only themselves do the best work in their power, but they will help others and will seek to make straight the way along which science must advance.

Our various scientific institutions should have the sincere support of all men of science. If our scientific journals seem less strong than those of Europe, this is not a reason for neglecting them, but rather for doing our utmost in their support. If our universities accomplish less original research than those of Germany, this should lead each to devote his best energy to research, not forgetting to advocate in season and out of season the truth that research is the essence of the university. If our National Academy of Sciences seems less active and influential than the Paris Academy, this is a reason for taking greater interest in its proceedings. If the American Association for the Advancement of Science does not accomplish as important work as the British Association, this is a reason for attending the present meeting.

Such institutions are essential for science, and those who do not aid in their support are parasites in the body politic. They are essential in part as connecting links between the man of science in his workshop and the intelligent public outside. Investigations require money; this will be forthcoming from the Nation, from the State and from the man of wealth if the needs and importance of science be brought into notice, but not otherwise. More than money, science requires recruits. The best ability of the younger men is needed and should be obtained. We must not depend on in-breeding, but should draw from the widest field.

Our scientific institutions are not only essential in order to keep science in connection with the outside world, but also to hold men of science in touch with each other. Specialization must not be carried so far that the final unity of science is forgotten, and men of science must not lose the stimulus of communication and personal contact. For, as Professor Newcomb wrote in his introduction to the new series of this JOURNAL, "The experience of centuries shows that great successes in advancing scientific knowledge cannot be expected even from the most gifted men so long as they remain isolated."

In order to do the best we can for science in America our duties are many and are often difficult and conflicting. But at the present moment the next step should be in the direction of Buffalo. The decennial meetings in that city have hitherto been successful, both from a scientific and from a social point of view. If all those will attend next week who have at some time proposed to do so, or who would if it were not for relatively slight obstacles, the meeting can be made the most important in the history of the Association.

*ZOOLOGY AS A FACTOR IN MENTAL CULTURE.**

IT is not my purpose at the beginning of this address to weary you with apologies. I

*An address delivered before the department of Natural Science Instruction of the National Educational Association, July 10, 1896.

President David Starr Jordan, of Stanford University, expected to discuss the subject of this paper before the Association, but his absence on the commission to investigate the seals in the Alaskan waters prevented him from preparing the paper and from being present at the meeting. The writer was solicited to fill the gap a few days before the meeting.

wish simply to pay my tribute of respect and admiration to the great zoologist and still greater man whom I, with you, hoped to hear this day.

It is with regret that we miss his noble presence and speech, but there is also an element of gratification, for he is the fittest possible representative the government could have chosen as head of the commission to investigate the seals in Alaskan waters, and thus to furnish the definite information upon the basis of which the two foremost nations of the globe can honorably unite in a common cause.

In the able addresses which have preceded there has been shown with great clearness and force how the mind of man, cultivated by the disciplines of physics, chemistry and botany, has been made fitter to yield the flower and fruitage of noble effort. What then has zoology contributed, and what is it likely to contribute when used as one of the agents or means in the cultivation of the mind? And as with the agriculturist, every factor is of interest which can serve in adding to the productiveness of the soil and the quality of what is produced, so to us, mind or soul culturalists, every factor in mind culture is of vital interest. What then is this zoology which is spoken of as a factor in mental culture? As botany in its broad sense includes everything known and knowable concerning plants, so zoology includes everything known and knowable concerning animals; or as botany is plant-biology, so zoology is animal-biology, and deals with the form, structure, activities, development and classification of animals and their economics or relations to each other and to man. And if we include *Homo sapiens* among the animals, it will be seen that if man and his doings are a part of zoology, zoology, like every other center of knowledge and investigation, reaches out to infinity in every direction like the rays from a luminous point.

