J. B. S. Haldane: His life and science

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Introduction

J. B. S. Haldane, the centenary of whose birth falls this year, was a remarkable human being. Today he is remembered mainly for his work on evolution, but that is because first-rate work in several other areas, each enough to make the reputation of a biologist by itself, pales in comparison with his work on evolution. His contributions to developing a quantitative theory of evolution were fundamental. Haldane was a superb popularizer of science; a strong believer in rationality; a Marxist; exuberantly boyish in many of his ways; chronically distrustful of power, authority and bombast; prickly at times but unselfish, kind and gentle at others. To talk about Haldane is at the same time easy and difficult. Easy, because of the huge amount of material available: a competent full-length biography by Clark, shorter reminiscences, anecdotes and notices by many others, pieces by Haldane himself—I include in this both purely autobiographical writing as well as popular essays—and, not the least, an immense amount of published scientific work carried out for well over 50 years. I do not need to elaborate on the point that this very richness of sources makes the problem of choosing what to say a difficult one. Like all great scientists, Haldane had more up his sleeve than the material he published (for example, an unpublished note—just discovered—shows that Haldane had worked out an approximate but fairly accurate solution to the problem of calculating the distribution of spontaneously occurring mutants, a problem made important by the experiments of Luria and Delbrück). I have organized this essay as follows: After a brief sketch of his life, I will try to give you a feeling for Haldane's contributions to science. As part of this, I will mention instances of Haldane's ability to anticipate future developments. Next I shall deal with Haldane the communicator, especially the writer of popular articles. Many of Haldane's writings were for the *Daily Worker*, a Communist newspaper, and I will touch upon Haldane the Marxist. This, at least in the version popularized by himself, leads naturally to the subject of Haldane in India. I end with quotations from two philosophical essays by him.

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A brief life-sketch

John Burdon Sanderson Haldane was born on 5 November 1892. His father, John Scott Haldane, was by then well on his way to being recognized as an authority on physiology, especially the physiology of respiration, and JBS's first steps in science were taken as an infant guinea pig in his father's experiments. Haldane was a precocious child, able to read by three and write by five. According to D'Arcy Thompson, already as a toddler he handled and studied objects with a scientific expression. Precocity was combined with a remarkable memory (even in later years Haldane had no need, it is said, to look up scientific references when writing his papers), intellectual brilliance and a strongly pugnacious nature. A fight was never far off when Haldane was around; again, a feature which endured all his life. After his preparatory school, where he had the reputation of teaching mathematics to the mathematics master, he went to the Eton 'Public' school, where he was extremely unhappy. One wonders how much this early exposure, to what must have been a snobbish and exclusive environment, was responsible for his life-long anti-establishment attitude. Oxford, which he enjoyed, followed. Here he studied mathematics, the European classics, and philosophy. Haldane never took a degree in biology. His love of what we would call the 'Arts' was enduring, and his writings are studded with quotations from Greek and Latin, Christian theology, and, later in life, from Hindu scriptures. Active service in the first world war (the absence of capital letters in 'world war' is a Haldanism), which he thoroughly relished, came next. After the war, a string of British academic appointments followed one after the other: Fellow at Oxford (1919–1922), Reader in Biochemistry in Gowland Hopkins' department, at Cambridge (1922–1932); 'Officer-in-charge of Genetical Investigations' at the John Innes Horticultural Institution (1927–1936), Professor of Physiology at the Royal Institution (1930–1932) and Weldon Professor of Biometry at University College, London (1937–1957). As the dates indicate, for a period Haldane held three part-time positions. He was married twice. His first wife, Charlotte, was a novelist and journalist; the second wife, Helen Spurway, was a geneticist and student of animal behaviour. JBS and Helen Spurway migrated to India in 1957 and stayed there for seven years. Haldane's initial appointment was at the Indian Statistical Institute in Calcutta. He moved from Calcutta to the Orissa Genetics and Biometry Laboratory in Bhubaneswar, where he died on 1 December 1964. Helen Spurway carried on with her researches in India and survived her husband by twelve years. Haldane did not have any children.

