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# *FAREWELL LECTURE BY PROFESSOR EDWARD SUESS ON RESIGNING HIS PROFESSORSHIP*

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# FAREWELL LECTURE BY PROFESSOR EDUARD SUESS ON RESIGNING HIS PROFESSORSHIP.[1]

In the last lecture we occupied ourselves with the structure of South America. We saw that the earlier volcanic occurrences are restricted entirely to the Cordillera of the Andes, but that in the course of their appearance there are long interruptions.

We have therefore arrived at the close of our hasty survey of the earth's entire surface, and today we will review the events which have been set forth during the last two semesters. The present lecture, moreover, also closes my active life as a professor, and I stand at the end of a career of teaching at this university, which I have been permitted to enjoy for eighty-eight semesters. Before I take up the short summary mentioned, I believe it suitable to say a few words in regard to the changes which our science has undergone during this long period.

My collegiate work as lecturer on general paleontology was begun October 7, 1857—two years before the appearance of Darwin's book, *The Origin of Species.*

It is well known that in the eighteenth century prominent thinkers, as Leibnitz, Herder, and others, properly recognized the connection and unity of all organic life. But, at the beginning of the nineteenth century, Cuvier, essentially by means of the fossils of the chalk of Montmartre, was able to present the surprising evidence that there had lived on the earth genera of animals which today are wholly extinct, and that similar changes have again and again occurred in the animal kingdom. He thus concluded that there had been repeated revolutions. In this he was followed by the great majority of inquirers, and at that time—the year 1857—everyone was completely under the influence of Cuvier's views. Personally, a paper by Edward Forbes, on the influence of the glacial period on migrations, had a great effect on me; the article merits reading even to this day.

[1] Given July 13, 1901, in the Geological Lecture Hall, Vienna University; taken stenographically by Mr. H. Beck. For the original lecture, in German, see *Mitth. Pal. u. Geol. Inst.*, Universität Wien, 1902, pp. 1–8. Translator, Charles Schuchert.

After the appearance of Darwin's book, there occurred a great and general change of view in all branches of biology. In fact, outside the great discoveries of Copernicus and Galileo, there cannot be cited another example having so deep an influence on the general opinions of naturalists. Darwin was not the first to conceive and pronounce upon the unity of all life; but that he was able to produce stronger proofs and to direct the trend of thought constitutes his undying fame.

In the field of paleontology the consummation of this change did not, of course, go on so simply and, at least with us, so entirely in accordance with the views of Darwin as one is apt to imagine. The Darwinian theory of the variability of species was essentially based on selection and related appearances. Paleontology, however, teaches otherwise. It teaches that the terminology for single divisions of the stratified terranes, characterized by their fossil remains, finds application over the entire earth. Therefore from time to time there must have occurred, in some way, general changes affecting the entire physical condition of the world. Nor is there seen a perpetual and continuous changing of organic beings, as would be the case through the constant influence of selection. On the contrary, there are entire groups of animals appearing and disappearing. Darwin sought to explain this by means of gaps in our knowledge, but today it is known that these supposed gaps possess too great a horizontal extension.

There now arises the thought that the changes in the outer conditions of life have a controlling influence. I may here state that on this question there was some correspondence between Darwin and our widely mourned Neumayr, and that Darwin in no wise took a dissenting stand against the objections. In this connection it is most remarkable that the great and general knowledge of paleontology which I have just indicated, should apparently have made upon so great a mind as Darwin's less of an impression than those small lines of variation noticed in certain fossil fresh-water snails, as, for example, in *Valvata* or *Paludina*.

Here and there conditions are combined which permit somewhat closer analyses of the relations of this subject. This for instance, is the case in the superposition of the Tertiary land faunas of Europe,

more particularly of Vienna. Here one recognizes the following: Living beings are dependent, on the one hand, on certain outer physical circumstances, as climate, moisture, etc.; on the other hand, they also are mutually and socially dependent upon one another. Every living province—or, as it is usually expressed, every zoölogical province—forms, as it were, an economical unity in which for so many flesh-eaters there must be so many plant-feeding food animals; for so many plant-feeders, so many food plants; honey-sucking Lepidoptera presuppose flowers; for insect-feeding song-birds a certain number of small insects are necessary, etc. The disturbance of one member of this unity can possibly destroy the balance of the whole.

