MICROBIOLOGY IN FABLE AND ART

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Modern science prides itself in being concerned only with the rational and the useful; it mistrusts the uncontrolled imagination and is disdainful of the fairy tales in which our ancestors rejoiced. This haughty attitude, however, is of recent date. In its youth, science expressed itself in art and poetry and knew the intoxication of magic. Only after it had reached adulthood and had to pay the penalty of its social influence did it begin to shun glamor and suffer from inhibitions. If you will permit me, I shall try this evening to liberate myself from these inhibitions, to recover some of the naïveté of the past.

When the modern scientist tires of his austere textbooks and professional articles, he can, if he wishes, seek relief and entertainment in the many strange tales found in the early annals of all fields of scientific endeavor. The astronomer can discover romance in the fanciful and poetical cosmogony of the ancients, the chemist in the weird imaginings of alchemy, the zoologist and botanist in the legendary creatures which enliven the lore of all people and give such festive and mysterious atmosphere to medieval books and tapestries. Furthermore, these quaint documents often yield facts of scientific value. The star which guided the wise men to Bethlehem, the prehistoric drawings of animals now extinct, the list of plants and flowers in the old herbals and in Shakespeare; all have found some place in the fabric of modern science.

Alone of biological sciences, microbiology appears at first sight to be without a remote and fanciful past. Its founder, Leeuwenhoek, was an acute, industrious and factual—but unromantic—bourgeois. For a century after him, microbiologists continued to work earnestly on problems of description and classification. Then Pasteur and Koch taught them to harness their skill and energy to the practical affairs of mankind in an effort to make their profession respected in the scientific community. The most diligent search discloses nothing but businesslike statements in the microbiological literature of Europe and America. It is true that a few years ago Dr. Paul Clark was bold enough to take advantage of his presidential address to give before our Society an essay entitled "Alice in Virusland", which he adorned with nonsense verses and delightful cartoons. But probably as a form of atonement, the Society of American Bacteriologists exacted a fine of one dollar of those of its members so frivolous as to wish to own a copy of this nontechnical document.

I shall not be as bold as Dr. Clark, nor do I have his skill as a versifier. I shall try, nevertheless, to show you that the lore of primitive civilizations, the poems, novels, drama and arts of all times yield much material that microbiology can legitimately claim as belonging to its past. These traces of the

1 Taken from an address presented at the annual banquet of the Society of American Bacteriologists in Boston, April 29, 1932.

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prehistory of our science are often indistinct and can be detected only by trained eyes. Unlike stars, animals and plants, microorganisms cannot be seen by the unaided senses. And just as it is only through their effects that we become aware of them, similarly it is only by trying to recognize the influence of microbial life on the adventures of civilizations that we can hope to discover the early romance of microbiology.

Familiar examples immediately come to mind. The Bible is full of allusions to the effects of yeast in causing the grape to ferment or the dough to rise. And all of us know that the red spots occasionally seen on the wafers used for communion in the Christian churches were long regarded as the miraculous blood of Christ until the bacteriologist identified them as colonies of *Bacillus prodigiosus* (a name better suited than *Serratia marcescens* to the present discourse). The soft glow of luminous bacteria and fungi growing on dead trees and leaf mold or on the decaying bodies of animals and men creates in the dark of the night an eerie atmosphere which has added mystery and terror to many events in the past.

The will-o’-the-wisp, perhaps better known as Jack O’ Lantern, is also probably a microbial phenomenon. It plays a role in countless legends of Northern Europe, Ireland, French Brittany and of the South in this country. During much of the 19th Century and until a few decades ago, the will-o’-the-wisp was a subject of lively discussion in learned scientific journals. Many trained observers have watched and measured these small balls of bluish fire hovering over marshy lands during warm nights, disappearing and suddenly reappearing a few feet away, like sylphids dancing lightly on the stagnant waters. In general, the accounts by modern scientists agree remarkably well with the description of storytellers recounting how mysterious and wicked lights lure the traveler astray and lead him to be lost in the swamps. Certainly the will-o’-the-wisp is not a mere product of imagination. But although it possesses physical reality, there is as yet no adequate account of its nature, and, to my knowledge, it has never been reproduced experimentally. All observers agree that will-o’-the-wisp appears only in water-logged places during warm weather under conditions where organic matter can be presumed to decompose anaerobically. It is often associated with a faint smell of garlic, and its transient lights float at a few inches above the surface of the ground or water. The known features of the phenomenon are compatible with the hypothesis that will-o’-the-wisp results from the spontaneous ignition of phosphine in the presence of methane since both gases can be produced simultaneously where organic matter decomposes in the absence of air. But I shall remember that hypotheses are themselves little more than will-o’-the-wisps that usually lead the scientist into disgrace. And instead of running the risk of letting myself be lured into the swamps of anaerobic fermentations, I shall return to the vapidous lands of history, where many things are so uncertain that hazy discourse is acceptable even to scientists.

