I do not wish to be understood as opposing the preparation and furnishing of an universal card index; the schemes proposed are beautiful in the glow and shimmer of their optimism—reminding one of Chimmie Fadden, "Up t' de limit an' strikin' er great pace t' git on de odder side of it," but they must be looked at from the practical business point of view by those who are to defray the cost, and who have, I feel sure, other important uses for their money and for the skilled brains required for such work, and more definite information is wanted with regard to the number of titles, etc., which must be indexed annually upon such a scheme before a wise decision can be made. For general Biology, Morphology, Physiology, Bacteriology and scientific Pathology, and other subjects of scientific importance connected with medicine, I think that about 10,000 cards a year would be sufficient if all second-hand matter and hash were carefully excluded.

Very truly yours,

J. S. Billings.

Washington.

SCIENTIFIC LITERATURE.

The Great Ice Age and its Relation to the Antiquity of Man. By James Geikie, LL. D., D. C. L., F. R. S., etc. Murchison Professor of Geology and Mineralogy in the University of Edinburgh, formerly of H. M. Geological Survey of Scotland. Third Edition, largely rewritten, with maps and illustrations. New York, D. Appleton & Company. 1895. 8vo., xxviii + 850.

Twenty-two years ago the first edition of this book appeared in England. The author then endeavored to give a systematic account of the Glacial Epoch, with special reference to its changes of climate. In so doing he entered first quite fully into the geological history of glacial and post-glacial Scotland, presenting many elementary matters, and taking more than half the book for this purpose. Afterwards he discussed the glacial phenomena as exhibited in England, Ireland, Scandinavia, Switzerland and North America. A newly acquired view with him related to the age of the paleolithic deposits of southern England—all of which he referred to inter-glacial and pre-glacial times. It was this book that first called the attention of many geologists to the doctrine of several periods of cold in the ice age separated by as many times of milder conditions. Like the early doctrine of Agassiz and Buckland that the drift phenomena were to be explained by the agency of glaciers, so this theory of a series of cold and warm periods has been vigorously contested by geologists, but bids fair to be as generally accepted as the former. In 1877 a second edition of the book appeared. The author remarks in its preface that great additions to our knowlege of the facts had been made, above those first presented, all of which strengthened his argument that the epoch was not one continuous age of ice, but consisted of a series of alternate cold and warm or genial periods; while the ancient cave-deposits cannot be assigned to a later date than the last genial interval of the ice age, and some of them were probably still older. Among the more important alterations he notes a change in the use of the terms *till* and *boulder clay*. Instead of calling one purely glacial and the other partly marine, both are referred more or or less directly to the grinding action of glaciers, and are strictly synonymous terms. Likewise he modifies his view of the *kames;* none of them are now regarded as of marine origin. There has been no great submergence of Scotland since the close of the glacial epoch, and thus the Scotch deposits are brought into much closer relationship with those of England. In the interim he made many personal studies of the English phenomena until able to say positively that after the deposition of the ossiferous gravels

and *Cyrena* beds, a great ice-sheet stretched south as far as the valley of the Humber, thus proving the existence of a later ice incursion. In the first edition the term *kames* was not differentiated from *esker* and *åsar*, and all of them were believed to have been of marine origin; now he separates the kames from the esker and åsar and adopts Hummel's river theory of the origin of the latter, besides disowning the necessity of any marine agency in the formation of the kames. The accounts of the glacial phenomena in Europe and America are given with greater fullness in the second edition. The second edition attained a bulk of xxx + 624 pages and a larger size of page than the first, which had xxv + 524 pages.

The third and present edition shows a similar increase in size above its predecessor, but not so great a modification in the fundamental principles. About one-fourth of the subject-matter, or that relating chiefly to Alpine, Arctic and Scottish parts has been revised; but the other three-fourths have been entirely rewritten. The glacial and interglacial deposits of the continent are treated with a fullness that was impossible before. Many sections of it have been visited personally and the results of others verified. Aid has been received from a multitude of friendly fellow laborers. Necessarily because of the astonishing increase in the literature of Surface Geology, many important contributions are unnoticed. He does not profess to write the history of the rise and progress of glacial geology, but simply to sketch its present position. Nowhere, he says, has glacial geology been more actively prosecuted in recent years than in America. While he has endeavored to keep abreast of this, he preferred to have a summary of the American evidence prepared by a recognized authority; and hence called upon Professor T. C. Chamberlin, of Chicago, to furnish him with a digest of this material; which is of great service to everyone, since we have been awaiting almost with impatience the announcement of some general statements here first presented to the public. Professor Geikie also expresses his great gratification that his conclusions should essentially agree with those of Professor Penck, of Vienna, in respect to the glacial phenomena of the Alpine lands, the Pyrenees and Auvergne.

