rise to an embryo. The normal number of free nuclei is in general four. The single suspensors are very long and thrust the embryos deeply into the endosperm. Only one of the embryos develops.

The Effect of Chemical Irritation upon the Respiration of Fungi: Ada Watterson.

These experiments concerning the effect of chemical irritation upon the respiration of fungi were carried on with the Kunstmann and with the Pettenkofer forms of apparatus. The fungi used were *Sterigmatocystis nigra* and *Penicillium glaucum,* and the irritants were $ZnSO_4$, $FeSO_4$ and LiCl. The results go to show that although the economic coefficient of the sugar is increased, yet the CO_2 respired by the fungus remains proportionally the same.

The Dehiscence of Anthers by Apical Pores: J. A. Harris.

The author presents a systematically arranged descriptive list of all genera in which the dehiscence of the anthers is by apical pores, and makes a series of comparisons of the floral structure of these forms with other members of the same family, showing the modifications in not only the stamens, but the other floral parts as well, upon the assumption of the apically dehiscent habit. The forms are divided into groups or 'types' on structural grounds and the ecological relations of these considered. While the types as a whole are not sharply limited, a pronounced similarity of form in the corresponding parts of the different genera is observable even when these belong to systematic groups differing widely in floral habit. For some of these types the geographical distribution of the genera and species has a similarity which does not seem to depend on systematic relationships. The only explanation which seems possible is that of the somewhat similar distribution of the Apidæ, upon which their structure indicates they are largely dependent for pollination.

Francis E. Lloyd,
Secretary.

GEOGRAPHY IN THE UNITED STATES. II.

It has been maintained that one of the embarrassments from which geography suffers is the incoherence of the many things that are involved in its broad relationships. This is not really a serious embarrassment, and so far as it is an embarrassment at all it is not peculiar to geography. It is not a serious embarrassment, because when any element of geography is treated in view of the relations into which it enters, it becomes reasonably interesting to all who are concerned with scientific geography. The embarrassment is not peculiar to geography, for it is found in all other studies; in history, for example, where an essay by a specialist on the modern history of South America is not likely to excite an enthusiastic interest in the mind of the student of classic times in Greece, or in the mind of the student of medieval church history in Germany; the embarrassment is known also in geology, where the student of the petrography of the southern Appalachians, or of the paleontology of the Trias in California, may care little for a paper by a colleague on the glaciation of the Tian Shan Mountains in Turkestan. Yet, however unlike these various topics in history or in geology may be, they are welcomed, if well treated, by all the members of the expert society or by all the readers of the special journal in which they are presented, because they so manifestly make for progress in the science to which they belong. Geographers need not, therefore, be embarrassed on finding discussions of magnetic declination as affecting the navigation of the antarctic re-

gions, of the relations of climate and religion among the Hopi amerinds, and of the facilities for irrigation peculiar to aggrading fluviatile plains, all in one journal; this diversity of topics only illustrates the great richness of geography, and thus likens it to history and geology.

