Infectious Diseases in Primitive Societies

Many common diseases are not maintained in primitive society and probably did not affect human evolution.

Francis L. Black

Infectious diseases have exerted some of the strongest of the pressures that shaped the development of modern man (*1, 2*). Historic records give dramatic accounts of the role which disease played in the displacement of American Indian and some Polynesian peoples from their lands (*3*), but more subtle effects of disease, working over long periods, may have had greater evolutionary impact. The penetration of the gene for hemoglobin S into West Africa has been cited by Livingston (*4*) as one instance in which disease has fostered the diffusion of a particular trait faster than other characteristics of the people who introduced it.

There is reason to believe, however, that many of our modern diseases did not exist in primitive populations. Measles, for instance, requires a larger population for its maintenance than existed in any coherent group in Neolithic times (*5*). The spectrum of diseases that afflicted man through most of his development may have been much smaller than that to which we have been subject in historic times.

Fossil and Historic Records

Paleopathologists have attempted to identify diseases prevalent in early man through lesions in his bones. From this evidence, tuberculosis seems to have had a very long history (*6*), and lepromatous leprosy a relatively short one, with the earliest definite cases dating from about A.D. 500 (*7*). The antiquity of syphilis has been the subject of much controversy. Examination of human bones, however, sheds no light on the much more numerous diseases that affect only soft tissues. Ancient soft tissues are only available from a few desiccated or anaerobically preserved human remains from limited areas and from the mummies of the relatively advanced Egyptian civilization. These provide evidence of various metazoan and protozoan parasites (*8*), but the amount and quality of material available has been inadequate to provide convincing data on the incidence of other infectious diseases.

Hare (*9*) pointed out that the ability of an infectious agent to multiply in a nonhuman host or to persist in the infected person beyond the acute phase of disease would have determined its ability to persist in the small populations of antiquity. Hare analyzed historical accounts without finding convincing evidence of smallpox before the first century A.D., of measles before the sixth century, or of cholera before the sixteenth century. He does, however, accept Hippocrates' description of mumps and a first-century description of herpes zoster (shingles). Interpretation of historical accounts is fraught with problems in identifying disease names and limited by the ability of the writers of the time to distinguish between diseases.

Modern Primitive Societies

Polunin (*10*) has suggested that contemporary primitive societies perpetuate conditions which existed in ancient peoples. The populations he studied in Malaysia were not sufficiently isolated to be free of infectious agents conferred on them by more cosmopolitan peoples, but he found a relatively small number of diseases responsible for the bulk of their morbidity. Among infectious diseases, malaria, yaws, and the fungal infection *Tinea imricata* were most common. Polunin recognized that his methods measured prevalence rather than incidence, and that other infections might account for more acute disease.

The study of modern primitive cultures is complicated both by the introduction of foreign disease to readily accessible populations and by the difficulty of determining long-term incidence rates in isolated groups. Many infectious diseases, however, leave a lasting trace, sometimes, as with smallpox, in the form of permanent physical changes, but more often in the form of persisting specific antibody titers. These traces can be determined with a single serum specimen or by a simple examination, and they can be used to estimate cumulated incidence rates for the total period covered by the life-span of the subjects. Where subjects of various ages are available for study, incidence rates for any period back to the birth of the oldest person can be estimated.

Paul *et al.* (*11*) used this approach to study poliomyelitis in a population of about 1000 north Alaskan Eskimos. By testing serums collected in 1949, they found a high incidence of type 2 poliovirus antibodies in persons born before 1930, but very few positive reactions in younger persons. Similarly, type 1 antibodies were confined to persons born after 1915, and type 3 to persons born after 1905. These results confirmed a history of a minor epidemic of paralysis in 1930 and a major one several years before 1921. Using this approach, they could not determine whether these viruses had been active in the community before the epidemic dates, but they could be confident that the viruses had not infected significant numbers of persons since the specified dates. It seems clear that, like measles in the Faroes (*12*) and the common cold in Spitzbergen (*13*), poliomyelitis spread in a small community with such efficiency that it soon killed or immunized so high a proportion of the population that the virus was unable to continue propagating. Since the virus is labile, when it could no longer replicate it died out from the community entirely.

