CHAPTER FIVE

A Sacred Theory of the Earth

> Whenever it is possible to find out the cause of what is happening, one should not have recourse to the gods.
>
> POLYBIUS

Hooke was a bibliophile, and one of his favorite pastimes was attending book auctions. Occasionally he jotted down in his diaries the titles he had acquired and was reading. No book is mentioned more often in the later of his two diaries than Thomas Burnet's *Sacred Theory of the Earth* (*1*). Hooke's interest in this work must not be counted as yet another of his eccentricities. Shortly after the first Latin edition was published in 1681, Charles II asked Burnet to issue an English version, which appeared in 1684. In 1689 the Latin text was doubled in length, and in the following year this expanded version was printed in English. A sixth edition appeared in 1726, and *Sacred Theory* is still in print today.

No one seems to have taken a neutral position toward Burnet. He was praised by Steele, Addison, and Wordsworth, and classed by some of his distinguished admirers as the peer of Plato, Cicero, and Milton. Coleridge proposed to recast *Sacred Theory* in blank verse, but never got around to the task. Some of the *philosophes* of the Enlightenment put him on a pedestal with Descartes and Newton. On the other hand, Swift, Pope, and Gay ridiculed Burnet's ideas. All this difference of opinion aside, some things seem clear. The *Sacred Theory* sparked a war between fundamentalist Christianity and natural science that still goes on in some quarters. This contest heightened interest in geology, and cost Burnet his career as churchman (*2*).

the Scriptural doctrines of Paradise and the Universal Deluge. Reason would be his first guide and if that should fall short, he would seek for light in the Scriptures. Anticipating that some critics would resent his engaging "the authority of Scripture in disputes about the Natural World, in opposition to Reason," he boldly asserted that no "truth concerning the Natural World can be an Enemy to Religion; for Truth cannot be an Enemy to Truth, God is not divided against himself" (*3*).

Beginning with the assumption that the earth was created out of chaos around 4000 B.C., Burnet reckoned that the Deluge occurred about 1,600 years later. But from where did the water of the Floods come? According to Burnet's arithmetic a body of water eight times as great as that in present oceans would be required to raise sea level above the tops of the highest mountains. Not even the heaviest torrents falling for forty days and nights could produce so much water. Nor are we to suppose that God created a superabundance of water for the Flood and then annihilated the floodwater when it had done its work. Those who call on God to make things appear and disappear "make very bold with the Deity" (*4*).

Those who would cut the knot of the problem by assuming that the Flood was only regional and not universal are denying the Mosaic account, Burnet cautioned. And if the hills of Judaea were overtopped, are we to imagine that the water stood as a great regional drop or a trembling jelly? (*5*)

Since the Scriptures tell that the earth had a beginning and will have an end, Burnet's argument continued, we cannot accept the Aristotelian idea that the earth is eternal. We have only to look about us to see that the form of the earth is changing. The higher parts tumble down during earthquakes, and wind and rain insensibly wear down the hills. "The Air alone, and the little drops of Rain have defac'd the strongest and the proudest monuments of the *Greeks* and *Romans;* and allow them but time enough, and they will of themselves beat down the Rocks into the Sea, and the Hills into the valleys" (*6*).

Granted then that the form of the earth has changed since the beginning, and granted that the earth in its present shape is incapable of sustaining a universal deluge, what must the shape of the earth have been before the Flood?

Burnet interpreted the first chapter of Genesis, which affirms that in the beginning the world was without form, to mean that the earth parts and particles of matter, mixt together, and floating in confusion, one with another" (7). The particles in such a mass would draw together to form a sphere, whose smooth surface would have been quite unlike the rough exterior the earth presents today. In this process of aggregation the heavier parts sank to the center of the earth and the lighter rose to the top, producing concentric shells of air and liquid around the solid core.

Thomas Burnet (Portrait from the 1734 edition of The Sacred Theory of the Earth)

We must resist the temptation to compare the three concentric shells of Burnet's model with the atmosphere, hydrosphere, and lithosphere of modern science. His "liquid shell" included not only ordinary water, but fat and oily liquids which rose to the top of that unit, so that it became divided into two parts: ordinary water below

and oily liquid above. Dust settling from the primeval atmosphere was incorporated in the oily shell, converting it into "a certain slime, or fat, soft, and light Earth, spread upon the face of the Waters" (8). As these sedimentary particles accumulated they soaked up the oily liquor, so that the outer liquid shell became firm, its surface suitable for habitation, its base resting upon a shell of water. These waters of the "deeps" would later form the world ocean, but when first accumulated were all vaulted over with a universal layer of fertile land.

> In this smooth Earth were the first Scenes of the World, and the first Generations of Mankind; it had the beauty of Youth and blooming Nature, fresh and fruitful, and not a wrinkle, scar or fracture in all its body; no Rocks nor Mountains, no hollow Caves, nor gaping Chanels, but even and uniform all over. And the smoothness of the Earth made the face of the Heavens so too; the Air was calm and serene; none of those tumultuary motions and conflicts of vapours, which the Mountains and the Winds cause in ours: 'Twas suited to a golden Age, and to the first innocency of Nature. (9)

Because the axis of Burnet's paradisiacal earth was upright and not tilted, there were no seasons. In the habitable temperate zones "there was neither Heat nor Cold, Winter nor Summer—every Season was a Seed-time to Nature, and every Season an Harvest." The fertile soil, moistened by water drawn up from the oceanic shell below by the heat of the sun to settle as dew or to fall as mild showers, teemed with the vital seeds of animals as well as plants. As Eve was the mother of all mankind, so the earth was a natural incubator, the "Great Mother" of all other living creatures.

Then, as a providential act of execution upon a sinful world, the solid shell of the earth broke and fell into the shell of water below. Thus "the fountains of the Great Abysse were broken open" and the Universal Deluge overflowed all parts and regions of the broken earth. When the agitation of the Flood subsided, the waters retired to the lower places, leaving the upward-projecting fragments of the paradisiacal world standing in ruins as islands and continents.

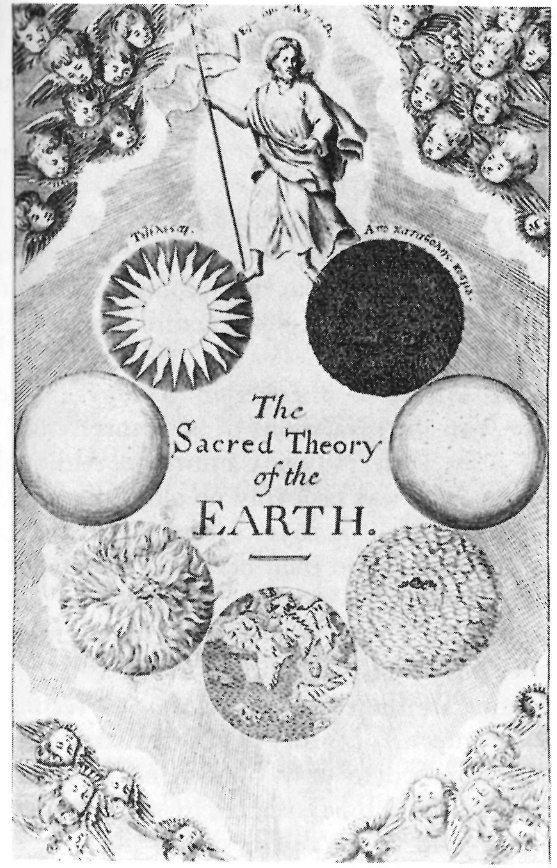
Burnet acknowledged that the Flood was an act of God, but insisted that the divine will was served by natural causes. Providence left it to Reason to detect the causes. He conjectured that the heat of the sun caused the originally fertile shell of the earth to dry and crack, causing the waters below to boil and vaporize, and finally to explode. This cracking of the earth's shell and the flooding that followed constituted "the first great revolution of Nature," in Burnet's view.

