MAN AND MICROBES

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[*Ed. Note: The London-born author is a former military medic who is retired from a career in the emergency medical and first aid field. He is a long-time philatelic exhibitor who has received national level Gold awards for his exhibits in varius classes. He has owned microscopes from 1940 to present.*]

This article is based on a "Display" type exhibit shown at several stamp shows, both at local and national level, and will examine the role of microbes, both useful and harmful. It will explain the beliefs, from earliest times to the present, relating to the causes of diseases, together with descriptions of specific infections.

Very few stamps actually show microbes, but much collateral material is available, such as famous scientists, scientific equipment, the World Health Organization (WHO), humanitarians, animals, insects, plants, etc. The scientific information included has been greatly simplified, to both inform and entertain the average reader.

In the term "Microbes" I include, bacteria, fungi, protozoa, viruses, and prions. Normally, microbes are defined as being too small to be seen with the naked eye, but one is known to grow to 0.5 mm in length.

Fig. 1. Hippocrates
Transkei, 1982, Sc#97

For centuries, diseases were considered to be a punishment from the gods, for mankind's transgressions. Even today, some think that human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) are a punishment from God for immoral behavior.

Others thought that diseases were curses placed on individuals by witches, demons, sorcerers, etc.

Another very popular idea included the "Balance of Humors" within the body: Blood, Black Bile, Yellow Bile and Phlegm. Galen supported this view, and it was not demolished until Virchow's work. (see later).

However, centuries ago, the idea of microscopic agents as the cause of diseases, especially the infectious types, was postulated. Texts in Sanskrit from ancient India suggested that invisible agents, possibly chemical, might cause disease: Hippocrates (460–377 BC) (Fig. 1) in ancient Greece stated, "Diseases are predictable, and are not caused by the supernatural." He supported the "Humoral" theory.

Fig. 2. Avicenna
Egypt, 1968, Sc#741

The Arabian physician Avicenna (980–1037) (Fig. 2) wrote *The Canon of Medicine* and also suggested that minute creatures were responsible.

Fig. 3. Johannes Wier
Netherlands, 1960, Sc#384

In the first century BC, a Roman, Marcus Terrentius Varro, stated, *"If there are marshy places, little animals multiply which the eye cannot discern, but which enter the body through the mouth and nose and cause grave diseases."*

Johannes Wier (1515–1588) (Fig. 3), a Dutch physician wrote *On Demonic Bewitchment, Conjuration, Exorcising, and Poisoning* in 1563, arguing against superstition.

Other writers concerned with anatomy and physiology also helped by providing detailed studies of the human body. Andreas Vesalius (1514–1564)(Fig. 4), a Belgian anatomist, provided detailed drawings (*De Humani Corporis Fabrica*) of every part of the body, while William Harvey (1578–1657) (Fig. 5), an English

Fig. 4. Andreas Vesalius
Belgium, 1964, Sc#606

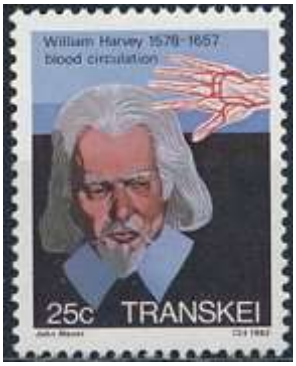

Fig. 5. William Harvey
Transkei, 1982, Sc#99

physician, proved the circulation of the blood. These researches enabled others to identify specific diseases with certain organs, and to show how blood could carry microbes throughout the body.

Fig. 6. Leeuwenhoek
Netherlands, 1937, Sc#B97

Air and water had long been associated with the spread of disease, but an Italian, Girolamo Fracastoro (ca. 1476–1553) also suggested that inanimate objects (fomites), *"…such as clothes, linen, etc., which although not themselves corrupt, can nevertheless foster the essential seeds of the contagion and can thus cause infection."*

However, all the clever theories regarding microbes could not be proven until the culprits could be seen and studied in detail. A magnifying glass (simple microscope) was considered insufficient for the job until special types were constructed by the Dutch cloth merchant Anton van Leeuwenhoek (1632–1723) (Fig. 6). These instruments consisted of a globular lens, about 4 mm diameter, sandwiched between two silver plates, and had a magnification of about ×50–300 diameters. With these, and extremely good eyesight, he was able to observe living cells, which he named "little animalcules."

