ARTICLE III.

THE GLACIAL EPOCH AND THE NOACHIAN DELUGE.

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II.

IN ancient times the desire to explain things led to the formation of myths. The same desire now leads to the construction of hypotheses. These are "scientific," if they satisfy all the conditions, are rational, and meet with a general acceptance. As such hypotheses necessarily underlie science, it may almost be said that Science is a lineal descendant of Myth. The word "science" is to some extent a misleading term. As it comes from a root meaning 'to know,' it is popularly supposed to deal only with positive knowledge. Superficially, it does; but its foundations are fairly honeycombed with hypotheses, of which little is heard.

Nature's methods of work, commonly called laws, are familiar enough; but the ultimate constitution of things and their true exciting causes elude analysis. No man really understands what mind is or what matter is or what the actual operation of gravity is or what that of sight is or even what that of digestion is, although some claim to know all about it. There is always something left which man cannot fathom, though he is constantly trying to do so. In recent years, the "indivisible" atoms of antiquity have been subdivided into ions, or 'goings,' and matter seems to be reduced by such a theory to a form of motion. Concerning some things men can only speculate.

So long as this is true, no apology is needed for attempting to provide a working hypothesis which shall account for and harmonize with the scientific data referred to in the previous discussion. Such an hypothesis is plainly needed, and it ought not to be unduly difficult to construct, if every fact is given its due weight. The first thing to be considered is the marvelous accumulations of ice during the Glacial Epoch, for which an adequate cause must be sought. A partial cause may be found in the elevation of the land; for geological investigations show that the greater part of Europe as well as the northern portion of North America was once much higher than it is now, the elevation in places being possibly three thousand feet greater than that of the present day. Such a change of altitude could not fail to affect climatic conditions as they now exist; but *now* is not synonymous with *then*. A tropical climate once prevailed in what are now the Arctic regions. Of this there is abundant proof. What caused it?

The only tenable solution thus far offered appears to be that suggested by Dr. Percival Lowell, who holds that this peculiarity was due to the internal heat of the earth itself. Such a conclusion is not only reasonable but it is also an inevitable outcome of both the nebular hypothesis and the teachings of modern geology. Internal heat was doubtless the primary cause; for it must have kept the ocean at a fairly high temperature, which would favor the production of warm air currents and clouds of steamy mist. The earth, too, must have retained in its crust a considerable amount of heat; and these two things would be enough to account for the facts, since the direct rays of the sun were not really needed. So far as can now be determined, a warm moist climate — no great amount of light was necessary — was all that was required for most of the vegetation then existing, and, as

Dr. Lowell says, the sun could not possibly have dominated the earth's climate, until such time as the vast mantle of clouds, in which it must once have been wrapped, had become sufficiently dispersed to allow the sunlight to reach a large portion of its surface during the greater part of the day.[1]

In other words, the sun was not a controlling factor in the world's affairs, until the earth had become cooled to such an extent that the ocean had acquired a fairly low temperature. This would so reduce evaporation that the sun could, at last, have a fair chance to exert its influence. It may be remarked in passing that this fact has a bearing on the "fourth day" in Genesis; but of that at another time.

The reduction in temperature would have another effect; for it would allow snow to begin to accumulate on the highest mountains, in some cases soon after their formation; and such a condition would slowly but surely tend to perpetuate itself, until there was a permanent snow cap in favorable localities at high altitudes, with a corresponding modification of neighboring plant life, etc. Because of certain peculiar complications, however, this result, as will appear below, may have occurred in the Antarctic regions considerably earlier than the time referred to. Elsewhere, apparently, it was as stated. There, for reasons given later, the influence of the sun on the enveloping clouds seems to have been effective at a very early day, as it may possibly have been in a few other limited areas. In time, "partly cloudy" became the normal condition of

[1] See Lowell, Mars as the Abode of Life, pp. 46 ff., 70 ff. It is not easy to accept all of Dr. Lowell's conclusions, and it is not necessary to do so; but his ideas are not to be lightly dismissed, and his general position is by no means invalidated by isolated geological facts that run counter to it or appear to do so. See Science, April 23, 1909, pp. 659 ff. "Exceptions prove the rule," and they have been allowed for in the present discussion.

certain regions, including probably the torrid zones, which were then in the making. Tropical rains must have been common, and they were doubtless often flood-like in their intensity.

These can hardly have been confined to what are now the tropics, however; for they must have been characteristic of the entire globe for many ages. It is safe to infer that, long before the final dispersion of the cloud envelope, snow rather than rain was the ordinary result of precipitation on lands in extreme latitudes and at all extreme altitudes. But if this is once admitted,— it is difficult to see how it can be questioned, — a rational explanation has been found for the Glacial Epoch, because the precipitation must have continued to be enormous until post-Tertiary times, and extensive snow areas could hardly fail to be produced under such conditions with the lapse of succeeding centuries. The polar seas would continue to be comparatively warm, so that evaporation from that source would still be considerable. The land breezes of those regions would thus be surcharged with moisture; while in regions near the equator, as the heated portions of the atmosphere rose upward, the higher strata — flowing outward to allow the lower strata to flow inward — would carry with them the humidity of the clouds, until the cooler upper air finally sent the dampness back to earth. The precipitation would begin as rain; but ultimately, in the colder zones, it would turn to snow.

