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ANIMAL DISEASES TRANSMISSIBLE TO MAN

THE ZOONOSES

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Man is an animal that has only recently, in a geological sense, set himself apart from other creatures. He arose as did other mammals from the same reptilian ancestors and has shared their parasites and their diseases in all stages of his evolution. Some of these diseases have become unique to him and others have retained an ability to infect many species. His continued close association with other animals maintains this sharing of parasites. The hazard of shared infection is greatest among men engaged in livestock production and in the associated industries.

Domestication of animals completely changed human history. Anthropologists do not agree on the process of domestication; some hold that it was the fortuitous result of religious rites. A few people in Indo-China still keep chickens so that the sun god will be greeted with the crowing of the rooster each morning and be properly appeased. Neither the birds or the eggs are eaten. Others believe that man recognized the value of keeping animals for food purposes from the first. Irrespective of this belief, almost all of the anthropologists agree that domestication was a long process taking perhaps 10,000 years and that as early as 8,000 years ago the process was near completion; all of the present domestic animals being found with remains of prehistoric man.

The development of farming led to a specialization of skills which gave rise to civilization itself. No longer was it necessary for all men to devote their lives to the raising of livestock and crops. Since the coming of the Industrial Revolution, a little over a hundred years ago, the number of people engaged in agriculture has rapidly decreased from 75 percent to less than 10 percent in the United States today. The city based majority tend to forget the sizable minority that raise animals and plants and, more important, the even larger number that work in related industries that serve farmers or process agricultural products and who share many of the farmers' hazards.

The association of man with animals is not limited to these fields of animal production and processing. Other people live and work or play in rural areas. The hunter handling rabbits, the fisherman landing a fish and the bridle-path devotee on his horse. Nor are cities devoid of opportunities for shared infections. Animals occupy an important place there. Even the apartments in midtown Manhattan have dogs, cats, budgeigars, hamsters and myna birds. The housewife cleaning an unused closet comes in contact with

paper and cloth soiled by mice. The tenament dweller may encounter in his cellar or alley a city dweller that far outnumbers man--the rat. The hazard of zoonosis is close to man in the city, too.

The world health organization lists some 80 zoonoses--diseases transmissible from animals to man. Many of them are rare and obscure. Pseudorabies, a virus infection of livestock, is one of the diseases enumerated. A rather careful review of the literature has uncovered only 3 human cases and the evidence for these cases is circumstantial. This is not true of many other diseases listed such as brucellosis. In Wisconsin alone, we have laboratory confirmation for several hundred cases. The 80 zoonoses include established and questionable, rare and common diseases.

It is difficult to measure the public health significance of an infection. We soon learn about those infections that can kill. Last year, 6 human beings died of rabies in the United States; a very small number compared to the toll exacted by many other causes, yet nearly every individual old enough to read a newspaper has heard of rabies. Can we say, however, that 6 persons are insignificant? Eastern equine encephalitis, although not well known by the public, has produced about 100 deaths in the past 20 years and it has caused irreparable brain damage in a number of children that exceeds the death toll. The United States Public Health Service rightly believes that eastern equine encephalomyelitis is an important health problem. In an area in southern Georgia where we have been working in cooperation with the Georgia State Health Department for several years, eastern equine encephalomyelitis infection of man is rare. In the same rural areas, we find that about 25 percent of the individuals have antibodies to vesicular stomatitis virus. What is vesicular stomatitis? It is a viral infection of livestock characterized by vesicular lesions of the mucous membrane. In man it produces an influenza-like disease. We know of no evidence of serious sequelae or death. On the basis of serology there are a hundred cases of vesicular stomatitis of man each year to every one of rabies or eastern equine encephalomyelitis. Is vesicular stomatitis of man important? If one believes that the transient infections of man deserve attention, then vesicular stomatitis as well as a considerable number of other minor diseases capable of infecting man should receive more careful consideration.

The zoonoses includes viral, rickettsial, bacterial and protozoan infections as well as infections with the larger parasities. They can be classified according to host animal although this is often confusing as many of the parasites have several animal hosts and a few are almost ubiquitous. The encephalitic viruses have been isolated from a long list of animals including birds and mammals of several orders. Eastern equine encephalomyelitis is an example of the confusion over host. It is primarily a disease of birds, particularly wild birds, that probably serve as the reservoir from which the disease is transmitted to man by mosquitoes. The horse, like man, is an accidental host of economical importance but of no significance in the natural cycle of the infection.

