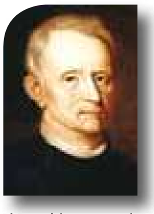
The history of modern microbiology

The existence of microorganisms was hypothesized for many centuries and well before their actual discovery in the 17th century. Scholars from many ancient civilisations believed that diseases could be spread by unseen entities. Quarantining and shunning of diseased individuals and burning of infected bodies that had died from disease were practiced by ancient peoples.



However the real science of microbiology began in tandem with the development of the microscope. The first person to report seeing microbes was an Englishman **Robert Hooke.** This was in the early 1660's and in 1665 he published "Micrographia", which described the microscopic world for the first time. However he was unable to "see" bacteria with his crude microscope.

Meanwhile in the Netherlands **Anton van Leeuwenhoek** was the first to see and describe bacteria, which he called "animalcules", or little eels. Up until his death in 1723 he worked tirelessly revealing the microscopic world to scientists of the day and is regarded as one of the first to provide accurate descriptions of protozoa, fungi and bacteria using a single lens of 300-500 fold magnification making these descriptions even more remarkable. Microscopes, however were rare and advancements in microbiology slow.


The theory of the day that held sway and was debated vigorously was that of "spontaneous generation" i. e. that life could spontaneously occur. It was refuted by **Francesco Redi,** who showed that fly maggots do not arise spontaneously from decaying meat, if the meat is covered. **Lazzaro Spallanzani** also disputed the theory by showing that boiled broth could not give rise to microscopic forms of life.

It was not until the latter half of the 19th century, when high-magnification microscopes of good optical quality became more widely available that the science of microbiology began in earnest. One of the most notable scientists to emerge was **Ferdinand J. Cohn** who in 1875 effectively founded the science of bacteriology (a branch of microbiology that studies bacteria). His main contribution was the classification system for bacteria and he coined the name "Bacillus".

Louis Pasteur would probably be considered today as the greatest biologist of the nineteenth century. It was he who finally ended the debate regarding "spontaneous generation". A genius at devising definitive experiments, he used swan necked sterile flasks, filled with broth and successfully showed that life could only be generated from existing life. Pasteur also showed that fermentation, a process used in baking and brewing, was caused by microorganisms. He performed numerous experiments to discover why wine and dairy products became sour, and proved that bacteria were to blame. As a result he went on to develop the process for sterilizing milk and this was named after him "pasteurization". He is also credited with the development of vaccines for (rabies and anthrax).

Pasteur called attention to the importance of bacteria in everyday life and if they could turn wine and milk bad, maybe they could cause human illnesses the "Germ theory" of disease. Pasteur's attempts to prove this theory were unsuccessful and it was left to **Robert Koch,** a German scientist, to provide this proof.

Koch did this by successfully isolating and cultivating anthrax bacteria from a diseased animal. He then injected this pure culture into mice, reproducing the disease and finally, the re-isolated the bacteria from the infected animal. These four steps became known as Koch's Postulate and we still in general follow these dictates today. Because anthrax was such a commercially important disease and his techniques were easily verifiable, he became famous. Like Pasteur he had his own institute and together they developed the basic techniques used in microbiology today.
These include sterile culture techniques, pure culture techniques, the use of Petri dishes, inoculation needles and solid medium, where agar and gelatine were used to produce a solid surface, (the use of Agar-agar as a means to solidify media is attributed to **Dr. Hesse** and his wife Angelina, who joined Koch's lab in1881).
Koch also discovered the etiological agents of cholera and tuberculosis.

Gram stains and other staining procedures were developed in Koch's lab and it was here, while studying differential staining, that **Paul Ehrlich** came up with the idea of a "magic bullet". He reasoned that if different chemical dyes could bind to different components of different eukaryotic cells and differentiate bacteria, perhaps there existed chemicals that could selectively kill certain pathogens without harming the host cells i. e. a targeted drug or "magic bullet". He embarked on a search to find the cure a "magic bullet" for Syphilis and after testing hundreds of chemicals finally found one he named Salvarsan. This discovery laid the ground for antibiotics and other chemotherapeutic agents.

