NATURAL HISTORY AND THE BRITISH PERIODICALS
IN THE EIGHTEENTH CENTURY

DISSETATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
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By

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* * * * *

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NOTES ON THE TEXT

The titles of the eighteenth century periodicals varied considerably. The following periodicals will therefore be cited in this paper by the shorter titles in the left column. The complete titles for representative years are listed in the right column.

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The Ladies Magazine

The Ladies Magazine; or, the Universal Entertainer

Literary Journal

Literary Journal

The Literary Magazine

The Literary Magazine: Or, Universal Review

The London Magazine

1733 - The London Magazine: Or, Gentleman's Monthly Intelligencer

1784 - The London Magazine, Enlarged and Improved

The Monthly Review

1749 - The Monthly Review. A Periodical Work Giving an Account, with Proper Abstracts of, and Extracts from, the New Books, Pamphlets, etc. as They Come Out

1789 - The Monthly Review; or, Literary Journal

Philosophical Transactions

1731 - Philosophical Transactions. Giving Some Account of the Present Undertakings, Studies, and Labours of the Ingenious in Many Considerable Parts of the World

1789 - Philosophical Transactions, of the Royal Society of London
The Scots Magazine

1739 - The Scots Magazine. Containing a General View of the Religion, Politicks, Entertainment, etc. in Great Britain

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INTRODUCTION

The eighteenth century was one of the most intellectually active eras in history. The critical and intellectual spirit of the Enlightenment extended to all areas of human knowledge. During this period natural history evolved as a new scientific discipline. A loosely defined field, natural history encompassed the biological and earth sciences. Although largely descriptive, the practitioners also searched for explanation, orderliness of event as well as of existence.

The natural historians or naturalists were a mixed lot. This group included every manner of individual from dilettanti to scientists of international stature. Naturalists were found in all the countries of Europe and their colonies, but the real center of natural history was in Great Britain. There scientists were at the center of a vast economic and political empire and therefore in communication with all parts of the globe.

With rare exceptions, all British natural historians were amateurs in that they did not depend upon their scientific activities for their livelihood. They might be
merchants, physicians, or clergymen who had an active interest in the world around them. Many of these men maintained a collection or "cabinet" containing natural curiosities. All of them relied upon written communications and printed material to stay abreast of the latest discoveries and developments in natural history around the world.

It is more than a coincidence that at the same time that interest in natural history increased in Great Britain, the popular periodical press experienced an unprecedented growth. The startling success of the Gentleman's Magazine, the Monthly Review, the Critical Review, and other serials was due, at least in part, to the inclusion of an expanding amount of natural history in the serials. These periodicals in turn were an important vehicle for the dissemination of information about natural history.

Much information can be gained about the mind of an age from its lesser writers. Most of the selections in the periodicals were written by men who were not first-rate scientific writers. But they were erudite men of the British Enlightenment. As one author reminds us:

The tendencies of an age appear more distinctly in its writers of inferior rank than in those of commanding genius. These latter tell of the past
and future as well as of the years in which they live. They are for all time. But on the sensitive responsive souls of less creative power, current ideas record themselves with clearness.¹

The reviews, articles, and letters in the periodicals supply valuable information about the way natural history grew and how men conceived of it.

Various threads of continuity run through the natural history in the periodicals. Some of these themes were remnants of century-old ideas, while others appeared for the first time during the eighteenth century.

The question of what role, if any, God had in the formation and maintenance of the earth was one of these topics. Naturalists debated the matter throughout the eighteenth century in the periodicals.

The great chain of being, the belief that all natural objects were arranged in a graded ladder of perfection, appeared in the pages of the serials. This was a concept that originated in the writings of Plato and Aristotle in the fourth century B.C. Other Aristotelian influences were also obvious.

A more modern idea, the belief in immanence, the idea that nature was governed by subtle fluids, influenced all
areas of natural history before the end of the century. The electrical discoveries of the era were an important part of immanence.

Natural historians approached their subject matter from two points of view: a world of a general character, reflected in immanence, God's work, and creation, or a world that a person knew in particular, a locality. In either case the scientists tended increasingly in the eighteenth century to look for immediate causes and to concentrate on naturalistic explanations. The dimensions of their endeavor encompassed not only general ideas of the universe--stable or changing--but also the most hotly debated subjects of the day, such as the migration of birds and the nature of earthquakes. In these discussions the serials provided a revealing picture of the ways in which various levels of sophistication went into the making of the scientific elements of Enlightenment thinking.
FOOTNOTE

1George Herbert Palmer, ed., The English Works of
George Herbert, Newly Arranged and Annotated and Considered
in Relation to His Life (3 vols.; Boston: Houghton Mifflin
and Company, 1915), I, xii.
CHAPTER I

THE TYPES AND VARIETY OF NATURAL HISTORY
IN THE PERIODICALS

Science, medicine, and technology were important subjects in the British periodicals of the eighteenth century. The editors of the Critical Review devoted more than 30% of their space to reviews of scientific and medical topics. A dozen other serials of that era had science as a featured subject. The inclusion of scientific material was undoubtedly one of the important reasons for the sudden growth of the periodical press in Great Britain during the eighteenth century.

A relatively new branch of science, natural history, was the most popular area of science. The educated public could not get enough information about the animal, vegetable, and mineral kingdoms. Between 1731 and 1789 natural history articles, letters, and reviews comprised 7.6% of the total pages in the Gentleman's Magazine, the leading popular British periodical of the century. It is not surprising that C. Lennart Carlson in his history of the periodical referred to the Gentleman's as a "magazine of popular science."
The amount of natural history in ten other serials will be examined in detail in this chapter. In addition a breakdown of the natural history into the various diverse areas of the discipline will be provided.

The contributors of natural history to the periodicals ranged from first-rate scientists like Carolus Linnaeus (1707-78) and the Comte de Buffon (1707-88), whose articles were usually reprinted from other publications, to uninspiring contributions from the casually interested. The selections furnished by these persons naturally reflected the scientific abilities of the individual writers. The natural history articles spanned the entire spectrum from very erudite to extremely banal pieces. Articles that appeared in the periodical suggest both the quality and distribution of the subject-matter in the various areas of natural history.

Edward Cave (1692-1754), the founder and editor of the Gentleman's Magazine, had a good scientific sense, as was evidenced by numerous publications in his serial. In at least two instances he was instrumental in bringing new and original scientific knowledge before the public.
Most British readers first learned of Benjamin Franklin's famous experiments with electricity through the efforts of Cave. In 1747 Franklin (1706-90) communicated the results of his early experiments with electricity to Peter Collinson (1694-1768), a London merchant and naturalist. Collinson showed this letter to Sir William Watson and some other members of the Royal Society of London. Watson communicated the contents of the letter to the Royal Society in a paper read on January 21, 1748, and reprinted it in a general article on electricity in the Philosophical Transactions in the same year. During the next year, Franklin made his first definitive statement on the electrical nature of lightning in a letter to Dr. John Michel in London. Various scientists discussed this hypothesis in 1750 in connection with a series of earthquakes that struck London. In the meantime, Cave in the January, 1750 issue of the Gentleman's published a brief account of Franklin's early work although he did not identify the experimenter. He merely stated that the experiments occurred "in Philadelphia." Cave learned of Franklin's observations either from the Philosophical Transactions or from general conversations with members of the Royal Society. In his summary, Cave indicated
that the experimenter believed electricity to be a real
element, "intimately united with all other matter." He re­
ported that electricity was more strongly attracted by
slender sharp points than by solid blunt bodies. In a
cryptic passage Cave alluded to the experimenter's identifi­
cation of lightning and electricity:

7. Various representations of Lightning, the
cause and effects of which were explain'd by
a more probable hypothesis than has hitherto
appeared; and some useful instructions given
on how to avoid the danger of it.4

In early 1750, some of Cave's friends in London includ­
ing Collinson and Dr. John Fothergill, urged Franklin to
publish his findings on electricity. Fothergill took
Franklin's papers to Cave in the hope that he would place them
in his magazine. Cave, however, judged the documents to be
important and decided to issue them as a separate pamphlet.
Being a good businessman, he realized a little advance pub­
licity would not hurt the sales of the booklet. He inserted
in the May, 1750, issue of the Gentleman's anonymously an
original letter from Franklin to Collinson.5 This note was
about lightning rods and it was never reprinted anywhere else
until the twentieth century. Franklin wrote:

I was very much pleased with some ingenious
papers in the late Transactions on the subject
of electricity.
There is something however in the experiments of points sending off, or drawing on, the electrical fire, which has not been fully explained, and which I intend to supply in my next. For the doctrine of points is very curious, and the effects of them truly wonderful; and, from what I have observed on experiments, I am of the opinion, that houses, ships, and even towns and churches may be effectively secured from the stroke of lightening by their means; for if, instead of the round balls of wood or metal, which are commonly placed on the tops of weathercocks, vanes or spindles of churches, spires, or masts, there should be put a rod of iron 8 or 10 feet in length, sharpen'd gradually to a point like a needle, and gilt to prevent rusting, or divided into a number of points, which would be better—the electrical fire would, I think, be drawn out of a cloud silently, before it could come near enough to strike; only a light would be seen at the point, like the sailors corpusante. [Cave added: It is usually taken for a meteor on the yards or shrouds, but is indeed no more than the spray of the sea saturated with luminous insects, frequent during the summer season in the Mediterranean.] This may seem whimsical, but let it pass for the present until I send the experiments at large. [Cave added: These will be inserted in the pamphlet above mentioned] . . . .

Cave published Franklin's first pamphlet on electricity in April, 1751, under the title, Experiments and Observations on Electricity. This work really marked the introduction of Franklin's name to the British reading public. In the years that followed, Cave and his successors published in the Gentleman's many additional articles and letters on electricity from Franklin and other electricians. A scien-
tist could have learned most of the major developments in electricity in the eighteenth century by reading the Gentleman's.

Cave also printed a letter in the Gentleman's containing the first accurate description of Niagara Falls. This account was contained in correspondence sent by the Finnish naturalist, Peter Kalm (1715-79), who was exploring in America, to a friend of his in Philadelphia. Kalm dated the letter September 2, 1750, in Albany, New York. Collinson obtained a copy of this letter and read it to the Royal Society on December 6, 1750. Cave published it in the January, 1751, issue of the Gentleman's Magazine together with a full-page plate of the Falls. In the five-page article, Kalm discredited the narration given by Father Louis Hennepin, a French explorer, who claimed the Falls was 600 feet in height. Kalm could hardly hold back his amazement when he first viewed the spectacle:

Before the water comes to this island [Goat Island]; it runs but slowly, compar'd with its motion when it approaches the island, where it grows the most rapid water in the world, running with a surprising swiftness before it comes to the fall; it is quite white, and in many places is thrown high up into the air! The greatest and strongest battoes [boats] would here in a moment be turn'd over and over. The water
that goes down the west side of the island, is more rapid, in greater abundance, whiter, and seems almost to out-do an arrow in swiftness. When you are at the fall, and look up the river, you may see, that the river above the fall is everywhere exceedingly steep, almost as the side of a hill. When all this water comes to the very fall, there it throws itself down the perpendicular! The hair will rise and stand upright on your head, when you see this! I cannot with words express how amazing this is!9

The editors of the magazines, and occasionally their counterparts in the reviews, regularly published letters to the editor. This correspondence usually contained comments about items previously promulgated in the periodical. Sometimes long drawn out disputes arose in the letters column that were continued for months, a feature which no doubt did not hamper sales! Now and then a reader supplied some original observations on the subject of natural history. He reported, perhaps, an extraordinary natural happening in his neighborhood. Often these commentators were extremely perceptive. For example, a Norfolk physician, John Aikin (1747-1822), wrote a letter that appeared in the January, 1786 issue of Gentleman's Magazine.10 Aikin described the plants he saw growing on the beach near Yarmouth. He understood the close relationship between plants and their environment. Aikin also realized that different plants occupy
similar locations in different habitats. He emphasized the need for natural historians to view not only individual plants but in addition to study the total environmental picture:

The study of Botany offers no speculation more curious than the attachment of plants to situations, and the vegetable societies, as they may be called, formed by means of this connection. Botanists, perhaps, have too much confined their attention to plants as individuals, or as allied only by resemblances of form and structure; whereas the manner in which they are grouped by Nature, and the purposes to which she makes them subserviant by such assemblages, surely merit consideration. Every thing, which is constant and general in Nature, must be important, since it must be founded on properties essential either to the existence or relative utility of the subjects in which they are found. Were it a matter of attention to draw out a sort of botanical maps, in which the vegetable inhabitants of each climate, soil and situation, were to be assigned in their due proportions, I think we could not fail of discovering various facts respecting the mutual action of soils and plants, and plants upon each other, which might lead to very important conclusions, both in an oeconomical and philosophical view. Such a sketch I have here attempted.11

Aikin went on to describe the beach. He began near the water line and detailed the changing plant types as he moved away from the ocean. He identified each plant by its scientific and common names, delineated its substrata and portrayed the density of ground cover. All in all, Aikin in his
letter demonstrated keen ecological insight.

Not all of the natural history in the periodicals was of the highest quality. Books were a common source of material for the editors of the periodicals. They especially preferred volumes on travels and geography. The unexplored oceans and lands of the globe were of particular interest. In many cases, the editors published on flimsy testimony tales of strange monsters, sea snakes, mermaids and assorted other creatures.

One of the most popular works for review and extraction was the *Natural History of Norway* by Erich Pontoppidan (1698-1761). His account contained a chapter devoted to "uncommon sea animals." Reviews were faced with a real problem—could they believe all of Pontoppidan's reports of strange animals? It was difficult to dismiss his tales, inasmuch as Pontoppidan was the Bishop of Bergen and a respected clergyman.

The very first article in the first issue of the *Hibernian Magazine* was an extract from Pontoppidan's *Natural History*. The Bishop had manifested no doubt that all the stories about the giant sea snakes were true:

In all my inquiries about this affair [sea snakes living in the North Sea], I have hardly
spoke with any intelligent person, born in the manor of Nordland, who was not able to give a pertinent answer, and strong assurances of the existence of this fish: and some of the North traders, that come here every year with their merchandise, think it a very strange question, when they are seriously asked whether there be any such creature; they think it as ridiculous as if the question were put to them, whether there be such fish as eel or cod.\textsuperscript{12}

The editor of the \textit{Hibernian} reproduced a plate of the sea snake next to a ship. The monster appeared to be as large as the ship. Pontoppidan reported numerous sightings of the animal including one off Greenland in 1734. He wrote:

On the 6th of July, 1734, there appeared a very large and frightful sea-monster which raised itself up so high out of the water, that its head reached above our main top [mast]. It had a long sharp snout, and spouted water like a whale, and very broad paws. The body seemed to be covered with scales, and the skin was uneven and wrinkled, and the lower part was formed like a snake.\textsuperscript{13}

The editor made no comments on the selection and was content to insert the article.

James Kirkpatrick reviewed the same volumes in three segments for the \textit{Monthly Review}.\textsuperscript{14} His analysis featured both excerpts and comments. Kirkpatrick exhibited a curious attitude toward the chapter on "uncommon sea animals." He obviously had doubts about the existence of "mer-men,"
"mer-maids," giant sea snakes, and "kraken" but at the same
time was open minded enough to realize that Pontoppidan
appeared to present some strong evidence in favor of their
existence. Kirkpatrick began:

Hitherto our natural historian had treated of
such animals only, as we may readily suppose to
exist, and acquiesce in his account of them; tho'
a few of 'em may vary in some respects, or be
differently circumstanced, from those we ordi­
arily see, or converse about. But in this
chapter concerning uncommon sea-animals, there
will be occasion, we apprehend, for many readers
to extend their imagination to conceive, and to
abstract their judgment from some preposses­sions
and limitations, in order to admit, the
reality of those animated beings; which we conf­
ress, all circumstances considered, we think we
have some just grounds for subscribing to our­selves. . . . . We shall premise, however, preparatorily, from our own reflection, that common
sense at once accedes to the great probability
of the vast inscrutable ocean's containing many
animals and substances, which neither chance
nor investigation has hitherto presented to the
eye of man.

Kirkpatrick then related the Bishop's description of
a monstrous creature known as a kraken which resembled a
giant crab. Kirkpatrick quoted Pontoppidan to the effect
that a full grown kraken had never been observed in its
entirety. Sailors described it as about one and one-half
English miles in circumference with horns "which grow
thicker the higher they emerge, and sometimes stand up as
According to Pontoppidan, kraken were especially dangerous to ships when they surfaced or dived because of the tremendous currents they produced. In conclusion, Kirkpatrick admitted there were some problems in believing this story such as the fact that previously men thought the whale was the largest creature on earth. He believed, however, that researchers must be open-minded and not preclude the possibilities of larger creatures living in the depths of the ocean. Kirkpatrick concluded by paying respect to the Bishop's integrity:

In the present instances, and particularly in that of the Kraken (not the most digestible of them) after paying but a just respect to the moral character, the reverend function, and diligent investigations of our author, we must admit the possibility of its existence, as it implies no contradiction.16

The many new and exotic varieties of snakes found in the New World were the source of many superstitions and tales. An anonymous reviewer in the Critical Review was intrigued by the report of a hissing snake found in Lake Erie in the book he was analyzing, Travels Through the Interior Parts of North America in the Years 1766, 1767, and 1768 by Jonathan Carver (1710-80). The hissing snake
was able to kill animals with "vapour" from its mouth. The
reviewer commented:

Lake Erie, we are informed, is prodigiously
infested with the water-snake. Of this kind
the most remarkable species is the hissing snake
which is about eighteen inches long, and
speckled. When any thing approaches, it flattens
itself immediately, and its spots, which are of
various colours, become considerably brighter
with rage. On this occasion, it discharges from
its mouth, with great force, a subtle vapour,
which is said to be of a nauseous smell; and if
inhaled with the breath, will infallibly bring
on a decline, which proves mortal in a few
months; no remedy being hitherto discovered to
counteract its noxious tendency.17

Even experienced naturalists occasionally fell victim to
snake fables. An anonymous writer in the Monthly Review com-
mented on a book by Kalm entitled, Travels into North
America.18 The reviewer quoted a long passage from the
work on Kalm's account of the black snake. Most of the com-
ments Kalm made about the snake were second or third hand
and were not very accurate. He described the snakes as not
being dangerous or harmful except in the spring when they
mate. If they were disturbed in this process, according to
Kalm, the snakes would pursue the intruder with the "swift-
ness of an arrow," overtake the fleeing man, trip him by
coiling themselves around his feet, and then administer
numerous bites. Kalm claimed the snake could move so fast
that a man could not possibly escape from it. He included the usual narration of snakes lying under a tree and charming its victims, squirrels and birds, into coming down to the ground where the black snake devoured them. To Kalm's credit, he was aware of the problem of relying on second hand information and in at least one instance he tried to verify his facts. Colonists had told him that if a person threw stones from a distance at a black snake, it would chase its tormentor. He tried this but nothing happened. Kalm reported:

Several people likewise assured me, from their own experience, that it may be provoked to pursue people, if they throw at it, and then run away. I cannot well doubt this, as I have heard it said by numbers of creditable people; but I could never succeed in provoking them. I ran away on perceiving it, or flung something at it, and then took to my heels, but I could never bring the snake to pursue me; I know not for what reason they shunned me, unless they took me for an artful seducer. 19

A reviewer of a natural history volume had a difficult task. Even if the reviewer was knowledgeable about scientific matters, he could not possibly be familiar with all the plants, animals, minerals, and natural occurrences in the world. He might have some doubts on various matters, as Kirkpatrick did on the reports of the sea monsters, but
he had to rely to a great extent upon the credibility of the author. If the author was a recognized natural historian or perhaps a respected clergyman, then it was difficult for the reviewer to reject the account. The reviewer moreover attempted to write an engaging article that would promote his periodical. Often he deliberately selected unusual passages that he felt were of interest to the reading public.

Virtually all periodicals of the eighteenth century contained scientific material of a questionable nature. Even the editors of the leading British scientific journal, the Philosophical Transactions, in this era published many papers containing myths and hearsay, although major naturalists such as Linnaeus and Thomas Pennant (1726-98) tended to ignore such material. Only after 1752 did the Royal Society attempt to upgrade their publication. Yet the pursuit of consistency in nature and naturalism in explanation can be traced in all of the British periodicals.20

Articles of many kinds about natural history occupied a significant portion of most of the general periodicals of the eighteenth century. The amount of material on the subject varied greatly from journal to journal and also changed through time. The percentage of pages about natural
history including botany, zoology, geology, mineralogy, geography, meteorology, and paleontology in various serials is shown in Table 1. The percentage was for the period from 1731 until 1789. Of the periodicals in this study only the Gentleman's Magazine was published throughout this time period.

The amount of natural history in the various periodicals was not constant throughout the span from 1731 to 1789. At the beginning of this era, little evidence existed in the periodicals of any real interest in natural history. As shown in Table 2 the Gentleman's Magazine for the years from 1731 to 1734 contained only 9 pages of natural history or 0.3% of the total magazine. The figures increased only slightly in the next five year period to 55 pages of natural history, which still represented only 1.4% of the total magazine. The London Magazine also contained very little natural history during its early years. From the founding in 1732 through 1734, the London had only 15 pages or 0.8% of the whole serial for natural history. The amount of natural history actually dropped in the era from 1735 to 1739 to 5 pages in the magazine, or a miniscule 0.1% of the volumes.
Table 1
The Percentage of Pages of Natural History in Selected British Periodicals 1731-1789

<table>
<thead>
<tr>
<th>Periodical</th>
<th>Dates of Issue Surveyed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literary Journal</td>
<td>1744-49</td>
<td>13.8%</td>
</tr>
<tr>
<td>The Literary Magazine</td>
<td>1756-58</td>
<td>8.7%</td>
</tr>
<tr>
<td>The Gentleman's Magazine</td>
<td>1731-89</td>
<td>7.6%</td>
</tr>
<tr>
<td>The Monthly Review</td>
<td>1749-89</td>
<td>7.5%</td>
</tr>
<tr>
<td>The Critical Review</td>
<td>1756-89</td>
<td>7.3%</td>
</tr>
<tr>
<td>The History of the Works of the Learned</td>
<td>1737-43</td>
<td>5.9%</td>
</tr>
<tr>
<td>The Court Magazine</td>
<td>1761-65</td>
<td>5.4%</td>
</tr>
<tr>
<td>The Hibernian Magazine</td>
<td>1771-89</td>
<td>4.6%</td>
</tr>
<tr>
<td>The London Magazine</td>
<td>1732-85</td>
<td>3.7%</td>
</tr>
<tr>
<td>The Ladies Magazine</td>
<td>1749-52</td>
<td>3.4%</td>
</tr>
<tr>
<td>The Scots Magazine</td>
<td>1739-89</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
Table 2

Natural History in *The Gentleman's Magazine* and *The London Magazine* During the 1730's

<table>
<thead>
<tr>
<th>Magazine</th>
<th>Period</th>
<th>Percentage of Natural History</th>
<th>Pages of Natural History</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>The Gentleman's Magazine</em></td>
<td>1731-34</td>
<td>0.3%</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1735-39</td>
<td>1.4%</td>
<td>55</td>
</tr>
<tr>
<td><em>The London Magazine</em></td>
<td>1732-34</td>
<td>0.8%</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>1735-39</td>
<td>0.1%</td>
<td>5</td>
</tr>
</tbody>
</table>
A startling increase in the amount of natural history in the periodicals occurred about 1745. The growth took place in virtually all the areas of the subject and appeared in all three of the principal magazines, the Gentleman's, the London, and the Scots. No particular reason for the broad, general increase in articles about nature is obvious. Perhaps the expansion can best be explained with reference to the growing awareness of the physical world which was a part of the Enlightenment culture. This transition will be explored further in chapter three.

The greatest growth in natural history occurred in the Gentleman's. As shown in Table 3 the percentage of natural history expanded from 1.6% to 16.5% in the five year epochs from 1740 to 1759. The total number of pages increased from 37 to 515 during the same period. The other two magazines demonstrated a similar growth in interest of natural history.

The foremost reviews, the Monthly and Critical Review, also contained more natural history as time progressed. The amount of material on the subject increased during the 1760's. Table 4 illustrates this phenomenon. Perhaps the growth can be explained as a continuation of the
Table 3

Increase of Natural History in the Principal British Magazines from 1740 to 1759

<table>
<thead>
<tr>
<th>Magazine</th>
<th>Period</th>
<th>Percentage of Natural History</th>
<th>Pages of Natural History</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Gentleman's Magazine</td>
<td>1740-44</td>
<td>1.6%</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>1745-49</td>
<td>7.7%</td>
<td>257</td>
</tr>
<tr>
<td></td>
<td>1750-54</td>
<td>13.2%</td>
<td>405</td>
</tr>
<tr>
<td></td>
<td>1755-59</td>
<td>16.5%</td>
<td>515</td>
</tr>
<tr>
<td>The London Magazine</td>
<td>1740-44</td>
<td>1.7%</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>1745-49</td>
<td>5.4%</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>1750-54</td>
<td>6.5%</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>1755-59</td>
<td>16.5%</td>
<td>231</td>
</tr>
<tr>
<td>The Scots Magazine</td>
<td>1740-44</td>
<td>0.6%</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>1745-49</td>
<td>4.1%</td>
<td>131</td>
</tr>
</tbody>
</table>
Table 4
Increase in Natural History in the Principal British Reviews from 1760 to 1789

<table>
<thead>
<tr>
<th>Review</th>
<th>Period</th>
<th>Percentage of Natural History</th>
<th>Pages of Natural History</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Monthly Review</td>
<td>1760-64</td>
<td>4.2%</td>
<td>225</td>
</tr>
<tr>
<td></td>
<td>1765-69</td>
<td>7.2%</td>
<td>418</td>
</tr>
<tr>
<td></td>
<td>1770-74</td>
<td>9.2%</td>
<td>548</td>
</tr>
<tr>
<td></td>
<td>1775-79</td>
<td>8.8%</td>
<td>510</td>
</tr>
<tr>
<td></td>
<td>1780-84</td>
<td>10.2%</td>
<td>591</td>
</tr>
<tr>
<td></td>
<td>1785-89</td>
<td>10.1%</td>
<td>637</td>
</tr>
<tr>
<td>The Critical Review</td>
<td>1760-64</td>
<td>3.5%</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>1765-69</td>
<td>3.3%</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td>1770-74</td>
<td>8.3%</td>
<td>402</td>
</tr>
<tr>
<td></td>
<td>1775-79</td>
<td>8.1%</td>
<td>394</td>
</tr>
<tr>
<td></td>
<td>1780-84</td>
<td>8.3%</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>1785-89</td>
<td>12.0%</td>
<td>611</td>
</tr>
</tbody>
</table>
earlier expansion of the 1740's. The editors of the various magazines were closely attuned to the interests of the reading public. When they observed an increase in concern among their readers for information on natural history, the editors quickly responded with more articles, letters, comments, etc. on the subject. The format of a magazine enabled the editor to react more quickly to changes of interests in his readership than the format of a review periodical. The editor of a review was forced to wait for the changing desires of the reading public to be registered with the authors and publishers of books. The growth of interest in natural history that began in the magazines in the 1740's did not appear in the review periodicals until about twenty years later.

The individual areas of natural history received varying treatments by the editors of the periodicals. Some segments of natural history were considerably more popular than others. Material in the periodicals on natural history can be divided into nine general categories: geology, mineralogy, botany, zoology, miscellaneous natural history (articles containing a variety of natural history topics), geography and travel, miscellaneous transactions of the
scientific societies, meteorology, and paleontology.

Geography was the most prominent segment of natural history in the periodicals. Of the total pages, geography represented in the various journals from 25.5% to 72.6% of the material on natural history.\textsuperscript{22} The readership of the periodicals seemed to have an almost insatiable thirst for geographic formation about the world. The interest in geography extended not only to the far-flung exotic regions of the globe but also to areas in the British Isles closer to home such as Scotland and Wales. Many of the articles on geography featured descriptions of assorted voyages, tours, and travels.

The amount of geographic material published in the popular periodicals was larger than the volume found in the \textit{Philosophical Transactions}. Samples of the \textit{Philosophical Transactions} at various times in the eighteenth century show that geography comprised only 9.6% of that prestigious English scientific journal.\textsuperscript{23} Clearly, there was more interest in tours, travels, and voyages among the general British readers than in the scientific circles of the Royal Society.
The periodicals also published much information about plants and animals. The botanical articles comprised from 6.0% to 12.9% of the natural history in the major periodicals. The editors of the periodicals printed even more material of a zoological nature. The pages about zoology embodied from 6.1% to 19.2% of the natural history in the major serials. In the almost sixty years of the Gentleman's, for example, the number of pages on botany totaled 412 while those on zoology equaled 612. Taken together, the Gentleman's contained 1024 pages devoted to various aspects of the plant and animal kingdoms.

The popular periodicals contained considerably less material on meteorology than the more scholarly publication of the Royal Society. The writers in the Philosophical Transactions devoted 17.9% of the pages on natural history to meteorology. The Gentleman's Magazine provided the most extensive coverage of the popular serials with 550 pages on the topic or 17.3% of the total natural history. The other major periodicals, however, published only from 1.5% to 12.3% of their gross natural history to meteorology. The editors of the Court Magazine, a minor serial, ignored the matter entirely. Although the number of pages given to meteorology
in the periodicals was not large, some significant debates occurred (see chapter eight).

Most periodicals virtually ignored mineralogy. None of the serials devoted more than 3.0% of their total natural history to this branch of science. The Critical Review, the journal with the most mineralogy, contained a total of only 74 pages on the subject in the period from its founding in 1757 until 1789. The lack of interest in mineralogy exhibited in the popular press contrasted sharply with the Philosophical Transactions. The pages on mineralogy in this journal included 8.4% of the total natural history.

The volume of articles, letters, etc. in the various divisions of natural history varied over time. Natural disasters influenced the editors of the periodicals in the selection of subject matter for their publications. During the 1750's, for example, a number of severe earthquakes shook Europe. The most famous occurred in 1755 in Lisbon, Portugal. As a result, the number of pages devoted to geology increased greatly after one of these calamities. The Gentleman's Magazine, for instance, printed 129 pages of geology during the 1750's. These pages represented more than half of the total 238 pages on geology published by the
magazine during the entire period from 1731 until 1789. The eruption of volcanoes also stirred much controversy and debate in the periodicals. Mt. Vesuvius, especially, was in an almost constant state of activity during the latter part of the century. Descriptions and theories of both earthquakes and volcanoes will be examined in detail in chapter seven.

The various periodicals emphasized different areas and amounts of natural history. The varying interests and tastes of the individual editors and readerships probably accounted for the differing subject matter. The Gentleman's Magazine was the exception. Cave and his successors provided a broad coverage of all the diverse fields of natural history, excluding mineralogy.

The London Magazine did not publish nearly as much natural history as its competitor, the Gentleman's. The editors printed 1351 pages on the subject which represented only 3.7% of the total pages in the magazine during the period under consideration. Their rivals at the Gentleman's, by contrast, published 3188 pages of natural history or 7.6% of the total. This was surprising since the publishers of the London closely copied and followed the lead of their rivals.
The *Scots Magazine* featured geography and geology. The editors devoted 39.9% and 17.9% of their natural history pages to these disciplines, respectively. These were the largest percentages for the two fields of any of the five major periodicals. Yet editors of the *Scots Magazine* virtually ignored the areas of mineralogy and paleontology; they printed comments on only a limited number of transactions of scientific and philosophical societies.

Ralph Griffiths (1720-1803), the editor, in his *Monthly Review* featured analyses of transactions of societies. He published 1900 pages of comments about the journals of these organizations. Approximately half of Griffiths' reviewers' comments on science were on various aspects of natural history. In addition to the transactions of British societies, he also emphasized works from various scientific societies on the Continent. The reviewers regularly reported in English the highlights of the transactions from the Royal Academy of Sciences at Paris, the Academy of Sciences at Berlin, the Royal Society at Gottingen, the Imperial Academy of Sciences at St. Petersburg, and others. These reviews comprised 27.2% of the natural history in the *Monthly Review*. The *Monthly* became one of the most important sources in
Britain of information and papers from the various scientific societies on the Continent.

The Critical Review by 1789 had the largest percentage of pages devoted to natural history of any of the major periodicals. From 1785 to 1789 the editor published 611 pages on the subject which represented 12.0% of the total journal. During this period, the Critical Review carried at least one major review of a work on natural history in every monthly issue.

Of the lesser publications, the Hibernian Magazine published a significant amount, 651 pages, of natural history. Over half of this total, 385 pages, or 59.1%, was in the area of geography. Most of the natural history in the other minor publications was in the field of geography. The editors of the Court Magazine devoted 72.6% of their space on natural history to the subject. Their counterparts at the Literary Journal and at the History of the Works of Learned published 51.4% and 58.0% of the natural history, respectively, in the same area.

As the previous material indicates, natural history became an important part of eighteenth century periodicals. The variety of subjects was almost endless. They reflected the nature of the medium in which they were discussed, but
the serials also involved the growing intellectual ferment of the Enlightenment. In science as well as other areas, the intellectual upheaval interacted with the medium, in this case the periodicals.
FOOTNOTES—CHAPTER I


4 Cave, "Experiments," p. 34.


6 *Ibid*.


9Ibid., p. 16.


11Aikin, "Account of Plants," p. 34.


13Ibid., p. 3.

14[James Kirkpatrick], review of Erich Pontoppidan, The Natural History of Norway, in The Monthly Review, 12 (June, 1755), 447-62; 12 (Appendix, 1755), 493-506; 13 (July, 1755), 35-62. The writer of this anonymous review was identified in Nangle, Indexes, p. 177. All other reviewers in The Monthly Review cited in this paper were also identified from Nangle unless otherwise noted.

15Kirkpatrick, review of Pontoppidan, pp. 35-36.

16Ibid., p. 43.


20 The problems of the Royal Society will be noted in a future chapter.

21 See the detailed tables in the appendix. If an article, review, letter, etc. on natural history occupied any part of a page, the author counted the page. In the case of a review of the transactions of scientific societies, a special scheme was employed. The editors analyzed the transactions as a whole and therefore included in their reviews much material that fell outside the realm of natural history. The transactions, for example, contained many papers on medicine, mathematics, and the physical sciences. The author found it virtually impossible to separate the comments on natural history from the other areas. Therefore, the author counted the total number of pages occupied by the reviews of the transactions and then divided this total in half, which was approximately the portion of the review that was devoted to natural history. Any column of statistics in this paper labeled "Miscellaneous Transactions" was calculated on this basis.

22 See the appendix for the percentages of geography in the various serials.

23 The author sampled twenty years of the *Philosophical Transactions* in the eighteenth century. The periods selected were 1730-34, 1750-54, 1770-74, 1785-89. The author divided the articles into the same nine categories used for studying the contents of the popular periodicals. See the appendix for the exact figures of the different areas of natural history.

24 The major periodicals were *The Gentleman's Magazine*, *The London Magazine*, *The Scots Magazine*, *The Monthly Review*, and *The Critical Review*. The author gave them this designation because of their widespread circulation and their uninterrupted years of publication.
CHAPTER II

BRITISH PERIODICALS: PURVEYORS OF NATURAL HISTORY

Periodicals were especially suitable for the dissemination of scientific discoveries. Serials could be printed and distributed relatively quickly in large numbers to publicize the new scientific findings while the news was fresh. Periodicals tended to be inexpensive and the publishers could achieve a large circulation. Most editors encouraged their readers to save and bind the individual magazines at the end of a year by providing them with an index for the period. If a subscriber collected the yearly volumes, he then had a systematic record of scientific occurrences.

The periodical, moreover, provided a flexible format for scientific matters. In a short news item the editor could report the latest developments. He could print in serialized form over a period of months subjects requiring broader coverage. The editor could provide his readers with up-to-date coverage of journeys of exploration. He could publish reviews of scientific books. Some journalists engendered a good discussion of a controversial matter in the letters to the editor section.
Two changes in British society in the eighteenth century influenced the periodical press. The first was the increasing interest in science, especially natural history, which was briefly considered in the opening chapter and which will be explored in depth in subsequent chapters. The second was the rising demand by the British educated public for books, pamphlets, and periodicals. Both of these trends were supported by the advancing economic prosperity that provided the British middle and upper classes with both the leisure time for reading and with the money to purchase printed matter.

The eighteenth century was an important era in the history of the periodical press. New formats evolved in this period and significant qualitative improvements occurred. Unfortunately very little information is available about various aspects of the eighteenth century periodical. For example, data on the readership, authorship and circulation of the serials is very limited.

A periodical must be distinguished from both books and newspapers. A periodical generally has seven features:

1. Periodicity—this was not always reliable in the eighteenth century because many books were serialized.
2. **Duration**—a periodical must be planned to continue indefinitely.

3. **Collectivity**—the diversity and heterogeneity of offerings distinguish it from a book; usually a periodical is the work of many authors.

4. **Availability**—it is obtainable by all those who wish to purchase it.

5. **Continuity**—has a unified character in its format and its editorial policy, the title repetitious and the numbering consecutive.

6. **Timeliness**—it is not time bound like a newspaper, i.e., not closely associated with day-to-day events.

7. **Universality**—not addressed to a general geographical audience like a newspaper; the periodical appeals to a public united by common interests.¹

Britain in the late seventeenth and eighteenth centuries produced a flood of new periodicals and newspapers. In excess of 2100 different periodical and newspaper titles appeared in Great Britain between 1620 and 1800. Most of them were printed for only a few issues and then ceased publication. No copies or records have survived from many of these publishing ventures.²
During the reigns of Queen Anne and King George I and II the growth of the periodicals was a part of the general Enlightenment culture. The endless variety of subjects in the British serials reflected this intellectual awakening. In philosophy the nature of the mind and knowledge were items of great interest. In economics the improvements in agriculture, industry, trade, and theories of international commerce attracted attention. In the area of manners and morals, gambling, dueling, immorality, profanity, and extremes of dress were debated. Religious controversies such as Latitudinarianism, Evangelicalism, the Bangorian debate, occasional conformity, and toleration for various bodies provided the editors with an endless stream of subject-matter. Magazine publishers constantly printed political items on the effects of the Glorious Revolution, rights and duties of Lords and Commons, foreign policy, management of the colonies, and the trial of Dr. Sacheverell. Periodicals provided also an outlet for works of literature and a forum in which to debate literary criticism.3

The relaxed censorship laws after the Glorious Revolution created a favorable legal climate for new publishing ventures. The loosening of censorship began during the
Puritan Revolution when Parliament won control of the printing trade away from the Crown. With the Restoration, the Stuarts attempted again to tighten the publishing laws, with mixed success. After 1695 the prerogative of the king became the right of Parliament when the latter body refused to renew the Regulation of Printing Act. The press did not win full freedom under the first two Hanoverians but control became more indirect and less arbitrary. In fact Parliament instituted "taxes on knowledge" in 1712 with the first of its many Stamp Acts. But strong control was infinitely better for the printers than strenuous suppression, and the conditions of serial publications were better under Robert Walpole than under Oliver Cromwell and Charles II. The party system, in fact, required an active press. Whigs and Tories criticized each other in the eighteenth century in a manner that had been totally unknown in the previous century. Parliament eventually lost even the right to keep its deliberations secret and in time the British press itself debated its liberty in terms of public responsibility and general welfare.4

During half of the first sixty years of the eighteenth century, Britain was at war with France on the Continent and
in America. In Queen Anne's reign the famous victories of the Duke of Marlborough were the signal of Britain's emergence as a great force in the world. England's constant military and naval victories made excellent subject-matter for the periodicals and newspapers. The progress of a campaign in some exotic land or on the sea provided first-rate material for news and comment. Peace also had its uses, for the calculation of the spoils of victory, the prospects of future alliances, and the recovery of more normal commercial conditions were all suitable subjects for periodic report and comment.  

The most learned class of early periodicals was the essay journal. During the late seventeenth century, publishers made some attempts to produce periodicals with collections of prose pieces. The classic representatives of this form were the incomparable Tatler and Spectator. Sir Richard Steele (1672-1729) with the help of Joseph Addison (1672-1719) published the Tatler from 1709 to 1711. The Spectator appeared during 1711, 1712, and 1714 and was dominated by Addison. The Tatler originally had five departments, including "gallantry, pleasure and entertainment," poetry, learning, news, and personal reflections.
The latter section, however, soon swallowed up the other four. Both Steele and Addison were conscious moralists and did not disguise their intention of improving the minds, morals, and manners of their readers. They used ironical sallies, turns of wit, easy imagery, learning fairly worn, and the wisdom of gentility, animated essays on social life, man- and womankind, belles lettres, daily philosophy, and high religion. The *Tatler* and *Spectator*, in addition to essays, contained genuine and minted correspondence, studies of people, and a taste of old and new poetry. Steele and Addison wove all these elements of form and substance into a serial publication to be read in the home and in the coffee houses.

A few successors to the *Tatler* and *Spectator* appeared but the essay journal form of periodical declined rather rapidly in the early eighteenth century. The waning of this type of periodical could be best explained in terms of the alteration of public tastes. The essay journal appealed to persons who had retained a taste for such literature as was favored in the years after the Restoration, rather than such as appealed to the rising middle class. It lost its market to other kinds of periodicals and to the newspapers.
Another variety of early serial was the miscellany journal. The first and most important of this type of periodical was the Gentleman's Journal that appeared in London in 1692. It was the work of Peter Motteux, an enterprising Huguenot refugee. He took for his motto, "E Pluribus Unum," and for his device, a bouquet of flowers held in a closed hand. Edward Cave later borrowed both of these symbols for his famous Gentleman's Magazine. The Gentleman's Journal took the form of a letter to a gentleman in the country, which imposed a kind of unity on a hodge podge of odes, songs with music, fables, allegories, fiction, dialogues, enigmas, questions, letters, translations, scientific articles, literary notes, essays, news, and even a few illustrations.  

The Gentleman's Journal was an important forerunner to the Gentleman's Magazine. The miscellany style used by Motteux was the format Cave adopted later for his publication. Both journals combined all of the popular and desirable elements of other serials, appeared on a monthly basis, and appealed to a wide variety of readers.

Another type of journal arose that served as a compendium of recent history. Unlike the issuers of earlier
periodicals, the editor's purpose was to inform and record rather than amuse. The historical collection or summary, as it came to be known, provided readers with accounts of important foreign and domestic news. As early as 1645 the Monthly Account called itself a "Collection of all the most speciall and observable Passages" of the preceding month, "briefly rallyed together, and brought into a small com­ passe; not filled with flatteries, forgeries, and contradic­tions." A few more short-lived historical collections appeared during and after the Puritan Revolution.

Henry Rhodes published in 1690 the Present State of Europe, the first historical collection of real importance in England. This was a translation of the French periodical, Mercure Historique et Politique. Rhodes's publication furnished readers with accounts of important foreign news until 1777. It contained dispatches from foreign countries and remarks on the news.

Samuel Buckley founded the Monthly Register in 1703 using the Present State of Europe as a model, but like all good copyists he tried to improve on it. Buckley's periodical was the first important attempt to provide the public with an accurate monthly journal of news. What he partic-
ularly attempted to do was to print news items alone, without any comments. Buckley deliberately criticized the practice of commenting on news items and in doing so helped determine the course of English periodical journalism in later years. Two features of the *Monthly Register* were important. First, Buckley attempted to provide absolute impartiality, and second, he emphasized the need for providing a faithful record of the age. Buckley inveighed against the general unreliability of newspapers. He explained that his purpose was to "compare one account with another, to reject what is found contradicted." He gave his readers good value for their money charging six pence for a thirty to forty page issue. Buckley also anticipated another scheme of the *Gentleman's Magazine* by providing a supplement and a yearly index. The *Monthly Register* ceased publication in 1707.14

The next historical collection with innovative features to appear was Abel Boyer's *Political State of Great Britain*, in 1711. This was in the form of a monthly letter from a correspondent in England to his friend in Holland. In addition to news, Boyer gave abstracts of books or pamphlets relating to the state of affairs, observations on political
matters, hereditary rights, and similar matters. With the first issue, Boyer began to give a complete and regular account of parliamentary proceedings. He was the first compiler of an English serial to print parliamentary news systematically. Boyer had the cooperation of the Earl of Stanhope and other prominent members of Parliament. This latter undertaking was to become a standard feature of later magazines.  

The *Monthly Chronicle* published in 1728 was the largest historical collection; the subjects were more various than any others of this type. It was issued by the *Monthly Chronicle*, an association of London booksellers headed by Aaron Ward. For the first time a monthly book catalogue was published. The books were listed by categories: gardening, historical, philosophy, political, proposals, theological, trade, trials, and wit and humor were most important. Such classification of books by the nature of their contents, originated by the publishers of the *Chronicle*, was later adopted by other magazines and became general practice as the century advanced. The publishers also hit upon the scheme of giving particular attention to their own books. The *Monthly Chronicle* featured a quarterly appendix
giving news of Parliament along with lists of members and speeches at the opening of the session. The appendixes also included edicts, political dispatches from foreign countries, and the speeches of foreign dignitaries. In 1730 accounts of commodity and stock prices, deaths, burials, preferments, marriages, and births became regular features. In order to make the periodical more useful, the publishers added a regular index. In the 1730 volume there were seven separate alphabetical indexes. A publication of this sort was an excellent work of reference. It had, however, several disadvantages. The Chronicle was cumbersome, involved, and expensive. Later publishers adopted the same framework but in simplified, more serviceable form.16

The year 1731 marked the beginning of an era in periodical literature. In January, Cave published the first issue of the Gentleman's Magazine. This was a new and successful type of periodical. Cave clearly borrowed much from the formats of the previous historical collection journals, but he provided the publishing world with a concept and term—"magazine." He tried to put together a journal that would "treasure up" from other sources and save a wide variety of useful and entertaining material.
As Cave announced in his advertisement:

It has been unexceptionally advanced, that a good abridgment of the law is more intelligent than statutes at large; a nice model is as entertaining as the original, and a true specimen as satisfactory as the whole parcel: This may serve to illustrate the reasonableness of our present undertaking, which in the first place is to give monthly a view of all the pieces of wit, humour, or intelligence, daily offer'd to the publick in the news-papers, (which of late are so multiply'd, as to render it impossible, unless a man make it a business to consult them all) and in the next place we shall join therewith some other matters of use and amusement that will be communicated to us.

Upon calculating the number of news-papers 'tis found that (besides diverse written accounts) no less than 200 half-sheets per month are thrown from the press in London, and about as many printed elsewhere in the three kingdoms; a considerable part of which constantly exhibit essays on various subjects for entertainment; and all the rest, occasionally oblige their readers with agreeable pieces of poetry, valuable receipts in physick, dissertations on trade, revolutions in kingdoms, secrets in art or nature, criticisms in literature, essays on government and proposals of public concern, communicated to the world by persons of capacity thro' their means: so that they become the chief channels of amusement and intelligence. But then being only loose papers, uncertainly scatter'd about, it often happens, that many things deserving attention, contained in them, are only seen by accident, and others not sufficiently publish'd or preserved for universal benefit and information.

This consideration has induced several gentlemen to promote a monthly collection, to treasure up, as in a magazine, the most remarkable pieces on the subjects above mention'd or at least impartial abridgments thereof, as a method much
better calculated to preserve those things that are curious, than that of transcribing.

In pursuance thereof, and the encouragement already given, this work will be continued, shall appear earlier, and contain more than former monthly books of the same price.¹⁷

Cave borrowed from the historical collection the all important ideal of presenting an impartial summary of the news, and he adopted their method of epitomizing accounts that had already appeared in the weekly journals. But he modified this accepted tradition to make it suit the requirements of a period of political and economic readjustment and growth.¹⁸

An examination of the first issue for January 1, 1731, showed many of the features for which the Gentlemen's Magazine was famous. On the title page was a cut of St. John's Gate and the name, "Sylvanus Urban Gent.," the pseudonym of Cave for editorial ubiquity. Cave divided the magazine into three main parts: I. A View of the Weekly Essays; II. Poetry; III. Domestic Occurrences. The first part was the section of the magazine which attracted the most attention. The first issue comprised extracts and epitomes of the essays which had appeared during January in the Craftsman, London Journal, Grub-Street Journal, Weekly Register, Universal Spectator, Free Briton, and others.
The essays from each journal were grouped together and arranged in chronological order to give a rapid view of the discussions in each throughout the month. After the first issue, however, Cave began arranging these essays in chronological order. He devoted four pages of the first issue to poetry. The last part contained such current information as extraordinary accidents, casualties, ships lost and taken, deaths, marriages, civil and military promotions, ecclesiastical preferments, sheriffs, stocks, bills of mortality, goods, foreign advices, bankrupts, books, fairs for the following month, together with a narrative from Edinburgh, an essay on witchcraft from "Pensilvania," and observations on February gardening.

Gentleman's Magazine gradually changed over the years. The alterations attested to Cave's ability to judge public tastes, his foresightedness, his editorial skill, and his tenacity of purpose. The variations revealed in a remarkable way the development of English interests and the widening of the sympathies of the educated middle class. 19

One of the most famous features added to the Gentleman's Magazine was the Parliamentary debates. These appeared first in the January, 1732, issue, when Cave printed the
King's speech. Cave was not prosecuted, and later in that year he added speeches from both Lords and Commons. Cave and a friend attended Parliament regularly and their notes on the proceedings were rewritten and published. For a while all went well but eventually in April, 1738, the "proceedings" had proved such a popular feature of the magazine that the Speaker of the House of Commons decided to put an end to the practice. Parliament resolved that publication of any account of debates and proceedings was subject to punishment. Cave was determined to continue the practice. He and Samuel Johnson devised a subterfuge in which the proceedings were printed, thinly veiled as "Debates in the Senate of Magna Lilliputia," with fictitious names for the speakers or the letters of their real names formed into an anagram. To further protect himself, Cave published his Magazine as by "Edward Cave, Jr." 20

A gradual but significant change occurred in the format of Gentleman's Magazine. In the 1740's the original practice of the "magazine," the abridgment of the current press, declined sharply. Cave began to print more and more original material. This tendency intensified so that by 1770 the magazine was made up chiefly of original articles. 21
The Gentleman's Magazine, like most other eighteenth century periodicals, contained very little social and political criticism. There was something undistinguished in the stolid matter-of-factness and in the unperturbed recording of the status quo by Cave. Had he attempted some social criticism, ventured occasional opinions, and analyzed contemporary problems with astuteness, he might have accustomed his readers to thinking critically about the England of their time. That the Gentleman's failed to do so was only further evidence of the faithfulness with which Cave recorded an age when self-criticism was a bit unfashionable. Cave contributed little to the modern tendency of making periodicals a medium for controversy and discussion.22

Cave in the Gentleman's generally avoided taking sides in political disputes. The later editors of the magazine continued this policy after his death in 1754. Had the Gentleman's given preference to the propaganda of only one party, the magazine would have alienated some of its readers. The very nature of a magazine made the presentation of any unified editorial point of view difficult. Cave reprinted most of his political material from popular
news-sheets. This practice resulted in a conglomeration of contemporary opinion.

The general political tone of the Gentleman's was nominally Whig in that the editors were against arbitrary government. Cave's publication of Parliamentary debates best illustrates this—especially after the government tried to suppress them. The editors were also often sympathetic to the viewpoint of the London commercial interests.23

The Gentleman's Magazine provided an abundance of comment on religion. The editors were quite willing to present a variety of opinions and their outlook appeared rather latitudinarian. The Gentleman's made no effort to insist on the orthodox practices of the Established Church, whose ritual was variously described as necessary and unnecessary in different articles.24 The editors believed that the Christian religion was firmly founded on reason and the evidence of science. Free reason was the best friend of religion, since Christianity stood on positive proof.25

The success of the Gentleman's Magazine soon engendered a competitor. In April, 1732, a little over a year after the founding of the Gentleman's, the London Magazine appeared. A group of London booksellers including J. Wilford,
T. Cox, J. Clarke, and T. Astley published this new periodical.26

The *London Magazine* was almost a page for page copy of its predecessor. Whereas Cave's subtitle was "Monthly Intelligencer," the subtitle of the *London* was "Gentleman's Monthly Intelligencer." The motto of the *Gentleman's* was "E Pluribus Unum," paraphrased by the publishers of the *London* into "Multum in Parvo." In make-up, the editors of the *London* perfectly matched their prototype. The "View of Weekly Essays and Disputes This Month" contained long extracts from the *Universal Spectator, Craftsman*, etc., and ran to thirty-six pages in the first issue of the *London*, longer than the same department in the *Gentleman's* for the same month. True to its model, the *London* had pages of "practical essays," poetry, a department of current news, as well as columns of births, deaths, and stocks, and concluded with a list of books.

