tional support. One hundred more subscribers in this country would probably encourage the editors to go on with it. These ought not to be difficult to get. To those who are unacquainted with it we may say that it is quite unique and occupies a different and higher plane than most bibliographic works. There is not merely a more or less roughly classified list of titles and brief abstracts of contents, but a series of logically arranged *critical* reviews pointing out the bearing of the paper, reviewed on the state of knowledge of the subject. The systems of cross referencing and indexing are wonderfully complete. The reviews are arranged primarily into twenty chapters, as follows: Cell, sex products and fertilization, parthenogenesis, asexual reproduction, ontogenesis, teratogenesis, regeneration, grafting, sex and pleomorphism, alternation of generations, latent characters, correlation, death, general morphology and physiology, heredity, variation, origin of species and specific characters, geographic distribution, nervous system and functions, general theories. Most of these chapters are elaborately subdivided. A feature has been comprehensive reports on the state of our knowledge of special topics. No one who is interested in the development of the topics named above can view with equanimity the prospect of the loss of this review. It is to be hoped that every biological laboratory and every library that has a scientific department and which lacks *L'Année biologique* will at once send a subscription to Schleicher frères, Paris, the publishers, or to Professor Y. Delage, Sorbonne, Paris, the chief editor.

Chas. B. Davenport,
Jacques Loeb.

THE EPIDIASCOPE.

To the Editor of Science: Who saw the epidiascope at the St. Louis Exposition? It appears in the catalogue of German scientific instruments at page 211, and is a most interesting type of projection apparatus, of especial utility to all schools. The possibility of speedy and facile transition from reflected to transmitted light, if worked out to the last optical and mechanical detail, would render it worthy of wide adoption. The diffusion of knowledge of all the arts and sciences ought to be very materially enhanced by this perfected apparatus. The projection of printed pages, photographs, charts and works of art, all without the necessity of photography, is most important. The name of the inventor is not given: presumably Carl Zeiss, of Jena.

David P. Todd.

Amherst College Observatory.

SPECIAL ARTICLES.

THE INFLUENCE OF CAVERNS ON TOPOGRAPHY.

It is well known that caverns, particularly those in regions underlain by limestone, are frequently associated with depressions in the surface above them, such as sink-holes, or swallow-holes, as they are commonly termed. It is also a familiar fact that the falling of portions of the roofs of caverns sometimes gives origin to ravines, canyons, etc., which are occasionally spanned by remnants of the roofs which remain in place, as in the case of the natural bridge of Virginia, and in other similar ways influence surface relief. A characteristic feature of this class of topographic changes is that depressions in the surface of the land are produced. The class of land forms to which attention is here invited, however, are exceptional, and, as it seems, have not been recognized as having a direct association with caverns, for the reason that they stand in relief and in some instances are conspicuous and picturesque on account of their height and boldness.

The topography of most regions the world over owes its leading characteristics, aside from elevation above the sea, to erosion. The chief exceptions are elevations produced by volcanic and glacial deposition. Erosion, particularly by streams, leads to the production of two classes of earth features, one class being due to the removal of material, as in the excavation of valleys, while the other class includes the remnants of uplands left when erosion to a plane surface is incomplete. In the production of such topographic changes, weak rocks, as a rule, are removed most readily and are replaced by depressions; while resistant rocks persist longer and are left in relief.

By weak rocks is meant those which offer a comparatively small degree of resistance to the agencies of abrasion, such as streams, glaciers, etc., or yield readily to the solvent action of water; while resistant rocks are such as have the opposite attributes in these particulars. Certain rocks are weak in reference to both mechanical and chemical erosion; and of the members of this class limestone is by far the most common.

On account of its comparative softness and solubility, limestone is, as a rule, more easily removed during the process of denudation than the formations with which it is usually associated, and when it occurs at the earth's surface side by side with more resistant rocks, its presence is frequently indicated by a depression. So generally is this the case, particularly if the rocks referred to occur in essentially horizontal beds, that it is a surprise to find limestone forming bold eminences in a region which has been stable for a long time and in which pronounced mechanical and chemical denudation has occurred. Examples of limestone standing in bold relief in regions where, for the most part, these several conditions obtain, are furnished by Mackinac Island, situated in the western portion of Lake Huron, and by Gibraltar, the well-known rock-fortress, one of the Pillars of Hercules.

Mackinac Island has a circumference of about nine miles, and an area of 2,221 acres. It rises to an elevation of 317 feet above the level of Lake Huron, and the surrounding water within a mile of its shore is from 150 to 200 feet deep; its total height above the bottom of the partially submerged valley in which it is situated is thus in excess of 500 feet. The rock of which the island is composed is limestone, which dips very gently to the south, and at several localities has been eroded so as to form vertical lake-cliffs. Limestone belonging to the same geological formation occurs on the neighboring St. Ignace Peninsula, but excepting these two circumscribed localities, has been deeply denuded over an extensive region, and the depressions formed are now occupied by the waters of Lakes Huron and Michigan.