Although a great many animals may become infected with a virus only a few act as essential reservoirs. Rabies can infect almost all mammals. Nevertheless, man is usually infected by dogs. Foxes or skunks act as the reservoir of rabies for cattle. Recently, we have learned that many insectivorous bats become rabid but we still do not know whether bat rabies has anything to do with dog, fox or skunk rabies. A discussion of about 10 of the zoonoses will illustrate the nature of these diseases and the scope of the control problem.

There are three species of brucella organisms: Brucella abortus of the cow, the least pathogenic for man of the three, Brucella suis of swine, of intermediate pathogenicity and Brucella melitensis of goats, which has the greatest pathogenicity for man. The risk of human infection differs according to the type of contact with infected animals. At the top of the list is the veterinarian and the dairy farmer who are exposed to cattle particularly at time of parturition. A great number of organisms is shed during the birth of a live infected calf or an aborted fetus. The packing-house worker is exposed in handling meat and the consumer may become infected through unpasteurized milk.

The national and state programs to control brucellosis are worth discussing from a public health and a regulatory standpoint. Burnet has pointed out that the control of many of the human infections for which science takes credit has not been due to public health agencies but has come about by the happy coincidence that man has become more polite as he has become more civilized and in this way causes less fecal contamination of himself and of others; we can point to the development of sewers and laundries, of washing of hands, installation of window screens and other pleasant inventions and habits. Even a decrease in a disease like malaria can be ascribed to the clearing of land and dispersal of human carriers to northern cities during the period of industrialization rather than to specific public health measures. The control of most animal diseases on the other hand has come about specifically by measures designed for that purpose. Brucellosis is a disease of economic importance; cause of abortions, infertility and loss of milk, but without a doubt, the public health implications have been an impetus behind the program.

The Wisconsin program for control of brucellosis was based upon research that showed that many infected animals become carriers and that these carriers could be detected by serological tests of two types; a blood test in which immune serum agglutinates the bacterial antigen or a milk test in which immune substances found in the milk enter into an agglutination reaction with the bacterial antigen. This latter is often called the ring test. The program to eradicate a disease-like brucellosis costs money; money that must be supplied by the state and federal governments. Such a program is not entered into lightly and must be approved by state legislatures and by Congress. Several questions must be asked, "Does public health importance of this disease warrant the cost of eradication?" The answer is probably "Yes" although the priority could be argued. "Does the tax of the disease on the dairy economy,

the abortions, the loss of milk warrant the cost." Here the answer is definitely "Yes." Nevertheless, the drive behind the program in Wisconsin was an ordinance passed by the Chicago Board of Health in 1951 setting a deadline, a time in 1955, after which milk from cows having brucellosis would no longer be accepted on the Chicago market. The control program in Wisconsin was initiated as a voluntary plan and then after this had gained acceptance county by county the plan became compulsory for the entire state in June of 1955. A state-wide program of this sort requires organization. Positive herds were found by a ring test on bulk milk. Then each individual in the suspect herds was tested. The Animal Disease Diagnostic Laboratory during the height of the campaign ran as many as 11,000 agglutination tests a day and over 3,000,000 tests a year. Cows positive on the serum test were sent to slaughter. Such herds were retested every 90 days until all of the animals remaining in the herd were negative. Over 114,000 cattle were eliminated in the 2 years between 1954 and 1956. Now all of the counties in Wisconsin have less than 1 percent reactors to the blood test. Out of the 144,000 cows in Dane County, less than 50 cows reacted on the last test. This is less than one-tenth of 1 percent.

The first important program for the eradication of a disease of human health importance was that for tuberculosis which began back in 1916. Eradication was a controversial subject at that time. Some men in both the medical and veterinary professions denied that tuberculosis could be transmitted from cattle to man. One city in Illinois made it illegal for any group within the limits of their jurisdiction to prohibit sale of tubercular milk. Nevertheless, the control program gained adherents. The Department of Bacteriology of the University of Wisconsin was very active in the early stages of this program. Dean Russell gave talks throughout the state in support of a testing program.