The editors of the *London Magazine* made it a habit to copy the innovations that appeared in the *Gentleman's Magazine*. The *London Magazine* began publishing the Parliamentary debates in a section called "Proceedings and Debates" in 1732 shortly after the *Gentleman's* began the
famous practice. After the attempt by Parliament to halt the practice, the editors of the London Magazine, however, developed a subterfuge a month before Cave's periodical. The London printed the proceedings as "Debates in the Political Club" and featured a group of young men, all with Roman or Greek names, discussing issues identical to those being considered in Parliament.

Politically the editorial viewpoint of the London Magazine was similar to that found in the Gentleman's. The editors supported the London commercial interests. The London Magazine, like the Gentleman's, fiercely fought any tendency toward arbitrary government as evidenced by the efforts of the publishers to continue printing the affairs of Parliament. 27

Though not severely orthodox, the religious comments in the London were more conservative than those in the Gentleman's. Like its rival, the London printed a broad spectrum of religious opinions, especially in letters to the editor. Only in an occasional book review or note did the editors reveal their point of view. The contrast with the Gentleman's was best expressed in the London's attack on the dissenters who sought to prevent the exercise of the
militia on Sundays. The editors attacked the "fanatical pharisaical spirit of some of the dissenters, especially the most ignorant sort." This censure appeared in the "History of the Last Session of Parliament" section.28

The editors of the London Magazine, like their competitors, believed the Christian religion was firmly grounded in reason and science. This viewpoint was evident even in a dispute over whether or not the dates in the Bible could be confirmed by scientific evidence.29

The London Magazine lacked a vigorous innovative editorial policy. The publishers were content to copy the Gentleman's. As might have been expected, the public eventually became aware that the latter was by far the superior of the two publications. The London Magazine after the 1740's began a slow decline and finally ceased publication in 1785.

Many other imitations of the Gentleman's Magazine appeared in the eighteenth century. Most were quite short-lived and made little impact. One competitor, however, had the advantage of geographical location: the Scots Magazine began operations in Edinburgh in 1739. To this day the original authors and projectors of this magazine remain unknown.30
Scotland was still relatively isolated in the middle eighteenth century. Most of the newspapers and magazines of the island were printed in London. Since important news from the Continent took weeks or even months to reach the northern kingdom, there was a large untapped market for fresh news in Scotland which was partially satisfied by this new magazine. Another reason for the success of the *Scots Magazine* was the lack of Scottish news in almost all the London publications. The English seemed to have little interest in what was happening in Scotland. The appearance of this new publication inspired a good deal of patriotism among Scotsmen.

The features of the *Scots Magazine* were modeled on those of the *Gentleman's Magazine*. There was a section on Parliamentary debates in which the speakers masqueraded under classical names. Much space was given to news extracts from various London publications. Each issue carried lists of births, marriages, deaths, and preferments with the emphasis mainly on Scots. The editors also printed a great deal of news about Scotland which was not found in any of the London serials.
The *Scots Magazine* like the others tried to give a balanced political and religious presentation. The publishers of the serial remained staunchly loyal to George II during a crisis created in 1745 by the landing of the Stuart pretender in the Highlands. At other times the editors freely criticized the government. The editors regularly reported the affairs of the Church of Scotland. They were tolerant, however, of all theological points of view, and they even had the appearance of admiring the sceptic, David Hume, who was not particularly in favor among the Scottish clergy. 31

The number of other eighteenth century magazines was almost endless. Most of the editors closely copied the successful serials and showed little originality. Three of these lesser publications, taken together with the three major serials, give a good cross-section of the British magazines.

The *Ladies Magazine; or, the Universal Entertainer* appeared biweekly between November 18, 1749, and December 23, 1752, in London. The fictitious "Jasper Goodwill of Oxford, Esq." published the magazine. As the title indicates, the *Ladies* was primarily a magazine for female readers. The
publication carried a large amount of poetry and fiction and contained very little current news.  

A magazine with a more literary orientation was the Court Magazine. Hugh Kelley published this monthly serial in London between September, 1761 and November, 1765. The Court Magazine was a miscellany magazine that contained the usual features. The principal feature of the serial was a section entitled the "Green Room," a theatrical department which also contained some fiction.  

The most significant magazine published in Ireland was the Hibernian Magazine, issued monthly in Dublin from 1771 until 1811. This was a true miscellany magazine, covering everything from stocks to poetry, from news to sentimental fiction. The Hibernian was famous for its copper-plate engravings of actors and actresses, in famous roles, as well as many pictures of real people. The editors also featured a respectable amount of science.  

The history of British book review periodicals was long and involved. A rudimentary form of book reviewing, a few critical comments on a new book or pamphlet, began during the Puritan Revolution. One side would print observations in various publications on the new books, half-
sheets, pamphlets, newspapers, etc., being published by their opponents in the struggle. These remarks were usually crude and inflammatory but they served the purpose of informing the people of the political and religious viewpoint of the author.35

The actual book review periodical began as a mere listing of new books. One of the first of these book lists, the Mercurious Librarius, appeared from 1668 to 1670. It contained no comments on the books listed. Commentary on the political and religious viewpoint was considered unnecessary in the tranquil time of the Restoration.36

The credit for establishing the first English reviewing or abstracting journals goes to a French Huguenot immigrant, Jean de la Crose. His Universal Historical Bibliothegue, published for a few issues in 1687, proposed to be an "An Account of Most of the Considerable Books Printed in All Languages. . . Wherein a Short Description is Given of the Design and Scope of Almost Every Book: and the Quality of the Author, if Known."37 These accounts were mainly translations of articles in Continental journals. De la Crose's reviews usually consisted of a summary of the work in question with very little critical discussion. He also
originated several other short-lived reviewing periodicals.

Numerous other reviewing journals emerged during the next half-century. Most of these followed the standard format of printing original or translated abstracts with or without excerpts. Few editors practiced "reviewing" in the modern sense of giving a critical analysis of the works. One early review of this type of useful in tracing scientific content because the editors devoted a rather significant amount of space to science. The *History of the Works of the Learned* was printed in London from January, 1737 until December, 1743. The editors of this monthly compendium gave "accurate abstracts," "impartial" reviews of books, with some critical comments, a general view of the state of learning throughout Europe, and "memoirs of the eminent writers."³⁸

At almost the same time that the *History of the Works of the Learned* appeared, a new and significant review journal emerged in Dublin—the *Literary Journal*, founded by Jean Pierre Droz in October, 1744, and continuing until June, 1749. Droz began the *Literary Journal* as another abstract periodical and he provided synopses of Latin, Dutch, German, and French books in English. He relied
extensively on abridgments printed in foreign periodicals. Later Droz inserted many original reviews. He approached very closely the critique form of later reviews, employing the method of analysis and quotation. The books analyzed were primarily of a religious nature but Droz did include reviews of many scientific volumes. This journal was a bridge from the serious abstract serials of la Crose to the Monthly Review of Ralph Griffiths, a few years later.\textsuperscript{39} Griffiths first published the Monthly Review in London in 1749. It appeared monthly for the next hundred years with the founder as editor until 1803. In view of the size of the Monthly, general quality, and long career as a periodical, it was the earliest review of importance in the English language.\textsuperscript{40} During the first few decades, Griffiths continued the traditional pattern of book critiquing, that is, he published mainly digests or epitomes of books with ... tie analysis. During the 1780's, however, this pattern began to change. Griffiths started detailed critical reviews in which the writer expressed a very definite opinion about the book under consideration. The main articles typically ran about ten pages and were followed by a section called the "Monthly Catalogue" which
contained a few shorter reviews. Griffiths selected works of a more popular nature for review and avoided scholarly books written strictly for an elite audience. This change of emphasis from previous review periodicals contributed greatly to the success of the Monthly.41

Griffiths organized the Monthly along the lines of a modern periodical. He personally devoted all his efforts to the publication. He had no associate editors. Griffiths early conceived the idea of a staff consisting not of a small group of hack writers paid a monthly salary, but of a large group of experts, each dedicating only a small part of his time to reviewing. These writers dealt with works in their own particular field and received a remuneration at a certain rate per printed sheet. The pay varied with the eminence and reputation of the individual. For example, Griffiths' three principal theological reviewers were Abraham Rees, Andrew Kippis, and William Rose, probably the three leading English dissenting clergymen. He also struggled to maintain the highest standards of honesty and to ensure impartiality in the reviews. He did not allow writers to review their own works or those of a friend. He ensured complete anonymity
for his writers and never disclosed until after a man's death the secret of his connection with the Monthly. This policy made it possible for his staff to remain active in social, political, and literary affairs, and to write without fear of incurring professional emnities or impairing their social standing.42

Griffiths' liberal political and religious outlook was apparent from the beginning in the Monthly. This did not mean that the Monthly presented only one philosophical view. Occasionally, however, Griffiths' Whiggism really burst into the open.43 The writers in the Monthly established a very liberal dissenter viewpoint in religious matters. They believed the real essence of the Protestant faith was reliance on human reason. Religion had to be based on truth and not on miracles. The reviewers regularly examined Christian revelation in the light of reason and science.44

Griffiths' success with this new type of review periodical soon engendered a competitor. Just as the London Magazine closely copied its successful predecessor, the new Critical Review imitated its forerunner.
Archibald Hamilton founded the *Critical Review* in London in 1756. He was a prosperous printer, who had been forced to leave Edinburgh because of his part in the Porteous Riot. In 1756 Tobias Smollett (1721-71) became virtual editor of the *Critical Review*. In the early years, "four gentlemen of approved abilities" assisted him and wrote many of the early articles. They probably were Thomas Francklin (1721-84), Samuel Derrick (1724-69), John Armstrong (1709-79), and Patrick Murdoch (d. 1774). At one time some historians believed that the *Critical Review* was established under Tory and Church patronage, but now most experts recognize that the founders conceived the review as a purely literary enterprise.

Smollett modeled his publication on the *Monthly*. The *Critical Review* appeared every four weeks and the editor attempted to cover most of the new books as soon as they appeared. Each issue contained about 120 pages with a number of long reviews followed by a "monthly Catalogue" of shorter reviews. Smollett also used a small group of professional reviewers. The publisher's payments to writers were alleged to be lower than the rate paid by Griffiths'.
Smollett was editor of the **Critical Review** until 1763. During his years with the review he was constantly embroiled in controversy. The nature of a review periodical lent itself to the possibilities for argument, and Smollett and his staff, unlike their rivals, overlooked few opportunities for polemics. Smollett was often hasty in forming opinions and frequently was a prejudiced judge. He applied the critical scourge without mercy and resented any retorts from his victims. His approach led to numerous petty squabbles and clamorous contests of rejoinder, recrimination, and abuse.47

Even in the realm of scientific affairs, Smollett's personality produced disputes. In a controversy between Alexander Monro Jr. (1735-1817), professor of anatomy and surgery at Edinburgh, and William Hunter (1718-83), the famous anatomist, involving claims for the priority of discovery of the lacrimal ducts, seminiferous tubules in man, and functions of the lymphatic system, the **Critical Review** became a participant. Smollett was a friend of Hunter and he took the latter's side in the debate.48

The writers in the **Critical Review** were generally more conservative than their counterparts at the **Monthly**. Unlike
the Monthly, the editorial policy of the Critical Review fluctuated during the sixty years of its existence. In the early years of the serial, the writers in the Critical Review favored the status quo and distrusted any form of rapid political change.49

The religious opinions in the Critical Review generally were conservative although not always Anglican. The reviewers in the Critical Review refused to permit science to corrupt religion and vice versa. Commentators in the serial did not equate scientific and theological reasoning, and they did not confuse the evidence of science with that of faith. Human reason was useful in this life but unimportant in the next. Science was useful in supporting faith and the word of God against deists and enthusiasts.50

The Monthly and Critical Review remained the two major British reviews until the nineteenth century. Imitators founded a number of other reviews but none approached the status of these two. Some editors even tried to combine the best features of the magazines and reviews.

One of these hybrid serials was the Literary Magazine, or, Universal Review which unknown persons published from May, 1756 until July, 1758. The Literary Magazine was more
of a review than a magazine. It was best remembered for one of its contributors, Samuel Johnson. He wrote the preliminary address, some twenty-five reviews, and six original articles on political matters. James Boswell believed Johnson wrote some of his best pieces for this publication. The Literary Magazine also contained many excellent articles and reviews of natural history phenomena. The selections on geography and zoology were especially numerous.

A historian can fairly easily determine the viewpoint and contents of these and other eighteenth century periodicals. The real dilemma for a researcher is to discover the readership and circulation of these serials in their own time. Very few records of circulation remain in existence and experts do not agree on the extent of literacy in eighteenth century Britain.

Johnson's remark in 1781 that England was a nation of readers requires qualification. Edmund Burke's alleged estimate--there is no evidence for it in his writings--that the reading public numbered 80,000 in 1790 is probably too high. The population of England, Scotland, and Wales at this time was about ten million persons. If Burke's estimate were accurate, less than one per cent of the
British were readers. This figure does not mean that fewer than 80,000 British citizens were literate, since a much larger number could actually read. "Reading public" denotes the portion of the public who regularly purchased or borrowed and read books, newspapers, and periodicals.52

The tremendous growth in the numbers of periodicals and the appearance of new serial forms in the eighteenth century did not necessarily signify that the literacy rate likewise greatly increased. No necessary relationship exists between the volume of periodical production and the size of the readership because the number of readers per copy cannot be assumed to be constant either over time or between publications. Many other factors besides a change in the literacy rate can cause variations in the numbers of periodicals printed. Technological changes such as the invention of new types of printing presses could increase production. Removal of legal restrictions like the ending of limitations on the number of printers, distributors, and the size of editions in the late seventeenth century heightened production. Modifications in governmental fiscal policy such as the varying of stamp rates influenced printing.53
In the eighteenth century little active readership existed among the lower classes. A sizeable portion of the working classes, however, were literate. It has been estimated that by the early Victorian period between two-thirds and three-fourths of this group could read. It is difficult to estimate just how much the percentage of literacy increased during the eighteenth century. In certain areas of Britain where workers toiled exceedingly long hours such as in the textile regions, the level of popular literacy actually fell during the eighteenth century. Any growth of literacy in the eighteenth century among the lower classes resulted from the efforts of various religious groups. The Wesleyans and members of the Sunday School movement concentrated their efforts amid the working classes in order that these people could be saved. Like most Protestants, the Wesleyans and the others firmly believed that every person should be able to read the Bible and other religious tracts. John Wesley himself was a pioneer in writing simplified versions of religious and moralistic works sold at very low prices and produced in great numbers. Though Wesley himself was widely read, members of the movement as a whole frowned on the reading of anything but moral tracts.
Little evidence exists which indicates that lower class people in any numbers read the periodicals previously mentioned. The type of printed material that received the attention of this class tended to be romantic and sensational fiction or religious pamphlets in cheap editions.\(^{57}\)

An average laborer in this period earned about ten shillings a week, an income barely enough to make ends meet. The poor could occasionally spend a penny or a half-penny for a cheap pamphlet or newspaper.\(^{58}\) Few lower class citizens at the end of the eighteenth century were able to afford one shilling six pence to two shillings every month for the *Gentleman's Magazine* or other periodicals. Even the costs of belonging to a proprietary library that subscribed to periodicals were more than the poor could bear.\(^{59}\)

During the eighteenth century, the taste for reading made great headway, however, among the middle classes. This increase was mainly an urban phenomenon and occurred not only in London but also in numerous provincial towns. The class of tradesmen and artisans marked the dividing line between the reading and non-reading public. Below this group were the non-readers and truly illiterate. These latter included small farmers, most laborers, soldiers,
and the street rabble. Above the tradesmen and artisans and below the old established middle class was the area of the social structure that most likely accounted for the primary increase in the size of the reading public. In this group were shopkeepers, independent tradesmen, administrative and clerical employees, clergymen, successful farmers, and academics. The evolution of these sectors of the middle class reflected to a great extent the growth of an economy that demanded literacy. The increasing affluence of these groups brought them into the orbit of the older and smaller middle class aggregation of bankers, merchants, large employers, and the superior professions.60

The "new literary balance of power" gave great impetus to middle class interests and values. For example, the novel Robinson Crusoe was one of the most popular of this period and expressed very favorably secularized Puritanism and economic individualism. Travel and exploration in general were the most popular types of books borrowed from the Bristol Library in the period 1773-84.61 The periodicals of the eighteenth century, especially the magazines, also had great appeal to the middle classes. The magazines were publications that contained practical information about
Great Britain and the rest of the world. Numerous writers emphasized the utilitarian value of natural history (see chapter three).

Attempts to determine circulation for the eighteenth century periodicals are mostly guesswork. Efforts to discover the circulation of the most famous serial, the Gentleman's Magazine, illustrated this problem. Cave kept his circulation figures a secret and also reprinted copies of the magazine after they were issued. Number 1 and 2 of the Gentleman's went through at least four editions. In 1746 in the "Preface," he claimed a distribution of 3,000 copies. Johnson asserted that Cave sold 10,000 copies and Sir John Hawkins in his biography of Johnson wrote that after the latter began to write the "Debates in the Senate of Magna Lilliputia" in 1738 the circulation rose to 15,000 per issue. Both of these figures probably were exaggerations.

Circulation figures for most other periodicals are as little existent. About the only circulation numbers were for the year 1797. The leading periodicals then were:
<table>
<thead>
<tr>
<th>Magazine</th>
<th>Circulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Monthly Review</td>
<td>5000</td>
</tr>
<tr>
<td>The Monthly Magazine</td>
<td>5000</td>
</tr>
<tr>
<td>The Gentleman's Magazine</td>
<td>4550</td>
</tr>
<tr>
<td>The British Critic</td>
<td>3500</td>
</tr>
<tr>
<td>The European Magazine</td>
<td>3250</td>
</tr>
<tr>
<td>The Critical Review</td>
<td>3500</td>
</tr>
<tr>
<td>The Universal Magazine</td>
<td>1750</td>
</tr>
<tr>
<td>The Analytical Review</td>
<td>1500</td>
</tr>
<tr>
<td>The Repertory</td>
<td>1000</td>
</tr>
<tr>
<td>Annals of Agriculture</td>
<td>1000</td>
</tr>
<tr>
<td>Nicholson's Journal</td>
<td>750</td>
</tr>
<tr>
<td>The Medical Review</td>
<td>750</td>
</tr>
</tbody>
</table>

The leading London newspapers in this same period had circulations from 2,000 to 7,000 per copy. 65

These figures are quite low compared with present day standards. A number of factors kept the circulation depressed. One of the difficulties was the technological level of the printing industry. The eighteenth century was still the era of the pre-steam press. Publishers were unable to print great quantities of material in a limited space of time. The primitive presses in use could produce only about 250 sheets an hour. Since the monthly issues of
periodicals were from 60 to 120 pages in length, one could appreciate that to produce 5,000 copies a month was no small undertaking.66

On the surface, then, circulation was small, but a multiplier effect was at work. In coffee houses, circulating libraries of various kinds, book clubs, and reading rooms, periodicals, books, and newspapers were available to a potentially large number of readers. Private circulation was secondary in importance when compared with the thousands of people who read the serials in places of this sort.

Although coffee houses apparently became less popular as the century progressed, a large number of them still existed in England at the end of the century. They catered to virtually every class and type of person. Richard Altick, the historian of British reading habits, suggests the link between reading and coffee houses. He wrote:

The great influence these periodicals had upon the eighteenth century reading habit was not due to large circulations but to the increase in the number of individual magazines and reviews and to their presence in the coffee houses, where they found most of their readers.67

He estimated that "many scores" of readers would pore over a single copy of the Gentleman's Magazine or Critical Review in a single month in such establishments. One expert
estimated that a possible readership of over 27,000 persons was available in London coffee houses. This approximation only included establishments in the capital, and there also were probably an equal number of them outside of London.\textsuperscript{68}

Various kinds of eighteenth century libraries were also important in the circulation of periodicals. One type of library was the rental library, operated more for profit than education.\textsuperscript{69} In addition, approximately 100 subscription or proprietary libraries were in existence in England at this time.\textsuperscript{70} Book clubs were numerous in the late eighteenth century and may have numbered as many as 200. There also were many newspaper and magazine clubs about which virtually nothing is known today, except that they were probably commercial ventures promoted by individuals in bookshops and newsrooms.\textsuperscript{71}

Groups and organizations like all of the above accounted for a large majority of the periodicals purchased.\textsuperscript{72} Periodicals were available to tens of thousands of readers who never individually purchased them. How large this multiplier effect was, it is obviously impossible to estimate. The periodicals clearly reached many influential people in Great Britain and her colonies. The high content of science in them reflected their tastes and perhaps their needs.
The influence of the British periodicals was also augmented in another way. Editors throughout the world appreciated the superior quality of the serials and republished a considerable number of individual articles from the British periodicals.

On the Continent, this borrowing from the British periodicals was especially common in Germany. For example, the editors of the Frankfurter medicinische Wochenschrift and the Neue medicinische Bibliothek translated and reprinted a large variety of medical articles and reviews from the Gentleman's Magazine and the Monthly Review. The editors of general periodicals such as the Physikalishe Belustigungen also printed articles in translation from the British magazines and often selected scientific essays for republication.

American editors likewise borrowed material from British serials. This practice was common especially before 1800 in many of the small, struggling and relatively short-lived journals.

Another problem in studying eighteenth century British periodicals, in addition to assessing circulation, lay in the individual articles themselves. The authors of the
various selections were difficult to identify, for a good portion of the writers did not sign their names. This anonymity applied to book reviews, articles, and letters to the editor.

Eighteenth century authors seemed to prefer writing anonymous articles. The writer by not revealing his name was free to make honest comments and evaluations of potentially sensitive subjects. Under the cover of anonymity, a country squire, government official, bishop, or politician could contribute to the periodicals without endangering his position. Anonymity was common for the authors of political and religious essays and letters, but the practice extended to other areas such as science and fine arts which would, on the surface, not seem to have required it. 76

The editors of the periodicals obviously knew the names of the contributors and in some cases they kept careful records of them. Since some of these registers or annotated copies survived to the present day, the authors of practically all the reviews in the Monthly Review, for example, are known. 77

We know, in addition, the identity of many of the authors of scientific articles which appeared in the maga-
Selections that were "borrowed" or reprinted from publications like the *Philosophical Transactions* generally carried the author's name, especially if the writer were a famous scientist like Linnaeus, Buffon, or Kalm. In some original articles letters, scientists and men aspiring to be scientists signed their own name.

In the case of the *Gentleman's Magazine*, *Critical Review*, and *Monthly Review* scholars have been able to compile lists of some of the authors of individual articles. These registers provide a good profile of the writer's social, economic, educational, and occupational background.

Table 5 shows the social-occupational status of 478 correspondents. The three major professions—church, law, and medicine—accounted for 53% of the total. The professional and artistic grades of the middle class, categories 2-8, produced 76% of the contributors. Based on the total sample, this was a highly respectable group by measurable standards, with 76% in the *Dictionary of National Biography*, 53% with university background and 29% with membership in learned societies such as the Royal Society.78
<table>
<thead>
<tr>
<th>Social-Occupational Status of Correspondents of <em>The Gentleman's Magazine</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1. Independent Means</td>
</tr>
<tr>
<td>2. Clergy</td>
</tr>
<tr>
<td>a) Church of England</td>
</tr>
<tr>
<td>b) Dissenter</td>
</tr>
<tr>
<td>3. Medicine</td>
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<tr>
<td>4. Law</td>
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<tr>
<td>5. The Arts</td>
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<tr>
<td>6. Writing</td>
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<tr>
<td>7. Academic-Scholarship</td>
</tr>
<tr>
<td>8. Public Office</td>
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<tr>
<td>9. Armed Forces</td>
</tr>
<tr>
<td>10. Science</td>
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<tr>
<td>11. Manufacture, Finance, and Commerce</td>
</tr>
<tr>
<td>12. Crafts and Retail Trade</td>
</tr>
<tr>
<td>13. Printer-Bookseller</td>
</tr>
<tr>
<td>14. Agriculture</td>
</tr>
<tr>
<td>15. Wage Labor and Poor</td>
</tr>
<tr>
<td>16. Listed in <em>DNB</em></td>
</tr>
<tr>
<td>17. Total Number of Writers Identified</td>
</tr>
<tr>
<td>18. Attended Oxford or Cambridge</td>
</tr>
<tr>
<td>19. Attended Scottish Universities</td>
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<tr>
<td>20. Attended Other Universities</td>
</tr>
<tr>
<td>21. Attended Dissenting Academies</td>
</tr>
<tr>
<td>22. Degrees Earned</td>
</tr>
<tr>
<td>23. Learned Society Memberships</td>
</tr>
<tr>
<td>24. Antiquaries</td>
</tr>
</tbody>
</table>

A comparable analysis of the Monthly Review is shown in Table 6. As with the Gentleman's group, this sample was also a highly respectable aggregation with 47% having university training, another 9% attended Dissenting Academies, 32% belonging to one or more societies, and 67% being listed in the Dictionary of National Biography. The professional and artistic grades of the middle class contributed 71% of the writers.\footnote{79}

Several differences appear in the statistics between the Monthly and the Gentleman's. The Dissenter orientation of the former showed up in the fact that 12% of the reviewers were Dissenting clergymen as opposed to only 5% for the latter. For the same reason, more writers for the Monthly attended Dissenting Academies and Scottish universities, 25%, than the comparable 12% in the Gentleman's. The Gentleman's had a much larger percentage of clergymen contributors, 39%, than the Monthly with 26%. The difference may be due to the fact that Griffiths selected people to write reviews for his publication and he hired men specially qualified to handle certain books. Hence the statistics for professional categories like science and academic life were larger in the Monthly. The correspondents to the Gentleman's were mostly voluntary contributors. The
### Table 6


<table>
<thead>
<tr>
<th>Social-Occupational Status</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>2. Clergy</td>
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<td></td>
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<tr>
<td>a) Church of England</td>
<td>26</td>
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<td>b) Dissenter</td>
<td>29</td>
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<td>3. Medicine</td>
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<td>8. Public Office</td>
<td>6</td>
<td>02</td>
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<tr>
<td>9. Armed Forces</td>
<td>8</td>
<td>03</td>
</tr>
<tr>
<td>10. Science</td>
<td>14</td>
<td>06</td>
</tr>
<tr>
<td>11. Manufacturing, Finance and Commerce</td>
<td>3</td>
<td>01</td>
</tr>
<tr>
<td>12. Crafts and Retail Trade</td>
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<td>01</td>
</tr>
<tr>
<td>13. Printer-Bookseller</td>
<td>2</td>
<td>01</td>
</tr>
<tr>
<td>14. Agriculture</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15. Wage Labor and Poor</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16. Listed in DNB</td>
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<td>67</td>
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<td>17. Total Number of Reviewers Identified</td>
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<td>19. Attended Scottish Universities</td>
<td>39</td>
<td>16</td>
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<td>09</td>
</tr>
<tr>
<td>21. Attended Dissenting Academies</td>
<td>22</td>
<td>09</td>
</tr>
<tr>
<td>22. Degrees Earned</td>
<td>94</td>
<td>39</td>
</tr>
<tr>
<td>23. Learned Society Memberships</td>
<td>77</td>
<td>32</td>
</tr>
<tr>
<td>24. Antiquaries</td>
<td>23</td>
<td>10</td>
</tr>
</tbody>
</table>

social, educational, and religious background of an author, of course, influenced the science treated and the way he handled a particular scientific topic.

Seven men contributed the majority of natural history reviews in the period from 1749-89. The principal contributor of natural history reviews to the *Monthly* was William Bewley (1726-83). He wrote at least 106 natural history reviews between 1749 and 1783. For a man who contributed so much to a major serial and was a knowledgeable scientist, very little is known about Bewley. He was not listed in the *DNB*. Bewley spent his whole life at Great Massingham, Norfolk, after 1749. By profession he was a surgeon and an apothecary. He combined his professional practice with the study of science and became especially learned in anatomy, chemistry, and electricity. Bewley contributed a review of Joseph Priestley's work on electricity to the *Monthly* and this led to a friendship between the two men. Bewley later contributed notes and appendixes to some of Priestley's works. In a long obituary in the *London Magazine*, a writer eulogized Bewley as the "philosopher of Massingham" and described his passion for science that lasted until the very end of his life:
A love for every liberal science and an insatiable curiosity after whatever was connected with them were his ruling passions. So strongly indeed did they operate, that he desired some books might be brought to him, on the evening before he died, when the excruciating pains of his disorder had a little abated. 82

Another important contributor of natural history reviews to the *Monthly* was Archibald Maclaine (1722-1805). He wrote at least 103 reviews, mostly on foreign scientific works. Between 1775 and 1789 he handled almost all of the analyses of foreign literature for Griffiths. He was especially adept at reviewing the transactions of foreign scientific societies such as the French Academy. Maclaine was well located for this task as he served for fifty years as minister at the English Church at The Hague. In this period he made only two brief visits to his homeland. 83

Griffiths wrote many reviews for his own publication and contributed at least 42 articles on natural history. He furnished analyses of important zoological works as Thomas Pennant's *British Zoology* and *Indian Zoology*. 84 Griffiths also provided reviews of consequential geographical and travel books. He prepared the review of Captain James Cook's second voyage around the world. 85 His long interest
in overseas areas, especially America, resulted in his receiving an honorary LL.D. degree from Dartmouth College in 1790.86

William Kenrick (1725?-79), a miscellaneous writer, reviewed at least twenty-one natural history volumes for Griffiths in the period from 1759 until 1765. Kenrick had the reputation of having a perverse and jealous temper and loving notoriety. Several of his reviews of literary works led to disputes, including his famous attack on Oliver Goldsmith's *Enquiry into the Present State of Polite Learning* in the *Monthly* in 1759.87 Most of Kenrick's reviews of natural history were analyses of geographical works and of transactions of various scientific societies.

Griffiths employed some notable scientists to review books. John Rotheram (1750?-1804) contributed at least twenty-nine natural history articles. He received his education at the University of Uppsala where he studied under Linnaeus and Torbern Bergman. In 1793 he became coadjutor to Professor Joseph Black in the chemistry chair at the University of Edinburgh. In 1795 he was elected professor of natural philosophy at St. Andrews University. He wrote a famous pamphlet, *Sexes of the Plants Vindicated Against*
William Smellie's Philosophy of Natural History, in which he defended the Linnaean system. All of his reviews for the Monthly were in the period after 1786. He was principal analyst of natural history from that point until after 1789.

Samuel Goodenough (1743-1827) also had a good botanical background. He graduated from Oxford with a D.C.L. degree and earned a reputation as a classical tutor. His real interest was botany and he was one of the founders of the Linnaean society in 1787. He served as treasurer and later as vice-president of that group. He contributed two excellent papers on the plant genera Carex and Fuci to the society's Transactions. Sir J. E. Smith, president of the Linnaean Society, dedicated the genera Goodenia to him. He was a Fellow of the Royal Society and likewise rose to the rank of vice-president in that body. He contributed at least fifteen reviews of natural history works through 1789. Goodenough and Rotheram replaced Bewley after the latter's death in 1783 as the main natural history writers for the Monthly. Goodenough wrote a number of good reviews of taxonomical works that will be examined later in this paper.
William Wales (1734?–98) was a prominent mathematician and world traveler who reviewed for Griffiths. In 1769 the Royal Society sent him to Hudson's Bay to observe the transit of Venus. Later the Board of Longitude employed him to accompany Cook on his second and third voyages around the world (1772–75; 1776–79). Wales subsequently became interested in demography and made a population study of Great Britain. Most of his articles were on books about Cook's voyages or the places that he and Cook had visited.

Historians were not so fortunate as to the identification of the writers for the other major review, the Critical Review. Only the reviewers in the first volume have been attributed to their proper authors. After 1756 only a scattering of contributors have been recognized. Smollett and his successors kept most of the reviewers' names a secret and a fire in 1803 destroyed many of the documents that might have thrown some light on their identity. As a result only about twenty-nine reviewers have been identified with any degree of certainty. In some cases historians know only that these individuals furnished some reviews for the Critical Review and they have not been able to ascertain which articles the authors wrote.
Table 7 summarizes the occupational and educational background of this small sample. In spite of the limited sample, the results compare rather well with those from the Gentleman's and the Monthly in terms of occupations. Seventy-two per cent of the known reviewers for the Critical Review came from the professional and artistic grades of the middle class as represented in categories 1-8.\textsuperscript{92}

It is possible to identify positively only four writers who contributed reviews on natural history to the Critical Review. Three of these men analyzed virtually all the new books in the early years of the Critical Review. The editor, Smollett, personally wrote four reviews of natural history volumes in the first year of publication.\textsuperscript{93} He had primarily a literary background and was not especially knowledgeable about scientific matters although he had served for a while as a surgeon in the fleet and later obtained an M.D. degree from Marischal College, Aberdeen. One of the reviews he contributed on a geographical work was poorly written.\textsuperscript{94} Smollett certainly wrote many more natural history articles besides the three that were credited to him, but no others have been positively identified.
Table 7

Social-Occupational Status of Reviews of
The Critical Review, 1756-1817

<table>
<thead>
<tr>
<th>Social Group</th>
<th>Number</th>
<th>Percent</th>
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</thead>
<tbody>
<tr>
<td>1. Independent Means</td>
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</tr>
<tr>
<td>2. Clergy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Church of England</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>b) Dissenter</td>
<td>1</td>
<td>03</td>
</tr>
<tr>
<td>3. Medicine</td>
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<td>6. Writing</td>
<td>13</td>
<td>39</td>
</tr>
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<td>7. Academic-Scholarship</td>
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<td>15</td>
</tr>
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<td>8. Public Office</td>
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<td>0</td>
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<td>9. Armed Forces</td>
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<td>11. Manufacturing, Finance, and Commerce</td>
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</tr>
<tr>
<td>12. Crafts and Retail Trade</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13. Printer-Bookseller</td>
<td>3</td>
<td>09</td>
</tr>
<tr>
<td>14. Agriculture</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15. Wage Labor and Poor</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16. Listed in DNB</td>
<td>25</td>
<td>76</td>
</tr>
<tr>
<td>17. Total Number of Reviewers</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Identified</td>
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<td>88</td>
</tr>
<tr>
<td>18. Attended Oxford or Cambridge</td>
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<td>24</td>
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<tr>
<td>19. Attended Scottish Universities</td>
<td>9</td>
<td>27</td>
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<td>20. Attended Other Universities</td>
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<tr>
<td>21. Attended Dissenting Academies</td>
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<td>22. Degrees Earned</td>
<td>7</td>
<td>21</td>
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<tr>
<td>23. Learned Society Memberships</td>
<td>2</td>
<td>06</td>
</tr>
<tr>
<td>24. Antiquaries</td>
<td>1</td>
<td>03</td>
</tr>
</tbody>
</table>

Francklin wrote many reviews for the early issues of the *Critical Review*. Only two articles on natural history, a review of a seven-column compendium of voyage and a geographical work on central Europe, have been definitely attributed to him. His interests were mainly along literary and theological lines. Francklin had a D.D. degree from Trinity College, Cambridge, and held the Greek chair at the University for a few years. Later he was appointed chaplain to King George III. Among his many published volumes were no works dealing with scientific subjects.

Another of Smollett's "four gentlemen" who contributed natural history reviews was Armstrong. He wrote only one review on the subject that has been positively identified but as one of the principal reviewers of the early years of the *Critical Review*, Armstrong certainly provided others. He was a physician with an M.D. degree from the University of Edinburgh. Armstrong served with the army in Germany during the Seven Years' War. He wrote a number of medical works including a famous study of venereal diseases and some didactic medieval poems. He also composed a number of literary volumes of considerable merit.
Oliver Goldsmith (1728?-74) was the only other reviewer explicitly identified as having contributed a natural history article. Goldsmith, of course, was one of Britain's leading literary figures in the eighteenth century. He was also a physician who practiced medicine. What many people do not realize, however, was that he had a keen interest in scientific occurrences. Goldsmith wrote a massive *History of the Earth and Animated Nature* in eight volumes. Although somewhat of a hack-work, this treatise demonstrated that Goldsmith was familiar with contemporary developments in science and especially with various theories on the formation of the earth. A review of Goldsmith's *History* appeared in 1774 in the *Critical Review* (see below, chapter 4).

The eighteenth century was an important era in the history of the British periodical press. Both the *Gentleman's* and the *Monthly* by eighteenth century standards were extremely successful serials and their prosperity soon engendered a host of competitors. After the outbreak of the French Revolution in 1789, the political turmoil in Europe produced changes in the British periodical press. These variations are really part of the history of the nineteenth century.
FOOTNOTES


4 Ibid., pp. 8-9.

5 Ibid., pp. 10-11.

6 Unfortunately there is no agreement among the experts of eighteenth century periodicals on how to classify them. Many writers divided the serials on the basis of their structure or form. Even if there was agreement on the various periodical forms, there was still the problem of the evolution of these types.


9 Carlson, The First Magazine, p. 36.


11 Walter Graham, English Literary Periodicals (New York: Octagon Books, 1930 [1966 reprint]), p. 151. This opinion was not shared by all experts. Carlson vigorously disputed
the above interpretation. He claimed the only similarity between the Gentleman's Journal and the Gentleman's Magazine was the borrowing on the part of Cave of the motto and device of the Journal. Carlson viewed the Journal as a rather dry, harmless, and tiresome literary publication with little news and nothing of historical value. Carlson did not believe such a publication could have served as a useful model for Cave's practical and informative publications. He preferred to place the Gentleman's Journal in the same general category as the Tatler and Spectator. He referred to all of these as literary serials. The Gentleman's Journal whether or not it was a true miscellany, had few imitations and none were of any real consequence. For a detailed discussion see Carlson, The First Magazine, pp. 31-35.


14Ibid., pp. 37-40.

15Ibid., pp. 40-41.

16Ibid., pp. 43-45.


18Carlson, The First Magazine, p. 45.

19Ibid., p. 13.

20Graham, English Literary Periodicals, pp. 156-57.


23 Assorted letters to the editor opposing the Cyder-Bill and thanking the city of London for opposing it, *The Gentleman's Magazine*, 33 (June, 1763), 300-04; anonymous letters to the editor against the Cyder-Bill, 33 (September, 1763), 446-48; 33 (August, 1763), 387-88. See also Robert Donald Spector, *English Literary Periodicals and the Climate of Opinion During the Seven Years War* (The Hague: Mouton & Co., 1966), pp. 149-51.


30 Graham, *English Literary Periodicals*, p. 164.


Ibid., p. 178.

Ibid., p. 182.


De la Crose quoted in Ibid., pp. 32-33.

Graham, *English Literary Periodicals*, p. 205.

Ibid., p. 207.

Ibid., p. 209.


47 Smollett's most famous dispute was with Admiral Charles Knowles during the Seven Years War. The Admiral had failed to carry out his part in the British attack on Rochefort, France. A board of inquiry had implied that Knowles either lacked judgment or courage. Knowles published a pamphlet defending his naval actions. Smollett reviewed the booklet in the *Critical Review* and his criticism was caustic enough to evoke a libel suit from Knowles. The dis-
pute almost led to a duel between the two and it ended with Smollett's imprisonment in 1759. See Graham, *English Literary Periodicals*, pp. 213-14; Spector, *English Literary Periodicals*, pp. 53-54.


1762), 81-82. Francklin was identified in Roper, "First Contributors," p. 44. All other reviewers in the Critical Review cited in this paper were also identified from Roper unless otherwise noted. See also Spector, English Literary Periodicals, pp. 84-86, 163.


54 Binder, Social Context, p. 6.


60 Ibid., pp. 16-17; Watt, Rise of the Novel, pp. 27, 40-41; Altick, English Common Reader, pp. 41, 65.
The most borrowed works were John Hawkesworth's *Voyages* and Patrick Brydone's *Tour in Sicily*. See Paul Kaufman, *Borrowings from the Bristol Library 1773-1784* (Charlottesville: Bibliographical Society of the University of Virginia, 1960), pp. 121-22.


Altick, *English Common Reader*, p. 47.


Binder, *Social Context*, pp. 12-13. Binder totaled up the number of these various organizations that helped diffuse matter. Taking the number of London coffee houses, 275, adding the number of circulating libraries of various kinds and book clubs, a minimum figure of just under 1,500 resulted. This was a conservative figure since it did not include coffee houses outside the capital, magazine clubs, or consider the instances where libraries and clubs might have received more than one copy of a periodical. He also did not figure in the other types of organizations such as natural history and antiquarian societies. He likewise did not account for the copies that went to the government and business offices, church rectories and schools.


Reviewing for money especially was considered ungentlemanly. Also some professions did not look favorably on their members contributing to periodicals.

See Nangle, *Indexes*. Unfortunately fire destroyed the editorial offices of two of the major publications, the *Critical Review* and the *Gentleman's*, in the early nineteenth century. The identification of some of the contributors for these two serials was probably lost forever. See Roper, "Politics of 'Critical Review'," p. 122; John Nichols, "The Rise and Progress of the [*Gentleman's*] Magazine; with Anecdotes of the Projector and His Early Associates," in *General Index to the Gentleman's Magazine from the Year 1787 to 1818* (2 vols.; London: Printed for John Nichols and Son and J. Harris and Son, 1821), I, lxxviii.
Nichols, "Rise and Progress," I, lxxiv-lxxviii; Binder, Social Context, pp. 61-62, 137-82. Nicholas, who was associated with the Gentleman's, named 525 contributors to that serial in the period from 1731 to 1818. Most of these people supplied letter, poems, or comments. Correspondence of this kind comprised between 20 and 25 per cent of the magazine. The authors were not identified as to specific articles, number of contributions, or subject matter. Binder warned this list might have reflected Nichols' bias in favor of the world of letters. He might also have been attempting to advertise the excellence of his contributors and selected the most eminent of them.

Binder, Social Context, pp. 53-54, 117-36.

Ibid., pp. 63-64.

Nangle, Indexes, pp. 4-5.


Elizabeth Eaton Kent, Goldsmith and His Booksellers (Ithaca: Cornell University Press, 1933), pp. 14-16. The D.N.B. article on Griffiths incorrectly stated he received his degree from the University of Philadelphia (now the University of Pennsylvania).

A. H. Millar, "Rotheram, John," *The Dictionary of National Biography*, XVII, 300,


A large group of men contributed a lesser number of reviews on natural history. These authors and the number of articles they furnished are:

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of Articles</th>
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<td>Samuel Badcock (1747-88)</td>
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<td>Edward Bancroft (1744-1821)</td>
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<td>Andrew Becket (1749-1843)</td>
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<td>John Berkenhout (1731?-91)</td>
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<td>John Campbell (1708-75)</td>
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</tr>
<tr>
<td>Edmund Cartwright (1743-1825)</td>
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<tr>
<td>A. Chisholme (not positively identified)</td>
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<td>Samuel Clarke (1728-60)</td>
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<tr>
<td>Thomas Cogan (1726-1818)</td>
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<td>William Enfield (1741-97)</td>
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<td>John Gillies (1747-1836)</td>
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<td>Oliver Goldsmith (1728?-74)</td>
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<td>James Grainger (1721?-66)</td>
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<td>John Hawkesworth (1715?-73)</td>
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<td>Jabez Hirons (1728-1812)</td>
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<td>James Kirkpatrick (c.1700-?)</td>
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<tr>
<td>John Langhorne (1735-79)</td>
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<td>Sir Tanfield Leman (1714-62)</td>
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<td>William Ludham (1714-88)</td>
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<td>Charles Wildbore (d. 1802)</td>
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94 [Tobias Smollett], review of Browne, Ibid.


CHAPTER III
THE INTELLECTUAL SETTING OF NATURAL HISTORY

Jean le Rond D'Alembert (1717-83), the great French mathematician, referred to the eighteenth century as the "philosophical century." In England and France the Enlightenment began when men such as Isaac Newton and John Locke broke down the older forms of philosophical knowledge, the metaphysical systems. Men lost faith in the "spirit of the systems," which served as an obstacle to philosophical reason. While renouncing and opposing the "spirit of the systems," the intellectuals of the eighteenth century furthered this same spirit in another and more effective manner. The result was a new "systemic spirit" that did much to further the progress of science.¹ The eighteenth century was pre-eminently the age of faith in science.² All enlightened men agreed in finding in the pursuit of science the sum of human wisdom. Buffon, for example, stated, "What enthusiasm is nobler than believing man capable of knowing all the forces and discovering by his labors all the secrets of nature?"³
During the Enlightenment, the philosophes campaigned to change man's thinking and to improve man's lot. Their battles were fought on all fronts: law, morality, ethics, art, literature, physics, and natural history. The scientific aspects of the philosophes' program were as significant as the legal and literary phase. Buffon and other naturalists have often been overlooked by historians. Historians of science, however, have been working to make a balanced picture possible.

During the seventeenth century, intellectuals developed an appetite for new knowledge about the world. The interest at first manifested itself as an idle curiosity about signs, portents, marvels, monstrosities, and freaks of nature. This crude desire for knowledge evolved into a widespread intellectual expansion during the eighteenth century. The quality and quantity of scientific knowledge improved greatly during this era, and demand increased for popular works on science. The growing volume of science in the British periodicals reflected this trend.

Perhaps the first and best writer of popularized science in the first stage of the Enlightenment was Bernard
le Bovier de Fontenelle (1657-1757). His *Dialogues of the Dead*, published in 1683, and *Conversations on the Plurality of Worlds*, issued in 1686, were extremely elementary expositions designed for the delectation of people of fashion in France. The 1686 book, *Conversations*, was an introduction to the Copernican system of astronomy. Up to that time only a handful of intellectuals understood and accepted the theories of Copernicus. Because of the extraordinary simplicity and clarity of *Conversations*, it remained the best initiation to astronomy for over a century. *Conversations* enjoyed immense popularity and numerous editions appeared in both France and England.

Fontenelle's exposition of astronomy was so influential that the Englishman, Sir Richard Steele, used *Conversations* as a literary model for the *Tatler* and the *Spectator*, the unique new cultural medium described above, half newspaper, half periodical.

Fontenelle was more than an amateur scientist and popularizer. He served as Perpetual Secretary of the French Royal Academy from 1697 until 1740. One of his duties each year was to write the history of the Academy. This involved reading old *Mémoirs*, assessing the scien-
tific importance of each, and writing an abstract of each. He did this task with a skill rarely surpassed. His comments on the biological issues of generation and spontaneous generation showed depth and perception. He delineated the many complex theories of generation and separated observed facts from speculation.\(^7\)

The study of all branches of science became increasingly popular in the late seventeenth century. Science was generally designated by the term "natural philosophy." The expression encompassed what today is denoted as medicine, chemistry, physics, biology, and everything else that was remotely connected with the phenomena of nature. In England a natural philosopher worthy of being a Fellow of the Royal Society was interested in all of them, even though he might, like a Newton or a John Ray (1627?-1705), acquire the reputation of virtuoso in one particular area.

Then, during the eighteenth century, one branch of natural philosophy became increasingly popular. This segment was known as "natural history" and included in a general way the animal, vegetable, and mineral kingdoms.

There were good reasons why during the eighteenth century no branch of science developed in England as
rapidly as natural history. The British had a long interest in botany that stemmed from the ancient necessity of gardening. A more practical reason for the study of plants throughout the Western world was the search for materia medica that could be used for the treatment of disease. Although the study of animals was considered less "genteel" than botany, by 1760 it too was generally included in the study of natural history, mainly through the spread of the new perceptions of Linnaeus.

About the middle of the century not only did the popular magazines begin competing with one another in catering to the interest of the reading public in natural history, but natural historians wrote books to appease an increasing demand for knowledge about the subject. The first index of the Monthly Review, for 1749-84, for example, listed 348 reviews of books on natural history. Collinson testified in a letter to Linnaeus in 1747: "We are very fond of all branches of Natural History: they sell the best of any books in England."  

While in Britain proper many scientists were pushing out the boundaries of natural history, much of the impetus to study came from abroad. The British, with their large
navy and merchant fleet, were especially active in the exploration of the globe. Amateur collectors, traders, and seamen shipped back to Great Britain a steady stream of plants, rocks, and animals. Many of these items came from Englishmen in the New World by way of the "natural history circle." The editors of the British periodicals obtained much of their natural history copy from this informal group of naturalists.

Many scientists of the period wrote on a staggering array of topics. Although many men demonstrated more interest and ability in some areas than in others, all of them were generalists. There were physicians who were recognized botanists, zoologists, and astronomers; ministers of the Gospel who served as physicists, botanists, zoologists and meteorologists; farmers, planters, ship captains, and civil servants who had natural philosophy as an avocation. The entire corpus of science was still within the capacities of a single scholar. The scientific activities of Joseph Priestley and Henry Cavendish, for example, almost defy summary.

The geographical location of British science changed markedly in the eighteenth century. London had been the
center for science in the previous century, especially after the founding of the Royal Society. In the eighteenth century, British science took on a decidedly provincial flavor. The new industrial cities of the midlands such as Leeds, Birmingham, Manchester, Bristol, and Newcastle upon Tyne among others, established scientific and philosophical societies. In Scotland science flourished in Edinburgh and Glasgow. The contributors of natural history to the periodicals reflected this decentralization of science. They lived in all parts of the British Isles and even in some of the colonies.

At the same time that natural history was flourishing, formal scientific institutions in Britain in the eighteenth century were in a state of decline. The foremost body, the Royal Society, stagnated during this period. Less than half of the Fellows were practicing scientists, properly speaking, and the rest were social and honorary members. Real reform did not come until the nineteenth century.14

The problems of the Royal Society were also reflected in the decline of its semi-official publication, the Philosophical Transactions. In the early eighteenth century the Transactions carried many trivial articles. Papers on
such topics as killing rattlesnakes, monstrous births, and
the raising of fish (put them in water) were far too
common. Many of the popular British periodicals contained
scientific articles which were comparable in quality to
those in the *Philosophical Transactions*. John Hill (1716-
75), a London apothecary and naturalist whom the Fellows
had snubbed in his efforts to join the Royal Society,
wrote in 1751 a stinging satire on the *Transactions*. Hill's
*Review of the Works of the Royal Society* demonstrated much
common sense and a desire to make science, especially
natural history, a reputable undertaking. The attack drew
much attention and led almost at once to changes of policy
announced by the Royal Society in March, 1752. The
society took responsibility for the *Philosophical Trans-
actions* away from the secretary, Dr. Cromwell Mortimer, and
the society as a whole assumed it. The Royal Society
appointed a committee to "reconsider" and "select" the
papers "most profitable" for publication. The result was
a somewhat better quality of scientific papers in the pub-
lication.15

Science in the English universities in the eighteenth
century was in a worse condition than in the Royal Society.
The Test Act excluded from Oxford and Cambridge Dissenters, Roman Catholics, and Jews, who made up a large proportion of the population. Within the universities favoritism was rampant, and a fellowship or chair was regarded as a sinecure; the obligation to teach or lecture was conveniently forgotten. Except for mathematics, little science was taught at the universities. Wealthy students dominated the universities, which could be described as little more than exclusive and somewhat eccentric clubs. An Englishman who wanted a good scientific or medical education usually went to Holland or Scotland. The University of Edinburgh in the late eighteenth century was the best university for science in the world and had lecturers in all scientific disciplines.¹⁶

The decline of the Royal Society and the stagnation of the English universities were the symptoms of a larger degeneration in British science. During the first half of the century, Britain produced no really first rate scientists in any area with the possible exception of Stephen Hales. This was a temporary phenomenon partly the result of the magnitude of achievements of the preceding century. In the latter part of the eighteenth
During the eighteenth century a significant shift occurred in the social class origins and educational background of the scientists. In the previous century a majority of the scientists came from England's upper classes. By 1800 only 18% of the scientists were from these social groups. At the beginning of the seventeenth century a majority of the scientists received their early education at one of England's great public schools or had been privately tutored. These men also attended Oxford or Cambridge. By 1800 only 16% of the scientists had obtained their education at a public school and merely 20% were graduates of the two universities. Clearly scientists were increasingly receiving their instruction outside of the public schools and the universities (see chapter two).