Where there was an environment of a suitable character, an ice cap would result. A continent that was low-lying or unstable, or both, would not furnish such an environment even in a high latitude; for inundations or warm air currents, or both, would prevent permanent accumulations of snow, save in isolated mountain regions, whose glaciation would not con-

stitute an ice cap in the technical sense. On the other hand, a fairly high and stable continent in a high latitude would naturally develop extensive snow fields as a result of excessive precipitation, since such a condition implies the presence of a more or less extensive and persistent cloud envelope, which would protect the snow, even though the sun did have some effect in tempering the climate during a part of the year.[1]

That such a cloud envelope existed well into the Quaternary Age is practically certain, and elevation and stability were given to the continents during the preceding (or Tertiary) Age. The sunlit belt was gradually expanding; but the snow areas on the high and stable continents were growing in size and depth. By the time the two came together the snow must have been exceedingly deep. Cloud and sunlight had long been struggling for the mastery over a broad expanse, and a prolonged contest was now begun between the sun and the snow, compacted into ice by the enormous pressure. Alternately advancing and retreating glacier boundaries would almost certainly result, and there are abundant evidences that they did. The elevation, however, would enable the snow to go on accumulating where it was still protected by the clouds.

Elsewhere, at the start, the sun would have some advantage, and it may be inferred that the glaciation was considerably diminished in the course of a few centuries. Only the borders were affected in this process; for the ice pack must have gone on increasing in both height and weight near its main centers. In time, this would turn the scale in its favor; but it is hardly to be supposed that the glaciation ever reached its ancient limits, save in isolated instances, since the reduction in cloud areas probably continued, and this must have influenced the final outcome. Ocean currents doubtless played their part;

[1] For the effect of Perihelion and Aphelion, see below.

for they always affect climatic conditions, and the ocean must even then have been many degrees warmer on the average than it is at the present time.

This last consideration may have some bearing on the fact that the ice accumulations appear to have been more slow to develop on our Pacific coast than they were to the eastward, since it may account for a warmer climate in that region. As to the hypothesis that there were two or more distinct periods of glaciation, except in limited localities,— it may be enough to say that with certain exceptions (see below) all the facts can be accounted for on the basis already laid down, and the law of parsimony forbids the postulation of more than one glacial period, unless such a postulation becomes a necessity to account for conditions otherwise inexplicable. An effective cause for a second ice cap and an adequate explanation of the destruction of the preceding one are elements in the problem, and for the Northern Hemisphere these things constitute no small barrier to the acceptance of separate ice ages in any true sense. Changes there doubtless were in the glaciated areas. In places also the land may have been somewhat unstable, and local conditions may have varied; but an ice age is not ended by local variations, and slight alterations of altitude, such as have been suggested by geologists, are not enough to cover the requirements in the premises. Neither are the changes that have taken place in the relation of Perihelion and Aphelion a satisfactory explanation of all the phenomena, although these had an important part to play as factors in the outcome. Actual submergence, such as the evidence seems to call for at the close of the Ice Age, involves too many consequences to be lightly appealed to, as will presently be made clear.

No one supposes that a vast empty space ever existed in the interior of the globe; and yet, if it did not, it follows that if the continents were once higher than they are now something else must have been lower to provide a compensation. The earth's shrinkage would make some difference; but it would hardly account for so great a discrepancy as must be accounted for, and shrinkage has usually meant wrinkling downwards as well as wrinkling upwards. This should be self-evident. It has far-reaching consequences. Whenever a portion of the earth's surface has suffered submergence, unless the movement has been a slight or a very limited one, it is safe to infer that some other part of its crust has been thrust upward. "Two bodies cannot occupy the same space at the same time." This is a law of Physics, and it is not abrogated in the earth's interior. Caverns there may be; but they are not large enough to balance a continent.

It should accordingly be clear that if Europe and North America were once higher than they are now, as was indicated in outlining the problem, some other part of the world must have been lower than it is at the present time. Conditions on the coast line of both continents favor the conclusion that the ocean really was lower at one time than it is in our day. Its bed may therefore have been deeper, on the whole, than it is at present, when this was the case. A comparatively plastic condition of the crust would make such a deepening possible, and Astronomy has recently furnished an exciting cause for such a deepening by showing that the moon was once a part of the earth itself but became separated from it at some time in their history.[1]

[1] See Lowell, Mars as the Abode of Life, pp. 16 ff. There is still considerable uncertainty concerning the movements of the earth's crust and their causes. The ocean beds were apparently outlined at

Now the Pleistocene ice pack must have steadily encroached upon the ocean by depleting its waters, and the great

