

Francesco Redi's Description of the Spontaneous Generation of Gall Flies

David Bardell

From the time of Aristotle (384-322 BC) until the 17th century it was commonly believed that some kinds of organisms could arise from matter and without the need for parent organisms of kindred stock. This belief, called the doctrine of spontaneous generation, came into existence to explain the generation of organisms for which there was no discernible evidence of parents' giving rise to the organisms. There was no general agreement on the kind of matter, or its condition, necessary for organisms to arise from it. The matter could be living or nonliving, from animals or plants, and even inorganic matter such as sand and water.

Scientific questioning of the doctrine of spontaneous generation, using controlled experiments, started in the 17th century and continued thereafter for more than 200 years. The experiments of Pasteur and Tyndall in the latter half of the 19th century finally disproved the doctrine.

Of all the investigations that refuted spontaneous generation, the experiments of Francesco Redi (1626-1698) are the best known. He proved that the maggots found on the rotting flesh of dead animals were not generated by the putrefying flesh, but were the larval stages of flies and were derived from eggs deposited on the flesh by flies (Redi 1668). Accounts of these experiments are found in most biology textbooks used in high schools and colleges, and consequently Redi appears as a major contributor to the disproof of the doctrine of spontaneous generation. However, although Redi unequivocally demonstrated that putrefying flesh did not give rise to flies, he reported that gall flies were spontaneously generated by plant tissue. Redi's description of the spontaneous generation of gall flies was published in the same book as his work that is now frequently presented to show the incorrectness of the long-held belief in spontaneous generation (Redi 1668).

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An insect-induced gall is an abnormal growth of tissue on a tree or other plant caused by an insect depositing eggs in plant tissue and by the subsequent activities of hatching and development of the fly. The young feed and live inside the gall and complete their development before emerging. Different species of insects cause formation of different types of galls. Some contain only one developing insect, while others have many. Insect-induced galls vary greatly in size from slight to large growths.

In the following quotation Redi (1668) uses the word "worm" to mean the worm-like larva of a fly.

I would state my belief that fruits, vegetables, trees and leaves become wormy in two ways. One way is that worms come in from outside, and seeking food, gnaw a path to the very heart of the fruit and the wood. The other way, which I esteem worthy of credence, is to be found in the peculiar potency of that soul or principle which creates the flowers and fruits of living plants, and is the same that produces the worms of these plants. Who knows? Perhaps many of the fruits of trees are produced with a secondary, rather than a primary purpose, not as pre-eminent in themselves, but as objects of utility, destined as a matrix for the generation of these worms, which remain in them for a determined length of time, and then come forth to enjoy the sunshine.

Redi appears to have been led astray by not being able to determine how gall flies deposited eggs in an internal location in plants that have a tough exterior surface.

I confess to you frankly that before making these experiments on the generation of insects I believed, or rather suspected, that galls were originated by the fly, which, in the spring, makes a small slit in the young twigs of the oak and hides one of her eggs in the opening; the gall arising thence; and I thought that all galls, glands, excrescences, etc., were never seen except on those branches wherein the flies had deposited their eggs; the galls themselves being a dis-

ease caused in the oaks by the fly's sting, in the same manner that we see swellings arise in the bodies of animals after they have been stung by similar insects. I was also in doubt whether the galls arose first, and the flies, on coming afterwards, deposited in them some kind of seminal fluid that, pregnant with procreative power, penetrated to the most remote parts, and fertilizing them, produced the worm. But I reflected that there are many kinds of fruits and vegetables, which, though protected by their rinds or pods, still are wormy. (Redi 1668)

Redi then gives a brief description of the formation of the gall fly with materials from the gall. The materials were passed from the gall to the developing fly via a network of threadlike structures. His famous experiment refuting spontaneous generation of flies by putrefying animal flesh is described in a similar brief manner.

Hence, I have changed my opinion, and I think it probable that the generation of worms in trees does not occur fortuitously, nor does it proceed from the eggs deposited by flies, especially as every gall or growth has its own peculiar kind of worm, gnat, or fly, which never varies. It is wonderful with what consummate skill nature forms the egg and prepares a place for it; admirable is the industry and patience with which she surrounds it in a network of fibers and filaments, connecting it with the gall, like so many veins and arteries, which furnish the necessary supply for the formation of the egg and the worm, and the indispensable nourishment of both. Though there are different kinds of galls which produce not only one, but many worms, still nature knows where they are and provides accordingly, as she does in the case of prolific animals, which give birth to numerous young at the same time. It is also to be noted that the worm of the gall receives a certain vital stimulus from the oak, for if such a growth should be pulled as soon as it appears on the tree, and when the eye cannot perceive any sign of an egg, this gall will not produce a worm, nor yet a fly. If the gall is plucked at a later stage, when it is larger, and the first beginnings of the newly-formed egg can be seen, and the taste is bitter, things will go badly, and the worm will not reach maturity; but if the worm does turn out well, it is because he has enjoyed a full term of development. (Redi 1668)

Redi affirmed his belief in the generation of gall flies from living plant materials by stating:

I cannot refrain from saying that I do not consider it a great sin against philosophy to maintain that the worms of plants are created by the same natural principle that produces the fruits of the plants; and although in some schools it is held as an axiom that the lower cannot produce the higher, I think that this is absurd, for it seems to me that the fact alone of flies and gnats being bred in galls is sufficient to remove all doubt. Besides, "low" and "high" are unknown terms in nature, invented to suit the beliefs of this or that sect, according to the needs of the case. But even if it were true, as the scholastics noisily assert, that the lower cannot produce the higher, I do not, for my part, see what there is degrading or paradoxical in the assertion that plants, in addition to their vegetative existence, possess a sensitive power to which this is subordinate, and which enables them to produce animal life. (Redi 1668)

Redi's book on the generation of insects went through five editions over a 20-year period during the author's life, and he did not alter his belief in the generation of gall flies from plant tissues (Redi 1688). The fifth edition of the book is available in English translation (Bigelow 1909).

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