Eradication was based upon several things. Tubercular animals, the carriers of the organism react with erythema and swelling when tuberculin is inoculated into the caudal fold. Reactors are removed and slaughtered. At the time the program was initiated in Wisconsin in 1921, 10 percent of the cows in the state were reactors. This was reduced in twenty years to 0.2 percent. The cattle are now tested at least every 6 years. The national program, which Wisconsin follows, is not necessarily the best one and dangerous foci can develop and have developed in a 6 year period. Within the past 6 months, as the federal testers went through Dane County, twice as many reacting herds were found as during the preceding testing period. Some of these animals, although reacting to the skin test, did not have any visible lesions of tuberculosis. This "false positive" reaction is a continuing problem. On the other hand, some herds contained many reactors with active lesions. Any animal found to have extensive lesions when sent to slaughter is condemned; the meat is cooked and used as tankage. The United States Department of Agriculture meat inspection program was established largely to inspect for evidence of tuberculosis in meat carcasses. Epizootiologists are now restudying the tuberculosis program so that improvement may be made.

A statistician, interested in reducing government expenditures, suggested not long ago that a random sample examination be used in packing plants as it is in plants manufacturing batteries. The statistician obviously failed to understand the nature of the population being sampled. This would be the same as suggesting that one of every 50 university students be examined and the medical treatment for the next 49 individuals be based on the sample.

Anthrax caused by the bacterium Bacillus anthracis affects cattle and other livestock. An outbreak of this disease occurred during the winter of 1952 in the Middlewest. There were over 80 cases in cattle, swine and horses in Wisconsin. The source of infection is believed to have been a bonemeal food supplement imported from abroad. This outbreak illustrates the change of events that may be set off by infection of one individual. Horses that died of anthrax were sold to fur farmers to be used as feed for their animals. One owner, somewhat suspicious, fed the horsemeat first to some foxes which were of little value. No disease developed and being unaware that the fox is very resistant and that his more valuable mink were susceptible, fed it to the mink. The mink died. He pelted the furs but the contamination was detected. The furs were sent to several laboratories for decontamination with ethylene oxide gas. It did not kill the spores of this organism and after further futile attempts, the furs were destroyed. Another farmer pickled his pigs when they died of anthrax. It took a court order to destroy the pickled pork which he planned for his family use. Anthrax spores are extremely persistent. Fields on the University campus were contaminated more than 50 years ago. Whenever animals have been placed on the fields for a period of time, the disease has reappeared. Presumably the problem will not come up in the future as most of the contaminated area has been recently covered by dormatories.

Ulcers and pustules sometimes appear on the tests and udder of cattle. These can be caused by cowpox, a disease closely related to vaccinia and transmissible to man. They can be caused by vaccinia which was transmitted to cattle from man. They can also be induced by a virus infection called milkers' nodules which is transmissible to man. This is one of the skin conditions peculiar to agricultural workers. The viruses of two vesicular diseases of cattle, foot-and-mouth disease and vesicular stomatitis, will attack man. Foot-and-mouth is an exotic infection for which the federal government maintains border inspection and for which it has erected a large isolated research station at Plum Island. Vesicular stomatitis is an indigenous disease having a reservoir in southeastern United States and in Mexico.

Transmission is not a one-way track always from animals to man. Smallpox vaccine brought to this country from Japan at the time of the first world war was contaminated with foot-and-mouth virus which then spread to the cattle in the Midwest and caused millions of dollars of damage before it was eradicated. Tuberculosis, vaccinia and streptococcus infections can be transmitted to cattle from man.