Although most of us are engaged in the profession whose high aim is to aid in starting the young on the road that leads to a truely liberal culture, it may perhaps be best, before discussing the part which zoology has taken and may take in liberal culture, to understand distinctly what is meant by culture or education, and especially by liberal culture. It seems to me that no one has so well pictured the ideal liberal culture or education, or has realized it more surely in a noble life than the great zoologist, Huxley. Hear his definition: "That man, I think, has a liberal education, who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of nature, and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness and to respect others as himself."

What has zoology done to make such culture possible? First and foremost, it has aided most powerfully to render free the human mind; and without freedom no human soul can enter into the fullness of its kingdom; the true glory of this kingdom is not for slaves.

At the present day no Caesar on the banks of a Rubicon would make his crossing depend upon the omens gained from the flight of birds. We do not decide upon attending the meetings of the National Educational Association by the key in which

the wolf howls or the quaver of the owl's hoot. We no longer expect our acquaintances to imitate the transformations of the companions of Ulysses in the palace of Circé, no matter how appropriate such transformations might be. No longer do we expect to see birds and beasts produced in the fruits of trees or from decayed wood washed by the sea; nor do we think that bees and other insects are generated by decomposing flesh. We know that no living thing exists without having received its life from a living parent like itself. Our path is no longer beset with hippogriff, basilisk or dragon, and our high hopes and noble aspirations are no longer at the mercy of fairies and genii. Living beings, as well as lifeless matter, are subject to law. 'Thus far and no farther,' applies to them as to the waves of the sea or the rush of a comet. The fairies are fled, the genii banished, the mermaid and the remora are captured, classified and harmlessly repose as objects of curiosity or instruction in the great museums. Zoological truth has freed us from their slavery.

Now that freedom has come how shall this subject be made an efficient means of mental culture, and what will its fruit be? In the first place, as for the subjects, the discussion of which has preceded this, Nature herself must be interrogated. The successful student of zoology, to quote again the trenchant words of Huxley, "absolutely refuses to acknowledge authority as such. For him, scepticism is the highest of duties, blind faith the one unpardonable sin. And it cannot be otherwise, for every great advance in natural knowledge has involved the absolute rejection of authority, the cherishing of the keenest scepticism, the annihilation of the spirit of blind faith; and the most ardent votary of science holds his firmest convictions, not because the men he most venerates hold them; not because their verity is testified by portents and wonders; but because his experience teaches him that whenever he chooses to bring these convictions into contact with their primary source, Nature, whenever he thinks fit to test them by appealing to experiment and to observation, Nature will confirm them. The man of science has learned to believe in justification, not by faith, but by verification." To complete this first law in the Decalogue of the scientific student it should be followed by this from his address upon Descartes' Discourse: "When I say that Descartes consecrated doubt, you must remember that it was that sort of doubt which Goethe has called 'the active scepticism, whose whole aim is to conquer itself;' and not that other sort which is born of flippancy and ignorance. "But it is impossible to define what is meant by scientific doubt better than in Descartes' own words. He says: 'For all that, I did not imitate the sceptics, who doubt only for doubting's sake, and pretend to be always undecided; on the contrary, my whole intention was to arrive at certainty, and to dig away the drift and the sand until I reached the rock or the clay beneath.'"

In this spirit, then, of reverent skepticism, of scientific doubt, must the teacher of zoology teach and the student learn. And if this is the spirit, the teachers are but elder brothers a little farther advanced, knowing a few more of the delusions and pitfalls which beset the way. Teacher and pupil work together—the one inspired by the great works of all his predecessors and by Nature herself, and he in turn inspiring and helping the student in his efforts. Such teachers, such pupils and such inspiring surroundings are described by Agassiz in his notable address upon Humboldt: "I was a student at Munich. That university had opened under the most brilliant auspices. Almost every name on the list of professors was also prominent in some department of science or literature. They

were not men who taught from text-books or even read lectures made up of extracts from original works. They were themselves original investigators, daily contributing to the sum of human knowledge * * * and they were not only our teachers but our friends * * *. We were often the companions of their walks, often present at their discussions, and when we met for conversation or to give lectures among ourselves, as we constantly did, our professors were often among our listeners, cheering and stimulating us in all our efforts after independent research. My room was our meeting place —bed room, study, museum, library, lecture room, fencing room—all in one. Students and professors used to call it the little academy * * *. It was in our little academy that Döllinger, the great master in physiology and embryology, showed to us, his students, before he had even given them to the scientific world, his wonderful preparations exhibiting the vessels of the villosities of the alimentary canal; and here he taught us the use of the microscope in embryological investigation."

