as " Papers for the second edition of part I of the Retrospect," a " List of my publications, 1793–1836 " established by Miller himself.

A bibliography of studies of the idea of progress would be endless and would include a large part of the work done by Lovejoy. I shall mention here, almost at random, only a few titles such as Lois Whitney, *Primitivism and the Idea of Progress in English Popular Literature of the Eighteenth Century* (Baltimore, 1934); Howard Mumford Jones, *Ideas in America* (Cambridge, 1944); Ronald S. Crane, " Anglican Apologetics and the Idea of Progress, 1699-1745," *Modern Philology*, Vol. XXXII, Nos. 3 and 4 (Feb. and May, 1934); Rutherford E. Delmage, " The American Idea of Progress, 1750–1800," *Proceedings of the American Philosophical Society*, Vol. 91, No. 4 (October, 1947); Theodor E. Mommsen, " St. Augustine and the Christian Idea of Progress," *Journal of the History of Ideas*, Vol. XII, No. 3 (June, 1951); Robert E. Palmer, *Catholics and Unbelievers in Eighteenth Century France* (Princeton, 1939); Gladys Bryson, *Man and Society: The Scottish Inquiry of the Eighteenth Century* (Princeton, 1948); and Adolf Koch, *Republic Religion* (New York, 1933). With the exception of Robert E. Palmer, however, the authors of these studies do not seem to have emphasized the distinction between progress and perfectibility—many of them use either term indifferently or list them together.



OWSEI TEMKIN

# *An Historical Analysis of the Concept of Infection* *

The most recent edition of one of our standard medical dictionaries defines " infection " as follows: " Invasion of the tissues of the body by pathogenic organisms in such a way that injury followed by reactive phenomena results." [1] This definition shows the earmarks of modern medical research. It is only since about 1800, the days of Bichat, that we have become accustomed to speak of the tissues of the body. The words " pathogenic organisms " remind us of the rise of bacteriology. Obviously, a definition of infection like the above could hardly have been formulated before the days of Pasteur, Koch, and Lister. And the qualification that the presence of pathogenic organisms, though necessary,

* In partly different form and under different title, this article was originally presented as a paper before the Sigma Xi Society, in Ithaca, N. Y., in 1952. Because of the great role of infection in medicine, the article is, by necessity, incomplete as to historical details and literature quoted. The following works may be cited as supplementing some of its omissions: C. E. A. Winslow, *The Conquest of Epidemic Disease*, Princeton University Press, 1943; Richard H. Shryock, *The Development of Modern Medicine*, New York, Knopf, 1947; John E. Gordon, Evolution of an Epidemiology of Health, in *The Epidemiology of Health*, Iago Galdston, editor, New York-Minneapolis, Health Education Council, 1953; also Vilmos Manninger, *Der Entwickelungsgang der Antiseptik und Aseptik*, Breslau, 1904 (Abhandlungen zur Geschichte der Medicin, Heft XII).

[1] *The American Illustrated Medical Dictionary*. Twenty-second edition, Philadelphia, W. B. Saunders Co., 1951, p. 738.

is not sufficient, that injury followed by reactive phenomena must have resulted, points to an even more recent date. In short, the above definition of infection seems to be scientifically accurate, consisting, as it does, mainly of terms which bear a well defined connotation verifiable by observation. I say *mainly*, because here, as elsewhere in medicine, there remains an element of more doubtful character. What exactly is an "injury," and what is an "invasion"? We shall come back to these disturbing elements in the definition. For the moment let us be content with the fact that the modern concept of infection is reasonably clear and that it is couched in the language of modern science.

This being the case, we may be all the more permitted to wonder at the incongruity between the definition and the term defined. The word "infection," as well as its counterparts in other languages, is much older than the nineteenth century. I need hardly point out that infection is derived from the Latin *infectio*. Now, one may easily say that there is nothing unusual in an old term receiving a more precise explanation with the advance of science. People talked about "fever" long before they knew how to measure the temperature of the body, and of "pneumonia" before any post mortem dissections had been performed on human bodies. Infection must have occurred at all times; the word expresses a phenomenon that has remained the same, although its scientific explanation was reserved for a more advanced age. Encouraged by this thought, we turn to ancient medical literature and we find indeed that Theodorus Priscianus, a physician of the fifth century A. D., devotes a whole chapter to "*infectio*" in his textbook of medicine. However, the chapter is entitled: *De infectionibus capillorum*,[2] i. e., "On the dyeing of hair." We shall have to admit, I think, that the

[2] Theodorus Priscianus *Euporiston libri III*, ed. Valentine Rose, Lipsiae, 1894, I, c. 2, p. 5 ff.





matter is not quite as simple as we assumed. The word included a connotation which it no longer possesses today.

There is no other way but to inquire more closely into the meaning of those words which have come to be used for the concept of infection. The Latin "*infectio*," as we just heard, means staining or dyeing. And to stain or to color is one of the principal connotations of the verb "*inficere*." The root meaning of this word is to put or dip into something, and the something may be a dye; or to mix with something, especially a poison; or to stain something in the sense that it becomes tainted, spoiled, or corrupted. Indeed, the English word "to stain" can still be used in the double sense of dyeing as well as polluting. Let us remember, then, that an infection is basically a pollution. And the same is true of the term "contagion" which indicates a pollution, especially by direct contact. Peculiarly enough, the Greek verb *miaino* presents a counterpart to the Latin *inficere*. Here too the mere staining can be included together with physical or moral defiling. And the corresponding noun "*miasma*" originally meant any pollution or polluting agent.

