

DATABASE 10**DEBATING ‘THE FORCE’**

By the end of the 1600’s, Redi’s work had convinced most that no creature visible to the naked eye was capable of spontaneous generation; but, the debate still raged concerning the origin of Leeuwenhoek’s microscopic creatures. The next battle was fought by **John Needham** (1713-1781) and **Lazzaro Spallanzani** (1729-1799). In 1749, Needham published results of experiments which he claimed showed life could be generated spontaneously from non-living things. He had put meat gravy in a flask, heated it to boiling point, and sealed it with a cork. After a few days, the gravy in the flask had something growing in it. Needham concluded these growths were spontaneously generated from the sterile (boiled) meat gravy in the sealed flask. He claimed this showed life had come from non-life without any outside help.

Twenty years later Spallanzani decided to test Needham’s work. He repeated the experiment, boiled the meat gravy for 30 to 45 minutes, then sealed the flask not with a cork, but by melting the mouth of the flask closed and then re-boiling. He observed after the flasks cooled down, that it didn’t matter how long he waited, growths never developed in the flasks until after they were broken open.

Needham responded with the claim Spallanzani’s experiment had not worked because a mysterious power, which existed in the gravy and produced living things from dead gravy, was so weakened by Spallanzani’s prolonged boiling, that it was unable to generate any further life. Therefore, Needham argued Spallanzani’s work did not prove a thing. Needham called this mysterious power **vegetative force**.

THINK IT THROUGH (10)

10-1. If you were Spallanzani, what additional experiments might you have done to disprove Needham’s objection?

10-2. Despite the work of Redi and Spallanzani, at the end of the 1700s, spontaneous generation still had much support. Can you suggest reasons for this? (HINT: See Biographies)

CHALLENGE QUESTION: OPTIONAL

10-3. Needham added to the **hypothesis** of spontaneous generation by vegetative force the claim that it was necessary for fresh air to be in contact with the gravy to stimulate the **vegetative force** to produce new life forms. Needham claimed this was proved by the fact that when flasks were broken open and new air allowed into the gravy, growth was soon seen to result. Can you suggest why “air” might have caused these growths?

CHALLENGE QUESTION: OPTIONAL

10-4. Despite the controversy, some were prepared to try to turn Spallanzani’s experiments into a profit and by 1810, they had succeeded. Discover what **Appert** in France and **Durand** in England are famous for.

CHALLENGE QUESTION: OPTIONAL

10-5. Needham’s hypothesis could have been disproved by designing an experiment to show that it was dust in the air that had life on it, which grew when the dust landed on the gravy. Design an experimental apparatus in which fresh air would be continually in touch with a sterilised gravy mixture and yet no growths enter the flask because no dust could settle onto the gravy.

ADDITIONAL BIOGRAPHIES (10)

John NEEDHAM 1713-1781 was born in London, UK, but lived in Belgium most of his life. He received a religious education and was ordained a Catholic Jesuit priest in 1732. He accompanied several young English Catholic noblemen on the Grand Tour to Rome before settling in Brussels as Director of the Royal Science Academy of Belgium. He pursued his scientific interest in order to defend his religion in the face of serious atheistic criticism which abounded at the time. He was well known throughout educated Europe for defending his Catholic faith and for disputes with the French arch-enemy of Christianity, Voltaire.

His experiments with broth were conducted in collaboration with a well-known Frenchman, Count Buffon - although Needham did not agree with Buffon's evolutionary ideas. Needham did not believe God allowed chance to play a role in reproduction.

Although his experimental technique in the broth experiment was proven later to be faulty, Needham made important observations on plant pollen and squids and did much to advance laboratory techniques in biology. Needham believed the Biblical account in Genesis that God created using the earth (Genesis 1:9-12) and water (Genesis 1:19-21) therefore Needham promoted Bishop Augustine's view that the ground and the water still had residual creation properties which could continue to spontaneously create life.

Lazzaro SPALLANZANI 1729-1799 was the son of an Italian lawyer who started studying law but was persuaded by a cousin (a woman professor of physics) to pursue his interest in science. He also studied philosophy and languages and became a Catholic priest. Although his career was to be devoted to scientific research, he continued to officiate at Mass throughout his life and was known as Abbe Spallanzani.