The scientists of the eighteenth century were mostly amateurs. They were not gainfully employed as scientists, or, if self-employed, there was no evident connection between their occupation and their scientific endeavors. Little opportunity existed for men to earn a living by
carrying out scientific research in this period. Only the Astronomer Royal received a stipend for his work as a scientist (and that was the small amount of 100 pounds), and the universities had few posts which required scientific training.\textsuperscript{20} As already noted, the contributors to the British periodicals were for the most part professional men.

An "amateur" in the eighteenth century was, however, not necessarily a dilettante, nor does "amateur" indicate an inferior degree of ability. Perhaps this will be clear when it is pointed out that amateurism was not confined only to science. Edward Gibbon, for example, was an amateur historian as David Hume was an amateur philosopher. Such men whether scientists or not, are best described as devotees, and the quality of their amateurism can be discovered in the tributes paid to them.\textsuperscript{21}

The educated public held many different and often conflicting ideas on just what constituted natural history. In spite of divergent notions, most literate people of the eighteenth century had a workable conception of what was included under the heading "natural history."
Natural historians in the eighteenth century often regarded their subject as the study of God's world. The author of the article, "Natural History," in the second edition of the Encyclopaedia Britannica (1781) pictured natural history as a reflection of God's wisdom:

Natural History is that science which not only gives complete descriptions of natural productions in general, but also teaches the method of arranging them into classes, orders, genera, and species. This definition includes zoology, botany, mineralogy, etc. But as a science so comprehensive could neither with propriety nor advantage be completely discussed under the general title, we have to refer the reader to the article Kingdoms. In the present article it is proposed to give a general and philosophical view of the subject. To set forth, in a summary way, whatever curious, worthy to be known, or not obvious to every observer, occurs in the three kingdoms of nature: with their constitution, laws and oeconomy; or, in other words that all-wise disposition of the Creator in relation to natural things, by which they are fitted to produce general ends and reciprocal causes.22

William Swainson (1789-1855), a naturalist of the early nineteenth century, went even further and claimed that natural history involved the study of God's perfect and unchanging world as opposed to man's imperfect creations:

It may be received as an indisputable truth, that no studies are so well suited to the intellectual powers of man, as those that relate to the forms and phenomena of Nature. Between
these, and such as are confined to human skill or to human erudition, there is this remarkable difference: that in the former we contemplate things which in themselves are perfect, because they emanate from the Fountain of Perfection; whereas in the latter our attention is absorbed in things which, at the best, are imperfect, however learned or acute may be the labours of their authors. The painter or sculpter may delight us by the faithfulness of their delineations; the poet may please us by the harmony of his verses; the historian instruct us by the narrative of circumstances and persons before unknown to us. But all these subjects, however interesting or pleasing, are alloyed with that imperfection and unsatisfactoriness which enter into every human performance. . . . If, on the other hand, we turn to those studies which more immediately concern Nature, we find a marked difference both in the facts and in the deductions. Here we have to do with things immutable, and with objects perfect in structure. Our mental perceptions are employed in contemplating phenomena which have remained, for the most part unchanged from the beginning, and will continue unchangeable so long as the laws which govern the universe remain in force. Here is no extinction of the species, no power of detecting imperfections, no regrets at the insufficiency of the artificer, no lamentations that such things will pass from the earth, and be forgotten. Nature is ever the same—ever young—ever the handmaid of One who cannot err. Her operations in the physical world were the same a thousand years ago as they are now; and if the works of her commentators are no more remembered, this oblivion originates not in any change in the things they treated of, but in the errors or insufficiency of the describers.23

In the British periodicals, some naturalists introduced God into natural history in unusual ways. The role of God
in nature will be explored in detail in future chapters.

Some naturalists, especially in the periodicals, stressed the more practical aspects of natural history and relegated God to the realm of the theologians. A writer in *The Complete Dictionary of the Arts and Sciences* in 1754 included in his definition of natural history: zoology, botany, agriculture, gardening, husbandry, mineralogy, hydrology, hydrostatics, hydraulics, navigation, aerology, meteorology, pneumatics, optics, perspective, and painting. An anonymous reviewer of the Dictionary in *Scots Magazine* concurred that natural history was a useful pursuit:

> Natural History constitutes a branch of knowledge on which depends the very life and well-being of mankind: for so close is our connection with the various productions of Mother Earth, that whilst some serve us for food and medicine, and others for dress and ornament, there are others which supply our manifold necessities, shelter us from the inclemency of the weather, defend us from the hostile attacks of our enemies whether of the human or brutal kind, waft us over immense oceans, and, in short, procure us all the conveniences as well as necessaries of life.²⁴

A few intellectuals of the eighteenth century characterized natural history in even broader naturalistic terms. The writer of the article "Natural History" in
Nicholson's *Encyclopedia* (1821) interpreted the subject to include the universe and everything in it:

> Natural history, taken in its most extensive sense, signifies a knowledge and description of the whole universe. Facts respecting the heavenly bodies, the atmosphere, the world, and indeed all the phenomena which occur in the world, and even those which relate to the external parts, as well as the actions of man himself, so far as reason can discover them, belong to the province of natural history.\(^{25}\)

Some writers tried to divide natural history and natural philosophy on the basis of the physical properties and processes in nature. These properties and processes included the primary laws of nature such as gravity. An author in the *Edinburgh Encyclopedia* (1832) defined natural philosophy as "that branch of knowledge which treats of the action of natural bodies upon one another when that is not accompanied by any permanent change in their internal conditions."\(^{26}\) A similar definition appeared in *Chamber's Cyclopaedia* in 1781. Natural philosophy was the "science which considers the powers of nature, the properties of natural bodies and their actions on one another: this is otherwise called physics."\(^{27}\)

Another approach is to separate these two areas by using the differences in methodology. One modern historian
of science points out that the natural historians worked by observation and classification of the world around them, while natural philosophers or physicists gathered information by experiment and calculation. Another contemporary writer emphasizes that the study of natural history involved almost no mathematics.

This approach was vigorously denied in 1834 by Swainson. He asserted that the rules and methods governing all areas of science were the same: "He who considers that natural history is to be studied by rules different from those by which all other physical sciences are prosecuted, is totally unfit to meddle with it." He went on to state that all areas of science had the same goal; to discover the primary laws of nature. Swainson continued:

Natural history has generally been termed a science of observation; and such in a restricted sense it undoubtedly is. The error of the definition is this, not that it is untrue, but it is partial and insufficient. . . . As it is with astronomy and chemistry, so it is with natural history: the knowledge of individuals, and of facts which belong to them, is undoubtedly the basis upon which this and all other sciences repose: but if the zoologist or botanist contents himself with this information, --if he remains satisfied
with isolated description drawn up in the name of a system, of hard names, he has no more right to term his pursuits intellectual, or to dignify them with the name of science than the astronomer who merely classifies, names, and computes stellar magnitudes. All branches of natural science, however varied may be their materials, or however diversified their nature, have but one and the same object in view—the discovery of the primary laws of nature. All sciences are based upon facts, known, or to be known from experience, so are they in their early state of development, matters of pure observation. It is only when we have acquired the power of generalising these facts that the theory of a science becomes either absolutely demonstrative or approaches so near to certainty, by force of analogical reasoning, that it is not contradicted by any thing known. The case for natural history, then is precisely this: In its early stages it is a science of observation; in its latter, it is one of demonstration. But the question resolves itself into this. Are there any fixed and universal laws by which the variations of the forms of nature are regulated?

Natural historians, therefore, reached no general explicit consensus as to what constituted the realm of natural history. But, by their works they explicitly spelled out some boundaries of their concerns.

Natural historians wrote two broad types of works. The first sort was the general natural history. This was usually a study of one kind of thing such as shells, fishes, minerals, or plants. A good model of the general treatise
was History of Quadrupeds published by Thomas Pennant in two volumes in 1781. He described and classified all of the known quadrupeds in the world. Each article contained a short portrayal of the distinctive characteristics of the animal, synonymous common names in other languages, the scientific names assigned to it by other scientists, and finally a page or two about the habits and economic value. Works of this kind were very popular. History of Quadrupeds went through several editions. The British periodicals contained many articles and reviews of works of general natural history.

A particular natural history was the second kind of tract. The author of this type usually dealt with a geographic area and included a wide range of subject matter. Robert Boyle (1627-91) supplied the prototype in the first volume of the Philosophical Transactions in 1666. Boyle did not write any natural histories but he merely supplied a list of the kinds of things a good one should include. He divided the subject into facts about the heavens, air, waters, and earth. Under the heading of heavens, Boyle included longitude, latitude, length of days, and visible stars. Observations about the air comprised temperature,
weight, clearness, seasonal variations, winds, diseases, and rainfall. Boyle's category of waters embraced depth, tides, currents, and saltiness of the sea; depth, length, course, quality, and gravity of rivers, lakes, springs, and information about fishes. He listed under the topic, "earth," a long catalogue of items: dimensions, situation, figure, plains, valleys, hills, mountains, promontories, fires, mines, soil types, and plants. He also included information about the people, their stature, diet, customs, education, and birthrate. He inquired, perhaps with an eye for economics, about the grasses, grains, fruits, herbs, flowers, timber trees, forests, wild and domestic animals, minerals, quarries, earths, and metals. Anyone who wrote a discourse containing all this information would have a first-rate work of local geography. Boyle's scheme was widely copied during the eighteenth century, especially in encyclopedias.

The most famous eighteenth century work on particular natural history, and one which loosely followed Boyle's plan, was Gilbert White's *A Natural History of Selborne* published in 1789. White (1720-93), curate of a small Hampshire parish, recorded his observations of the area, thirty-miles...
in circumference, with a critical eye that has seldom been equaled and missed nothing of interest in the animal, vegetable, or mineral kingdoms. Perhaps White's and Boyle's conceptions of natural history gives a sound basis for defining a particular kind of study. Natural history was the study of the natural world around man, and included what we would now call the disciplines of botany, zoology, geography, paleontology, mineralogy, geology, and meteorology.

British natural historians tended to embrace two contradictory approaches to science during the eighteenth century. Many British scientists followed the scheme of Francis Bacon (1561-1626), the famous English philosopher. He had emphasized that the collection of facts about nature was the first step toward science. Bacon believed that when these facts and results of experiments were gathered together into books or "natural histories," as he called them, only then could science make real progress. After scientists had completed the preliminary collecting of information, then they could proceed to develop their hypotheses and theories. The Baconian approach to science was a worthwhile one, since it urged the scientist not to
enter into a lot of abstract speculating before he had relevant facts. 36

Scientists of the eighteenth century also provided much non-Baconian science. A researcher had to have discipline to sustain him through methodical collecting of facts and exhausting experiments, and restraint to resist drawing premature conclusions. Many eighteenth century naturalists unfortunately lacked discipline of either kind. They often indulged their imaginations in almost poetic outbursts of speculation meant to serve the purpose of scientific explanation. 37 The sheer mass of new and exotic plants, animals, rocks, and other assorted scientific discoveries that descended upon British scientists in the eighteenth century from the four corners of the earth was enough to overwhelm anyone.

The natural history in the periodicals closely reflected the eighteenth century British attitudes toward the relation of science and religion. British scientists traditionally had been pious men. Newton, Boyle, Ray, John Wilkins, and others all saw evidence of God's wisdom in the natural world. Not only were science and religion closely intertwined, but most natural historians attempted
to reconcile any obvious contradictions in the two realms. 38

During the eighteenth century, British clergy often stressed the importance of nature and scientific study in supporting religion. Cotton Mather (1663-1728), who was a divine in what was surely the Western world's most thoroughly religious civil society, wrote in 1721 that the new science was Christianity's handmaiden. 39 Priestley, a Unitarian minister in addition to being a scientist, believed that a life spent in scientific pursuits was very worthwhile. He noted:

What great and exalted beings would philosophers be, would they but let the objects about which they are conversant have their proper moral effect upon their minds! A life spent in the contemplation of the productions of divine power, wisdom, and goodness, would be a life of devotion. The more we see of the wonderful structure of the world, and the laws of nature, the more clearly do we comprehend their admirable uses, to make all the percipient creation happy: a sentiment, which cannot but fill the heart with unbounded love, gratitude and joy. 40

The Reverend Dr. Samuel Horsley (1733-1806), a mathematician, physicist, and astronomer in addition to being a pillar of Anglican orthodoxy who later became bishop of St. Asaph, claimed in 1801 that every clergyman had an
obligation to possess a knowledge of science and to encourage its development in the universities. He denied that a Newtonian approach to science required the adoption of a mechanistic image of ultimate reality. He regarded the laws of inertia and gravitation as proof of the primacy of the spirit.\textsuperscript{41}

The Enlightenment had distinctive features differentiating an English from a French version. In eighteenth century France, scientists and philosophers were, for the most part, militant enemies of religion. In England, that peculiarly English phenomenon of the alliance between science and religion persisted until nearly the close of the century. The succession of English physio-theologians from Bacon, through Boyle, Locke, Newton to Priestley, remained largely unshaken by the intellectual turmoil on the Continent.\textsuperscript{42} The differences between the British and French intellectual climate were obvious in the writings of natural historians in the periodicals. French naturalists were much more likely to formulate theories which undermined certain tenents of orthodox Christianity. This tendency was most apparent in the theories of cosmogony which will be examined in chapter four.
British theologians and scientists looked to nature for different kinds of inspiration in the eighteenth century. During the first half, they emphasized the orderliness of the universe, believing that the new discoveries of science furnished illustrations of God's wisdom in the creation. This point of view was very common in the periodicals of the day. In the final half century, the leaders of thought stressed how the homely things of the English countryside were elucidations of the wisdom of God. This change in accent was also tied into the pre-romantic movement, a phenomenon of the late eighteenth century that heralded the end of the Enlightenment.

By the mid-century, the Christian, the deist, and the atheist in England maintained very similar basic attitudes toward the authority of nature in settling theological and philosophical disputes. The difference was one of degree, measured by the extent to which each one regarded natural revelation as having supplanted the necessity of supernatural intervention. Indeed, the persistent scrutiny of the credentials of Christianity in the light of nature and of new science, characteristic of the deist's attitude, could lead through a mechanistic view of life and thought to what was virtually an atheistic outlook.
Religion in eighteenth century England was firmly founded on reason. A few dissenters like the skeptic Hume and Evangelical clergymen such as John Wesley and William Law implied that reason was irrelevant to religion or that religion could not be founded on reason. Most articulate thinkers, however, continued to believe in the rational demonstration of Christianity. Nothing shows the faith in reason better than the outraged reception that greeted the skepticism of Henry Dodwell, Jr., who wrote a book called, *Christianity Not Founded on Argument* in 1743.45

Yet despite the intermingling of natural history, natural philosophy, and religion, since the seventeenth century there had been certain latent incompatibilities in educated men's views of the universe. Newton, Boyle, and Ray had attempted to weld into a single philosophy of nature two not entirely reconcilable conceptions. First, they viewed nature as a system of matter and motion bound by laws. Second, they looked upon nature as a habitation created for the use and edification of intellectual beings by an omnipotent, omniscient, and benevolent God. These two ideas dwelt side by side for a long time in men's minds in a state of tension. The doctrine of creation
postulated a stable universe created and conserved by God. But the concept of a self-contained system of matter in motion, naturalism, seemed to imply the transiency of all particular structures provided by the combinations and permutations of the system.

In support of the immutability of nature, many natural historians introduced an old idea, the great chain of being into their arguments. They viewed the inorganic and organic worlds as a plenum of graded entities. God in the beginning had fashioned every form of object which could possibly exist. The universe still remained in its original form after almost 6,000 years (see chapter five).

The debate over the immutability of nature of course appeared in the periodicals in the late eighteenth century. The difficulties occurred in various areas of natural history. The struggle between religion and science first emerged in the discipline of geology after 1760. Before that time the diluvian theory of fossils was not seriously challenged, and although theories on the origin of the earth were numerous and abstract, most writers struggled to vindicate Genesis. Voltaire even chose to regard fossils as an argument for Christianity. Late in the
century difficulties arose in France. Buffon, Claude Nicholas Le Cat (1700-68), a French surgeon, and others all put forth theories on the formation of the earth that diverged sharply from the Biblical account. Only about the turn of the century in Britain did people really begin to suspect that Genesis and geology were going in different directions. In botany and zoology, the fixity of species was assumed by most men throughout the eighteenth century. If anything, Linnaeus fortified the static view of species in the second half of that century. The actual development of evolutionary biology lay almost entirely in the next centennium. The real struggle between science and religion was to come in the nineteenth century. 47

Even after the scientific revolution of the sixteenth and seventeenth centuries, many remnants of Aristotelianism remained embedded in the scientific corpus. Various aspects of the chain of being can be traced directly to Aristotle. Numerous eighteenth century scientists still considered Aristotle's four elements, earth, water, fire, and air, as the basic building blocks of the earth. They continued to assume that the two heavier elements, earth and water, sought their natural location at the center of the earth
while the other two lighter elements moved toward the heavens. The naturalists believed this natural movement of elements accounted for diverse phenomena such as waterspouts, earthquakes, or volcanoes. A few writers even stressed the Aristotelian notion of the eternity of the world.

A more recent addition to scientific thinking was the idea of immanence (the theory that nature was governed by subtle fluids). This belief had its origins in Newtonian philosophy. Many scientists in the eighteenth century were obsessed with the supposition that one or more of these subtle fluids caused gravity, light, heat, plant and animal motion, and other natural activities in the world. With the discovery of the electrical nature of lightning, many scientists were convinced that electricity was the subtle fluid (see chapter six).

Natural history, like other branches of knowledge, was deeply affected by certain broad intellectual developments of the eighteenth century. This was an age of reason based upon faith. Educated men had confidence in the stability and regularity of the universal frame of nature. By 1789, however, the age of reason was rapidly
turning into an epoch where man responded emotionally to the world around him. The famous *cogito ergo sum* of René Descartes was superseded by the *je sens, donc je suis* associated with Jean Jacques Rousseau. This change culminated in the romanticism of the nineteenth century.
FOOTNOTES


7Garrison, "Medical and Scientific Periodicals," pp. 296-97.


19 Ibid.


22 "Natural History," *Encyclopaedia Britannica; or, A Dictionary of Arts, Sciences, etc.* (2nd ed.; Edinburgh: Printed for J. Balfour and Co., 1781), XIV, 5299.


28. Gillispie, Genesis and Geology, pp. 16-17.


31. Ibid., pp. 104-106.

32. History of Quadrupeds was actually a revision and enlargement of an earlier work, Synopsis of Quadrupeds, by Pennant. Synopsis was a one volume book published in 1771.


35. Ibid.


39 Stromberg, Religious Liberalism, p. 22.


44 Carl L. Becker, The Heavenly City of the Eighteenth Century Philosophers (New Haven: Yale University Press, 1932), p. 53; Willey, Eighteenth Century Background, pp. 2-8; Raven, Natural Religion and Christian Theology, pp. 143-44.

45 Stromberg, Religious Liberalism, p. 10.


CHAPTER IV

GOD IN NATURE

In almost every new issue of the periodicals there were articles on geography, geology, botany, zoology, paleontology, mineralogy, or meteorology. The articles exposed many unsolved problems, and from time to time pointed to new questions. During some periods certain issues became quite controversial. The authors of articles and the authorities they cited changed through time. Yet it is possible to make sense out of this mass of material. Three different themes unified the area of natural history: God in nature, the great chain of being, and the doctrine of immanence.

These themes were very much a part of the thinking of the typical eighteenth century natural philosopher and natural historian. In a general way, these men were desperately attempting to make some sense of a material world that was still very much of a mystery. In addition, for most naturalists, God was a part of the natural world and some of them interpreted the Bible literally in the eighteenth century.
What role had God played in the established order of events, the authors repeatedly asked, particularly what part had He performed in the formation of the solar system and the earth? Writers in the periodicals, especially the analysts in the *Monthly Review* and the *Critical Review*, provided some excellent accounts of the many new cosmogonical systems proposed in the eighteenth century. Some of the most analytical, objective, and detailed articles which appeared in the periodicals were the reviews of various books on cosmogony.

The editors of the periodicals provided extensive accounts of the diverse theories proposed by Continental writers on the formation of the earth. The hypotheses of some French cosmogonists provoked a great deal of discussion in Great Britain. French writers especially questioned whether the description in Genesis of the creation of the earth could be literally interpreted.

Most men, since the ancient Greeks, had believed that God played an active part in the universe. Isaac Newton in the seventeenth century allowed a small role for Him in his mechanistic scheme of the universe. Only toward the end of the next century did Joseph Louis Lagrange, Pierre
Simon Laplace, and other French mathematicians and astronomers show that the solar system was a perfectly self-regulating mechanism and that there was no need for involving God in the daily or yearly movement of the planets. Even if the idea of an immanent God lost favor in the eighteenth century, the concept of a transcendent God, one who in the beginning created the universe, remained firmly a part of most men's thinking. God as a First Cause was still a fundamental part of the deist's model of the universe. Christians of a more orthodox vein accepted the account of the creation of the earth that appeared in the Book of Genesis.

The belief that God had played, or was still playing, a part in natural phenomena created problems for the scientists in the eighteenth century. As previously mentioned most of them were devout Christians or at least deists. Difficulties arose when scientists realized that there appeared to be conflicts between their religious beliefs and their work as investigators of the natural world. The puzzle perhaps was not so much a matter of religion versus science but a dilemma of religion still being a part of science.
A great many natural historians of the early eighteenth century believed the account of the formation of the earth in seven days by God as the process was depicted in the Bible. They also accepted, for the most part, the record of the Mosaic flood which covered the earth. The natural historians assented to the intervention of God but they still attempted to provide an explanation of His methods based on the laws of science. They sought sound, reasonable, scientific interpretations that would support the Biblical texts. When studying geology, for example, some natural historians tried to resolve what happened to all the water from the flood. Others tried to explain how Noah was able to collect, house, and feed all the hundreds of animals on his ark.

In many instances, the problem was how to reconcile the Bible with natural laws and observations when the two seemed to be in direct conflict. Often the natural historians, to their way of thinking, were successful in resolving their dilemmas. About 1750 some natural historians began to move away from any attempts at reconciliation. They concentrated solely on trying to explain the formation of the earth by using natural laws. If threatened
by clergymen, these naturalists made only a feeble effort to harmonize the Bible and geology.

A number of new and fanciful theories of cosmogony appeared in Europe during the seventeenth century. Several writers attempted to propound theories that accounted for the origin of the earth and universe in harmony with the teachings of Christianity. Science had not advanced far enough to afford any firm basis for cosmogonical speculation. As a result, the theories were very abstract and speculative. British clergymen and physicians were especially prone to engage in this type of activity. The craze reached its height at the end of the century with the publication of cosmogonical theories by Thomas Burnet (1635?-1715), William Whiston (1667-1752), and John Woodward (1665-1728). Their ideas provided the basis for most of the cosmogony found in the periodicals during the eighteenth century.

Burnet published his *Sacred Theory of the Earth* in 1681. As the title indicated, he meant to support orthodox religion. He stated that in the beginning the earth was a fluid heterogeneous mass. The heaviest parts formed a solid body which became the core of the earth. Water
surrounded this center, and the lightest materials were above the water. Impurities then settled out of the air onto the oily surface of the water. These particles formed the smooth shell of the earth, and the planet remained in this state for 1600 years. The sun dried out this shell, and eventually it cracked and the water came up from the center of the earth. Such was the Mosaic flood recorded in the Bible. Finally, chunks of the old crust floated to the surface and became the islands and continents of the present world.  

Woodward wrote his Essay Toward a Natural History of the Earth in 1695. He also proceeded in the supposition that the Mosaic history was true. He concerned himself mostly with the flood. Woodward believed that at the time of the deluge the outer layers of the earth became dissolved. The solution gradually settled out according to the specific gravities of the components and formed the various rock strata. The fossil remains of plants and animals also were deposited in this process. This settling produced an earth with layers like an onion.  

Whiston published his New Theory of the Earth in 1696. He suggested that the earth originally was an uninhabited
comet in a state of chaos. On the first day of creation every material in this rude mass began to arrange itself according to its specific gravity. The heaviest substances formed the core of the earth, heavy fluids settled on top of this core, and the crust floated in the heavy liquid. Whiston believed the light appeared, as was described in Genesis, and then gradually the crust settled and formed mountains and valleys. The antediluvian earth supported more plant and animal life than the present earth due to the warmer climate caused by the hot central core. A comet approached the earth and caused the deluge with its gravitational field, by forcing the ocean water over the land surface and breaking open the crust which caused the underground abyss to flow to the surface. In addition to all this water, the tail of the comet also deposited a large amount of water vapor in the atmosphere which resulted in the great rain storm described in the Bible. Wiston claimed a mighty wind dried up a large portion of the water, forced the rest back into the central abyss, and left the remaining water in the oceans, lakes, and rivers. 5

Most of the writers in the eighteenth century on cosmogony and the Mosaic deluge followed Burnet, Whiston,
and Woodward and attempted to give a scientific explanation that was compatible with the Scriptures. As the century progressed, naturalists increasingly based their theories more on the geologic evidence around them and less on a word for word reading of the Bible. After 1772 no naturalist in the periodicals here examined seriously attempted to construe the Bible literally.

One anonymous author in Fog's Journal in 1736 maintained that a Christian must accept on faith the Biblical accounts. Cave reprinted the article in his Gentleman's Magazine and stirred up a heated controversy. The anonymous writer cited two examples. First, he believed that no scientist could explain how the earth was repopulated so rapidly after the deluge. Secondly, the author believed that no one could give a rational interpretation of what happened to all the water that covered the earth during the flood.6

The unknown writer stated that Egypt embraced a population so large 20,000 towns could hardly contain the inhabitants. He wanted to know how it was possible for the three children of Noah to beget such a large number of people. He claimed that no writer had ever accounted for this sudden explosion in population.
According to the nameless author, the Mosaic flood presented even more difficulties. Experts had calculated that the oceans of the world did not contain enough water to cover the top of Mt. Ararat with fifteen cubits of water. He also mentioned a philosopher who determined that forty days of rain would have produced water sufficient to cover the early only 240 feet deep.

The anonymous author affirmed that no philosophers had ever solved these two problems and that further speculation about them was useless. The writer acknowledged that God could accomplish anything He desired and might conceal His means from the understanding of man:

But what signifies these vain disputes of the learned, which clear up nothing! To uphold the argument, that the deluge was not universal, but designed to punish an ungrateful people, is idle and ridiculous; it is bringing proofs of the designs of God against the word of God left us in the Sacred Books. Such useless enquiries do not consume the moments that might be better employed, and since it has not pleas'd the Divinity to transmit to us the means he used in re-peopling the world so early after the flood, it is sufficient to know that he who from nothing created the universe, who supports it, and who so wisely governs it, will meet with no difficulties in executing his designs.

An immediate response to the anonymous writer appeared in the next issue of the Gentleman's. A contributor who
identified himself as R.Y. wrote a total of seven long articles and attempted to refute the arguments of his opponent. R.Y. objected to the attack on science and even more strenuously protested the unknown writer's assault against human reason. R.Y. accused his adversary of attempting to introduce Popery into Britain! He wrote:

However it seems very plain to me, that the design of this perplexed discourse is by rendering the plain history of the creation, flood, etc. as incomprehensible as the most absurd Popish doctrines, to endeavor to introduce his beloved Popery into this island, for he thinks if he can persuade people that there is as unsurmountable difficulties in the history of the creation [sic], as in the most ridiculous Popish tenets, then those who can believe the one, will easily be persuaded to adhere to the other.9

R.Y. attempted to demonstrate that the oceans of the earth contained enough water to cover the land surfaces. In a long and abstruse explanation, he claimed that the antediluvian world had two large sections of land and water. The atmosphere above the water consisted of a turbulent incessant rain storm. During the Mosaic flood, God brought the rain over the land, which caused flooding and the shifting of the land and water masses. The result was the jumbled areas of land and ocean that compose the present earth.10
R.Y. reported the results of a detailed study he made of the histories of the Egyptians, Chaldeans, Scythians, Greeks, and Chinese. He claimed that all of the records of these civilizations were so inaccurate that no conclusions could be made about the size of their populations. R.Y. calculated that the historical accounts of the ancient civilizations only went back to 1400 years after the Mosaic flood. He wanted to provide a chronicle of the actual repeopling of the earth by the sons of Noah after the deluge but he asserted that he lacked space in the Gentleman's.

In 1744 Richard Yate, who may have been the previous R.Y., explained his theory of the antediluvian earth and the flood in a series of articles. He strongly emphasized that any theory of cosmogony must be both reasonable and consistent with Biblical revelation. Yate began his essay by attacking the hypotheses of Burnet, Whiston, and Abraham de la Pryme (1672-1704).

He accused Burnet of being both unreasonable and unscriptural. Burnet had claimed that the antediluvian earth had a crust that was perfectly smooth and level. A level earth, Yate believed, was not consistent with
scientific reasoning. If the earth were completely flat, then there would have been no mountains and hills to cause wind and rain and no small lakes and streams for aquatic animals. Yate stated that Burnet's scheme also conflicted with revelation. According to the Bible, Moses made mountains the standard of height for the flood. How then, Yate asserted, could Burnet claim the previous world had no mountains, when Moses stated every mountain under heaven was covered and the highest of them buried under twenty feet of water? Yate also objected that the Bible did not support Burnet's claim that the earth contained a large central abyss. The Scriptures did mention an abyss, but Yate believed the reference was to the ocean. He pointed out that Job spoke of the face of the abyss being frozen. 

Yate likewise disapproved of Whiston's allusion to the central abyss. If the abyss was connected to the ocean, then the gravitational attraction of the passing comet would have forced the water from underground into the oceans and the crust would not have burst. If, on the other hand, Yate argued, the water was sealed into a central abyss, then the comet's attraction would not have
been strong enough to break up the earth's crust unless the comet made a direct hit upon the earth. Yate believed that Whiston's claim that a mighty wind forced the water back into the central abyss was unsupportable. Finally, Yate presented a technical discussion of comets which he thought made Whiston's whole idea absurd.  

Yate also objected to the hypothesis of de la Pryme. The latter had claimed that the antediluvian earth contained external oceans and land surfaces supported by pillars. At the time of the flood, these pillars collapsed causing the land mass to sink and be flooded. At the same time the floors of the oceans rose and produced the land mass of the present earth. Yate could not understand how so many of his contemporaries felt de la Pryme's explanation was consistent with Scripture. Noah knew the flood waters had subsided because a dove returned with an olive branch. Yate wondered how an olive tree could grow in the ocean. He believed a shell-fish would have been a more likely omen. Also Yate pointed out that Moses expressly said that the rivers of paradise were the same as the rivers of the earth after the deluge.  

Finally Yate explained his own unique theory of the Mosaic flood. He presented a discussion of the proper
translation and meaning for some of the Hebrew words and passages in the Bible. Yate mentioned that Genesis 1:6-7 tells us "And God said, 'Be there an atmosphere in the midst of the waters, and let it divide the waters from the waters.' 'Twas thus God formed the atmosphere, and divided the waters under the atmosphere from the waters above the atmosphere--'Twas done." Yate felt that this water above the atmosphere acted as a filter and protected the antediluvian earth from harmful vapors and particles from space. He assumed this filtering action accounted for the Biblical fact that man had greater longevity before the deluge. The waters above the atmosphere also helped the scientist explain the Biblical fact that the antediluvian atmosphere and weather were calmer than at present. Finally, the upper water provided an explanation for the flood.

Yate asserted that God produced the deluge by moving the sun from the center of the earth's orbit and by altering the orbits of all the planets. This event had three effects, according to Yate. First, God modified the length of the year from the 360 days of Moses' time to the present 365½ days by changing the earth's orbit. Second,
God caused the seas on the earth to overflow the land. Third, God forced open the windows of heaven which resulted in the famous rain of forty days. The resulting chaos was a flood of 150 days duration. During the flood the soil and rock churned up by the original catastrophe settled out of the water and produced layers of rock and soil containing fossil remains. Finally God commanded the water to return to the sea beds and underground springs. Yate firmly believed his account was both Biblical and scientifically reasonable.  

An anonymous letter writer who styled himself "Philomathes Cantabrigiensis" disputed Yate's assertion that the concept of a central abyss in the earth was contrary to Scripture and scientific testimony. Philomathes cited evidence of the earth having water underground. He mentioned the aquatic fossils found deep in the earth, the moist soil far underground, the fertilizing effect of ground water and the general opinion of most philosophers who believed that the earth contained a large quantity of water. Philomathes also cited a number of Biblical experts and historians who agreed that the passages in Genesis which referred to the "fountains of the great deep" meant just what was stated.
Another concept which correspondents debated in the periodicals was the issue of whether the earth contained a central fire. Most of the articles on the matter dealt with volcanoes, which will be discussed later, but one letter writer concerned himself with the problem of what role, if any, the molten mass at the center of the earth would play in the final fiery destruction of our planet as prophesied in the Bible.

Paul Gemsage in a letter to the Gentleman's Magazine in 1753 disputed the claim made by many others that the central fire will eventually destroy the earth. He asserted that just because the Bible predicted a fiery end of the earth, naturalists need not assume that this conflagration will come from the bowels of the planet. Gemsage stated that nowhere in the Bible is any mention made of God using fire to create the earth or that the fire He will use to annihilate it must come from the earth itself. God, for example, might send a burning comet to ignite the planet.

For the most part, however, Gemsage drew upon natural examples to support his contention that the earth did not have a hot central core. He wondered how a massive fire
could burn deep in the earth without any spiracles or air vents. He asserted that volcanoes were not numerous enough to supply the necessary air, were not deep enough to connect to the center of the earth, nor did they produce enough smoke. He explained that the deepest of chasms and pits were a few thousand feet deep and that they gave no indication of any movement of air or smoke. Gemsage concluded by saying that his comments were only superficial observations thrown out to induce others to make a thorough investigation of the matter.  

Most writers on cosmogony, however, continued to concern themselves with the formation of the earth and the deluge. In 1766 an anonymous reviewer in the Critical Review analyzed a work by Samuel Pye entitled The Mosaic Theory of the Solar, or Planetary, System. Pye attempted to combine the description of the formation of the universe in Genesis with various eighteenth century natural philosophic concepts. Pye provided his own interpretation of the first chapter of Genesis in the language of contemporary science. The result was a rather unique mixture of science and religion. According to the reviewer, Pye presented his ideas in the form of ten "propositions": 
Prop. I. That the Mosaic creation is an historical account of the creation, and formation, of the solar or planetary system, exclusive of every other being, or system of beings, in the universe.

Prop. II. That by the heaven or heavens, Moses manifestly means the heavenly bodies, which together with our earth compose the solar system.

Prop. III. That when Moses says, in the beginning God created the heaven and the earth, he is to be understood to mean, that God out of nothing made, or commanded into existence the several masses of matter, of which those heavenly bodies and this earth do consist.

Prop. IV. That these several masses of matter were, at their creation, in a chaotic state, each of them a distinct fluid chaos; without any form, except what arose from that particular gravity, or tendency of their several particles to the centres of their respective masses, which the Creator seems to have impressed on them, at the beginning.

Prop. V. That the face of the deep, and the face of the waters, are synonymous expressions for the fluid surfaces of these chaotic masses.

Prop. VI. That as the immense mass of matter, of which the body of the sun consists, was (by prop. iv.) in a chaotic state, void of motion, light, and heat; darkness must necessarily have been upon the fluid surface; and consequently, upon the fluid surfaces of every body in the system.

Prop. VII. That the motion impressed on these bodies, by the spirit of God, was of their fluid surfaces alone; whilst their respective axes remained at rest.

Prop. VIII. That the moment these bodies were impressed with this motion, that carried them about their respective axes, the sun became a globe of fire; and there was light.

Prop. IX. That general or universal gravity did not take place in our system, till the fourth day.

Prop. X. That every planet that rolls about our sun, was formed in the same manner as the earth was formed. 18
Pye also discussed the Mosaic deluge in light of the "late improvements in natural philosophy." Basically he accepted an explanation of the flood based upon Whiston's famous comet. Pye differed from Whiston, however, on several major points. First, he did not accept Whiston's claim that the tail of the passing comet dumped a large quantity of water and soil upon the earth. Pye believed this added mass would have radically altered the earth's orbit by destroying the equilibrium between the planet's centripetal and centrifugal forces.

Pye took exception to Whiston's hypothesis that the earth contained a closed central abyss full of water and argued that a comet would not possess a gravitational field strong enough to break open the earth's crust by attracting the interior water. Instead, Pye argued that the great abyss was interconnected to the oceans on the surface of the globe. He felt these connections were necessary to square the Biblical account of the deluge with theories of natural philosophy. Pye explained that the comet drew water from the ocean basins onto the land surface. Water then flowed from the abyss through the connecting channels
into the empty ocean basins. At this stage, Pye claimed the earth was in the same aqueous state as on the third day of creation, before God fashioned the dry land. After the fountains of the deep were empty, the weight of the flooded land mass caused the earth's crust to collapse into the empty abyss. Pye believed the wind that Moses spoke of in Genesis 8:1 passed through the mass of solid earth and opened a new grand chasm for the reception of the retreating waters.

At this point, the anonymous reviewer objected to Pye's hypothesis. He cited some studies that illustrated the tremendous quantity of water needed to cover the earth. The reviewer questioned whether any great wind could possibly have excavated a large enough internal abyss to embrace all the flood waters. The analyst also had doubts about Pye's ten propositions. He did not like the idea of God's creating the sun on the first day but not lighting it until the fourth day when gravity and rotation of the planets were initiated. The reviewer concluded by saying he could not entirely assent to Pye's opinion, but on the whole Pye's plan was more rational and consistent than others he had seen.19
In 1773 William Worthington (1703-78), an Anglican clergyman, introduced a new theory of cosmogony in his book, The Scripture-Theory of the Earth. An anonymous reviewer in the Critical Review took a curious position in regard to Worthington's and other naturalists' theories of cosmogony. He asserted that in 1774 the hypotheses of Burnet and Whiston were no longer admired; they were merely romantic speculations without any foundations. He wrote:

We have had two very different theories of the earth, the productions of two of our countrymen, Burnet and Whiston; both ingenious; both admired for a time; but now considered as no more than romantic speculations without any foundations in nature, philosophy, or Scripture.20

His objection to the hypotheses of these men and others was not based upon scientific facts but upon Scripture. By 1774 the authors of very few reviews, articles, or letters in the periodicals insisted that people had to accept God's work on faith alone and not attempt to explain His activities on the basis of natural laws. The reviewer in the Critical Review, however, asserted:
These two celebrated writers have led the way to several others, both at home and abroad, who have likewise attempted to contrive hypotheses, for the explication of some important circumstances, relative to the creation and deluge. But they have only served to convince us, that the operations of infinite wisdom are not to be comprehended by the human understanding, or explained upon mechanical principles.21

Abraham Rees' review of Worthington's volume in the *Monthly* illustrated the liberal viewpoint of that publication. Rees, a leading Dissenting cleric, mentioned that many theories of the earth had been proposed, but most of them contained too much theorizing and not enough hard evidence. Naturalists had a tendency to marshall facts in support of some preconceived notions. Rees protested:

There is reason to regret that genius and invention have had too great a share in this business, and that the authentic evidence of history has been applied to, rather than in support of a preconceived system, than as the ground of its formation. It would be easy to mention more instances than one, in which a great profusion of learning and eloquence has been displayed in dressing up an agreeable fiction, while the unornamented history of facts has been too much neglected. With respect to the laborious philosophical researches of skillful naturalists, it must be acknowledged that many curious and important inferences have been drawn from them, and that many more are perhaps in a fair way of being produced. The time, perhaps, is not far distant, when the learned world will be astonished at the success of these profound and indefatigable enquirers who have been, for the
many years past, employed in digging deep for truth, which has long been supposed, to lie hidden in the bowels of the earth. 

Rees confidently envisioned no conflict between natural history and church doctrine.

Both reviewers provided a detailed account of Worthington's hypothesis. He claimed that when God created the earth He also caused it to spin on its polar axis at a ninety degree angle to the sun. The erection of the globe occasioned the heavy particles of earth to collect at the equator and most of the fluid particles to gather at the polar regions. The result was a large flat land mass around the equator and two large oceans at the poles. Man occupied the fertile land until his wickedness led to the fall of man. At this time, God sent a powerful earthquake to convulse the planet. This disturbance produced the hills, mountains, and valleys that have been an accustomed part of the earth ever since. The sinfulness of man continued to increase until God sent a second and more violent quake that resulted in a shift in the earth's axis and a change in the center of gravity. The axis inclined 23½° in relation to the plane of the ecliptic. This catastrophe caused the vast polar seas to flood the land
and also created an atmospheric disturbance that resulted in forty days of rain. Gradually the waters returned to the poles and the new ocean basins. Both reviewers had grave doubts about Worthington's scheme. Rees, especially, could not understand how a shift in the earth's axis would have resulted in a change in the earth's center of gravity.

Worthington's book, on the whole, was a classic eighteenth century attempt to reconcile the Bible with observations of the natural world. He also introduced into his discussion a hint of the uniformitarian geology of the next century. Worthington claimed that the Mosaic flood greatly changed the face of the earth with its power of erosion. He realized the erosive power of water continued to his own time, for he mentioned that mountains were gradually being leveled and valleys filled with sediment until a state of equilibrium will prevail. He failed, however, to grasp the fact that mountains are constantly being formed to replace those which are being worn down. Washington wrote:

The tops of the mountains were washed away, and their sides and skirts were furrowed and channeled in the manner we behold them, by the first abatement of the deluge, and by the sub-
sequent draining, and running off of the waters; by these and other means, the moun-
tains have been lowering ever since, and the valleys filling and rising. The earth,
upon the whole, becomes less uneven; and afford a prospect of being by degrees brought
nearly level.\textsuperscript{25}

John Whitehurst (1713-88), a self-educated horologer and expert field geologist, published a major new theory of cosmogony in 1778 in his book \textit{An Inquiry into the Original State and Formation of the Earth}. Like most cosmogonical writers toward the end of the century, when Whitehurst attempted to reconcile geology with Scripture, he emphasized natural observation more than he did Genesis. Whitehurst had extensively studied the strata in Derbyshire and based his theory upon his own field work.\textsuperscript{26}

Both William Bewley and John Rotheram, who analyzed his work in the \textit{Monthly}, provided excellent reviews of the \textit{Inquiry} in which they praised Whitehurst for his field work and for his inclusion of cross-section diagrams in his book to support his conclusions.

Bewley was well aware that Whitehurst often gave only passing reference to the Mosaic account of the formation of the world. Bewley emphasized that Whitehurst did not speculate about how the \textit{Creator} might have formed the
world had he so pleased, but instead he studied geology to determine how the Supreme Being chose to form the world. Bewley noted that Whitehurst often reminded his readers of the many areas where his theory and the Biblical version coincided. Bewley then remarked, with tongue in cheek, that "in some few instances, Moses may perhaps be thought to hang nearly as heavy on our theorist, as he lately did on the neck of Canon Recupero."

Whitehurst, like Burnet, Whiston, and Woodward, believed that the earth began in a liquid state, a spinning heterogeneous mass of particles. The heaviest compounds settled to the center of the aggregate and the particles with the lightest specific gravity rose to the surface. In addition, similar particles attracted each other and formed masses of homogeneous substances, such as iron, sulfur, quartz, etc. The surface of the planet was covered with a sea containing a variety of simple marine animals. The sun, moon, and other planets which were formed at the same time as the earth, exerted a gravitational pull on the surface mass. The resulting tides moved back and forth across the globe and piled up sand banks and other sediments. Gradually primitive islands
formed which became firm low-lying land masses. Many re- 
 mains of marine animals settled in the sediments and became 
 fossilized in rock strata. 28

Unlike most naturalists, Whitehurst believed that both 
 fire and water played an important role in the deluge and 
 later formation of the earth. He thought the planet con- 
 tained a subterranean fire that was the result of spontan- 
 eous combustion in the newly formed strata deep in the 
 earth. He observed that all bodies expand when heated 
 and claimed that the subterraneous fire distended the over- 
 laying strata. Whitehurst asserted that the earth's crust 
 was weaker under the oceans than beneath the primitive 
 islands since, in the latter, the weight of over-lying 
 matter was greater. Because the central fire generally 
 occurred in the same strata beneath the entire planet, 
 the rising of the earth's crust was universal under all 
 the oceans. The ocean bottom elevated and forced some of 
 the overlying water onto the land surface. This event 
 was the Mosaic flood. Internal pressure finally produced 
 a parting of the rock strata, and, as a consequence a 
 coming together of ocean water with subterranean fire 
 produced an explosion infinitely beyond all human conception.
The terraqueous globe burst into millions of fragments. A heap of ruins resulted. Water in great quantity drained into the subterranean caverns so that more dry land was exposed. The antediluvian island, for the most part, sank into the oceans; what had once been ocean floor became dry land.29

Jean André Deluc (1722-1817), a Genevan who later settled in London, proposed still another system of cosmogony in 1780. He, like Whitehurst, claimed that his theory was consistent with both revelation and observation, but his emphasis was clearly on the latter. Deluc was concerned about the loss of faith which followed upon a rationalistic disbelief in revelation, but he was optimistic about the potentialities of scientific study of nature as a means of Christian rehabilitation. Deluc believed that the study of natural history confirmed the truth and authenticity of Mosaic history.30

Archibald Maclaine wrote a twenty-eight page analysis of Deluc's work, *Lettres physiques et morales sur l'histoire de la terre et de l'homme*, in the *Monthly Review*. Maclaine recognized the importance of the extensive geological evidence which Deluc offered in support of his theory.
Maclaine was impressed by Deluc's efforts to forge a middle ground between French naturalists, who like Buffon, advocated a slow transformation of the earth, and writers like Burnet, Whiston, Woodward, and others who were catastrophists. Deluc had no use for any theory that the earth was formed by geological forces observable during his life.

Maclaine correctly summarized Deluc's views:

Not one of the causes, which are known to act upon, and influence our globe, and which, by their nature, must have acted upon it formerly, as they do now could have produced the universal change of land into sea, and sea into land, which had undoubtedly taken place, and of which vestiges are evident.31

Deluc had his own involved theory of cosmogony. He believed the antediluvian world consisted of oceans and continents situated exactly opposite from those of the present earth, that is, the areas of the globe which now are above water, were under water at the Creation. The bottom of the old ocean contained large mountain chains which Deluc described as "primordial." These mountains rose above the surface of the water and formed islands. The islands and continents were lush and well populated. Gradually sediment from the sea water and rivers settled
to the bottom of the oceans and formed calcareous layers of rock and soil. These layers contained the remains of both marine and land organisms that washed into the sea. Fires deep in the earth spewed forth lava from volcanoes and cracks in the sea bottom. Slowly giant caverns formed under the oceans. Water entered these caverns and undermined the pillars causing occasional collapses of the ocean floor. The subterranean fires and water eroded passages under the land surface. Finally the columns supporting the land mass collapsed and slowly the antediluvian continent sank beneath sea level and the Mosaic flood resulted. At this point, the sea covered all the globe except for the islands. The additional weight of the water on the subsiding land forced the falling of more underground vaults. Eventually the antediluvian continents sank below the level of the previous ocean floor and all the water drained from the latter, leaving our present continents above water.\textsuperscript{32}

Near the close of the eighteenth century, one additional factor entered the cosmogonical debate. The naturalists were constantly striving to explain God's actions using the common laws of nature. These men did not like having to use miracles to interpret geological events.
Even if the naturalists could explain the origin of the waters of the deluge, they still had to find some natural agent powerful enough to provide a motive force to break up the fountains of the deep and to open the windows of heaven. While earlier writers relied on gravity, fire, or comets, another possibility, one that attracted a great deal of attention in the eighteenth century, was electricity as an immanent force.

How electricity caused the flood became the concern of several naturalists. The editor of the *Scot's Magazine* in 1784 and his counterpart at the *Hibernian Magazine* in 1787 reprinted a portion of an article entitled, "Of the Deluge," from the *Encyclopedia Britannica*. The anonymous writer of this essay reviewed many of the theories of the Mosaic flood mentioned above. At the end of his article, he turned to the possibility that electrical energy might have been the motive agent. The nameless author observed that electrical activity was usually associated with meteorological phenomena such as thunderstorms and waterspouts. He felt that electricity could raise immense quantities of water high into the atmosphere. When the electrical fluid departed from the atmosphere, as in a
thunderstorm, rain descended. In the case of the Mosaic flood, the anonymous writer asserted that God caused the electrical fluid to flow from the atmosphere into the earth for forty days. The result was a long rainstorm and the breaking up of the fountains of the deep as a consequence of excess electrical energy rolling in the earth. The author explained that this interpretation accounted for a flood that, according to the Bible, came quietly and gradually without any great violence. He believed also that this solution best explained the subsidence of the waters. God returned electrical fluid to the air above the earth, which enabled the atmosphere to "reabsorb" water vapor and allow the remainder of the liquid to return to the bowels of the globe. \(^{33}\)

All of the naturalists mentioned above attempted, with various degrees of success, to reconcile observed geological facts with the Mosaic account of the formation of the earth. Some writers like Yate followed closely the version in Scripture and tailored their hypothesis to fit Genesis. Others like Whitehurst gave only lip-service to Moses. Most British natural historians in the eighteenth century, in fact, saw no serious inconsistencies in their attempts
to reconcile the two sources of authority. An exception or two will be noted shortly, but in general, in Britain there was no serious attack on the idea of Divine Providence in nature until the next century was well advanced. Occasional French writers, however, put forth cosmogonical conjectures that deviated radically from the orthodox religious viewpoint. Many French theories were widely discussed and debated in Britain during the last half of the eighteenth century. At least one French writer, Buffon, made little effort to conceal the fact that his views diverged fundamentally from the Scriptural version of the creation, and as a result the Catholic clergy forced him to retract some of his writings. The British, too, presented some geological ideas in these periodicals that varied from traditional explanations.

About the year 1744, Claude Nicolas Le Cat formulated a new theory of the earth. Bewley reviewed for the Monthly an article in *Nouveau magazine français* about Le Cat's theories. First Bewley provided an explication of Le Cat's cosmogony. The latter believed that in the beginning the earth was a large ball of soft mud. The various substances settled out in the order of their specific gravities.
The entire surface of the planet was covered with a thick layer of water. Le Cat believed that after this settling process God created the sun and moon. These bodies exerted a gravitational pull on the fluid surface of the earth and produced a violent motion of "flux and reflux." The force of gravity caused the mud on the bottom of the sea to pile up in tremendous heaps, mountains. The sun dried out this refuse and created large areas of dry land.37

At this point Le Cat merely followed in the footsteps of other eighteenth century naturalists. Then he introduced a new variation. The flux and reflux of the sea piled more material on the land and continually enlarged the continents. The action of water also formed many "fossils." Gradually the waters on the surface of the earth eroded deeply into the soft mass located toward the center of the planet. Eventually the flux and reflux of the sea water reduced the earth to little more than a hollow shell, like an orange peel. Finally the outer surface of the shell collapsed into the interior, dissolving completely to form a heterogeneous solution. After this catastrophe, the whole process began over again. According to Le Cat, the cycle could occur any number of times.38
Bewley reprinted a number of letters objecting to Le Cat's hypotheses. Some critics raised serious difficulties with various physical aspects of the theory. For example, how could water erode away all of the interior of the earth? Even if such erosion were possible, from where did all of the water come? Most writers, however, vigorously disputed Le Cat's "interpretation" of Scripture. Le Cat denied that his theory opposed the account of the formation of the earth which Moses gave in Genesis. He pointed out, first, that God promised not to destroy the world with a second flood. What, he asked, was to stop God from destroying the planet by fire before the next natural collapse of the globe?