This brief linguistic excursion will suffice to bring out a basic element in the concept of infection: impurity. If we look for examples we have only to turn to chapter 13 of Leviticus which deals with Zara'ath, the disease commonly translated as leprosy. "And the leper in whom the plague is, his clothes shall be rent, and his head bare, and he shall put a covering upon his upper lip, and shall cry, Unclean, unclean. All the days wherein the plague shall be in him he shall be defiled; he is unclean; he shall dwell alone; without the camp shall his habitation be" (ch. 13, vs. 45 and 46). The leper is obviously isolated so that he may not communicate his uncleanness; for persons, animals, and things unclean make those who come in contact with them unclean too. This, according to the Bible, holds true of men

suffering from gonorrhea, and of men and women in the sphere of sexual functions; it holds true of the beasts that are unclean and forbidden food; and it also holds true of dead objects.

The chapter dealing with Zara'ath greatly influenced the medieval attitude towards leprosy and the segregation of lepers. The contagiousness of leprosy was dreaded beyond the real danger of infection. Nevertheless, this attitude may have helped to make those countries where regulations were rigorously enforced almost free of leprosy around 1600. No wonder that the sanitary significance of Leviticus has been greatly praised, especially since washing of clothes and bathing in water were mandatory in the process of purification![3] It is not necessary to deny that, as far as leprosy, gonorrhea, and the eating of carrion flesh are concerned, an empirical insight into the real danger existed. But the guiding thought was that of a ritualistic religious taboo. "Thus shall ye separate the children of Israel from their uncleanness; that they die not in their uncleanness, when they defile my tabernacle that is among them."[4] The diseases mentioned as unclean in Leviticus are but one type of pollution among others.[5] We are not even quite certain exactly what disease Zara'ath was. Even if it included what we now call leprosy,[6] it must have included other conditions as well. The sufferer from Zara'ath might recover and be cleansed from his impurity. On the other hand, even garments and houses could be affected by Zara'ath.

According to an age-old belief, disease could be sent by the gods as punishment for a crime with which men had defiled

[3] Leviticus, ch. 14, v. 8.

[4] Leviticus, ch. 15, v. 31.

[5] Wolf von Siebenthal, *Krankheit als Folge der Sünde,* Hannover, 1950, passim, has shown a similar relationship in other civilizations between disease and pollution.

[6] This has been doubted by F. C. Lendrum, *J. A. M. A.*, 1952, vol. 148, p. 222.





themselves. The Bible mentions leprosy as well as plague as instances. According to the Greeks, Apollo shot his plague arrows upon the Greek host before Troy because their leader, Agamemnon, had abducted the daughter of his priest. The girl had to be returned. "And," as Homer tells us, "they purified themselves, and cast the defilement into the sea, and offered to Apollo acceptable hecatombs of bulls and goats by the shore of the unresting sea."[7] Likewise, Apollo sent the plague upon Thebes because Oedipus, the King, had killed his father and married his mother, so that a pollution, a miasma, infested the land.[8] The ideas of a disease caused by a foul deed, and of a disease defiling the sufferer, were almost interchangeable.

Around 400 B. C., a Greek physician wrote a book "On the Sacred Disease," the popular name for epilepsy, in which he attacked the popular healers. "For the sufferers from the disease they purify with blood and such like, as though they were polluted, bloodguilty, bewitched by men, or had committed some unholy act." But to the belief that gods or demons might cause the disease, our author opposes his own enlightened view: "However, I hold that a man's body is not defiled by a god, the one being utterly corrupt the other perfectly holy. Nay, even should it have been defiled or in any way injured through some different agency, a god is more likely to purify and sanctify it than he is to cause defilement."[9] This opposition of a natural explanation of disease to the religious or magic one which is expressed in the so-called Hippocratic writings is of great import for the concept

[7] Homer, *Iliad,* I, 314-316. Translation by A. T. Murray, Loeb Classical Library, I, p. 27. E. R. Dodds, *The Greeks and the Irrational,* Berkeley, 1951, p. 36, claims that the belief in pollution as infectious was post-Homeric; see, however, my review in *Isis*, 1952, vol. 43, p. 375 f.

[8] Sophocles, *Oedipus the King,* 96-98.

[9] *Hippocrates,* with an English translation by H. W. S. Jones, Loeb Classical Library, II, p. 149.

of infection. Speculating on the significance of air, another Hippocratic author reasons that pestilences or epidemic fevers must be due to the air that all men inhale at the same time. "So whenever the air has been tainted with such pollutions (*miasmasin*) as are hostile to the human race, then men fall sick . . . ."[10] Keeping within the old terminology of miasma, a secularization has been achieved. The plague is no longer considered a punishment for religious or moral defilement; instead it has become the result of a defilement of the air, due to some mysterious agents suspended in it. The transmutation is not even so startling as we might think at first. In the myths it is the sun god Apollo that sends pestilences, now it is still the sky—especially the sun—that acts upon the air. "Why is it that when considerable vapor arises under the action of the sun, the year is inclined to plague?" asks a somewhat later philosopher.[11] We have it on good ancient authority that the forecasting of "droughts and rainstorms and plagues and earthquakes and other changes in the surrounding vault of a similar character" was considered a serious part of astronomy not on a par with the casting of nativities.[12]

Medicine from Antiquity to the Renaissance is replete with references to planets and conjunctions that breed pestilences and new diseases. The name for "influenza" is derived from the influence of the stars. But there is also intermingled a good deal of climatology that may be wrong but not dependent upon ideas

[10] *Ibid.*, p. 235. I have substituted "tainted" where Jones has "infected."

