet system. The major planets, from Venus out to Neptune, are revolving in nearly a common plane. The Sun, containing 99 6/7 per cent. of all the material in the system, has its equator inclined 7 degrees to the planet plane. This discrepancy is a very serious and I think fatal objection to Laplace's hypothesis, as Chamberlin has emphasized.

8. Laplace assumed a nebula whose form was a function of its rotational speed, its gravitation, its internal heat, and, although he does not so state, of its internal friction. He did not distribute the matter within the nebula to conform in any way to the distribution as we observe it to-day, but he let the entire structure contract, following the loss of heat, until the maintenance of equilibrium required the successive abandoning of seven or eight rings. He mentions a central condensation, but gives no further particulars. Thirty years ago Fouche established clearly that the condensing of Laplace's assumed nebula into the present solar system would involve the violent breaking of the law known as the conservation of moment of momentum. Fouche proved that a distribution of matter beyond any conception of the subject by Laplace must be assumed. Fully 96 per cent. must be condensed in the central nucleus AT THE OUTSET, and not more than 4 per cent. of the total mass must lie outside of the nucleus and be widely distributed throughout the volume of the solar system. Chamberlin puts the case very strongly in another way. If the planet Mercury was abandoned as a ring of nebulosity, the equatorial velocity of the remaining central mass must at that time have been in the neighborhood of 45 km. per second, as this is the orbital speed of Mercury. If the central mass condensed to the present size of the Sun, the Sun's equatorial velocity of rotation should now be fully 400 km. per second, in accordance with the requirement of the rigid law of constancy of moment of momentum. The Sun's actual equatorial velocity is only 2 km. per second!

In several other respects the hypothesis of Laplace, as he proposed it, fails to account for the facts as they are observed to exist.

Poincare devoted his unique talents to the evolution problem shortly before his death. He recognized that the Laplace hypothesis is not tenable except upon such an assumed distribution of matter as was defined by Fouche. Accepting this modification, and extending the hypothesis to involve the application of tidal interactions at many points throughout the solar system, Poincare expresses the opinion that the Laplacian hypothesis, of all those proposed, is still the one which best accounts for the facts.[3] However, he does not utilize the hypothesis of rings rotating as solids, for he finds it necessary to conclude that the planetary masses in the beginning must have had retrograde rotations. In the large planetary masses of Jupiter and Saturn, for example, the materials which form the outer retrograde satellites were abandoned while the rotations were still retrograde, and when the diameters of the planetary masses were several scores of times their present diameters. In these extended masses the Sun would create tidal waves, and here, as always, such waves would exert a retarding effect upon the rotations. A time would come, Poincare thought, when these planets would rotate once in a revolution; that is, present the same face to the Sun; and this is in fact a west to east rotation. Further contraction of the planetary masses would give rise to increasing rotational speeds in the west to east direction. The materials which form the inner satellites of Jupiter and Saturn were abandoned successively after the west to east direction of rotation had become established. According to modifications of the same theory, tidal retardation has slowed down Saturn's speed since the abandonment of the materials which later condensed to form the inner ring of that planet; or, possibly, the ring materials encountered resistance after the planet abandoned them, with the consequence that the ring drew in toward the planet and increased its speed; and similarly in the case of Mars and its inner satellite.

[3] Poincare has made the following interesting comments on Laplace's hypothesis: "The oldest hypothesis is that of Laplace; but its old age is vigorous and for its age it has not too many wrinkles. In spite of the objections which have been urged against it, in spite of the discoveries which astronomers have made and which would indeed astonish Laplace himself, it is always standing the strain, and it is the hypothesis which best explains the facts; it is the hypothesis which responds best to the question which Laplace endeavored to answer, Why does order rule throughout the solar system, provided this order is not due to chance? From time to time a breach opened in the old edifice (the Laplace hypothesis); but the breach was promptly repaired and the edifice has not fallen."

To me this modification of the Laplacian hypothesis is unsatisfactory, for several reasons. To mention only one: if Jupiter was a large gaseous mass extending out as far as the 8th and 9th satellites, the gaseous body was very highly attenuated; friction in the outer strata would be essentially a negligible quantity, and tidal retardation would not be very effective; and it would be under just these conditions that loss of heat from the planet should be most rapid and the rate of increase of retrograde rotation resulting therefrom be comparatively high. It would seem that the rotation of the planet in the retrograde direction must have accelerated under the contractional cause, rather than have decreased and reversed in direction under an excessively feeble tidal cause.

The recognized weaknesses of Laplace's hypothesis have caused many other hypotheses to be proposed in the past half century. The hypotheses of Faye, Lockyer, du Ligondes, See, Arrhenius, and Chamberlin and Moulton include many of the features of Kant's or Laplace's hypotheses, but all of them advance and develop other ideas. It is unfortunate that space limits do not permit us to discuss the new features of each hypothesis.

(To be continued.)

PROGRESS AND PEACE

BY PROFESSOR ROBERT M. YERKES

HARVARD UNIVERSITY

LASTING peace among the nations of the earth we must regard as of supreme moment, the discovery of the conditions thereof, as most worthy of human effort. Physical struggle is no longer accepted as either a necessary or a desirable means of settling differences between individuals. Why, then, should it be tolerated to-day in connection with national disagreements? To admit the impossibility or the impracticability of universal peace is to stigmatize our vaunted civilization as a failure. Surely we will not, can not, humble ourselves by such an admission until we have exhausted our energies in searching for the conditions of national amity.

With my whole life I believe in the possibility and value of worldwide friendliness and cooperation. I am writing to discuss not the attainability or the merits of peace, but ways of achieving it; not to criticize present activities on its behalf, but to indicate the promise of a neglected approach and to present a program which should, I believe, find its place in the great "peace movement."

Must peace be achieved and maintained by brute strength, regardless of sense and sentiment, or may it be gained through intelligence, humanely used? Must the pathway thereto be paved with human skulls, builded with infinite suffering and sacrifice, or may it he charted by scientific inquiry and builded by the joyous labor of mutual service and helpfulness? Is it possible, in the light of the history of the races of man, to doubt that we must place our dependence on intelligence sympathetically employed, not on physical prowess? To me it seems that peace must be achieved peacefully, not by the clash of arms and bloodshed.

But even if we grant that science is our main hope, there remains a choice of methods. On the one hand, there is the way of material progress, physical discovery and feverish haste to apply every new fact to armament; on the other, that of biological research, social enlightenment, and ever-increasing human understanding and sympathy.

Firm believers in each of these possible approaches, through science, to international peace, are at hand. The one group argues that nations, like individuals, must be controlled in all supreme crises by fear; the other contends that civilization has developed in enlightened human sympathy a higher, a more worthy, and a safer control of behavior.

As a biologist and a believer in the brotherhood of man, I wish to present the merits of sympathy, as contrasted with fear, and to plead for larger attention to the biological approach to the control of international relations. For I am convinced that the greatest lesson of the present stupendous world-conflict is the need of thorough knowledge of the laws of individual and social human behavior. Surely this war clearly indicates that the study of instinct, and the use of our knowledge for the control of human relations, is incalculably more important for the welfare of mankind than is the discovery of new and ever more powerful explosives or the building of increasingly terrible engines of destruction.

During the last half-century the physical sciences, technologies, arts and industries, have made marvelous advances. At enormous cost of labor and material resources there have been discovered and perfected means of destroying life and property at once so effective and so terrible to contemplate that preparedness for war seemed a safe guarantee of peace. But who is there now to insist, against the evidence of blood-drenched Europe, that material progress, physical discovery, and armament based thereupon, assure international friendship?

Only if one of the nations should discover, and guard as its secret, some diabolically horrible means of destroying human life and property by wholesale and over materially unbridged distances, can armaments even temporarily put an end to war. In such event—and it is by no means an improbability—the whole world might suddenly be made to bow in terror before the will of the all-powerful nation. Before this approaching crisis, can we do less than earnestly pray that the translation of physical progress into armament may be halted until the brotherhood of man has been further advanced? Dare we stop to contemplate what would happen to-morrow if Germany, with half the civilized world arrayed against her, should come into possession of some imponderable, and to the untutored mind mysterious, means of directing her torpedoes, exploding magazines, mines, shells from distant bases? Undoubtedly we are close upon the employment of certain vibrations for this deadly purpose. Shall we veer in time and take a safer course, or are we doomed to the inevitable?

For the certain result of pushing forward relentlessly on the path of preparation for war—in the name of peace—is the dominance of a single nation and the destruction or subjugation of all others. This is as inevitable as is death. If we would preserve and foster racial and national diversity of traits, promote social individuality as we so eagerly foster the diversity of selves, we must speedily focus attention upon human nature and seek that knowledge of it which shall enable us to control it wisely rather than to destroy it ruthlessly.

Even were I able to do so, I should in no degree belittle the achievements of the physical sciences and their technologies, for I believe whole-heartedly in their value, and long for the steady increase of our power to control our environment. But when these achievements are offered as means of creating or maintaining certain desired conditions of individual and social life, I must insist that other knowledge is essential—nay, more essential—than that of the physicist or chemist. Knowledge, namely, of life itself.

Most briefly, the situation may thus be described. In peace and in war there are two large, complex and intricate groups of facts to be dealt with by those who seek the welfare of man. The one group comprises the phenomena of physical nature as the condition of life—environment; the other is constituted by the phenomena of life and the relations of lives. Those who sincerely believe in preparedness for war as a preventive measure, misconceive and attempt to misuse the emotion of fear and its modes of expression. It is as though we should strive tirelessly to develop machinery and methods for educating our children, the while ignorant of the laws of child development and branding as of no practical importance the fundamentals of human nature.

To nations no more than to individuals is it given to live by fear alone. By it a nation may become dominant, and diversity of body, mind, and ideals be eradicated. To base our civilization upon fear entails uniformity, monotony of life; the sacrifice of peoples for the unduly exalted traits and national ideals of a single homogeneous social group—a single all-powerful nation. Knowledge of life, and the sympathy for one's fellow men which springs from it, must control the world if nations are to live in peaceful and mutually helpful relations. If life, whether of the individual or of the social group, is to be controlled, it must be through intimate knowledge of life, not through knowledge of something else. The world must be ruled by sympathy, based upon understanding, insight, appreciation. This is my prophecy, this my faith and my present thesis.

Material as contrasted with purely intellectual or spiritual progress is the pride of our time. We worship technology as reared upon physics and chemistry. But what is our gain, in this progress, so long as we continue to use one another as targets? Would it not be wiser, more far-sighted, more humane, more favorable to the development of universal peace and brotherhood, to give a large share of our time and substance to the search for the secrets of life? As compared with the physical sciences, the biological departments of inquiry are, in general, backward and ill-supported. Why? Because their tremendous importance is not generally recognized, and, still more, because the control of inanimate nature as promised by physical discovery and its applications appeals irresistibly both to our imagination and to our greed. We long for peace—because we are afraid of war—we long for the perfecting of individual and social life, but much more intensely and effectively we long for wealth, power and pleasure.

What I have already said and now repeat in other words is that if we really desired above anything attainable on earth the lasting peace of nations, we should diligently foster and tirelessly pursue the sciences of life and seek to perfect and exalt the varied arts and technologies which should be based upon them. Experimental zoology and genetics; physiology and hygiene; genetic psychology and education; anthropology and ethnology; sociology and economics, would be held in as high esteem and as ardently furthered as are the various physical sciences and their technologies.

Does it not seem reasonable to claim that human behavior may be intelligently controlled or directed only in the light of intimate and exhaustive knowledge of the organism, its processes, and its relations to its environment? If this be true, how pitiably, how shamefully, inadequate is our knowledge even of ourselves! How few are those who have a sound, although meager, knowledge of the laws of heredity, of the primary facts of human physiology, of the principles of hygiene, of the chief facts and laws of mental life, including the fundamental emotions and their corresponding instinctive modes of action, the modifiability or educability of the individual and the important relations of varied sorts of experience and conduct, the laws of habit, the nature and role of the sentiments, the unnumbered varieties of memory and ideation, the chief facts of social life and their relations to individual experience and behavior. Not one person in a thousand has a knowledge of life and its conditions equal in adequacy for practical demands to his knowledge of those aspects of physical nature with which he is concerned in earning a livelihood. Even those of us who have dedicated our lives to the study of life are humble before our ignorance. But with a faith which can not be shaken, because we have seen visions and dreamed dreams, we insist that the knowledge which we seek and daily find is absolutely essential for the perfecting of educational methods; for the development of effective systems of bodily and mental hygiene; for the discovery, fostering and maintenance of increasingly profitable social relations and organizations. In a word, we believe that biology, of all sciences, can and must lead us in the path of social as contrasted with merely material progress; can and ultimately will so alter the relations of nations that war shall be as impossible as is peace to-day.

Fortunately the biologist may depend, in his efforts to further the study of all aspects of life, not upon faith and hope alone, but also upon works, for already physiology and psychology have transformed our educational practices; and the medical sciences given us a great and steadily increasing measure of control over disease.

At least two men, as different in intellectual equipment, habits of mind, and methods of inquiry as well could be, the one an American, the other an Englishman, have heralded the broadly comparative and genetic study of mind and behavior—let us call it Genetic Psychology—as the promise of a new era for civilization, because the essential condition of the intelligent and effective regulation of life.

The one of these prophets among biologists, President G. Stanley Hall, has lived to see his faith in the practical importance of the intensive study of childhood and adolescence justified by radical reforms in school and home. Hall should be revered by all lovers of youth as the apostle to adolescents. The other, Professor William McDougall, has done much to convince the thinking world that all of the social sciences and technologies must be grounded upon an adequate genetic psychology—a genetic psychology which shall take as full and intelligent account of behavior as of experience; of the life of the ant, monkey, ape as of that of man; of the savage as of civilized man; of the infant, child, adolescent as of the adult; of the moron, imbecile, idiot, insane, as of the normal individual; of social groups as of isolated selves. It is to McDougall we owe a most effective sketch—in his introduction to Social Psychology of the primary human emotions in their relations to instinctive modes of behavior.

Hall, McDougall and such sociologists—lamentably few, I fear—as Graham Wallas would agree that for the attainment of peace we must depend upon some primary human instinct. I venture the prediction that no one of them would select fear as the safe basis. Instead, they surely would unite upon sympathy.

Among animals preparedness for struggles is a conspicuous cause of strife. The monkey who stalks about among his fellows with muscles tense, tail erect, teeth bared, bespeaking expectancy of and longing for a fight, usually provokes it. We may not safely argue that lower animals prove the value of preparedness for war as a preventive measure! Among them, as among human groups, the only justification of militarism is protection and aggression. Preparedness for strife is provocative rather than preventive thereof.

As individual differences, and resulting struggles, are due to ignorance, misunderstanding, lack of the basis for intelligent appreciation of ideals, motives and sympathy, so among nations knowledge of bodily and mental traits, of aims, aspirations, and national ideals fosters the feeling of kinship and favors the instinctive attitude of sympathetic cooperation.

Every student of living things knows that to understand the structure, habits, instincts, of any creature is to feel for and with it. Even the lowliest type of organism acquires dignity and worth when one becomes familiar with its life. Children in their ignorance and lack of understanding are incredibly cruel. So, likewise, are nations. The treatment of inferior by superior races throughout the ages has been childishly cruel, unjust, stupid, inimical to the best interests not only of the victims, but also of mankind. This has been so, not so much by reason of bad intentions, although selfishness has been at the root of immeasurable injustice, but primarily because of the utter lack of understanding and sympathy. To see a savage is to despise or fear him, to know him intimately is to love him. The same law holds of social groups, be they families, tribes, nations or races. They can cooperate on terms of friendly helpfulness just in the measure in which they know one another's physical, mental and social traits and appreciate their values, for in precisely this measure are they capable of understanding and sympathizing with one another's ideals.

Selfishness, the essential condition of individualism and nationalism, must be supplanted by the sympathy of an all inclusive social consciousness and conscience if lasting peace is to be attained.

To further the end of this transformation of man we should become familiar with the inborn springs to action, those fundamental tendencies which we call instincts, for we live more largely than is generally supposed by instinct and less by reason. All of the organic cravings, hungers, needs, should be thoroughly understood so that they may be effectively used. And, finally, the laws of intellect must be at our command if we are to meet the endlessly varying and puzzling situations of life profitably and with the measure of adequacy our reason would seem to justify.

Clearly, then, the least, and the most, we can do in the interest of peace is to provide for the study of life, but especially for the shamefully neglected or imperfectly described phenomena of behavior and mind, in the measure which our national wealth, our intelligence and our technical skill make possible. For one thing, it is open to us to establish institutes for the thorough study of every aspect of behavior and mind in relation to structure and environment, comparable with such institutions for social progress as the Rockefeller Institute for Medical Research. The primary function of such centers for the solution of vital problems should be the comparative study, from the genetic, developmental, historical, point of view of every aspect of the functional life of living things, to the end that human life may be better understood and more successfully controlled. Facts of heredity, of behavior, of mind, of social relations, should alike be gathered and related, and thus by the observation of the most varied types, developmental stages, and conditions of living creatures there should be developed a science of behavior and consciousness which should ultimately constitute a safe basis for the social sciences, for all forms of social endeavor, and for universal and permanent peace.

I submit that such centers of research as the psycho-biological institute I have so imperfectly described are sorely needed. For it is obvious that the future of our species depends in large measure upon how we develop the biological sciences and what use we make of our knowledge. I further submit, and therewith I rest my case, that familiarity with living things breeds sympathy not contempt, and that sympathy in turn conditions justice.

May it be granted us to work intelligently, effectively, tirelessly for world-wide peace and service. not by the suppression of racial and national diversities, the leveling of the mass to a deadly sameness, but through steadily increasing appreciation of racial and national traits. May the world, even sooner than we dare to hope, be ruled by sympathy instead of by fear.

THE PROGRESS OF SCIENCE

THE MISSOURI AND THE NEW YORK BOTANICAL GARDENS

THE Missouri Botanical Garden has recently celebrated the twenty-fifth anniversary of its foundation and the New York Botanical Garden its twentieth anniversary. Within these short periods these gardens have taken rank among the leading scientific institutions of the world. Botanical gardens were among the first institutions to be established for scientific research; indeed Parkinson, the "botanist royal" of England, on the title page of his book of 1629, which we here reproduce, depicts the Garden of Eden as the first botanical garden and one which apparently engaged in scientific expeditions, for it includes plants which must have been collected in America. However this may be, publicly supported gardens for the cultivation of plants of economic and esthetic value existed in Egypt, Assyria, China and Mexico and beginning in the medieval period had a large development in Europe there being at the beginning of the seventeenth century botanical gardens devoted to research in Bologna, Montpellier, Leyden, Paris, Upsala and elsewhere. An interesting survey of the history of botanical gardens is given in a paper by Dr. A W. Hill assistant director of the Kew Gardens, prepared for the celebration of the Missouri Garden, from which we have taken the illustration from Parkinson and the pictures of Padua and Kew.

The papers presented at the celebration have been published in a handsome volume. It includes addresses by a number of distinguished botanists, though owing to the war several of the foreign botanists were unable to be present. Dr. George T. Moore, director of the garden, made in his address of welcome a brief statement in regard to its origin in the private garden and by the later endowment of Mr. Henry Shaw. Mr. Shaw came to this country from England in 1818, and with a small stock of hardware began business in one room which also served as bedroom and kitchen. Within twenty years he had acquired a fortune and retired from active business to devote the remaining forty-nine years of his life to travel and to the management of a garden surrounding his country-home on the outskirts of St. Louis. In 1859 he erected a small museum and library, and in 1866 Mr. James Gurney was brought to this country as head gardener. Mr. Shaw died in 1889, leaving his estate largely for the establishment of the Missouri Botanical Garden, but providing also for the Henry Shaw School of Botany of Washington University and a park for the city. With this liberal endowment constantly increasing as the real estate becomes more productive, Dr. William Trelease, the first director, and Dr. George T. Moore, the present director, have conducted an institution not only of value to the city of St. Louis but largely contributing to the advance of botanical science.

The New York Botanical Garden, largely through the efforts of Dr. N. L. Britton, the present director was authorized by the New York legislature in 1891. The act of incorporation provided that when the corporation created should have secured by subscription a sum not less than $250,000 the city was authorized to set aside for the garden as much as 250 acres from one of the public parks and to expend one half million dollars for the construction and equipment of the necessary buildings. The conditions were met in 1895, and the institution has since grown in its land, and its buildings, in its collections and in its herbaria, so that, in association with the department of botany of Columbia University, it now rivals in its material equipment and in the research work accomplished any botanical institution in the world.

THE SECOND PAN-AMERICAN SCIENTIFIC CONGRESS

THERE will be held at Washington from Monday, December 27, to Saturday, January 9, the second Pan-American Scientific Congress, authorized by the first congress held in Santiago, Chili, six years previously. This was one of the series of congresses previously conducted by the republics of Latin America. The Washington congress, which is under the auspices of the government of the United States, with Mr. William Phillips, third assistant secretary of state, as chairman of the executive committee, will meet in nine sections, which, with the chairmen, are as follows:

I. Anthropology, Wm. H. Holmes.

II. Astronomy, Meteorology, and Seismology, Robert S. Woodward.

III. Conservation of Natural Resources, Agriculture, Irrigation and Forestry, George M. Rommel.

IV. Education, P. P. Claxton.

V. Engineering, W. H. Bixby.

VI. International Law, Public Law, and Jurisprudence, James Brown Scott.

VII. Mining and Metallurgy, Economic Geology, and Applied Chemistry, Hennen Jennings.

VIII. Public Health and Medical Science, Wm. C. Gorgas.

IX. Transportation, Commerce, Finance, and Taxation, L. S. Rowe.

Each section is divided further into subsections, of which there are forty-five, each with a special committee and program. Several of the leading national associations of the United States, concerned with the investigation of subjects of pertinent interest to some of the sections of the congress, have received and accepted invitations from the executive committee of congress to meet in Washington at the same time and hold one or more joint sessions with a section or subsection of corresponding interest. Thus the nineteenth International Congress of Americanists will meet in Washington during the same week with the Pan-American Scientific Congress, and joint conferences will be held for the discussion of subjects of common interest to members of the two organizations

As an example of the wide scope of the congress we may quote the ten subsections into which the section of education is divided. Each of these subsections is under a committee of men distinguished in educational work and men of eminence have been invited to take part in the proceedings. The subjects proposed for discussion by each of these sections are:

Elementary Education: To what extent should elementary education be supported by local taxation, and to what extent by state taxation? What should be the determining factors in the distribution of support? Secondary Education: What should be the primary and what the secondary purpose of high school education? To what extent should courses of study in the high school be determined by the requirements for admission to college, and to what extent by the demands of industrial and civic life? University Education: Should universities and colleges supported by public funds be controlled by independent and autonomous powers, or should they be controlled directly by central state authority? Education of Women: To what extent is coeducation desirable in elementary schools, high schools, colleges and universities? Exchange of Professors and Students between Countries: To what extent is an exchange of students and professors between American republics desirable? What is the most effective basis for a system of exchange? What plans should be adopted in order to secure mutual recognition of technical and professional degrees by American Republics? Engineering Education: To what extent may college courses in engineering be profitably supplemented by practical work in the shop? To what extent may laboratory work in engineering be replaced through cooperation with industrial plants? Medical Education: What preparation should be required for admission to medical schools? What should he the minimum requirements for graduation? What portion of the faculty of a medical school should be required to give all their time to teaching and investigation? What instruction may best be given by physicians engaged in medical practice? Agricultural Education: What preparation should be required for admission to state and national colleges of agriculture? To what extent should the courses of study in the agricultural college be theoretical and general, and to what extent practical and specific? To what extent should the curriculum of any such college be determined by local conditions? Industrial Education: What should be the place of industrial education in the school system of the American republics? Should it be supported by public taxation? Should it be considered as a function of the public school system? Should it be given in a separate system under separate control? How and to what extent may industrial schools cooperate with employers of labor, Commercial Education: How can a nation prepare in the most effective manner its young men for a business career that is to be pursued at home or in a foreign country.

SCIENTIFIC ITEMS

WE record with regret the death at the age of ninety-two of Henri Fabre, the distinguished French entomologist and author; of William Henry Hoar Hudson, late professor of mathematics at King's College, London; of Dr. Ugo Schiff, professor of chemistry at Florence; of Susanna Phelps Gage, known for her work on comparative anatomy; of Charles Frederick Holder, the California naturalist, and of Dr. Austin Flint, a distinguished physician and alienist of New York City.

DR. RAY LYMAN WILBUR, professor of medicine, has been elected president of Leland Stanford Junior University. He will on January 1 succeed Dr John Caspar Branner, who undertook to accept the presidency for a limited period on the retirement of Dr. David Starr Jordan, now chancellor of the university. Dr. Wilbur graduated from the academic department of Stanford University in 1896.

AT the Manchester meeting of the British Association for the Advancement of Science, Sir Arthur J. Evans, F.R S., the archeologist, honorary keeper of the Ashmolean Museum, Oxford, was elected president for next year's meeting, to be held at Newcastle-on-Tyne. The meeting of 1917 will be held at Bournemouth.

DR. MAX PLANCK, professor of physics at Berlin, and Professor Hugo von Seeliger, director of the Munich Observatory, have been made knights of the Prussian order pour le merite. Dr. Ramon y Cajal, professor of histology at Madrid, and Dr. C. J. Kapteyn, professor of astronomy at Groningen, have been appointed foreign knights of this order.

MR. JACOB H. SCHIFF, a member of the board of trustees of Barnard College and its first treasurer, has given $500,000 to the college for a woman's building. It will include a library and additional lecture halls as well as a gymnasium, a lunch room and rooms for students' organizations.

BY the will of the late Dr. Dudley P. Allen, formerly professor of surgery in the Western Reserve University, $200,000 has been set aside as a permanent endowment fund for the Cleveland Medical Library.

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THE INSIDE HISTORY OF A GREAT MEDICAL DISCOVERY

BY ARISTIDES AGRAMONTE, M.D., Sc.D. (HON.)

UNIVERSITY OF HAVANA.

THE construction of the Panama Canal was made possible because it was shown that yellow fever, like malaria, could be spread only by the bites of infected mosquitoes.

The same discovery, which has been repeatedly referred to as the greatest medical achievement of the twentieth century, was the means of stamping out the dreaded scourge in Cuba, as well as in New Orleans, Rio de Janeiro, Vera Cruz, Colon, Panama and other Cities in America.