the beginning; but they have been deepened at some time in the remote past. See Enc. Brit. (Ninth Ed.), vol. iii. p. 16. Such a movement, accompanied by a corresponding upward thrust, or rather pull, may have taken place at the time suggested. Just when that was, is uncertain; but the extensive disturbances, including mountain-making, the ejection of igneous rocks, and the extermination of animal life, which took place at the merging of the Carboniferous and Mesozoic ages, may possibly be attributed to this cause. Some have assumed that the moon once reposed in the bed of the Pacific: but it seems more likely that the Antarctic continent or archipelago — it is uncertain which is the better term — represents the stub from which the moon broke away. Molten matter must have been drawn outward in the process (the meteorites are witnesses of this), and the ocean bed must have settled somewhat to atone for the loss. (See below.) The place of separation would ultimately be high land, ragged and volcanic, and much of the moon's surface would resemble it. The facts seem to tally with these considerations in each instance. But if the earth and moon were once a pear-shaped body (see Lowell, *l.c.*, and G. H. Darwin, The Tides, pp. 276 ff., 342), they must have revolved about a common center of gravity — they do so yet — as well as about a common axis; for otherwise they would have merged into a single globe. (The first motion is supposed to have occupied five hours or less, the time of the second is not certain, and the time of both has apparently been changed by tidal friction. See Darwin, *l.c.*, pp. 264 ff.) Earthy and especially aqueous matter would thus be drawn toward our Northern Hemisphere and drawn with increasing force as the speed diminished (cf. *Ibid.*, pp. 316 ff.),— a consideration which may help to account for the present excess of land in that region as well as for its early submergence and general instability. The cloud cap at the small end of the pear would soon be dispersed; for the cooling would be rapid, since this end must have had less than one-eightieth of the total mass, as the moon now testifies. With the heat, the vapor would speedily vanish. In time the sea also would tend to depart almost entirely from this portion of the joint body as the waist contracted with the loss of speed (see below); for the attraction of the larger end and its tendency to bulge northward would be too powerful to resist. Dry land would thus become the portion of what was to be the moon, and this would be likely to unite with South America, Africa, New Zealand, Australia, and even India, *via* the East Indies and Siam. The peculiar fossils of those regions may find an explanation in this possibility, although glacial conditions, due to the

plateaus beneath the surface of the sea along the coasts of the ancient Atlantic must have been more and more exposed, until they became dry land. Elevation also did its part. These

moisture-laden winds, must have early prevailed in the mountainous parts of the southern belt lands. As these conditions would gradually extend northward, it may be possible to accept not only the evidences of glacial action from the south, which have been found in late Carboniferous strata in our present Southern Hemisphere, but also the belief that there was floating ice elsewhere, since icebergs may have been produced of sufficient size to be carried by swift currents — everything moved rapidly in those days — as far as India, whose striated Permian rocks have been attributed to such a source, or even into more northern seas, in the vicinity of which other such rocks occur. They are not necessarily the product of local glaciation. The gradual contraction of the waist of the pear, due to a diminution of speed (see *Ibid.*, pp. 325, 327), probably led to the ultimate rupture, and the unequal cooling doubtless tended to hasten the catastrophe. It must have involved fearful earthquakes, enormous accretions of heat, melting ice, extensive submergence, and a general readjustment. The shock and the shifting of the center of gravity must have altered the motion of each disconnected part, the twist given to each body being sufficient to divert the moon from a north and south orbit into an approximately east and west one. (See below.) During the next era (Mesozoic), the sun probably began its dominant influence. An elevation of the lands in high latitudes seems to have taken place near the close with a change to a cooler climate and a loss of tropical life. (This might provide for Darwin's postulated subsidence in the ocean bed to account for the formation of coral atolls, for which evidence has been lacking.) The next age (Tertiary) also shows instability, and it seems likely that the moon was partly responsible for these crust movements, since it must have been considerably nearer the earth than it is at present during both ages. (Cf. *Ibid.*, pp. 3, 101 ff., 273 ff.) A general elevation in high latitudes seems finally to have taken place, and a long period of stability followed. The earth appears to have been at Aphelion during the northern winters, and this gave opportunity for the accumulation of enormous masses of snow and ice before the final dispersion of what now remained of the cloud envelope, which must have persisted to a greater or less extent for many ages in some localities, just as similar cloud caps now persist on other planets of our system. Isolated areas of glaciation, some of which may have existed during several previous eras, were thus merged into true ice caps on different continents, and these produced the Glacial Epoch.

three things, then,— the deeper ocean basins, the reduction in the amount of their contents, and the greater height of the land,— explain the cañon-like extensions that are found in the bed of the sea at the mouths of some rivers, since, taken together, they must have greatly lowered the ocean itself as modern nations know it. They also explain the fiords of Norway, although it may be necessary to postulate the action of glacial ice to account in full for their formation. Other results of the conditions named would be the joining of the British Isles to the continent of Europe, the draining of the shallow water west of Gibraltar till the Mediterranean was cut off, the depletion of the latter's waters until a great marsh inhabited by countless hippopotami extended from Africa to Sicily, the uniting of the two Americas by the Antilles, and the merging of the continental islands of Asia with the mainland; all of which things unquestionably took place in Pleistocene times or during the Ice Age.

Such, in brief, may have been the story of the Glacial Epoch up to its culmination. Any theory which attempts to deal with this period should adjust itself to all the facts so as to form an integral part of a consistent world history. The claims of Astronomy deserve recognition as well as the laws of Physics, and geological evidences must be squared with other evidences of every available sort. Even the infinitesimals ought not to be ignored, until the equation nears its final solution; for no single science, taken by itself, is equal to the task involved. This should be clear, although questions concerning minor points may still be numerous.

Details can be worked out only after long and patient study by many investigators; but general principles do not change. Glaciers of gigantic proportions once existed in various parts of the earth, and they had an adequate cause or causes. Their

effects must have been far-reaching, and their ultimate destruction cannot be accounted for in a satisfactory way, unless some force or forces equal to the task can be made apparent. Modern glaciers do not prevent a temperate climate in their near neighborhood, and, in spite of their extent, it is not unreasonable to suppose that in those days a temperate climate on both continents was to be found in close proximity to the ice fields. Such a climate must have existed, in point of fact, to account for the melting ice and its resulting formations along the borders of the glaciated areas. It involves no real difficulty. But what of conditions in Asia?