Fig. 8. Agostino Bassi
Italy, 1953, Sc#640

Robert Hooke (1653–1703) (Fig. 7), an English physicist, used a primitive compound microscope, and published in 1667, *Micrographia*, in which he described microscopic details of plants, insects, etc. He also introduced the term "Cell" to biology as the small parts reminded him of monk's rooms.

Fig. 7. Fly (from *Micrographia*)
G.B., 1989, Sc#1286

Agostino Bassi (1773–1856) (Fig 8), an Italian researcher studying Muscardine (Silkworm Disease) in 1835, noticed a white material on a dead silkworm, and found by microscopical examination that it was *"organic, living, and vegetable. It is a parasitic fungi."* He stated, *"Perhaps some of my readers will respond with a smile to my doctrine of living contagions."* In 1844, he published *Sui Contagi in Generale* and stated that *"Smallpox, spotted fever, bubonic plague, and syphilis are caused by living parasites, animal or vegetable."*

Rudolph Virchow (1821-1902) (Fig. 9), a German pathologist, served on a commission to look into a typhus epidemic in Silesia in 1848, and criticized the government for allowing people to live in such squalid conditions, which he stated had spread the disease so rapidly. He de-bunked the "Humoral" theory of disease; and published his famous work, *Cellularpathologie*, in 1858.

Fig. 9. Rudolph Virchow
Hungary, 1989, Sc#3216

Fig. 10. Early Microscopes (1740 & 1845)
DDR, 1980, Sc#2124 & 2126

Early compound microscopes suffered severe problems due to both spherical and chromatic aberrations, which led to empty magnification and difficulty in focusing. Generally, early micro-scopes were used for entertainment, but many amateur microscopists improved both the optics and the mechanical parts (Fig. 10).

The introduction of achromatic lenses and the Abbe sub-stage condenser, radically changed the usefulness of microscopes, and turned them into true scientific instruments. Microscopes manufactured in the mid to late 19th century are still in use and capable of being used for serious study. (Fig. 11).

Fig. 11. Zeiss Microscope (1873)
DDR, 1980, Sc#2127

Microscopes (Figs. 12, & 13) have a limit of useful magnification of about ×2,000 due to the wavelength of light rays, and are generally not of sufficient power to show viruses. Therefore, electron microscopes have to be used. Lenses are replaced by magnets to bend rays of electrons instead of light rays.

Fig. 12. Light Rays Passing through Microscope Germany, 1968, Sc#980

Fig. 13. Modern Microscope South Africa, 1981, Sc#2127

Fig. 14. Electron Microscope (1938) Canada, 1988, Sc#1208

One of the first successful electron microscopes (Fig. 14) was built by E. F. Burton and his students at the University of Toronto, Canada, in 1938. Enhanced images created by a modern electron microscope can magnify an object ×2,000,000.

The basic types of organisms that cause disease are viruses, bacteria, fungi, and protozoa (Fig. 15).

Fig. 15. Protozoa, Fungi, Bacteria Pitcairn Islands, 1968, Sc#95

Viruses (from the Latin for poison or venom) are normally a single strand of nucleic acid (RNA or DNA) within a protein coat (capsid) with projections to assist in attachment to living cells. Viruses are not true living organisms. They can exist outside the host, but can only replicate inside a living cell, using the cell's own resources. When the replication has filled the cell, the cell ruptures, sending more viruses to infect other cells. Viruses may occur in many forms, including spheres, rods, or icosahedrons (twenty faces).

Bacteria are primitive living cells with a loose clump of DNA (nucleoid) in the cytoplasm, with outer coats for shape, protection, and exchange of water, gasses, etc. They may be shaped as spheres (cocci), rods (bacilli), commas (*Vibrio*), or corkscrews (spirochaetes). They may be found singly and in clumps or chains. Some may have flagella or cilia for movement, while others can produce spores for survival: Reproduction is by division.