Le Cat asserted (and this idea therefore appeared probably for the first time in an article on geology in an English periodical) that the Bible must not be interpreted literally. He emphasized that theological passages in the Bible were the word of God and they must be obeyed. The parts of Scripture dealing with the arts and sciences were merely opinions of fallible men. According to Bewley, Le Cat stated that:
The inspired truths are all those passages which relate to our salvation, and which are the tenets of our religion, and the articles of our faith. All these proceed from God, and consequently are true, sacred, and respectable. The human opinions intermixed with those of respectable truths, are all those passages which relate to arts and sciences, the opinions and customs of nations, or of the writer whom God was pleased to employ. With regard to these latter passages, the spirit of truth has not thought proper to rectify the common notions, its end, in these declarations being religious truths and holiness, not curiosity or literature.39

Le Cat went on to illustrate the dangers of interpreting the Bible too literally. He demonstrated that according to Scripture the earth is flat, square, and supported by water. Le Cat cited the examples of Copernicus and Galileo to show what happens when blind priests interpret literally the text of the Old Testament. If precisely read, the Bible was full of errors that could be used by enemies of religion to discredit Christianity.40

Le Cat believed that the best solution to this problem was to separate theology from natural philosophy. He wanted philosophers and clergymen each to work in their own disciplines. In fact Le Cat claimed that God Himself ordained this division. He wrote, said Bewley:
For God's sake, why should not philosophers, that is, naturalists, have, in their particular province, all proper scope? Please to observe the vast extent of liberty granted them by the Creator himself.—He has given up the world to the disputes of men—Now this province of the naturalists comprehends the world, the universe, the whole expanse of nature. This is an extent fixed by God himself, and who shall dare to abridge it? It is the concern of all mankind, that no invasion should be made on the dominions of a science, devoted to their wants and conveniences. And very far be the thought from all christians, that a religion thus true, thus holy, thus transcendent, has anything to fear from the progress and improvement of the sciences. 41

As the eighteenth century progressed, more and more philosophers had doubts about the reality of the general flood described in Genesis. They were skeptical about a number of practical problems. Some writers claimed that the flood was not a world-wide event but limited only to the Middle East.

Samuel Clarke in 1767 reviewed in the Monthly Review a book by Samuel Engel (1702-84), a Swiss naturalist writing under the pseudonym, E. B. d'E., in which the latter had argued in favor of a partial flood. Engel was greatly impressed by the remains of high levels of civilization discovered in Mexico and Peru. He argued that the builders of these ruins could not have obtained
such an advanced culture in the brief time period after the flood. Therefore, Engel believed the ancient Americans dated from the time of Cain and Abel. The descendents of one of these two men peopled the New World long before the flood and were not harmed by that catastrophe. Engel also claimed that there was just not enough water on or in the earth to flood the planet completely. He did not believe that God miraculously created the water before the flood and then destroyed it afterward. Finally, Engel wondered how it was possible for all the different species of animals from various environments to congregate in the Holy Land and board the ark.

Engel asserted that the naturalists could solve these and other problems by demonstrating that the Mosaic flood was a local event confined to the Middle East. The flood itself was probably caused by a slight shift in the earth's center of gravity which led to a settling of water over the land surface in the Holy Land. Noah and his family boarded the ark and took with them a few domestic animals. Gradually the center of gravity shifted back to its original position and the flood waters subsided. Engel felt the New World was entirely spared from the disaster and its inhabitants were not affected in any way.
The reviewer, Clarke, was not particularly impressed by this scheme. In his thorough and well-written review, he noted that Engel too closely followed his imagination instead of his judgment. Clarke also pointed out that Engel's version differed considerably from the Bible even though he claimed that his theory was scripturally sound.42

Daines Barrington (1727-1800), a well-known British naturalist, expanded on Engel's ideas. Barrington claimed that many animals could not have survived the flood either in the ark or outside it. Fresh or saltwater fishes, for example, must have perished because they could not live in the flood waters of different salinity from their usual environment. Barrington wondered how animals from various parts of the world which eat only one particular type of plant obtained their nourishment on the ark. He believed the solution to these problems was obvious—the flood occurred only in the part of the world where Noah and his family lived.43

Buffon proposed probably the most famous and controversial eighteenth century theory of the formation of the earth. The British periodicals carried at least a dozen major articles and reviews of Buffon's works and his name
was often mentioned in discussions on natural history. Most of the comments and controversy about Buffon centered on whether he adequately explained the observed natural world. Surprisingly, very few writers objected explicitly to Buffon's considerable divergence from the narrative of Genesis.

Buffon believed that a comet struck the sun and broke off a part of that fiery body about 75,000 years ago. This piece disintegrated and formed all the planets and moons of our solar system. Buffon divided the subsequent history of the world into what he called seven epochs. The first epoch found the earth in its original fiery state. The earth in a fluid state rotated on its axis; centrifugal force formed the earth into an oblate spherical body with a bulge at the equator. During the second epoch the earth gradually cooled and the surface became deformed and wrinkled from the settling vitrifiable masses. The formation of mountain ranges occurred at this time. For the period of the third epoch, the earth continued to cool and finally it became cold enough to allow rain to fall on its surface without immediately evaporating the water back into the atmosphere. Immense quantities of rain flooded
the planet. Marine life appeared in the vast oceans and their remains settled to the bottom, forming fossils. The movement of water by the tides broke up the vitreous strata and sedimentary rock. During the fourth epoch the waters retreated into the earth. Numerous volcanoes were active. It was in this period that the globe basically acquired its present day form.

Higher animal forms appeared on the earth during the fifth epoch. At the poles the earth was cool enough for large tropical animals like the elephant to exist. Buffon thus thought he could explain the discovery of fossil elephant bones in the extreme northern and southern areas of the globe. As the earth continued to cool, the large animals at the poles moved toward the equator to find a more hospitable environment. During the sixth epoch, the land masses of the old and new world separated. This disjunction happened at about the same time the animals moved toward the equator, and many species were trapped by mountain ranges and arms of the ocean and became extinct. Buffon believed that this change accounted for the fossilized bones of extinct species discovered by his contemporaries.

Man appeared during the seventh and final epoch. He emerged in the northern regions of North America and Asia
as the planet cooled. Originally man was all of one race, of short stature with long black hair and brutish manners. As the earth cooled and man moved into different environments, the climate and man's manner of living produced the various races. Buffon believed that the earth continued to lose heat and eventually in another 93,000 years would be too cold to support life.  

The few critics of Buffon's theory who based their argument on Scripture were relatively gentle in their treatment of the Frenchman. Bewley in 1775 in his review in the Monthly said that Buffon's theory was scientifically sound. He observed that Buffon had little interest in answering objections by the French clergy that his hypothesis was not scripturally precise. Bewley concluded by subtly observing that according to Buffon the final end of life on earth will occur because of a loss of internal heat, while the Bible stated that God would destroy the planet by fire.  

An anonymous letter writer objected to Buffon's description of early man. He quoted Genesis to the effect that the sons of God or sons of Adam were perfect and rational beings. The nameless author stated that Buffon's early
man was a bizarre brute. In spite of this obvious difference in the two accounts, the writer did not seem to feel that this divergence was particularly serious.\(^46\)

Surprisingly, no writer objected to Buffon's extending the age of the earth back 70,000 years more than Moses authorized.\(^47\) Archibald Maclaine writing in the *Monthly* observed that Buffon considered the six days of which Moses spoke to actually have been six periods of indefinite duration that could be extended to thousands of years to correspond with his first six epochs. Maclaine held this opinion to be a reasonable assumption and not sacrilegious.\(^48\)

Most critics of Buffon founded their objections to his theory on its extreme illusory nature. They often noted that some natural observations seemed to support parts of Buffon's system but that more scientific data was needed before any definite conclusions could be reached. An anonymous reviewer in the *Critical Review* summarized the feelings of most English commentators when he stated that Buffon's ideas were "visionary" but that the Frenchman had assembled many valuable "facts."\(^49\)

Other writers were not so gentle with Buffon. Maclaine, for example, in a review in 1780 of one of
Deluc's books characterized Buffon's hypothesis as entertainment for Parisians who enjoy stories of elephants marching south. He also hinted that the theory was losing favor. Maclaine wrote:

This system which was a pretty entertainment for the beaux and belles of Paris, intoxicated some people from whom more wisdom might have been expected; and many readers were so amused to see the elephants and rhinoceroses [sic] galloping toward the equinoctial that the epochs of nature were almost universally applauded, and warmly defended. But they have had their day, like the elephants of the north, and are now contracting the influence of that refrigeration which their inventor attributed to our terrestrial globe.  

Maclaine elsewhere described Buffon's theory as a "fairy tale in all the extent of the term." Other naturalists also were attempting to increase the age of the earth beyond the 6000 years accounted for by Moses. Giuseppe Recupero (1720-78), an Italian cleric, attracted some attention in the British periodicals. Recupero had spent a large portion of his life studying the volcano, Mt. Etna. He carefully investigated a number of lava flows near the mountain and noticed that fertile soil formed very slowly on barren lava. He observed one lava flow that occurred, according to Roman historians, during the Second Punic War almost 2000 years previously.
Recupero observed very little soil, not enough to grow corn or grapes, on the surface of it. He studied a cross section of the soil in a well on the other side of the mountain. He found several sheets of lava alternating with thick layers of earth. In a pit near Jaci, Recupero also found the same phenomena, seven alternating layers of lava and earth. He concluded that if the soil did not form on the lava for at least 2000 years, then the bottom layer of lava in this pit must have flowed from Mt. Etna at least 14,000 years ago. Recupero was "exceedingly embarrassed" by these discoveries and noted, according to one correspondent, that "Moses hangs like a dead weight upon him." The bishop of his diocese was also distressed and warned Recupero not to let his computations outrun the Mosaic account.

Contributors to the periodicals objected to Recupero's time scale. One anonymous writer provided a detailed account of the Biblical antediluvian chronology and claimed that the Mosaic version allowed only 6000 years as the age of the earth. He attacked Recupero strictly on a theological basis and cited no hard natural evidence to support his position.
Another writer assailed Recupero with scientific testimony. The unknown author questioned the Canon's comparison of lava formations. He observed that the lava flow that occurred during the Second Punic War formed a promontory into the ocean. The critic noted that this formation was not a likely site for rapid soil accumulation. The well and pit mentioned by Recupero, on the other hand, were located in depressions in the local terrain, and their location was an ideal collecting ground for soil washed down the mountain. The anonymous writer also disclosed reports of enormous eruptions of volcanic ash which blanketed the countryside. After a few years these deposits became very fertile soil. All in all the author of the letter based his arguments on natural observations and did not mention the Bible.54

Most of the previously discussed theories of cosmogony contained very little natural evidence. These schemes provide good examples of non-Baconian science. Writers founded their hypotheses on their own imaginations. Such naturalists often selected a few observations and fitted them into whatever conceptual framework had captured the author's fancy. This characteristic applied both to
theories closely related to Genesis and also to hypotheses that diverged from Scripture. Probably the Theory of the Earth written in 1795 by the Scotsman James Hutton (1726-97) was the first geological synthesis based strictly on observation rather than on imagination. This volume marked the beginning of uniformitarian geology. Hutton argued that only such geological forces as are seen in operation today should be used to explain the past formation of the earth. He believed that the earth was very old, much older even than Buffon's estimate of 75,000 years.

Like most ideas, hints of uniformitarianism had appeared from time to time in the periodicals before 1789. Buffon, as previously cited, thought in terms of slow, gradual changes on the earth. Other naturalists gave specific examples of the slow inevitable modifications of the planet.

Alexander Dalrymple (1737-1808) in an article in the Philosophical Transactions that was reprinted in the Scots Magazine in 1768 made some observations about the coral islands and atolls of the South Pacific. He did not totally understand the formative processes that caused the islands but he was aware of the powerful force of the ocean and
the tremendous time element necessary to fashion them. Dalrymple explained that the monsoon winds heaped up coral fragments in massive piles. After a long period of time, coral banks emerged above the water. These banks trapped ocean debris which contributed a primitive soil. Plant seed arrived in the wind and water and grasses and palms grew. Next, according to Dalrymple, birds took up residence on the coral islands and contributed their dung and feathers which acted like a fertilizer. A complete tropical island was the result.56

In 1780 George Hoggart Toulmin, a young physician, published a book, *The Antiquity and Duration of the World*, based upon the principles of uniformitarianism. Toulmin drew a number of conclusions about the history of the earth similar to the ideas later proposed by Hutton.57 Like Hutton, he believed that the earth was eternal, that it had always existed and always would. Toulmin expressed his utmost contempt for any writer who attempted to fix a date to the origin of the earth: "Their vague stories on this subject should be ranked among the grossest errors of mankind."58 He went even further and explicitly excluded God from any role in the creation of the world.
Although Toulmin was not a field geologist, he drew extensively upon geological evidence to support his contention that the earth was eternal. He mentioned numerous fossils discovered deep in the earth, findings which indicated to him that the rock strata contain remains formed over a long period of time. No universal flood could have destroyed all these ancient plants and animals and deposited them at varying depths in the earth. Toulmin believed the rock strata indicated numerous slow advances and retreats of the sea upon the land mass. He indicated that many of the present day islands of the globe had previously been the highest land of adjoining continents. He claimed that the sea was continually altering the very face of the earth and in the eternal lapse of time it had alternately encroached upon and retreated from the land masses.\textsuperscript{59}

Toulmin clearly understood the basic concepts of uniformitarianism. He wrote: "Nature is invariably the same; her laws are eternal and immutable. Substances that seem inanimate, are yet perpetually in action, admit of changes regular and uniform."\textsuperscript{60} Not only did he realize the earth underwent constant transformation, he also
intimated that the plant and animal life of the planet slowly changed. Toulmin, according to a commentator in the Critical Review, expressed a number of facts that must "indisputably appear:"

That not one single substance in nature is either permanent or primary.
That the animals, the vegetables, the earths, the stones, the minerals, alike take their origin in the gradual progress of time, and, in its unceasing succession, are alike exposed to innumerable transmutations.
That the globe itself, from a multitude of causes, is subject to the most slow but interesting revolutions. That it undergoes incredible changes from heat and cold, volcanos and earthquakes.
That vast alterations are perpetually made by the decay, generation, petrification, and other transmutation of vegetables and animals.61

An anonymous reviewer in the Critical Review objected to Toulmin's assertion that man was eternal. He mentioned that all men appeared to have descended from the same ancestor at a not very distant period. The reviewer stated that many languages had common origins. Also the reviewer noted the relatively recent beginnings of written history, laws, arts, and sciences. He also wondered why, if mankind was eternal, on half the earth man lived a barbaric existence.62

In 1785 Hutton published a paper in the Transactions of the Royal Society of Edinburgh. Hutton in this paper
presented a brief account of his theory which he later published in book form. He argued, unlike the Neptunists who stressed the role of water in forming geological strata, that the principal force involved in forming rocks were heat and pressure. He stated that all present rocks formed under the waters of a former ocean, from the decay of a former earth. Heat from subterranean fires fused this rock material together and created pressures that resulted in the uplifting of large land masses above the surface of the water. The processes of erosion, settling, fusion, and uplift were an ongoing event. He did not discriminate between the organic and inorganic realms.

Hutton, like Aristotle, conceived the earth as a dynamic body, akin to an organism. Hutton made no estimate as to the age of the earth, nor was he concerned about what role, if any, God had played in its history. He concluded his essay with a famous paragraph:

If the succession of worlds is established in the system of nature, it is vain to look for anything higher in the origin of the earth. The result, therefore, of our present enquiry is that we find no vestige of a beginning,--no prospect of an end.

John Rotheram reviewed Hutton's paper in the Monthly. He gave little indication in his review that the Scotsman's
hypothesis was anything out of the ordinary. Rotheram noted that Hutton attributed the geological form of the earth mostly to the forces of heat and fusion instead of the activity of water. Rotheram mentioned some experiments by others that seemed to him to suggest that rock strata could be formed by sedimentary processes. He indicated that Hutton's claim that the present earth was formed from materials of a preceding earth was very similar to the theory of Whitehurst. Rotheram concluded by quoting Hutton to the effect that the earth had no beginning or end but he made no comment about the matter. 

An anonymous writer in the Critical Review analyzed Hutton's article in a long review. He, like Rotheram, also questioned Hutton's emphasis upon heat and fusion as the principal geological agents. The reviewer gave some examples of the important role of crystallization and consolidation played in the formation of certain types of rocks. He correctly pointed out that the geological record indicated that water had been an important creative agent. The anonymous writer said of Hutton: "We can allow him great merit though we differ in many respects."
The most negative reaction to Hutton in the periodicals came in an anonymous review published in the Gentleman's Magazine. The reviewer understood all the naturalistic implications of Hutton's theory and he did not like them. He founded some of his doubts on a scientific basis. The reviewer said that if fire and heat performed such an important function in the past, he wondered what "prevented from dissipating in vapor the whole water of the ocean?" He also pointed out that the water deep in the ocean was colder than at the surface. This fact seemed to indicate to the writer that Hutton was wrong in regard to the role of heat in the formative processes. The unknown author based his most vigorous objections, however, upon Hutton's slighting of God and the Bible: "To the Mosaic theory of the earth he gives no credit," noted the reviewer. The reviewer also took exception to Hutton's famous comment about the eternity of the earth. He concluded by remarking that Hutton unquestionably was a man of science and a genius who had "thrown out several hints" that might be useful to more sober philosophers. The reviewer bitterly protested, however, that Hutton had attacked the very foundations of established religion and the analyst ques-
tioned what the real goals and purposes were of the Royal Society of Edinburgh if they accepted impious ideas. He asserted:

The obvious tendency of his work is, to establish the eternity of the world, to exclude the superintending care of Providence, and, by consequence, to sap the foundation not only of the religion of his country, but of everything which can be called religion. That a philosopher has an undoubted right to examine, with utmost freedom, every system of religious belief, and to publish the result of his examination, we readily acknowledge; but we are not quite satisfied that, in a country where there is an establishment, it becomes a corporate body to usher into the world, among its Transactions, an open attack upon the national faith; and we apprehend that, before a place had been here given to Dr. Hutton's *rudis indigestaque moles*, it would not have been improper in the committee for publication to consider for what purposes the Royal Society of Edinburgh received its charter, as the sovereign who gave it is not generally believed to be a friend to infidelity.70

This reaction by the reviewer was one of the most bitter criticisms in a periodical of any geological paper that appeared in the eighteenth century.

Many other naturalists were attempting to harmonize individual Biblical passages with the scientific knowledge of the eighteenth century. They endeavored to provide naturalistic explanations for a number of seemingly miraculous events recorded in Scripture. These efforts at
reconciliation produced some interesting discussions in the pages of the periodicals.

One of the problems that faced the proponents of the Mosaic version of the deluge, was to explain how Noah could have kept a large number of animals on his ark for a year. Cave published in the Gentleman's Magazine in 1749 a description of the ark, complete with a detailed plate. He used John Wilkins' (1614-72) account of how the vessel was stocked and provisioned, a plate from an unnamed Dutch volume, and assorted other commentaries. As Wilkins explained, the ark was 300 cubits in length, 50 in breadth, and 30 in height, a cubit being 18 inches in English measure. The ark had different levels with the lower story containing all the beasts, the middle level for food and the upper story for the birds and their food and also apartments for Noah and his family. Wilkins provided a list of all the animals Noah had on the ark. He claimed Noah took 58 species of large animals or 197 individual animals. Noah supposedly had two of all species except the clean animals of which he carried 7 of each species on the ark. Wilkins did not include in his list animals like the rat, mole, etc. which required no separate pens,
or various reptiles that could live very comfortably in
the hold, or marine fishes and animals which could survive
the deluge on their own. Wilkins calculated the amount of
space necessary for all the animals, and he even allowed
additional room for the new species that naturalists
would discover in the future.

Wilkins admitted the main logistical problem on the
ark was to provide enough food for all the large animals for
a year. He theorized that Noah might have fed the carniv­
orous animals sheep and calculated that 1825 sheep would
have been sufficient food for them during the voyage. All
of these animals resided on the lower level of the ark.
The second story, according to Wilkins, housed hay for the
herbivorous creatures. He computed that these animals
needed 109,500 "solid cubits" of fodder which he reckoned
could easily have been stored on the ark. The assorted
foods for the birds could have been kept on the upper level
of the ark as this material did not take much space.71
The article made no attempt to discuss the problem raised
by naturalists as to how all the various animals congre­
gated in the Holy Land to board the ark.
An interesting debate developed in the *London Magazine* when two contributors attempted to apply naturalism to another event in the Old Testament. The editors of that magazine had published a number of articles on the hoards of locust that ravaged the Continent in the late 1740's. One correspondent in a letter noted that Moses in Exodus 10:4-20 described a plague of locusts that God sent to plunder Egypt and punish the Pharaoh. In the same chapter, the anonymous writer noted, God later sent three days of darkness to punish the Pharaoh for not keeping his promise to let the children of Israel go. The writer observed that "God Almighty often works miracles by second causes" and he pondered how naturalists would explain the darkness. He wondered if perhaps God had darkened the earth by sending a comet between it and the sun.\(^{72}\)

J. Cole replied in a letter in the next issue of *London Magazine*. He noted briefly that any comet would have darkened the entire earth, not just Egypt as in the Biblical account.\(^{73}\)

The writer of the original query replied in the October issue and objected that a comet need not darken the whole earth. He noted that all comets were relatively small and if they passed close to the earth they might only
darken a small area. The Bible expressly stated that the Israelites were not in darkness. The anonymous correspondent wondered if perhaps the Jews were in the penumbra of the eclipse. He also observed that certain Greek fables recorded a darkness of several days and theorized that maybe this darkness was not the same one chronicled in Exodus. 74

Cole responded in the December issue. He granted that perhaps a comet could eclipse only a small portion of the globe but then raised another obstacle. Cole claimed that no eclipse could last for three days when the shadow of the interposing body was so small. The diurnal rotation of the earth would have quickly carried Egypt out of the shade of the comet. For a comet to cause the darkness, Cole claimed, three conditions must have prevailed. First, Egypt must have been exactly a circle to have been within the penumbra only. Second, the section of the comet's shade at the earth must have been a figure equal in area to Egypt. Finally, instead of the sun standing still about a whole day as in the time of Joshua, the earth's annual and diurnal motion, as also the motion of a comet in its orbit, must have ceased for about three days. Cole concluded by noting these last particulars were highly improbable. 75
The Biblical narrative of Jonah and the whole was another issue that caused debate about naturalism among naturalists and theologians. Several correspondents contributed letters to the Gentleman's Magazine in 1768 on this matter. An anonymous writer noted that many scholars doubted the authenticity of the incident for various reasons. He claimed:

The history of Jona \(\text{sic}\), as it is usually understood, hath raised scruples on some serious minds; but it hath furnished scoffers with abundant matter of scorn and ridicule. It hath been urged that no fish of the enormous bulk which this here spoken of must have been, is ever found in the Mediterranean \(\text{sic}\);--that to suppose god would create one for the purpose, or miraculously convey one already created to the spot, is to attribute much too prodigious means for the end proposed. ... the whole story carries with it the face of a fable, too gross for the digestion of any stomach but that of a Jew.\(^76\)

The anonymous contributor also cited some other Biblical incidents, such as Isaiah's walking three years naked and barefoot, as examples of delusions. He asserted that God put visions in the minds of various Biblical people, including Jonah. The writer stated a number of these tales were very unlikely occurrences. He wrote that we must:

acknowledge the high improbability at least that such things were really and literally
performed, and believe that they were transacted in vision only. I think we may with reason admit the same of the story of Jonah; and conclude that the whole of it, from the time of his arrival at Joppa in his absurd attempt to flee from Jehova, till his coming to a better mind, and his beginning his journey to Nineveh was performed only in a vision, exhibited to him by the direction of the almighty, that by Jonah's preaching he might accomplish his gracious purposes towards the inhabitants of that city. Thus will all apparent difficulties vanish at once. 77

Another anonymous writer replied to this claim that the Biblical miracles were visions. He did not like this attempt to discredit the authority of the sacred writings especially in the age of "dissipation and levity." The writer noted, first of all, that God could easily have created a large enough fish to swallow Jonah. This special creation, however, was not necessary as he claimed naturalists already knew of such an animal. He described the "white shark" as being sixteen feet long and frequently found in the Mediterranean. The anonymous writer asserted that the body of a man had recently been found in a white shark, so Jonah might also have been swallowed. 78

In a later issue of the Gentleman's, a naturalist who signed his letter J.P. stated that a large "monster" washed up on the shore of Minorca. This fish supposedly was
seventeen feet long. J.P. included a drawing of a tooth from this fish. He also claimed that even larger teeth had been found in the past on the island of Malta in the Mediterranean Sea. J.P. argued that the size of the teeth from Malta indicated a fish large enough to swallow a horse! He definitely believed the Mediterranean contained fish large enough to swallow a man. J.P. admitted that a problem still existed as to how Jonah was able to live three days inside a fish. He believed perhaps Jonah might have existed in a state of semi-hibernation.79

In 1772 a dispute arose between two correspondents in the Gentleman's which illustrated the problems involved when someone attempted a literal interpretation of Scripture. A Biblical literalist noted that St. Paul in I Corinthians 15:36-39 used a parable of a seed that sprouted to illustrate the resurrection of the dead:

_Thou fool, that which thou sowest is not quickened, except it die: And that which thou sowest, thou sowest not that body that shall be, but bare grain, it may chance of wheat or of some other grain: But god giveth it a body as it hath pleased him, and to every seed his own body._

The writer observed that when a seed was sown, it underwent a dissolution similar to the body of a man laid in the
grave. The future plant or body was then brought forth by an immediate act of God. The anonymous author believed that experience and philosophy demonstrated that God does not perform miracles. He claimed that philosophy and experience taught us about the permanent, regular, and settled laws of nature. The seed germinated and grew as part of a natural operation according to the laws of nature. The seed sown contained a little plant and was therefore really the plant "that shall be." The unknown correspondent concluded by asking, "is not this doctrine of Paul, therefore, \textit{ad captum vulgi}?"

Two months later, in July, another anonymous gentleman replied to this interpretation and claimed the original correspondent had ignored the power of God. The writer in the July issue believed that God was the first cause of everything in the universe. A grain of wheat sprouted not because of a miracle, but by virtue of the natural operation of the world. He claimed that "God has appointed the end and the means; and whatever part may be attributed to the means, still the whole is in his hands." The anonymous author asserted further that St. Paul had chosen a good simile to illustrate the disintegration of a body.
All men, both learned and ignorant, he argued, were familiar with the problems of the farmer. The cultivator realized that not every crop sprouted and not all seeds grew. The nameless writer concluded by stating that this parable was not *ad captum vulgi*.

In September the original writer replied to his antagonist and asserted that God was the author and first cause of all natural operations of the universe. He quoted Francis Bacon to the effect that God worked nothing in nature except by second causes. The anonymous author restated that St. Paul used a poor analogy. Some seeds never sprouted due to dry weather, etc. and indeed underwent a dissolution similar to the body of men laid in the grave. The seeds that germinated, however, sustained a different pattern. They did not die or undergo dissolution but instead produced a new crop. This phenomena was a continuation of life. He again expressed that this doctrine of St. Paul was *ad captum vulgi*.82

The dispute between these two men continued for a few more months. What was significant in this discussion was the attempt by the original writer to interpret the events in the world in terms of natural laws. His opponent
agreed that there was no real conflict between Scripture and natural history. St. Paul used good examples from the real world that could be understood both by the learned and the ignorant. The controversy between these two men in 1772 was the last significant attempt to explain the Bible literally which appeared in the periodicals here examined.

By 1789 faithful readers of the British periodicals should have noted several changes in the attitudes of naturalists toward the role of God in the natural processes of the earth. In the 1730's and 1740's most writers generally still accepted the cosmogonical account in the Old Testament. They attempted to confirm the Book of Genesis by providing geological evidence in support of Moses. Any conflicts between Scripture and geology were usually resolved in favor of the Bible. By 1789, however, some naturalists like Hutton entirely ignored the Biblical cosmogony. He and others based their theories on geological evidence gathered during extensive field research.

The attitude of naturalists toward individual Biblical passages also changed during the eighteenth century. In the period after 1751, natural historians attempted to provide a scientific explanation for such matters as how
Noah was able to feed and house all the animals on his ark. By 1789 naturalists had ceased to accept a literal interpretation of Biblical passages. Some theologians continued to discuss and elucidate Scriptural verses, but natural historians for the most part did not take part in these discussions.

Naturalists also changed their views on the age of the earth. In 1731 virtually all contributors to the periodicals believed the earth was approximately 6,000 years old. By mid-century Buffon had extended this estimate to 75,000 years. In the 1780's several scientists began to claim the globe was much older than 75,000 years and perhaps even of an infinite age.
FOOTNOTES


4 Ibid., p. 159.

5 Ibid., pp. 156-61.


7 Ibid.

9 Ibid., 6 (October, 1736), 601
10 Ibid., 6 (November, 1736), 665–67.
11 Ibid., 7 (April, 1737), 198–99.
13 Ibid., p. 85.
14 Ibid., 14 (April, 1744), 201.
21 Ibid., p. 290.

23Ibid., pp. 444-50; William Worthington, The Scripture-Theory of the Earth, Throughout All Its Revolutions, and All the Periods of Its Existence, from the Creation, to the Final Renovation of All Things (London: Printed for J. and F. Rivington, 1773).

24Ibid., p. 450.


26Davies, Earth in Decay, pp. 131-33.

27[William Bewley], review of John Whitehurst, An Inquiry into the Original State and Formation of the Earth: Deduced from the Facts and the Laws of Nature, in The Monthly Review, 60 (January, 1779), 37-39; John Whitehurst, An Inquiry into the Original State and Formation of the Earth; Deduced from Facts and the Laws of Nature (2nd ed.; London: Printed for W. Bent, 1786). The reference to Giuseppe Recupero involved his claim that on the basis of extensive studies of lava deposits, he believed the earth was much older than the 6,000 years indicated in the Bible. He was faced with the difficult task of reconciling his findings with Scripture. Recupero's work will be examined later in this chapter.


29Ibid., pp. 16-17.


32 Ibid., 64 (Appendix, 1781), 481-85.


38 Ibid., pp. 381-83.

39 Le Cat quoted by Bewley in Ibid., pp. 385-86.


42[Samuel Clarke], review of E.B. d'E. [Samuel Engel], Essai sur cette question: quand et comment l'Amérique a-t-elle peuplée d'hommes et d'animaux?, in The Monthly Review, 37 (Appendix, 1767), 535-41; E.B. d'E. [Samuel Engel], Essai sur cette question: quand et comment l'Amérique a-t-elle peuplée d'hommes et d'animaux? (5 vols.; Amsterdam: Mare Michel Rey, 1767).


45 Bewley review of Histoire naturelle, pp. 537-38.


47 For a good discussion of the various theories on the age of the earth see Francis C. Haber, The Age of the Earth: Moses to Darwin (Baltimore: The Johns Hopkins Press, 1959).


51 Maclaine, review of *Histoire naturelle*, p. 539.


54 Anonymous letter to the editor, *The Scots Magazine*, 38 (September, 1776), 458-60.

55 Gillispie, *Genesis and Geology*, pp. 41-42.


61 Ibid., pp. 39-40.

62 Ibid., pp. 40-41.

63 Tomkeieff, "James Hutton," pp. 270-75. Tomkeieff claimed that the theories of both Toulmin and Hutton contained a number of Aristotelian elements such as a belief in the eternity of the earth.

64 James Hutton, "Theory of the Earth or an Investigation of the Laws Observable in the Composition, Dissolution, and Restoration of the Land upon the Globe," Transactions of the Royal Society of Edinburgh, 1 (1788), 304.


69 Ibid., p. 714.
Ibid., 719; the reviewer differed with Hutton on philosophical grounds. He might have been a Wernerian (geologists who followed the German, Abraham Werner (1749-1817), who claimed the rock strata of the earth were formed by deposition in a primeval ocean.) The author, however, found no evidence in the periodicals of any division of naturalists into Huttonian and Wernerian schools.


Ibid.


Anonymous letter to the editor, The Gentleman's Magazine, 42 (May, 1772), 225. The phrase ad captum vulgi translates, for the purposes of winning the masses of popular support.

CHAPTER V

THE GREAT CHAIN OF BEING

The second theme naturalists of the eighteenth century incorporated into their thinking they rarely discussed as a direct issue. It was usually a part of a philosopher's sub-conscious metaphysics. Arthur O. Lovejoy has termed this complex set of hypotheses the "great chain of being" and has traced the development of this concept in a classic study.¹

Lovejoy found the genesis of the chain of being in the writings of Plato and Aristotle in the fourth century before Christ. As the scheme developed during the following centuries, the inorganic and organic creation was a chain of being, a graded ladder of perfection stretching from the simplest inanimate material to the highest and most perfect being, God Himself. The series was continuous and harmonious without chasms or gaps, and the forms that made it up were thought to blend insensibly into one another. The Creator's power and wisdom was so great that He fashioned in His universe every form of being which could possibly exist.²
The chain of being with its attendant principles of plenitude, continuity, and gradation reached its widest extension in the first half of the eighteenth century. A very significant change in the concept, however, occurred during the century. Lovejoy described the modification as the "temporalizing of the chain of being." Instead of being a description of a static universe, the chain came to be conceived of as a process of creation occurring in time. The principle of plenitude became the program rather than the description of the universe. At some point in the future, God will have created all possible forms of life. In a very general sense this change of emphasis contributed to the development of evolutionary thought. As the eighteenth century progressed, more and more naturalists realized that gaps and discontinuities existed in the animal kingdom. By the end of the century, support for the idea of a chain of being had faded away. Echoes of the concept remained well into the next century, mostly in forms of romanticism.³

An ancient and widely held notion, very evident in the periodicals was that the structure and processes of plants was analogous. A naturalist might, for example, interpret and describe a plant with reference to analogous animal
forms nearby on the chain of being. The assumption that analogies existed led some naturalists to extreme lengths. Some claimed that plants slept like animals. A few went so far as to imagine that stones and minerals "grew" like plants.

Natural historians in the eighteenth century faced another difficult problem trying to determine if an "organism" was a plant, an animal, or a mineral. In certain specific cases, some philosophers argued the form was changeable. These questions were not as ridiculous as they might appear to be to someone in the twentieth century. If nature was a plenum and a continuum, then the three kingdoms of nature were closely related and certain organisms or forms bridged the gaps between the mineral and the plant and the animal kingdoms. Compounding the issue were the many new and strange organisms that explorers sent back to Europe from all parts of the globe. And all of these facets of the idea of a chain of being appeared in the periodicals.

In a few instances, writers explicitly accepted or rejected the chain of being. One naturalist in 1784, who signed himself P.B.C. in a letter to the Gentleman's Maga-
zine (the letter was later republished in the *Scots Magazine*), supplied a rough outline for the entire scale of nature from man to "substances more subtle than fire." His scheme was:

<table>
<thead>
<tr>
<th>MAN</th>
<th>ZOOPHYTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orang-Outang</td>
<td>Sensitive Plants</td>
</tr>
<tr>
<td>Monkeys</td>
<td>Vegetables</td>
</tr>
<tr>
<td>QUADRUPEDS</td>
<td>Liverworts</td>
</tr>
<tr>
<td>Flying Squirrel</td>
<td>Mushrooms</td>
</tr>
<tr>
<td>Bat</td>
<td>Trufles [sic]</td>
</tr>
<tr>
<td>Ostrich</td>
<td>Lithophytes</td>
</tr>
<tr>
<td>BIRDS</td>
<td>Asbestus</td>
</tr>
<tr>
<td>Water-Birds</td>
<td>Talc, Gypsum, Selenites</td>
</tr>
<tr>
<td>Amphibious Birds</td>
<td>Slate</td>
</tr>
<tr>
<td>Flying Fish</td>
<td>Stones</td>
</tr>
<tr>
<td>FISH*</td>
<td>Figured Stones</td>
</tr>
<tr>
<td>Eels</td>
<td>Crystallisations</td>
</tr>
<tr>
<td>Water Snakes</td>
<td>Salts</td>
</tr>
<tr>
<td>Serpents</td>
<td>Vitriols</td>
</tr>
<tr>
<td>Naked Snails or Slugs</td>
<td>Metals</td>
</tr>
<tr>
<td>Snails</td>
<td>Semi-metals†</td>
</tr>
<tr>
<td>Shell Fish</td>
<td>Sulphurs</td>
</tr>
<tr>
<td>Scropulae</td>
<td>Bitumens</td>
</tr>
<tr>
<td>Moths</td>
<td>Earths</td>
</tr>
<tr>
<td>INSECTS</td>
<td>Pure Earth</td>
</tr>
<tr>
<td>Gall Insects</td>
<td>Water</td>
</tr>
<tr>
<td>Toenia, or Tape-Worm</td>
<td>Air</td>
</tr>
<tr>
<td>Polyps</td>
<td>Fire</td>
</tr>
</tbody>
</table>

*Whales and other cetacean fish, form the connecting link between quadrupeds and fish; as frogs, toads and other reptiles, do between quadrupeds and serpents.

+Zinc is the connecting link between the metals and semi-metals; and black-lead, or wadd, connects these with the sulphurs. Innumerable points of union of the same kind may be observed in all parts of nature."
P.B.C. apologized if he had offended anyone by putting man next to the monkeys. He noted that in his chain he was considering man as an animal but explained that man was also a rational and moral being.

Some writers in the periodicals openly attacked the idea of a chain of being. One of the most severe critics of this concept was Voltaire (1694-1788). Following a common practice with the works of famous men, the editor of the Gentleman's Magazine in 1765 printed some excerpts from Voltaire's Dictionnaire philosophique. One of the articles reprinted was entitled, "Chain of Created Beings." Voltaire assailed the whole hypothesis for a variety of reasons. Voltaire observed that the first time he read Plato he was amazed and awed by the gradation of the natural world from the smallest atom to the Supreme Being. He mentioned other accounts that described the hierarchy of the Church, located on the chain between man and God. After critically examining the idea of the chain he declared "this great phantom vanished, as, of old, all apparitions fled in the morning at the crowing of the cock." Voltaire gave three main reasons for his loss of belief in the chain of being. First, some species of
plants and animals were extinct, creating gaps in the chain. Other species like lions and rhinoceroses, he noted, were becoming scarce and someday might become extinct. Voltaire also believed that some races or species of man no longer existed. Second, Voltaire asserted that naturalists could conceive of imaginary species intermediate between the actual existing species. In the gap between man and the apes, for example, he imagined a number of species that combined human and ape-like features, providing intermediary forms. Finally, Voltaire objected to the implication that the completeness of the chain required a vast hierarchy of immaterial beings above man. While a Christian might believe in such creatures, the only evidence for their existence, according to Voltaire, came from revelation and not from science. Even in the material world of the heavens, Voltaire saw no gradations in the planets and their orbits. Newton had shown that all matter was influenced by gravitational attraction. Voltaire concluded by asking, "How can you suppose that in these great void spaces there is a chain which unites us all?"6

Many eighteenth century naturalists were not convinced that the gap existed between the plant and animal kingdoms.
For example, Linnaeus classified a wide variety of simple plants and animals as "Zoophyta" or organisms with characteristics of both plants and animals. Unlike modern biologists, many naturalists of two centuries ago chose to dwell upon the similarities, rather than the distinctions, between plants and animals. The effort to establish analogies was such a preoccupation that the recital of resemblances became an end in itself. This preoccupation on the part of natural historians with creating analogies and comprehensive explanations of the natural world caused many men to overlook the differences between plants and animals. The drawing of analogies between plants and animals reached its climax in the eighteenth century and the practice declined drastically during the next century.

The use of analogical reasoning in studying the natural world has been traced back to Aristotle. He, unlike Plato, was not inclined to arrange natural objects into separate ideal categories. For Aristotle, the real differentiation between plants and animals was dependent upon differences in function. He did not make an essential distinction between plants and animals writing, instead, of zoophytes or intermediate marine forms. Aristotle viewed
differences in plants and animals mainly as a result of their different locations in the chain of being. He arranged organisms on the ladder by referring both to their structural complexity and to their complexity of function. Aristotle's pupil, Theophrastus, explicitly used the scale of being to support analogies between plants and animals. Theophrastus mentioned that both plants and animals had veins of sorts, plant fibers resembled muscular tissue, both types of organisms conserved moisture and heat, and both could be adapted for aquatic life. Naturalists continued to delineate similar analogies in nature for the next 2000 years.

Writers used a great variety of analogies in the periodicals during the eighteenth century. Some analogies were reasonable and based upon scientific evidence; others bordered on the absurd. Analogy in general appeared in two forms: first, broad analogue schemes; second, specific likenesses between the plant and animal realms.

In 1750 an anonymous writer of a letter to the London Magazine outlined the similarities and differences between plants and animals. He drew upon the writings of Buffon for his information. The anonymous writer stated three
general differences between the two kingdoms. First, plants lacked mobility. Second, plants did not have "perception." Finally, plants could not feed themselves. The correspondent then noted serious exceptions to these three distinctions and he concluded that there was no absolute separation between the two kingdoms. He also referred to the chain of being as evidence that nature varied by imperceptible degrees. The unknown writer asserted:

From this examen we evidently see, that there is no difference absolutely general and essential between animals and vegetables; but that nature descends by imperceptible degrees from the most perfect to the imperfect animal, and from thence to the most perfect vegetables.  

The writer proceeded to list the resemblances between the two kingdoms. First, he mentioned that both plants and animals reproduced their own kind by similar methods. Second, both types of organisms possessed the ability to grow and to differentiate. Third, both plants and animals could reproduce asexually. A tree could propagate by a slip and the hydra could do the same in the animal realm. The writer concluded saying once again that "animals and vegetables are beings of the same order."
The most complete system of plant and animal analogies appeared in two periodicals in the late 1780's. The editors of the Scots Magazine and the Hibernian Magazine printed extracts from An Essay on the Subjects of Chemistry, and Their General Division by Richard Watson (1737-1816), professor of chemistry at Cambridge.

Watson drew an analogy between plants and animals with regard to their shapes and sizes. Some naturalists had stated that plants, unlike animals, never reached a fixed adult size. A tree, for example, grew and increased in expanse as long as it was alive. Watson observed that this distinction was not valid. Eighteenth century natural historians had discovered that corals, corallines, sponges and anemones were animals and not plants. None of these organisms grew to a determinant size, and therefore figure was not a basic difference.

Watson, like the previous anonymous writer, mentioned that both plants and animals had the faculty of perception; however, he elaborated in a new way. Watson believed that all living organisms experienced "happiness" to a varying degree. All living creatures, according to Watson, shared the happiness that God built into the world; the higher the
level of sensibility the species possessed, the greater its share in the happiness of the world. As Watson described it:

Where-ever there is a vascular system containing a nutritive succus, there is life; and where-ever there is life there may be, for aught we can prove to the contrary, a more or less acute perception, a greater or lesser capacity for the reception of happiness: the quantity, indeed, of sensibility, will . . . be small in each individual; yet is the existence of it in the nature of things possible, from the analogy of nature probable; and who can tell whether in the system of nature, confessedly contrived for the production of the greatest possible good, it may not also be necessity?12

Watson expressed the similarities in the reproductive processes of plants and animals. He noted that the male and female sexes occurred in both domains and that some members of each kingdom were hermaphrodites. In addition, he claimed that nature provided nourishment to fertilized embryos in an analogous way. The foetus in an animal's womb received nutrition from the umbilical cord of the mother. Similarly, the tiny plant in a seed got its food from the cotyledon of the seed, where the nourishment in the cotyledon was provided by the parent plant. Furthermore, Watson pointed out that the mating of different species in both kingdoms led to the production of hybrid
plants and animals.

Watson claimed that another likeness between plants and animals was the fact they both produced "seeds and ova" that remained fertile for years under adverse conditions. He cited the erroneous example of corn smut as being an "insect" whose "ova" survived indefinitely but correctly noted that infusoria animalcula exhibited the same phenomenon.

Watson showed an analogy in the way in which specific plants and animals required a particular type of soil or food. An "aquatic pine" withered away if it was planted in dry sandy ground.

Both plants and animals, too, had the power to resist mutilation by regeneration. Watson noted that if a tree branch were broken off, then a new one would eventually take its place. An analogous process occurred if a crab lost one of its legs. Likewise pieces of certain species of plants and animals formed a new complete organism when they were removed from the parent.

Another analogous feature of plants and animals was the shedding of external coverings. Trees lost their leaves in the autumn while animals shed their hair and birds their feathers.
Perhaps Watson's most tenuous analogy was his claim that both plants and animals exhibited the characteristic of sleep. He observed that most higher animals rested sometime during the day and he also asserted that many plants showed the same behavior. Some species regularly folded their leaves or flowers during the night.\textsuperscript{13}

Watson concluded by introducing a new factor into the analogical discussions. He performed some chemical analyses on a variety of plants and animals and found no significant difference in the chemical substances that composed the two realms. He was not surprised by his finding as he noted that all animals were "mediately or immediately" wholly nourished from vegetables. He claimed that animals' bodies tended to produce by distillation more volatile alkaline than plants and the latter generated more acid than the former. He did not believe, however, that this difference constituted a significant contrast between the two kingdoms. He wrote:

\begin{quote}
Animals, it is true, in general yield a greater proportion of volatile alkaline, than of an acid salt, by distillation; vegetables, on the contrary, abound in acid, and yield not any volatile alkali, unless with the last degree of heat, or when they have undergone putrefaction: . . . However, as some animals and
some parts of most animals, yield a portion of acid, and as most vegetables, by a strong fire in close vessels, or when converted into soot, afford a volatile alkali, altogether similar to that obtained from animal substances, we cannot from these circumstances establish any distinctive marks between the two kingdoms.\textsuperscript{14}

Watson thus introduced a new element into the old practice of drawing analogies. He inserted the use of quantitative methods of analysis from the newly evolving discipline of modern chemistry into the realm of natural history. This change was indicative of the new methods that would be used during the nineteenth century in biology. Scientists continued to find similarities between plants and animals but increasingly they based the likenesses upon a broad biochemical basis instead of such superficialities as the common shedding of leaves and feathers.

The editors of the periodicals published numerous analogical schemes similar to those of Watson and the anonymous correspondent. In addition to these lists of general analogies, many naturalists debated the validity of the second kind of analogy, specific correspondences between plants and animals.
One of the most controversial analogies in the eighteenth century was the naturalists' comparison of the "circulatory" system in plants and animals. In the seventeenth century Timothy Clarke (d. 1672) had suggested that certain types of plant phenomena could be best explained by hypothesizing a circulatory system analogous to that found in animals. Later naturalists generally attempted to prove or disprove this analogy on the basis of experiments. These trials received much attention in the pages of the serials. The pioneer work by Stephen Hales (1679-1761) in plant and animal physiology served as a model for the experimenters, a number of whom referred to Hales' famous book, *Vegetable Staticks*, published in 1727. It was a collection of experiments on plant physiology in which Hales utilized the Newtonian experimental approach.

A man who identified himself as "A.B." published an interesting essay in the *Gentleman's* in which he attempted to discover the origin of dew in the early morning on the leaves of plants. He sought to prove that dew on plants was analogous to animal perspiration. At night he inverted a tub over a variety of plants to keep the air from
settling on them; in the morning the plant leaves were always covered with dew. He performed the same experiment in the day-time in the shade and found similar results. A.B. noted that dew did not appear on dead leaves but only upon leaves in good condition. On the basis of these and other experiments, he decided that most dew came from plants.

A.B. concluded that the dew from a plant was similar to the perspiration from animals. He noted that plants had a circulatory system analogous to that found in most animals. If plants possessed a circulatory system, why should they not have a means of disposing of excess fluids?

It seems to be a point pretty well agreed, by the naturalists, that there is a circulation, or distribution, of the sap or nutritious juices, in vegetables, something similar or analogous to that of the blood in animal bodies: and if so, why may not the vegetables as well as the animals have some way or other of sweating out the redundant juices? That there is indeed something in all of them analogous to perspiration in animals is highly probable. 17

Julius V. Coulon (1767-1843), a Dutch physician, in 1789 extended the analogy to include the claim that plants pumped fluid through their vessels in a manner similar to the circulatory system in animals. Again he based his
comparison on his own extensive experiments. Thomas Cogan, a clergyman and medical practitioner, reviewed his book in the Monthly Review and described Coulon's investigations. Coulon cut a branch of the plant Euphorbia transversely and observed that fluid flowed from the wound. He believed the quantity of acrid fluid discharged from the cut indicated that the liquid flowed under pressure. He concluded that the voluminous discharge was caused by the spontaneous contraction of the vessels. Coulon further claimed he saw a sort of healing process when he observed the cut vessels under a magnifying lens. This occurrence, he noted, was similar to that which took place in wounds inflicted upon animals.¹⁸

Cogan, the reviewer, added that naturalists generally accepted the circulation of plant fluids. He thought that Coulon's investigations "seem to confirm" the fact "beyond a doubt."¹⁹ Cogan overstated the general acceptance of the circulation analogy. Many naturalists in the eighteenth century did not believe that plants had a circulatory system similar to that found in animals. John Hill, for example, disputed the circulation analogy but did not entirely reject this concept. He did not think that plant
juices circulated to all parts of plant systems. An anonymous reviewer in the *Monthly* quoted Hill to the effect that the outer layers of plants lacked any circulatory apparatus analogous to that found on animals and these layers merely served as surfaces for absorption and evaporation. Hill was quoted:

They erred who fancied a circulation in all parts of plants; for the use of exterior coats is merely absorption and evaporation; but I must be allowed to say, since plain facts confirm it, that neither were they right, who thought absorption and evaporation gave growth to the essential parts of vegetables. 

Other naturalists toward the end of the century cited experimental evidence that indicated that the circulation analogy was not valid and the reviewers paid attention to the work. Nicholas Alexandre Mustel, a botanist of Rouen, in a paper published in 1773 in the *London Magazine*, attempted to refute the ancient belief. He noted that the analogical claim had not been proved or disproved. He claimed that Hales seemed to believe in the circulation analogy, but this assertion was properly challenged in a footnote by the editor. Mustel related that the French naturalist Henri Duhamel du Monceau (1700-81) listed points for and against the circulation analogy and appeared to oppose it but took no strong stand on the matter.
Mustel mentioned that no concrete evidence had ever been offered to substantiate the analogy. No investigator had ever found a plant organ similar to the heart. No scientist had ever detected any plant valves corresponding to the valves in the veins of animals.

Further, Mustel devised an experiment that he believed discredited the analogy. He placed several potted apple and rose shrubs inside his greenhouse and additional ones outside in winter weather. He put a branch from each of the indoor plants outdoors through various holes in the greenhouse windows, and he also arranged a limb from each of the outdoor shrubs through the greenhouse windows into the interior of the warm greenhouse. One week after beginning the experiment, Mustel noticed that all the branches inside the hothouse showed enlarged buds. Approximately one month later all the limbs inside the greenhouse displayed leaves and young flowers. The twigs and plants outside the greenhouse, however, remained in a state of total dormancy. By the 15th of March all the interior branches were in full bloom while the limbs of the same trees outside in the cold showed no change. As spring arrived and the weather warmed, the branches and stalks
outside the hothouse began their normal spring changes.

From this experiment, Mustel derived three conclusions. First, there is no circulation of sap in plants analogous to that which occurs in animals. Mustel argued that no circulation could possibly have taken place in the plants outside the greenhouse. Their roots and stems were frozen and it was impossible for any sap to have risen in the stem from the frozen ground and into the branch growing inside the warm greenhouse. Second, Mustel believed every part of a tree contained enough sap to effect the first production of buds, flowers, and fruits. Finally, he believed heat, either artificial or natural, was the force that caused plants to produce leaves and flowers. Mustel concluded by stating, "It appears that the vegetable oeconomy is different from the animal, and that those who endeavoured to establish the circulation in both, carried their analogy too far."22

In 1782 an anonymous article appeared in the Hibernian Magazine in which the author denied the circulation analogy. Like other naturalists, he cited various experimental works, especially some of the recent discoveries on gases in the field of chemistry. He believed that the air
contained a variety of "particals" that interacted with living plants. Air promoted vegetation, both "materially" and "actively." Air directly effected the circulation of "juices" within the plant's body by causing inspiration and transpiration. The anonymous writer believed plant and animal circulation was not analogous: "Not by a circulation of fluids similar to that in animal bodies, but by an alternate inspiration and transpiration, influenced by the various temperatures of the air, the oeconomy of vegetable life is conducted." Thus, heat and cold regulated the activities of plants.

