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# INSECTS AND DISEASE.*

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NEW YORK.

IT is a gruesome commonplace of existence that any given form of life can be maintained only by subsisting upon some other life. The mammalia, beginning with man, kill and prey upon each other and on the lower forms down to the end of the sentient scale. On the other hand bacteriology reveals a microscopic world in which the organisms can thrive only by parasitism upon and often by destruction of the higher forms of life. And these microscopic parasites have in turn other parasites still more minute which feed upon them. Again there are other creatures which make it their business to bring these microorganisms into congenial contact with their hosts. Of such, for instance, are animalculæ which enter the human intestinal canal, burrow into its mucous tissues, and thus make a portal of entry for bacteria. It seems that bacteria do not, as a rule, penetrate the uninjured mucous membrane; but with this aid which the animalculæ offer they may find ingress to the various tissues and organs and produce their character-

* Read before the Medical Association of Greater New York, May 18, 1908.

istic lesions. It has been found that typhoid and cholera cases may come about in this way. The whip-worm (Trichuris) was a century ago looked upon as a cause of typhoid; its abundant presence was noted in epidemics of that disease; we know now it but played the part—and the very important part—of an intermediary. Metchnikoff has suggested that appendicitis might originate by the penetration of bacteria through the tissues which have been made permeable by intestinal parasites. The intermediaries with which we are here concerned are insects; and they play their part in various ways. The germs may stick to their bodies; or the germs may be eaten by them and deposited upon human food and drink with their excreta; or the insects may eject germs from their mouths; or the insects may die after eating the germs and the bodies of the insects may fall into food; or they may dry up, crumble, be disseminated as dust, and be either inhaled or ingested by human beings; or the insects may inject into the host disease-permeated blood which they have previously sucked from an infected animal.

First with regard to the common house fly: The tubercle bacillus is unquestionably distributed by flies. No one can doubt this who has seen the photograph which depicts a Petrie plate containing a nutrient medium upon which was deposited a fly that had previously walked in and had got the sputum of a consumptive entangled in its feet. A glass cover confined the fly. The plate was at first perfectly clear; soon colonies, visible to the naked eye and made up of uncountable bacilli, developed upon the track made by this fly.

A word seems here in place concerning any possible phthisiophobia that might arise from

this fact. There is no disease from which human beings suffer regarding which a just sense of proportion is so essential. The fly certainly is a factor in the propagation of tuberculosis, but only one of a number, nor is it one of the chiefest. We have flies with us only a part of the year, whereas tuberculosis is with the race throughout the year and is contracted in various ways in one perpetual round.

It is certain that flies help greatly to swell the infant death rate. The infant mortality is greatest in fly time. There are few more congenial culture media for bacteria than milk, especially amidst the uncleanliness which obtains in the houses of many very poor people. This fluid easily becomes contaminated with the excreta of flies and with the noxious matter clinging to their feet. Tuberculosis is thus in a very appreciable manner contracted by children, as also dysenteries and diarrheas. This is especially so since we are now convinced that all kinds of diarrheas, except the comparatively few cases which are induced by mechanical causes, are due to specific germs. The work which has been accomplished by the authorities, with the co-operation of medical and other beneficent societies, has had the result that contamination of milk by flies, before it reaches the consumer, is probably rare now-a-days; the infection which results from milk through the agency of flies becomes possible mostly after delivery to the consumer.

Typhoid fever is certainly disseminated by flies, although there are of course other sources of infection. Flies pollute food and drink by means of the excreta which they convey from dung-heaps, manure pits, open closets, and of the refuse which they convey from rotting vegetable matter. They breed almost exclusively in excre-

ment. They certainly disseminate cholera; and cases of tetanus seem to have been originated through their agency.

