

## LETTERS TO THE EDITOR.

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## The Problem of the Random Walk.

THIS problem, proposed by Prof. Karl Pearson in the current number of NATURE, is the same as that of the composition of  $n$  iso-periodic vibrations of unit amplitude and of phases distributed at random, considered in *Phil. Mag.*, x., p. 73, 1880; xlvii., p. 246, 1899; ("Scientific Papers," i., p. 491, iv., p. 370). If  $n$  be very great, the probability sought is

$$\frac{2}{n} e^{-r^2/n} r dr.$$

Probably methods similar to those employed in the papers referred to would avail for the development of an approximate expression applicable when  $n$  is only moderately great.

RAYLEIGH.

Terling Place, July 29.

## The Causation of Variations.

It is sometimes said that natural selection has ceased as regards civilised man; but very clearly this is an error. All civilised and most savage races are very stringently selected by various forms of zymotic disease. Thus in England practically everyone is brought into contact with the organisms which give rise to tuberculosis, measles, and whooping-cough; those individuals who are the most resistant to the organisms repel infection (*i.e.* do not fall ill), the less resistant suffer illness but survive, the least resistant perish. Abroad, malaria, dysentery, and many other complaints play a similar rôle. Probably no one is absolutely immune to any disease; but since illness only follows invasion of the tissues by a sufficient number of the microbes (the sufficiency of the number varying with the individual attacked), and since the microbes are more abundant in some localities than in others, the stringency of selection as regards any disease is greater in some places than elsewhere. For example, selection by tuberculosis is more stringent in the slums of cities than in the country. It should be noted, also, that resisting power against any one disease does not imply resisting power against any other; thus an individual innately strong against measles is not necessarily strong against tuberculosis. The result of all this elimination by diseases demonstrates the action of natural selection very beautifully. Every race is resistant to every disease strictly in proportion to its past experience of it. Thus Englishmen who have suffered much from tuberculosis are more resistant to it than West African Negroes who have suffered less, and much more resistant than Polynesians who have had no previous experience of it; that is, as a rule, Englishmen, under given conditions, contract the disease less readily, or if infected recover more frequently, or if they perish do so after a more prolonged resistance than Negroes and Polynesians. Negroes, on the other hand, as South American plantation experience proves, are more resistant to malaria than Asiatic coolies, who in turn are more resistant than Englishmen and Polynesians.

Against some diseases (*e.g.* tuberculosis) no immunity can be acquired, that is, experience of the disease confers no increase of resisting power, the disease pursuing a course of indefinite length. Against other diseases (*e.g.* measles) immunity may be acquired, that is, experience of the disease, if not fatal, confers after a definite time a more or less permanent immunity on the sufferer. In the former case the survivors are mainly those who have an inborn power of resisting infection; in the latter they are those who have an inborn power of recovering from infection. Evolution has proceeded on these lines. Thus Englishmen are less readily infected with tuberculosis than Polynesians, but nearly all Englishmen, like Polynesians, readily take measles, though a much greater proportion of them survive and acquire

immunity. Lastly, in relation to such very "mild" diseases as chicken-pox, which render the individual very ill while they last, but cause hardly any elimination, no race appears to have undergone any change; for instance, no race, apparently, is more resistant to chicken-pox than any other race.

The pathogenetic organisms of all prevalent human diseases are more or less entirely parasitic on man. Most of them, therefore, flourish best in crowded populations, where they can pass readily from one susceptible individual to another. Thus tuberculosis is most prevalent in the slums of great cities. An important exception is malaria, the parasites of which require special conditions, and which, therefore, is more prevalent in the open country than in towns. The inhabitants of the eastern hemisphere have been afflicted by a multitude of zymotic diseases for thousands of years. Of old, with the increase of population, the conditions slowly became worse, the stringency of selection became greater, and the human races underwent continual evolution. But before the voyage of Columbus zymotic disease, with the exception of malaria, appears to have been almost, if not quite, unknown in the New World. We have fairly definite accounts of the first introduction of most Old World diseases to this and that aboriginal race, and of the frightful destruction of life that followed, the principal agent of elimination being tuberculosis. With their diseases the European immigrants introduced modern civilised conditions of life, especially churches, schools, and other enclosed spaces in which the natives, crowded together, conveyed infection to one another, and clothes, which acted as a deterrent to cleanliness, and which, besides, harboured the microbes of disease better than the naked skin. As a consequence, except when protected by malaria in extensive forests or when dwelling remote in unsettled regions, the natives rapidly perished. It is a significant fact that, whereas in Asia and Africa every town inhabited by Europeans has its native quarter, no European town in the temperate parts of the western hemisphere (*i.e.* where tuberculosis is most rife) has its native quarter. Published health statistics demonstrate quite definitely that the abnormally high mortality of the natives is caused by introduced diseases. Since civilisation implies a dense and settled population, it follows that no race can now achieve civilisation that has not undergone evolution against tuberculosis and kindred diseases. The case of the Negroes is interesting. In Africa they had undergone some evolution against tuberculosis. In America, when they were first taken to it, the disease prevailed to a comparatively slight extent, especially amongst the agricultural population; but the conditions slowly became worse, and the descendants of the early slaves underwent concurrent evolution. To-day they are able to persist in the northern cities, though their death-rate there is still abnormally high. But though a constant stream of Negro slaves and soldiers (*e.g.* in Ceylon) was poured for centuries into parts of Europe and Africa, they have left no trace on the population. All perished in a few generations, the elimination being so stringent as to cause extinction, not evolution. It is tolerably certain that a fresh immigration of African Negroes to America would end as disastrously.

These facts appear to establish conclusively two truths, first that evolution is due solely to natural selection, and second that variations, except, perhaps, in rare instances, are not due to the direct action of the environment on the germ-plasm, but are "spontaneous." The Lamarckian doctrine is quite out of court. If ever acquirements are transmitted, it should be in the case of the profound and lasting changes affecting the whole body which result from disease; but in no instance is the effect produced by any disease on the race similar to that produced by it on the individual. Thus tuberculosis injures the individual but confers resisting power on the race; measles confers immunity on the individual, but none on the race. Were the Lamarckian doctrine true, man could not persist on the earth. Presumably this is true of all other species, since probably all organisms are subjected to causes of slow deterioration similar to disease. If ever external agencies acting directly on the germ-plasm alter its composition and so cause variations (of any sort) in offspring,