

Année 2010

THÈSE DE L'UNIVERSITÉ DE LYON

Délivrée par
L'UNIVERSITÉ CLAUDE BERNARD – LYON 1
en vue de l'obtention du

DIPLÔME DE DOCTORAT
(arrêté du 7 août 2006)

soutenue publiquement le 15 septembre 2010
par

Simon GOUZ

Spécialité :

Histoire, philosophie et épistémologie des sciences, des techniques et des technologies

École Doctorale :

485 – E.P.I.C.

Biographie d'une vision du monde :
Les relations entre science, philosophie et politique
dans la conception marxiste de J.B.S. Haldane

Directeur de thèse : Olivier PERRU

Versions originales des citations traduites dans le
manuscrit

Versions originales des citations traduites

Nous reproduisons ci-dessous, les versions originales des citations longues (ie celles qui sont présentées séparées du corps du texte, en police réduite et précédées d'un retrait), traduites par nos soins dans notre travail. Entre crochets : les parties de textes originaux omis dans nos citations.

Introduction :

note 13, p. 242 : Andrew J. Hammond, 2004, *JBS Haldane and the Attempt to Construct a Marxist Biology*, thèse, University of Manchester, Faculty of the Life Science, p. 20 :

There are several possible reasons for the omissions from Haldane's archives. Firstly, friends or family may have retained various items. Secondly, [as will be seen, in the case of his early reading of the Marxist writings on science] he was able to extensively discuss relevant issues with colleagues at the Dunn laboratory and may therefore not have felt the need to commit his thoughts to paper. Thirdly, there are claims that he would often keep his thoughts private on an important issue until he was fully decided upon it. [At least one close associate of Haldane's suggests that Haldane's close friends were taken by surprise at his conversion to Marxism for this very reason (Rendel 1966).] Fourthly, Haldane was known to rely upon his well-known exceptional memory and may have used this as a substitute for extensive note making.

Première partie :

Chapitre 1 :

note 3, p. 31 : JBS Haldane, 1990 [1961], « An Autobiography in Brief », Krishna Dronamraju (Ed.), *Selected Genetics Papers of J.B.S. Haldane*, Garland Publishing, New York & London, p. 19 :

I used to play on the floor of his laboratory and watch him playing a complicated game called « experiment » - the rules I didn't understand, but he clearly enjoyed it.

note 5, p.32 : Ronald Clark, 1969 [1968], *J.B.S. : the Life and Work of J.B.S. Haldane*, Coward-McCann, New York, p. 18 :

This brilliance, which quickly developed from that of the exceptionally bright boy into that of the near-prodigy, brought JBS in 1903 to the top of the Dragon School in Latin, translation, arithmetic and geometry before he reached the age of twelve [or even entered the top form ; only two of the whole school passed him in Greek or Latin verse.] This almost disconcerting success was surpassed the following year, 1904, when he walked off with an armful of prizes, including the first scholarship to Eton.

note 9, p. 33 : Ronald Clark, *J.B.S. : the Life and Work of J.B.S. Haldane*, p. 22 :

"I could read Latin, Greek, French and German," he later wrote. "I knew enough chemistry to take part in research, enough biology to do unaided research, and I had a fair knowledge of history and contemporary politics."

note 11, p. 33 : JBS Haldane, « An Autobiography in Brief », *loc. cit.*, p. 20 :

The teaching of chemistry was good, and by the age of sixteen I had learned some facts discovered since my father had studied that subject, so that I could help him and C.G. Douglas.

note 12, p. 34 : JBS Haldane, « An Autobiography in Brief », *loc. cit.*, p. 20 :

But as nobody can study mathematics intensively for more than about 5 hours daily and retain sanity, I also attended the final honors course in zoölogy in my first year.

note 33, p. 38 : JBS Haldane, 1924, « A Mathematical Theory of Natural and Artificial Selection, Pt. I », *Transactions of the Cambridge Philosophical Society*, Vol. 23, n°2, p. 19 :

A satisfactory theory of natural selection must be quantitative. 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 pas transmutations.

note 34, p. 38 : JBS Haldane, 1924, « A Mathematical Theory of Natural and Artificial Selection, Pt. I », *Transactions of the Cambridge Philosophical Society*, Vol. 23, n°2, p. 19 :

The principal work on the subject so far is that of Pearson, Warren, and Norton. Pearson's work was based on a pre-Mendelian theory of variation and heredity, which is certainly inapplicable to many, and perhaps to all characters. Warren has only considered selection of an extremely stringent character, whilst Norton's work is as yet only available in the table quoted by Punnett.

note 59, p. 45 : Sahotra Sarkar, 1992, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane, 1922-1937 », *Biology and Philosophy*, Vol. 7, p. 388-389 :

At that point, Haldane's philosophical views were in full accordance with that of J. S. Haldane [reflecting how the latter, rather than L. K. Haldane, had come to be the dominant force in their son's intellectual life. For a scientist, J. S. Haldane was always uncharacteristically immersed in philosophy. In spite of his own successes in physiology, where physiological phenomena were explicated using the ordinary mechanisms of organic chemistry, J. S. Haldane always maintained that a completely mechanistic account of all living phenomena was impossible. Indeed, he interpreted these successes as consistent with his teleology (see Sturdy 1988, p. 333). Early in life, he even advocated a species of vitalism (Haldane 1898), though later came to prefer "organicism" to describe his point of view which emphasized the unity of the organism (Haldane 1906).] The crucial philosophical influence in the development of his views, as in the case of most of the nineteenth-century anti- mechanist German biologists, was the second part of Kant's Critique of Judgement.

note 68, p. 47 : John Scott Haldane, 1929, *The Sciences and Philosophy*, Doubleday, Doran and Co., New York, p. 306 :

The present widespread belief that Religion will die out as Science advances is nothing but evidence of intellectual blindness. Existing Churches will decay if they do not amend their creeds; but Religion will no more die out than Science will, or Philosophy will. Religion and Philosophy are in reality one thing, which is just as indispensable as Science is.

note 69, p. 48 : JBS Haldane, 2002 [1927], « Science and Theology as Art Forms », *Possible Worlds*, Transaction Publishers, New Brunswick/London, p. 239-240 :

Religion is a way of life and an attitude to the universe. It brings men into closer touch with the inner nature of reality. Statements of fact made in its name are untrue in detail, but often contain some truth at their core. Science is also a way of life and an attitude to the universe. It is concerned with everything but the nature of reality. Statements of fact made in its name are generally right in detail, but can only reveal the form, and not the real nature, of existence. The wise man regulates his conduct by the theories both of religion and science.

note 70, p. 49 : JBS Haldane, 1968 [1934] « If... », *Science and Life*, Pemberton Book, p. 18 :

Religion is still parasitic in the interstices of our knowledge which have not yet been filled. Like bed-bugs in the cracks of walls and furniture, miracles lurk in the lacunae of science. The scientist plasters up these cracks in our knowledge; the more militant Rationalist swats the bugs in the open. Both have their proper sphere, and they should realize that they are allies.

note 75, p. 50 : John Maynard Smith, « JBS Haldane », *loc. cit.*, p. 46 :

Those references are not only to Christianity, but to classical mythology and, after he settled in India, to Hindu and Buddhist writings. This is not an attempt to use religious arguments to support his case: Haldane was not a believer and, at least as far as Christianity was concerned, he rather enjoyed blasphemy. Neither was it, in any simple sense, an attempt to settle scores with a religion he had abandoned. [I mention this possibility because such a motive has been very important in my own case; having been raised in a rather literal version of Christianity, my interest in Darwin was first aroused because of the apparent contradiction between the theory of evolution and the Christian faith. Other evolutionary biologists have had a similar experience: E. O. Wilson is, I believe, an example, and I was amused to discover how many of my co-workers are lapsed Catholics.] But Haldane seems never to have been a religious believer.

note 92, p. 54 : JBS Haldane, 1968 [1965], « On being Finite », *Science and Life*, p. 201 :

If Marx was right, and I happened to agree with him, inventors are doing more for world revolution than many politicians. Changes in productive 'forces' generate a social instability which brings about change in productive relations, and hence in social structure. Those inventors who are Marxists are quite aware of this.

note 98, p. 55 : JBS Haldane, 2009, [1958], « Darwin in Indian Perspective », *What I Require from Life*, Oxford University Press, Oxford, p. 211 :

Hinduism is not a religion as this term is understood by the adherents of proselytizing religious beliefs. It is an attitude to the universe compatible with a variety of religious and philosophical beliefs.

note 100, p. 57 : Gary Werskey, 1979 [1978], *The Visible College*, Holt Rinehart and Winston, New York, p. 55 :

The clan as a whole embodied the liberal virtues of the intellectual aristocracy instead of the more reactionary attitudes associated with the landed gentry and established entrepreneurs.

note 104, p. 57 : Gary Werskey, *The Visible College*, p. 55 :

My mater and I are very sorry to hear of Mr Chamberlain's resignation, but hope he will get into the office again soon.

note 110, p. 59 : Ronald Clark, *J.B.S. : the Life and Work of J.B.S. Haldane*, p. 36 :

He also enjoyed the killing, which he regarded as a respectable if vestigial legacy from primitive times. The feeling left its mark, and the pleasure JBS took from the war worried him for the rest of his life.

note 111, p. 59 : Ronald Clark, *J.B.S. : the Life and Work of J.B.S. Haldane*, p. 43 :

This first experience of war had revealed in Haldane what he knew was a disconcerting enjoyment of its grimmer moments. Yet he knew also that he was an exception and that his enjoyment was wrong. Thus while one part of him was raised to a higher power by the experience, another part could regard war objectively and with a severely critical eye.

note 112, p. 60 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 27 :

Returning from the war Haldane found that almost all of his friends were dead. [He never again made friends so lightly. From here on in there was little distinction for Haldane between friends and work colleagues (Mitchison 1968: 300).] This loss, the realisation that the War had not been fought for high ideals yet massacring so many, his recognition that the War had exposed liberalism as woefully inadequate, and his newly found respect for the masses led Haldane towards the Left.

note 115, p. 61 : Charlotte Haldane, 1950, *Truth will out*, Vanguard Press, New York, p. 37 :

Our interest in politics had always been a strong one. We both were and had been, long before we had met, socialists and, to use the horrible cliché that, at about that period, began to pass into the language, 'left-wing intellectuals'.

note 116, p. 61 : JBS Haldane, « On Being the Right Size », *Possible Worlds*, p. 26 :

The extreme socialists desire to run every nation as a single business concern. [I do not suppose that Henry Ford would find much difficulty in running Andorra or Luxembourg on a socialistic basis. He has already more men on his pay-roll than their population. It is conceivable that a syndicate of Fords, if we could find them, would make Belgium Ltd or Denmark Inc. pay their way.] But while nationalization of certain industries is an obvious possibility in the largest of states, 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.

note 117, p. 61 : JBS Haldane, « The Duty of Doubt », *Possible Worlds*, p. 217 :

I should be willing to risk my life on its behalf in defending it against government by a military autocrat like the Kaiser or a secret society like the Ku Klux Klan. Yet I hope that I have not closed my mind to the claims of other forms of government, for example the rule of such a voluntary aristocracy as the governing group in Italy or Russia.

note 120, p. 62 : Charlotte Haldane, *Truth will out*, p. 37 :

So it was that we began to feel more than slight curiosity in the Soviet Union, and in the theories of Marx and Engels which had inspired Lenin and Trotsky, and on which this State was founded. When the opportunity arose to visit the Soviet Union, we eagerly accepted it.

note 122, p. 62 : JBS Haldane, « The Place of Science in Western Civilization », *The Inequality of Man*, p. 134 :

There is a second alternative, and that is that a serious attempt will be made to incorporate scientific ideas, as well as scientific inventions, in our national and international life. That attempt is being made to-day in Russia.

note 123, p. 63 : Charlotte Haldane, *Truth will out*, p. 52 :

My first impression of Soviet Union, or rather my first superficial view of it, had been an unfavourable one. Nevertheless, there had been several impressive glimpses of individuals and institutions that could engender optimism for the future of this colossal new social and political experiment, which, at that time, was eleven years old.

note 136, p. 66 : JBS Haldane, 1937, « A Dialectical Account of Evolution », *Science and Society*, Vol. 1, p. 473 :

This paper requires a preliminary apology. It is written in Spain, and as the writer is taking a very minor part in the defence of Madrid he is unable to consult many works of reference.

note 137, p. 67 : Ronald Clark, *J.B.S.: the Life and Work of J.B.S. Haldane*, p. 134 :

And in Spain he saw that it was mainly the Communists who were welding together the varied pro-government parties in a coherent front against the rebels ; the situation confirmed his belief that in an imperfect world, support for the Communists represented the least unsatisfactory option.

note 140, p. 68 : JBS Haldane, 1938, *ARP – Air Raid Precautions*, Victor Gollancz, London, p. 7

note 143, p. 69 : Gary Werskey, *The Visible College*, p. 160 :

Only after he had mastered to his own satisfaction the Marxist 'world-view' did Haldane allow himself, in 1942, to be put forward as a full member of the Communist Party.

note 147, p. 69 : Charlotte Haldane, *Truth will out*, p. 266 :

I was still the wife of J.B.S. Haldane, who, almost immediately on my return, was permitted by the Party to identify himself openly with it; obviously, to counteract, as compensation to Moscow and Party propaganda, my defection.

note 161, p. 73 : JBS Haldane, 1968 [1958], « A Passage to India », *Science and Life*, p. 130-131 :

I am also going to India because I am a socialist. I think that socialism is not only juster but more efficient than capitalism; that is to say, that it increases the national income and the standard of living more rapidly. [I am quite aware that there has been plenty of oppression and injustice in those countries where socialism has so far been established. It was only established after prolonged war against internal and external enemies, and war always generates oppression and injustice. Capitalism only replaced feudalism by violent means. Neither Cromwell nor Napoleon was particularly just or merciful. But they did a good job. So, in my opinion, did Stalin and Mao.