The following is a summary of the glacial succession in Europe as determined by Professor Geikie from a consideration of all the facts:

1. *Older Pliocene.*—Before the advent of the cold the sea occupied considerable tracts in the east and south of England, in Belgium, Holland, northern and western France and the coast lands of the Mediterranean, and boreal forms are just beginning to make their appearance.

2. *Newer Pliocene—First Glacial Epoch.*—The Weybourn crag and Chillesford clay of England with their pronounced arctic fauna represent a part of the evidence for this time of cold; also the bottom moraine near the Baltic sea, in southern Sweden, where the movement was from the southeast to the northwest. Arctic animal remains have also been detected in East Prussia at a similar horizon. Hence it is suggested that a gigantic glacier occupied the basin of the Baltic sea, and the mountainous parts of Scandinavia and the British Isles were snow clad. In the Alps the snow line was depressed for 4,000 feet or so below its present level, and all the great mountain valleys were filled with glaciers which left behind terminal moraines at the foot of the chain. In central France very considerable glaciers descended from the great volcanic cones of Auvergne and Cantal.

3. *First Interglacial Epoch. Latest Pliocene. Forest Bed of Cromer.*—The arctic fauna retreated from the North Sea, and dry land occupied the southern part of this sea up to the latitude of Norfolk. The river

Rhine flowed across this land. A temperate flora, much like that now existing in England, prevailed; and among the land animals were elephants, hippopotami, rhinoceroses, horses, bison, boar, deer, machærodus, hyæna, wolves, glutton, bear, beaver, etc. In other parts of Europe similar genial conditions prevailed. A luxuriant deciduous flora occupied the valleys of the Alps, attaining heights greater than the present limits of the same vegetation. Elephants existed with the flora in northern Italy. From the amount of river-erosion effected during this epoch it would appear that the stage was one of long duration.

4. *Second or Maximum Glacial Epoch.*—The mountains of Scandinavia seem to have been the center of dispersion of the ice at this time, and the glaciers extended easterly so as to become confluent with the Ural system in western Siberia, southwesterly into the basin of the Volga, southerly into the basin of the Dnieper, Poland, Saxony, Belgium, southwesterly to the British Islands, excepting a small part of southern England, and to the westward 600 feet below the present surface of the Atlantic ocean, from off Ireland to the Arctic sea. Both the Baltic and North seas were covered by ice, and erratics from the Scandinavian hills were strewn more or less over this entire area. They were also transported from lower to higher levels in the British islands, to a height of 3500 feet in Scotland, and the highest peaks may have projected through the ice as *Nunatakker*, like the bare spots thus designated in Greenland. This area is rudely elliptical in shape, 2700 miles long and 1600 miles wide. In Switzerland the Alpine glaciers reached their greatest extension, the snow line extending 4700 feet lower than it is at present, the ice being 4000 feet thick in the low grounds, and immense blocks of stone were carried across to the Jura Mountains to an elevation of 3099 feet above Lake Geneva. In connection with the presence of this ice, Arctic-Alpine plants and animals occupied the low grounds of Europe, extending even to the Mediterranean. This epoch constituted the beginning of the pleistocene or quaternary period.

5. *Second Interglacial Epoch.*—The return of the temperate flora and fauna in north Germany and central Russia is suggestive of a milder and less extreme climate than is now experienced in those regions. Britain must have been connected with the continent and Italy with North Africa. The rivers of this epoch eroded their valleys to great depths.

6. *Third Glacial Epoch.*—An extensive ice-sheet overwhelmed most of the British Islands and much of the continent. The northwestern limits are much the same in the edges of the Atlantic and Arctic oceans, but to the east it extended about a hundred miles beyond St. Petersburg, and just reached Berlin to the south. From the Alps glaciers descended to the low grounds, dropping conspicuous moraines, which extend in curving lines between the highly denuded moraines of the earlier epochs, and the associated extensive fluvio-glacial gravels.

7. *Third Interglacial Epoch.*—The youngest interglacial beds of the Baltic coastlands belong here, with both arctic and temperate marine faunas—as the mammoth, wooly rhinoceros, hare, urus and Irish deer. It is probable that a considerable portion of the old alluvial deposits of Britain and Ireland, hitherto classed as post-glacial, belong here.