This article is intended to narrate the motives that led up to the investigation and also the manner in which the work was planned, executed and terminated. No names are withheld and the date of every important event is given, so that an interested reader may be enabled to follow closely upon the order of things as they occurred and thus form a correct idea of the importance of the undertaking, the risk entailed in its accomplishment and how evenly divided was the work among those who, in the faithful performance of their military duties, contributed so much for the benefit of mankind; the magnitude of their achievement is of such proportions, that it loses nothing of its greatness when we tear away the halo of apparent heroism that well-meaning but ignorant historians have thrown about some of the investigators.

The whole series of events, tragic, pathetic, comical and otherwise, took place upon a stage made particularly fit by nature and the surrounding circumstances.

Columbia Barracks, a military reservation, garrisoned by some fourteen hundred troops, distant about eight miles from the city of Havana, the latter, suffering at the time from an epidemic of yellow fever, which the application of all sanitary measures had failed to check or ameliorate and finally, our experimental camp (Camp Lazear), a few army tents, securely hidden from the road leading to Marianao, and safeguarded against intercourse with the outside world; the whole setting portentously silent and gloriously bright in the glow of tropical sunlight and the green of luxuriant vegetation.

Two members of a detachment of four medical officers of the United States Army, on the morning of August 31, 1900, were busily examining under microscopes several glass slides containing blood from a fellow officer who, since the day before, had shown symptoms of yellow fever; these men were Drs. Jesse W. Lazear and myself; our sick colleague was Dr. James Carroll, who presumably had been infected by one of our "experiment mosquitoes."

It is very difficult to describe the feelings which assailed us at that moment; a sense of exultation at our apparent success no doubt animated us; regret, because the results had evidently brought a dangerous illness upon our coworker and with it all associated a thrill of uncertainty for the reason of the yet insufficient testimony tending to prove the far-reaching truth which we then hardly dared to realize.

As the idea that Carroll's fever must have been caused by the mosquito that was applied to him four days before became fixed upon our minds, we decided to test it upon the first non-immune person who should offer himself to be bitten; this was of common occurrence and taken much as a joke among the soldiers about the military hospital. Barely fifteen minutes may have elapsed since we had come to this decision when, as Lazear stood at the door of the laboratory trying to "coax" a mosquito to pass from one test-tube into another, a soldier came walking by towards the hospital buildings; he saluted, as it is customary in the army upon meeting an officer, but, as Lazear had both hands engaged, he answered with a rather pleasant "Good morning." The man stopped upon coming abreast, curious no doubt to see the performance with the tubes, and after gazing for a minute or two at the insects he said: "You still fooling with mosquitoes, Doctor?" "Yes," returned Lazear, "will you take a bite?" "Sure I ain't scared of 'em," responded the man. When I heard this, I left the microscope and stepped to the door, where the short conversation had taken place; Lazear looked at me as though in consultation; I nodded assent, then turned to the soldier and asked him to come inside and bare his forearm. Upon a slip of paper I wrote his name while several mosquitoes took their fill; William E. Dean, American by birth, belonging to Troop B, Seventh Cavalry; he said that he had never been in the tropics before and had not left the military reservation for nearly two months. The conditions for a test case were quite ideal.

I must say we were in great trepidation at the time; and well might we have been, for Dean's was the first indubitable case of yellow fever about to be produced experimentally by the bite of purposely infected mosquitoes. Five days afterwards, when he came down with yellow fever and the diagnosis of his case was corroborated by Dr. Roger P. Ames, U. S. Army, then on duty at the hospital, we sent a cablegram to Major Walter Reed, chairman of the board, who a month before had been called to Washington upon another duty, apprising him of the fact that the theory of the transmission of yellow fever by mosquitoes, which at first was doubted so much and the transcendental importance of which we could then barely appreciate, had indeed been confirmed.

STATE OF THINGS BEFORE THE DISCOVERY OF MOSQUITO TRANSMISSION

Other infectious diseases, tuberculosis, for instance, may cause a greater death-rate and bring about more misery and distress, even to-day, than yellow fever has produced at any one time; but no disease, except possibly cholera or the plague, is so tragic in its development, so appalling in its action, so devastating in its results, nor does any other make greater havoc than yellow fever when it invades non-immune or susceptible communities.

For two centuries, at least, the disease has been known to exist endemically, that is, more or less continuously, in most of the Mexican Gulf ports, extending its ravages along the West India Islands and the cities of the Central and the South American coast.

In the United States it has made its appearance in epidemic form as far north as Portsmouth, N. H. At Philadelphia in 1793, more than ten per cent. of the entire population died of yellow fever. Other cities, like Charleston, S. C., suffered more than twenty epidemics in as many summers, during the eighteenth century. In the city of New Orleans, the epidemic which developed in the summer of 1853 caused more than 7,000 deaths. Later, in 1878, yellow fever invaded 132 towns in the United States, producing a loss of 15,932 lives out of a total number of cases which reached to more than 74,000: New Orleans alone suffered a mortality of 4,600 at that time. Recently (1905), this city withstood what is to be hoped shall prove its last invasion, which, thanks to the modern methods employed in its suppression, based upon the new mosquito doctrine, only destroyed about 3,000 lives.

It is by contemplating this awful record, and much more there is which for the sake of brevity I leave unstated, that one realizes the boon to mankind which the successful researches of the Army Board have proved. The work of prevention, the only one that may be considered effective when dealing with the epidemic diseases, was entirely misguided with regard to yellow fever until 1901: the sick were surrounded by precautions which were believed most useful in other infectious diseases, the attendants were often looked upon as pestilential, and so treated, in spite of the fact that evidence from the early history of the disease clearly pointed to the apparent harmlessness even of the patients themselves. All this notwithstanding, cases continued to develop, in the face of shotgun quarantine even, until the last non-immune inhabitant of the locality had been either cured or buried.

The mystery which accompanied the usual course of an epidemic, the poison creeping from house to house, along one side of a street, seldom, crossing the road, spreading sometimes around the whole block of houses before appearing in another neighborhood, unless distinctly carried there by a visitor to the infected zone who himself became stricken, all this series of peculiar circumstances was a never-ending source of discussion and investigation.

In the year 1900, Surgeon H. R. Carter, of the then Marine Hospital Service, published a very interesting paper calling attention to the interval of time which regularly occurred between the first case of yellow fever in a given community and those that subsequently followed; this was never less than two weeks, a period of incubation extending beyond that usually accorded to other acute infectious diseases. The accuracy of these observations has later been confirmed by the mosquito experiments hereinafter outlined.

FACTORS WHICH LED TO THE APPOINTMENT OF THE BOARD

One may well believe that such a scourge as yellow fever could not have been long neglected by medical investigators, and so we find that from the earliest days, when the germ-theory of disease took its proper place in modern science, a search for the causative agent of this infection was more or less actively instituted.

Men of the highest attainments in bacteriology engaged in numerous attempts to isolate the yellow fever microbe: unfortunately not a few charlatans took advantage of the dread and terror which the disease inspires, to proclaim their discoveries and their specific CURES; one of these obtained wealth and honor in one of the South American republics for presumably having discovered the "germ" and prepared a so-called vaccination which was expected to eradicate the disease from that country, but for many years after the foreign population continued to suffer as before and the intensity and the spread of yellow fever remained unabated, although thousands of "preventive inoculations" were made every month.

Geo. M. Sternberg in 1880, then an army surgeon, was directly instrumental in exposing the swindle that was being perpetrated, putting an end, after the most painstaking investigation, to all the claims to discovery of the "germ" of yellow fever that had been made by several medical men in Spanish America. The experience which he obtained during a scientific excursion through Mexico, Cuba and South America gave him a wonderful insight as to the difficulties one has to contend with in such work and made him realize the importance of special laboratory training for such undertaking. It is interesting to note that, as surgeon general of the U. S. Army, twenty years after, General Sternberg chose and appointed the men who constituted the yellow fever board, in Cuba.

The year before the Spanish-American war, an Italian savant, who had obtained a well-deserved reputation as bacteriologist while working in the Institute Pasteur of Paris, came out with the announcement from Montevideo, Uruguay, that he had actually discovered the much-sought-for cause of yellow fever; his descriptions of the methods employed, though not materially different from those followed by Sternberg many years before, bore the imprint of truth and his experimental inoculations had apparently been successful. Sanarelli—that is his name—for about two years was the "hero of the hour," yet his claims have been proved absolutely false.

The question of the identity of his "germ" was first taken up by the writer under instructions from General Sternberg: during the Santiago campaign I had opportunity to autopsy a considerable number of yellow fever cases and, following closely upon Sanarelli's directions, only three times out of ten could his bacillus be demonstrated; at almost the same time, Drs. Reed and Carroll, in Washington, were carrying out experiments which showed that Sanarelli's bacillus belonged to the hog-cholera group of bacteria and thus when found in yellow fever cadavers could play there only a secondary role as far as the infection is concerned.

Unfortunately, two investigators belonging to the U. S. Marine Hospital Service, Drs. Wasdin and Gleddings, were, according to their claims, corroborating Sanarelli's findings: there was nothing to do but that the investigation should continue, and so I was sent by General Sternberg to Havana in December, 1898, with instructions and power to do all that might be necessary to clear up the matter. Wasdin and Geddings had preceded me; the work carried us through the summer of 1899; we frequently investigated the same cases; I often autopsied bodies from which we took the same specimens and made the same cultures, in generally the same kind of media, and finally we rendered our reports to our respective departments, Wasdin and Geddings affirming that Sanarelli's bacillus was present in almost all the cases, while I denied that it had such specific character and showed its occurrence in cases not yellow fever. A virulent epidemic which raged in the city of Santiago and vicinity during 1899 afforded me abundant material for research.

In the meantime the city of Havana was being rendered sanitary in a way which experience had taught would have overcome any bacterial infection, and, in fact, the diseases of filth, such as dysentery, tuberculosis, children's complaints and others, decreased in a surprising manner, while yellow fever seemed to have been little affected if at all.

Evidently, a more thorough overhauling of the matter was necessary to arrive at the truth, and while the question of Sanarelli and his claims was practically put aside, Surgeon-General Sternberg, recognizing the importance of the work before us and that its proportions were such as to render the outcome more satisfactory by the cooperation of several investigators in the same direction, wisely decided to create a board for the purpose and so caused the following to be issued:

Special Orders No. 122
HEADQUARTERS OF THE ARMY,
ADJUTANT GENERAL'S OFFICE,
WASHINGTON, May 24, 1900

Extract

34. By direction of the Secretary of War, a board of medical officers is appointed to meet at Camp Columbia, Quemados, Cuba, for the purpose of pursuing scientific investigations with reference to the infectious diseases prevalent on the Island of Cuba. Detail for the board:

Major Walter Reed, surgeon, U. S. Army;
Acting Assistant Surgeon James Carroll, U. S. Army;
Acting Assistant Surgeon Aristides Agramonte, U. S. Army;
Acting Assistant Surgeon Jesse W. Lazear, U. S. Army.

The board will act under general instructions to be communicated to Major Reed by the Surgeon General of the Army.

By command of MAJOR GENERAL MILES,
H. C. CORBIN,
Adjutant General

It may be of interest to the reader to learn who these men were and the reasons why they were probably selected for the work.

Major Reed, the first member in the order of appointment, was the ranking officer and therefore the chairman of the board. He was a regular army officer, at the time curator of the Army Medical Museum in Washington and a bacteriologist of some repute. He deservedly enjoyed the full confidence of the surgeon general, besides his personal friendship and regard. Reed was a man of charming personality, honest and above board. Every one who knew him loved him and confided in him. A polished gentleman and a scientist of the highest order, he was peculiarly fitted for the work before him.

Dr. James Carroll, the second member of the board, was a self-made man, having risen from the ranks through his own efforts: while a member of the Army Hospital Corps he studied medicine and subsequently took several courses at Johns Hopkins University in the laboratory branches. At the time of his appointment to the board he had been for several years an able assistant to Major Reed. Personally, Carroll was industrious and of a retiring disposition.

Dr. Jesse W. Lazear was the fourth member of the board. He had graduated from the College of Physicians and Surgeons (Columbia University) in the same class as the writer, in 1892, and had afterwards studied abroad and at Johns Hopkins. Lazear had received special training in the investigation of mosquitoes with reference to malaria and other diseases. Stationed at Columbia Barracks, he had been in Cuba several months before the board was convened, in charge of the hospital laboratory at the camp. A thorough university man, he was the type of the old southern gentleman, kind, affectionate, dignified, with a high sense of honor, a staunch friend and a faithful soldier.

The writer was the third member of the Army Board. Born in Cuba during the ten years' war, while still a child, my father having been killed in battle against the Spanish, I was taken to the United States and educated in the public schools and in the College of the City of New York, graduating from the College of Physicians and Surgeons in 1892. At the breaking out of the war I was assistant bacteriologist in the New York Health Department. The subject of yellow fever research was my chief object from the outset, and, at the time the board was appointed, I was in charge of the laboratory of the Division of Cuba, in Havana.

It may be readily seen from the brief sketch regarding the several members that the components of the yellow-fever board really constituted a perfectly consistent body, for the reason, mainly, that they were all men trained in the special field wherein their labors were to be so fruitful and that before their appointment to the board they had been more or less associated in scientific work.

FIRST PART OF THE WORK OF THE BOARD

My first knowledge of the existence of the board was had through the following letter from my friend Major Reed:

WAR DEPARTMENT,
SURGEON GENERAL'S OFFICE,
WASHINGTON, May 25, 1900

DR. A. AGRAMONTE,
Act'g Asst. Surgeon U. S. A.,
Military Hospital No. 1,
Havana, Cuba

My dear Doctor: An order issued yesterday from the War Department calls for a board of medical officers for the investigation of acute infectious diseases occurring on the Island of Cuba. The board consists of Carroll, yourself, Lazear and the writer. It will be our duty, under verbal instructions from the Surgeon General, to continue the investigation of the causation of yellow fever. The Surgeon General expects us to make use of your laboratory at Military Hospital No. 1 and Lazear's laboratory at

Camp Columbia.

According to the present plan, Carroll and I will be quartered at Camp Columbia. We propose to bring with us our microscopes and such other apparatus as may be necessary for the bacteriological and pathological work. If, therefore, you will promptly send me a list of the apparatus on hand in your laboratory, it will serve as a very great help in enabling us to decide as to what we should include in our equipment. Any suggestions that you may have to make will be much appreciated.

Carroll and I expect to leave New York, on transport, between the 15th and 20th of June and are looking forward, with much pleasure, to our association with you and Lazear in this interesting work. As far as I can see we have a year or two of work before us.

Trusting you will let me hear from you promptly, and with best wishes,

Sincerely yours,
(Signed)
WALTER REED

On the afternoon of June 25, 1900, the four officers met for the first time in their new capacity, on the veranda of the officers' quarters at Columbia Barracks Hospital. We were fully appreciative of the trust and aware of the responsibility placed upon us and with a feeling akin to reverence heard the instructions which Major Reed had brought from the surgeon general; they comprised the investigation also of malaria, leprosy and unclassified febrile conditions, and were given with such detail and precision as only a man of General Sternberg's experience and knowledge in such matters could have prepared. After deciding upon the first steps to be taken, it was unanimously agreed that whatever the result of our investigation should turn out to be, it was to be considered as the work of the board as a body, and never as the outcome of any individual effort; that each one of us was to work in harmony with a general plan, though at liberty to carry out his individual methods of research. We were to meet whenever necessary, Drs. Reed, Carroll and Lazear to remain at the Barracks Hospital and I to stay in charge of the laboratory in Havana, at the Military Hospital, where I also had a ward into which yellow-fever cases from the city were often admitted.

Work was begun at once. Fortunately for our purpose, an epidemic of yellow fever existed in the town of Quemados, in close proximity to the military reservation of Camp Columbia. Even before the arrival of Reed and Carroll, Lazear and I had been studying its spread, following the cases very closely; subsequently a few autopsies were made by me, Carroll making cultures from the various tissues and Lazear securing fragments for microscopical examination; a careful record was kept and the results noted; cases gradually became less in number as the epidemic slowly died out, about the middle of August.

In the meantime a rather severe outbreak of yellow fever had occurred in Santa Clara, a city in the interior of the island, having invaded the garrison and caused the death of several soldiers; as the origin of the infection was shrouded in mystery, and cases continued to appear among the troops even after they had moved out of the town, it was agreed that I should endeavor to trace the source of the epidemic and aid the medical authorities in establishing whatever preventive measures might seem proper. This service is here recorded because in the general discussion of the start and course of the epidemic with Dr. J. Hamilton Stone, the officer in charge of the military hospital, we incidentally spoke of the possible agency of insects in spreading the disease, pointing particularly in this direction the fact of the infection of a trooper who, suffering from another complaint, occupied a bed in a ward across the yard from where a yellow fever case had developed two weeks before.

The infection of the city of Santa Clara had evidently taken place from Havana, distant only one night's journey by train. Captain Stone, a particularly able officer, had already instituted effective quarantine measures before my arrival, so that I only remained there a few days.

But as to the actual cause of the disease we were still entirely at sea; it helped us little to know that a man could be infected in Havana, take the train for a town in the interior and start an outbreak there in the course of time.

Upon rejoining my colleagues (July 2) we resumed our routine investigations; not only in Quemados, where the disease was being stamped out, but also in Havana, at "Las Animas" Hospital and at Military Hospital No. 1, where my laboratory (the division laboratory) was located. There was no scarcity of material and the two members who until then had never seen a case of yellow fever (Reed and Carroll) had ample opportunity, and took advantage of it, to become acquainted with the many details of its clinical picture which escape the ordinary practitioner, the knowledge and the appreciation of which, in their relative value, give the right to the title of "expert."

Since the later part of June, reports had been coming to headquarters of an extraordinary increase of sickness among the soldiers stationed at Pinar del Rio, the capital of the extreme western province, and very soon the great mortality from so-called "pernicious malarial fever" attracted the attention of the chief surgeon, Captain A. N. Stark, who, after consulting with Major Reed, ordered me to go there and investigate. A man had died, supposedly from malaria, just before my arrival on the afternoon of July 19. The autopsy which I performed at once showed me that yellow fever had been the cause of his death, and a search through the military hospital wards revealed the existence of several unrecognized cases being treated as malaria; a consultation held with the medical officer in charge showed me his absolute incapacity, as he was under the influence of opium most of the time (he committed suicide several months afterwards), and so I telegraphed the condition of things to headquarters; in answer I received the following:

CHIEF SURGEON'S OFFICE,
HDQRS. DEPT. HAVANA AND PINAR DEL RIO,
QUEMADOS, CUBA, July 20, 1900

SURGEON AGRAMONTE,
Pinar del Rio Barracks,
Pinar del Rio, Cuba

Report received last night. My thanks are due for your prompt
action and confirmation of my suspicions.
STARK,
Chief Surgeon

Conditions in the hospital were such as to demand immediate action; the commander of the post refused to believe he had yellow fever among his 900 men and was loath to abandon his comfortable quarters for the tent life in the woods that I earnestly recommended. In answer to my telegram asking for official support, I received the following:

CHIEF SURGEON'S OFFICE,
HDQRS. DEPT. HAVANA AND PINAR DEL RIO,
QUEMADOS, CUBA, July 21, 1900

SURGEON AGRAMONTE,
Pillar del Rio Barracks,
Pinar del Rio, Cuba

Take charge of cases. Reed goes on morning train. Wire for anything wanted. Nurses will be sent. Instructions wired commanding officer. Other doctors should not attend cases. Establish strict quarantine at hospital. You will be relieved as soon as an immune can be sent to replace you. Report daily by wire. STARK, Chief Surgeon

When Major Reed came to Pinar del Rio (July 21) I had, the day before, established a separate yellow-fever hospital, under tents, attended by some of the men who had already passed an attack and were thus immune. The Major and I went over the ground very carefully, we studied the sick report for two months back, fruitlessly trying to place the blame upon the first case. I well remember how, as we stood in the men's sleeping quarters, surrounded by a hundred beds, from several of which fatal cases had been removed, we were struck by the fact that the later occupants had not developed the disease. In connection with this, and particularly interesting, was the case of a soldier prisoner who had been confined to the guard-house since June 6; he showed the first symptoms of yellow fever on the twelfth and died on the eighteenth; none of the other eight prisoners in the same cell caught the infection, though one of them continued to sleep in the same bunk previously occupied by his dead comrade. More than this; the three men who handled the clothing and washed the linen of those who had died during the last month were still in perfect health. Here we seemed to be in the presence of the same phenomenon remarked by Captain Stone in reference to his case at Santa Clara, and before that by several investigators of yellow fever epidemics; the infection at a distance, the harmless condition of bedding and clothing of the sick; the possibility that some insect might be concerned in spreading the disease deeply impressed us and Major Reed mentions the circumstance in his later writings. This was really the first time that the mosquito transmission theory was seriously considered by members of the board, and it was decided that, although discredited by the repeated failure of its most ardent supporter, Dr. Carlos J. Finlay, of Havana, to demonstrate it, the matter should be taken up by the board and thoroughly sifted.

The removal of the troops out of Pinar del Rio was the means of at once checking the propagation of the disease.

On the first day of August the board met and after due deliberation determined to investigate mosquitoes in connection with the spread of yellow fever. As Dr. Lazear was the only one of us who had had any experience in mosquito work, Major Reed thought proper that he should take charge of this part of the investigation in the beginning, while we, Carroll and I, continued with the other work on hand, at the same time gradually becoming familiar with the manipulations necessary in dealing with the insects.

A visit was now made to Dr. Finlay, who, much elated at the news that the board was about to investigate his pet theory, the transmission of yellow fever from man to man by mosquitoes, very kindly explained to us many points regarding the life of the one kind he thought most guilty and ended by furnishing us with a number of eggs which, laid by a female mosquito nearly a month before, had remained unhatched on the inside of a half empty bowl of water in his library.

Much to our disappointment and regret, during the first week of August, Major Reed was recalled to Washington that he might, in collaboration with Drs. Vaughan and Shakespeare, complete the report upon "Typhoid Fever in the Army." Thus we were deprived of his able counsel during the first part of the mosquito research. Major Reed was detained longer than he expected and could not return to Cuba until early in October, several days after Lazear's death.

The mosquito eggs obtained from Dr. Finlay hatched out in due time; the insects sent to Washington for their exact classification were declared by Dr. L. O. Howard, entomologist to the Agricultural Department, to be Culex fasciatus. Later, they have been called Stegomyia fasciatus and now go under the name of Stegomyia calopus (Aedes cal.).

Lazear applied some of these mosquitoes to cases of yellow fever at "Las Animas" Hospital, keeping them in separate glass tubes properly labeled, and every thing connected with their bitings was carefully recorded; the original batch soon died and the work was carried on with subsequent generations from the same.

The lack of material at Quemados caused us to remove our field of action to Havana, where cases of yellow fever continued to appear. We met almost every day at "Las Animas" Hospital, where Lazear was trying to infect his mosquitoes, or now and then I performed autopsy upon a case, and Carroll secured sufficient cultures to last him for several days of bacteriological investigation.

Considering that, in case our surmise as to the insect's action should prove to be correct, it was dangerous to introduce infected mosquitoes amongst a population of 1,400 non-immunes at Camp Columbia, Dr. Lazear thought best to keep his presumably infected insects in my laboratory at the Military Hospital No. 1, from where he carried them back and forth to the patients who were periodically bitten.

Incidentally, after the mosquitoes fed upon the yellow fever patients, they were applied, at intervals of two or three days, to whoever would consent to run the risk of contracting yellow fever in this way; needless to say, current opinion was against this probability and as time passed and numerous individuals who had been bitten by insects which had previously fed upon yellow fever blood remained unaffected, I must confess that even the members of the board, who were rather sanguine in their expectations, became somewhat discouraged and their faith in success very much shaken.

No secret was made of our attempts to infect mosquitoes; in fact many local physicians became intensely interested, and Lazear and his tubes were the subject of much comment on the part of the Havana doctors, who nearly twenty years before had watched and laughed at Dr. Finlay, then bent apparently upon the same quest in which we were now engaged. Dr. Finlay himself was somewhat chagrined when he learned of our failure to infect any one with mosquitoes, but, like a true believer, was inclined to attribute this negative result more to some defect in our technique than to any flaw in his favorite theory.

Although the board had thought proper to run the same risks, if any, as those who willingly and knowingly subjected themselves to the bites of the supposedly infected insects, opportunity did not offer itself readily, since Major Reed was away in Washington and Carroll, at Camp Columbia, engrossed in his bacteriological investigations came to Havana only when an autopsy was on hand or a particularly interesting case came up for study. I was considered an immune, a fact that I would not like to have tested, for though born in the island of Cuba, I had practically lived all my life away from a yellow fever zone; it was therefore presumed that I ran no risk in allowing mosquitoes to bite me, as I frequently did, just to feed them blood, whether they had previously sucked from yellow fever cases or not. And so, time passed and several Americans and Spaniards had subjected themselves in a sporting mood to be bitten by the infected (?) mosquitoes without causing any untoward results, when Lazear applied to himself (August 16, 1900) a mosquito which ten days before had fed upon a mild case of yellow fever in the fifth day of his disease; the fact that no infection resulted, for Lazear continued in excellent health for a space of time far beyond the usual period of incubation, served to discredit the mosquito theory in the opinion of the investigators to a degree almost beyond redemption, and the most enthusiastic, Dr. Lazear himself, was almost ready to "throw up the sponge."

I had as laboratory attendant a young American, a private belonging to the Hospital Corps of the Army, who more than once had bared his arm to allow a weak mosquito a fair meal with which to regain its apparently waning strength; Loud, for that was his name, derided the idea that such a little beast could do so much harm as we seemed ready to accuse it of, although he was familiar with the destruction caused by bacteria, but then, he used to say, "bacterial work in armies of more than a million bugs at the same time and no one would be d—— fool enough to let more than one or two gnats sting him at once."

This state of things, the gradual loss of faith in the danger which mosquitoes seemed to possess, led Dr. Lazear to relax a little and become less scrupulous in his care of the insects, and often, after applying them to patients, if pressed for time, he would take them away with him to his laboratory at Columbia Barracks, where, the season being then quite warm, they could be kept as comfortably as at the Military Hospital laboratory. Thus it happened that on the twenty-seventh of August he had spent the whole morning at "Las Animas" Hospital getting his mosquitoes to take yellow-fever blood: the procedure was very simple; each insect was contained in a glass tube covered by a wad of cotton, the same as is done with bacterial cultures. As the mouth of the tube is turned downwards, the insect usually flies towards the bottom of the tube (upwards), then the latter is uncovered rapidly and the open mouth placed upon the forearm or the abdomen of the patient; after a few moments the mosquito drops upon the skin and if hungry will immediately start operations; when full, by gently shaking the tube, the insect is made to fly upwards again and the cotton plug replaced without difficulty. It so happened that this rather tedious work, on the day above mentioned, lasted until nearly the noon hour, so that Lazear, instead of leaving the tubes at the Military Hospital, took them all with him to Camp Columbia: among them was one insect that for some reason or other had failed to take blood when offered to it at "Las Animas" Hospital.