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Although the precise understanding of the relation of microorganisms to natural phenomena is a recent acquisition of science, the thought that minute
invisible forms of life are responsible for many transformations of matter and for aspects of disease has certainly occurred many times in the course of ancient history. In Roman literature there is a suggestion of it in the sixth book of Lucretius' poem *De Rerum Natura*.

There are many seeds of things that support our life, and on the other hand, there must be many flying about that make for disease and death. Even more explicit is the warning given by Varro in 50 B.C. to those about to select a place for a dwelling. Said he,

> There exist in the air minute animals too small to be seen, but which can penetrate into the mouth and nose, and cause disease.

The germ theory of disease appeared again sixteen centuries later in the writings of one of the last great writers of the Latin language, the Veronese Fracastoro, who was a physician, better known as a poet. Fracastoro's interest in the disease that had spread like wildfire through Europe in the early part of the 16th century has come down to us chiefly through his great poem *Syphilis* published in 1530. Syphilis, as you will recall, is the name of one of the chief characters of the poem, a young shepherd who had been stricken by the malady as a penalty for lack of respect to the gods. So immensely popular was the poem that the name of its hero has remained associated with the disease ever since. In addition to having introduced the word syphilis, Fracastoro's poem also provides information concerning the severity and treatment of the disease during the 16th century. We learn, for example, that the shepherd went to worship at the altar of Mercury in an attempt to cure his malady, for the metal was even then known to have some value as a therapeutic agent. Fracastoro also begs his Muse to assure immortality to the poem in order that subsequent generations be aware of the destructiveness of syphilis in its acute form. He had noticed that the disease was decreasing in severity but feared that it might some day recover its original virulence. So ancient is the recognition that epidemics fall and rise in an unpredictable manner!

Although diseases have long been recognized to exert an influence on history, it is chiefly their effects on large events which have been emphasized. Microbiologists, meeting in Boston, cannot fail to recall how Hans Zinsser illustrated in his witty book *Rats, Lice and History* the part played by typhus in the great wars of the past. It is also held by many historians that malaria contributed to the downfall of the Greek, Roman and Mayan empires by progressively sapping the energy of the affected populations. But wars and political events are not the only aspects of life which are affected by epidemics. Many microbial diseases have certainly played an immense historical role in modifying habits and emotions, literature and arts, and indeed, the very moods of civilizations. Thus, leprosy has long held a strange sway on the minds of men. In the Bible, as you know, it is the object of very detailed instructions by Leviticus. The ritual devised by the Christian churches to deal with the leper during the Middle Ages betrays the horror inspired by the disease. In a dramatic ceremony, the leper was declared "dead to the world" being allowed to move among men only if he advertised his presence with a bell and with the word "Unclean".
Plague also was a dreaded disease of the Middle Ages and Renaissance. As with leprosy, its prevalence and destructiveness are reflected in countless illustrations and paintings of the time. Let us note in passing that the depiction of rodents in all illustrations of plague makes it clear that the relation of these animals to the epidemics has long been recognized. Plague, the Black Death, had a profound influence on the history of Renaissance art through many indirect effects. Immediately after 1350, dire prophecies of new pestilences to come prompted the donation of huge sums of money for the creation and embellishment of churches, chapels and monasteries. The immense death toll in Florence forced relaxation of the guild laws which limited the immigration of artisans, physicians and jurists into the city. Within a few years a class of nouveaux riches arose out of the reshuffle of wealth, and their unsophisticated tastes imposed more conservative formula of creation upon the artists whom they commissioned.