However, now that a good third of the human species is living under socialism, it becomes possible to make the transition with much less injustice. We may take it that, if the Soviet Union and China were not socialist States, any attempt at socialism in India would be met by foreign invasion to 'restore order'. In this way socialism was extinguished in Finland, Esthonia, Latvia, Lithuania, and Hungary in 1919 and in Spain in 1936-1938. If the US were not in existence, the governments of the neighbouring socialist countries might attempt to impose socialism in India by drastic economic pressure, or even by force.] As things are, the Indian government is taking the socialist path, though perhaps rather slowly, and can reasonably hope to do so without external interference.

note 162, p. 73 : JBS Haldane, « A Passage to India », *loc. cit.*, p. 130 :

I am quite aware that there has been plenty of oppression and injustice in those countries where socialism has so far been established. It was only established after prolonged war against internal and external enemies, and war always generates oppression and injustice. Capitalism only replaced feudalism by violent means. Neither Cromwell nor Napoleon was particularly just or merciful. But they did a good job. So, in my opinion, did Stalin and Mao.

note 164, p. 74 : JBS Haldane, « A Passage to India », *loc. cit.*, p. 131 :

Finally, I am going to India because I consider that recent acts of the British government have been violations of international laws.

Chapitre 2 :

note 171, p. 80 : JBS Haldane, « Preface », *Possible Worlds*, p. xxxix :

Many scientific workers believe that they should confine their publication to learned journals. I think, however, that the public has a right to know what is going on inside the laboratories, for some of which it pays.

note 172, p. 81 : JBS Haldane, « Preface », *loc. cit.*, p. xxxix :

And it seems to me vitally important that the scientific point of view should be applied, so far as is possible, to politics and religion.

note 176, p. 82 : Ronald Clark, 1969 [1968], *J.B.S. : the Life and Work of J.B.S. Haldane*, Coward-McCann, New York, p. 74 :

When he and his friend Julian Huxley had both been dons at Oxford a few years previously, Huxley had written his first popular article – largely to explain and modify the sensational press account of an experiment he had recently finished. A highly distracted Haldane had immediately called upon Huxley and his young wife to protest that this was not the task of a serious scientist.

note 179, p. 83 : JBS Haldane, *Daedalus*, p.40 :

With regard to the application of biology to human life, the average prophet appears to content himself with considerable if rather rudimentary progress in medicine and surgery, some improvements in domestic plants and animals, and possibly the introduction of a little eugenics.

note 180, p. 83 : JBS Haldane, *Daedalus*, p.53-54 :

Far more profound will be the effect of the practical applications of biology. I believe that the progress of medicine has had almost, if not quite, as deep an effect on society in Western Europe as the industrial revolution. Apart from the important social consequences which have flowed from the partial substitution of the doctor for the priest, its net result has been that whereas four hundred years ago most people died in childhood, they now live on an average, (apart from the late war), until forty-five. [Bad as our urban conditions are, there is not a slum in the country which has a third of the infantile death-rates of the royal family in the middle ages.] Largely as a result of this religion has come to lay less and less stress on a good death, and more and more on a good life, and its whole outlook has gradually changed in consequence.

note 181, p. 83 : JBS Haldane, *Daedalus*, p.85 :

I think then that the tendency of applied science is to magnify injustices until they become too intolerable to be borne, and the average man whom all the prophets and poets could not move, turns at least and extinguishes the evil at its source.

note 191, p. 85 : JBS Haldane, « Science and Politics », *Possible Worlds*, p. 182 :

Sometimes I fear I have answered that politics are no occupation for an honest man. If I made that answer I was wrong, for it is my duty, and every one's duty, to try to alter that state of affairs if it exists. But the true answer was that I thought I could be of more use where I was.

note 192, p. 85 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 183 :

I believe that social problems can only be solved in the long run by the application of scientific method, such as has made possible modern industry and modern medicine.

note 193, p. 86 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 183 :

If I thought that science in its present embryonic state could be applied to politics I should become a politician? But it certainly cannot.

note 194, p. 86 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 183-184 :

But to predict the behaviour of men in the mass we require knowledge of a special kind of psychology. And at the present moment the expert politician knows ten times as much of it as the best psychologist. But there is this big difference between the two. What little knowledge the psychologist possesses, though it is so abstract and meagre as to be of very little practical value, can be put in a form accessible to other psychologists. The same cannot be said of the politicians.

note 198, p. 87 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 185 :

Mechanics became a science when physicists had decided what they meant but such words as weight, velocity, and force, but not till then. The psychologists are still trying to arrive at a satisfactory terminology for the simplest phenomena that they have to deal with.

note 199, p. 88 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 185 :

Moreover, I do not believe that psychology will go very far without a satisfactory physiology of the nervous system, any more than physiology could advance until physics and chemistry had developed to a certain point. This is not to say that physiology is a mere branch of physics or chemistry, or the mind a mere by-product of the brain. But it is a fact that we can only know about life by observing the movement of matter.

note 201, p. 89 : JBS Haldane, *Daedalus*, p.10-11 :

When his scientific ideas were formed, flying and radio-telegraphy, for example, were scientific problems, and the centre of scientific interest still lay in physics and chemistry. Now these are commercial problems, and I believe that the centre of scientific interest lies in biology. A generation hence it may be elsewhere, and the views expressed in this paper will appear as modest, conservative, and unimaginative as do many of those of Mr. Wells to-day.

note 203, p. 90 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 187 :

For the moment, then, I believe that the man with a gift for thought on scientific lines is of more use to his fellows in the laboratory than out of it.

note 204, p. 90 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 188 :

But as long as the principles of politics are unsystematized and incommunicable, I, for one, shall continue to regard any political projects as interesting experiments which may or may not promote human happiness but will certainly furnish important data for future use.

note 206, p. 91 : JBS Haldane, « The Duty of Doubt », *Possible Worlds*, p. 211-212 :

Modern science began with great acts of doubt. Copernicus doubted that the sun went round the earth, Galileo that heavy bodies fall faster than light ones, Harvey that the blood flowed into the tissues through the veins. [They had each a theory to replace the old one, and their observations and experiments were largely designed to support that theory. But as time went on these theories, too, were found wanting. The planets do not go round the sun in circles as Copernicus thought ; gravitation is a more complex affair than Galileo or even Newton believed. And nowadays, though many experiments are made to support old or new theories, large numbers merely go to prove them false without putting anything in their place. One can hardly open a scientific journal without finding a paper with such a title as 'On an Anomalous Type of Inheritance in Potatoes' or 'Deviations from the Law of mass Action in Concentrated Sugar Solutions'. The statement of any general principle is enough to raise active doubt in many minds. Moreover, the authors very often make no attempt to put forward an improved theory ; and if they do so it is generally in a very tentative form. 'The results so far obtained are consistent with the view that...' has taken the place of 'Thus saith the Lord...' as an introduction to a new theory.] Moses apparently regarded 'An eye for an eye and a tooth for a tooth' as an absolute principle of right conduct ; Einstein would certainly not regard any of his laws as final accounts of the behaviour of matter.

note 208, p. 91 : JBS Haldane, « Science and Theology as Art Forms », *Possible Worlds*, p. 227 :

In scientific thought we adopt the simplest theory which will explain all the facts under consideration and enable us to predict new facts of the same kind.

note 209, p. 92 : JBS Haldane, « Science and Politics », *loc. cit.*, p. 182 :

'But why?' my questioner might have asked, 'if you can find a method of reducing the amount of potassium in your own blood or altering the distribution of sugar between the different tissues of your body, should you not apply your mind to reducing the amount of unemployment in the country or helping to bring about a juster distribution of its wealth?' I could not answer that these questions do not interest me. I have not to take many paces outside my laboratory to see the need for political and social reform. As a skilled manual worker and a trade unionist, I have a strong idea where I should find my political affinities.

note 214, p. 94 : JBS Haldane, « The Scientific Point of View », *The Inequality of Man*, p. 13 :

Science affects the average men and women in two ways already. He or she benefits by its application, driving in motor-car or omnibus instead of a horse-drawn vehicle, being treated for disease by a doctor or surgeon rather than a priest or a witch, and being killed with an automatic pistol or a shell in place of a dagger or a battle-axe. It also affects his or her opinion. Almost everyone believes the the earth is round, and the heavens nearly empty, instead of solid. And we are beginning to believe in our animal ancestry and the possibility of vast improvement in human nature by biological methods.

note 216, p. 94 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 13 :

But science can do something far bigger for the human mind than the substitution of one set of beliefs for another, or the inculcation of scepticism regarding accepted opinions. It can gradually spread among humanity as a whole the point of view that prevails among research workers, and has enabled a few thousand of men and a few dozen of women to create the science on which modern civilization rests.

note 218, p. 95 : JBS Haldane, « The Place of Science in Western Civilization », *The Inequality of Man*, p. 139 :

The scientific point of view is the point of view which has been taken up by scientific men, first, about their own problems and later about the problems of the world in general : a point of view which is finding every day a wider and wider applicability.

note 219, p. 96 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 14 :

What are the characteristics of that standpoint? In the first place, it attempts to be truthful and, therefore, impartial. And it carries impartiality a great deal further than does the legal point of view. A good judge will try to be impartial between Mr. John Smith and Mr. Chang Sing. A good scientist will be impartial between Mr. Smith, a tape-worm, and the solar system.

note 220, p. 97 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 14 :

He will leave behind him his natural repulsion of the tape-worm, which would lead him to throw it away instead of studying it as carefully as a statue or a symphony, and his awe for the solar system, which led his predecessors either to worship its constituents, or at least to regard them as inscrutable servants of the Almighty, too exalted for human comprehension.

note 222, p. 97 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 14-15 :

In so far as it places all phenomena on the same emotional level, the scientific point of view may be called the God-eye view. But it differs profoundly from that which religions have attributed to the Almighty in being ethically neutral. Science cannot determine what is right or wrong, and should not try to. It can work out the consequences of various actions, but it cannot pass judgment on them.

note 224, p. 99 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 20 :

We demand the general adoption of the scientific point of view because in its absence human effort is so largely devoted to conflicts with fellow-men, in which one, if not both, of the disputants must inevitably suffer. It is only in times of disaster that the average man devotes a moment's thought to his real enemies, 'the rulers of the darkness of this world' from bacteria to cyclones. Until humanity adopts the scientific point of view those enemies will not be conquered.

note 225, p. 99 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 22 :

But until the scientific point of view is generally adopted, our civilization will continue to suffer from a fundamental disharmony. Its material basis is scientific, its intellectual framework is pre-scientific. The present state of the world suggests that unless a fairly vigorous attempt is made in the near future to remedy this disharmony, our particular type of civilization will undergo the fate of the cultures of the past. Those who consider that it is worth saving should realize the kind of effort which is necessary, [and the kind of opposition which that effort will encounter].

note 227, p. 102 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 20-21 :

This adoption will inevitably be a slow process. But it will be quiet unnecessarily slow unless those who desire it realize the nature of the opposition to it. One of the necessary pre-requisites is adequate biological teaching in schools. Such teaching will only be adequate if it brings biology in relation with daily life. [In an agricultural community this would be possible by a study of agricultural plants and animals. In towns it can only come through the study of human anatomy and physiology, man being the only living organism familiar to the urban child.] Any attempt to teach these subjects involves the violation of the most formidable taboos.

note 229, p. 102 : JBS Haldane, « The Scientific Point of View », *loc. cit.*, p. 21-22 :

To take a simple example, it would be ridiculous to frame a practical course of that science which did not involve the analysis of urine, or a theoretical course which omitted the physiology of reproduction. Most people desire that thought on the latter subject should remain in the pre-scientific stage, and heavily charged with emotion. The emotion may vary in different cases. Some find it a subject for sentimentality, others for disgust, others, again,

for humour. All agree in fearing an objective and scientific attitude to it, though this fear is rationalized in a number of different ways.

note 232, p. 104 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 123 :

It is clear, then, that the general policy, [no doubt not stated in so many words,] of the present Government, and of Governments in the past, is to prevent, as far as possible, new applications of science, either to life or to industry. England is an industrial country, and if it is to be fed it must keep up with the rest of the world in the application of science to industry. The only alternative is to reduce the population, but that also, as we saw, is being discouraged. Now such an attitude, although ridiculous, is perfectly natural, because the ruling classes in this country are ignorant of the results of scientific work and still more grossly ignorant of the mental attitude which has led to scientific discoveries.

note 235, p. 105 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 131 :

Such, then, is the present position of Western civilization. There has been a complete failure to integrate into its intellectual structure the scientific ideas which have furnished its material structure. There are two alternatives, as it seems to me, before it. In the first place, scientific ideas may not be accepted by the ruling classes.

note 238, p. 105 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 134 :

There is a second alternative, and that is that a serious attempt will be made to incorporate scientific ideas, as well as scientific inventions, in our national and international life.

note 239, p. 106 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 134 :

That attempt is being made to-day in Russia. They have altered the ruling class. They did not try to educate the old one. Their attempts to apply science to life are crude, they are embryonic, sometimes ridiculous, like a good many other things in Russia; but they are being made in Russia and not seriously made anywhere else.

note 241, p. 106 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 134 :

Science and politics take the place which are taken in England and the United States by religion and sport. The children in the towns of Russia learn a great deal more science than the corresponding children in England, and they learn it not as text-book subject like French grammar, but in relation to their ordinary life. If you go round the book-shops in central Moscow – there are plenty of book-shops there; a good many more per hundred yards than in central London – you will have a very long way to go before finding a book-shop whose window does not contain books on pure science.

note 242, p. 107 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 135 :

I do not say for one moment that Russia is a scientific State. I say that it purports to be a scientific State in the same way that the States of medieval Europe purported to be Christian.

note 243, p. 107 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 135-136 :

Now I am not going for one moment to suggest that there is not a very grave danger for science in so close an association with the State. It may possibly be that as a result of that association science in Russia will undergo somewhat the same fate as overtook Christianity after its association with the State in the time of Constantine. It is possible that it may lead to dogmatism in science and to the suppression of opinions which run counter the official theories, but it has not yet done so.

note 244, p. 107 : JBS Haldane, « The Place of Science in Western Civilization », *loc. cit.*, p. 137 :

It is quite certain, I think, that if the Union of Socialist Soviet Republics lasts for another ten years without an economic collapse, other States will imitate it to a greater or less extent.

note 246, p. 110 : JBS Haldane, *Daedalus*, p.12 :

Ever since the time of Berkeley it has been customary for the majority of metaphysicians to proclaim the ideality of Time, of Space, or of both. But they soon made it clear that in spite of this, time would continue to wait for no man, and space to separate lovers. The only practical consequences that they generally drew was that their own ethical and political views were somehow inherent in the structure of the universe. The experimental proof or disproof of such deductions is difficult, and --- if the late war may be regarded as an experimental disproof of certain of Hegel's political tenets --- costly and unsatisfactory.