Let me consider next the advantages that will come to geography from the systematic collection and classification of all the facts pertinent to it. The popular idea of geographical research is fulfilled when an explorer discovers a new mountain or a new island; but discovery is not enough. The thing discovered must be carefully described in view of all that is known of similar things, and the relation into which the thing enters must be sought and analyzed. Careful work of this nature involves the development of systematic geography, in which all items of a kind are brought together, and all kinds of items are arranged according to some serviceable scheme of classification. Geographers are far behind zoologists and botanists in this respect, for there is to-day no comprehensive scheme of geographical classification in general use. Existing schemes are too generally empirical and incomplete. So important a group of land forms as mountains has never yet been thoroughly treated in a physiographic sense, while the organic responses to inorganic controls are as a rule not classified by geographers at all; yet a comprehensive scheme of classification should certainly provide systematic places for the organic responses as carefully as for inorganic controls. In the absence of a generally accepted scheme of classification, it is natural that items of one kind and another should be neglected in text-books and elsewhere; for it is well known that incompleteness of treatment goes with unsystematic methods. So simple and manifest a response to the globular form of the earth as is afforded by a wide extent of modern commerce is seldom mentioned in connection with its control. The many important and interesting responses to the eternal and omnipresent force of gravity are not habitually treated as geographical topics at all; nor is the definition of boundaries in terms of meridians and parallels usually recognized as a response that civilized nations now habitually make to the form and rotation of the earth, when they have occasion to divide new territory in advance of surveys and settlement. Yet surely all these responses to environment deserve systematic mention when the earth is described as a rotating, gravitating globe, just as the location of villages and the growth of cities at some point of advantage to their inhabitants deserve mention in the pages given up to geography of the more conventional kind. The development of a well-tested scheme of systematic geography may, therefore, be urged upon every geographer as a problem well worthy of his attention. A practical step toward the construction of such a scheme is evidently the accumulation of items that call for classification; therefore, let the geographer study the world about him: and a most effectual aid in the accumulation of items is found in searching for the organic response to every inorganic control, and for the inorganic control of every organic response that comes to one's attention; therefore, let the geographer think carefully as he looks about him over the world. It can hardly be doubted that the explorer who goes abroad or the student who stays at home will make better progress in his investigations in proportion to the completeness of the systematic scheme with respect to which he consciously carries on his work. I would, therefore, urge the development of the habits of always associating causes with their consequences and consequences with their causes, and of always referring both

causes and consequences to the classes in which they belong. If to these two habits we add a third, namely, that of making a careful arrangement of the classes in a reasonable and serviceable order, we shall have taken three important steps in geographical progress, and, as a result, geography will flourish.

There is no device by which the work of the specialist is so helpfully relieved of its narrowing influence as by the simple device of looking always for the general geographical relations of any special topic. The specialist in the geographical study of ocean currents, of caverns or of deltas, of forests, of trade routes or of cities, should not lessen his attention to his chosen line of work, but he should, often to his great advantage, increase his attention to the place that his chosen subject holds in the whole content of geography. Not only will his work be broadened in this way, but both he and his work will be brought into closer relations with the whole body of geographers and the whole content of geography, and the possibility of organizing a society of mature geographical experts will be thereby greatly increased. If the geographical relations of a special topic are not looked for, the specialist fails to that extent of becoming a geographer. The climatologist who studies the physical conditions of the atmosphere for their own sake, the oceanographer who makes no application of the physical features of the ocean as controls of organic consequences, the geomorphist who is satisfied with the study of land forms as a finality, the student of the location of cities and the boundaries of states who makes no search for the explanation of his facts as affected by physiographic controls—these specialists may all be eminent in their own lines, but they fall short of being geographers. In the same way it might be shown that a petrographer who makes no study of field relations and discovers no results of processes and no sequences in time, fails of being a geologist, for geology deals essentially with processes and structures in time sequence; likewise a chronologist who is satisfied with mere dates of occurrence fails of being a historian, for history involves the meaning as well as the mere sequence of human events. There is, of course, no blame to be attached to interest in specialization, no praise to an interest in larger relations; it is merely a matter of fact that the isolated specialist remains somewhat to one side of the larger sciences with which he might become associated. On the other hand, the geographer is not necessarily so broad-minded that he must be shallow; he may specialize deeply on the climatologic, oceanographic, geomorphic, topographic, organic divisions of his subject; but if he wishes to be considered a geographer he should cultivate all the geographic relations into which the facts of his chosen division enters, and he will find that it is largely through these relations that he associates himself profitably with other geographers.

Two of the most beneficial results of the systematic study of geography are the great increase in the number of classes or types with which the geographer becomes familiar, and the great improvement in the definition of these types. This is particularly the case with those types which contain many individual examples, such as rivers and cities, and which are, therefore, capable of division into many headings. So long as the geographer deals only with things in an empirical fashion, he may be satisfied with a rough classification; as soon as he begins to treat his problems more carefully, his classification becomes more refined and he has relatively more to do with classes of things than with the things themselves. The things are actual, the classes are ideal, and therein lies one

of the greatest values of systematic geography; it enforces attention upon the idealized type; by means of this increased attention the type is more fully conceived, and both observation and description of actual things are greatly aided. Let me illustrate.