This mosquito had been hatched in the laboratory and in due time fed upon yellow-fever blood from a severe case on August 15, that is, twelve days before, the patient then being in the second day of his illness; also at three other times, six days, four days and two days before. Of course, at the time, no particular attention had been drawn to this insect, except that it refused to suck blood when tempted that morning.

After luncheon that day, as Carroll and Lazear were in the laboratory attending to their respective work, the conversation turning upon the mosquitoes and their apparent harmlessness, Lazear remarked how one of them had failed to take blood, at which Carroll thought that he might try to feed it, as otherwise it was liable to die before next day (the insect seemed weak and tired); the tube was carefully held first by Lazear and then by Carroll himself, for a considerable length of time, upon his forearm, before the mosquito decided to introduce its proboscis.

This insect was again fed from a yellow fever case at "Las Animas" Hospital on the twenty-ninth, two days later, Dr. Carroll being present, though not feeling very well, as it was afterwards ascertained.

We three left the yellow-fever hospital together that afternoon; I got down from the doherty-wagon where the road forks, going on to the Military Hospital, while Carroll and Lazear continued on their way to Camp Columbia. On the following day, Lazear telephoned to me in the evening, to say that Carroll was down with a chill after a sea bath taken at the beach, a mile and a half from Camp, and that they suspected he had malaria; we therefore made an appointment to examine his blood together the following morning.

When I reached Camp Columbia I found that Carroll had been examining his own blood early that morning, not finding any malarial parasites; he told me he thought he had "caught cold" at the beach: his suffused face, blood-shot eyes and general appearance, in spite of his efforts at gaiety and unconcern, shocked me beyond words. The possibility of his having yellow fever did not occur to him just then; when it did, two days later, he declared he must have caught it at my autopsy room in the Military Hospital, or at "Las Animas" Hospital, where he had been two days before taking sick. Although we insisted that he should go to bed in his quarters, we could only get him to rest upon a lounge, until the afternoon, when he felt too sick and had to take to his bed.

Lazear and I were almost panic-stricken when we realized that Carroll had yellow fever. We searched for all possibilities that might throw the blame for his infection upon any other source than the mosquito which bit him four days before; Lazear, poor fellow, in his desire to exculpate himself, as he related to me the details of Carroll's mosquito experiment, repeatedly mentioned the fact that he himself had been bitten two weeks before without any effect therefrom and finally, what seemed to relieve his mind to some extent, was the thought that Carroll offered himself to feed the mosquito and that he held the tube upon his own arm until the work was consummated.

I have mentioned before that, as Lazear and I, vaguely hoping to find malarial parasites in Carroll's blood, sat looking into our microscopes that morning, the idea that the mosquito was what brought him down gradually took hold of our minds, but as our colleague had been exposed to infection in other ways, by visiting the yellow fever hospital "Las Animas," as well as the infected city of Havana, it was necessary to subject that same mosquito to another test and hence the inoculation of Private Dean, which is described in the opening chapter of this history.

TERMINATION OF THE FIRST SERIES OF MOSQUITO EXPERIMENTS.

DEATH OF LAZEAR.

The month of September, 1900, was fraught with worry and anxiety: what with Carroll's and Private Dean's attacks of yellow fever and Major Reed's inability to return, Lazear and I were well-nigh on the verge of distraction. Private Dean was not married, but Carroll's wife and children, a thousand miles away, awaited in the greatest anguish the daily cablegram which told them the condition of the husband and father, who was fighting for life, sometimes the victim of the wildest delirium caused by consuming fever, at others almost about to collapse, until one day, the worst of the disease being over, the wires must have thrilled at our announcement, "Carroll out of danger."

Fortunately both he and Dean made an uninterrupted recovery, but we were still to undergo the severest trial, a sorrow compared to which the fearful days of Carroll's sickness lose all importance and dwindle almost into insignificance.

On the morning of the eighteenth my friend and classmate Lazear, whom in spite of our short intercourse I had learned to respect and in every way appreciate most highly, complained that he was feeling "out of sorts." He remained all day about the officers' quarters and that night suffered a moderate chill. I saw him the next day with all the signs of a severe attack of yellow fever.

Carroll was already walking about, though enfeebled by his late sickness, and we both plied Lazear with questions as to the origin of his trouble; I believe we affectionately chided him for not having taken better care of himself. Lazear assured us that he had not experimented upon himself, that is, that he had not been bitten by any of the purposely infected mosquitoes.

After the case of Dean so plainly demonstrated the certainty of mosquito infection, we had agreed not to tempt fate by trying any more upon ourselves, and even I determined that no mosquito should bite me if I could prevent it, since the subject of my immunity was one that could not be sustained on scientific grounds; at the same time, we felt that we had been called upon to accomplish such work as did not justify our taking risks which then seemed really unnecessary. This we impressed upon Major Reed when he joined us in October and for this reason he was never bitten by infected mosquitoes.

Lazear told us, however, that while at "Las Animas" Hospital the previous Thursday (five days before), as he was holding a test-tube with a mosquito upon a man's abdomen, some other insect which was flying about the room rested upon his hand; at first, he said, he was tempted to frighten it away, but, as it had settled before he had time to notice it, he decided to let it fill and then capture it; besides, he did not want to move in fear of disturbing the insect contained in his tube, which was feeding voraciously. Before Lazear could prevent it, the mosquito that bit him on the hand had flown away. He told us in his lucid moments, that, although Carroll's and Dean's cases had convinced him of the mosquito's role in transmitting yellow fever, the fact that no infection had resulted from his own inoculation the month before had led him to believe himself, to a certain extent, immune.

How can I describe the agony of suspense which racked our souls during those six days? It seemed to us as though a life was being offered in sacrifice for the thousands which it was to contribute in saving. Across the span of thirteen years the memory of the last moments comes to me most vividly and thrilling, when the light of reason left his brain and shut out of his mind the torturing thought of the loving wife and daughter far away, and of the unborn child who was to find itself fatherless on coming to the world.

Tuesday, the twenty-fifth of September saw the end of a life full of promise; one more name, that of Jesse W. Lazear, was graven upon the portals of immortality. And we may feel justly proud for having had it, in any way, associated with our own.

The state of mind in which this calamity left us may better be imagined than described. The arrival of Major Reed several days after in a great measure came to relieve the tensity of our nerves and render us a degree of moral support of which we were sorely in need.

Lazear's death naturally served to dampen our fruition at the success of the mosquito experiments, but, this notwithstanding, when the facts were known we were the subjects of much congratulation and the question whether the theory had been definitely demonstrated or not was the theme of conversation everywhere, about Havana and Camp Columbia particularly. We fully realized that three cases, two experimental and one accidental, were not sufficient proof, and that the medical world was sure to look with doubt upon any opinion based on such meager evidence; besides, in the case of Carroll, we had been unable to exclude the possibility of other means of infection, so that we really had but one case, Dean's, that we could present as clearly demonstrative and beyond question. In spite of this, we thought that the results warranted their presentation in the shape of a "Preliminary Note," and after all the data were carefully collected from Lazear's records and those at the Military Hospital, a short paper was prepared which the Major had the privilege to read at the meeting of the American Public Health Association, held on October 24, in the city of Indianapolis.

For this purpose Major Reed went to the States two weeks after his return to Cuba, and Carroll also took a short leave of absence so as to fully recuperate, in preparation for the second series of inoculations which we had arranged to undertake, after the Indianapolis meeting.

These inoculations, according to our program, were to be made upon volunteers who should consent to suffer a period of previous quarantine at some place to be selected in due time, away from any possibility of yellow fever.

It so happened then that I was left the only member of the board in Cuba and, under instructions from Major Reed, I began to breed mosquitoes and infect them, as Lazear used to do, wherever cases occurred, keeping them at my laboratory in the Military Hospital No. 1. Major Reed had also asked me to look about for a proper location wherein to continue the work upon his return.

ORIGIN AND DEVELOPMENT OF THE MOSQUITO THEORY

The possible agency of insects in the propagation of yellow fever was thought of by more than one observer, from a very early period in the history of this disease. For instance, Rush, of Philadelphia, in 1797, noticed the excessive abundance of mosquitoes during that awful epidemic. Subsequently, several others spoke of the coincidence of gnats or mosquitoes and yellow fever, but without ascribing any direct relation to the one regarding the other. Of course, man-to-man infection through the sole intervention of an insect was a thing entirely inconceivable and therefore unthought of until very recently, and in truth the discovery, as far as yellow fever is concerned, was the result of a slow process of evolution of the fundamental fact, taken in connection with similar findings, in other diseases.

The earliest direct reference is found in the writings of Dr. Nott, of Mobile, Ala., who in 1848 suggested that the dissemination of the yellow fever poison was evidently by means of some insect "that remained very close to the ground." But the first who positively pointed to the mosquito as the spreader of yellow fever, who showed that absence of mosquitoes precluded the existence of the disease and who prescribed the ready means to stamp it out, by fumigation and by preventing the bites of the insects, was Dr. Louis D. Beauperthuy, a French physician, then located in Venezuela. The writer has an original copy of his paper, published in 1853, where he fastens the guilt upon the domestic mosquitoes, believing, in accord with the prevailing teachings of medical science, that the mosquitoes infected themselves by contact or feeding upon the organic matter found in the stagnant waters where they are hatched, afterwards inoculating the victims by their sting. He recognized the fact that yellow fever is not contagious and therefore could not think of the possibility of man-to-man infection, as we know it to-day. The keenest observer was this man Beauperthuy, and, even at that benighted time in the history of tropical medicine, made most interesting studies of the blood and tissues, employing the microscope and the chemical reactions in his research. No one believed him, and a commission appointed to report upon his views said that they were inadmissible and all but declared him insane.

This field of investigation remained dormant for a comparatively long period of time. Meanwhile another medical writer, Dr. Greenville Dowell, mentions in 1876, that "if we compare the effect of heat and cold on gnats and mosquitoes with yellow fever, it will be difficult to believe it is of the same nature, as it is controlled by the same natural laws." Soon after this, in 1879, the first conclusive proof of the direct transmission of a disease from man-to-man was presented by the father of tropical medicine, Sir Patrick Manson, with regard to filaria, a blood infection that often causes the repulsive condition known as elephantiasis and which the mosquito takes from man and after a short time gives over to another subject. This discovery attracted world-wide attention and many looked again towards the innumerable species of biting insects that dwell in the Tropic Zone, as possible carriers of the obscure diseases which also prevail in those regions.

In 1881, Dr. Carlos Finlay, of Havana, in an exhaustive paper read before the Royal Academy of Sciences, gave as his opinion that yellow fever was spread by the bites of mosquitoes "directly contaminated by stinging a yellow fever patient (or perhaps by contact with or feeding from his discharge)." This latter view he held as late as 1900, which, although correct in the main fact of the transmission of the germ from a patient to a susceptible person by the mosquito, the modus operandi, as he conceived it, was entirely erroneous.

Dr. Finlay, unfortunately was unable to produce experimentally a single case of fever that could withstand the mildest criticism, so that at the time when the Army Board came to investigate the causes of yellow fever in Cuba, his theory, though practically the correct one, had been so much discredited, in a great measure by his own failures, that the best-known experts considered it as an ingenious, but wholly fanciful, one and many thought it a fit subject for humorous and sarcastic repartee. Finlay also believed, erroneously, that repeated bites of contaminated insects might protect against yellow fever and that the mosquitoes were capable of transmitting the germ to the next generation.

The wonderful discoveries of Theobald Smith, as to the agency of ticks in spreading Texas fever of cattle, and those of Ross and the Italian investigators who showed conclusively that malaria was transmitted by a species of mosquito, brought the knowledge of these various diseases to the point where the Army Board took up the investigation of yellow fever.

SECOND AND FINAL SERIES OF MOSQUITO EXPERIMENTS

Major Reed came back to Havana in the early part of November,
Carroll following a week after.

During their absence, I had been applying mosquitoes to yellow fever patients at "Las Animas" Hospital, keeping them in my laboratory, as it was done at the beginning of the investigation; the season being more advanced, now and then a cold "norther" would blow and my insects suffered very much thereby, so that I had the greatest trouble in preventing their untimely death: to this may be added the difficulty met in feeding them blood, for now that I knew their sting was dangerous, unto death perhaps, I could not allow any indiscriminate biting, but had to select for the purpose individuals who had suffered an attack of the disease and were therefore immune.

The necessity for an experimental camp became more imperative as time passed, not only where proper quarantine and isolation could be established, but also where the insects intended for the inoculations might receive better care. This entailed considerable expense.

Fortunately for us, the military governor of the island at that time, Brigadier General Leonard Wood, was a man who had received a thorough medical training; broad and clear-minded, he fully appreciated the importance of what might be the outcome of our researches. We found in him the moral support which we so much needed and, further, he promptly placed at the disposal of the board sufficient funds with which to carry on the experiments to the end. I firmly believe that had other been the circumstances, had a more military and less scientific man been at the head of the government, the investigation would have terminated there and then, and many years would have passed, with hundreds of lives uselessly sacrificed, before we could have attained our present remarkable sanitary triumphs.

We immediately set about choosing a location for our camp. I had already looked over the ground, preferring the proximity of Camp Columbia, from where supplies could be easily obtained and because the Military Hospital there could be used for treating the cases that we intended to produce; I was therefore favorably impressed with the seclusion offered by a spot situated a short distance from the main road, in a farm, named San Jose, belonging to my friend Dr. Ignacio Rojas, of Havana. Major Reed decided upon this place after looking at many others in the neighborhood, so that on the twentieth of November we inaugurated our camp, which we named Camp Lazear, in honor to the memory of our dead colleague, consisting then of seven army tents, guarded by a military garrison, composed of men who had been carefully selected by virtue of their previous good record and their interest in the work to be undertaken.

Feeling that we had proved, to ourselves at least, the agency of the mosquito in yellow fever, it became our duty to disprove the theory, until then held as a certainty by many authorities, to the effect that the soiled bedding and clothing, the secretions and excreta of patients, were infectious and in some way carried the germ of the disease. We therefore designed a small wooden building, to be erected a short distance from the tense, with a capacity of 2,800 cubic feet. The walls and ceiling were absolutely tight, the windows and vestibuled door screened and all precautions taken to prevent the entrance of insects.

Into this, called the "infected clothing building," three beds and a stove, to maintain a high tropical temperature, were introduced; also mattresses and pillows, underwear, pajamas, towels, sheets, blankets, etc., soiled with blood and discharges from yellow fever cases: these articles were put on the beds, hung about the room and packed in a trunk and two boxes placed there for the purpose.

The building was finished and equipped on November 30. That Friday evening, Dr. Robert P. Cook, U. S. Army, with two other American volunteers, entered it and prepared to pass the night: they had instructions to unpack the boxes and trunk, to handle and shake the clothing and in every way to attempt to disseminate the yellow fever poison, in case it was contained in the various pieces. We watched the proceedings from the outside, through one of the windows. The foul conditions which developed upon opening the trunk were of such a character that the three men were seen to suddenly rush out of the building into the fresh air; one of them was so upset that his stomach rebelled; yet, after a few minutes, with a courage and determination worthy only of such a cause, they went back into the building and passed a more or less sleepless night, in the midst of indescribable filth and overwhelming stench.

For twenty consecutive nights these men went through the same performance; during the day they remained together, occupying a tent near their sleeping quarters. Dr. Cook, by voluntarily undergoing such a test, without remuneration whatsoever, proved his faith in the mosquito theory; his demonstration of the harmless character of so-called infected clothing, in yellow fever, has been of the greatest importance. The other six men (two of them with Dr. Cook) who were subjected to this test, received each a donation of one hundred dollars for his services.

Many days even before the establishment of the experimental camp, the board had heard that several men who knew of our work were willing to submit to the inoculations and thus aid in clearing up the mystery of yellow fever. Two of these require special mention, John R. Kissinger, a private in the Hospital Corps of the Army, was the first to offer himself most altruistically, for, as he expressed it, his offer was made without any desire for pecuniary or other consideration and solely "in the interest of humanity and the cause of science," the other, J. J. Moran, a civilian employee, also stipulated as a condition that he was to receive no pay for his services. Both these men, in due time, suffered from yellow fever and until very recently had never obtained any reward for the great risk which they ran so voluntarily and praiseworthily.

Kissinger, who after several years' service in the army became disabled, is receiving a pension from the government; Moran, I hope, is still well and in the employ of the Isthmian Canal Commission, justly enjoying the friendship and confidence of his superior officers. The names of Kissinger and Moran should figure upon the roll of honor of the U. S. Army.

On the day the camp was definitely organized, Kissinger, who had not gone outside the military reservation for more than a month, moved into Camp Lazear and received his first bite from a mosquito which evidently was not "loaded" for, again on November 23, he was stung by the same insect without result. On December 5, five mosquitoes were applied, which brought about a moderate infection in three days. Moran was also bitten by mosquitoes which were supposed to be infected on November 26 and 29, both times unsuccessfully. As will be seen, he was infected later on.

By this time we had decided, the weather having cooled considerably, that it was better to keep the mosquitoes at a higher temperature and nearer to the men who were to be inoculated; therefore it was planned to put up another small wooden structure, which was to be known as the "Mosquito Building" in which an artificial temperature could be maintained; at my suggestion, the building was so designed that it might serve to infect individuals; by liberating infected mosquitoes on the inside and exposing some person to their stings, we could try to reproduce the infection as we felt it occurred in nature. Another reason for the mosquito house was the need to obviate the transportation of the insects from the Military Hospital, where I kept them, to our camp, which could not be easily done without subjecting them to severe injury. Upon one occasion I was taking four infected mosquitoes in the pocket inside my blouse from the laboratory in Havana to the experimental camp, accompanied by my attendant Private Loud; the horse which pulled my buggy, a rather spirited animal, becoming frightened at a steam roller, as we went around the corner of Colon Cemetery, started to race down the hill towards the Almendares River: Loud was thrown out by the first cavortings of the horse, who stood on its hind legs and jumped several times before dashing away, while I held tightly to the tubes in my pocket, as the buggy upset and left me stranded upon a sand pile in the middle of the road; the mosquitoes were quite safe, however, and upon my arrival at Camp Lazear I turned them over to Carroll for his subsequent care.

Another difficulty afterwards encountered was the scarcity of material susceptible to infection, for, although several men had expressed a willingness to be inoculated, when the time came; they all preferred the "infected clothing" experiment to the stings of our mosquitoes. We then thought best to secure lately landed Spaniards, to whom the probable outcome of the test might be explained and their consent obtained for a monetary consideration. Our method was as follows; as soon as a load of immigrants arrived, I would go to Tiscornia, the Immigration Station across the Bay of Havana, and hire eight or ten men, as day laborers, to work in our camp. Once brought in, they were bountifully fed, housed under tents, slept under mosquito-bars and their only work was to pick up loose stones from the grounds, during eight hours of the day, with plenty of rest between. In the meantime, as the days of observation passed, I carefully questioned them as to their antecedents, family history and the diseases which they might have suffered; those who had lived in Cuba or any other tropical country before were discarded at once and also those who were under age or had a family dependent upon them. When the selection was finally made, the matter of the experiment was put to them. Naturally, they all felt more or less that they were running the risk of getting yellow fever when they came to Cuba and so were not at all averse to allow themselves to be bitten by mosquitoes: they were paid one hundred dollars for this, and another equal sum if, as a result of the biting experiment, they developed yellow fever. Needless to say, no reference was made to any possible funeral expenses. A written consent was obtained from each one, so that our moral responsibility was to a certain extent lessened. Of course, only the healthiest specimens were experimented upon.

It so happened that some reporter discovered what we were about, or perhaps some invidious person misrepresented the facts; at any rate, on the twenty-first of November a Spanish newspaper appeared with flaring headlines denouncing the American doctors who were taking advantage of the poor immigrants and experimenting with them by injecting all sorts of poisons! It called upon the Spanish consul to look after his subjects. In view of this we felt that if such campaign continued, in a short time it would either make it impossible to secure subjects or cause diplomatic pressure to be exerted against the continuance of our experiments. It was thought best to "beard the lion in his den" so the three of us called upon the consul the following day. He was surprised to hear one of us address him in his own language, having taken us all for Americans on first sight, and when I explained to him our method of procedure and showed him the signed contracts with the men, being an intelligent man himself, he had no objections to offer and told us to go ahead and not bother about any howl the papers might make.

The first three cases (two of them Spaniards) which we produced came down with yellow fever within a very short period, from December 8 to 13; it will therefore not surprise the reader to know that when the fourth case developed on December 15, and was carried out of the camp to the hospital, it caused a veritable panic among the remaining Spaniards, who, renouncing the five hundred pesetas that each had in view, as Major Reed very aptly put it, "lost all interest in the progress of science and incontinentally severed their connection with Camp Lazear."

But there was a rich source to draw from, and the unexpected stampede only retarded our work for a short time. Our artificial epidemic of yellow fever was temporarily suspended while a new batch of susceptible material was brought in, observed and selected. The next case for that reason was not produced upon a Spaniard until December 30.

In the face of the negative experiments with supposedly contaminated articles, it rested with us to show how a house became infected and for this purpose the main part of the "mosquito building" was utilized.

This chamber was divided into two compartments by a double wire-screen partition, which effectually prevented mosquitoes on one side from passing to the other; of course there were no mosquitoes there to begin with, as the section of the building used for breeding and keeping them was entirely separated from the other, and there could be no communication between them.

On the morning of December 21, a jar containing fifteen hungry mosquitoes, that had previously stung cases of yellow fever, was introduced and uncovered in the larger compartment, where a bed, with all linen perfectly sterilized, was ready for occupancy. A few minutes after, Mr. Moran, dressed as though about to retire for the night, entered the room and threw himself upon the bed for half an hour; during this time two other men and Major Reed remained in the other compartment, separated from Moran only by the wire-screen partition. Seven mosquitoes were soon at work upon the young man's arms and face; he then came out, but returned in the afternoon, when five other insects bit him in less than twenty minutes. The next day, at the same hour of the afternoon, Moran entered the "mosquito building" for the third time and remained on the bed for fifteen minutes, allowing three mosquitoes to bite his hands. The room was then securely locked, but the two Americans continued to sleep in the other compartment for nearly three weeks, without experiencing any ill effects.

Promptly on Christmas morning Moran, who had not been exposed to infection except for his entrance into the "mosquito building" as described, came down with a well-marked attack of yellow fever.

The temperature in this room, where these mosquitoes had been released, was kept rather high and a vessel with water was provided, where they might lay their eggs if so inclined, but notwithstanding all these precautions, it was subsequently found that the insects had been attacked by ants, so that by the end of the month only one of the fifteen mosquitoes remained alive.

It is hardly necessary to detail here how seven other men were subjected to the sting of our infected mosquitoes, of which number five developed the disease, but it may be interesting to note that two of these men had been previously exposed in the "infected clothing building" without their becoming infected, showing that they were susceptible to yellow fever after all.

The evidence so far seemed to show that the mosquito could only be infected by sucking blood of a yellow-fever patient during the first three days of the disease; to prove that the parasite was present in the circulating blood at that time we therefore injected some of this fluid taken from a different case each time, under the skin of five men: four of these suffered an attack of yellow fever as the result of the injection. The other one, a Spaniard, could not be infected either by the injection of blood or the application of mosquitoes which were known to be infected, showing that he had a natural immunity or, more likely, that he had had yellow fever at some previous time.

While selecting the Spaniards, it was often ascertained that they had been in Cuba before, as soldiers in the Spanish army usually, and the natural conclusion was that they had undergone infection; it was very seldom that any escaped during the Spanish control of the island.

Thus terminated our experiments with mosquitoes which, though necessarily performed on human beings, fortunately did not cause a single death; on the other hand, they served to revolutionize all standard methods of sanitation with regard to yellow fever. They showed the uselessness of disinfection of clothing and how easily an epidemic can be stamped out in a community by simply protecting the sick from the sting of the mosquitoes and by the extensive and wholesale destruction of these insects which, added to the suppression of their breeding places, if thoroughly carried out, are the only measures necessary to forever rid a country of this scourge.

Besides keeping a sharp lookout against the importation of yellow fever cases, these are the simple rules that have kept the Panama Canal free and prevented the slaughter of hundreds of foreigners, so generally expected every year, in former times.

Since we made our demonstration in 1901, our work has been corroborated by various commissions appointed for the purpose, in Mexico, Brazil and Cuba, composed variously of Americans, French, English, Cuban, Brazilian and German investigators. Nothing has been added to our original findings; nothing has been contradicted of what we have reported, and to-day, after nearly thirteen years, the truths that we uncovered stand incontrovertible; besides, they have been the means of driving out yellow fever from Cuba, the United States (Laredo, Texas, 1903 and New Orleans, La., 1905), British Honduras and several cities of Brazil.

Of the Army Board only I remain. Lazear, as reported, died during the early part of our investigations; Reed left us in 1902 and Carroll only five years later. The reader may wonder of what benefit was it to us, this painstaking and remarkable accomplishment which has been such a blessing to humanity! See what the late Surgeon General of the U. S. Army had to say in his report (Senate Document No. 520, Sixty-first Congress, second session):

1. Major Walter Reed, surgeon, United States Army, died in Washington, D. C., from appendicitis, November 23, 1902, aged 51. His widow, Emilie Lawrence Reed, is receiving a pension of $125 a month.

2 Maj. James Carroll was promoted from first lieutenant to major by special act of Congress, March 9, 1907. He died in Washington, D C., of myocarditis, September 16, 1907. His widow, Jennie H. Carroll, since his death, has received an annuity of $125 a month, appropriated from year to year in the Army appropriation bill.

3. Dr. Jesse W. Lazear, contract surgeon, United States Army, died at Camp Columbia, Cuba, of yellow fever, September 25, 1900. His widow, Mabel M. Lazear, since his death, has received an annuity of $125 a month appropriated from year to year in the Army appropriation bill.

4. Dr. Aristides Agramonte is the only living member of the board. He is professor of bacteriology and experimental pathology in the University of Habana and has never received, either directly or indirectly, any material reward for his share in the work of the board.

It is not for me to make any comments: the above paragraphs have all the force of a plain, truthful statement of facts. Perhaps it is thought that enough reward is to be found in the contemplation of so much good derived from one's own efforts and the feeling it may produce of innermost satisfaction and in forming the belief that one had not lived in vain. In a very great measure, I know, the thought is true.

