certain crops grown in the same field, particularly corn and timothy sod. It rarely occurred in continuous culture of tobacco, and fields strongly infested with brown root-rot usually recovered after one or two years of tobacco culture. It is thought that the rate of decomposition and nitrification of crop residues is an important factor governing the occurrence of the disease. Its ephemeral character under certain conditions is well established.

Because of the facts presented under 1, 2, 3, 4 and 5, it seems that the unoxidized forms of nitrogen resulting from the decomposition of organic matter are indirectly the cause of brown root-rot. Secondly, because of its ephemeral and transitory character and its relation to the cropping system, as shown under 6, 7, and 8, it appears that the unoxidized form or forms of nitrogen concerned originate from plant residues and possibly, also, from organic nitrogenous fertilizers supplied in large quantities in tobacco culture. Finally, it appears that the rotting of the roots is due to the comparatively high concentration of nitrogen in the roots, or a narrowed carbon-nitrogen ratio, caused by rapid absorption of basic nitrogen. The basic forms of nitrogen are not in themselves toxic in the concentrations usually found in the soil, but produce a condition in the roots which makes them easy prey to decay organisms commonly present in the soil. This explanation of the cause and nature of brown root-rot is presented as a working hypothesis, awaiting further work for its substantiation or disproval.

A. B. Beaumont

NAMES OF AND SYMBOLS FOR THE ARTIFICIALLY RADIOACTIVE ELEMENTS

The system of naming the artificially radioactive elements, and especially the symbols used for these names, have apparently been adapted from the systematic naming of the naturally radioactive elements which follow radon in the radium family. Due to the number of elements known to be artificially radioactive, a possibility of ambiguity in the symbols has arisen. The symbols for radium F and for radiofluorine are Ra F and RaF; the symbol for radiosulfur and the formula of the compound radium sulfide are both RaS. The first pair of symbols is similar; in the second case, the symbol of an element and the formula of a compound are identical. In the event of a compound composed of two or more artificially radioactive elements, the formula may become very confusing: radiophosphorus radiotriiodide, $RaPRaI_3$, is an example. This could readily be confused with the formula of a molecular compound.

The systematic naming of the later members of the radium family is quite distinct from the naming of the artificially radioactive elements: the first are rad*ium* A, etc., the second, rad*io*phosphorus, etc. One is a member of the radium family of elements; the other is not. To emphasize this difference, it is proposed that the artificially radioactive elements be named in such a way that the element is considered to be of primary importance, and the radioactivity secondary: the radioactivity is indicated by the hyphenated italicized prefix *radio-*; *e.g.*, *radio*-phosphorus. This nomenclature is entirely analogous to that of isomeric organic compounds, such as *para*-nitrophenol, and the emphasis is placed on the element rather than on one of its attributes. The symbol *ra*-P contains only one capital letter, and so can not lead to the confusion now possible in chemical formulae. The symbols mentioned in the first paragraph would become Ra F and *ra*-F, *ra*-S and RaS, and *ra*-P-*ra*-I_3. The subscript and superscript now used for the atomic number and the atomic weight may be included in the usual manner. No confusion is anticipated between the symbol *ra-* for *radio-* and the *r-* (or occasionally *ra-*) which is sometimes used for racemic compounds.

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THE WEATHERING OF FLINT ARTIFACTS

I want to get some information about the weathering or patination of flint flakes and artifacts. Under the direction of the Smithsonian Institution Dr. A. R. Kelly has been doing a systematic study of the Indian mounds so numerous in the vicinity of Macon, Georgia. This is said to be the largest enterprise of the kind in the eastern United States, employing several hundred men for nearly two years. I had noted in a deep trench cut through at least four former levels of Indian civilization that there was an increasing amount of patination of the flints at the lower horizons. The study of several lots of 250 to 1,000 artifacts taken from this and other places of study seems to reveal an *average* definite increase for apparent age. The larger number, perhaps all, of these flints are derived from the near-by residuum of the Ocala limestone, one of the local upper members of the Eocene period. This limestone is associated with the unconsolidated sediments of the Coastal Plain, which have not been subjected to metamorphism.

The amount of patination found varies from zero to more than four millimeters, and the effects are found in all types of flints. The more attractive jaspers are undoubtedly affected by actinic rays, but a loosening of their silicic binding material occasionally exceeds the bleaching. Information from Dana, Merrill and others throws little light on the subject. Eoliths from Kent, England, show a different type of patination, which would prove to be affected easily by frost and other weathering factors.