Early science

Before discussing Haldane's contributions to our understanding of how evolution operates, a word about his early work. While still a school boy he had begun helping his father in physiological experiments. These were mainly concerned with respiration under conditions of deep-sea diving and working in mines. The experiments continued during the first world war, when the problem of devising an effective gas mask was acute. The work was risky; JBS took part in it, with an almost reckless disregard for his own health and safety, a disregard encouraged by his father. The most remarkable piece of research carried out by the young Haldane dates from his recognition, when a boy of just 16, that certain of the data presented in

a paper on mouse genetics by Darbishire did not fall into the Mendelian expectation of 'independent assortment'. Haldane had discovered the phenomenon of linkage, one of the first hints that genes, the particles of heredity, were not free to 'move' independently of one another but were instead physically associated in the manner of beads on a string. He proceeded to verify this hypothesis by means of breeding experiments carried out at home with the assistance of his sister Naomi and a friend. Unfortunately, publication was delayed by the war and the paper came out only in 1915. By then evidence for linkage had been derived independently by the group of T. H. Morgan in New York working with the fruit fly *Drosophila*.

The Darwinian theory of evolution

Darwin's main claim to greatness is that he put forward an overwhelmingly plausible theory of evolution. In order for plausibility to get transformed to conviction, it needed Mendel and his successors to account for both the mechanism of heredity and the origin of variation: until then, crucial but mysterious features of Darwinian theory. Once this was done, there was an explosive burst of activity culminating in what came to be known as the neo-Darwinian synthesis. Two distinct lines of research fuelled the synthesis. On the one hand, there was field work aimed at strengthening the base that Darwin had built. This involved careful analysis of fossil records (G. G. Simpson), of geographical diversity (E. Mayr), and of naturally occurring genetic variants (N. I. Vavilov, Th. Dobzhansky, N. W. Timofeef-Ressovsky). On the other hand, there was the need to prove beyond all doubt that Mendelian principles could provide the link between genetics and evolution demanded by Natural Selection (as Darwin's theory is called). This gigantic task was accomplished primarily by four men: S. S. Chetverikov in Russia, Sewall Wright in the USA, and R. A. Fisher and J. B. S. Haldane in England. In his own way, each of these four tackled similar questions: given that the reactions catalysed by certain genes lead to certain traits, and given that the traits contribute more or less successfully to the ability of individuals to reproduce, what gene combinations survive in the long run? How is this process affected by the breeding structure of the population, by the physical organization of genes, and by the vagaries of chance? This enterprise, called the quantitative theory of evolution, or population genetics, was essentially finished by the early 1930s. It is a measure of the completeness of the task then accomplished that we have had just one fundamentally new idea in population genetics in all the 60 years since then. This is a hypothesis, due to Kimura, that there is only a loose link between evolution as it is normally thought of—in the 'large'—and evolution at the molecular level, with the latter ticking away steadily like a clock and being on the whole neither advantageous nor disadvantageous. John Maynard Smith, Haldane's most distinguished student and a leading evolutionary geneticist, said on one occasion that any result in evolutionary theory ought to be considered original, and as such publishable, if the only person to have obtained it previously had been Haldane, Fisher, or Wright. Otherwise, Maynard Smith implied, very little research could get done.

The neo-Darwinian synthesis also set the seal on a philosophical revolution. In the physical sciences, an experimenter's skill is judged by the extent to which she can "prepare" a system for examination—that is, insulate it from all possible disturbances from the surroundings (meaning, from whatever is deemed to be irrelevant). Correspondingly, the theorist develops models of isolated systems: the smooth sphere rolling with no friction down an inclined plane, the hydrogen atom in a vacuum, and so on. In order to explain some things (e.g. the properties of water) one needs to deal with large aggregates, but these are collections of the same basic unit. For evolution, the single isolated system (in the sense the term is used in physics) is an uninteresting concept. The unit of evolutionary thinking, on the other hand, is a population of distinct individuals together with their environment. To appreciate what this implies, imagine what the consequences might have been for physics or chemistry if they had needed this type of populationist thinking: the fate of a sodium atom would then depend on all the sodium atoms in the universe, as well as on all the molecular combinations into which that atom entered. The second part of the philosophical revolution ushered in by evolutionary thinking is that history is brought in as an essential part of scientific explanation. Every living system carries within it indissoluble links with its past, a heritage which we need to invoke if we want to understand its present.