Fungi. Although most fungi are quite large (e.g., mushrooms), other types may be very small (e.g., yeasts and molds).

Protozoa are true living cells with a nucleus and other organelles in the cytoplasm, and with an outer coat. They may resemble an amoeba or a flatworm.

Prions. These will be mentioned later in connection with "Mad cow disease."

The sizes of microbes, compared with a human red blood cell, are shown in Fig. 16.

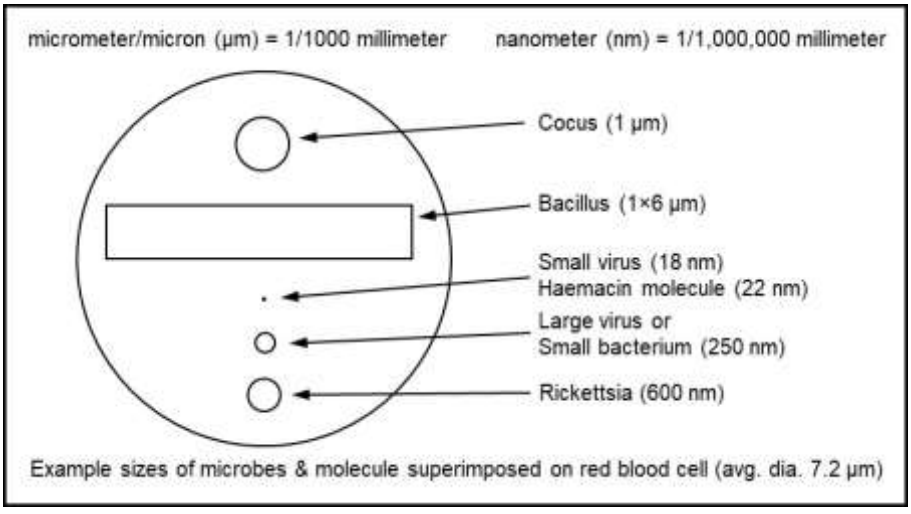

Fig. 16. Relative Size of Microbes

Microbes are colorless and generally have to be stained or coated in order to examine them. This will be explained later when discussing laboratory equipment and techniques.

Before we examine specific diseases and agents, we should realize that harmful types are an extremely small proportion of all microbes. Without microbes to break down dead plants and animals, plus other microscopic forms that produce oxygen, extract nitrogen from air and convert it into nitrates, and many other useful functions, all life

on earth would perish. Fifty percent of the world's population relies on rice for food. In paddy fields, the bacterium *Anabaena azolae* produces huge amounts of nitrates, without which the output of rice would be drastically reduced, causing famine (Figs. 17, 18, 19).

Fig. 17. Rice Paddy
Thailand, 1999, Sc#1852

Fig. 18. Wine & Cheese
Canada, 2006, Sc#2168 & 2178

Fig. 19. Yoghurt (*Lactobacillus bulgaricus*)
Bulgaria, 2005, Sc#4362

Fig. 20. Pasteur and his work
Monaco, 1972, Sc#854

Fig. 21. Rabies Injection
France, 1995, Sc#1979

It was while studying some of these useful microbes, that Louis Pasteur (1822–1895) (Fig. 20), a French industrial chemist, who may be said to be the founder of modern experimental medical science, made several major discoveries. He was working on the problem of why some batches of wine became vinegar. This led to a study of fermentation and putrefaction and he concluded that contamination was the problem.

He tested his theory by adding meat broth to long necked glass flasks. He then bent the long necks into a double curve, and heated the broth to drive out all the air. He left the flasks for several weeks, with no signs of putrefaction. But when he broke off the long necks, the broth became contaminated and soon teemed with micro-organisms.

He used heat to kill off harmful bacteria in milk and wine (Pasteurization). This process is still in operation and is used for many other foodstuffs.