Anticipating the denouncements of his critics, Burnet declared that "it is no detraction from the Divine Providence that the course of Nature is exact and regular." God, the maker of the celestial clock, could not only fashion a machine that would strike the hours regularly, but also design one that would fall apart at some appointed time (*10*).

Burnet thought that the world we live in is a wreck, "a broken and confus'd heap of bodies, plac'd in no order to one another, nor with any correspondency or regularity of parts" (*11*). Anyone who views the present aspect of nature in a more generous light is an "oratour," not a philosopher.

> Oratours and Philosophers treat Nature after a very different manner; Those represent her with all her graces and ornaments, and if there be anything that is not capable of that, they dissemble it, or pass it over slightly. But Philosophers view Nature with a more impartial eye, and without favour or prejudice give a just and free account, how they find all the parts of the Universe, some more, some less perfect. And as to this Earth in particular, if I was to describe it as an Oratour, I would suppose it a beautiful and regular Globe, and not only so, but that the whole Universe was made for its sake; that it was the darling and favourite of Heaven, that the sun shin'd only to give it light, to ripen its Fruit, and make fresh its Flowers; And that the great Concave of the Firmament, and all the Stars in their several Orbs, were design'd only for a spangled cabinet to keep this Jewel in. This *Idea* I would give of it as an Oratour; But a Philosopher that overheard me, would either think me in jest or very injudicious, if I took the Earth for a body so regular in it self, or so considerable, if compar'd with the rest of the Universe. This, he would say, is to make the great World like one of the Heathen Temples, a beautiful and magnificent structure, and of the richest materials, yet built only for a little brute Idol, a Dog or a Crocodile, plac'd in some corner of it. (*12*)

In Burnet's view the mountains of the earth are "nothing but great ruins" containing many hollows some of which appear at or near the surface as grottos, sea-caves, and mouths of caverns. Continued collapse of underground vaults and arches causes earthquakes. The fact that volcanic fire and smoke issue from some of these cavities indicates that "magazines of combustible materials are treasur'd up in them."



Frontispiece of Burnet's Sacred Theory. *The seven spheres portray Burnet's ideas on how the earth arrived at its present state and on what will happen to it hereafter. Beginning at the upper right and proceeding clockwise, we see in succession the primordial earth, the smooth paradisiacal earth, the earth enveloped in Noah's Flood (with the ark shown riding the waves), the earth in its ruinous present state, the earth in flames, the earth restored to a paradisiacal condition, and the earth finally transformed to a star.*

The last two books of *Sacred Theory* are more prophetic than historical. Burnet accepts the prophecies found in the second letter of Peter and in other parts of the New Testament that as the first world was destroyed by water so shall the present world be consumed by fire. As for the time when the Conflagration is to begin, Burnet could not be certain. But the flame would be volcanic; coal beds and other combustible materials would provide the fuel. And if natural agencies were not enough to liquify the whole outer shell of the earth, "let us allow *Destroying Angels* to interest themselves in the work, as the Executioners of the Divine Justice and Vengeance upon a degenerate World" (*13*). As for the *place* where the fire would be lit, Burnet the Anglican had few doubts. The territory around Rome is uniquely qualified to serve as a fuse for the Conflagration because it is at once a seat of volcanism and the seat of the Pope. We need not follow Burnet further in his account of how a new earth, better than any before, will be reconstructured from the burnt ruins of the present one.

Burnet's zealous efforts to discover in geology a "second revelation" compatible with the revelations of Scripture reflect his training and associations at the University of Cambridge. Although his date of birth is not recorded, he was probably no older than seventeen when he registered at Clare Hall in 1651. He received the bachelor's degree four years afterward, and then became first a fellow and later a proctor at Christ College. While at Cambridge he worked closely with a group called the Cambridge platonists, of which Ralph Cudworth and Henry More were prominent members.

One of the aims of these platonists was to reconcile the new science of the seventeenth century with Christian teachings. As a group they were opposed to purely mechanistic theories of nature such as the one published by Descartes in 1644. A persistent thesis in More's writings held that *all* parts of the universe proclaim "the power and providence of God." Sometimes the platonists were called "latitude men" because they valued morality above dogma and held that persons should be free to choose whatever religious organization best helped them to show their love of goodness. This tolerance extended to interpretation of Scripture. Taken literally, the sacred writings serve as guides for the unlettered; interpreted allegorically by the learned the Scriptures disclose truths more profound. For their probing beneath the surficial message of the Bible, these latitude men were sometimes called unitarians, or even atheists.

In 1671 Burnet began his travels in Europe, first as governor to the young earl of Wiltshire and later in the company of the young earl of Orrery. These travels extended over a period of three years, and in the course of them Burnet crossed the Alps. During this period he began work on his *Sacred Theory*, which was published ten years after he first left England.

In the course of his travels Burnet was overwhelmed by the irregularity of the earth's surface. He could find no pattern in the distribution of land and sea. Islands are scattered here and there "like limbs torn from the rest of the body." Promontories and capes "shoot into the Sea, and the Sinus's and Creeks on the other hand run as much into the Land; and these without any order or uniformity." Considering the whole surface of the earth, "t'is a broken and confus'd heap of bodies, plac'd in no order to one another, not with any correspondency or regularity of parts." Both the earth and the moon present the "picture of a great Ruine, and have the true aspect of a World lying in its rubbish" (*14*). Burnet the platonist, searching for a semblance of perfect geometrical form in nature, could find none. Only by looking backward in time could he envision the perfect globe of the original Creation, the Mundane Egg of Paradise with its fruitful gardens tended by men who could live hundreds of years.

Sacred Theory immediately attracted the attention of persons in high places who could read Latin. Publication of the first English edition expanded Burnet's readership and led to his professional advancement. In 1685, he was named Master of the London Charterhouse, a combination chapel, hospital, and school. Shortly afterward he became chaplain to William III. Burnet was considered a likely candidate for appointment to the Archbishopric of Canterbury.