The so-called "sensitive" plants were some of the most studied in the sixteenth, seventeenth, and eighteenth centuries. These plants reacted with visible movement of some part of the organism when touched. Ancient naturalists had known about some types of plant movements but sensitive plants attracted little attention before the sixteenth century when *Mimosa pudica* was introduced into Europe. It responds to touch by folding its pinnulae. A number of English naturalists examined the *Mimosa* at that time and some like Thomas Vaughan and Henry More believed it demonstrated that all nature was permeated by an immaterial
animistic force. These mysterious motions of the sensitive plants came to be regarded as unimpeachable evidence for the idea of botanical analogy. On the scale of being, the sensitive plant came to be considered above the non-sensitive plants and below the sensitive animals.

While many naturalists wrote about other kinds of vegetable sensibility, the more spectacular variety of plant motions provide the best examples of irritability. One of the most unusual plant discoveries of all time occurred in about 1765 in the American colonies with the unearthing of the Venus's-flytrap (Dionaea muscipula). In 1768 John Ellis (1710-76), a London merchant, published a letter in the London Magazine which described this new plant. The editors of the various periodicals printed numerous accounts of Ellis's writings and experiments with the flytrap. Ellis noted first of all the numerous comparisons made between the sensitive plants and simple animals. He claimed that no one had been able to explain the movement of these strange vegetables and their secret "probably will lie hid from the strictest investigations of human philosophy." 

The editors of the periodicals published numerous other letters and articles written by Ellis about the Venus's-
flytrap. *Scots Magazine* in 1770 reprinted a letter Ellis sent to Linnaeus in which Ellis provided the Swedish botanist with a description and specimen of the mysterious plant. Ellis told his friend, "I know every discovery in nature is a treat for you; but in this you will have a feast." A long informative account of the Dionaea by Ellis appeared in the *Gentleman's Magazine* in 1776. Here Ellis gave a detailed narration of how the plant reacted to stimulation and included directions on the cultivation in England of this new "sensitive plant."

Others were interested in various plants that demonstrated irritability or spontaneous motion in their stamens and pistils. The French researcher, René Louiche Desfontaines (1732-89), and other naturalists investigated the phenomenon. The editor of the *Critical Review* in 1788 in his column, "Foreign Literary Intelligence," reported on Desfontaines's work. Desfontaines noted that the stamens of many plants in the Liliaceae, Tropaeolaceae, Geraniaceae, and Zingiberaceae families exhibited rapid spontaneous motion when the anthers opened. The anthers released the pollen and Desfontaines felt the motion was an important part of the process of pollination in these plant
families. He claimed that in some plant species the stamens bent toward the pistil in a uniform and regular manner. The stamens flexed, one by one, always in the same order, just before the anthers released their pollen. Desfontaines believed that "it is impossible to refer it [the motion] to a mechanical cause, or to consider it as fortuitous."\(^{30}\)

Later in the same year, James Edward Smith (1759-1828), the founder of the Linnean Society, wrote a paper in the *Philosophical Transactions* that an anonymous critic reviewed in the *Critical Review*. Smith had noticed that the stamens of the common barberry (*Berberis communis*) were bent toward the petals of the flower. If irritated, however, they sprang up toward the pistil in the center of the flower. He noted that the sensitive areas of the filament of the stamens were located in a place on which an insect might naturally land. After the irritation, the stamen normally returned to its former state but was still capable of additional movement if it was again disturbed. Smith also described the irritability of various other plant species including a type of cactus, *Opuntia tuna*.\(^{31}\)

Smith observed that some plants and most animals demonstrated irritability. He attempted to exercise some
responsibility in not pushing to extremes the analogy between the two kingdoms of nature. Most naturalists in the eighteenth century did not display such restraint and no real progress was made in the questions of plant motion until they set aside thoughts of analogy with animals.  

The claim that plants exhibited a type of rest analogous to the sleep of animals was prevalent in the pages of the periodicals. Various plants such as tamarind and clover have a periodic cycle in which leaves or flowers open and close in response to conditions in the environment. This so-called "sleep" of plants was not a new discovery, as Pliny the Elder had noted the phenomenon in the first century A.D. Seventeenth century naturalists like Jacques Philippe Cornut (1606-51) believed that sleep in plants was a mechanical reaction to heat and cold. In the next century, Linnaeus firmly felt that certain plants slept at night. In his Philosophia botanica in 1751, Linnaeus listed forty-six "vigilant flowers" that opened and closed at set times; he drew a strong analogy about their behavior to the animal realm. A few years later, he discussed the phenomenon extensively in his essay, "Somnus plantarum."
Linnaeus's comments received much attention in the periodicals. An anonymous man identified only as "a Fellow of the Royal Society" wrote an abstract and review of Linnaeus's "Somnus plantarum" for the Gentleman's Magazine in July, 1757. The unnamed author provided a discussion of the analogous properties that Linnaeus claimed plants and animals shared. Linnaeus's analogies were generally the ones most naturalists accepted in the eighteenth century. He rejected, however, the claim that both plants and animals experienced sensation and locomotive power. He noted that even in the case of the leaves of *Mimosa* which responded to stimuli, this occurrence should not be attributed to sensation. Linnaeus observed that because plants lacked real sensation, they could not experience true sleep. Linnaeus still thought in terms of the Aristotelian distinction between the vegetative soul of plants and the sensitive soul of animals.\(^{34}\)

The reviewer generally agreed with the observations of the Swedish naturalist. He stated that the term "sleep" as applied to plants might cause some confusion. Since most naturalists, however, used the word, the reviewer decided to retain it. He believed that when plants "rested"
at night they received new strength and vigor. He men-
tioned that young plants, like young animals, needed more
sleep than fully mature organisms. He followed Linnaeus in
concluding that probably both darkness and coldness at
night contributed to produce sleep. The unnamed writer
concluded his essay with Linnaeus's list and description
of forty plant species that slept at night.35

In a pamphlet of 1757 entitled The Sleep of Plants and
Cause of Motion in the Sensitive Plant Explained, Hill re-
ported the results of his experiments conducted to determine
the physical cause of sleep in plants. The booklet
dedicated to King George III took the form of a letter to
Linnaeus. Reviews of this work appeared immediately upon
publication in both the Monthly Review and the London Maga-
zine.36 Hill performed his experiments with Abrus, a type
of legume. He determined that lack of light, not the
presence of cold, was the cause of the leaves of the Abrus
folding up at night. He also tried varying the light to a
Mimosa and discovered it collapsed its leaves in darkness
in the same way in which the plant responded to irritation.
In the case of the sensitive plant, Hill, according to the
reviewers attributed the strange behavior to "vibrations."
The next year two anonymous writers contributed letters to the Gentleman's on the subject of plant slumber. Gemsage in the June issue cited a number of passages from various writings of Geoffrey Chaucer in which the famous author alluded to the sleep of plants. Gemsage believed coldness produced this condition. In the next issue, a gentleman who signed himself R.P. responded to Gemsage's letter. He attempted to distinguish between two different types of sleep in plants, the vigiliae florum and somnus plantarum. He defined the former as: "That faculty which the flowers of many plants exhibit of opening and closing their petals at certain times." For example he noted the flowers of the male pimpernel (Angallis mass) constantly opened about eight o'clock and closed again at noon. R.P. claimed somnus plantarum was "that faculty which the leaves of many plants have of assuming in the night time, a situation different from which they bear in the day;" clover, kidney beans, and moon trefoil had this characteristic. R.P. directed Gemsage to Hill's work on the matter and he noted that Gemsage was wrong in asserting that cold was responsible for plant slumber. He also observed that Linnaeus himself had confused the two different phenomena in his Philosophia
botanica but in his "Somnus plantarum" had corrected his error.

Naturalists while debating the question of such botanical analogies as sleep and irritability, made little reference to the certain "problem" organisms that seemed to be half plant and half animal. They were more interested in finding common general characteristics in both kingdoms. During the eighteenth century analogizing became extreme when some natural philosophers concerned themselves with analogies between the plant and mineral kingdoms. If one believed in the great chain of being, then certain forms must exist in the transitional region between plants and minerals. Other naturalists firmly imagined that under the proper conditions certain species of plants could be transformed into animals or vice versa—an idea akin to viewing the chain of being not as a static object, but as the representation of an ongoing process of change in nature. The editors of the periodicals seemed especially to be intrigued by claims of naturalists that certain organisms underwent changes in form; the editors also printed many articles on a number of species traditionally thought of as plants but which in the eighteenth century had been classified as animals.
One of the most startling articles in the periodicals was a letter signed "L.C." in the Gentleman's Magazine in January, 1751 in which the correspondent gave an account of "stone plants." L.C. wrote a description of some "fossil flowers" or "trochitae stones" he had discovered in Yorkshire. He claimed these trochitae, fossilized crinoids, were actually stone plants which possessed a "true life and growth," and were half vegetable and half mineral.

L.C. represents the end of the long tradition; since antiquity many naturalists believed that the rocks and minerals grew and had other characteristics analogous to plant life. Even the great Linnaeus believed that rocks "grew." L.C. provided a detailed drawing of the trochitae. The stone plants contained a soft white pith which, he observed, was probably the condition of the young plant while it was actively growing. As the plant matured he believed that "mineral steams and moisture" turned the plant to stone. He referred to a paper in the Philosophical Transactions on stone plants written by John Beaumont (d. 1731) in 1676 who also had reached similar conclusions. L.C. by noting the twenty different known species of trochitae resembled no living types of plants.
or animals stated that it was inconceivable that so many different species diffused throughout the earth could ever have become extinct. The stone plants, therefore, were real "organisms" that existed in the bowels of the earth. To L.C., the trochitae were important species occupying a significant place in the chain of being.\(^{41}\)

In the next month's issue of the *Gentleman's*, L.C. published another letter retracting his ideas on stone plants. In the meantime, he had read a new book by Hill, *A Review of the Works of the Royal Society of London*, in which the latter had bitingly satirized the Society for publishing so many trite and false articles in the *Philosophical Transactions*. One of the naturalists Hill attacked was Beaumont; he discredited his article on stone plants. L.C. supplied Hill's extract of Beaumont's paper and also Hill's rejoinder to it. In L.C. words: "It is now extremely proper that you should let the world know this doctrine is exploded by the above ingenious writer [Hill]."\(^{42}\)

L.C.'s comments were significant for two reasons. First, they demonstrate that even in the mid-eighteenth century, some naturalists believed that organisms existed
to fill the gap between the plant and mineral realms. Second, they illustrate the open-mindedness of a natural historian who was willing to admit in print that he was wrong. Too often in the periodicals, naturalists continued to maintain a viewpoint which was decisively discredited by other writers.

Various other naturalists of the eighteenth century claimed that some organisms changed their place in the chain of being. Investigators reported instances of plants becoming animals and in one case of animals turning into a plant. The whole issue of transformation of form was closely related to the age old controversy over spontaneous generation. Spontaneous generation involves two separate phenomena. When scientists spoke of spontaneous generation they meant the theory that living organisms could be generated from inorganic matter. This concept should properly be identified as abiogenesis. This doctrine was never really a serious issue in the eighteenth century. What was controversial was the principle of heterogenesis, or the belief that organic matter was capable of generating living organisms of a different species, for example, that a tapeworm might arise in the human body from the intestines.
Baron Karl Friedrich Hieronymous von Münchhausen (1720-97) and other naturalists claimed to have observed "seeds" of various species of fungi turn into animals by a process of heterogenesis. Münchhausen placed some mushroom spores into lukewarm water and later observed little worms swimming about. He thought these animalcules again became plants after a period of time! Even Linnaeus believed this instance of heterogenesis. Ellis, however, did not accept Münchhausen's work and performed his own experiment. He publicized his results in a letter to the Royal Society and also in an article in the Philosophical Transactions. He sent a copy of his letter to the Gentleman's and Bewley reviewed his article in the Monthly in 1771. Ellis in a note attached to his letter to the editor indicated he was concerned not only with the scientific connotations but also with the religious inferences in the controversy. Ellis asserted he was trying to prevent "the growth of an absurd, unnatural doctrine, exactly similar to the Romish doctrine of transubstantiation."44

Ellis repeated the Baron's experiments and he was able to explain the mystery. He placed mushroom spores
in water and soon discovered them moving around in the liquid. Using his microscope, Ellis observed infusoria swimming in the water. After further study, he found these tiny one celled animals around the mushroom spores. Later these spores germinated and produced the expected fungi. Ellis concluded that Munchhausen had a contaminated culture and that he confused the spores with the infusoria. Nothing "unnatural" had occurred in the process, said this proponent of naturalistic explanation.  

At about this same time, naturalists reported in the periodicals a strange "vegetable fly" or "vegetating fly," another organism that some naturalists claimed was capable of changing from an insect into a plant. Most of the interest centered around a fly from the Lesser Antilles. Auguste Denis Fougeroux de Bondaroy (1732-89), a well known French botanist, published a paper in 1769 in the *Histoire de l'Academie Royale des Sciences* on this phenomenon. He described several instances in which he discovered a fungus growing directly from the body of a dead insect. Bondaroy seriously thought the insect was in the process of becoming a plant. Bewley reviewed the *Histoire* in the *Monthly Review*. He gave the correct
explanation for the mysterious event. The occurrence was nothing more miraculous than a fungus growing on the body of a dead insect. The plant and animal were two distinct organisms. Bewley dismissed the whole matter:

We can see nothing more wonderful in the growth of a small plant on the body of a scarabée, than in a fungus vegetating on a beer cask, or a wall flower on a bare stone. As those plants that have been found growing on the bodies of certain insects there can be no doubt that they are merely parasites, whose seeds have fallen on them, and have there found a proper support and pabulum.47

Jean Louis Antoine Reynier (1762-1825), a French naturalist, claimed an interesting variation on the theory that animals could become plants. He studied a number of dead insects that had a beautiful saffron colored mushroom growing on them. Reynier noted that often these mushrooms grew through the shell of the insect. He claimed most naturalists believed that all mushrooms grew from "seeds." If this hypothesis was correct, then Reynier wondered how the "seed" of the mushroom got inside the insect, was able to resist the digestive juices and grow through the insect's shell. He concluded the most reasonable explanation was that the insect produced a vegetable. He put forth a complex theory of life to account for this change in form.
Reynier believed the "matter" of plants and animals differed only in that the former contained less "fire" than the latter. This fire was a constituent part of all organisms and if an excess or deficit of fire accumulated, then the form of the organism changed. In the case of the vegetable fly, the insect died, decayed, and as a result of putrefaction lost fire, and became a mushroom. An anonymous reviewer in the *Critical Review* explained Reynier's theory and then commented sarcastically: "We must . . . wonder that every dead daphne is not changed into a laurel; or that yews in our church-yards, are not as common as graves." Reynier's conjectures about a fire fluid were part of the theory of immanence, a popular hypothesis of the eighteenth century that will be examined in detail in the next chapter.

In addition to assorted organisms that some naturalists believed changed forms and location on the chain of being, philosophers in the eighteenth century learned that entire groups of living creatures previously believed to be plants, were in fact animals, and therefore located incorrectly on the chain. Many of these coelenterates and polyzoa seemed to be intermediate forms between plants and
animals, the zoophytes as the naturalists called them. Careful readers of the periodicals learned quickly about reports and experiments concerning these problematic organisms.

One of the most memorable events in eighteenth century natural history was the rediscovery of the fresh water hydra or polyp in 1739. Charles Bonnet (1720-93), a Genevan naturalist, believed the hydra was the missing link in the scale of nature between plants and animals; he went so far as to predict that soon naturalists would discover the bridge between the vegetable and mineral kingdoms.49 Abraham Trembley (1710-84), also a Genevan naturalist, first observed the hydra (Chlorohydra viridissima) in a drainage ditch while in Holland. The hydans, about a quarter inch long, were bright green leading Trembley to assume for a while that they were plants. He cut up a number of them and found that they regenerated like plants into complete and whole organisms. He also noticed that the polyps reproduced by a process of budding. They seemed to be especially sensitive plants that responded to stimulation. Trembley, however, observed the hydans feeding upon pond life, migrating around the glass to follow
sunlight, and moving in spontaneous motion. Finally he came to the conclusion they were animals. The news of these amazing organisms spread rapidly throughout Europe. French philosophe like Julien Lamettrie (1709-51) and Denis Diderot (1713-84) cited the seeming indestructability of the hydra as evidence to support their materialistic theories. For them the hydra seemed to show that small bits of matter had the capacity to organize.50

The editors of British periodicals published long accounts of Trembley's famous polyps. The most amazing feature of these animals was their ability to reproduce and regenerate missing parts. Trembley reported how he chopped up the hydros and watched with his own eyes as the segments again became complete animals. As he told British readers:

If a body of a polypus is cut into two parts, each of them becomes a compleat polypus. The very day of the operation, the anterior part lengthens itself, creeps and eats; and the other part, which has no head, gets one, a mouth forms itself at the anterior end, and shoots out arms. . . . I have seen arms begin to sprout out twenty four hours after the operation, and the new head perfected in a few days. . . . A polypus may also be cut in two, length-ways, first splitting the head, and then the stomach, so that each part forms
a half-pipe; the edges of which soon close. . . . 
I have cut one thus between seven and eight in 
the morning, and between two and three in the 
afternoon, each of the parts was able to eat a 
worm as long as itself.51

Goldsmith in his eight-volume *An History of the Earth*
and *Animated Matter* compared the polyp and the sensitive
plant. An anonymous writer in the *Critical Review* noted 
that Goldsmith found many similarities in the two organisms 
but he still believed a gap separated the plant and animal 
kingdoms. All organisms in the animal kingdom were 
superior, even to the most developed plant. Goldsmith 
compared the polyp and sensitive plant and noted:

> It [the polyp] changes its situation; and there­
fore possesses a power of chusing its food, or 
retreating from danger. Still, therefore, the 
animal kingdom is far removed above the vegetable; 
and its lowest denizen is possessed of very 
great privileges, when compared with plants with 
which it is often surrounded.52

Another problematic organism in the eighteenth century
was the sponge. Ellis published a paper on sponges in the
*Philosophical Transactions* in 1765. Writers in both the
*Critical Review* and *Monthly Review* analyzed his paper. John
Berkenhout, a physician and army officer, who wrote the
review in the *Monthly* traced the opinions of naturalists 
since the ancient Greeks. Aristotle and Pliny both
observed that sponges had a degree of sensation. Luigi Marsigli (1658-1730), however, had pronounced them vegetables. Jean André Peyssonnel (1694-1759) found some extraneous worms on a sponge and concluded that they had built the sponge as a refuge. Ellis studied the sponges and concluded the Ancients were correct in their assertion that the sponges experienced sensation. Ellis placed a sponge in a glass and noted contraction and dilation of its pores as the animal received and expelled water. He determined that the sponge was an animal sui generis.53

Ellis named a diverse group of simple animals "corallines." Many articles appeared in the periodicals about these unusual creatures. Today zoologists classify most of these animals in the phylum Polyzoa, or moss animals, and place them near the arthropods, well removed from the phylum Coelenterata. Most of them resemble the corals in their mode of life, even though their colonies are flexible because the animals do not secrete large amounts of lime. Some of the delicate corallines bear a startling resemblance to sea plants.

Bewley reviewed in the Monthly in 1755 a book of Ellis's that traced the history of the controversy over the
corallines and delineated the anatomy of these creatures. According to Ellis, Ray believed the corallines to be plants. Bernard de Jussieu (1699-1777), Keeper of the Royal Gardens at Trianon, believed the organisms were the work of animals. Jussieu observed a great number of "insects" living in the various parts of these marine productions. He claimed the bodies were only "cases" produced by the insects for their habitation. Actually, this assumption was quite reasonable. The corallines consist of two different parts. One form is a living enclosure or case (the zooecium) which often resembles the head of a bird of prey. The other part is the polypide, which in a sense inhabits the zooecium, has a digestive track and differentiated muscle tissue not found in the coelenterates. From time to time the polypide collapses into a "brown body" which the zooecium ejects and replaces. Ellis provided the correct anatomy of the animals.  

Ellis divided the corallines into four types, the vesticulated, tubular, celliferous, and articulated corallines. He also described where the corallines were to be found in the seas around the British Isles and how a naturalist might obtain and raise them. Bewley praised
Ellis' work and exclaimed that he "seems to have put the matter beyond dispute" in demonstrating that the corallines were really an animal with different forms. Ellis also published a letter in the London Magazine and provided more descriptions of corallines in addition to a well-executed plate illustrating some of the more common species.

Ellis was not able to convince all naturalists of the truth of his assertion that corallines were animals. A number of investigators continued to claim that the zooecium part of the coralline was a plant inhabited by a separate animal, usually termed a polype. An anonymous naturalist contributed a letter to the London in 1756 and reported the results of his own study. He made an analogy with a plum leaf encrusted with insects. The leaf was still part of a plant even though it was no longer recognizable. The polypes covered sea plants but they did not change the basic nature of their host. The writer also observed the regularity and symmetry of the corallines with their stems and branches. He concluded that no animal was capable of this type of growth. The anonymous writer claimed the corallines produced "seed-vessels" and "roots,"
structures which no animal had. On the basis of all these plant structures, he decided that corallines were indeed plants with numerous polypes living in and on them.57

Ellis attempted to make a definitive separation of the plant and animal kingdoms. He asserted, unfortunately, that all the corallines described by Ray and Joseph Pitton de Tournefort (1656-1708) were animals even though Peyssonel and William Watson (1715-87) had warned that some were seaweeds. Ellis' problems were due mostly to inexperience and his insistence upon a single criterion for distinguishing plants— their inability to secrete lime (calcareous algae can synthesize lime).58 Job Baster (1711-75) recognized that Ellis was a little careless in his work and in a paper in 1757 in the Philosophical Transactions corrected Ellis' error with regard to the calcareous algae. Ellis in a rejoinder in the same publication admitted his mistake. An anonymous reviewer in the Gentleman's commented on both of these papers.59

Ellis was the first naturalist in the periodicals to reject analogies between plants and animals. In 1776 he published a paper in the Philosophical Transactions on gorgonia, commonly known as sea fans, sea feathers, and sea whips (coelentrates of the subclass Octocorallia
distinguished by their soft coral-like forms and limited mobility). An anonymous reviewer in the Critical Review praised Ellis for having demonstrated that sea feathers were real marine animals and not of a mixed animal and vegetable nature. He noted that Ellis exploded the analogy used by others in comparing the bush-like gorgonia to land shrubs. The reviewer commented that Ellis had discovered that sea feathers lacked the "hollow fibres and little tubes" of woody plants. The side "branches" of the gorgonia lacked any connection with the "pith" of the main stem.60

Another anonymous reviewer in the Critical Review in 1786, ten years after Ellis' death, still maintained, incorrectly, that the latter drew analogies between the gorgonia and land shrubs.61 The unnamed reviewer stated that Ellis followed Linnaeus in attempting to demonstrate this analogy. The critic noted that Ellis adduced arguments to prove, that the zoophytes are animals vegetating like plants with flowers, bark, and wood. This is another proof of a servile imitation of the Swedish naturalist. He ought to have neglected every reference to the vegetable kingdom, for coral resembles the bone of an animal more than the wood of a tree. Besides, if a gorgonia is divided, it re-produces the part like any other animal
of the same kind, by first forming a little cone, which expands and is evolved into the new part. 62

A careful reading of Ellis' book shows that Ellis did exactly what the reviewer desired—refute Linnaeus on the analogy issue. Ellis devoted ten pages to a detailed discussion of why the structure of gorgonia was not similar to that of shrubs. Ellis commented in summary that he endeavored "to answer the arguments that have been advanced by late writers to prove their [gorgonia] being of a mixt nature; that is, that they are animals, vegetating in the manner of plants with flowers, bark, and wood." 63 This was one of the few reviews where the analyst completely misunderstood the aims of the author.

Another group of organisms that attracted the attention of naturalists throughout Europe in the eighteenth century were the stony corals or true coral. Like a number of other organisms, coral had been considered a plant by most naturalists. Gradually the researchers began to discover the animal status of these branching marine animals. The editors of the magazines closely followed the controversy between those who believed that the corals were plants and those who recognized that they were animals.
The editor of the Gentleman's in 1709 reprinted a paper by Jussieu that the latter had published in the *Histoire de l'Académie Royale des Sciences*. In this paper Jussieu briefly traced the history of the coral controversy. In 1711 Marsigli, while studying small sea plants, accidently observed some "small flowers" on branches of a coral plant. He noticed that when he removed the coral from sea water, the flowers disappeared. Marsigli's discovery prompted other naturalists to investigate the corals. Peyssonel disclosed that these flowers were sea animals or "insects" and that the interior core of the coral had no structures analogous to plant stems. Peyssonel submitted a paper to the French Academy but René Antoine Ferchault de Réamur (1683-1757), a member of the Academy, condensed Peyssonel's observations and published them anonymously in 1727 in the *Histoire* to save Peyssonel from ridicule. Thomas Shaw (1694-1751), an English physician, a few years later observed small "roots" on coral that seemed to him to confirm the botanical nature of the organism. Finally, in 1741, Jussieu, who said he was fascinated by such diversity of opinion described how he went to the coast of Normandy and observed the polypides of *Alcyonaria* (a soft coral).
His observations of this and other corals convinced him "to depart from the common idea of them, since repeated experiments assure me they are not plants, but a concretion of the cells of insects." Jussieu concluded with a plate and descriptions of a variety of corals.

The belief that corals were animals encountered vigorous opposition from defenders of the chain of being who were unwilling to elevate a "plant" to so high a status. The editor of the Gentleman's published a paper William Stukeley (1687-1765) had read to the Royal Society. He mentioned that "coral tree" were really plants. "Polypuses" used the trees as a home and a nest. He cited the "branches," "roots," and "sap" of the corals as obvious characteristics of the vegetable world. He asserted that the coral received its nourishment from sea water in a manner analogous to the way that some aloetic plants got their food from the air. The polypuses lived in the coral tree, and, in Stukeley's words "this tree was made for the animals, the animals did not make the tree." He simply did not believe that millions of polypuses could "act in concert and fabricate so elegant, regular and uniform a structure" as a coral.
Most naturalists eventually realized that corals were animals. The editor of the *London Magazine* republished in 1758 a letter from Trembley giving an account of Vitaliano Donati's latest studies on coral. Donati (1717-63), professor of botany at Turin, had maintained that coral was a zoophyte. Donati investigated coral along the coast of Provence and gradually came to the viewpoint that they belonged in the animal kingdom. He was thoroughly satisfied that the "polypes are fixed to their shells."

In a particularly astute observation Donati noted the polyps had the same relation to their coral covering as a snail had to its shell. He believed the polyps themselves were only the heads of the animal, surrounded by a bone in the shape of a shrub. According to Trembley, Donati concluded:

> I am now of the opinion, that coral is nothing else than a real animal, which has a very great number of heads. I consider the polypes of coral only as the heads of the animal. This animal has a bone ramified in the shape of a shrub. This bone is covered with a kind of flesh, which is the flesh of the animal.68

This quotation represented an abandonment of Donati's earlier position. He realized that the corals were true animals and not half-animal, half-plant, and he used analogies of the animal, not of the plant, kingdom.
The readers of the British periodicals between 1731 and 1789 found an ancient set of hypotheses, the chain of being, linking together the animate and inanimate world. Until late in the century, many natural historians viewed nature as a plenum and a continuum with no gaps between the plant and animal and the plant and mineral kingdoms. Usually the chain was an implicit part of a naturalist's thinking.

The attempts on the part of natural historians to link together the plant and animal realms caused naturalists to seek analogies between these two kingdoms. Some of the similarities they emphasized such as sexual reproduction, growth, and differentiation were valid biological comparisons. Often however, the naturalists went to absurd lengths and claimed plants slept or experienced happiness in a manner analogous to animals. At the end of the time period, Richard Watson introduced chemical analysis as a means of comparing the two kingdoms. Ellis was the first naturalist who specifically attempted to eliminate the use of analogies.

In the periodicals, readers were able to learn that the chain of being was not a static formation. Some
naturalists claimed "vegetable-flies" and other creatures were sometimes plants and sometimes animals. At the upper end of the plant kingdom was a large group of organisms described by Linnaeus as zoophytes or questionable species. After much debate, controversy, and some extensive research by Ellis and others, the corallines, corals, sponges, polyps, and anemones by 1789 were placed with the animals. The reassignment of these organisms to the animal realm widened the gap between the plant and animal worlds.

By 1789 in the periodicals, writers questioned the traditional modes of thinking. As mentioned in the previous chapter, the idea of God playing an active role in nature was being pushed aside by naturalistic explanations. Natural historians were beginning to realize that the Aristotelian chain of being contained distinct gaps.
FOOTNOTES


2 Lovejoy, Great Chain of Being, p. 183.


5 Voltaire, quoted in "Extracts from Dictionaire philosophique," The Gentleman's Magazine, 35 (October, 1765), 471.

6 Ibid., p. 472.


Ibid.


Ibid., 50 (November, 1788), 529-31.

Ibid., p. 531.


Hales actually disproved the circulation analogy in Experiment I in *Vegetable Staticks*. This refutation was probably overlooked by eighteenth century naturalists because of Hales' comment in his book that a circulation of subtle vapors or fluids was possible in a plant. Stephen Hales, *Vegetable Staticks: Or, an Account of Some Statical Experiments on the Sap of Vegetables: Being an Essay Towards a Natural History of Vegetation* (London: Printed for W. and J. Innys, and T. Woodward, 1727 [1961 reprint], pp. 1-7; Ritterbush, *Overtures to Biology*, pp. 84-86.


Ibid.
20 Hill, quoted from *The Vegetable System*, in an anonymous review, in *The Monthly Review*, 21 (December, 1759), 492.


28 Letter from John Ellis to Carolus Linnaeus, reprinted in *The Scots Magazine*, 32 (August, 1770), 408.


46 Fougeroux de Bondaroy, "Memoir sur des insectes sur lesquels on trouve des plantes," Histoire de l'Academie Royale des Sciences (1769), 467-76.


51 Abraham Trembley, "Observations and Experiments on the Fresh-Water Polypus," The Scots Magazine, 5 (January, 1743), 9; see also, Abraham Trembley, "Memoirs for the Natural History of a Kind of Fresh-Water Polypus," Literary
Journal, 2 (1745), 114-23; Abraham Trembley, "Observations and Experiments upon the Freshwater Polypus," Philosophical Transactions, 42 (1743), vii-x.


55 Bewley, review of Corallines, p. 181; Ellis, Corallines, pp. 1-3.


58 Ritterbush, Overtures to Biology, p. 136.

59 Anonymous review of Job Baster, "Observationes de corallines," in The Gentleman's Magazine, 28 (June, 1758),
473-74; Job Baster, "Observationes de corallines, iisque insidentibus, polypis, aliiisque animalculis marinis," Philosophical Transactions, 50 (1757), 258-80; anonymous review of John Ellis, "Remarks on Dr. Job Baster's 'Observationes de Corallines,'" in The Gentleman's Magazine, 28 (June, 1758), 473-74; John Ellis, "Remarks on Dr. Job Baster's 'Observationes de Corallines,'" Philosophical Transactions, 50 (1757), 280-87.


62 Anonymous review of Zoophytes, pp. 3-4.

63 Ellis and Solander, Zoophytes, p. 70.

64 Bernard de Jussieu, "De quelques productions marines qui ont été mises au nombre des plantes, & qui sont l'ouvrage d'une sorte d'insects de mer," Histoire de l'Academie Royale des Sciences, 1742), 290-302.

65 Ibid., p. 301; Bernard de Jussieu, "Examination of Some Productions in the Sea, Which Have Hitherto Been Accounted Plants, but Are Really the Works of a Sea-Insect," The Gentleman's Magazine, 19 (April, 1749), 158.

67 Ibid.

The hypothesis of the chain of being was not the only concept in the eighteenth century linking the animate and inanimate world. Many natural historians and natural philosophers believed interrelated subtle fluids caused all physical and vital phenomena in the universe. Philip C. Ritterbush has termed this synthesis "the idea of immanence." Naturalists expressed this idea of immanence in various ways. They imagined that fire, electricity, gravity, nervous impulses, repulsion, chemical action, refraction of light, etc. were all caused by a highly attenuated gas or "ether."

The supposition of immanence has a complex history. In the seventeenth century, Boyle, René Descartes (1596-1650), and other philosophers formulated a mechanical theory of matter. The mechanists reduced all observable events to matter in motion, often supporting their theories with naive mechanical models. Boyle, for example, imagined air particles shaped like springs. At the end of the
century, Newton theorized that gravity might be caused by a subtle ether that was rarefied within dense bodies; pressure from the denser parts of the medium he suggested caused material objects to draw together. He also speculated that the ether produced the reflection and refraction of light and that vibrations of ether along the nerves constituted nervous impulses. Newton's ethereal medium that penetrated all bodies was a central pillar of his system of nature. Newton's ether replaced gross corpuscles as the ordering principle of nature.2

Newton's conjectures that all physical forces might be interrelated contributed to much eighteenth century speculation about metaphysical harmony. Some scientists attempted to formulate theories that explained all the processes in the universe. Bryan Robinson of Dublin (1680-1754) was a typical eighteenth century speculator who abandoned limited explanation in favor of universals. He attempted to describe gravity, light, heat, muscle motion, and the transmission of nervous impulses in terms of a single fluid. Newton had advanced ether as a hypothetical substance; Robinson believed its existence was a demonstrated fact. George Berkeley (1685-1735) in 1744 in Siris
contributed a vitalistic concept of subtle fluids. He presented a hermetic concept of God as the soul of the universe with a subtle fire as His instrument. Newton's ether was too mechanical for Berkeley, who believed fire was a real vital spirit. Actually, Berkeley deified Newton's ether.³

Naturalists gradually abandoned the idea of corpuscles in the plant and animal kingdoms. Nehemiah Grew (1641-1712), a British speculative plant physiologist, believed that gross fluids could not circulate in plants because their vessels were too fine for "anything more gross than vapor." Many naturalists, as previously noted, drew an analogy between the circulation of fluids in plants and in animals. Even though investigators discredited the claim that plants had a circulatory system similar to animals, some naturalists continued to argue in favor of a circulation of subtle fluids, and as a result, it became an important part of plant and animal physiological theories until the end of the eighteenth century.⁴

The idea of immanence appeared in a variety of forms in the British periodicals. Naturalists identified particular kinds of subtle fluids, such as electricity, ether,
phlogiston, gravity, and heat, with life itself. Other re-
searchers investigated nervous fluids. Finally, some
naturalists were intrigued with the discoveries of Franklin
and other electricians concerning the properties of
electricity. These men attempted to utilize their findings
with various electrical experiments involving plants and
animals. The source of electrical charges of fishes was a
very popular topic of debate.

One of the first naturalists explicitly to identify
subtle electric fire with life was John Freke (1688-1756).
Both Cave in the Gentleman's and his competition in the
London printed large abstracts of Freke's essay on elec-
tricity which first appeared in 1746. Freke noted that
electrical apparatus never lost any matter while producing
electricity. The electric fire, therefore, had to come
from the surrounding air. Air was universally impregnated
with electricity, he noted, but fire was the active
principle, the pabulum vitae, of the animal and vegetable
world. Any organism that lost its fire no longer pos-
sessed the living element and ceased to be in a state of
life. An organism without electricity was a mere caput
mortuum. The sensitive plant had the most electric fire of
any vegetable; when touched, the plant discharged and folded its leaves. It remained in a languid state until it recovered electricity from the surrounding air. Freke claimed that the electric fire collected in the stamens and pistils of most plants. The process of pollination was really the result of the natural attraction of fire. Freke concluded with a strong warning to everyone. People must not lodge young children together with old people. Old people with less natural fire in their bodies tended to draw fire from children and weaken the latter.6

An anonymous letter writer in the Gentleman's in 1762 identified electric fire with life in an even more mystical sense. He claimed that recent electrical discoveries supported the theories of the German mystic, Jacob Boehme (1575-1624) and the British evangelical preacher, William Law (1686-1761). Law, drawing upon Boehme, believed that nature had seven properties: compressing, attracting, whirling, fire, light, life, and spirit.6 The anonymous writer thought that electricity produced all of these. He noted that the first two, compressing, or enclosing, and drawing, or attracting, had equal strength and power but always in opposition to each other. This phenomenon was
analogous to the behavior of positive and negative electrical charges. When the first two forces opposed each other, the third property, "whirling round," occurred. The anonymous writer noted the obvious connections between electricity and the fourth and fifth properties, fire and light. Law's sixth property, life, was a consequence of electric fire. The writer cited an experiment. If one put an animal and a lighted candle in a closed container, they both expired at the same instant. He believed the candle and animal used all the electric fire in the container; it was the lack of fire, not air, that produced their demise. The writer referred to Freke's experiments as proof of his claim. Law's final property of nature, spirit, could be felt by holding the conductors of an electric machine. The nameless writer concluded by noting that the seven properties of nature were based upon electric fire and that "nature took its use from the will of the deity."

The Abbé Bertholon de St. Lazare (1742-1800) in De l'électricité des végétaux claimed that electric fire was necessary for living things. According to Maclaine in the Monthly, Bertholon believed that water transmitted the
electric fluid to plants. Rain water, especially from a thunderstorm, was rich in electricity. Bertholon thought that most well water was not suitable for irrigation of vegetables because it contained very little electric fluid. He mentioned some experiments that he believed proved that plants in an electrified vase grew faster than non-electrified ones. He claimed that the sensitive plant contracted its leaves only when touched by a conductive substance that drew off electric fire from the plant. Bertholon thought that if someone prodded the *Mimosa* with a non-conductive material, it did not react. Maclaine described Bertholon's famous machine, a giant lightning rod with tubes to distribute the electric fluid to various parts of a field, designed to put electricity into the ground, the "electro-vegeto-meter." A farmer could utilize this device to enrich his soil with electricity.

D. Stephenson, an employee of the Office of Ordnance, in a letter in the *Gentleman's Magazine* in 1747 claimed that all operations of nature were the result of the interaction of two substances—ether and air. He asserted that naturalists could best understand the universe by postulating the fewest and simplest causes. Stephenson
believed that ether and air together were the sole cause of all phenomena of light, color, heat, fire, and electricity. He theorized that both air and ether circulated between living plants and animals and their environment. Warm sunshine increased the exchange of ether, and he pointed to the increased vigor of plants and animals during the summer months. Stephenson believed that no organism could live, grow, or reproduce without air and ether for two reasons. First, both fluids formed a strong "elastic case or bandage" to compress and support the animal and vegetable solids. Without these cohesive forces all organisms would be unable to resist the "distending force of circulating rarefied fluids." In a general sense, Stephenson believed that air and ether were the organizing principles of living things and enabled the organism to resist the disorganizing effects of outside forces in the environment. Second, both air and ether mixed into all other fluids and served as a "universal menstruum to preserve the texture, heat, fluxility, etc." of the fluids. For these two reasons, to Stephenson, air and ether were as necessary in the composition and mechanism of animals and vegetables as blood and other fluids.\(^9\)
Phlogiston was probably the most widely accepted subtle fluid of the eighteenth century. Natural philosophers of this period believed that phlogiston was exhausted from a body during oxidation or released from bodies as the fluid of heat. Jean Senebier (1742-1809), a Genevan naturalist, asserted that phlogiston was similar and perhaps identical to electricity. Senebier stated his viewpoint in a volume, Mémoire sur le phlogistique, considéré comme du développement de la vie & de la destruction de tous les êtres dans les trois règnes, which Maclaine reviewed in the Monthly in 1777. According to the reviewer, Senebier based his arguments on the fact that the electric fluid and phlogiston produced similar effects on plants and animals; both fluids accelerated the circulation of blood and sap. Senebier claimed they both augmented the fluidity of blood and of sap; both produced cutaneous eruptions and removed obstructions in the vessels, irritated the muscles, and acted upon organisms when other stimulants had no effect. These two substances appeared in quantity in animals and vegetables and they seemed to stimulate their growth. Senebier noted that animals could be killed both by electric fluid and by "phlogistic vapors." In the nonliving world,
Senebier felt that both phlogiston and the electric fluid melted and calcined metals. They also tended to promote evaporation from liquids. Senebier promised further experiments to determine if phlogiston and the electric fluid were the same force.10

Buffon was also a firm believer in immanent forces. He attributed all the various phenomena of living matter to two sources—gravity and heat. Although he never explicitly identified gravity or heat as fluid substances, or anything else for that matter, the attributes Buffon gave them were similar to the behaviors of the subtle fluids other naturalists postulated. When Buffon spoke of "living matter" he referred not only to all animals and vegetables, but likewise to light, fire, and heat. Bewley reviewed a volume of Buffon's *Histoire naturelle* and attempted to explain his "powers of nature." Bewley quoted a long paragraph from the volume in which Buffon claimed that all action in nature was caused by two "primitive forces," gravity and heat, and the force of "impulse" that was subordinate to these. Impulse depended upon gravity for its particular effects and upon heat for its general effect. An impulse could not act but by
means of the elastic power in bodies as the latter could not exert itself except in consequence of the force which brought together the parts which had been removed from each other.\textsuperscript{11}

Bewley reacted to Buffon's theorizing by accusing him of reverting to Scholasticism:

In pursuing this short specimen the reader will fancy himself transported back into the age of Aristotle, or the schoolmen, when words stood for things, and when every philosophical difficulty was at once readily solved by the dextrous application of powers and qualities.\textsuperscript{12}

Bewley attempted to explicate Buffon's distinction between animate and inanimate matter. Buffon believed gravity or attraction produced all the effects of inanimate matter. The same force of attraction joined to that of heat produced all the phenomena of living matter. Living matter always tended from the center to the circumference, whereas inanimate matter tended, on the contrary, from the circumference to the center. An expansive force animated living matter and an attractive force ruled inanimate. These two forces opposed and counterbalanced each other.\textsuperscript{13} Buffon's abstract theorizing was too much for Bewley. He condemned Buffon:
Partial as we are to the great and acknowledged talents of the author, we could not avoid giving these specimens of the figurative and licentious mode of treating philosophical matters, which runs through the greater part of these two dissertations. . . . that plays on the imagination, and seems to have scarce any other foundation.14

Bewley objected to Buffon's abstruse theory, although he was not opposed to immanence per se. For example, Bewley believed that the electric fluid was an important motivating force in nature.

Most naturalists, especially after the electric discoveries of the 1740's, assumed that one or more subtle fluids were a motivating force or forces in both the living and non-living realms. Some investigators even examined animals to attempt to discover the "nervous fluid" they believed flowed in the nervous systems of higher animals.15

In 1717 in the twenty-fourth query attached to his Optics, Newton had speculated that the nerves contained a vibrating ether which transmitted nervous impulses.16 Naturalists took the cue and began to probe the matter. James Kirkpatrick reviewed in the Monthly a book by Malcolm Flemyng (d. 1764), a Scottish physician and physiologist, entitled The Nature of the Nervous Fluid, or Animal Spirits, Demonstrated. Kirkpatrick prefaced his review by providing
background information from Albrecht von Haller (1708-77), the Swiss physician, who had also claimed the existence of a nervous fluid. Haller vigorously opposed those physicians and naturalists who believed nerves transmitted impulses in a manner analogous to a vibrating string. Kirkpatrick next presented Flemyng's theory of nerves. He believed that an animal's nervous system was a complex of hollow tubes which contained a subtle fluid and animal spirits. These two substances might or might not be identical. Flemyng believed that the brain secreted the nervous fluid from raw materials supplied by the blood. Flemyng thought the fluid probably contained phlegm, water, oil, animal, salt, and earth, "all highly attenuated and subtilized, and intimately mixed and incorporated together." The nervous fluid also supplied the raw materials from which the nerves themselves were formed.

Kirkpatrick raised a problem that faced anyone who attempted to describe and analyze subtle fluids. Flemyng could not be sure that the fluid in the nerves contained only the substances he listed. The fluid might contain a type of "spirit" or material so subtle that it could escape any type of detection. Flemyng himself was aware of the difficulty and noted:
I pretend not to prove, that there is nothing else in the nervous fluid, besides the principles I have enumerated. . . . There may be in animal fluids in general, and that of the nerves in particular, some subtle aether, fire or spirit, or whatever other name it may be called by, diffused through the atmosphere, and perhaps over our whole system, acting by laws unknown to us, and in a particular manner in organized bodies; I say, there may be such a spirit necessary to cause muscular motions, in co-operation with the proper fluid of the nerves, which is the product of the animal fabric and oeconomy, and yet all my reasonings stood good.18

Kirkpatrick imagined that either the animal body formed the nervous fluid, and it was really animal spirit, or the nervous fluid was the vehicle for the animal spirit. He believed the latter possibility the most probable.19

Le Cat also believed that the nervous fluid contained a subtle fluid that was the cause of animal motion. According to an anonymous reviewer in the Monthly, Le Cat believed that the connection between the brain and body parts via the nerves was not essential for every single motion. Le Cat mentioned a heart may be entirely removed from an animal's body and yet it will continue to beat for some minutes. The nerves were not the only connection necessary for muscular motion. The arterial canals supplied essential blood to the muscles. Le Cat concluded that for
continued muscle function a connection between the brain and muscles via the nerves, and likewise between the heart and the muscles by way of the arteries was essential. Both of these contacts were requisite only as a mediate and general cause, but not as the immediate and simultaneous causes of every single motion.20

The reviewer commented on Le Cat's conception of the nervous fluid. Le Cat believed it bore little resemblance to the other fluids of the body and that a researcher could form no conception of it by comparing the fluid to any other fluid or material substance. Le Cat defined nervous fluid as a kind of middle substance between soul and body capable both of motion and thought. The nervous fluid was a kind of first class material substance but at the same time it was closely allied to "immaterial Beings." The anonymous reviewer did not entirely believe Le Cat's description of the nervous fluid. He noted that "M. Le Cat is a much better anatomist than a metaphysician."21

Le Cat concluded his theory with a discussion of muscular motion. According to the reviewer, Le Cat believed the muscles were composed of hollow fibers similar to feather quills. The nerves and arteries connected to
these muscle fibers supplies them with nervous fluid and blood. Le Cat asserted these fluids dilated the muscle fibers or their interstices and caused the muscle to contract.

Not all naturalists believed in the subtle nervous fluid. "E.K." contributed a letter to the Gentleman's contesting the prevailing opinion. He objected to the nervous fluid supposition for three reasons. First, he said, the network of nerves in an animal's body were not the sole organs of sensation. He noted that every part of the human body was sensitive to stimulation and he could not accept that the body was a gigantic mass of nerve tubes. Second, he wondered why, if the nervous fluid existed, naturalists or physicians had never been able to observe it or concretely demonstrate its existence. If a nerve contained a circulating fluid, then it should dilate when a ligature was tied on it. Since this phenomenon occurred on a tied artery, why not on a nerve also? Third, said E.K., a single fluid could not be responsible for so many manifestations. He remarked that naturalists claimed the fluid was responsible for both sensation and for muscular movement. E.K. asserted that the systole of the
heart muscle exerted a force equal to 100,000 pounds. He believed that all matter was basically inert or in a state of rest. E.K. could not fathom how an invisible fluid could stimulate inert matter to produce a powerful motion equal to fifty tons. 22

If E.K. did not entertain the theory of nervous fluids, how did he account for sensation and muscular movement? He never really spelled out his beliefs but instead promised to elaborate them in future correspondence. He hinted that notion might be caused by some unknown perpetual force within the body. Perhaps both movement and perception might not "with the greatest propriety, be referr'd to the secret operations and will of our almighty maker [sic]." 23 The acceptance of nervous fluids was an important part of the idea of immanence. The principal objection to nervous fluids and indeed to all subtle fluids was that they could not be isolated and identified.

Another aspect of the doctrine of immanence was the effect of one subtle fluid, electricity, on living plants and animals. Electricity was an exciting subject in the eighteenth century. As might be expected the editors of the periodicals inserted numerous experiments and reports
on the subject in the pages of their serials. Approximately half of all the articles on electricity dealt with the effects of electricity on living organisms. The invention of the Leyden jar in 1745 by Pieter van Musschenbroek enabled experimenters to store and release large electric charges. The invention of this device produced a flurry of electrical experiments throughout Europe after 1745. William Watson discharged a jar across the Thames River in 1747. Later he sent a shock through two miles of wire and two miles of ground. Next electricians turned their attention to the effect of electricity on living organisms.

