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Terrestrial Epidemiology [and Discussion]

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Terrestrial epidemiology

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Although there are many lacunae in our understanding of the origins and mode of spread of infective disease, it does not appear that the lacunae can be most economically filled by invoking a recurrent extraterrestrial origin for the microbes. For many infections, there is no need, since the pathogens are always demonstrable in the community, and the striking variations in epidemic capability are probably explicable by changes – including lysogenization with phage – in the existent population rather than by recruitment from without. Influenza undoubtedly has many epidemiological perplexities but the very subtle secular variations in antigenic structure, referred to as antigenic drift, seem most rationally explained by evolution in human hosts on Earth.

Introduction

Our knowledge of the factors that determine the distribution of microbial diseases in man or animals undoubtedly has many lacunae. These lacunae have naturally generated a great variety of speculations, among which, it is fair to say, the hypothesis advanced by Sir Fred Hoyle (Hoyle & Wickramasinghe 1979) is perhaps the most bizarre. Hoyle & Wickramasinghe assert that there is continuing recruitment of the terrestrial population of pathogenic bacteria and viruses from Space and in particular that cometary tails may constitute an environment in which the microbes could be preserved and from which they could rather readily be transported to Earth. I take my remit to be to look at the patterns of a few infective diseases to see whether the lacunae in knowledge are so profound as to justify invoking such extraterrestrial recruitment to our stock of pathogenic microbes, or whether the known facts suggest the vigorous application of Occam's razor.

Epidemiology is beset by anecdote, because epidemics often display quirks of behaviour that catch story-telling imagination. Anecdote may often be indicative, even seminal in ideas, but can rarely be evidence.

A major problem in tracing the spread of almost all infective disease is the fact that not all those individuals (or animals) that harbour a pathogenic microbe show overt signs of infection, so 'clinical' observation alone is quite inadequate to plot the distribution of the microbes. Moreover, particular clinical signs are by no means always diagnostic of a particular infection: it is not possible on clinical grounds alone to distinguish influenza due to the epidemic virus A from a host of other infections, nor a sore throat due to *Streptococcus pyogenes* from other similar but aetiologically different diseases. It is, *a fortiori*, impossible to detect all environmental reservoirs by any means other than laboratory examination. And it has to be admitted that even laboratory methods are by no means totally effective.

The transmission of infection between individuals is a complex process dependent on many factors. Among infected individuals not all harbour the microbe in a site from which it is readily dispersed; even if infected at such a site, the numbers of organisms may be small, or the individual's habits may not be conducive to active dispersal. Even given that large numbers of

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microbes may be dispersed, potential recipients have to be within effective range, in space and time, and have to be acting in such a way as to acquire – by inhalation, ingestion or contact – the dispersed microbes. Moreover, simple entry into the body is not sufficient: the 'invaders' may be rejected or killed by any of a number of defence mechanisms. And even if the invasion is successful, disease need not result; nor need the effective disperser necessarily have shown overt signs of his infection.

These problems – the existence of covert infection and the unpredictable nature of the transmission process – mean that great care has to be taken in interpreting observations on the spread of infection if they are not supported by extensive and appropriate laboratory investigations. The absence of a record of infection is not equivalent to the absence of infection.

We may now examine a few of the infections for which Hoyle has proposed a cometary origin.

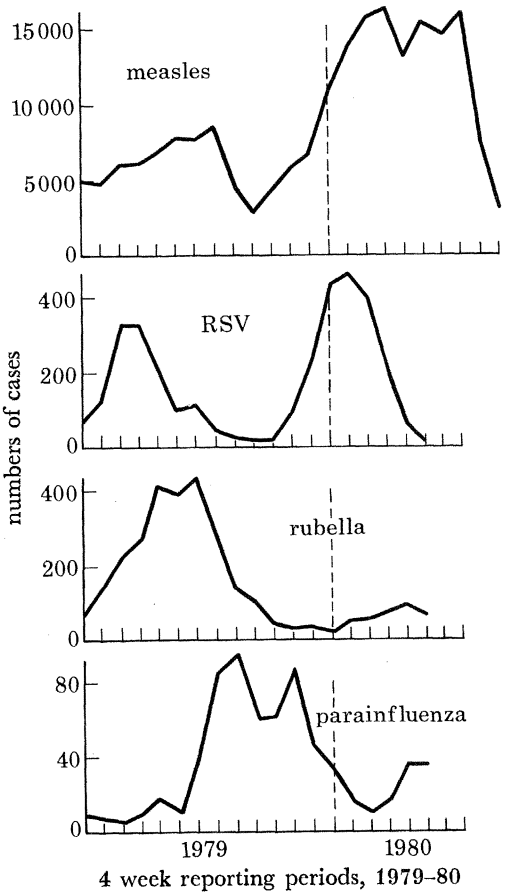

FIGURE 1. Seasonal distribution of infections with four viruses presumed to enter by the respiratory tract. Numbers of notifications (measles) or laboratory reports (rubella, respiratory syncytial virus (RSV), and parainfluenza 3) per 4-week period (England and Wales, 1979–80).

