Peter McLaughlin
Max Planck Institute for the
History of Science, Berlin

Spontaneous vs Equivocal Generation in Early Modern Science

As recent scholarship has pointed out, the demise of spontaneous generation has been celebrated at least three times in the modern age: once each in the latter 17th, 18th, and 19th centuries. Each time the size of the organisms sought for has decreased—first insects, then infusoria, then bacteria.[1] Since the beginnings of modern science in the early 17th century there have been two major breeding grounds for theories about spontaneous generation: the first is the question of the generation in the *present* of small organisms especially insects and intestinal worms; the second is the question of the *historical origin* of life itself including larger animals. Both sorts of questions are related at various levels, but it has been possible for scientists to agree on the answer in one area and to disagree in the other. I am not going to give a chronicle of various theories of spontaneous generation, rather I shall use only a few examples which illustrate the conceptual problems which such theories were dealing with.

First I shall introduce a conceptual distinction between spontaneous generation and equivocal generation (*generatio aequivoca*). This distinction is, I think, essential to an understanding of 17th and 18th century theories of generation.

Second, I shall illustrate the importance of this distinction on the example of the intestinal worms of the domesticated pig as the problem was analyzed by one important biologist near the end of the 18th century.

Thirdly, I shall present and analyze the kind of explanation of the historical origin of life proposed by Buffon in the middle of the 18th century in order to point out the philosophical presuppositions of this sort of theory.

---

[1] See John Farley, *The Spontaneous Generation Controversy from Descartes to Oparin*, Baltimore: Johns Hopkins, 1977. and Everett Mendelsohn, "Philosophical Biology vs Experimental Biology: Spontaneous Generation in the Seventeenth Century," in *Topics in the Philosophy of Biology* (M. Grene and E. Mendelsohn, eds.), *Boston Studies, 27,* Dordrecht: Reidel, 1976, pp. 37-65.

Section 1

The two terms *spontaneous* generation and *equivocal* generation are often used synonymously by historians and were also often used synonomously by scientists in the 17th and 18th centuries, at least by those who *rejected* spontaneous generation. A number of those advocating spontaneous generation distinguish between the two and reject equivocal generation (e.g. Gassendi, Highmore, Needham). In fact aside from the Aristotelians and some eclectics of the mid 17th century I don't know of any serious scientists who favored equivocal generation, although many favored spontaneous generation. So what is the difference?

Spontaneous generation is relatively straightforward: when an organism arises out of organic matter (heterogenesis) or when anything organic arises out of anorganic matter (abiogenesis), we can speak of spontaneous generation. Whenever an organism arises without parents we have spontaneous generation.

Equivocal generation is somewhat more complicated. It was considered a form of accidental, non-lawlike generation. In logic an argument is equivocal if you change the meaning of a term in the course of an argument. Equivocation in *generation* is changing the species of progeny in generation; that is when parents and progeny don't belong to the same species of thing, the progeny are equivocally generated. For instance, if something organic arises from something non-norganic, it is specifically different from that from which it was generated. But also if an animal of one species gives birth to an animal of another species, we have a case of equivocal generation. Thus if an elephant were to give birth to a hippopotamus or to anything that is not an elephant, generation would be equivocal, although it is not spontaneous in any usual sense. This means that any kind of "degeneration," transformation or evolution which continues beyond the boundaries of the species would be a form of equivocal generation, generation which is not species-true. This sort of generation was universally rejected in the 18th century. The question is: can there be any spontaneous generation that is not equivocal?

Many scientists of the 18th century believed that spontaneous generation could be unequivocal. For instance, if the same solutions, the same ingedients, always give rise to the same species of infusoria, and different solutions give rise to different kinds of infusoria, what is equivocal about this sort of generation? If there is a lawlike connection between the ingredients mixed and the species of organisms produced, then one could maintain (and many did) that there is nothing accidental or equivocal about this. We have merely an instance of matter in motion following its necessary laws and of particles combining into those structures into which they can be organized. Perhaps the most prominent advocate of spontaneous generation in the 18th century, John Turberville Needham, maintained that the vegetative force which he introduced to explain generation (including spontaneous generation) was constant for each species and prevented generation from being equivocal.[2] Spontaneous generation can thus be considered to be just as lawlike and unequivocal as sexual generation.

Section 2

Let me now take an example from the first area of spontaneous generation, the generation of insects and intestinal worms to illustrate where the distinction between spontaneous and equivocal can lead us. I shall present a problem analyzed by the German physiologist and natural historian, Johann Friedrich Blumenbach, around 1790. I shall accept the facts and their interpretations as he presents them, since the purpose of the example is to illustrate how to deal *conceptually* with the problem.