In the March, 1747 issues of both the Gentleman's and Scots, Stephenson published a list of seventeen electrical experiments for a gentleman to perform with plants and animals. Stephenson's register of questions was similar to Francis Bacon's famous "natural histories" which investigators were to produce after a thorough investigation of a particular area of science. Stephenson, like Bacon, wanted a community undertaking to solve the mysteries of the electric fire and to provide useful and beneficial information for mankind. One of Stephenson's suggested
experiments was designed to determine whether or not electricity could make plants grow more rapidly:

If all vegetables that grow in pots, boxes, etc. are daily and frequently electriz'd, will they not have a better circulation, growth, nutrition, etc. and their flower, fruit, seed, etc. be more perfect than those not electrified? And will not this practice greatly advance all the branches of gardening, as the nursery, green-house etc.²⁴

Stephenson wondered if the quality of alcoholic beverages might not be improved by a generous application of electricity. He quieried "whether the fermentation, depuration, preservation, etc of all liquors, may not be greatly improved by a proper application of electricity, as the several processes will admit?²⁵

He believed electricity might be of use in treating certain diseases and purifying the air in sick rooms:

Will not the frequent electrifying [sic] of bedsteads, bedding, wearing apparel etc. render them much more wholesomer, and more especially when persons are sick, or the constitution of the air bad, either from noxious exhalations, or a pestilential disposition? And will not the frequent exciting such currents of ethereal fire in the bed-chambers serve to purify the air therein, as thunder and lightning do the general atmosphere, and prove of more use for that purpose than any ventilators, etc.?²⁶

Stephenson pondered what the effects on an animal's constitution might be if an electric tube were inserted in
the proper body opening. He inquired:

Whether by putting a tube into the anus of any animal the electric vapour may not be propagated through the whole compound intestinal canal to the mouth, and contrarywise from the mouth to the anus, and be transmitted also through the lacteal vessels to the blood, and so communicated to the whole animal system? And what effects the often repeating this operation will have on the animal functions of digestion, circulation, perspiration, secretions, and in curing the iliac colic, palsy, convulsions, consumptions, apoplexies, hysteric and hypochondriac affections, and other diseases of the head, thorax, and abdomen? And what effects will this ethereal vapour have, if communicated to the womb of animals, either pregnant or not; and likewise to the urinary bladder?²⁷

Like Stephenson, other naturalists were fascinated by the possibility that electricity would cause plants to grow rapidly. In 1747 Stephen Demainbray (1710-82), George III's tutor in science, reported in two letters to the Scots Magazine the results of his experiments with myrtle. He removed a pot of myrtle from his greenhouse and electrified it seventeen times over a period of one month. The plant produced several new shoots, the longest of which was three inches. A number of control plants that he left in the greenhouse showed no new growth.²⁸ In the next issue he described a second experiment. He removed two myrtle plants from his greenhouse and placed them side by side in
the same room. He electrified one but not the other. The treated myrtle sprouted several new shoots of three inches while the control plant again showed no change. Demainbray concluded by stating he did not have time to pursue his discovery further as he was occupied with running a girls' boarding school. He urged others to continue his investigations.29

Not all experiments with plants achieved the desired results. The editor of the Literary Journal reprinted a letter from the Philosophical Transactions from a John Browning to Henry Baker (1698-1774), a minor poet. Browning had an electrician at Bristol electrify a number of small trees with a good machine. Browning hoped to see the leaves become erect when electricity was applied to the plant, but nothing happened. He reported, however, if he brought his finger near the tree "a stream of fine purple-blue coloured light, much resembling an amethyst . . . issued from the extremity of each leaf upwards."30 Browning attributed this occurrence to the "watry particles in the earth." He noticed that by turning the electric fluid on and off, he caused a "trembling motion" in the leaves, but Browning reported no permanent changes in the electrified plants.
Cave reprinted in the Gentleman's a letter from the Philosophical Transactions in which the Abbé Jean Antoine Nollet (1700-70) reported the results of his experiments in France. He electrified a garden pot with assorted seeds planted in it for several hours each day for fifteen days. The seeds in this pot germinated earlier than those in a non-electrified pot. He repeated this experiment several times with identical results. The treated seeds always sprouted two or three days earlier than the others and a larger percentage of them grew. He concluded that "the electric virtue facilitates the growth of plants." \(^{31}\)

Nollet performed another series of investigations. He electrified for four or five hours fruits, plants, and a sponge dipped in water. He reported that all of them lost weight as a result of the electrification. Next Nollet repeated the experiment with animals. He selected matched pairs of cats, pigeons, chaffinches, and sparrows. The electrified animal lost weight in every instance while the control animal showed no weight decrease. Nollet decided to repeat the experiment using a human. He electrified several persons and calculated that they lost several ounces. He admitted that his trials with humans
might be of questionable validity "because the cloathing hinders one from forming a good judgment of the whole effect of the electric virtue."\textsuperscript{32}

Naturalists had long observed the snap and crackle of electric fire produced by stroking the back of a house cat. A person who identified himself only as "O.C.B." wrote a letter to the Gentleman's Magazine about the matter. While petting his cat he observed sparks between his hand and the animal's fur. He believed the snapping sound was similar to the noise emitted by an electric machine.\textsuperscript{33}

Another letter writer, "G.," asserted the existence of two types of electricity, artificial and natural. Artificial electricity was found in glass and other material that had to be rubbed to produce electricity. Natural electricity was common to many species of animals such as the electric fire found in a cat. G. believed that a cat's hair was electrical. The feline utilized its electrical powers while hunting at night. G. claimed that a cat raised its fur while stalking its prey, and the erection of fur caused a rush of electric fire to the animal's eyes. The fire illuminated the cat's pupils and enabled the beast to observe better its prey at night. G. called upon other
naturalists to study the wild members of the feline family in order to determine if they also used electrical fire in a similar manner.\textsuperscript{34}

Some naturalists may have considered cats electric animals and experimented with them, but by far the most debated and studied electric animals were the electric fishes. In the mid-eighteenth century naturalists made much of the electric torpedo of the Atlantic and Mediterranean Seas, the electric eel of the Guianas (\textit{Electrophorus electricus}), or "\textit{Gymnotus electricus}," as contemporaries called it, and the African electric catfish (\textit{Malapterurus electrophorus}). The unusual character of the torpedo had been known since classical times. In the 1670's members of the Accademia del Cimento in Florence investigated it, but the effects they observed were not identified as electric. Stefano Lorenzini and others at that time asserted that the torpedo transmitted some sort of material effluvia through the water and stunned its victims. In the early eighteenth century most natural historians believed Réaumur's explanation of the torpedo. He claimed that the fish caused its unusual numbing sensation by contracting its muscles and dealing a sharp blow that could
be transmitted through liquids. Most mechanists accepted this interpretation since they refused to countenance "pain at a distance." Robert Turner in his book, *Electriocology*, in 1746 was probably the first naturalist to suggest that the torpedo was electric, but his claim was ignored for about twenty years.\(^{35}\)

An article about the torpedo by Peter Templeman (1711-69), a physician, appeared in the *London Magazine* in 1754. He studied and experimented with a number of torpedoes while visiting in Italy, where some local fisherman supplied him with fresh specimens. He prodded and poked one for a considerable time before the animal finally discharged. He described the numbing sensation:

> I felt a kind of numbness that suddenly seized my whole arm, from the hand to the shoulder, and which even stunned my head. It was very different from the common numbness, it was attended with a considerable, though stupifying pain. I was unable to move my hand and arm, in such a situation as the Latins express by the word *attonitus*.\(^{36}\)

He went on to describe a few additional encounters with the torpedo.

Templeman next gave a summary of the two different theories being used to account for the phenomena. He
noted the claim of Lorenzini and other naturalists that the torpedo threw off an "abundance of little bodies proper to numb the part into which they insinuate themselves." 37 Men of this persuasion believed that the occurrence was somewhat analogous to the way in which a fire emitted an abundance of corpuscles. Templeman did not mention electricity in his discussion of this explanation.

Templeman took the second hypothesis from the writings of Alphonse Borelli (1608-78), professor of mathematics at Pisa. Borelli considered the emission of corpuscles by the torpedo as imaginary. He imagined the fish trembled violently and administered the painful numbness by literally inflicting blows upon its victims.

Templeman had no preconceived prejudice as to which theory was correct. He wanted to determine the cause of the torpedo's mysterious power for himself. After repeated experiments, Templeman made the following observations. He noticed that the torpedo's flat back was normally slightly convex. When someone annoyed the fish, it gradually altered the shape of its back to a concave position. The instant the torpedo attacked, the curvature of its back went from concave to convex again. This happened so rapidly that the
human eye could not see the movement. Templeman had never seen faster motion, not even the flight of a musket ball. He could not observe any violent trembling but believed the torpedo produced numbness by a single quick violent stroke.38

Bewley also supposed that the torpedo mechanically struck its victims. He reviewed in the Monthly in 1767 Priestley's The History and Present State of Electricity. Priestley in this volume had completely ignored some Dutch naturalists, principally J.N.S. Allamand (1713-87), who attributed the numbing sensation of the electric eel of Surinam to an electric shock. Bewley felt that the omission by Priestley of this controversial matter was unfortunate. But Bewley himself did not believe that the torpedo was an electric animal, citing the work of Réaumur who supposedly had demonstrated the torpedo physically beat its victim. Bewley ended by mildly ridiculing the whole concept of electric fishes:

We do not call in question the reality of the concussion given by the American gymnotus; as that produced by the European torpedo has been satisfactorily and circumstantially ascertained by the experiments of Réaumur, made on himself and others; who plausibly accounts for it by the sudden mechanical action of certain
muscles on its back. Certainly the experiments and conclusions above-mentioned are so contrary to the best-established electrical principles, that we think we shall do not injustice to this piscine electricity, if we venture to rank it among the deliramenta of electricians, in company with Mr. Grey's planetarium, the Italian medicated tubes and globes, and the beatification of Professor Boze.39

The American naturalist, Edward Bancroft (1744-1821), was probably the first person to demonstrate that some marine animals had the power of electric shock. He published An Essay on the Natural History of Guiana in which he described his experiments with the electric eel. An anonymous reviewer in the Critical Review devoted over a page in his review to a summary of Bancroft's findings. Bancroft listed seven reasons why Réaumur was wrong in claiming the torpedo delivered a muscular stroke to its victim. First, the eel shocked fishermen who caught them even though they held the other end of a line. Second, the animal could shock a group of people standing in a circle. Third, a man received the numbing effect from the eel in spite of being ten feet away in the water. Fourth, Bancroft claimed a person could receive a shock even though his hand was above the surface of the water six inches away from the animal. Fifth, no shock occurred when
a person held his hand near the animal unless it was disturbed. Sixth, the Indians ate the eel after killing it. Finally, the shock was violent when the *gymnotus* was angry. Bancroft, therefore, concluded that the eel shocked "by an emission of torporific or electric particles." The *gymnotus*, he said, voluntarily controlled the discharge of these electric particles from all areas of its body. Upon death, the eel lost its electric ability. Bancroft admitted that since he studied the electric eel and Reaumur investigated the torpedo, the possibility existed that the two animals had different numbing apparatus, but Bancroft believed this possibility was rather remote. Both animals, he felt, possessed natural electricity. Bancroft returned to England from Guiana in 1769 and circulated his theory among members of the Royal Society. He met John Walsh (1725?-95) and encouraged him to try experiments on the European torpedo.

By 1774 Bewley had realized that his original assessment of the torpedo was wrong, and it was Walsh's investigation of the torpedo that was responsible for Bewley's reassessment. Bewley reviewed the volume of the *Philosophical Transactions* that contained Walsh's famous monograph.
He began his critique by noting that some naturalists went too far in attributing almost every conceivable occurrence in the world to electricity. By 1774 most naturalists who believed in immanence had reduced the number of subtle fluids to one—electricity. Bewley noted that other natural historians, including himself, were overly cautious and failed to realize the widely varying events caused by electricity:

The electric fluid is now found to act so important and multifarious a part in the drama of the universe, as almost to justify the very whimsies of those who have had immediate recourse to it for the solution to every physical difficulty. But though some philosophers have undoubtedly been too liberal in recurring to it as the cause of every phenomenon that they could not otherwise account for; others it seems, have been too sparing and cautious in questioning its presence and agency, in certain phenomena which appeared to them to be repugnant to the known laws, by which the electric matter had hitherto been observed to be regulated. In this last class of circum­spect, but probably mistaken, reasoners, we include ourselves; and voluntarily take this opportunity of atoning our error, by reminding our readers of it, and acknowledging it.43

Bewley found it hard to believe that an animal produced large amounts of electricity. The electric power of the torpedo seemed to violate the principles of physics and common sense. But he noted, "la verité n'est pas toujours
du côté de la vraisemblance—truth and probability do not constantly go together.\textsuperscript{44}

Bewley recounted the experiments made by Walsh in France. Walsh visited the isle of Ré and obtained some torpedoes taken by local fishermen in their nets. He put a torpedo on a table and placed a long wire against the "breast" of the fish. Then he placed the other end of the wire in a basin of water and asked a man to put one finger in this water. He instructed the man to place a finger from his other hand into another basin of water. In this way Walsh formed a ring of seven people and from the last ran a wire which he put in contact with the back of the torpedo. All persons in the chain received a shock, just as those who took part in the classic experiment done with a Leyden jar. To Walsh, the demonstration clearly illustrated the electric power of the torpedo. In addition Walsh established that the torpedo had an almost inexhaustible supply of the electric fluid. He and other natural historians received over one hundred shocks from a single fish in the space of one minute.\textsuperscript{45}

Walsh, according to Bewley, also observed that the fish voluntarily controlled its discharge and signaled a
shock by a "depression or winking of his eyes." Walsh was troubled by the fact the fish seemed to be a living Leyden jar, that is, had opposite charges on its dorsal and ventral surface, but he was never able to produce an electric spark in experiments with the fish. In addition, the torpedo's electric charge seemed to have no effect upon pith balls. Walsh accounted for these anomalies by speculating that since the torpedo contained a large number of electric organs, at least 1182 of them over a large body surface area, the electric charge was greatly "diluted."

Bewley in the same review analyzed an article by John Hunter (1728-95), the famous comparative anatomist. The latter had dissected a torpedo's electric organs and discovered them to be well stocked with nerves. Hunter recalled that nerves were usually associated with either sensation or muscular movement. He believed that the electric organs were no special instruments of sense and that they seemed to entirely lack motion. Therefore he theorized that the network of nerves was involved in the formation, collection, and management of the electric fluid. Hunter, and indirectly Bewley, urged naturalists to investigate further the nervous system of the torpedo as more
information about the fish probably would lead to a greater understanding of the functions and power of the nerves of all animals. 47

Sir John Pringle (1707-82), the President of the Royal Society, presented Walsh with the Copley Medal on November 30, 1774 and honored him for his discoveries with the torpedo. The editors of both the Critical Review and the Scots Magazine published long accounts of the ceremony including excerpts from Pringle's address. Here he recounted the various explanations of the torpedo's power and here he also heaped lavish praise upon Walsh. 48

Word of Walsh's experiments with the torpedo quickly spread throughout Europe. Jan Ingenhousz (1730-99), the famous Dutch scientist, repeated some of Walsh's experiments and published his results in the Philosophical Transactions. 49

An anonymous reviewer in the Critical Review commented on the paper. Ingenhousz tested five different torpedoes and received shocks from them. He held them in his hands, with his thumbs against the upper body and his fingers on the lower surface. He noted that the shocks lasted two or three seconds and were rather weak. He attempted unsuccessfully to collect electricity from the fish in a Leyden jar.
Ingenhousz also was unable to produce a spark or crackle when the fish discharged itself.\textsuperscript{50}

Hugh Williamson (1735-1819), an American physician, studied the electric eel to determine if its properties were identical to the electrical ones of the torpedo. He, too, reported his results in a paper in the *Philosophical Transactions*, which an anonymous writer reviewed in the *Critical Review*.\textsuperscript{51} Williamson reported five conclusions from his observations of the eel. First, it had the power of communicating a painful sensation to animals near it. Second, this effect depended entirely upon the will of the eel. Third, the eel's power was not due to muscular action, because it was able to shock an object at great distances. Fourth, the numbing sensation was produced by "some fluid" which the eel discharged from its body. Finally, the fluid emitted affected the same parts of the human body as were acted upon by the electric fluid. The eel, like an electric machine, stunned or killed animals; it conveyed its fluid through the same conducting materials, and could not send its fluid through nonconducting substances. Therefore, the fluid produced by the eel was the "true electric fluid," and the shock given by the eel was the "true electric shock."\textsuperscript{52}
After Walsh and the other naturalists in the 1770's established that the torpedo produced genuine electric shocks, the editors of the periodicals published very few articles during the 1780's dealing with animal electricity and the idea of immanence as it applied to the plant and animal kingdoms. As a matter of fact, during the 1790's the idea of immanence became less popular with natural philosophers and historians. By the end of the century, Alessandro Volta and other researchers were demonstrating that electricity might arise from ordinary chemical reactions and that it was actually a property of common matter and not a mysterious vital force. The idea of immanence gradually faded from the thinking of most serious scientists in the nineteenth century. Only a few thinkers of the Romantic and/or Naturphilosophic schools, such as Friedrich Schelling continued to espouse a belief in a universal life-force at work in all mechanical, physical, and chemical phenomena.

Two important suppositions came together in the idea of immanence in the eighteenth century. First was the Aristotelian belief that no sharp gap existed between the living and non-living world. Change was a constant feature
of both realms. Second was the Newtonian theory that the universe contained one or more subtle fluids which governed the processes in the world and provided the motive force in nature. As a result of the merging of these two notions, scientists during the eighteenth century constantly searched for fluids to explain natural occurrences on earth. Readers of the periodicals noted how researchers claimed that these mysterious fluids were the vital force in the plant and animal kingdoms. After the 1740's electricity became the principal fluid which naturalists investigated. During the next fifty years, scientists gradually came to realize that electricity was not a mysterious motivating force, but was a common property of matter.

By 1789 few references to immanence appeared in the serials. Contributors were beginning to realize that the natural world was an exceedingly complex realm governed by a wide variety of processes and causes. Most natural historians understood that the postulation of subtle fluids did not contribute to the unraveling of the mysteries of nature. Increasingly they turned their attention to the study of particular problems in isolated disciplines.
FOOTNOTES


2 Ibid., pp. 2-5.

3 Ibid., pp. 7-13.

4 Ibid., pp. 74-75, 81, 87-88.


7 Anonymous letter to the editor, "A Letter to the Author of the Gentleman's Magazine: Wherein the Principles of Electricity Are Proved by Experiments to Be the Same with Those of Jacob Behmen's and Mr. Law's Philosophy," The Gentleman's Magazine, 32 (April, 1762), 177-79.


12 Ibid.


18 Flemyng, *Nervous Fluid*, p. 27; Kirkpatrick, review of *Nervous Fluid*, p. 54.

19 Kirkpatrick, review of *Nervous Fluid*, p. 54.


Mr. John Browning of Bristol, to Mr. Henry Baker, F.R.S.
Dated Dec. 11, 1746 Concerning the Effect of Electricity on Vegetables," Philosophical Transactions, 44 (1746), 374.


35 Ritterbush, Overtures to Biology, p. 35.


37 Ibid., p. 218.

38 Ibid.


(April, 1769), 190; [Edward Bancroft], An Essay on the
Natural History of Guiana, in South America (London:

41 Ritterbush, Overtures to Biology, p. 39.

42 John Walsh, "On the Electric Property of the
Torpedo," Philosophical Transactions, 63 (1774), 461-77.

43 [William Bewley], review of John Walsh, "Of the
Electric Property of the Torpedo," and John Hunter,
Review, 51 (September, 1774), 219.

44 Ibid.

461-77.

46 John Hunter, "Anatomical Observations on the
Torpedo," Philosophical Transactions, 63 (1774), 478-89.

p. 223.

48 Anonymous review of John Pringle, A Discourse on the
Torpedo, Delivered at the Anniversary Meeting of the Royal
Society, November 30, 1774, in The Critical Review, 39
(January, 1775), 44-46; 39 (February, 1775), 90-92; anony-
mous review of John Pringle, A Discourse on the Torpedo,
Delivered at the Anniversary Meeting of the Royal Society,
November 30, 1774, in The Scots Magazine, 37 (February,
1775), 90-92.

49 John Ingenhousz, "Extract of a Letter from Dr. John
Ingenhousz, F.R.S. to Sir John Pringle, Bart. P.R.S. Con-
taining Some Experiments on the Torpedo, Made at Leghorn,
January 1, 1773 (after Having Been Informed of Those of Mr.
Walsh)," Philosophical Transactions, 65 (1775), 1-4.


CHAPTER VII

GEOLOGY

Still another way of plumbing the nature of the studies of the natural historians is to focus on conspicuous controversial issues or problems that showed up in discussions in the periodicals. Often naturalists invoked elements of the general themes, immanence for example, to support their viewpoint on the particular matter under consideration. In most instances, naturalists debated various issues for the entire sixty year period under discussion but never reached a generally accepted definitive explanation. Some of the geological issues, for example, the cause of earthquakes, continued to defy scientific explanation until the twentieth century. Occasionally, as in the case of the devastating Lisbon earthquake of 1755, a scientific problem became part of the general news coverage of the magazine. For the most part, the naturalists usually discussed the issues from a purely scientific standpoint in the periodicals. Only rarely did theological explanations intrude into the realm of science. In these specific instances, divine activity was understood to be immediate rather than ultimate.
During the eighteenth century, the geological sciences were for the most part undeveloped and unorganized. Until 1778 when Deluc coined the term "géologie," no comprehensive word existed to delineate the earth sciences. Nevertheless, geology was still the subject of widespread interest, and often of close study throughout the century, both because of its intrinsic interest and because of its economic importance—the practicality particularly of Englishmen. Many important developments occurred in the geological sciences during the late eighteenth century.

Reflecting the importance and urgency of the progress of the sciences, the editors of the periodicals published a large number of articles and reviews about geology. Writers offered numerous hypotheses to account for the eruptions of volcanoes and related occurrences. Earthquakes were another geological phenomena that occupied hundreds of pages in the periodicals. And there was another important debate over the causes and distribution of fossils, particularly the many pachyderm bones unearthed during the late eighteenth century.

The occurrences of volcanoes and earthquakes have always been events of wonder and terror to mankind. Naturalists in the eighteenth century exhibited, for the most part,
little understanding of the processes deep in the earth, but they persisted in searching for naturalistic explanations. The frequent and often devastating eruptions of Mts. Vesuvius, Etna, Stromboli, and other volcanoes in southern Italy had for centuries prompted much speculation about the forces in the earth causing these outbursts. Most naturalists writing about volcanoes in the eighteenth century periodicals attributed the causes of volcanoes to water, combustibles in the earth, or even electricity. At least one reputable geologist maintained that air was an important agent in the eruption of some volcanoes. In the absence of easily understandable facts, theory flourished and opened the way for non-Baconian approaches.

The editors of both the Scots and London magazines reprinted a description of an unusual type of volcano by Déodat de Dolomieu (1750-1801), the pioneer French geologist, from his Voyage aux Isles de Lipari. He described a "new species of volcano" in Sicily. Dolomieu personally journeyed to Mt. Maccaluba to provide a first-hand description of the mountain. He expected to find an ordinary volcano. Near the summit he saw a broad plain containing a large number of truncated cones, similar to the usual formations
found on many volcanoes. Most of these craters contained bubbling masses of mud. He expected to find the mud in a heated condition but instead determined that it was rather cold to the touch. Dolomieu thrust his arm into a bubbling puddle and found the mud colder beneath the surface. No smoke was visible and the smell of sulfur was entirely absent. He examined the surrounding terrain and discovered only grey clay and a variety of sedimentary rocks that showed no evidence of having ever been altered by fire. He collected a bottle full of the "air" that escaped from the cones and determined that it was "fixed air," or carbon dioxide.2

At the time Dolomieu visited Mt. Maccaluba, it was in a state of inactivity. He discovered from local observers, however, that the volcano erupted almost every year. These eruptions produced earthquakes, smoke, explosions, cold mud flows and most of the occurrences of other volcanoes with the notable exceptions of heat and hot lava flows. Dolomieu was extremely surprised by his discoveries. He described his reaction:

I did not suspect that there was any other agent in nature except fire capable of producing the phenomena that had been announced to me; but I was quickly undeceived. I saw nothing around
me that indicated the presence of the igneous element, which when in action impresses a distinctive character on all its productions; and I was soon convinced that nature employs very different means to produce effects that resemble each other. I saw that fire was not the principal agent, nor even concerned in the phenomena of this mountain, and if in some eruptions smoke and heat were observed, that these circumstances are no more than casual or accessory, and do not point out the true cause of the explosions.  

Dolomieu attempted to explain the operations of this unique volcano. He noted the presence of large quantities of clay with gypsum. Dolomieu also noticed a large salt water spring on the mountain. He claimed that a chemical reaction occurred between the salt water and the clay which resulted in the release of large quantities of carbon dioxide and the deposit of gypsum. He believed that the carbon dioxide gas produced all the volcanic effects.

Most volcanologists were mainly concerned with the hot volcanoes. During the seventeenth and eighteenth century the majority of naturalists believed that volcanoes were caused by local deposits of inflammable materials such as sulfur or coal in the earth. Few naturalists believed that any connection might exist between surface volcanoes and a central fire that burned deep in the earth. John Ray, for example, studied volcanoes and was convinced they were
produced by combustible materials in the hollows of moun-
tains. He also was willing to admit the existence of a
central fire, and he apparently never thought of connecting
this central fire with the operations of active volcanoes. 5

Numerous accounts of volcanic eruptions in southern
Italy appeared in the periodicals. Most of the observers
limited themselves to a description of the event. Only
occasionally did the writer offer some suggestions as to
the cause of the eruption. Edward Cave in 1747 published
in the Gentleman's Magazine a report by a group of anonymous
Italian volcanologists of a 1737 volcanic activity at
Mt. Vesuvius. Cave also added as a brief appendix an
account of an ancient eruption of the mountain by Pliny the
Younger. In addition, they speculated on the cause of vol-
canic activity. The Italians asserted that the ground
around Naples contained large quantities of sulfur, asphalt,
saltpeter and other "first principles of fire." These
flammable substances caught fire, perhaps by spontaneous
combustion, and set off an eruption. The anonymous authors
commented:

It is not to be questioned then, that the
Neapolitan soil is full of the seeds, or
first principles of fire, which having in-
creased, and amassed themselves in some particular place, have, by the means of some internal motion, taken fire, split the upper stratum that confined it, to give vent to its rage, with all the violent phenomena of volcanos.⁶

The unknown writers provided experimental proof for their conjectures. They mentioned the famous artificial volcano constructed by the French experimental geologist, Nicholas Lemery (1645-1715). Lemery mixed a paste, composed of equal parts iron and sulfur and moistened the mixture with water. He buried the composition in the ground and after about nine hours, the ground began to swell and crack open. Hot sulfurous smoke came forth and after a few more minutes flames burst out. The volcanologists believed Lemery's artificial volcano was analogous to the soil conditions in southern Italy.⁷

In 1761 an anonymous reviewer in the Critical Review evaluated a book about Mt. Vesuvius entitled Histoire et phénomènes du Vésuve by the Italian Jesuit, Jean Marie de la Torre (1713-82). The reviewer praised the accurate descriptions of the historical eruptions of the volcano. He also provided a brief exposition of de la Torre's comments on the causes of volcanoes. De la Torre, like the previous group of writers, felt the outbursts were affected
the combustion of iron, sulfur, and other materials in the earth. In the case of Mt. Vesuvius, air and water entered into the bowels of the mountain, which consisted of iron, sulfur, vitriol, bitumen and other substances. "Fermentation" resulted and a violent eruption ensued. 8

In 1770 a description appeared in the Gentleman's of a volcanic island near the island of Thera in the Aegean Sea. An anonymous letter writer contributed an account by a Father Goree of the formation of this new island in 1707. The contributor believed that the readers of the magazine would find the narration of interest because much material on volcanoes had recently appeared in the Gentleman's as a result of an eruption of Mt. Vesuvius. In his article Goree speculated that volcanoes appeared to be caused by a burning mine. He believed that these mines consisted of "vitriol of sulfur." The strength of a volcano depended upon the quantity of combustible material contained in the particular mine. 9

Peter Simon Pallas (1741-1811), the famous German naturalist, attempted to account for the origin of volcanoes in terms of his general theory of orogeny, or mountain building. Archibald Maclaine reviewed his work entitled
Observations sur la formation des montagnes et les changements arrivés au globe in the Monthly in 1779. Pallas based his theories on his extensive travels in the Russian Empire and especially upon his detailed study of the Ural Mountains. Maclaine provided an extensive account of Pallas' theory and paid particular attention to the latter's comments on volcanoes. Pallas grouped all mountains into three categories—primordial, secondary, and tertiary. Pallas asserted that the primordial mountain chains were composed of huge blocks of granite. Gradually the oceans eroded these primitive mountains and secondary mountains appeared on the flanks of the primordial chains. These secondary mountains consisted of crystalline schists formed from the decomposed granites. The tertiary mountains were principally the result of extensive volcanic activity. Pallas asserted that the combustible volcanic materials were deposits of "pyrites" on the ocean floor. These pyrites originated from large quantities of "ferrugineous matters" washed into the sea and "phlogistical matters" from the remains of marine plants and animals. Originally on the earth, the volcanic activity had been much more extensive than at the present time. Pallas, according to
Maclaine, mentioned that perhaps a massive eruption had produced a general deluge. The current scattered volcanoes were only the remnants of this earlier condition. Other naturalists, while realizing the importance of combustible materials in the earth, believed that an influx of sea water into a volcano was the actual event that triggered an eruption. An unsigned history of Mt. Vesuvius appeared in the Gentleman's in 1752. The anonymous author related all the various eruptions of the mountain until 1709. In addition, he included some thoughts as to their causes. The volcanologist listed all of the assorted substances which Mt. Vesuvius had spread on the surrounding areas. These materials included quantities of "sulfur, alum, vitriol, antimony, mercasite, arsenick, petroleum, and nitre, and also iron, brass, tin, lead, gold, silver, and all sorts of minerals." The anonymous writer mentioned that "some philosophers" believed that the sea was the chief cause of the eruptions of Mt. Vesuvius. These philosophers thought that subterranean channels existed between the sea and the interior of the mountain. Sea water, air, and mineral exhalations came together inside the volcano and produced the violent
eruptions associated with Mt. Vesuvius. The unknown author described the process:

They [the philosophers] say that there are subterraneous channels and passages from the sea to the root of the mountain, and that the agitation and collocation of the sea water, the air in the caverns, and the mineral exhalations cause a violent fermentation and effervescence, which at length break out into the flames, and ejects smoke, rocks and torrents of burning matter from the vast aperture at the top of the mountain, and that the great stones and rocks which are shot up perpendicularly falling back into its bowels and cavities, together with the internal explosions of the ignited matter, are the cause of those terrible noises and rumblings, with which an eruption is always attended.12

The anonymous author mentioned that shortly before the eruption of 1631 the sea level in the Bay of Naples receded. The level also withdrew twelve paces prior to the eruption of 1698 and during the same outburst a torrent of water poured down the mountainside. He noted that during an eruption in 1538 of another volcano, liquid sulfur containing numerous shellfish poured from this other mountain.

Two years later, in 1754, more speculations along this line appeared in the Gentleman's. This article was an extract of a paper by the Abbé Jean Antoine Nollet which he had published originally in the Histoire of the French Academy.13 Mollet reported the results of an investigation carried out by the Academy of Naples. The academicians had
studied Mt. Vesuvius to determine what role, if any, sea water played in the previous eruptions of the volcano. They examined reports of the retreat of the sea mentioned above. These scientists could find no evidence of any subsidence of the ocean or any remains of shellfish in the volcano material ejected in the eruption of 1737. The academicians concluded that any inundations from the volcano originated from rain water and not from ocean water.

Nollet rejected these findings and emphasized that on the basis of his own studies he believed that sea water was an important element in the volcanic processes. He likened the interior of Mt. Vesuvius to a vast crucible or furnace. As the combustible materials burned in this furnace, some of the surrounding rock which contained the volcanic fuel collapsed. This relatively cool matter falling into the furnace caused the vapors in the hollow cavity to condense. This process, according to Nollet, created a powerful vacuum which drew in sea water. When the cold water hit the molten matter inside the volcano, it instantly became steam, expanded and created a violent eruption and explosion. Some of the steam and water condensed and produced the rain storms which often accompanied volcanic eruptions. Nollet
believed his hypothesis best explained the retreat of the sea, earthquakes, torrents of water, explosions, and rains that often occurred along with the outbursts.¹⁴

With the interest in electricity and the popularity of the idea of immanence in the eighteenth century, it was inevitable that some naturalists believed that electricity produced volcanic activity. A man who identified himself as "H." in 1782 provided an article to the Gentleman's Magazine noting that the text had been previously rejected by the Royal Society. In this abstruse and confusing essay H. asserted that volcanoes and certain other phenomena were caused by an excess of electric fluid in the earth. He claimed that the atmosphere contained "metallic particles" which absorbed electricity. When these aerial particles were completely saturated, electricity built up in the conductors deep in the earth. When the terrestrial conductors became overcharged, a violent volcanic eruption and perhaps an earthquake occurred to restore equilibrium. The event was analogous to the discharge of a Leyden jar. In support of his argument H. reported a tale of a farmer using an iron plow on his field in Iceland, which set off a volcanic outburst because the plow attracted electric fluid from deep in the earth.¹⁵
A French volcanologist was reported in the 1789 Critical Review to believe, like Pallas, that in prehistoric times volcanic activity was much more widespread and intensive than at present, noting that the only active volcanoes then known were in Iceland, Italy, and Sicily. He cited the large numbers of extinct volcanoes in central France as proof of his assertion. The reason that volcanic eruptions had subsided, he said, was because of greater "electrical equilibrium" in his time. The electric fluid was in greater equilibrium because man had cleared the countrysides of forests. 16

The interest in volcanoes demonstrated by eighteenth century naturalists extended to other aspects of volcanology in addition to the causes of eruptions. In numerous articles in the periodicals, the naturalists indicated great interest in the products of volcanism. A dispute arose in the eighteenth century over another volcanic product, basalt. Jean Etienne Guettard (1715-86), the famous French geologist, who discovered the remains of extinct volcanoes in Auvergne, found basalt in various volcanic deposits, but he insisted until late in his life that it was formed by crystallization in an aqueous fluid. Nicholas Desmarest (1725-1815), another French geologist, also examined the volcanic region
of central France, but reached a different conclusion—
basalt was of an igneous origin and often was ejected as part
of a volcanic eruption.17

Bewley reviewed in the *Monthly* Desmarest's paper and
concurred with him that basalt was an igneous rock. Bewley
claimed that perhaps basalt formations were even more wide­
spread in Europe than Desmarest had realized. Bewley men­
tioned the recent, and first detailed descriptions by
Joseph Banks (1743-1820; P.R.S. 1778-1820) of an immense
columnar basaltic formation on the island of Staffa off
the western coast of Scotland. Bewley, himself an astute
naturalist, suggested a couple of problems that still had to
be solved by Desmarest or any other volcanologist. First,
he noted that Desmarest's field work was mostly upon extinct
volcanoes in France. Bewley pointed out the necessity of
finding prismatic basalts among the products of an active
volcano in the state of eruption. Second, he noted the need
to explain how basalts crystallized or formed from the
melted lava flowing from a volcano.18

Sir William Hamilton (1730-1803), the English Ambassa­
dor in Naples and probably the foremost eighteenth century
volcanologist, attacked this latter problem. Spending most
of his adult life in Naples, he had a firsthand opportunity
to study Mt. Vesuvius and other volcanoes of the area. He
was an expert field geologist and carefully amassed evidence
on the topic before he formulated a hypothesis. His astute
scientific observations on volcanoes and their eruptions
regularly appeared in almost all of the periodicals examined
in this study. He published in the *Philosophical Transactions*
a description of the eruption during 1784-85 and of related
phenomena. Both the *Gentleman's* and the *Scots* magazines
printed excerpts from and comments on Hamilton's article.

Hamilton examined the lava formations of southern Italy
and found basalt in them. He noted that many deposits of
basalt were located along shorelines and concluded that
lavas which ran into the sea and cooled quickly tended to
indicate that igneous material when cooled could form the
regular prismatic (crystalline) structure that characterized
basalt. He had inquired among London glassmakers, the last
time he was in England, if any of them ever had a batch of
glass form into prisms or crystals. He got negative
responses from all the glassmakers except a Mr. Parker of
Fleet Street. Parker informed him that some years previous
a quantity of flint glass took such a form while cooling.
He presented Hamilton with a few specimens of it. These
resembled miniature basaltic columns. This experimental evidence convinced Hamilton that basalt could be formed from volcanic lava.21

During the eighteenth century, for the first time, naturalists began to understand that volcanoes were not merely forces of destruction. They realized that volcanoes were important agents responsible for mountain building and the present formations of the earth in general. The investigations of the creative nature of volcanoes played an important part in the development of the uniformitarian point of view.

Before the pioneer work of Sir William Hamilton, scientists believed that volcanic eruptions always occurred from pre-existing mountains or range of mountains. No one realized that a volcano could form its own cone or mountain from the large quantities of lava, cinder, and other materials which poured forth during an eruption or series of eruptions. An anonymous reviewer in the Critical Review in 1770 commented on a paper of Hamilton's which the latter had published in the Philosophical Transactions.22 Hamilton reported about a well sunk near the base of Mt. Vesuvius. At twenty-five feet below sea level, the workers encountered a layer of lava. Hamilton noted that had they kept digging, "God knows how much deeper they might have still found other
lavas. " In addition, Hamilton remarked that during a single eruption of Mt. Vesuvius in 79 A.D., the city of Pompeii was buried under almost fifteen feet of lava, ash, and pumice. He also learned that in 1538 a curious mountain called Montagno Nuovo near Puzzole rose in a single night about 150 feet, out of Lucrine Lake. He concluded by asserting that "if I was to establish a system, it would be that mountains are produced by volcanos, and not volcanos by mountains."

In 1773 Bewley analyzed another paper of Hamilton's in the *Monthly Review*. The latter had reported again in the *Philosophical Transactions* more observations he had made on the area around Naples. Hamilton observed that at almost every step of his expeditions, he met with more evidence that confirmed his belief that Vesuvius originally rose from the bottom of the sea and, in fact, that the entire Naples area was composed of volcanic material to a depth below the level of the Mediterranean Sea. Bewley likened the whole volcanic phenomena around Naples to the work of moles in a field, both throwing up here and there a hillock. Eventually the volcanic lavas filled up the spaces between the cones and formed terra firma from what had once been ocean.
Hamilton continually stressed the creative powers of volcanoes in many of his papers. For example, at the end of his description of the eruption of Mt. Vesuvius in 1784-85, he described the formative faculty of volcanoes in general and suggested that they probably produced many of the remote oceanic islands:

The more opportunities I have of examining this volcanic country, the more I am convinced of the truth of what I already ventured to advance; which is, that volcanoes should be considered in a creative rather than a destructive light. Many new discoveries have been made of later years, particularly, as you well know, Sir, in the South-Seas, of islands which owe their birth to volcanic explosions; and some, indeed, where the volcanic fire still operates. I am led to believe, that upon further examination, most of the elevated islands at a considerable distance from continents would be found to have a volcanic origin.26

The many areas of Europe naturalists found to be of volcanic origin or at least overlaid with lavas included southern Italy and nearby islands, central France, northern Ireland, and much of Iceland. In addition, during the 1770's several articles appeared in the periodicals about some areas of Germany also of igneous derivation. Hamilton was responsible for discovering the remains of extinct volcanoes in the Rhine Valley.27

Naturalists since ancient times had noted that earthquakes seemed to occur most frequently in areas of volcanic
activity. Earthquakes, especially the terrible one that struck Lisbon in 1755 were a favorite topic of controversy in the periodicals. Many articles appeared in the serials in which the writer attempted to explain the causes for these mysterious events or to describe the devastation that resulted.

Over the centuries people tended to invoke either theological or physical explanations or a combination of the two to account for earthquakes. Religious persons and clergymen have often asserted that God sent earthquakes to punish man for his sinful behavior, or to warn man that his actions did not meet with His approval. Writers of the eighteenth century turned to an astonishing array of physical causes to account for quakes. Naturalists invoked the three Aristotelian elements of air, fire or water as the sources of earthquakes. Other writers added to the list of ancient causes electricity, an immanent fluid, a distinctly eighteenth century subject.

The periodicals contained a large number of articles in which the author invoked God's supernatural powers as an explanation for earthquakes. Actually this interpretation was even more prevalent in the sixteenth and seventeenth centuries. After the Reformation theologians and contro-
versialists wrote much occasional literature from a theological standpoint. These men pointed to natural disasters and, using appropriate Biblical texts, expounded the occurrences as signs of God's power or as summonses to repentance.28

On February 8 and again on March 8, 1750 earthquakes struck London. They caused little damage but aroused a great deal of interest and controversy in the capital. The periodicals for several months carried many pages of comments about the temblors.

Many commentators and writers claimed that God sent the earthquakes as a specific warning to the English. The contributors said that if the populace did not heed His warning and reform, God would soon send a devastating quake to destroy London. The Bishop of London wrote a long letter to the clergy and people of London and Westminster, which the editors of the Gentleman's and Scots magazines reprinted.29

In addition, the Bishop ordered 40,000 copies of his letter distributed among the poor in the metropolitan area. He explained clearly what he considered to be the cause of the quakes—the sinfulness of the local population. He even went on to give specific examples of the kinds of behavior that
provoked God to shake the earth. He was especially concerned with the publication of large numbers of impious books. He noted that the "press for many years past [has] swarmed with books, some to dispute, some to ridicule, the great truths of religion, both natural and revealed." The Bishop was further shocked by the widespread "lewdness and debauchery" that prevailed in the city, especially among the lower classes. If all these sins were not sufficient reason for God to punish the city, there was one additional serious problem: Popery was increasing in the kingdom. He warned that every man must reform himself and encourage others to do likewise in order to prevent total destruction of the city. Repentance was the only means of preventing future temblors. The Bishop affirmed that "a city without religion can never be a safe place to dwell in." He asserted that God sent the two quakes as a warning directed to the citizens of London and Westminster. Everyone must heed His summons:

It is every man's duty, and it is mine, to call upon you to give attention to all the warnings which God in his mercy affords to a sinful people. Such warnings we have had, by the two great shocks of an earthquake; a warning which seems to have been immediately and especially directed to these great cities, and the neighbourhood of them; where
the violence of the earthquake was so sensible, tho' in distant parts hardly felt, that it will be blindness, wilful and inexcusable, not to apply to ourselves this strong summons from God to repentance.\textsuperscript{32}

Finally, the Bishop warned the people against the "little philosophers" who claimed to be able to explain earthquakes by natural causes and completely ignore the power of God:

Thoughtless or hardened sinners may be deaf to these calls; and little philosophers, who may see a little, and but very little into natural causes, may think they see enough to account for what happens, without calling in the aid and assistance of a special providence; not considering that God, who made all things, never put any thing out of his own power, but has all nature under command, to serve his purposes in the government of the world. But be their imaginations to themselves, the subject is too serious for trifling, and calls us off to other views.\textsuperscript{33}

Many other periodical author reached the same conclusion as the Bishop. In the March issue of the \textit{London}, Cave reprinted from the \textit{Westminster Journal} an account in which the anonymous writer recalled the earthquakes of 1692-93 that struck Palermo and Catanea on the island of Sicily. He quoted figures to the effect that in the former city, 60,000 persons perished from a population of 254,900. In Catanea which had a total of 18,914 residents, 18,000 died. The commentator in the \textit{Westminster Journal} believed an earthquake was produced "when the God of nature shakes his [\textit{sic}]"
own work, and warns us how much it is in his [sic] power to overset not only our policies and projects, but to bury us and our devices at once in the bowels of the earth that from which we were made." The writer noted that God shook London twice in a single month. He shuddered to think how many people might perish in the metropolis, if God sent a third quake of a magnitude similar to the ones that destroyed the Sicilian cities.

The London temblors also prompted a flood of letters to the editors of the periodicals. The writers often suggested that God was the effective cause of the tremors; occasionally they suggested ways for the citizenry to show contrition. An individual who called himself "Philanthropos" contributed a letter to the Ladies Magazine which borrowed a number of comments about the Sicilian quakes from the article in the Westminster Journal and added some additional thoughts. Philanthropos believed that a reformation in morality was necessary to prevent a future disaster. It was the upper classes or people in "high station" who should mend their ways and set a good example for other Londoners. 35

In 1750 a self-styled Biblical expert provided a letter for the April issue of the Gentleman's. This anonymous writer cited five passages from the Scriptures in which
God either threatened to send an earthquake or actually caused a tremor. He claimed that the Bible clearly demonstrated that the quakes were under the control of God from which the citizens of London could not flee. They must build their city on a solid foundation—belief in God. The anonymous contributor asserted:

Earthquakes are under the divine management, and are made use of by God to fulfill his [sic] pleasure, and consequently that they deserve our most serious attention when our part of the world is thereby made to reel to and fro like a drunkard; and at the same time teach us to seek a kingdom that cannot be moved; a city that has foundations, solid and lasting foundations, whose builder, and maker, is God.36

In the next issue of the Gentleman's another letter writer explained how the residents of the Italian city of Leghorn attempted to keep God from sending another temblor to devastate their city. It was in 1742 that Leghorn suffered from a tremor of several days duration. The citizens were aroused by the warning from God, and the anonymous writer claimed that the magistrates, clergy, and people of that city all vowed to observe a solemn fast every year on the anniversary of the quake. They resolved to prohibit any public or private balls, masquerades, carnivals, or plays. The author, like the Bishop of London,
noted, however, that when the "same rod was shaken over this nation" the citizenry did not respond in the same way. The Londoners in the months since the quakes had demonstrated little interest in any sort of moral revolution.\textsuperscript{37}

Comment and speculation about the London quakes had hardly subsided when the Lisbon earthquake hit, on November 1, 1755. This severe temblor, estimated at a magnitude of 8.7-9.0 on the Richter Scale, killed tens of thousands of Portuguese, provoked comments all over Europe, and was at least partially responsible for Voltaire writing his famous \textit{Candide}.\textsuperscript{38}

The \textit{Gentleman's Magazine}, in particular, provided extensive accounts of the disaster. In the December issue and in the yearly Supplement, the editors published first-hand descriptions from Lisbon and from the surrounding areas. In these two issues of the magazine, the editors devoted nineteen pages to the catastrophe including no less than forty-three separate articles and letters.\textsuperscript{39} After the initial shock subsided, readers began to contribute more letters and articles to the periodicals in which the writers attempted to explain the cause of the quake. As with the earlier temblors, many "experts" claimed that God caused the Lisbon disaster. An anonymous British merchant who
witnessed the quake reported in a letter to the Gentleman's that many Portuguese clergymen asserted that God had punished the people of Lisbon "for suffering heretics among them."40

A number of British Protestants, on their part, noted that a Catholic city had suffered the consequences of God's wrath. They usually compared the Lisbon tragedy or the general state of the world to certain Biblical passages. A contributor to the Gentleman's who identified himself as "A.B." gave significance to the fact that Protestants escaped the earthquake, and he urged comments by "good and virtuous protestants" on their fortune. A.B. cited Luke 21:25-26 and claimed that God was in the process of attempting to "cleanse and purify" the world to make way for the glorious kingdom of the millennium. He believed that God had begun to shake the world and He had, for good reason, chosen Lisbon as His starting point. A.B. mentioned that God selected Lisbon because it contained the most bigoted Catholics, that God commenced there because first of all at this most opulent and flourishing city of Lisbon, belonging to perhaps the most bigotted zealots in the Romish faith; and where the most dreadful tribunal of the inquisition emitted the infernal flames with the greatest fury and hottest violence.41
A.B. warned the British Protestants that their behavior also left much to be desired. God had struck a blow at the worst city on earth but next time He shook the earth, Britain might be the victim. A.B. noted that the only way for the British to protect themselves was for everyone to reform his moral standards.

The editors of the Gentleman's Magazine printed many articles and letters in which the authors attached theological causes or significance to the Lisbon quake. At a certain point, however, they called a halt to this sort of speculation. For example, an anonymous review of Peter Peckard's Dissertation on Revelations Ch. XI, V. 13 appeared in the magazine. Peckard in this volume argued that the Lisbon quake was prophesized in Revelation 11:13. The earthquake, according to Peckard was one of a series of events that was leading up to the millennium. The reviewer demonstrated, however, that Peckard had twisted the chronology in Revelation to fit his own scheme.42

These articles and letters are only a small sample of the great amount of material in the periodicals in which various theologians and naturalists asserted God was the cause of various earthquakes. A much smaller group of writers provided an explanation of temblors in which they
invoked God as the first cause but also gave an account of how He performed his task by means of secondary or physical causes. In effect these naturalists combined theological and physical causes in interpreting the phenomenon.

One good example was an anonymous review, appearing in the London Magazine in 1750, of a pamphlet on earthquakes by Stephen Hales published in the same year. Hales, in his role as divine, argued against those people who claimed that God was the sole cause of quakes and who were offended by any attempt to give the phenomenon a natural explanation. He differed with naturalists who ignored the hand of God and who believed they could account for earthquakes solely with reference to natural causes. Hales assumed that God produced quakes by the use of natural agents observing that "the hand of God is not to be overlooked in those things, under whose government all natural agents act."^43

Hales warned that God chastised mankind by sending earthquakes, wars, and plagues. But Hales also provided a delineation of the physical means God employed in effecting an earthquake; God caused the mixing of "airs" and "sulpherous vapours." These vapors rose from mineral substances, especially pyrites, in the earth, he said. A large black cloud of them near the earth in an atmosphere of pure calm,
air generated "explosive lightning," which caused "ascending vapours" still in the bowels of the earth to explode and produce an earthquake." 

Still other writers advocated divine and natural causation simultaneously, but many naturalists ignored any possible theological implications in earthquakes and developed naturalistic hypotheses to account for them. Contributors to the periodicals proposed an astounding variety of explanations for quakes, from the behavior of varying movements of the four terrestrial elements of Aristotle—earth, air, fire, or water—to calling into play more recent eighteenth century theoretical developments in electricity and volcanology.

Thales of Miletus (c. 625-545 B.C.), like many other ancient writers, was impressed by the awesome force of one or more of the four elements. He lived on the island of Miletus and observed the devastation wrought by the water when the sea waves beat upon the shore with such violence they seemed at times to shake the land. One can easily understand how he came to believe that water was responsible for a variety of natural phenomena, including earthquakes. Thales believed the earth was a great lumbering vessel
floating on the surface of a large body of water, and move-
ments of the water produced earthquakes.45

Even in the eighteenth century some writers continued
to stress the role of water in production of earthquakes,
just as they did in the case of volcanoes. Usually
naturalists believed that water combined with certain other
materials, such as air or fire, to trigger a temblor. They
still, however, assigned to water a notable function, per-
haps the most important part, in a chain of events that
caus ed a tremor.

In February, 1756, "A.B." provided a letter to the
Gentleman's Magazine, later republished by the Scots Magazine,
on earthquakes. In this letter, A.B. demonstrated that he
was a knowledgeable student of natural history by claiming
to have formed his hypothesis as a result of studying
experiment number 106 in Hale's Vegetable Staticks. In this
experiment Hales showed the power of a burning candle in
evacuating a jar and drawing water into the voided space.

A.B. theorized that large quantities of water existed
in subterranean caverns. These caverns had connections
with the surface seas, rivers, etc. When an underground
fire happened to ignite near one of these reservoirs, the
proper conditions existed for a quake. The heat from the fire
caused air trapped in the cavern with water to expand and force some of the water to the surface via the channels. The fire eventually burned itself out and removed some "elasticity," i.e., oxygen, from the trapped air. As the underground air contracted due to the loss of oxygen and cooling, water re-entered the cavern. Unfortunately some "elastic air" still remained along with some "fresh air" generated by the fires. The incoming water forced these airs into the surrounding rock strata. As the adjacent rocks cracked as a result of tremendous air pressure, an earthquake resulted. As soon as the confined air escaped into the atmosphere, sometimes with a violent explosion, the last stage of the quake occurred. Air from the atmosphere entered the new passages created by the quake and it forced some underground water into the connecting channels and back into the oceans and rivers at the surface.

A.B. not only believed that his theory accounted for the cause of earthquakes, he also claimed it could be used to predict them and perhaps to save countless lives. During the first stage of the series of events, when the underground fires forced subterranean water to the surface, the ocean, river, and lake levels rose appreciably. An astute naturalist, according to A.B., could observe this
unusual and rapid change in time to warn the population of the area of an impending disaster. 46

In 1759 William Kenrick reviewed in the Monthly an essay by Jean André Peyssonel of the island of Guadaloupe in which the latter had given an example of how wave pressure could cause an earthquake. On the island of Guadaloupe at a place known as the Cauldrons of Lance Caribe, the sea coast had many hollow rocks and underground vaults. Peyssonel observed the ocean water push deep into these underground caverns and compress the air which was trapped in them. Near the edge of the cliff he noticed a small hole from which air rushed. As he peered into the opening, the earth trembled under his feet. The hole in the field was connected to a giant cavern in the cliff near the edge of the ocean. He observed waves breaking into the cavern and noted every seventh wave seemed to be stronger than the preceding six. He surmised that the six waves compressed the air in the cavern and the seventh created such a great pressure that an "earthquake" resulted while the compressed air escaped through the fissure in the earth. Peyssonel did not know what to make of his discovery but he suggested that other naturalists might be able to use his findings, perhaps even to explain the Lisbon earthquake. 47
Occasionally the editors of the periodicals overlooked what later appeared to be an important contribution to science. John Michell (1724-93), a distinguished astronomer, mathematician, and classical scholar, wrote an important paper on earthquakes in the *Philosophical Transactions* in 1760. *Tanfield Leman in the Monthly* and an anonymous reviewer in the *Critical Review* that same year commented on Michell's paper. Both men believed his paper was not a good performance. A later judgment holds the paper "by far the most important contribution to this branch of science [the study of earthquakes] that had yet appeared in any language or country." 