Large portions of Siberia show no appreciable signs of an ice cap; but these districts are low-lying and appear to have always been so, and warm ocean currents directed against the Asiatic shore may have entailed effects similar to those now produced by the Chinook on our western coast or the Föhn of the Alps, both of which consume snow and ice like hoarfrost. To these probable causes may be added a lack of excessive precipitation, except, perhaps, in the extreme northern portions; for warm air currents, coming from the sea, pass over low-lying lands without depositing their moisture, until they are compelled to do so by a change of temperature. In the extreme northeast and the extreme northwest Siberia shows signs of glaciation, as do some of the mountain ranges and some of the highlands of Central Asia. It is therefore probable that this continent also had its share of ice, although some of the higher regions in its southwestern portion were probably exempt.[1]

There is a limit to the endurance of the earth's crust, and Dr. Wright has called attention to this fact. Evidences of submergence were abundant; but a cause appeared to be lack-

[1] See J. Geikie, The Great Ice Age (Third Ed.), pp. 691 ff.

ing. He has supplied it by showing that the enormous weight of the accumulated ice and snow constitutes a *vera causa* in the premises. Ice averaging a mile or more in depth must ultimately break the back of a continent and drive it downward into the plastic portion of the earth's interior. Vast quantities of water had been taken from the ocean, and a corresponding weight had been removed from its supporting bed. The land groaned beneath its load and probably began to yield, slowly settling for many a decade as the snow increased. At last there came a time when it could bear no more. It then gave way and sank steadily downward with increasing speed. Submergence was the result.[1]

But what of its effects? The laws of Physics cannot be evaded, and they must apply here. First, however, let it be said that Dr. Wright has exacted no toll for ice in Asia or in the Southern Hemisphere. He did not need to do so to prove his point; but there are other elements in the problem. The ice now stored in the Antarctic regions is said to be sufficient, if melted, to add many feet to the present depth of the ocean. There must have been ice in that part of the world at the time under discussion, and the snow which formed it must have come from the ocean by evaporation. The same is true of the ice in Asia, and in each case every ton of ice represents a loss of pressure on the ocean floor, precisely as it did in the other instances.

In the Southern Hemisphere the earth is now nearer to the sun in summer than it is in winter; but this condition was reversed some ten thousand five hundred years ago. The Northern Hemisphere then received an excess of heat in the short summer months and an excess of cold in the long winter

[1] See G. F. Wright, Scientific Confirmations of Old Testament History, pp. 220 ff. Translations of this book are rapidly being made.

ones. Trade winds and ocean currents must have been affected, sudden fogs and mighty snow-storms must have fostered an ice cap at the southern pole, as they now foster one in Greenland, and whatever ice there may have been on the other lands of that hemisphere must have tended to persist even after the sun had become the dominating factor in the world's climatic conditions; for continental ice had probably accumulated there also to a considerable depth, where conditions were favorable, since the cloud cap must have had some effect in that part of the globe as well as elsewhere. The Greenland summer sun is hot and it shines incessantly; but the ice cap is not melted. Fog and the lack of land areas to radiate the heat are the causes of this, and the same thing must have been true of the Antarctic ice pack ten thousand years or more ago. Even now, at Perihelion, the cold of the Antarctic summer is intense at times, as all explorers testify.[1]

Signs of glaciation are found in Patagonia and the Andes, in the mountains of South Africa, in New Zealand, and in the Australian Alps, in connection, apparently, with Pleistocene remains. This is as it should be theoretically; for the sun was largely powerless even with a warmer ocean to reinforce its efforts, since it was blanketed by the fog and the clouds. Warm air currents from the great expanse of sea probably hindered the growth of the glaciers to some extent; but they favored their preservation by an excessive evaporation, and the southern seas were steadily cooling in those days. They received less heat than they now do, while the northern seas received more. The Arctic Ocean was thus probably much warmer than it is at present, and this may account, in part, for the fact that the centers of the northern ice formations were so far south of the pole itself.

[1] See J. Geikie, The Great Ice Age, *l.c.*, pp. 800 f.

Taken altogether, the ice in the Southern Hemisphere combined with that in Asia must have equaled in area the glaciation of Europe and North America, although it was hardly so deep on the average in all probability. It was there and it was there during the Ice Age, according to the evidence. To estimate its bulk at one half that of the ice caps of Europe and North America cannot be excessive; but that means that the total number of tons of water taken from the ocean exceeded, by one half, the entire amount of ice on the two continents last named. If either of them sank, as has been suggested, this fact is of importance; for something had to give way upward when the land went downward.

Although it now seems likely that the earth's interior is practically a solid mass, because the pressure must make it so; it is clear that it must also be a viscous one for many miles beneath the outer crust, since, if it were not, the seismograph would not operate so effectively. As it is, slight earthquake shocks are registered many hundreds of miles away; for the resulting vibrations impinge on the solid surface with sufficient force to cause it to transmit waves of two kinds. The first are now believed to be waves of compression depending on a change of volume; while the second, which are slower and more violent, are supposed to be waves of distortion due to a change of shape.

But if a slight earthquake produces such a commotion in the mobile portion of the globe's interior, what would a sinking continent do? The removal of pressure leads to liquefaction in volcanic vents, and molten rock and boiling mud are then ejected. It follows that a similar condition might be caused within the earth, if the pressure were sufficiently reduced. A result approaching this may actually have

occurred at some time in the past, and it may even have occurred in this connection, as will now be shown.