THE EVOLUTION OF THE STARS AND THE FORMATION OF THE EARTH. IV

BY WILLIAM WALLACE CAMPBELL

DIRECTOR OF THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

THE PLANETESIMAL HYPOTHESIS

THE most elaborate structure yet proposed to explain the origin of the solar system is the planetesimal hypothesis by Chamberlin and Moulton. The energy which these investigators have devoted to formulating and testing this hypothesis, in the light of the principles of mechanics, has been commensurate with the importance of the subject. They postulate that the materials now composing the Sun, planets, and satellites, at one time existed as a spiral nebula, or as a great spiral swarm of discrete particles, each particle in elliptic motion about the central nucleus. The authors go further back and endeavor to account for the origin of the spiral nebula, but this phase of the subject is not vital to their hypothesis. However, it conduces to clearness in presenting their hypothesis to begin with the earlier process.

It may happen, once in a while, that two stars will collide. If the collision is a grazing one, they say, a spiral nebula will be formed. However, a fairly close approach of two stars will occur in vastly greater frequency and the effect of this approach will also be to form a spiral nebula or two such nebulae. The authors recall that our Sun is constantly ejecting materials to a considerable height to form the prominences, and that the attractions of a great star passing fairly close to our solar system would assist this process of expulsion of matter from the Sun. A great outbreak or ejection of matter would occur not only on the side of our Sun turned toward the disturbing body, but on the opposite side as well, for the same reason that tides in our oceans are raised on the side opposite the Moon as well as on the side toward the Moon. As the Sun and disturbing star proceeded in their orbits, the stream of matter leaving our Sun on the side of the disturbing body would try to follow the other star; and the stream of matter leaving the other side of the Sun would shoot out in curves essentially symmetrical with those in the first stream. As the disturbing star approached and receded the paths taken by the ejected matter would be successively along curves such as are represented by the dotted lines in Fig. 28. At any given moment the ejected matter would lie on the two heavy lines. The matter would not be moving along the heavy lines, but nearly at right angles to them, in the directions that the lighter curves are pointing. As the ejections would not be continuous, but on the contrary intermittent, because of violent pulsations of the Sun's body, there would be irregularities in the two spiral streamers. The materials drawn out of the Sun would revolve around it in elliptic orbits after the disturbing body had passed beyond the distance of effective disturbance, as illustrated in Fig. 29. The orbits of the different masses would have different sizes and different eccentricities. There would also be a wide distribution of finely-divided material between the main branches of the spiral. All of the widespread gaseous matter, hot when it left the Sun, would soon become cold, by expansion and radiation; and only the massive nuclei would remain gaseous and hot.

I see no reason to question the efficiency of this ingenious explanation of the origin of a spiral nebula: the close passage of two massive stars could, in my opinion, produce an effect resembling a spiral nebula, quite in accordance with Moulton's test calculations upon the subject. Some of the spirals have possibly been formed in this way (see Fig. 30); but that the tens of thousands of spirals known to exist in the sky have actually been produced in this manner is another question, and one which, in my opinion, is open to grave doubt. But to this point we shall return later.

There are marked advantages in starting the evolution of the solar system from a spiral nebula, aside from the fact that spirals are abundant, and therefore represent a standard product of development. The material is thinly and very irregularly distributed in a plane passing through the Sun, and the motions around the Sun are all in the same direction. The great difficulty in the Laplace hypothesis, as to the constancy of the moment of momentum, is here eliminated. There are well-defined condensations of nuclei at quite different distances from the Sun. According to this hypothesis the principal nuclei are the beginnings of the future planets. They draw into themselves the materials with which they come in contact by virtue of the crossings of the orbits of various sizes and various eccentricities. The growth of the planets is gradual, for the sweeping up and combining process must be excessively slow. The satellites are started from those smaller nuclei which happen to be moving with just the right speeds not to escape entirely the attractions of the principal nuclei, nor to fall into them. The planes of the planetary orbits and, in general, the planes of the satellite orbits should agree quite closely with each other, but they could differ and should differ from that of the Sun's equator.

The authors call attention to the fact that the Sun's equator is inclined at a small angle, 7 degrees, to the common planes of the planetary system, and Chamberlin holds this to be one of the strong points in favor of the planetesimal hypothesis. He reasons thus: the star which passed close to our Sun and drew out the planetary materials in the form of spiral streams must have moved in the plane of the spiral; that is, in the plane of our planetary system. Some of the materials would be drawn out from our Sun only a very short distance and then fall back upon the Sun. Great tidal waves would be formed on opposite sides of the Sun, and these would try to follow the disturbing body. The effect of these waves and of the materials which fall back would be to change the Sun's original rotation plane in the direction of the disturbing body's orbital plane.

Now the chance for a disturbing star's passing around our Sun in a plane making a large angle, say from 45 degrees to 90 degrees, with the Sun's equator, is much greater than for a small angle 0 degrees to 45 degrees. The chances are greatest that the angle will be 90 degrees. Only those disturbing stars which approach our Sun PRECISELY in the plane of the Sun's equator could move around the Sun in this plane. All those approaching along any line parallel to the Sun's equatorial plane, but lying outside of this plane, and all those whose directions of approach make any angle whatever with the equatorial plane, would find it impossible to move in that plane. That the angle under this hypothesis is only 7 degrees is surprising, though, as we are dealing with but a single case, we can not say, I think, that this militates either for or against the hypothesis. We are entitled to say only that unless the approach was so close as to cause disturbances in our Sun to relatively great depths, the angle referred to would have only one chance in ten or fifteen or twenty to be as small as 7 degrees. Any disturbance which succeeded in taking out of the Sun only 1/7 of 1 per cent. of its mass could scarcely succeed in shifting the axis of rotation of the remaining 99 6/7 per cent. very much, I think. If the angle were 30 degrees or 50 degrees or 80 degrees, instead of 7 degrees, the case for the planetesimal hypothesis would be somewhat stronger.

A remarkable fact concerning the Sun is that the equatorial region rotates once around in a shorter time than the regions in higher latitudes require. The rotation period of the Sun's equator is about 24 days; the period at latitude 45 degrees is 28 days; and at 75 degrees, 33 days. The planetesimal hypothesis attributes this equatorial acceleration to the falling back into the Sun of the materials which had been lifted out to a short distance by the disturbing body, and to the forward-rushing tide raised in the equatorial regions by the disturbing body. This may well have occurred. However, we must remember that the same phenomenon exists certainly in Jupiter and Saturn, and quite probably in Uranus and Neptune; that is, in all the bodies in the system that are gaseous and free to show the effect. It seems to be the result of a principle which has operated throughout the solar system, not requiring, at least not directly requiring, the passage of a disturbing star. I think the most plausible explanation of this curious phenomenon is that great quantities of materials originally revolving around the Sun and around each of the planets have gradually been drawn into these bodies, by preference into their equatorial areas. Such masses of matter moving in orbits very close to these bodies must have traveled with speeds vastly higher than the surface speeds of the bodies. To illustrate, the rotational velocity of a particle now in the Sun's surface at the equator is approximately 2 km. per second. A small body revolving around the Sun close to his surface, rapidly enough to prevent its falling quickly upon the Sun, must have a velocity of more than 400 km. per second. If, now, this small body encounters some resistance it will fall into the Sun, and as it is traveling more than 200 times as rapidly as the solar materials into which it drops, it will both generate heat and accelerate the rotational velocity of the surrounding materials. In the same way the equatorial accelerations in Jupiter and Saturn can receive simple explanation. The point is not necessarily in opposition to the planetesimal hypothesis; but whatever the explanation, it ought to apply to the planet as well as to the Sun.

If the spiral nebulae have been formed in accordance with Chamberlin and Moulton's hypothesis, the secondary nuclei in them must revolve in a great variety of elliptic orbits. The orbits would intersect, and in the course of long ages the separate masses would collide and combine and the number of separate masses would constantly grow smaller. Moulton has shown that IN GENERAL the combining of two masses whose orbits intersect causes the combined mass to move in an orbit more nearly circular than the average orbit of the separate masses, and in general in orbit planes more nearly coincident with the general plane of the system. Accordingly, the major planets should move in orbits more nearly circular and more nearly in the plane of the system than do the asteroids; and so they do. If the asteroids should combine to form one planet the orbit of this planet should be much less eccentric than the average of all the present asteroid eccentricities, and the deviation of its orbit plane should be less than the average deviation of the present planes. We can not doubt that this would be the case. Mercury and Mars, the smallest planets, should have, according to this principle, the largest eccentricities and orbital inclinations of any of the major planets. This is true of the eccentricities, but Mars's orbit plane, contrarily, has a small inclination. Venus and the Earth, next in size, should have the next largest inclinations and eccentricities, but they do not; Venus's eccentricity is the smallest of all. The Earth's orbital inclination and eccentricity are both small. Jupiter and Saturn, Uranus and Neptune, should have the smallest orbital inclinations; their average inclination is about the same as for Venus and the Earth. They should likewise have the smallest eccentricities. Neptune, the smallest of the four, has an orbit nearly circular; Jupiter, Saturn and Uranus have eccentricities more than 4 times those of

Venus and the Earth. Considering the four large planets as one group and the four small planets as another group, we find that the inclinations of the orbits of the two groups, per unit mass, are about equal; but the average eccentricity of the orbits of the large planets, per unit mass, is 21 times that of the orbits of the small planets.[1] The evidence, except as to the asteroids and Mercury, is not favorable to the planetesimal hypothesis, unless we make special assumptions as to the distribution of materials in the spiral nebulae.

[2] The average eccentricity of the orbits of the four inner planets (per unit mass) is 0.0221, and of the four outer planets is 0.0489.

The fact that the disturbing body drew 225 times as much matter a great distance to form the four large planets as it drew out a short distance to form the four small planets and the asteroids seems difficult of explanation on the planetesimal hypothesis. However, this distribution of matter is at present a difficulty in any of the hypotheses. The planetesimal hypothesis explains well all west to east rotations of the planets on their axes, but to make Uranus rotate nearly at right angles to the plane of the system, and Neptune in a plane inclined 135 degrees to the plane of the system, is a difficulty in any of the hypotheses, unless special assumptions are made to fit each case.

The authors succeed well, I think, in showing that the satellites should prefer to revolve around their planets in the direction of the planetary revolution and rotation, especially for close satellites, and, on the basis of special assumptions, in the reverse direction for satellites at a greater distance. They show that the chances favor small eccentricities for satellites revolving about their planets in the west to east, or direct sense, and large eccentricities for satellites moving in retrograde directions. The inner satellite of Mars and the rings of Saturn make no special difficulty under the planetesimal hypothesis.

The evidence of the comets, as bona fide members of the solar system which approach the Sun almost, and perhaps quite, indifferently from all directions, is that the volume of space occupied by the parent structure of the system was of enormous dimensions, both at right angles to the present principal plane of the system and in that plane. We are accustomed to think of the spiral nebulae as thin relatively to their major diameters. To this extent the planetesimal hypothesis does not furnish a good explanation of the origin of comets, unless we assume that a small amount of matter was widely scattered in all directions around the parent spiral; and this conception leads to some apparent difficulties. The origin of the comets is difficult to explain under any of the hypotheses.

RESUME OF HYPOTHESES

Kant's hypothesis had the great defect of trying to prove too much. It started from matter AT REST, and came to grief in trying to give a motion of rotation to the entire mass through the operation of internal forces alone—an impossibility. Kant's idea of nuclei or centers of gravitational attraction, scattered here and there throughout the chaotic mass, which grew into the planets and their satellites, is very valuable.

Laplace's hypothesis had the great advantage of starting with an extended mass already in rotation, but it violated fatally the law of constancy of moment of momentum. We should expect this hypothesis to create a solar system free from irregularities, very much as if it were the product of an instrument-maker's precision lathe. The solar system as it exists is a combination of regularities and many surprising irregularities.

Chamberlin and Moulton's hypothesis has the advantage of a parent mass in rotation, practically in a common plane, and with the materials distributed at distances from the nucleus as nearly in harmony with the known distribution of matter in the solar system as we care to have them, except perhaps as to the comets. In effect it retains all the advantageous qualities of Kant's proposals. It seems to have the flexibility required in meeting the irregularities that we see in our system.

CONCERNING THE ORIGIN OF SPIRAL NEBULAE

I think it is very doubtful whether the spiral nebulae have in general been formed by the close approaches of pairs of stars, as the authors have postulated for the assumed solar spiral.[2] The distribution of the spirals seems to me to negative the idea. To witness the close approach of two stars we must look in the direction where the stars are. To the best of present-day knowledge the stars are in a spheroid whose longer axes are coincident with the plane of the Milky Way. If this is so, the close approach of pairs of stars should occur preeminently in the Milky Way, and we should find the spirals prevailingly in and near the Milky Way. This is precisely where we do not find them. In fact, they seem to abhor the Milky Way. The new stars, which are credibly explained as the products of collisions of stars with nebulae, are found preeminently in the Milky Way and almost negligibly in the regions outside of the Milky Way. Again, the spirals are believed to be, on the whole, of enormous size. They are too far away to let us measure their distances by the usual methods, and they move too slowly on the surface of the sphere to have let us determine their proper motions. Slipher's recent work with a spectrograph seems to show that the dozen spirals observed by him are moving with high speeds of approach and recession; from 300 km. per second approach in the case of the Andromeda nebula to 1,100 km. per second recession in the case of several objects. If the spirals are moving at random their speeds at right angles to the line of sight must be even greater than their speeds of approach and recession. Unless they are very distant bodies their proper motions should be detected by observations extending over only a few years. My colleague Curtis has this year compared recent photographs of some 25 spirals with photographs of the same object made by Keeler fifteen years ago. They reveal no appreciable proper motions, or rotations. In this same interval Neptune has revolved more than 30 degrees. Slipher has recently measured the rotational speed of one "spindle" nebula, believed to be a spiral. He finds it to be enormously rapid; no motions in the solar system approach it in magnitude. The evidence is to the effect that the spirals are in general very far away;[3] perhaps on or beyond the confines of our stellar system, but not certainly so. Accordingly, we are led to believe that the spirals studied thus far have diameters 20 times or 100 times, or in some cases several thousand times, the diameter of our solar system. It is difficult to avoid the conclusion that in general they are immensely more massive than is our solar system. The spiral which has been assumed as the forerunner of our system must have been of diminutive size as compared with the larger and brighter spirals which we see to-day.

[2] It would seem that all rotating nebulae should in reality possess some of the attributes of spiral motion. Whether the spiral structure should be visible or invisible to a terrestrial observer would depend upon the sizes and distances of the nebulae, upon the distribution of materials composing them, and perhaps upon other factors. See developed the hypothesis that spiral nebulae owe their origin to the collision of two nebulae. Collisions of this kind could readily occur because of the enormous dimensions of the nebulae, and motions of rotation and consequently spiral structure might readily result therefrom. The abnormally high speeds of the spiral nebulae are apparently a very strong objection to the hypothesis.

[3] Bohlin found a parallax of 0"17 for the Andromeda Nebula, and Lampland thinks that Nebula N.G.G. 4594 has a proper motion of approximately 0"05 per annum.

We are sadly in need of information concerning the constitution of the spiral nebulae. Their spectra appear to be prevailingly of the solar type, except that a very small proportion contain some bright lines in addition to the continuous spectrum. So far as their spectra are concerned, they may be great clusters of stars, or they may consist each of a central star sending its light out upon surrounding dark materials and thus rendering these materials visible to us. The first alternative is unsatisfactory, for all parts of spirals have hazy borders, as if the structure is nebulous or consists of irregular groups of small masses; and the second alternative is unsatisfactory, for in many spirals the most outlying masses seem to be as bright as masses of the same areas situated only one half as far from the center, whereas in general the inner area should be at least four times as bright as the outer area. All astronomers are ready to confess that we do not know much about the conditions existing in spiral nebulae.

THE EARTH-MOON SYSTEM

Our Earth and Moon form a unique combination in that they are more nearly of the same size than are any other planet and its satellites in our system. It required a 26-inch telescope on the Earth to discover the tiny moons of Mars; but an astronomer on Mars does not need any telescope to see the Earth and Moon as a double planet—the only double planet in the solar system.

According to the Kantian school of hypotheses the Earth and Moon owe their unique character to the accident that two centers of condensation—two nuclei—not very unequal in mass, were formed close to each other and were endowed with or acquired motions such that they revolved around each other. They drew in the surrounding materials; one of the two bodies got somewhat the advantage of the other in gravitational attraction; it succeeded in building itself up more than the other nucleus did; and the Earth and the Moon were the result.

According to the Laplacean hypothesis, on the contrary, the Earth and Moon were originally one body, gaseous and in rotation. This ball of gas radiated heat, diminished in size, rotated more and more rapidly, and finally abandoned a ring of nebulosity, which later broke up and eventually condensed into one mass called the Moon. The central mass composed the Earth. It is a curious fact that Venus, which is only a shade smaller than the Earth, should not have divided into two bodies comparable with the Earth and Moon. Have the tides on Venus produced by the Sun always been strong enough to keep the rotation and revolution periods equal, as they are thought to be now, and thus to have given no opportunity for a rapidly rotating Venus to divide into two masses?

A third hypothesis of the Moon's origin is due principally to Darwin. He and Poincare have shown that a great rotating mass of fluid matter, such as the Earth-Moon could be assumed to have been, by cooling, contracting and increasing rotation speed, would, under certain conditions thought to be reasonable, become unstable and eventually divide into two bodies revolving around their common center of mass, at first with their surfaces nearly in contact. Here would begin to act a tide-raising force which must have played, according to Darwin's deductions, a most important part in the further history of the Earth and Moon. The Earth would produce enormous tides in the Moon, and the Moon much smaller tides in the Earth. Both bodies would contract in size, through loss of heat, and would try to rotate more and more rapidly. The two rotating bodies would try to carry the matter in the tidal waves around with the rest of the materials in the bodies, but the pull of each body upon the wave materials in the other would tend to slow down the speed of rotation. The tidal resistance to rotation would be slight if the bodies at any time were attenuated gaseous masses, for the friction within the surface strata would be slight. Nevertheless, there would eventually be a gradual slowing down of the Moon's rotation, a gradual slowing down of the Earth's rotation, and a slow increase in the distance between the two bodies. In other words, the Moon's day, the Earth's day and our month would gradually increase in length. Carried to its logical conclusion, the Moon would eventually turn the same face to the Earth, the Earth would eventually turn the same face to the Moon, and the Earth's day and the Moon's day would equal the month in length. The central idea in this logic is as old as Kant: in 1754 he published an important paper in which he said that tidal interactions between Earth and Moon had caused the Moon to keep the same face turned toward us, that the Earth's day was being very slowly lengthened, and that our planet would eventually turn the same face to the Moon. Laplace, a half-century later, proposed the action of such a force in connection with the explanation of lunar phenomena, and Helmholtz, just 100 years after Kant's paper was published, lent his support to this principle; but Sir George Darwin has been the great contributor to the subject. His popular volume, "The Tides," devotes several chapters to the effects of tidal friction upon the motions of two bodies in mutual revolution. We must pass over the difficult and complicated intermediate steps to Darwin's conclusions concerning the Earth and Moon, which are substantially as follows: the Earth and Moon were originally much closer together than they now are: after a very long period of time, amounting to hundreds of millions of years, the Moon will revolve around the Earth in 55 days instead of in 27 days as at present; and the Moon and Earth will then present the same faces constantly to each other. The estimated period of time required, and the final length of day and month, 55 days, are of course not insisted upon as accurate by Darwin.

These tidal forces were unavoidably active, it matters not if the Earth and Moon were originally one body, as Laplace and Darwin have postulated, or originally two bodies, growing up from two nuclei, in accordance with the Kantian school. Whether these forces have been sufficiently strong to have brought the Earth and Moon to their present relation, or will eventually equalize the Moon's day, the Earth's day, and the month, is a vastly more difficult question. Moulton's researches have cast serious doubt upon this conclusion. All such investigations are enormously difficult, and many questionable assumptions must be made if we seek to go back to the Moon's origin, or forward to its ultimate destiny.

Tidal waves, in order to be effective in reducing the rotational speed of a planet, must be accompanied by internal friction; and this requires that the planet be to some extent inelastic. It was the view of Darwin and others that the viscous state of the Earth and Moon permitted wave friction to come into play. Michelson has recently proved that the Earth has a high degree of elasticity. It deforms in response to tidal forces, but quickly recovers from the action of these forces. It therefore seems that the rate of tidal evolution of the Earth-Moon system at present and in the future must be extremely slow, and possibly almost negligible. What the conditions within the Earth and Moon were in the distant past is uncertain, but these bodies probably passed through viscous stages which endured through enormously long periods of time. No one seriously doubts that Jupiter, Saturn, Uranus and Neptune are now largely gaseous, and that they will evolve, through various degrees of viscosity, into the solid and comparatively elastic state. It is natural to assume that the Earth has already passed through an analogous experience.

The Moon turns always the same hemisphere toward the Earth. Observations of Venus and Mercury are prevailingly to the effect that those planets always turn the same hemispheres toward the Sun. Many, and perhaps all, of the satellites of Jupiter and Saturn seem to turn the same hemispheres always toward their respective planets. This widely prevailing phenomenon is no doubt due to a widely prevailing cause, which astronomers have all but unanimously attributed to tidal action.

BINARY STAR SYSTEMS

That an original mass actually divided to form the Earth and Moon, according to the Laplacian or the Darwin-Poincare principle, seems to be extremely doubtful, especially on account of their diminutive sizes, and I greatly prefer to think that the Earth and Moon were built up from two nuclei; but that very much greater masses, masses larger on the average than our Sun, composing highly attenuated stars, have divided each into two masses to form many or most of our double stars, I firmly believe. The two component stars would in such a case at first revolve around each other with their surfaces almost or quite in contact. Tidal forces would very gradually cause the bodies to move in orbits of larger and larger size, with correspondingly longer periods of revolutions, and the orbits would become constantly more eccentric. While these processes were under way the component bodies would be radiating heat and growing smaller, and their spectra would be changing into the more advanced types. We can not hope to watch such changes as they occur, but we can, I think, find abundant illustrations of these processes in the double stars. I have given reasons for believing that one star in every two and one half, as a minimum proportion, is not the single star which it appears to be to the eye or in the telescope, but is a system of two or more suns in mutual revolution. The formation of double stars, therefore, is not a sporadic process: it is one of the straightforward results of the evolutionary process.

Some of the variable stars offer strong evidence as to the early life of the double stars. The so-called beta Lyrae variables vary continuously in brightness, as if they consist in each case of two stars so close together that their surfaces are actually in contact in some pairs and nearly in contact in others, so that from our point of view the two stars mutually eclipse each other. When the two stars are in line with us we have minimum brightness. When they have moved a quarter-revolution farther, and the line joining them is at right angles to our line of sight, so to speak, we have maximum brightness. In every known case the beta Lyrae pairs of stars have spectra of the very early types. Some of them even contain bright lines in their spectra. The densities of these great stars are known to be exceedingly low, in some cases much lower on the average than that of the atmosphere which we breathe.

About 80 Algol variable stars are known. These are double stars whose light is constant except during the short time when one of the components in each system passes between us and the other component. All double stars would be Algol variables if we were exactly in the planes of their orbits. That so few Algols have been observed amongst the tens of thousands of double stars, is easily explained. The two component stars in the few known Algol systems are so great in diameter, in proportion to the size of their orbits, that eclipses are observable throughout a wide volume of space, and the eclipses are of long duration relatively to the revolution period. Their densities are, so far as we have been able to determine them, on an average less than 1/10th of the Sun's density. Let us note well that their spectra, so far as we have been able to determine them, are of the early types; mostly helium and hydrogen stars, and a very few of the Class F, intermediate between the hydrogen and solar stars. There are no known Algols of the Classes G, K, and M: these stars are very condensed and therefore small in size, as compared with stars of Classes B and A; and the components of double stars of these classes are on the average much denser and therefore smaller in size than the components in Classes B and A double stars; the components are much farther apart in Classes G to M doubles than in Classes B and A doubles; and for these reasons eclipses in Classes G to M doubles occur but rarely for observers scattered throughout space. It is difficult to avoid the conclusion that the components of double stars separate more and more widely with the progress of time. The conclusions which we have earlier drawn from visual double stars are in full harmony with the argument.

It is agreed by all, I think, that tidal action has been responsible for at least a part of the separation of the Earth and Moon, for at least a part of the gradual separation of the components of double stars, and for at least a part of the eccentricity of their orbits. See's investigations of 25 years ago led him to the conclusion that this force is sufficient to account for all the observed separation of the components of double stars, and for the well-known high eccentricities of their orbits. In recent years Moulton and Russell have seriously questioned the sufficiency of this force to account for the major part of the separation and eccentricity in the double star systems. I think, however, that if the tidal force is not competent to account for the observed facts as described, some other separating force or forces must be found to supply the deficiency.

THE FORMATION OF THE EARTH

Does the condition of the Earth's interior give evidence on the question of its origin? There are certain important facts which bear upon the problem.

1. The evidence supplied by the volcanoes, by the hot springs, and by the rise in temperature as we go down in all deep mines, is unmistakably to the effect that there is an immense quantity of heat in the Earth's interior. Near the surface the temperature increases at the average of 1 degrees Centigrade for every 30 meters of depth. If this rate were maintained we should at 60 km. in depth arrive at a temperature high enough to melt platinum, the most refractory of the known metals. What the law of temperature-increase at great depths is we do not know, but the temperature of the Earth's deep

interior must be very high.

2. The pressures in the Earth increase from zero at the surface to the order of 3,000,000 atmospheric pressures at the center. We know that rock structure, or iron or other metals, can be slightly compressed by pressure, but the experiments at very high pressures, notably those conducted by Bridgman, give no indications that matter under such pressures breaks down and obeys different or unknown laws. It should be said, however, that laboratory pressure-effects alone are not a safe guide as to conditions within the Earth, where high pressures are accompanied by high temperature. Unfortunately it has not been found possible to combine the high-temperature factor with the high-pressure factor in the laboratory experiments. It is well known that the melting points of metals, including rocks, increase with increase of pressure; and although the temperatures in the Earth's interior are very high, it is easy to conceive that the materials of the Earth's interior are nevertheless in the solid state, or that they act like solids, because of the high pressures to which they are subjected.

3. The specific gravity of the entire Earth is 5.5 on the scale of water as one, whereas the density of the stratified rocks averages only 2.75; that is, the stratified rocks have but one half the density of the Earth as a whole. The basaltic rocks underlying the stratified attain occasionally the density 3.1, and perhaps a little higher. It follows absolutely that the density of the materials of the Earth's interior must be considerably in excess of 5.5. If the interior is composed chiefly of substances which are plentiful in the Earth's surface strata, our choice of materials which principally compose the interior is reduced to a few elements, notably the denser ones.