I have in connection with this subject been greatly interested in the work done by Daniel D. Jackson, S.B., in behalf of the Merchants' Association of New York, as presented in their report to Governor Hughes *on the pollution of New York Harbor as a menace to health by the dissemination of intestinal diseases through the agency of the common house fly*. In considering the ways in which flies act as agents in the propagation of disease, one should first take into account atmospheric impurities. Dr. Jackson has found, for instance, in one specimen of city dust, plaster, iron rust, stone-dust, cement from building operations, dirt from excavations or from badly constructed tents, ashes, house-sweepings, and dried garbage blown from barrels and cans, chimney-soot and cinder from industrial plants, excrement of horses, dogs and other animals, dried sputum of the tuberculous and of those having bronchitis, naso-pharyngeal catarrh or pneumonia in its first stages.

How pathogenic a dirty atmosphere may be is impressed upon any one who has seen the series of plates which Dr. Woodbury had exposed when he was the Metropolitan Street Cleaning Commissioner. Of two such plates one would represent atmospheric conditions in densely crowded neighborhoods, where the sanitary conditions were comparatively poor. And such a plate would presently, after exposure, teem with bacteria, moulds, fungi and every kind of impurity deleterious to human health. Its companion plate, exposed in a cleanly and salubrious district under precisely similar conditions, would be almost wholly free of impurities.

It is surely no trifling matter when all such impurities are taken up by flies and other insects and are deposited upon food stuffs which are exposed upon the thoroughfares and in the homes. There is nothing like a specific instance to illustrate a situation; Dr. Jackson supplies this when he states that he captured along the New York river front a fly which was carrying in its mouth and on its legs 100,000 fecal bacteria. "He had been behind the large packing boxes down by the wharf and was on his way to the nearest milk-pitcher."

We have long looked upon the house fly as a sort of necessary nuisance, as a sort of scavenger which people must put up with who will persist in uncleanly habits; it is only up to recently, however, that we have come to look upon it as a dangerous pest. Dr. Jackson computes that in New York City it is the occasion of some 50,000 cases of sickness, of some 650 deaths from typhoid and 7,000 deaths from other intestinal diseases. We look upon typhoid as an autumnal fever. Many an urbanite has returned from his vacation stricken with this disease, and the cause has frequently been assigned to tainted wells. Wells are certainly from time to time at fault, but not so generally as is often assumed. If we count back two months from the fall rise in typhoid deaths to the time when the disease is contracted, it will correspond exactly to the curve of prevalence of flies and to the curve of rise in deaths from diarrheal diseases of both children and adults. It will also correspond to the temperature curve; it is, therefore, erroneous to attribute these diseases to hot weather alone. Climatic conditions may predispose by reducing the vitality, but they are not the essential cause; temperature does not produce

the specific germ—the causal agent—which invariably accompanies the disease. The activity of the house fly, states Jackson, is in proportion to the temperature, and the time when this insect is most active and most numerous corresponds exactly with the time of contraction of diarrhea and of typhoid fever.

Infantile disorders and the dysenteries prevail throughout civilization in hot weather; these diseases are of germ origin. The immunity from diarrhea of breast-fed babies and the frequency of its occurrence among artificially fed infants point conclusively to germ transmission in food and drink. Several epidemics of a malignant type of dysentery have radiated from a single point and have disappeared completely when proper disinfection of closets was enforced. Flies generally go but a few rods from their breeding places except in warm and sultry weather, when they extend their travels by day and flock indoors at night. Food and filth attract them equally.

Typhoid fever is disseminated whenever the bacilli in the excreta of typhoid patients are not properly destroyed by disinfection or burning. They may be carried from open or box privies by means of underground drainage into wells, streams, small lakes and reservoirs; the flies carry the germs from such excreta to food and drink, by which means the disease is propagated. Typhoid carriers may for months and years harbor the germs, for the most part in the gall-bladder, and may by means of their evacuations spread the disease.

In order to avoid typhoid, waters should not be contaminated; in cities sanitary plumbing is essential and filters may be used. Milk should

be pasteurized where one cannot be assured of its source. In rural districts large metal vessels should be used; the excreta should be covered with earth, and the vessel should be emptied daily in a place where it is certain the drainage would not be dangerous. Manure is to be put into tight pits or vaults without wire screens (which would be corroded by disinfectants); there should be an outer door from which the manure can be shoveled away. A barrel of chlorid of lime should be at hand, which should be sprinkled upon each deposit of manure. Thus the breeding of flies is prevented.*

Trachoma is transmissible by flies; as also anthrax by the horse-fly. The ordinary fly may ingest the eggs of tapeworms and of other intestinal parasites and defecate these ova in viable condition. Chantemesse declares Asiatic cholera to be conveyed by flies.