The first result of the pressure, combined with other causes, which was induced by the increasing accumulations of snow was doubtless the great activity in the volcanic belt, that was characteristic of late Tertiary times. The slight settling thus indicated seems to have added to the rigidity of the continents, and this appears to have been still further augmented by a later settling which resulted in the final upheaval of the Himalayas and the neighboring plateaus, an event which must apparently be assigned to early Quaternary days.[1] A snow cap soon began to accumulate on the mountains thus recently elevated; but it never attained to any size, since it lacked the opportunity. Because of this increase in the stability of the continents, the great ice caps became a possibility; but, when the accumulations had reached a certain point, the effect of their enormous weight was tantamount to an upward thrust, too powerful to be longer resisted; and this must have been chiefly felt by the weaker portions of the ocean bed, because it was now deprived of too large a part of its load to retain its stability.

There could be but one outcome. They gave way upward, as the abundant evidence already given testifies. The natural consequence was a diminution of pressure in the earth's interior and an enhanced mobility. With its support thus largely reduced, the weaker continent would begin to sink. The other would almost certainly follow, though with consequences that would be less conspicuous. Both would be carried downward with increasing speed, until the disaster became a fearful cataclysm. Other glaciated areas would feel the shock; but,

[1] Cf. Enc. Brit., *l.c.*, vols. xi. pp. 824 ff; xii. pp. 735 ff.

as their instability was comparatively slight, they would suffer accordingly.

The consequences of actual submergence must have beggared description. As the continents sank, huge rents, torn in the solid crust, could not fail to belch forth molten lava and volcanic mud, while every crater on the globe would tend to add its contribution to the awful chaos. Land adjoining the depressed portions would be carried downward to a greater or less extent; and, at the outer limits of the most pronounced submergence,— because of the bending to which the crust would be subjected,— fissures and clefts, such as are found in Southern Europe, would be opened in the rocks and hardened earth. Some of these would be left. Others would be filled with molten rock because of their greater depth.

But "Action and reaction are always equal"; and, with the culmination of the upward movements in the ocean floor, a rebound would be sure to take place on the part of the two continents involved. Months, if not years, would have to elapse before the terrible "seesaw" thus begun could terminate and a condition of stable equilibrium be restored. In the meantime the commotion in the sea would also be prolonged. Forced skyward by the initial uplift, its waters would necessarily be sent landwards with increasing speed and violence, as the catastrophe progressed; and a constantly augmented tidal wave would thus be driven towards and over the continents, until the inevitable reaction took place. A return wave would then be produced, and the fearful ebb and flow would continue, until a balance could be struck, as the inequalities of pressure were gradually overcome. But what of the submerged ice packs?

Broken into huge bergs in some places; ground into countless fragments in others; assailed from beneath by the

terrible heat of molten lava, volcanic mud, and superheated steam, from the earth's interior; torn asunder by the impact of the tidal waves; tossed about by the heaving earth, until they came to the surface of the rising deluge to augment its tempestuous waters:— what chance did they have? They could bid defiance to the sun, entrenched as they were, but not to the allied earthquake, fire, and flood. The heat set free through the ruptured crust must have been enormous, to say nothing of that engendered by the friction of the "faulting" rocks. Even the conflicting bergs, some of which must have been dashed together with tremendous force, may have produced friction enough to develop a little heat, which could but hasten their melting and final dissolution.

Great as the ice accumulations certainly were, hardly a trace of them would survive, save in exceptional instances, including certain low-lying fields which would be likely to be deeply buried beneath loose earth, washed over them before they had time to break loose from the frozen ground and come to the surface. Lands which did not sink would also be involved; for hardly any part of the globe could fail to be affected, to some extent at least. The Lisbon earthquake of 1755 produced a tidal wave fully sixty feet in height, which went rushing inland. What, then, was the ultimate height of this tidal wave, generated by such titanic forces? It may have begun gradually, and it doubtless did; but, as it increased in violence with the augmented upward thrust, it must have attained to gigantic proportions; and, if it did, it must have been carried over everything but the peaks of the highest mountains, with some possible exceptions in Central Africa, Kashmir, and Thibet. The ice of the Southern Hemisphere would thus be destroyed, including even that of the Antarctic regions; the great mammals of South America would perish, with those

of North America, Europe, and most of Asia, as the evidences show that they did; and the story of Noah and, in part, the other tales, previously outlined, would be justified.

If allowance is made for the topography of the Euphrates valley, the experiences of Noah, as they are depicted in the Bible story, will not appear to be exaggerated. Genesis has, in fact, but baldly stated them. Weird as are the tales of the Druids, solemn as are the narratives of the Chinese, and fanciful as are the legends of tthe Greenlanders, they all contain elements of truth. This is not too much to say; for the facts seem to fully warrant it. In places, the land must have been greatly broken or "tilted over" by the subsidence; and it was in just such spots, far enough away from the glaciers to make animal and vegetable life possible, that men were likely to be found. Nor is it unreasonable to suppose that some volcanic action attended such phenomena, and that men beheld its results.

