DATABASE 7 # OF MICE AND MEN

1500 - 1700 AD

The observations in Database 6 were made before microscopes were invented. Many people prior to the 1600's accepted life could appear suddenly from non-living things, given the right conditions. They believed flies developed from dead meat, living things crawled out of non-living milk, and dead horse hairs turned into live worms in horse troughs. Because they believed these living things were generated as a result of forces in the dead meat or bowl of milk, this belief became known as **Spontaneous Generation. Jean-Baptiste van Helmont** (1577-1644) suggested mice are spontaneously generated from wheat. Van Helmont believed it was human sweat which provided the generating principle of life and hence his experiments needed dirty shirts as well as wheat germ and 21 days of fermentation after which the vapours from the shirt with the vapours from the seeds would generate live mice. Van Helmont was surprised to find that such mice were exact replicas of natural mice originating from mouse parents.

It is easy to laugh and say how could they have believed such a thing, but let's be scientific. How could you prove they were wrong? How would you find out what actually did or does happen?

THINK IT THROUGH 7

Discuss and answer the following, then write a summary of your discussion in the space provided below.

7-1. What experiment could you set up to disprove the idea that mice grow out of wheat?

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7-2. How difficult would it be to show that mud does not 'spontaneously' turn into living things if you do not have a microscope?

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7-3. What facts would you need to know about insect life cycles before you could prove or disprove the idea that dead meat turned into crawling maggots which became living flies?

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CHALLENGE QUESTION: OPTIONAL

7-4. Do long thin worms appear in horse troughs and if so, where do they come from?

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ADDITIONAL BIOGRAPHIES 7

Jean-Baptiste VAN HELMONT (1579-1644) was a Flemish nobleman who studied philosophy and theology at the European University of Louvain. He later qualified in medicine in order to satisfy an interest in natural science and a desire to help others. He was independently wealthy and practised medicine without charge. He invented the word **'gas'** and is noted for his many experiments involving the production of gases.

In his early adult life he travelled extensively. Catholic church authorities condemned some of his propositions as impudent arrogance associated with Lutheran and Calvinist doctrine. Thereafter, Van Helmont led a somewhat secluded life mostly on his own estate. He believed that all knowledge was the gift of God and his major work *"Ortus Medicinae"*, which was published (by his son) following his death, was dedicated to Jehovah. He also made important contributions to the study of disease processes such as fever, tuberculosis, and asthma and rejected the ancient view of disease as an imbalance of humours and temperament.

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DATABASE 8 THE COMING OF EMPIRICAL SCIENCE

Francis BACON (1561-1626) is credited with being the philosopher who best put into words the experimental techniques which have become known as the **SCIENTIFIC METHOD.** He built on thw work of Roger Bacon (c1220-1292) who had introduced the study of the science into university courses.

In 1605 he published "Advancement of Learning" which was the start of his project for re-organising the study of natural science. Bacon stated "*There are two books laid before us to study to prevent our falling into error: first the volume of the Scriptures, which reveals the will of God; then the volume of the creatures which expresses His power*". Bacon also stated "*To conclude therefore, let no man... think or maintain that a man can search too far or be too well studied in the book of God's word, or in the book of God's works; divinity or philosophy; but rather let men endeavour an endless progress or proficiency in both"*. In 1623 he published 'De Augmentis Scientiarum' and in 1624 his translation of Hebrew Psalms from the Bible.

Bacon's aim for the scientific method was to restore man's God given control over nature, which he believed had been largely lost. Bacon's opposition came from those who accepted the authority of ancient Greeks such as Aristotle, and maintained there was nothing new to learn.

Bacon combined Aristotle's principles of induction, with his own beliefs in Divinely created law and order, cause and result, to devise what has become known as the scientific method of inductive reasoning. Bacon's "Art" (as he called it) of scientific reasoning meant that a first observation provoked a speculative idea or working hypothesis, which an experiment was then designed to test. The results of this may provoke further experiments, which might result in disproof or confirmation of the idea to the level of theory. This should produce further experiments until when no exceptions are discovered to the idea, it is pronounced a law.

After his forced retirement Bacon wrote 'New Atlantis' which describes a Utopian society where scientists pooled their work and ideas. This work gave birth to the still existing science establishments based on "The Royal Society of London". 'New Atlantis' appeared in 1627 after his death.

William HARVEY (1578-1657) was a medical contemporary of Bacon who discovered how the human blood system worked. He was an independent first class exponent of experimental method. Bacon knew nothing of Harvey's experimental work on the human blood system, and Harvey had no appreciation of the long term importance of Bacon's work, stating "he writes philosophy (i.e. science) like a Lord Chancellor".

THINK IT THROUGH (8)

8-1 To the best of our knowledge Bacon never performed a scientific experiment in his life, so why would he have believed it should work?

