developing. At present there are few men whose opinion on such a subject is worth any thing, and the number constantly grows less.

The greatest difficulty partly expresses itself in, and partly arises from, the multiplication of societies which include specialists as members, and specialties as the subjects of their discussions. We no longer have much life in the old academies, where men of diverse learning once sought to give and receive the most varied teaching. The geologists herd apart from the zoölogists: and in zoölogy the entomologists have a kingdom to themselves; so have the ornithologists, the ichthyologists, and other students. 'That is not my department,' is an excuse for almost entire ignorance of any but one narrow field. If naturalists would recognize this 'pigeon-holing,' not only of their work, but of their interests, as an evil, we might hope to see a betterment. Until they come to see how much is denied them in this shutting-out of the broad view of nature, there is no hope of any change. Special societies will multiply; men of this sort of learning will understand their problems less and less well; until all science will be '*caviare* to the general,' even when the general includes nearly all others beyond the dozen experts in the particular line of research.

The best remedy for this narrowing of the scientific motive would be for each man of science deliberately to devote himself, not to one, but to two ideals; i.e., thorough individual work in some one field, and sound comprehension of the work of his fellows in the wide domain of learning, — not all learning, of course, for life and labor have limits, but of selected fields. In such a system there will be one society-life meant for the promotion of special research, and another meant for the broader and equally commendable work of general comprehension.

It is in a certain way unfortunate that investigation is to a great extent passing out of the hands of teachers. This, too, is a part of the subdivision work; but it is in its general effects the most unhappy part of it. As long as the investigator is a teacher, he is sure to be kept on a wider field than when he becomes a solitary special worker in one department.

The efforts now being made for the endowment of research will, if successful, lead to a still further tendency to limit the fields of scientific labor. A better project would be to keep that connection between inquiry and exposition from which science has had so much profit in by-gone times.

HIBERNATION OF THE LOWER VERTEBRATES.

In a recent article in *Science*, I gave the details of a series of observations of the habit of hibernation as it occurs among our mammals, and endeavored to show that this habit was not so fixed and regular as is commonly supposed.

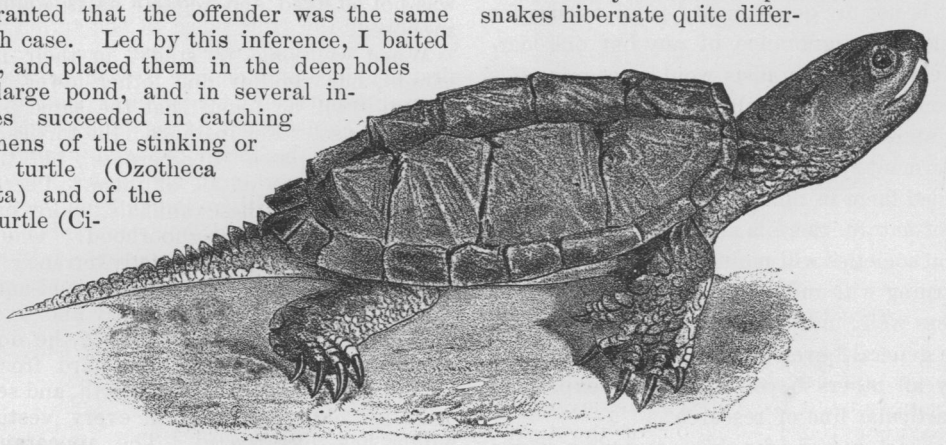
When we come to study, in their native haunts, our reptiles and other lower vertebrates, it will be found that the same is true of them also. For instance: the turtles, as a class, are supposed to hibernate; but this is not strictly true of all of them. There are nine species of these animals, more or less abundant, in my neighborhood. One, the common box-tortoise, is strictly terrene; while the others are either aquatic or semi-aquatic. The box-tortoise more regularly and systematically hibernates than do any of the aquatic species. After two or three hard frosts, it burrows quite deeply into the earth, and seldom quits its hiding-place until every vestige of winter has disappeared. The appearance of the box-tortoise is the best 'sign' of settled spring weather that I know, though it sometimes fails; but to assert that "tortoises creep deep into the ground, so as to completely conceal themselves from view when a severe winter is to follow," and that "they go down just far enough to protect the opening of their shells"[1] when it is to be mild, is nonsense. The water and mud turtles, of which I have carefully studied eight species, appear, on the approach of cold weather, to bury themselves deeply in the mud at the bottoms of ponds and streams, and to remain there until spring. This is the common impression; and a superficial glance at their haunts during the winter seems confirmatory of it. Is it, however, strictly true of these turtles? The habit of hibernating is at least affected very materially by the severity of the winter. Furthermore, in most ponds of any considerable extent, frequented by turtles, there are sure to be one or more deep holes wherein many of the

[1] Signal-service notes, No. ix.: Weather-proverbs. 1883.

turtles take refuge after the first hard or plant-killing frost. There they remain in the deeper and warmer water, when the shallower portions of the pond are coated with ice. Do they lie in the mud, in these holes, in a torpid condition?

