sociate Professor C. L. Eddy was made professor of railroad engineering; O. M. Stone was advanced to assistant professor of descriptive geometry, W. E. Nudd to assistant professor of drawing, T. D. Owens to assistant professor of electrical engineering, C. F. Prutton to assistant professor of chemical engineering, H. D. Churchill to assistant professor of mechanics, Max Morris to assistant professor of mathematics and K. H. Donaldson to assistant professor of mining engineering.

PROFESSOR R. W. REID has handed in his resignation from the chair of anatomy at the University of Aberdeen, which he has held since 1889.

PROFESSOR RICHARD GOLDSCHMIDT, junior director of the Kaiser Wilhelm Institute for Biology, Berlin, has declined the chair of zoology in Berlin University.

DISCUSSION AND CORRESPONDENCE

THE "UNDERTOW"

PEOPLE who have had long experience in bathing in Lake Michigan state—and they state correctly—that there are, at certain times and places, currents which may carry a swimmer away from shore and therefore put him in danger of drowning. The bathers speak of such currents as "undertow." Professor Walter C. Jones[1] writes that the undertow is a myth, and he gives the impression that there are no currents dangerous to bathers in Lake Michigan. It is possible that some reader who trusts this impression and acts upon it may be drowned in consequence. Therefore I write to state that there *are* dangerous currents in Lake Michigan and that they are the currents which the bathers (correctly or incorrectly) name "undertow"; and I shall give a brief account of *one* set of conditions under which these currents are produced.

During a northeast storm at Chicago there is a very considerable movement of surface water toward the shore. But this movement is complicated by certain local conditions. The wind from the lake blows, as a rule, not at right angles to the shore, but obliquely from a northerly direction. Consequently, as the wind drives the surface water before it, it causes a drift along-shore southward. At a point here and there on the beach the southward drift is blocked by a pier—a straight, solid wall extending vertically out from shore. On meeting the pier, the southward drift is turned from its course, and in some cases it produces a current which flows directly away from shore, which is strong at the surface and extends to an unknown depth, and which is swift enough to prevent the average swimmer (at least) from making any headway against it. Near 75th Street, Chicago, when I used to swim there, we bathers made it a rule to keep far away from such piers as I have described during a northeast storm.

The fact that Professor Jones never encountered such a current is not at all surprising. It simply means that he never swam in the lake under the special conditions of time and place under which the current comes into existence. Shore currents in general are local and variable phenomena; that very fact makes them dangerous.

The warning here given to bathers in Lake Michigan should be extended to surf bathers elsewhere. There are many surf beaches on which a dangerous outward current exists at certain times, and the people call it an "undertow." I do not know whether they are correct in naming it an undertow, but the important fact remains that the dangerous current exists and that "undertow" is the common name for it. At any bathing beach in the United States, if an intelligent and trustworthy native tells you that he has at times observed an undertow on that beach, do not dismiss his statement as a myth, but understand what he means by it. He means that he has observed a dangerous current of some sort. Give heed to his warning.

WALLACE CRAIG

BIOPHYSICS LABORATORY,
HARVARD MEDICAL SCHOOL

I HAD just got the salt water out of my throat after an encounter with what would commonly be called an "undertow" when I read Professor W. M. Davis's article on the subject, and believe that I can offer some relevant observations. They will support Mr. Davis's protest against the common conception of an "undertow," although I can assure him that the seaward current is sometimes more persistent than he is willing to concede.

I might, perhaps, be classified as an expert swimmer, although not as a powerful or fast one. That is, I can swim several miles without resting, when in practice, and use the breathing system employed in the Australian crawl. Because swimming and breath control are automatic, I was able to observe the conditions in this "undertow," despite the alarm one feels when the conditions of the bath are not of his choosing.

I went swimming a few days ago at Carmel-by-the-Sea. There was a light offshore breeze. Carmel has a "pocket beach" of the most pronounced type, about three miles across at the entrance, a couple of miles deep and rounded in the center. It is exposed to the full sweep of the Pacific, and shelves quite rapidly to deep water.

[1] SCIENCE, Vol. LXI., April 24, 1925, p. 444.