Mastitis is probably the most important disease of cattle from an economic standpoint. Streptococci and staphylococci are often associated with the disease. Management factors, misuse of milking machines and even diet play a part. Viruses may be predisposing factors. The problem is complex and there is no organized program of control. Antibiotics are widely used to treat mastitis caused by streptococci and staphylococci. The drugs are extensively misused by farmers who read the ads for antibiotics in farm journals. One result has been an apparent shift from streptococcal mastitis to staphylococcal and mycotic mastitis. Another is trouble with starters in cheese factories. Microbial cultures used as cheese starters are very sensitive to antibiotics. A bacteriologist who studied the recent episode of food poisoning caused by staphylococcal toxins associated with a Colby cheese believes that it was the result of antibiotic residues. A slow starter (known to be a problem at Colby) permits the growth of staphylococci and the elaboration of toxin. A good starter would turn the batch of cheese acid rapidly and inhibit growth of staphylococci. Still another possibility was reported by the Food and Drug Administration, who found in 1956, that 7 percent of several thousand milk samples they tested had antibiotic residues sufficient to provoke a reaction in sensitized individuals. Effort is being made to reduce the hazard by regulations.

Additives are becoming a problem in livestock production. Hormones and antibiotics are added to feed to speed growth and increase feed conversion efficiency. Some systemic insecticides are now used. Paging through several issues of farm journals will give one an education in mass dispensing of drugs. Aureomycin and terramycin are sold by the ton. What do we know about the safety of these additives when passed on to the consumers of livestock products? The short-term toxicities have been explored but almost nothing is known about the long-term effects on health and on the resistence of man to disease.

We continually recognize new diseases in livestock. This does not mean that the disease is new. Our recognition may be new. Q-fever was recognized in Wisconsin cattle over 3 years ago. This disease has caused serious and fatal infections in dairy workers in California, slaughterhouse workers in Texas, Italian sheepherders and American soldiers. So far, only one clinical case has been observed in man in Wisconsin. Although the organism is shed in milk, the hazard from that source is likely to be small. The Milwaukee Board of Health fed raw milk containing a thousand guinea pig infective doses per millimeter to volunteers for more than a month. No infection developed. Can we then forget about it? Not until we know why Q-fever kills in one community and remains benign in another.

Leptospirosis is another sleeping giant. A killer in Palestine, a cause of serious infection in southeastern United States, it has caused few if any human infections in this area. The disease is widespread in cattle and swine although it is not considered a common disease. Several hundred cases are reported by Wisconsin veterinarians every month. The signs of disease in cattle are fever, abortion, bloody milk and icterus. The same organism, Leptospira pomona occurs in deer.

Beef tapeworm is not as rare as we like to believe. The cysts were found abundantly in the flesh of almost every cow in one herd sent to a Milwaukee slaughterhouse. Migrant workers had defecated in the pasture. Two years ago, 130 out of 188 cattle sent to a Chicago slaughterhouse from a Wisconsin farm were infected with Cysticercus bovis. The herd man was shedding proglottides in his stool.

Swine erysipelas is a common and important disease of swine. Several thousand cases are reported every month by Wisconsin veterinarians. Erysipeloid infections occur particularly among farmers and veterinarians. Fish and turkeys are another source of human infections.

Trichinosis is largely a disease of garbage-fed hogs. Five percent of the garbage-fed and one percent of grain-fed are infected. Accounts of human cases may be seen in the paper rather frequently--usually the victim ate rare sausage or raw hamburger. In 1935, examination of human cadavers revealed that from 5 to 30 percent of the population was infected. The proportion may be less now but no one knows. Properly processed meat is safe as refrigeration at 5 F for 20 days or 2 F for 24 hours kills the parasite. The prevalence of trichinosis among swine should decrease in the future because of the acceptance and enforcement of garbage cooking laws in all of the states. This reform unlike the program for control of brucellosis did not come about for public health reasons. Garbage cooking went into effect to control a disease of no human significance called vesicular exanthema but it should help to control two other important garbage-borne diseases; trichinosis and hog cholera.

Newcastle disease was introduced into the United States during World War II and spread within a few years to every state. In birds, it induces both a respiratory disease and central nervous system disturbance. Strains vary in lethality. Some kill almost every chicken; others induce inapparent infections. The disease in man is usually a conjunctivitis, but general respiratory manifestations have been frequently reported. Most human infections are associated with preparing birds for market. Several million dollars worth of vaccine for chickens is produced each year. Over ten years ago it was injected by syringe, an instrument the modern poultry farmer has abandoned. Mass-vaccination procedures were pioneered with Newcastle disease virus. Vaccine is now given in drinking water and by aerosol sprays. It can be dusted by airplane. These new mass-vaccination methods deserve study from the standpoint of public health.