Transparency

Blumenbach[3] ascertains two facts which present him with an interesting problem.

Fact 1. Domesticated pigs constitute a *race* descended from wild pigs within recent history. Although the two races have certain morphological differences, there is no question that they belong to the same species.

---

[2]John Turberville Needham, "A Summary of Some Late Observations upon the Generation, Composition, and Decomposition of Animal and Vegetable Substances..., *Philosophical Transactions of the Royal Society 45* (1748), pp. 615ff.

[3]Johann Friedrich Blumenbach, "Über Menschen-Racen und Schweine-Racen," in *Magazin fur das Neueste aus der Physik und Naturgeschichte, 6* (1789), pp. 1-13, and *Beyträge zur Naturgeschichte,* vol. 1, (2nd ed.) Göttingen, 1806.

Fact 2. Domestic pigs have intestinal worms of a *species* not found anywhere else. Wild pigs have a different species of intestinal worms. The worms of domesticated pigs cannot survive in wild pigs.

Problem Where do the worms in domestic pigs come from? How can a new *race* of pigs contain a *new species* of intestinal worms?

There seem to be two possible solutions to this problem.

First The species of intestinal worms in domesticated pigs could be descended from that of wild pigs (just like the domesticated race has branched off from the wild type). This would imply that at some point in time the species boundary was crossed in generation,that is, that equivocal generation had occurred and that an individual of one species of intestinal worms generated an individual of another species of worms. In this case generation would be equivocal but not spontaneous.

The *second* possibility is that the new species of intestinal worms in the domestic race of pigs arose spontaneously as soon as the domesticated pigs had changed enough so that their intestines presented a significantly different material environment which had not before existed. Thus a combination of matter which had not been viable earlier could now be viable under the new circumstances. In this case generation is spontaneous but not equivocal.

Blumenbach of course opted for spontaneous and against equivocal generation.

Section 3

Let me now turn to the question of the spontaneous first origins of life. Some sort of spontaneous generation of the first life forms whether in one step or in a series of stages is an almost inevitable part of any materialist system. In the mid 18th century the static deistic systems of the 17th century gave way to materialist theories of the origin of the earth which had the planets explode out of the sun and cool down, or had evenly distibuted particles gravitate into central bodies and heat up. For such theories the question of the origin of life was significantly different from the question of the first origin of matter itself: it was a physical question.

The most famous (today) of these new systems is probably Immanuel Kant's *Theory of the Heavens*. Kant's book concludes with a speculation entitled "On the inhabitants of the celestial bodies", where he maintains that it would be "absurd" to *deny* that most of the planets are inhabited at some time or other, but he says nothing at all about how he thinks they come to be inhabited. He sticks to generalities.

The trouble (for the historian) with most writers of the time is similar: They say enough, that one can infer that they *must* have believed in some form of spontaneous generation even of elephants and whales, if they were to be at all consistent, but they avoid making explicit and unequivocal statements to this effect. However, at least one major figure in the Enlightenment had no qualms about making explicit the logical consequences of materialism. Georges Louis Leclerc de Buffon published the following table in 1775 in the second supplement volume of his *Histoire naturell*:[4]

Transparency

On the left all the known planets and their moons are listed. Then four figures are given for each planet. The labels on these columns are somewhat misleading. The title of the table itself is somewhat clearer: "Beginning, end, and duration of the existence of organized nature on each planet." Column 1 gives the dates for the beginning of life on each planet, counting from the year in which the planets were formed. Column 2 gives the dates at which life ceases on each planet. Columns 3 and 4 give the durations of life. Take the second row for instance: on the Moon the first life forms arose 7,890 years after the formation of the Moon, they all died out 72,514 years after the formation of the Moon, lasting a total of 64,624 years, and there is now no more life on the Moon.

This is all well and good. But how does Buffon think he knows all this? He is not merely maintaining that there is probably life on other planets. He gives exact figures where and when; and, what you can't see from the table, he is not speaking merely of the origin of life, but of the origin of *particular species* of organisms, which he can name. (The first organisms are huge aquatic animal, i.e. sea monsters.)

[4]Buffon, *Oeuvres complètes de Buffon*, (ed. Flourens) vol. 9, Paris, ca. 1855, p. 426.

