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On Biological Exchanges Between the Two Worlds

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Summary. The Columbian discovery of the New World gave rise to major biological changes of an extent which had probably never occurred so rapidly before in the history of human populations. While the earlier peopling of the Americas must have been largely from eastern Asia, the late medieval intrusions were to be from Europe and Africa, transforming the population characteristics of most regions of the New World—but having little impact elsewhere in return movements across the Atlantic. In contrast to this one-way influence, was the impact on the nature and distribution of world food resources. The consolidation of the dominant European societies in the New World resulted in the introduction of a range of plant foods and livestock. There was also the gradual adoption of some plant resources from the Americas, to be differentially planted in appropriate environments of Europe, Africa and beyond. But in contrast to these plants, indigenous New World animal domesticates were not seen as of economic value. The introduction of epidemic diseases into the American peoples resulted in a demographic holocaust, although the impact of certain conditions (including tuberculosis and syphilis) is still a matter of some debate.

IT MAY WELL BE that back into prehistory, even to the meeting of contrasting fossil hominid groups, there have been rapid and significant biological exchanges. But without doubt, prior to the Columbian contacts with the New World, it is highly improbable that there have ever been such significant biological exchanges on so many fronts. These exchanges fall into four major categories, and I shall attempt to give some brief

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consideration to each. Beginning with the meeting of biologically distinct human populations, I shall move on to natural resources—animals then plants. Finally, returning to human populations, I want to consider some aspects of microbial exchanges.

Gene Movements in Human Groups

It is not in my brief to discuss in any detail the demographic contrasts between the indigenous and intrusive populations of the Americas, but of course the reproductive crossing of populations of the Two Worlds has been the main factor behind gene pool changes over the past few centuries. Gene movement has certainly not been equal in all directions, and, as far as the African populations are concerned, intermixing with indigenous or European communities was far more curtailed in the early post-Columbian times, compared with the period following the abolition of slavery (Farley 1970). The evaluation of the extent of hybridization is not easy, and although in some parts of the U.S.A. the number of hybrids (mulattoes) is recorded as fluctuating, but generally on the increase from 11% to 16% between 1850 and 1920 (Holmes 1937), these are crude assessments at the most. The United States is also not the best part of the New World in which to consider this question of mixing as there were probably relatively few slaves in the north before the eighteenth century, and there were neither regular censuses nor reliable birth registration systems.

In contrast, the Latin American area has probably displayed some of the highest indigenous population densities, and has been a "melting pot" of peoples, not only in post-Columbian times with the intrusion of European, African and other groups, but to a lesser extent in pre-Columbian times also. Certainly in the sixteenth century records of the "New Spain" there are plenty of reports from different localities of both "mestizos" and "mulattoes"—sure evidence of actual population intermixing (Gerhard 1972). What has emerged over the past five centuries is a demographic pattern determined by trans-Atlantic population history. As one anthropologist puts it: "For Latin America, therefore, the major anthropo-geographical equation reads: Highlands: American Indians, Europeans and their mixtures. Tropical and semi-tropical coastal lowlands: Africans, Europeans and their mixtures. Temperate south: Europeans" (Harris 1964:2). This basic pattern is not a reflection of differential adaptability to contrasting climates, but to a combination of other factors, including numerical variation in regional indigenous populations, numbers of African slaves (and their possible better adaptation to more tropical environments), and the better survival chances of Europeans and Negroes

in the face of the intrusive diseases they were themselves bringing into the New World.

Regarding the more precise evaluation of gene movements from the intrusive groups to the indigenous Amerindians, or in the other direction, blood group studies—especially of the Diego system—would seem to indicate that little Amerindian gene movement has ever occurred back into the Old World. On the other hand, genetic markers in some Amerindian groups certainly appear to indicate that serological patterns in some communities have been modified by post-Columbian colonization. For instance, the Guayqueri Indians of the Venezuelan island of Margarita have been in contact with Spanish settlers since 1509, when the rich pearl beds became a resource of European interest. Intermarrying was occurring by 1524 and the genetic picture was eventually complicated by African slaves. Serological gene flow has been studied in some detail for this population (Layrisse et al. 1958), and it is suggested that there is now a 45% Spanish and 12% Negro contribution to the genetic makeup of the population. A marked contrast to this situation is provided by the detailed study of the Yanomama, where data on 28 serological and other genetic systems strongly suggest that there is no admixture with European or African groups (Neel et al. 1977).