According to all appearances, such disturbances have occurred from time to time in land faunas, and they may have been of very diverse kinds. Then again an entire fauna is seen to vanish over all Europe, or over a still greater region, and a new fauna comes in to take its place. This new fauna nevertheless always has a more or less strongly vicarious relationship to its predecessor; it is clearly a variation of the former, probably in the main a resulting adaptation to changed conditions; and even if the sequence of strata were completely unknown, one could readily discern which was the first, the second, or the third fauna.

Besides this, the numerous phylogenetic lines which unite nearly all the great groups of fossil animals; or the unity in the developmental nature of single organs, as the extremities; or the general superposition of gills and lungs; or the rows of striking harmonies that exist between the development of certain groups of animals, and of single individuals of these groups—all indicate with certainty the correctness of the Darwinian basal idea, namely, the unity of life.

Stratigraphic geology and paleontology show that the evolution of organic life was probably never completely interrupted, but that it did not go on in a uniform manner. Disturbances have occurred. The struggle for existence continues; yet it is only of secondary importance. Single very old types, as *Hatteria* (*Sphenodon*), have continued to maintain themselves to our day with but slight changes.

Allow me now to speak of a few tectonic questions.

When I began my collegiate work, there prevailed, especially in

Germany, the idea that mountain chains were built symmetrically; one group of oldest rocks formed the lifted or lifting axis, and upon each side were arranged younger rocks in parallel zones. Thus, you will still find in my own writing on the substructure of Vienna, in the year 1862, a presentation of the Alps as symmetrical mountains.

Of course, this idea did not prevail without objections. At nearly every gathering of German naturalists at that time, the old Bergrath Dücker arose to protest against it. No one listened to him. With Schimper it was the same. The authority of Leopold von Buch, who expressed himself for symmetrical construction, remained unshaken. Then Leopold von Buch died. Upon this primary question of modern geology you will find no explanation for the origin of mountains in the leading text-books of that time, as, for instance, Lyell's justly celebrated *Principles of Geology*.

For the investigation of this problem no part of Europe was more advantageously situated than Austria. There the land is arrayed before us in unusual variety. Hardly anywhere in Europe are tectonic contrasts so plainly presented—contrasts between the Bohemian Mass and the Alps, between the portion of Russian table-land beneath the Galician plain and the Carpathians, the peculiar connection of Alps and Carpathians, the continuance of the Turkestan depression over the Aral Sea into the depression of the Danube and to Vienna, and much besides. In the year 1857 the idea was still often maintained that the deposits found in the eastern Alps did not occur at all outside of the Alps, so great were the difficulties which the application of the accepted stratigraphic divisions of England and south Germany bore to the strange occurrences in the Alps themselves.

Soon, however, it was recognized that in the Bohemian Mass the stratigraphic sequence was far less complete than in the adjoining regions of the Alps, and that in Bohemia particularly there is an extraordinary interruption of marine deposits extending upward into the Middle Cretaceous, whereas in the Alps all these great epochs are represented by marine strata. This same transgression of the Middle and Upper Cretaceous shows again in Galicia, then far into Russia, on the other side of the French Central Plateau, on the Spanish Meseta, in large parts of the Sahara, in the valley of the Mississippi, and northward over this region to the vicinity of the Arctic Sea, in

Brazil, finally on the shores of central and southern Africa, in east India; and, in fact, over such extraordinarily vast regions that it became impossible longer to explain such transgressions of the sea, according to the older views of Lyell, by means of the elevation and depression of continents.

Through this and similar observations the newer idea has recently come into prominence that some general change must have occurred either in the shape of the hydrosphere or in its entire volume. It was seen that by the forming of a new oceanic depth, due to sinking, a certain amount of the hydrosphere was drawn off into the new depression, and that at the same time there appeared to be a general land elevation, or, more correctly, there must have resulted a general sinking of the beach lines. The older view of the numerous oscillations of the continents has also given way more and more to the teachings of marine transgressions, and through the denudation of continents, a more exact examination into the actual mountain movements has become possible.

If one were to assert that the Alps are folded, but that the Bohemian Mass is not, and that because of this there has resulted a damming up, then this assertion would not be exact. The Bohemian Mass is also folded, and there is at present no known portion of the earth's surface of which at least the archaic base is not folded. The difference, however, consists in this, that the folding has ended early at certain places; at others it has continued into a later or very late time, and possibly has also continued with a change in the ground-plan.

