courses in the history of political economy into our colleges." And yet, at least as early as 1878, and I believe for several years before that date, Professor Dunbar gave at Harvard university an advanced course in political economy, in which a large part of the time was occupied with a careful examination of the history and development of economic doctrines. The writings of Adam Smith, Ricardo, and Malthus were naturally given especial attention. The course of which this historical study was a part has continued to be given from year to year since it was first instituted. Other institutions may also have offered courses of the same kind; but certainly in this instance the history and literature of political economy were studied before the new school had entered the field.

There is a tendency in the new school to claim for itself perhaps an undue share of credit for the advances in economic thought and economic teaching which have taken place in the last ten or fifteen years,— a tendency which seems to me to be illustrated by Professor Ely's somewhat hasty remark.

F. W. TAUSSIG.

Newport, July 4.

Sea-level and ocean-currents.

In the number of *Science* of Jan. 1, I published some notes on the great equatorial westward flow of the earth's atmosphere and its influence upon oceanic circulation. I credited to this great atmospheric current the westward movement of the surface water of the ocean beneath it, and considered the friction of the winds as the most important factor in the whole system of oceanic circulation. In an interesting letter published in *Science* of Jan. 22, on sea-level and ocean-currents, Mr. William Ferrel states that the theory which attributes the movement of ocean-currents to the friction of the winds is untenable, saying, among other things, "that it is well known that ordinary winds have very little effect in changing sea-level except in very shallow water." He fortifies this assertion by quoting, from the report of the chief of engineers, observations which seem to show that the mean level of the water at either end of Lake Ontario varies but one-third of an inch with changes of wind; that the sea-level is precisely the same on both sides of the Isthmus of Darien; and that the sea-level on the coast of Ireland is the same in summer and winter, though the more violent westerly winds of winter should raise that level if winds were capable of moving and heaping up water on a coast.

Though fully appreciating the accuracy and value of Mr. Ferrel's work, and differing from so high authority with extreme reluctance, I deem it but justice to myself to say that the question is by no means so simple as he represents it, and that there are many facts which prove, beyond all argument, the power of wind to move great masses of water, and to produce all the phenomena of oceanic circulation. For example: for ten years I occupied in summer a country house on an island in Lake Erie, and I have more than once known a strong westerly wind to depress the level of the water in the west end of the lake, and raise it at Buffalo by two feet or more. This means the actual transfer, within a few hours, of a sheet of water of half the area of Lake Erie, and one foot in thickness, from the western to the eastern portion of the lake.

I was once detained at Indianola, Tex., three days by a norther, which blew the water off the coast till the harbor was almost dry land.

Again: since this discussion began, violent south-easterly gales have forced the ocean water into New York harbor, and raised the water-level six feet or more, inundating much of the lower portion of the city, and causing great destruction of property. As this rise was general along the coast, and was felt as sensibly at Sandy Hook as at the Battery, it is evident that we here have proof that wind is capable of moving vast bodies of water before it, even where the depth is considerable.

All the facts cited by Mr. Ferrel in support of his statement are of equivocal bearing on this question. The sea-level on the isthmus is still under discussion, and, if it shall be proved to be the same on both sides, that fact would be as difficult of explanation on the gravitation as the wind theory.

Capt. John Brown of Put-in-Bay Island reports to me that "a strong westerly wind sometimes depresses the water-level at Put-in-Bay four feet below the normal." And Mr. Julius Pohlman of Buffalo writes me as follows: "I learn from the records of the signal office here that the heaviest south-west storms on record raised the waters at this end of the lake between eight and nine feet above the ordinary level.

It is true that more violent winds are encountered on the Atlantic in winter than in summer, but almost none of these are continuous across the ocean. All the cyclones are rotary, and the storms not such are local and temporary. A change or reversal of direction of the wind would soon neutralize its effect, and in winter the antagonistic easterly winds are correspondingly violent on the European coast. On the whole, it is doubtful whether the sum of the impulses of the westerly wind is much greater in winter than in summer.

Since the atmosphere presses on the ocean with a weight of nearly fifteen pounds to the square inch, it is evident that when the air is moved the friction must be great. This is demonstrated by the rapid raising of ridges of water before a strong wind; and these ridges are all waves of translation. Waves of oscillation occur, but they are rare; and the apparatus so frequently employed for illustrating wave-motion by vertical rods successively lifted is misleading.

Mr. Ferrel says, in conclusion, "A continuous wind for some time in any direction causes merely surface currents of considerable velocity;" but it requires no argument to show that such surface currents, if continuous, would infallibly produce a movement of the deeper strata of water in the same direction.

The time estimated by Zöppritz for the transmission of surface motion to the depth of a hundred metres seems to me grossly exaggerated: but even if ten times longer than his estimates, the great equatorial wind, which has doubtless been blowing from east to west since the ocean has had an existence, would be amply sufficient to establish a movement that would form a *primum mobile* for the whole system of oceanic circulation.

That gravitation is a factor in oceanic circulation is proven by the presence of ice-cold water in the abysses of the ocean under the equator, — water that must have flowed in from the polar regions, — but it has seemed to me, and to many others whose opinions are worth more than mine, that it is a much

less important factor than wind-friction. Those interested in the subject will do well to read the chapters on ocean-currents in Croll's 'Climate and time,' and the papers by Croll and Carpenter in the London and Edinburgh *Philosophical journal*, and the Proceedings of the Royal society.

