Papers and Originals

Darwin's Health in Relation to His Voyage to South America*

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The nature of Darwin's illness presents a fascinating problem bearing on general and tropical medicine, and on the understanding of the minds of men of genius. There can be no doubt that Darwin was a genius and also that he was an intensely kind, sensitive, and gentle person. Throughout all his letters and writings his warm humanity is abundantly apparent, and this sensitivity, perceptiveness, and brilliance may have rendered him more susceptible than most people to anxiety when under stress.

His voyage to South America is relevant to his illness principally because it was there that he may have been exposed to infection with South American trypanosomiasis or Chagas's disease, and also there that he made observations from which he came to conclusions about the origin of species. He delayed publication of those conclusions for nearly 30 years, a delay which may well have a bearing on the diagnosis.

Darwin was 22½ years old when he embarked in H.M.S. *Beagle* for a voyage round the world, and he was five years older when he returned to Britain to lead a life of chronic semi-invalidism for which Adler (1959) made the brilliant suggestion that South American trypanosomiasis was responsible. It was at Luxan, in the province of Mendoza, Argentina, that, while on a trek, he "experienced an attack (for it deserves no less a name) of the Benchuca, a species of Reduvius, the great black bug of the Pampas," and he stated, "it is most disgusting to feel soft wingless insects, about an inch long, crawling over one's body" (Darwin, C., 1906). These bugs were almost certainly *Triatoma infestans*, the principle vector of Chagas's disease, or South American trypanosomiasis. This disease can cause myocardial damage and heart failure, and may also damage autonomic plexuses in the oesophagus and colon, causing dilatation of these organs which becomes gross in some cases. It may be associated with dysphagia, regurgitation of food, vomiting, or constipation. In many persons, however, the infection is symptomless, and surveys latterly carried out in South America have shown considerable proportions of the healthy population to have a positive complement-fixation test for the disease, the position in this respect being somewhat similar to that caused by primary tuberculosis with its effect on the tuberculin test.

Clinical Picture

In examining the cause of Darwin's illness the first question to consider is what the symptoms were. In his autobiography (Barlow, 1958, p. 79) one finds one of the first references to it in the account of the period just before the *Beagle* set sail for South America. He wrote: "These two months at Plymouth were the most miserable which I ever spent, though I exerted

myself in various ways. I was out of spirits at the thought of leaving all my family and friends for so long a time, and the weather seemed to me inexpressibly gloomy. I was also troubled with palpitation and pain about the heart, and like many a young ignorant man, especially one with a smattering of medical knowledge, was convinced that I had heart disease. I did not consult any doctor, as I fully expected to hear the verdict that I was not fit for the voyage, and I was resolved to go at all hazards."

Chronic undue fatigability was a feature of the illness, but this too he had before leaving for South America, and he wrote to his sister and to Professor Henslow in September 1831 about it (Darwin, F., 1958, pp. 125-6). The fatigue mentioned in these two letters may have been no more than normal, for he had been travelling at the time; but, even so, for a young man of 22 to emphasize his fatigue in multiple letters indicates his concern about it. A more important reference to it, however, is in a letter to Professor Henslow (Darwin, F., 1958, p. 123) written at a time when he was uncertain, as a result of his father's objections, whether he would go on the voyage. He wrote: "Even if I was to go, my father disliking would take away all energy, and I should want a good stock of that." From this it seems that, at this early age, he appreciated that, in him, lack of energy could arise from the stress of mental conflict and opposition to the views of those whom he respected, stress to which his later work subjected him greatly.

In the same month, September 1831, he also wrote about his hands, and from later references to the same complaint it appears that this consisted of trembling of the fingers and possibly some degree of dermatitis. He wrote: "Ask my father if he thinks there would be any objection to my taking arsenic for a little time, as my hands are not quite well, and I have always observed that if I once get them well, and change my manner of living about the same time, they will generally remain well. What is the dose?" (Darwin, F., 1958d, p. 127). The quotation shows that this affection of the hands, like the fatigability and heart symptoms, had been present for some time before he embarked.

He returned home from his voyage in October 1836, and in 1838 was offered, and hesitatingly accepted, the post of secretary to the Geological Society, London. The reason for this hesitation is described in the volume of reminiscences and selected letters edited by his son (Darwin, F., 1958, p. 153). Darwin's doctors had urged him, so he wrote, "to give up entirely all writing and even correcting press for some weeks. Of late anything which flurries me completely knocks me up afterwards, and brings on a violent palpitation of the heart."