How many of them survived is a problem; but it is certain that they were few in number and of superior intelligence. Genesis does not necessarily imply that every human creature outside of Noah's immediate family was destroyed; for it has to do with the world as its author knew it and not with the earth of modern Geography. It tells the facts as they occurred in the region where Noah lived; but it goes no further. It is unreasonable to expect it to do so. The voyage inland and northward, the swift drifting for hundreds of miles, the obliteration of the mountains by the breaking up of the "fountains of the great deep," the torrents of rain, the gruesome horror, and the final stranding on the Mountains of Ararat after being swept back and forth for many days, are all true to the life; for they portray exactly what ought to be expected under the circumstances. A flood was the only possible out-

come of the peculiar geological conditions, all of which have left behind them abundant evidences of their reality. Is it reasonable to maintain that the Bible story is an account of a local disturbance, confined to the Euphrates valley but exaggerated by an excited imagination? Was it a myth?

That the melting of the glaciers occupied but little time, comparatively speaking, must be clear. Such a conclusion cannot be avoided, and it incidentally solves one of the most puzzling features of the deluge problem; namely, How was a universal flood possible, if fresh water life, both plant and animal, was to survive? The melting bergs took care of that; for they made the adjacent waters so dilute that they were no longer "salt." Carried backward and forward by the alternately advancing and retreating flood, they continued to melt, until they either disappeared or were stranded on the rising land in spots remote from their place of origin. The waters that covered the continents were thus kept comparatively fresh, and some influence was exerted by the melting ice even in sections far remote from the glaciated areas. Fresh water produced in this way often floats for many days on top of the heavier brine beneath, as northern explorers have found to their cost in impeded progress; and, in this manner, the shifting surface seas must have been kept much fresher, even at great distances from the ice packs, than the saline character of the ocean depths would appear to warrant. By these contingencies the last stronghold of the opposition is destroyed, and a way is opened for a broader and more comprehensive view of this entire subject.

The ocean basins finally became somewhat stable; but neither continent was restored to its ancient level. Each was left in a position lower than the one it formerly held and in a position favorable to a temperate climate. This was due, in

part, to changes in the ocean itself. Its bed was less deep, on the average, than it had been in former ages; for its elevated portions could not sink back to their old positions so long as the continents failed to rise sufficiently to give the required room. To this must be added the great increase in its bulk, due to the melted ice. For these reasons the surface of the sea must have been left considerably higher than it is at present. Low-lying lands the world over would thus be affected, and many large tracts would be submerged.

The great Caspian basin was full; but the melting ice had left its waters fairly fresh, while Gobi was probably filled to the brim with seawater. The lakes and rivers must not be forgotten; but they could not have helped Gobi to any great extent, when the fearful tidal wave came sweeping inland, and the melting ice was not sufficient in quantity to protect it. Its waters must therefore have been fairly salt. Many great depressions in North America seem to have fared as the Caspian did. With the enormous evaporation from these shallow lakes and seas, the precipitation must have been far greater than it is at present; but the ocean would tend to maintain its level for a considerable time, even after the glaciers and polar ice caps of our day had begun to form, since the silt washed into its basins must have covered vast areas to a greater or less depth in the course of the succeeding centuries. Terraces and raised beaches, found in different parts of the world, would seem to indicate that this was at least two hundred and fifty feet above the present limit. In various parts of the world changes of level of a recent date must be allowed for; but the figures given appear to be conservative. The Mediterranean and the sea which filled the Sahara must have been affected by the drift ice, and their waters were probably brackish for many decades.

In Europe and North America a sort of neutral ground, such as is now found in Greenland, must have existed between the ice packs and the sea; for the winds, coming in from the warmer waters, would tend to melt the ice for a considerable distance inland. The sinking continents probably caused the nearer portions of this neutral belt to bend downward to some extent, and the curious table-lands of the North Atlantic coasts may have been produced in this way, at least in part, since the chance that there was a return to former conditions is slight. The result was, in each instance, a sort of terrace along the borders of the continents. Whatever their origin may have been, these terraces were no longer dry land. They were now completely covered with water, and water has an equalizing effect on temperature. It absorbs vast quantities of heat; but it does so slowly. It gives up its heat with the same reluctance, and that is one reason why the North Atlantic allays the summer's excessive warmth and mitigates the winter's bitter cold along its borders. It lags for months behind the land in its changes of temperature, and climatic conditions vary accordingly. Extremes are thus prevented on the continents by their encircling seas, while the islands are given a remarkably even climate.

Whatever glaciers may have been left in remote and inaccessible mountain fastnesses, probably involved but a small percentage of the ice formerly on the earth's surface. The rest was melted in the sea, and the fact must be allowed for.[1] When the foundations had once been laid for the ice accumula-

[1] This can only mean, relatively speaking, that all land altitudes were diminished after the Glacial Epoch, since a higher ocean must involve continents proportionally lower. Ararat is therefore relatively lower than it was in Noah's day, although it has probably suffered no actual change of position with relation to the earth's crust.

tions of modern days, they continued to develop, doubtless with increasing speed for a time; but in the courses of the ages a change took place. The accretions certainly began to diminish with the reduction that took place in the volume of water, particularly that in shallow places, which was especially subject to evaporation; and, in time, the ice attained to such proportions that a balance had to be struck, because only limited areas were now under its dominion. Forced outward and melted at its edges, or broken off in huge masses, where it was in contact with the sea, it began to return most of the water that it had absorbed; and the ocean, helped somewhat by the silt emptied into it by the rivers, thus tended to remain nearly stationary. This appears to be its condition at the present time. It has not always been so, and the atlases of ancient geographers may be less ridiculous than they have been made to appear. Incidentally, it becomes clear that the ocean, and therefore the Red Sea, could not have been reduced in the days of Moses to its present level. The modest contention of Dr. Wright that the waters of that sea, as indicated by raised beaches in its neighborhood, may have been higher at that time than they are now, accordingly becomes more than a possibility. It is, in fact, a practical necessity. His conclusions are supported by Kiepert's Atlas, a most excellent authority; and, whatever questions may remain concerning details, his general position with regard to the crossing of the Red Sea by the Israelites is certainly sound.[1]