Let me illustrate these points by giving you my favourite example of the difference between a physical explanation and an evolutionary explanation. The problem is: why do apples fall down? We all know the answer Newton gave; an apple falls down because of the pull of the earth's gravity. A possible evolutionary explanation of the same fact might go as follows: 'In ancient times, hundreds of thousands of apple tree generations ago, apples used to fall in all directions, down as well as up. However, those apples which fell straight down had a higher than average probability of taking seed and giving rise to other apple trees. These, in their turn, carried on with the winning strategy—dictated by their heritage—of falling directly downwards. Eventually only their successors were left. This is why today all apples are seen to fall down.

Haldane's contributions to evolutionary theory

In a series of papers starting in 1924, Haldane began to develop a comprehensive theory of population genetics (and, as we have seen, so did Chetverikov, Fisher and Wright). His contributions were organized in book form in 1932 (*The Causes of Evolution*). Even though he continued to work in the field for the rest of his life, he does not seem to have attempted a comparably wide-ranging look at evolution at any later time. The aim of the early papers was set out in the very first one: "In order to establish the view that natural selection is capable of accounting for the known facts of evolution, we must show not only that it can cause a species to change, but that it can cause it to change at a rate which will account for present and past transmutation". The emphasis on rates is characteristic of Haldane. In this enterprise he was aided by a sound knowledge of the facts, especially of

genetics and palaeontology, mathematical skill of a high order, deep intuition, and an ability to get quickly to the essence of a specific problem. The last of these traits partly distinguishes Haldane from Fisher and Wright.

Fisher tended to generalize, to look out for 'universal' laws which—to the anguish of generations of students—he often derived, or at any rate expressed, using purely verbal arguments. Wright was a synthesizer, and sought to develop a unified perspective on evolution by taking into account as many contributory factors as possible. Haldane, in contrast, always seems to have had in mind a practical problem to which he wanted a specific, preferably numerical, answer. Thus: How many generations would it need for a beneficial trait with a selective advantage of 0.001 to lead to a gene frequency change from 0.001 to 0.01? What were the rates of evolution in the lineage leading to the modern horse? If obviously deleterious traits (e.g. hemophilia) are seen generation after generation, their origin might be due to fresh (recurrent) mutation: what mutation rate would be necessary to account for the observed frequency of a trait? Could the curious correlation, seen between malarial prevalence and the blood defects of sickle cell anaemia and thallasaemia, have a causal basis? If so, what degree of protection would the sickling trait (say) need to confer in a malarial environment in order for it to persist? (It is being increasingly appreciated today that in drawing attention to disease as a possible driving force for evolution, Haldane had put his finger on something deep.) What is the minimum level of fecundity, the 'cost' of natural selection, required to maintain a stable population, given that not all individuals have the same fitness? How do rates of mutation caused by high energy radiation compare with those occurring spontaneously? In the light of this, is there something like a 'safe' dose of radiation?

It would be grossly unfair to say that each of Haldane's evolutionary studies had a narrow focus when considered by itself. Even the questions I have mentioned lead to obvious generalizations, and Haldane made them. But the immense diversity of the problems tackled by Haldane has left us with a legacy which is both rich and somewhat disjointed. It is difficult to pin down Haldane—as one can Fisher or Wright—and summarize in a few sentences just what his contributions to evolutionary theory were; or as Crow has pointed out, to mention one path-breaking accomplishment due to him. The favourable aspect of the situation is that whereas Fisher forces you to convince yourself of the correctness of his conclusions, and Wright motivates you to make the immense effort of trying to work through his analyses, with Haldane you not only understand what he says at once, you are invariably put in mind of a new problem to solve. It hardly needs to be said that population genetics did not solve (and indeed has not solved) all the problems of evolutionary biology. What it did do, and this was a tremendous achievement, was to show that using a certain set of approaches led to *possible* solutions. This point has not always been appreciated. One of the last pieces written by Haldane is an essay in which he vigorously defends the 'single beans in a bag' approach used in much of population genetics (the piece was written in response to the derisive comments of Mayr, who had attacked what were—he asserted—exaggerated claims made by theorists).