They are becoming interested in flies in London; the Public Health Committee of the County Council has received many complaints which led to an investigation and report by Dr. Hamer, who selected in different parts of London twelve centers, at each of which businesses were conducted which might be assumed to be favorable to the breeding of flies. Included in these centers were refuse depots and dust wharves, a manure depot, stables, cow houses, offensive trade premises and a jam factory. From June through October of last year observations were made in ten or more living rooms at varying distances from each center, from which it was manifest that accumulations of manure and, in less degree, of house dust and other refuse, promoted the fly nuisance, which was noticeable not only in the

* L. O. Howard, House Flies, U. S. Dept. of Agriculture. Bureau of Animal Industry.

immediate neighborhood, but at a distance of two thousand yards or more.

Howard relates that the following method of destroying the eggs and the larvæ of the house-fly is being tried in France: residuum oil is used in privies and cess-pools. Two liters per superficial meter of the pit is mixed with water, stirred with a wooden stick and then thrown into the receptacle. This covering of oil should kill all the larvæ, prevent the entrance of flies into the pit and, at the same time, the hatching of eggs. A protective covering is thus made for the excrement, and this is said to hasten the development of anaerobic bacteria as in a true septic pit, leading in this way to the rapid liquefaction of solid matters and rendering them much more unfit for the development of other bacteria. For manure it is recommended to mix this residuum oil with earth, lime and with phosphates and spread it at different times, in the spring by preference, upon the manure of farms and stables. To destroy flies in houses, Delamarre of Paris advises that a solution of formol in water, one part to nine, be put on plates; twenty-four hours later not only the plates, but a little space around them will be covered with flies and mosquitoes which have been attracted by the mixture and its emanations. The solution should be changed every day. Of course, the best prophylaxis against flies is such cleanliness in and about houses that there will be nothing to invite these scavengers.

As to mosquito fever, which term we are now invited to use in preference to malaria: anopheles breeds in still water, in moist sand or moss, in pools by the side of open streams, in permanent accumulations of water of any sort—irrigating ditches, stagnant waters, where there is green scum, in beds of old canals, old horse troughs

and the like. It conveys from the blood of a malaria patient the plasmodium, which develops in the erythrocyte; subdividing, it bursts through the cell and enters the serum as spores. When the blood of a malaria sufferer is sucked into the stomach of anopheles, the parasite undergoes sexual development and gives birth to numerous spindle-shaped "blasts," which enter the mosquito's salivary glands and are ejected with the poison into the body of the next person bitten; and if this latter unfortunate has been non-malarial, he thus contracts the disease. Prophylaxis lies in destroying all breeding places within the radius of a mile (anopheles do not usually fly to great distances). We drain or fill in with earth, or cover the surface of water with a thin film of kerosene oil, or introduce numerous sticklebacks, or gold or sunfish, which eat the larvæ of the mosquito. Houses are screened; the mosquitoes which have entered the house are destroyed; pyrethrum powder is burned upon a tin dish. Especially are mosquitoes kept from biting those who are sick with or have suffered from malaria. Anopheles bites mostly after sundown; therefore, we caution people against sitting exposed outdoors at night. In our latitudes two kinds of mosquitoes prevail: anopheles and culex. The latter does not transmit malaria. There are appreciable differences between these mosquitoes: the culex has clear wings; its palpi are short; when resting on a wall it appears humpbacked; the head and beak are not in the same plane with the body and wings, but project at an angle toward the surface of the wall. Anopheles has wings more or less spotted; its palpi (which extend along the side of the beak) are long, nearly as long as the beak; when at

rest, its head and beak are on practically the same plane with its body; the insect seems to be standing on its head.