[11] Pseudo-Aristotle, *Problems*, I, 21. Translation by W. S. Hett, Loeb Classical Library, I, p. 19. According to a late Greek source (Clemens Alexandrinus) the Egyptians too derived epidemics from the sun; see Theodor Puschmann, *Die Geschichte der Lehre von der Ansteckung*, Wien, 1895, p. 4.

[12] Sextus Empiricus, *Against the Professors*, V, 2. Translation by R. G. Bury, Loeb Classical Library, IV, p. 323. On Aristotle's theory, e. g. to explain evaporations and earthquakes by action of the sun, cf. Otto Gilbert, *Die meteorologischen Theorien des griechischen Altertums*, Leipzig, 1907, p. 307.





of universal sympathy and astral spirits. At any rate the notion that epidemic diseases were connected with weather and winds, seasons, floods, and earthquakes remained firmly established until the second half of the nineteenth century. Here again it is hard to say where actual experience of the seasonal prevalence of such diseases as infantile paralysis, malarial fevers, upper respiratory infections, diarrhea of infants, and others ended and where meteorological speculation, which saw in epidemics a telluric event of divine or cosmic origin, began.

## II

Although all diseases could conceivably be judged as punishment for crime, it appears that there existed a popular classification of diseases into clean and unclean, the latter being "infections" par excellence. Of these latter, we mentioned leprosy, gonorrhea, plague, and epilepsy, to which insanity might be added. In the popular mind these types of diseases had and have a moral or religious stigma. The plague as God's wrath at a sinful people, leprosy and venereal disease as filthy, mental disease as a disgrace, are notions very much alive even today. In former times these diseases were popularly considered not only as pollutions but also as possibly catching. The superstitious Greek or Roman spit when he met insane or epileptic persons, and people were afraid to eat or drink from a dish an epileptic had used. The pressure of opinion seems to have induced medieval physicians to uphold this belief, at the same time rationalizing it by a natural explanation. The breath of the epileptic was now accused of carrying the contagion. This explanation was ready-made since the ancients had ascribed such a role to the breath in other diseases, e. g., consumption.

Only in the sixteenth century was the fable of the contagiousness of epilepsy definitely eliminated from the medical literature.[13]

Although the occurrence of contagion among men and animals was known to the ancients, they did not elaborate the concept systematically.[14] It is still one of the great puzzles of historical pathology that such infections as measles, scarlet fever, and smallpox are not recorded in classical literature. Did they not exist, or were they not conceived as specific diseases? Whatever the answer may be, the fact remains that the first systematic enumeration of contagious diseases is to be found in the so-called *Book of Treasure*, an Arabic textbook of medicine, compiled not later than about 900 A. D. The author enumerates the following contagious diseases: "Leprosy, scabies, small-pox, measles, ozaena, ophthalmia and the pestilential diseases."[15] To this list we may add a Latin one, dating from the thirteenth century, naming acute fever, consumption, epilepsy, scabies, ignis sacer, anthrax, ophthalmia, and leprosy.[16] These lists show a considerable knowledge of "contagious diseases, that is those which infect others," as they were called,[17] although their nosological interpretation is not easy. Karl Sudhoff explained the "acute fever" as plague or typhus, and "ignis sacer" as erysipelas,

[13] See O. Temkin, *The Falling Sickness*, Baltimore, The Johns Hopkins Press, 1945, pp. 7 and 114 ff.

[14] See Puschmann, *Die Geschichte der Lehre von der Ansteckung*, Wien, 1895; Karl Sudhoff, Infektionsverhütung im Wandel der Zeiten und Anschauungen. Reprinted in *Arch. Gesch. Med.*, 1929, vol. 21, pp. 207-218. The concept of medical infection is clearly expressed in Thucydides' account of the plague, especially II, 51 where he uses the same verb "*anapimplemi*" that also carries the notion of "defiling."

[15] Max Meyerhof, The "Book of Treasure," an Early Arabic Treatise on Medicine, *Isis*, vol. 14, 1930, pp. 53-76, see p. 61.

[16] Karl Sudhoff, Die acht ansteckenden Krankheiten einer angeblichen Baseler Ratsverordnung vom Jahre 1400. Reprinted in *Arch. Gesch. Med.*, vol. 21, 1929, pp. 219-227, see p. 224 f.

[17] *Ibid.*, p. 227: "*Hii sunt morbi contagiosi, id est inficientes alios. . . .*"





although ergotism is just as likely an interpretation. Sudhoff was obviously guided by the idea that these diseases should be infectious from our point of view. The naming of ozaena in the Arabic list, together with epilepsy in the Latin one, shows how misleading this may be. Ozaena is a condition characterized by a foul discharge from the nose. Quite possibly it was the evil smell that led to the belief of contagiousness. Nevertheless, we may say that the clinical study of infectious diseases was well under way. By the middle of the sixteenth century, the nervous diseases had been eliminated from serious medical consideration, while syphilis, typhus, scarlet fever, and influenza had been added. The further development of this clinical knowledge is outside our theme. Instead we have to return to the theory of infection as pollution and the associations it evoked of something bad, to be avoided and if possible removed.