In September 1842 Darwin and his family moved from London to Down, and of this period he wrote in his autobiography (Barlow, 1958, p. 115): "We went a little into society, and received a few friends here; but my health almost invariably suffered from the excitement, violent shivering and vomiting attacks being thus brought on. I have therefore

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been compelled for many years to give up all dinner-parties; and this has been somewhat of a deprivation to me, as such parties always put me into high spirits. From the same cause I have been able to invite here very few scientific acquaintances." Adler (1959) suggested that Darwin's exhaustion after physical effort could be explained on the basis of myocardial involvement with *Trypanosoma cruzi*, the causative organism for South American trypanosomiasis. There is, however, good documentary evidence from his letters, some of which I have quoted, that the complaint of exhaustion existed before his exposure to infection with Chagas's disease. A second very important point is that these symptoms were brought on by emotionally charged situations, not by physical effort as they would have been were they caused by myocarditis. Thus within a few weeks of his severe ill-health in 1838 he went on a geological expedition to Glen Roy, in Scotland, and wrote in a letter to Lyell (Darwin, F., 1958, p. 155): "I wandered over the mountains in all directions, and examined that most extraordinary district." He mentioned studying an erratic block on a peak 2,200 feet above sea-level. Clearly the palpitations at this time, three years after the biting by the benchuca bugs, were not associated with impairment in exercise tolerance but were similar to those which he had before sailing.

In 1848, just after his father's death, he wrote to his friend Hooker (Darwin, F., 1958, p. 169): "All this winter I have been bad enough . . . and my nervous system began to be affected, so that my hands trembled, and my head was often swimming." Again it seems that he was suffering from a continuation of the trouble with his hands, of which he wrote to his sister while waiting for the *Beagle* to sail. In 1852 he wrote to Mr. W. D. Fox (Darwin, F., 1958, p. 171): "My nights are *always* bad, and that stops my becoming vigorous. . . . My dread is hereditary ill-health." In 1858 he wrote to his friend Hooker (Darwin, F., 1958, p. 214) concerning the proofs of the *Origin of Species*: "Murray proposes to publish the first week in November. Oh, good heavens, what a relief to my body to banish the whole subject from my mind!" In 1860 again to Hooker he wrote (Darwin, F., 1958, p. 255): "I have been very poorly, with almost continuous bad headache for 48 hours and I was low enough, and thinking what a useless burden I was to myself and all others, when your letter came, and it has so cheered me." In 1871 he wrote to Professor Lankester (Darwin, F., 1958, p. 304) concerning vivisection, "it is a subject which makes me sick with horror so I will not say another word about it, else I shall not sleep to-night." In his son's reminiscences of him it is stated (Darwin, F., 1958, p. 85) that "in 1871 he went to the little church for the wedding of his elder daughter, but could hardly bear the fatigue of being present through the service." The same was true of other occasions when he was present at such ceremonies, and it is also recorded that this symptom prevented him from attending his father's funeral.

The causative relationship between mental stress and fatigue is noteworthy, particularly when it is recalled that he had earlier recognized that to go against his father's wishes would deprive him of energy. A special emotional relationship with his father also appears to be indicated and is referred to later.

The clinical picture, then, is of palpitations, lassitude but not true weakness, headaches, shivering, tremulousness, sleeplessness, and, we now know from his health diary, flatulence. These symptoms were brought on or aggravated not by exercise but by meeting people, facing public gatherings, the anxiety of correcting proofs against time (editors and publishers please note), and emotionally charged meetings, including attendance at church.

Suggestion of Chagas's Disease

In seeking the truth about the nature of this illness, of which it is certain Darwin himself would have approved no matter what the findings were, the question that can most usefully

be tackled probably is whether this clinical picture could have been caused by Chagas's disease. Adler (1959), in making this thought-provoking suggestion, states that "a purely psychological aetiology for Darwin's illness cannot be accepted as conclusive until all other factors have been eliminated." This, of course, is arguable. Diagnosis is best made not by a negative process of exclusion but by positive recognition of symptoms and signs. In that respect we are fortunate in this case; Darwin in his letters and writings gives us a better history than one can obtain from most patients, and he was examined by the best observers of the day, who assure us there were no abnormal physical signs. But can we eliminate Chagas's disease? I believe we can. Regarding the suggestion that Darwin's exhaustion after little effort could be explained on the basis of an infection with *T. cruzi* there is good documentary evidence from his letters, some of which I have quoted, that symptoms of exhaustion existed before his exposure to infection with Chagas's disease.