Burnet continued to elaborate on his theory, and as he did so opposition to his views began to mount. In 1689 he issued a new and expanded version in Latin. The following year Erasmus Warren, Rector of Worlington in Suffolk, delivered a blast at Burnet in a book entitled *Geologia*. Warren attacked the sacred theory on scientific, theological, and philosophical grounds. In particular he denied Burnet's basic assumption that the present world is a great "Ruine," from which the *Sacred Theory* derived the notion that some former world must have been more perfect geometrically. To Warren the present world is a composition of surpassing beauty, with its "raised work, of Hills; the Embossings, of Mountains; the Enamelings, of lesser Seas; the Open-Work, of vast Oceans; and the Fret-work, of Rocks," not to mention "those stately Curtains overhead . . . the Clouds" (*15*). Those who might contend that mountains are not beautiful must at least concede that they are useful, Warren argued. This theme of the usefulness of mountains appeared in John Ray's influential *Three Physico-Theological Discourses*, published in 1693. Ray accepted mountains as features of a providential nature that caused rains to fall and runoff to spread replenishing soils over lowland farms.

In the course of what has been called the Burnet controversy, several alternative and more or less sacred theories of the earth were proposed. John Woodward, in his famous *Essay toward a Natural History of the Earth* (1st ed., 1695), proposed that the original crust of the earth did not collapse in ruins to cause the Universal Flood but rather was "dissolved" by the floodwaters. Later the particles settled out in order of gravity to form strata with their entombed fossils and minerals. William Whiston, who succeeded Isaac Newton at Cambridge, in 1696 accepted Woodward's idea on the origin of strata, but attributed the Flood to the close approach to the earth by a comet, which caused great rains to fall and the "Abyss" to open.

A new English edition of *Sacred Theory* appeared in 1691 and in the following year Burnet published his *Archaeologiae Philosophica*, an attempt to reconcile his theory with the account of creation in Genesis. Burnet's effort at reconciliation was widely interpreted as heterodox and profane ridicule of God's word. He was forced to resign his position at court and to retire to the Charterhouse, where he continued to write in defense of his ideas until near the time of his death in 1715.

Thomas Sprat in his early history of the Royal Society, published in 1667, anticipated that the new experimental science would be opposed by many who did not understand it. Over-zealous divines would denounce natural philosophy as the pursuit of carnal knowledge, while businessmen would dismiss it as a useless preoccupation. Misunderstandings of these kinds might be corrected by education; but ridicule of natural philosophy by the "wits" is another matter.

> I confess I believe that *New Philosophy* need not (as Caesar) fear the pale, or the melancholy, as much as the humorous, and merry: For they perhaps by making it ridiculous, becaus it is *new*, and becaus they themselves are unwilling to take pains about it, may do it more injury than all the Arguments of our severe and frowning and dogmatical *Adversaries.* (*16*)

William King, a younger contemporary of Burnet, was one of those merry people who could see the funny side of controversies involving prominent persons. King's ballad, "The Battle Royal," is a

fanciful account of a debate between a trinitarian, a unitarian, and an atheist over which led the best life and had the most grace. Burnet, who is cast as the atheist, is made to proclaim:

> That all the books of Moses
> Were nothing but supposes;
> That he deserv'd rebuke, Sir,
> Who wrote the Pentateuch, Sir,
> 'Twas nothing but a sham.
>
> That as for father Adam,
> With Mrs. Eve his madam,
> And what the serpent spoke, Sir,
> 'Twas nothing but a Joke, Sir,
> And well-invented flam. (*17*)

According to King's editor, "Battle Royal" became popular and was translated into Latin and several other languages. Many of the nobility and gentry sent presents to the author, making it evident that their sentiments were against having "the mysteries of our Holy Religion discussed and canvassed after so ludicrous a manner."

Burnet failed in his diligent efforts to construct a history of the earth wherein the principal events are attributed to natural causes, without at the same time doing violence to deeper meanings found beneath the bare words of the Scriptures. By the harshest judgment, his science may seem as fantastic as his religion surely seemed heretical to many of his contemporaries—to borrow Bacon's adjectives. Nevertheless the Burnet controversy aroused interest in geology and prompted others to try casting better theories of the earth. Friends and critics alike would remember Burnet's injunction that "we must not by any means admit or imagine, that all Nature, and this great Universe, was made only for the sake of Man, the meanest of all intelligent creatures we know of: Nor that this little Planet where we sojourn for a few days, is the only habitable part of the Universe. . . ." (*18*)

In the next century this concept of the immensity of the universe in space would be coupled with the idea of the vast extension of the earth in time.

CHAPTER SIX

Telliamed's Story

> All the plains which lie between the seas and the mountains were once covered by the salt waters.
>
> LEONARDO DA VINCI

In 1692, when the publication of *Archaeologiae Philosophica* inflamed the Burnet controversy, Benoît de Maillet, French diplomat and traveller, began composing a theory which among other matters held that the earth is more than two billion years old.

Born in 1656 of a noble family of Lorraine, de Maillet's diplomatic career began with his appointment as Consul General in Egypt at age thirty-five. In 1708 he was named consul in Livorno, a post he held for seven years. Thereafter he served for five years as inspector of French establishments in the Levant and along the Barbary Coast. In 1720 he retired with royal pension from government service, and after spending two years in Paris moved to Marseilles where he died in 1738 at the age of eighty-two (*1*).

In the course of his travels, de Maillet acquired a first-hand knowledge of the geography and geology of the lands around the Mediterranean. His skill with languages, both ancient and contemporary, provided access to Arabic and Western European writings on geography, geology, and cosmology. Combining some parts of what he had read with all that he had observed, he developed a coherent and unorthodox theory of earth history in which the dimension of time would approach the order of magnitude believed to be valid by modern scientists.

To begin with, he turned away from the Mosaic account of Cre-

Benoît de Maillet (Portrait reproduced by permission of Albert V. Carozzi and the University of Illinois Press. © 1968 by the Board of Trustees of the University of Illinois Press)

mogony (*2*). Descartes had envisioned the material bodies of the universe as concentrated in a vast number of whirlpools, or vortices. Rotating in the center of each vortex is a burning star or sun with its array of opaque bodies—planets and their satellites—revolving about it. Ashes from the burning sun are propelled by the sun's rays toward the periphery of its vortex, gathering on their way dust and water which accumulate on the planets. By this process the planets grow in size, and in due course develop watery envelopes of oceans through which dust and salt continue to settle.

When the sun burns out and becomes a dark cindery body of low density, one of two things may happen. The extinguished sun may whirl to the edge of the vortex, in which case the nearest planet will take its place and flare into brightness as a new sun. Or the whole vortex may disperse as a comet and spin away to join other vortices.

planets that have developed watery envelopes before their sun burned out may continue to receive water or may begin to lose water depending on their position in the new vortex.

De Maillet accepted the Cartesian idea that the earth is an extinguished sun. At some former stage of development, he theorized, the solid earth was covered by a universal ocean. Over long periods of time the ocean has been losing water by evaporation into outer space. This process of drying will continue until at last the planet will ignite and become a sun again. De Maillet estimated that about five billion years would be required for a new sun to burn out and convert to a planet, be restored in mass by addition of water and solids, and be ignited again. Presumably these cycles of burning and renovation of heavenly bodies will go on forever (*3*).