In this respect central Europe shows a quite peculiar arrangement. The oldest folding is seen in the gneiss of the western Hebrides. Younger and of pre-Devonic age are the folds of the Caledonians, which can be traced down to Ireland. On these, farther south, are ranged the Armoricanian and Varischian folds, which embrace south-western England, Normandy and Brittany, the Central Plateau, the mountains of the Rhine, and the Bohemian Mass, inclusive of the Sudetes. Its principal folding was accomplished before the close of Carboniferous time, but minor movements of various kinds have followed. The Alps and Carpathians even underwent decided folding in the Miocene. Each part has moved northward toward the pre-

ceding, or toward the horsts, in which the earlier member was dissolved by sinking, and thus Europe has resulted through a succession of younger and younger folds.

Meanwhile, more and more light came regarding the strange development which certain Mesozoic deposits, particularly the Triassic of the Alps, show when compared to the north-lying lands, as Würtemberg or Franconia. The observations in Asiatic highlands, especially in the Himalayas, taught that this type of Triassic development has a very wide distribution toward the east; and it even became possible to prove that directly across present Asia, from the existing European Mediterranean to the Sunda Islands, there once extended a continuous sea. This sea has, as you know, received the name Tethys. The old continent along its southern side was named Gondwana Land, and that on its northern side, Angara Land. The present Mediterranean is a remnant of Tethys.

This Mediterranean, however, consists of a series of areas of diverse construction, and we have had opportunity to convince ourselves that, since Middle Tertiary time, first a portion was separated, as, for instance, the Danube plain, then a portion was added, as the Ægean Sea.

The progress of geological research during the last ten years, however, has been so extremely great that a far more extensive knowledge of the seas has become possible. They are of different kinds. We examine a world-map, and thereby, in accordance with oft-repeated warning, seek to guard against the deception which the distortion of Mercator's projection so easily produces. We see that, with the exception of the two Chinese rivers, Yang-tse-kiang and Hoang-ho, hardly another great stream finds its way to the Pacific Ocean. All waters of the continents flow toward the Atlantic or Indian Ocean. Many years ago the Russian General von Tillo drew on a little map the watershed of the earth, and showed how surprisingly small an amount of fresh water the Pacific receives.

These two oceanic areas differ also in a feature of far greater importance. At the beginning of these lectures I noted the remarkable fact that from the mouth of the Ganges eastward to Cape Horn the continents are bounded ocean-ward by long arcuate mountain ranges, all of which appear to be moving toward the Pacific Ocean.

When, however, one follows the coast from the mouth of the Ganges westward, and again to Cape Horn, totally different conditions are met. Disregarding the bending of the mountains at Gibraltar and vicinity, which the American Cordilleras in the Antilles also show—at both places, as you know, folded mountain chains do approach the Atlantic area, but they bend backward as if held back by some secret force—one sees encircling the Atlantic and the Indian Oceans only similar amorphous coast lines, namely, such as are in no wise predicated by the structure of the lands. Therefore we have distinguished a Pacific and an Atlantic type of coast.

We can go still farther. In whatever direction one proceeds from the land to the Pacific, an unfolding sequence of marine series is seen. If one goes from the wide Archean areas of South America, on which lie horizontal Paleozoic sediments, toward the west, in the Andes are found marine beds of the Jura, the Lower Cretaceous, also the Middle and Upper Cretaceous. It is the same if one goes from the old Laurentian Mass in Canada westward toward the sea. This is also the case in Japan, etc. From the foregoing we may conclude that the Pacific is of very ancient origin, and that it has existed for an extraordinarily long time.

With the other oceans it is different. When one nears the Indian Ocean, horizontally disposed marine beds are met with, not folded strata as in the Pacific area. These, however, do not begin with the Trias, but in east Africa as in western Australia start with the Middle Jura, and in Madagascar with the Middle Lias. Similarly, on the shores of the Atlantic Ocean horizontal non-folded strata are found, and these, in west Africa as in North America and Brazil, begin with the Middle and Upper Cretaceous. From this we conclude that the Pacific Ocean is older, the Indian Ocean younger, and the Atlantic Ocean essentially still younger.

I have mentioned yet another ocean, Tethys, which in Mesozoic times lay across present Asia, and whose remnants constitute our Mediterranean. The entire area of Tethys is laid in folds, and from the Pacific Ocean to the Caucasus throughout these folds are also moving southward; their margins in the south are overthrusted; the entire province of the sea is crushed from the north, and even remnants of the old southern foreland—the Gondwana Land, or the

Indian peninsula—are included within this folding. You have heard that Kinchinjinga and its neighbors, the highest peaks of the earth, though within the folds of the Himalayas, still have, so far as known from their foothills, the stratigraphic sequence of Gondwana Land.