A second very important point is that these symptoms were brought on by emotionally charged situations rather than by physical effort, as they would be were they caused by myocarditis. The record of going off to Scotland in 1838 and undertaking strenuous mountain walking just after being severely ill is important. There is no evidence here of myocardial failure. Writing in 1876 at the age of 67, he recollects that it was in 1842 that he was for the last time strong enough to climb mountains or take long walks for geological work (Barlow, 1958, p. 99), but there is nothing to suggest that true physical incapacity rather than lassitude of functional origin was the cause of this lack of strength. Moreover, in 1842 he was becoming increasingly preoccupied with non-geological work and with his family and residence at Down. If in 1842 myocardial failure had been the cause of his giving up high mountain walking, is it conceivable that he could live till 1882 without developing overt physical signs of such failure? I have discussed this point with several eminent cardiologists and physicians, and they all consider such a course inconceivable. This point, even were it the only one to be taken into consideration, virtually excludes an organic basis for his illness.

Exercise Tolerance

I have gone further into his exercise tolerance because it is fundamental to a consideration of this diagnostic problem and have done some little research into exercise known to have been carried out by Darwin throughout his long life. In his son's reminiscences of his father (Darwin, F., 1959, p. 75) one finds that he "took a short turn before breakfast, a habit which began when he went for the first time to Down and which was preserved to almost the end of his life." After breakfast he worked, read his letters, had others read to him, and at midday took a walk whether it was wet or fine—a point to note, for a sick man seldom ventures out in bad weather if he can avoid it. This exercise usually consisted of several turns round the sand-walk. This he did almost to the end of his life at the age of 73. I visited Down and asked the way to the sand-walk to see for myself what a round of it entailed. I was surprised to be told by the janitor, "It will take you a full 20 minutes to go round." I had imagined it to be a much less arduous piece of exercise. It consists of a circuit, and a very pleasant one, through trees, many planted by Darwin. Pacing it out showed that the nearest part of the circuit was 475 yards from the house and that a single circuit of the sand-walk itself measured 580 yards, so that to walk to the sand-walk, take a single turn round it, and return to the house is almost one mile. We know that he took several turns round the sand-walk, and, according to his son's reminiscences (Darwin F., 1958, p. 75), "used to count them by means of a heap of flints, one of which he kicked out of the path each time he passed."

His exercise tolerance was very well maintained until the end, for his son writes: "It is curious to think how, with regard to the sand-walk in connection with my father, my earliest recollections coincide with my latest; it shows the unvarying character of his habits." A further point concerns his gait. Again his son wrote (Darwin, F., 1958, p. 71): "He walked with a swinging gait using a stick heavily shod with iron, which he struck loudly against the ground, producing as he went round the sand-walk at Down, a rhythmical click which is with us all a very distinct remembrance. . . . When interested in his work he moved about quickly and easily enough, and often in the midst of dictating he went eagerly into the hall to get a pinch of snuff, leaving the study door open, and calling out the last words of his sentence as he left the room." In order to limit his use of snuff he kept the snuffbox on the hall table; thus he had to get up from the sitting-room or study and walk out into the hall in order to get a pinch of it.

Much new information has come from the recent publication of the correspondence between Darwin and the vicar of Down, the Reverend Brodie Innes (Stecher, 1961, p. 256). From this we learn that for six months Darwin kept his snuffbox in the cellar and the key to it in the garret of his house. Surely this habit in itself is one which indicates strongly that there could be no significant degree of cardiac insufficiency. A person with symptoms due to such a cause soon learns to use habits which avoid exertion and would not resort to one like this, requiring effort. The exercise tolerance, the swinging gait, the heavy striking of the stick, and the deliberately contrived, effort-requiring impediment to the obtaining snuff all combine to exclude symptoms due to significant myocardial damage. It was not exercise but anxiety and meeting people which caused his complaints.