The water was waist deep in the trough when I started to swim. I had taken only a few strokes when I glanced toward shore and saw that it was nearly a hundred yards farther away. I let down in a trough and touched bottom with my toes, but drifted outward into water that was over my head. There was no perceptible difference between the rate of flow at the surface and near the bottom—it was all outward.

After that, I began swimming shoreward, but went steadily seaward, in spite of the repeated breakers that went over my head. Perhaps, as Mr. Davis contends, the entire current changes with each breaker, but if so, this was an instance in which the outflow was far more powerful, in its effect on a swimmer, than the inflow. I could observe that the shore was steadily receding, and people on shore told me afterward that I kept going out while swimming in. That point is definite, and it was not confined to a single trough. At least half a dozen breakers went over during this phase.

Next, I came to an apparent standstill just under the crest of the outermost breaker. While a dozen breakers were passing, my swimming and the inflow of the breakers just about balanced the outflow of the troughs.

The last phase consisted of a powerful shoreward drive of the breakers, four or five of them, with little outward movement in the troughs. These breakers, with my swimming, took me into shallow water.

The only point I would flatly challenge in Mr. Davis' article is that there can be no "undertow" in a pocket beach without an onshore wind. I noticed the offshore wind in particular, because of the drift of the clouds in an afternoon when the sunny intervals were comfortable.

But in the main the "undertow" was not an undertow. The troughs all ran outward, and if there was a conflict of currents in the breakers, it was not noticeable.

I think Mr. Davis's article overlooked one important point in the analysis of these offshore currents, and that is the succession of high swells and low swells. I started to swim at the end of a succession of high swells, when there was a great amount of water to run off the beach. The succeeding low swells—and small breakers—could not stem this outward movement. Later came another series of high swells and big breakers, the outgoing troughs were completely flooded and the general movement of the water was landward. I know that while I was going out, the breakers were small, while just before they began to carry me shoreward they were curling six feet above my head.

I can add two or three observations which may help to explain the belief in an "undertow." The trough is a steady current seaward, which carries all objects at its own speed. The breaker is a tempestuous dash of water, which goes well past a swimmer before it checks his outward movement. This creates the impression that the main current is seaward, because the seaward current is the more effective as a carrier.

In the second place, the inexperienced swimmer, if taken out by the receding water of a succession of big breakers, loses control of his faculties before he is brought in by the next succession of big breakers. He goes under, and that is the end of him, and he seems to have been pulled under by an undertow when in fact the water merely piled on to him.

The fact is, though, that "undertows" are believed in a thousand miles from the ocean. Whenever somebody strangles in a freshwater mill pond, there is some newspaper reporter to characterize it as the work of a mysterious undertow.

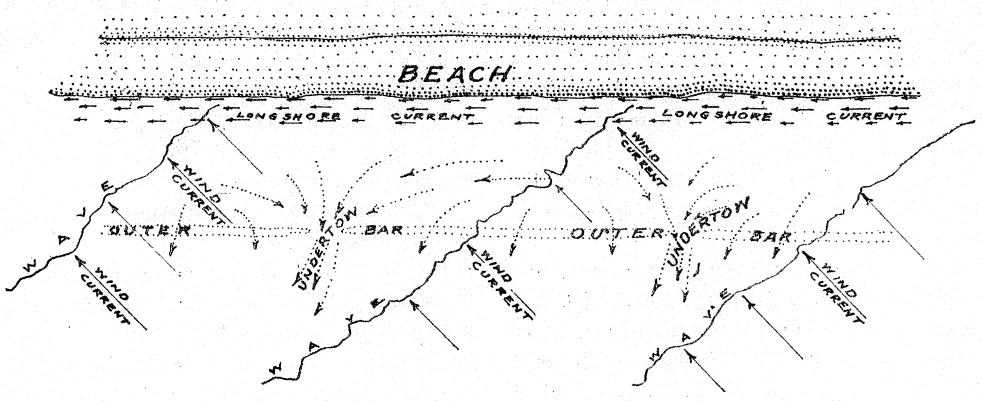
The combination of powerful breakers and a bottomless trough can be quite uncomfortable without any actual undertow, but in the case I have described I found that the bad feature was the light specific gravity of the breaker after it had begun to froth. A swimmer breathes out through his nose, or holds his breath, by exerting pressure from his lungs slightly greater than, or equal to, the pressure of the water in his nostrils. Meeting the accustomed pressure becomes as natural, and as automatic, as breathing in the air. I found that in the frothy breakers I breathed out too fast, with the result that I kept gulping salt water. Let me emphasize that ability to control the breath is far and away the most important factor in dealing with tumultuous water. Without it, swimming ability is next to worthless. A poor swimmer who is a good "water breather" will come through currents that the most powerful athlete, lacking breath control, would struggle against in vain.

