...r. A short piece of large glass tubing is fitted to the upper end of the barometer tube with a rubber stopper. Pure mercury is now poured into the barometer tube and allowed to stand at a height of an inch or more in the large tube at the top. Four or five Bunsen burners are clamped at various heights beside the gas pipe and the whole thing heated till the mercury has boiled for some minutes. A piece of iron wire worked up and down in the tube aids in removing the air bubbles. After the whole apparatus has cooled the tube may be removed and inserted in the usual manner. The height of the mercury in the tube will be found to differ very little from the reading of the standard barometer.—School Science and Mathematics.

MOSS DWELLERS.

By PROF. RICHTERS.

THE fauna of moss constitutes a very interesting variety of diminutive, often microscopic creatures, which from their smallness escape the eye of the casual observer and of which very few persons have any knowledge, for comparatively little attention has been paid, even by naturalists, to these little animals. The study of butterflies and beetles has fascinated thousands, the fauna of the ocean, streams and ponds are objects of diligent investigation, but few have given a glance to the moss dwellers.

The reader who wishes to study this little world with his own eyes is advised to select a very thin layer of soft moss, stripped from the sunny side of a rock or a tree, as the cushions of coarse ground-moss are much less densely populated. Under the thin layer of moss, and attached to it, there is usually a brownish black, peat-like layer, more or less mingled with mineral dust. This layer is also inhabited and hence it should not be detached from the moss. It is by no means necessary to use fresh material for observation. It is even preferable, for reasons given below, to allow the moss to dry, for the moss dwellers, after remaining dry and apparently lifeless for months, may be restored to life by the application of water. This remarkable peculiarity appears necessary, and therefore less astounding, when we think of the fierce, desiccating solar heat to which moss growing on walls and boulders may be exposed day after day. Creatures that live in such conditions *must* be so organized that they can adapt themselves to extreme variations in temperature and moisture. In December, 1904, I examined some moss that was gathered in Spitzbergen in August, 1903, and had lain in my warm laboratory, quite dry, for fifteen months—the greatest possible change from the long cold winters and the damp air of Spitzbergen. The moss contained large numbers of "bear animalcules" (*Macrobiotus coronifer*), all of which were brought back to life within half an hour by wetting and shaking. The promptness of the resurrection excludes the possibility of the observed living creatures having been, then and there, hatched from the egg.

The dried moss, when wanted for examination, is picked into very small pieces and, together with the dust that is thus separated, is mixed with water in a glass, stirred carefully and allowed to stand from a quarter of an hour to an hour, according to the degree of desiccation. Most of the moss rises to the surface and can be skimmed off. When the sediment, consisting of the animal moss dwellers, together with vegetable and mineral particles, has settled to the bottom the clear water is poured off. A few drops of the residuum, diluted if necessary and spread over a microscope slide, presents, with a magnification of thirty diameters, a picture resembling Fig. 2. Of course, one must not expect to find twenty different species in the field of view. In some cases the moss dwellers are few, in others very abundant. From a piece of the common forest moss, *Hypnum cupressiforme*, from the Taunus Mountains, one centimeter square and a third of a centimeter thick, I obtained 91 bear animalcules. In a quarter of a gramme of dried moss from Spitzbergen I found 121 bear animalcules, belonging to four different species, and in moss taken from an oak near Frankfort I found literally countless numbers of *Diffugia globulosa*.

The moss dwellers belong to various groups of protozoa, worms and arthropoda.

The lowest forms of life are the amœbæ (1, Fig. 2). These terrestrial amœbæ do not, like their cousins of the ponds, adhere closely to supports and creep over them. In form and translucency resembling grains of sharp sand, they move along slowly, absorbing vegetable particles, bear and wheel animalcules (*rotifera*), and everything else edible that falls in their way. It is a strange sight to see a highly organized creature fall a victim to such a lump of protoplasm. Is the gluttonous amœba devoured, in turn, by some other moss dweller? Very likely, for most of its relations are furnished with armor which protects them from some enemies, at least. One protozoon, *Diffugia*, (3) builds its house of fine sand; while *Nebela* (6), and *Euglypha* (5) secrete little scales. In *Arcella* (2) the scales are united to form a chitin-like structure, shaped like the bell of a medusa, or sea-nettle, from which protrude portions of the protoplasm which serve as organs of locomotion and are therefore called pseudopodia, or false feet.

