a different denominator. It is, in the present notation,

$$i = 2\frac{(aa)(bb) - (ab)(ba)}{\left\{(aa) + (ab) + (ba) + (bb)\right\}^2 - (aa)^2 + (ab)^2 + (ba)^2 - (bb)^2}.$$

For Sergeant Finley's tornado-predictions, $(aa) = 28$, $(ab) = 72$, $(ba) = 23$, $(bb) = 2{,}680$. From these data, Mr. Gilbert finds $i = 0.216$, while my formula gives $i = 0.523$.

If the questions should present more than two alternatives, it would be necessary to assign relative values or measures to the different kinds of mistakes that might be made. I have a solution for this case.

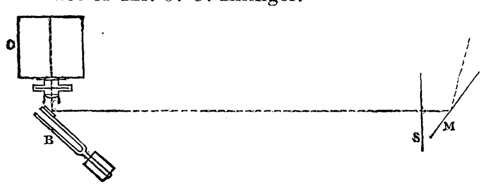
Another problem is to measure the utility of the method of prediction. For this purpose, let p be the profit, or saving, from predicting a tornado, and let l be the loss from every unfulfilled prediction of a tornado (outlay in preparing for it, etc.); then the average profit per prediction would be,

$$\frac{p \,.\, (aa) - l\,(ab)}{(aa) + (ab) + (ba) + (bb)}.$$

C. S. PEIRCE.

Measurement of the speed of photographic drop-shutters.

The usual method adopted for this purpose depends on photographing a white clock-hand revolving rapidly in front of a black face.[1] The chief difficulty in this case is to maintain a uniform rotation at high speed. To avoid this difficulty, and to determine the uniformity of exposure of any particular shutter under apparently like circumstances, the following method has been suggested. In carrying out the experiment in practice, I have had the assistance of Mr. J. O. Ellinger.



A tuning-fork, B, with a mirror attached to the side of one of the prongs, is placed in front of the camera-lens. This mirror is so arranged as to reflect into the camera, C, a horizontal beam of sunlight, which, before reaching the fork, has passed through a half-inch hole in a screen, S, placed about ten feet distant. This produces on the ground-glass a minute brilliant point of light. If the fork be set vibrating, the point will become a short, fine, horizontal line: if the fork be rotated about its longitudinal axis, the line will become a sinusoidal curve described on the circumference of a circle of long radius. A photographic plate is now inserted, and the drop-shutter attached. On releasing the latter, it will be found that a portion of the sinusoid has been photographed; and the precise exposure may be determined by counting the number of vibrations represented on the plate.

The mirror employed should be somewhat larger than the lens to be measured, so as to cover its edges during the whole exposure. The mirror may be glued directly to the prong of the fork with strong carpenter's glue, after first scraping off a little of the silvering at the edges of the glass. The rate of the fork is then determined, by comparison with a standard fork, by the method of beats. W. H. PICKERING.

Photographic laboratory,
Mass. inst. of technology.

[1] For other methods, see *Brit. journ. photography*, Aug. 31, 1883, and May 23, 1884.

THE IMPORTANCE OF CHEMISTRY IN BIOLOGY AND MEDICINE.

THE position of chemistry in the biological sciences has long been, in English-speaking communities, a very indefinite one: in fact, it may be questioned whether the science has, even at the present day, any generally recognized position among biologists themselves. That this has been the case for many years, even in Europe, is evident from the fact that until recently the published results of investigation in the field of physiological chemistry have had to be sought for in widely diverse places. Many papers have been published in purely chemical journals, others in journals devoted to physiology, while still others have appeared in so-called 'natural-history' journals, — a fact which in itself plainly indicates the past status of this branch of science.

There can be no question that physiological chemistry should occupy a definite place among the biological sciences. Biology is confessedly a study of life, and, as such, has to do with the development, structure, and function of living organisms. The first two of these we suppose to be included under the heads of embryology and morphology; while the third, constituting, in the words of Herbert Spencer, "the second main division of biology, embracing the functional phenomena of organisms, is that which is in part signified by physiology." Further, "that part of physiology which is concerned with the molecular changes going on in organisms is known as organic chemistry," or, with equal propriety, as physiological chemistry: hence a study of the functions of the body, to be at all complete, must include a study of the chemical changes incident to life, and cannot be restricted to the purely physical phenomena of the organism. Yet it is very noticeable that wherever 'biology' is taught in this country, even in the most liberally conducted institutions, where the course of study embraces embryology, animal and vegetable morphology, experimental physiology, etc., physiological chemistry is rarely mentioned.

We need to inquire whether this is due to a lack of appreciation of the importance of the subject, or whether it is generally considered as outside the pale of biological inquiries. We are more inclined to believe that the rapid development of the past twenty years in the various branches of biology, so divergent from chemistry, has tended to push into the background the chemical phenomena of life to such an extent that the existence of chemical science as a part of biology is in danger of being forgotten.

Physiology in its entirety, dealing with all the functions of the living organism, both animal and vegetable, is truly a broad subject; but that by itself does not constitute a sufficient reason why the chemical composition and chemical processes of the organism should be so seldom studied. By this it is not meant that all applications of chemistry to physiology are overlooked, or that there is an utter lack of appreciation of its importance, but rather that the average instruction in physiology in this country, and apparently likewise in England, disregards almost every thing pertaining to chemistry, aside from the common fundamental facts; so that, whether as a part of physiology, or as physiological chemistry, the average student in biology acquires but little knowledge of the chemical processes of the animal organism; by 'knowledge' being meant that personal knowledge, which, in the case of an experimental science, can be obtained only in a properly equipped laboratory.