De Maillet cast his theory of the earth in the form of a dialog between two imaginary characters: a French missionary and an Indian philosopher named Telliamed (de Maillet spelled backward). His manuscript, entitled *New System on the Diminution of the Waters of the Sea*, is supposed to be the missionary's report on Telliamed's disclosures during lengthy conversations between the two at meetings in Cairo.

We soon learn that studies of the diminution of the sea have been a family project for three generations. These studies began when Telliamed's grandfather observed that near the shore bordering his seaside home a rocky prominence which had been awash during his youth had emerged above sea level years later. This phenomenon prompted grandfather to examine the rocks of mountains far inland. In the strata forming these mountains he found sea shells, sufficient proof that the sea had formerly been more extensive. Moreover, the strata were not all of a kind but were distinguishable one from another by differences in composition and color. Thus they could not have been formed all in one instant, but must have accumulated layer by layer.

So much for the strata and the fossils; how now were the mountains formed? To attack this problem grandfather invented gear for divers to explore the near-shore bottoms and map the directions of currents. Beyond that he designed a submarine for work at greater depths. The end result of these labors was the discovery that strong marine currents, moving in complicated patterns, are today heaping and molding sediment into sea mountains and valleys similar both in variety of contour and in magnitude to the mountains and valleys of

the bordering lands. Thus the mountains are formed on the bottom of the sea and later emerge in essentially their original form with the diminution of the waters. *Voila!*

As for the origin and development of life Telliamed also had ready answers. When the summits of the current-built seamounts were about to emerge above the level of the diminishing ocean, the seeds of organisms began to germinate in warm shallows nearest the air. Seaweed flourished, and fish and shellfish multiplied. Remains of these organisms began to accumulate in new strata spread seaward by waves and currents. With the continued shrinking of the sea, shorelines of the emerging continents lengthened, marine life increased, and consequently the newer layers of offshore sediment became more fossiliferous. This process of emergence of the continents and building of seamounts from the sedimentary waste eroded from the shores will continue as long as there are lands to supply sediments and seas to receive them. *Soit!*

Confronted with the problem of accounting for terrestrial life, Telliamed again turned to the sea for an answer. All life, plant and animal, originated in sea water, he asserted. Fish gave rise to birds, animals that creep on the floor of the sea to animals that walk on the land, and seaweed to shrubs and trees. If flying fish marooned in reeds should transform to birds, their fins changing to wings, this would be no more amazing, Telliamed reasoned, than the transformation of a caterpillar to a butterfly. By the same token elephant seals may have been the ancestors of elephants (*4*).

Telliamed applied this same transformist theory to the origin of man. He relates mariners' tall tales of sighting sea-men and seawomen with tails like fishes but human-like from the waist up. These tritons and mermaids were as likely the descendants of seals as they are the ancestors of mankind (*5*).

How much time has elapsed since the first mountains appeared above the level of the diminishing sea? Telliamed's ingenious grandfather reasoned that knowing the height of the highest mountain and the secular rate at which sea level is lowering, an approximate answer could be given. Accordingly he constructed near his home a hydrographic station designed to measure fluctuations in sea level. Observations continued for more than 75 years indicated that sea level is falling at the rate of three inches per century (*6*). As confirmation, Telliamed cites the situation of a seaside fortress at Carthage. This edifice has basement openings evidently designed for the admission of sea water. But the base of these openings now stands five to six feet above sea level, which must have dropped by that amount in some 2,000 years (hence 3 to 3.6 inches per century). Similar situations at Alexandria and Acre supply the same results (*7*).

With the continued shrinking of the ocean, Telliamed confidently predicts, present port cities will be left high and dry as they become inland cities. By the same token, certain ancient inland settlements, or their ruins, surely originated as seaports (*8*). In terms of their present elevations, the highest of these stand perhaps 6,000 feet above sea level. Again assuming an average fall in sea level of three inches per century, the oldest maritime settlements date back some 2,400,000 years. Petrified masts of ships are found today in many inland situations, as for example in the Western Desert of Egypt—proof sufficient for the diminution of the sea (*9*).

A long period of time must have elapsed between the time the first land emerged and the time that these ancient harbors were occupied by man, Telliamed reasoned. On any reasonable assumption, he concluded, the diminution of the sea must have been going on for the past two thousand million years (*10*).

After de Maillet returned to Paris in 1720, copies of his manuscript made their rounds in French intellectual circles. The original is missing, but seven handwritten copies are preserved in French and American libraries. Struck off at various times between 1722 and 1729, these differ in detail because the author continued to revise the text until near his death in 1738 (*11*).

For editorial assistance preparatory to publication de Maillet entrusted his manuscript to the Abbé J. B. le Mascrier, who professes to have begun his work in 1732. After de Maillet's death, however, the abbot evidently had misgivings about admitting to the editorship of so heretical a book. The first edition, in French, of *Telliamed: or Conversations between an Indian philosopher and a French missionary on the diminution of the sea* did not appear until 1748. Le Mascrier's name does not appear on the title page; instead the editorship was ascribed to J. A. G. (one Jean Antoine Guer, a lawyer who apparently had no connections with de Maillet). Not until the appearance of a third edition in 1755 did the abbot acknowledge his association with the book (*12*).

Comparisons of the third edition with the extant manuscript copies have shown that le Mascrier took liberties that go far beyond the

bounds of editorial privilege. His main concern was to reconcile the text with Christian orthodoxy. Certain troublesome passages he simply deleted. In some instances de Maillet's billions and millions of years were reduced by moving the decimal point three or four places to the left; elsewhere in the text quantitative estimates of geological time were translated into vague qualitative language. Glosses were introduced to make this materialistic system seem more palatable to believers (*13*).

Despite all le Mascrier's doctoring, the import of Telliamed's message was as clear to his readers as it must have been to the patient French missionary who supposedly heard the original version. Voltaire denounced *Telliamed* as the work of a charlatan who tried to play God (*14*). Other critics less well known were no more charitable. Then, as now, outraged denunciation simply worked to the advantage of booksellers. *Telliamed* became a popular book: an English translation appeared in 1750, and an American printing of 1797 capitalized on its controversial character by announcing on the title page that this is "*a very curious book.*" Not until 1968 did the authentic version of de Maillet's work appear in print, a masterpiece of scholarship by Albert Carozzi. This reconstruction, combined with Carozzi's critical commentary, shows that de Maillet's theory was not a frivolous and fanciful construction of the imagination but a serious effort at interpreting the history of the earth, mainly on the basis of observations made in the field.

Evidence that the continents have in the past been submerged beneath the sea comes from all parts of the world. The occurrence of fossilized remains of marine life in continental strata constitutes the most compelling evidence. In addition, raised beaches and wave-cut benches rise in stair-step fashion above the present strand lines in many parts of the world, as for example in Scandinavia, along stretches of the Mediterranean shore, and in California.

Thus the hypothesis of the diminution of the sea was viable in de Maillet's time. His basic assumption that the rocks forming the earth's crust were deposited from sea water identifies de Maillet as a neptunist, forerunner of a school of thought that would play a prominent and controversial role in geological developments during the interval 1775–1825 (*15*).