4. The observed phenomena of terrestrial precession can not be explained on the basis of an Earth with a thin solid surface shell and a liquid interior, for the attractions of the Moon and Sun upon the Earth's equatorial protuberance would cause the surface shell to shift over the fluid interior, instead of swinging the entire Earth.

5. If the Earth consisted of a thin solid shell upon a liquid interior there would be tides in the liquid interior, the crust would yield to these tides almost as if it were composed of rubber, and the ocean tides would be only an insignificant amount larger than the land tides. As a result we should not see the ocean tides; their visibility depends upon the contrast between the ocean tides and the land tides. If the Earth were absolutely unyielding from surface to center the ocean tides would be relatively 50 per cent. higher than we now see them. The conclusion from these facts is that the Earth yields to the tidal forces a little less than if it were a solid ball of steel, supposing that the well-known rigidity and density existed from surface to center of the ball. This result is established by Darwin's and Schweydar's studies of ocean tides, by studies of the tides in the Earth's surface strata made by Hecker, Paschwitz and others, and by Michelson's recent extremely accurate comparison of land and water tides. Michelson's results establish further that the Earth is highly elastic: though distortion is resisted, there is yielding, but the original form is recovered quickly, almost as quickly as a perfectly elastic body would recover.

6. Some 25 years ago it was discovered by Kustner that the latitudes of points on the Earth's surface are changing slowly. Chandler proved that these variations pass through their principal cycle in a period of 427 days. The entire Earth oscillates slightly in this period. The earlier researches of Euler had shown that the Earth would have a natural oscillation period of 305 days provided it were an absolutely rigid body. Newcomb showed that the period of oscillation would be 441 days if the Earth had the rigidity of steel. As the observed oscillation requires 427 days, Newcomb concluded that the Earth is slightly more rigid than steel.

7. The first waves from a very distant earthquake come to us directly through the Earth. The observed speeds of transmission are the greater, in general, the more nearly the earthquake origin is exactly on the opposite side of the Earth from the observer; that is, the speeds of transmission are greater the nearer the center of the Earth the waves pass. Now, we know that the speeds are functions of the rigidity and density of the materials traversed. The observed speeds require for their explanation, so far as we can now see, that the rigidity of the Earth's central volume be much greater than that of steel, and the rigidity of the Earth's outer strata considerably less than that of steel. Wiechert has shown that a core of radius 4,900 km. whose rigidity is somewhat greater than that of steel and whose average density is 8.3, overlaid by an outer stony shell of thickness 1,500 km. and average density 3.2, would satisfy the observed facts as to the average density of the Earth, as to the speeds of earthquake waves, as to the flattening of the Earth,—assuming the concentric strata to be homogeneous in themselves,—and as to the relative strengths of gravity at the Poles and at the Equator. The dividing line, 1,500 km. below the surface—1,600 km. would be just one fourth of the way from the surface to the center—places a little over half the volume in the outer shell and a little less than half in the core. Wiechert did not mean that there must be a sudden change of density at the depth of 1,500 km., with uniform density 8.3 below that surface and uniform density 3.2 above that surface. The change of density is probably fairly continuous. It was necessary in such a preliminary

investigation to simplify the assumptions. The observational data are not yet sufficiently accurate to let us say what the law of increase in density and rigidity is as we pass from the surface to the center.

8. The phenomena of terrestrial magnetism indicate that the distribution of magnetic materials in the Earth is far from uniform or symmetrical; the magnetic poles are distant from the Earth's poles of rotation; the magnetic poles are not opposite each other; the lines of equal intensity as to all the magnetic components involved run very irregularly over the Earth's surface. There is reason to believe that iron in the deep interior of the Earth, in view of its high temperature, is devoid of magnetic properties, but we must not state this as a fact. We know that iron is very widely, but very irregularly spread throughout the Earth's outer strata. Whatever may be the main factors in making the Earth a great magnet, to whatever extent the rotation factor may be important, the Earth's magnetic properties point strongly to a very irregular distribution of magnetic materials in the outer strata where the temperatures are below that at which magnetic materials commonly lose their polarity.

9. Irregularities in the direction of the plumb-line and in the force of gravity as observed widely and accurately over the Earth's surface indicate that the surface strata are very irregular as to density. To harmonize the observed facts Hayford has shown the need of assuming that the heterogeneous conditions extend down to a depth of 122 km. from the surface. Below that level the Earth's concentric strata seem to be of approximately uniform densities.

10. The radio active elements have been found by Strutt and others in practically all kinds of rock accessible to the geologists, but they are not found in significant quantities in the so-called metals which exist in a pure state. These radioactive elements are liberating heat. Strutt has shown that if they existed down to the Earth's center in the same proportion that he finds in the surface strata they would liberate a great deal more heat than the body of the Earth is now radiating to outer space. The conclusion is that they are restricted to the strata relatively near the Earth's surface, and are not in combination with the materials composing the Earth's core. They have apparently found some way of coming to the higher levels. Chamberlin suggests that as they liberate heat they would raise surrounding materials to temperatures above the normals for their strata, and that these expanded materials would embrace every opportunity to approach the surface of the Earth, carrying the radioactive substances with them.

The evidence is exceedingly strong, and perhaps irresistible, to the effect that the Earth is now solid, or acts like a solid, from surface to center, with possibly local, but on the whole negligible, pockets of molten matter here and there; and further, that the Earth existed in a molten, or at the least a thickly plastic, state throughout a long part of its life. The nucleus, whether gaseous or meteoric, from which I believe it has grown, may have been fairly hot or quite cold, and the materials which were successively drawn into the nucleus may have been hot or cold: heat would be generated by the impacts of the incoming materials; and as the attraction toward the center of the mass became strong, additional heat would be generated in the contraction process. The denser materials have been able, on the whole, to gravitate to the center of the structure, and the lighter elements have been able, on the whole, to rise to and float upon the surface very much as the lighter impurities in an iron furnace find their way to the surface and form the slag upon the molten metal. The lighter materials which in general form the surface strata are solid under the conditions of solids known to us in every-day life. The interior is solid or at least acts as a solid, because the materials, though at high temperatures, are under stupendous pressures. If the pressures were removed the deep-lying materials would quickly liquefy, and probably even vaporize.

If the Earth grew from a small nucleus to its present size by the extremely gradual drawing-in of innumerable small masses in its neighborhood, the process would always be slow; much slower at first when the small nucleus had low gravitating powers, more rapid when the body was of good size and the store of materials to draw upon plentiful,and gradually slower and slower as the supply of building materials was depleted. Meteoric matter still falls upon and builds up the Earth, but at so slow a rate as to increase the Earth's diameter an inch only after the passage of hundreds of millions of years. If the Earth grew in this manner, the growth may now be said to be essentially complete, through the substantial exhaustion of the supply of materials.

Whether the Earth of its present size was ever completely liquefied, that is, from center to surface, at one and the same time, is doubtful. The lack of homogeneity, as indicated by the plumb-line, gravity, terrestrial magnetism and radiaoctive matter, extending in a perceptible degree down to 122 km., and quite probably in lesser and imperceptible degree to a much greater depth, is opposed to the idea.

Solidification would respond to the fall of temperature down to the point required under the existing high pressures, and it is probable that the solidification began at the center and proceeded outwards. It is natural that the plastic state should have developed and existed especially during the age of most rapid growth, for this would be the age of most rapid generation of heat. Later, while the rate of growth was declining, the body could probably have solidified slowly and successively from center out to surface. In later slow depositions of materials, the denser substance would not be able to sink down to the deepest strata: they must lie within a limited depth and horizontal distance from where they fell, and the outer stratum of the Earth would be heterogeneous in density.

The simplest hypothesis we can make concerning the Earth's deep interior is that the chief ingredient is iron; perhaps a full half of the volume is iron. The normal density of iron is 7.8, and of rock formations about 2.8. If these are mixed, half and half, the average density is 5.3. Pressures in the Earth should increase the density and the heat in the Earth should decrease the density. The known density of the Earth is 5.5. We know that iron is plentiful in the Earth's crust, and that iron is still falling upon the Earth in the form of meteorites. The composition of the Earth as a whole, on this assumption, is very similar to the composition of the meteorites in general. They include many of the metals, but especially iron, and they include a large proportion of stony matter. Iron is plentiful in the Sun and throughout the stellar universe. Why should it not be equally plentiful in the materials which have coalesced to form the Earth? It is difficult to explain the Earth's constitution on any other hypothesis.

The Earth's form is that which its rotation period demands. Undoubtedly if the period has changed, the form has changed. Given a little time, solids under great pressure flow quite readily into new forms. Now any great slowing-down of the Earth's rotation period within geological times would be expected to show in the surface features. The strata should have wrinkled, so to speak, in the equatorial regions and stretched in the polar regions, if the Earth changed from a spheroid that was considerably flatter than it now is, to its present form. Mountains, as evidence of the folding of the rock strata, should exist in profusion in the torrid zone, and be scarce in or absent from the higher latitudes of the Earth. Such differential effects do not exist, and it seems to follow that changes in the Earth's rotation period and in its form could have been only slight while the stratification of our rocks was in progress.

Geologists estimate from the deposition of salt in the oceans, and from the rates of denudation and sedimentation, that the formation of the rock strata has consumed from 60,000,000 to 100,000,000 years. If the Earth had substantially its present form 80,000,000 years ago we are safe in saying that the period of time represented in the building up of the Earth from a small nucleus to its present dimensions has been vastly longer, probably reckoned in the thousands of millions of years.

For more than a century past the problem of the evolution of the stars, including the solar system and the Earth, has occupied the central place in astronomical thought. No one is bold enough to say that the problem has been solved. The chief difficulty proceeds from the fact that we have only one Earth, one solar system and one stellar system available for tests of the hypotheses proposed; we should like to test them on many systems, but this privilege is denied us. However, the search for the truth will undoubtedly proceed at an ever increasing pace, partly because of man's desire to know the truth, but chiefly, as Lessing suggested, because the investigator finds an irresistible satisfaction in the process. There is always with him the certainty that the truth is going to be incomparably stranger and more interesting than fiction.

A METRICAL TRAGEDY

BY DR. JOS. V. COLLINS

STEVENS POINT, WIS.

THE war in Europe has opened up a large field of trade in South America. Three things especially stand in the way of its development, viz., the absence of a proper credit system, the failure to make goods of the kind demanded and third, the use of our antiquated system of weights and measures, all the South American countries employing the metric system. Of these three obstructing influences, the first two are in a fair way to be obviated soon; not so the last.

It is the use by our modern progressive country of an ancient system of weights and measures which it is here proposed to discuss and show up as an absurdity. Our present system is organized and set forth in arithmetics under some fifteen so-called "tables." These tables are all different and there is no uniformity in any one table. Only one unit suggests convenience in reductions, viz., hundredweight. It is easy to reduce from pounds to hundredweight and vice versa. Some fifty ratio numbers have to be memorized or calculated from other memorized numbers to make the common needed reductions. History shows that ancient Babylonia had tables superior to those now in use, and ancient Britain a decimal scale which was crowded out by our present system.

The metric system of weights and measures was developed in France about 1800 and has come to be employed over all the civilized world except in the United States, Great Britain and Russia. The system was legalized in the United States in 1866 but not made mandatory and here we are fifty years later using the old system, with most of the civilized world looking on us with more or less scorn because of our belatedness.

In this age everywhere the cry is efficiency, always more efficiency. Ten thousand improvements and labor-saving devices are introduced every day. But here is an improvement and labor-saving device which would affect the life of every person in the land and in many instances greatly affect such persons' lives, and yet almost no one really knows anything about the matter.

So let us now consider the good points in the metric system (each implying corresponding elements of great weakness in the common system), and then study briefly what stands in the way of its adoption in this country. These good points are:

First, the metric units have uniform self-defining names (cent, mill, meter and five more out of the eleven terms used already familiar to us in English words), are always the same in all lands, known everywhere, and fixed with scientific accuracy.

Second, every REDUCTION is made almost instantaneously by merely moving the decimal point. There are no reductions performed by multiplying by 1,728 or 5,280, etc., or dividing by 5 1/2, 30 1/4 or 31 1/2, etc., and hence there is A GREAT SAVING in the labor and time of making necessary calculations.

Third, there are but FIVE tables in the metric system proper, these taking the place of from twelve to fifteen in our system (or lack of it). These are linear, square, cubic, capacity and weight.

Fourth, any one table is about as easy to learn as our United States money table, and after one is learned, it is much easier to learn the others, since the same prefixes with the same meanings are used in all.

Fifth, the weights of all objects are either known directly from their size, or can be very quickly found from their specific gravities.

Sixth, the subject is made so much easier for children in school that a conservative expert estimate of the saving is two thirds of a year in a child's school life. The rule in this country is eight years of arithmetic, the arithmetic occupying about one fourth of the child's activity. With metric arithmetic substituted for ours, what it now takes two years to prepare for, could be easily done in 1 1/3 years. This involves an enormous waste of money and energy every twelvemonth.

Seventh, only ONE set of measures and ONE set of weights are needed to measure and weigh everything, and ONE set of machines to make things for the world's use. There would be no duplication of costly machinery to enter the foreign trade field, thus securing enormous saving. It is well known that the United States and Great Britain have lost a vast amount of foreign commerce in competition with Germany and France, because of their non-use of the metric units. Britain realizes this and is greatly concerned over the situation.

Eighth, every ordinary practical problem can be solved conveniently on an adding machine. Our adding machines are used almost solely for United States money problems.

Ninth, no valuable time is lost in making reductions from common to metric units, or vice versa, either by ourselves or foreigners. To make our sizes in manufactured goods concrete to them foreign customers have to reduce our measures to theirs and this is a weariness to the flesh.

Tenth, the metric system is wonderfully simple. All the tables with a rule to make all possible reductions can be put on a postal card.[1]

[1] See article by the writer in Education (Boston), Dec., 1894.

The metric weights and measures constitute a SCIENTIFIC SYSTEM; our weights and measures are a DISORGANIZATION. Naturally one can expect a GREAT SAVING OF TIME, THOUGHT AND LABOR from the use of a system, and this is the fact. If one dared introduce ordinary arithmetical problems into an article like this, it would be easy to show by examples how a person has to be something of a master of common fractions in order to solve in our system common every-day problems, whereas in the metric system nearly everything is done very simply with decimals. In our system a mechanic after making a complicated calculation with common fractions is as likely as not to get his result in sixths, or ninths, etc., of an inch, whereas his rule reads to eighths, or sixteenths, and he must reduce his sixths, or ninths, to eighths, or sixteenths, before he can measure off his result. In the metric system results always come out in units of the scale used. The metric system measures to millimeters or to a unit a trifle larger than a thirty-second of an inch. In our system one is likely to avoid sixteenths or thirty-seconds on account of the labor of calculation. Then, besides, the amount of figuring is so much less in the metric system. Take the case of a certain problem to find the cubical contents of a box. Our solution calls for 80 figures and the metric for 35, and this is a typical case, not one specially selected. Thus, metric calculations, while only from one third to two thirds as long, are likely to be two or three times as accurate, are far easier to understand, and the results can be immediately measured off. Hence, we waste time in these four ways. Shakespeare in Hamlet says: "Thus conscience does make cowards of us all." In like vein it might be said: Thus custom (in weights and measures) doth make April fools of us all. It is no exaggeration to say that counting grown-ups solving actual problems and children solving problems in school we are sent on much more than a billion such April fool errands round Robin Hood's barn every year.

Noting how much time is saved in making simple every-day calculations by using the metric system, suppose that we assume of the 60 or more millions of adults in active life in this country, on the average only one in 60 makes such calculations daily and that only twenty minutes' time is saved each day. Let us suppose that the value of the time of the users is put at $2.40 per day or 10 cents for 20 minutes. Then 1,000,000 users would save $100,000 per day or $30,000,000 per year. But perhaps some one is saying that much of this time is not really saved, since many persons are paid for their time and can just as well do this work as not. The answer to this is that in many instances such calculations take the time of OTHERS as well as the person making the calculation. Occasionally a contractor might hold back, or work to a disadvantage a gang of a score of workmen while trying to solve a problem that came up unexpectedly.

An estimate of the value of all weighing and measuring instruments places the sum at $150,000,000. Thus, we see that in five years, merely by a saving in TIME—for time is money—all metric measuring and weighing instruments could be got NEW at no extra expense. This estimate of the cost of replacing our weighing and measuring instruments by new metric ones and of saving time has been made by others with a similar result.

A matter of very much more importance than that just discussed is the extra unnecessary expense put upon education, viz., two thirds of a year for every child in the land. Presumably if the metric system were in use with us, all our children would stay in school as long as they now do, thus getting two thirds of a year farther along in the course of study. Actually, if arithmetic were made more simple, vast numbers would; stay longer, since they would not be driven out of school by the terrible inroads on their interest in school work by dull and to them impossible arithmetic. If metric arithmetic texts were substituted for our present texts, it is safe to say children would average one full year more of education. What the increased earning power would be from this it would be hard to estimate, but clearly it would be a huge sum.

Consider also how much more life would be worth living for children, teachers and parents if a very large portion of arithmetical puzzles inserted to qualify the children to understand our crazy weights and measures were cut out of our text-books. If we were to adopt the metric system, literally millions of parents would be spared worry, and shame, and fear lest Johnny fail and drop out of school, or Mary show unexpected weakness and have to take a grade over again; uncounted thousands of teachers would be saved much gnashing of teeth and uttering of mild feminine imprecations under their breath; and, best of all, the children themselves would be saved from pencil-biting, tears, worries, heartburns, arrested development, shame and loss of education!

A committee of the National Educational Association has recently reported that Germany and France are each two full years ahead of us in educational achievement, that is, children in those countries of a certain age have as good an education as our children which are two years the foreign childrens' seniors. Surely one of these years is fully accounted for by the inferiority of our American ARITHMETIC and SPELLING. This much, at least, of the difference is neither in the children themselves, nor in the lack of preparation of our teachers, nor in educational methods.

Professor J. W. A. Young, of the University of Chicago, in his work on "Mathematics in Prussia," says: "In the work in mathematics done in the nine years from the age of nine on, we Americans accomplish no more than the Prussians, while we give to the work seven fourths of the time the Germans give." Professor James Pierpont, of Yale, writing in the Bulletin of the American Mathematical Society (April, 1900), shows a like comparison can be made with French instruction. Pierpont's table exhibits only one hour a week needed for arithmetic for pupils aged 11 and 12! As the advertisements sometimes say, there must be a reason.

But if the children are kept in school two thirds of a year longer somebody pays for this extra expense. Now children do not drop out of school until they are about 12 years of age and have both appetites and earning power. The number of these children that drop out each year is probably about 2 1/2 millions. Of this number let us say 1 1/2 millions would become wage earners, thus passing from the class that are supported to the class that support themselves and earn a small wage besides. We have then three items in this count: (1) The cost to the state in taxes for the education of 2 1/2 million for two thirds of a year, or $50,000,000; (2) The cost to the parents for support of 1 1/2 millions for two thirds of a year at $67 each, or $100,000,000; (3) The wages of 1 1/2 millions over and above the cost of their support, say $50 each, or $75,000,000.

The above figures are put low purposely so that they can not be criticized. It should be remembered that 46 per cent. of our population is agricultural, and that on the farm, youths of from 13 to 15 very often do men's and women's work: also that in many manufacturing centers great numbers of children get work at relatively good wages, and that the number of completely idle children out of school is not large.

With these figures in hand let us consider now a kind of debit and credit sheet against and for our present system of weights and measures.

PRESENT SYSTEM OF WEIGHTS AND MEASURES

In ANNUAL account with UNCLE SAM

Cr. By culture (?) acquired by the children through learning more common fractions and our crazy tables of weights and measures.......... $?

Dr. To cost in school taxes of keeping 2 1/2 millions of children in school 2/3 year. $50,000,000 To cost to parents for supporting 1 1/2 millions children 2/3 year............. 100,000,000 To loss of productive power of 1 1/2 millions youth for 2/3 year .... 75,000,000 To loss of earning power by having children driven out of school by difficulties of arithmetic as now taught .... 25,000,000 To loss of time in making arithmetical calculations by men in trade, industries and manufactures......................... 30,000,000 To extra weighing and measuring instruments needed for sundry tables....... 10,000,000 To loss of time in making cross reductions to and from our system and metric system .... 5,000,000 To loss of profit from foreign trade because our goods are not in metric units .... 20,000,000 ——————— Total annual loss $315,000,000

Commenting for a moment on the credit side of the above ledger account, it can be said that recent psychology shows conclusively that training in common fractions and weights and measures can not be of much practical help as so-called culture, or training for learning other things, unless those other things are closely related to them, and there are not many things in life so related to them once we had dropped our present weights and measures.

It may be complained that the expense of changing to the new system is not taken account of in the above table. The reason is that that expense would occur once for all. The above table deals with the ANNUAL cost of our present medieval system.

One powerful reason for the adoption of the metric system different in character from the others is the ease of cheating by the old system. In the past the people have been unmercifully abused through short weights and measures. Many of the states have taken this matter up latterly and prosecuted merchants right and left. Nine tenths of this trouble would disappear with the new system in use.

Let us consider now for a little time the reasons why the metric system has not been accepted and adopted for use in the United States. Evidently the great main reason has been that the masses of the people, in fact all of them except a very small educated class in science are almost totally uninformed on this whole question. Such articles as have been published have almost invariably appeared in either scientific, technical or educational magazines, mostly the first, so that there has been no means of reaching the masses, or even the school teachers with the facts. For another reason the United States occupies an isolated position geographically, and our people do not come into personal contact with those in other countries using the metric system. But there is still another potent reason. After the United States government legalized the metric system in 1866, all the school books on arithmetic began presenting the topic of the metric system, and, quite naturally, they did it by comparing its units with those of our system and calling for cross reductions from one system to the other. No better means of sickening the American children with the metric system could have been devised. Multitudes of the young formed a strong dislike for the foreign system with its foreign names, and could not now be easily convinced that it is not difficult to learn. Every school boy knows how easy it is to learn United States money. The boy just naturally learns it between two nights. The whole metric system UNDER FAVORABLE CONDITIONS is learned nearly as easily. By favorable conditions is meant the constant use of the system in homes, schools, stores, etc. These favorable conditions, of course, we have never had.

In 1904 an earnest effort was made again both in this country and Great Britain to have the metric system adopted for general use. The exporting manufacturers in both countries grew much concerned over the whole situation. A petition to have the metric system adopted in Great Britain was signed by over 2,000,000 persons. A bill to make the system mandatory was passed by the House of Lords and its first reading in the House of Commons. The forces of conservatism then bestirred themselves and the bill was held up. Forseeing a movement of the same kind in this country, the American Manufactures' Association got busy, laid plans to defeat such movement which they later did. Strictly speaking this action was not taken by the association as such but only by a part of it. One fourth of the membership and probably much more than a fourth of the capital of the association was on the side for the adoption of the system. Politically, however, the side opposed to the new system had altogether the most influence.

Careful study of the whole matter showed that the main cost to make the change to the new system would be in dies, patterns, gauges, jigs, etc. A careful estimate put this cost at $600 for each workman and assuming a million workmen, we have a total cost of $600,000,000. But we have just seen that the annual expense of retaining the old system of weights and measures is over $300,000,000. Thus we see that two short years would suffice to pay for what seems to the great manufacturers association an insuperable expense. From all this we see that the question is not one for N. M. A. bookkeeping, but for national bookkeeping.

Many well-informed people studying the matter superficially, think the difficulties in the way of a change to the new system insurmountable. Thus, they think of the cost to the manufacturer—which we have just seen to be rather large but not insurmountable; they think of the changes needed in books, records, such as deeds, and the substitution of new measuring and weighing instruments. Germany and all the other countries of continental Europe made the change. Are we to assume that the United States can not? That would be ridiculous. Granting that commerce has grown greatly, so also has intelligence and capability of the people for doing great things.

Scientists are universally agreed as to the wisdom of the adoption of the metric system. The country, as a whole, must be educated up to the notion that sooner or later it is sure to be universally adopted, that it is only a question of time when this will be done. Already electrical, chemical and optical manufacturing concerns use the metric units and system exclusively. The system is also used widely in medicine and still other arts. Then all institutions of learning use the metric system exclusively whenever this is possible. All that is needed is to complete a good work well begun.

There is one rational objection to the metric system and but one. It is that 10 is inferior to 12 as a base for a notation for numbers, but the world is not ready to make this change nor is it likely to be for generations to come. Moreover, this improvement is far less important than uniformity in weights and measures. For these reasons this objection can be passed over. Men said the metric system would never be used outside of France; but it has come to be used all over the world. The prophets said we should never have uniformity as regards a reference meridian of longitude. But we have. And so it will be with the adoption of the metric system in the United States and Great Britain. It is only a question of whether it comes sooner or later. When that day comes, the meter, a long yard, will replace the yard, the liter, the quart (being smaller than a dry and larger than a liquid quart), the kilogram will replace the pound, being equal to 2.2 pounds, and the kilometer (.6 mi.) will replace the mile. Within a week or so after the change has been made to the new system, all men in business will be reasonably familiar with the new units and how they are used, and within a few months every man, woman and child will be as familiar with the new system as they ever were with the simplest parts of the old. So easy it will be to make the change as far as ordinary business affairs are concerned. However, for exact metal manufactures years will be needed to fully change over to the new. Here the plan is to begin with new unit constructions and new models, as automobiles using new machinery constructed in the integral units of the metric system. All old constructions are left as they are and repaired as they are. This was the plan used in Germany and of course it works.

In conclusion it can be said that we started with the idea that the change to the metric system was needed for the sake of foreign commerce. We now see that we need it also for our own commercial and manufacturing transactions. If we are to have the efficiency so insistently demanded by the age in which we live, then we must have the metric system in use for the ordinary affairs of daily life of the masses of the people, we must have it in commercial and manufacturing industries, and we must have it in education. If efficiency is to be the slogan, then the metric system must come no matter what obstacles stand in its way.

ADAPTATION AS A PROCESS

BY PROFESSOR HARRY BEAL TORREY

REED COLLEGE

FOR the physicist and chemist the term adaptation awakens but the barren echo of an idea. In biology it still retains a certain standing, though its significance has, in recent years, been rapidly contracting, as the influence of the conception for which it stands has waned. Many biologists are now of the opinion that their science would be better off entirely without it. They believe it has not only outlived its usefulness, but has become a source of confusion, if not, indeed, reaction.