The breezes that descend from mountain valleys at night are well known and well understood phenomena. As a result, one may form a well-defined conception of such a breeze—a type mountain breeze—imagining its gradual beginning, its increase in strength with its extension in area, and its gradual extinction; all its phases of waxing and waning being duly related to the passing hours of the night and to the associated changes of temperature. It is safe to say that no actual mountain breeze is as well known by direct observation of all its parts and stages as is the type breeze, in which all pertinent observations are properly generalized, and in which the deficiencies of observation are supplemented as far as possible by inferences deduced from well-established physical laws. It is entirely possible that there may be some errors in the deduced elements of the ideal type-breeze, but it may be confidently asserted that the errors will be replaced by the truth through the methods involved in observing, imagining and checking, guided by the conception of the type, sooner than the truth will be discovered by blind observation unguided by the aid that a well-defined type affords.

It is the same with an alluvial fan; an element of land form that has, by the way, more similarity to a mountain breeze than appears on first thought. Observation shows only the existing stage of the surface of a fan; the fully developed type-fan includes the structure as well as the surface, the process and the progress of formation, extended into the future as well as brought forward from the past. There can be no question that the explorer who is equipped with a clear conception of a type-fan can do much better work in observing and describing the fans that he may find than will be done by an explorer who thinks he can dispense with all idealized types, and who proposes simply to describe what he sees. The shortcomings of the simple observational method would be less if it were not so difficult to see what one looks at and to record what one sees; but any one who has had experience in field studies knows how far short seeing may be of looking, and how far short recording may be of seeing. The best results in geographical investigation can only be obtained when every legitimate aid to observation and description is summoned; and of all aids, that furnished by carefully considered types, reasonably classified, is the greatest. When large and complicated features, such as valley systems or cuestas, are to be described, the need of types is vastly increased. Hence one of the most important and practical suggestions that can be made toward the maturing of geographical science is to cultivate the geographical imagination in the direction of acquiring familiarity with a large, systematic series of well-defined ideal types. As progress is made in this direction there will be profitable advance from that narrow conception of geography which is based on the school-day study of names, locations and boundaries—the only conception of geography that many mature persons in this country possess—to a wider conception in which everything studied is considered as an example of a kind of things, so that it shall appeal to the reasonable understanding rather than to the empirical memory. Progress of this sort is already apparent in the schools, but it has not yet reached a desirable measure of advance.

One of the best results that follow from the systematic recognition of a large num-

ber of well-defined types will be the natural development of an adequate geographical terminology. When review is made of modern geographical articles it is curious and significant to find only a small addition to the school-boy list of technical terms. This is not true of any subject that is cultivated in the universities as well as in the schools. It is a reproach to geography that the results of mature observation are so generally described in the inadequate terms of immature study; this reproach will have the less ground the more thoroughly systematic geography is studied. With the development of more mature methods of description there may come a larger share of attention to the thing described, and thus a relative decrease of attention to matters of merely personal narrative. I do not wish to lessen the number of entertaining books of travel which now fill many of the shelves in libraries called geographical, but it would be a great satisfaction to see the standard works of geographical libraries given a more objective quality, so that they might compare favorably with the standard works of geological or botanical libraries, in which the element of personal narrative is reduced to its properly subordinate place.

Another step of equal importance with the establishment of geographical types is the change from the empirical to the explanatory or rational or genetic method of treating the elemental facts that enter into geographical relationships. The rational method has long been pursued in regard to the facts of the atmosphere and the ocean; it is coming to be adopted for facts concerning the lands; and since the adoption of an evolutionary philosophy, the evolutionary explanation of the organic items of geography may replace the teleological treatment that obtained in Ritter's time. It is, however, very seldom the case that geographers adopt the rational method consciously and fully; hence special attention to this phase of the theoretical side of geography may be strongly urged. It may be noted in this connection that the application of the explanatory method has been so lately made to the treatment of land forms that the geographer may for the present make himself to his advantage something of a specialist in this branch of the subject. It should be added that, so long as he studies land forms in order better to understand the environment in which living things find themselves, he remains a geographer and does not become a geologist. There is a needless confusion in this matter, which may, perhaps, be lessened if its untangling be illustrated by the following geological comparison.