The nausea and flatulence would, it has been suggested, fit in with Chagas's disease. Again, however, the evidence is against this. First, it is very doubtful whether alimentary symptoms occur in Chagas's disease in the absence of myocardial damage, and of this, as has been indicated, there was no good evidence. Second, it is a common psychosomatic symptom; a large proportion of those with psychosomatic disease are air swallows and have just these complaints. Thirdly, of these alimentary symptoms also there is evidence that they existed before he could have been infected. Before sailing in the *Beagle* he wrote to Professor Henslow from Devonport (Darwin, F., 1958, p. 128): "I have only now to pray for the sickness to moderate its fierceness, and I shall do very well." It has been suggested that the sickness here referred to was seasickness. The letter was written on 15 November 1831 and the *Beagle* did not attempt to leave harbour till 10 December 1831 so that the sickness he then complained of, if seasickness, must have been due to motion of the ship while at anchor in harbour. Such a set of circumstances would in itself indicate that Darwin was unusually susceptible to nausea, but it is doubtful if he was living aboard the *Beagle* at that time, for in the same letter of 15 November he wrote: "My chief employment is to go on board the *Beagle*, and try to look as much like a sailor as I can." In a letter of 3 December (Darwin, F., 1958, p. 129) he wrote, "to-night I am going to sleep on board," and it seems that this was the first time he had done so.

Physical Signs

Darwin was intermittently ill for about 50 years, from shortly before he sailed in the *Beagle* in December 1831 until his death in 1882. He was looked after by many doctors, some of them among the most distinguished of his day, including Sir Andrew Clark and Dr. Bence Jones, an astute clinical observer whose discovery of the proteinuria which bears his name is a lasting tribute to that ability. Yet none of these found any sign of organic disease. Such signs would not have been difficult to find had his symptoms for all these years been due to organic disease such as Chagas's disease. If palpitations, weakness, and

prostration had been due to myocardial damage, oedema or some other sign of cardiac insufficiency would certainly have been present at some stage; but instead we find that no physician could detect any organic source of his trouble and that Dr. Bence Jones, from whose treatment his son states he derived much benefit, prescribed for it not rest but horse-riding, and "he enjoyed these rides extremely" (Darwin, F., 1958, p. 77). It is possible for persons to die and for evidence of unsuspected, asymptomatic Chagas's disease to be found at necropsy, but it is beyond credibility that Chagas's disease could produce symptoms of cardiac insufficiency for between 40 and 50 years and not produce some physical signs.

Epidemiological Evidence

It has been stated (Adler, 1959) as evidence for Darwin's illness being Chagas's disease that in the Argentinian province of Mendoza, where Darwin was bitten, as many as 60% of the population give a positive complement-fixation test for the disease and as many as 70% of *Triatoma infestans* are infected with causative trypanosomes. "Darwin was therefore definitely exposed to infection." The validity of these figures for some surveys is not disputed, but the deduction that Darwin was definitely exposed to infection cannot be allowed to stand. There is no certainty that the bugs which bit him were infected.

Precise figures for Mendoza are not available, but Professor Rodrigues da Silva, Director of the Department of Tropical and Infectious Disease, University of Brazil, Rio de Janeiro, has kindly provided me with figures collected by Neghme and Schenone (1962) indicating that in the epidemiologically continuous Chilean regions bordering on Mendoza *Triatoma* infection rates are not as high as 70%. Thus of 2,332 people examined by the complement-fixation test in the Provinces of Santiago, Valparaíso, and Aconcagua between 1949 and 1958, only 346, or 14.8%, were positive. These were people of all ages, so that they had had many years of opportunity to become infected, whereas Darwin was exposed for only a quite brief period. In the Province of Aconcagua 147, or 24.2%, of 607 *Triatoma infestans* captured between 1939 and 1959 were infected, and in Santiago Province the comparable figure was 31.8% of 12,791 bugs. Professor A. Neghme, Director of the Department of Tropical Medicine and Parasitology, University of Chile, Santiago, has also provided me with figures collected by Mazza *et al.* (1941) and Coll (1940) in Mendoza itself giving the age-groups of those presenting with acute manifestations of Chagas's disease. These indicate primary infection, and it is notable that the peak incidence of them occurs in the group aged 10-15 years (Fig. 1). In other words, the majority of persons

FIG. 1.—Ages of Patients with acute Chagas's disease confirmed in Mendoza, Argentina, where Darwin was bitten by *Triatoma* bugs.

who develop such infection have been exposed, we can say with certainty, not just for a few weeks but for several years.

A point to be remembered is that it is not the bite of these insects which causes infection but contamination of wounds with their excreta, which they produce at the time of biting.

To be bitten even by several infected insects would not therefore of necessity produce infection.