Darwin's first task, in the "Origin of Species," was to demonstrate that species had not been independently created, but had descended, like varieties, from other species. But he was well aware that

such a conclusion, even if well founded, would be unsatisfactory until it could be shown how the innumerable species inhabiting the world have been modified, so as to acquire that perfection of structure and coadaptation which justly excites our admiration.

To establish convincingly the doctrine of descent with modification as a theory of species, it was necessary for him to develop the theory of adaptation which we now know as natural selection.

The origin of adaptive variations gave him, at that time, little concern. Though keenly appreciative of the problem of variation which his studies in evolution presented, he dismissed it in the "Origin" with less than twenty-five pages of discussion. Such brevity is not surprising, since a more extended treatment would only have embarrassed the progress of the argument. In fact, his restraint in this direction enabled him, first, to avoid the difficulties into which Lamarck, with his bold attack on the problem of variation, had fallen; and second, by doing so, to deal the doctrine of Design a blow from which it has never recovered.

The latter was a service of well-nigh incalculable value to the young science of biology—and, as it appeared, to modern civilization as well. But it has not been uncommon, from Aristotle's day to this, for the work of great men to suffer at the hands of less imaginative followers. Sweeping applications of Darwin's doctrine have been repeatedly made without due regard either for its original object or for the success with which that object was achieved. So I believe it to be no fault of Darwin that the growing indifference of European laboratories toward natural selection should find occasional expression in such a phrase as "the English disease." Disease, indeed, I believe we must in candor admit that devotion to it to be which blinds its devotees to those problems of more elementary importance than the problem of adaptation, which Darwin clearly saw but was born too soon to solve.

The problem of species has profoundly changed since 1859. For Darwin it was perforce a problem of adaptation. For the investigator of to-day it has become a part of the more inclusive problem of variation. Along with the logical results of natural selection he contemplates the biological processes of organic differentiation. He is no longer satisfied to assume the existence of those modifications that make selection possible. In his efforts to control them, the conception of adaptation as a result has been crowded from the center of his interest by the conception of adaptation as a process.

The survival of specially endowed organisms, the elimination of competing individuals not thus endowed, are facts that possess, in themselves, no immediate biological significance. Selection as such is not a biological process, whether it is accomplished automatically on the basis of protective coloration, or self-consciously by man. Separating sheep from goats may have a purely commercial interest, as when prunes and apples, gravel and bullets, are graded for the market. Such selection is, at bottom, a method of classification, serving the same general purpose as boxes in a post-office. Similarly, natural selection is but a name for the segregation and classification that take place automatically in the great struggle for existence in nature. The fact that it is a result rather than a process accounts, probably more than anything else, for its remarkable effect upon modern thought. It is non-energetic. It exerts no creative force. As a conception of passive mechanical segregation and survival, it was a most timely and potent substitute for the naive teleology involved in the idea of special creation.

As a theory of adaptation, then, natural selection is satisfactory only in so far as it accounts for the "preservation of favored races." It throws no light upon the origin of the variations with which races are favored. Since it is only as variations possess a certain utility for the organism that they become known as adaptations, the conception of adaptation is inevitably associated with the welfare of individuals or the survival of races. To disregard this association is to rob the conception of all meaning. Like health, it has no elementary physiological significance.

Our profound interest in the problem of survival is natural and practical and inevitable. But in spite of Darwin's great contribution toward a scientific analysis of the mechanism of organic evolution, and in spite of the marvelous recent progress of medicine along its many branches, the fact remains that so far as this interest in the problem of survival is dominant it must continue to hinder adequate analysis of the problem of adaptation. Indeed, it is in large measure due to such domination in the past that biology now lags so far behind the less personal sciences of physics and chemistry. For survival means the survival of an individual. And there is no doubt that the individual organism is the most conspicuous datum in the living world. The few who, neglectful of individuals and survivals, find their chief interest in living substance, its properties and processes, are promptly challenged by the many to find living substance save in the body of an organism. Thus, in a peculiarly significant sense, organisms are vital units. And since the individual organism shows a remarkable capacity to retain its identity under a wide range of conditions, adaptability or adjustability comes to be reckoned as the prime characteristic of life by all to whom the integrity of the individual organism is the fact of chief importance.

With the use of the words adaptability and adjustability, our discussion assumes a somewhat different aspect. Instead of contemplating further the mechanical selection of individuals on the basis of characters that, like the structure of "the woodpecker, with its feet, tail, beak and tongue, so admirably adapted to catch insects under the bark of trees," can not be attributed to the influence of the external conditions that render them useful, we are invited to consider immediate and plastic adjustments of the organism to the very conditions that call forth the response. For the fortuitous adjustments that tend to preserve those individuals or races that chance to possess them, are substituted, accordingly, the direct primary adjustments that tend to preserve the identity of the reacting organism. We turn thus from the RESULTS of the selection of favorable variations to the biological PROCESSES by which organisms become accommodated to their conditions of life.

At once the old questions arise. Are these processes fundamentally peculiar to the life of organisms? Does the capacity of the organism thus to adjust itself to its environment involve factors not found in the operations of inorganic nature? Our answers will be determined essentially by the nature of our interest in the organism—whether we regard its existence as the END or merely an incidental EFFECT of its activities. The first alternative is compatible with thoroughgoing vitalism. The second, emphasizing the nature of the processes rather than their usefulness to the organism, relieves biology of the embarrassments of vitalistic speculation, and allies it at the same time more intimately than ever with physics and chemistry. This alliance promises so well for the analysis of adaptations, as to demand our serious attention.

Physiologically, the living organism may be thought of as a physico-chemical system of great complexity and peculiar composition which varies from organism to organism and from part to part. Life itself may be defined as a group of characteristic activities dependent upon the transformations in this system under appropriate conditions. According to this definition, life is determined not only by the physical and chemical attributes of the system, but by the fitness of its environment, which Henderson has recently done the important service of emphasizing.[1] Relatively trifling changes in the environment suffice to render it unfit, however, that is, to modify it beyond the limits of an organism's adaptability. The environmental limits are narrow, then, within which the transformations of the organic system can take place that are associated with adaptive reactions. The conditions within these limits are, further, peculiarly favorable for just such transformations in just such physico-chemical systems.

[1] "The Fitness of the Environment."

The essential characteristic of the adaptive reaction appears to be that the organism concerned responds to changing conditions without losing certain attributes of behavior by which we recognize organisms in general and by which that organism is recognized in particular. It exhibits stability in the midst of change; it retains its identity. But this stability, let us repeat, is the stability of a certain type of physico-chemical system, with respect to certain characters only, and exhibited under certain circumscribed conditions. In so far as the problem of adaptation is thus restricted in its application, it remains a question of standards, a taxonomic convenience, a problem of the organism by definition only, empty of fundamental significance.

It is to be expected that systems differing widely in composition and structure will differ in their responses to given conditions. This will be true whether the systems compared thus are organic, or inorganic, or representative of both groups. The compounds of carbon, of which living substance is so characteristically composed, exhibit properties and reactions that distinguish them at once in many respects from the compounds of lead or sulphur. They also differ widely among themselves; compare, in this connection, serum albumen, acetic acid, cane sugar, urea. No vitalistic factor is needed for the interpretation of divergencies of this kind. But there are many significant similarities between organisms and inorganic systems as well. These are so frequently overlooked that it will now be desirable to consider a few illustrative cases. For the sake of brevity, they have been selected as representative of but two types of adaptation commonly known under the names of ACCLIMATIZATION and REGULATION.

Let us first consider the case of organisms which become acclimatized by slow degrees to new conditions that, suddenly imposed, would produce fatal results. Hydra is an organism which becomes thus acclimatized finally to solutions of strychnine too strong to be endured at first. Outwardly it appears to suffer in the process no obvious modifications. Yet modifications of a physiological order take place, as is shown, first, by the necessary deliberation of the acclimatization, second, by the death of the organism if transferred abruptly back to its original environment.

In other forms the structural changes accompanying acclimatization may be far more conspicuous. For example, the aerial leaves of Limnophila heterophylla are dentate, while those grown under water are excessively divided. Again, the helmets and caudal spines of Hyalodaphnia vary greatly in length with the seasonal temperature.

In these and the large number of similar cases that might be cited, stability of the physiological system under changed conditions is only obtained by changes in the system itself which are often exhibited by striking structural modifications.

Compare with such phenomena of acclimatization the responses of sulphur, tin, liquid crystals and iron alloys to changes of temperature. The rhombic crystals that characterize sulphur at ordinary temperatures and pressures, give place to monoclinic crystals at 95.5 degrees C. Sulphur thus exists with two crystalline forms whose stability depends directly upon the temperature.

Similarly, tin exists under two stable forms, white and gray, the one above, the other below the transitional point, which is, in this case, 18 degrees C. At this temperature white tin is in a metastable condition, and transforms into the gray variety. The transformation goes on, then, at ordinary temperatures, but, fortunately for us as users of tin implements, very slowly. Its velocity can be increased, however, by lowering the temperature, on which, then, not only the transformation itself, but its rate depends.

In this connection may be mentioned cholesteryl acetate and benzoate and other substances which possess two crystalline phases, one of which is liquid, unlike other liquids, however, in being anisotropic. As in the preceding cases, these phases are expressions of equilibrium at different temperatures.

Especially instructive facts are afforded by the alloys of iron and carbon. Iron, or ferrite, exists under three forms: as alpha ferrite below 760 degrees, as beta ferrite between 760 degrees and 900 degrees, and as gamma ferrite above 900 degrees. Only the last is able to hold carbon in solid solution. The alloys of iron and carbon exist under several forms. Pearlite is a heterogeneous mixture containing 0.8 per cent. carbon. When heated to 670 degrees, it becomes homogeneous, an amount of carbon up to two per cent. dissolves in the iron, and hard steel or martensite is formed. In appearance, however, the two forms are so nearly identical as to be discriminated only by careful microscopical examination. Cementite is a definite compound of iron and carbon represented by the formula Fe<3 subscript>C.

When cooled slowly below 670 degrees, martensite yields a heterogeneous mixture of pearlite and ferrite (or cementite, if the original mixture contained between 0.8 per cent. and two per cent. of carbon). Soft steels and wrought iron are thus obtained. When cooled rapidly, however, as in the tempering of steel, martensite remains a homogeneous solid solution, or hard steel.

One can not fail to notice the remarkable parallel between these facts and the behavior of Hydra in the presence of strychnine. In both cases new positions of stability are reached by modifying the original conditions of stability; and in both, the old positions of stability are regained only by returns to the original conditions of stability so gradual as to afford time sufficient for the necessary transformations in the systems themselves.

The forms which both organic and inorganic systems assume thus appear to be functions of the conditions in which they exist.

The fact that Hydra is able to regain a position of stability from which it had been displaced connects the behavior of this organism not only with the physical phenomena already cited, but still more intimately with the large class of chemical reactions which are similarly characterized by equilibrium and reversibility. Such reactions do not proceed to completion, which is probably always the case wherever the mixture of the systems under transformation is homogeneous, as in the case of solutions. They occur widely among carbon compounds. The following typical case will suffice to indicate their essential characteristics.

When ethyl alcohol and acetic acid are mixed, a reaction ensues which yields ethyl acetate and water. But ethyl acetate and water react together also, yielding ethyl alcohol and acetic acid. This second reaction, in a direction opposite to the first, proceeds in the beginning more slowly also. There comes a time, however, when the speeds of the two reactions are equal. A position of equilibrium or apparent rest is thus reached, which persists as long as the relative proportions of the component substances remain unchanged.

A great many reversible reactions are made possible by enzymes. In the presence of diastase, glucose yields glycogen and water, which, reacting together in the opposite direction, yield glucose again. In the presence of emulsin, amygdalin is decomposed into glucose, hydrocyanic acid and benzoic aldehyde, and reformed from them. Similarly in the presence of lipase, esters are reformed from alcohols and fatty acids, their decomposition products.

With the introduction of enzymes, certain complications ensue. Though it has been shown that lipase acts as a true catalyser, this may not hold for all, especially for proteolytic, enzymes. That reversible reactions actually occur in proteids, however, accompanied as they are in some cases at least by certain displacements of the position of equilibrium, there appears to be no question.[2]

[2] Robertson, Univ. Calif. Publ. Physiol., 3, 1909, p. 115.

These examples are but suggestions of the many reversible reactions that have now been observed among the compounds of carbon. That they have peculiar significance for the present discussion resides in the fact that living substance is composed of carbon compounds, so many and in such exceedingly complex relations as to present endless possibilities for shifting equilibria and the physical and chemical adjustments resulting therefrom.

With these facts in mind we may now turn from the consideration of acclimatization to a brief discussion of certain phenomena of regulation—adaptive reactions that are especially conspicuous in the growth and development of organisms, but separated by no sharp dividing line from adaptive reactions of the other type.

When a fragment of an organism transforms, under appropriate conditions, into a typical individual, the process includes degenerative aa well as regenerative phases. There is always some simplification of the structures present, whose character and amount is determined by the degree of specialization which has been attained. The smaller the piece, within certain limits, and the younger physiologically, the more nearly does it return to embryonic conditions, a fact which can be studied admirably in the hydroid Corymorpha. In some cases the simplification is accomplished by abrupt sacrifice of highly specialized parts, as in Corymorpha, when in a process of simplification connected with acclimatization to aquarium conditions, the large tentacles of well-grown specimens fall away completely from their bases. In other hydroids (e. g., Campanularia) the tentacles may be completely absorbed into the body of the hydranth from which they originally sprang. Among tissue cells degenerative changes may be abrupt, as in the sacrifice of the highly specialized fibrillae in muscle cells; or they may be very gradual, as in the transformation of cells of one sort into another that occurs in the regeneration of tentacles in Tubularia.

An interesting case of absorption of parts came to my notice while studying the larvae of the pennatulid coral Renilla some fifteen years ago. As will be remembered, Renilla possesses eight tentacles with numerous processes pinnately arranged. During a period of enforced starvation, these pinnae were gradually absorbed, and the tentacles shortened, from tip to base. With the advent of food —in the form of annelid eggs—the reverse of these events took place. The tentacles lengthened and the pinnae reappeared, the larvae assuming their normal aspect.

It appears, then, that in some circumstances at least, the process of simplification may resemble very nearly, even in details, a reversal of the process of differentiation. That one is actually in every respect the reverse of the other is undoubtedly not true. This, however, is not to be wondered at. Mechanical inhibitions that are so conspicuous in some cases (e. g., Corymorpha) are to be expected to a certain degree in all. The regenerative process itself depends upon the cooperation of many physical and chemical factors, in many and complex physicochemical systems in varying conditions of equilibrium. And it is important to note that even the equilibrium reactions by which a single proteid in the presence of an enzyme, is made and unmade, do not appear always to follow identically the same path in opposite directions.[3]

[3] Robertson, vid. sup., p. 269.

Whatever their course in the instances cited and in many others, reversals in the processes of development do take place. In perhaps their simplest form these can be seen in egg cells. The development of a fragment of an egg as a complete whole involves reversals in the processes of differentiation of a very subtle order. The fusion of two eggs to one involves similar readjustments. Such phenomena have been held to be peculiar to living machines only. Yet it may be pointed out that there are counterparts of both in the behavior of so-called liquid crystals. When liquid crystals of paraazoxyzimtsaure-Athylester are divided, the parts are smaller in size, but otherwise identical with the parent crystal in form, structure and optical properties. The fusion of two crystals of ammonium oleate forming a single crystal of larger size has also been observed. Though changes in equilibrium that accompany such behavior of liquid crystals are undoubtedly very much simpler than the changes that accompany the regulatory processes exhibited by the living egg, the striking resemblance between the phenomena themselves tempts us not to magnify the difference.

Further temptation in the same direction is offered by the recent discovery[4] that the processes of development stimulated in the eggs of the sea urchin Arbacia by butyric acid or weak bases, and evidenced by the formation of the fertilization membrane, is reversible. When such eggs are treated with a weak solution of sodium cyanide or chloral hydrate, they return to the resting condition. Upon fertilization with spermatozoa, in normal sea water, they proceed again to develop.

[4] Loeb, Arch. f. Entw., 28, 1914, p. 277.

The facts that have now been briefly summarized have been selected to emphasize the growing intimacy between the biological and the inorganic sciences. No harm can conceivably come from it. On the contrary, there is every reason to be hopeful that the investigation of biological problems in the impersonal spirit that has long distinguished the maturer sciences of physics and chemistry will continue to develop a better control and fuller understanding of the processes in living organisms, of which the phenomena of variation in general, and of adaptation in particular, are but incidental effects.

WHY CERTAIN PLANTS ARE ACRID

BY PROFESSOR WILLIAM B. LAZENBY

OHIO STATE UNIVERSITY

EVER since my first lessons in botany, the characteristic qualities and properties of plants have given me much thought. Why certain plants produced aromatic oils and ethers, while others growing under the same conditions produced special acids or alkaloids, was a subject of endless speculation.

The pleasing aroma of the bark of various trees and shrubs, the spicy qualities of the foliage and seeds of other plants; the intense acridity; the bitterness; the narcotic, the poisonous principle in woody and herbaceous species; all were intensely interesting.

This interest was biological rather than chemical. I cared less for the ultimate composition of the oils, acids, alkalis, etc., than I did for their use or office in the plant economy, and their effect upon those who might use them.

Perhaps no one plant interested me more from this point of view, than the well-known Indian turnip (Arisoema triphyllum). As a boy I was well acquainted with the signally acrid quality of this plant; I was well aware of its effect when chewed, yet I was irresistibly drawn to taste it again and again. It was ever a painful experience, and I suffered the full penalty of my rashness. As an awn from a bearded head of barley will win its disputed way up one's sleeve, and gain a point in advance despite all effort to stop or expel it, so did every resolution, every reflection, counteract the very purpose it was summoned to oppose, and to my sorrow I would taste the drastic, turnip-shaped corm wherever opportunity occurred.

It is a well-known fact that the liquid content of the cells of plants contain numerous inorganic substances in solution. Among these, not considering oxygen, hydrogen, nitrogen and carbon dioxide, there are the salts of calcium, magnesium, potassium, iron, sulphur and phosphorus. The above substances are found in the cells of every living plant. Other substances like salts of sodium and silica are also found, but these are not regarded as essential to the life and growth of plants. They appear to be present because the plant has not the power to reject them. Many of the substances named above, are found deposited either in an amorphous or crystalline form in the substance of the cell wall. In addition to this, crystals of mineral matter, having various shapes and sizes, are often found in the interior of cells. The most common of these interior cell crystals are those composed of calcium oxalate and calcium carbonate. Others composed of calcium phosphate, calcium sulphate and silica are sometimes found. These crystals may occur singly or in clusters of greater or less size. In shape they are prismatic or needle-like.

It is not the object of this paper to treat of plant crystals in general, but to consider the peculiar effect produced by certain forms when found in some well-known plants.

The extreme acridity or intense pungency of the bulbs, stems, leaves and fruit of various species of the Araceae or Arum family, was recognized centuries ago. The cause of this characteristic property or quality was, until a comparatively recent date, not definitely determined.

As far as I am aware the first scientific investigation of this subject was made by the writer. At a meeting of the American Association for the Advancement of Science held at Indianapolis in 1890, some studies and experiments were reported in a short paper entitled "Notes upon the Crystals in certain species of the Arum Family."

This paper expressed the belief that the acridity of the Indian turnip and other plants belonging to the same family, was due to the presence of needle-shaped crystals or raphides found in the cells of these plants. This conclusion was not accepted by Professor T. J. Burrill, of the University of Illinois, nor by other eminent botanists who were present and took part in the discussion that followed the reading of the paper.

The opposition was based mainly on the well-known fact that many other plants like the grape, rhubarb, fuchsia, spiderwort, etc., are not at all, or but slightly acrid, although the raphides are as abundant in them as in the Indian turnip and its allies.

Up to this time the United States Dispensatory and other works on pharmacy, ascribed the following rather indefinite cause for the acridity of the Indian turnip. It was said to be due to an acrid, extremely volatile principle. This principle was insoluble in water and alcohol, but soluble in ether. It was dissipated both by heating and drying, and by this means the acridity is destroyed. There was no opinion given as to the real nature of this so-called principle.

More recently it has been intimated that the acridity may be due to some ferment or enzyme, which has been derived in part from the self-decomposition of protoplasm and in part by the process of oxidation and reduction.

Here the question appeared to rest. At all events I was unable to glean any further knowledge from the sources at my command.

Some time later the subject was taken up in a more comprehensive manner and the following report is the first detailed description of an investigation that has occupied more or less of my leisure for some years.

A dozen or more species of plants have been used for examination and study. Among these were:

Indian turnip (Arisoema triphyllum).
Green dragon (Arisoema dracontium).
Sweet-flag (Acorus).
Skunk cabbage (Spathyema).
Calla (Richardia).
Caladium (Caladium).
Calocasia (Calocasia).
Phyllodendron (Phyllodendron).
Fuchsia (Fuchsia).
Wandering Jew (Tradescantia).
Rhubarb (Rheum).
Grape (Vitis).
Onion (Allium).
Horse-radish (Armoracia).

Most of the plants selected were known to have crystals in certain parts. Some of them were known to be intensely acrid. In these the acridity was in every instance proportional to the number of crystals.

The following order of study was pursued and the results of each step noted. Only the more salient points of the methods employed and the conclusions reached are presented.

1. The Character of the Taste Itself.—It was readily noted that the sensation produced by chewing the various acrid plants was quite different. For example, the Indian turnip and its close allies do not give

the immediate taste or effect that follows a similar testing of the onion or horse-radish. When the acridity of the former is perceived the sensation is more prickling than acrid.

The effect produced is more like the pricking of numerous needles. It is felt not only upon the tongue and palate, but wherever the part tasted comes into contact with the lips, roof of mouth or any delicate membrane. It is not perceived where this contact does not occur.

The acridity of the onion and horse-radish is perceived at once and often affects other parts than those with which it comes into direct contact.

2. The Acrid Principle Is Not Always Volatile.—This is shown by the fact that large quantities of the mashed or finely grated corms of the Indian turnip and allied species, produced no irritation of the eyes or nose even when these organs were brought into close contact with the freshly pulverized material. This certainly is in marked contrast with the effect produced by freshly grated horse-radish, peeled onions, crushed mustard seed when the same test is applied.

It seems fair to assume that in the latter case some principle that is volatile at ordinary air temperatures is present. The assumption that such principle is present in the former has no room.

In order to test this matter further a considerable quantity of the juice of the Indian turnip was subjected to careful distillation, with the result that no volatile principle or substance of any kind was found.

Various extractive processes were tried by using hot and cold water; alcohol, chloroform, benzene, etc. These failed in every instance to remove any substance that had a taste or effect anything like that found in the fresh Indian turnip.

3. The Acrid Principle Is Not Soluble in Ether.—Inasmuch as various works on pharmacy made the claim that the active or acrid principle of the plants in question was soluble in ether, this was the next subject for investigation. The juice was expressed from a considerable quantity of the mashed Indian turnip. This juice was clear and by test was found to possess the same acrid property as the unmashed corms.

Some of the juice and an equal quantity of ether were placed into a cylinder and well shaken. After waiting until the ether had separated a few drops of the liquid were put into the mouth. For a little time no result was perceived, but as soon as the effect of the ether had passed away the same painful acridity was manifest as was experienced before the treatment with the ether. A natural conclusion from this test was that the acridity might come from some principle soluble in ether.

Observing that the ether was quite turbid and wishing to learn the cause, a drop or two was allowed to evaporate on a glass slide. Examining the residue with a microscope it was found to consist of innumerable raphides or needle-like crystals. Some of the ether was then run through a filter. The filtrate was clear. An examination showed it to be entirely free from raphides, and it had lost every trace of its acridity. The untreated acrid juice of the Indian turnip, calla, and other plants of the same family was then filtered and in every instance the filtered juice was bland and had lost every trace of its acridity. These tests and others that need not be mentioned, proved conclusively that the acridity of various species of the Arum family was not due to a volatile principle, but was due to the needle-shaped crystals found so abundantly in these plants.

Several questions yet remained to be answered. (1) If these needle-like crystals or raphides are the cause of the acridity of the plants just mentioned, why do they not produce the same effect in the fuchsia, tradescantia and other plants where they are known to be just as abundant? (2) Why does the Indian turnip lose its acridity on being heated? (3) Why does the dried Indian turnip lose its acridity?

It was first thought that the raphides found in plants having no acridity, might be of different chemical composition than those which produce this effect.

A chemical examination proved beyond question that the raphides were of the same composition. The needle-shaped crystals in all the plants selected for study were composed of calcium oxalate. The crystals, found in grape, rhubarb, fuchsia and tradescantia were identical in form, fineness and chemical composition with those found in the plants of the Arum family. How then account for the painfully striking effect in one case and the non-effect in the other? This was the perplexing question.

In expressing some juice from the stems and leaves of the fuchsia and tradescantia it was found to be quite unlike that of the Indian turnip and calla. The juice of the latter was clear and limpid; that of the former quite thick and mucilaginous. There was no difference as to the abundance of crystals revealed by the microscope.

After diluting the ropy, mucilaginous juice with water, and shaking it thoroughly with an equal volume of ether, there was no turbidity seen in the supernatent ether. Allowing a few drops of the ether to evaporate scarcely any crystals could be found. Practically none of them had been removed from the insoluble mucilaginous covering. Here and there an isolated specimen was all that could be seen. So closely were these small crystals enveloped with the mucilaginous matter that it was almost impossible to separate or dissect them from it.

It was now easy to explain why certain plants whose cells were crowded with raphides were bland to the taste, while other plants with the same crystals were extremely acrid.

In one case the crystals were neither covered nor embedded in an insoluble mucilage, but were free to move. Thus when the plant was chewed or tasted the sharp points of these needle-like crystals came into contact with the tongue, lips and membranous surface of the mouth.

In the other case the insoluble mucilage which surrounded the crystals prevented all free movement and they produced no irritation.

Why do these intensely acrid, aroid plants lose their acridity on being heated? It is well known that the corms of the Indian turnip and its allies contain a large amount of starch. In subjecting this starch to heat it becomes paste-like in character. This starch paste acts in the same manner as the insoluble mucilage. It prevents the free movement of the crystals and in this way all irritant action is precluded. In heating the Indian turnip and other corms, it was found that the heat applied must be sufficient to change the character of the starch or the so-called acridity was not destroyed.

One other question remains to be answered. It has long been noted that the old or thoroughly dried corms of the Indian turnip are not acrid like those that are fresh. The explanation is simple. As the plant dries or loses its moisture, the walls of the cells collapse and the crystals are closely encased in the hard, rigid matter that surrounds them. This prevents free movement and the crystals can not exert any irritant action.