Despite the advances in microbiology during this golden age, it was rarely possible to administer life saving therapy to an infected patient. Eventually in 1928 **Alexander Fleming** accidentally discovered the antibiotic substance penicillin produced by the fungus Penicillin notatum. When it was finally recognised for what it was, the most efficacious life-saving drug in the world, it spawned the development of a

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huge pharmaceutical industry, (post World War II) producing large volumes of synthetic penicillins that would reduce the incidence of many diseases and infections that had been the scourge of mankind. These included pneumonia, tuberculosis, meningitis, syphilis, gangrene and many others.

Because Koch and Pasteur mainly focused on microorganisms having direct medical relevance, their work did not reflect the true diversity of the microbial world. It was only by the late 19th century and the work of **Martinus Beijerinck** and **Sergei Winogradsky,** the founders of general microbiology (an older term encompassing microbial physiology, diversity and ecology) that the true breadth of microbiology was revealed. Beijerinck made two major contributions to microbiology, the discovery of viruses and the development of enrichment culture techniques **(Dmitri Ivanovski** discovered viruses in 1892 but failed to report his findings)**.** While his work on the Tobacco Mosaic Virus established the basic principles of virology, it was his development of enrichment culture methods that had the most immediate impact on microbiology allowing cultivation of a wide variety of different microbes with very different physiologies.

Meanwhile it was Winogradsky who was the first to develop the concept of chemolithotrophy and to thereby reveal the essential role played by microorganisms in geochemical processes He was also responsible for the isolation and description of nitrifying and nitrogen-fixing bacteria**.**

Work with viruses however was limited by the magnification of available microscopes. In the 1930's two German scientists **Max Knoll and Ernst Ruska** invented the Electron Microscope. This microscope used electrons, not light, to see the object being studied.
During the1940's the electron microscope was further developed and could magnify objects by a million fold. In that decade cultivation methods for viruses were also introduced. The knowledge of viruses grew rapidly and by the 1950's and 60's many viral diseases such as polio, measles, mumps and rubella were under control due to the introduction of vaccines.

Whilst in the past the study of microbiology has in the main focused on diseases and their cure leading to huge progress in the eradication of these, many microbes are responsible for beneficial processes**.** These include such processes as industrial fermentation e. g. (the production of alcohol, vinegar and dairy products). This type of production has long been practised albeit not on an industrial scale however our advancement in knowledge of microbes particularly with regard to molecular microbiology and genetic engineering has allowed us to harness microbial production on a scale and for a variety of substances like never before.

One of the main areas of applied microbiology is biotechnology. This generally implies "engineered" production of a substance that has involved some sort of genetic engineering (movement of a gene sequence to a microbe). The microorganisms are then used as living factories to produce pharmaceuticals and other substances that could not otherwise be manufactured. These substances include the human hormone insulin, the antiviral substance interferon, numerous blood clotting factors, clot dissolving enzymes and a number of vaccines.

Ironically, microbes are used to produce biotechnological important enzymes such as Taq polymerase, reporter genes for use in other genetic systems and novel molecular biology techniques such as the yeast two-hybrid system.

Microbes are used for the industrial production of amino acids, biopolymers, etc. and as vectors for cloning in higher organisms such as plants.

Microorganisms are also used in the microbial biodegradation or bioremediation of domestic, agricultural and industrial wastes and subsurface pollution in soils, sediments and marine environments. The ability of each microorganism to degrade toxic waste depends on the nature of each contaminant. Therefore, in general, a mixture of bacterial species and strains are used.

Recent research has suggested that microorganisms could be useful in the treatment of cancer. Various strains of non-pathogenic clostridia can infiltrate and replicate within tumours. Clostridial vectors can be safely administered and their potential to deliver therapeutic proteins has been demonstrated in a variety of preclinical models.
The field of microbiology can be said to be still in it's infancy relative to older biological disciplines such as zoology and botany and offers great potential to solve key problems and answer fundamental scientific questions for mankind today.