8. *Fourth Glacial Epoch.*—The ice-sheets of the British Islands are now local and entirely separate from the Scandinavian mass. In Scotland the snow line did not exceed 1600 feet in elevation above the sea; the land was 100 feet higher than now, and an arctic marine fauna occupied the coasts. The Scandinavian peninsula supported an ice-sheet of more importance,

which discharged icebergs at the mouths of fiords in western Norway. Finland was overwhelmed, and the Baltic basin was occupied by a great ice stream, which invaded north Germany and Denmark. As the ice melted, a wide area in Scandinavia was submerged in a cold sea communicating with the Baltic. In the Alps the snow line was 300 feet lower than now.

9. *Fourth Interglacial Epoch.*—The British Islands were connected with the continent. Deciduous trees spread far north into regions now bereft of them. The Baltic sea became converted into a great lake; Denmark and Sweden were united; the Rhine flowed quite near England and Scotland, over the upraised bed of the North Sea, meeting the main ocean above Bergen; the Seine flowed through the English channel beyond Brest, and there was a large river flowing over the bed of the Irish Sea, having the Severn for a tributary, and meeting the ocean quite near the mouth of the Seine, and there was a land connection between the continent, Great Britain, Iceland and Greenland. When the salt water finally returned, the fauna was more temperate than it is at present. This epoch is not yet recognized in the Alps.

10. *Fifth Glacial Epoch.*—In Scotland the snow line reached an average height of 2,500 feet, the shore line being fifty feet lower than it is now. Occasionally glaciers discharged bergs into the sea on the northwest coast of Scotland. Most of the corrie rock-basins of the British Islands were excavated in this epoch, each one marking the presence of a distinct glacier. In the Alps there were advances of the glaciers giving rise to terminal moraines, the snow line reaching a depression of 1,600 feet below the present limit.

11. *Fifth Interglacial Epoch.*—The upper 'buried forests' of northwest Europe show that this epoch was characterized by drier conditions and a remarkable recrudescence of forest growth. It is uncertain whether Britain was connected with the continent.

12. *Sixth Glacial Epoch.*—This is indicated by the latest raised beaches of Scotland, indicating twenty or thirty feet of depression. The snow line stood at an elevation of 3,500 feet, and thus a few small glaciers could exist in the loftiest highlands. In the western Alps there were some high level moraines.

13. *The Present.*—The sea has retreated to its present level, drier conditions prevail and permanent snow fields have disappeared from most of the regions in northern Europe once so completely submerged by glacial ice. The term post-glacial properly describes only the present epoch.

Professor Geikie devotes three chapters to a discussion of the presence of man in the Pleistocene. His bones and implements are found chiefly in the extra-glacial regions, associated with the remains of both extinct and living mammalia, such as have been mentioned as occurring in several of the interglacial epochs. Man would naturally migrate towards the glaciers as they receded, and retreat southerly as they advanced. The large animals would have done the same; hence a perfectly satisfactory correlation of the several terranes in the glaciated and extra-glacial regions is of difficult attainment. Our author concludes that Paleolithic man existed abundantly in the second interglacial epoch in company with the *elephas antiquus* and hippopotamus. Some of the caves occupied by him appear to have been abandoned before the third glacial epoch reached its climax, because they are sealed up by the moraines of that stage. During this epoch Paleolithic man seems to have retired to southern France, and, if negative evidence is of value, he never revisited northwestern Europe.

American geologists will be more than pleased with the sketch of the glacial phenomena of North America by Prof. Cham-

berlin. The facts correspond in a general way with those described by Professor Geikie in Europe. The attempt is made to group the stages of glaciation and deglaciation both on a two-fold and a three-fold basis, without deciding which is the more acceptable. The foundation of the grouping is what is called 'imbrication' of the till, or the superposition of the later or more northern sheets upon the earlier or more southern ones. The oldest is the *Kansan*, next the *East Iowan*, and thirdly the *East Wisconsin* stage of glaciation, followed by six, seven or more terminal moraines. Professor Geikie says that these general conclusions harmonize with the results obtained in Europe, and without hesitation he correlates the Kansan stage with his second glacial epoch, the time of maximum glaciation, after which the ice sheets declined in importance.

Granting the correctness of the correspondence of the Kansan stage to the second or maximum glacial epoch of Geikie, American geologists can easily complete the correlation. The Lafayette or Orange sand deposit will correspond to the first or Pliocene phase of the glacial epoch. This reference will be satisfactory to those who believe in elevation as a prime cause of refrigeration, as it is generally conceded that the late Pliocene was a time of continental uplift. It should be satisfactory to the advocates of the unity or continuity of the ice-age, because there was just one period of maximum intensity or culmination of refrigeration—the Kansan phase. It was preceded by the Pliocene-Lafayette flood, and followed by the gradually less intense Iowan, Wisconsin and later phases. It will, however, enlarge our conceptions of the magnitude of the ice age in geological history; for we cannot deny that the remotest centers of dispersion have been active from the beginning of refrigeration. The latest geological epochs are fundamentally glacial for the countries above forty degrees of latitude on both sides of the equator; ice-action characterizes the time. The writer has hitherto been esteemed an advocate of unity; but he has repeatedly insisted that the several margins of glacial accumulation indicate just so many phases of more intense glaciation, and that they are to be our criteria of classification. He is satisfied that they can be interpreted to correspond with the several glacial and interglacial epochs established by Professor Geikie.