In more general terms, it has been suggested that indigenous South American tribes possess only the O gene of the ABO system; thus when A and B genes are present in some areas this is therefore mainly due to the influence of European and African settlers. Similarly, the occurrence of haemoglobin variants originated purely with the African slaves. Finally, an example of how relaxed sexual practices could have had considerable genetic impact on smaller disease-reduced populations is seen in the Caribs of Belize. This mixed population has been studied for a rare allele (M^9) of the MNSs system. Very surprisingly, an M^9 frequency of 7% was found in the sample studied (Tills 1982), suggesting that a combination of admixture with African slaves and subsequent genetic drift in a much reduced Belize Carib group gave rise to this surprising frequency.

Except for a few protected tribal groups, therefore, there appears to have been considerable but regionally varying human gene movement westwards across the Atlantic, but nothing detectable going eastwards.

Animal Resources

Let me now move on to animal resources, beginning with the edible small mammal, the guinea pig. Although Spanish colonists in Peru were the first to see guinea pigs kept as food, it appears to have been Dutch merchants

trading into Surinam as late as 1667 who first began to ship small numbers back to Holland, and not as food but as pets (Dembeck 1965). Selective breeding in Europe greatly increased the variation in the following two centuries, but the food potential of these animals has never been realized in the Old World. In the case of the domestic camelids of South America, their numbers and distribution reached a peak during the expansion of the Inca empire. But with the early post-Columbian introduction of European farm species, a major decline set in, and by 1561 relatively few llamas and alpacas remained (Novoa and Wheeler 1984). Preference was given to European livestock except in high altitudes and poor environments, where camelids were better adapted. Attempts to establish camelid herds in other parts of the world have been only modestly successful in competition with other livestock.

In perhaps slight contrast to guinea pigs and camelids, the muscovy duck, a native of Latin America, has now spread very widely throughout the world, and has become adapted to quite variable environments. By what route this duck arrived in Europe is uncertain, but it was certainly established and being illustrated by 1555. Although it has been used as food, it has also been kept for show, and it was even incorporated into armorial bearings (Donkin 1989). But for all its early worldwide dispersal, it has never become a major food species, although again the potential is there.

So we are left with turkeys as the only well marketed animal species to come from the New World. Domesticated turkeys were recorded as being taken to Europe between 1500 and 1512 (Schorger 1966). Cortés found plenty of evidence of these birds in Mexico in 1519. By the early seventeenth century, they were to travel across the Atlantic again, and become a more widespread domestic food resource in the eastern region of North America (Crawford 1984).

In general terms, the exchange of domesticated food species presents a particularly interesting contrast between animals and plants. Vertebrate domesticates of the New World were limited in value to the new colonists. For the meat-eating Europeans, New World animal resources were seen to be minimal, especially in the islands, so that provisions for livestock were made accordingly. A consideration of two of these species should exemplify clearly the extent to which the early European colonists brought over livestock and transformed the domestic animal resources available at that time. Pigs could easily be transported by ship and were omnivorous and hardy. They were already on the second Columbian voyage to the Indies (1493) and between 1505 and 1511 were established as breeding stocks in Jamaica, Puerto Rico and Cuba. The following three decades saw pigs established throughout Central America and coastally well south into South America (Donkin 1985).

There is some irony in the fact that not only the New World peccary was neglected as a potential domesticate, but the North American bighorn was also never drawn into any domestic economy. Yet domesticated sheep from the Old World early became a widespread food resource to the incoming Europeans. The Spanish hairy Churro, the hybrid Criollo variety (Churro × Merino) and the West African "hair" sheep were probably the earliest flocks to arrive (Ryder 1983). Later, other breeds were landed. When in 1555 the Englishman Robert Towson commented on the sheep in New Spain (Mexico), numbers were probably in the order of 25,000. By the end of the seventeenth century the sheep population in that area had probably increased to 500,000, expanding in two further decades to a million. Sheep became important in other parts of the Spanish-Portuguese territories with locally named varieties evolving from the original stocks. Initially, sheep moved into North America with Spanish colonial expansion, but between 1600 and 1650, considerable numbers arrived at the British colonies in the eastern region. By 1812, sheep farming had extended westwards into Indiana and Illinois and the sheep population had expanded to 12 million.