## III

The statement that epidemic disease is caused by miasms, i. e., pollution of the air, in itself seems to have given the illusion of an explanation. This illusion was supported by the meaning of infection as staining. The analogy with a tincture where a small drop of dye-stuff suffices to color a large amount of fluid played an important role in medieval alchemy and medicine. It helped to explain how the whole body could become sick from mere contact or inhaled breath.[18] Finally, and perhaps most important, there was the decay and putrescence of organic bodies, "*sepsis*," to cite the Greek word which we still use. Putrescence became the pattern of pollution and the evil smell it propagated

[18] Aretaeus, VIII, 131, speaking of the communicability of elephantiasis (leprosy) refers at once to the "*baphe*" (in the sense of the Latin "infectio") and its transmission ("*metadosis*") by the breath.

was taken as an indication and guide. To quote an old English version of a medieval poem, the so-called School of Salerno:

> *Though all ill savours do not breed infection,*
> *Yet sure infection commeth most by smelling*[19]

The evil smell from the refuse of slaughter houses and from a sick person was supposed to cause infection, as was the unpleasant odor hovering over marshes, the malaria, bad air, of later days. The latter in particular was called "*virus,*" a word that could also designate the poisonous secretion of snakes. A chain of associated words and images thus provided a theory of infection, and it is remarkable how our modern terminology has remained within the orbit of ancient and medieval imagery. Indeed, the fight against epidemic diseases was guided by very similar notions in the fourteenth century and in the middle of the nineteenth. In 1347 bubonic plague, the black death, began its devastating reign and stimulated the creation of public health measures in medieval towns in times of pestilence. The streets were cleaned, the keeping of pigs and the emptying of cesspools were forbidden. In England the first general statute against nuisances was enacted in 1388.[20] To cleanse the air, pyres were lighted in the streets, the rooms and beds were scented with vinegar and perfumes. Since evil smell caused sickness, a pleasant one would remove it.[21] Here we witness the fallacy of ascribing physical effects to what was pleasant, a confusion of science and aesthetics. Pyres disappeared in the eighteenth century when

[19] *The School of Salernum,* New York, Hoeber, 1920, p. 87.

[20] John Simon, *English Sanitary Institutions,* London, 1890, p. 41, note.

[21] The idea of fire and good odors combating the plague goes back to antiquity. Galen, Ad Pisonem de theriaca liber, c. 16 (ed. Kühn, vol. 14, p. 281) tells the story of Hippocrates who ordered the Athenians to have fires lighted throughout their city and to use the best smelling substances as fuel.





better means of ventilation were invented, but in many respects the great sanitary movement of the nineteenth century followed in the old medieval footsteps. It started in England in the 1830's under the impact of the asiatic cholera that had invaded Europe in 1831 and of the appalling morbidity and death rate of the working population herded into the cities by the industrial revolution. These people lived in squalor and filth, and the sanitarians directed their efforts against these conditions. This is what John Simon, one of the medical protagonists of public health, in 1874, had to say of the fatal influence of uncleanliness:

> . . . I do not refer to it in its minor degrees, as compared with high standards of cleanliness or chemical purity, but refer chiefly to such degrees of it as fall, or ought to fall, within the designation of FILTH:–to degrees, namely, which in most cases obviously, and in other cases under but slight mask, are such as any average man or woman should be disgusted at: such as, eminently, the presence of putrescent refuse-matter, solid and fluid, causing nuisance by its effluvia and soakage. Also in imputing to Filth, as thus illustrated, that its effluvia are largely productive of disease, I do not ignore that disease is also abundantly caused by air which is fouled in other ways.[22]

More briefly and poetically the same thought had been expressed in the following verses:

> *In houses where you mind to make your dwelling,*
> *That neere the same there be no evill sents*
> *Of puddle-waters, or of excrements,*
> *Let aire be cleere and light, and free from faults,*
> *That come of secret passages and vaults.*[23]

Today we distinguish between disinfectant and deodorant.

[22] John Simon, *Public Health Reports,* vol. 2, London, 1887, p. 450.

[23] *The School of Salernum,* op. cit., p. 87.

But as long as pollution of the air was a guiding concept, including any impurity noticeable to the senses or by its alleged results, such a distinction was almost impossible to make. In 1881, Littré's dictionary still defines "désinfection" as: "Action d'enlever à l'air, à un appartement, aux vêtements, aux divers tissus organiques, ou à un corps quelconque, les miasmes dangereux ou les odeurs désagréables qui les infectent."[24] It is, therefore, not astonishing to see that physicians and surgeons in using disinfectants or antiseptics largely relied on their deodorant effect. Thus Semmelweis, who in 1847 discovered that childbed fever was caused by "disintegrating organic material" carried by the attending obstetricians, prescribed disinfection of hands with chlorinated lime, guided by the deodorant action of this substance.[25]

As regards the scientific explanations of infection originating between the late Middle Ages and about 1850, they did not contribute much to a better understanding either, ingenious and interesting, nay even prophetic, as many isolated contributions were.

Limiting ourselves to a very brief survey, we find Fracastoro, in the sixteenth century, elaborating a theory of contagion that summarizes ancient and medieval experience; while Sydenham in the seventeenth century reformulates epidemiological doctrines.[26] According to Fracastoro, contagious diseases spread

[24] E. Littré, *Dictionnaire de la Langue Française*, T. 2, Paris, 1881, p. 1105.

[25] Ignaz Philipp Semmelweis, Die Aetiologie, der Begriff und die Prophylaxis des Kindbettfiebers, in *Gesammelte Werke*, ed. Tiberius von György, Jena, G. Fischer, 1905, p. 130: "Dass nach der gewöhnlichen Art des Waschens der Hände mit Seife die an der Hand klebenden Cadavertheile nicht sämmtlich entfernt werden, beweist der cadaveröse Geruch, welchen die Hand für längere oder kürzere Zeit behält."