By applying the principle of superposition, adherents of neptunism could demonstrate that similar sequences of rocks containing distinctive kinds of fossils are present in many different parts of the

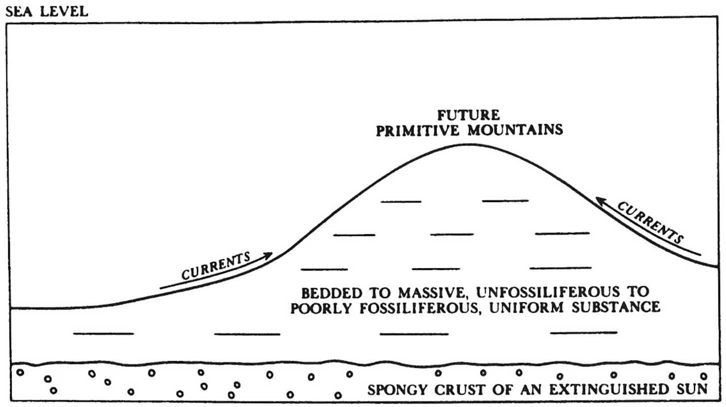


Fig. 13. Stage 1. Formation of the primitive mountains by the action of currents on the bottom of the ocean.

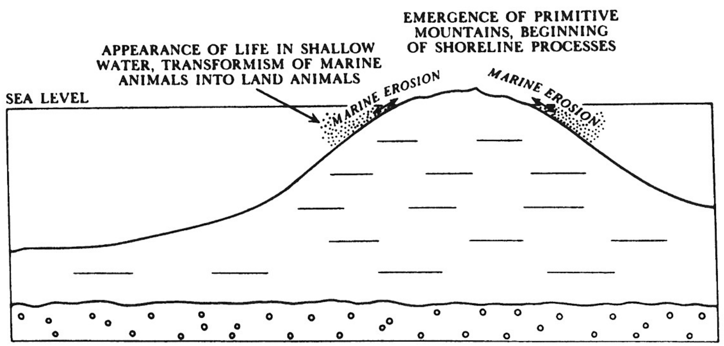


Fig. 14. Stage 2. Emergence of the primitive mountains, appearance of life in shallow waters, transformism of marine organisms into terrestrial ones, and population of the continents.

Carozzi's diagrams illustrating the evolution of the earth's crust according to de Maillet's theory (Reproduced by permission of Albert V. Carozzi and the University of Illinois Press. © 1968 by the Board of Trustees of the University of Illinois Press)

world. Two deficiencies in neptunist schemes arose from a failure to comprehend the essential difference between igneous and sedimentary rocks, and from the assumption that the earth's crust stands immobile through time. Granite and other kinds of igneous rock were regarded as sediments, either mechanically assembled or precipitated

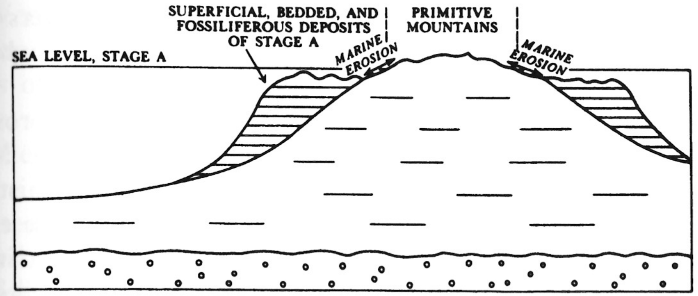


Fig. 15. Stage 3. Beginning of the formation of the secondary mountains by shoreline erosion of the primitive mountains.

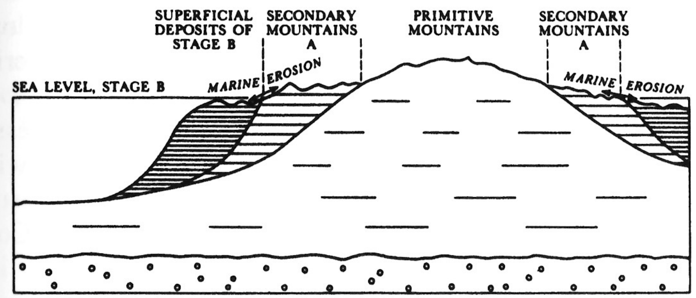


Fig. 16. Stage 4. Formation of the lower secondary mountains by shoreline erosion of the upper secondary mountains.

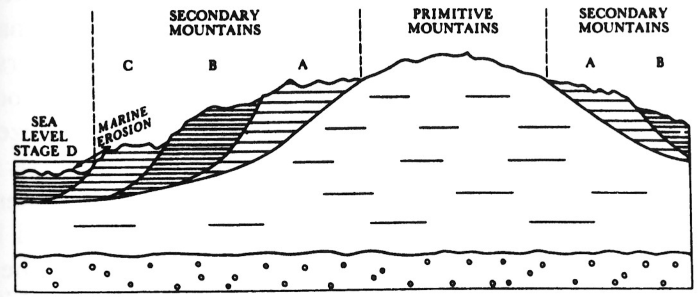


Fig. 17. Stage 5. Formation of present-day marine sediments by shoreline erosion of the lowest secondary mountains.

from a once-universal ocean. Folded strata were regarded as products of deposition over hummocky bottoms or as masses deformed by slumping of submarine sediments. Volcanic activity was generally de-emphasized and usually attributed to the burning of subterranean coal or other combustible materials. Getting rid of the waters of the shrinking ocean proved an embarrassment to neptunists of whatever stripe or vintage.

Because he denied the importance of subaerial agents of erosion—wind, streams, and glaciers—in shaping the landscape, de Maillet has been called an ultra-neptunian. Later and more sophisticated theories of the same genus allowed for the operation of these erosive agents as soon as land emerged. But as the neptunist doctrine became more refined, late in the eighteenth century, its adherents seem to have become less explicit in regard to the duration of geologic time. Emphasis on determining sequences of events from order of superposition became the rule of the day, leaving the door open to those who would encompass all these events within a Scriptural framework.

De Maillet had no patience with the tiresome and fruitless business of trying to "save the Faith" by reconciling geology with the Holy Word. His Indian sage warns that we should not measure the duration of the earth in terms of our own short lifetimes. Consider the immensity of the universe. Consider the virtually infinite number of suns, around which hundreds of millions of planets like ours revolve. Can we imagine, he asks, that all this was created in 4004 B.C.? Beyond this, is it necessary to assume that matter and motion had a beginning at all? Then may not nature be eternal (*16*)?

Nor would de Maillet accept as authentic the Biblical version of neptunism as contained in the story of Noah's Universal Flood. The mountains of Armenia are built of strata containing fossilized sea-fish, he observes. Are we to assume that the strata of these mountains were laid down in forty days as a mass of soft sediment? Or were the mountains there before the Flood and so softened by the floodwaters that sea-animals burrowed into them? Even if the Flood overtopped the highest of the Armenian mountains by 40 cubits, still it would not have covered the highest mountains of the world. Granted the Flood was an historic event, one need not assume that it was world-wide. After the ark was wrecked on the coast of Armenia, Noah and his party may be forgiven for guessing they were sole survivors of a universal catastrophe. But assuming they in fact were so, how then does one account for all the different races of man who live on the earth today (*17*)?