Several members of the crew of H.M.S. *Beagle* went with Darwin on his excursions inland, and in his *Journal* he also records the way in which an officer permitted a *Triatoma* bug which he had caught to feed upon him. I therefore sought evidence of illness which might have been Chagas's disease among the crew of the *Beagle* when Darwin was with the ship. The Admiralty records on this matter are remarkably complete, and through the kindness of Mr. J. S. Stevenson, of the Admiralty Records Department, I was able to consult the statistical reports of the health of the Navy. They paid particular attention to superficial inflammations and swellings, as Fig. 2 shows, and, of course, to fevers. From the records of the ships on the South American station during the years 1832–6 Mr. Stevenson has abstracted all entries relative to the crew of the *Beagle*, and these are shown in the Table, from which it is seen that no fevers other than those associated with disease of the lungs, bowels, rheumatism, whitlows, boils (then biles), and respiratory infections were reported, nor were there any unusual swellings. It would be unwise to place much reliance on clinical records approximately 130 years old, but the evidence has some small value and its existence is in itself of considerable interest. The epidemiological evidence therefore indicates that although there was the possibility of exposure to infection there is no strong probability that he was infected.

THE SOUTH AMERICAN SQUADRON.

87

which persons living ashore are very little liable. The object of the Table is not so much to show the amount of such diseases, as to ascertain the rate of their prevalence in different commands, and thereby endeavour to determine whether climate operates materially in their production, or whether the nature of the duties, and the interior economy of ships of war, are the principal agency, or to what extent they act separately and jointly.

In respect of the first, the superficial inflammation of the extremities, there is no doubt that the nature of some parts of the duty, especially that of cleaning decks by washing and stoning, operates extensively; but there is little doubt that some climates co-operate with the duty and aggravate the evil. The inflammation in question is generally confined to the lower extremities, and to the lower part of them, seldom reaching above the knees. It often terminates in abscess, which, though seldom involving more than the skin and contiguous cellular tissue, sometimes extends deeply and widely, and proves tedious of cure. Such results, with the frequency of the disease, render it a source of considerable suffering and temporary reduction of strength. The number of cases treated being 2879 in seven years, the ratio per 1000 of force is 166.9 per annum.

The annual ratio of rheumatic cases was 72.3 per 1000 per annum of force, the total number treated being 1248, of which 43 were invalided, and four, probably from attacking internal organs, terminated fatally. The annual ratio of invalided is 2.5 per 1000 per annum of force, which, considering the nature of the service, the character of the disease, the difficulty which is sometimes encountered in detecting imposture, when it is feigned, that the name is sometimes applied to other affections, and the want of hospitals, is not high.

The ratio of attacked by catarrh is 139.8 per 1000 per annum of force; 25 were invalided; being in the ratio of 1.5 per 1000 per annum. The ratio of attacked is moderate, but that of invalided is high. One out of the whole number terminated fatally.

The ratio of cases of diarrhoea is 80.6 per 1000 per annum of force; of which seven terminated in a chronic condition, which led to invaliding: none terminated in death.

TABLE, No. 4, for Seven Years, from 1830 to 1836.

SHOWING THE TOTAL NUMBER OF FREQUENT, BUT NOT OFTEN FATAL, DISEASES; THE NUMBER SENT TO HOSPITAL, INVALIDED, AND DEAD; WITH THE RATIO OF EACH PER 1000 OF MEAN STRENGTH.

FIG. 2.—EXTRACT RELATING TO SWELLINGS, FROM *THE STATISTICAL REPORTS ON THE HEALTH OF THE NAVY* FOR THE YEARS 1830–6. H.M.S.O., London, 1841.

Familial Nature of the Illness

The Darwin-Innes (Stecher, 1961, p. 201) letters have made generally available, for the first time, details of the illness of Darwin's fourth child, Henrietta, who became well known in the Darwin literature as Aunt Etty. In 1860, when Etty was 7 years old, Darwin wrote to Innes (Stecher, 1961, p. 205): "I have been a good deal knocked up of late and had to resort to the water cure; but our anxiety with Etty for 12 weeks has been enough to knock us up," and in September of the same year "the doctors are convinced there is no organic mischief."