In the *Critical Review* the anonymous reviewer provided a summary of Michell's hypothesis. Michell, like writers on volcanoes, believed that quakes resulted from the sudden admission of water to subterranean fires. The resulting "elastic vapours" produced a dreadful convulsion in the earth. The cautious reviewer, for his part, objected strongly to Michell's claim that the subterranean fires burned without the assistance of either fire or water. He asserted that air was always necessary for underground combustion. He also thought that water passing over pyrites probably kindled the fires. The critic did list Michell's
five conclusions. First, Michell noted some areas of the globe experienced recurring quakes. Second, volcanic activity and earthquakes often occurred in the same areas. Third, the motion of a quake was partly propagated by waves and partly tremulous. Fourth, recurring temblors often came from the same compass direction. Finally, the great Lisbon earthquake was succeeded by a number of smaller ones. Because of the difference of opinion on underground fires, the reviewer failed to examine closely many of Michell's excellent comments and observations about earthquakes which totaled sixty-nine pages. The reviewer concluded: "Upon the whole, we have reason to applaud the industry of Mr. Michell; but we cannot with-hold our censure from the awkward [sic] loose manner in which he has thrown his thoughts together." 50

Leman in his review for the Monthly wrote only about a paragraph on Michell's essay. He described Michell's basic theory of the origin of quakes. Leman concluded by saying, "The author's arguments are ingenious, but rather specious than convincing; and, indeed are liable to some material objections." 51

Both reviewers failed to note several important contributions to geology by Michell. He was probably the first
man to estimate the velocity of a quake. He believed that the tremors of the Lisbon quake traveled at a speed at least equal to that of sound. In his paper he also attempted to pinpoint the place of origin, or epicenter, of an earthquake. In the case of the Lisbon quake, he believed the center was off shore under the Atlantic Ocean. In addition he attempted to make a "random guess" as to the depth of the Lisbon quake by estimating it had occurred from one to three miles under the ocean floor. Finally, he also pointed out that the vibrating motion during tremors was due to the propagation of elastic waves in the earth's crust. 52

Other naturalists blamed not water but the second of the four Aristotelian elements—fire. Anaxagorus (488-428 B.C.) was probably the first writer to attribute the cause of earthquakes to fires within the earth. He claimed that thick clouds of vapors collided in caverns deep in the earth. These clouds exploded into flame and as it was the nature of fire to rise, a quake resulted as the fire forced its way through obstructing rock strata to the surface of the earth. Some later adherents of this view believed fires in the earth burned away supporting columns causing massive cave-ins.
In the seventeenth century, Athanasius Kircher (1601-80), a German Jesuit, compared the sound of an earthquake to that of a cannon being fired.53 This notion that the earth exploded like a cannon remained popular in the eighteenth century. Perhaps, in an echo of this earlier work, "H.P." from Loughborough compared an earthquake to the firing of a battery of artillery in a letter to the Gentleman's in 1756. H.P. described a number of observations on rock strata made by the lead miners in the Peak of Derbyshire. In this area the rock layers contained two types of veins or openings often partly filled with combustible materials. The tubular veins or pipes ranged from a few inches in diameter to forty yards wide. H.P. noted that miners usually found these pipes in clusters. They often occurred in a north to south direction with a gradual dip into the earth. The upper end terminated near or at the surface of the earth with perhaps a thin covering of soil. The miners called the smaller type of veins "rekes." Rekes were really nothing more than fissures or cracks in the rocks; their direction was generally from east to west and they intersected the pipes.

H.P. believed that various parts of the earth contained large numbers of pipes and rekes and, as a result, these
areas received frequent earthquakes. He explained that under certain conditions sulfurous fumes or exhalations collected in these tubes. Long, but dry, summers appeared especially conducive to the accumulation of vapors. H.P. asserted that a spontaneous spark was sufficient to cause a violent and widespread explosion of the trapped exhalations. The greater the number of tubes and the more concentrated the fumes, the stronger the earthquake. An extremely large explosion, such as the one that occurred at Lisbon, might produce a concussion large enough to alter the earth's axis for a brief time and produce tidal waves.  

A naturalist who called himself "Physicus Londinensis" also proposed a slightly different theory that explained quakes on the basis of underground fire. Physicus Londinensis noted that all readily inflammable substances, such as gunpowder, nitrous or sulfurous minerals, when ignited generated a large quantity of "air." Naturalists knew that large deposits of combustible material existed deep in the earth, often in large caverns or shafts. Occasionally one of these masses began to "ferment" due to water or spontaneous combustion. This fermentation produced a large volume of air under great pressure, and an earthquake resulted when the air broke out of the bowels of the earth.
Physicus Londinensis claimed he had experimental proof for his hypothesis. He cited the famous experiment by Hermann Boerhaave (1668-1738) in which the latter buried twenty pounds of iron fillings and twenty pounds of sulfur, packed down the substances, added a little water and produced an "artificial earthquake," similar to Lemery's volcano.\(^{55}\)

In 1750 the editor of the *London Magazine* printed a synopsis of Buffon's hypothesis that two different types of earthquakes existed. The identical article also appeared a few months later in the *Ladies Magazine*.\(^{56}\) The anonymous author noted that Buffon believed one species of tremor occurred over a large area across a long narrow band of territory. This type of quake occasionally shook England, France, Germany, and Hungary. A temblor of this sort was caused by a quantity of fermenting pyrites and other sulfurous substances deep in the earth. These materials generated a large quantity of air that remained compressed in a small space. This condensed air moved some of the overlying rock strata and created horizontal fissures which permitted the expanding air to travel great distances from the site of origin. The result of this underground activity was an earthquake at the surface.
Buffon, according to the London Magazine author, commented on the correlation between volcanic and earthquake activity and attempted to account for it. The type of earthquake associated with volcanoes was usually confined to a small geographic area but was of greater intensity than the previous variety of tremors. Fermentation in the earth was also the cause of this species of quake. This process of fermentation differed from the previous one in that a lesser quantity of air was produced and a large mass of molten material was formed. The molten substance expanded under great pressure. If subterranean caverns existed to relieve the pressure, then an earthquake but not a volcanic eruption occurred. Often, however, a great quantity of combustible material from the process of fermentation was trapped in solid compact earth. This material under these conditions formed its own vent to the surface either through an existing volcano or by creating a new one. A violent earthquake and volcanic eruption resulted.\(^5\)

Sir William Hamilton also directly associated volcanic eruptions and earthquakes in southern Italy, but he attributed both to fire. In 1783 he reported in the Philosophical Transactions an account of a devastating quake that struck the province of Calabria on February 5, 1783.
The editors of the Gentleman's, London, Scots, and Critical Review all inserted long extracts from the article, sometimes with comments on Hamilton's observations. The Scots Magazine and London Magazine actually reprinted the entire eighteen page article.58

Hamilton described the devastation he observed while on a long journey through Calabria and Sicily. He then gave his theory as to the cause of the quakes and explained how to construct an isoseismic map. Hamilton believed a new volcano had erupted, probably under the ocean between the island of Stromboli and the mainland. He clearly understood that earthquakes radiated from a central point or epicenter as Michell had previously proposed. Hamilton described for his readers how to calculate the severity of the tremor:

If on a map of Italy, and with your compass on the scale of Italian miles, you were to measure off 22, and then fix your central point in the city of Oppido, (which appeared to me to be the spot on which the earthquake had exerted its greatest force) form a circle, . . . will then include all the towns, villages, that have been utterly ruined, and the spots where the greatest mortality has happened, and where there have been the most visible alterations on the face of the earth. Then extend your compass on the same scale to 72 miles, preserving the same center, and form another circle, you will include the whole of the country that has any mark of having been affected by the earthquake. I plainly observed a gradation in the damage
done to the buildings, as also in the degree of mortality, in proportion as the countries were more or less distant from this supposed center of evil.\(^59\)

This was probably the first isoseismic map ever constructed.\(^60\)

Hamilton disputed many of his contemporaries who claimed the earthquake proceeded from the Apennine Mountains, posing a question for these naturalists:

Did the Aelolian or Tipari Islands (all which rose undoubtedly from the bottom of the sea by volcanic explosions at different, and perhaps very distant, periods) owe their birth to the Apennines in Calabria, or to veins of minerals in the bowels of the earth, and under the bottom of the sea?\(^61\)

To account for the Italian quake, Hamilton believed two possibilities existed. First, the foundation may have been laid under the ocean for a new island or volcano, which might not appear above the sea for many ages, or in the case of the volcano no eruption might occur. Tremors might simply have been due to the escape of the "exhalations of confined vapours, generated by the fermentation of such minerals as produce volcanoes."\(^62\) In either case, the operation of underground fires was responsible for the earthquake.

Some eighteenth century naturalists still believed that wind or cold vapors (in contrast to fiery gases), another of
the four Aristotelian elements, produced earthquakes. This theory was a remnant of the hypotheses of a number of Greek and Roman philosophers. The Ionian, Archelaus, in the fifth century B.C. first proposed that winds caused earthquakes. He believed that air found its way into the interior of the earth through passages leading downward from the surface. As the underground passages and caverns filled to capacity, Archelaus thought the underground air became so compressed that violent storms resulted which blasted away everything in their path. The result was an earthquake. Other philosophers expanded Archelaus' hypothesis and, in fact, among ancient writers the pneumatic theory of earthquakes was probably the most widely accepted theory. Aristotle claimed in his Meteorologica that wind rushing violently into or out of the earth or moving tumultuously within it caused earthquakes. Aristotle's theory was widely accepted until the sixteenth century for he was considered the best authority on scientific matters.⁶³

Even in the eighteenth century some naturalists were of the opinion that winds, vapors, or exhalations in the earth produced earthquakes. An anonymous writer in 1750 who believed that the planet constantly emitted vapors contributed
a letter to the Gentleman's in which he claimed that cold vapors in the earth produced temblors. Normally winds harmlessly dispersed these vapors as they arose from the pores of the earth, but he claimed that since 1739 England experienced very cold winters and cool summers. During the severe winter of 1739 the ground froze to an unusual depth, and the pores through which the vapors normally escaped were blocked. Warm weather returned in 1749-1750 and the "perspiratory ducts" were opened as a result of a general thawing of the earth. The anonymous writer believed, however, that the earth contained a large quantity of trapped vapors. As these exhilarations escaped from the bowels of the earth, two quakes occurred which shook London sharply. He supposed that as long as the warm weather continued, there would be no more earthquakes in England.  

Later in the same year, a writer, "E.A.," provided his theory of how underground winds caused earthquakes. He reported a tremor which struck Lincolnshire on August 23, 1750, and described the phenomenon as "a sound from the earth of a rushing wind, and it shook all the houses with everything that was therein." He claimed that the soil and rocks of Lincolnshire contained no nitre, sulfur, or other combustible materials. The soil was composed mostly
of loose sand and black clay. Given these facts, E.A. attempted to account for the tremor by means of a "rushing lateral wind" which escaped from the earth and caused the disturbance.

Next E.A. attempted to account for the cause of the wind. He pointed out that the area had experienced a long and hot summer. The earth was thoroughly heated, and the air in subterranean caverns expanded and rushed out of the ground.

The earth being heated, by reason of the drought (for such a dry and hot summer has not been known in the memory of man) the air in the bowels was rarefied to such a degree as at last to break its prison, and rush out, just as any common air enclosed in a bladder, may be made by expansion, as in the airpump for example, or when placed over a fire, to burst it, and fly all abroad. Such an eruption of the imprisoned air, would be attended with a noise as the earthquake was, and would shake the buildings all around.66

As proof of his contention, E.A. cited the undulating nature of both earthquakes and wind storms.

As we have noted, various naturalists in the eighteenth century periodicals believed that earthquakes were caused by one of the three ancient elements--air, water, or fire. No writer, however, claimed that the fourth element, earth, produced tremors. There was, however, one other proposed
explanation, electricity, which was a new contribution by eighteenth century naturalists to the investigation of earthquakes and as previously mentioned, of volcanoes.

William Stukeley firmly believed in the idea of immanence. He was probably the first natural historian to claim that electricity caused earthquakes; Stukeley published a letter, "The Philosophy of Earthquakes," in the Philosophical Transactions in 1750. The editor of the London Magazine extracted a one-page account from Stuckeley's letter. The latter attempted to account for the two quakes which shook London. Like air theorists, he turned to weather conditions and observed that the previous winter had been both dry and warm and the earth was in a "state of electricity." To support his claim, he commented upon the extraordinary growth of vegetation and the unusual displays of aurora borealis, both caused by the electric fluid. All that was necessary to produce an earthquake, according to Stukeley, was a "non-electrick" body. Stukeley claimed clouds raised from the ocean were such a body. If a non-electric cloud happened to drift over a land mass in a state of electricity, then an earthquake would occur when the non-electric cloud discharged its
"contents" upon any part of the earth. Stukeley noted that Britain did not receive as many tremors as countries with hotter and drier climates. Areas near the ocean were also more susceptible to temblors than locations near the centers of large continents.68

In 1773 a reader, "Physicus," contributed to the Scots Magazine a letter on the electrical nature of earthquakes. A recent tremor in Shropshire prompted him to write. Physicus supposed the disturbance not to have been a true quake, for he asserted that a large piece of land slid into the Severn River, producing a localized tremor. Physicus also discussed the nature of earthquakes and repeatedly referred to the hypothesis of Stukeley. Physicus attempted to discredit the theory that combustible subterranean substances caused quakes, since no scientist had ever been able to establish the cavernous nature of the planet, and burning coal pits never cause an earthquake. In addition, he asked why, if sulfurous vapors exploded and shook the earth, no one smelled any unusual smoke during the two London quakes. He concluded his argument against the fiery origin of tremors by noting that quakes often occurred over wide areas. This indicated to him that in order for fire to produce the earthquake, extremely large quantities of gunpowder
located deep in the earth would be required to produce the observed effects.  

Physicus concluded that electricity was the only physical force which could account for earthquakes. He noted that fishes were often affected by quakes and believed that only electricity traveled with enough velocity to disturb water. Physicus asserted that large areas of land were instantaneously disturbed by tremors. The London temblors of 1750 affected over 4000 square miles of England. Again he claimed that the behavior of underground fires could never account for this large-scale disturbance. Stukeley found persons who were physically harmed by the 1750 quake, said Physicus. These victims suffered from pains in the back, headaches, cholics, and rheumatic and hysteric affections for several days after the quake. Only electrification could have produced these symptoms, said Physicus, and he concluded that all quakes were the result of electric discharges.  

Beyond volcanoes and earthquakes, a third basic geological question occupied numerous pages in the British periodicals. At issue was the origin and meaning of what we now call fossils. The eighteenth century was a period of great interest in fossils, and most of the foundations for
the modern science of paleontology were laid during that era. The distribution of fossils was also a significant matter in the cosmogonical schemes of this era (see chapter four). The contributors to the serials, in the first place, explained the origin and distribution of fossils. In the second place, the writers gave particular attention to the discoveries of a particular type of unusual remains—pachyderm fossils.

The word "fossil" was derived from the Latin word *fossilis* which referred to anything dug out of the earth including metals and minerals. It was not until the nineteenth century that scientists restricted the word consistently to describing recognizable remains of organic bodies. As might be expected, ancient and medieval writers put forth a wide variety of explanations to account for organic remains. Different philosophers claimed that such phenomena were caused by occult powers, by forces of evil, by irradiations from heavenly bodies, or even by God Himself when He engaged in several preliminary attempts to create plants and animals. 71

At the turn of the eighteenth century, the unsophisticated state of the scientific knowledge about fossils can be well illustrated by the beliefs of the great natural
historian, John Ray. He was never able to satisfy himself as to the nature and real origin of "formed stones." Ray had considerable reservations about accepting fossils as the remains of organic life. He mentioned at various times, for example, that fossils might have been the result of a "spermatic principle." Ray was also well aware that certain fossils were quite unlike any existing ones. He realized, however, that if some plants and animals were extinct, then some links in the chain of being were missing. This meant that nature was imperfect. Ray took the easy way out of this dilemma by suggesting that some species of plant and animal life existed deep in the ocean or on remote shores, far from the eyes of naturalists.

The discussion of fossils in the periodicals was surprisingly naturalistic and non-speculative. Almost all naturalists agreed that fossils were the remains of organisms that had lived at some period in the past. Unlike Ray, the writers seemed to be little concerned about the problem of whether the fossilized remains were of plants and animals now extinct or not. For these men the problem was cause; most authorities agreed that the fossil deposits were the result of some catastrophe, usually of the Mosaic flood. Naturalists who wrote of fossils in the periodicals
for the most part attempted to correlate their theories about cause with Scripture. As in the cosmogonies mentioned in chapter four, however, some writers were extremely liberal in their Biblical interpretations.

A naturalist who signed himself "T.M." put forth an unusual explanation in a letter to the Gentleman's in 1751. T.M. claimed that the fossils of the earth were remains of an ancient world, one that existed before God formed the present planet as described in Genesis. He asserted that his theory was consistent with both Scripture and reason. Citing the Hebrew word, Barah, "renew or reform," made use of by Moses in his description of the formation of the world, T.M. referred his readers to Psalms 51:12 where the word clearly meant "to renew or reform," not "to create" from nothing. T.M. believed God created the present earth from the remains of a previous one. There might have been thousands of previous earths which God created, only to have to destroy them because of the wickedness of the former inhabitants. T.M. supposed these antecedent worlds contained many of the same species of animals which inhabit our present globe. When God destroyed the old world and created the new one, He undoubtedly performed His work in a thorough way. In the chaos, the remains of the other animals were
buried at all depths of the earth; an economical God used
the old rocks, minerals, waters, etc. in forming our current
planet. T.M. pointed out that his theory overcame a dif­
ficulty that was insolvable for the naturalists who believed
that the Mosaic deluge accounted for fossilized remains.
If the flood had killed the animals, then their remains
should have been deposited at very shallow depths. T.M. noted
that this was not the case, for natural historians had dis­
covered exuviae at great depths in the earth. 74

William Worthington was another writer who in 1773 pro­
vided an additional hypothesis which accounted for the
deposition of fossils before the general deluge. He attempted
to reconcile geological evidence with Scripture. His
thoughts were a part of his general theory of cosmogony (see
chapter four). Worthington believed that God had sent a
powerful earthquake and other "great commotions" which
devasted the globe at the time of the fall of man and
resulted in the uplifting of mountain ranges. During this
great upheaval the fossil remains of animals were trapped
within the various rock layers. Worthington claimed God
could not have created the mountains when He formed the
earth since today exuviae are found deep inside mountains.
According to Moses, God formed the earth first and only
later created life; therefore the fossils, shells, and the mountains could not be coeval. Worthington noted that according to the Bible the mountain ranges existed at the time of the Mosaic flood. Consequently, the mountains with fossils must have been formed in an upheaval sometime between the creation and the deluge. An anonymous reviewer in the *Critical Review* refused to accept this hypothesis. He pointed out that no evidence existed, either scientific or theological, to indicate a massive upheaval at the time of the fall of man. Also the analyst noted that Worthington believed fire to have been the agent used by God for this catastrophe. Why then, he asked, do not the fossilized remains show some evidence of damage from heat? 

John Whitehurst, whose cosmogony has previously been discussed, believed that water deposited most fossils before and also during the great flood. Bewley in 1779 in a review of Whitehurst's first edition devoted a large section to the subject of petrified remains. Whitehurst during his geological observations in Derbyshire noticed that the upper rock strata contained the exuviae of many terrestrial plants while the underlying rocks held the remains of many marine animals. These circumstances indicated that the deposition of the latter exuviae occurred while the earth was covered
with water, while the creation of the former remains had to have happened after the formation of dry land.\textsuperscript{76}

Whitehurst believed the earth originally was completely covered by an ancient sea which contained a great variety of marine life. As these animals died their remains settled to the ocean floor and became a part of the mud which eventually changed to stone. Terrestrial plant and animal life also existed on primitive islands in the ancient sea. When the Mosaic flood occurred, due to the collapse of the land surface, plant and animal life perished in the catastrophe; their remains also became fossilized in the uppermost strata.\textsuperscript{77}

Whitehurst also provided an explanation of why the fossils of some animals exist in areas far removed from their present day habitat. He asserted that the climate on the flat antediluvian islands was uniformly mild and as a result plants and animals existed over a much wider range than at present. After the flood, large continents with great mountain ranges lay exposed. The uneven terrain of the new continents resulted in many extremes of climate among which plants and animals could survive in only a limited range.\textsuperscript{78}
Occasionally a reviewer disagreed with an author who attempted to interpret the Bible literally. An anonymous reviewer in the *Literary Journal* in 1744 objected to the claim by Louis Bourguet (1678-1742), a professor at Neuchâtel in Switzerland, that the Mosaic deluge was the only cataclysm which could have distributed the fossils over the entire earth. In his review of Bourguet's *Mémoires pour servir à l'histoire naturelle des pétrifications*, the nameless critic devoted about half of his sixteen-page article to an attempt to refute Bourguet's arguments. 79

The reviewer put forth five objections. First, citing the uneven distribution of fossils around the earth, he claimed that the flood waters should have produced a more uniform dispersal of the plant and animal exuviae. Second, the reviewer wondered why fossils occurred forty or fifty feet underground in the same numbers that naturalists found them on the surface. He claimed that if Bourguet supposed that this was affected by "violent commotions," no need existed for the Mosaic flood, as any catastrophe might have caused the same result. Third, the reviewer pointed out that most fossils existed in a mutilated condition. Naturalists found crabs without legs, crocodiles lacking heads, etc. The evidence indicated these animals met some end more
violent than a gradual advance and subsidence of the sea. Fourth, he remarked that naturalists found the fossils of marine animals at a greater depth in the rocks than the exuviae of land animals. Many terrestrial creatures made their homes in a burrow in the ground while few marine creatures lived in the ocean floor. The reviewer stated that one would naturally expect to find the remains of animals in the earth, as many of them would have been trapped in their holes by the flood waters. On the other hand, the analyst asked how could Bourguet explain the fact that the remains of marine animals had been found at a greater depth than terrestrial animals? Finally, the reviewer noted that a naturalist could construct a more reasonable theory than the Mosaic one by supposing the fossils came from some unknown source deep inside the earth.80

Whether or not the Mosaic flood was responsible for the exuviae continued to be a matter of considerable debate; the argument can be epitomized by the discussions over the pachyderm bones. Eighteenth century naturalists knew that elephants were native to two areas, India and Africa. It was not until late in the century that they realized that these were two distinct species. Throughout the century various persons unearthed elephant-like bones in areas like
the Ohio Valley and Siberia where these creatures did not exist in a living state. The finds raised several knotty problems. Were the fossils the exuviae of the same species that resided in India and Africa? If so, how did one account for finding the bones so distant and in such different climates from the existing elephants? If the fossil bones were not from species of living elephants, of what were they the remains? These queries and others occupied the attention of many leading naturalists during the century.  

William Hunter conducted a study of the pachyderm bones in various collections in Great Britain. He published the results of his research in a paper in the Philosophical Transactions in 1768. Bewley in the Monthly and an anonymous reviewer in the Critical Review commented upon the essay.  

Using Baconian standards, Bewley provided a detailed analysis of Hunter's paper in which the latter attempted to establish that the pachyderm bones from the New World were not those of the common elephant but of a small carnivorous animal incognitum. Hunter disputed the claim by the Frenchmen, Buffon, and his assistant, Jean Louis Marie Daubenton (1716-1800), who believed that the pachyderm remains discovered in America and Siberia were elephant exuviae. Hunter studied all the pachyderm bones he could locate in Britain,
including the ones in the British Museum, at the Tower of London, at the Royal Society, and those in the possession of the Earl of Shelburne. Hunter reached the conclusion that the common elephant and the American animal were different species. He based his finding on two points: first, the fossil bones were much larger than the bones of known elephants; and second, the bones, especially the jaw bone, of the animal incognitum differed both in their general character and in their particular parts and features. Hunter also took a fossil tusk from the animal incognitum to a number of London ivory dealers. They assured him the tusks were genuine elephant ivory. This led Hunter to conclude that "genuine ivory is the production of two different animals; and not of the elephant alone."

Hunter speculated that the American and Siberian species would probably prove to be the same animal, animal incognitum, and it was apparently extinct.

Bewley provided a number of his own comments on the matter. Hunter claimed that some naturalists did not understand how elephants could formerly have lived in North America and Siberia in a climate so different from the tropical climate in which they currently lived. Hunter noted:
It was thought strange that elephants should have been formerly so numerous in western countries, where they are no longer natives, and in cold countries, Siberia particularly, where they cannot now live.\textsuperscript{84}

Bewley believed the reason advanced by Hunter as to why the pachyderm bones found in Siberia and America could not have been the remains of a common elephant, also operated against his own theory. Bewley commented:

Now the objection to the common opinion, implied in the first part of this quotation certainly proves too much. The reason here suggested against the opinion, that the fossil bones are the bones of the elephant, will equally operate against his opinion, that they are the bones of the \textit{Incognitum}, or indeed any animal whatever. If the whole race of the \textit{Incognitum} could become extinct in America, so might that of the elephant. With regard to the latter part of the quotation, we shall observe that, as the author has met with grinders of the \textit{Incognitum}, which were found in the Brazils and at Lima, it appears almost as improbable that the \textit{Incognitum}, which could live within 12 degrees of the line, should have been likewise a native of Siberia, as that an elephant should. We say almost; for we do not pretend to determine where an \textbf{Animal Incognitum} can or cannot live.\textsuperscript{85}

Bewley in this quotation anticipated an important problem still to be unraveled by naturalists. Hunter and most other naturalists assumed that the American and Siberian bones came from the same extinct animal. (Actually the New World remains were from the American mastodon $[\text{Mastodon americanus}]$ and related species, while the Russian
fossils were from the woolly mammoth \([\text{Elephas primigenius}]\). Georges Cuvier (1769-1832) and Johann Blumenbach (1752-1840) first established at the beginning of the next century that five extinct species of mastodons had existed in addition to three species of true elephants, two of which were still extant.86

Thomas Jefferson (1743-1826) contributed his opinion on the question of pachyderm extinction in his \textit{Notes on the State of Virginia}, and an anonymous reviewer in the \textit{Critical Review} in 1787 commented on his book. Jefferson disputed Buffon's theory that the animal forms of the New World were degenerated from the Old World species. Buffon noted that the animals of the Americas were fewer in number, less prolific, and smaller in stature than those in Eurasia and Africa. Jefferson having examined some of the American bones concluded that they were not the remains of the common elephant, as Buffon had claimed, and furthermore he asserted the exuviae were of an elephant-like creature vastly larger in size than the Old World elephant. Jefferson supposed these large beasts were not extinct and still existed in the remote forests of North America. The anonymous reviewer praised Jefferson for having established from "real facts" that Buffon was wrong in his claim.87
Rudolph Eric Raspe (1737-94), a German naturalist, believed that elephants could become extinct as a result of non-catastrophic causes. Bewley reviewed in the *Monthly* an essay of Raspe's which had originally appeared in Latin in the *Philosophical Transactions*. Raspe argued that the pachyderm bones found in northern countries were the remains of an elephant-like creature that was native to the area. In addition, according to Bewley, Raspe said that these animals became extinct as a result of some natural process, not as a consequence of some catastrophe. Raspe took exception to those experts who claimed that a rapid change had occurred in the inclination of the earth's axis to the plane of the ecliptic, an alteration which produced a corresponding change in the climate of the northern regions. He believed this theory was too *ad hoc*. Likewise he objected to the hypothesis put forth by other naturalists that the earth's axis had shifted with time. Raspe believed that the shape of the earth indicated that no change had taken place in the earth's axis.

Raspe, continued Bewley, rejected the theory of some naturalists who believed that elephant bones were washed north by the waters of the universal deluge. He also regarded as fallacious the claim that ancient armies had
brought elephants to Russia from India or Africa. Raspe was of the opinion that the exuviae were of a particular species of elephant capable of surviving the rigors of a cold climate. These animals became extinct because of the operation of unknown causes. He pointed to the decrease or total extinction of wolves and several other species of animals in different parts of the world.

Bewley concluded by praising this naturalistic explanation by comparing Raspe's ideas with those of Samuel Engel. The latter removed all of the unsolved problems involving the bones by postulating that the exuviae were remains of "angelic beings" who were the original inhabitants of the globe. Bewley sarcastically compared the theories of Raspe and Engel:

There is something laughable in the idea, that the numerous fossil skeletons, now lying in heaps in the marsh at the Salt Lick, on the banks of the Ohio, and which M. Raspe, and other naturalists, soberly suppose to have belonged to a troop of pseudo-elephants, who accidently sunk into the swamp, and perished there, while they were gratifying their palates, should, by another writer be deemed to be nothing less than the venerable remains of a company of fallen angels.

The editors of the periodicals also had an elephant bone controversy to report much nearer to home. An article about the discovery of elephant bones at various sites in Britain
appeared in the May, 1757, Gentleman's Magazine. In this paper, Peter Collinson extracted three letters describing the fossil finds and then gave his own opinion on the matter. Collinson was at a loss to explain how elephants got to the island. He stated that the Romans were the only people who could possibly have brought such a large number of the quadrupeds to Britain. Collinson noted, however, no evidence existed to indicate that the Romans ever transported any elephants to the island. He claimed that, unless naturalists accepted John Woodward's hypothesis of the deluge, "it is difficult to conceive how the teeth, bones, etc. of this vast animal came to be found so frequently on this island."\textsuperscript{92}

A reader, J. Coleridge, commented in the July issue on Collinson's claim that no record existed of the Romans introducing elephants into Britain. He cited Stratagems by the Roman writer Polyaenous of the second century A.D. Polyaenous recorded a battle in which Julius Caesar attempted to cross a "great river," probably the Thames, but found his way opposed by an army of Britons. Caesar ordered a large elephant brought forward, and the sight of the beast in mail with a turret on it terrified the natives and caused them to flee. Coleridge noted that Caesar probably omitted
the incident from his own *Commentaries* because it would have detracted from the honor of his conquests. Coleridge believed that he could safely draw three conclusions. First, Caesar had at least one elephant in his retinue and it helped him to conquer the island. Second, if Caesar reaped such an advantage from one beast, it was reasonable to suppose he brought more animals. Third, since the Roman conquests were chiefly in Sussex, Essex, and Kent, naturalists might expect to find the most remains in these counties.  

Later the same year, another contributor who signed himself as "S.--" pointed to a flaw in Coleridge's scheme. He claimed that "few scruple to believe" the Romans brought elephants to Britain. Even if the Romans had them, S.-- asserted, Coleridge's theory still lacked credibility. He observed that when people unearthed elephant remains, they usually found the bones of other large animals in the same pits. S.-- did not believe the Romans selected special locations to bury the remains of their elephants. In addition, these same pits held the remnants of what appeared to have been some "great marine animals." S.-- did not offer any suggestions that might have accounted for the pachyderm bones.
During the period from 1731 until 1789, the faithful readers of the British periodicals could have observed a curious mixture of old and new ideas in the rapidly developing science of geology. Some writers still maintained that the old Aristotelian elements of air, fire, or water were responsible for the eruption of volcanoes or the outbreak of devastating earthquakes. Clergymen and others did not hesitate to claim that quakes were a warning from God, although curiously, no writer attached any theological significance to volcanism. Some natural historians, on the other hand, believed a newly discovered force, electricity, produced eruptions and temblors.

The serials publicized several important geological discoveries and concepts. Readers learned of Desmarest's and Sir William Hamilton's findings that basalt was igneous in origin and usually associated with volcanism. The educated public could read about Hamilton's concept of volcanoes as a creative land-forming phenomena. The readership could learn from Michell and Hamilton that earthquakes were local geological disturbances centering around an epicenter. The readership also reacted with interest to Hamilton's account of how to draw an isoseismic map for the Italian tremor of 1783.
The editors provided extensive comments about fossils. Naturalists during the mid-eighteenth century began to consider fossils as important natural objects, not just as matters to be discussed in a cosmogonical scheme or Biblical framework. Most natural historians by 1789 believed that fossils were the remains of living organisms. Many contributors also came to the conclusion that some of the fossilized species were no longer extant.

All of these geological concerns involved certain themes. For example, natural historians were less apt to attempt to harmonize Scripture with scientific data gathered in the field. They emphasized naturalism instead. The Aristotelian heritage was still present but not as evident as it was in the early part of the century.
FOOTNOTES


4Ibid., p. 104.


6Anonymous, "Extract from The Natural History of Mt. Vesuvius, Translated from the Original Italian, Compos'd by the Royal Academy of Sciences at Naples," The Gentleman's Magazine, 17 (September, 1747), 421.

7Ibid.

8Anonymous review of Jean Marie de la Torre, Histoire et phénomènes du Vésuve, exposés par la Pére Dom Jean Marie de la Torre, in The Critical Review, 11 (April, 1761), 327-28. Fermentation in the eighteenth century usually referred to a chemical reaction characterized by effervescence, not by the release of large quantities of heat.


11 Anonymous, "A Description of Mount Vesuvius, or Monte di Somma, with an Historical Account of All Its Eruptions to the Year 1709," The Gentleman's Magazine, 22 (December, 1752), 557.

12 Ibid., p. 558.


15 H., "An Attempt to Explain the Cause of Volcanoes: In Which the Causes of Thunder, Lightning, Earthquakes, Heat, and Wind, Are Incidentally Treated of," The Gentleman's Magazine, 52 (May, 1782), 228; 52 (June, 1782), 284-86.


18 [William Bewley], review of Nicholas Desmarest, "On the Origin and Nature of the Basaltes, with Large Polygonous Columns; Ascertained by the Natural History of That Stone,


21 Hamilton, "Some Particulars of Mount Vesuvius," The Scots Magazine, 48 (December, 1786), 584. During the same year, 1786, a thorough study of the basalts in County Antrim in Ireland appeared in the Hibernian Magazine ("Analysis of Volcanic Theory of Basalt," 16 (July, 1786), 341-44). A second William Hamilton (1755-97), an Irish clergyman and naturalist, wrote this article. Hamilton was also interested in basalts and lavas and he noted that a complete study had never been made of the Irish formations. He strongly believed that basalt was of igneous origin and he marshaled an impressive amount of evidence to support his case.

23 Hamilton quoted by an anonymous reviewer, in The Critical Review, 30 (September, 1770), 175; Ibid., p. 19.


28 Wolf, History of Science, pp. 183-84.


Philanthropos, letter to the editor, The Ladies Magazine, 10 (March 10-24, 1750), 156.


The Gentleman's Magazine, 25 (December, 1755), 554-64; 25 (Supplement, 1755), 587-94).


Hales, quoted in an anonymous review of Stephen Hales, "Some Considerations on the Causes of Earthquakes," in


John Michell, "Conjectures Concerning the Cause, and Observations upon the Phoenomena of Earthquakes; Particularly of That Great Earthquake of the First of November, 1755, Which Proved Fatal to the City of Lisbon, and Whose Effects Were Felt as Far as Africa, and More or Less Throughout Almost All of Europe," Philosophical Transactions, 51 (1760), 566-634.

Geikie, The Founders of Geology, p. 274.


52 Michell, "Conjectures Concerning the Cause," pp. 566-634.


55 Physicus Londinensis, letter to the editor, The Scots Magazine, 16 (December, 1755), 595-96.


57 Ibid.


62 Ibid.

63 Aristotle Meteorologica 3. 7-8; Adams, Birth of the Geological Sciences, pp. 400-10.


66 Ibid., p. 457.


70 Ibid.


77 Bewley, review of Whitehurst, pp. 40, 43; Whitehurst, Inquiry, pp. 40-60.

78 Bewley, review of Whitehurst, pp. 43-44.

Ibid., pp. 113-21.

For a detailed account of the history of the discovery of pachyderm fossils see, Greene, The Death of Adam, chapter IV.


Bewley, review of "Observation on the Bones," p. 108.

Greene, The Death of Adam, pp. 120-24.


Rudolph Raspe, "Dissertatio epistolaris de ossibus et dentibus elephantum, aliarumque belluarum in America.
A contributor to the Gentleman's known only as "M.M.M." had a different supposition as to the origin of the pachyderm bones in Siberia. He reported occasionally from Russia on his personal travels through the vast country. M.M.M. related that many persons had uncovered relics and bones of ancient warriors. These soldiers usually appeared to have been killed in battle. Sometimes workers discovered heads on iron pikes among the remains. M.M.M. stated many of the Asiatic countries used elephants in battles. He wondered if the pachyderm bones simply were not the exuviae of army elephants marched into Siberia for some ancient war. M.M.M. believed his theory was plausible as naturalists usually found bones in low-lying areas, shallow in the earth. Rivers depositing silt might easily have covered these exuviae.


Ibid., pp. 204-05.


Meteorological subject-matter, like the geological, took various forms in the serials. Monthly tables of weather data were for a long time a standard feature of the Gentleman's Magazine. Reports of severe storms were also a regular part of the magazine format. In addition to these customary offerings, the editors inserted series of articles on particular disputes in meteorology.

One of the most popular meteorological issues in the serials revolved around the question of what caused the aurora borealis, or northern lights. Some naturalists and theologians claimed that, as in the case of earthquakes, the aurora borealis was a form of warning to the citizenry from God. A large majority of contributors, however, stressed a more naturalistic explanation. A few naturalists believed that the aurora resulted from Aristotelian vapors of reflected light, but the most widely accepted hypothesis was that electricity produced the auroral displays. Many of the writers of this persuasion also held a strong belief in the doctrine of immanence.
A second meteorological issue is to be found in disputes over the cause and nature of waterspouts. Some naturalists of the eighteenth century believed that the large quantity of water contained in these funnels came from somewhere in the cloud itself. They implicitly assumed that this water was in the process of returning to its natural Aristotelian place on or beneath the surface of the earth. Other researchers asserted that the spout sucked water up from the ocean or lake over which it traveled. Finally, a few writers believed that electricity was the motive force in waterspouts also.

Classical writers knew of the aurora borealis even though the spectacle rarely occurred in the Mediterranean region. Even in the more northern latitudes of the British Isles, auroral displays were rare enough that they received little notice until relatively modern times. In the seventeenth century an investigator, probably Pierre Gassendi (1592-1655), applied the name "aurora borea" to the northern lights. Only in the eighteenth century did a serious investigation of the aurora borealis begin. Two spectacular displays, visible all over Europe, occurred in 1707 and 1716 and heightened scientific interest.
Edmund Halley (1656-1742), the famous British astronomer, undertook the first systematic investigation of the aurora. After the 1716 auroral display, he felt that the "lights seen in the air" were caused by water vapor and "sulphureous steams." Later Halley changed his hypothesis when he realized that it did not explain why the aurora was confined to northern latitudes. He asserted that the earth, being a giant magnet, was surrounded by a circulating magnetic effluvia which under some conditions gave off light.  

Unlike those concerned with earthquakes, very few writers in the periodicals attached religious significance to the northern lights. Perhaps this difference arose because the aurora did not result in death and destruction of property as did earthquakes. Paul Gemsage in a letter to the Gentleman's in 1756 attacked William Whiston and other unnamed persons who had claimed the auroral displays of 1716 "foreshew the grand event of the restoration of the Jews, and the commencement of the millennium."  

Gemsage attempted to adopt a naturalistic stance by citing the numerous past reports of northern lights visible in Great Britain. He quoted accounts of them for the years 555, 567, 743, 776, 794, 926, and 979, all long before the Norman conquest. Gemsage could find no reports of any un-
usual events happening after the displays. Gemsage, in addition, asserted that the aurora was extremely common in northern lands and that in Greenland the aurora appeared almost every night. Further, he referred to the writings of the French philosophe, Pierre Bayle (1647-1706), in which the Frenchman maintained that comets did not predict future events. Bayle also warned that ignorant people and superstitious clergy often tried to use unusual natural phenomena, such as comets, to mislead or arouse the population. Gemsage pointed out that almost all of Bayle's arguments against the predictive nature of comets were equally applicable to northern lights. Gemsage concluded that the auroral displays were not tokens of divine displeasure but ordinary meteorological occurrences. He wrote:

No longer then let us be misled by men of warm heads and enthusiastic minds, to imagine, that these appearances are signs from heaven (Luke 21:11) or any certain tokens of divine displeasure, but regard them as, what they really are, the ordinary and unmeaning phaenomena of nature, to be ranked with comets, meteors, and mock suns.

Some contributors believed that the aurora resulted from the reflection of sunlight from the surface of the ocean, another naturalistic explanation. The writer, "W.W.," commented in the Gentleman's in 1752 on the northern lights. He noted a report in the previous issue of a simul-
taneous earthquake and an auroral display at the town of Stavanger, Norway. This event seemed to confirm an old hypothesis of his. W.W. believed the aurora borealis resulted from a "tremulous motion" in the sea which caused a reflecting and refracting of the sun's rays back into the heavens. He asked the readers to place a basin of water in the direct sun in a room. W.W. claimed that the slightest movement in the water would cause the light to be reflected about the room in a way analogous to the aurora, also a reflection.

W.W. noted that earthquakes frequently occurred under the ocean basin. These disturbances agitated the water, and with the proper atmospheric conditions, an auroral show resulted. W.W. stated that many naturalists believed that quakes were caused by subterranean vapors breaking out of the earth. He theorized that perhaps the release of these vapors produced a favorable rarefied condition in the atmosphere for the northern lights. W.W. felt that the oblate figure of the earth near the equator blocked the reflection of light and prevented appearance of the aurora in the tropics. He noted that during the famous three day auroral display of 1716 the intensity of the northern lights decreased on each successive evening. W.W. reasoned that this was because the seas grad-
ually calmed after an initial disturbance. The correspondent remarked, in addition, that light reflected from the ocean might have been responsible for the glimmering effect observed during the eclipse of 1715.  

In the next issue of the Gentleman's, a writer calling himself "Senex" raised some hard-headed objections to W.W.'s theory, also reflecting the naturalism of the time. He claimed that the atmosphere must be in a dense, not rarefied, condition to catch the undulating light which produced the aurora. He objected that the northern lights occurred more frequently than earthquakes. Senex asserted that as the sun sank further beneath the horizon and the angle of reflection increased, the aurora should occur closer to the horizon, but what was actually observed was the opposite. In addition, he noted that during the display of 1716 the undulating streams of light moved from northeast to southwest, retrograde to the motion expected from W.W.'s theory. Senex claimed the auroral display of 1726 occurred at all points of the compass, again indicating that W.W.'s hypothesis was erroneous. As for the eclipse of 1726, Senex stated the glimmering light during the eclipse could not have been reflected by the ocean since the sun was almost in its meridian.
In the December issue of *Gentleman's Magazine*, a person calling himself "A By-Stander" gave his opinion about the aurora. He basically agreed with W.W. that reflected light caused the aurora borealis and he rejected the claim of other naturalists that the electrical fluid was involved. A By-Stander replied to Senex that earthquakes were not always necessary to begin the aurora as the sea itself had enough wave action on the surface to cause a shimmering reflection of light if the atmospheric conditions were suitable. He also agreed with W.W. that the atmosphere must be rarefied, not dense as Senex believed, in order to engender the aurora. A By-Stander cited a number of descriptions of northern lights to prove his point. He believed that Senex was wrong in his assertion that the further the sun was below the horizon, the lower the aurora should be in the sky. A By-Stander said that as the angle of light reflection from the ocean increased the aurora would move from the horizon toward the zenith, which was precisely what occurred during a display. As for the eclipse of 1726, he could find no record of any shimmering light in the account by Halley. A By-Stander maintained that this was a peripheral issue and really irrelevant. He believed that W.W.'s hypothesis best explained the aurora borealis but that much more in-
vestigation of the matter was still required. 7

As one reviewer, Maclaine, noted, since the discovery of atmospheric electricity by Franklin, most naturalists sought to explain all aerial luminous meteors by the principles of electricity. 8 The notion of immanence was usually explicit in their thinking. One of the first writers to propose this electrical theory was Franklin. In 1752 an abstract by an anonymous writer of one of Franklin's writings appeared in the Scots Magazine. The abstracter explained that Franklin believed that the oceans contained large quantities of electrical fire and that particles of water rising from the oceans constantly carried off this fire. The water vapor and fire collected in clouds which remained in an electrified state until discharged. Occasionally one of these clouds with ocean vapors drifted over the polar region and descended toward the earth. There it met non-electric vapors which arose from the land mass. The electric cloud gradually discharged to the polar vapors and a display of aurora borealis resulted. 9

Later the same year, a man who called himself "Sunderlandensis" contributed letters to the Scots and Gentleman's in which he claimed that electricity produced the northern lights. In the latter magazine he rejected W.W.'s theory
of reflected light and stated his own hypothesis. Sunderlandensis believed that ether, pure elementary fire, and electric fire were all the same substances. He supposed that the aurora and lightning were both caused by electricity. He claimed the diurnal rotation of the earth caused a continual flux of this matter toward the poles. Sunderlandensis emphasized that at the poles the electric fire met unusual atmospheric conditions as the air had a peculiar density and composition. The motions, shiftings, and coruscations of the northern lights were a result of the alternate attractions and repulsions of the electric fire similar to the behavior of gold leaves in a laboratory electrometer. Sunderlandensis asserted the aurora borealis was actually a very weak form of lightning.10

A By-Stander in the same letter in which he criticized Senex also attacked Sunderlandensis's theory. He rejected as absurd the notion that the rotation of the earth pushed the electric fire toward the poles. A By-Stander claimed that a more logical theory would be that the motion of the earth caused fire to fly out into space. He also wondered why the aurora was seen only in the northern part of the sky if a continued influx of electric fire existed from the tropics. A By-Stander concluded by asking Sunderlandensis
how the repulsion and attraction of gold leaves in the laboratory was any proof that the electric fire had the property of attracting and repelling itself.¹¹

In 1769 Bewley reviewed in the *Monthly* a work by Hugh Hamilton (1729-1805), Professor of Natural Philosophy at the University of Dublin. Hamilton, like the previous naturalists, believed that the aurora borealis was of an electrical nature. He asserted that the aurora was similar to the tail of a comet. Hamilton rejected Newton's contention that a comet's tail shone as a result of reflected light from the sun for he believed that the tail consisted of luminescent "electric matter" discharged from the "dark hemisphere" of the comet. In an analogous manner the earth emitted "a rare and lucid substance" from the hemisphere opposite from the sun and it was this substance which observers occasionally perceived as the northern lights. According to Bewley, Hamilton remarked that if an observer could see the earth from space, it would appear to have a tail like the comet. He noted that the aurora was different from a comet's tail in that it was much less intense, more unsteady and changeable in form, and of a shorter duration than the latter.¹²
In such areas as meteorology, where scientists had to depend mostly upon observation, or, as in the case of the gold leaf example, inference from an experiment, various types of opinions could and did flourish. Late in the 1780's a very curious and rather one-sided debate appeared in the serials illustrating the latitude of discussion. Beginning in 1781 the Reverend John Lindsay, the rector of the parish of St. Catherine in St. Jago de la Vega, Jamaica, carried on a one man crusade in the Gentleman's against Franklin and other naturalists. He claimed that waterspouts were "descending" clouds which deposited large quantities of water from the atmosphere into the oceans. Lindsay attacked Franklin who believed that waterspouts were "ascending" in that they were whirlwinds which sucked up water from the ocean like a giant vacuum pump and swirled it into the air.

Basically, the theory that waterspouts were of a descending nature was a remnant of Aristotelian thinking. Although Aristotle never specifically discussed waterspouts, he commented extensively on whirlwinds or tornadoes. Aristotle believed that "dry exhalations" from the earth were the cause of all manner of winds. In addition he thought that "moist exhalations" from the earth were the cause of
rain. When the moist exhalations cooled in the atmosphere, the water returned in the form of rain to its natural location on or in the planet. Some eighteenth century naturalists, like Lindsay, continued to argue that the moisture in waterspouts descended into the ocean.

In his first article in December, 1781, Lindsay argued against the conclusions drawn from Franklin's experiments in which the latter, by rapidly swirling a tub of water, demonstrated how water adhered to the side of the tub in a manner similar to a waterspout. Lindsay acknowledged that the demonstration was correct and applicable to the central issue but noted that no researcher had ever succeeded in raising water more than a few feet up the sides of a spinning vessel. Several feet, Lindsay noted, is far short of the thirty-two feet which Franklin claimed that a waterspout could support water.

Lindsay continued his thoughts in the Supplement to the magazine that same year. He described a waterspout that he personally observed while on shipboard near Jamaica. The spout appeared within a mile of the ship and at best he and the crew could estimate it to have been about six feet in diameter. They also judged the waterspout was at least forty times as tall as it was wide. Lindsay pointed out
that a vacuum could raise water only thirty-two feet; he wondered how Franklin and others could explain the uniform appearance of the funnel. Lindsay also mentioned that the air and sea were extremely calm, even at the point where the funnel touched the ocean. He claimed that if the waterspout removed water from the ocean, then the ocean and air should have been in a great state of agitation.15

Lindsay continued his debate in 1783 with some accounts of waterspouts he observed at Jamaica. He described a number of unusual rain storms which had struck the island. Lindsay stated that rain often descended in localized torrents so that one field would be deluged while an adjoining one did not receive a drop of water. Lindsay believed that his observations proved that a relatively small cloud contained a vast quantity of water necessary to form a waterspout. This illustration also added strength to his own waterspout hypothesis. He believed his descending theory of spouts explained much better than the other one how waterspouts occasionally dumped large amounts of water on dry land.16

Lindsay in another letter in 1785 remarked that his theory "having met with a favourable reception," he would supply additional pertinent information. He began his long
letter by attempting to distinguish waterspouts from the two types of whirlwinds. Waterspouts were relatively stationary and finished their existence at no great distance from the site of their origin. The powerful whirlwind or tornado, by contrast, was destructive, swift, furious and impetuous. The small whirlwind or dust devil was sportive and harmless but still moved a considerable distance.  

Lindsay turned next to what he considered were the erroneous ideas about whirlwinds that were perpetuated by the compilers of dictionaries. He cited an article from the Marine Dictionary in which the author claimed in the article on waterspouts that the wind blew from all the compass points toward a central area where a waterspout formed. Lindsay noted that almost every waterspout he had personally read about or observed first-hand occurred during relatively calm weather conditions. In addition the writer of the same book asserted that the appearance of a waterspout indicated a cooling trend in the weather. Again Lindsay replied that in most cases the weather continued to be hot and sultry after the formation of a waterspout. He was especially distressed by the compiler of another dictionary who pronounced with finality that a waterspout was a whirlwind "which becomes visible in all its dimensions by the
water it carries up with it."

Lindsay's principal argument in favor of the descending theory of waterspouts was that the powerful vacuum necessary to draw water up from the ocean, as the proponents of the other view asserted, could not exist during the calm conditions normally reported during a sighting. Lindsay claimed that common sense indicated that in order for this powerful vacuum to be created, equally strong winds would have to blow toward the waterspout from all compass points. If these powerful spiral winds existed, then they certainly would churn up the surrounding water in the ocean. Yet, as Lindsay stressed, observers did not report this happening.

Lindsay concluded his letter by stating that most sailors believed in the ascending nature of waterspouts. He ridiculed the notions of the sailors by asking, "what must we ... expect from the unlettered and barbarous accounts of seamen?" Even worse, according to Lindsay, these sailors had convinced landsmen of the correctness of their views and completely clouded the issue.

Lindsay contributed his fourth and final letter on waterspouts to the Gentleman's Magazine in February, 1788. He added no new evidence for his theory and occupied almost three pages in disputing a description of a waterspout by
Franklin. Including this letter, Lindsay had furnished over sixteen pages of discussions and descriptions of waterspouts to the Gentleman's over a seven year period. The readers of the serial by this time must have been thoroughly weary of Lindsay's tirade on the subject.

Lindsay was not the only natural historian who claimed that waterspouts were of a descending nature. Dr. John Perkins of Boston defended the descending theory in a paper in the Transactions of the American Philosophical Society in 1786. Rotheram reviewed Perkins's paper in the Monthly. Perkins claimed that the descending hypothesis was the correct one for two reasons. First, he noted that a great roar always accompanied a spout. He compared this noise to the roar of a cataract and claimed that both sounds were caused by the rapid fall of water. Second, Perkins noted that the bottom of a waterspout had a rounded base. He believed this was produced by the partial rebound of the descending water as it hit the ocean.

An anonymous reviewer in the Critical Review also analyzed Perkins's paper and added the doctrine of immanence to the discussion. The commentator believed the descending theory best accounted for the phenomena of waterspouts and such descent could easily be explained by the principles of
science. The reviewer believed that the laws of electricity accounted for the behavior of a waterspout. For some unknown reason, an electrically charged cloud heavily laden with water, suddenly lost its electricity and dropped all its water. He did not elaborate his ideas further.  

Only one proponent of the ascending theory actually appeared in the serials. Andrew Oliver (1731-99), a well-known American jurist, espoused this point of view in an article in the *Transactions of the American Philosophical Society*. Rotheram also reviewed this essay in the *Monthly* and by remaining neutral showed that he had faith in ultimately getting an answer from the facts. He quoted Oliver to the effect that in the tropics great heat developed above the ocean surface. In certain areas this hot air rose rapidly into the atmosphere and caused an inflow of the surrounding air. This process accelerated until finally a spiraling air current developed which resembled "the screw of Archimedes" in that air pressure forced water up into the atmosphere. Rotheram concluded his review by noting that mariners had the best opportunity to view spouts and that they "cannot be expected to observe them with the same circumstantial accuracy which may be necessary for the foundation of a physical solution of so extraordinary an
appearance." Rotheram believed that naturalists must suspend judgment on the ascending vs. descending controversy until more waterspouts "have been observed by men of science." 