His interests were wide ranging. He studied volcanoes, meteorology and geology, as well as varied aspects of biology, including nocturnal animals, the physiology of digestion and respiration, and carried out artificial insemination in dogs. He discovered that bats can find their way when blindfolded, but not with their ears plugged - but he refused to believe any animal could "see" with ears. He travelled extensively and collected many specimens for the museum at Paris where he was Professor of Natural History, and a champion of special creation. He believed God had created life in the beginning, but no creation property resided in matter.

DATABASE 11**POUCHET'S PROBLEM**

In the nineteenth century, **F. A. Pouchet** (1800-1872) performed experiments to try to settle the issue. He did experiments similar to Needham's and Spallanzani's and yet continued to observe growth in his gravy cultures, even after the cultures were boiled for a considerable time. His work tended to support the work of Needham (in favour of spontaneous generation) and provide disproof of Spallanzani's ideas (against spontaneous generation). Pouchet's work showed that even with prolonged boiling in a flask, sealed by melting the neck, (which should have killed all life forms known at that time), the sealed gravy culture still produced growths of living things when left alone without the seal being broken.

THINK IT THROUGH (11)

11-1. Suggest why Pouchet's experiments, despite extra precautions at sterilising them, may still have produced living growths on the gravy before the seals were broken open.

11-2. What effect might seemingly contradictory experiments and conflicting opinions amongst scientific experts have on the general public?

ADDITIONAL BIOGRAPHIES (11)

Felix-Archimede POUCHET 1800-1872 was the son of a French industrialist who qualified in medicine and later taught at the Ecole de Medecine in Rouen. He had a life-long interest in general biology and was Director of the Museum d'Histoire Naturelle at Rouen for most of his working life. Although a member of many learned societies, he desired to make science interesting to lay people and wrote much material on a wide range of topics designed to interest ordinary people in the natural sciences. He made many useful contributions to experimental techniques in microbiology and was honoured and respected for this and his writing by his contemporaries. He became Chevalier of the Legion of Honour in 1843.

DATABASE 12**THE DEMISE OF SPONTANEOUS GENERATION****1850 - 1920**

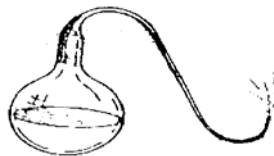
The famous French scientist **Louis Pasteur** (1822-1895) was the next to try to resolve the issue. Pasteur was working at the same time as famous German medical scientist, **Rudolf Virchow** (1821-1902) had successfully shown living cells are formed only from living cells. Pasteur provided an answer to the question - **“Can you construct an experiment so that fresh air is continually in contact with a sterilised culture yet no living thing appears?”** If no living thing grew in such an experiment, the adherents of spontaneous generation could not claim it was because of the absence of fresh air.

Examine the diagrams below to see how Pasteur conducted his experiment in 1861.

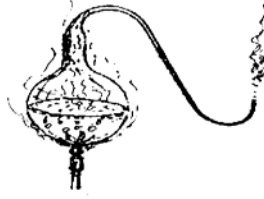
Step 1 Nutrient rich soup was placed into a flask.



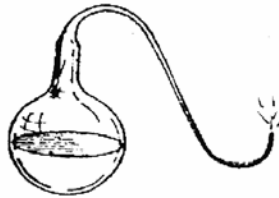
Step 2 The neck of the flask was heated and bent but not sealed.



Step 3 The soup was boiled and air was forced out.

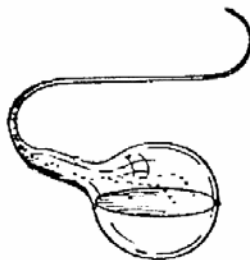


Step 4 As the liquid cooled, air (and therefore dust) were drawn in. However, the dust was trapped in the bend of the neck.

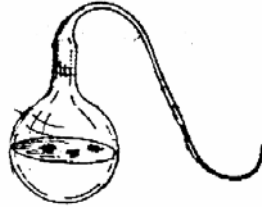


Step 5 Time was allowed to pass, yet no living growth was observed. This experiment has been repeated many times and can still be done today. The results have always been the same.

Step 6 He next tilted the flask until the liquid contacted the dust.