The isolation of small oceanic island populations is often sufficient to give rise to long intervals between epidemics

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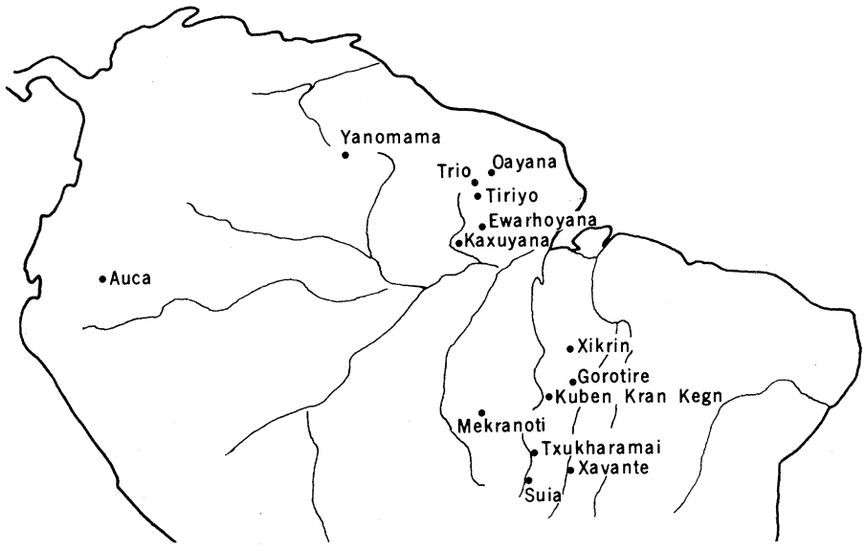

Fig. 1. Sketch map of northern South America indicating the locations of tribes referred to in the article.

of individual diseases. It can be shown with many diseases that the intervals are due to the infectious agent dying out and that new epidemics start, not with activation of latent pathogen in an island population, but only when the agent is introduced from the outside. An exception to this pattern is varicella (chicken pox), epidemics of which were shown by Hope-Simpson (*14*) to have originated by activation of latent virus. Isolation by wide stretches of water has never been typical of the majority of mankind, and failure of certain diseases to persist in the islands had not been seen as relevant to the condition of the human race in general.

In fact, the isolation of primitive mainland groups from one another may be as profound as the isolation of island populations. The Eskimos studied by Paul *et al.* are a case in point. Also, Adels *et al.* (*15*) have shown that measles did not persist in certain isolated Australian and Papuan primitive communities, and Anderson and Mufson (*16*) found that reovirus type 3 failed to persist in an isolated African tribe. The largest area still inhabited by primitive cultures is on the periphery of the Amazon basin (Fig. 1). Several workers, including the author, have looked at the epidemiology of infectious disease in the people of this area. Serological and clinical evidence of disease in the Xavante of Brazil was the subject of a major study by Neel *et al.* (*17*). Baruzzi and his colleagues (*18, 19*) have conducted various studies of the tribes of the Xingu Park, and Schaad (*20*) has studied two Surinam tribes. Black *et al.* (*21*) recently completed a study of seven Carib and Kayapo tribes in Brazil.

People of the Amazon, who retain their traditional social structures, are in Fenner's (*2*) second stage of human development, with incipient agriculture and relatively settled villages of about 300 persons. Tribes of more than a few hundred are unstable and tend to split, often violently. The Kayapo tribes, which we have worked with, seem to have arisen by such a fissioning process (*22*). If the population of a tribe falls below 100 persons, other pressures come into play, particularly the problem of finding marital partners not forbidden by incest taboos. Two small tribes in northern Brazil have recently joined the Tiriyo for these reasons (*23*). The population of the Amazon periphery is very sparse, and 200 kilometers or more of forest may separate neighboring tribes. Even then, the only contact may be hostile.

Table 1. Immunological evidence of past infection with various disease agents in isolated Brazilian Indian tribes. Suia and others include data on the Suia and associated tribes of the southern Xingu Park from Baruzzi *et al.* (*18*). Data on the Xavante are from Neel *et al.* (*17*). The numbers in parentheses after the tribes' names are the total population and the specimens available.

Characteristic	Disease	Percentage of sample giving positive reaction									
		Tiriyo (220, 200)	Ewarhoyana (14, 9)	Kaxuyana (40, 27)	Xikrin (123, 118)	Gorotire (400, 219)	Kuben Kran Kegn (300, 57)	Mekranoti (190, 175)	Suia and others (755, 258)	Xavante (1600, 412)	All (3640, 1475)
Endemic—high incidence, low morbidity	Herpes	91	75		90			93			95
	Epstein-Barr virus	97	100		97			96			97
	Cytomegalovirus	43		95	72			96			54
	Hepatitis B	5			61			71			56
	Treponema*	0	0	0	19		85	62		0	32
Enzootic—low prevalence over long time	Yellow fever	14			37	4	0	5	5	3	8
	Mayaro (arbovirus A)	47			46	37	20	49	30	18	33
	Toxoplasmosis	43			46			52	52	100	57
Introduced—explosive, transient	Measles	4	11	89	3	98	33	0	78	86	45
	Mumps	29	11	73	23	73	33	22			33
	Rubella	95	11	74	0			1			32
	Influenza A_2	13	0	22	16			5	2	0	8
	Influenza B	0	0	0	0			0	42	13	13
	Parainfluenza 2	3	0	14	89						47
	Poliovirus 1				30		49	4		87	54
Introduced—persistent	Tuberculosis				27			29	4	1	17
	Malaria†				41			6	84	62	50