Contributions to other areas in biology

Haldane's interest in genetic structure, exemplified by the early work on linkage in mice, was lifelong. He was the first to derive a formula for mapping genes along the chromosome; a process comparable, in a very approximate sense, to drawing a geographical map on the basis of distances measured locally (the formula popularly used today is based on a modification due to Kosambi). This too was with a potential application in mind. The idea is that if a gene with a benign but visible effect (e.g. colour blindness) is closely associated with another gene which can have a severely deleterious effect but whose presence is masked (e.g. haemophilia, an inability of blood to clot), the presence of the first gene can alert a medical practitioner to the possible presence of the second, and so can aid in early therapy or in genetic counselling. Haldane was also the first to discover linkage in man; he presented the first genetic map of a human chromosome and was the first to estimate a human mutation rate (as well as to suggest that it might be different in the two sexes). He was a pioneer in the application of genetics to biochemistry or indeed in asserting that the two had anything to do with each other at all. His early appreciation of the importance of Garrod's studies on inborn metabolic deficiencies and, much later, his association with the work on flower colours at the John Innes Horticultural Institution, led him to consider the 'one gene, one enzyme' hypothesis well before Beadle and Tatum. In fact, he seems to have raised the possibility that a gene makes a particular chemical species of enzyme as early as 1920, though—characteristically—he says he got the idea from Cuénot. In biochemistry proper, Haldane (together with Briggs) gave the correct interpretation of the kinetics of the simplest enzyme reaction and, on his own, wrote an influential textbook on enzymes. The Briggs–Haldane derivation showed that the Michaelis constant (Km) was a complex ratio of two rates rather than the equivalent of a dissociation constant as Michaelis and Henri had suggested. Among non-evolutionary biologists, Haldane's name is most widely associated with the theory he developed—independently of Oparin—for the origin of life. The basic idea here was that in the primeval oxygen-free (and so reducing) atmosphere, the action of ultraviolet light on a mixture of carbon dioxide, water and ammonia could lead to the formation of more complex molecules out of which, given a sufficient concentration ('the consistency of hot dilute soup'), proteins might be formed. Typically for Haldane, the hypothesis is tossed off as an aside within two paragraphs of an article dealing with Pasteur, fermentation and other matters and written for a general readership in *The Rationalist Annual*. Had he not taken to biology, Haldane might have become a professional mathematician. His interest in mathematics was always an outgrowth of some problem in genetics or evolution and to a large extent consisted of devising improved statistical methods for analysing data and estimating 'inverse' probabilities. JBS and his wife Helen were both seriously interested in animal behaviour and there is a marvellous

joint paper in which they analyse the dance language of the honey bee from the viewpoint of information theory.

I must draw special attention to one feature of Haldane's non-technical scientific writings: the number of times he stuck his neck out and made what looked (at the time he made it) like a daring guess which subsequently has turned out to be plausible if not correct. For example, he has stated (with no reasons given!) that ribonucleic acid (RNA)—not DNA—may have been the first self-replicating molecule, an idea that has caught on in the light of very recent evidence pointing to the enzymatic activity possessed by some RNA's; that it should be possible to design antibodies which function like enzymes (here he provided sound chemical arguments based on which this has been accomplished); and that altruistic behaviour could be fostered by kinship, in other words by the probability that the recipient of the behaviour shares genes with the altruist (the hypothesis which, after its clear elucidation by W. D. Hamilton in 1964, has fuelled much of modern sociobiological research).

When compared to the amount he wrote to get scientific ideas across, Haldane did not write much about his view of the philosophy of science, or indeed whether he had a definite philosophical attitude at all. His essays on Marxist philosophy and dialectical materialism constitute prominent exceptions. He held Kant in high regard: "In biology we are for the moment in a curiously Kantian position ···. Every process in the living organism which has been studied by physical and chemical methods has been found to obey the laws of physics and chemistry, as must obviously be the case if, as Kant thought, these laws merely represent the forms of our perception and abstract understanding. But these processes are coordinated in a way characteristic of the living organism. Thus we cannot avoid speaking of the function of the heart, as well as its mechanism. At present, with Kant, we are compelled to leave open the question 'whether in the unknown inner ground of nature the physical and teleological connection of the same things may not cohere in one principle'; we only say that our reason cannot so unite them" (from *Possible Worlds*). I do not think anyone would disagree with this even today.