The Baltimore publisher who advertised *Telliamed* as "a very curious book" was surely correct. Tritons and mermaids do not

exist. Venice is sinking, not rising above the sea. Not all shores have stair-step marine terraces. Petrified logs don't derive from the timbers of ancient ships. And so for many details of de Maillet's scheme, viewed from a twentieth-century perspective.

On the other hand, two grand ideas developed in *Telliamed* would continue to leaven geologic thought. The concept that terrestrial life originated in the sea brought praise from Georges Cuvier, father of comparative anatomy and vertebrate paleontology (*18*). Above all else, *Telliamed* was a geologic time-stretcher. The realization that thick sequences of strata forming high mountains were built layer by layer "from the bottom up" implied duration of time outrageously long, judged by contemporary precepts. Nevertheless, in a universe so vast as the *philosophes* of the eighteenth century were willing to concede, an earth whose age is to be measured in millions or billions of years began to seem reasonable.

CHAPTER SEVEN

The Epochs of Nature

Au commencement, Dieu créa
les cieux et la terre.

MOÏSE

Au commencement, Dieu créa
LA MATIÈRE du ciel & de la terre.

BUFFON

In 1749, a year after *Telliamed* appeared in first edition, the first three volumes of *Histoire Naturelle, Générale et Particulière* were published in Paris. The author was Georges-Louis Leclerc, then in his tenth year of service to Louis XV as Keeper of the Jardin du Roi. When appointed to this post he had been asked to catalog the collections of a natural history museum which was a part of the royal gardens. Once engaged in this curatorial work, he conceived the grand idea of preparing an encyclopedia that would treat all of nature—animal, vegetable, and mineral—in a systematic manner. Obviously too much for one man to accomplish, one would say; yet at the time of Leclerc's death 35 of a projected 50 volumes had been completed (*1*). In 1772 the author's name acquired the noble suffix *comte de Buffon*, by grace of the king. It is as Buffon and not as Leclerc that he is remembered as a prominent figure of the Enlightenment.

Buffon was born in 1707 in the Burgundian town of Montbard. His father was an officer of government whose duties included administration of the salt tax. The family suddenly became wealthy in 1714 when his mother inherited a large estate from a brother who had prospered in service to the King of Sicily. Leclerc *père* quickly proved himself equal to the task of spending his wife's money. He purchased the nearby lands and village of Buffon and a townhouse in

college, and at the age of eighteen had completed his general studies and passed his examinations in the law (*2*).

For the next several years Buffon continued his studies privately, not in the law but in mathematics, botany, and medicine. By a fortunate circumstance, which is not documented, he met and became a friend of the young second Duke of Kingston, who was travelling in France with his tutor. Late in 1730 he embarked on The Grand Tour with these English companions, travelling through France and Switzerland and across the Alps to Rome. The Duke travelled in a style befitting his title, and through him Buffon learned some lessons in expensive living.

Buffon

Buffon's travels were briefly interrupted in the autumn of 1731 by the death of his mother. Little more than a year later his troubles increased when he learned that his father proposed to marry again, this time a woman who seemed ineligible on two counts: she was not wealthy, and she was only twenty-two years old. When he was unable to persuade his father that this union would sully the family name, he returned to Montbard to demand his share of the mother's had urged him to acquire in the first place, to arrive at a settlement out of court, and at no greater cost than a mutual and undying alienation of affection. The settlement was handsome; in addition to a large sum in cash, he received the family real estate at Montbard and Buffon.

During the seven years that elapsed between the time of his inheritance and his appointment as keeper of the royal gardens, Buffon gained in reputation as a scientist and at the same time added to his wealth through business ventures. On his lands in Burgundy he began investigating ways of growing improved grades of timber, for use both in programs of reforestation and in building tougher ships for the French Navy. Out of this venture grew a commercial tree nursery, which Buffon later sold to the government with the understanding that he would receive a salary as manager (*3*). At the hamlet of Buffon, he built an iron foundry, where among other articles cannons for the French army and navy and iron fences for the royal gardens were cast. The design of the factory reflected the style of the builder. Blast furnace, bellows, and other gear manned by up to 400 workmen were hidden behind an elegant façade, and flanked by gardens. At a chapel in the main courtyard, services were held each Sunday (*4*). These business operations, while lucrative, did not prevent Buffon from pursuing studies of mathematics, physics, and zoology. His name was entered in the rolls of the Académie des Sciences in 1734, and five years later he was elected Associate Member in Botany. His silvaculture had paid a second dividend, this time in prestige.

In addition to the three introductory volumes of *Natural History* published in 1749, Buffon was able to complete twelve volumes on mammals, nine on birds, and five on minerals, together with six lengthy supplements. The most famous of his scientific essays, *Des Époques de la Nature*, appeared in the fifth supplementary volume, published in 1778.

In the *Époques*, Buffon attempted a synthesis of earth history from the beginning to the present, including the origin and development of life and a numerical estimate of the duration of geologic time that was outrageously long for his day (*5*).

Buffon proposed that the planets of the solar system formed as a result of a collision between a comet and the sun. The shock of impact caused about 1/650 of the sun's mass to eject as a streamer of hot liquid and gaseous matter which separated into globular masses to

form the planets. The planets spun off satellites, fell back toward the sun, and began their circles around it.

Thus in the beginning the earth was a globe of molten material in the nature of a siliceous magma. The globe cooled and solidified from the surface inward. As cooling progressed the outer crust developed blisters, wrinkles, and cracks. These irregularities of surface, though negligible on a global scale, constituted a surface of high relief viewed in human perspective. Thus were formed the primitive mountains and plateaus, which are part of the main body of the earth and owe nothing to the action of water.

At one stage in the cooling of the earth the primitive siliceous crust was solid, but metallic substances with lower melting points were still liquid. Near the surface these metallic materials pooled in cavities, while at greater depths they vaporized and condensed along vertical fissures in the already solid crust. By these processes of concentration were formed the primordial ore deposits, which owe nothing to the action of water.

With further cooling a point in time was reached when water vapor could condense and fall as rain without steaming back into the atmosphere on striking the still-hot surface. Water began to gather in depressions over the earth's surface, first in the polar regions then everywhere. In time water covered the whole earth, except for local high prominences of the original crust. The work of water began.

There followed a time of intense chemical activity involving the interaction of air, earth, fire, and water. Charged with acids and salts, water infiltrated and altered the dust and slag of the primitive crust. These surficial materials disintegrated or decomposed to form deposits of sand and clay. Clay, by various degrees of hardening, changed to shale, slate, and schist. Sand, clay, and their lithified derivatives constitute one class of rocks formed by the action of water upon the raw materials of the primitive earth.

A second class of rocks made possible by water includes those which owe their origin to organisms. According to Buffon, limestones and other calcareous strata are built of the whole, broken, or pulverized hard parts of shellfish. The occurrence of limestone in the stratigraphically lower and hence older part of the stratigraphic column indicates that the universal ocean, once formed, was soon populated with innumerable shellfish.