No flints secured from localities of metamorphic rocks have been observed which had any such effects. Cyrus N. Ray records such patination in finds about Abilene, Texas, and Dr. A. H. Godbey read a paper before the Society for American Archeology, indicating similar observations. Both of these could have been accessible to flints derived from Coastal Plains deposits.

After a study of several thousand artifacts, we believe we are upon the track of a yard-stick for the dating of several Indian civilizations in the Southern United States, but I doubt the validity of the same set scale for other locations. The existence of Folsom man in Georgia seems very probable, though the data in Minnesota and New Mexico apparently give a much longer time than seems indicated at Macon and at other places in this vicinity. We set a provisional date of 6,500 years, but await further study to claim this, and it may be exceeded.

I ask information bearing on the matter of weathered or patinated flints in America and their probable source. The weathering of quartz and obsidian arrows does not seem to be related to that of the flints from the Coastal Plain.

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SPECIAL ARTICLES

ELECTRIC IMPEDANCE AND PERMEABILITY OF LIVING CELLS

OWING to the lack of agreement between recent papers on the electrical impedance of living cells it seems pertinent to indicate the value of the Wheatstone bridge and centrifuge in analyzing impedance. I took a university course in radio engineering and spent seven years in improving a Wheatstone bridge for high frequency currents.[1] It was shown by Richardson[2] that there is no "skin effect" in electrolytic conductors up to 8 megacycles.

A living cell is not merely a spherical drop of electrolyte solution, but the surface layer has a greater impedance than the interior. It is therefore difficult to apply Clerk Maxwell's formula for the electrical resistance of a suspension of spheres to a suspension of living cells. It simplifies the problem to centrifuge down the cells until they touch one another. I showed that erythrocytes may be centrifuged down in 6 minutes at 20,000 revolutions per minute,[3] and recently that the cells of the thyroid gland may be centrifuged down at less than 100,000 revolutions per minute.[4]

In experiments on sea urchin eggs I found[5] that the electric impedance (resistance to an alternating current) of sea urchin eggs decreased on fertilization. In order to simplify the interpretation it was necessary before the first determination of impedance to wash off the glyco-protein jelly that surrounds the egg. The method used was that of quickly (to avoid lack of oxygen) packing the unfertilized eggs down by centrifugal force in the electrode vessel, marking a line at the upper border of the eggs, determining the impedance, dispersing the eggs in sea water of the same electric conductivity as that in which they had been before packing, but to which spermatozoa had been added, and after the necessary lapse of time quickly packing them down again to the same level and determining the impedance. In this way the total impedance was more nearly that of the eggs themselves and was little affected by the film of sea water between them. It was thus not necessary to use any formula for the ratio of eggs to sea water, since sea water was in a vanishingly small quantity. This work was confirmed by Gray,[6] but later denied by Cole[7] with the words, "No specific change has been found in the interior resistance or the surface impedance which can be related either to membrane formation or cell division." In later papers, however, Cole has come to the opposite conclusion. He finds that the impedance of the surface is *reduced* on fertilization. In a study on Hipponoë eggs[8] he states, "The membrane of the fertilized egg is practically non-conducting at low frequencies and shows a static capacity 2.5 times that of unfertilized egg." Since the impedance,

$$Z = \sqrt{R^2 + \left(2\pi f L - \frac{1}{2\pi f C}\right)^2}$$

(where R = resistance, C = capacity, L = inductance and f = frequency), where C is increased the impedance is diminished. In a study of Arbacia eggs[9] Cole states: "The unfertilized egg has a static plasma membrane capacity of $0.73\,\mu f/\text{cm}^2$, which is practically independent of frequency. The fertilized egg has a static membrane capacity of $3.1\,\mu f/\text{cm}^2$ at low frequency which decreases . . . at high frequencies.

In electric impedance measurements of erythrocytes

[1] Hemingway and McClendon, *Physics*, 2: 396, 1932.
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[4] SCIENCE, 83: 283, 1936.
[5] *Am. Jour. Physiol.*, 27: 240, 1910.
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[8] *Jour. Gen. Physiol.*, 18: 877, 1935.
[9] *Jour. Gen. Physiol.*, 19: 625, 1936.