We will now take a glance at the distribution of the lines of folding on the earth's surface. In the region of Lake Baikal lies an extensive, somewhat crescentically arranged mass of very ancient Archean rocks. It is folded, with a nearly northeast strike in the east and a northwest strike in the west, and the folds are of pre-Cambrian age. This old strike locus or vertex embraces Sabaikalia, northern Mongolia, and the East Sajan. Farther northwest there is developed another, younger vertex, or a second center of folding—the Altai. From this second younger locus proceeds an extraordinarily great system of bow-shaped folds, which, in an almost incomprehensible manner, embraces the entire Northern Hemisphere. The Altai encircle the old vertex, and its bows repeat themselves in the east from Japan and Kamschatka to the Bonin Islands. Toward the west they form the broad ranges of the Tian-shan and Bei-shan. Their southeastern branches appear in the bows of Burmah. In front of them to the south lie the marginal bows of the Himalayas—the Iranic; and farther along, the Tauric-Dinaric bows. They press over the Caucasus to Europe, and form here the two previously mentioned chains of folds.

These two chains of folds are themselves preserved in different ways. The one, older, embracing the Varischian and Armoricanian folds, is first discernible in Mähren. It reaches the Atlantic Ocean in southwestern Ireland and Brittany, and disappears as a Rias coast. Years ago, however, Marcel Bertrand called attention to the fact that such a broad and mighty mountain system—on the Atlantic coast it is as broad as the bows of the Himalayas—could not possibly suddenly end here, but that in all probability it is continued to the other side of the ocean in the Rias coast of Newfoundland. As you have heard, Marcel Bertrand accordingly continued the Armoricanian primary lines directly across the ocean to the Appalachians.

Of the Appalachians, however, it has been learned in recent years that they are far longer than was formerly believed. They form a bow which is not, as in the Asiatic and European chains,

folded toward the convex side, but toward the concave side, first westerly, then northerly, and continues west of the Mississippi into the Washita Mountains.

The second or younger type, the Altai, strikes with decided flexing, narrowed through older horsts, from the Balkans to the Carpathians and the Alps, and at Gibraltar the latter join those bows of the western Mediterranean that are completely reversed.

Let us return once more to North America. As we have heard, the American term as Laurentia the wide Archean area which embraces the region of the Hudson Bay, middle Canada, and the central part of the United States. The Appalachians to the east and south of this mass, as we have seen, have a concave strike, are folded toward Laurentia, and vanish in the Washita hills. West of Laurentia, also, it is similar. It could have been shown that the Cordillera, whose connection with northern Asia has of course not yet been established, is, on its eastern side, in Canada, also folded toward Laurentia. It, too, bends toward the south with a more and more concave strike; continuing through Mexico, it is folded to the northeast, and then part of its folds finally turn toward Cuba and in the direction of the Antilles.

Thus on both sides is North America encircled by concave-striking chains of folds. It is as if the folds extended away from Asia and toward Laurentia. This entire grand phenomenon may be illustrated by a comparison. By the eruption of Krakatoa the oceans were moved; long waves proceeded from the place of eruption, traveled around the entire earth, and met themselves on the other side of the sphere. This is merely a comparison, not an explanation.

In the Southern Hemisphere the state of things is wholly different. For some time it has been known that in East India and South Africa, during Permian and Trias time, there flourished identical land floras—the Gondwana floras. Accordingly, it is concluded that these two continents were once united, and the area was named Gondwana Land. Later such floras were also found in Australia; then in the Argentine Republic. Thus it spread around the south. But the conclusion drawn from this as to the continuity of so great a continent was shattered by the circumstance that not only the

characterizing plants of Lower Gondwana, but, in addition, the South African occurrences of associated animals, were also found in the Permian deposits of Perm in north Russia.

What then results is an exceedingly similar distribution of land plants and land animals of that time, and a great continent in the south; yet immediate proof of its continuity is lacking.

In fact, only on the Pacific margins of this supposed or actually united continent is it found that folding has taken place, and, indeed, in the east of Australia and the west of South America; while the intermediate Atlantic and Indian coasts are without younger folds. It is true that more recently, folding of pre-Carboniferous time has been described in South Africa, but in general the entire area between the western South American Cordilleras and the eastern Australian Cordilleras appears dead and unmovable. This is in contradistinction to the great diversity in movements of the Northern Hemisphere.