note 250, p. 111 : JBS Haldane, *Daedalus*, p.12 :

A prophet who can give signs in the heavens is always believed.

note 251, p. 112 : JBS Haldane, *Daedalus*, p.14-15 :

We may not call ourselves materialists, but we do interpret the activities of the moon, the Thames, influenza, and aeroplanes in terms of matter. Our ancestors did not, nor, in all probability, will our descendants. The materialism (whether conscious or sub-conscious does not matter very much) of the last few generations has led to various results of practical importance, such as sanitation, Marxian socialism, and the right of an accused person to give evidence on his or her own behalf.

note 253, p. 113 : JBS Haldane, *Daedalus*, p. 12-13 :

Einstein, so far from deducing an new decalogue, has contented himself with deducing the consequences to space and time themselves of their ideality. These are mostly too small to be measurable, but some, such as the deflection of light but the sun's gravitational field, are susceptible of verification, and have been verified. The majority of scientific men are now being constrained by the evidence of these experiments to adopt a very extreme form of Kantian idealism. The Kantian Ding-an-sich is an eternal four-dimensional manifold, which we perceive as space and time, but what we regard as space and what as time is more or less fortuitous.

note 256, p. 114 : JBS Haldane, *Daedalus*, p. 16 :

A time will however come (as I believe) when physiology will invade and destroy mathematical physics, as the latter have destroyed geometry. The basic metaphysical working hypothesis of science and practical life will then, I think, be something like Bergsonian activism. I do not for one moment suggest that this or any other metaphysical system has any claims whatever to finality.

note 259, p. 115 : JBS Haldane, « Kant and Scientific Thought », *Possible Worlds*, p. 128 :

I do not suggest that either a physicist or a biologist need to be a Kantian if he adopts any metaphysics : I claim, however, that other metaphysical systems, though they may be preferable on other grounds, are all definitely harder to adapt to the present data of science.

note 260, p. 115 : JBS Haldane, « Kant and Scientific Thought », *loc. cit.*, p. 129 :

I should be the last to suggest that the Kantian standpoint was any more final than the Cartesian. On the other hand, There seems to me to be little ground for supposing that after another two centuries of scientific search [(the conduct of politician suggests that they may not be continuous)] the data of science, which will then presumably include much of psychology, will support one rather than another of several post-kantain systems.

note 261, p. 116 : JBS Haldane, « Kant and Scientific Thought », *loc. cit.*, p. 126 :

But according to the general theory of relativity, which enabled Einstein to predict, amongst other things, the observed deflection of light by gravitation, space-time is not homogeneous, but bears a relation to the 'flat' space-time of the special theory similar to that between the surface of an orange and a plane. If this is accepted (and scientific men in

general accept it, because it enables them to predict certain observable phenomena with accuracy), it is clear that the action of the mind in perceiving homogeneous space and time is truly constitutive, and it is dubious how far the space-like character of the event-manifold is not a mere concession to our ideas of what a 'real' world ought to be like.

note 263, p. 117 : JBS Haldane, « Kant and Scientific Thought », *loc. cit.*, p. 126-127 :

The criticisms of the reality of space and time which arise from the theory of radiation by atoms are still more serious. The state of the atom before and after it radiates, and the subsequent history of its radiation, can be expressed in terms of the older physics, supplemented by relativity, with such accuracy that disagreements of less than one part in a thousand between theory and observation are the signal for a storm of further experiments. The probability of the passage of an atom from one stationary state to another, which coincides with the act of radiation or absorption, can also be dealt with by a mathematical theory due mainly to Planck and Bohr, and often with considerable accuracy. But every attempt to represent the process of radiation in terms of continuous space, time, or space-time, has broken down in the most hopeless manner. Bohr at least is convinced of the futility of any attempt at a 'model'. [He is content to develop his beautiful, but highly formal mathematical theory :

'und schreibt getrost ; Im Anfang war die Tat']

And so the world of physics reduces to a manifold of transcendental events, which the mind distributes in space and time, but by doing so creates a phenomenal world which is ultimately self-contradictory. And this is approximately the position reached by Kant in the Critique of Pure Reason.

note 264, p. 119 : JBS Haldane, « Kant and Scientific Thought », *loc. cit.*, p. 127-128 :

In biology we are for the moment in a curiously Kantian position. The mechanistic interpretation has nowhere broken down in detail. Every process in the living organism that 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 taught, these laws merely represent the forms of our perception and abstract understanding. But these processes are co-ordinated in a way characteristic of the living organism. Thus we cannot avoid speaking of the function of the heart, as well as its mechanism. Some biologist cherish the pious hope that the physico-chemical explanation will be found to break down at some point ; others the impious expectation that all apparently organic order will be reduced to physics and chemistry. There is very little in our present knowledge of biology to justify either of these standpoints, though evidence from other sources may seem to favour the former. The physiologist is therefore at present left in the peculiarly exasperating position reached by Kant in the second part of the Critique of Judgment. However mechanistic his standpoint, he must use the idea of adaptation at least as a heuristic principle. He will probably attempt to account for it as a result of natural selection, but natural selection is more fitted to explain the origin of given adaptations than the existence of living being to which the term of adaptation can be applied with a meaning. 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'.

note 275, p. 124 : JBS Haldane, « Kant and Scientific Thought », *loc. cit.*, p. 129 :

If, with J.S. Haldane, we regard purpose as more fundamental than mechanism, we have to look forward to a complete restatement of physics on a teleological line in the future, without being able to form any clear idea of how in detail this is possible.

note 279, p. 125 : JBS Haldane, 1937 [1932], « My Philosophy of Life », *The Inequality of Man*, p. 204 :

Dean Ingen H. G. Wells, and I agree to a considerable extent about the nature of the invisible world, because we are all, in some degree, disciples of Plato.

note 280, p. 125 : JBS Haldane, « My Philosophy of Life », *loc. cit.*, p. 203 :

Man lives in two worlds, the visible world which changes with time, and an invisible world whose constituents do not change. But both worlds can only be described as they appear to

us, that is, from a human and imperfect standpoint. Among the components of the invisible world are the realities corresponding to mathematical statements like $16+9=25$. This is a statement of fact as real as the Albert Memorial, it was a reality 10,000 years ago, and it will be 10,000 years hence. There are also invisible realities corresponding to scientific laws, and I think also to some of our general notions of what is beautiful and good.

note 284, p. 126 : JBS Haldane, « Some Consequences of Materialism », *The Inequality of Man*, p. 169 :

Though an Agnostic, I am personally much attracted by a modified Hegelian view which regards mind as absolute, and finite minds as contingent, their actual behaviour being regulated by laws of the same general type as other phenomena.

note 287, p. 127 : JBS Haldane, « Some Consequences of Materialism », *loc. cit.* p. 157-158 :

If Materialism is true, it seems to me that we cannot know that it is true. If my opinions are the result of chemical processes going on in my brain, they are determined by the laws of chemistry, not those of logic. If I believe that I am writing with real ink on real paper [(for, as I write on subjects other than pure science almost entirely in railway trains, I do not use a typewriter),] I have no guarantee that this is true.

note 290, p. 129 : JBS Haldane, *Causes of Evolution*, p. 154-157

My main prejudice is in favour of monism. Roughly speaking, the monistic systems may be grouped under absolute idealism, materialism, and intermediate systems such as the "neutral monism" of Russell. Materialism of course includes many forms far more subtle than the crude materialism of fifty years ago, and if you are willing to concede enough unexpected properties to so-called dead matter it becomes distinctly idealistic. To quote Lenin's words, "For every materialist the laws of thought that reflect the forms of the real existence of things are totally like, and in no way different from, those forms." If Lenin was right, as seems to me not unlikely, so much the better for "things."

Over against these stand various pluralistic systems which hold that the distinction between different minds, or between mind and matter, is irreducible. My objection to them is just that they proclaim certain problems to be insoluble merely because three thousand years of thought by a few members of a species which may have many thousand million years ahead of it has not yet solved them. For a scientific man a philosophy is a programme rather than a creed. Some parts of the monistic programme may be impossible, but we need not abandon it until a really serious attempt has been made to carry it out. Thus a study of cerebral physiology is leading to results which at present can be interpreted either as the mind-like nature of certain objects which we generally call material systems, or as the mechanical character of conscious behaviour. Until the attempt has failed we need not, I think, fall back on mind-body dualism. Meanwhile, monism has the advantage that if it is wrong it will ultimately lead to self-contradiction, whereas dualistic systems, which purport to give a less complete account of the world, are therefore less susceptible of disproof. My preference among monistic systems has been stated elsewhere, and is irrelevant to the present discussion.

Particularly hostile to true scientific progress are the extremer forms of the doctrine of emergence. According to these, a material system of a certain degree of complexity suddenly exhibits qualitatively new properties such as life or mind, which cannot be explained by those of the constituents of the system. There is clearly an element of truth in this view. We can only discern a little mind in a dog, and at present none in an oyster or an oak. Nevertheless science is committed to the attempt to unify human experience by explaining the complex in terms of the simple. This may be a vain endeavour, but I do not at present see any evidence of its vanity.

note 294, p. 132 : JBS Haldane, « Some Consequences of Materialism », *loc. cit.*, p. 169 :

I have taken the word in its widest sense, to denote the view that all occurrences depend on phenomena obeying definite mathematical laws, which it is the business of physics to discover. It is quite unimportant whether we call our ultimate reality matter, electric charge, Ψ -waves, mind-stuff, neutral stuff, or what not, provided that it obeys laws which can, in principle, be formulated mathematically.

note 309, p. 139 : Mark B. Adams, 2000, « Last Judgment: The Visionary Biology of J.B.S. Haldane », *Journal of the History of Biology*, Vol. 33, n°3, p. 476 :

Traditional religion is untenable. We live in a material, Darwinian world, governed by the laws of science, and we must understand our existence and our future in an evolutionary, cosmic time-scale. Humanity is at a crucial moment in its history as a species, with only a few centuries remaining for us to seize control of our destiny: left to natural law, humanity will degenerate and, like all other biological species, eventually become extinct; our planet (and later our sun) will die. But the new biology affords us a way out: In the short-term, we can halt our degeneration through some form of negative eugenics, social experimentation, world government and technocratic socialism. In the long term, using positive eugenics and bioengineering, we can create new kinds of humans for moving into space and colonizing other planets, within – and, if possible, beyond – our solar system. In this way, human progress can proceed for many eons, producing future descendants with even higher (perhaps telepathic or communal) forms of mentality. This is the science-based faith that will provide what Christianity and other religions cannot: scientific answers to the profound questions of ethics, human destiny, our place in the universe and the meaning of life. To realize our true destiny, we must be guided not by a myth from our past, but by a vision of our future.

note 311, p. 140 : JBS Haldane, « The Last Judgment », *Possible Worlds*, p. 295 :

Human evolution has ceased. Natural selection had been abolished, and the slow changes due to other causes were traced to their sources and prevented before very great effects had been produced. It is true that some organs found in primitive man, such as teeth (hard, bone-like structures in the mouth), had disappeared.

note 314, p. 141 : JBS Haldane, « The Last Judgment », *loc. cit.*, p. 300-301 :

For the human race on earth was never greatly influenced by an envisaged future. After physiology was discovered primitive men long continued to eat and drink substances which they knew would shorten and spoil their lives. Mineral fuels were also oxidized without much forethought. The less pigmented of the primitive races exhausted the fuel under the continents on which they lived with such speed that for some centuries the planet was dominated by the yellow variety resident in eastern Asia, where mining had developed more slowly ; until they too had exhausted their fuel resources. The unpigmented men appear to have foreseen this event, but did little or nothing to prevent it, even when it was clearly only a few generations ahead.

note 319, p. 142 : Mark B. Adams, « Last Judgment: The Visionary Biology of J.B.S. Haldane », *loc. cit.*, p. 477 :

I am not suggesting that this credo functioned dogmatically or mechanistically – that he “consulted” it, that it “directed” him, or that it “determined” specific scientific research he undertook or particular political choices he made. Rather, I think it functioned as a vision, a “worldview,” almost religiously infusing and informing his multifarious activities.

note 322, p. 143 : Mark B. Adams, « Last Judgment: The Visionary Biology of J.B.S. Haldane », *loc. cit.*, p. 481

Haldane’s credo, then, was an informing vision that begins to make sense of his various political activities – a vision that was antecedent to those activities, and continued after them.

note 325, p. 145 : JBS Haldane, « Possibilities of Human Evolution », *The Inequality of Man*, p. 98-99 :

Such speculations as these are very far from idle. They are eminently desirable, because man does not generally even know what he wants, much less how to get it. A discussion on possibilities will have two effects. It will enable people to come to some opinions as to the possible goal of human evolution (not the ultimate goal, of course, but the furthest limit to which our desires and imagination reach). And it will focus attention on the necessity for more knowledge before we can even suggest means of attaining that goal.

Pictures of the future are myths, but myths have a very real influence in the present. [Modern political ideas are largely the creation of the Jewish prophets, who foresaw the new Jerusalem in the future, at a time when their contemporaries of other nations had no

particular hopes for the betterment of humanity. History has certainly been very different from what Isaiah and Daniel believed it would be; but they helped to make it what it is, and perhaps they would not be altogether dissatisfied with it if they could live to-day.] Our greatest living mythologist, Wells, is certainly influencing the history of the future, though probably in ways which he does not suspect.

note 327, p. 146 : JBS Haldane, « Possibilities of Human Evolution », *loc. cit.*, p. 92 :

Before mankind can seriously attempt to control its own evolution, there must be an enormous development of two sciences which are now in their infancy, namely individual psychology and genetics.

note 329, p. 148 : JBS Haldane, « Man's Destiny », *The Inequality of Man*, p. 144 :

There is no theoretical limit to man's material progress but the subjection to complete conscious control of every atom and every quantum of radiation in the universe. There is, perhaps, no limit at all to his intellectual and spiritual progress.

note 330, p. 148 : JBS Haldane, « Man's Destiny », *loc. cit.*, p. 144 :

But, whether any of these possibilities will be realized depends, as far as we can see, very largely on the events of the next few centuries. If scientific research is regarded as a useful adjunct to the army, the factory, or the hospital, and not as of all things the most supremely worth doing both for its own sake and that of its results, it is probable that the decisive steps will never be taken.

note 332, p. 149 : JBS Haldane, « Man's Destiny », *loc. cit.*, p. 142 :

Physics and chemistry have made us rich, biology healthy, and the application of scientific thought to ethics by such men as Bentham has done more than any dozen saints to make us good. The process can only continue if science continues.