The body louse, it would seem, has possibilities of disease propagation beyond the pruritus and the local lesions which it occasions. Nakao-Abe* has reported an examination of lice which had been about typhoid cases, and about those in attendance upon such cases. He immersed these insects for some minutes in a 1:1000 solution of mercuric chlorid, washed them again in sterile water and finally ground them in an aseptic mortar. The material thus triturated was inoculated into animals and upon culture media. By this means the bacillus was found in the lice of three out of four typhoid cases.

J. P. Mackie† relates the features of an epidemic of relapsing fever in which the pediculus corporis seemed a causative factor. The epidemic arose in a mixed settlement of boys and girls living under similar conditions, but inhabiting different buildings. A very high percentage of the boys fell victims to the disease in the course of a few weeks; a much smaller percentage of the girls fell ill and at infrequent intervals extending over three months. The boys differed from the girls in being infested with body lice from which the girls were almost wholly free. A well marked percentage of the lice taken from the infested wards (in which the boys lived) contained living and multiplying spirilla. The stomach of the louse was the chief seat of multiplication; and this was carried on notwithstanding active digestion, and after the disappearance of all other cellular elements. Other organs became secondarily infected. The secretions ex-

* *Muenchener Med. Wochensch.*, Sept. 24, 1907.
† *Brit. Med Jour.*, Dec. 14, 1907.

pressed from the mouths of the infected lice contained many living spirilla, which existed also in the upper digestive tract. The ovary was frequently infected, but spirilla were not found in deposited ova. With the increase of the epidemic among the girls body lice became more in evidence. With the subsidence of the epidemic among the boys the percentage of infected lice fell.

Relapsing fever we find to be generally associated with poverty-stricken, half-starved and overcrowded communities, where lice are apt to be in evidence; in mixed communities the disease seems to single out principally the poor and the unclean. In Russia, it is said, there is a great deal of this disease.

The bed bug has from time immemorial been obnoxious enough on his own account. Undoubtedly cases of smallpox epidemics are disseminated by them in cheap lodging houses, and perhaps more frequently than by any other means. And were it not for the frequent vaccinations which are made by Health Departments, epidemics of this disease would certainly be much more frequent than they are now. Tubercle bacilli have been found in the blood of the bed bug. Dr. Gerault, of the Department of Agriculture, at Washington, has found that this insect (the cimex, or clinocoris) may live for many weeks without food. During the winter it becomes comatose and may live thus beyond three months; it has been known to exist thus eight months. And the species may in this way continue its existence under adverse circumstances from season to season, in lumber camps, summer houses, empty apartments and the like. The bed bug seems to have other host relations besides those with the human race. Mice and rats, for

instance, both living and dead, are attacked by them; of this more presently.

Weber has investigated certain small insects, the procidæ, which are to be found in great profusion in barns and outhouses where animals are kept. These are chewing insects, fond of farinaceous food; they live about troughs, granaries, feed-chests and mangers. There is a wingless form of them which is known popularly as the "death watch" and which has often been mistaken for lice. A tuberculous cow will deposit sputum swarming with bacilli mixed with meal over the woodwork of her stall. These insects consume this feed and fill their stomachs with saliva, sputum and meal. Weber held a single sheet of a newspaper under the bag in a room and with a few taps caught two thousand specimens. He found that some of these harbored tubercle bacilli. He injected the ingested material into the peritoneal cavity of guinea pigs and developed tuberculous disease in the latter.

It is not at all unlikely that cancer is an infectious disease. Tynes* describes what certainly seems to be an epidemic of cancer extending through a number of years in and about Fishersville, Va., the region in which he has been practicing. The work of Gaylord and Clowes in the Cancer Laboratory of the New York State Department of Health would seem to demonstrate the communicability of cancer. It is relevant, therefore, to note the paper by Webb in the *London Lancet* of March 21, 1908, entitled: "Do Fleas Spread Cancer?" He describes a case, from which he concludes:

A woman, aged fifty-eight, in good health, visited toward the end of November, 1907, a

* *Journal of the American Medical Association*, March 21, 1908.