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8-2 It is commonly believed today that Philosophy, Science and Religion are 3 separate and mutually exclusive disciplines. Is this a valid approach to knowledge?

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8-3 Do many theories make it to the point of being regarded as a law? How should this affect your commitment to any scientific theory?

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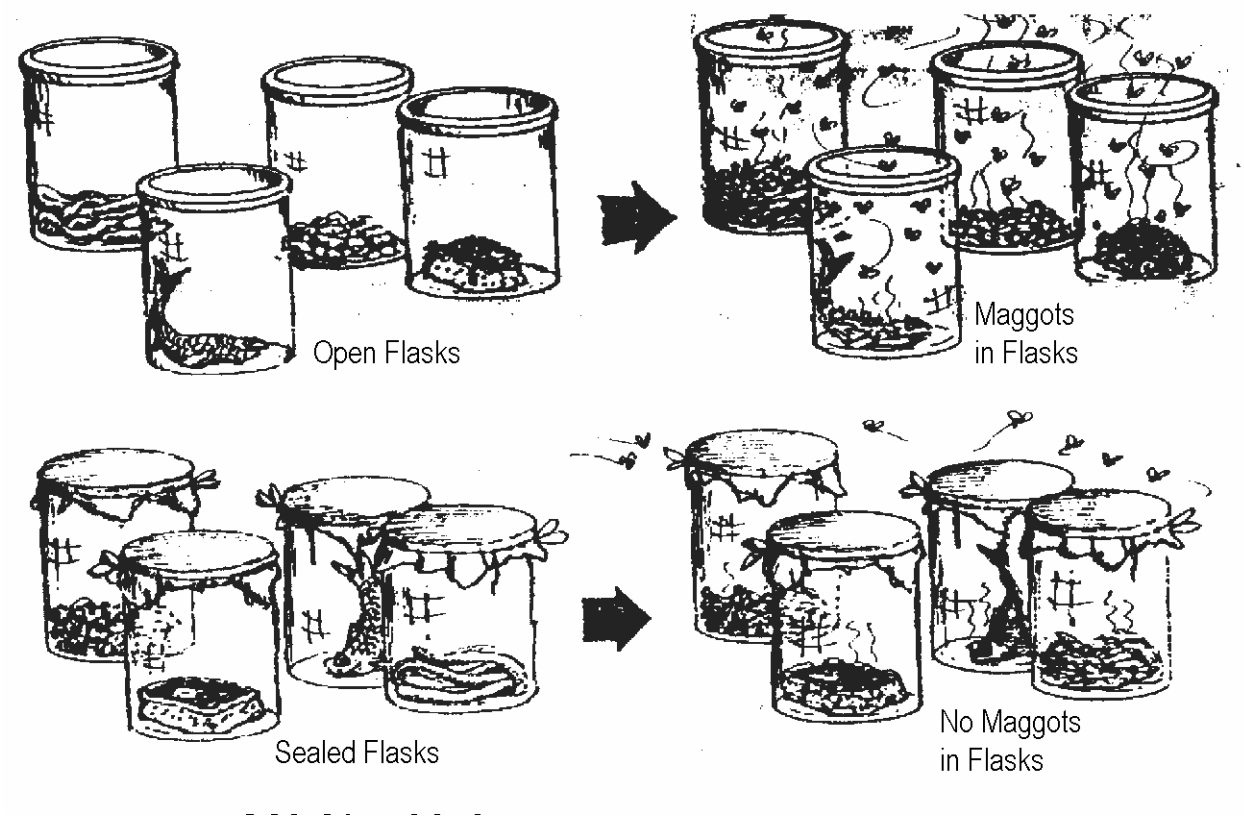
ADDITIONAL BIOGRAPHIES (8)

Francis BACON (1561-1626) was a philosopher, Essayist and Lord Chancellor of England. He entered Trinity College Cambridge in 1573 and was admitted to Barrister 1582. In 1584 he became a member of parliament. He became Lord Keeper in 1617, and Lord Chancellor 1618, (as well as being made a Baron). He became famous for his publication 'Novum Organum' in 1620, and was created Viscount of St Albans (1621). Shortly after this Bacon was accused of taking bribes, fined £40,000, and imprisoned in the Tower of London at the King's pleasure. His imprisonment lasted 4 days, and he received a general pardon in October 1621. Bacon was a member of the Church of England, educated in philosophy and law, and studied Aristotle in the original Greek. He was unimpressed with Greek science, but impressed with Aristotle's method of inductive logic.