And pure science is a delicate plant. [It has never flowered in Spain, and to-day it is almost dead in Italy. Everywhere there are strong forces working against it. Even when research is rewarded, the usual reward is a professorship with a full-time programme of teaching and administration. The bacteriologist can most easily earn a title and a fortune if he deserts research for medical practice. The potential physicist or chemist can often quadruple his income by taking up engineering or manufacture. In biology and psychology many lines of research are forbidden by law or public opinion.] If science is to improve man as it has improved its environment, the experimental method must be applied to him. It is quite likely that the attempt to do so will rouse such fierce opposition that science will again be persecuted as it has been in the past.

note 335, p. 153 : Mark B. Adams, « Last Judgment: The Visionary Biology of J.B.S. Haldane », *loc. cit.*, p. 481 :

Haldane's vision also helps us to understand his politics. It is well known that, in the 1930s, Haldane turned from a quasi-Fabian socialist into a card-carrying member of the British Communist Party. This fact is often treated as yet another peculiarity of Haldane's personal evolution, without any connection to his scientific life – but, surely, it had very much to do with his scientific life. As we have already noted, it is easy to mistake a variant of Wells's futurology for socialism, Marxism or communism. For Haldane, both his science and his politics flowed from his deeper visionary orientation toward the human future. And revolutionary Russia appeared to many, at least potentially, to be that future in the making: a new society devoted not only to rational, scientific planning, but also to human experimentation on a grand scale.

Chapitre 3 :

note 337, p. 162 : Ronald Clark, *J.B.S.: the Life and Work of J.B.S. Haldane*, Coward-McCann, New York, p. 128 :

That Haldane moved from that position to the far left in a matter of years was largely a result of the logic of history – he did not move so much as was pushed.

note 338, p. 163 : Ronald Clark, *J.B.S.: the Life and Work of J.B.S. Haldane*, p. 134 :

And in Spain he saw that it was mainly the Communists who were welding together the varied pro-government parties in a coherent front against the rebels ; the situation confirmed his belief that in an imperfect world, support for the Communists represented the least unsatisfactory option.

note 339, p. 163 : Ronald Clark, *J.B.S.: the Life and Work of J.B.S. Haldane*, p. 131 :

The benevolent nonintervention with which the British government greeted the rise of the right-wing dictatorship in Europe would probably have driven Haldane into the arms of the Communist party whatever else happened.

note 340, p. 163 : Ronald Clark, *J.B.S.: the Life and Work of J.B.S. Haldane*, p. 131 :

Most of those who had previously put him off Communism, [he added,] were not party members but intellectuals who thought that Marxism was a nice theory. Haldane could have stuck at this point – as, [he admitted,] most of his advanced academic colleagues had stuck.

note 343, p. 165 : Gary Werskey, *The Visible College*, p. 159 :

Indeed Haldane had undergone a political transformation. He did not eventually support the Communists merely because, to quote his biographer, they represented 'in an imperfect world ... the less unsatisfactory option'. They were that for Haldane; but they were also the only significant Marxist revolutionary party in Britain. And J.B.S., by the late thirties, had decided that Marxism was 'true', and that the prospects of achieving socialism in Britain, without recourse to violent revolution, were growing slimmer every year.

note 344, p. 165 : Gary Werskey, *The Visible College*, p. 160 :

The central motif in the 'new' Haldane's political outlook was that the ruling class – his class – had to be divested of its control over the means of mental and material production. Socialists therefore had to develop, within the labour movement, institutions that were dedicated to the obstruction – and eventual destruction – of the smooth administration of the capitalist state. Obviously both axioms were derived from the writings of Marx, Engels and Lenin.

note 345, p. 166 : Gary Werskey, *The Visible College*, p. 160 :

Only after he had mastered to his own satisfaction the Marxist 'world-view' did Haldane allow himself, in 1942, to be put forward as a full member of the Communist Party.

note 346, p. 166 : Gary Werskey, *The Visible College*, p. 160 :

As early as 1933 Haldane had begun to study their work in the earnest. What they had to say increasingly helped him to make sense of what was happening to his world and vice versa.

note 353, p. 168 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 405 :

It remains to draw some overtly philosophical conclusions. A first, and somewhat trivial, one is that, [even more so than Fisher, and much more so than Wright,] Haldane was explicit in both expounding his philosophical views and attempting to integrate them to his scientific beliefs. [However, beyond mere explicitness, the differences with Fisher are severe: (i) Haldane was as concerned with metaphysical issues as with political (or ideological) ones.] The only political ideology to which he ever gave full support was Marxism in the 1940s, and what has been said above strongly suggests that his adoption of Marxism was principally because of a commitment to what he took to be the Marxist view of science, that is, dialectical materialism. For Haldane, this was a choice of metaphysics.

note 354, p. 169 ; Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 405 :

There is no doubt that the political struggles of the 1930s played a role in Haldane's turn to Marxism and it is very likely that he actually joined the Communist Party, rather than opt for being a fellow-traveller, because of the advent of fascism and nazism. However, the

choice of Marxism was a metaphysical choice. It was possible for somebody in Haldane's circle of socialist scientists to remain a non-Marxist (for example, Hogben).

note 361, p. 170 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 396 :

He was not, however, going to get there - in the 1930s, instead, he turned to Marxism and its official metaphysical credo, dialectical materialism.

note 362, p. 171 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 398-399 :

Characteristically, for Haldane, the test of dialectical materialism was neither whether it contributed towards desirable political goals, nor whether it was a precondition or consequence of an ideology which led to appropriate political practice, but simply whether it afforded an adequate representation of science.

note 363, p. 171 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 406 :

a much more influential factor seems to have been that dialectical materialism allowed him to incorporate the successes of biochemistry and genetics without recourse to Hopkins' mechanistic materialism.

note 365, p. 172 : Arthur Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 70 :

If we are to assess the impact of Haldane's Marxism on his science, we must be able to define the period when he was a Marxist. Was his a gradual awakening or a sudden conversion?

note 377, p. 176 : JBS Haldane, « Why I am a Materialist », *Science and Life*, p. 29-30 :

although I was a materialist in the laboratory, I was a rather vague sort of idealist outside, for the following reason. [I had learned that matter had certain properties. It consisted of atoms which united in particular patterns. They moved in definite paths under given forces, and so on. My belief in these theories was not a matter of mere docility either. I had tested them and risked my life on their substantial accuracy.] Clearly, if matter had the properties attributed to it by physicists and chemists, something more was needed to account for living organisms. [And it was far harder to account for mind. As a believer in evolution I had to reject such theories as T. H. Huxley's epi-phenomenalism, according to which mind is a secondary consequence of a small class of material events (namely, those which go on inside our heads), but does not influence them. Apart from my very strong belief that I can act, the evolution of something as complicated as my mind, yet absolutely functionless, seemed most unlikely. Not that functionless organs are never evolved. On the contrary, it is probable that most organs are evolved in a rudimentary form before they develop a function. And I have not enough faith in the theories of Paley and his like to believe that every organ--for example, a cock's comb, a pigeon's cere, or a cassowary's wattle--has a function. However, I cannot believe that a system so complicated, and within its limitations so efficient, as the human mind could have evolved if it were functionless.

Nor did I see how, on a materialist basis, knowledge or thought was possible. The light which reaches my eyes causes nervous impulses in about half-a-million fibres running to my brain, and there gives rise to sensation. But how can the sensation be anything like a reality composed of atoms! And, even if it is so, what guarantee have I that my thoughts are logical! They depend on physical and chemical processes going on in my brain, and doubtless obey physical and chemical laws, if materialism is true. So I was compelled, rather reluctantly, to fall back on some kind of idealistic explanation, according to which mind (or something like mind) was prior to matter, and what we call matter was really of the nature of mind, or at least of sensation. I was, however, too painfully conscious of the weakness in every idealistic philosophy to embrace any of them, and I was quite aware that in practice I often acted as a materialist.]

The books which solved my difficulties were Frederick Engels's Feuerbach and Anti-Duhring, and later on V. I. Lenin's Materialism and Empirio-Criticism. But the actual progress of scientific research in the last fifteen years also helped me enormously.

note 378, p. 177 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 187 :

the following conclusions can certainly be drawn from my study. In the early 1930s Haldane's intellectual development went through a synthesis that included an acceptance of DM. Events of particular importance here included his visit to the Soviet Union in 1928, his association with Hogben over eugenics, the rise of the Fascist government in Germany in 1933, and (slightly later) the Spanish Civil War. Amongst the philosophical factors involved in this synthesis were the influence of the new physics and Hopkins' holistic materialism[(especially Hopkins' version of levels of organisation and his general approach to biochemistry in the form of dynamic equilibrium).] The background for these developments included Haldane's growing political radicalisation.

note 382, p. 181 : JBS Haldane, 1934, « Quantum Mechanics as a Basis for Philosophy », *Philosophy of Science*, Vol. 1, n°1, p. 78 :

Biologists have as yet taken but little cognizance of the revolution in human thought which has been inaugurated by physicists in the last five years, and philosophers have stressed its negative rather than its positive side.

note 383, p. 182 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 78 :

However it is formulated it appears that space-time, even as modified by relativistic notions, is an inadequate co-ordinate system for matter. Two types of uncertainty emerge. On the one hand no observation can determine at the same time the position of a particle and its momentum with complete accuracy. On the other we have no certain method of distinguishing two similar particles.

note 385, p. 182 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 79 :

It has been claimed (by myself among others) that modern physics are a refutation of materialism.

note 386, p. 182 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 79-80 :

I do not think that this is true. They are a refutation of the Cartesian view of matter as definitely localized in space, but I should call this theory spatialism rather than materialism.

note 389, p. 183 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 80 :

The physicist sticks to matter, to hard facts. If the matter refuses to resolve itself without contradiction into particles localized in space, so much the worse for particles and space.

note 391, p. 184 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 80 :

Putting the same ideas in a different terminology, that of dialectical materialism, our ideas about matter are subject to an internal contradiction, which shows itself in the uncertainty principle.

note 393, p. 185 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 80 :

Turning to biology we find a number of facts which are hard to reconcile with materialism as ordinarily understood. A living organism is always, in greater or less degree, a self-repairing and self-reproducing system. Every biologist, however mechanistic, takes this fact for granted. This fundamental postulate appears to differentiate biology from the physical sciences. Many biologists-perhaps most-think that such facts will ultimately be explicable in terms of physics and chemistry. But they have not yet been so explained, and a large group of biologists doubt whether they are so explicable, while a vigorous minority proclaim that they are inexplicable.

note 395, p. 185 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 81 :

The detailed analysis by biochemists of the events taking place within the cell is continuing successfully along physico-chemical lines, and shows no signs of meeting any obstacles except the extreme complexity of the systems studied.

note 397, p. 186 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 81 :

The theory that mind takes advantage of the uncertainty principle is only a form of vitalism. For the essence of the uncertainty principle is that certain events are equally likely to occur. If mind renders one event more probable than the other, the laws of physics are violated to that extent.

note 399, p. 186 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 80-81 :

Another group, often idealistic in their outlook, hold that the facts of biology disprove mechanism, and that the mechanistic account is incorrect not only for living organisms, but for other material systems. Physics and chemistry will have to be restated in such a way as to take cognizance of the facts of biology, and later of psychology. This is the view taken by J. S. Haldane among others.

note 401, p. 187 : John Scott Haldane, *Mechanism, Life and Personality*, p. 104-105 :

The idea of life is nearer to reality than the ideas of matter and energy, and therefore the presupposition of ideal biology is that inorganic can ultimately be resolved into organic phenomena, and that the physical world is thus only the appearance of a deeper reality which is as yet hidden from our distinct vision, and can only be seen dimly with the eye of scientific faith.

note 402, p. 187 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 82 :

The organicist standpoint has, I think, more to be said for it. In almost all biological work we take for granted the existence of the organism as a whole, as a system capable within certain limits of self-regulation and self-repair. This is still so when we are explaining in physico-chemical terms some detail of that self-regulation. This postulate until quite recently differentiated biology from physics and chemistry. It might be explicable in physico-chemical terms, but it seemed to constitute a real difference in methodology.

note 403, p. 188 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 82-83 :

The fact that the behaviour of a hydrogen atom, as revealed by its spectrum, is much more complex than could be deduced from the known properties of free electrons and protons, held up physics for a generation. But the physicists refused to surrender to holism. And finally the electron was shown to possess properties of a hitherto unexpected complexity, which can be expressed, perhaps somewhat figuratively, in terms of wave mechanics. [The "wave systems" associated with different electrons interact, but in a predictable manner. The success of predictions based on this interaction is shown in such striking discoveries as the existence of two isomeric forms of H₂.] There is no suggestion of the "emergence" of a character inexplicable in terms of the constituent units.

note 404, p. 188 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 83 :

It may be that to explain the organism as a whole we shall require to postulate more complex properties in electrons and other constituents than are at present recognized.

note 405, p. 189 : JBS Haldane, *Causes of Evolution*, p. 157 :

[But] the hydrogen atom has very complex properties. It emits a series of characteristic radiations whose frequencies are related by definite laws like those of the notes of a piano. This is the simplest example of emergence, or holism, the properties of the whole being far more complex than those of the parts. It held up the progress of theoretical physics for a

generation. Then de Broglie (1930) produced wave mechanics. To explain these facts, he said, we must attribute to the electron certain undulatory properties. [These properties were soon afterwards experimentally verified by G. P. Thomson (1930) and others. The electron and the proton were shown to be more complex than they at first appeared, though by no means so complex as the hydrogen atom.]