Sediments accumulating on the bed of the ocean were swept about by currents, variously generated by the tides, by the winds, or by the rotation of the earth itself. These currents shaped the bottom sediments into relief features of the same kinds we see on the continents. Slowly the sediments hardened, and at the same time sea level fell by degrees. This retreat was due to episodic collapse of arches over the enormous caverns beneath the "blisters" of the primitive crust. With each such collapse, sea water rushed down to fill the caverns, the level of the sea fell by proportional amounts, and additional land emerged. Elevations and depressions, first shaped on the sea floor, thereby became the mountains and valleys of the land.

Vegetable life appeared on land early in the emergent stages of the continents, as evidenced by coal beds in various parts of the world. The great forests of primitive times, weakened by age and battered by winds, were sources of wood which, transported by streams and ocean currents and mixed with pyritic materials, finally became buried in the bosom of the earth. These masses of buried combustible material would burst into flame upon contact with water, giving birth to volcanos both submarine and terrestrial. Because subterranean water is necessary for their eruption, volcanos rarely exist except near the sea. With retreat of the sea, the near-shore volcanos became inactive as new ones burst into action at lower levels. Thus most volcanos in the central parts of the continents are inactive or nearly so.

At this juncture, sea level had stabilized at about its present position. The continents had emerged from the universal ocean, plastered with marine sediments molded into mountains and valleys. Over broad areas the sedimentary strata remained in their original nearly horizontal positions; but wherever the great subterranean caverns of the primitive earth had collapsed, the overlying strata were deformed. Water continued to work in its various ways. Underground water transported metallic mineral substances, concentrating them in secondary mineral deposits. Waves beat against the shores, destroying certain natural barriers such as those at Gibraltar and the Bosporus.

A last major geologic event would take place before the earth would appear in its present form. This would be the formation of the Atlantic Ocean by foundering of the lands which until this time had joined North America and Eurasia as a single great continent. Since Buffon's evidence for this event was based on paleontology, it is appropriate here to consider his views on the origin and development of life.

tial elements of all forms of life consist of "organic molecules." These molecules are of two kinds: animal and vegetable. Both originated by the action of heat on watery, oily, and "ductile" materials of the earth, after the surface had cooled to a critical temperature favorable to such reaction. Because these molecules formed during one stage in the secular cooling of the earth, they must be finite in number for this planet. And since other planets have passed or will pass through similar critical stages of cooling, organic molecules have been or will be produced on them also.

In Buffon's view the first organisms to appear on earth were not primitive or simple, but as complex as any living today. Due to the high temperatures prevailing at the time the organic molecules first began to form, the generative forces of nature were particularly active. Giant ammonites appeared in the ocean soon after the waters covered the earth. Mammoths and rhinoceroses were early inhabitants of the emerging continents. These large beasts were adapted to a higher temperature than their modern counterparts could endure, and so they disappeared when the temperature fell below a point they could tolerate.

Fossilized remains of mammoths are found both in Eurasia and in North America. In Buffon's reasoning this meant that the two continents were formerly joined by a land bridge which has since subsided beneath the waters of the Atlantic.

Buffon has sometimes been called a transformist, a forerunner of Darwin; but an analysis of his system shows that he was not. He maintained that terrestrial life originated in the north polar regions. These would have been the first to cool to the critical temperature required for formation of organic molecules. With continued cooling of the polar area, the plants and animals adapted to a higher range of temperature would migrate southward or else disappear. Migrating organisms would leave behind quantities of unused organic molecules. These particles would aggregate into newer organisms adapted to a more severe climate; and the new crop in turn would seek survival by southward migration as the temperature continued to fall. Thus the successive biotas spontaneously generated in the northlands were not kin to each other, only sequential and formed from the same matter.

Buffon accorded man a special place in the natural order. Taking a cue from Descartes, he distinguished man from other organisms by his gift of reason; and reason is not matter. Granted that man is the conquest; but he is not sovereign by divine law, he is not the purpose of Creation. Moreover life and thought are not confined to this planet alone but must be present on others throughout the vast universe.

Buffon divided the history of the earth into seven "epochs." This division is somewhat arbitrary and was not essential to his system. Evidently he hoped that the number seven would make less difficult a reconciliation of his history with the creation epic of Genesis.

Buffon's first epoch spanned the time when the earth was a globe of molten material. During the second epoch the earth consolidated, and the primordial features of relief and structure developed on its surface in the form of blisters, wrinkles, and cracks. The third epoch was the time when the ocean formed and life appeared. During the fourth epoch the waters withdrew from the continents and volcanos became active. Elephants and other kinds of animals which at present live in warm climates populated the northern parts of the continents during the fifth epoch. The major physical event of the sixth epoch was the separation of the American and Eurasian continents. The seventh epoch is the Age of Man, the time when man acquired dominion over nature in the senses of understanding her workings, exploiting natural resources, and in various ways modifying the natural scene.

The problem now was to estimate the time required for the earth to cool from its original state of fusion to its present temperature. Having thus calculated the age of the earth, the duration of the several epochs could be estimated as fractions of this total.

In his search for numbers to measure the age of the earth in years, Buffon set up an experiment in his iron foundry. He had his workmen fashion ten balls of iron graduated in diameter by half-inches up to a maximum of five inches. These balls were heated to near the melting point. Then he measured the time required for each ball to cool, first to the point that it could be touched without burning the fingers, and then to the point that the temperature was the same as that of the air in a nearby cave. These experiments showed that with each increase of a half-inch in diameter, the time required for cooling to the first point increased by 12 minutes, and for cooling to cave temperature by 54 minutes. With a bold extrapolation he calculated that a globe of molten iron the size of the earth would require 49,964 years and 221 days to cool to the point that it would not burn the hand when touched; and 96,670 years and 132 days for the temperature to fall to the present temperature of the earth. In other calculations Buffon arrived at a figure of 4,026 years for a globe of the same size to pass from a molten to a consolidated condition.

Buffon repeated the experiments in cooling, this time using mixtures of metallic and non-metallic substances more like the actual composition of the earth. He made corrections in his figures to allow for retardation in cooling due to the heat that the earth would receive from the sun. To follow him through all of his arithmetic would be tiresome: the key figures he finally published are the following:

2,936 years for the earth to consolidate from a molten condition;
37,500 years for cooling before the earth could be safely touched; and
75,000 years for the earth to cool to its present temperature.

These figures are not cumulative: according to Buffon the earth was 75,000 years old in the 18th century A.D. Interpolating between the above figures, he estimated that the oceans formed and life appeared when the earth was about 35,000 years old, that the stabilization of sea level took place at between 50,000 and 55,000 years, that the mammoths appeared in Siberia around year 60,000, that the continents separated around year 65,000, and that the southward migration of elephants ended at year 70,000 (*6*).

