much, at least, for mental discipline and culture as for their practical usefulness. Of the importance of thorough discipline in the English language and literature, history, logic and political economy it is not necessary to speak. Determinative mineralogy may be provided for in the second or third year. Courses in agricultural or pharmaceutical chemistry, or in other special fields, should differ in the details of the third and fourth years from the course outlined above.

In college and university courses, theoretical chemistry and chemical literature receive more attention, and in general less attention is given to practical applications. I do not accept the idea sometimes expressed. that original investigation should not be attempted outside of the university. We are all too well aware of the difficulties in the way of carrying on special study in connection with the responsibility of undergraduate courses; and yet I am sure we appreciate the influence of such work in the atmosphere of the laboratory, as well as upon the instructor himself. Then there are always in the laboratory bright students who are able to undertake with profit the study of special problems. As a part of the preparation for teaching I look upon a certain acquaintance with the methods of original research as an essential attainment; I do not intend to assert that without it there can be no good teachers, but it certainly strengthens the equipment of a teacher who aspires to a high position.

Earlier in this paper I endeavored to give an outline of what seem to be the principal objects to be kept in view in teaching chemistry as an educational subject. Students continue in chemistry with the intention of securing professional employment either in teaching or in applied chemistry. How often are we met with the question as to what is the prospect of employment after graduation; whether the inducements are more promising in teaching or in practical fields. Concerning teaching as a profession, the reply is easy: a person with an aptitude for teaching and with broad training has little difficulty in securing a position commensurate with his attainments, especially at present, with the wonderful extension of our educational institutions. But the number of positions is limited and there are few vacancies; if they were abundant not all persons, even with the best possible preparation, would succeed in teaching chemistry. In applied chemistry the conditions are not the same. With our enormous stores of natural products yet undeveloped, vigorous enterprise in business operations and great industrial wealth, there cannot fail to be rapid developments in the fields of manufacturing chemistry. Within the ten years just elapsed we have witnessed great changes; manufacturers who, ten years ago, conducted their operations almost without the aid of chemical skill, now employ several chemists. Eight years ago I visited a large plant for the manufacture of sulphuric acid, which contained neither a Glover nor a Gay Lussac tower. Further improvements, which are necessary for the production at home of the chemical products that are now imported in large quantities, require broad qualifications with extended experience; if our graduates are not sufficiently well trained chemists will be secured elsewhere.

If there are portions of the educational field in chemistry which appeal to us with greater force than others, perhaps the elementary teaching in the secondary schools and the advanced study in preparation for teaching or for positions requiring independent skill and originality in methods are worthy of attention. The recent growth of knowledge within special fields has introduced new features into methods of instruction. In addition to courses which are adapted for all students, those who intend to undertake investigations in any particular direction should have training under the guidance of a specialist in that field. There are many economic problems of the utmost importance awaiting solution, which require not only the application of all accumulated knowledge, but the discovery of new methods. The maintenance of a healthful water supply and the economic disposal of sewage are serious problems for the present generation, and the engineer must be aided by the best skill of the chemist and of the bacteriologist.

Every laborer is directly interested in the promotion of investigations on an economic and healthful food supply. To the great army of workmen who are struggling to support families on incomes of three or four hundred dollars a year it is a matter of serious importance to secure the best nutrition at the smallest cost. Yet it is rarely, if ever, that a judicious selection of food materials receives attention; it is usually a question of individual taste, so far as the means at hand will permit, with a complete ignorance of any principles of economy or health. In these directions and others of no less importance there are great opportunities in the domain of sanitary chemistry to render inestimable benefits to humanity.

What has been said of sanitary chemistry applies with equal force to medical chemistry, to agricultural chemistry and to other special fields. But I feel sure that the details of methods of instruction, as well as a consideration of methods based on other recent discoveries, such as the use of models in teaching structural chemistry, can best form a part of the general discussion by teachers who are especially occupied in those particular fields. Perhaps, also, the great border land between chemistry and physics, or chemical physics, should receive attention from those whose investigations are extending our conceptions of the fundamental principles of chemistry.

If I have presented this subject more especially from the standpoint of the preparation for professional occupation, it is because this seems to be the principal demand for instruction in chemistry beyond the elementary branches. But if the value of training in chemistry as a factor in liberal education has not been set forth with due prominence, it should receive just consideration in the discussion which follows. I have not attempted in this paper to include methods or conditions outside of our own institutions; yet we cannot fail to derive great benefit in extending our knowledge of the methods in other institutions through the eminent professors with whom it is our good fortune to meet.

## NOTES ON THE WOOD OR FALLOW ANT OF SOUTHEASTERN MASSACHUSETTS.

BY J. B. WOODWORTH, CAMBRIDGE, MASS.

ANECDOTES of the ant form, apparently, a large part of the minor contributions to journals of natural history. The fact that so many stories have been published, and the hope that the following will interest some student of the psychological habits of ants, encourage me to relate two observations of my own upon the behavior of the large Wood or Fallow ant (*Formica rufa*, Linné) of southeastern Massachusetts.*

While examining the sands of Horse Neck Beach, opposite Westport Point, Mass., on July 25th, 1893, I had my attention called to a large winged ant, with a reddish brown head and prothorax and black abdomen, which started to run away from a shell on which I had trodden. I stepped back a pace, when the ant, perceiving me, began to approach. Upon this movement I continued to retreat in order to get out of her way, but finding that the creature still pursued me, I was led to see how far

*I am indebted to Mr. Samuel Henshaw, of the Museum of Comparative Zoology, for reference to McCook's account of this ant in the Trans. Amer. Ent. Soc., Vol. VI., p. 253, and for naming the form here referred to.

the ant would continue the pursuit. Between the water's edge and the dry sand of the upper beach was a strip of wet sand some fifty feet wide and gently sloping. Over this area the ant followed me with strange persistence, both with and against the strong southwest wind then blowing. Not only would she follow me up on successively drier and firmer sand to the edge of dry sand, but back again to the water's edge, so that once she was overtaken by the swash of a small surf. The ant followed readily at a distance of three feet without regard to the direction of the wind, but, at a distance of six or more feet, entirely lost the trail. This circumstance, with the additional one that when I walked in a circle she would leave my footsteps and take a direct path towards me, shows that she was guided by sight rather than by the sense of smell.