This table stands at the end of a full volume of reported experiments and calculations which are supposed to prove the conclusions drawn in the table. Buffon's empirical base for these assertions consists almost entirely of a series of experiments, in which he had metal and stone balls of various sizes and compositions heated in his iron foundry and then measured their cooling rates and extrapolated to larger spheres. From this data he concludes e.g. that in 13,574 B.C. sea monsters arose on Jupiter's third moon.

The question I want to ask is: under what assumptions, philosophical, physical, historical, etc. is it reasonable or perhaps even compelling to believe this. I shall present some assumptions necessary to make the argument plausible that can be found explicated elsewhere in various other writings of Buffon.

Transparency

Assumption 1: All planets were thrown out of the sun at the same time.

Implications

1) All planets have basically the same composition and have been cooling down for the same amount of time.

2) The surface temperature on different planets are thus a function of the sizes of the planets, with minor adjustments for differences in the distance from the Sun and from one another.

3) Inferences about the material composition of the planet Earth, its age, and the date at which its its surface temperature fell below the boiling point of water can be generalized to the other planets.

Thus, Buffon's table gives his best estimate of the dates at which the surface temperatures of the various celestial bodies dropped down to a temperature where life is possible.

Let us accept Buffon's estimates of the dates at which the physical conditions of life become available on various planets. We still need some further assumptions before we can deduce the existence of life from its mere physical possibility.

Assumption 2: Reductionism or mechanistic determinism: all bodies or systems are unequivocally determined by the properties of their parts and by the laws governing the motions and interactions of the parts.

Implications

1) The same kinds of particles will combine into and determine the same kinds of systems under the same conditions.

2) Buffon concludes: as soon as the temperature drops a certain amount below the boiling point of water organic molecules arise. Once organic molecules have arisen they begin to combine due to mechanical and chemical forces. All possible combinations are attempted; all stable and viable combinations become fixed: these are organisms. All species of organisms that are viable under these physical conditions must exist. Each of the planets has the same spectrum of animals and plants as does the Earth.

In Buffon's words: The same heat, the same matter produces everywhere the same organisms.[5]

We can check this interpretation out with a thought experiment. What would happen if some catastrophe occurred and wiped out all the inhabitants of a planet but afterwards allowed the physical conditions to return to normal. Buffon would have to assume that all the wiped out species would return very soon. And in fact he plays through this experiment and accepts exactly this conclusion, merely assuming the organisms would be somewhat smaller due to the cooling of the earth and that the larger species might not make it the second time around. This very same thought experiment was carried out by Blumenbach with the same results: the same vital force working on the same materials would produce the same spectrum of organic forms.[6]

[5]Buffon, *Oeuvres complètes,* p.
[6]Blumenbach, *Beyträge*, pp. 19-20

Buffon on the Origin and Duration of Life on the Planets and Their Moons

Time elapsed since the Formation of the Planets .... 74,832 years

BEGINNING, END & DURATION of the Existence of ORGANIZED NATURE on each Planet

			END OF LIFE	ABSOLUTE DURATION OF LIFE	DURATION OF LIFE FROM TODAY ONWARD
BEGINNING OF LIFE					
number of years after the formation of the planets			number of years after the formation of the planets	number of years after the formation of the planets	number of years after the formation of the planets
5th	satellite of Jupiter	5,169	47,550[1]	42,389 yrs.	0 yrs.
	THE MOON	7,890	72,514	64,624	0 yrs.
	MARS	13,685	70,326[2]	56,641	0 yrs.
4th	satellite of Saturn	18,399	76,525	58,126	1,693 yrs.
4th	satellite of Jupiter	23,730	98,696	74,966	23,864
	MERCURY	26,053	187,765	161,712	112,933
	THE EARTH	35,983	168,123	132,140	93,291
3rd	satellite of Saturn	37,672	156,658	118,986	81,826
2nd	satellite of Saturn	40,373	167,928	127,555[3]	93,096
1st	satellite of Saturn	42,021	174,784	132,763	99,952
	VENUS	44,067	228,540	184, 473	153,708
	Ring of Saturn	56,396	177,568	121,172	102,736
3rd	satellite of Jupiter	59,483	247,401	187,918	172,569
	SATURN	62,906	262,020	199,114	187,188
2nd	satellite of Jupiter	64,496	271,098	206,602	196,266
1st	satellite of Jupiter	74,724	311,973	237,249	237,141
	JUPITER	115,623	483,121	367,498	

(*Histoire naturelle 1778*, suppl. 2)

[1] orig. 47,558
[2] orig. 60,326
[3] orig. 127,655