Plant Resources

While only a few species of animals were involved in trans-oceanic exchanges, this cannot be said of varieties of plants. At least thirty major crop plants became important for the first time in either the Americas or the Old World. About a third of these were crop plants introduced to the New World, not for the benefits of the indigenous communities, but to consolidate the food resources or developing economies of the European colonists.

Those species taken to Europe, or to suitable environments in Africa and Asia, were more numerous, but their impact was quite variable at first. Varieties of peppers appear to have received quick acceptance in the culinary world of European society, but in some countries, tomatoes were first regarded with some reserve until their lack of toxicity was confirmed. Similarly the potato, which the Spanish introduced to Europe as late as about 1570, was first viewed with suspicion in some quarters and was adopted slowly. It finally came full circle in 1621 when it crossed the Atlantic again to North America. While Europe was to receive some plants directly (peppers, tomato, potato, sunflower), others were to be planted in extensions of Europe in the colonies climatically more suitable for species survival (papaya, sweet potato, beans, cotton, pineapple, cocoa and cassava). Some plant travellers were to be later moving, rubber

plantations being a nineteenth century phenomenon, for instance. Most of the plants which could adapt to African climates were transported initially along slave routes. Plants crossing to the New World were mainly but not exclusively from Europe (wheat, barley, sorghum, chickpea, cowpea, onion, fig, cherry, coffee, citrus fruits, yams). In the case of some plants, such as the grape, there were multiple intrusions at different coastal localities and times. The history of one or two species may be regarded as distinctive, if not notorious. For instance, there appears to have been active repression of grain amaranth cultivation in Hispanic America (Sauer 1979), because it was viewed as a symbol of paganism. Also, contrary to popular belief, quinine was probably not an Amerindian prophylactic specifically for malaria, but became a European drug for that disease in particular.

Little need be said here of tobacco, which moved to Europe and Asia during the sixteenth century. Described over the last few centuries as a "noxious weed", we are nevertheless still not free of this Amerindian "gift", now a killer of millions.

The Impact of Epidemic Diseases

There is nothing new in the idea that when two populations, separated over a long time period, are brought together, the chances are that one or both will suffer from diseases as a result of contact with the other. Because there is no evolved or recently acquired immunity, the impact of the disease on the population not acquainted with it will be especially strong.

In terms of New World peoples, we are considering groups not only cut off from Old World diseases for thousands of years, but ones which had probably evolved separately over long periods—adapting to different environmental pressures and challenges. The meeting of these two worlds in 1492 was thus a recipe for epidemiological disaster. Few, except perhaps an unusually observant physician of the time, could have guessed at the devastation to come. And no wonder the horror of some of these conditions destabilized tribal communities, to the extent that some fragmented in terror.

In reviewing some of the major diseases which have been considered to be, or might have been, of epidemic importance, I will not discuss possible contacts with the New World peoples prior to 1492. This is not because I do not think they occurred. Limited intrusions of such diseases as influenza and measles could certainly have occurred as a result of the restricted Viking settlement and contact with the north-east coast of North America. More debatable claims of earlier transatlantic and transpacific

links could well have had some disease significance—if contact was indeed made. But whatever these amounted to, from an epidemic point of view they pale into insignficance compared with the barrage of microorganisms which stormed in after 1492.

For the purpose of this review, I propose to divide the diseases to be considered into two groups. This division is not based on the kind of disease but on whether we have to consider its epidemiological history by reference to earlier literary sources, or can hope to build up part of its story from the archaeological records—especially of a skeletal nature.

Let me begin by considering five major epidemic diseases as they first struck the central part of the Americas. There is no doubt that the records of these epidemics are intimately linked with European voyagers to the New World. Of these epidemics, the one with the most social and medical impact has surely been smallpox. The virus in fact includes a number of different clinical types from a mild form to a so-called "fulminating" kind with the most haemorrhaging and about 100% mortality. The second most destructive form is the "malignant confluent" type, with considerable fever, again haemorrhaging, and the visually distressing "exfoliation", or stripping away of the skin. If anyone doubts the horrific nature of Amerindian smallpox, then it is worth reading an account by William Bradford, an early seventeenth century historian of the Plymouth Settlement in New England. He writes: "As they lie on their hard mats, the pox breaks and matters and runs, their skin sticking to the mats they lay on, so that when they turn a whole side will flay off at once, and they will be all one gore of blood, dreadful to behold; and then, what with the cold and other hardships, they die like rotten sheep." This is a perfect but grisly description of the malignant confluent type of smallpox. Earlier, Cortés described the impact of smallpox on the Aztecs of Mexico City. "The city was a vast charnel-house, in which all was hastening to decay and decomposition" (Shrewsbury 1964). In view of the virulent nature of this one disease alone, it is no wonder that estimates of epidemic mortality in the Aztec Empire alone are given as $3\frac{1}{2}$ million people.