[26] For details cf. C. E. A. Winslow, *op. cit.*





by a transfer of imperceptible particles (*seminaria*)[27] from an infected body to another by direct contact, via an intermediate object (*fomes*), or at a distance.[28] While infection can originate in a sick body spontaneously, contagion accounts for the transmittal of the same disease to other bodies. Infection, primary as well as induced, is a form of putrescence.[29] The most original feature in Fracastoro's work, apart from his clinical differentiation of typhus and other diseases, is his insistence that the seeds of contagion are particles which can even propagate themselves in neighboring parts, and his differentiation of two kinds of putrefaction, one accompanied by "a stench and a disgusting taste"[30] and the other which may proceed without it like the change of wine into vinegar. These views are interesting regardless of whether Fracastoro really anticipated the fermentative, or enzymatic, action involved in infectious processes or merely realized that there were different ways for things to get spoiled.

Sydenham's interest, conforming with his intention to imitate Hippocrates and to describe diseases as they appeared and disappeared, centered on the epidemic constitution of years and seasons. It is not too great an exaggeration to say that the medical theory of infection around 1850 had not progressed considerably beyond these two men. For one thing it was very much confused. Infection was used synonymously with, or differently from, contagion. If distinguished, infection was attributed to agents consisting "almost entirely of decayed or diseased organized

[27] Hieronymus Fracastorius, *De contagione et contagiosis morbis et eorum curatione, libri III.* Translation and notes by C. Wright, New York, Putnam, 1930, book I, ch. 3, p. 10.

[28] *Ibid.*, ch. 2 ff.

[29] *Ibid.*, especially chs. 1, 3, and 9.

[30] *Ibid.*, ch. 9, p. 41. Although Fracastoro hardly believed in the organismic nature of these particles, such a view became widespread towards the end of the seventeenth century, see Manninger, *op. cit.*, p. 26 ff.

substances, and of animal emanations or secretions . . . found to exist most abundantly in marshy and alluvial soils, in slaughter-houses, common-sewers, dissecting-rooms, graveyards, and in those places where a large number of living persons are crowded together, particularly if the effluvia of their excretions taint the atmosphere. Such places are called centres or foci of infection, because from the morbid influence there concentrated, disease spreads in every direction." [31] The infectious agents or miasms were usually supposed to enter the system through the lungs. Contagious diseases "strictly so called" were those "which cannot be traced to any other source than communication mediate or immediate with persons already attacked by them, and which cannot be referred to any atmospheric or other external cause, or combination of causes, but only to pre-existent causes of the same kind . . . ." [32]

The existing confusion can best be documented by another quotation from the same author, Stillé of Philadelphia.

> A cargo of rags from the Levant arrives at one of our ports, and on being discharged, creates disease in all the neighbourhood of the vessel; if the disease thus originating is like one which was prevalent at the place whence the cargo came, the rags are a source of *contagion*. If there is no such similarity, or there was no prevalent disease at the Eastern port, then the newly-arisen malady must be attributed to the filth of the cargo, which is, in that case, a source of infection.[33]

No wonder that there was violent disagreement over the infectious or contagious character of such diseases as plague, cholera, and yellow fever! [34] This controversy was embittered by the

[31] Alfred Stillé, *Elements of General Pathology*, Philadelphia, 1848, p. 95.
[32] *Ibid.*, p. 100.
[33] *Ibid.*, p. 101.
[34] See Erwin H. Ackerknecht, Anticontagionism between 1821 and 1867, *Bull. Hist. Med.*, 1948, vol. 22, pp. 562-593.





practical consequences that if these diseases were contagious, ships from suspected countries had to be quarantined for a lengthy period of time. The confusion was further heightened by the assumption of "septic poisons, or those which are generated by putrefaction," and were believed to enter the body with the food, through the air, or "through a wound as so frequently happens to those engaged in anatomical studies." [35] But whether infection or contagion, the question remained how the virus acted in the body from the moment of its introduction to the outbreak of the disease. Stillé cites Liebig as believing in a fermentative action comparable to that of yeast. "Other observers," he adds, "upon the ground of an alleged discovery, that leaven acts by propagating vegetable germs, suppose the different sorts of virus to contain animal ova, or vegetable germs, which, by rapid generation, fill the body with parasitic insects or invisible plants, whose presence constitutes the disease." Stillé recommends waiting till the microscope has "revealed the existence of either of these sorts of bodies." [36]

We have cited Stillé's work at some length as a representative example of generally accepted medical theory. The book appeared in 1848 when the great sanitary movement was under way in England and when demands for public health reform were heard on the Continent as well. If it is true that the insight into the nature of infectious disease had not changed much between 1550 and 1850, then the intensification of the fight against infection must be due to other factors which had relatively little to do with an understanding of its mechanism.

[35] Stillé, *op. cit.*, p. 93.
[36] *Ibid.*, p. 104 f.

## IV

Viewed in long-range perspective, the intensification of the fight against "filth" that animated the sanitarians can be seen as a stage in the process of civilization, a consequence of the ever increasing interdependence of men since the Middle Ages.[37] It can also be seen as specifically conditioned by industrialization, urbanization, and outbreaks of cholera,[38] and facilitated by the use of statistical methods. In addition, however, it can be understood as a changing attitude towards cleanliness.

Looking backwards we have difficulties in gauging the degree of cleanliness of past ages as judged by modern standards.[39] We are too easily misled by superficial analogies with our customs and their allegedly rational motives. For instance, the medieval custom of frequenting a bathhouse has been hailed as an important chapter in the history of hygiene. Undoubtedly persons bathing regularly will acquire a certain degree of cleanliness, although bathing is of little avail if the clothes are not kept clean too.[40] There are even medieval pictures showing groups of people using a tub and otherwise cleaning themselves. But other pictures, showing men and women bathing together, eating, drinking, and listening to music, indicate that the main attraction was not cleanliness but pleasure or the medicinal effect of water.[41]

[37] Norbert Elias, *Über den Prozess der Zivilisation*, 2 vols., Basel, Haus zum Falken, 1939.