When an outbreak of Chicken Cholera occurred, he isolated the causative organism (*Pasturella aviseptica*) and then used a weakened form of the bacteria to produce a vaccine to inoculate the chickens. He also produced a vaccine to prevent Anthrax, a disease primarily of cattle and sheep, but which can also affect humans.

Probably his most notable work was in producing a treatment for Rabies, a deadly viral disease. It was not possible to see the virus at that time, but inclusion bodies caused by the virus could be demonstrated in stained slices of brain tissue. A boy named Joseph Meister had been bitten by a rabid dog and was taken to Pasteur who, on 16 July 1885, commenced a course of injections, saving the boy's life (Fig. 21).

Pasteur had no medical qualifications, and if he attempted the same today, likely would be charged with reckless endangerment, child abuse, practicing medicine without a licence, and many other crimes.

Fig. 22. Robert Koch with microscope & enlarged TB bacilli
Germany, 2005, Sc#2361

Fig. 23. Robert Koch with lab equipment & TB bacilli stained red
China PR, 1982, Sc#1775

Fig. 24. Robert Koch with lungs & bacteria
Afars-Issas, 1973-75, Sc#C87

Robert Koch (1843–1910) (Figs. 22, 23, 24), a German doctor, is justifiably called the "Father of Bacteriology." He discovered the bacteria that cause Tuberculosis (*Mycobacterium tuberculosis*), Anthrax (*Bacillus anthracis*), and Cholera (*Vibrio cholerae*). He developed several vaccines, and a test for TB. He also produced a solid culture medium using agar (from seaweed) with various nutrients, and special culture containers (Petri dishes).

He placed bacteriology on a firm scientific foundation by his four postulates, which were:

1. *A micro-organism is proved to be the cause of a disease when the organism can be isolated in every case of the disease.*
2. *It can be cultivated in a pure culture.*
3. *Inoculation from such a culture must reproduce the disease in susceptible animals.*
4. *It must be re-obtained from such animals and again grown in pure culture.*

He was awarded the Nobel Prize for Medicine in 1905, as well as the Order Pour le Mérite (Civil).

Fig. 25. Sir Alexander Fleming with Clostridia microbes
Mauritius, 1978, Sc#465

Fig. 26. Petri dish with bacteria colonies & mold
Mauritius, 1978, Sc#466

Fig. 27. *Penicillium notatum*
Mauritius, 1978, Sc#467

Many people had sought cures or treatments for diseases with varying success. Paul Ehrlich (1854–1915) sought a "magic bullet" to cure all diseases. Sir Alexander Fleming (1881–1955), a Scottish bacteri-ologist, who had served in the Royal Army Medical Corps during WW1, had witnessed the large number of deaths caused by certain organisms even in small wounds.

Two of these microbes belong to the same group, the Clostridia (Fig. 25). These are anaerobic, Gram-positive, spore forming bacilli. *Clostridium perfringens* (formerly *C. welchii*) causes gas gangrene, while *C. tetani* is responsible for tetanus.

In 1928, he noticed a bacterial culture in a Petri dish had been contaminated with a mold (Fig. 26). This was not unusual, but he also noted that no bacterial colonies grew close to the mold (*Penicillium notatum*) (Fig. 27). However, he did not have the resources to produce a suitable form for treating patients.

Howard W. Florey (1898–1968) and Ernst B. Chain (1906–1979) produced the active chemical "penicillin," which was generally harmless to people, but deadly to many bacteria, especially the Gram-positive types.

Fleming, Florey, and Chain were jointly awarded the Nobel Prize in 1945. This discovery led to many other fungi being tested, resulting in Aureomicin, Terramicin, and other antibiotics. Unfortunately, due to overuse on trivial complaints, many bacteria have now built up resistance against several antibiotics.

As mentioned earlier, bacteria, protozoa, and minute fungi are colorless, and generally require staining with special chemicals in order to be examined through the microscope. Some stains are extracted from plants or insects, while others come from aniline dies.