But smallpox combined with one or more other epidemic conditions must have ensured even greater mortality. Yellow fever, another intrusive virus disease, known for its fever, higher temperature and "black vomit" probably had a fatality of 50% to 60% (Carter 1931). Transmission is by mosquito, but once established this would not have impeded the progress of the disease.

Typhus, a high fever caused by minute microorganisms of the Rickettsia group, are seen in Old World history as diseases of wars and famine. Transmitted by human lice or rat fleas, their intrusion into the New World would have been easy enough. Finally, the viral conditions measles and

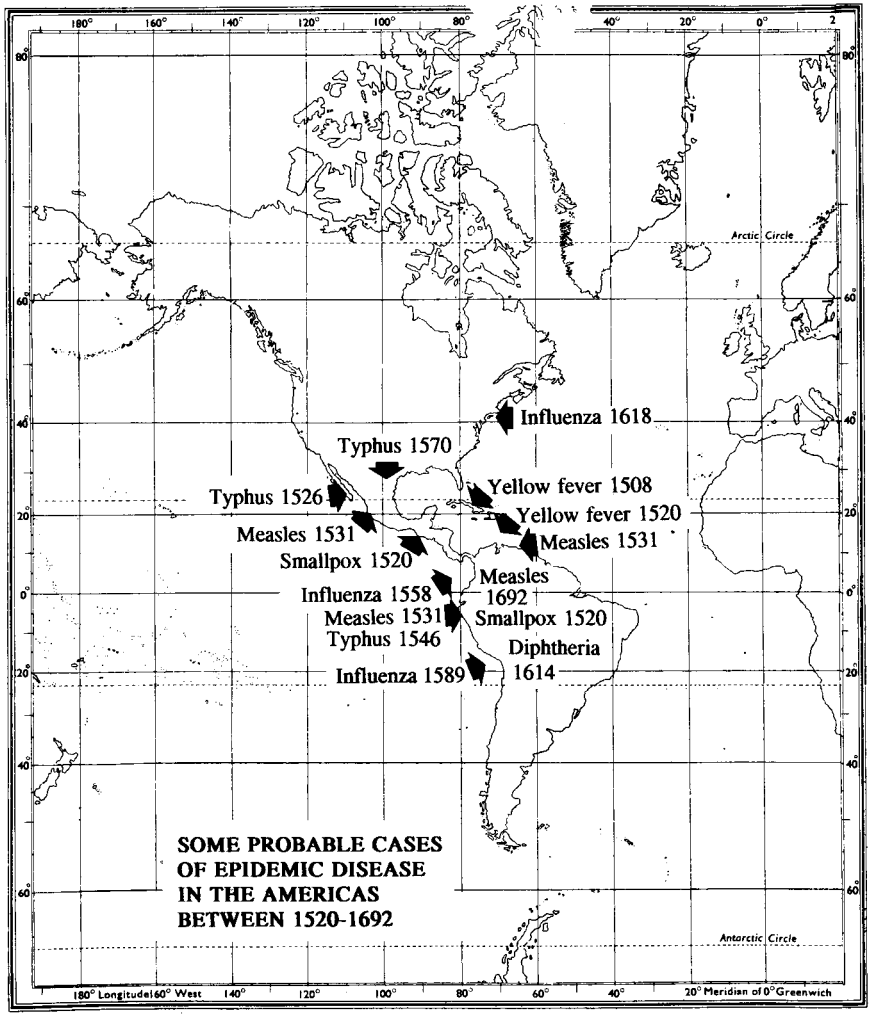

Figure 1 Evidence of the multiple instrusion of epidemic diseases into the Americas during the sixteenth and seventeenth centuries, based on Spanish records.

influenza need no clinical explanation, except to say that their impact on Amerindian groups in the past was far, far greater than we see in Europe today.

