or orange, on horizon, purple glow getting somewhat brighter; 4:30 P.M., orange glow continues on horizon, the afterglow has changed from purple to pink and is much more brilliant, extending to within 7° of the horizon, maximum brilliancy about 15° altitude; 4:35 P.M., the orange glow continues on the horizon, maximum brightness of the afterglow about 10°; 4:40 P.M., orange glow on horizon growing fainter, the maximum brightness of the secondary glow is at an altitude of 7° and is growing somewhat fainter; 4:45 P.M., primary joined to secondary glow and forms a bright orange band about 6° wide on horizon; 4:50 P.M., bright red band about 3° wide on horizon, with here and there short streams extending toward zenith, a faint purple tertiary glow has appeared at an altitude of about 45°; 4:55 P.M., red glow about 2° wide on horizon, tertiary glow brighter and extending from altitude 20° to zenith, maximum about 40°; 5:00 P.M., tertiary glow bright, with maximum about 20°; 5:05 P.M., red glow on horizon fading, purple tertiary glow still bright, with maximum about 15°; 5:10 P.M., tertiary glow fading, maximum about 10°; 5:10 P.M., reddish glow about 5° wide on horizon lasting until 5:25 P.M., when it began to fade rapidly; 5:30 P.M., red band on horizon about 1° broad and growing faint; 5:35 P.M., reddish glow still visible; 5:40 P.M., glow gone.

The duration of these sunsets was considerably longer than the normal sunsets, and it is probable that they were due to the dust from the West Indian volcanoes.

Henry Helm Clayton.
Blue Hill Meteorological Observatory.
January 11, 1903.

SHORTER ARTICLES.

Some Corrosions found on Ancient Bronzes.

At the suggestion of Gen. C. G. Loring, of the Boston Museum of Fine Arts, I undertook, some years ago, the investigation of various corrosions appearing on ancient bronzes. The large collection of Grecian and Egyptian bronzes in the Boston Museum furnishes sufficient variety to make the observations of general value. The results obtained may, therefore, be of interest to collectors and curators of other museums.

The ordinary dark green corrosion or *patina* familiar to every one, and most commonly observed on bronze statues exposed to the weather, consists of basic copper carbonate and is comparatively harmless. On very old statues, especially if they have been buried, two different corrosions have been noticed, which from their appearance may be designated as the *pale blue* and *pale green* excrescences. As will be seen later, both may endanger the life of the bronze, and especially the pale blue is the seat of an active chemical reaction.

The *pale blue* excrescence occurs in blotches all over the surface of the bronze and is especially noticeable in less exposed parts, such as indentations or cavities. It has a very fine powdery appearance and, on account of the ease with which it seems to spread from one bronze to the other, was supposed to be of bacterial origin.* A chemical analysis, however, indicates a different origin of the corrosion. About a gram of the substance was carefully collected and found to consist of 50 per cent. sodium carbonate, 25 per cent. copper carbonate, 25 per cent. sand and a trace of sodium stannate. The large percentage of sodium carbonate leads to the following theory as to the origin of the blue rust: As long as the bronze lay buried in the dry Egyptian soil, no reaction took place; on exposure to a moist atmosphere, however, some moisture condensing gave the carbonic acid of the air a chance to combine with the sodium carbonate, forming acid sodium carbonate. This then attacks the metal, forming copper carbonate and regenerating the sodium carbonate, which combines with the copper carbonate to form a double salt, thus accounting for the blue color. It is easy to see how in the course of time a large amount of metal may be thus corroded. To test the above hypothesis a fresh piece of bronze and some powdered sodium carbonate were exposed for several months to a warm, moist atmosphere. The pale blue excrescence appeared and was identical in all respects with the original rust col-

* Dr. Wm. Frazer, *Nature*, 1898, May 19.

lected from the statuettes. The pale blue rust can be best removed as follows: The statuette is immersed in a bath of hot water and live steam passed in for one hour to keep the temperature up to 100° C. The sodium carbonate is thus completely dissolved, the blue color changing to black as the sodium carbonate goes into solution. Careful brushing from time to time facilitates the process. After about one hour's treatment the metal is exposed and the rust completely removed. The dark green patina is not at all altered by this treatment. Any loosely adhering fragments of stucco can easily be preserved by exercising a little ordinary care.

The *pale green* excrescence resembles the pale blue in almost every particular except the color. It occurs in patches or layers sometimes several millimeters in thickness, and can be distinguished from ordinary patina by its lighter color and more powdery appearance. On chemical analysis it was found to contain no sodium carbonate and to consist mainly of copper carbonate. The removal of the pale green corrosion is much more difficult and liable to damage the statuette. With care, however, the following method gives good results: The bronze is immersed in a hot solution of five per cent. caustic soda for several minutes. The green color immediately turns to blue and the rust is loosened sufficiently to be removed with a dull instrument. Alternate treatment with the alkali and mechanical scraping will finally remove all of the corrosion. All of the alkali must now be removed by careful rinsing, and if necessary with a very dilute solution of hydrochloric acid. The dark green patina is also removed by this process and an ancient statue may acquire an undesirable appearance of newness.

The desirability of cleansing the bronzes at all must also be considered. In the case of the pale blue corrosion this seems necessary, as considerable quantities of metal can be destroyed by the action of the sodium carbonate. In the case of the pale green the destruction of the metal does not take place as rapidly, and other factors must be considered. If the bronze is to be used as a show specimen it is better to leave it unchanged in its antique appearance. For purposes of study, however, a complete cleansing of the surface is necessary, as tracings and engravings have often been exposed which otherwise might not have been revealed. After cleansing the statues should be kept as much as possible in a dry atmosphere. Statuettes in the Boston Museum cleansed by the above methods and placed in air-tight cases have not again become corroded. Some implements are made of very thin metal, and the removal of the thick layer of corrosion would leave too thin a shell. Such cases must be individually considered, and it is better not to place the responsibility of cleansing valuable bronzes in unreliable hands.

WALDEMAR KOCH.
CHICAGO, ILL., September, 1902.

NOTE ON THE CIRCULAR SWIMMING OF SAND-DOLLAR SPERMATOZOA.

WHILE studying artificial parthenogenesis in the sand-dollar (*Echinarachnius parma*) during the past summer, the writer independently observed that when the spermatozoa of this species are placed in a drop of sea-water on a slide they nearly or quite all gather at the upper and under surfaces of the drop and move there in circles. As seen from above, those at the upper surface move in a clockwise direction, and those at the under surface in a counter-clockwise direction. That is, since the head of the spermatozoon is directed towards the surface of the water, considered from its position the motion is always counter-clockwise.

This motion is so common as to seem at times to be universal, and it occurs without regard to the presence or absence of a cover-glass above the drop. The circle is approximately constant in size, having a diameter of about the length of the spermatozoon.

This attraction of the spermatozoon to the surface of the drop apparently shows it to be strongly stereotropic. Two possibilities suggest themselves as explanations of the circular motion. One is that the spermatozoon is differentiated in two planes, so that it has what may be called dorsal, ventral, right and left