form carbohydrates. If this view is correct, the addition of proper compounds of these elements to a carbon dioxide water system should catalyze the photosynthesis of carbohydrates.

We are all looking forward to most spectacular advances in the overlapping fields of organic chemistry, physiological chemistry and medicine. Modern miracles are happening every day. I suspect that most of us could find in our immediate families or among our close friends individuals alive and in good health who a short twenty-five years ago must have taken the long journey in spite of all the aid which even the best of science could have given them. We may be certain that in our own time man's years of comfortable, happy, useful life will be greatly increased, and what more can we ask of chemistry than an enlarged opportunity to be of service to our fellows?

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SHORELINE INVESTIGATIONS ON THE ATLANTIC COAST

IN the course of researches on the supposed progressive subsidence of the Atlantic coast it has been discovered that many of the apparent changes of level were in fact caused by local fluctuations of the high tide surface due to changes in the form of the shoreline. As low tide levels are likewise known to vary with variations in the form of the shore, but as a given shore change does not necessarily produce equal or equivalent changes in the high tide and low tide levels, the question arises as to whether mean sea level itself may not change with changes in the form of the shore. It has generally been assumed that mean sea level, when determined by accurate observations extending over a long period of years, is essentially a constant plane; and differences of mean sea level as determined at different periods have been held to prove progressive submergence of the coast; while differences determined at different localities at the same time have been ascribed to errors in tide gauge readings or computations, or to errors in levelling. It seems possible that these observed differences of mean sea level may have been correctly determined and represent merely the fluctuations of an irregular surface, the inequalities of which vary, both from time to time and from place to place, with variations in the form of the shore.

The importance of determining whether mean sea level is locally an irregular surface (aside from the broader inequalities known to exist due to gravitative attraction of mountain masses, direction of ocean currents and other causes previously studied,) and whether it may change to an appreciable degree and with rapidity consequent upon changes in the form of the shore, is obviously very great. Many of the supposed proofs of a recent and continued subsidence of the Atlantic coast of North America can be interpreted as due to local fluctuations of high tide level amounting in cases to as much as several feet. Proof of subsidence, if it exists at all, must be based on a comparison of mean sea level observations made at different periods; and it is clear that the necessary evidence can be regarded as reliable only as it be demonstrated that changes in shore form do not affect the position of mean sea level. At present all arguments for changes in the relative level of land and sea based on observed changes of mean sea level are open to suspicion.

The altitudes of the official benchmarks throughout the country referred to mean sea level are calculated on the basis of tide-gauge records obtained in localities many of which are apparently favorable to local fluctuation of the high and low tide surfaces, and hence possibly of the mean sea level surface. This results from the fact that tide gauges are most conveniently located in bays, harbors or other protected re-entrants in the coast, the very places most subject to fluctuations of tidal levels. If neither accurate tide-gauge observations extending over long periods of years nor the most precise levelling from gauge to permanent benchmarks gives results of permanent value because a gauge is unfortunately located, this fact should be known.

It is not alone the scientific investigator, the surveyor and the geodesist who have a vital interest in this question. Every owner of property bordering the sea has an actual or potential interest of no mean importance. Where waves are attacking the coast, the value of property may in considerable measure be determined by the probable future rate of coast erosion, and the consequent nature and expense of the protective engineering works required to check the inroads of the sea. Even the title to ownership of property may hinge in part on rates of erosion in the past, as has been demonstrated in recent cases in litigation. In all such cases the question of possible changes of sea level needs to be taken into account; for if this coast is subsiding at the rate of one or two feet per century, as many geologists have believed, the erosion will be much more vigorous than if the coast is stable. Other cases have arisen in which title to valuable property has depended directly on whether or not the land has subsided.