With these points in mind, we can now view the map (Figure 1) and some of the records which probably indicate these diseases from Mexico south as far as Bolivia, between about 1500 and 1700. It can be seen that every decade or two, there were reports of the intrusion of one or other condition. Smallpox was probably the most hard-hitting, although

diagnosis of this disease was probably far easier than with the other diseases. The extent and rapidity with which these diseases spread were obviously dependent on political, social and demographic factors. The more urban and populated, the better the chance of rapid disease transmission. Thus, in view of the well peopled and integrated Inca Empire, diseases may have travelled faster than the Europeans, and perhaps by the time Pizarro landed on the Peruvian coast in the early 1530s, epidemic diseases so aptly called the "shock troops of the conquest" may have already greatly reduced Inca numbers.

However, looking from Mexico, the epidemic picture may have been somewhat different. In California, population sizes and social organization were different and disease progress may have been slower. However, with the establishment of more Spanish missions by 1770, waves of infection probably began to have more impact. Once the populations were reduced, it has been suggested (Walker and De Niro 1989) that they tended to be held down by a low birth rate due to sterility caused by venereal diseases. I will come back to the question of syphilis later, but it is certainly worth mentioning that the intrusion of other venereal diseases—especially gonorrhoea—could have been quietly devastating, not as killers but in their impact on fertility. Gonorrhoea was certainly noted as a serious disease in early Californian mission records (Cook 1976), but it should be remembered that until recent times there was much confusion in the precise recording of venereal diseases.

And there may have been other confusions, with other diseases quietly moving into the New World without recognition. For instance, the enigmatic "sweating sickness", described in the sixteenth century, could have found its way across the Atlantic, but there is no mention of it. On the other hand, J. Eric Thompson (1956) interpreted hookworm as another Old World condition which seriously undermined the health of the Maya and thus assisted in the decline of Mayan cities. However, we now have clear evidence from a Pre-Columbian Peruvian dried body that hookworm was a health threat prior to European intrusions.

Yet another confusion has probably been in relation to American leishmaniasis, caused by an indigenous parasite (*Leishmania*), transmitted by a small New World insect *Phlebotomus*. The facial destruction which can result from this condition may well have been mistaken for syphilis by early European observers. Indeed as a result of changes seen on Pre-Columbian pottery faces and skulls, the question of indigenous leprosy was debated late into the last century (Ashmead 1897). In fact leprosy is not a very infectious condition, and although it was probably transported in slave ships to the New World, very few Amerindians are likely to have contracted the condition as a consequence.

The three most controversial diseases in terms of their presence or absence in pre-Columbian times, and of their impact on Amerindian peoples, are malaria, tuberculosis and syphilis (Stewart 1973). These are killers by stealth rather than by acute attack, but they are certainly conditions which need to be considered as regards their potential long-term destructive effects. But what was their status in the New World after 1492? Were they intrusive and new? Over the years this question has been debated extensively as regards malaria and there is now general agreement that the disease was either brought in by individuals from malarious parts of Europe and/or Africa. And as in the conditions previously discussed, it is highly probable that it was brought into the New World on more than one occasion.

Very briefly, the argument against Pre-Columbian malaria in the Americas is that there is no evidence of long-term adaptation to the disease among the indigenous New World peoples. The shunting of the malaria parasite in Palaeo-Indians across the Siberian-Alaskan land bridge is highly improbable, especially as, in this northern region, conditions for malaria transmission were quite unsuitable (Dunn 1965). Also, early colonial records show that malaria was unknown to indigenous groups before the Europeans and Africans arrived. So here we have another major disease which arrived after 1492. As a serious debilitating condition, it has certainly contributed to the deaths of millions since its arrival in the Americas. And once established in the New World, it continued as a health threat through the centuries, at times probably resulting in considerable mortality—even up to 75% (Cook 1955). The only factor working against the spread of malaria was the climate, and whereas regions such as South Carolina developed bad health records for this and other diseases, drier and less tropical environments were at an advantage as regards some diseases.

Tuberculosis has been a particularly interesting disease, or group of diseases, from the point of view of Amerindian disease history. And, unlike most of the diseases I have previously discussed, there are far better prospects for reconstructing the history of tuberculosis by reference to archaeological material. There are essentially two major questions to ask as regards this condition. (1) What is its antiquity in the New World? (2) What impact has it had on Amerindian populations?