General writings

Haldane was a peerless communicator of scientific ideas. He wrote partly for the money it brought him, perhaps partly because he enjoyed it, but also because he had a passionate belief in the value of knowledge and the duty one had of sharing it with those less lucky or less able. Also, "··· the public has a right to know what is going on inside the laboratories, for some of which it pays". A random sampling of the titles of his essays conveys a feeling for the range of topics covered: Was England a Yugoslav Colony?; Heat and History; Why the Earth is a Magnet; Why Steal Beetles?; How Bees Communicate; On Being One's Own Rabbit; Man as a Sea Beast; Should Scientific Research be Rewarded?; even How to Write a Popular Scientific Article; one can go on and on. His sister has stated that he never thought that the bounds of science stopped anywhere.

As much as his grasp of ideas and ability to convey meaning in simple words, what makes a Haldane piece irresistible is the vividness of his language. Let me give you a few examples. "··· I find it no easier to picture a completely socialized British Empire or United States than an elephant turning somersaults or a hippopotamus jumping a hedge···" "Einstein was the greatest Jew since Jesus···" "··· Besides His Majesty the King, His Holiness the Pope and His Worship the Mayor, I should like to be able to speak of His Ferocity the Major General, His Velocity the Air Marshal···".

Not only could Haldane write on almost any subject, he had the ability to weave in more themes than one within the same piece. In an essay titled The Hungarian Invasion, Haldane starts with an account of the spread of Hungarian frogs in England, takes time off to comment on how to pronounce the sounds made by the frog chorus in Aristophanes, and in a tangent to this tangent, goes on to state that oral traditions have largely preserved the purity of pronunciations in Sanskrit, but 'Frogs are probably even more conservative than Hindus'. In a perceptive essay on animal communication and the possible origin of human language, he offers us a stage instruction from Shakespeare as support for his suggestion that muscular activity is not only a reflection of a mental state but also serves to reinforce that state.

Haldane the person

Haldane was physically a large man. He called himself 'a man of violence by temperament and training'. In personal relationships he could be at times very friendly and at others insulting, but claimed that he insulted everyone impartially. He seems to have applied the strict test of rationality not only to his own words and actions (which was fine), but also to the actions of others (which could lead to problems). He would pay from his own pocket for a student's air fare to attend a conference but could fumble (successfully, one guesses) when paying for tea in the canteen. He was perennially quotable, never shy of offering his opinion on any topic publicly; J. F. Crow calls him a reporter's dream. An extremely stubborn and argumentative man, in scientific matters he was most unselfish and generous in giving credit to colleagues and students. There are many references to papers by others whose implications were appreciated first by Haldane and elucidated in an appendix to the main text. Thanks to this, many young scientists are said to have learned that their work was more important than they realized. Like many intellectuals of his time, Haldane was attracted by the egalitarian philosophy of socialism. His thinking was on the whole materialistic and uncompromisingly rational. As such, he saw that the only justifiable attitude to the mind was that it was a by-product or epiphenomenon of certain material systems. His family background had been unreligious, and much as he enjoyed quoting scripture, he had no time for organized religion, let alone for bogus sciences like astrology and palmistry. Once, when asked if he believed in God, Haldane, prompted by the fact that the overwhelming majority of animal species are insects, is said to have replied "I do not know if God exists, but if He does, He must be inordinately fond of beetles". A fair poet, Haldane had absolutely no ear for music; he said he could tell when the British national anthem was being

played only by seeing everyone stand up. He claimed that lack of interest in music was an advantage, because that meant he wasted less time away from work. His capacity for work was tremendous. Rail journeys were always in first-class because that meant he had the opportunity to get going with some piece of writing.