It is generally believed by biologists that the milky juice, aromatic compounds, alkaloids, etc., found in plants have no direct use in the economy of the plant. They are not connected with the nutritive processes. They are excretions or waste products that the plant has little or no power to throw off. There can be little doubt, however, that these excretory substances often serve as a means of protection. Entomologists have frequently stated that the milky juice and resins found in the stems of various plants act as a protection against stem boring insects. In like manner the bulbs, stems and leaves of plants that are crowded with crystals have a greater immunity from injurious biting insects than plants that are free from crystals. It is quite generally believed that the formation of crystals is a means of eliminating injurious substances from the living part of the plant. These substances may be regarded as remotely analogous to those organic products made by man in the chemical laboratory.

Some progress has been made in this direction, but so far the main results are certain degradation-products such as aniline dyes derived from coal tar; salicylic acid; essences of fruits; etc. Still these and many other discoveries of the same nature do not prove that the laboratory of man can compete with the laboratory of the living plant cell.

Man has the power to break down and simplify complex substances and by so doing produce useful products that will serve his purposes. We may combine and re-combine but so far we only replace more complex by simpler combinations.

The plant alone through its individual cells, and by its living protoplasm has fundamentally creative power. It can build up and restore better than it can eliminate waste products.

HOW OUR ANCESTORS WERE CURED

BY PROFESSOR CARL HOLLIDAY

UNIVERSITY OF MONTANA

SUPPOSE you had a bad case of rheumatism, and your physician came to your bedside and exclaimed loudly, "Hocus pocus, toutus talonteus, vade celeriter jubeo! You are cured." What would you think, what would you do, and what fee would you pay him? Probably, in spite of your aches and pangs, you would make astonishing speed—for a rheumatic person—in proffering him the entire room to himself. But there was a time—and that as late as Shakespeare's day—when so-called doctors in rural England used just such words not only for rheumatism, but for many another disease. And to this hour the fakir on the street corner uses that opening expression, "Hocus pocus." Those words simply prove how slowly the Christian religion was absorbed by ancient Anglo-Saxon paganism; for "Hocus pocus" is but the hastily mumbled syllables of the Catholic priest to his early English congregation—"Hoc est corpus," "this is the body"; and the whole expression used by the old-time doctor meant merely that in the name of the body of Christ he commanded the disease to depart quickly.

How superstitions and ancient rites do persist. To this hour the mountaineers of southwestern Virginia and eastern Tennessee believe that an iron ring on the third finger of the left hand will drive away rheumatism, and to my personal knowledge one fairly intelligent Virginian believed this so devoutly that he actually never suffered with rheumatic pains unless he took off the iron ring he had worn for fifteen years. It is an old, old idea—this faith in the ring-finger. The Egyptians believed that a nerve led straight from it to the heart; the Greeks and Romans held that a blood-vessel called the "vein of love" connected it closely with that organ; and the medieval alchemists always stirred their dangerous mixtures with that finger because, in their belief, it would most quickly indicate the presence of poison. So, too, many an ancient declared that whenever the ring-finger of a sufferer became numb, death was near at hand. Thus in twentieth century civilization we hear echoes of the life that Rameses knew when the Pyramids were building.

Our Anglo-Saxon forefathers had great faith in mysterious words. The less they understood these the more they believed in the curative power. Thus the name of foreign idols and gods brought terror to the local demons that enter one's body, and when Christianity first entered England, and its meanings were but dimly understood, the names of saints, apostles and even the Latin and Greek forms of "God" and "Jesus" were enemies to all germs. Then, too, what comfort a jumbling of many languages brought to the patient, especially if the polyglot cure were expressed in rhythmic lines. Here, for instance, in at least five languages, is a twelfth century cure for gout:

Meu, treu, mor, phor,
Teux, za, zor,
Phe, lou, chri
Ge, ze, on.

Perhaps to our forefathers suffering from over-indulgence in the good things of this world, this wondrous group of sounds brought more comfort than the nauseous drugs of the modern practitioner. Any mysterious figure or letter was exceedingly helpful in the sick room of a thousand years ago. The Greek letters "Alpha" and "Omega" had reached England almost as soon as Christianity had, and the old-time doctor triumphantly used them in his pow-wows. Geometric figures in a handful of sand or seeds would prophesy the fate of the ills—and do we not to this day tell our fortune in the geometric figures made by the dregs in our tea-cups? Paternosters, snatches of Latin hymns, bits of early Church ritual were used by quacks of the olden days for much the same reason as the geometric figures—because they were unusual and little understood.

It would have been well had our Anglo-Saxon forefathers confined their healing practices to such gentle homeopathic methods as those mentioned above; but instead desperate remedies were sometimes administered by the determined medicine-man. Diseases were supposed to be caused mainly by demons—probably the ancestors of our present germs—and the physician of Saxon days used all the power of flattery and threat to induce the little monsters to come forth. When the cattle became ill, for instance, the old-time veterinarian shrieked, "Fever, depart; 917,000 angels will pursue you!" If the obstinate cow refused to be cured by such a mild threat, the demons were sometimes whipped out of her, and, if this failed to restore her health, a hole was pierced in her left ear, and her back was struck with a heavy stick until the evil one was compelled to flee through the hole in her ear. Nor was such treatment confined to cattle. The muscular doctors of a thousand years ago claimed they could cure insanity by laying it on lustily with a porpoise-skin whip, or by putting the maniac in a closed room and smoking out the pestering fiends. One did well to retain one's sanity in those good old days.

This use of violent words or deeds in the cure of disease is as ancient almost as the race of man. The early Germans attempted to relieve sprains by reciting confidently how Baldur's horse had been cured by Woden after all the other mighty inhabitants of Valhalla had given up the task, and even earlier tribes of Europe and Asia had used for illness such a formula as: "The great mill stone that is India's is the bruiser of every worm. With that I mash together the worms as grain with a mill stone." Long after Christianity had reached the Anglo- Saxons of England, the sick often hung around their necks an image of Thor's hammer to frighten away the demon germs that sought to destroy the body. This appeal to a superior being was common to all Indo-European races, and the early Christian missionaries wisely did not attempt to stamp out a belief of such antiquity, but merely substituted the names of Christ, the Virgin Mary and the saints for those of the heathen deities. And even into the nineteenth century this ancient form of faith cure persisted; for there are living yet in Cornwall people who heard, as children, this charm for tooth-ache:

Christ passed by his brother's door,
Saw his brother lying on the floor;
What aileth thee, brother!
Pain in the teeth.
Thy teeth shall pain thee no more,
In the name of the Father, Son and Holy Ghost,
I command the pain to be gone.

Let us no longer boast of the carefulness of the modern physician; the ceremonies and directions of the Anglo-Saxon doctor were just as painstaking in minuteness and accuracy. When you feel the evil spirits entering you, immediately seek shelter under a linden tree; for out of linden wood were not battle-shields made? Long before Christianity had brought its gentler touches to English life the tribal medicine man wildly brandished such a shield, and sang defiantly to the witch maidens or disease demons:

Loud were they, lo! loud, as over the land they rode;
Fierce of heart were they, as over the hill they rode;
Shield thee now thyself, from their spite thou may'st escape
thee.
Out, little spear, if herein thou be!
Underneath the linden stand I, underneath the shining shield,
For the might maidens have mustered up their strength,
And have sent their spear screaming through the air!
Back again to them will I send another,
Arrow forth a-flying from the front against them!
Out, little spear, if herein thou be!

This business of singing was very necessary in the old time doctor's practice. Sometimes he chanted into the patient's left ear, sometimes into his mouth, and sometimes on some particular finger, and the patient evidently had to get well or die to escape the persistent concerts of his physician. Not infrequently, too, the doctor placed a cross upon the part of one's anatomy to which he was giving the concert, and often the effect was increased by putting other crosses upon the four sides of the house, the fetters and bridles of the patient's horse, and even on the foot prints of the man, or the hoof prints of the beast. Faith in the cross as a charm was unwavering; "the cross of Christ has been hidden and is found," declared the Saxon soothsayer, and by the same token the lost cattle will soon be discovered.

Many and marvelous were the methods to be followed scrupulously by the sick. Cure the stomachache by catching a beetle in both hands and throwing it over the left shoulder with both hands without looking backward. Have you intestinal trouble? Eat mulberries picked with the thumb and ring finger of your left hand. Do you grow old before your time? Drink water drawn silently DOWN STREAM from a brook before daylight. Beware of drawing it upstream; your days will be brief. It reminds one of the practice of the modern herb doctor in peeling the bark of slippery elm DOWN, if you desire your cold to come down out of your head, or peeling it up if you desire the cold to come up out of your chest. One not desiring to place his trust in roots and barks and herbs might turn for aid to the odd numbers, and by reciting an incantation three or seven or nine times might not only regain health, but recover his lost possessions. Or the sufferer might transfer his disease by pressing a bird or small animal to the diseased part and hastily driving the creature away. The ever-willing and convenient family dog might be brought into service on such an occasion by being fed a cake made of barley meal and the sick man's saliva, or by being fastened with a string to a mandrake root, which, when thus pulled from the ground, tore the demon out of the patient.

The cure of children was a comparatively easy task for the Anglo-Saxon doctor; for the only thing to be done was to have the youngster crawl through a hole in a tree, the rim of the hole thus kindly taking to itself all the germs or demons. So, too, minor sores, warts and other blemishes might easily be effaced by stealing some meat, rubbing the spot with it, and burying the meat; as the meat decayed the blemish disappeared. So to this day some Indians, and not a few Mexicans make a waxen image of the diseased part, and place it before the fire to melt as a symbol of the gradual waning of the illness. So, too, the ancient Celts are said to have destroyed the life of an enemy by allowing his waxen image to melt before the fire.

To cure a dangerous disease or the illness of a full-grown man was, however, a much more difficult matter. Inflammation, for instance, was the work of a stubborn demon, and stubborn, therefore, must be the strife with him. Hence, dig around a sorrel plant, sing three paternosters, pull up the plant, sing "Sed libera nos a malo," pound five slices of the plant with seven pepper corns, chant the psalm "Misere mei, Deus" twelve times, sing "Gloria in excelsis, Deo," recite another paternoster, at daybreak add wine to the plant and pepper corns, face the east at mid-morning, make the sign of the cross, turn from the east to the south to the west, and then drink the mixture. Doubtless by this time the patient had forgotten that he ever possessed inflammation.

Long did the superstitions in medicine persist. In Chaucer's day, the fourteenth century, violent and poisonous drugs were used, but luckily they were often administered to a little dummy which the doctor carried about with him. As we read each day in our newspapers of the various nostrums advertised as curing every mortal ill, we may well wonder if the average credulity has really greatly lessened after twelve centuries of fakes and faith cures, and we almost long for the return of the day when the medicine man practiced on a dummy instead of the human body.

EMINENT AMERICAN NAMES

BY LAUREN HEWITT ASHE

UNIVERSITY OF PITTSBURGH

THE article entitled "The Racial Origin of Successful Americans," by Dr. Frederick Adams Woods, which appeared in the April (1914) issue of The Popular Science Monthly, set forth some very interesting and instructive results. The methods used to arrive at these results, however, do not seem to be such as to establish them as final and conclusive.

It is not sufficient to consider merely the number of persons bearing certain names in "Who's Who in America," for the purpose of establishing the relative capability of various nationalities. The percentage of the number bearing that name in the city in question is the significant figure.

The writer has, therefore, taken the directories[1] of the four American cities, which were the subjects of study in the original article, and has estimated the number of persons of a certain name living in each city by first counting the number of names printed in a whole column of the directory and then multiplying this figure by the number of columns occupied by that name. The number of persons bearing the same name in "Who's Who in America" (1912-1913) is then taken for each city. The percentage is finally calculated of the number of the "Who's Who in America" names in the number of those bearing that name in the directories.

[1] (1) Trow's General Directory—Boroughs of Manhattan and Bronx, City of New York, 1913. Trow Directory, Printing & Bookbinding Company, Pub. (2) Boyd's Philadelphia City Directory, 1913. C. E. Howe Company, Pub. (3) The Lakeside Annual Directory of the City of Chicago, 1913. Chicago Directory Company, Pub. (4) The Boston Directory, 1913. Simpson and Murdock Co., Publishers.

It seems best, furthermore, to narrow down the consideration from the fifty most common names in each city to only those of this number which are common to all four cities in order that any one family may not have too great a weight. The names in each city are then arranged according to the established percentages.

The grouping of names as an indication of race or nationality is taken from Robert E. Matheson's "Surnames in Ireland." It is found to agree exactly with the grouping in the article by Dr. Woods, who classified them from the table given in the New York World Almanac and Encyclopedia for 1914, which table was, no doubt, compiled from Matheson.

NAMES COMMON TO ALL FOUR CITIES, NATIONALITY, ATTBIBUTED TO THEM, AND THE PROPORTION FOR EACH NAME OF THE NUMBER OF TIMES IT OCCURS FOR EACH CITY IN "WHO'S WHO IN AMERICA" (1912-1913) AND THE TOTAL NUMBER OF THE SAME NAME IN THE SAME CITY

New York (Exclusive of Brooklyn)
E White 1.39%
E Williams 1.18
E Clark 1.05
E Taylor 1.02
E Jones 0.89
E Martin 0.87
E Smith 0.78
E Thompson 0.74
E-Sc-G Miller 0.73
E Wilson 0.71
E Brown 0.70
E-Sc Moore 0.60

E Davis 0.59
E-Sn Johnson 0.56
Sc-Sn Anderson 0.55
I Murphy 0.46
I Kelly 0.37
E Klien 0.24
E Hall 0.23
Sc Campbell 0.17
I O'Brien 0.14
E Lewis 0.12
E-Sc Young 0.10

Nationality Averages

G German 0.73%
E English 0.69
Sn Scandinavian 0.55
Sc Scotch 0.43
I Irish 0.32

Chicago
E Hall 0.72
E-So Moore 0.41
E Wilson 0.35
E Davis 0.27
E-Sc Young 0.27
E Thompson 0.26
E Brown 0.22
E Lewis 0.20
E Taylor 0.17
E-Sc-G Miller 0.17
E Martin 0.16
I Kelly 0.16
E Williams 0.15
E White 0.14
E Clark 0.14
E Smith 0.14
E Allen 0.13
Sc Campbell 0.11
E Jones 0.10
E-Sn Johnson 0.06
I Murphy 0.06
Sn-ScAnderson 0.05
I O'Brien 0.00

Nationality Averages

E English 0.22%
Sc Scotch 0.20
G German 0.17
I Irish 0.11
Sn Scandinavian 0.05

Philadelphia
E White 0.46%
E Lewis 0.32
E Taylor 0.31
E Wilson 0.30
E Jones 0.27
E-Sn Johnson 0.23
E Williams 0.22
E-Sc Moore 0.20
E Davis 0.18
E-Sc Young 0.18
E Clark 0.14
E Smith 0.13

E Brown 0.13
E-Sc-G Miller 0.12
E Martin 0.08
E Thompson 0.08
I Murphy 0.08
Sc Campbell 0.08
Sn-Sc Anderson 0.00
I Kelly 0.00
E Allen 0.00
E Hall 0.00
I O'Brien 0.00

Nationality Averages

E English 0.18%
Sn Scandinavian 0.16
G German 0.12
Sc Scotch 0.11
I Irish 0.02

Boston

E Allen 0.72
E Williams 0.67
E Brown 0.61
E Hall 0.43
E Campbell 0.33
E Clark 0.30
E Smith 0.29
E Thompson 0.28
E Taylor 0.25
Sn-Sc Anderson 0.22
E Lewis 0.20
E-Sn Johnson 0.19
E White 0.18
E-Sc Moore 0.17
E Wilson 0.13
E Jones 0.11
I O'Brien 0.08
I Murphy 0.05
E Martin 0.00
E-Sc-G Miller 0.00
E Davis 0.00
I Kelly 0.00
E-Sc Young 0.00

Nationality Averages

E English 0.25
Sn Scandinavian 0.20
Sc Scotch 0.14
I Irish 0.06
G German 0.0?

Name Averages

E Williams 0.55
E White 0.54
E Taylor 0.44
E Brown 0.41
E Clark 0.40
E Wilson 0.37
E Jones 0.34
E Thompson 0.34
E-Sc Moore 0.34
E Hall 0.34
E Smith 0.33
E Martin 0.27

E Allen 0.27
E Davis 0.26
E-Sn Johnson 0.26
E-Sc-G Miller 0.25
E Lewis 0.21
Sn-Sc Anderson 0.20
Sc Campbell 0.17
I Murphy 0.16
E-Sc Young 0.14
I Kelly 0.13
I O'Brien 0.05

Nationality Averages
E English 0.34
G German 0.25
Sn Scandinavian 0.24
Sc Scotch 0.22
I Irish 0.12

The nationality attributed to each name is indicated in the tables below by capital letters in the parallel columns. In some cases a name is shared by two or even three nationalities. The percentages belonging to such names are attributed to each of the sharing nationalities in making the final averages. This, of course, is a serious source of error, since the division of such names among the nationalities is not known. No stress can be laid on our figures for the German, Scotch and Scandinavian nationalities, because they contain so many of these indecisive names.

The names in each city are then arranged in groups according to their nationality and averages computed from the percentages established for each name. These averages, which appear at the bottom of each column, give a fair estimation of the capability of the different nationalities, but are, nevertheless, open to a few minor errors. For instance, the Germans head the list in New York with 0.73 per cent. for only one third of a single name, while the English rank second with a total of 15 5/6 names. The final averages for nationality, however, which appear at the bottom of the fifth column and which are made from the averages computed for each city, partly eliminate this error and place the groups in their proper rank.

In order to make the results more conclusive, general averages are drawn for each name from the percentages established for that name in all four cities and are placed in the fifth column according to their rank. Final averages of percentages for nationalities are then made from this column, just as they were for each city. The results obtained agree exactly with the final averages made before and, therefore, are placed coincident with them at the bottom of the fifth column.

The results finally arrived at seem to corroborate the conclusions of Dr. Wood; namely, that in the four leading American cities, New York, Chicago, Philadelphia and Boston, "those of the English (and Scotch) ancestry are distinctly in possession of the leading positions, at least from the standpoint of being widely known." Yet it does not seem safe to disregard entirely those other nationalities which rank so closely with the English merely because of the small number of them included in our consideration; for, as has been stated above, we do not know what proportion of a certain name to attribute to various nationalities.

There is one serious, but unavoidable, source of error, moreover, which has apparently been overlooked. The conclusions as to the relative intelligence of various races are drawn from the number of names, belonging to these races, which appeared in "Who's Who in America." According to the standards of this compilation, eminence is very largely dependent upon education, which does not give the emigrants, who are too poor to get proper education, an equal opportunity to display their intellectual power and, therefore, to be considered in the above calculations. Races that immigrated predominantly in the last century will be less handicapped than those which have only recently immigrated in large numbers. It is very difficult, however to know how much weight to place upon this modifying influence.

Another source of error is the fact that certain nationalities or races seem to have natural inclinations and desires to follow in disproportionate numbers one kind of activity or occupation and are content to let other people rise to those positions which make them "the best-known men and women of the United States." As Dr. Woods states, the Jews could not be expected to show as large a percentage, since they largely turn their attention to the banking, wholesale and retail trades, in which they have been very successful, but in which eminence is not correspondingly recognized in "Who's Who in America."

No comment is made on Jewish achievement, however, because no Jewish name is among the fifty most common in all four cities, and hence there are not enough numbers for study. But the Irish, by their traditional devotion to politics and their success in attaining the lower ranks of political leadership, would seem to be in line for recognition in large numbers, which they nevertheless do not attain.

In spite of these qualifications, however, it becomes apparent that the statistics above established can not be rejected. Although they do not exactly justify Dr. Woods's conclusions, they at least show that the intellectual achievements of different races vary. They also show that a much more extensive study of the subject must be made before any conclusions can be established as final.

We believe, therefore, that Dr. Woods's conclusion—that "there have been a few notable exceptions, but broadly speaking all our very capable men of the present day have been engendered from the Anglo-Saxon element already here before the beginning of the nineteenth century"—should be modified. A sounder conclusion and, in fact, the only one that could be reached through the results established above, would be this: Achievement in those activities represented in "Who's Who in America" is acquired disproportionately by stocks predominantly Teutonic in comparison with the Irish.

A VISIT TO OENINGEN

BY PROFESSOR T. D. A. COCKERELL

UNIVERSITY OF COLORADO

AS the Rhine broadens on its approach to the Lake of Constance or Boden Sea it flows through a region made classic by the researches of scientific men. Here at low tide it is sometimes possible to see wooden piles which in prehistoric times supported the houses of the lake-dwelling folk, whose work is so well represented in various museums, especially at Zurich. From the river, on each side, the land rises rapidly, and the rounded summits of the hills are well wooded. It is on the left side of the Rhine, about two and a half miles below the town of Stein, that we come to the famous locality for Miocene fossils, the European representative of our Florissant in Colorado.

In all the books the fossil beds are said to be at Oeningen, which is the name of a once celebrated Augustinian monastery about two miles away. Actually, however, the locality is above the village of Wangen, which is situated on the north bank of the river. In some quite recent writings Oeningen (Wangen) is referred to as being in Switzerland; it is in Baden, though the opposite bank of the Rhine is Swiss. The error is natural, since the fossils have chiefly been made known by the great Swiss paleontologist Heer, of Zurich, and the best general account of them is to be found in his book "The Primaeval World of Switzerland," of which an excellent English translation appeared in 1876.

It was at the Oeningen quarries, in the eighteenth century, that a wonderful vertebrate fossil, some four feet long, was discovered. A writer of that period, Scheuchzer, announced it as Homo diluvii testis, a man witness of the deluge! Cuvier knew better, and was able to demonstrate its relationship to the giant salamanders of Eastern Asia and North America. It forms, in fact, a distinct genus of Cryptobranchidae, which Tschudi, apparently mindful of the early error, named Andrias; though the proper name of the animal appears to be Proteocordylus scheuchzeri (Holl.). The stone at Wangen was used for building purposes, and at one time there were three or four quarries actively worked. In earlier times the larger fossils naturally attracted most attention, fishes, snakes, turtles, fresh-water clams and a variety of leaves and fruits. Such specimens were saved, and were sold and distributed to many museums. The supply was good, yet at times not sufficient for the market; so the monks at Oeningen, and others, would carve artificial fossils out of the soft rock, coating them with a brown stain prepared from unripe walnut shells. In later years, during the middle part of the nineteenth century, the period of Darwin, the great importance and interest of the fossil beds came to be better appreciated. Dr. Oswald Heer, professor at Zurich, an accomplished botanist and entomologist, did perhaps nine tenths of the work, describing plants, insects, arachnids and part of the Crustacea. The fishes were described by Agassiz, and later by Winkler. The remaining vertebrates were principally made known by E. von Meyer.

From 1847 to 1853 Heer published in three parts a great work on fossil insects, largely concerned with those from Oeningen.[1] In this and later writings he made known 464 species from this locality; but in the latest edition of "The Primaeval World of Switzerland" it is stated that there are 844 species, 384 of these being supposedly new, and named, if at all, only in manuscript.

[1] "Die Insektenfauna der Tertiargebilde von Oeningen und von Radoboj in Croatien" (Leipzig:

Engelmann).

My wife and I, having worked a number of years at Florissant, were very anxious to see the corresponding European locality for fossil insects. The opportunity came in 1909, when we were able to make a short visit to Switzerland after attending the Darwin celebration at Cambridge. We went first to Zurich, where in a large hall in the University or Polytechnicum we saw Heer's collections. A bust of Heer stands in one corner, while one end of the room is covered by a large painting by Professor Holzhalb, representing a scene at Oeningen as it may have appeared in Miocene times, showing a lake with abundant vegetation on its shores, and appropriate animals in the foreground. Numerous glass-covered cases contain the magnificent series of fossils, both plants and animals. Dr. Albert Heim, professor of geology and director of the Geological Museum, was most kind in showing us all we wanted to see, and giving advice concerning the precise locality of the fossil beds. Professor Heim is an exceedingly active and able geologist, but neither he nor any one else has continued the work of Heer, whose collections remain apparently as he left them. The 384 supposedly new insects are still undescribed, with a few possible exceptions. I had time only to critically examine the bees, of which I found three ostensibly new forms. Of these, one turned out to be a wasp,[2] one was unrecognizable, but the third was a valid new species, and was published later in The Entomologist. There can be no doubt that Heer was too ready to distinguish species of insects in fossils which were so poorly preserved as to be practically worthless, consequently part of those he published and many of those he left unpublished will have to be rejected. Nevertheless, the Oeningen materials are extremely valuable, both for the number of species and the good preservation of some of them. All should be carefully reexamined, and the entomologist who will give his time to this work will certainly be rewarded by many interesting discoveries.

[2] Polistes, or very closely related to that genus.

Provided with instructions from Professor Heim, we started on August 4 for Wangen, going by way of Constance. Thanks to the map furnished by the Swiss railroad, we had no difficulty in finding the Rosegarten Museum in Constance, which contains so many interesting fossils and archeological specimens from the surrounding region. At the moment we arrived, the old man in charge was about to go to lunch, and we were assured that it was impossible to get into the museum. It was then or never for us, however; and when the necessary argument had been presented, the curator not only let us in, but remained with us to point out all the objects of interest, showing a great deal of pride in the collection. The series of Oeningen fossils could not, of course, rival that at Zurich; but it contained a great many remarkable things, including some excellent insects. We then boarded the river steamer, and, passing through the Unter Sea, reached the small village of Wangen in the course of the afternoon. This is not a tourist resort of any consequence; the local guide book refers to it as follows: "Wangen (with synagogue). Half an hour to the east is the Castle of Marbach, now a well-appointed sanatorium for disorders of the nerves and heart. To the west the romantic citadel Kattenhorn, formerly used as a rendezvous by notorious highwaymen (at present in the possession of a pensioned off German officer)." The guide continues, calling our attention to "Oberstaad. Formerly a castle, now a weaving mill for hose. Above it (448 meters) the former celebrated Augustine monastery Oehningen. Near by interesting and curious STONE FOSSILS are found." Thus the visitor is likely to be misled as to the whereabouts of the fossils, the tradition that they are at Oeningen having misled the author of the guide. At Wangen we found a small but most excellent hotel conducted by George Brauer, where we hastily secured a room, and went out to hunt the fossil beds. We were to walk over half an hour northward, up the hill, and look for the quarries near the top of the high terrace above the village. This we did, but at first without result. We passed a small grassy pit, where some of the rock was visible, but it did not look at all promising. We went back and forth, and up the hill, until we were practically on the top. The country was beautiful, and by the roadside we found magnificent red slugs (Arion ater var. lamarckii[3]) and many fine snails, including the so-called Roman snail, Helix pomatia. We accosted the peasants, and enquired about the "fossilen." The word seemed to have no meaning for them, so we tried to elucidate it in the manner of the guide: where were the "stein fossilen"? Immediately, with animation, we were shown a road going westward to the town of Stein, where, it was naturally assumed, the object of our enquiry would be found. Quite discouraged, we wandered down the hill until we came to the pit we had noticed when going up. Close by was a neat little cottage, and it occurred to us to try our luck there as a last resort. We were glad indeed when there appeared at the door an educated man, who in excellent Shakespearian English volunteered at once to show us the fossil beds. It was Dr. Ernst Bacmeister, a man of considerable note in his own country, whose life and deeds are duly recorded in "Wer ist's?" He came, with his wife and child, to Wangen in the summer time, to enjoy these exquisite surroundings, where he could write happily on philosophical subjects, without much danger of interruption. Dr. Bacmeister informed us that the poor little pit close by was in fact one of the noted quarries, with the sides fallen in and the debris overgrown with herbage. A short distance away we were shown the others, in the same discouraging condition.