[38] See above, p. 133.

[39] Material bearing on this and related questions will be found in Cabanès, *Mœurs intimes du passé*, Paris, Albert Michel; Norbert Elias, *op. cit.*, and Reginald Reynolds, *Cleanliness and Godliness*, New York, Doubleday and Company, 1946.

[40] This has been emphasized by J. F. D. Shrewsbury, The Plague of Athens, *Bull. Hist. Med.*, 1950, vol. 24, p. 11.

[41] The medicinal effect of bathing has to be clearly separated from its hygienic one. According to Meuli, Scythica, *Hermes*, 1935, vol. 70, pp. 121-176, there is also a relationship between the Finnish bath and shamanism. For pictorial material see Alfred Martin, *Deutsches Badewesen in vergangenen Tagen*, Jena, Diederichs, 1906.





As late as 1752, a passage in Smollett's *Essay on the External Use of Water*, one of the few medical writings of the novelist, expresses the traditional evaluation. "Indeed," he writes, "the warm Bath is so well understood in its Anodyne capacity, that every body (almost) after the fatigue of a journey, or other hard exercise, has recourse to the Bagnio for refreshment: and so agreeable is the operation of this medicine, that in ancient times, as well as in these days, it has been considered as a point of *luxury* and *pleasure* . . . ." [42]

At the same time, the religious and ceremonial meaning of purity or cleanliness still stands very much in the foreground. Thus the large German encyclopedia published by Zedler around 1750 contains detailed discussions of the meaning of purity in the Bible, while the same entries have nothing to say about worldly cleanliness. A book by the famous Dr. Friedrich Hoffmann, that appeared in 1722 and described how to enjoy health and long life in conformity with the teachings of Holy Writ, is a popular text on personal hygiene.[43] It mentions food, drink, the use of wine, baths, and tobacco—with hardly a word about cleanliness.

All this goes to show that as late as the eighteenth century the avoidance or removal of substances because of their poten-

[42] Tobias Smollett, *An Essay on the External Use of Water*, edited with introduction and notes by Claude E. Jones, Baltimore, The Johns Hopkins Press, 1935, p. 61 (italics mine). Praise and blame of bathing can be found in Martial's epigrams and is succinctly expressed in the *School of Salernum*, *loc. cit.*, p. 84:

> "*Wine, women, Baths, by Art or Nature warme,*
> *Us'd or abus'd do men much good or harme.*"

[43] Herrn Friederich Hoffmanns *Gruendlicher Unterricht* etc., Ulm, Daniel Bartholomäi, 1722.

tially harmful physiological action has not yet become the leading concept in the idea of cleanliness. This "physiological concept" of cleanliness is however gaining ground, especially, it would appear, in the Anglo-Saxon countries, concomitant with sanitary reforms in the army, navy, and jails.

It has been stated that cleanliness used to be a matter of aesthetics.[44] The truth of this is confirmed by Francis Bacon's dictum: "For cleanness, and the *civil beauty* of the Body was ever esteemed to proceed from a modesty of behaviour, and a due reverence *in the first place* towards God, whose creatures we are, then towards society, wherein we live; and then our selves, whom we ought no less, nay, much more to revere, than we do any others."[45] These lines occur under "Cosmetic" which, according to Bacon, relates to the beauty of the body rather than to its health. Shortly afterwards, the theme is taken up by George Herbert who demands of the country parson that "his apparrell [be] plaine, but reverend and clean, without spots, or dust, or smell; the purity of his mind breaking out and dilating it selfe even to his body, cloaths, and habitation."[46] Elsewhere Herbert generalizes this sentiment in the following verses:

*Affect in things about thee cleanlinesse,*
*That all may gladly board thee, as a flowre.*
*Slovens take up their stock of noisomnesse*
*Beforehand, and anticipate their last houre.*

[44] Henry E. Sigerist, *Civilization and Disease,* Cornell University Press, 1943, p. 26.

[45] Francis Bacon, *Of the Advancement and Proficiencie of Learning,* Interpreted by Gilbert Wats, London, 1674, Book 4, ch. 2, p. 130.

[46] The Country Parson, ch. 3, in: *The English Works of George Herbert,* ed. G. H. Palmer, 3 vols., Boston and New York, Houghton Mifflin and Company, 1905; vol. 1, p. 214. The parson is also to teach that "after religion . . . three things make a compleate servant: Truth, and Diligence, and Neatnesse or Cleanlinesse" (*ibid.*, p. 237).





*Let thy minde's sweetnesse have his operation*
*Upon thy body, clothes, and habitation.*[47]

The last two lines are used by John Wesley in 1791 in his sermon "On Dress," in which he argues that "slovenliness is no part of religion" and that Scripture nowhere "condemns neatness of apparel. Certainly this is a duty, not a sin. 'Cleanliness is, indeed, next to godliness.' Agreeably to this, good Mr. Herbert advises every one that fears God:–

*Let thy mind's sweetness have its operation*
*Upon thy person, clothes, and habitation.*

And surely every one should attend to this, if he would not have the good that is in him evil spoken of."[48]

It has been noticed long ago that Wesley refers to "Cleanliness is next to godliness" as to a proverb.[49] However that may be, the significance of the quotation does not lie in the expression of a new truth; rather it lies in the religious fervor with which "the lower and middle ranks of life," i. e., those whom scripture forbids "to be adorned with gold, or pearls, or costly apparel,"[50] are admonished to keep themselves clean in appearance. Wesley wanted the dress of the Methodist to be plain as well as cheap. This meant that he could not easily hide dirt under perfumes and fashionable clothes. To the Methodist–as probably to the Quaker and others before him–cleanliness becomes a sign of respectability, and that means that even the respectable poor are now expected to avoid dirt.