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Measles

Hoyle asserts that in his view the measles virus is likely to have a direct Space origin with no need for a long-term terrestrial reservoir. Need or not, the reservoir exists: even based on notifications, there is no week in the year when cases are not recorded in England (figure 1). Of the existence of person-to-person spread there can really be no doubt, from numerous records following the observed introduction of a single infective case into a schoolroom or, more dramatically into isolated island communities that had been free from infection, in some cases for many years (see, for example, Christensen *et al.* 1953).

The influence of season on the spread of infection is undoubtedly a major lacuna in our understanding. Measles prevalence generally starts to rise from its interepidemic level (not from an absence of cases) in the autumn to reach a peak in the late spring. Hoyle & Wickramasinghe, starting from the assumption that the 'first cases' arise in the late winter, devised an explanation involving the precipitation to Earth of cometary material from the stratosphere which they thought could be attributable to the meteorological conditions common in that season.

Measles is not the only virus infection that must be presumed ordinarily to gain access to the body by the respiratory route, and it is very striking how regular, and different, are the seasonal patterns for the various viruses. A few examples are shown in figure 1: the annual epidemic due to measles starts in September–October, that due to respiratory syncytial virus in December, rubella in January–February and parainfluenza 1 in the late summer. There are many terrestrial variables correlated with season that can be envisaged as affecting the complex process of transmission of infection, including the incidence of solar radiation, temperature, humidity, social and recreational behaviour, nutrition and perhaps immunity. These need to be explored much more systematically before we are driven to postulate the whole variety of extraterrestrial effects that would need to be invoked to bring down to Earth a regular succession of cometary pathogens stockpiled in an extraterrestrial environment.

Cholera

Cholera provides an interesting example of a lacuna that characterizes our understanding of many diseases, namely how it is that the pathogens exhibit big changes in behaviour from time to time. We can be certain that disease with diarrhoea has existed for as long as man, but certainly something seems to have happened, presumably to the cholera vibrio itself, some time in the first two decades of the last century that led to the pandemic of cholera that is reckoned to have started in 1817, and which spread from Asia through Europe and North America with unprecedented morbidity and mortality. More recently we have good records on a similar phenomenon. The El Tor variant of the cholera vibrio is known to have been present and causing small numbers of cases over a number of years in the 1930s in the Indonesian island of Celebes (de Moor 1949). Around 1961, the disease due to the El Tor cholera vibrio became 'epidemic' rather than endemic, and spread – essentially by geographical contiguity – to neighbouring and then to more distant countries (Barua 1972). The epidemic strain of the El Tor cholera vibrio is indistinguishable, by laboratory tests, from the endemic strains that had been infecting small numbers of people in previous years. While accepting that this reveals the inadequacy of our tests – because some change in behaviour has certainly taken place – it does

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seem to be asking for a remarkable blunting of Occam's razor to suppose that a comet deposited an indistinguishable epidemic strain in just the area where the endemic strain had previously existed. The observations of cholera in West Africa in 1970 (Barua 1972) also seem to demonstrate clearly the importance of contiguity in determining spread. That modern air travel has not effected more rapid dispersal is not really surprising when one recalls that the communities that, through inadequacies of hygiene and water supply, suffer from cholera are not those that contribute many passengers to intercontinental airlines.

Staphylococcus aureus

There is an interesting analogy with the appearance of epidemic cholera in the appearance of the particularly communicable strain of *Staphylococcus aureus* phage type 80/81. First recognized in Australia in 1953 (Rountree & Freeman 1955) it had, within 2 or 3 years, spread to become the dominant strain in hospital-acquired infections in many parts of the world. There is very good evidence that the strains from all countries are identical, and the variant appears to have arisen by a double lysogenization with two bacteriophages. How this induced the peculiar ability of type 80/81 to cause skin lesions, and to spread so effectively, we do not know; but it is clear that the 80/81 strains subsequently – in many different places – lost one of the two phages and in consequence changed type and, simultaneously, seem to have changed in epidemic character (see Parker *et al.* 1974). This experience with staphylococci appears to constitute a model that may be analogous to similar changes in the epidemic behaviour of other microbes.