There are a number of Haldane anecdotes, and these convey the flavour of Haldane better than any amount of description (or, one imagines, psychological analysis). Be that as it may, like all good stories they improve with the telling; and that is excuse enough for repeating a few. Once, after hearing a talk on the scientific man, Bernard Shaw wanted to know exactly what the phrase meant; could *he* be called a scientific man? Haldane's reply was "Mr. Shaw, you are a great and famous playwright. One cannot be *everything* in this life". Shaw, for those not aware, had violently anti-Darwinist sentiments; he could not get reconciled to the possibility that evolution was based on "blind chance". At the end of his address on the occasion of the Karl Pearson centenary, Haldane went out of his way to point out that buying Pearson's books and making them accessible to students would be a more meaningful way of honouring Pearson than making speeches and eating food—not, one feels, remarks likely to be appreciated by the organizers. In his delightful book *Animal Days* Desmond Morris describes Haldane's prescription for crossing a busy Parsian street down which Kamikaze drivers were hurtling: "'As a good ethologist', boomed Haldane, 'you should know how to get across this street. It is all a matter of making the appropriate display. Most people try to stop incoming traffic with a frontal display like this', and he raised a palm towards the speeding cars as if trying to repel them. "Wrong!" he thundered. 'That merely foreshortens your display and makes your arm look smaller. What is need is a *lateral* display, *like this*'. And he thrust one arm stiffly out in front of him and the other stiffly behind him, at right angles to the traffic. 'Now I look much bigger to them, like an aggressive fish displaying side-on'. And without the slightest hesitation he walked straight out into the road. To our surprise it worked. The drivers screeched and swirled around him, but his determined, stiff-armed walk got him through", Morris adds that the rest of them were less courageous and took ages to make the same crossing. When Maynard Smith was in India many years ago, some of us heard a story illustrating Haldane's ability to respond rapidly to a demanding situation. *Prof (as he was known)* and his students had been out drinking in a pub. On the way back, a carelessly thrown match set the car's upholstery alight. Without wasting any time, Prof stopped the car, ordered the students to jump out and look the other way, and proceeded to douse the fire by a judicious application of the contents of his bladder.

The Lysenko affair

A general sympathy for the underdog, the attraction of Socialist ideals, and disgust for the workings of capitalism made Haldane a Marxist. He remained one for most of his life, but maintained formal allegiance to the Communist Party of Great Britain for just 8 years (he gave it up in 1950). Events in the USSR caused Haldane and many like him to face a difficult choice, a choice forced by their deep sympathy for the Soviet Union on the one hand and ever-stronger evidence of the serious damage caused to Soviet biology by the activities of Trofim Lysenko, a favourite of Stalin, on the other.

There are too many threads in the story for me to disentangle here. Lysenko's enduring notoriety is based on the sensational claim, never satisfactorily substantiated, that by inducing certain seeds to germinate earlier than usual, their *descendants* would be better equipped to survive the early frosts of extreme Northerly latitudes. Not content with striking in this manner at the heart of conventional Darwinian thinking, Lysenko went on to suggest that by performing grafts he could cause different species (of plants) to hybridize, adding a blow at genetic orthodoxy as well. Stalin took to Lysenko's ideas because they appeared to provide easy solutions to difficult problems, perhaps also because they seemed to offer scientific underpinning to the Soviet ambition of creating a new kind of human being. Unfortunately, not only were Lysenko's beliefs disastrous for Soviet agriculture—because they were wrong—but in the attempt to justify those beliefs, genetical thinking was rediculed, the Soviet Union lost its place in contemporary biology, and many of its leading biologists were deprived of work, security, and on occasion, even their lives.

In this situation Haldane's attitude was at best equivocal. He never abandoned his scientific views, but at the same time he bent over backwards to suggest that Lysenko might be on to something after all: one feels that his political loyalties demanded this much. At most Haldane would concede that Lysenko's views were disputed and that he was "engaged in a lively controversy with some of the older workers". Even the practical certainty that N. I. Vavilov—the doyen of Soviet agricultural scientists and a man held in high esteem by Haldane—had died under dubious circumstances did not move Haldane to the open condemnation one should have expected from him. Here he stands in contrast to H. J. Muller, another great geneticist, highly original evolutionary thinker in his own right and not unlike Haldane in some respects. Even though he too waffled at first, eventually Muller emphatically distanced himself from the official Soviet line on Lysenko. In the case of JBS, the break did come finally, but the reason, as I see it, was more typical: functioning within the rigid norms of official Marxist dogma and as part of a highly organized structure was too un-Haldanian to last. He never dismissed Lysenko's claims in their entirety; interestingly, in this attitude he may even have been technically correct.