I regard this as a model for scientific explanation.

note 406, p. 189 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 83-84 :

As an example of the way in which these ideas can be introduced into biology, take the notion of heredity in its simplest form. When a cell divides in two the two daughters generally resemble the parent closely, and neither can be identified with the parent more than the other. The science of genetics has shown that certain quite small intracellular units, the genes, have this same property of reproducing their like. Moreover, when a gene within a cell is altered, at least in certain ways, the so altered gene reproduces. The gene is (at least generally) below the limit of microscopic vision, and very possibly no larger than certain protein molecules. Other evidence suggests that it can legitimately be regarded as a large molecule rather than a group of similar molecules. The problem then is as follows: How does a molecule reproduce its like?

note 407, p. 190 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 84 :

It cannot be supposed to swell up and burst, like a drop of liquid. We can only assume that it is copied. That is to say it is stretched out in a thin layer or chain, and a similar layer or chain laid down upon it from materials available in the nuclear sap. The process can be compared to crystallization. I have discussed it in greater detail elsewhere. So the new gene may be regarded as a copy, and the old gene as a model. That is so from the point of view of pre-quantum physics.

note 408, p. 190 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 84 :

Provided the genes do not differ as regards isotopic atoms, there is no certainty which of them corresponds to the original. The uncertainty, expressible as a probability of interchange, gives rise to a certain term in their joint energy. At most we can only say that one of the two is the more likely to be the original. And this would be so however carefully the system was observed. The truth therefore appears to be intermediate between the crude biological idea that the gene has divided in two, and the crude chemical idea that it has been copied.

note 409, p. 191 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 79 :

Now if we consider a class of objects such as tables or dogs we can label any given member so as to distinguish it from any other member. There is no very obvious reason why we should stop our classification at "dog," rather than at "pug" or at an individual "Ponto." But this is not apparently the case with electrons. We can say that the universal "electron" is embodied in N individuals, where N if not infinite, is probably about 10^{80} . But we cannot label any individual or attach any verifiable meaning to its individuality.

note 410, p. 191 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 78-79 :

When the electrons approach within distances of the order of an atomic diameter, their individuality becomes meaningless. In general to a pair of electrons, say in two H atoms, we can assign a number which (in the Heisenberg type of interpretation) measures the probability that they will exchange places within a given time. This increases very rapidly as the electrons approach.

note 411, p. 192 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 83 :

Meanwhile let us examine what is meant by "wholeness" as applied to an atom or molecule. Its most essential feature is what in physical terms is called "degeneracy," that is to say, a loss of degrees of freedom. For example, a neon atom consists of a nucleus and ten electrons. If these are all separate, as they probably are at a sufficiently high temperature (many millions of degrees) their motions have 39 degrees of freedom, apart from spins. Each can have any velocity in 3 mutually perpendicular directions. But in the atom almost all this freedom is lost. Only 3 of the 39 degrees are maintained at ordinary temperatures. Less rigid and symmetrical molecules have more degrees of freedom. They can rotate and vibrate at low temperatures, but they never have the full number of degrees of freedom that their constituents would possess.

note 414, p. 193 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 84 :

Actually the exchange probability would appear to be very small, that is to say the chemical idea is much more nearly true.

note 415, p. 194 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 84 :

Similarly it is possible in a heterozygous, i.e. hybrid organism to say with certainty whether a given gene in a gamete was contributed by the father or mother. Apparently the paternal and maternal genes are separated mechanically. But in a homozygote each parent contributes a like gene, and these may be "chemically identical" so that at zygotene or pachytene when they lie close together their exchange probability becomes appreciable. It is thus impossible to say with full certainty that a given gene in a gamete from a homozygote is derived from one parent rather than another. And this is still so when the gene in question is located by closely linked genes.

note 416, p. 194 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 84-85 :

It thus appears that the introduction into biology of modern physical ideas enables us to throw some light on the biological phenomenon of heredity. There is a sense in which two molecules can both be the heirs of a like molecule. There is also a sense in which two molecules can both be the parents of two like molecules. In each case quantum mechanics suggests a compromise between the biological idea of equal heredity, and the chemical idea of no heredity. The compromise is based on the fact that a pair of genes in close approximation, whether at once after gene reproduction, or when the genes from two different parents fuse, form a somewhat degenerate system.

note 418, p. 196 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 86 :

Mental events cannot in general be exactly located in space. While vision appears to be localized in the occipital cortex, Sherrington has pointed out that the co-ordination of binocular vision is, in his own words, non-spatial in certain cases. It would perhaps be more accurate to say that it cannot be sharply localized in space. It certainly depends on events inside our own heads rather than in our great toes or kidneys. Still less is it possible to locate a general idea present to our minds in one particular cerebral area. The study of cerebral injuries in man makes this point clear.

note 419, p. 196 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 86 :

Localization of mental events in time is also incomplete. They can doubtless be located between material events so far distant as to allow a relatively complex conscious process to be interposed between stimulus and response, -that is to say within a time of the order of half a second. This is about the length of the specious present, which gives a rough limit to the accuracy of introspective timing. It is moreover abundantly clear that in general mental events fade in and fade out, and that it is extremely hard to say just when they begin and end.

note 420, p. 196 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 87-88 :

We must now see how far in the light of modern physics a materialistic account of these facts is possible. [Very clearly we cannot give a full account. Such an account would demand, among other things, a vastly extended knowledge of cerebral physiology. There is nothing novel in finding that mental events are inexactly localized in space-time. So are all other events. But the scale of indeterminacy is very large, in fact of the order of ordinary measurements, such as 10 cm. or 0.1 sec.] If mind is to be regarded as expressive of the wholeness of the body, or even of the brain, it should probably be thought of as a resonance phenomenon, in fact part of the wave-like aspect of things. [In a degenerate system degrees of freedom are lost because certain periodic systems oscillate together instead of independently. This resonance gives rise to various observable phenomena. It is responsible for certain terms in the energy of a material system. As the resonators are removed from one another, the energy falls off very rapidly. If mind is a resonance phenomenon we do not as yet know what the resonators are. They might conceivably be molecules on the one hand, or more probably whole cells or large parts of them on the other. For of course cells in the nervous system undergo periodic electric disturbances, and Lapicque's idea of isochronism does not perhaps differ essentially from resonance. In any case the amount of energy concerned in mind must be exceedingly small.]

If mind is a resonance phenomenon it is at once clear why it cannot be definitely located, either in space or time, though it is obviously enough connected with definite events in a definite material structure. [The smaller the mass (or energy) of a mental event, the greater may we expect its indeterminacy to be. Thus the continuous character of our sensory experience becomes intelligible.] From the dialectical standpoint the contradictions involved in an attempt to locate resonance energy exactly in space-time are the basis of the wholeness and continuity of mind.

note 421, p. 197 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 92-93 :

The idealistic account of the world starts with mind. On such a monistic view as I have put forward an idealistic account of the universe may be ultimately possible. But our knowledge about matter is a great deal more exact than our knowledge about mind, and less liable to be distorted by pride and prejudice. Moreover we have discovered in the uncertainty principle the internal contradiction in the properties of matter which makes it impossible to believe in the old-fashioned mechanistic materialism. [As a matter of fact mind is subject to spatial, temporal, and other contingency. But philosophers tend to regard this fact as an illusion, partly on religious and economic ground, partly from a desire to have some foundation for theory which is not contingent. The physicists have repressed this latter desire fairly successfully.]

The internal contradiction in matter as an interpretation of the universe which, as I have tried to show, allows a materialistic account of life and mind, is the uncertainty principle. I do not think that the analysis of mind has yet been close enough to disclose its internal contradiction in any detail. Unless or until this can be done it is unlikely that any form of idealism will be as fruitful a philosophy as dialectical materialism.

note 422, p. 198 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 93 :

I am inclined, however, to think that if we knew enough it might ultimately be as possible to give an account of matter in terms of mind as conversely. Such an account might occasionally be useful, as for example line co-ordinates are sometimes more useful than point co-ordinates in geometry.

note 424, p. 199 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 94 :

Ethically also the program of a materialistic philosophy, provided it transcends materialism, is not only truer but more useful than that of idealism. In our own individual lives, and very possibly in our social development, we started with crude ideas appropriate to individuals as isolated as the atoms postulated by nineteenth century physicists. Such moral

ideas might be appropriate to a castrated tom cat, but hardly to an animal capable of parental or sexual affection, let alone a social being like a dog or man. We realize the unsatisfactory character of these ideas, and transcend them to a greater or less extent. Dialectical materialism should and can help us in the process. It enables us to see in detail how, for example, the idea of personal property, while appropriate enough to a toothbrush, breaks down hopelessly when applied to a railway or a wife (in the U. S. A. a husband). Of course, the majority of dialectical materialists go much further than this, and adopt the ethical views of Lenin in detail.

An attempt to build up an ethical system from the other end has several disadvantages. It attempts to present the system as ready made, when it is really constantly growing, and growing by a dialectical process. Moreover once we admit that mind as such (or even man as such) implies a system of duties, we are confronted by a series of kindly but firm gentlemen who are ready to enunciate such systems. They offer us the Torah, the Bible (as interpreted by some particular church), the Uncreated Koran, and so on.

note 425, p. 200 : JBS Haldane, 1934, « Preface », *Faith and Fact*, Watts and Co., London, p. v-vi :

My philosophical views have also changed, [and, unless my brain hardens prematurely, will go on changing for some years to come.] For one thing, the progress of physics, by showing that matter does not possess various properties attributed to it by metaphysicians, has rendered Materialism a good deal more plausible than seemed likely even ten years ago. For another, I have begun to assimilate Dialectical Materialism, a doctrine very different from the Mechanistic Materialism of the eighteenth and early nineteenth centuries, and to my mind far more plausible.

note 426, p. 201 : JBS Haldane, « Quantum Mechanics as a Basis for Philosophy », *loc. cit.*, p. 97 :

I am aware of the extremely speculative character of the opinions put forward in this paper. Any or all of them may be rendered ridiculous by the progress of physics or biology.

note 430, p. 204 : JBS Haldane, « Why I am a Materialist », *loc. cit.*, p. 29-30 : cf. note 377 de ce chapitre.

note 434, p. 205 : JBS Haldane, 1948, « Biology and Marxism », *The Modern Quarterly*, Vol. 3, n°4, p. 3 :

An increasing number of biologists have become more or less completely Marxists, and are no longer condemned to oscillate between a mechanistic and a vitalistic standpoint.

note 436, p. 207 : JBS Haldane, *The Marxist Philosophy and Sciences*, p. 121 :

I think it is clear that the Marxist point of view leads one to look for these creative antagonisms in nature, and to investigate them when one finds them, but certainly not to accept them blindly.

note 437, p. 207 : JBS Haldane, *The Marxist Philosophy and Sciences*, p. 45 :

In the application of Marxism to science, we must proceed with the very greatest caution. At best Marxism will only tell a scientist what to look for. It will rarely, if ever, tell him what he is going to find, and if it is going to be made a dogma, it is worse than useless.

note 438, p. 208 : JBS Haldane, « Preface », *What is Life?*, p. v :

This book is permeated by one point of view, namely, that people can and should think scientifically about themselves. This point of view has led me, along with thousands of other European scientists, fair numbers in Asia and Latin America, and so far comparatively few in North America, to adopt Marxism as a working hypothesis about how men behave and how changes, both in nature and in society, occur.

note 440, p. 209 : JBS Haldane, « What Use is Science to You? », *What is life?*, p. 121 :

This is why Marxism is rightly called scientific socialism. It is based not merely on an analysis of the breakdown of capitalism, and what is needed to replace it, but on a study of how social changes actually do occur.

note 441, p. 210 : JBS Haldane, *The Marxist Philosophy and Sciences*, p. 170-171 :

The Marxist criticism of such writers is simply that they do not sufficiently realize how far the prevailing ideas are determined, not on a basis of pure reason, but on an economic basis. For example, today Mr. Keynes would like to persuade the capitalists to be contented with a greatly lowered rate of interest; [and I have very little doubt that if Mr. Keynes were able to carry out this and other reforms, capitalism could be made to last for a considerable time.] From the Marxist point of view one of the main defects in Mr. Keynes' writings is that he never explains why the capitalists do not follow his advice and are not likely to do so; [why, for example, the British Government at the time that the Versailles Treaty was drafted did not follow his advice.] A Marxist would give good reasons why his advice could not then and will not now, be followed. It is just for that reason that Marxian socialists claim to be scientific and not Utopian. They recognize the type of historical process by which changes are wrought about.

note 443, p. 211 : JBS Haldane, 1946, « Is Psychology a Science? », *A Banned Broadcast*, Chatto and Windus, London, p. 144 :

Some critics of Marxism say that we cannot apply scientific method to politics until we understand the psychology of the individual. This is incorrect. We knew a great deal about the behaviour of solids, liquids, and gases, consisting of large numbers of atoms, before we knew anything about the atoms. In the same way we can predict human behaviour in the mass, without knowing what an individual will do. We know that if the price of cigarettes rises, fewer will be bought. We do not know if Mr. Smith will economize on fags or movies. Though Marxism will certainly benefit from advances in individual psychology, it is already a genuine and scientific analysis of human behaviour in the mass.

note 447, p. 214 : JBS Haldane, 1940, « The Marxist Philosophy », *Adventures of a Biologist*, Harper & Brothers Publishers, New York, p. 255-257 :

I found that the political and economic life of Britain was becoming riddled with internal contradictions. At a time when national self-sufficiency in food might be of vital importance, farmers were fined for growing too many potatoes. [At a time when two European statesmen were openly claiming portions of the British Empire, I found the Conservative leaders in Britain abrogating the principles of international law and refusing to carry out their obligations under it, in such a way as to favour the statesmen in question. I found the Conservative Members of Parliament greeting with laughter and cheers the news that British ships had been captured.]

And I observed similar phenomena in the moral field. The growth of corruption in public life was obvious, [even if only rarely, as in the case of Mr. Thomas, did a lapse from nineteenth-century standards of honesty receive publicity. The events leading to the abdication of King Edward VIII showed how hollow were the phrases and how artificial the sentiment which supported so important an institution as the monarchy. It is true that few among our political leaders possess the intellectual honesty of Captain Balfour, the Under-Secretary for Air, who wrote, in a letter to The Times on British foreign policy:

This conclusion may be right morally or it may be wrong. It may be said to be breaking a pledge made by politicians in the past, or it may be said that we are not bound by any pledges. But none of this matters.

Nevertheless it was clear that in practice the moral standards to which the British ruling class for a century or more had rendered complete service in word and a good deal in deed, had become obsolete.]

And this was not, as might have been supposed, part of a general decay of morality. Our prisons were being emptied. Drunkenness had enormously declined during my own life-time. The average man and woman had become kinder and I think juster, if perhaps a little less honest. [The decay of religion could hardly be blamed, when Lord Halifax lectured on the League of Nations on the unpractical character of moral ideas, and the Pope blessed the bombers of Barcelona.]

In fact the situation did not make sense, from my existing point of view. A realization of such facts has driven one group of intellectuals into a belief that civilization is doomed, whilst others call for a return to pre-scientific thought and practice. The latter solution seems to me particularly futile.