A rare privilege is it, my fellow teachers, to be not only teachers, but friends to our students. For Agassiz, Humboldt and Cuvier were his teachers and friends; for Darwin, were Henslow and Sedgwick. Darwin paid his debt of gratitude by never turning a deaf ear to an inquirer; and in the Origin of Species, the Descent of Man and his other works he becomes a companion to all of us and takes us into his confidence. And Agassiz, what shall we in America not say in gratitude to him! Who like him breathed confidence into the ardent young men who now are bearing the burden and heat of the day in the noble onward march of American science? Who like Agassiz showed us our rich inheritance and inspired this New World to arise and take possession of its own? As in holiness, so in literature, so in science, it is the living gospel, the living teacher whose inspiring touch awakens a spirit that thenceforward can never repose in idleness and indifference, but with a noble enthusiasm ever presses onward.

But, after all, the student comes back in his own mind to the serious personal question: How shall I begin; what can I do to gain this mental culture? Though the practice is difficult, the theory is simple. Observe, study, reflect. But reflection must always follow the others or there will result only empty subtleties, while without reflection observation and study are barren and fruitless. Perhaps it is unnecessary to add that zoological culture does not come from the study of a fourteen weeks' course, prepared by a man who does not know the subject at first hand. Learning the names and a little of the structure and some of the habits of a few animals is not zoological culture, although it may be a beginning. It is such a beginning as learning the Greek alphabet is for the appreciation of the immortal epic of Homer and the whole glorious array of Greek art and literature. Or it is such a beginning as a knowledge of the multiplication table is for mathematics. I have thought sometimes that in our enthusiasm for scientific study we have cut and trimmed and selected for our fourteen weeks' courses till verily when our students ask us for bread we have only a stone to offer.

Did Darwin think out natural selection and the survival of the fittest or Agassiz the glacial theory in fourteen weeks? Not every pupil can spend 28 years or even a tenth of that upon a single subject; it nevertheless remains true that the mental culture gained by the study of zoology will, as with other disciplines, depend *first upon the original power of the student* *and *second upon the time and energy devoted to the subject.*

*The original ability of the student is mentioned prominently in this paper because, in too many discus-

If we take some of the aspects under which zoology may be considered, as anatomy, physiology, embryology, classification and economics, and think for a moment what is involved in understanding them, perhaps it will be clear why it is so insisted upon that to gain true mental culture from zoology time is required. Time for observation and study, and, after that, time for reflection, so that there may be assimilation and some kind of real comprehension of the subjects considered. And I take it that in the comprehension gained lies the very pith and marrow of whatever culture zoology can give.†

If anatomy is considered, what a field is there for observation and study. This animal machine with its muscles and nerves, digestive system and brain, bones and sinews; what nice adaptations they show for their various purposes, and to the far seeing eye how many bungles and compromises there are too. As compared with the machines made by human hands the animal machine is as a printed volume to a simple diagram. In these archives are stored the history of the past, the ascent or the descent from something different, but like the manuscript that has been written over and over after partial erasure, so is this structure clear only in part. Some words have been spelled out, but the master to decipher the whole manuscript is yet to appear.

And physiology, that is, the activities of the living animal, how beautiful they are, how diverse. The mother love that saves the world, the mighty thought of Newton or Shakespeare are somehow bound up with or in this living matter whose chemistry and physics even, still almost wholly elude us.