Psittacosis or ornithosis is a problem associated with turkey production. In Oregon and Texas, turkeys die of the infection and so does man. In Wisconsin, the turkeys show no signs and man suffers a mild disease. The disease is widespread in many other birds; 50 percent of the Wisconsin pigeons appear to be infected and 10 percent of the ducks in one area on the upper Mississippi River were found to have antibodies.

A variety of Salmonella species occur in poultry. S. typhimurium, S. anatum, S. newport, S. derby and S. bareilly have been found in spray-dried

eggs. All can induce clinical illness in man. Two hundred and three human cases occurred among individuals eating pastries made with contaminated duck egg albumin. The Home Economics Department at the University of Wisconsin has shown that the standard roasting and broiling procedures will not necessarily destroy Salmonella in the more protected portions of the carcass of chickens.

The equine encephalomyelitis viruses are primarily diseases of birds. Outbreaks of the disease with fatal human cases are well-known on the East and West Coasts. Most people are unaware that these infections exist among wild birds in areas in which the disease is unreported in man and rare among horses. Pheasants, robins, crows and grackles in Wisconsin have antibodies to eastern equine encephalomyelitis virus. Does this mean they have the infection? During the past pheasant season, we took blood from birds shot by hunters and isolated the virus. Why haven't there been human cases in Wisconsin? We do not know.

Several unique problems in the control of zoonoses arise from social and economic factors. Physicians should be aware of them.

Farmers are reluctant to publicize livestock diseases. They do not like to become involved in a subject as complex as the relationship of livestock infections to human disease. There is often no gain in public health and there may be a loss in markets when sensational writing transforms a possible hazard under special circumstances into a danger that threatens the entire populace. Psittacosis and Q-fever are hazardous to a few people and not to the community. Employees of turkey dressing plants, particularly the men who take the birds out of the crates and those who do the defeathering, run considerable risk of developing psittacosis. Men who truck and raise turkeys are exposed to a much lesser risk. We have no evidence that consumers who handle the eviscerated turkeys in preparing them for the oven have ever been exposed to the virus. Plant operators and spokesmen for the turkey industry agree that physicians, who may treat employees of the turkey dressing plants, should be made aware of the possible exposure of their patient to psittacosis but they argue, "Why worry the consumer." To acquaint physicians with the real problem and to avoid public controversy over a hypothetical problem they suggest that psittacosis publicity be handled by the State Board of Health or the State Medical Society through professional channels and not through popular media of communication.

The professional channels have sometimes been inadequate. At a meeting jointly sponsored by the New York Academy of Science and the United States Public Health Service, several fatal cases of anthrax were reported among workers in mills handling imported goats' hair. No deaths occurred among workers who were attended by physicians alerted to the hazard of anthrax among the employees of the mill. Deaths did occur in a few individuals in which the diagnosis was tardy. This is evidence of the importance of a continuing effort to acquaint physicians in every locality with the special problems of zoonoses that exist in their communities.

When investigation revealed in 1956 that rickettsia of Q-fever could be isolated from raw cow's milk in southern Wisconsin, Department of Agriculture officials became concerned about the impact of this information on out-of-state consumers of Wisconsin milk. The information was reported at scientific meetings and in medical publications. It was not publicized in the press because there was no evidence that a significant public health hazard existed.

Rabies always poses problems. The word itself carries an emotional impact. It has overtones of centuries of dread, of a shining Pasteur, of anti-vaccinationists, of long letters to the editor and of endless controversy. During the recent epizootic of wildlife rabies, the three men in the community to whom citizens went for advice--the physician, veterinarian and game warden--sometimes gave conflicting information which showed a lack of understanding of their relative roles in the management of the rabies problem and of a failure to seek recent information available to their professions. In other communities one of the three took the initiative, seeking and achieving proper liason.