Entries Relating to Crew of H.M.S. *Beagle* for the Years 1832–6
Abstracted by Permission of the Medical Director-General (Naval)
from "The Statistical Reports on the Health of the Navy"

	1832	1833	1834	1835	1836
Febrile Diseases					
Order 1—Fever	—	—	—	—	—
Order 2—Inflammations with Fever:					
Inflammation of lungs	1	1	—	1	2
Inflammation of bowels	—	1	—	—	—
Inflammations	—	—	1	—	—
Rheumatism	—	—	—	3	—
Whitlow	—	—	—	1	—
Biles	—	—	—	4	—
Inflammatory sore throat	—	—	—	1	1
Bronchial inflammation	1	—	—	1	—
Order 3—Eruptive fevers	—	—	—	—	—
Order 4—Haemorrhages, with fever:					
Piles	—	—	—	2	—
Order 5—Fluxes, with fever:					
Catarrh	3	4	2	2	1
Nervous Diseases					
Order 1—Soporose diseases:					
Vertigo	—	—	1	—	—
Apoplexy	—	—	—	—	1
Order 2—Defect of vital power:					
Visceral derangement	1	1	—	1	—
Order 3—Spasmodic diseases:					
Diarrhoea	3	—	—	3	2
Colic	—	1	2	—	1
Order 4—Mental diseases:					
General excitement	—	—	—	1	—
Cachectic Diseases					
Order 1—Emaciation of the body:					
Order 2—Swellings	—	—	—	—	—
Order 3—Cutaneous diseases:					
Syphilis	—	1	—	3	1
Excoriation	1	—	—	—	—
Local Diseases					
Order 1—Diseases of the senses	—	—	—	—	—
Order 2—Depraved appetites	—	—	—	—	—
Order 3—Depraved motions	—	—	—	—	—
Order 4—Increased discharges:					
Gonorrhoea	—	2	—	—	—
Order 5—Obstructions:					
Constipation	1	—	1	3	1
Retention of urine	—	—	—	—	1
Order 6—Tumours:					
Contusions	—	2	—	—	2
Biles	1	—	—	2	2
Swollen testicle	1	—	—	—	1
Bubo	—	—	—	1	1
Order 7—Protrusions	—	—	—	—	—
Order 8—Solutions, or disunion:					
Wounds	1	2	1	—	1

Etty appears to have been a problem child from a very early age, for her mother wrote to her aunt when Etty was 3 years old (Litchfield, 1915): "Charlotte writes to me for a receipt for a punishment for Edmund. If she will send me ditto for Etty I will engage to furnish her, but I am quite as much nonplussed as she can be. Since she has been unwell the whims in her little head are wonderful. Now she will never have her night shift on, and it has to be put on after she is asleep. I must come to a downright quarrel I am afraid, but I am always in hopes these fancies will blow over." Later in 1860 Darwin wrote to Innes (Stecher, 1961, p. 207), "on account of Etty we lead a more retired life than ever, though this seems hardly possible." Etty's illness was evidently being brought in to reinforce his wish for seclusion.

It is perhaps significant that the year 1860 was, for Darwin, one of considerable stress, for his *Origin of Species* had been published in 1859 and it was in 1860 that Bishop Samuel Wilberforce attacked Darwin bitterly both verbally and in writing. Gwen Raverat, one of Darwin's grandchildren, has written a charming account of life at Down. I hesitate to quote from it, for in reading it I have the impression of having access to a very personal diary or being allowed to participate, confidentially, in highly personal family matters. She writes of Aunt Etty (Raverat, 1960, p. 122) that when "13 the doctor recommended, after she had had a 'low fever' that she should have breakfast in bed for a time. She never got up for breakfast again in all her life" and in spite of all this illness she lived until she was 86 years old. We also read (Raverat, 1960, p. 123) that "ill health became her profession and absorbing interest," and further she writes (Raverat, 1960, p. 122): "but of one thing I am quite certain; that the attitude of the whole Darwin family to sickness was most unwholesome. At Down ill-health was considered normal." Her husband came under the same influence, and "if the window had to be opened to

air a room in cold weather Aunt Etty covered him up entirely with a dust sheet for fear of draughts; and he sat there as patient as a statue until he could be unveiled" (Raverat, 1960, p. 125).

To return to the Darwin-Innes letters we learn that other members of the family were similarly affected. Darwin wrote to Innes (Stecher, 1961, p. 212): "but now we have Horace failing badly with intermittent weak pulse, like four of our other children previously. It is a curious form of inheritance of my poor constitution, though I never failed in exactly that way." We also learn (Stecher, 1961, p. 206) that Etty, on being taken to the seaside to recover, "progressed very well here for four weeks, but I am sure you will sympathize with us to hear that she had a terrible attack of sickness." Again symptoms similar to her father's.

There is evidence, therefore, that a condition very similar to that which affected Darwin—that is, weak and irregular pulse with sickness, lassitude, and headache—affected also four other members of the family—none of whom had been to South America. This surely is a further strong indication that the condition which caused his trouble was not South American trypanosomiasis.