Gibraltar rises 1,349 feet above the surface of the Mediterranean, and the water within a mile of the borders of the peninsula is from 300 to more than 600 feet deep. The length of the promontory is about two and one half miles and its width from 550 to 1,550 yards.* It is composed mainly of limestone in highly inclined strata, and, as is rendered evident from its isolated position and the presence of similar limestone on the African side of the adjacent strait, is a remnant of a once extensive formation.

Mackinac Island and Gibraltar are similar in several particulars; for example, each one is situated on the border of a navigable strait, and is of great strategic importance, as history has demonstrated; but a more fundamental fact is that they are composed mainly of fissured and cavernous and in part brecciated limestone, which is thus rendered especially favorable for the downward percolation of water. The only conspicuous difference between the two elevations seems to be that the rock of Mackinac Island is essentially horizontal, while the rock of Gibraltar is steeply inclined. In each case bordering precipices are present which, no doubt, have been produced in part by under-cutting by waves and currents, but the isolation of the great rock masses themselves seems to be due to the lowering of the region about them respectively, and this lowering, as it seems most reasonable to conclude, has resulted from subaerial denudation. Precisely why bold remnants of formerly widely extended formations should have been left at these two localities, however, has, so far as I am aware, never been explained.

Another example of limestone standing in relief in a deeply denuded region, and one which is especially instructive in the above connection, is furnished by a low hill at

* A. C. Ramsy, and James Geikie, 'On the Geology of Gibraltar,' in *Quarterly Journal of the Geological Society of London*, Vol. XXXIV., 1878, pp. 505–541.

I should, perhaps, state in partial justification for presenting the present article, that I have visited each of the localities mentioned above, and have at least some first-hand information concerning them.

Luray, Va. The hill referred to has extensive caverns beneath it, and, as appears evident, has been left in relief owing to the more rapid denudation of the surrounding country; the reason being that rain falling on the area where the rock is cavernous percolated downward and was prevented from forming surface streams and in consequence lost its ability to mechanically erode, while the surrounding country where the existence of surface streams was possible was degraded more rapidly.

The influence of subterranean drainage, as must be well known although seldom mentioned, is frequently indicated by minor elevations, especially in limestone regions where joints and other openings permit of the ready descent of surface water. Similar conditions on a larger scale, as just stated, may reasonably be held accountable for the origin of the hill above the caverns at Luray, and seemingly furnish the basis for an hypothesis which meets the conditions present at Mackinac Island and Gibraltar. If this hypothesis is sustained by future tests, it not only furnishes an explanation of the origin of the elevations just mentioned, but embodies a principle which is widely applicable. For example, it is frequently stated in modern text-books of physical geography, that residual hills standing on plains of subaerial denudation or 'monadnocks,' owe their prominence to the greater resistance of the rocks of which they are composed, mainly because of their hardness, in comparison with the rocks about them; or have been spared on account of their geographical position, that is, they occur at localities where streams originated and flowed away in various directions, and in consequence were left in relief after the country about them had been conspicuously degraded. To these explanations of the origin of monadnocks a third may now be added, namely: If the rocks of a given area are more open and porous, or traversed by fissures or caverns to a conspicuously greater degree than the rocks beneath the surrounding region—the general elevation being sufficient to favor subterranean drainage—they may be left in relief because the water reaching them will be conducted away by means of underground channels and thus in a great measure and in general almost entirely deprived of its power to mechanically erode, while adjacent areas are not favored in this manner.

A consideration of all the known facts relating to the rocky heights forming Mackinac Island and Gibraltar indicates that at each of these localities a residual of the nature of a monadnock has been left as the region about it was lowered by erosion; the controlling condition being that the rocks left in relief are fissured and cavernous, thus facilitating subterranean drainage, while the country about them was denuded at a more rapid rate through the agency of surface streams.

Israel C. Russell.
University of Michigan.

A NOTABLE ADVANCE IN THE THEORY OF CORRELATION.

To Professor Karl Pearson the new science of biometry is indebted not only for its name, but also for those refinements and extensions of the methods of statistical analysis without which it would be far from occupying the position which it holds to-day. In the remarkable series of memoirs which have appeared under the general title 'Mathematical Contributions to the Theory of Evolution,' Pearson and his assistants have laid a foundation on which a superstructure of great import to biology can, and will be, reared. The most recent of the memoirs in this series* brings forth a very interesting extension of the theory of correlation which at once greatly widens the range of problems and material which can be effectively handled by biometric methods.

In the development of the method of determining the degree of correlation between characters not admitting of quantitative measurement,† it was thought necessary in forming the correlation table to arrange the classes

* 'Mathematical Contributions to the Theory of Evolution,' XIII. 'On the Theory of Contingency and its Relation to Association and Normal Correlation.' Drapers' Company Research Memoirs, Biometric Series, I., pp. 1–35, 2 pl., 1904.

† *Phil. Trans.*, Vol. 195 A, pp. 1–47, and pp. 79–150.