Far more highly organized are the widely distributed terrestrial nematodes, tiny worms, nearly akin to trichinæ and thread worms. To the layman all look alike, differing only in length and thickness, and zoologists have expended much labor on the study and classification of these creatures.

To the worms belong also the rotifera or wheel animalcules (7) which swarm in every pond, and are rarely lacking in moss. In young growths they and the nematodes are always the first colonists. They are especially abundant in some specimens of liverwort (*Frullania*), the cap-shaped leaves of which form excellent lurking places. Often four or five specimens of *Callidina symbiotica* may be found under a single leaf-cap, either entirely sheltered or extending their bodies and drawing in, by the action of their "wheels," currents of water laden with decaying vegetable matter. Perhaps the excrement of the wheel animalcules is of use to the plant. If so, plant and animal form one of those partnerships for mutual benefit to which the term symbiosis is applied.

Among the arthropoda we find the creatures that

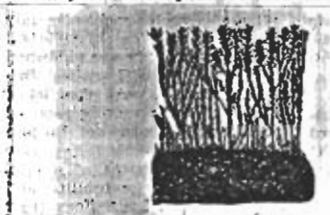

FIG. 1.—A PIECE OF MOSS TURF.

are peculiarly characteristic of the moss fauna—the very diversified mites called oribatids (10), and the bear animalcules or tardigrades (13, 14, 16, 17, 18).

The former occur also on leaves, both growing and fallen, and there are one known fresh water and two marine species of bear animalcules, but most of these animals are true moss dwellers. That the very interesting bear animalcules have been hitherto almost entirely neglected by zoologists is due, in my opinion, to the fact that so little attention has been given to their natural habitat, moss. According to most writers they live in roof gutters. On what? Tin, zinc or street dust? They are occasionally found in gutters, to which, probably, the rain has washed them from moss-grown or thatched roofs.

Their principal food is chlorophyl, which they extract with their sharp probes from the moss leaves. Their stomachs are almost always found full of half digested chlorophyl. Greeff asserts that he has often found, also, the mandibles of wheel animalcules, but a bear animalcule is rarely seen to attack a wheel animalcule.

The bear animalcules, which resemble pigs or armadillos even more than bears, are very curious creatures. Most of them are as transparent as glass, so that the whole structure of the living animal can be seen under the microscope. When dried and then molistened they remain, if not disturbed, in an apparently lifeless state in which they can be studied to the best advantage. As they are motionless and yet alive. Shaking or pressure promptly restores their activity, in many cases.

Their eggs are particularly interesting. They are usually smooth and oval, and are inclosed in the entire cast skin of the animal, which, as it carries with it all the claws, readily attaches itself to any object. These egg sacks (15) contain from 2 to 30 eggs. Many species of *Macrobiotus*, however, deposit uncovered eggs, generally spherical and provided with delicate and beautiful anchor appendages, which prevent them from being washed away by rain. The eggs of *M. antarcticus* have no anchors, but a glutinous coating which serves the same purpose.

Tiny crabs are also found in moss, even in the most unlikely places. *Ophiocamptus muscicola* (9) which I first discovered in Taunus moss, I found afterward in moss from a lofty cliff in the Sauertal, remote from ponds and water courses. Crabs, however, are evidently newcomers in the moss fauna, for they have not become sufficiently well adapted to their habitat to survive long drying, and in winter they seek warmer quarters, while the bear and wheel animalcules calmly submit to freezing.

Larvæ of small gnats and a most fantastic millipede, three or four millimeters long, *Polyxenus lagurus*, are also common in the moss of German forests.

