rials for our homes, new paints and varnishes. These new uses require as raw materials the molecular aggregates which we take off the land in annual crops. It is true that the chemist can synthesize them in his laboratory, and some of them he will undoubtedly produce there, but this year and for many years to come the sunshine and the rain, the fertility of our soils and the patient labor of our farmers will grow the crops industry needs more cheaply than the chemist can make them.

The better living conditions secured through the increased wealth provided by science, together with the application of science to hygiene and medicine, have considerably increased the average expectancy of life. This great achievement in public health is sufficient to justify the belief that those who call our industrial civilization mean in quality have narrow views and scant idealism.

Chemistry and medicine are establishing a more cooperative program of research, and a good example is some work that has been under way since 1926 on the treatment of pneumonia.

The results of this teamwork between chemists and medical scientists have been of outstanding importance. Woven throughout the whole progress of the investigation is ample human drama cloaked from the layman by such chemical names as hydroxyethylhydrocupreine, apocupreine, ethylapocupreine, hydroxyethylapocupreine and other necessarily abstruse terms. Briefly, the problem was less to find a compound effective with pneumonia and allied diseases than to find one that would not harm the eyes. Certain of the cinchona alkaloids were known to be effective in treating pneumonia, but they were not to be used without great probability of eye damage. Such a dilemma is, of course, a challenge to the chemist and to the physician. The results so far indicate the discovery of cinchona alkaloid derivatives, as new compounds, which give the profession of medicine what it has long sought—a safe treatment of all types of pneumonia which will not harm the human eye and therefore can be both effective and safe.

To date, close to eighty preparations have been tested biologically by the medical collaborators. Some were found to cause no eye disturbance, but to have little activity with pneumonia. The most promising drug found, showing greater activity against the disease, lower toxicity than any of the others, has also been tested in scores of clinical cases, which have demonstrated a very high tolerance in the human being to the drug, absence of any untoward visual results and a high proportion of recoveries from severe pneumococcic infections of all types.

The investigations must go on, the clinical trials must be conducted on a wider base, production of the compound on a large scale must be undertaken. All these projects are now under way, and the chances of ultimate success are very promising.

When trained minds and proper facilities are applied to specific problems, practical solutions are expected. If they were not forthcoming—that would be news.

Fifty years ago, Europe led the world, chemically speaking. Far-seeing men predicted even then that in another half-turn of the century the chemical leadership of the world would pass to America. This change has come about, and the American Chemical Society as an organization deserves a large share of the credit. The scientists of each nation have worked with might and main to surpass one another in chemical discoveries; and the advantage that we have gained has been largely due to the cooperative spirit generated by our society activities. A nation must be able to stand chemically alone unless it would be subservient, so utterly does present-day civilization depend upon chemistry for a thousand-and-one everyday foods and materials. And it grows more and more apparent that to help one's country to be chemically independent is the profoundest kind of patriotism.

The objective of scientific research to-day, moreover, is broader than the solution of technological and chemical problems. It takes into its view the responsibility for enlivening the imagination of the masses who will be the chief beneficiaries of these new ways of living.

A true scientist never grows old in his way of thinking. His mind is constantly working to improve his surroundings and to better understand the laws of nature. He expects to live in a changing world.

RÔLE OF ARTESIAN WATERS IN FORMING THE CAROLINA BAYS

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IN an earlier issue of SCIENCE the writer advanced evidence in support of the hypothesis that oval bays of the Carolina coast and adjacent regions were basins of former lakes, that the basins resulted in part from the solution of limestones or other soluble beds underlying surface sands of the coastal plain, and that the rims partially encircling the basins were accumulations of wind-blown sand. In this paper it was shown that subsidence of overlying sand or sandy loam into relatively small and irregular sink-holes would produce relatively large and symmetrical surface basins; that the so-called "sinks" would serve not only to receive waters descending from above, but also in many cases to discharge waters rising from below; and that these upwelling waters might be an important factor in producing the oval basins. It was fully realized that the oval basins or "bays" occurred in areas where limestone was not known to exist; but it was shown that the solution of alumina, iron and other soluble constituents of non-calcareous beds was known to have produced sink-holes in this general region.