Then if we turn to embryology and try to trace with patient care the work of the unseen artificer who arranges the apparently simple and almost structureless mass of the ovum into heart and brain, muscle and nerve, and changes the formless into forms of beauty and power, be it butterfly, bird or man, we cannot but receive culture and uplifting; for are we not seeing with

sions upon subjects for culture, teachers and methods, it seems to be assumed that, given a proper subject of study, a good method and an expert teacher, the desired result will be attained. That is, the material upon which the teacher works is tacitly left out of the count, and the teacher is blamed or the method or subject is condemned if cultured men and women are not turned out regardless of their ability. It is a historical fact, however, that with good or poor teachers or with no teachers, with good or poor methods or apparently with no methods, and with a great variety of subjects, cultured men and women have appeared in all ages. Subject, method and teacher are only helps that the student uses according to his ability, and important as the helps are, the result depends infinitely more upon the native ability of the student than upon the helps. Subject, method and teacher cannot create they can only modify or facilitate development.

†It is not for a moment claimed that so thorough a study of zoology as is here advocated is the only way to obtain *useful* information concerning the animals upon the earth and in the water. To continue the comparison used in the text, a little knowledge of Greek is useful in studying astronomy, and for gaining a better appreciation of English words derived from the Greek, but no one claims that such elementary knowledge is Greek culture. So information concerning edible fishes, mollusks and the ordinary four-footed creatures, a knowledge of poisonous snakes, useful and harmful insects, and many other practical and useful things, may be known about the animals, but that is not the knowledge that makes culture, although the profounder knowledge advocated in this paper and which comes with culture in zoological science includes this which in itself is merely practical and useful. Real science or culture gives foundation principles which alone make applied or useful knowledge possible in the higher fields. While I believe most thoroughly that zoology for culture is a very serious subject and one requiring much time as well as much observation and reflection, it is not desired for a moment to discourage the study of zoology, or indeed any subject, for purely utilitarian or practical purposes. While indeed such knowledge cannot be called culture, it is often true, as aptly stated by Prof. Atkinson in discussing this series of papers, that study for purely utilitarian purposes is very likely to lead to the higher kind of study which does make for culture.

our own eyes what is described in the sublime words of the Psalmist: "I am fearfully and wonderfully made * * *. My substance was not hid from thee when I was made in secret and curiously wrought in the lowest parts of the earth. Thine eyes did see my substance, yet being unperfect; and in thy book all my members are written, which in continuance were fashioned when as yet there was none of them."

Classification requires knowledge of all the above, for it is an arrangement in due order of the complex beings of the earth from the microscopic animalcule to the mighty elephant. For the classification to be successful the mind must see the true relations between all the forms, must know their structure and activities and how they were curiously wrought and transformed from generation to generation for unnumbered ages; in a word, the classifier must know their evolution; or, in the noble words of Agassiz, he must 'become the translator of the thoughts of God.'

And lastly we come to the economics of zoology, that is, the relations of the animals to the earth, the plants, to one another and to man, and his relations to them. Here one is brought face to face, not merely with the glory of living, thinking and acting, but with destiny; with the solemn fact of life *with* death, or, more truly stated, life *by* death. More are born than can possibly survive even the short span granted for the typical life cycle. Indeed, it almost appears as if nature in her efforts for life had become a Moloch of death. How graphically Darwin has painted the picture of this scene of strife, the plant crowding its neighbors to get a little more sunshine or nutriment, the animals crowding each other and devouring both the plants and their fellows; and then there is the whole foul brood of animal parasites. In these latter days we know also that the plants are not simply content to strive for sunshine and soil in order to elaborate from the inorganic world the compounds that alone make animal life possible, but in turn, a multitude of them, which no man can number, the bacteria, are devouring the animals, including man. The knowledge of this fact, so largely due to the great Pasteur, has given new significance to hygiene and a new meaning to cleanliness.