[Even God cannot abolish historical facts.' If we go back to a medieval or earlier type of civilization it will be through disaster and not through Erwhonian planning.]

But from a Marxist point of view the social phenomena of our day are intelligible.

note 448, p. 215 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 274 :

One of the commonest criticisms of Marxism is that it is a body of quasi-religious dogma which must be blindly accepted. "Our theory is not a dogma but a guide to action" said Marx and Engels. For this reason it is impossible to accept it without taking part in action.

Note 450, p. 216 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 275 :

Here my own reaction to it has been like my reaction to organic chemistry. I could not wholeheartedly believe in the latter until I had merely verified the feasibility of textbook experiments, but actually used it as a guide to action, and correctly predicted the properties of some hitherto uninvestigated substances.

note 465, p. 226 : JBS Haldane, « Preface », *What is Life?*, p. v : cf. note 438 de ce chapitre.

note 473, p. 229 : D. Aerts, L. Apostel, et al., 1994, *World views: From fragmentation to integration*, VUB Press, Brussels, p. 25 :

The following seven questions represent, in our opinion, basic elements that must be accounted for in every world view.

- 1. What is the nature of our world? How is it structured and how does it function?*
- 2. Why is our world the way it is, and not different? Why are we the way we are, and not different? What kind of global explanatory principles can we put forward?*
- 3. Why do we feel the way we feel in this world, and how do we assess global reality, and the role of our species in it?*
- 4. How are we to act and to create in this world? How, in what different ways, can we influence the world and transform it? What are the general principles by which we should organise our actions?*
- 5. What future is open to us and our species in this world? By what criteria are we to select these possible futures?*
- 6. How are we to construct our image of this world in such a way that we can come up with answers to (1), (2), and (3)?*
- 7. What are some of the partial answers that we can propose to these questions?*

note 475, p. 230 : D. Aerts, L. Apostel et al., *World views: From fragmentation to integration*, p. 15 :

"World views" is designed to overcome this process of fragmentation. We certainly do not want to renounce the complexity of the modern world, but we would like to search for new means of integration.

note 477, p. 231 : JBS Haldane, *Heredity and Politics*, p. 181 :

It is, or should be, the main task of politics to see that the resultant of individual desires does not run counter to those desires, that for example, a sincere desire for peace should not lead to war, either by one-sided disarmament or by the piling up of huge forces which many citizens honestly believe to be needed for defence.

Deuxième Partie

Chapitre 4 :

note 72, p. 257 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 29 :

In what follows I propose to give a sketch of the dialectic so brief and abstract as to be almost a caricature. I shall pass over many of its essential features, and attempt to summarize a few of its main principles. Such a presentation lays itself open to a sever criticism. The dialectic, which is a unity, appears as a collection of rules of thumb, one or other of which should be applied wherever possible. Such a point of view would, I am sure, be dispelled by a reading of Marx, Engels, and Lenin.

note 73, p. 258 : JBS Haldane, « *The Marxist Philosophy* », *loc. cit.*, p. 260 :

By materialism is meant the acknowledgment of the temporal priority of matter over mind, and the belief that there are unperceived events. The word is not taken to imply the unreality or "lesser reality" of mind, as compared with matter, or the theory that either man or the universe are mere machines.

note 75, p. 258 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 139-140 :

The mind is a part of nature, and in particular it modifies the rest of nature, as well as being modified by it. Just because the mind is a part of nature, the processes which go on in it can be and are like the processes which go on in other parts of nature, [and they do actually mirror them, although more or less incompletely]

note 76, p. 258 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 26 :

It is clear, [therefore,] that what Marxism calls materialism is something a good deal less mechanical than the materialism of the French eighteenth-century philosophers.

note 77, p. 259 : JBS Haldane, *Dialectical Materialism and Modern Science*, p. 13 :

We shall not be able to counter the arguments which philosophers and scientific workers bring against materialism unless we understand not only their social origin but the considerable measure of truth behind them. [Lenin wrote that "Philosophical idealism is only nonsense from the standpoint of crude, simple metaphysical materialism. On the other hand from the standpoint of dialectical materialism, philosophical idealism is a one-sided, exaggerated development of one of the features of knowledge into an absolute, divorced from the matter..."]

In each generation the undialectical materialism try to explain everything in terms of matter and motion described in terms which may be adequate for school physics, but are quite inadequate even for the very abstract view of the world needed by the laboratory physicist. No wonder they are of little use to the biologist, and still less to the psychologist. The syllogism of the idealistic biologist runs, "Matter has the properties which were taught to me at school. These properties will not explain life, let alone mind. Therefore matter does not exist, or at any rated there is a spiritual world independent of matter." Because the first and third clause are untrue, we must not forget that the second is true. Many of the idealistic writings of contemporary scientists (though not all) are of real value as criticisms of mechanistic materialism.

note 78, p. 260 : JBS Haldane, « *The Marxist Philosophy* », *loc. cit.*, p. 261 :

What sort of properties has nature, or matter? In it in constant flux. No one can cross the same stream twice, as Heraclitus, to whom Marx and Engels acknowledged their debt, put it. And it embodies the unity of opposites. Plato saw that a body was at once large and small, hard and soft, and concluded that size and hardness were real, but matter was unreal. If we have resolved Plato's contradictions, or at least become accustomed to them, we are confronted to-day with still stranger contradictions, such as the fact that matter and light combine properties appropriated to particles with others appropriate to system of waves. I do not think that there is any choice between denying the reality of matter and admitting the unity of opposites.

note 79, p. 261 : JBS Haldane, « What is Matter? », A Banned Broadcast, p. 45 :

So scientists are more and more adopting the view of Marx and Engels that nature consists of processes or events rather than things, and that though hydrogen, oxygen, iron, and so on, are much more stable than the so-called elements of the Greeks and Romans, they are not the eternal bricks of the universe. [This was made fairly certain by the work of Rutherford and his pupils. They showed that though atomic nuclei and electrons were mostly very stable at ordinary temperatures, yet some atoms broke up, without external shocks, and all were liable to change at very high temperatures.] In fact, all forms of matter change, and change is part of the very being of matter. The change may be very quick indeed. Some of the molecules which exist in a flame can only last for a thousandth of a second or less. Other material structures, for example the fossils in old rocks, last for hundreds of millions of years. None last for ever.

note 80, p. 261 : JBS Haldane, Dialectical Materialism and Modern Science, p. 5 :

[Thus] the living substance is a unity of anabolism, or building up, and catabolism, or breaking down of chemical compounds, and this even applies to the bones. The end of this unity of opposites is death. [Once an animal is dead, it is possible to preserve it, and the atoms in its tissues mostly stay put for centuries.]

If either tendency is carried too far, the unity is destroyed. A man may die of a disease like cancer, where too much material is built up in certain parts, or of a wasting disease like diabetes, where not enough is built up.

note 82, p. 262 : JBS Haldane, The Marxist Philosophy and the Sciences, p. 32 :

In modern physics it is familiar under the name quantization. Not only mass, but energy, can only be transferred from one system to another (at least in certain cases) in definite quantities. [We shall deal with this matter in more detail in Chapter 3.] It may well be that quantum phenomena are the most fundamental and primitive expression of this principle, and that the other examples of it will ultimately be explicable as a basis of quantum theory.

note 83, p. 262 : JBS Haldane, The Marxist Philosophy and the Sciences, p. 33 :

I learn to drive a motor-car, and among other things to steer it. Then I drive a little faster than usual, and skid. Skidding is the negation of steering. After skidding a number of times, I learn to control a skid in the direction which I desire. That is a passage to a higher level of motor driving.

note 84, p. 263 : JBS Haldane, The Marxist Philosophy and the Sciences, p. 34 :

One of Marx's examples from economics is interesting [as showing how he applied this idea in the economic field.] First of all, he describes medieval English industry, in which the workers owned the means of production, their own tools; and in some cases, their own land; but he was particularly concerned with handicraft production. Then, with the development of industry in the early stages of capitalism, the immediate producers were expropriated, ceasing to own their means of production, either forcibly, as through the enclosures of the land, or more generally by the competition of far more efficient industry based on division of labour and on capital. The hand-loomers were killed by the factories. This process was the negation of the ownership by the workers of their means of production. But Marx claims that this process is now being negated. In the present stage of capitalism, capital is negating itself.

note 85, p. 265 : JBS Haldane, The Marxist Philosophy and the Sciences, p. 87-88 :

The relation of chemistry to industry is well known, though not so well understood. If I had the time and the knowledge I would particularly stress the way in which organic chemistry and chemical industry have aided one another in Germany, and the close connection between Imperial Chemical Industries and research work in Britain today, a connection which has both its good and its bad side. I should point out, in particular, how organic chemistry started as the study of chemical compounds found in living organisms, and developed into the study of synthetic carbon compounds largely under the influence of industrial demand, until the old organic chemistry was resurrected within the last thirty years

under the name of biochemistry, which in turn has become to a considerable extent bound up with the food and drug industries.

note 87, p. 266 : JBS Haldane, *Dialectical Materialism and Modern Science*, p. 12 :

Finally the negation of negation is extremely typical of the development of scientific theory and practice. [here at last Hegel was not standing on his head. His account of the dialectic needs far less modifications in connection with human history than with nature. The dialectic development of mathematics was described by Engels, to whom readers are referred.] At the end of the nineteenth century the atomic theory of chemistry was generally accepted, though Ostwald and a few other chemists stood out. But the number of atoms in a gram was uncertain within a factor of a hundred or more. Then Thomson showed that electrons could be detached from atoms in a gas, and Rutherford that atoms broke up. This negated the atom as an "eternal brick", but made it possible to count atoms with great accuracy, since individual electrons or atomic explosions produce effects which are visible with a microscope.

note 89, p. 268 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 265 :

However, capitalism is now developing its own internal contradictions. Cyclical disturbances are increasing in intensity. And monopolism is leading to the restriction of production. When this breakdown becomes sufficiently severe it leads to socialism, in which the workers once more own the means of production, though no longer, save in very rare case, individually. The negation is negated; the expropriators are expropriated.

note 91, p. 268 : JBS Haldane, « Measuring Human Needs », *Science Advances*, p. 114 :

Science and technology have made an age of plenty for all quite possible.

note 92, p. 269 : JBS Haldane, « Medical Measurements », *Science in Peace and War*, p. 34 :

The socialisation of medicine will mean an even greater revolution in the doctor's work than in that of the factory hand. And until medicine is socialised, many of the methods of which I am speaking will remain scientific curiosities of little value to the ordinary man or woman.

note 95, p. 270 : JBS Haldane, « Science in a World Community », *A Banned Broadcast*, p. 189 :

In these terrible times many people will think it utopian to write sunshine stories about the future. If our Government will not even state its war aims, is it not ridiculous for members of a small minority to discuss what they hope will happen?

I don't agree. Marxists think that history is moving towards universal Socialism and the breakdown of barriers not only between classes but between nations. And one solid block of two hundred millions in the Soviet union is working towards these goals. Not towards a world state. States are instruments which are efficient for class war and international war, and very inefficient for many other purposes. A world-wide Socialist community would probably be so different from any existing state as to deserve some quite different name.

One of the first tasks of scientists in a world organization would be a real world survey. This has so far been done in a very uneven and unorganized way, owing to rivalry between nations and firms, and to the predominance of the profit motive.

note 96, p. 270 : JBS Haldane, « Science in a World Community », *loc. cit.*, p. 197 :

Power would be available in vast quantities, but it would not be based on the yearly sacrifice of thousands of coal-miners, and the spoiling of vast areas of what was once beautiful countryside. The nearest approach to this ideal is found today in countries such as Switzerland, where water power is very abundant. In a properly organized world it will be the normal human environment.

note 97, p. 271 : JBS Haldane, « Soviet Science », *What is Life?*, p. 155 :

Science plays a bigger part in Soviet education than in that of any other country. The full results of this fact will not be seen for another generation. The quality of Soviet science is still uneven because in the immense expansion after the Revolution there were responsible

jobs for everyone with a scientific training. [The majority of the younger generation will not get so far, but the standard of the picked few will be higher.

Within the last few years there has been a considerable separation between the universities and the research institutes. Many foreigners regard this as a backward step. It would certainly be so in most countries. In England the gap is between academic science on the one hand and industrial and military on the other, the latter two being more or less secret. In the Soviet Union the tendency is to associate a good deal of pure or fundamental research with industry or war. For example, the Academy of Military Medicine before the war was working on chemical changes in developing eggs. The same man cannot do pure research, teaching, and application at all thoroughly. Only time will show whether the Soviet policy is correct. It may or may not lower the standard of teaching. It will tend to bring research nearer to practical problems. This has its dangers and its advantages. As the scientific level of the average citizen rises I think that the advantages will outweigh the dangers.]

It is impossible to predict the future, but judging from the quality and quantity of the work so far done, and the solid preparations made for future work, it is entirely possible that a generation hence the contribution of the Soviet Union to many fields of science will be as obviously greater than those of any other country as are those of the United States today.

note 100, p. 273 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 260 :

To begin with, Marxists acknowledge the unity of theory and practice, but the primacy of practice over theory. They hold that academic philosophies have been largely futile because their authors did not test them on the hard touchstone of action. Indeed many of them tried to avoid practical activities so far as possible. But Marx wrote, "Other philosophers have interpreted the world. The point is to change it." And as a Marxist must be prepared at any moment to stake his life on the truth of his philosophy, it is natural that he attaches a greater importance to practice than does the metaphysician. In the same way the physicist who proposes to test his theories in an actual aeroplane flight keeps closer to hard facts than the theorist of the expanding universe!

note 101, p. 274 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 274-275 :

One of the commonest criticisms of Marxism is that it is a body of quasi-religious dogma which must be blindly accepted. "Our theory is not a dogma but a guide to action," said Marx and Engels. For this reason it is impossible to accept it without taking part in action. It presents very real difficulties to one who has been brought up in the metaphysical tradition. Yet a previous acquaintance with Spinoza, the French eighteenth-century materialists, and Hegel, is ultimately of great value to a Marxist. But it is not until one applies it to concrete problems that one realizes its power.

note 103, p. 275 : JBS Haldane, « Practice and Theory in Science », *Science and Everyday Life*, p. 190-191

Scientific theories are always guides to practice, or at least to prediction. Chemical theory tells you how to prepare a metal or a drug. Astronomical theory tells you when and where to look for an eclipse. The old theories were certainly wrong. It was supposed that the sun went round the earth, and that when you heated iron ore with charcoal a stuff called "phlogiston" came out of the charcoal and united with the ore to make iron.