* Treponema is endemic only in the Kayapo tribes Xikrin, Kuben Kran Kegn, and Mekranoti, as tested by the FTA-ABS or the treponema pallidum immobilization (TPI) test. † Positive tests are enlarged spleen in the Xikrin or fluorescent antibody in the Xavante.

Endemic Diseases

Serological test results and other evidence of past infection in South American Indian populations indicate that the prevalence of infectious disease may vary greatly with different diseases and in different tribes (Table 1). In one group of diseases, very high antibody prevalence rates were found in all but the very youngest age groups. We include in the category of endemic diseases those which showed a uniform proportion of positive test results in persons over 10 years of age, even if the proportion was considerably less than 100 percent, when it was known that the test being used was only sensitive enough to detect the higher titers. Herpes simplex (Fig. 2A), chicken pox, Epstein-Barr (infectious mononucleosis), hepatitis B, and cytomegalovirus diseases fall into this category. These are diseases that seemed to be very well adapted to persistence in primitive communities. Their prevalence in these communities was higher than commonly found in more advanced cultures, and no tribe was found free of them. They caused little apparent morbidity and did not threaten the continuance of their host population. The infectious agents of all these diseases are known to remain in infected persons for long periods of time and to be reactivable.

Evidence of treponemal infection was not found in the Surinam tribes, the Brazilian Tiriyo, or the Xavante, except in a few instances where contact with outsiders could be presumed. In the three Kayapo tribes tested, however, a very high prevalence of positive tests was found. Sixty percent of the adult members of these tribes were positive by both the standard flocculation (VDRL) test and the more specific fluorescent antibody (FTA-ABS) test, and another 19 percent were positive by one test or the other. No FTA positive reactions were found in children under 7 years of age, but there were several positive by both tests in the prepubertal age group. Clinical examination revealed no evidence of venereal or congenital syphilis, pinta, or yaws. The serological tests indicate that some treponema is very commonly encountered by these people. The absence of clinical signs suggests that it does minimal harm. Many authors have suggested that syphilis was indigenous to the Western Hemisphere, yet the pathological evidence in pre-Columbian bones is far from conclusive (*24*). If it were indigenous, it must certainly have been less virulent than the syphilis that appeared in Europe at the end of the 15th century. Either the agent active among the Kayapo is of low virulence or the people possess unusual resistance; for either reason, a stable relationship exists in this setting, which permits continuance of both parasite and host.

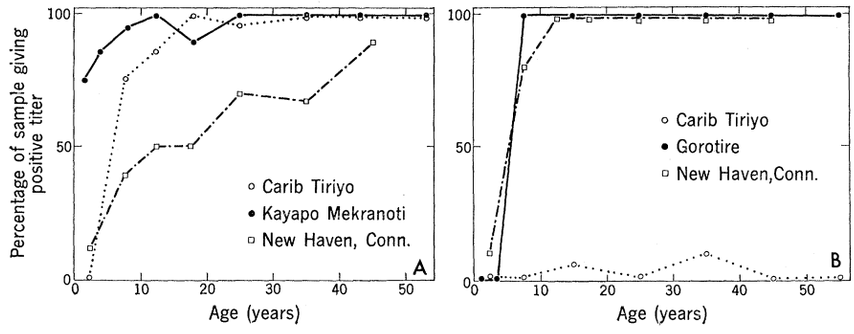

Fig. 2. Distribution by age of subject of (A) herpes simplex neutralizing antibody titers (≥ 8) and (B) measles hemagglutinin inhibiting antibody titers (≥ 10) in serum from isolated Indian and cosmopolitan populations.

Another category of recurrent diseases are caused by agents whose chief host is some animal with a higher population density than man. The arboviruses of yellow fever and Mayaro are representative of this enzootic group. Toxoplasmosis and leishmaniasis are also in this category. The prevalence of antibody to these viruses varied from one tribe to another, presumably depending on the availability of some other host or vector in the immediate area. However, where antibody was found in the human population, the proportion positive increased gradually and steadily with increasing age. Apparently the risk of infection was proportional to duration of exposure, and the infections had not occurred in the form of major epidemics.