The aspects of the case briefly outlined above could readily be developed at greater length, but enough has been said to indicate both the scientific importance and the practical value of the results to be obtained

from an authoritative experimental determination of the facts at issue. Some time ago the matter was presented to the director of the United States Coast and Geodetic Survey, who expressed interest in the project and promised the cooperation of the survey to the limit permitted by existing laws and appropriations. The Division of Geology and Geography of the National Research Council undertook to secure necessary funds and to arrange if possible for the cooperation of certain other government bureaus and private individuals in a careful study of the nature and variations of mean sea level at selected points along the Atlantic coast. A Committee on Shoreline Investigations was appointed, consisting of Isaiah Bowman, N. M. Fenneman, R. S. Patton, and the writer as chairman, this committee being charged with perfecting plans for a study of mean sea level variations as affected by shoreline changes and with the prosecution of other shoreline studies. The following discussion is based largely on the report of the chairman of the committee presented at the last annual meeting of the division and sets forth the present status of the operations.

Correspondence with the chief hydrographer of the Canadian Hydrographic Office has led to a tentative promise of assistance from the Canadian authorities, provided the expense involved does not prove prohibitive. The region of St. John, New Brunswick, seems to offer exceptionally favorable conditions for comparing the mean level of the sea with that of a large embayment (Kennebecasis Lake) connecting with the ocean by an extremely narrow inlet and receiving great quantities of fresh water. The tidal range is great, twenty to twenty-five feet, while the distance over which a line of precise level would have to be run to connect a gauge in the embayment with one in the outer harbor is small. A line of levels, possibly of adequate precision, has already been run between St. John on the harbor and Rothesay on the lake. A tide gauge has long been maintained in the harbor at St. John and it is hoped that the Canadian authorities will establish a gauge in the lake and operate the two simultaneously for one year as an aid in the committees' investigations.

Conferences with the chief engineer and with the division engineer in charge of tidal observations, of the Department of Docks of New York City, resulted in an offer on the part of the department to operate three or four tide gauges in Jamaica Bay near New York City for a period of one year, providing the committee could secure the loan and installation of gauges of suitable type, and could further arrange to have the gauges connected by lines of precise level. The chief engineer of the Department of Plants and Structures of New York City has expressed a willingness to cooperate in the matter of securing proper installation of the gauges, while the United States Coast and Geodetic Survey has agreed to loan the necessary number of instruments. Further details of cooperation are being worked out under the active direction of Commander G. T. Rude, of the Coast Survey. Jamaica Bay offers special advantages for the study in hand. The adjacent region is covered by a network of lines of precise level surveyed with a high degree of refinement under direction of the New York City Board of Estimate and Apportionment from 1909 to 1914. The tidal range is moderate (four to six feet); the channel connecting with the open sea is fairly wide, while the amount of upland water entering the bay is negligible, thus offering in three important respects a useful contrast with conditions in the St. John area.

Dexter P. Cooper Incorporated, of Eastport, Maine, has agreed to operate, for a period of one year, three or four tide gauges in the vicinity of Eastport, Maine, including the arms of Cobscook Bay. Mr. Cooper has also generously agreed to carry out the precise levelling required to connect the gauges, which here must be widely separated in a region where no lines of precise level have been run. At Eastport the tidal range is great, eighteen to twenty feet, and there are broad bays connecting with the ocean by narrow inlets. The fact that the region is one involved in a large scheme for utilization of tidal power adds interest to its selection as an appropriate site for mean sea-level studies. If the proposed engineering works for controlling tidal waters are installed here, further tidal observations during their construction would reveal any changes in mean sea level due to progressive interference with the tidal régime in bays and channels gradually blocked by the building of dams.

A competent officer of the Division of Tides and Currents of the United States Coast and Geodetic Survey has approved the committee's selection of the three localities described above as being well suited to the purposes of this investigation. Preparations for the Jamaica Bay study are well advanced and five tide gauges will be installed in Jamaica Bay and adjacent localities during the latter part of October. The observations at Eastport must wait, apparently, until the Coast Survey can free a sufficient number of its larger tide gauges for the work. Final decision on the St. John project is awaited from the chief hydrographer of Canada. If the tidal studies projected for the New York, Eastport and St. John regions can be carried to completion on the basis above indicated, they should make possible definite conclusions as to the nature and extent, if any, of local variations in mean sea level due to variations in the form of the shore.

