Laboratory Section

HISTORY AND CHEMISTRY OF DISINFECTANTS.*

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Man has an instinctive repugnance to all noxious odors, and from the earliest time has sought to mask their presence by the use of aromatic substances. The use of perfumes is probably a relic of the effort of primitive man to counteract this evil. Many religious ceremonies, such as the burning of incense, have also the same origin, and embalming, as practiced by the Egyptians, is a good example of successful attempts to arrest putrefaction in very early ages. Sulphur has been employed from the earliest times, and Homer describes its use in religious ceremonies. In the time of Hippocrates, sulphur was regarded as an antidote against the plague. Ovid makes mention of the fact that sulphur was employed by the shepherds of his time for bleaching fleeces and for purifying their wool from contagious diseases. During the plague of Athens, Acron, according to Plutarch, stayed the spread of the epidemic by lighting fires in the middle of the public places and in the streets where deaths had occurred; and the lighting of fires during times of plague has been customary until quite recent times.

The Mosaic law, with all its minute instructions as to the purification of the people and their belongings, shows the same combination of religious ceremonial and sanitary precautions. The preservation of physical well-being is looked upon in Judaism as a religious command. The neglect of one's health was regarded as a sin; and the Nazarite who vowed to abstain from wine was considered a sinner, as well as he who fasted or underwent other penance without reason. There was not a distinct department of public health in the government of the ancient Jews. The charge of infectious diseases, such as leprosy, and of epidemics of all kinds, was delegated to the priests, who acted as the physicians. The Talmud mentions the office of a physician in the Temple, whose duty it was to look after the health of the priests. In later times every town counted among its permanent officials a physician who supervised the circumcision

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of children and looked after the communal well-being. A scholar was forbidden to live in a city where there was no physician. For domestic sanitation the commandments given in the Bible direct the covering of the blood of a fowl or of a wild beast with dust, and the covering of excreta with earth, and the appointing of a special place outside of the camp for depositing the excreta. In order to prevent the spread of leprosy, a complete system of quarantine laws was developed in the Levitical code. Here I may mention that from the data of various writers, it is reasonable to conclude that Biblical and modern leprosy are, in all probability, not the same disease, the former not being considered contagious, the segregation of lepers being regarded, at any rate, at certain periods, more in the light of a religious ceremonial than as a hygienic restriction. The numerous laws of purity and health scattered throughout the Bible were afterward regarded as important factors, and the system of bath ablution which forms a large portion of the Jewish laws of cleanliness has had a marked influence on the physical health of the people, so that in epidemics they have frequently been immune.

The Indian who, instead of embalming or burying his dead friend, hangs the body under a tree exposed to the air, makes use of the property of dessication, which, as is well known, is very efficient in arresting decay, and is the basis of a modern patent for keeping yeast. Earth is a very powerful deodorant and will also act as an antiseptic; the gases given off by decaying bodies are absorbed, and thus the burying of a body under proper conditions may be regarded as an efficient means of disinfection. The use of fire for cremating bodies undergoing decay or likely to cause a nuisance is, of course, an illustration of the employment of heat for the destruction of micro-organisms.

DISINFECTION IN THE MIDDLE AGES.

During the long period of the Middle Ages, the alchemists did little to advance our knowledge of this subject; they collected a few facts, and described, with more or less accuracy, the properties of some of the more important chemical compounds; but one may search in vain for a correct account of any example of preventive medicine. Notwithstanding the ravages of the cholera, the plague, and other epidemics, as well as the frequency of leprosy, the idea of contagion was only imperfectly understood, and the common people were far less cleanly in their habits than the Jews, for example, or heathen nations, who, as we have already mentioned, mingled primitive sanitary precautions with their religious services. Perhaps one of the earliest papers of any importance which we have is a "*Memoire sur les substances septiques et antiseptiques*," written by Pringle in

the middle of the eighteenth century. In this memoir some forty-eight experiments are described, in which the author took pieces of fresh meat and placed them in contact with various amounts of substances which he believed to have an antiseptic action. Amongst the substances tried we find common salt, sal ammoniac, acetates of ammonia and potash, nitre, borax, camphor, aloes, and succinic acid. These experiments, which were conducted in a very systematic manner, are even now not without some value. By taking as a standard the antiseptic action of sixty grains of salt on two grains of meat in two ounces of water, he was able to show that the other substances enumerated above had a greater antiseptic power than this standard, and thus succeeded in arriving at their relative antiseptic value.

BACTERIOLOGY.

Even the pioneers of modern chemistry at the beginning of the present century, did little towards promoting our knowledge of disinfectants, and it was not until the biologists showed that decay was due to the action of living organisms which float in the air, that fresh attention was directed to the subject. Francesco Redi, by protecting meat from flies with wire gauze, showed that the maggots which infest decaying flesh were produced from the eggs of the flies. Subsequently the formation of molds on the surface of jams, or other organic substances, was similarly shown to be determined by micro-organisms floating in the air. It was further noticed that filtration of air through cotton wool was effectual, not only in removing the dust, but also in preventing the ingress of micro-organisms.

The gradual accumulation of such facts as these by the biologists led the chemists to realize that the removal of the odor was not, after all, the only work necessary; and thus fumigation with nitrous acid, hydrochloric acid, chlorine, and other pungent bodies, which had been recommended, fell gradually into disfavor.