Significantly enough, the stress on the religious meaning of

[47] The Church Porch, LXII, *ibid.*, vol. 2, p. 57.

[48] John Wesley, "Sermon 88, On Dress" in *Works,* vol. 7, fifth edition, London, 1860, p. 16. For the date, 1791, see *N. E. D. s. v.* "Cleanliness."

[49] W. Davenport Adams, *Dictionary of English Literature,* new and revised edition, London, Paris and New York, Cassell Potter and Galpin, p. 138.

[50] John Wesley, *loc. cit.*, p. 17.

cleanliness is paralleled by increasing emphasis upon its medical meaning. As a preacher, John Wesley quoted Herbert; as a lay medical adviser he quoted the physician George Cheyne. The latter, in his *Essay of Health and Long Life*, had said: "Every one, in order to preserve their Health, ought to observe all the Cleanness and Sweetness in their Houses, Cloaths, and Furniture, suitable to their Condition." [51] With slight changes, these lines reappear in the preface to John Wesley's *Primitive Physic*, dated 1747.[52]

There are other voices, apart from Wesley's, praising the medical and moral virtues of cleanliness. Dr. William Buchan, in his famous *Domestic Medicine*, a popular medical handbook, has a chapter "Of Cleanliness" in which it is recommended "as necessary for supporting the honour and dignity of human nature, as agreeable and useful to society, and as highly conducive to the preservation of health." [53] Reversing the order,

[51] George Cheyne, *An Essay of Health and Long Life*, London, 1724, p. 18. The particular meaning of these words evinces from p. 12: "Nor shall I add any pressing instances, to avoid *wet* Rooms, *damp* Beds, and *foul* Linnen, or to remove *Ordure* and *Nusances*; the Luxury of *England* having run all these rather into a *Vice*."

[52] John Wesley, *Primitive Physic:* or, An Essay and Natural Method of Curing most Diseases. Twenty-first edition, London, 1785, p. xiii: "Every one that would preserve health, should be as clean and sweet as possible in their houses, clothes and furniture." The date of the preface is given on p. xvi. The role of John Wesley in the spread of a "health" movement has probably been over-emphasized by Sir George Newman, *Health and Social Evolution*, London, Allen and Unwin, 1931, p. 61; cf. Shryock, *op. cit.*, p. 90. Moreover, Sir MacFarlane Burnet, in the *Lancet* of Jan. 17, 1953, p. 103, has drawn attention to the efforts made in the nineteenth century to impart the relatively high standards of cleanliness of upper class society to its lower strata. But it seems nevertheless important to note the currents among other than aristocratic and well-to-do circles.

[53] William Buchan, *Domestic Medicine:* or, A Treatise on the Prevention and Cure of Diseases by Regimen and Simple Medicines. Second edition, London, 1772, p. 131. The whole chapter (VIII) is worth attention because of the inferences it allows to the widespread prejudice against cleanliness in the case of sick people.





John Pringle, the British army physician, says: "Cleanliness is conducive to health, but is it not obvious, that it also tends to good order and other virtues?" [54] And Benjamin Rush, who quotes these lines with approval, states that "too much cannot be said in favour of cleanliness, as a physical means of promoting virtue." [55]

The insistence on cleanliness is vague as long as it is not accompanied by definite requirements. In 1794, Dr. Hufeland, in his treatise on long life, suggested not only daily washing but even, if possible, a daily change of linen.[56] For the majority of the population, the latter was as yet a utopian demand. However, the introduction of the Leblanc process, in 1791, for the manufacture of soda, and the contemporary revolution in the cotton industry laid the preconditions for an eventual realization of this utopia. At any event, by the end of the eighteenth century, the physiological concept of cleanliness had not only been greatly advanced over previous times but had also become imbued with a moral and religious force. Cleanliness was trans-

[54] Quoted from Benjamin Rush, *An Inquiry into the Influence of Physical Causes upon the Moral Faculty* (1786), Philadelphia, 1839, p. 15. Rush refers to Pringle's "oration upon Captain Cook's Voyage, delivered before the Royal Society in London" as his source (*ibid.*). In his *Observations on the Diseases of the Army*, seventh edition, London, 1775, p. 92. Pringle writes that "officers judge rightly with respect to the health of the men, as well as to their appearance, when they require cleanness both in their persons and clothes." Remarkably enough, he believes that "plague, pestilential fevers, putrid scurvies, and dysenteries, have abated in Europe within this last century; a blessing which we can attribute to no other second cause, than to our improvement in every thing relating to cleanliness, and to the more general use of antiseptics" (p. 332). Regarding London, he admits that there is room for hygienic improvement, but adds that "some of the main points have been well attended to; such as regard the privies, the common sewers, and the supplies of fresh water; and the people in general are very cleanly" (p. 335).

[55] Rush, *loc. cit.*

[56] Christopher William Hufeland, *The Art of Prolonging Life*. Translated from the German, 2 vols., London, 1797; see vol. 2, p. 236.

ferred from the domain of cosmetics to that of health, and with the Enlightenment, the appeal to health became an ever more powerful motive for action. Guided by their own rationalization of life, men also rationalized the past. The laws of the Bible imposing the ritualistic stamp of clean and unclean were now explained as wise sanitary prescriptions by a shrewd law giver.[57] This change in the mentality of modern man also brought about a change in his concept of infection.