For some decades past a new method of treatment has been applied to the study of rocks, greatly to the advantage of geologists. The method requires a good knowledge of inorganic chemistry and of optical physics, and the geologists who have specialized in the study of rocks have had to make themselves experts in these phases of physics and chemistry; but they are not for that reason classified as physicists or chemists. They remain geologists, though sometimes taking the special title of petrographer. So with the geographer who specializes in the study of land forms; he must make himself familiar with certain phases of geology, but he does not, therefore, become a geologist; he remains a geographer. His object is not to discover for their own sake the past stages through which existing land forms have been developed; he studies past forms only in order to extend his knowledge of systematic physiography and thus to increase his appreciation of existing forms. As far as he studies the sequence of past forms he is studying a phase of geology, just as the geologist who examines existing arrangements of climate, of oceanic circulation, or

of land forms, is studying a phase of physiography. The two sciences are manifestly related, but they need not be confused. For, as has been shown for sciences in general, geology and geography are best characterized by the relations in which their topics are studied, and not by the topics themselves. Both are concerned with the earth and life. The whole content of knowledge concerning the earth and life might be shown by a cube, in which vertical lines represented the passage of time, and horizontal planes represented phenomena considered in their areal extension; then if the whole mass of the cube were conceived as made up of vertical lines, that would suggest the geological conception of the whole problem; while if the cube were made up of horizontal planes, that would suggest its geographical aspect; and the whole series of paleogeographies, horizontally stratified with respect to the vertical time line, would culminate in the geography of to-day.

Objection is sometimes made to the plan of geography, as here set forth, that it involves hypotheses and theories, instead of being content with matters of fact, as the advocates of a more conservative method in geography suppose themselves to be. There is no doubt that geographical investigation of the kind here exposed does involve abundant theorizing, but that is one of its chief merits, for therein it adopts the methods of all inductive sciences. Furthermore, as between the progressive geographer, who candidly recognizes that he must theorize, and the conservative geographer, who thinks that he observes facts only and lets theories alone, the chief difference is not that the first one theorizes and the second does not, but that the first one knows when he is theorizing and takes care to separate his facts and his inferences, to theorize logically, to evaluate his results, while the second one theorizes unconsciously and hence uncritically, and, therefore, fails to separate his inferences sharply from his facts, and gives little attention to the evaluation of his results. Geography has, indeed, suffered so long and so seriously from the failure of geographers to cultivate the habit of theorizing as critically as the habit of observing—studies of the atmosphere and the ocean still excepted, as above—that a strong recommendation must be given to the acquisition of the methods of theoretical investigation, in which deduction is an essential part, by every one who proposes to call himself a scientific geographer. Let me give an example of the loss of time that has resulted from the failure of geographers to develop the habit of theorizing.

For forty years past there has been active discussion as to how far land forms in glaciated regions had been shaped by glacial erosion, but not till within five years has any geographer clearly defined the deductive side of this problem. In order to determine whether land forms are carved by glacial erosion or not, two methods have been open: one is to observe the action of existing glaciers and thus determine whether they are competent or not to carve land forms; but this is difficult, because the beds on which glaciers lie can not be well examined. The other method is to deduce the appropriate consequences of both the affirmative and the negative suppositions, and then to confront these consequences with the facts found in regions once glaciated, and see which set of consequences is best supported. This deductive method is very simple. Its application involves no principle that was not perfectly well known fifty years ago, though it does involve a facility in theorizing that does not seem to have been familiar or habitual with geographers until more recent times. On the supposition that gla-