In the opinion of the committee an important phase of its activities should be to promote the securing and recording of full and accurate information regarding changes in the form of our shorelines resulting from erosion and accretion, or from variations in the relative levels of land and sea due to either local or general causes. Such changes not only result in frequent and serious damage to public and private property, bringing heavy charges upon taxpayers and property owners, but they precipitate legal controversies, the solution of which depends upon a proper understanding of the changes and their causes, and they necessitate costly shore protection works for the proper construction of which the engineer demands a fuller knowledge of shore changes than is now available to him. The committee brought to the attention of the United States Coast and Geodetic Survey the importance of having its field parties make and record in their field reports accurate measurements of the distances between permanent marks established on the coast, and changing elements of the shore, such as high water line, top of beach slope, crest of cliff and other easily recognized shore features. In response to this representation the survey issued to its field parties special instruction for the making and recording of the desired measurements.

As a further step in the direction of securing fuller knowledge of shoreline changes, the committee, confining its attention for practical reasons to the Atlantic Coast,[1] has addressed to geologists, geographers and engineers (including appropriate state and municipal authorities) in the Atlantic and Gulf coastal states a circular letter emphasizing the economic value of natural and artificial beaches, the practical importance of their adequate protection and the lack of precise data required by marine engineers for the proper installation of protective devices; and requesting information regarding shoreline conditions and shoreline studies in each coastal state.

The committee also addressed a similar letter to the chiefs of the Coast Guard and Lighthouse Services, and requested the chiefs of these services to circulate among their officers and employes stationed on the Atlantic and Gulf coasts a carefully prepared questionnaire, designed to elicit information regarding shoreline changes taking place under the observation of men whose regular duties give them special facilities for noting the variable effects of waves and currents. It is the thought of the committee that replies received from both letters and questionnaires will serve to indicate more clearly the directions in which further steps can most profitably be taken.

As a contribution to the work of the committee the chairman assigned certain shoreline problems to a limited number of graduate students in physiography. W. D. Burden completed a study of shore changes on Gardiners Island and parts of the northern coast of Long Island, in which past rates of coast erosion and successive positions of the shoreline are considered at some length. E. I. Winter has made a study of variations in mean sea level in the course of which much data useful to the committee were assembled. H. S. Sharp carried out an examination of artificial beach construction along the New York and Connecticut shores, with a view to determining certain of the physical factors favorable to and unfavorable to enterprises of this type. O. Kuthy collected and analyzed published data on elevated beaches in order to determine how far such data may properly be used as evidence of sea-level changes as distinguished from changes in the level of the lands. D. A. Nichols is engaged on a study of the evolution of the southern shoreline of New Jersey, this work being prosecuted with support from the Geological Survey of New Jersey. In the opinion of the committee the results already obtained from these studies justify the belief that investigations of shoreline phenomena at various points along our coast, carried on by properly qualified and directed graduate students, can be made to contribute substantially toward the objects which the committee has in view, both by discovering and making known facts of shoreline changes, and by directing public attention in an increasing measure to the importance of shoreline problems. With a view to furthering studies of this type the committee decided to get in touch with professors of geology and geography in our coastal states, and to ascertain to what extent they would be willing to encourage shoreline studies by competent students under their direction.

The committee believes that there is much need of an enlightened public opinion to demand and support intelligent action by governmental agencies—federal, state and municipal—in dealing with the protection and development of our shores. In Great Britain, Holland and other countries the burdens which coast erosion throw upon the taxpayer are better understood, and support for constructive action by public authorities has not been lacking. Our people must be made to realize that loss of coastal land in the long run becomes a charge upon them, whether or not they live upon the shore. They must understand the advantages which may be enjoyed by the whole public if their representatives take proper steps to protect existing beaches and to create new ones.