## V

The nineteenth century completed what we may call the secularization of the concept of infection by redirecting the basic meaning of the term, by giving it a new scientific content and a new moral force. If we look up the words "infection" and "to infect" in the New English Dictionary, we find that the medical meaning is emerging as the most concrete one. The notion of immersing or staining an object has become obsolete and so has the notion of impurity in the chemical sense of an alloy or the adulteration of a substance. The medical meaning, in various shades, stands in the foreground and overshadows the other broader meanings of corruption and defilement. The latter still exist but seem relegated to the status of similes and metaphors. Such a semantic circle was made possible by the purge to which the Enlightenment of the eighteenth century had subjected everything "superstitious." But the semantic change could not have been achieved without filling the notion of infection with a more strictly scientific content than it had had before. This was done by the rising science of bacteriology which substituted pathogenic microorganisms for the miasmata, contagia, effluvia, and corruptions of old. It would be repetitious

[57] See e. g. Rush, *loc. cit.*





to recount the well-known tales of Schwann who proved that putrefaction needed an external agent; of his colleague Henle, at the Berlin laboratory of Müller, who postulated the identity of contagions and miasms, believing in the organic nature of both; of Josiah Nott's animalcular theory of the transmission of yellow fever; and of John Snow's theory of cholera propounded a few years later. The endeavors of these and many others prepared the way for Pasteur's investigations and the work of Robert Koch and Joseph Lister. Much resistance had to be overcome, yet by 1900 the victory was complete. To dwell upon the progress which has since been made would be to repeat another often told tale. Instead we had better sum up what we have said so far.

We started out with the observation that our modern medical concept of infection emerged from the notion of ritualistic or religious pollution of which disease was but one type. The Greek physicians accepted this older terminology, at the same time giving it a naturalistic turn. This was the first secularization of the concept. I must leave it to those better trained psychologically to decide how successful this turn was. I expect that they will claim that a good deal of the dread of higher powers and of feelings of guilt still are hidden in our minds. During the Middle Ages and Renaissance we found a progressive recognition of what, today, we call infectious diseases. The belief in disease entities of a specific character was strengthened in the nineteenth century by the discovery of bacteria as specific etiologic agents. The interpretation of infection as resulting from filth guided public health measures in the medieval cities as well as in the industrial centers of the early nineteenth century. The notion proved insufficient and was replaced by deepened scientific insight. But the emergence of nineteenth century hygiene and bacteriology and asepsis were themselves conditioned upon willingness to rationalize the conduct of life in accordance with

medical rules. This process, initiated in the eighteenth century by a widening regard for individual cleanliness, led to the second secularization of the concept of infection. The medical meaning of the word, backed throughout by the sciences of bacteriology and immunology, has become the prime meaning.

These are the structural elements of the concept of infection which our historical analysis has revealed to us. To check its completeness we turn once more to the definition from which we started. Infection, we read, is an "invasion of the tissues of the body by pathogenic organisms . . . ." We may stop here and wonder again about the use of the curious word "invasion," reminiscent of hostile armies whose onslaught ought to be resisted. If we had looked up another dictionary we might have found another word instead of "invasion." Yet some image seems necessary to explain the encounter between the human being and his enemies, the pathogenic organisms.

In its early enthusiasm of some seventy years ago, the bacteriological school believed that man plus germ equalled disease. It was then realized that the matter was not so simple and that natural or acquired immunity and somatic as well as psychic disposition had to be taken into account in order to explain why some people fall ill, while others remain healthy; and why the same person may long harbor germs before the germs suddenly produce disease. It was during that period that Dr. Ottmar Rosenbach, in an essay still worth reading, pointed out the similarity between the old protective measures against evil spirits defiling man's soul and the extreme bacteriologist's endeavor to protect the welfare of the body.[58] Far from accepting Dr. Rosenbach's analysis as criticism, I believe that he really laid bare a necessary desideratum. As long as infection was held

[58] O. Rosenbach, *Physician versus Bacteriologist*, New York and London, 1904, p. 247.





to be a pollution, it was understandable in human terms. It was punishment for a trespass, a sin, or a crime, or merely the danger threatening from a supernatural power. At any rate, man thought he knew why he had become infected.

The nineteenth century tried to break radically with this anthropomorphic heritage. It succeeded as far as the explanation of the mechanism of infection is concerned. The bacteriologist's job was to find out what happened after man and germ had met. Why had they met? As far as the bacteriologist was concerned, this question was irrelevant. "By accident," he might say, if an answer was insisted upon. But as a physician, or public health officer, or citizen, the same bacteriologist took quite a different attitude. The more he came to know about the mechanics of infection, the more he believed that he knew how infection could and should be avoided. Responsibility for the prevention and cure of infection has now become a moral and even political force which it never was before. This being the case, our attitude has to be acknowledged as part of our concept of infection. In defining infection as an injury caused by an invasion by pathogenic microorganisms, we indicate our readiness to resist them. Modern physics boastfully or plaintively speaks of the meaningless universe. But there is no meaningless universe in medicine. Human beings are not satisfied with viewing health and disease as matters of mere chance separable from their lives. Health, diseases, recovery, and other medical categories mark biological conditions as desirable or undesirable. The latter characteristic accounts for the medical nature of the concept of infection and for its persistence under different cultural conditions with different notions about the fight against pollution.