The Black Death appears frequently in the literature of the Renaissance. You recall that Boccaccio's Decameron deals with ten young men and women of Florence who retired to a villa in the hills in an attempt to escape the epidemic which devastated the city in the year 1348 and how they spent leisurely days together entertaining themselves with the tales which have entertained the world ever since. Soon, however, Boccaccio himself became the victim of the dark state of mind that the Black Death engendered in his contemporaries. The pestilence was almost universally regarded as the manifestation of the wrath of an aroused God punishing mankind for its wickedness. The sense of guilt and resultant asceticism is reflected in Boccaccio's novel the Corbaccio published in 1354. In fact, the gloomy vision of the world which then pervaded most of Italy led the author of the carefree Decameron to turn bitterly against his own early work. It is also from the plague that Manzoni derived four centuries later some of the most exciting situations that he introduced in I Promessi sposi, the first novel of importance in the modern Italian language.

During the 19th century, tuberculosis was the greatest single cause of disease and death. Because it killed so many young men and women, and wounded so many hearts, it contributed certainly to the melancholy mood of the Romantic era by introducing in daily experience the stabbing sense of the brevity of life. The fading away of young women dying of consumption—in a decline, as it was then the fashion to say—became the most poetical theme of literature. Need I mention the heroines of Edgar Allan Poe's short stories and poems, all modeled after his young wife, Virginia, dead of tuberculosis at the age of 18; or the tragic atmosphere in the novels by the Brontë sisters, all killed in their youth or early adulthood by tuberculosis? On the stage who does not recognize as victims of tuberculosis Marguerite Gautier in La Dame aux Camelias or La Traviata and the pathetic Mimi of La Bohème. It was also two young consumptives who served as models for the "long, cadaverous women with sensuous lips" so commonly seen in the pictures of the English Pre-Raphaelite school of painting.

Throughout the life of the 19th century in Europe and North America, it is
easy to detect the influence of tuberculosis in diaries, letters, literature, the arts, and even in fashion. For example, the desire by young women and also by men to acquire the romantic and fashionable aspect of the tuberculous individual accounts in part for the widespread use of whitening powders. Even the symbols and images used in the literature of the time reflect the influence of the disease. Autumn and the falling of leaves came to represent the death of everything in nature, and the colors of the dying foliage were likened to the blood of the consumptive. In *Ode to the West Wind*, Shelley described the falling leaves as “pale, and hectic red,” like “Pestilence-stricken multitudes.” Thoreau observing the first spotted maple leaves “with a greenish center and a crimson border” was led to remark in his *Journal* “Decay and disease are often beautiful, like... the hectic glow of consumption.”

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Although it is as agents of disease that microorganisms have exerted their most obvious effects on civilization, other forms of microbial life have also influenced the emotions and beliefs of men, often in a more subtle but profound manner. “All are of the dust and return to dust again” had said Ecclesiastes, and Lucretius paraphrased the Bible many centuries later by proclaiming “Whatever earth contributes to feed the growth of others is restored to it... the universal mother is also the common grave.” Thus, the observed fact that all things which grow decay, and that new life grows out of the products of decay gave birth to the concept that everything in nature is in a constant state of flux. Lucretius expressed his belief in this continuity of living matter through the symbol of the torch of life, passed from hand to hand as in an eternal race.

This resplendent vision was not born entirely *de novo* in the mind of the Roman poet. It had emerged in philosophy and poetry as a word structure from a deep substratum of ancient emotions and beliefs. Almost universally among primitive populations living in intimate contact with nature and its primeval forces, one can perceive the vague but overwhelming awareness that life possesses a continuity which transcends the existence of the individual organism—plant, animal or man. All religions and folklore have tried to symbolize and celebrate in their legends and festivals the reawakening of nature at the end of the winter. In ancient times the pageantry of the rites of Spring was not merely a display of gladness at seeing new foliage, flowers, birds and young animals playing in the fields. It had a more profound and mystic inspiration, symbolizing as it did the resurrection of life through the fecundation of the earth. In Greece, the largest sacred monuments and the most elaborate celebrations were dedicated to Demeter, the goddess of the procreative power. She represented the fertilizing principle of nature in general and of the soil in particular. Every September there was held at Eleusis, in Attica, the great “mysteries” to commemorate the abduction by Pluto of Persephone, daughter of Zeus and Demeter, and her disappearance into the kingdom of the dead. And in the early Spring another festival at Agrae near Athens celebrated the return of Persephone to the earth. It is clear that the myth of Demeter and Persephone symbolizes the
death of vegetation at the end of autumn followed by the resurrection of dead nature in the Spring. It implied some form of belief in the continuity of life, a faith in immortality.