[Now, we say that the earth goes round the sun, and that oxygen leaves the iron ore to combine with the charcoal (or nowadays coke). But the old theories were partly right. They were right in saying that the sun was further away than the moon, and that the amount of charcoal needed was proportional to the amount of iron to be made.]

No doubt our present theories will have to be altered. But they are truer because they are nearer to practice. One can be sure that one's theory is incomplete and partly wrong, and at the same time be sure that it is near enough to the truth to enable one to do a particular job.

[For example, I have eaten about two-thirds of the quantity of ammonium chloride which would kill me. I made some calculations beforehand which were based on the theory that all atoms of chlorine were alike, and similarly for nitrogen and hydrogen. This is false. Some hydrogen atoms are twice as heavy as others. But it was true enough, in this connection, for me to stake my life on it.]

In the same way, I don't believe in the absolute truth of Marxism in the way that some people believe in religious dogma. I only believe that it is near enough to the truth to make it worth while betting my life on it against any rival theory.

note 106, p. 281 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 267 :

[at this point, or earlier] a critic is likely to accuse Marxists of clandestine idealism. "You are talking about contradictions in matter, whereas contradictions are mental phenomena. It was legitimate for Hegel to use dialectic, because he was an idealist. It is wrong for you to do so." The Marxist replies that he has a good deal of confidence in the human mind. He thinks it is so intimately dependent on matter that it really can mirror its behaviour. And he points out that the unite of opposites, for example, is very often a hard physical fact. An electron is completely hard in the sense of being indivisible, a gas completely soft in the sense that it opposes no resistance to division, if this is done slowly enough. Hardness and softness are united in ordinary solids. Acetic acid is an acid, ammonia is a base; glycine, which is one of the essential constituents of proteins, is both an acid and a base at once, and therefore has some new properties.

note 108, p. 282 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 30-31 :

At any stage in the development of science we can undoubtedly explain away contradictions which puzzled our ancestors. For example, today, instead of saying, like Plato, that a table is both hard and soft, we can ascertain by a number of measurements the degree of hardness of the wood, its breaking strain, and so on.

There are a number of things which were Paradoxical to Plato and are not to us. On the other hand, in our own time new contradictions have appeared which seem just as trying to us as contradictions which we find trivial appeared to Plato. For example, electrons have apparently at the same time properties which compel us to regard them as particles, and other properties which can be explained if they are systems of waves. Two thousand years from now, these difficulties may seem very elementary indeed, but I think that our descendants will probably still be finding opposites embodied in matter which they will find difficult to unify.

note 110, p. 284 : JBS Haldane, « The Marxist Philosophy », *loc. cit.*, p. 267 :

The Marxist theory of truth is straightforward. Absolute truth, except perhaps on trivial matters, is never reached, but continually approached.

note 111, p. 284 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 17 :

The most that a Marxist can say for Marxism is that it is the best and truest philosophy that could have been produced under the social conditions of the mid-nineteenth century.

note 112, p. 285 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 45 :

In the application of Marxism to science, we must proceed with the very greatest caution. At best Marxism will only tell a scientist what to look for. It will rarely, if ever, tell him what he is going to find, and if it is going to be made a dogma, it is worse than useless.

note 113, p. 286 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 17 :

This is not, of course, to say that Marxism does not include a great deal of systematic theory, which is to a large extent the fruit of the method. But the details of Marxist theory, like those of the theories of natural science, are the result of applying the method to concrete situations.

note 118, p. 292 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 97-99 :

We now pass to a great question which still agitates biologists, although the philosophers claim to have decided it long ago - "is a living organism a machine?" The mechanists say "yes". The vitalists say, roughly, that it is a machine plus a soul, or vital force, which constantly interferes with the mechanical working. The organicists speak of a unity of a special kind - a unity of the organism such as is not found in machines.

We can agree with them up to a point; but still, I think, we can say rather more than that. We have to ask ourselves, what do we mean by a machine? I think we mean a whole whose

behaviour can be explained by the individual properties of its parts; and further in a great many cases we mean that a part can be removed and another actually substituted for it. That is not always the case, but it is a very common property of machines that spare parts are of value. From one point of view, the opposite of a machine is an individual, which, of course, etymologically means something which cannot be divided. [A well-known example of this definition was Humpty Dumpty. You will remember that when Humpty Dumpty had his great fall, "All the king's horses and all the king's men couldn't put Humpty Dumpty together again." Whereas with an ordinary machine, unless it is broken too seriously, it is possible to put it together again, perhaps with the help of a few spares.]

Now it is probable that from the point of view of modern physical theory both a machine and an individual are abstractions. There is no such thing as a 100 per cent machine or a 100 per cent individual, because we cannot actually isolate any system completely from the rest of the universe. Therefore if our knowledge of a so-called machine is sufficiently accurate, there will always be something unexplained by the internal properties of the system we are studying. That is one form of the uncertainty principle. [Again, you do not seem to find 100 per cent individuals, even in the case of electrons. The form of the uncertainty principle to which I referred on page 82 implies that it is bound up with the fact that you cannot label them or distinguish them in any way except by constant interference.]

Now it is part of the very nature of an organism to interact with its environment. It not only adapts itself to the environment, but to some degree it adapts the environment to itself. [The latter activity is most strikingly displayed in the activity of man. Further, there is no sharp line between an organism and its environment. For example, few physiologists would claim that food in the stomach was part of the living system, but they will be considerably more doubtful as to whether the sugar from the digested food was really part of the living system when it had passed into the blood-stream. And after it has been stored away as glycogen in a cell most people would say it was part of the living matter. There is no particular point at which you can draw the line.]

Let us see what happens if we say "A living organism is at once a machine and an individual." As soon as we do that, we stop asking whether man is an individual, which is a metaphysical sort of question. We ask, how much of an individual is he? Is he more so than an apple-tree or a frog? As soon as we ask that question, we begin to get a very interesting set of answers.

note 119, p. 294 : JBS Haldane, *The Marxist Philosophy and the Science*, p. 99-100 :

If a man were completely an individual, he would have no spare parts, so to speak. But he has some replaceable parts. If you lose a pint of your blood, you can replace it by a pint of mine. If your pancreas ceases to function properly and to manufacture insulin, so that you get diabetes, you can replace it to a considerable extent by insulin derived from the pancreas of a pig; [though you have to exercise considerable caution about the amount which you put in your blood, whereas your pancreas manufactures the right amount without your thinking about it.] It is quite certainly established, on the other hand, that a leg does not usually function as a spare part. You cannot in general graft one from one man to another, or even from one mammal to another, unless they are genetically very similar. Further, if you cut a man in two, either one part dies or both parts die. If you cut him at a finger joint, the finger tip dies; if you cut him at the neck, both parts die. Whereas you can cut many plants and some worms in two in such a way that both parts will live. You can graft together frogs, not merely of different parentage, but of different species, provided you do it at a sufficiently early stage in their life history. What is more, you find that although an adult man certainly cannot divide in two, a sufficiently early human embryo can do so, producing a pair of monozygotic twins. As soon as we look at the thing from this point of view, we conclude that on the whole there has been a progress towards more complete individuality, both in the development of the individual and in the evolution of the race. This is the kind of help you get to your thinking if you once admit that these apparently opposite statements about our individuality have a certain amount of sense in them.

note 121, p. 295 : JBS Haldane, « *Biology and Marxism* », *loc. cit.*, p. 3-4 :

Supposing we coll down a simple animal, such as a sea anemone or a worm, or deprive it of oxygen, its activities gradually slow down, and it sinks into a state of torpor which leads to death unless it is warmed up again or supplied with oxygen within a certain time. This is

what one would expect if the animal is a chemical mechanism whose changes, like other chemical changes, slow down when the temperature is lowered, and depends on a supply of oxygen. But if we do the same experiment on a higher animal, such as a rabbit or a man, the result is very different. It responds to cold by shivering and a variety of muscular movements which serve to keep up its temperature. It responds to oxygen want by panting and an increased heart beat, which serve to keep up the supply of oxygen to its tissues. Only if these responses are unsuccessful does it sink into torpor.

Even in the simplest organisms we can always find some such self-preserving and self-regulating activities. Even in the highest we can find pieces of thoroughly mechanistic behaviour. A man, for example, does not protect himself against carbon monoxide poisoning as he protects himself against oxygen want. He absorbs the gas just as an inert fluid would, until he ceases to breathe, though even here he can acquire a measure of immunity by practice. Every living thing is at once a mechanism and an organism.

note 123, p. 297 : JBS Haldane, *New Paths in Genetics*, p. 43-45 :

When a cell divides, it produces two cells in each of which, apart from mutation, every gene in the original cell is replaced by a similar gene. Doubtless structures outside the nucleus are also reproduced. But the method of their reproduction is different. For if structures outside the nucleus are artificially altered, this alteration is not copied. On the other hand, alterations in the genes produced by X-rays or otherwise are copied, at least in many cases. The biologist will be inclined to say that the gene is an elementary organism, and divides to give two "heirs" like itself. But we cannot imagine the gene swelling till it divides like an overgrown drop of water. For it does not consist of a number of like parts. If it did it could not be completely changed by the hit of a single electron. Further, the gene is in the range of size protein molecules, and may be a nucleo-protein molecule like a virus. If, the chemist will say, we must conceive reproduction as follows. The gene is spread out in a flat layer, and acts as model, another gene forming on top of it from pre-existing material such as amino-acids. This is a process similar to crystallization [or the growth of a cellulose wall.

Now] suppose that the biologist and the chemist go round to a physicist, and ask him whether he thinks the gene in the two "daughter" cells are the heirs of the original gene, or that one is the model and the other the copy. The physicist will have to say something like this: "Your alternative is a false one. I can't yet put the true answer unambiguously in words, but I can put it in symbols. Here is the difficulty. How can one distinguish between model and copy? Perhaps you could use heavy nitrogen atoms in the food supplied to your cell, hoping that the 'copy' genes would contain it while the models did not. But unfortunately all proteins in a living cell seem to exchange nitrogen with the fluid around them. So the most you could do would be to say that there was a certain probability of one gene being the model and the other the copy. No doubt if the cell divides quickly enough this probability is pretty high. But one can never say that either of your alternatives is completely correct. Remember that it is not just a question of human ignorance. On the contrary, the impossibility of distinguishing between two things is only our human expression for a relation between them which also manifests itself in a term in their joint energy, or, if you like that word, in a force attracting them. No doubt this attraction is very small in the case of genes. But it must be there, and it may yet prove to be important in biology, as similar attractions are in physics. So you are both right and both wrong."

I think that throughout genetics an attempt to impose mechanistic interpretations such as the model and copy theory will break down in some such way as this. However, a refutation of mechanism is not a refutation of materialism. On the contrary, even if we reject Morgan's mechanism, we must be grateful to him for showing that the gene, the physical basis of heredity, is a material object.

note 124, p. 298 : JBS Haldane, 1934, « Quantum Mechanics as a Basis for Philosophy », *Philosophy of Science*, Vol. 1, p. 80 :

In the case of the many electrons this antinomy has now been resolved. Unfortunately the solution can at present only be stated in mathematical symbols. A solution in words is rendered impossible by the fact that grammar is less elastic than algebra. For example, the

pronoun "this" should not be used of electrons. But some are more nearly individualized than others.

note 128, p. 302 : JBS Haldane, « Biology and Marxism », loc. cit., p. 4-5 :

It is striking that the results in some fields of biological investigation are much more compatible with a mechanistic interpretation than those in others. Thus the optician treats the eye as a mechanism with faults to be corrected by means of spectacles, or even by an operation such as the removal of a lens which has become opaque through cataract. The treatment of disease such as retinitis pigmentosa or glaucoma, which cannot be regarded as mechanical defects is much less satisfactory. One reason is that it is easy and safe to experiment on the eye with spectacles, and difficult and dangerous to do so with surgical operations or local chemical treatments. Similarly genetics have inevitably a rather mechanistic outlook, because although we can build up all kinds of combinations of different genes, we cannot yet influence a given gene. Hence the genes can be regarded as atom-like units without this leading to false conclusions in many problems of practical breeding. On the other hand, it is important that geneticists should realise that the nature of their material gives them a somewhat mechanistic bias.

Similarly, an embryologist will tend to start with a bias in the direction of vitalism once he had discovered that development is not a mere unfolding of previously existing structure, as early embryologists believed when they thought they saw a little man sitting in a spermatozoön. [Not merely does a fertilized egg usually develop into an adult if adequately protected, but it will often develop into two adults if divided in two, which would not be the case if each part had a destiny, as in the construction of a machine.] We are now gradually finding out that development depends on very complicated interactions between the different parts of the embryo, and constructing a more balanced, or dialectical, theory of development.

note 129, p. 303 : JBS Haldane, « Biology and Marxism », loc. cit., p. 3 :

An increasing number of biologists have become more or less completely Marxists, and are no longer condemned to oscillate between a mechanistic and a vitalistic standpoint.

note 131, p. 304 : JBS Haldane, « Biology and Marxism », loc. cit., p. 5 :

My own work has been largely in the field of genetics and evolution, and it seems worth showing in some detail how Marxism has helped me there.

note 133, p. 304 : JBS Haldane, « A Dialectical Account of Evolution », loc. cit., p. 473 :

Evolution is pretty generally accepted as an historical fact. But some biologists and many popularizers of biology believe that Darwin's account of how and why it happened is incorrect. This is of course true in one sense. Darwin was not infallible. But because we have had to modify Dalton's ideas about atoms we do not say that he was wrong. We say that he was not completely right. And as no one (except His Holiness the Pope, speaking ex cathedra on a matter of faith or morals) is always completely right, this need not trouble us.

note 135, p. 305 : JBS Haldane, « A Dialectical Account of Evolution », loc. cit., p. 473 :

The other difficulty is more serious. The discoveries of different workers seem to contradict each other flatly. And here a dialectical approach is essential.

note 137, p. 305 : JBS Haldane, « A Dialectical Account of Evolution », loc. cit., p. 474 :

Darwin was at great pains to stress the variability of plant and animal species. We shall look for populations showing as little variation as possible, because we want to see how variation arises.

note 139, p. 306 : JBS Haldane, « A Dialectical Account of Evolution », loc. cit., p. 476 :

Now under normal conditions genes do change, and chromosomes do rearrange themselves, though much more slowly than under X-ray bombardment. For example, in one of the human chromosomes there is a gene whose function is to make the blood clot rapidly. Once in about 50,000 generations this gene changes, or mutates, so that it can no longer perform its function, and a man carrying such a changed gene becomes a haemophiliac, whose blood will not clot.

note 140, p. 307 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 476-477 :

This process of natural mutation is strictly accidental. [It is apparently due to too great a concentration of energy at a particular point, which alters a gene or chromosome.] An accident does not mean an event with no cause. It means an event outside our control, and in this case outside the control which a living organism can exercise over its constituents. [If one of Franco's "Made in Germany" bombs disintegrates me rather than some other comrade before I have finished writing this, it will be an accident, since the Fascist aviators are in much too great a hurry to escape the Loyalist pursuit planes to aim with any great care. Similarly] if one gene rather than another mutates, that is an accident. Marx was very clear as to the importance of accidents. "World history would, indeed, be very easy to make, if the struggle was taken up only on condition of infallibly favorable chances. It would, on the other hand, be of a very mystical nature if 'accidents' played no part. These accidents themselves fall naturally into the general course of development and are compensated again by other accidents."