poor woman suffering from advanced rectal cancer. The visitor was severely flea-bitten on the right breast. On December 2d, Webb was shown the breast, which was inflamed and resembled that of a woman the third day after delivery, except that the nipple was somewhat retracted. The condition was diagnosed as interstitial mastitis, and after a week's treatment external signs of inflammation were gone and the breast was nearly its normal size, but in a week or so it had enlarged again. There was little pain and the size fluctuated; later blood was discharged from the nipple. On February 1st obstruction of ducts by papilloma and congestion were diagnosed. On February 17th the entire breast and an enlarged gland were removed. On microscopic examination the growth showed in part simple papilloma, but in others it had the malignant characters of a duct carcinoma. While it may have been only a coincidence, Webb emphasizes the following points: (1) The patient was bitten by fleas from the bed of a cancer patient; (2) there followed an inflammation (though not necessarily *propter hoc*); (3) after about a fortnight a definite growth developed, ending in duct carcinoma.

The flea is a very essential factor in the transmission of the bubonic plague from the rat to man; in all probability it must be considered most of all in the propagation of the disease in its epidemic form. It sucks the bacillus pestis from the blood of the victim; but unlike other disease-transmitting insects its defecations upon the skin convey the infections. Thus those who bathe well are so much less likely to be stricken. No measures of prophylaxis which ignore the flea will be successful. Man seems to play an important part in plague propagation; the destruction

and removal of rats is of course imperative; but effective prevention of the plague must eliminate the flea, which is the chief carrying agent. When the rats die the fleas desert their bodies for other rats or for human beings; besides conveying the infection from rats they no doubt transmit it from man to man, from the stricken to the healthy, without any intermediation on the part of the rat.

A gentleman of a cheerfully Darwinian turn of mind has observed that any one species of creature would, if the destructive and restrictive forces of nature were held in abeyance, and if its members were all to die natural deaths, overcome the whole earth in a discouragingly brief period of time. The rat, for example breeds three or four times a year. The female begins when from four to five months old. The average litter is ten; oftentimes it is fourteen or more. Upon a decidedly conservative estimate a single pair, breeding without check or life losses, three litters of ten each in a year, would in three years have progeny exceeding twenty millions; the eleventh generation would begin the fourth year numbering over one hundred million. And as to the propagation of the fleas which live upon the rat—where is the mathematician whose psychism is of sufficient scope to undertake so infinite a computation?

Spotted or Rocky Mountain fever occurs during the spring months in Montana and neighboring states.* Dr. Wilson and Dr. Chowning have found the specific cause to be a protozoon organism (a pyroplasma) which is transmitted from cattle to man through the agency of the tick, an insect which is responsible for Texas or cattle fever. Other diseases which are contracted

* Rickett's Infection, Immunity and Serum Therapy.

through the intermediation of insects are: the sleeping sickness by the tzetze fly, elephantiasis and filariasis by the mosquito; the bubonic plague in the East by means of lice, and typhus and leprosy and other diseases prevalent among vermin-infested people, by means of fleas. I do not touch upon stegomyia, since the part it plays in the production of yellow fever is familiar.

I have in writing this paper been painfully conscious that it would hardly come in the same category with a description of a pink tea; I feel rather apologetic regarding some of its gruesome details. Nevertheless, the subject is obviously becoming very important—and in many other aspects beside the purely medical one. It would seem a far cry indeed from flies and fleas and mosquitoes to national catastrophes and empires and civilizations; yet the relation is logical and very close. Consider what devastation the bubonic plague has wrought in the world's history; how on the other hand such men as Ross and Haffkin are to-day driving it from India. Consider how malaria has for many centuries malignly influenced Grecian and Roman civilization; how Koch and his associates are now making regions in Africa, which have hitherto been deadly, perfectly safe and habitable by the white man; how the Panama Canal, which will certainly be built, could never have been cut were not Gorgas and his colleagues making and keeping the canal zone as salubrious and as free of infection as any American community.

But these things, as Kipling would say, are another story, which by reason of the time I have already taken, I may not here begin.

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