Of many moss dwelling protozoa, including *Arcella vulgaris, Diffugia globulosa, D. constricta, Assulina seminulum, Euglypha collaris*, etc., we already know that they occur in many parts of the world, and the same thing may be true of many of the tardigrades. *Macrobiotus ornatus* (16), which I first found in the Taunus, I met again in moss from St. Gothard, Stowanger, and Spitzbergen, and Schandinn has found it on Bear Island. *M. Sattleri*, another new Taunus species, occurs also in Kerguelen Land. I have seen *Milnesium tardigradum* (13) in moss from Germany, Scandinavia, Spitzbergen, Java, and Kerguelen Land, and in all probability our commonest German bear animalcule, *Macrobiotus Hufelandi*, is equally cosmopolitan. I recently found in Iceland moss the little crab already mentioned. In my examination of the material collected by the German Antarctic expedition I have already established the occurrence in the Antarctic of eight Arctic species of tardigrades, and I was greatly astonished to find again in the Schwarzwald a very curious nematode recently discovered in Kerguelen Land and Possession Island.

The moss dwellers will surely well repay study whether regarded from the viewpoint of biology, of systematic zoology or of the terrestrial distribution of animal forms.—Abstracted for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

THE EVIDENCE OF EVOLUTION.*

By HUGO DE VRIES.

THE noble aim of university teaching is the lifting up of mankind to a higher appreciation of the ideas of life and truth. It has to cultivate the most intimate connection between theory and practice, between abstract science and actual life. Throughout the world of research this connection is felt to be the real stimulus of the work, the very basis of its existence. American universities and American science have developed themselves on this leading principle, and it is especially on this account that high admiration is given them by their European sisters. Nowhere in this world is the mutual concourse between practice and science so general as here, and nowhere is the influence of universities so widely felt as in this country. Perfect freedom of thought and investigation, unhampered rights of professing and defending one's conviction, even if it should be wholly contrary to the universal belief, are the high privileges of all real universities. Wealthy citizens spend their possessions in the founding of such institutions, convinced that this is the best way of promoting public welfare. The government liberally supplies funds for scientific research whenever its application to practical business is clear. Your system of promoting agriculture by means of experiment stations, of scientifically conducted farm cultures,

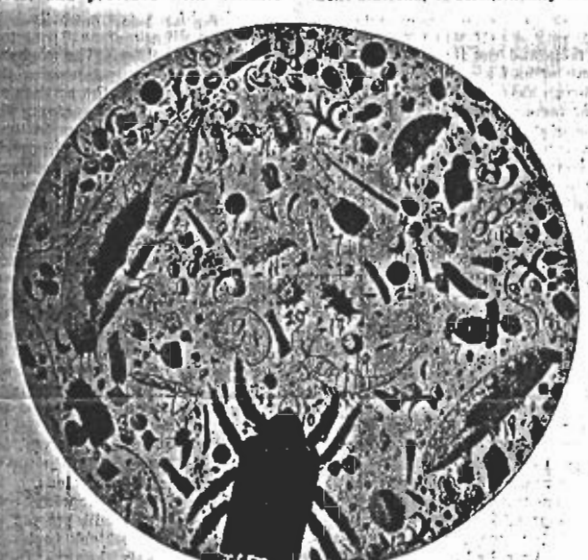

FIG. 2.—MOSS INHABITANTS.

1, Amœba terricola; 2, Arcella vulgaris; 3, Diffugia globulosa; 4, Assulina seminulum; 5, Euglypha spec.; 6, Nebela spec.; 7, Callidina spec.; 8, Nemotodes; 9, Ophiocamptus muscicola; 10, Notaxus borrilus; 11, Egg of Cunaxa setirostris; 12, Egg of Balda arenaria; 13, Milnesium tardigradum; 14, Macrobiotus Hufelandi; 15, Deposit of Macrob. tetradac.; 16, Macrobiotus ornatus tylus; 17, Echiniscus arctomys; 18, Echiniscus quadrispinosus; 19, Egg of Macrob. Hufelandi; 20, Egg of Macrob. echinogenitus.

of inquiries in all parts of the world, and of collecting, introducing, and trying all kinds of plants that might become useful crops is not only admired, but even highly envied by us Europeans.

It is not without hesitation that I have accepted the

* Convocation address, University of Chicago, September 2, 1904. Printed in the Smithsonian Institution's Annual Report.