Godman states that the differences are inconstant, that a complete gradation evidently exists between the extreme types, and that the two forms can not be considered as more than subspecifically distinct. It is undoubtedly the Atlantic subspecies *flavirostris* which regularly visits our coasts. According to the American system, Number 88 of the A. O. U. Check-list, 3d edition, should evidently stand as *Puffinus kuhli flavirostris* Hartert, Yellow-billed or Azorean Shearwater. Gerald H. Thayer

Monadnock, New Hampshire,
June 21, 1915

IRON BACTERIA

It has been known for many years that some of the higher bacteria are concerned in the precipitation of ferric hydroxide from iron-bearing waters. Thus *Crenothrix polyspora,* which is often abundant in city water pipes where the water contains a small percentage of iron, is held to be responsible for the frequent turbidity of the water in such places, due to the separating out of ferric hydroxide, and also for the filling of pipes with ferric hydroxide which sometimes occurs. Certain other forms, like *Chlamydothrix ochracea, Spirophyllum ferrugineum* and *Gallionella ferruginea,* have been abundantly encountered in surface iron-bearing waters, where they form thick gelatinous deposits of yellowish-brown scum.

More recently certain lower bacteria have been described which show the same characteristics with regard to the precipitation of ferric hydroxide and which seem to be very abundant in surface waters.

Different investigators have attempted to explain this phenomenon in different ways. Some, notably Winogradsky and Lieske, believe that there is an oxidation from ferrous to ferric iron and that this furnishes the bacterial cell with energy. Lieske also claims that, as the iron is usually in solution as ferrous bicarbonate, the carbon dioxide set free by the oxidation is used by the cell for building up its tissues. Other investigators, like Molisch and Ellis, state that the precipitation of ferric hydroxide is a simple chemical phenomenon and is not connected with the life processes of the cell. They believe that the accumulations of ferric hydroxide upon these organisms or upon their remains is purely mechanical. At the same time they admit the association of iron bacteria with iron-bearing waters, and realize that ocherous scums in such waters consist largely of bacterial remains.

Most of the investigations on iron bacteria have been made in Europe and relatively few investigators have concerned themselves with the problem. At the present time the writer is engaged in a field and laboratory study of these organisms and it is hoped that this work may throw some further light on the peculiar phenomena connected with their activities.

During the field work it has been found that iron bacteria are present in almost all iron-bearing waters, surface as well as underground. *Crenothrix* and *Spirophyllum* have been found in city waters, *Spirophyllum* and *Gallionella* have been found in the underground workings of mines even to a depth of several hundred feet, while *Chlamydothrix* and *Spirophyllum* have been found in surface iron springs and bogs. It seems that the bacterial flora of different localities varies. In some localities iron-bearing waters have a mixed flora, while in other localities one finds almost pure cultures of one or another of the higher iron bacteria. Thus some iron springs contain big, fluffy masses of *Chlamydothrix,* while others contain a brownish-yellow deposit consisting almost entirely of *Spirophyllum.* Some mines contain in their underground workings only *Spirophyllum,* while others contain mixed cultures. The reason for this difference is not known, but it is possible that the character of the salts in solution influences the bacterial flora.

Lower bacteria, of the coccus or bacillus forms which precipitate ferric hydroxide, are more difficult to study than the higher iron bacteria, as they can be distinguished only by their physiological activities. In order to determine the general distributions of such organisms in nature various iron solutions were inoculated with different types of water and soil and it was found that ferric hydroxide was

precipitated from these solutions after an interval of time which varied with the different inoculations. These experiments show the almost universal presence of organisms capable of precipitating ferric hydroxide. In order to show definitely that organisms were responsible for this precipitation, sterilized duplicates of the different cultures were prepared and these did not show any precipitation.

It was found likewise that solutions of different iron salts are affected in a different manner during these inoculations. In some solutions no precipitate forms, perhaps because the salts used inhibit bacterial growth. In other solutions, notably solutions of inorganic salts, the precipitation of ferric hydroxide takes place almost immediately, due to oxidation by oxygen present in the solvent. Certain solutions were kept under anaerobic conditions by passing carbon dioxide through them and it was found that in some of them ferric hydroxide was precipitated while in others no precipitation took place. In general the experiments have shown that precipitation may take place from solutions of ferric, as well as ferrous salts.

Up to the present the writer's attempts to isolate the lower bacteria present in soil and water, which are responsible for the precipitation of ferric hydroxide, have been unsuccessful, but it is planned to prepare and to experiment with various kinds of media in order to bring about this result. Until this isolation has been accomplished it will not be possible to study their morphology.

The morphology of the higher iron bacteria, unlike that of the lower, can be studied very readily, as they can easily be distinguished from other types due to their characteristic form. While it is comparatively easy to cultivate such forms as *Crenothrix* and *Chlamydothrix* in the laboratory, it is extremely difficult to isolate them from other forms in order to study their physiological processes. This is because of the fact that numerous lower bacteria find lodgment on the threads of these higher types, and are continually transferred with them.

One of the principal points of interest in connection with these investigations has been to note the relation that the iron bacteria might have to the formation of iron ore deposits. It has been claimed that they play an important part in the formation of numerous small deposits of bog iron ore, and it seems possible that their activities may in part be responsible for extensive beds of sedimentary iron ore as well. Further, the fact of finding iron bacteria in underground mines opens the possibility that certain underground deposits of iron ore have been formed by them.

The writer hopes soon to publish a detailed report on the results of these various investigations.

E. C. HARDER

U. S. GEOLOGICAL SURVEY

A TYPICAL CASE

I HAVE read your correspondent's letter on "A Typical Case Exemplified" in the number of SCIENCE dated May 21, 1915, and I have been struck by certain parallels and differences in his case and my own case. I feel that perhaps my case is worthy of citation.

I, too, completed my work for the doctorate in one of the oldest and largest of eastern institutions and, after having spent a year as instructor there, came to the northwest at the invitation of the president of the institution and the head of my department with the promise that I should have a *fair* opportunity for original investigation. During my sojourn of five years here, I have encountered no such conditions as cited by your correspondent and know of no such conditions in any western institution with which I am familiar. Before completing my work for the doctorate, I spent my time in three western institutions as student and instructor. In all of them, I found the research spirit freely encouraged. In my experience I have never been told that research was personal and that I must bear the expense and take time for it from my recreation and sleep. As a rule, the man imbued with the research spirit is not likely to allow such obstacles to stand in his way without surmounting them and is likely