Most stained films are of dead organisms. However, some modern chemicals (supra-vital stains) will color living organisms. The basic method used to differentiate between two major groups of bacteria is the "Gram" stain. A dried bacterial smear on a slide is stained with crystal violet, rinsed, and then treated with an iodine solution. The smear is then decolorized with an acetone or ether mixture. The smear is air dried and counterstained with safranin, and rinsed with water.

Fig. 28. Field's stain with malarial protozoa
Malaysia, 1976, Sc#139

Gram-positive bacteria are stained blue, while Gram-negative are stained red. The cause of the difference lies in the outer coats of the organisms.

Some other bacteria, such as the tubercle bacillus, have more complex coats and require a special stain, carbol fuchsin, which has to be added to the film, heated to boiling temperature, then cooled and decolorized with a concentrated mixture of alcohol and hydrochloric acid, then counterstained with methyl blue. The bacteria are red and other cells are blue.

Blood and protozoa are generally stained by a mixture of methyl blue and eosin, such as Field's stain (Fig. 28). I believe this is the only microscopy stain shown in detail on a stamp.

Some specific diseases that are illustrated on stamps are described below.

Fig. 29. Anopheles mosquito
Angola, 1962, Sc#439

Fig. 31. Malarial protozoa in red blood cells
Cuba, 1962, Sc#757

Fig. 32. Anopheles mosquito in feeding position
Yugoslavia, 1962, Sc#649

Fig. 30. Battista Grassi
Italy, 1955, Sc#701

Malaria. The name is derived from *mala aria* (bad air) as the disease often occurred near smelly swamps or marshes. It now is known that the cause is a protozoan (*Plasmodium*) that is transmitted by the dappled wing Anopheles mosquito (Fig. 29). The organism goes through several stages, a sexual cycle in the mosquitoes gut, and asexual cycle in man and other animals. This was shown by Battista Grassi (1854–1925), an Italian scientist (Fig. 30) who also proved that only the female Anopheles mosquito could pass on the infection. The mosquito sucks blood from an infected person, and after some time injects another person with new cells mixed with haemolytic saliva (Figs. 31 & 32).

Sleeping Sickness. A protozoan (*Trypanasoma gambiense*) infection spread by the biting Tsetse Fly (*Glossina papalis*) (Fig. 33). It occurs in tropical and sub-tropical Africa.

Fig. 33. Tsetse Fly, protozoa, & red blood cells
Poland, 1978, Sc#2275

Fig. 34. Trypanosomes & red blood cells
MicrobeWiki, Kenyon College

Chaga's Disease. Caused by a similar organism (*Trypanasoma cruzi*) (Fig. 34), which is transmitted by various Reduvidae such as the Assassin Bug (Fig. 35). The insect feeds and defecates at the same time. The bite causes itching and the person scratches the lump and introduces the organism into the bloodstream. It is found in Central and South America.

Fig. 35. Assassin Bug
US, 1999, Sc#3351g

Fig. 36. Human Immunodeficiency Virus
France, 1994, Sc#2419

HIV/AIDS. There is considerable confusion about this combination. The human immunodeficiency virus (Fig. 36) may attack the "T" white blood cells, thus compromising the body's defense mechanisms, allowing other infections to flourish.

The acquired immunodeficiency syndrome is the actual disease. Not all persons infected by HIV develop AIDS, but may spread the virus to other people who may then develop AIDS.

Fig. 37. HIV & Blood
Morocco, 2006, Sc#1030

The illustration of the virus shown (Fig. 37), which has pricked a finger and drawn blood, has an outer coat of spikes. But the actual virus is as shown in Fig. 38.

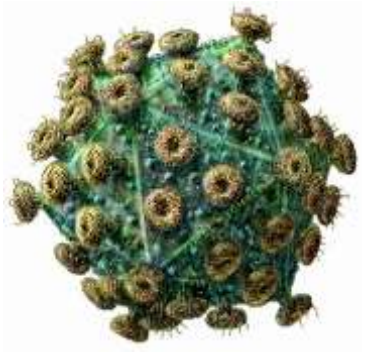

Fig. 38. HIV particle (viron)
Russell Knightly Media