This death and disease of the animals by means of the pathogenic germs, which also bring disease and death to man, has put a new aspect upon man's relations with the animals. They are indeed his kin, and *zoological economics* may almost be said to have become dignified into *zoological ethics*. None stands or falls alone. The earth is the mother of us all, but she bestows her gifts in a very roundabout fashion sometimes. The soil, air and sunshine of Montana may furnish the conditions for the grass; the old world gave the foundations of the life which we now find realized in perfect form in the sturdy beeves which grow and fatten on the Montana grass; and finally, without a thought of the sun, or the soil of Montana, or of the life which they made possible, or of the fear and suffering which may have resulted, we calmly nourish ourselves on the beefsteak while discussing politics, education or the hereafter. But often enough to take away undue indifference, the beef or other food may contain the germs of what is death to us, although it may be teeming life to the germs; and there is forced upon us a consideration of our relations with our living environment. If knowledge and reflection are sufficient, it does not take a very great philosopher to see that the economical standpoint changes with the change of organism. For the plant, the sunshine, the soil and the rain are for it. For the plant-eating animal, sunshine, soil and rain are to produce the plant for it. And from man's standpoint, all are for him; but if we change the stand-

point slightly and judge of the workings of a tiger's mind by its actions, we would see that sunshine, soil, rain and dew, the plants, the fat beeves and even man himself are for the tiger's sole benefit.

Surely if the other sides of zoology call for imagination, acute observation, profound study and cold, logical reasoning for their comprehension, this side demands all these and in addition a philosophic spirit, that flower of the cultivated human mind.

I think what has been said will suffice to show that in zoology there is a factor of true mental culture; and that by it the philosopher, the philanthropist, the man of affairs, is better fitted in his own sphere for work and for leisure. If the student feels that some of the inspiration to this culture has departed, that the structure, function, embryology, classification and economics of animals have been almost all discovered and determined, and may be found in the ponderous volumes and monographs in the great libraries, refer him to Aristotle, Darwin, Dana, Gray or Agassiz, or to any of the devoted men and women who have been and are trying to find out the truth and to follow it, they will say: Be of good cheer, and not faint hearted. Look and listen with *brain* as well as eye and ear, for on every side are thrilling sounds whose music no human ear hath heard, and sights whose exquisite beauty no human eye hath seen.

In closing this address I cannot summarize my belief in the cultivating power of the earnest study of zoology better than by saying that a profound contemplation of the factors in the problem of animal life on the earth will bring out and cultivate the mind. It will show man his true relations to his fellow men and to his lowly fellows, the animals. It will not fill the mind with pride, for ultimate knowledge is as yet unattainable; it will rather give the humility expressed by Job: "Canst thou by searching find out God? canst thou find out the Almighty unto perfection?" or by Newton: "I do not know what I may appear to the world; but to myself I seem to have been only a boy playing on the seashore and diverting myself in finding now and then a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." And another from one of the foremost physicists of our own day, Sir William Thompson, at the jubilee of his appointment as professor of natural philosophy at the University of Glasgow: "One word characterizes the most strenuous efforts for the advancement of science that I have made perseveringly through 55 years; that word is failure; I know no more of electric and magnetic force, or of the relations between ether, electricity and ponderable matter, or of chemical affinity, than I knew and tried to teach my students of natural philosophy 50 years ago in my first session as professor." Yet there is also the pean, if not of victory, of the consciousness of power that comes to him whose mind has been truly cultured by the disciplines brought before you in this series of addresses and none has a surer right to that consciousness or with a surer voice has expressed it than the zoologist in whose place I stand to-day: "The world of thought and the world of action are one in essence. In both truth is strength, and folly and selfishness are weakness. Say what we may about the limitations of the life of man, they are largely self limitations. Hemmed in is human life by the force of the fates; but the will of man is one of the fates, and can take its place by the side of the rest of them."

SIMON HENRY GAGE.
CORNELL UNIVERSITY.

INSTINCT AND EDUCATION IN BIRDS.

THE discussion, first provoked by the note in SCIENCE of February 14th relative