Course of the Illness

The course that the illness took gives us a further clue to its nature. Among his bad years was 1831, when he was going against his father's wishes and making up his mind to sail in the *Beagle* rather than become a parson; 1837, when he had just returned from his five-year voyage and was adjusting himself to his fresh life in London; the few years that followed 1837, including the period of his marriage in 1838 and his decision to move to Down; the time around his father's death in November 1847 and the year or two just after the publication of the *Origin of Species* in 1859.

His son in his reminiscences of his father (Darwin, F., 1958, p. 345) wrote: "During the last ten years of his life the state of his health was a cause of satisfaction and hope to the family. His condition showed signs of amendment in several particulars. He suffered less distress and discomfort, and was able to work more steadily. Scattered through his letters are one or two references to pain or uneasiness felt in the region of the heart. How far these indicate that the heart was affected early in life I cannot pretend to say; in any case it is certain that he had no serious or permanent trouble of this nature until shortly before his death." It was not until December 1881 that he was seized by serious precordial pain, and after several such incidents during the next 4 months he died in April 1882 in his 74th year. If Darwin's weakness and other symptoms were to be explained by organic damage brought about by Chagas's disease it would have had to cause a very curious form of myocardial degeneration to prostrate him in his 30's and at intervals during his middle age and then to have become materially better during his last decade. The course of the illness is surely much more compatible with a psychological or psychosomatic disorder which, like so many of its kind, becomes a "pestilence which wasteth the noon day" of life but which eventually as the emotional fires die down allows some "peace at eventide."

Diagnosis

If Chagas's disease did not cause Darwin's symptoms what did? My personal diagnosis would be an anxiety state with obsessive features and psychosomatic manifestations. Anxiety clearly precipitated much of his physical trouble, and regarding the obsessive component there are several important points. In this respect he would not be unusual among men of genius (Brain, 1949).

Darwin exhibited the obsessional's trait of having everything "just so"; he kept meticulous records of his health and symptoms like many obsessional hypochondriacs. Everything had to be in its place; he even had a special drawer for the sponge which he used in bathing; this is perhaps a minor point, but it is only by close attention to such detail that an accurate diagnosis can be made. The obsessive nature of his make-up comes out more clearly in his son's reminiscences (Darwin, F., 1958, p. 84): "each week he used to read nearly the whole of *Nature*, though so much of it deals with mathematics and physics. I have often heard him say that he got a kind of satisfaction in reading articles which (according to himself) he could not understand." Surely the obsessive, compulsive driving force which made him do this must have been one of very considerable intensity. Then there is the health diary he kept. Days and nights were given a score according to how good they were; the score was added up at the end of each week, and there is evidence of frequent changing of mind in deciding whether a night was very good or just good.

Finally, there is the question of why he "sat on the fence" for over 25 years in delaying publication of his *Origin of Species*. From my earlier reference it is clear that he had the main idea in 1832. Greenacre (1963) has pointed out that in 1844 he made a draft of his ideas, confiding them to only a few intimate friends: his sense of patricide in entertaining this idea was so great, however, that he wrote to his friend Professor Hooker that in stating his views he felt as though he were confessing murder. It should be noted here that the conflicts which his ideas generated within him were such that they became "expressed in obsessional doubts and exaggerated need for certainty which undoubtedly slowed up his work and made him quite ill." That is the opinion of one of the world's leading psychoanalysts, an opinion which has much in common with that of Hubble (1943) and of Kempf (1921). It was only under the stimulus of fear of loss of priority when Wallace was known to be about to publish on the same subject that he finally went to press.

Conclusion

It may well be that many of the points which I have made, taken individually, would not exclude the diagnosis of Chagas's disease: Darwin's good exercise tolerance, the absence of physical signs of organic disease, the absence of evidence of Chagas's disease among the other members of the *Beagle's* crew, the fact that the illness was compatible with long life although Darwin suffered from it for more than 50 years, and the fact that his symptoms improved towards the end of his life. Each of these would cause doubts, and some of them grave doubts, about a diagnosis of Chagas's disease, but taken collectively they make a case of overwhelming strength against it. If he had been infected with it the infection could not account for the features of the illness but was similar to that, for example, with primary tuberculosis and remained quiescent and asymptomatic. But over and above all these points is the fact that the complaints that incapacitated him throughout these 50 years were complaints of which there is evidence that he suffered before he went to South America and before he could therefore have become infected. If the readers of this article constituted the jury in a court of law, trying the *Triatoma* bugs which are accused of having given rise to Darwin's ill-health, I would submit that there is but one verdict that could be returned, and that is "Not guilty."