J. S. NEWBERRY.

Columbia college, July 1.

Private research and government science.

Since the promulgation and discussion of the bill to curtail the work of the scientific bureaus at Washington, and Mr. Herbert's appeal "to the best literary and scientific thought of the country to come to our aid and join us in the effort to effect a reform and arrest this pernicious tendency," much has been written and said upon this subject.

One of the chief arguments brought to bear by those opposed to the extraordinary scientific progress being made, and the vast amount of scientific work being done by this country at the seat of its government, is, that this work is proving detrimental to private research in similar channels.

Further, it has been said by the opposition that these scientific publications of the U. S. geological survey are valueless in the book-markets of the world; and Mr. Herbert points to that law in the organization of the survey which specifies that it shall sell all its publications not exchanged at cost, and that during the past six years this sale has realized an amount but slightly exceeding fifteen hundred dollars.

Now, one of the best proofs that this scientific activity on the part of the government is in no way checking private research, has been recently brought forward by Professor Agassiz, who laid before this commission of investigation the titles of forty-eight publications of the Museum of comparative zoölogy at Cambridge, alone.

But perhaps a still better light is thrown upon these two latter questions by an unprejudiced examination of such a catalogue as is published by Dulan & Co. of 37 Soho Square, London. Here we find five of Mr. O. G. Elliot's zoölogical monographs on sale for five hundred and forty-five dollars, and other evidences of the very highest activity in private research in America on every page. Moreover, to prove that the government publications of this country are not held as being valueless in the book markets of the world, we see any number of the publications of the geological survey, and other scientific bureaus of Washington, on sale in the above catalogue, and being sold at prices fully equalling those of private pulications. That more money has not been realized at the survey for the sale of its works, simply speaks in favor of how eagerly they are sought in exchange, leaving but a few copies each year on hand for sale.

The excellent handbooks of geology of this country by Dana and LeConte do not seem to have been suppressed by government interest in this highly important work; and if we run our eyes over the bibliography and illustrations of this science, as set forth in these two volumes, I defy any one to say that the government work is not appreciated, or that private researches in this field are checked. The same holds good for all the other sciences.

I think when the sense of the vote of the "best literary and scientific thought of this country" is taken upon Mr. Herbert's appeal to suppress such works as the paleontological monographs of Marsh, Ward, White, and others, and the magnificent publications in the bibliography of science undertaken and accurately carried through by our government, there will be an enormous zero on his side of the ticket. Government moneys can be squandered on far worse things in the times of peace, than such schemes as powerfully aid the progress of knowledge, culture, science, and learning. Be it said to the credit of this country that she sees fit to invest her surplus means to the advancement of such ends.

R. W. SHUFELDT.

Fort Wingate, N. Mex., June 29.

Expulsion theory of comets.

Mr. Proctor's article in a recent number of the *Nineteenth century*, on the expulsion theory of comets, leads one to believe that the solution of this problem is not only as far off as ever, but that little headway is being made for a general clearing-up of the 'mystery.' There are many serious objections to this particular theory of the origin of comets. We admit, of course, that the earth and Mars, for instance, or even the moon, may have been at one time scenes of vast fiery eruptions, etc. But that this cast-off matter should go out into space in a burning state, and continue to go out, probably, for a great number of years, then return, still in a burning state (the alleged comet),—while the body from which it was expelled, and a much greater size as a matter of course, always remaining in close proximity to the sun, and drawing closer all the time, should cool down and become solid and non-luminous, such as the earth, Mars, or the moon is at the present time,—is certainly something on which Mr. Proctor's theory throws little light. The expelled matter must naturally cool down the same as the body from which it was expelled, and except by accident, considering the distance it would have to travel to meet another source of heat (a sun), we can only come to one conclusion in regard to the expulsion theory, it won't do. G.

Brooklyn, June 29.

Flooding the Sahara.

Mr. G. W. Plympton's very interesting and suggestive article on the flooding of the Sahara (*Science*, vol. vii. pp. 542–544) induced me to make some numerical estimates, based upon the data furnished by him, which may be of some interest to readers of *Science*. He shows that "the area, which, lying below the Mediterranean, can possibly be flooded by it" (the united areas of the depressed portions), is, by M. Roudaire's measurements, about 3,100 square miles; and the average depth, if flooded, would be 78 feet. Now, assuming the area of the cross-section of the water of the Inlet Canal to be 2,000 square feet, and the average velocity of the inflowing water during the whole time of flooding to be 2 feet per second (not a low estimate), it follows that the average inflow would be 4,000 cubic feet per second $=3{,}456\times10^5$ cubic feet per day $= 1{,}262{,}277\times10^5$ cubic feet per year.

Again: 3,100 square miles $= 864{,}230\times10^5$ square feet; and, the average depth being 78 feet, the amount of water required to flood it to this depth $= 67{,}409{,}971\times10^5$ cubic feet. Consequently such a canal would require 53.4 years to flood the comparatively small and shallow Saharian lake, under the assumption that during the inflow no water was lost by evaporation or by absorption into the porous bed.