This published chronicle was actually Buffon's "short version." In manuscripts which were not publicized until the nineteenth century, he opted for a much longer scale of time. Among other considerations he was impressed with the length of time that must have been required for thick sequences of limestone strata to form. Not centuries, he conjectured, but centuries of centuries must be required for the growth of shellfish, their accumulation as entire shells or fragments in successive strata, and their hardening to form the rocks we see in our quarries. Buffon estimated that the rate of deposition of mud in the seas of today averages less than five inches a year. Thus a single formation of clay 6,000 feet thick would have required more than 14,000 years to accumulate. Buffon was no field geologist, but he must certainly have been impressed by the enormous thickness of sedimentary rocks he saw when crossing the Alps on his grand tour.

Of the several "long chronologies" found in the unpublished manuscripts, the longest one estimates the age of the earth at nearly three million years, and would have life appear after the planet was between 700,000 and a million years old (*7*). Internal evidence strongly suggests that Buffon favored the longer version. Why, then, did he elect to publish the shorter? Surely not to appease the theologians, who would have considered the proposed 75,000 years for the age of the earth as much a departure from Scriptural truth as 3,000,000. The best guess is that he thought the lower figure was about as much as the traffic would bear. His readers simply would not be prepared to contemplate *le sombre abîme* of time plumbed in millions of years.

Natural History made Buffon famous, not only as a scientist but also as a literary figure. His election to the Académie Française in 1753 came as recognition of his accomplishments as stylist, and his *Essay on Style* is still highly regarded. "Style is the man himself," Buffon declared in a phrase often quoted. The reference of course is to literature, but in the case of this man the meaning could also apply to style of living. Though already an international figure in his middle years, and wealthy too, he continued to be self-disciplined and industrious.

In 1767 Buffon acquired financial control of his encyclopedia and so became his own publisher. This must have been a sound investment, because *Natural History* became a popular work during and after his lifetime. One can count fifty-two complete editions in French, and a total of twenty others translated into German, Italian, English, Spanish, and Dutch (*8*).

Buffon was less successful in his family affairs. When he was forty-five years old he followed his father's example by marrying a woman of twenty who brought no dowry with her. For his only son, born in 1764, he provided the best in training and polite upbringing that money and social connections could afford. Unfortunately, the boy was not equipped to carry on the intellectual tradition of the father. "Buffonet," as he was nicknamed, has been described as a crackbrain and rakehell. He did manage to marry into high society, but his wife had a scandalous affair with the Duke of Orleans. At age 30 he was guillotined, a victim of the French Revolution.

In 1788 Buffon died at his apartment in Paris. Buffon once observed that the scientific study of nature required of the investigator two opposite qualities of mind: the ability to conceive the whole grand picture at a glance, and the capability of focusing patiently upon a single aspect of the whole (*9*). Most certainly he qualified on the first count: his vision of the history of nature was panoramic, and he conveyed it with consummate skill and grace.

As for focusing upon a single aspect of the whole, he was content to glean most of his facts from the literature and from personal correspondence. Let others provide the bricks; he would design and build the edifice! Officials of the French colonies supplied information on remote parts of the world. Others of his better known correspondents included Catherine the Great of Russia, the Kings of Denmark, Poland, Sweden, and Prussia, Benjamin Franklin, and Thomas Jefferson (*10*).

Buffon had a serene confidence in the power of scientific reasoning. His basic assumption was that nature is rational, product of a rational Creator. Hence nature can be understood. He could foresee no limits to human understanding of the universe. We begin our interrogation of nature, he argued, by comparing like things and events. Anything unique, unrelated to anything else, is beyond comprehension. Thus God is incomprehensible, because unique. Appealing to God to explain natural phenomena is a form of mental laziness, as pretending to understand God's designs is a symptom of human weakness. Science must deal solely with secondary causes, never with those primary causes which are God's will. Hence science is concerned with the *how* of secondary causes, not with the divine *why*.

In attempting to establish the sequence of changes the earth has undergone since its beginning, Buffon held that the scientist should appeal to those ordinary causes of change that are in operation today (*11*). Invoking extraordinary or catastrophic causes leads to the invention of groundless hypotheses, he warned. He dismissed as wild and romantic speculations Woodward's Deluge which was supposed to have dissolved all the rocks of the earth's crust, and Whiston's comet which opened the floodgates of the Abyss.

The just reward of the scientist's labors, Buffon concluded, is to perceive the simplicity and economy of means by which natural forces have shaped the earth. The basic operations of nature, he believed, are few in number, involving force, motion, chemical reaction, heat, and vital energy. He placed great emphasis on force as an underlying cause of change. Force, he reasons, is the result of the mutual attraction between bodies which produces motion; chemical reaction the result of attractions between the smaller particles of matter; and life itself the result of attractions of small particles combining under the influence of heat to form organic molecules.

These sentiments were displeasing to the Faculty of Theology at the University of Paris. In 1751, two years after the first volumes of *Natural History* appeared, Buffon escaped censure at the hands of the theologians only by dismissing his theory for the origin of the planets as "pure philosophical speculation" (*12*). In writing the *Époques* Buffon tried to forestall any additional threat of censure by explaining how his theory was not actually contrary to Christian dogma. His exegesis is all one would expect of genius artfully at work on an insoluble problem (*13*). The first verse of Genesis, he argued, should be interpreted to read: "In the beginning God created *the materials* of Heaven and Earth": all else would follow according to the laws governing matter and energy. The theologians were not pleased, but their investigations stopped short of censure, apparently at the suggestion of the King (*14*).

Through his writings Buffon aroused popular interest in natural science. Beyond that he was the first to undertake geophysical experiments in the search for numbers to measure the age of the earth. In so doing he broke with the prevailing Biblical chronology which compressed earth history within a time frame of a few millennia, and offered instead a chronicle calibrated in tens and scores of thousands of years. In this respect the *Époques* were epochal. So was the author, at least in the view of one admirer.

> Qu'il soit béni le jour qui vit naître Buffon!
> Buffon sera, chez la race future,
> Pour les amis du vrai, du beau, de la raison
> Une époque de la nature. (*15*)
>
> GUÉNEAU DE MONTEBEILLARD, 1778

CHAPTER EIGHT

View from the Brink

> The abyss from which the man of science should recoil
> is that of ignorance . . . .
>
> JAMES HUTTON

In 1788, the year of Buffon's death, James Hutton's *Theory of the Earth* appeared in Volume I of the *Transactions of the Royal Society of Edinburgh*. The ideas expressed in that long essay, together with the author's later elaborations of them, are considered by many to mark the beginning of modern geology. Hutton emphasized the work of streams in shaping the surface of the land. He recognized the significance of angular unconformities between two sequences of strata as recording successive events of deposition, deformation, erosion, and burial. Through his own field observations he established the igneous origin of granite and basalt. In constructing his theory he appealed to processes currently in action, as causes sufficient to account for past changes on the earth. Thus he held that most valleys have been formed through protracted erosion by the streams that now occupy them, not by some catastrophic flood. He proposed that in the past whole continents have been leveled by the day-to-day action of waves and running water. The time required for this decay of the continents would necessarily be vast; but this was of no concern to Hutton, who steadfastly believed that geologic time is virtually infinite in duration.

Any young scholar who suffers pangs of anxiety concerning the choice of a suitable career should take heart from the story of James Hutton, who changed his course three times and was sixty-two years