In the second place, a person caught in a seaward current should swim flat on the surface and offer all possible resistance to the breakers, so that they will pick him up instantly, out of the receding trough, and carry him on their crest.

I. BRANT

THE flat sandy beaches of our Atlantic Coast have a menace for bathers which is usually spoken of as the "undertow," though this is a grossly misleading term. This menace is elusive, for it varies widely in violence and at times is entirely absent so that even some scientists suspect it to be a myth.

Generally speaking, this menace is real when a



wind is blowing onshore and within an hour or so, either way, of high tide. It is most real and apparent at the top of the tide with a strong onshore wind and a high surf. Possibly the best sign is water warmer than the air. The cautious bather entering the surf near high tide may well take alarm if he find the water much warmer than usual, the surf high and a strong wind blowing from off the sea. If he will look along the beach carefully it is quite likely that he will discover, at varying intervals, streams like small rivers running through the surf directly out to sea. These streams or rivers are the so-called "undertow," and the swimmer may well avoid them, the menace, the widely heralded, sadly misnamed "undertow."

The "undertow" is not, as some imagine, a hidden current of water running along the bottom all along the beach and of approximately equal velocity everywhere. It is a sort of river, a stream showing on the surface deep and powerful, easily perceptible, running with the velocity of a mill race. So swift and powerful is it that a motorboat could not stem its sweeping current. It will carry brick, large rocks and even chunks of lead far out to sea. The most powerful swimmer will find himself helpless as a babe in its rushing grasp. He will find his utmost exertion of no avail in opposition, though if he understands its nature he may easily swim across it to the quiet zone on either side. He may find this unfitly named as a zone of quiet, for it is a surf zone where wild waves break with greatest vigor, but their trend is shoreward and in it he may with skill and patience win the beach and safety.

The "undertow" is not always present; days and days may elapse with hardly a sign of it. Now comes the full moon, the "spring" tides, a fresh ocean breeze and a powerful surf begins to mount. The beach is delightful, there is life and action in nature and bathers are enticed into the surf where they are overjoyed to find the water delightfully warm. They do not realize that this warmth is deceptively due to their enemy, the onshore wind, which has blown the warm surface layer of water into the surf. They joy only in the contact of pleasantly warm water, until one more adventurous than the rest suddenly recedes farther and farther from them and only, long afterward, they realize their menace in the misnamed "undertow."

Practically all sand beaches have what is called an "outer bar," a shoal, entirely submerged, cast up by the first breaking surf waves. This outer bar is parallel with the beach and from one to six hundred feet seaward from it. This bar and the beach form a narrow basin.

Waves are of two kinds—"oscillation" and "translation." Deep water waves are of the oscillation type, in which the water undulates but does not move forward. When this type reaches shoal water it changes and becomes the translation type in which the water itself is carried forward with the wave. The hardy bather who has breasted a powerful surf and been thrown about by the tons of moving water readily realizes that surf waves are actually moving water waves and much different from those he encounters off shore.

Practically all surf waves are of the translation type, and the water in them is carried forward to the beach and into the basin formed by outer bar and beach. Under favorable conditions these waters "heap up" and fill this basin to overflowing. Obviously there must be an escape for these heaped-up waters and the misnamed "undertow" is their method and means of escape. Low points form in the outer bar and widen and deepen until a sort of river appears every few hundred feet along the beach. This is the misnamed "undertow," the heaped-up waters carried shoreward by wind and wave escaping back to the sea.