When allowed to come up to me, the ant crawled under the shadow of my shoe and rested on the sand, and once crawled over the uppers, but returned to the space forward of the heel. When led to the dry sand she would cease to follow, and would begin to care for her chitin. In the course of the few minutes I gave to watching her, the ant followed me upwards of two hundred feet on the wet sand of the beach.

The difference in the behavior of this ant on the wet and dry sand seems to afford a clue to its mental processes. It seems to me probable that the ant had a sense of peril in its position on the wet sand, which was liable to be overrun by the sea, and that she turned toward me as she would have to a tree, or other high object, as a means of escape.

A more striking instance of intelligence in the same species of ants fell under my observation upon the island of Martha's Vineyard. These ants here, as elsewhere, build hills from one to three or more feet in height. The singular activity of the creatures, when disturbed, often led me to offer slight provocations to the occupants of one of these hills. On the occasion which I am about to describe, a number of workers were running back and forth over the summit of a hill, when I spat on it. At once the ants nearest the objectionable meteorite rushed towards it, and with their antennæ made an examination. These workers then ran a little distance away, picked up each a large grain of sand coated with a yellowish clayey film, and carrying it to the edge of the liquid, threw the pellet hastily in. This process, engaged in by at least a dozen ants, soon resulted in filling up the little pool. As these clayey pellets were thrown into the liquid they changed color through the absorption of the water by the clay. The absorption of the spittle by the pellets was evidently not yet complete, when all but one of the ants went about their customary walks. This solitary sentinel placed a pellet on the little heap and watched it soak up water, the pellet changing, as it did so, its yellowish color for a slaty hue. Another pellet was brought up and piled on as the others had been, but the process of absorption was now complete, and this last grain did not change color. The ant stood off at a distance of about half an inch from the grain he had deposited, intently watching the effect of his labors. When after a few seconds it was to be observed that the last grain was not affected by moisture, this ant turned abruptly away and joined his fellows, and no more attention was given to the object which had caused them so much concern.

The obvious effect of this application of clayey pellets was to prevent the moisture from penetrating through the roof of the ant hill into the cavities beneath. This was a clear case of stopping a leak, and that these ants know the value of sandy clay as an absorbent seems further illustrated by the frequency with which these clay-coated grains of sand are distributed about their hills. After rains, the ants may be seen bringing these objects up out of the peripheral holes of a hill and placing them on the dome to dry. It would be interesting to note whether or not dry pellets are taken below to serve as sponges in drying their underground rooms.

## PROBLEMS OF ZOOLOGY.*

LADIES AND GENTLEMEN :—Let me assure you that I am not unmindful of the favor shown in electing me to open this International Congress of Zoölogists.

Thirty years have nearly passed since I had the pleasure—as a then resident of this bustling city of Chicago—of listening to a series of lectures on zoölogy by Louis Agassiz, and as I recall the popular interest and enthusiasm which the great master inspired, and the singular activity and devotion of Kennicott, Stimpson and others of Chicago's earlier zoölogists, I am led to hope for a renewal of that early spirit and enthusiasm as a result of your meeting here.

Zoölogy, but a few years back, dealt chiefly with the habits, structure and classification of animals, and was weighted with two prevalent fallacies which theology had so generally impressed on the human mind. These were: the Biblical idea of the creation of organisms as they now exist and their consequent fixity and the homoistic notion that man was, in physical as well as psychical endowment, apart from, and not a part of, the rest of the animal world. Released from the oppressive incubus of these long-cherished fetiches, zoology has, during the past quarter of a century, bounded into the front rank of the sciences, with so many of which she is so intimately bound.

Inspired and guided by the search-light of Evolution, which reveals and makes intelligent so much that was hidden or unmeaning before, zoölogy must lead her sister sciences in all study of the genesis of life upon our planet, whether in past or present time. With the induction of the unity of all psychic phenomena and the conviction that these are inseparable from animal organization, it is her mission to give rational explanation of the subtlest of such phenomena and to check the vagaries which exist as to their abnormal manifestations; for even among lower animals there are senses and sense-organs not yet understood by us, while some species have developed a telepathy which, in its power and ease of demonstration, may well astonish those who have hitherto confined their investigations to man.

Deeper study of electricity, as exemplified in the animal world, may help the electrician to a better understanding of the nature of that force, the practical application of which to the affairs of civilized man has made such gigantic strides of late; while animal phosphorescence may yet illumine, when better understood, the path of the physicist in his investigations of the phenomena of light. Animal mechanics, as exhibited in flight, may hold the solution of practical aeronautics, which promises to cap the marvelous and momentous discoveries of the century; while to the inventor they are pregnant with yet untold and unthought-of suggestions.

That branch of zoölogy which concerns the interrelations and interactions of animals is not only fascinating to the philosophic student, but has a most important economic bearing, especially to those engaged in agricultural and horticultural pursuits.

But the subject which just now seems to be receiving most attention from zoölogists, is heredity, and the cognate question which has divided us into two opposing camps, as to whether or not characters and functions acquired during the lifetime of the individual are trans-

*Remarks made at the opening of the International Zoological Congress, Chicago, August 19, 1893, by Dr. C. V. Riley of Washington, D. C., as Honorary Chairman.