ciers do not erode, the valley systems of once glaciated mountains ought not to exhibit any significant peculiarity of form, but should correspond to the normal stream-worn valley systems of non-glaciated mountains. On the supposition that glaciers do erode, the valley systems of once glaciated mountains should exhibit the highly specialized feature of a discordant junction of branch and trunk; for the channels eroded by a small branch glacier and by a large trunk glacier must stand at discordant levels at their junction, just as the channels of a small stream and a large river do, though the measure of discordance is much greater in the channels of the clumsy, slow-moving ice-streams than in the channels of the nimble, quick-moving water-streams. There can be no question that these well-specialized consequences, deduced from the postulate that glaciers can erode their channels, are much more accordant with the actual features of valley systems in once glaciated mountains than are the consequences deduced from the opposite postulate; but my reason for introducing this problem here is not to call attention to the value of 'hanging valleys' in evidence of glacial erosion, as first clearly set forth by Gannett in 1898 in his account of Lake Chelan, but rather to point out how slow geographers have been to employ the deductive method in solving this long-vexed problem. The moral of this is that geographers as well as geologists, physicists, astronomers, ought to have good training in scientific methods of investigation, in which all their faculties are employed in striving to reach the goal of full understanding, instead of depending so largely on the single faculty of observation.

Some may, however, object that the problem of glacial erosion, just touched upon, belongs exclusively to geology, and not at all to geography. It belongs to both; its association will be determined by its application, as the following considerations will show. The accumulation of sand-dunes by wind action, the abrasion of sea-coasts by waves, the erosion of gorges by streams, the construction of volcanoes by eruptions now in progress, manifestly belong in the study of physical geography, in close association with the blowing of the winds, the rolling of the waves, the flowing of streams, and the outbursting of lavas and gases. Both the agent and the result of its action are elements of the environment by which life is conditioned. Similarly, the grass-covered dunes of Hungary, the elevated sea-cliffs of Scotland, the abandoned gorges of central New York, and the quiescent volcanoes of central France, are all elements of land forms and are all treated as geographical topics and explained by reference to their extinct causes in the modern rational method of geographical study. Likewise the discordant valley systems of glaciated mountains are proper subjects for explanatory treatment in the study of geography, although the glacier systems that eroded them are extinct; they deserve explanatory treatment in geography just as fully as do the accordant valley systems of non-glaciated mountains. It is true that discussion as to whether certain sculptured land forms are due to glacial erosion is likely to continue more or less actively through the present decade; but when this problem is as well settled as the problem of stream erosion has already been, the geographer will be content with the simplest statement of the evidence that is essential to the conclusion reached; and the explanatory descriptions of land forms will include due reference to forms of glacial origin, just as much as a matter of course as they now include reference to forms of marine or of subaerial origin. Forms of glacial sculpture will be given as assured a place in

geographical study as forms of glacial deposition are already given. Neither the thing studied, nor the agent by which it was produced, nor the method by which the agent is shown to be accountable for the thing, suffices to show whether the thing is of a geological or a geographical nature. This question will be decided, as has already been shown, by the relations into which the thing enters. It would be as unreasonable to omit all reference to glacial erosion in a geographical description of Norway as to omit all reference to subaerial erosion in a geographical account of our Atlantic coastal plain.

Nowhere is the cultivation of systematic geography more helpful than in the study of local or regional geography. The truth of this may be appreciated by considering the case of botany. No botanist would attempt to describe the flora of one of our states until he had obtained a good knowledge of systematic botany in general. Such knowledge would help him at every turn in his study of a local flora, not only in describing the plants that he might find, and in arranging the descriptions in a serviceable order, but also in finding the plants themselves. I believe that a closely equivalent statement might be made with regard to the geography of a state; and yet there is not, to my knowledge, a single work on regional geography in which a recognized scheme of systematic geography has been avowedly followed as a guide for the treatment of local features. The adoption of such a guide would lead to various advantages; on announcing that a certain scheme of systematic geography has been chosen as a standard, the writer of a regional work thereby gives notice in the simplest manner to the reader as to the kind and amount of knowledge necessary to understand the work in hand; descriptions are made at once briefer and more intelligible than by phrasing them in terms of a scheme that is elsewhere stated in full; relative completeness of treatment is assured, for with a systematic list of all kinds of geographical relations at hand, the writer is not likely to overlook any element of the subject that occurs within his chosen region; the reader can easily find any desired topic, not only by means of the table of contents and index, but also by means of the standard scheme of classification in accordance with which all elements are arranged; and finally, books on different regions will come to exhibit a desirable uniformity of treatment when they are based on a common scheme of systematic geography. Although no books of this kind now exist, I do not think it overventuresome to say that some such books will soon exist, and that they will form very serviceable contributions to the literature of our subject.