Pasteur's work, together with the general development of the modern science of bacteriology, has given to chemists a means of ascertaining the relative value of the various chemical substances discovered from time to time. It was to Pasteur's careful investigations that the close analogy which exists between fermentation and putrefaction was established. Pasteur himself defined putrefaction as "fermentation without oxygen," and showed that all decay was due to the action of organisms, the *Bacterium termo* being the common organism which begins eremacausis.

Owing to the slight knowledge which we possess as yet of the nature of the pabulum in which these bacteria of decay live, the investigation of the way in which they act is a matter of great difficulty. In recent years, however, the life-history of known organisms has been carefully studied, and the chemical changes which are produced when they live in media of known compositions have been followed. The organisms have been allowed to grow in solutions of calcium formate and calcium acetate, both of which substances have a definite chemical constitution. The bacteria decompose these salts, evolving carbonic acid gas, mixed with hydrogen in the former solution, and carbonic acid, mixed with marsh gas, in the latter. Lactic acid and its salts, butyric acid and its compounds, have also in recent years been examined bacteriologically. From studies such as these it seems to be clearly established that, just as yeast is killed by the alcohol it produces, when it converts sugar into alcohol so these other micro-organisms secrete chemical compounds which are inimical to their own life. In the decomposition of animal matter containing nitrogen, compounds which are soluble in weak alkaline solutions, and known as alkali albumens, are first produced; and these subsequently change into albumoses and peptones, to be again broken down into tyrosine, indol, and other compounds. These latter have strong antiseptic properties and illustrate the facts already alluded to, viz., that the products of decomposition are in the majority of cases themselves inimical to the bacteria which give rise to them.

By disinfection we mean that the power which the living organism possesses of infecting a healthy individual or animal has been destroyed.

This is brought about in various ways:

1. By natural processes, such as air, light,—particularly sunlight—rain, natural filtration, and dessication.

2. By mechanical means, such as artificial filtration, absorption and heat.

3. By chemical agents.

This comprises an exceptionally large group of products, and it is impossible in this short space of time to take them all up in detail. I shall limit myself only to a brief description of those that mostly interest the sanitarian, and endeavor to familiarize him with their most important chemical and bacteriological properties, in order, in the absence of official guidance, to make the proper selection, when the question of disinfection is brought before him.

While it is probably difficult to explain the manner in which disinfection is accomplished in many cases, still I think the subject is best approached from a purely chemical standpoint.

We can divide the disinfectants generally used into five distinct classes:

(A) Those that act as reducing agents.

To this group belong the sulphites, sulphur-dioxide, and ferrous salts, such as copperas. The reducing disinfectants are open to the objections that they are in great part wasted at first by the free oxygen of the air and the water, lose their strength by absorption of oxygen and do not act on anaerobic bacteria.

(B) Those that act as oxidizing agents.

To this group belong chlorine, bromine, hypochlorites, peroxides, permanganates, ozone, and various commercial preparations, whose efficiency depends on the amount of available chlorine. The greatest objections to the substances in this group is that they are very unstable, some rather expensive, and some corrosive to tissue and metals; they are mostly employed for special work only, such as water purification or sewage treatment.

(C) Those that act as absorbents and deodorants.

To this group belong sulphate of lime, or gypsum, slaked lime, and quicklime.

(D) Those that act by their toxic power and as precipitants of albuminous matter.

This group comprises most of the metallic salts, such as those of mercury, zinc, copper, silver, etc. Very little that is new can be added to the chemistry of this group. It is well known that, according to the theory of ionization, a salt when dissolved in water becomes more or less dissociated, and that the amount of metallic ions is greater with the chloride salt, than with any other, which probably explains their higher efficiency.

(E) Those that enter into chemical combination with albuminous matter and form new products that resist further decomposition by bacteria.

The most representative type in this class is formaldehyde, which is the ideal disinfectant for room fumigation, when properly used, i. e., in its gaseous form, in the presence of water vapor. Of late years, however, it has been found that in its aqueous solution, such as formalin, it is far inferior to pure phenol, possessing only one-third the bacteriological efficiency of the latter.

A good many disinfectants combine one or more qualities mentioned in the preceding grouping and thereby form a special class by themselves.

A group of organic substances obtained in the destructive distillation of tar, which constitute today the most important branch of disinfectants for all practical work, are products such as phenol, cresols, and phenoloids, and a good many commercial preparations containing the

above either with or without hydrocarbon oils, forming with water, either clear solutions or emulsions. Their action is based either on precipitating albuminous matter or on toxicity of their constituents, which is highest with phenol, and decreases as the hydrogen of the benzine ring is replaced by either methyl of hydroxyl groups. The best of these commercial products are far superior in their bacteriological efficiency to pure phenol or cresols, being less toxic and corrosive, and possess the great advantage over all other disinfectants, that their emulsions have a thoroughly cleansing effect, acting to all purposes and intent like a liquid soap. The superior efficiency of the emulsifying disinfectants is best explained by the fact that the particles of the emulsion exhibit active Brownian movement, and that the bacteria practically become surrounded by the disinfectant in much greater concentration than exists throughout the liquid.

In concluding, I should like to emphasize the fact that the time has come when the sale of disinfectants should be put under governmental and scientific control, for this industry has grown to such an extent in recent years that the public is entitled to protection from frauds and impositions.