Louis Pasteur (1822–1895)

Pasteur was a French chemist and microbiologist who is best known for inventing pasteurization—a process to stop the bacterial contamination of wine and milk. In terms of the matters discussed in the text, our interest here is in how he helped defeat the notion of spontaneous generation.

Spontaneous generation is a theory having to do with the emergence of living forms under conditions in which no prior life was evident. Essentially, it is the proposition that life is generated from matter that is without life. The idea had a long history. Aristotle, for instance, had offered it as an explanation (Strick, 2000). The classic example was that of maggots that arose from decaying meat but from ancient times it had been proposed that various insects, worms, eels, frogs, and mice came into existence through spontaneous generation. The ideas persisted for generations that many life forms were generated spontaneously. Earth worms were thought to be generated by the soil with the advent of heavy rains (Keeton and Gould, 1986). Van Helmont, in the 17th century, had found that if one placed a sweat-ridden shirt in a dark corner and sprinkled wheat over it one would discover mice to have emerged from it. The issue would persist into the 20th century and finally be settled by Louis Pasteur. Well before Pasteur, however, challenges began to arise with the invention of the microscope and the discovery of microorganisms.

For the mechanists microorganisms had a significant part to play in the debate against the vitalists (Asimov, 1964). Such miniscule, yet living, things, it was thought, may be a link between the animate and the inanimate. If it could be demonstrated that life formed from dead matter, the connection between life and non-life would be established and no assumptions of an infusing life-force, invigorating inert matter would be required. The vitalist held that such a process could not be possible. No matter how simple the life form may be, there would still be a gap between it and lifeless matter that could not be bridged. For both camps, during the 18th century, their favoring or opposing the proposition was complicated by their religious devotions. It seemed, from the perspective of the vitalist, that the Bible had described a process of spontaneous generation in the act of creation and, therefore, given their religious viewpoint, it seemed that the idea that life could arise from non-life was a matter that had to be entertained. The mechanists had a similar religious complication. If, as mechanistic materialism was proposing, lifeless matter spontaneously generated life under current conditions, the idea of God as the Creator would be of little further relevance (Strick,

2000). The emergence of life from the non-living in present time would in fact challenge the whole belief in the act of creation. The microscope was truly a catalyst for challenging cherished beliefs and the question of the emergence of life itself was a truly vexing problem.

Prior to the microscope, when humans had to depend on immediate, unaided eyesight, there were many living forms that were detectable—animals, insects, reptiles, etc., all of which were animate. Once the microscope was discovered, however, the distinction between the living and the inanimate was not as clear-cut as it had been (Asimov, 1964). Previously, it was readily apparent that large animals, including humans, arose from within the mother's body or from eggs, but the origins of smaller beings was not so easy to establish. With the microscope it now became clear that a plethora of tiny life forms, previously undetected, could exist in even a small drop of water. Perhaps such tiny forms of life, rather than inanimate matter, were the productive force behind the propagation of eels, frogs, insects, etc. Maggots in particular would be especially informative.

Francisco Redi (1926–1697) was the first to test spontaneous generation in an experiment performed in 1668 (Asimov, 1964). Meat was placed in flasks with half of the flasks exposed to air and the other half not. Maggots appeared on the meat that was not sealed off, to which flies had access, but not on the other. In a further test, a flask was sealed with gauze that allowed air to pass but not flies; no maggots developed. Apparently maggots were the result of flies laying miniscule eggs on the meat. This may have ended the debate were it not for the microscope. Many beings thought to have arisen spontaneously, e.g., many insects, were now found to be generated from minute larvae (Singer (1931/1950). The further discovery of microscopic protozoa (single-celled organisms) kept the issue alive. It was still possible that these diminutive entities arose from spontaneous generation. Efforts were therefore made to further screen a medium such as broth, to prevent unwanted intrusions from outside, by treating it chemically, or boiling it. It was thought that this could possibly prevent the generation of these tiny creatures or it could simply delay their appearance. No clear resolution was as yet apparent.

The debates over spontaneous generation reached a literal boiling point during the mid-18th century (Singer, 1931/1950). John Needham (1713–1781) thought that there was a potential ground for error in the work of Redi. He considered it possible that unrecognized microorganisms may have remained to produce the obtained microorganisms. In 1728, the broth from mutton was boiled, to kill off any residing organisms, and then carefully sealed in

a sterilized test tube so that none of the tiny animals that may be in the air could enter and generate offspring (Asimov, 1964). After a few days the flask was opened and was found to be verily swarming with “animalcules” (miniscule organisms). Spontaneous generation had resulted from dead material. Other animal and vegetable solutions yielded the same findings (Singer, 1931/1950).

Unconvinced by Needham’s demonstration, Lazzaro Spallanzani (1729–1799) undertook greater control in 1748 (Asimov, 1964). Having repeated Needham’s work and obtaining the same results he recognized that the organisms he was dealing with were exceptionally small, smaller than a microscope could reveal. Such organisms may well have been carried in the air and may have somehow contaminated Needham’s findings. To test for this, five flasks had broth placed in them. One was left open to the air. The other four were completely sealed and their contents were heated to boiling for a half second to two minutes. A multitude of microorganisms inhabited the open flask and ever less in the flasks subjected to longer boiling. Finally, boiling for up to 45 minutes resulted in no microorganisms. Things appeared settled. Supporters of spontaneous generation proposed that some imperceptible “vital principle” may have existed in the air that could infuse lifeless matter with life (note the hint of vitalism) and that Spallanzani’s boiling may have destroyed it. The matter would be brought to a conclusion in the early 20th century.

It was Louis Pasteur (1822–1895) who finally ended the viability of the spontaneous generation notion (Singer, 1931/1950). First, Pasteur drew air through a cotton filter. The filter was dissolved and observed under a microscope; microorganisms similar to those found in fermentation were found. The previously filtered air was again drawn through another filter and no such entities were found. It was concluded that such organisms therefore existed in the air. Opponents argued that those organic structures were not alive. A second experiment would settle the matter. Substances that could be fermented (a process thought to involve spontaneous generation) were placed in flasks that had a long, narrow, neck in the shape of a sideways-S (like the rise and fall of a sound wave) with an open end. After boiling for sterilization, the flask was placed within a chamber of undisturbed air for days up to months. There was no fermentation. Whatever atmospheric life forms were there could not pass beyond the S-shape to act upon the fermentable substance. Subsequently, the S-shape was removed so that the substance could be exposed to falling dust in the air. Within hours fermentation occurred. This resulted in the theory of *biogenesis* which holds that only life can

generate life (Keeton and Gould, 1986)**.** The position of modern biological theorists is that, given the current conditions upon the planet, life is not likely to arise spontaneously. It is allowed, however, that life could have been due to spontaneous generation under earlier conditions in the evolution of the planetary atmosphere and that from those conditions the initial evolution of life forms occurred.

References

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