Thirty years ago, the late Dr Dan Morse, then Director of a tuberculosis hospital in Illinois, examined all the New World skeletal, epidemiological and art evidence for the disease and concluded that the Pre-Columbian antiquity of widespread tuberculosis was not proven (Morse 1961). One powerful argument for a post-Columbian history for the disease was that Amerindian communities in general reacted badly to one or other of these

mycobacteria (human and bovine forms). At the time of Morse's study, an evaluation of Navaho health (Adair et al. 1957) stated that their tuberculosis death rate was about five times that of the general population of the U.S.A. (53, compared with 10.5 per 100,000). But this was nothing compared with the epidemic proportions tuberculosis had reached in Alaska, and in the middle 1950s the mortality rate in that area was 282 per 100,000. Indeed, an X-ray survey revealed that 30% of the indigenous adult Alaskans had active or healed lesions in the lungs (Comstock and Philip 1961). Morse was thus impressed, as previous observers had been, by the apparent lack of resistence to the disease in Amerindians.

In the last thirty years, the amount of archaeological evidence has increased considerably. This has been in the form of discoveries of spinal pathology of a kind typical of tuberculosis. Dried soft tissue evidence and calcified lung lesions (Allison et al. 1981; Buikstra and Cook 1981) have been more unusual evidence of the disease. Some of this evidence is without doubt Pre-Columbian, so here we have something of a puzzle. The susceptibility of Amerindian groups to tuberculosis, even through to recent times, has argued in favour of a late arrival of the disease in the New World, but the palaeopathology indicates clearly its far greater antiquity.

The answer to this apparent incompatibility of information may be a complex one, and it seems advisable to be cautious until further investigations are made. Tuberculosis was long established in the Old World (Morse et al. 1964) and it is highly likely that Europeans and Africans entering the Americas after Columbus, would have contributed positively to the spread of tuberculosis. Those who were tubercular would do this by direct contact. Also, the general environmental stresses following the European conquests would have encouraged tuberculosis to take hold (just as the two World Wars this century have influenced TB rates in Europe).

But the tuberculosis evidence from the New World may be telling us something more. Were the mycobacteria present in the Pre-Columbian New World the same as those later intruded from Europe and Africa? Had the New World form a long history of separate evolution with the Amerindian groups? Just as influenza types are not all the same, is it possible that later intrusive varieties of mycobacteria were more virulent? Clearly, there are still some interesting problems left to investigate as regards tuberculosis.

And now I come to the most controversial of all the diseases, venereal syphilis. Was this, like tobacco, a part of "Montezumas revenge" intruded into the Old World with devastating health consequences? Some still believe this to be so (Baker and Armelagos 1988), but the situation may be far more complex (Brothwell 1981). Venereal syphilis is only one of four human pathogenic treponemes. Pinta, a New World form, is least

destructive and may be a late, advanced, well adapted form which evolved purely in Amerindian groups. Yaws and endemic syphilis are tropical and arid environmental forms, evolving in the Old World but possibly moving in ancestral form into the Americas. Venereal syphilis may be a medieval European adaptation to a contrasting and, to the treponemal microbes, least satisfactory cooler environment. Growing archaeological evidence from the Americas, the Pacific islands, south-east Asia and Europe all points to the occurrence of bone-changing treponemal disease, prior to 1492 in these various regions. Columbian contact with the New World could have complicated the epidemiological picture considerably, but I do not think it initiated a major treponemal epidemic in the Old World. More likely, and this has never been debated as an alternative to the Columbian venereal syphilis story, is that there was to a modest extent an exchange of treponemal pathogens across the Atlantic, and possibly even west into the Pacific. Separately evolving varieties of Amerindian treponematosis may have been exchanged for African yaws, endemic syphilis of the eastern Mediterranean and the late-evolved European venereal syphilis. Because one form of treponemal pathogen confers some degree of immunity to other forms, the development of an aggressive epidemic of an intrusive type of treponeme is highly unlikely. The myth of a highly destructive post-Columbian pandemic of syphilis into Europe and beyond should thus be put to rest.

Biological exchanges following 1492 were thus mainly of two kinds. As far as Amerindian communities were concerned, they mainly received microbes, which decimated their populations, lost them many battles and rendered their cultures second class. Europe and its colonies were transformed in agricultural and gastronomic terms, but in remarkably little else.

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