Summary

Darwin was ill for 50 years, and it has been suggested that he suffered from Chagas's disease or South American trypanosomiasis contracted during his voyage in H.M.S.

Beagle. He certainly was bitten by the vector of Chagas's disease, but there is no certainty that they were infected. The infection can cause myocardial damage and heart failure, megacolon and megaesophagus, but it is often asymptomatic.

Evidence from Darwin's writings and those of some of his relatives indicates that his symptoms were of palpitations, lassitude, headaches, tremulousness, sleeplessness, and flatulence brought on by meeting people and by emotionally charged situations. His exercise tolerance remained good until shortly before his death at the age of 73.

Though attended by some of the best clinical observers of the day no signs of disease were detected. Persons may die with asymptomatic Chagas's disease, but it is considered to be beyond credibility that severe incapacity could have been produced by it for 40–50 years without the development of physical signs.

There is evidence that several of Darwin's children who were not exposed to infection with Chagas's disease nevertheless had a disease similar to their father's.

The course of the illness was unlike that of an organic disorder causing cardiac insufficiency in that the symptoms improved during the last decade of his life. The features of the illness strongly suggest a diagnosis of a functional disorder.

Perhaps the most important piece of evidence is that the principal symptoms developed before Darwin sailed for South America.

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Creatine Kinase Levels in Women who Carry Genes for Three Types of Muscular Dystrophy

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Severe sex-linked muscular dystrophy is a condition for which it would be most valuable to have a reliable test to identify carrier women. A young woman who has seen two brothers die of the disease is naturally anxious to know the risk that she may have affected sons; one in two such women are not carriers and if identifiable could be reassured. Probably one in three women who have one son with the disease but no other affected male relative do not carry the gene, and, if identifiable, could be reassured that they were unlikely to have a second affected son or a carrier daughter.

Claims that the level of serum aldolase is helpful in the detection of carrier women (Schapira *et al.*, 1960; Chung *et al.*, 1960; Hughes, 1962a) have, unfortunately, not been confirmed (Leyburn *et al.*, 1961; Clayton *et al.*, 1963). However, Schapira *et al.* (1960) also reported high levels of creatine kinase (adenosine triphosphate creatine phosphotransferase) in 8 out of 19 carriers of the gene for severe sex-linked muscular dystrophy. This enzyme is found only in muscle and nerve tissue and so high levels are not produced by red-cell haemolysis *in vitro* or by liver disease, both of which result in a raised level of serum aldolase. Aebi *et al.* (1961–2) in Switzerland, and Hughes (1962a) reported more encouraging results with creatine kinase. Hughes found that six out of seven women known to carry the gene for severe sex-linked muscular dystrophy had raised levels, and the Swiss workers (Richterich *et al.*, 1963) also found that six out of seven known carriers had high levels. More recently Pearce *et al.* (1964b) found

that five out of seven known carriers and 17 out of 35 possible carriers had high levels by their standards.

We now report a series which indicates that, taking the mean of three separate estimations, about 90% of heterozygotes for the gene for the severe sex-linked form have an enzyme level higher than that reached by all but 10% of controls; also that a substantial proportion of heterozygotes for the mild (Becker) type of sex-linked dystrophy may be detected.

Method

The reaction—creatine phosphate + ADP $\rightleftharpoons$ creatine + ATP—is a linear function of creatine kinase activity except for serum in which the level of creatine kinase is very high (above about 14 units). The forward reaction proceeds 10 times faster than the backward, and so methods using it are to be preferred. The creatine formed by the forward reaction was estimated by Hughes's (1962b) modification of the method of Dreyfus and Schapira (1961) on serum from capillary blood. There was no significant difference in levels of the enzyme in serum and plasma, but the latter was apt to deposit fibrin clots on deep freezing. All results are expressed in units which are μ M creatine per ml. serum per hour at 37° C.; the conversion factor to "international units" is 16.67.

The serum creatine kinase levels were found to be unaffected by deep freezing or by standing at room temperature for 24 hours. Specimens were stored at –25° C. and the enzyme level was estimated within six weeks of collection, as Hughes (1962b) observed a decrease in activity after eight weeks' storage. A significant decrease in enzyme activity was found

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