The anonymous reviewer in the Critical Review who commented on Perkins's paper raised objections to Oliver's viewpoint that spouts ascended. The analyst made it clear that he believed the opposite theory was the correct one. He asserted that the major difficulty with Oliver's paper and, in general, with the ascending theory was that no one had been able to account for the strong vacuum necessary to raise the water. The reviewer concluded: 

The cause of this vacuum, or a degree of rarefaction approaching to it, he has not explained very satisfactorily; nor has he shown that it really exists. If we allow all his positions, a water-spout, with the usual progressive appearances, could not be the consequence from the known laws of hydrostatics. 

The meteorological material in the periodicals reflected the general characteristics of eighteenth century meteorology. The age-old influence of Aristotle's Meteorologica was still in evidence. Naturalists, however, were beginning to separate themselves from the Aristotelian ascendancy. They placed more emphasis on systematic observing and
recording of atmospheric phenomena. Natural historians also adapted the new discovery, atmospheric electricity and the idea of immanence, into their explanations.
FOOTNOTES


2 Ibid., p. 304.


4 Ibid.

5 W. W., letter to the editor, The Gentleman's Magazine, 22 (June, 1752), 274-75.


7 A By-Stander, letter to the editor, The Gentleman's Magazine, 22 (December, 1752), 565-68.


John Lindsay, "An Examination of the Hypothetical Doctrine of Water-spouts, in Opposition to the Ingenious Speculations of Dr. B. Franklin of Philadelphia F.R.S.," *The Gentleman's Magazine*, 51 (December, 1781), 559-60.

15 John Lindsay, "An Examination of Water-spouts," *The Gentleman's Magazine*, 51 (Supplement, 1781), 615-16.


20 John Lindsay, letter to the editor, *The Gentleman's Magazine*, 58 (February, 1788), 106-08.


26 Ibid.

Another area of natural history that the editors of the periodicals covered extensively was biology, or, as the study would have been known in the eighteenth century, botany and zoology. Writers viewed plants and animals as creations of the hand of God, to be studied and analyzed.

Much of the coverage of flora and fauna was descriptive, or else was concerned merely with isolated monsters and curiosities. The problem of organization appeared explicitly in the extensive debate over taxonomic principles. Men of the Enlightenment believed that the systematization of the universe was possible. It was during the eighteenth century that Linnaeus created the first practical classification. At the time, many naturalists rejected his work for a variety of reasons. Some scientists were conservative and set in their ways and did not like a new system with strange Latin names. A few naturalists appeared to base their hostility to Linnaeus on the basis that he was a Swede and not a Briton. Other natural historians objected to his artificial system of taxonomy, which they believed was inferior to a natural
one that would be designed to reflect the chain of being. A few men went so far as to construct alternate systems of classification in opposition to Linnaeus; all of these systems engaged the periodical writers.

As the range of plants and animals known to Europeans expanded, writers in the magazines reflected the struggle of the educated public to comprehend and organize their conceptions of the flora and fauna about them in the world. One level of this struggle appears in attempts to place life in an environment that was no longer local. A seemingly minor problem in zoology, the migration of birds, illustrates the types of thinking involved in the new global viewpoint, and because of the implications of the problem for expanding perceptions, the subject received a great deal of attention from naturalists and editors during the eighteenth century.

Since ancient times, some naturalists believed the common European swallow (Hirundo rustica) and some related species of birds did not migrate but instead hibernated in Europe. Aristotle was largely responsible for the continuation of this myth because he repeated the story that swallows hibernated in an unfeathered condition in holes in the ground.\(^1\) The swallow also had certain habits, such as often being in a torpid state during spring and autumn, which led some
observers to maintain the correctness of Aristotle's claim. Many naturalists continued to accept the legend, on the authority of Aristotle, until the twentieth century. In the eighteenth century periodicals the debate over whether swallows hibernated or migrated was especially vigorous. A majority of the natural historians commenting on the issue believed that birds did not migrate.

Jacob Theodor Klein (1685-1759), Court Secretary at Danzig, was one of the naturalists who claimed that some birds hibernated during the winter. An abstract of one of his essays on the matter appeared in the Gentleman's in 1759. Klein began his paper by citing evidence that the debate over whether swallows hibernated or migrated went back at least to the time of Aristotle. Klein then proposed three questions that he intended to explore in his paper.

Klein asked first, what were the habits of swallows in other parts of the world? For a description of American swallows, Klein turned to the writings of Mark Catesby (1683-1749), a knowledgeable colonial natural historian. According to Klein, Catesby mentioned two swallows, the purple martin (Progne subis), and the barn swallow (Hirundo rustica). Klein noted that the martin did not have the habits of the swallow, as the martin built its nest in holes in houses, etc.,
and also drove away birds of prey. Catesby stated that the martin disappeared from Virginia during the winter and returned again in the spring. Catesby, according to Klein, said little about the swallow except that he thought it migrated to Brazil in the winter but offered no evidence to support this contention. Klein also mentioned several other species of swallows in the New World, including the golden swallow (Kalochelidon euchrysea) of Jamaica. He referred to Dr. Henry Stubbes's (1632-76), a British physician and traveler, description of the habits of this bird and noted that Stubbes claimed that the bird "departed" the island in the winter. Klein asserted by the word "depart" the doctor merely meant "disappear." Klein warned naturalists not to assume that the golden swallow migrated from Jamaica, for it could early have moved to more remote parts of the island. Klein mentioned other swallows in various parts of the world and argued that in no instance was there any reputable report of bird migration.²

Klein next inquired into the number of species of swallows found in Europe. He enumerated four different species, the common swallow, the martin (Delichon urbica), the sand martin (Riparia riparia), and the swift (Apus apus), and remarked that they all had forked tails and ate only insects.
Klein's final question was: "What is to be learnt from the experience of people of learning and others, relating to the dispositions of swallows within the limits of Poland and Prussia?"³ Klein asserted that the sand martins, on the approach of winter, retiring into holes prepared during the summer, shut up the holes, and hibernated during the cold months. He cited other naturalists who claimed to have found sand martins in a state of hibernation in their holes. Klein reported that his father had once found several swifts in a state of torpor inside an old oak tree.

Klein presented his own theory as to the whereabouts of the swallows during the winter. He admitted that it was not based upon first-hand evidence but mostly on sightings from "sensible and observing country people." As the weather grew colder in the autumn, the swallows collected about pools and lakes. Sometimes several birds perched on a single reed and slowly sank along with it into the water. Occasionally people reported they saw swallows take a hollow straw in their beak and dive into the pond. Klein also noted that some birds rolled themselves into a ball and threw themselves into the water. He stated that hibernation of swallows was not a ridiculous idea, for many animals,
including some insects, were known to hide themselves in the earth or under water during the cold season.⁴

Klein's ideas were based on observation. The editor of the Gentleman's printed with the abstract of Klein's paper a critique by one Dr. Wright (probably Dr. William Wright (1735-1819), a well-known Scottish naturalist and physician). Wright had two practical and naturalistic objections to Klein's hypothesis. First, he did not believe that swallows could survive several months under water. Wright remarked that the bird's blood must continue to circulate. The act of respiration appeared to be necessary during circulation, and Wright did not believe that a swallow under water could get enough air to survive. Wright's other doubt concerned the matter of how the birds got out of the water in the spring. When the swallows entered the water they were heavier than the water. But how, he asked, could the swallow get enough air into its body to enable it to float to the surface of the water?⁵

But the hibernation theory was backed by substantial ocular evidence. A letter from Antoine Achard (1696-1772), a clergyman and natural historian in Berlin, to Collinson, which the latter read to the Royal Society, seemed to supply strong evidence that some swallows hibernated in the Rhine-
land. The letter was republished in the London Magazine in 1764 with comments by Collinson. Achard reported that while on a cruise down the Rhine he observed a group of boys removing torpid sand martins from their holes in the bank. This occurred near the end of March in cold weather, and he and his companions spoke to the boys and learned these martins spent the winter in the sand bank. The boys gave Achard and his friends some birds in a state of semi-hibernation. They placed the sand martins inside their shirts and after a short time the warmth of their bodies revived the birds. Collinson took the position that perhaps some birds migrated and others remained behind in their holes and spent the winter in these "dormitories." He seemed to be convinced by Achard's discovery that the sand martin was a bird of this type.

How fine the line was between naturalism and folklore and supernaturalism was shown by a variation of the dispute about swallows appearing in the Gentleman's in 1750. The editors of the serial during the late 1740's and early 1750's occasionally inserted a miscellany column entitled "Huetiana." This section featured short translated excerpts from the book of the same name by the famous French scholar, Pierre Daniel Huet (1630-1721). In the February issue, the editor pub-
lished some of Huet's comments on the swallow. Huet reported that in Sweden in the autumn swallows plunged themselves into a lake and remained frozen under the ice until the spring thaw. Local residents even reported breaking a hole into the ice and finding the birds in a state of hibernation.8

In the April issue of the Gentleman's, W. Jackson in a letter questioned the credibility of Huet's report. Jackson wondered if Huet actually observed these birds in the water while traveling in Sweden or if he cited any written authorities. Jackson declared that if swallows really hibernated under the ice, then the event must be a miracle of nature. He wrote that if the story were true:

We must allow that the Swedish swallows are the most extraordinary kind of amphibious creatures in the known world; and indeed I think a greater miracle in nature cannot be produced.9

In the May issue, the translator of Huetiana replied to Jackson. He stated Huet never personally observed the hibernating swallows while he was in Sweden but reported what he had learned from the Swedes.10 In the June issue, an anonymous contributor, "Not the Editor of Huetiana," advised Jackson where he could learn about "this miracle of nature." He recommended William Derham's Physico-Theology for a description of how a swallow hibernated. The latter
related that Scandanavians netted torpid swallows from beneath the ice of frozen lakes.\textsuperscript{11}

In the same issue, Jackson contributed another letter to object to the theory that a swallow could hibernate under the water. Jackson wished that Huet had actually seen swallows under the ice instead of relying on hearsay evidence. He could not believe that a bird received enough air from the water to be able to pass the winter under the ice.\textsuperscript{12}

Jackson in the next issue ridiculed "Not the Editor of Huetiana" and Derham. He read Derham's volume and discovered that the latter did not really explain how swallows could survive a winter under the ice. If swallows ceased breathing, as some writers claimed, then "the metempsychosis of Pythagoras" would be necessary to account for the bird's revival in the spring. Jackson also questioned what became of the bird's "soul" while the animal was underwater. He jeered at the suggestion that the avian soul might reside in the body of creatures during the cold months:

Their souls, after having deposited their bodies in the floods, transmigrate into those of other creatures; and as they are fond of warmth, I make no doubt but that during the winter months they take up their habitations in the bodies of ladies favourite cats, lap-dogs, monkies, parrots, and singing-birds; and perhaps, in the ladies them-
selves, (for it is observable that they are more garrulous in the winter than summer) where they lie secure from the cold till the next dawn of summer, when they again resume their drowned bodies, and sport anew in the airy fields.\textsuperscript{13}

Not all naturalists went to such extreme lengths to explain the hibernation of swallows. Reputable men like Buffon believed that at least some swallows hibernated and they attempted to prove it experimentally. Gilbert Stuart reviewed the first volume of Buffon's \textit{Histoire naturelle des oiseaux} in the \textit{Monthly} in 1770 and devoted a large part of his article to Buffon's comments on bird migration. Buffon noted that arguments existed both for and against migration. He remarked that the proponents of both hibernation and migration supported their position with repeated observations and wondered, "how is the truth to be extracted from these contradictions?"\textsuperscript{14}

Buffon, not content with observation, devised an experiment which he believed would settle the issue. He had found that when quadrupeds hibernated, their body temperature dropped considerably. Buffon obtained some swallows and kept them in an icehouse "for some time." None of the birds "fell into the torpid state" and the greater part of them died. Buffon observed that none of them revived after being moved into the warmth of the sun. From this trial Buffon
concluded that the common species of swallow "was not liable to that state of torpor and insensibility, which supposes, notwithstanding, and very necessary, the fact of its remaining at the bottom of the water during the winter." In addition Buffon cited another kind of eyewitness testimony, that of the French botanist, Michel Adanson (1727-1806), who had observed the arrival and departure of the common swallow in Senegal. Buffon concluded that these facts plainly demonstrated that the common swallow did migrate to Africa.

Even Buffon, however, was still troubled by all the testimony from naturalists who claimed to have found swallows in various states of hibernation. Buffon could think of only "one means of reconciling these facts." He stated, "we must suppose that the sleeping and travelling swallows are of different species, though the difference, for want of attention, has not been observed." Buffon speculated that the species of swallow that hibernated might be the "little martin" or bank swallow. He called upon other naturalists to perform experiments similar to his and determine if the blood of other swallows "might be chilled into a state of torpor." Buffon concluded by stating that the debate over swallows illustrated how little knowledge naturalists possessed about the animals around them.
Probably the leading British advocate of bird hibernation was Daines Barrington, who made a thorough investigation of the cases of alleged avian migration. His original comment on the debate was in the form of a paper in the *Philosophical Transactions* in 1772.17 Bewley commented on the paper in the *Monthly*. Barrington recognized the importance of geographical extensions of the argument and disputed Adanson's observations of European swallows in north Africa. Barrington claimed that Adanson had confused two species of African swallows with their European relatives. Adanson had also reported personally seeing four swallows land on a ship on the 6th of October about fifty leagues from the coast. He believed that they were migrating south for the winter. Barrington replied that even if they were European swallows, and he believed they were not, then the birds were flying from the Cape Verde Islands to Africa and not migrating from Europe. In addition, Barrington repeated the usual sightings by naturalists of birds having been discovered in ponds etc.18

Bewley was not convinced by Barrington's arguments, and, in his review, he offered another argument in favor of the passage of birds. Bewley commented that the British always saw the swallows in full plumage. The process of moulting
had to occur somewhere. Bewley believed that it was absurd to suppose the shedding of feathers took place while the birds were asleep in caverns, hollow trees, or in the mud at the bottom of a pond. Bewley declared that the swallows, therefore, must moult in some distant country after their migration.¹⁹

Barrington added some additional arguments to the question in his Miscellanies, reported in the Critical Review in 1781. He attempted to refute, one by one, the assertions naturalists had offered in favor of the passage of birds, and then he shifted from observation to another type of naturalism. One question he raised was that people rarely saw birds traversing the oceans. Some writers had claimed that flocks of birds flew at such a great height that no one could observe them passing over the oceans. Barrington retorted that birds could not fly at such altitudes because the air was too rare for them to breathe. Other unnamed naturalists asserted that birds migrated at night. Barrington objected that the supposed migration routes of some species were so long that the birds could not possibly make the flight in one night. He also wondered why, if birds migrated at night, no sailors reported hearing their calls.
In addition, Barrington pointed out that birds usually slept at night and did not fly by "owl-light."  

Barrington next discussed the problem of why so few birds were ever found in a state of hibernation. First, he noted that until recent times hardly any men paid much attention to the study of natural history. Second, Barrington stated that common laborers had the best chance to discover hibernating birds. Most of them in fact did believe birds hibernated and when they found one in a torpid state, the workers did not mention the unearthing as they did not believe it to be unusual or worthy of note. Third, the birds by natural instinct were secretive and selected secluded areas for their hibernation.

Of the proponents of bird migration, only one writer in the serials invoked a theological argument in support of avian migration. This lack of emphasis was surprising since in the Bible in Jeremiah 8:7 reference is made to the migration of birds. An anonymous author in the London in 1750 anthropomorphized birds of passage. He observed that each species had its "allotted time" to migrate, some in the spring, some in the summer. It was as if someone published a "general edict." A "kind of council" of birds fixed the day when the entire species was to begin its annual journey.
He asked, "why they do not keep, like other hire, to the country where they have brought up their young, which have been so kindly treated in it?"23 The anonymous author wondered "by what disposition to travel does this new brood which knows no other than its native country, conspire all at once to quit it?"24 To these and other queries the unnamed author replied that God has provided for everything and He often concealed His means from man. The author concluded "O Lord, how manifold are thy works, in wisdom hast thou made them all!"25

Catesby provided the best arguments in the periodicals in favor of bird migration, and he represented dramatically the impact of exploration and travel. In 1748 in an article in the London Magazine, reprinted from the Philosophical Transactions, he blasted the reports of avian hibernation as "ill attested and absurd." Catesby explained that cold weather caused a decrease in the birds' supply of food. The birds which depended, for example, on insects were forced to begin moving south in order to survive. Catesby remarked that vast tracts of the globe remained unexplored. Birds could migrate virtually unobserved to these areas. He suggested that perhaps birds of a particular latitude in the northern hemisphere flew south in the winter to the same
latitude in the southern hemisphere. In this manner, Catesby argued, nature affords them "their proper and natural food." Catesby next turned to the rigors of the migratory flight. He explained that no need existed for birds to undertake a long exhausting journey in a few days. He claimed that they moved south gradually. They might fly for a few hours a day and then stop to rest and eat. Catesby believed that many birds probably traveled at night to escape detection by their enemies. He reported that while on a sloop off the northern coast of Cuba for three successive nights, he heard the distinctive calls of the ricebird (Dolichonyx oryzivorus) flying over his ship.

Catesby also devoted several pages to a description of the "winter birds of passage," or birds which wintered in England. He alluded to the fieldfare (Turdus pilaris) and the redwing (Turdus iliacus) as examples of birds which left the island and migrated north for the summer. Catesby claimed that these birds found it necessary to migrate from Sandanavia in the winter when ice and snow prevented them from finding their normal food. These birds existed on haw berries during the winter in Britain. Catesby admitted that he could not explain why the fieldfare, redwing, and other birds left Britain in the spring. He noted that their food supply was
probably no better in Scandanavia in March. He concluded that the reason for the birds withdrew from Britain "is one of the secrets in nature which are not yet discover'd," and so left the debate open for those who wished to answer with merely local observations.  

Another variation of the debate over naturalism in bird migration vs. hibernation appeared in the Gentleman's in 1748. Cave extracted an anonymous article in which the original author attempted to refute some naturalists who claimed that birds migrated "above the atmosphere." He asserted that this statement "is above my comprehension" and dismissed it by noting no animal could exist in the rarefied air above the atmosphere. The nameless author also offered his own thoughts on the subject. He believed that when swallows or other birds of passage began their migratory flights, they flew at a steep angle high into the atmosphere while they were "strong and vigorous." Then they began a long slow glide toward the earth which ended in the country of their destination. The anonymous author felt that his theory explained how birds were able to make a long flight which required a great deal of endurance.

Collinson usually presented naturalistic arguments in favor of the passage of birds, although as previously men-
tioned, when faced with what appeared to be hard evidence, cautiously he expressed some doubts about the issue. The Gentleman's Magazine in 1761 reprinted a letter of Collinson's from the Philosophical Transactions. Collinson disputed Klein on the matter, for he could not accept Klein's claim that birds hibernated underwater. Collinson remarked the swallow lacked the necessary organs to spend an extended period at the bottom of a pond. In addition Collinson knew of no one who had ever found a swallow hibernating in the extensive reed beds along the Thames River. He observed that every winter laborers cut down these islands of willows and reeds for various purposes. As the swallows congregated in the reeds in the autumn, Collinson believed someone would find them if indeed they were hibernating. 30

Collinson was determined to meet the hibernation advocates on their own grounds. A clergyman friend in Surrey lived near a sand cliff which was the home of a large number of sand martins. Collinson requested his friend to make a thorough examination of their holes during the winter season to determine if any martins were hibernating. The clergyman inspected over forty excavations and found not a single bird. Collinson was therefore totally convinced that the sand martin did not hibernate. 31
The debate over avian migration persisted through the entire era, from 1731 to 1789. Another continuing biological issue of importance was the Linnaean system of taxonomy. The serials were an important instrument in the dissemination and popularization of the Linnaean scheme. The pages also contained much debate over the merits of Linnaean taxonomy. A large majority of the pages in the serials devoted to zoology and botany included taxonomic discussions (see chapter one and the appendix).

Linnaeus published his main work, *Systema naturae*, in Latin in 1735 and it went through twelve editions during his lifetime. The first edition contained only a dozen pages, but he expanded later editions to include all of the known organisms. He devoted his life to the classification of the great number of new plants which were discovered and brought to Europe from all over the world. He grouped plants into classes, orders, genera, and species, and named them by using binomial nomenclature. Linnaeus used the number of pistils to determine the order to which a plant was assigned; the number of stamens resolved by its class. By this method he divided the plants into twenty-four main classes. Linnaeus's botanical system was an artificial one, since he utilized
only one characteristics, the reproductive organs, for classification.  

In spite of many criticisms, the Linnaean system was the most widely accepted in Europe. It was especially popular in Great Britain, where naturalists quickly recognized its practical value in identifying plants. Numerous English editions and popularizations of the scheme appeared after 1740, and the magazines and reviews provided extensive articles about these new books. In fact an aspiring naturalist could easily have learned the fundamentals of the Linnaean and other systems merely by reading the reviews and articles in the serials.

One of the first books in English describing the Linnaean system of botany was John Hill's *General Natural History* published in 1751. Hill, in the second of three volumes, provided a basic course in botany. Not only did he define and detail the various technical terms like pistil, calyx, etc., but he also provided a complete delineation of all twenty-four Linnaean classes. Hill in addition expanded the Linnaean plant descriptions by supplying an account of the roots, stalks, and leaves to complement Linnaeus's narration of the parts of fructification.
John Ward, vice-president of the Royal Society, gave an extensive analysis and condensation of General Natural History in the Monthly Review. He devoted most of his review to a detailed explanation of the principles of plant taxonomy. He described the various sexual parts of a plant and detailed how Linnaeus and Hill used them for taxonomic purposes. Next Ward delineated the twenty-four Linnaean classes and described the orders in each one. He concluded his review by selecting one genus, Lilium, providing Hill's complete treatment of it.

An even more elementary treatment of the Linnaean scheme, An Introduction to Botany, by James Lee (1715-95), a nurseryman, appeared in 1760. An unnamed reviewer in the Monthly claimed that this book was the "first in our own language that professedly treats the elements of that science." According to the reviewer, Lee's express purpose in writing the book was to provide an understanding of botany and the Linnaean system for his English readers. Again the reviewer gave a long explanation of the sexual system and expressed approval of several of Lee's innovations. These latter included two extensive tables in which Lee provided exhaustive cross-references of Latin and English names for the various species, genera, orders, etc. In addition the
unnamed reviewer summarized Lee's comments on how a beginner could learn to classify plants. Lee explained that first a natural historian had to master the twenty-four different classes so that he could classify a plant with little effort. According to the commentator, Lee also urged his readers to begin with large, showy flowers in which the stamens and pistils were distinct and readily visible.

An even more straightforward book, *A Botanical Arrangement of All the Vegetables Naturally Growing in Great Britain*, by William Withering (1741-99), a physician, botanist, and mineralogist, appeared in 1776. An anonymous reviewer in the *Critical Review* lauded it as simpler and easier to understand than Lee's volume. The critic remarked that where Lee had merely translated the Linnaean terms, Withering attempted to replace every Latin word with an English synonym so a farmer or husbandman did not have to load his memory with a lot of foreign phrases. Withering directed his practical book to the literate farmers of Britain. He, in the tradition of the agricultural reformers like Jethro Tull, Charles Townshend, Robert Bakewell, and Arthur Young, wanted to make English agriculture more productive. According to the reviewer, Withering in his book emphasized that by systemically studying botany, a yeoman
farmer could put his land to better use. A farmer should not be burdened with a strange system with foreign words:

The oeconomical uses of vegetables [plants], have been hitherto but little attended to by men eminent for botanical knowledge. The theory of the science, and the practical uses have been too much disjoined. At length, however, the generality of mankind are tired with disputes about systems, and the vegetable productions of Europe are pretty well arranged; it is time therefore to think of turning our acquisitions to some useful purpose. 36

Farmers could obtain much worthwhile knowledge merely by determining which plants certain domestic animals ate. Cognizance of the poisonous species was also useful. For example, Withering wrote,

It is certainly a matter of the greatest consequence to determine what species of plants are preferred by particular animals; for what is noxious to one animal is often nutritious to another. Thus the Water Cowbane is a certain poison to cows; whereas the goat browses upon it greedily. Monkshood kills goats, but will not hurt horses. Bitter almonds are poisonous to dogs, but not to men. 37

In 1785 an anonymous reviewer in the Monthly gave an additional reason beyond the practical ones for the various translations of Linnaeus's volumes: national pride. The unnamed critic wrote:

Let not Britain forgo any advantage, which the dignity of her name, the advancement of her
science, and the refinement of her manners, prompt her, and indeed entitle her most justly to claim.18

He continued that the English language was the equal of any ancient or modern tongue for the expression of scientific material. The reviewer boasted:

If definitive words, strong, full, concise and plain, can be found out to mark precisely every distinction, it [English] must be allowed to be adequate. Of this it cannot be denied, that our language is fully capable as any language, ancient or modern. For well is it said of the English by one of high authority, that it rivals the Hebrew in simplicity, the Greek in richness, force and harmony, and the Latin in ease.39

Clearly to him, a good deal was at stake.

A number of British natural historians voiced objections in the serials to the Linnaean scheme. Many of their comments involved rather insignificant and trifling matters. Some of the critics, as was the case with the previous reviewer, had patriotic motives: they were disappointed that Linnaeus was not a British citizen writing in English. Sometimes these disputes over the merits of the Linnaean system developed into long drawn-out debates in the letter to the editor sections.

Barrington was probably the most persistent and vocal of Linnaeus's critics in the periodicals. He devoted a section of his Miscellanies to strictures on the Swedish
An anonymous reviewer in the Monthly in 1781 repeated a number of Barrington's criticisms. The latter described the Latin in the Systema naturae as "barbarous" and "obscure." He noted there was scarcely a naturalist on earth who had not found faults with the system. Barrington wondered how a book of 532 pages, which contained descriptions of all the animals on earth, could be anything more than a "vocabulary, grammar, or dictionary." He also accused Linnaeus of stifling the development of natural history because his admirers were so fanatical about learning and using the Linnaean arrangement that they never made any original contributions to the discipline. In addition, Barrington claimed it took so long to master the Linnaean elements that a person was old before he could apply them to any "article of natural history." 

An anonymous reviewer of Miscellanies in the Critical Review cited some other of Barrington's remonstrances. Barrington objected that Linnaeus's sexual system was of use in classifying plants only when they were in bloom. If a naturalist could not observe the stamens and the pistils then it was difficult for him to determine the identification of an unknown species. Barrington also remarked that the Linnaean scheme was virtually useless on dried plants and
he urged the development of a taxonomic scheme which could be used to classify plants in any season of the year and one which did not require the frequent use of a microscope to inspect minute plant parts.  

Some of Linnaeus's admirers responded to Barrington's comments in the periodicals. A correspondent to the Gentleman's Magazine who called himself "Lucius" provided two letters in 1782 in defense of Linnaeus. He asserted that the Linnaean descriptions of the various species, although brief, were adequate to delineate the organism. Lucius argued that the Systema naturae was much more than a dictionary in that Linnaeus had extracted useful information from the writings of other naturalists, added much more material, and arranged it all into a workable scheme.  

In his second letter, Lucius took up some of Barrington's specific complaints. For example, Barrington had criticized Linnaeus's description of the linnet (Acanthis cannabina). He was disturbed because the Swedish naturalist had not noted the unique undulating flight pattern, the nesting habits, and the call of the linnet. Lucius, like Linnaeus, believed that other characteristics better described the bird; its size, shape, and color were more important than its habits. As Lucius noted, most naturalists studied
preserved specimens and if the bird was not native to the naturalist's country he would never have the opportunity to observe its flight and nest or hear its note.45

The next year, in 1784, "P.B.C." defended Linnaeus in two letters to the editor of the Gentleman's. P.B.C. asserted that Barrington's charge that the Linnaean system stifled natural history was absurd. He remarked that every science must have basic elements which have to be mastered before a novice could become proficient in it. P.B.C. granted that the fundamentals of the Linnaean scheme were difficult and he also observed that English grammar was not easy but it was a necessary evil.

P.B.C. claimed that Barrington's strictures on the Linnaean account of the goldfinch (Carduelis carduelis) were groundless. P.B.C. listed in English the Linnaean description of the bird:

1. It haunts juniper grounds throughout Europe.
2. In winter it feeds on the capitatae or thistles, and the like.
3. It collects seeds.
4. It sings very loud in a cage.
5. It breeds with the canary and produces a mule bird.
6. This mule bird produces, but the next generation does not.46

Barrington had claimed that the goldfinch did not frequent junipers in England and wondered what part of the bush the
bird ate in the various seasons of the year. P.B.C. retorted that the goldfinch did indeed inhabit the junipers in Sweden and perhaps Linnaeus might have slightly overstated point number one. He pointed out that Linnaeus never asserted that the goldfinch fed on the juniper. Linnaeus wrote only "habitat in Europae juniperetis" which meant the goldfinch inhabited the junipers. P.B.C. concluded his first letter by indicating that Linnaeus wrote his *Systema naturae* as a general reference work and that it was impossible for him to take into account local natural history.

P.B.C. responded with a second letter and in it he defended the botanical part of the Linnaean system from Barrington's attacks. He agreed with Barrington that the Linnaean scheme was of little use on dried plants. P.B.C. argued, however, that systems of plant taxonomy were always intended for the identification of living specimens. In any case, if a naturalist were familiar with plants, he should be able to at least determine the class of a preserved plant.

Barrington cited the wild carrot (*Daucus Carota*) as an example of a plant inadequately described by Linnaeus. In addition Barrington claimed that Ray in his *Historia generalis plantarum* had provided a more complete description of it. The matter under debate was the fact that the
flower of the *Daucus* had different forms at various times during the summer. P.B.C. pointed out that Linnaeus had in fact noted the changeable flower shape when he depicted it as "florem plana, fructifera concavo-connivens." P.B.C. conceded that some of Ray's descriptions were more complete than those of the Swedish naturalist, but he also remarked that this was to be expected when comparing a book containing accounts of 1,500 plants to one with 10,000 species.

P.B.C. claimed the plant characteristics which Barrington wanted to use to classify plants were not "of first importance." Barrington had advocated the classification of plants by smell, taste, form of the root, color of the leaves in autumn, their culinary uses, and by the insects which feed upon them. P.B.C. affirmed that the last two of Barrington's distinguishing traits had nothing to do with "botany properly so-called."

P.B.C. concluded his letter with a call to eliminate the faults of the Linnaean system. He rejected Barrington's appeal for a new and better system of plant and animal taxonomy, and pointed out that the Linnaean scheme had stood the test of time and had few serious defects. In addition, most naturalists throughout the civilized world understood and used it.
Other natural historians had reservations about the Linnaean arrangement for a more significant reason—it was an artificial system. Linnaeus had often grouped together unlike organisms or had separated closely related species. Contributors to the periodicals enjoyed pointing out the shortcomings of specific schemes, reflecting a belief that there were natural relationships among plants which could provide a basis for classification.

The naturalists of the eighteenth century inherited from antiquity two rather contradictory views of the organic world, both of which had been elaborated by Aristotle. On the one side were those who depicted the various plants and animals as links in the great chain of being (see chapter five); on the other side there were those who viewed organic species as a hierarchy of creatures with comparatively large discontinuities between their ranks. Aristotle, himself, for example, had only eleven classes in his hierarchy of animals.53

In the practice of zoological and botanical classification, these two conceptions could not be reconciled, and they gave rise to two different kinds of classificatory technique. The naturalists who developed artificial systems classified the species of plants and/or animals into discon-
tinuous and well-marked groups using a few or even only one characteristic for the purposes of systematics, such as the nature of the reproductive organs. The proponents of the natural systems, on the other hand, aimed to put organic species into natural families in which there was a continuity of creatures. The taxonomists who fashioned natural systems strove to use as many individual characters as possible to help them establish the affinity of the organisms within a family. The debate between the two sides was conscious and open; both sides cited historical antecedents of attempts to classify plants and animals, and both sides were aware that their own age ought to produce a culmination of taxonomic progress.

A good example of the absurdity of some arbitrary groupings appeared in a discussion of an artificial system for the classification of insects. Cave in 1747 printed a review by the French entomologist, Pierre Lyonet (1707-89), of an entomological treatise by Friedrich Christian Lesser (1692-1754), a German scientist and theologian. Lyonet commented on some of the taxonomic systems for insects which Lesser examined in his book. One of the most ridiculous schemes was that of the Italian naturalist, Antonio Vallisneri (1661-1730). Vallisneri grouped insects into four
divisions according to the places where they were found. He believed that insects lived on plants, in liquors, on animals, or in animals. Lyonet remarked that an entomologist was at a loss to know under what class to place a certain insect which lived in multiple environments or which changed habitats as it matured. He noted, for example, that some insects begin life in the earth and then live on plants. The arrangement of Vallisneri was about as artificial as could be imagined.56

William Watson pointed out a number of serious problems in Linnaeus's botanical scheme which were the result of its artificiality. He provided an anonymous review of Linnaeus's Species plantarum for the Gentleman's Magazine in 1754. Watson gave a brief summary of the Swidish naturalist's sexual system. Watson listed a number of examples of deficiencies in Linnaeus's artificial scheme. In the class Octandria, plants with eight stamens, Linnaeus placed the genus Polygonum which should have eight stamens; but Watson pointed out that various species of that genus had from five to eight stamens. In addition Polygonum also broke the rule for the formation of orders. A genus should contain species with the same number of pistils and not be broken up into different orders. The Polygonums, however, consisted of
some species with two pistils and others with three. The genus *Hypericum* likewise was composed of assorted species with from two to five pistils. Watson especially demonstrated that Linnaeus's classification of the grasses raised numerous similar problems. Watson, like many other natural historians stressed the need for a more natural botanical scheme.\(^{57}\)

The attempts to formulate the perfect natural system led to a proliferation of taxonomic schemes and to extravagant claims. John Hill for many years promised to construct a natural arrangement for the plant kingdom. Instead this voluminous writer produced a series of hastily written books on botany. In 1758 an anonymous reviewer in the *Critical Review* commented humorously on Hill's productivity. He concluded:

> It was not without reason that the humorous H[ogg] th, in his representation of Beer-street, exhibited a porter sweating under a load of Dr. H[ill] 's works; but should this ponderous writer live a few years longer, half a dozen of porters, assisted by as many asses, will scarce be sufficient to carry all his works to the Trunk-makers.\(^{58}\)

In Hill's work under consideration, *The British Herbal* (published in 1756), the reviewer remarked that the author largely copied from other natural historians, principally
Linnaeus and Ray. Hill had intended to include all British plants but he had ignored many species. In addition Hill devised his own taxonomic system which he based upon the number of petals, arrangement of the leaves, shape of the flower, the number of seed capsules, and other arbitrary items. Hill also dropped the binomial nomenclature of Linnaeus and adopted his own Latin phrases in their place. The end result was a botanical work more likely to confuse than help a naturalist. It was a good example of what happened when a taxonomist totally ignored the achievements of Linnaeus.59

Hill published an eleven volume Vegetable System in 1767. Many naturalists, including John Berkenhout who reviewed the volumes in the Monthly, assumed that this was Hill's much touted "natural system." They were wrong. Hill had compiled a massive botanical work complete with yet another artificial scheme. He devoted the first two tomes to a long history of botany and a detailed presentation of plant anatomy and physiology. Finally, in volume three Hill elaborated his system.60

Hill readily admitted that his arrangement was an artificial one. In fact, he preferred to call it a "botanical index or dictionary." Berkenhout wondered how Hill
could refer to it as an index since the system took eleven folio volumes and still was not complete. In addition he asked why Hill called it the vegetable system. Hill believed that he provided a set of books in which a person who was a beginner in botany could look up an unknown plant as easily as one could find a word in the dictionary. Hill especially designed his system for women and young naturalists. According to Berkenhout, Hill clearly stated that his arrangement was arbitrary:

We mean in the following work to have no mercy upon any class, any order, any system, that stops a minute our pursuit. With the utmost reverence for Nature, we chuse in this performance an easier guide; and if we attain the end proposed, this mere artificial index shall pave the way to a system of another kind; we are bold to say, a more natural one than has hitherto appeared.61

Berkenhout wondered in what year of the next century the natural system could be expected if the present one was only a harbinger of it.

Hill divided the plant kingdom into herbs, trees, shrubs, and undershrubs. He separated herbs into those with flowers visible and invisible to the naked eye. The former group constituted ten distinct series and the latter the last four in Hill's system. The subdivisions of these fourteen series made forty-two classes. The first two series
comprised those herbs which bore flowers assembled together in a common cup. The other eight comprehended those whose flowers were on separate pedicles. The first ten classes were:

Series 1. with united chives
   The corolae tubulated with rays—1. Radiates
   tubulated without rays—2. Florets tongued—
   3. Semi-florets
Series 3. issuing from one point—6. Umbellas
Series 4. regular flowers
   with one petal—7. one-petalled
   two petals—8. two-petalled
   three petals—9. three-petalled
   four petals—10. four-petalled

Hill divided each of the classes into orders on the basis of the calyx-cup entire, cup simple, cup double, etc.\textsuperscript{62}

The serials also contained a great deal of discussion about a natural system of plant taxonomy developed at the turn of the century by Joseph Tournefort, a system widely used in France until about 1780, when it was superseded by another natural system promulgated by Bernard de Jussieu.\textsuperscript{63} Tournefort's arrangement was used sparingly in Great Britain in spite of the fact it was an attempt at the long sought natural plant system. Part of the lack of British enthusiasm for it was undoubtedly due to prejudice against anything that was French.
Berkenhout in 1766 in the *Monthly* discussed the Tournefortian system while reviewing an anonymous French work entitled *Démonstrations élémentaires de botanique, a l'usage de l'Ecole Royale Vétérinaire*. These two volumes contained a large section on *materia medica* and Berkenhout was somewhat surprised to discover that the anonymous author adopted the Tournefortian system rather than the Linnaean one (although the latter was also briefly discussed). According to Berkenhout, the author gave two reasons for his decision. First, Tournefort described a much smaller number of plants than the Swedish naturalist. Tournefort delineated virtually all the plants native to France so his system met the needs of the French veterinarians and did not confuse them with a large number of additional plants from all parts of the world. Secondly, since the students were taught to identify plants in an herb garden, they would find it much easier to use an arrangement where the primary division was into trees and herbs rather than into twenty-four classes based on stamens. The anonymous author observed that the Tournefortian scheme was "better adapted to a garden than the sexual system, which, following nature, places the burnet at the foot of the oak."

Berkenhout supplied a third reason of his own—Tournefort was French. He noted that at
the time of his writing, 1766, the Linnaean system was virtually unknown in Paris, largely because of the patriotic preference for the French arrangement.65

Colin Milne (1743-1815), a London botanist and Anglican divine, considered some of the perplexities in the Tournefortian system. Jebez Hirons reviewed Milne's Institutes of Botany in the Monthly Review in 1772. According to Hirons, Milne compared the Tournefortian arrangement to that of the German botanist, August Rivinus (1652-1723), who had constructed an artificial system based upon the number of petals. Tournefort also used the number of petals as a distinguishing feature but he combined this trait with a consideration of the general shape of the flower and produced a more natural scheme. For example Tournefort combined plants with bell-shaped flowers like the nightshades, bell flowers, mallows, gentians, and others into the same natural class. Milne was not pleased with the result because Tournefort's taxonomic scheme was more difficult for a naturalist to use than either Linnaeus's or Rivinus's method. He asked, for example, how could a botanist always distinguish a bell shaped flower from a funnel shaped bloom? Milne seemed to prefer a good natural scheme over an artificial one provided it was easy to use.66
In the animal kingdom, a new taxonomic system by Thomas Pennant produced significant comments in the pages of the periodicals. Pennant modeled his system on a similar one by his countryman, Ray. His arrangement of mammals was more natural than Linnaeus's scheme for Pennant's main criticism of Linnaeus's taxonomy was that the Swedish naturalist was constantly modifying it with each succeeding edition of his work. Pennant believed that these changes indicated that Linnaeus himself realized his own system had shortcomings, perhaps serious ones.  

In his *History of Quadrupeds* published in 1781, Pennant listed specific difficulties in the Linnaean scheme for mammals. An anonymous reviewer in the *Critical Review* quoted them word for word from Pennant's book. Pennant rejected the first order, which Linnaeus called primates, because his vanity "will not suffer me to rank mankind with apes, monkies, maucaucos, and bats, the companions Linnaeus has allotted us even in his last system." Pennant did not like Linnaeus's second order, Bruta, because it included the half-reasoning elephant with the discordant and stupid sloths, anteaters, armadillos, and walruses. He repudiated the third order, Ferae, because it grouped the mole, shrew, and hedgehog with the lion, bear, and wolf. Pennant generally
concurred with the fourth and fifth orders, Glires and Pecora. He agreed for the most part with the hoofed animals in the sixth order, Bellue, but insisted on a different internal arrangement. Pennant noted good reasons existed for putting the whales in a seventh order, Cete, but he preferred to place them with the fishes.

Pennant modestly claimed only a small share of originality in his own zoological system. He followed Ray in dividing animals into hoofed and digitated divisions, but Klein formed within the hoofed division separate genera for the rhinoceros, the hippopotamus, the tapir, and the musk ox. Pennant placed the camel in this division since it was a ruminating animal without the upper front teeth and only rudimentary hoofs.

Pennant grouped the apes in the same manner as Ray, and they formed the first section in his second division of digitated animals. The second section, carnivorous animals, deviated little from Ray's system and was subdivided according to Linnaeus after omitting the seal, mole, shrew, and hedgehog. In the third section, herbivorous quadrupeds, Pennant classed the species in about the same way that Ray had grouped them except that the above-mentioned four animals were included. He thought the mole was somewhat
different because of its cutting teeth, but Pennant felt it belonged to this section and not with the Ferae as Linnaeus had placed it. Pennant's fourth section of digitated quadrupeds included those without cutting teeth, such as the sloth and armadillo. His last section included the animals like the anteater that have no teeth. 69

Pennant placed the seal, walrus, and the manatee in his third division or order of pinated animals. He thought that these were imperfect animals that seemed to form a link between the quadrupeds and cetaceous animals. His last division was for winged quadrupeds (bats). They seemed to him to form a gradation to the birds and therefore merited a separate group. Pennant added these last two divisions to Ray's system. 70

The anonymous reviewer did not comment on the merits of Pennant's scheme, but other correspondents and reviewers admired it. One got the impression from reading their remarks that national pride for a British naturalist played a large role in the formation of their opinions. In 1769 a contributor to the Gentleman's who identified himself as "D.H." praised Pennant's work. He based his remarks on an earlier zoological tract, British Zoology, which Pennant published in the late 1760's. He was so enthusiastic about
Pennant's taxonomic scheme that he gave a complete explana-
tion of it in his letter.\footnote{71}

The faithful readers of the serials in the period from 1731 until 1789 would have drawn a number of conclusions about botany and zoology. The natural historians of this era appeared to be obsessed with the search for order. They attempted to describe and classify all the species of flora and fauna from the various parts of the world. Naturalists not only wanted all species classified, but they wanted them arranged in that elusive "perfect natural system."

The botany and zoology of the period also reflected a great deal of nationalism in science. In many instances in taxonomy, British natural historians were disturbed by the fact that Linnaeus was Swedish and not British. They emphasized the need for British schemes in English. Yet these same men looked with amusement on the French naturalists who rejected the Linnaean system in favor of a French alternative.

This same parochialism appeared in the debate over avian migration. The naturalists of the various nationalities seemed to have a difficult time accepting the possibility that animals might migrate freely from country to country or
even from continent to continent.

The comments in the serials concerning bird migration and taxonomy demonstrated that botany and zoology were in a transitional state. The debates over migration and classification had their basis in Aristotelian science. On the other hand, many natural historians were beginning to study plants and animals as being a part of a larger world-wide setting. Increasing emphasis was being placed on systematic observation and study. For the most part, the writers stressed naturalism. As in the case of geology, a foundation was being formed for a new comprehensive science—biology.
FOOTNOTES


3 Ibid., p. 358.

4 Ibid., p. 359.


9 W. Jackson, letter to the editor, The Gentleman's Magazine, 40 (April, 1770), 162.

10 Anonymous comment by the "Translator of Huetiana," 40 (May, 1770), 203.

11 "Not the Editor of Huetiana," The Gentleman's Magazine, 40 (June, 1770), 263; William Derham, Physico-Theology: or,


15 Stuart, review of Histoire naturelle, p. 571; Buffon, Histoire naturelle, pp. xiv-xvi.

16 Stuart, review of Histoire naturelle, p. 573; Buffon, Histoire naturelle, pp. xvii.


Anonymous review of Miscellanies, p. 418; Barrington, Miscellanies, pp. 174-244.

22. Jeremiah 8:7, "Yea, the stork in the heaven knoweth her appointed times; and the turtle [dove] and the crane and the swallow observe the time of their coming; but my people know not the judgment of the Lord."


Ibid.

Ibid.


Ibid., p. 117. Catesby in most of his writings took every opportunity to argue his case in favor of avian migration. In his "Essay on Carolina" he provided a description of the swallow, its habits, and the fact it migrated.


Peter Collinson, "Account of the Migration of Swallows," The Gentleman's Magazine, 31 (June, 1761), 259-60; Peter Collinson, "A Letter to the Honourable J. Th. Klein, Secretary to the City of Dantzick, from Mr. Peter Collinson, F.R.S. Concerning the Migration of Swallows," Philosophical Transactions, 51 (1760), 459-64.


36 Withering quoted by an anonymous reviewer, in *The Critical Review*, 42 (September, 1776), 207, from *A Botanical Arrangement of the Vegetables Naturally Growing in Great Britain*.

37 Ibid.


39 Ibid.


43 Lucius, letter to the editor, *The Gentleman's Maga-
zine, 52 (March, 1782), 119.

44 Barrington, Miscellanies, pp. 268-70.


47 Barrington, Miscellanies, p. 270.

48 P.B.C., letter to the editor, p. 133.

49 Barrington, Miscellanies, pp. 271-72.


51 Barrington, Miscellanies, pp. 274-75.

52 P.B.C., letter to the editor, pp. 415-16.


54 Ibid.


61Hill quoted by Berkenhout, pp. 187-88, from The Vegetable System.

62Berkenhout, review of The Vegetable System, p. 189.


64Anonymous author quoted and translated by [John Berkenhout], in a review in The Monthly Review, 35 (Appendix, 1766), from Démonstrations élémentaires de botanique, a l' Ecole Vétérinaire.

65Berkenhout, review of Démonstrations, pp. 534-37.

66Hirons, review of Institutes of Botany, pp. 267-70.

67Anonymous review of Thomas Pennant, History of Quad­rupeds, in The Critical Review, 52 (December, 1781), 426;

68 Pennant quoted by an anonymous reviewer, 426, from the *History of Quadrupeds*; Pennant, *History of Quadrupeds*, pp. iii-iv.


CONCLUSION

By their patronage the reading public of the eighteenth century showed a desire for information about natural history. Editors of periodicals such as Edward Cave of the Gentleman's Magazine and Ralph Griffiths of the Monthly Review saw this desire and took advantage of it. As the interest in the subjects of natural history heightened as the century progressed, editors devoted a larger and larger percentage of the pages of their serials to this topic, so that in the course of a few decades the percentage devoted to botany, zoology, geography, and mineralogy, paleontology, geology, geography, and meteorology in the serials rose sharply.

The contributors of natural history articles were a mixed lot. They ranged from dilettanti who provided superficial comments to first-rate naturalists like Linnaeus, John Ellis, and William Hamilton. Some of the reviewers, especially William Bewley in the Monthly, gave evidence of having a good scientific background in the particular field they were analyzing. These critics often demonstrated that they
followed closely all the latest developments and discoveries in natural history. Both British and Continental writers contributed natural history to the serials, but the majority of the articles came from the pens of British and colonial naturalists. However, the pages of the periodicals also contained a generous selection of monographs from leading Continental authorities, chiefly from French and Swiss natural historians; some German, Italian, and Scandanavian naturalists, also furnished a significant number of contributions. The periodicals, therefore, presented a picture of the important developments and discoveries in natural history throughout western Europe.

In assessing the significance of natural history in Britain's eighteenth century periodicals, several different types of factors have to be considered. One, of course, is the medium itself, which grew and flourished as England's middling classes expanded and developed tastes and interests that included both reading and science. The natural history content confirms a remarkable growth of interest after 1745, and the practical and applied aspects of science that cropped up in almost any discussion, from the electrizing of plants to make them grow, to preventing earthquake damage, was testament to the nature of the readership.
The content reflected the various levels of cultivation of knowledge and learning that could be found in a culture undergoing substantial social change. Morbid interest in monsters, unabashed Biblicism, and confused thinking found a place right alongside the most advanced botanical and zoological taxonomy, vulcanology, and accurate geographical descriptions.

Yet, as the century progressed, even in this relatively popular medium changes occurred, and the writers showed fresh ways of viewing the world. First, they acknowledged that some old ideas such as the existence of stone plants, were no longer tenable. Then the writers went on to show, instead, how exciting they found recent science based on precise experimentation and systematic classification, like Linnaeus's work, or how worthwhile they found a modest contribution such as John Aikin's acute observations and description of a Norfolk beach.

The best and some of the worst of amateur investigators were found in the Philosophical Transactions as well as in the popular periodicals. Yet in both types of media the calibre of science improved dramatically. The serials and readership grew in numbers and sophistication reflecting this upsurge in quality.
The framework of natural history changed. Natural history was the study of God's world. Over the century few of the writers whose contributions were printed questioned the general approach. But by the 1770's Biblical literalism seldom appeared, and the explanations in terms of various levels of secondary causation tended to give a different aspect to the Creator's handiwork. In the periodicals such Biblical arguments as the size and capacity of Noah's ark or the possibility of a whale swallowing a man no longer received serious attention from naturalists. Men like Buffon and Giuseppe Recupero had begun to push the age of the earth beyond the 4,000 year period literally interpreted from the Bible.

The search for unity in God's world led in many directions. Naturalists conducted an extensive search for the existence of analogous creations in the three kingdoms of nature. The ancient idea of a chain of being encompassing the organic and inorganic realms gave a oneness to all natural objects. Immanence provided a unifying or motive force for all dynamic occurrences in the universe. Even the study of a small geographic area furnished an opportunity for a natural historian to emphasize the integrated character of God's creation.
How else can one measure quality? One index—involed frequently by the likes of Ellis or Bewley—was the extent of naturalism in the scientific discussions. Throughout the century the record of progress of naturalistic explanation was not steady, but a distinct shift was noticeable. The quest for naturalism was most apparent in the realm of geology. In the early years of the eighteenth century, no writer in the serials failed to include the Divine hand in cosmogony, but by 1789 George Toulmin, James Hutton, and others stressed uniformitarianism without mentioning or even implying the existence of God.

In the first third of the century, significant intellectual changes had occurred in the British Isles. The founding of the Gentleman's Magazine in 1731 supplemented other media then becoming available for the dissemination of scientific material. The growing middle class offered implicit and explicit support for science on various levels, dramatically illustrated by quantitative shifts of subject matter in the general serials. The educated public read and thus encouraged the exploration of immediate as well as ultimate cause in God's world. Men of the Enlightenment increasingly tried to gain a better understanding of the
natural world around them and sought ways to integrate the new scientific discoveries into their conceptual framework.

As the century progressed, the popular periodicals reflected certain changes in the British intellectual climate. Slowly a view of God's world, more regular and timeless, grew. This trend occurred most obviously at the expense of Biblicism and anthropomorphism.

The interests of most naturalists of the eighteenth century were reflected in the widely-circulated British serials. For the first time, discoveries, experiments, and theories were circulated for the debate and conjecture by the reading public. This emphasis on natural history was part of the more general Enlightenment culture. The periodicals showed themselves a sensitive indicator of the state and expansion of natural history in the eighteenth century.
APPENDIX
### Table 8

Total Pages and Percentages of Various Fields of Natural History in British Periodicals

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<th>Micropaleontology Pages</th>
<th>Paleontology Per cent</th>
<th>Botany Pages</th>
<th>Botany Per cent</th>
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BIBLIOGRAPHY

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