Throughout the winter I have found that many of our fish also congregate in these same deep holes, and the turtles prey to a certain extent upon them; the snapping-turtles (Chelydra serpentina) occasionally catching one, and the other turtles feeding upon the remains of the snapper's feast. What first gave me this impression was the fact, that even in mid-winter, in nets set under the ice, I frequently found fishes that had been partially eaten; and, as this also occurs in summer, I took it for granted that the offender was the same in each case. Led by this inference, I baited hooks, and placed them in the deep holes of a large pond, and in several instances succeeded in catching specimens of the stinking or musk turtle (Ozotheca odorata) and of the mud-turtle (Cinosternum pennsylvanicum). In the same way snapping-turtles have been caught, during the severest cold weather, in deep holes, and about large springs that discharge their waters on level ground. It would seem, therefore, that, if the water remains above the freezing-point, these turtles can remain in a fairly active state, even though they do not find any large amount of food. In such spring-holes the grass remains green throughout winter; a few frogs linger in the waters; an occasional bittern haunts the spot; pike, too, are not unusual; and the snapper, therefore, has company at least, and occasionally he makes a meal of some one of the hardy visitors, which, like himself, brave the winter, and do not seek to avoid its rigors by a protracted torpid sleep. As I have not found specimens of each of the aquatic and mud turtles under such circumstances, it may be that some of them are less hardy, and do regularly hibernate for some six months of each year; and, again, it is certain that the species mentioned as active during the winter, do also, under certain conditions, regularly hibernate. The most, therefore, that can be claimed from my observations, is, that the habit, in some species, if not all, is under the control of the animal, and that its exercise is optional.

Snakes, I find, are by far the most sensitive to cold of all our animals, and avoid exposure to it by every available means. Certain of them, when hibernating, are stiff, cold, and unyielding, their condition more nearly resembling death than that of other animals under like conditions. Still we see a difference in the conditions when we compare the habit as exercised by different species. The water-snakes hibernate quite differently from upland snakes. The former seek refuge from the cold in mud beneath water: the latter burrow into dry earth. The former, when disturbed, or on exposure to the atmosphere, 'come to' almost immediately: the latter may be literally broken into pieces without giving evidence of life. By 'water-snakes' I mean, not one or two species of Tropidonotus, that are strictly aquatic, but the several garter-snakes (Eutaenia), and all those that readily take to the water when pursued, as distinguished from the terrestrial species proper, such as the black snake, adder, calico-snake, and others. Indeed, I have sometimes wondered if the true water-snake (Tropidonotus sipedon) really hibernates at all. By dipping a foot or two beneath the sand of any spring-hole, we can usually find one or more of these snakes; and, though somewhat sluggish in their movements, they are not slow to swim off when released, however cold the water may be. I have



CHELYDRA SERPENTINA (ONE-HALF NATURAL SIZE).

noticed, further, that this species and the common garter-snake (Eutaenia sirtalis) are

HYLA VERSICOLOR (NATURAL SIZE).

the first to re-appear in the spring; and, of all our serpents, these sleep least profoundly.

Passing now to the batrachians, my observations upon the hibernation of the turtles applies equally to the frogs and salamanders. The toads and tree-toads, terrestrial and arboreal animals, are more sensitive to a low temperature than the frogs and salamanders, and therefore disappear quite promptly after a few frosts in autumn, and are seldom seen again until the weather is uniformly mild. On the other hand, this does not hold with the aquatic batrachians. When the ice begins to form along the edges of the ponds, and hoar-frost has wilted the grass, frogs and salamanders withdraw to the deeper and warmer waters, — the former to the bottoms of ponds and deep ditches; the latter to the uniform temperature of the springs, and its adjacent mud. They do not, at this time, enter directly into a torpid condition. They appear, rather, to be sleeping lightly, and, when disturbed, respond by hopping or running off, as the case may be. Of course, the warm spots about bubbling springs soon become crowded, and hibernation proper is the only alternative; but those that can retain their positions in such springs quietly remain from autumn until spring, sleeping, it may be, but never becoming torpid. During the winter I have found all of our frogs, and three species of salamanders, congregated in a hogshead sunk in the ground to collect the waters of a spring. Here I have watched them closely during the winter months; and the only variation from their ordinary habits of the rest of the year was, that they kept close to the bottom of the hogshead, and seldom voluntarily moved about. All their functions were, of course, very sluggish; and life was sustained by skin respiration, as with the turtles under like circumstances.