Haldane and India

Haldane's reasons for leaving England were probably many and complex, but the Anglo-French invasion of Suez provided a convenient and dramatic stimulus. He announced that he no longer wished to live in a criminal state. Helen Spurway did her bit by getting arrested in a farcical incident involving her stepping inadvertently on a police dog's tail and subsequently telling the policeman what she thought of his kind (the dog was unhurt and apparently treated the stepping as a friendly gesture). Her arrest embarrassed the

authorities and delighted the Haldanes, who seized upon it as evidence of state persecution. More seriously, Haldane had developed a genuine interest in India and the prospects for doing useful science there. His readings in Hindu, Buddhist and Jaina philosophy bolstered this interest; in his younger days he had been attracted by the simplicity and egalitarianism of Islam. His friendship with P. C. Mahalonobis led him to join the Indian Statistical Institute in Calcutta. Later Haldane was to take up Indian citizenship.

Things started off well; Haldane collected a small band of enthusiastic young students, put them on to interesting problems, continued to travel and lecture, and maintained the high standards of the *Journal of Genetics* (which he had brought with him to India). However, problems were not long in coming. Part of it was the intrinsic difficulty Haldane felt in functioning within a bureaucratic structure which was also vague (the nature of his relations with ISI remained hazy throughout his time there). The ISI administration expected Haldane—of all people—to conform to his role as one of the Sahib-log (a phrase which immediately calls to mind Kipling's term Bandar-log; I like to think that Haldane would have enjoyed the association). There was one incident in which an employee was punished for smoking in the presence of his superior. In another, Haldane, as a form of protest, decided to sign himself in and out just as the lower orders were expected to. As often with Haldane, when the break with ISI came, it was over an episode which could have served as no more than an irritation by itself. Without any warning, Mahalonobis had countermanded—at the last moment—his arrangement for displaying the work of his group during a visit by Kosygin (the future Prime Minister of the USSR). Coming on top of his unhappiness with the hierarchic setup, for Haldane this provided provocation enough to resign.

What followed was worse than anything at ISI. In pursuance of an offer made by Vice-President Radhakrishnan, Dr M. S. Thacker, as head of the Council for Scientific and Industrial Research, persuaded Haldane to start a Genetics and Biometry Unit in Calcutta. He was assured that buildings, laboratory and ground would follow in due course. Nothing was done. I find it plausible to believe that having got him (as it must have thought) in its grasp, the system displayed an inability to differentiate between Haldane and everyone else; at times he seems to have been treated with the standard indifference and benign neglect characteristic of Indian administrators. At one stage he was asked to sign a document confirming his willingness to be transferred anywhere in India at a month's notice; later he was informed that no employee of CSIR could approach a foreign organization for help in travelling abroad without first getting official approval. For Haldane, at his stage of life, the CSIR encounter was a needless tragedy. He had enough spirit left to call his employer the Council for the Suppression of Independent Research, and one cannot help wondering what an unprejudiced observer would say to that today. After a whole year had been wasted, Haldane left CSIR. In his letter of resignation he said something which remains depressingly true today: 'It is the intolerable conditions imposed by bureaucrats and not the low salaries or the lack of equipment which cause so many Indians to take up posts abroad'.

There were deeper reasons behind Haldane's dissatisfaction with the ISI or CSIR than apparent on the surface. These were to persist in all his encounters with the Indian way of doing things (until shortly before his death). The cultural problems resulting from our attempts to do modern ('European') science in an Indian setting deserve detailed analysis, and this is not the place to do so. Let me nevertheless give a brief indication of my hypothesis by taking the specific case of J. B. S. Haldane. Modern science as it is practised in the West is, to a large extent, an activity which places a premium on individual enterprise and assertiveness. Among the traits which are considered to be important for success in scientific research are a readiness to question accepted belief, passionate commitment to the truth, free and rational argument, and nonconformism. These traits characterized Haldane (as well as his wife); they had already led to more than one awkward situation in Britain. Here he was, transported to what was on the surface a scientific environment, but underneath it there existed a rigidly conformist society with a strong class structure. Science is basically a subversive activity, but the Indian tradition prizes consensus and stability above most things; its dominant motto could be 'Don't rock the boat'. Honest to the point of bluntness in both speech and action, Haldane was completely unprepared for modes of behaviour which could be described by the sayings प्रियं ब्रूयात् (one should say what is pleasing) and न ब्रूयात् सत्यं अप्रियं (one should not speak the truth if it is unpleasant). Anyone who has grown up in this culture knows that irrespective of whether a promise is made by a bureaucratic functionary, scientist, plumber or dhobi, the sensible thing is to keep in mind the possibility that the sole purpose of the promise is immediate gratification. Even when a purportedly factual statement is made, one understands that it should not always be taken seriously. Haldane was known to be a great man; the promises made to him must have been befittingly extravagant. Unfortunately, he expected them to be kept.