The various recommendations that I have made are likely to remain in the air, or at most to secure response only from isolated individual students, unless those who believe that the adoption of these recommendations would promote the scientific study of geography are willing to give something of their time and thought toward organizing a society of geographical experts—an American geographers' union. From such a union I am sure that geography would gain strength, but it is not yet at all clear in my mind that any significant number of persons would care to accept the strict conditions or organization which appears to me essential for the success of such an enterprise. The most important of the conditions are as follows:

1. The adoption of some definition for geography that shall sufficiently indicate the boundaries as well as the content of this broad subject.

2. The limitation of membership to persons with whom geography as thus defined is a first or at least a second interest, and

by whom more than one geographical article of advanced grade, based on original observation and study, has been published.

3. The independence of the union thus constituted of all other geographical societies.

Although we can not adduce any existing geographical society in this country as a witness competent to prove that geography has sufficient unity and coherence to tempt geographers to form such a union as is here contemplated, a careful review of the problem convinces me that a sufficient unity and coherence really exist in the science as I have treated it; and I, therefore, believe that the formation of an American geographers' union is feasible as well as desirable.

It has been my object in this address to describe briefly the status of mature geography in our country, and to suggest several steps that might be taken for its improvement. Certain branches of the subject have reached a high development, but the subject as a whole does not thrive with us. The reason for its relative failure is not, I believe, to be found in the very varied nature of its different parts, but rather in the failure to place sufficient emphasis on those relationships by which, more than by anything else, geography is to be distinguished from other sciences, and by which, more than by anything else, geographers may come to be united. Among the great number of persons—many thousands in all—whose attention is given primarily to subjects that are closely related to geography as here defined, there must certainly be many—probably several hundred—with whom mature geography is a first interest. It is upon these persons, geographers by first intention, that the future development of sound and thorough, mature and scientific, geography among us primarily depends. To these geographers, in particular, I would urge the importance of developing the systematic aspects of the science, and of constantly associating the special branch that they cultivate with the subject as a whole. Observation will not suffice for the full development of geography; critical methods of investigation, in which deduction has a large place, must be employed; for only by the aid of careful theorizing can an understanding of many parts of the subject be gained. With the progress of systematic geography we may expect to see a parallel progress of local or regional geography. As the science is thus developed, societies of mature geographical experts will be formed, and scientific geography will thrive; but whether thus developed into a thriving science or not, I hope that another long term of years may not pass without a representative of geography in this vice-presidential chair.

W. M. Davis.

Harvard University.

KARL ALFRED VON ZITTEL.

In the death of Karl Alfred von Zittel paleontology has lost one of its most distinguished advocates. Although a German by birth, Professor von Zittel belonged to every country, and through his remarkable work 'Handbuch der Palæontologie' his influence extended everywhere. It is probably not an exaggeration to say that he did more for the promotion and diffusion of paleontology than any other single man who lived during the nineteenth century. While not gifted with genius, he possessed extraordinary judgment, critical capacity and untiring industry.

The first volume of his great work bears the date 1876–1880, covering the extinct Protozoa, Cœlenterata, Echinodermata and Molluscoidea; the second volume, covering the Mollusca and Arthropoda, bears the date 1881–1885; the third volume, beginning the Vertebrata, was issued between 1887 and 1890, and covers the Pisces, Am-