Further studies of the problem of bay origin have convinced the writer not only that the upwelling waters in regions of karst topography in the coastal plain are often artesian in their nature, but that the rôle of artesian waters in forming oval bays has been of major importance. These waters circulate most freely where solution of limestones, marls, arkosic sandstones and other soluble beds opens passageways of appreciable size; but they also pass readily through coarse siliceous sands and deposits of gravel in which solution is negligible. Thus while most of the oval bays occur in regions of soluble rocks, they are also found in localities underlain by notable deposits of coarse sand and gravel.

The hypothesis of bay origin previously advanced by the writer, expanded to emphasize more fully the important rôle played by upwelling waters, may be restated somewhat fully as follows:

As the Atlantic Coastal Plain emerged from beneath the ocean, rainfall gave rise to surface streams which flowed approximately northwest to southeast down the surface slope, and to an underground circulation which moved through the sediments in general from northwest to southeast down the dip of the beds. The Coastal Plain formations consist of lenses of sands, gravels and other pervious deposits, alternating and interfingering with lenses of clay and other impervious beds. Hence water entering pervious layers higher up the slope often migrated seaward between impervious layers under ever increasing pressure. Where wells tap the pervious layers and the contained water is under sufficient pressure, artesian flows of water are secured at the surface. In many cases, however, the imprisoned underground water did not proceed far before it found means of escape to the surface, whether because an overlying lense of impervious material had thinned out and disappeared or for some other reason. This water, welling up from below under moderate pressure, created over vast areas of the Coastal Plain what might be called "artesian springs," since the conditions of flow were exactly similar to those of artesian wells, except that in the latter case the passageways to the surface are artificially created.

Before the surface streams had entrenched themselves deeply into the Coastal Plain, thus affording opportunity for underground waters to escape at lower levels, the outflow of "artesian springs" on the nearly flat Coastal Plain surface was a phenomenon of major importance. Locally its importance may have increased greatly as time went on, due to the fact that flow of water through limestone, marl, feldspathic sands and other soluble materials developed underground passages which much facilitated further water movement. We should picture vast stretches of the Coastal Plain having the surface dotted with literally countless springs, many so small that their waters might filter away through the surrounding soil; others so large that copious streams flowed from them in definite channels they had carved for their escape; and all "boiling" or "fountaining" in greater or less degree, due to the artesian pressure of water entering the sediments farther up the Coastal Plain slope. Other large portions of the Coastal Plain surface had few or no such springs, because impervious layers near the surface or other unfavorable geological conditions constrained the waters to continue underground until they reached areas where escape to the surface was easy.

The immediate surface layer of the Coastal Plain was then, as now, prevailingly of sand, whether because surface weathering and wash had produced a residue of quartz grains from the decomposition of surface formations, or because advance and retreat of the sea had left a coating of wave-washed sand. Immediately below the loose surface sand there was usually a loamy sand or sandy loam. Because surface streams were not yet deeply entrenched, the groundwater level must at that time have been very close to the surface of the plain. Consequently the upwelling "artesian springs" reached the surface in a layer of loose sand or sandy loam effectively saturated with water.

Where springs are active in saturated sand or loam two things are apt to occur. The escaping waters carry away some of the sand, especially the finer grains, and much of all of the clay and silt contained in the loam. Thus a cavity or depression in the surface is formed. Toward this depression saturated loose sand slumps or flows freely inward from all directions, while sandy loam disintegrates and moves more slowly. Thus there develops a progressively enlarging more or less rounded basin, and the spring is transformed first into a pool, then into a lake, on the bottom of which the upwelling waters may be seen making the sand to "boil." It is believed that countless such lakes developed on the surface of the undissected Coastal Plain where superficial sand or sandy loam was saturated by a high-standing groundwater level and where subsurface waters, previously migrating seaward under pressure beneath an overlying impervious formation, found ready escape to the surface. Where the surface was underlain by loam containing a high percentage of clay, or by some other relatively compact or impervious formation; and where geological conditions underground did not bring to a given region abundant supplies of water under artesian pressure, springs were rare or absent, and lakes of the type described failed to develop.