It remains only to notice the chapter upon the cause of the climatic and geographical changes of the glacial period. The ratio of precipitation was the same as now prevails. Snow fields gathered most abundantly in those regions which in our day enjoy the largest rainfall. What are now dry regions were formerly regions of limited snowfall. But the amount of precipitation was greater, snow in the north and rain in the south. Arctic currents prevailed near the equatorial in the cold epochs, but the reverse was true in the interglacial phases. The land seems to have been elevated at the commencement of every cold epoch and depressed at its close, submergence having been more characteristic of the glacial than of the interglacial phase. The fiord valleys were mostly excavated before glacial times. The Scandinavian flora migrated to Greenland after the close of the fourth glacial epoch, when the land was continuous between the continents. There are considerations favorable to the view that the accumulations of ice in the several glacial epochs produced depressions, not excluding epeirogenic warpings of the crust. The cause of the remarkable connection between glaciation and depression is still an unsolved problem. All the proposed astronomical causes of refrigeration are rejected as untenable, except that of Dr Croll, supplemented by Ball, who believed the

climatic changes of the glacial period resulted from the combined influence of precession of the equinoxes and secular changes in the eccentricity of the earth's orbit. In favor of this view, the mean temperature of the globe was lowered, and the ratio of the precipitation increased; the dominant set of the currents in the Atlantic was from north to south in the colder terms. In the interglacial climates the summers were cooler and the winters warmer, while the Atlantic currents flowed northerly. The maximum glaciation came early, succeeded by cold epochs of diminishing severity. Glacial epochs in the northern hemisphere were necessarily contemporaneous with interglacial conditions in the southern hemisphere. Hence the astronomical theory would appear to offer the best solution of the glacial puzzle; while it is conceded that this answer is not completely satisfactory. C. H. HITCHCOCK.

Biological Lectures and Addresses, by ARTHUR MILNES MARSHALL. Macmillan & Co., New York. Price $2.25.

Lectures on the Darwinian Theory, by ARTHUR MILNES MARSHALL. Macmillan & Co., New York. Price $2.25.

It was a curious coincidence by which accidents in mountain climbing deprived English science of two of its prominent biologists, and two who were at the same time personal friends. Prof. F. M. Balfour, as every one remembers, lost his life in a journey in the Alps, and Prof. Arthur Milnes Marshall, upon the last day of 1893, in a somewhat similar manner, met his death in mountain climbing. Prof. Balfour and Prof. Marshall were personal friends and naturally worked upon kindred subjects, although their work was very unlike. Prof. Marshall was still a young man, only about forty years of age. Early in life he entered upon studies looking toward the profession of medicine, but in 1879 gladly accepted the chair of Zoölogy in Owens College, and continued to occupy the chair until his death.

His additions to the literature of science have been of two general types. There are first a series of papers embodying the results of original research. These, because of his intimate association with Balfour, were at first of an embryological nature, while some of the later ones were more distinctly anatomical. His chief contributions to science of this sort were upon the *Segmental value of Cranial Nerves*, the *Pennatulida of the Porcupine and Triton Expeditions*, and upon *The Nervous System of the Crinoids*. The second class of his papers were more distinctly characteristic of his special powers. They were of a more general character and included a text-book on *The Frog*, on *Practical Zoölogy*, and a more recent work upon *Vertebrate Embryology*. In addition, we have in the recent posthumous volumes a large number of lectures and addresses given in various places before various societies.

Above all things, Professor Marshall was a teacher. It was in this direction that his powers showed at their best. He had the happy way of putting subjects so that they were intelligible to his audiences, and had the somewhat unusual power of putting himself in the position of his audiences, in such a way that he could understand how and what was needed in his teaching to render his subjects clear. His lectures were always abundantly illustrated both by drawings, and especially by homely though terse illustrations. His illustrations for rendering scientific facts intelligible were drawn sometimes from the most surprising sources, and altogether rendered his addresses and his class lectures of the very highest character in the way of scientific teaching. Since his death Macmillan & Co. have published his collected lectures and addresses in the two volumes which are the subject of this notice. The first series consists of miscellaneous addresses given by him at various intervals