The wind itself tends to heap up water in the shore basin, but this is of little moment as compared

with the enormous quantities swept there by the surf waves.

Let the bather beware, the "undertow," however incorrectly named, is real and a serious menace to the most powerful swimmer. Beware the treacherously warm water and stay away from the outer bar at high tide with onshore wind and strong surf.

M. P. HITE

ELIZABETH CITY, N. C.

AMONG a number of letters received from observant surf bathers on the Atlantic and Pacific coasts, most of whom agree that there is no such thing as a persistent undertow, is one from Miss L. R. Craig, Agawam, Massachusetts, who gives a graphic account of a true undertow experienced when swimming opposite the middle of a concave or pocket beach between rocky points at Hampton, New Hampshire, in July, 1923; although she is an expert swimmer, a current was felt like that of a river, except that it was below the surface so that it dragged her under water; she was pulled down as if by suction in water over her depth. She escaped by swimming obliquely to the shore, as it was impossible to make headway against this undertow. The note is added that "strong men have been drowned at Hampton Beach by undertow." This would therefore seem to be an example of the kind that I mentioned in my article on "The Undertow Myth," except that no mention is made of an on-shore wind as its cause; but the day was "cold and dreary," thus implying a wind from the ocean.

It is because of the occasional occurrence of such verified undertows that I regret the use of that ominous term by Mr. Hite in his letter above, as applied to surface streams. It appears to me also that he gives too great importance to the transformation of oscillatory into translatory waves as the surf rolls on shore, and also to the off-shore bar, as causes of the local, outflowing streams. An on-shore wind would tend to brush the surface water shoreward without a bar on the bottom and without that transformation at the surface; and compensating outflows might then be produced at various points along a straight beach. But the term, undertow, should not be applied to them.

Mr. Brant misunderstands me if he thinks I am not "willing to concede" the existence of any current, surface or elsewhere; such currents are well attested by observation; for example, the general seaward surface drift that he describes as occurring for a time in a bay on the California coast; but such a current appears to be quite different from a possible "undertow," either there or elsewhere. Furthermore, I see no sufficient ground in Mr. Brant's observations for his "flat challenge" of my suggestion that a real *under*tow may be caused in a bay by an *on*shore wind: the *surface* current that he observed in a bay during an offshore wind seems to me aside from the case. In the interest of clear discussion, I think it is undesirable to use the word "current," in describing the oscillatory movement of the water in swell and surf: the essence of a "current" is a persistent movement in one direction over a considerable area for a considerable time. True, the term is used in naming the flood and the ebb of the tides, which are, in relation to great oceanic spaces, local and temporary; but as they run over areas of scores or hundreds of miles and for periods of several hours, they seem to be currents. For waves, terms like crest advance and trough recession seem more appropriate, as more likely to convey the true and intended meaning.

The difficulty in the undertow problem lies in the fragmentary nature of the facts: and so in the curious offshore and onshore drift that Mr. Brant describes, his account is naturally enough, as it depended on a swim in the bay, incomplete. It might be possible to explain the phenomena if they were more fully recorded.

W. M. DAVIS

CAMBRIDGE, MASS.

PAUL TO THE THESSALONIANS

PROFESSOR C. W. E. MILLER, of the Greek department of the Johns Hopkins University, has kindly pointed out to me that in SCIENCE of April 17, 1925, page 419, the well-known admonition of Paul to the Thessalonians, in being requoted, suffered "startling maltreatment of the Greek words." Professor Miller gives me the following as the exact wording and accentuation of the verse:

πάντα δοκιμάζετε,
τὸ καλὸν κατέχετε.

If you will kindly publish this correction I shall be obliged.

CHARLES D. SNYDER

ERROR IN HERALDRY

THE "fable" in the issue of SCIENCE for May 29 involves a serious error in heraldry. There is no such charge as a "bar sinister." A bar is a band horizontally across the shield and can, therefore, be neither dexter nor sinister. The indication of bastardy is the "baton sinister," a narrow band not reaching to either side of the shield but lying obliquely from the sinister area to the dexter.

HENRY LEFFMAN