Thanks to the enterprise and initiative of Bjju Patnaik, Haldane was able to move to Bhubaneswar. An entirely independent research establishment was set up and run by him and his young colleagues from Calcutta (S. K. Roy, T. A. Davis, K. R. Dronamraju and S. D. Jayakar). One has the impression that for the last two years of his life, J. B. S. Haldane was happy. In Suresh Jayakar he had found a man after his own heart, and some of the Haldane–Jayakar papers on population genetics are as enduring as the best of Haldane's own early work. Haldane had always stressed the suitability of ethology—the study of animal behaviour—as a subject for biological research for countries unable to spend large sums of money on technical equipment. Helen Spurway was a behavioural biologist herself, and the two of them, together with students, worked on problems such as nest-building in wasps, ant behaviour, and the consequences for evolution of selective visits by butterflies to flowers.

After a year of ill-health, Haldane died of rectal carcinoma on 1 December 1964. Out of misplaced kindness, the doctors who had operated on him in England when the condition was first diagnosed had left him with the impression that he was out of immediate

danger, he dashed off a poem titled *Cancer's a Funny Thing*. He was understandably unhappy when the truth became known; he maintained, with justification, that he would have planned his last days quite differently—less ambitiously in terms of science, for one thing. He had left express instructions that he wanted his body to be put to use even after death, and it was sent to a medical college for dissection.

Concluding remarks

The picture one has of Haldane is of a person who was like an intensely curious child all his life. He was constantly asking Why, and his learning and formidable memory helped in the quest. There is no doubt whatsoever that he shares equal place with Fisher and Wright for having made the Darwinian theory of evolution acceptable. M. J. D. White has written that in the history of genetics Haldane remains a great, sympathetic and deeply *tragic* (my emphasis) figure, explaining: "The tragedy of his life was that the breadth of his interests and activities precluded the long concentration of effort needed to develop a distinct new field of biology ···. He was possibly too much interested in the work of others to bother greatly in what directions his own was tending ···" White wrote his piece soon after Haldane's death, and I think that the intervening years have made not only the richness of Haldane's accomplishments more obvious, but his quirks and failures less serious. As Crow asks, Can a life that full be tragic?

I would like to end by quoting from Haldane. The first is an uncharacteristically reflective passage (for Haldane) from *The Causes of Evolution*. As one of the few places in his evolutionary writings in which one detects a hint of emotion, it might also offer an unusual insight into his mind. "If I were compelled to give my own appreciation of the evolutionary process as seen in a great group such as the Ammonites, where it is completed, I should say this: In the first place, it is very beautiful. In that beauty there is an element of tragedy. On the human time-scale the life of a plant or animal species appears as the endless repetition of an almost identical theme. On the time-scale of geology we capture that element of uniqueness, of Einmaligkeit, which makes the transitoriness of human life into a tragedy. In an evolutionary line rising from simplicity to complexity, then often falling back to an apparently primitive condition before its end, we perceive an artistic unity similar to that of a fugue, or the life work of a great and versatile painter like Picasso ··· To me at least the beauty of evolution is far more striking than its pupose."

The second quotation is from *Possible Worlds* and goes "Our only hope of understanding the universe is to look at it from as many different points of view as possible. This is one of the reasons why the data of mystical consciousness can usefully supplement those of the mind in its normal state. Now, my own suspicion is that the universe is not only queerer than we suppose, but queerer than we can suppose ···. I suspect there are more things in heaven and earth than are dreamed of, or can be dreamed of, in any philosophy. That is the reason why I have no philosophy myself, and must be my excuse for dreaming".

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