[3] The earliest name for this richly colored variety is Limax coccineus Gistel, but it is not Limax coccineus Martyn, 1784; so the next name, lamarckii, prevails.

One could see that there had once been considerable excavations, but the good layers were now deeply covered by talus, and could only be exposed after much digging. It was about thirty years since the pits had been worked. Dr. Bacmeister found for us a strong country youth, Max Deschle, who dug under our direction all next day in the quarry near the house. The rock is not so easy to work as that at Florissant, and it does not split so well into slabs, but we readily found a number of fossils. Most numerous were the plants; leaves of cinnamon (Cinnamomurn polymorphum), soapberry (Sapindus falcifolius), maple (Acer trilobatum), grass (Poacites loevis) and reeds (Phragmites oeningensis), with twigs of the conifer Glyptostrobus europoeus. We obtained a single seed of the very characteristic Podogonium knorrii. Certain molluscs were abundant; Planorbis declivis, Lymnoea pachygaster, Pisidium priscum, with occasional fragments of the mussel Anodonta lavateri. Ostracods, Cypris faba, were also found. The best find, however, was a well-preserved fish, the lepidocottus brevis (Agassiz), showing in the region of the stomach its last meal, of Planorbis declivis. This greatly interested Max, who during the rest of the day chanted, as he swung the pick, "Fischlein, Fischlein, komme!"—but no other Fischlein was apparently within hearing distance. Not a single insect was obtained, except that on the talus at one of the other quarries I picked up a poorly preserved beetle, apparently the Nitidula melanaria of Heer.

We left Wangen on the morning of August 6, and proceeded up the Rhine to Schaffhausen and Basle. At Basle we found a certain number of Oeningen (Wangen) fossils in the museum.

Comparing Wangen with Florissant, it appears that the Colorado locality is more extensive, more easily worked, and provides many more well-preserved fossils. On the other hand, Wangen has proved far richer in vertebrates and crustacea, and on the whole gives us a better idea of the fauna as it must have existed. Florissant far exceeds Wangen in the number of described species, but this is only because it has so many more insects. Each locality furnishes us with extraordinarily rich materials, enabling us to picture the life of Miocene times. Each, by comparison, throws light on the other, and while the period represented is not sufficiently remote to show much evidence of progressive evolution, it is hard to exaggerate the value of the facts for students of geographical distribution. Much light may also be thrown on the relative stability of specific characters.

Work on the Florissant fauna is going forward, though not so fast as one could wish. It is very much to be hoped that the Wangen quarries will receive attention before many years have passed. Labor is comparatively cheap in Germany, and with a force of a dozen men it would not take long to open up the quarries and get at the best beds. It is really extraordinary that no one has seen and taken advantage of the opportunities presented. Probably no obstacles of any consequence would be put in the way; at least the owner of the quarries came by when we were digging, and expressed only his good will. With new researches in the field, combined with studies of the rich materials awaiting examination at Zurich and elsewhere, no doubt the knowledge we possess of the European Miocene fauna could be very greatly increased, to the advantage of all students of Tertiary life.

THE THEORY AND PRACTISE OF FROST FIGHTING[1]

[1] Some of the instruments used were obtained through a grant from the Elizabeth Thompson Science Fund.

BY ALEXANDER McADIE

BOTCH PROFESSOR OF METEOROLOGY, HARVARD UNIVERSITY

ONLY in recent years have aerologists given much attention to the slow-moving currents of the lower strata of the atmosphere. These differ greatly from the whirls and cataracts of both low and high levels which we familiarly know as the winds. The upper and larger air streams play a part in the formation of frost, and we do not underestimate their function; but primarily it is a slow surface flow, almost a creeping of the air near the ground, which controls the temperature and is all-important in frost formation. So important is it that the first law of frost fighting may be expressed as follows:

Where air is in motion and where there is good circulation, frost is not so likely to occur as where the air is stagnant.

In other words frost in the ordinary meaning of the word is a problem IN LOCAL AIR DRAINAGE. It is true that there are times when with thorough ventilation and mixing of the air strata the temperature will fall rapidly and damage from frost result; but such conditions are perhaps more fittingly described as cold waves or freezes, as distinguished from frosts. Thus, in California during the first week of January, 1913, when there was much air movement, the citrus fruit crop was damaged to the extent of $20,000,000. The condition is generally referred to as a frost, but it was quite different from the usual frost conditions in that section. It is, however, interesting to note that improved frost-fighting devices were used with much success and the total savings aggregated about $25,000,000. The orange growers also had the benefit of accurate forecasts and expert advice and were thus able to provide fuel and labor in advance. Passing over at present the larger disturbances, we shall consider only the frosts of still nights. And it should not be forgotten that the accumulated losses of these frosts may equal the losses of the individual freezes, for the latter occur at long intervals, while the quiet frosts of the early fall and the late spring are recurrent, destroying flowers, fruits and tender vegetation in many sections, year after year.

Air may flow in any direction, but attention has been centered more upon the flow in a horizontal than in a vertical direction. Thus none of the wind instruments used at Weather Bureau stations gives any record of the up and down movement of the air. In frosts of the usual type this vertical displacement is all-important. True, there may be brought into the district, by horizontal displacement, large masses of cold air and the temperature thus materially lowered; but the marked INVERSION of temperature occurs only when these horizontal currents or winds are lulled. On windy nights, as is well known, there is less likelihood of frost than on quiet nights, because of the thorough mixing of the air vertically. There is then no tendency for stratification and the formation of levels of different temperature, followed by low surface temperature.

In general, the temperature falls as one rises in the air; but, at times of frost, it is found that the higher levels are warmer than the lower ones. The coldest stratum is found about ten centimeters (four inches) above the ground; while at a distance of ten meters temperatures are as much as five degrees higher than at the ground.

It may be well to refer for a moment to the variations in temperature known as inversions. In the accompanying diagram it will be seen that the temperature falls with elevation, and starting from the ground on a day when the temperature is near the freezing point, 273 degrees A., one finds at a height of seven thousand meters a fall of about forty degrees. It is not easy to represent on a single diagram the variation in detail and therefore we have divided the air column into three parts, the scales being as one to a hundred.

The right-hand diagram shows the gradual rise in temperature for a height of one meter and the peculiar inversion that occurs a few centimeters above the ground. Unfortunately it is in this layer where detailed temperature observations are most needed that our instruments are least satisfactory. Ordinary thermometers can not be relied on for such small differences and the exploration of this stratum by self-recording instruments is difficult. In the middle diagram is shown the temperature gradient at times of frost, from the ground to a height of one hundred meters. It will be seen that at a height of fifty meters the temperature may be ten degrees higher; and in general the rise continues with elevation. A good illustration of a valley inversion is given by the chart of May 20, in which continuous records for three levels, 18, 64 and 196 meters above sea level, are given. At such times fruit or flowers on hillsides escape damage from frost while in all the depressions and low level places the injury may be marked. These differences in temperature are not at all unusual and may be anticipated on clear, still nights during spring, fall and winter. Clouds or a moderate wind will prevent such an inversion. We shall refer again to this in speaking of the cranberry bogs of the Cape Cod district and the frost warnings issued from Blue Hill Observatory.

The great inversion in the atmosphere, however, is that which we have indicated as occurring at the height of nine thousand meters. Above this, the temperature ceases to fall and we enter what has been called the stratosphere or isothermal region. For convenience we will call this upper change the MAJOR inversion and the lower one near the ground the MINOR inversion. In some ways we know more about the former than the latter. Strictly speaking, the minor inversion is the chief factor in determining local climate since it controls night and early morning temperatures and in large measure the early or late blooming of flowers and ripening of fruits.

Ordinarily cold air falls to the ground; but not always, for under certain conditions cold, heavy air may actually rise, displacing warm, lighter air. But such conditions can be explained and there is no contradiction of the fundamental law that if acted on only by gravity, cold air, being denser, will settle to the ground and warm air, being lighter, will rise. And there must be a certain relation between the height of the level from which the cold air falls and the level to which the warm air rises. In other words, we have to apply the laws of falling bodies since a given mass of air, although invisible, is matter and as subject to gravity as a cannon ball.

One of Galileo's most ingenious experiments consisted in swinging a pendulum and then by means of a nail driven in various positions intercepting the swing. He found that the bob always rose to the same level whatever circuit it was forced to take. But Galileo did not know what every schoolboy to-day knows, that air exerts pressure and is subject to physical processes like other matter, else he would certainly have given to the world a delicate air pendulum; and devised experiments on the movement of air that would have opened men's eyes to the fascinating flow and counter-flow of the air, even on a seemingly still night, one favorable for the formation of frost.

The problem of the moving air mass, however, is more complicated than it looks. For with the air is mixed a quantity of water vapor. In a strict sense they are independent variables, and the view set forth in most text-books that air has a certain capacity for water vapor is misleading. We seldom meet with pure, dry air. A cubic meter of such a gas mixture would weigh 1,247 grams, at a temperature of 283 degrees A. (50 degrees F.). If chilled ten degrees, that is, to the freezing point of water, it would weigh 46 grams more. So that by cooling, air becomes denser and heavier. A cubic meter of a mixture of air and water vapor at saturation, at the first temperature above mentioned weighs only 1,242 grams, or five grams less, and if this were cooled ten degrees the mixture would weigh three grams less than the same volume of pure dry air. We see that in each case the mixture of air and water vapor weighs less than the air by itself. One would think that by adding water vapor which, while light, still has weight, the total weight would be the sum of both. It really is so, notwithstanding the above figures, and the explanation of the puzzle is that there was an increase in pressure with expansion, so that the volume of the air and saturated vapor was greater than one cubic meter. Since then a cubic meter of air and saturated vapor weighs less than a cubic meter of dry air at freezing temperature, speaking generally, we may expect moist air to rise and dry air to fall. Consequently, if in addition to falling temperature there is also a drying of the air, we shall have an accelerated settling or falling of cold dry air to the ground, which of course favors the formation of frost. The water vapor plays also another role besides that of varying the weight per unit volume. The heat received by the ground consists of waves of a certain wavelength; but the heat re-radiated by the ground consists of waves of longer wave-length, and these so-called long waves (12 thousandths of a millimeter) are readily absorbed by water vapor. Thus water vapor acts like a blanket and holds the heat, preventing loss of heat by radiation to space. Further on we shall speak of the high specific heat of both water and water vapor as compared with air and show the bearing of this in frost fighting; but at present we may from what precedes formulate the second law of frost fighting as follows: "Frost is more likely to occur where the air is dry than where it is moist." It is also true that a dusty atmosphere is less favorable for frost than a dust-free atmosphere. Thus we may generalize and say that whatever favors clear, still, dry air favors frost. The theory of successful frost fighting then is to interfere with or prevent these processes which as we have seen facilitate cooling close to the ground. In what way can this best be done?

The most natural way would be by conserving the earth's heat, which could be accomplished by covering plants with cloth, straw, newspaper, or perhaps better still, modern weather-proof sheeting, or in still another way by a cover of moistened dense smoke, generally called a smudge. A second method would be by means of direct application of heat; and this is accomplished in orange groves by means of improved orchard heaters. Large fires waste heat and are neither economical nor effective. A third method would be based upon a mixing of the air strata, thus getting the benefit of the warmer higher levels. Fourth, advantage might be taken of some agency such as water or water vapor, having a high specific heat. Finally, if the crop is of a certain character such as the cranberry, it will be found advisable to use sand, to drain and clean, here again making use of the specific heat of some intermediary. And, furthermore, any one of these methods may be combined with some other method.

Regarding the first method, that of covers, it may be said that the practice goes back to the early husbandmen; but only in the last few years has the true function of the cover been properly interpreted and we are still far from obtaining maximum efficiency. Nor is there yet a suitable, scientific cover available. Any medium that interferes with loss of heat through free radiation before and after sunset is a cover. The best type of cover is a cloud; and clouds, whether high or low, are good frost protectors. On cloudy nights there is little likelihood of frost; and when we can bring about the formation of a layer of condensed water vapor we can practically eliminate frost. We have mentioned above the fact that the earth radiates the heat it has received not in the same but in longer wave-lengths perhaps three times as long. These are easily trapped and held by the vapor of water. Furthermore, the rate of radiation is a function of the absolute temperature and so the rapidity of loss depends somewhat upon the heat received. Therefore the cover should be used as early in the afternoon as possible, that is just before sunset. Aside from the water cover or vapor cover there are cheap cloth screens, fiber screens and in some places lath screens.

The second method, that of direct heating, has met with much success in the orange groves of California and elsewhere. Modern heating and covering methods date from experiments begun in 1895.

A number of basic patents granted to the writer in this connection have been dedicated to the public. At the present time there are on the market some twenty forms of heaters, which have been described with more or less detail in farm journals and official publications. It is not necessary to refer to them further here. The fuel originally used was wood, straw and coal, but these are now supplanted by crude oil or distillate. It has also been seriously proposed to use electric heaters; also to use gas in the groves. With modern orchard heaters properly installed and handled, there is no difficulty in raising the temperature of even comparatively large tracts five degrees and maintaining a temperature above freezing, thus preventing refrigeration of plant tissue.

The third method, that of utilizing the heat of higher levels by mixing, has not yet been commercially developed; but the methods of applying water, either in the spraying of trees or the running of ditches or the flooding of bogs, together with methods of sanding, cleaning; and draining, have all been proved helpful. Methods available and most effective in one section may not necessarily be effective in another section or with different crop requirements. Certain devices most effective in the groves of California may not answer in Florida or Louisiana because of entirely different weather conditions. In the Gulf coast states where water is available it may be advantageously used to hold back ripening and retard development until after the cold waves of middle and late February have passed, whereas in the west coast sections conditions are very different, water having a definite value and the critical periods coming in late December or early January.

In what precedes stress has been laid chiefly upon the fall of temperature and the congelation of the water vapor. There is, however, another important matter connected with injury to plant tissue, and that is the rise in temperature AFTER the frost. A too rapid defrosting may do considerable damage where no damage was originally done by the low temperature. It is in this connection that water may be used to great advantage. Water, water-vapor and ice have, compared with other substances, remarkably high specific heats. If the specific heat under constant pressure of water be taken as unity, that of ice is 0.49; of water-vapor 0.45 and of air 0.24. Or in a general way we may say that water has four times the capacity for heat that air has. Therefore it is apparent that water will serve excellently to prevent rapid change in temperature. This is important at sunrise and shortly after when some portion of the chilled plant tissue may be exposed to a warming sufficient to raise the temperature of the exposed portion ten degrees in an hour. The latent heat of fusion of ice is 79.6 calories and the latent heat of vaporization of water is nearly 600 calories (a gram calorie is the amount of heat that will raise the temperature of a gram of pure water one degree) or in exact terms from 273 degrees A. to 274 degrees A. Therefore in the process of changing from solid to liquid to vapor, as from ice to water to vapor, there is a large amount of heat required. The latent heat serves to prevent fall in temperature and also serves to retard a too rapid rise. This does not mean, as is generally assumed, that the air will be warmed, but it does mean a retardation of temperature change. And it is essential that the restoration of the tissues and juices to their normal state be accomplished gradually, neither too rapidly nor yet too slowly.

There is probably an optimum temperature for thawing or defrosting frozen fruits and flowers. Finally the temperature records as ordinarily obtained need careful interpretation. It may be that the freezing point of liquids under pressure in the plant cells or exposed to the air through the stomata is not the same as in the free air. It is unfortunate too that in most places data showing temperatures of soil, plant and air are of doubtful character. A word of warning may be given against the too ready acceptance of Weather Bureau records made in cities and on the roofs of buildings. Garden and field conditions vary greatly from these. It is further advisable to obtain a continuous record of the temperature of evaporation such as is shown by the records herewith. The two temperature curves made simultaneously and easily read at any moment enable the gardener or orchardist to forecast the probable minimum temperature of the ensuing ten or twelve hours. But not always, and some study is necessary. A slight increase in cloudiness or a slight shift in wind direction will prevent the fall in temperature which otherwise seemed probable. With a persistent inversion of temperature there is sometimes an increasing absolute humidity.

SUMMARY

The problem is many sided and we must consider the motion of the air vertically as well as horizontally. Air gains and loses heat chiefly by convection, and any gain or loss by conduction may be neglected. The plant gains heat by convection, radiation and perhaps by conduction of an internal rather than surface character. The ground gains and loses heat chiefly by radiation. But the whole process is complicated and may not even be uniform. Frosts generally are preceded by a loss of heat from the lower air strata, due to convection and a horizontal translation of the air. Then follows an equally rapid and great loss of heat by free radiation. There are minor changes such as the setting free of heat in condensation and the utilization in evaporation, but these latent heats are of less importance than the actual transference of the air and vapor and the removal of the latter as an absorber and retainer of heat.

Frosts are recurrent phenomena reasonably certain to occur within given dates, and, as pointed out above, the cumulative losses are considerable. Methods of protection to be serviceable must be available for more than one occasion, for there is no profit in saving a crop on one night and losing it on the succeeding night. But the effort is worth while. Consider that the horticulturist regularly risks the labor of many months on the temperatures of a few hours. An efficient frost fighting device is in a way the entering wedge for solving problems of climate control. One may not take a crop indoors, it is true, but there is no valid reason, in the light of what has been already accomplished, why at critical periods which may be anticipated, the needed volume of surface air may not be sufficiently warmed; and the losses which have heretofore been considered inevitable be prevented.

THE PROGRESS OF SCIENCE

THE NEW YORK MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences held its annual autumn meeting during the third week of November in the American Museum of Natural History. The central situation of New York City and its scientific attractions led to a large meeting and an excellent program There were present over sixty members, nearly one half of a membership widely scattered over the country. When the academy was established in 1863 as the adviser of the government in scientific questions, the membership was limited to fifty which was subsequently increased to 100, under which it was kept until recently. The present distribution of the 141 members among different institutions in which there are more than two is: Harvard, 19; Yale, 15; Chicago, 13; Johns Hopkins, 12; Columbia, 11; U. S. Geological Survey, 8; Carnegie Institution, 5; California, Rockefeller Institute, Smithsonian, 4; Clark, Wisconsin, Cornell, Stanford, 3.

The scientific program of the meeting began with a lecture by Professor Michael I. Pupin, of Columbia University, who described the work on aerial transmission of speech of which no authentic account has hitherto been made public. To Professor Pupin we owe the discovery through mathematical analysis and experimental work of the telephone relays which recently made speech by wire between New York City and San Francisco possible, and we now have an authoritative account of speaking across the land and sea a quarter way round the earth. One session of the academy was devoted to four papers of general interest. Professor Herbert S. Jennings, of the Johns Hopkins University, described experiments showing evolution in progress, and Professor John M. Coulter, of the University of Chicago, discussed the causes of evolution in plants Professor B. B. Boltwood made a report on the life of radium which may he regarded as a study of inorganic evolution. Professor Theodore Richards, of Harvard University, spoke of the investigations recently conducted in the Wolcott Gibbs Memorial Laboratory. These are in continuation of the work accomplished by Professor Richards in the determination of atomic weights, which led to the award to him of a Nobel prize, the third to be given for scientific work done in this country, the two previous awards having been to Professor Michelson, of the University of Chicago, in physics, and Dr. Carrel, of the Rockefeller Institute, in physiology.

Of more special papers, some of which, however, were of general and even popular interest, there were on the program 36, distributed somewhat unequally among the sections into which the academy is divided as follows: Mathematics, 0; Astronomy, 3; Physics and Engineering, 7; Chemistry, 1; Geology and Paleontology, 6; Botany, 7; Zoology and Animal Morphology, 8; Physiology and Pathology, 4; Anthropology and Psychology, 0. A program covering all the sciences belongs in a sense to the eighteenth rather than to the twentieth century; still there is human as well as scientific interest in listening to those who are leaders in the conduct of scientific work.

The academy was fortunate in meeting in the American Museum of Natural History, where in addition to the scientific sessions luncheon and an evening reception were provided. The museum has assumed leadership both in exhibits for the public and in the scientific research which it is accomplishing. The planning of museum exhibits is itself a kind of research and in this direction the American Museum, together with the National Museum in Washington and the Field Museum in Chicago, now surpasses any of the museums of the old world and in the course of the next ten years will have no rivals there. It is interesting that the city and an incorporated board of trustees are able to cooperate in the support of the museum, as is also the case with the Zoological Park and the Botanical Gardens which the members of the academy visited in the course of the meeting.

FREDERIC WARD PUTNAM

POWELL in Washington, Brinton in Philadelphia and Putnam in Cambridge may be regarded as the founders of modern anthropology in America. In the death of Putnam, at the age of seventy-six years, we have lost the last of these leaders.

Putnam is often spoken of as the father of anthropological museums because he, more than any other one person, contributed to their development. He seems to have been a museum man by birth, for at an early age we find him listed as curator of ornithology in the Essex Institute of Salem, Mass. The Peabody Museum of Archeology at Cambridge is largely his work, he having entered the institution in 1875 and continued as its head until his death. This institution is in many respects one of the most typical anthropological museums in America. During his college career Professor Putnam came under the influence of Professor Louis Agassiz and was for several years an assistant in the laboratory of that distinguished scientist. It seems likely that this was the source of Professor Putnam's faith and enthusiasm for the accumulation and preservation of concrete data. As his interest in anthropology grew, he seems to have sought to bring together in the Peabody Museum a collection of scientific material that should have the same relation to the new and developing science of anthropology as the collections of Professor Agassiz's laboratory had to the science of biology. Professor Putnam's great skill in developing the Peabody Museum brought him into public notice and led to his appointment as director of the anthropological section of the World Columbian Exposition in Chicago The exhibit he prepared made an unusual impression and it is said that largely to his personal influence is due the interest of the late Marshall Field in developing and providing for the museum which now bears his name. After this achievement Professor Putnam was invited by the American Museum of Natural History to organize the department of anthropology which he proceeded to do upon broad lines, giving it a status and impetus which is still manifest. Later on he was invited to the University of California to organize a department and a museum similar to the one at Harvard and this also is now one of our leading institutions. Thus it is clear that the history of American anthropological museums is to a large extent the life history of Professor Putnam.

The one new and important idea which Professor Putnam brought into his museum work was that they should be in reality institutions of research. Until that time they were chiefly collections of curios brought together by purchase of miscellaneous collections without regard to the scientific problems involved. Professor Putnam's idea was that the museum should go into the field and by systematic research and investigation develop a definite problem, bringing to the museum such illustrative and concrete data as should come to hand in the prosecution of research. Professor Putnam also played a large part in securing the recognition of anthropology by universities and by his position at Harvard pointed the way to mutual cooperation between museums and universities. He possessed an unusual personality which enabled him to approach and interest men of affairs so as to secure their financial support for anthropological research and as a teacher he was intensely interested in young men, offering them every possible opportunity for advancement and never really losing personal interest in them as long as he lived.

SCIENTIFIC ITEMS

WE record with regret the deaths of Brigadier-general George M. Sternberg, retired, surgeon-general of the army, from 1893 to 1902, distinguished for his investigations of yellow fever and other diseases; of Edward Lee Greene, associate in botany at the Smithsonian Institution; of Wirt Tassin, formerly chief chemist and assistant curator of the division of mineralogy, U. S. National Museum; of Augustus Jay Du Bois, for thirty years professor of civil engineering in the Sheffield Scientific School, Yale University; of Sir Andrew Noble, F.R.S., distinguished for his scientific work on artillery and explosives; of Edward A. Minchin, F.R.S., professor of protozoology in the University of London, and of R. Assheton, F.R.S., university lecturer in animal embryology at the University of Cambridge.

THE Nobel prize for chemistry for 1914 has been awarded to Professor Theodore William Richards, of Harvard University, for his work on atomic weights. The prize for physics has been awarded to Professor Max von Laue of Frankfort-on-Main, for his work on the diffraction of rays in crystals.

PROFESSOR ADOLF VON BAEYER celebrated his eightieth birthday on October 31. With the beginning of the present semester he retired from the chair of chemistry at Munich in which he succeeded von Liebig in 1875.—The Romanes lecture before the University of Oxford will be delivered this year by Professor E. B. Poulton, Hope professor of zoology in the university, on December 7. The subject will be "Science and the Great War."

AT the recent meeting in Manchester, as we learn from Nature, the general committee of the British Association unanimously adopted the following resolution, which has been forwarded to the Prime Minister, the Chancellor of the Exchequer and the Presidents of the Board of Education and of Agriculture and Fisheries: "That the British Association for the Advancement of Science, believing that the higher education of the nation is of supreme importance in the present crisis of our history, trusts that his Majesty's government will, by continuing its financial support, maintain the efficiency of teaching and research in the universities and university colleges of the United Kingdom."

COLUMBIA UNIVERSITY received by the will of Amos F. Eno the residuary estate which may amount to several million dollars. In addition, the General Society of Mechanics and Tradesmen receives $1,800,000, and bequests of $250,000 each are made to New York University, The American Museum of Natural History, the Metropolitan Museum of Art and the New York Association for improving the Condition of the Poor—Mr. James J. Hill has presented $125,000 to Harvard University to be added to the principal of the professorship in the Harvard graduate school of business administration, which bears his name. The James J. Hill professorship of transportation was founded by a gift of $125,000, announced last commencement day, the donors including John Pierpont Morgan, Thomas W. Lamont, Robert Bacon and Howard Elliott.—The sum of about $400,000 has been subscribed in the University of Michigan alumni campaign for $1,000,000 with which to build and endow a home for the Michigan Union, as a memorial to Dr. James B. Angell, president emeritus.

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