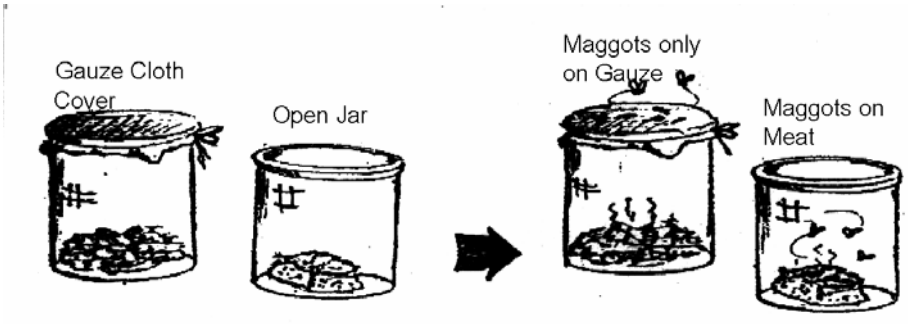
William HARVEY (1578-1657) was an English Physician, educated in Canterbury and Cambridge, who discovered (1616) the circulation system of human blood (published 1626). He also published a famous work on embryology (1651) and coined his enduring phrase "omni vivum ex ovo" (all living from the egg). He was physician to James 1 and Charles 1. He believed that spontaneous generation of worms and insects could occur through the action of special forces liberated in decay processes.

DATABASE 9 REDI'S INSECT EXPERIMENTS

Around the time **Francesco Redi** was born (1616), a book by English medical researcher William Harvey had suggested that creatures , such as flies, may have hatched from seeds too small to be seen. After reading this book, Redi published (1668) a study called 'Observations on the Generation of Insects' based on the results of his research on meat, maggots, and flies. The two key experiments he performed to test Harvey's ideas were rather simple ones. In Redi's first experiment, he prepared eight jars with fresh meat, shown in the diagrams below. Four were sealed and four left open to the air. The meat in all eight went putrid but only the open flasks 'developed' maggots which turned into flies.



In Redi's second experiment, (below) he placed freshly killed meat in two separate jars. One was covered with gauze cloth and the other was left open to the air. He observed that maggots developed only in the jar where the meat was uncovered. No maggots developed on the meat in the covered jar. However, he did find tiny eggs on the cloth covering the meat and observed that the eggs on the cloth hatched into maggots without touching the meat.



THINK IT THROUGH (9)

9-1. What had Redi proved?

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9-2. Explain why his experiments had proved this.

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9-3. Some people quickly accepted that Redi had disproved spontaneous generation. They agreed he had shown non-living things cannot give rise to living things. What part of his experiment is convincing?

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9-4. How did Redi deal with the objection that sealed jars could not develop flies because the meat used up the air before flies had time to spontaneously develop?

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9-5. Some proponents of spontaneous generation claimed support from new observations made by **Anton van Leeuwenhoek** who had focused the newly discovered microscope on a drop of pond water and discovered a new world of previously invisible organisms. Proponents of spontaneous generation quickly concluded microscopic animals developed from water only. What does this suggest about people's ability to 'let facts speak for themselves'?

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9-6. Do you think the problem in the previous question might ever apply to you?

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CHALLENGE QUESTION: OPTIONAL

9-7. Without a microscope, how would you have disproved the claim of the defenders of spontaneous generation that microscopic pond organisms spontaneously develop from water only?

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ADDITIONAL BIOGRAPHIES (9)

Francesco REDI 1616-1697 was personal physician to two Grand Dukes of Italy, and a court physician to the Medicis. He was also a great literary scholar, poet, and linguist, and was one of the first to make a study of dialects. He pioneered the study of worms, snake venom, and various insects. His observations of the egg producing apparatus of various insects led to his experiments on spontaneous generation which were performed in 1668.

Anton van LEEUWENHOEK 1632-1723 was the son of a Dutch basketmaker who never attended university or studied the classics. After serving an apprenticeship to a cloth merchant in Amsterdam, he returned to his birthplace of Delft and kept a drapery shop. He became janitor for Delft city hall and held this job all his life. During his career, Leeuwenhoek built many single lens microscopes ground with incredible precision, which could magnify up to 200 times, some of which he sent to the Royal Society in London. His observations of the life histories of insects and his studies of spermatazoa of many diverse species led him to **reject the idea of spontaneous generation**.

Leeuwenhoek found that single lenses of very short focus were preferable to the compound microscopes then in use. His careful powers of observation enabled him to give the first accurate description of red blood corpuscles in 1674. In 1680 he described the cells in yeast and was made a Fellow of the Royal Society. In 1683 Leeuwenhoek was the **first** man to see bacteria. He published the **first** diagram of bacteria in 1683. He argued that sea shells were not generated from sand at the seashore but from spawn in the regular course of generation. He maintained the same for fresh water mussels whose ova (eggs) he examined carefully and claimed *"we can now easily conceive, that in all rainwater which is collected from gutters and cisterns, and in all waters exposed to the air, animalcules* (microscopic animals) *may be found; for they may be carried thither by the particules of dust blown about by the winds"*.

His work became well known in Holland, England and France. He was elected to membership of the Royal Society and to the French Academy of Science in 1680. He was also visited by Royalty and the Dutch East India Company sent him insects for study.