'Legionnaires' disease'

The dramatic epidemic of pneumonia among the veterans of the American Legion attending their Convention in Philadelphia in 1976 looked as if it could represent a truly new disease: for months no pathogen could be recognized by any of our standard methods, and indeed even when *Legionella* (as it has subsequently been named) was isolated it proved to belong to none of the known families of bacteria. But, as so often happens, an apparently new disease really just represents the introduction of a new test. Retrospective examination of material from patients affected in earlier incidents made it clear that it was not a new microbe in Philadelphia in 1976, and subsequent experience has revealed *Legionella pneumophila* and related organisms to be quite commonly present in soil and natural waters, and in the water supplies and air-conditioning cooling systems of many hotels, hospitals and similar buildings. What may be relatively new in the aetiology of Legionnaires' disease is the exposure of many people to the spray from cooling-towers, and the circulation in hospitals of warm, rather than hot, water with the consequent opportunity for the bacteria to multiply in plumbing systems.

Influenza

It is the lacunae in our understanding of the epidemiology of influenza that have stimulated the recent speculation on cosmic or other unconventional explanations. The particular peculiarities of influenza are, first, the fact that the new serotypes of virus, which appear at intervals of one to a few years, turn up almost simultaneously over large areas of the world and almost always completely supplant the previous serotype (table 1); second, that case-to-case transmission in households is difficult to demonstrate; and, third, the virus seems to disappear

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TABLE 2. OUTBREAKS OF INFLUENZA IN CLOSED COMMUNITIES, JANUARY 1978

week	number of outbreaks	attack rates (%) in outbreaks with high rates
1	2	46
2	2	—
3	8	23, 28, 50
4	17	30, 34, 40, 62, 67
5	20	16, 30, 34, 40, 58, 62

TABLE 3. CROSS HAEMAGGLUTINATION–INHIBITION FOR INFLUENZA A VIRUSES CIRCULATING IN THE U.K., 1968–77

antisera against A virus...	HK/1/68	E/42/72	PC/1/73	Sc/74	Vic/1/75	E/864/75	Tex/1/77
years...	1968–71	1972	1973–4	1974	1975–7	1975–7	1977–8
virus							
HK/1	**2560**	2560	320	80	20	20	20
E/42	40	**1280**	320	160	40	40	20
PC/1	20	640	**640**	160	40	40	20
Sc/74	—	40	40	**640**	—	—	—
Vic/1	—	—	—	20	**1280**	160	80
E/864	—	—	80	20	320	**5120**	80
Tex/1	—	—	80	20	320	5120	**1280**

idea received support from observations in the 1957 outbreak of 'Asian' influenza, when a few cases were recognized in Britain in June but no more were detected until the autumn reassembly of schools.

Hope-Simpson (1979) has extended the idea of latency to provide, in addition, an explanation for the drift of serotype that occurs from year to year. He postulates that the acquisition of infection with the influenza virus is followed not by illness but by the establishment of a latent infection and an immune reaction to the infecting strain. The latent infection, it is suggested, is reactivated by seasonal factors in the following year but the immunity developed by the carrier to the original serotype means that it is only variants showing some antigenic drift that can emerge. While one cannot accept Hope-Simpson's assertion that influenza patients 'do not transmit the virus during their illness' as universally true, his theory does take account of the small antigenic changes that occur in the viruses epidemic in successive years.

The pattern of change in the serotype of the influenza virus dominant in successive years seems to point inescapably to an evolutionary process that can most reasonably be considered as occurring in human (or possibly animal) hosts. At intervals of 10 or more years the influenza virus shows a substantial change in type, referred to as antigenic 'shift'. But between these shifts there is a progression of small changes referred to as 'drift'. Dr M. S. Pereira of the P.H.L.S. Virus Reference Laboratory has provided me with data that illustrate this situation.

The pattern of drift within the H3N2 serotype that was active during the years 1968–78 was illustrated broadly in table 1; a number of different variants were recognized. Table 3 summarizes the results of antigenic analysis and it can be seen that each successive strain differs, but only rather slightly, from its predecessor. It seems quite inconceivable that the random events that might, in Space, create new virus particles could do so in a way that would deliver

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