But while in America little has been done either to advance or to teach the chemical side of physiology, in Europe it has been very different, until now as a growing science, following a natural law of progressive division of labor and of thought, the chemical phenomena of the living body have massed themselves together, and, aided by increased interest and added workers, a division of physiology has become necessary; and to-day there exists, in Germany at least, a new science, or rather a specialized portion of an old one, viz., that of physiological chemistry.

We would lay all possible stress on the important position of physiological chemistry in Germany, its relation to medicine and biology in general, the large number of important researches emanating from her laboratories, and on all that tends to make the science so progressive in that country; and then, by contrast, how small and insignificant appears the little work done in our own country! If we look to the biological laboratories of our colleges, to our medical schools, and to the laboratories connected with our hospitals, we find an almost utter lack of work tended to increase the boundaries of the science. Seldom do we hear of a piece of original work in physiological chemistry; and few American names are being added to that long list of German investigators whose united work has made the science what it is to-day.

There is also a practical side to this question. Not every medical student, it is true, can become proficient in physiological chemistry, there is not time for it; but many a man gifted with powers of observation, and endowed with a love of knowledge, may find much to do of direct practical value to medical science. Every student of medicine should, however, possess some knowledge of physiological chemistry. Dr. Perkin, in his recent address before the Chemical society of England at its anniversary meeting, says, "If there is any value in chemical products as curative agents, if there is any value in physiological chemistry, or any importance in toxicology, surely medical students should have a sound knowledge of chemical science, and not simply learn to detect an acid and a base in a mixture, — an operation which is of no value, except as an intermediate exercise to be followed by more advanced work."

What is needed in this country is a fuller appreciation of the importance of physiological chemistry, both in biology and in the science of medicine. A host of questions are to be answered regarding digestion, nutrition, respiration, etc., — questions to be answered only through the agency of chemical science; and, if America is to do her share in the clearing-up of the mysteries surrounding the chemical processes of the living organism, physiological chemistry must be raised to a higher plane among the biological sciences.

THE NAVIGATION OF THE NILE.

THE Nile, which during thousands of years has attracted much attention from the intelligent portion of mankind, yet remains in many respects the most interesting of the great rivers of the globe. Its sources, which for so long a time were a mystery, have within the last quarter of a century been rediscovered; but that rediscovery has only rendered it more interesting, and more worthy of study.

The great fluctuations in its flow, and the remarkable, almost mathematical, regularity, year after year, of these fluctuations, can now be practically studied, and their causes clearly understood.

Having its great first reservoir under the equator, we now know that it derives its waters from the region between a few degrees south of that line, and latitude about 13° north. It receives its last affluent, the Atbara, south of latitude 13° north, and yet continues its flow, notwithstanding evaporation, receiving nothing, and giving life to the lands it traverses, until it pours the waters of south central Africa into the Mediterranean Sea, in latitude 32° north, carrying in those waters, each year, masses of the *débris* of the mountains of the interior to continually fertilize and extend its delta.

Early in June of each year the flow is the least. The current near Cairo has then a rapidity of only a little more than one mile per hour, and the amount of water passing is only from four hundred to five hundred cubic yards per second. Before the end of June the annual rise commences; and by the end of September the rapidity of the current reaches nearly, if not quite, three and a half miles per hour, the quantity of water passing a given point becoming from *nine thousand* to *ten thousand* cubic yards per second.

Late in October, or early in November, it commences a somewhat rapid decline, which continues until January, when the decline becomes more gradual and regular; this gradual decline continuing until about the end of May, when the minimum flow is again reached, to give place the following month to the new annual rise.

The great regularity of the fluctuations is due to the peculiar sources of supply, and the admirable system of reservoirs and checks which nature has there provided.

The Egyptian Nile is formed by the junction, at Khartum, of the Blue Nile and White Nile.

The Blue Nile (*Bahr-el-Azrack*), taking its rise in the centre of Abyssinia, and fed by the rains which yearly fall in the mountains of that country during the months of April, May, June, July, and August, furnishes the great masses of water which cause the rapid summer rise, and also furnishes the rich silt, which, torn from the mountains of Abyssinia, spreads over the cultivatable lands of Egypt, and yearly renews the fertility of those lands.

The White Nile (*Bahr-el-Abiad*), flowing from the great reservoir under the equator, guarded in that and the subordinate reservoirs, Lake Ibrahim and Lake Albert, and guarded also by the great system of dams called 'the cataracts,' furnishes the steady flow of clear water which continues throughout the year.

No human engineer has ever devised, on any thing like so grand a scale, so admirable a system for the collection, preservation, and distribution of irrigating waters, as has there been formed by nature for the supply of Egypt.

Lake Victoria, with a surface of some forty thousand square miles, collects and stores, for the use of the Sudan and Egypt, the rainwater falling on a basin of more than a hundred and sixty thousand square miles of surface. The average yearly rise of the lake may be fairly taken, according to observations made on the spot, as two feet, which gives for distribution through its only outlet, the Victoria Nile (the Somerset of Speke), the enormous volume of more than sixty-eight thousand million cubic yards of water per annum, or more than two thousand cubic yards per second.

It will be seen that this storage is so well devised, that, in order to give *one inch* of rise to the Victoria Nile, more than *twenty-eight hundred millions* of cubic yards must be stored in this great reservoir.

Then come the two secondary reservoirs,— first Lake Ibrahim (discovered by Col. Long in 1874), in latitude north $1\frac{1}{2}°$, which must be filled before the flow can continue on towards Egypt; and then Lake Albert, which must be filled over its surface of perhaps three thousand square miles before the direct distribution of waters through the White Nile can fairly commence. But this is not all that nature has there done to regularize the great distribution. Between Lakes Ibrahim and Albert, there is a great system of natural dams in the cataracts which are found between Foweira and Lake Albert. Then coming north, down the White Nile, we find, first at Duffli, and soon again at Beddin, successions of rapids, the results