Many other points remain to be considered; but they must be left for subsequent treatment. In the meantime, let it be said that not a single one of the geological puzzles, enumerated above in outlining the problem, is left without an adequate explanation, provided the events of the Glacial Epoch

[1] See Scientific Confirmations of Old Testament History, pp. 87 ff.

have been correctly outlined. Even the seals are accounted for, since ice floes from the north, and therefore seals, could have been swept inland over the Siberian plains and carried into the two great basins where Arctic seals can now be found. As to the shells on the Skagerak, it is plain that the general disturbance, caused by the upheaval, and the rushing waters, confined as they must have been for a time within a comparatively narrow channel, are enough to account for what took place.

The only real difficulties, apart from some matters affecting Noah which will be considered later, are connected with the inland seas. There is no room for these matters in the present discussion; but they will also be taken up in due time. To make what has preceded clear, a brief summary will now be given, based on Astronomical, Geological, Physical, and Biblical considerations; but it must be remembered that scientific data, so-called, are more or less unstable. Results are therefore tentative, as, in fact, they usually are.

Archæan Age — Genesis, 'DAY ONE.' Matter in a nebulous state, but breaking up into Solar and other systems; Nebulæ become more and more phosphorescent; Earth gradually assumes definite form, molten, pear-shaped, and self-luminous; Water exists as vapor only; Outside crust begins to form and to wrinkle; Sun and stars continue to be somewhat nebulous (size counts in this problem: see Lowell, Mars as the Abode of Life, pp. 9 ff.).

Silurian Age — 'DAY SECOND.' Earth cools and slackens speed: Vapor condenses into a vast cloud mantle above and incessant rain beneath; Water begins to accumulate; Crust wrinkling increases; Water-plants appear; Invertebrates follow; Rock-making goes on apace (it continues with diminishing speed in subsequent ages); Sun and some of the smaller stars take on definite shape.

Devonian Age — 'DAY THIRD.' Earth continues to cool; Speed diminishes; Wrinkling increases; Oceans are outlined; Dry land extends; Vertebrate fishes develop; Land vegetation begins; Clouds and rain persist nearly everywhere; Sun becomes fairly

luminous; Some stars begin to be so; Pear-shaped earth tends to bulge towards the pole of the larger end; Small end loses much of its vapor.

Carboniferous Age — 'DAY FOURTH.' Sun becomes brilliantly luminous; Certain stars begin to be visible; Others are still nebulous; Earth becomes fairly cool; Vegetation increases to excess; Instability of land and sea; Coal measures begin to form; Unceasing fog, rain, and clouds, save in limited areas and at the small end of the pear; Snow and ice accumulate near small end on the high portions of the belt lands; Small end loses its vapor and most of its sea; Speed about the center of gravity becomes too slow for stability; Pear begins to elongate in consequence and to contract its waist; Ocean beds settle as this progresses; Large end contracts laterally in the process, producing Appalachians and extensive "folds" in the rocks; Pear assumes an hour-glass shape; Rupture follows; Meteorites are formed as the elongated neck of the hour-glass parts and its molten core is scattered in fragments through space; Earth and moon each assume a globular shape; Great disturbances and changes in both; Enormous loss of life; Antarctic lands are formed; Volcanic activity in those regions and great accretions of heat; Extensive submergence of former land areas and destruction of glaciers; Tropical climate everywhere; Equatorial clouds begin to disperse; Polar clouds and probably some others follow; Moon begins to revolve about the earth in close proximity to it, but far enough away to maintain its shape, in a general way, and not go to pieces.

Note. According to Professor Darwin, pear-shaped bodies, so far as such forms have been investigated, seem to be stable within certain limits, but to lose their stability with their speed of revolution. (See G. H. Darwin, The Tides, pp. 325, 327.) The process of parting appears to follow the lines indicated. In the case of the earth and moon, the shock produced thereby, combined with the creation of an independent center of gravity within each of the newly formed spheres, must certainly have altered their relative positions and affected their future movements. For this reason, it is probable that the earth's greater eccentricity in former ages, its inclination to the plane of the ecliptic, its variations of axis in the past with reference to that plane, and the moon's orbital inclination to the plane of the ecliptic, which produces its peculiar spiral course, together with its revolution in an eccentric and approximately west to east orbit,— instead of in a north and south one such as was to be expected from its place of generation,— are all to be traced, in some measure, to this one original source, although all these

things have been influenced and are still being influenced by the attraction of the other heavenly bodies. (The pear probably revolved about its center of gravity in the plane of the ecliptic, the rotation on its longitudinal axis being a secondary motion.) Untold centuries were consumed in the abovementioned events; but it will not do to postulate too much time, since "astronomers and physicists, headed by Lord Kelvin, would limit" geological time "to 24,000,000" years. (See Bibliotheca Sacra, vol. lx. pp. 31 f.)