In general, these are the chains which we have sought to follow in detail in the course of these two semesters. The attempt toward a geometric arrangement of the mountain chains, which recently has been undertaken by distinguished specialists, finds, I fear, but little confirmation in actual occurrences. The tectonic lines that are met in nature tend generally at most to follow straight lines only in fissures or faults. The foldings, however, maintain themselves more like long waves, and they give way to the older horsts. This is seen more clearly in the youngest Alps, or that branch of the Altai trending toward Europe; the bows of the Banda Islands are similar.

I should now like to say a little about the conditions of life upon the earth. We have already spoken of the wide distribution of the land faunas and land floras of Lower Gondwana. Earlier types of Carboniferous land floras had spread themselves from the Arctic region to South Africa. The Culm flora is known in Europe, Mongolia, and Australia. Still more noteworthy is the fact that in the basalt streams of western Greenland there are interbedded plant layers of Lower and Middle Cretaceous, as well as of Tertiary times, and that during all this period there lived in this Arctic region first ferns and then leaf-bearing trees. In a word, in west Greenland

are seen occurrences of different times which throughout cannot be brought into harmony with the climatic conditions of the glacial period nor with those of the present; thus this entire younger epoch appears as an exception. One gets the impression that not at all times did there exist the present diversity of climate, and also that the diversity of life was not at all times a varied one. The great Indian land fauna of today, with its tigers and elephants, can be considered as an independent unity, but here and there it is accompanied by older Malayan remnants which increase the diversity.

Gentlemen, as you see by this attempted survey, I can point out only some of the various directions in which our studies may be continued, and there exist so many hundreds and hundreds of questions that all, even the keenest ambition, will find the portals open and may hope for satisfaction. New discoveries are in prospect for all conscientious inquirers.

In the course of the years I have seen and experienced much. In the beginning a man has honestly to endeavor with zeal, and with certain restrictions upon himself, to learn the detail; and sometimes the hair whitens before he is in a position to obtain a general view and to risk a first synthetic attempt. This first step to synthesis is, however, the deciding step in the life of the inquirer. Soon he notes that his judgment obtains more consideration among his colaborers; he becomes more careful and conservative with the same; and finally the hour arrives in which his soul is filled with the highest satisfaction, because he has been able to add to human knowledge some new view or a new fact—a feeling over against which everything naturally vanishes that the outer world is able to offer in acknowledgment.

Bulwer Lytton says in his novel: "When a man of great age is surrounded by children, he then sees at the end of his days, not a period, but only a comma." This applies in equal measure to the inquirer and to his students. This is my good fortune, which today becomes my portion.

Many have departed from us. The dumb tablets in our collection halls give their names, and it is our duty today to remember them gratefully. Stolizcka found his end on Kara-Korum, Lend on Kilima-ndjara, Foullon on Gaudalcanar; Rodler brought his death

germ from the Bachtyari Hills; we all think of Oscar Baumann with admiration.

I rejoice today with all my heart that I am enabled to greet, not a series of students, but generations of students, from the renowned gray-haired members of the Royal Academy to the young fellows with sharp eyes.

To the young ones among you I should at this moment like to say another word. The old ones know it already. In the course of these forty-four years much has occurred on the earth, but nothing at this time so penetrating, nothing so decisive for the entire culture of humanity, as progress in the natural sciences. Into all departments of human life and doings it has entered; it influences and changes our social conditions, our philosophical conclusions, our political economy, the strength of states, everything. He who will look closer, however, can perceive that, besides the natural sciences, the naturalist himself is coming more and more to the front, that his social significance is being recognized, and that the worth of his studies is being more valued.

Accordingly, the growing generation of inquirers has an increased duty, which consists in this, that the ethics of their personal life shall become more precise, so that, by the increasing influence of naturalists on all social and state life, the naturalist will also feel himself more worthy to take part in the guidance of intellectual humanity.

And now I have reached the comma. When I became a teacher, I did not cease to be a student; and now that I cease to be a teacher, I shall not cease to be a student so long as my eyes see, my ears hear, and my hands can grasp. With this wish, I therefore do not step out, but take up my former position.

And now I thank you all from the depths of my heart for your presence, and beg of you to retain for me a friendly remembrance.