Where the surface was underlain by soluble formations, such as limestone, marl or arkosic sands, progressive solution developed channels or caverns underground and sink-holes and similar karst phenomena on the surface. Some sink-holes would result directly from the solvent action of descending local rain water. Others may have resulted from the caving in of underground channels and caverns in the soluble beds, while still others were developed by waters upwelling to the surface. The resulting "sinks" served in part as intakes for descending surface waters, and in part as exits for uprising artesian waters, depending upon local conditions. The same openings might serve first one purpose, then the other, as changes in groundwater level, underground circulation and other local conditions varied.

In localities where compact material was at or close to the surface, sink-holes would exhibit the irregular outlines commonly observed in limestone regions, and many of them might be of very small size and relatively deep. But where the soluble formation was buried under a thick cover of loose sand, the surface depressions would tend to be comparatively shallow, circular or oval in outline, and even the smaller examples of relatively large diameter. This is because loose sand slumping into a cavity moves obliquely inward from all sides, with the result that the surface depression may have a diameter many times that of the cavity into which the sand below slumps; while the irregular outlines of the smaller opening are practically lost in the greatly enlarged outline at the surface. The subsidence crater thus produced in loose sand will be scarcely perceptible if the quantity of material slumping into the underlying cavity is small, while even a large amount of underground slumping will leave a surface crater relatively shallow. A deep crater in the overlying sand could be produced only in the improbable event that great quantities of the material were carried off through underground passageways and effectually disposed of where it could not impede continued sand removal. Relatively large, shallow, regular craters would be the rule, circular in outline unless the underground cavity were notably elongated, oval in the latter case. Craters originally round might later become oval, for reasons to be discussed fully in a later publication.

We have seen that the groundwater level must have been close to the surface of the plain prior to incision of stream valleys. This would have two important consequences for subsidence craters in loose sand. First, thoroughly saturated loose sand would flow inward toward the depressions from greater distances, increasing the diameter of the craters and rendering them more shallow. Second, the craters would hold lakes wherever and so long as the groundwater level was sufficiently high. Where compact clayey loam or other resistant material slumped as the result of removal of underlying soluble material, the surface depressions would not necessarily be much larger than the areas of slumping below, and might retain highly irregular outlines. In such depressions irregular lakes, large or small according to the extent of underground solution and slumping, would persist where and when the groundwater level was high.

Across the countless lakes formed by "artesian springs" upwelling in sand and loam and by subsidence of sand and other material into solution cavities, the winds drove waves and currents which attacked the shores of the lakes and moved material along their borders. Due to wave refraction, and in obedience to the law that irregularities of youthful shores tend to become smooth in the stages of submaturity, maturity and old age, irregularities of the lake-shores would tend in time to disappear, and the lakes thus acquire rounded or oval outlines. The transformation would take place quickly where the lake basins had formed in loose sand, especially if the initial outline of the lake were fairly simple, with only minor irregularities. Where a lake basin with minor irregularities was developed in loam, or where, as might occasionally happen, a lake basin formed in loose sand had shore irregularities of large magnitude, the attainment of the simpler form would be long delayed. And where a highly irregular basin was formed in clayey loam or more resistant material, the shore irregularities might not be reduced before the lake was extinguished by down-cutting of the outlet, by filling of the basin or by some other process.

It appears that vast numbers of the Coastal Plain lakes were quickly reduced to oval forms, but that some retained a greater or less degree of irregularity, while others continued highly irregular. This accords well with the fact that the lakes developed under a variety of geological conditions.