Similar myths with similar symbolism are found in all religions. Primitive man living in intimate contact with nature could not help experiencing the mysterious travail that goes on in the earth before it can again bear crops and flowers. He divined a multitude of living agencies, and before these could be identified by modern science they were personalized and deified by popular beliefs. We, whose senses have been dulled by centuries of life in a man-made environment, can even now recapture in early spring the cosmic sense of participation in the rebirth of nature. We, too, feel the genial processes of nature actually at work, as if some spirit of life were really circulating beneath the leaf mold and in the sap of the trees. It is this intoxicating experience which is at the origin of the festivals of Resurrection common to all religious faiths at the end of winter.

Indeed the rebirth in the Spring means more than resurrection. It suggests some perpetual working, some continuous act of conception which assures the continuity of life. To most primitive people decay does not appear as an end but merely as a phase in the transmission of the living principle. Thus, the concept that all life is part of some great whole and flows everlastingly from one form into another—and into man—is at the basis of many ancient philosophies and religions, and it has inspired some of the greatest poems of humanity.

This concept began to acquire scientific meaning during the 17th and 18th centuries when it became understood that the minerals of the soil and the gases of the air are incorporated into living material during the growth of plants and pass from plants into the structure of animals. Furthermore, it was then realized that all organic matter eventually returns to the inorganic state before re-entering the cycle of life. But while the conversion of matter from the inorganic to the organic state could be apprehended in general outline, the steps through which organic matter returns to the inorganic state were shrouded in mystery. As appears from a statement by Lavoisier, this problem haunted the natural philosophers of the pre-microbiological era. Said Lavoisier,

Plants extract from the air that surrounds them, from water and in general from the mineral kingdom, all the substances necessary to their organization. Animals feed either on plants or on other animals which themselves have fed on plants, so that the substances of which they are constituted originate, in final analysis, from air or from the mineral kingdom. Finally fermentation, putrefaction and combustion endlessly return to the atmosphere and to the mineral kingdom the principles which plants and animals had borrowed from them. What is the mechanism through which nature brings about this marvelous circulation of matter between the three kingdoms?

It was microbiology which provided the answer to this great riddle by revealing that many types of microorganisms can precisely degrade complex organic molecules to the inorganic state and thus prepare them to become again available
to plants. The practical applications of the new science of microbiology in medicine, agriculture and industry were so great and immediate that they overshadowed completely the importance of the discovery of the microbial world for the understanding of the cycle of life. True enough, the philosophical import of the problem is discussed in Pasteur's early writings, and a vague awareness of it persists in the expressions: "carbon cycle", "nitrogen cycle", by which textbooks attempt to convey graphically the uninterrupted flow of matter from the inorganic to the living state through the agency of microbes. But few are the microbiologists who think in those terms today, and it is hardly ever emphasized that the events of microbial life have implications which transcend the understanding of the biochemical mechanisms involved in the transformation of matter. For the history of thought, it was a great step forward when microbiological science began to explain why decay is not death but merely a change of forms as Lucretius and many before him had anticipated. Like plants and animals, microbes contribute some of the essential links in the endless chain which binds together the whole range of living forms. They, too, like runners in a race, hand on the lamp of life.

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The pagans celebrating the fecundation of the earth in the rites of Spring, the philosopher-poets of the Classical world pondering over the eternal flux of matter and life, were motivated by preoccupations which still loom large in modern philosophy. The ancient myths are acquiring new significance as we begin to visualize the whole cycle of life. Wandering through the woods and fields on a warm humid day, we can decipher in part the message sent us through the pervasive odor of organic matter decomposing in the earth, the mysterious luminescence of bacteria and fungi on rotting wood. These microbial phenomena are more than the signs of biochemical reactions, they are the symbol of the creative power of life present always and everywhere in nature. To fully understand the symbol is beyond the reach of our time. But we have the right nevertheless to sublimate our small individual efforts by the faith that they will illuminate with the glorious light of reason obscure but venerable beliefs generated long ago by a mystic sense of wonder.