Introduced Diseases

When antibody to certain other disease agents was measured, a very high prevalence was found above a certain age in specific tribes; and there was practically no evidence of infection below that age. Where this was the case in one tribe, other tribes often exhibited no evidence of infection at all, except perhaps in a few of the most traveled individuals. This was true of measles (Fig. 2B), mumps, rubella, influenza, parainfluenza, and poliomyelitis. This group of diseases corresponds—with the exceptions that poliomyelitis is added and varicella-zoster is not included—to Hare's group (*9*) of "acute infections in which the organisms disappear when recovery or death occurs." If travelers are infected with one of these diseases while they are outside the tribal area, they are not likely to carry it home. If the diseases are brought in, they spread rapidly to essentially the whole population and then die out. Children born after the epidemic remain free of disease. This group includes many of the most prominent infectious diseases of cosmopolitan populations. However, because they do not persist in small populations, it is unlikely that, in their modern form, they were a problem to ancient man. Conversely, they are the diseases to which modern man may have had the least time to adapt.

Tuberculosis and malaria also seem to represent diseases that have been introduced to the Amazon tribes in recent time. As yet, none of the members of the Auca tribe of the Ecuadorian Amazon give positive tuberculin tests, but the incidence of positive tests is increasing in the Suia, Txukharamai (*25*), and Xikrin (*21*). There is no evidence in these tribes of hemoglobin S or the unusual glucose-6-phosphate dehydrogenase genes, which have been correlated with long-term selective pressures from malaria (*26*). Both these diseases entail long infectious periods and neither confers solid immunity after an acute attack. They, therefore, seem quite able to maintain themselves in these populations, and if they were not to be found in these groups prior to recent contact with outsiders, it may only reflect an accident of geography. However, both diseases cause high morbidity in the tribes, and there is serious

concern that they may actually destroy the Indian populations. Thus, the persistence of these diseases may ultimately be no more certain than if the population became immune.

The geographical features that separated the South American Indians from important sources of evolving disease agents and the filtering effect of the Bering and Panamanian land bridges may have protected the people we studied from a number of diseases, including tuberculosis and malaria. However, another factor, their small population concentrations, would have protected them from many diseases even if the disease agents reached the area. The small population groupings that characterize the Amazon tribes are a very general phenomenon among primitive cultures, and similar groups have been studied with similar results in Australasia (*15*). It seems probable, moreover, that ancient man was also divided into small social groupings. Unless ancient conditions were fundamentally different from those of surviving primitive cultures, measles, influenza, smallpox, and poliomyelitis could not have been present during the period of human emergence nor through most of man's history. The time that we have had in which to adapt to these diseases is probably less than 200 generations.

Summary

Incidence of various infectious diseases in several Amazon Indian tribes has been determined serologically. Diseases that infect only man fall into two distinct categories. Those which can persist in an individual for a prolonged period are highly endemic, but those which are infectious only in the acute phase die out quickly after introduction. The suggestion is made that the latter diseases could not perpetuate themselves before the advent of advanced cultures and did not exert selective pressures on the human genetic constitution until relatively recently.

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NEWS AND COMMENT

Ford's First Budget: DOD, Energy R & D Up, Health Is Ailing

Considering that the United States is deep in the throes of a recession, two cheers from the research community may be in order for President Ford's first budget. Overall, the White House is asking Congress to increase the federal commitment for research and development in fiscal 1976 by 15 percent to $21.6 billion in obligations, with an additional billion dollars for new R & D facilities. Outlays for the conduct of R & D are projected to rise by 11 percent to $20.7 billion, or about 3 percent more than the budget makers believe the cost of doing research has risen in the past year.

As was the case last year, defense and energy took the lion's share of growth while health research came out the loser.

During a day-long round of briefings for reporters on 1 February, officials of the Office of Management and Budget were at pains to note that these increases were among the largest for R & D since the middle 1960's. And in fact, it appeared that R & D fared better than some other sectors of the $93 billion that the Administration considers to be the "relatively controllable" part of the federal budget. Commitments for environmental programs, including pollution abatement, for example, would go up only about 7 percent during fiscal 1976, which begins 1 July. Aid to elementary and secondary education would decline by a few percent.

Still, there are bleak spots for science in the new budget that Congress may or may not choose to brighten this spring.

Basic Research

Health research stands out in this respect. Federal support of medical schools, including both research and training, would decline slightly in the new budget. Funds for the National Institutes of Health would sink substantially in practical terms, with even the specially favored cancer program receiving far less than it had expected.

Moreover, according to the OMB's analysis of the R & D budget, outlays for colleges and universities—traditionally presented as a measure of basic research support—would rise by only 2 percent to $2.3 billion in fiscal 1976, considerably less than inflation's bite.* Academe's share of the soaring federal energy budget would rise from