Wave work on the shores of the lake in time developed sandy beaches, quickly where loose sand was already available, more slowly where sandy loam had to be reworked and sand separated from silt and clay. Sometimes waves and currents transported sand along shore, building bars across the mouths of re-entrant bays or in front of the somewhat sharper curves at the ends of the oval basins.

Whenever the sand cast upon the lake-shore beaches was dry, it was subject to transportation by the winds. Thus it happened that ridges of wind-blown sand accumulated on the upper parts of the beaches, transforming beach ridges into dune ridges which encroached upon the land immediately to the rear of the beaches. On small lakes the beaches were characteristically insignificant features; but there was no limit to the height and breadth that the dune ridges replacing them might acquire. Often the sand from the beaches was carried up over the rim of the crater and accumulated as a dune ridge resting upon the Coastal Plain strata at the crater's edge.

Before streams had incised their valleys below the nearly flat surface of the Coastal Plain, the groundwater level or water table must have been fairly constant in its position close to the plain surface. But as stream valleys were deepened, conditions changed. At wide intervals underground waters found opportunity to escape into major streams at levels well below the surface of the plain. Near the valleys the water table was permanently lowered, so far indeed that lakes near the rivers must have gone dry, and their basins have become subject to dissection by minor streams gnawing headward from the valleys into the adjacent upland. Farther away from the valleys, and especially in the central portions of the broad, undissected interstream areas, the lowering of the water table was much less pronounced. Here lakes may long have persisted in the craters, even where lake levels were permanently lowered. Under the new conditions temporary fluctuations in the groundwater level must have developed, the water table rising during periods of abundant rains and falling during periods of drought. This would cause lake levels to fluctuate, with the result that sandy beaches might form at different levels at different times, while beaches dry at one period might be wet or submerged at another.

As solution of limestone and other soluble formations progressed, another type of change affected the lakes. Subterranean passageways were gradually enlarged, and new channels and connections were opened from time to time. These changes in soluble formations caused changes in the circulation of underground waters, which in turn affected the position of the water table. When such changes were gradual lake levels may have shifted gradually; but the sudden opening of a new underground connection between passageways may well have caused a sudden rise or fall of lake surfaces. Beach formation and the development of dune ridges would thus be suddenly shifted from one level to another.

Progressive deepening of river valleys and progressive development of underground channels connecting eventually with the ever deepening streams, tended toward one end—the ultimate extinction of the lakes through lowering of the groundwater level below the bottoms of the lake basins. To the same end operated the filling of lake basins with marshy deposits and peat. In time most of the lakes were transformed into dry depressions or into marshy basins called "bays." Relatively few basins, specially favored by local conditions, still contain open lakes. In time they too will be drained or filled; and ultimately the progressive dissection of the Coastal Plain by headward growing branches of the major streams will destroy every trace of the countless basins and their contained lakes which once diversified broad areas of the Coastal Plain surface.

Such is the history of the initiation, development and extinction of the curious Carolina bays, according to what may be called "the hypothesis of complex origin," since it involves artesian, solution, lacustrine and aeolian factors. It remains to test the validity of this hypothesis: first, by determining whether it will adequately account for the many facts concerning the bays already reported in the literature of the subject; and second, by deducing as fully as may be the reasonable consequences of the hypothesis, and then ascertaining whether newly discovered and previously recorded facts correspond to the consequences thus deduced. To this task the writer has for some time devoted his attention, and the results will be published at an early date.

OBITUARY

HERMAN DIEDERICHS

HERMAN DIEDERICHS, dean of the College of Engineering of Cornell University, died on August 31 at the age of sixty-three years.

For forty-four years Dean Diederichs, whose career began as a poor German immigrant boy, has been identified with Cornell University as a student, teacher and, since July 1, 1936, as dean of the engineering college.

He was regarded as an authority in experimental engineering with special reference to materials of engineering. His text-book, in collaboration with the late Professor R. C. Carpenter, published in 1910, is standard in the field. He is co-author with W. C. Andrae of a monumental work on mechanical experimental engineering, dealing with engineering instruments, published in 1931.

A prolific writer, he was co-author of three bul-