It is scarcely necessary to pursue this subject further. What has already been said of the aquatic reptiles and batrachians is applicable to fishes. To a certain extent, these hibernate in the true sense of the term; but it is the exception rather than the rule. The first evidence of a change is seen in the withdrawal from their usual haunts as the water becomes chilled; but, if we follow this movement, it will be found to be a change from shallow to deep waters; and, unless the cold is very intense, a further change from deep water to mud is not adopted. A remarkable feature of the hibernation of fishes consists in the fact, that, while many individuals of a given species

RANA SYLVATICA (NATURAL SIZE).

may sometimes be found lying in the mud in a torpid condition, others of the same species,

frequenting the same stream, may simply congregate about some bubbling spring, that, issuing from the bed of the pond or creek, tempers the surrounding waters, and renders it habitable during the severest weather. This, it seems to me, is a marked instance of the exercise of choice on the part of fishes, and has an important bearing on the question of their intelligence; and it is, furthermore, corroborative of the statement, made at the commencement of our former article, that hibernation is a faculty which many animals possess, the exercise of which is largely, if not wholly, optional.

CHARLES C. ABBOTT, M.D.

TAIT'S HEAT.

Heat. By P. G. TAIT. London, *Macmillan*, 1884. 368 p. 8°.

THE author says in his preface, "Clerk Maxwell's work is on the theory of heat, and is specially fitted for the study; that of Stewart is rather for the physical laboratory: so that there still remains an opening for a work suited to the lecture-room."

The book before us is the best text-book for a student who is beginning the study of heat that we have seen. The author begins by giving the reader a good idea of force and energy, of the nature of heat, and of the difference between heat and temperature. Heat is a form of energy: temperature must at first be looked on "as a mere condition which determines which of two bodies, put in contact, shall part with heat to the other."

We do not, however, think that a student can get a clear idea of the second law of thermodynamics, and of absolute temperature, from the brief sketch given in chap. iv. In order to have confidence in the deductions from Carnot's cycle, a much more thorough study of thermodynamics is necessary. Chap. xi., on thermoelectricity, contains a very good account of the theory and of the experimental part of the subject. The results of Tait's experiments upon the form of the thermo-electric lines at high temperatures are given, and also a table of the calculated specific heats of electricity for many metals.

The chapter upon combination and dissociation, showing the application of the two laws of thermo-dynamics to chemical combination, is valuable, as such a discussion is not often to be found in text-books.

This book is not everywhere easy reading. Though by far the greater part can be understood by a student who has no knowledge of differential calculus, yet there are certain parts — as in the application of Fourier's method to determine the temperature of the earth's crust, and in chap. xxi., on the elements of thermodynamics — where a knowledge of calculus is necessary.

MERRIMAN'S METHOD OF LEAST SQUARES.

A text-book on the method of least squares. By MANSFIELD MERRIMAN. New York, *Wiley*, 1884. 8+194 p. 8°.

THIS author published his Elements of the method of least squares in 1877. It was favorably received; and, the edition having been exhausted, the work has been now recast, and republished under the above title. In the original work the author attempted, in the first part, to explain the method, and its application to the combination of observations, and, in the second part, to establish analytically the mathematical principles of the subject. In the present work the principles are first developed, and the applications follow: this order of arrangement must, on the whole, be better than the other. The endeavor to have the reader become practically acquainted with the subject before he makes any extended analytical study of it, may possibly enable the student who is somewhat deficient in his mathematical training to obtain a command of the method when otherwise it would be beyond his reach; but it does not seem worth while to assume that those who are to use this method are such poor mathematicians that the work should be modified in this way for their benefit. The author has done well in this new work in making a straightforward, logical development of the method and its applications. In a cursory examination of the work, it does not appear that the author has, in general, enlarged the book by materially adding to the theoretical part, which was already sufficient for the purposes in view. The additions are found in the practical portion of the work, and are of a nature to considerably enhance its value to the civil engineer, for whom the book is primarily intended.

It has seemed to the writer that the introductory chapter, which treats of the general principles of probability, might have been enlarged to advantage, or at least that the reader should have been referred to some good source of information, such as the excellent little book of Whitworth on choice and chance; as this is a subject respecting which he probably has little or no previous knowledge. Taken as a whole,