Step 7 Pasteur observed that wherever the liquid touched dust - new growths appeared, very quickly. Identical results are obtained when the experiment is done today.



THINK IT THROUGH (12)

12-1. What have Steps 1-5 of the above experiment demonstrated?

12-2. Does Pasteur's experiment help us understand Pouchet's results? Explain your answer.

12-3. What was Pasteur demonstrating in this part of the experiment?

12-4. Does this part of the experiment help you to explain Pouchet's results?

12-5. Did Pasteur's experiment disprove Needham's ideas? If so, explain how.

12-6. In 1858, the famous German scientist, **Rudolf Virchow**, had concluded that 'living cells are derived only from pre-existing living cells'. Virchow rejected spontaneous generation of cells from non-living matter. Pasteur's experiment, a few years after Virchow's comment, was regarded as the end of the argument. Why do you think people accepted Pasteur's experiment as proving Virchow's "**statement**" beyond doubt.

12-7. Pasteur discovered much about how to sterilise liquids such as milk. What famous process is named after him? What does this tell you about the side benefits of scientific research which, at first sight, may seem purely 'academic'?

12-8. Pasteur kept some other flasks (**controls**) which were allowed to sit for a long time without life developing in them. After this he deliberately broke off the long curved neck, and growths quickly developed on the culture. What was Pasteur showing?

12-9. What do Pasteur's **control** flask experiments demonstrate about the need to investigate every possibility when you are seeking to solve a problem?

12-10. Pasteur's experiments proved that under all known present circumstances on earth, life comes only from life. Does this conclusion support or oppose the idea that 'earth's' original living things could have come into existence from non-living things by spontaneous generation?

12-11. What does Pasteur's experiment suggest about how life first originated on earth?

12-12. In what way, if any, did Pasteur's experiments appear to reinforce the then popular belief that chemicals associated with living things (now known as **organic chemicals**) were somehow different than other chemicals i.e. they had a '**vital force**' or life difference?

CHALLENGE QUESTION: OPTIONAL

12-13. What conclusions did Pasteur reach about the source of organisms that fermented substances such as milk, wine, or sugar beet juice, and what practical benefit have his conclusions been to mankind?

ADDITIONAL BIOGRAPHIES (12)

Louis PASTEUR 1822-1895 was the son of a French tanner and during his youth was interested mainly in art and desired to be a professor of fine arts.

He became interested in chemistry after attending lectures by Dumas and Balard (well known chemists of his time). Pasteur's discovery of mirror image crystals won him a gold medal from the Royal Society. His studies of fermentation proved that the chemicals in wine (alcohol plus carbon dioxide) were produced by the action of yeast on sugar. (In his day it was believed these chemicals had generated the yeast.) He showed the yeast got into the wine from the (white bloom) on the grape skin and this gave him a method to solve the spontaneous generation debate. It also led him to his germ theory of disease which revolutionised both medicine and food processing. The process of destroying germs by heating milk (and other liquids), is named after him - Pasteurisation. As a scientist, he is probably best remembered for his experiments which refuted the theory of spontaneous generation. Due to Pasteur's success, Pouchet is largely remembered as the man Pasteur proved wrong.

Pasteur was the first continental European scientist to publicly oppose Charles Darwin's theory of evolution. A man of deep religious convictions, Pasteur's scientific research only increased his religious convictions which grew throughout his life. When asked about it he once replied: "The more I know, the more does my faith approach that of a Breton peasant. Could I know all, I would have the faith of a Breton peasant woman."

Rudolf VIRCHOW 1821-1902 qualified in medicine in 1843 at the University of Berlin and was the first to describe the disease leukaemia. He also described diseases associated with blood clotting, and became professor of Pathological Anatomy at the University of Berlin in 1856. Virchow is best remembered for his 1858 application of the cell theory to diseases and for his neat summary of that theory: "all cells arise from cells", which he stated in Latin as "**Omnis cellulae cellula**". His theory was that diseases are caused by a dis-function in the cell, so he refused to accept Pasteur's theory of germs.

He had strong convictions and a social conscience. Although not a socialist, he campaigned vigorously for improvements in public health and went into politics in order to achieve this. He strongly rejected Darwin's theory of evolution and while a member of the German Parliament voted for a law which banned the theory from being taught in schools.