Effective liason improves the standing of all professions, particularly in the field of zoonosis in which progress is dependent to a considerable extent upon community action. The incidence of human infections with bovine tuberculosis and brucellosis has been markedly reduced by control of those diseases in livestock; a control that has been achieved to a large extent by state and federal regulatory agencies. Danger to the health of man from these diseases and from Q-fever has also been reduced by laws requiring pasteurization and inspection of meat. A concerted effort of the United States Public Health Service to control rabies of man through licensing and vaccination of dogs has resulted in an impressive decrease in canine and human rabies, at a time when wildlife and livestock rabies has been increasing.

Whether laws and regulations will effect control of disease depends upon the wisdom with which they are written. At the present time, the publicized prevalence of rabies in wildlife is being used by a segment of the population to urge the re-establishment of bounties on foxes. The fact that the skunk is the primary reservoir of wildlife rabies in Wisconsin and that the fox is of minor importance is not mentioned. A regulation considered unwise by men concerned with wildlife management may be enacted in the name of public health. Another example can be taken from the turkey ornithosis situation. We have no way of protecting employees of turkey processing houses from this disease at the present. Hasty enactment of regulations to prohibit the shipment of infected turkeys to processing plants would result in an unworkable and meaningless law as we have no method of detecting inapparent infections in turkeys. Control may be effected in another way. Epidemiologists have found that transmission to man appears to be by means of contaminated dust, particularly feathers soiled with fecal material. Use of dust control devices in the receiving, killing and picking rooms of a turkey evisceration plant might well prevent transmission of ornithosis to man.

Control of zoonoses is dependent upon research and continuing programs to educate both professional men and the general public.

We should recognize that agriculture as well as our entire environment is continually changing. The benign infection of last year may kill tomorrow. We should remain alert to research developments.

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Activities which Expose Individuals to Zoonoses

Groups at Risk	Diseases
Bird fanciers (pigeon and parakeet owners)	ornithosis-psittacosis
Children exposed to biting arthropods	encephalitis
Chicken farmers (broiler operators, egg producers)	Newcastle disease
Chicken packing plant employees	Newcastle disease
Clerks in pet shops and markets	ornithosis-psittacosis
Consumers of raw milk and new milk cheese	streptococcosis, brucellosis, Salmonellosis, tuberculosis, staphylococcal enterotoxemia
Consumers of uninspected meat	trichinosis, beef tapeworm, Salmonellosis, tuberculosis
Dairy farmers	milkers' nodules, cowpox, brucellosis, vesicular stomatitis, Q-fever
Diagnosticians, laboratorians and producers of biologics	Newcastle disease, ornithosis, brucellosis and others
Housewives	lymphocytic choriomeningitis
Hunters	tularemia
Livestock buyers and truckers	erysipeloid, brucellosis, anthrax
Pet owners	rabies, tapeworms, ringworm
Rendering plant workers	anthrax, brucellosis, Q-fever, erysipeloid
Swine farmers	erysipeloid, brucellosis, leptospirosis
Turkey farmers	ornithosis, Newcastle disease
Turkey packing plant employees	ornithosis, erysipeloid
Veterinarians	erysipeloid, brucellosis, Q-fever, rabies

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Signs and Lesions of Zoonoses in Man

Arthritis-myalgia

arthritis--erysipelas, brucellosis
myalgia--trichinosis, vesicular stomatitis

Conjunctivitis--Newcastle disease, tularemia, listeriosis

Cutaneous lesions

acneform lesion--cryptococcosis
erythemya and scaling--erysipeloid, ringworm
granulomatosis
ulcers--histoplasmosis
nodules--milker nodules
pustules and ulcers--anthrax, cowpox, tularemia

Encephalitis--meningitis

depression--brucellosis
encephalitis--viral encephalidities, listeriosis, rabies
meningitis--cryptococcosis, lymphocytic choriomeningitis, tuberculosis, listeriosis

Gastroentestinal disorder

enteritis--beef tapeworm
gastroenteritis--Salmonellosis, staphenterotoxin
typhoidal signs--tularemia

Mononucleosis and anemia

anemia--fish tapeworm
mononucleosis--listeriosis

Pulmonary disease

bronchiopneumonia--anthrax
pneumonia--ornithosis, Q-fever
sore throat--streptococcosis
tubercles--cryptococcosis, histoplasmosis, tuberculosis

Septicemia

febrile and debilitating--brucellosis
jaundice--leptospirosis