[1] A Committee on Features and Changes of the Shoreline of the Pacific Coast has since been formed in the Division of Geology and Geography of the National Research Council.

As an aid toward arousing a wider and more intelligent public interest in shoreline problems and to collect information of possible value concerning shoreline phenomena, the committee is asking all who are interested in the work to communicate to the committee information on the following points:

(a) Changes in the shoreline (backward cutting, forward building, shifting of inlets, etc.) now in process of taking place, or which have taken place very recently. Precise data, or the names of reliable persons able to give precise data, are particularly desired. Photographs, especially photographs taken at intervals from the same viewpoint, are valuable in showing cliff retreat under wave attack, the progressive growth of bars and sandspits, the erosion of beaches and the destruction of seawalls, houses and other artificial structures.

(b) Engineering works now in process of construction for the protection of shore cliffs or beaches, for the maintenance of inlets or channels across beaches or bars, or for any other purpose which will involve a checking or changing of the natural operation of waves or currents along the coast. Information as to the purpose of the works in construction, with addresses of engineers or contractors in charge of construction, will be especially valuable.

(c) Completed engineering works that are of especial interest, either because they have proven unusually successful in accomplishing their purpose, or because they have signally failed to achieve the results for which they were designed. Addresses of engineers, contractors or other authorities who can furnish reliable detailed information are particularly desired.

(d) New beaches created by artificial means, whether completed or in process of development. Photographs or sketches showing original condition of the shore and its appearance after the new beach was formed, together with information as to conditions of wave and current action in the vicinity and the degree of success obtained in securing a satisfactory beach will be useful. The addresses of engineers, contractors or others in charge of the development work are desired.

(e) Addresses of individuals or organizations willing to cooperate with the committee by measuring and recording shoreline changes in their vicinity, by photographing rapidly changing shorelines at stated intervals, by observing the behavior of waves and currents on their parts of the coast in different seasons, or by loaning the committee photographs, sketches, engineering drawings, unpublished reports or other data throwing light on shoreline changes and the results (whether satisfactory or not) secured by shore protection and improvement works will be most welcome.

Communication may be addressed to the present chairman of the committee, Commander R. S. Patton, United States Coast and Geodetic Survey, Washington, D. C., or to the undersigned.

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FRANK HALL KNOWLTON

AT the close of a distinguished career it is quite impossible to separate the influences of heredity and environment, but both were certainly united in making a naturalist of Frank Hall Knowlton. His ancestors were of that sterling old Vermont stock which originally settled that region. He was born at Brandon, Vt., on September 2, 1860. At Middlebury College where he arrived in due season he came under the influence of Ezra Brainerd and Henry M. Seely, those distinguished naturalists who taught all the sciences and collaborated on the difficult problems of geologic research among the older rocks of that region. Their influence on the lad can not be doubted.

Knowlton's earliest interests were ornithology and botany and he retained these undiminished through life. In his early days in the West for the Geological Survey he collected recent birds and plants as well as fossil plants. The wonderfully isolated lignites of Brandon, unique in all New England, with their great variety of curious Eocene fossil fruits, must also have early stimulated his imagination and he returned to their study in his later years. In 1884 Middlebury gave him the B.S. and three years later the M.S. degree.

Knowlton came to Washington in 1884 in connection with the preparation of the U. S. National Museum exhibit for the Cotton Centennial Exposition at New Orleans, remaining afterward at the museum on a slender salary, first as aid and then as assistant curator. When Lester F. Ward was placed in charge of paleobotany by Major Powell, then director of the survey, Knowlton was made one of his assistants being employed in collecting fossil plants in the summers and studying the anatomy of fossil woods during the winters, his first work of this kind being on the woods and lignites of the Potomac formation. In 1894 he was appointed assistant paleontologist on the U. S. Geological Survey, and in 1907 he was advanced to the rank of geologist.

For nine of his earlier years in Washington he was professor of botany in Columbian (now George Washington) University, from which he received the