Mesozoic Age—'DAY FIFTH.' Rains continue; Clouds break away in fresh places; Sun begins its dominating influence; Snow forms on lofty peaks in high latitudes, where such peaks exist; Huge reptiles appear (Genesis implies that there was a vast increase of marine life already existing, a further development of bird life, and the creation of great sea monsters, quite in accordance with the teachings of Geology); Land continues to be very unstable, the moon's tidal influence being enormous; Mountain-making goes on extensively; Climate changes somewhat; Tropical life disappears in many northern latitudes; Seasons begin to develop; Conifers and palm-like trees abound; Tidal friction gradually lengthens sidereal day; Moon's rotation is much retarded by the same force; Great volcanic activity in India, the Andes, and Western North America; Marine life is largely exterminated, apparently by the development of cold currents in the sea.

Cenozoic Age—'DAY the-SIXTH.' Tertiary Period:— Clouds and rain continue; Sunlit belts widen; Seasons become fixed; Ocean remains comparatively warm but grows slowly cooler; Temperate climate persists in the Arctic regions near the coast; Snow and ice are found inland at high altitudes, except, possibly, in the tropics; Great mammals appear (Genesis seems to refer to an increase of the life already existing as well as to the creation of new forms); Fresh disturbances with volcanic action, due partly to the moon's continued though lessening proximity, but helped by the internal pressure produced by the accumulating snow; Continents settle and gain somewhat in rigidity; Mountain-making nears completion; Day continues to grow slowly longer; Modern trees appear; Ice caps begin to form.

Quaternary Period:—Man is created; Cloud caps persist in limited areas; Rain abounds; Heavy snows in high altitudes and high latitudes; Snow attains great depth, especially in Europe and North America; Readjustment ensues; Himalayas are completed; Glaciation increases; Sea is more and more depleted; Continents are more and more exposed; England be-

comes a part of Europe; Antilles join North and South America; Japan, Ceylon, Australia, etc., become parts of Asia; Europe and Africa are united at Gibraltar; Mediterranean becomes in part a marsh; North America and Asia are joined at Bering Strait (Alaska seems to have had but little ice at that time); Coast gorges are cut by North Atlantic rivers; Fiords are deepened by glacial action; Palaeolithic men become widely distributed (conditions were everywhere favorable to this as no boats were needed); Sidereal day continues to lengthen but very slowly; Moon becomes rigid as the time of its rotation is reduced to once a month by the tidal friction produced by the earth's attraction, and such friction then ceases; Ocean floor grows more and more unstable from the loss of untold tons of water; Weak spots begin to give way upward; Europe (glaciated portions) settles rapidly; North America follows; Upheavals become more pronounced; Earthquakes abound; Tidal waves are generated; Continents sink steadily (probably as the culmination of a long period of settling, as Gen. vi. 3 indicates); Flood-like rains begin; Tidal waves increase in violence and begin to cover the land; Other glaciated areas are affected and rendered more or less unstable; Submergence continues to spread; Tidal waves become very violent; All the continents are affected, but high mountain peaks in some places, Central Africa, and parts of Asia escape because of their conformation; Land animals are mostly exterminated; Some escape in favored places; Reaction begins after a number of days (Genesis vii. 4, 12, would make the time forty days); Ebb and flow continues for many days (Gen. vii. 24 implies one hundred and ten); Readjustment continues for months with a gradual cessation of the flow and a lowering of the waters; Glacial ice is melted in the process; Reëlevation of the continents accompanies the receding movement of the sea; Equilibrium is reached with parts of the continents lower and parts of the ocean bed higher than they were before; Glacial Epoch ends.

Note. Much has had to be taken for granted, especially in this brief summary; but attention has been called to the fact that, while the ice areas diminished somewhat in extent by losses along their comparatively thin edges, they increased in depth and therefore in weight elsewhere, especially toward their main centers. Pressure was thus more and more concentrated on a slowly shrinking base, while the load on the ocean floor was growing lighter because of the constant drain produced by the accumulating snow. When the increase of pressure had decidedly accelerated the glacial flow, the ice areas may have broadened somewhat; but this had no appreciable effect in

checking the final catastrophe, which such conditions naturally led to, since the other continents, including the Antarctic, were increasing their load all the while, and were thus adding to the instability of the ocean floor, as each ton of water was abstracted from the sea. Readjustment was inevitable, and this ultimately led to submergence. The same thing may happen to Greenland some day; for it has been slowly settling for the past six centuries under its load of ice. Calculations based on the earth's motion seem to show that its crust is thickest about the poles, and this may affect the outcome, especially in Antarctic regions where the ice pack is now enormously thick, although a Perihelion summer prevails there. Croll's theory fails to work at all in that region, and it fails to work on cloudless Mars in spite of the excessive eccentricity of the planet's orbit. The cloud-cap factor is the important one. (See Lowell, *l.c.*, pp. 112 ff.)

The submergence of the Quaternary Period, which ended the Glacial Epoch, was the Noachian deluge. It involved all lands to a greater or less extent, but it was most destructive where the earth's crust gave way, either upward or downward. The ocean was vastly increased in volume by the melting ice, and it attained a level much higher than that now reached by it. Extensive areas of what is now dry land were covered. Inland seas of enormous size were created. Loess and gravel were scattered far and wide. Drowned animals and other things were buried and so preserved. Marine animals were stranded on high places. Clefts were opened and later filled with animal remains washed down as the sea retired. The whole world, indeed, was changed. Details may need revision; but such, in general, was the flood. Through the few who survived its terrors, it has left its imprint on the literature and legends of all nations save the Blacks, and the evidences of the havoc which it wrought have been traced in many lands. It was no myth and no local disturbance but a far-reaching and intensely significant reality.