Evolution is not "of a very mystical nature." It depends on accidents. In ally numerous species these accidents happen often enough to give rise to statistical certainty. If the gene for haemophilia arises afresh on an average once in 50,000 generations, it is very nearly certain that it will arise between 9000 and 11,000 times in the next 500 million people born. On the other hand, with a rare species such as the Indian elephant, comprising perhaps only 20,000 individuals, chance assumes a great importance.

note 141, p. 309 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 477 :

The accidental character of mutation is clear in many other ways. Almost, though not quite, all mutations lower the fitness of an organism in its natural state. This is equivalent to saying that organisms are pretty well fitted to their environment (fitness is defined later) and any change due to chance is likely to be for the worse. If mutation were an adaptive phenomenon like the growth of a muscle when exercised, as Lamarck believed, this would not be so. Most mutations would be useful. The same would (I suppose) be true if mutation were a manifestation of the Life Force (whatever he, she or it may be). Naturally enough, biologists to whom dialectical materialism means nothing, or means a weapon of the abominable Marx, cannot understand how harmful mutations can be a condition of evolutionary progress. They therefore deny them any importance.

note 142, p. 309 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 477-478 :

The self-repairing, self-reproducing organism is negated by accidents of a certain type. It can no longer reproduce itself unchanged. But since it does reproduce itself in the changed form (say as a white mouse in place of a brown, or a beardless wheat in place of a bearded) the negation is negated. This dialectical process is called "mutation," and leads to inheritable variations within a species. If we do not look at it dialectically, we are apt to label it either as pathological or progressive. In fact it constitutes a union of these opposites.

note 143, p. 310 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 478 :

Mutation alone, then, would cause every species to break down into a collection of freaks, some of which could only be preserved alive by a miracle. We have every reason to ask whether it is really of evolutionary importance.

note 144, p. 310 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 478 :

The antithesis to mutation, which nearly negates its effects, is natural selection.

note 145, p. 310 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 479 :

In artificial selection we can select for anything we please--for example, for innate capacity to sing, to produce many eggs, to grow long hair, or to develop cancer, though unless the suitable genes are available selection is fruitless. But natural selection selects for one character only, which Darwin called fitness, but never defined rigorously.

note 149, p. 311 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 481 :

[In consequence] there is an immense reserve of variability in a population, due to recessive genes which are harmful in the existing environment, but not necessarily so in a different one [--a fact first proved experimentally by Tschetverikoff].

note 150, p. 312 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 481 :

Just as mutation negates the fixity of a species, natural selection, to a first approximation, negates the negation, and we are apparently back where we were before, at a uniform population.

note 151, p. 312 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 481 :

To put the matter in different words, evolution, as Sewall Wright first realized, is a second order effect, due to the fact that two processes, which at first sight are in equilibrium, do not quite balance.

note 153, p. 313 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 481-482 :

*Let us now consider the species in dynamic equilibrium between mutation and selection. In such a species a number of genes will be found to be fairly common which are slightly disadvantageous in the particular environment considered, but may be advantageous if the environment is changed. Thus Timofeeff-Ressovsky found that in *Drosophila melanogaster* white eye color (associated with lack of pigment in internal organs) diminished the life span except at very high temperatures. But at high temperatures it was actually advantageous. Dynamic equilibrium ensures that there will be a reserve of genes of this kind, so that a species may be expected to change fairly quickly in a new environment.*

note 156, p. 314 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 483 :

Now suppose each gene is recessive, and has a frequency of one in one hundred. The homozygous recessives will have a frequency of one in ten thousand, the double recessives will have a frequency of one in one hundred million. Even if it is very fit, it will be too rare to cause the genes to spread, in the face of the adverse selection exercised by the single recessives, which are ten thousand times as common. Nevertheless the population is potentially unstable.

note 157, p. 314 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 483 :

The actual revolutionary situation may probably arise in two ways. A small population may be geographically isolated in which both genes are common enough to enable the double mutant to prevail. Or by a chromosomal rearrangement both the genes may be bound together so tightly that they act as a unit. In either case the new type will have a chance of ousting the old.

note 159, p. 315 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 484 :

Let us now consider the nature of fitness in greater detail. A given heritable change may have two effects (not of course mutually exclusive or even completely separable). It can make an organism fitter in relation to its environment of inorganic nature and other species. Or it can make it fitter in relation to its neighbors, the members of its own species. I have elsewhere called these changes increases in absolute and relative fitness.

note 160, p. 316 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 484 :

[Now] suppose that a plant in a cross-fertilized species which is normally fully fertilized produces more pollen, or pollen grains whose tubes grow quicker down the style. This plant will succeed in fertilizing a greater proportion of its neighbors than the average. Its characteristic, if heritable, will spread through the species. But as a result of this the species will not necessarily increase in numbers. It will be no fitter. It may be less fit, because an unnecessary amount of material is turned into pollen rather than seeds, roots, stems and leaves.

note 161, p. 316 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 484 :

We see then that fitness may diminish as a result of the selection of the fittest. This result will however be found characteristically in successful species. So long as a species is rare, the struggle for life is a struggle with the environment. When it becomes common, it is largely a struggle with neighbors of the same species. This latter struggle will sometimes

lead to the selection of valuable factors. But it will very often lower fitness. [Further, in a crowded species the revolutionary situations arising from the isolation of small groups will be infrequent, and thus will tend to slow down the evolutionary process by preventing certain kinds of sudden change.]

In fact a successful species tends to develop internal contradictions. It is now intelligible why the dominant groups of the past, such as the dinosaurs and the titanotheres, have left no descendants. They characteristically got bigger until they became extinct. Mere size is probably an advantage in the intraspecific struggle, especially the struggle for mates. It is not necessarily of any value in the struggle with the environment.

At this level the struggle between individuals becomes transformed into a struggle between species. And it is a struggle which places a premium on characters of a higher order, at least in animals. A species which does not indulge in unrestricted competition is less likely to lose in fitness than one which does so, should both of them become successful and crowded.

note 162, p. 318 : JBS Haldane, « A Dialectical Account of Evolution », loc. cit., p. 485 :

I am fully aware of the inadequacy of this sketch. I have distinguished three Hegelian triads:

Thesis	Antithesis	Synthesis
Heredity	Mutation	Variation
Variation	Selection	Evolution
Selection of the fittest	Consequent loss of fitness	Survival of noncompetitive species

I am perfectly aware that these represent a certain abstraction from reality. Thus selection probably affects the rate of mutation. An animal species alters its environment to some extent, and the human species does so to a great extent. Thus the evolutionary process itself affects the environment, which in turn determines its direction. Nevertheless, I hope I have shown that dialectical materialism furnishes us with a very powerful weapon for the interpretation of biological facts. It may well be that some theorists in the Soviet Union have attempted to apply dialectics to scientific problems for which simpler logical forms are better suited. Nevertheless, in other countries the attempt has not yet gone far enough.

Some writers, including biologists such as Hogben, while expressing a measure of sympathy with Marxism, have no use for those elements in it which are derived from Hegel. I have tried to show that, in biology at any rate, the intellectual technique of Marx, Engels and Lenin makes for clear thinking.

note 165, p. 319 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 7-8 :

Such an attempt as mine inevitably invites one of two criticisms. If one confines oneself to well-established scientific facts, one is told that it is easy to apply Marxism after the event, and that with sufficient ingenuity one can find a quotation from Marx or Engels which is apposite to any piece of recent scientific work. If, on the other hand, one ventures into speculation one is certain to be wrong on points of detail, if not on more fundamental matters.

note 168, p. 319 : JBS Haldane, « Professor Haldane Replies », loc. cit., p. 242 :

And I hope that no student of biology will become a user of the dialectic unless he or she is persuaded that it is (as I believe and Dr. Lerner does not) an aid both to the understanding of known biological facts and to the discovery of new ones.

note 169, p. 320 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 46 :

[Most scientific work is done in a limited field.] It no more needs dialectic than it need the differential calculus or a microscope. [Nevertheless, I am convinced that Marxism proves the greatest value in studying the development of science, and the relationship of the different sciences to one another, particularly the relation of chemistry to physics, and of biology to

chemistry.] And it is particularly useful in those branches of science which are themselves concerned with change, for example, in the theory of evolution.

Chapitre 5 :

note 179, p. 331 : JBS Haldane, 1938, « Professor Haldane Replies », Science and Society, Vol. 2, p. 239 :

The article in question was devoted to exposition, not to an account of my researches. Nevertheless, I claim that a good deal of my recently published research has been inspired by my gradually increasing knowledge of dialectical materialism. [For example, I recently published the first serious estimate of the rate of mutation of a human gene. I did this after I had been compelled, when writing an essay on "The Present State of the Theory of Natural Selection" for Gosisdats (one of the Moscow publishing houses), to try to state the Mendelian theory of evolution in dialectical terms. Some five years earlier, I had discussed the equilibrium (or near equilibrium) between mutation and selection in mathematical terms. The intellectual effort of doing so had exhausted me, and it was not until (thanks to Engels) I could state the situation verbally, that I saw how this approximate equilibrium gave the key to many surprising facts, including the frequency of hemophilia in human populations.

*I do not think it is a mere coincidence that my laboratory is probably the only place outside the Soviet Union where this equilibrium and its disturbances are being studied. In the same way, a study of Engels has enabled me, after some years, to crystallize a number of heterogeneous data regarding selection of domestic animals into what I believe to be a new principle, first enunciated in *The Modern Quarterly* (London), I, no. 2.]*

I do not claim that these results could not have been obtained without a study of Engels. I merely state that they were not reached without such a study, and that so long as I find dialectical materialism a valuable tool in research, I propose to state the fact.

note 180, p. 332 : JBS Haldane, 1938, The Marxist Philosophy and the Sciences, George Allen & Unwin, p. 45-46 :

In the application of Marxism to science, we must proceed with the very greatest caution. At best Marxism will tell a scientist what to look for. It will rarely, if ever, tell him what he is going to find, and if it is going to be made a dogma, it is worse than useless.

In the first ten years of scientific research in the U.S.S.R. certain writers – one can hardly dignify them by the title of workers – attempted to apply dialectical materialism to every kind of activity from portrait painting to fishing. They produced a great deal of utter non-sense. Indeed, the worse a scientific paper was, the more likely it was to be embellished with irrelevant quotations from Marx, Engels, and Lenin. Good science needs no such justification, and an experienced Marxist will notice evidences of dialectical thinking without any need to draw his attention to them. The curious reader will find a number of ludicrous examples of bogus dialectical materialism in an article by Stetski in the Pravda of June 4, 1932, which has been extensively cited in other countries to prove the decay of science in the Soviet Union. He may forget that Stetski, a member of the central committee of the communist party, had deliberately picked the most ridiculous out of many thousands of scientific and technical articles in order to check a dangerous tendency.

note 182, p. 334 : JBS Haldane, The Marxist Philosophy and the Sciences, p. 46 :

If dialectical materialism has sometimes been misapplied in the U.S.S.R. this does not imply that a little more of it would hurt British scientific thinkers. It is, in fact, already being used by a small number of them. Unfortunately a citation of some of the best examples might endanger the posts and salaries of the workers concerned.

Most scientific work is done in a limited field. It no more needs dialectic than it need the differential calculus or a microscope. Nevertheless, I am convinced that Marxism proves the greatest value in studying the development of science, and the relationship of the different sciences to one another, particularly the relation of chemistry to physics, and of biology to chemistry. And it is particularly useful in those branches of science which are themselves concerned with change, for example, in the theory of evolution.

note 184, p. 337 : JBS Haldane, « Biology and Marxism », *The Modern Quarterly*, Vol. 3, n°4, p. 5 :

My own work has been largely in the field of genetics and evolution, and it seems worth showing in some detail how Marxism has helped me there. In the experimental field, I have found (at first rather to my surprise) that the principles formulated by Mendel, and by Morgan and his school, work in a variety of organisms ranging from primroses and snapdragons to flies, hens, mice, cats and men. I further calculated how natural selection would act on a mixed population, causing some genes to spread at the expense of others? My outlook was, I suppose, essentially mechanistic, like that of a physician who regards the eye as a camera, the heart as a pump, a joint as a hinge, and so on. But twenty-five years ago I was only considering on type of conflict – the conflict between individuals of the same species, which Darwin described as the struggle for existence. Gradually at first, and more rapidly after reading Lenin on dialectics, I came to see that evolution depends on conflict at many different levels, and is only explicable in terms of these various conflicts.

note 185, p. 337 : JBS Haldane, « Biology and Marxism », *loc. cit.*, p. 7 :

The essentially dialectical nature of Wright's thought may be gauged from the fact that in one of his fundamental papers he lists no less than nine antagonistical processes in the "mechanism" of evolution.

note 187, p. 337 : Sewall Wright, « Evolution in mendelian populations », *loc. cit.*, p. 155 :

The frequency of a given gene in a population may be modified by a number of conditions including recurrent mutation to and from it, migration, selection of various sorts and, far from least in importance, mere chance variation.

note 188, p. 338 : Sewall Wright, « Evolution in mendelian populations », *loc. cit.*, p. 157 :

Evolution as a process of cumulative change depends on a proper balance of the conditions, which, at each level of organization—gene, chromosome, cell, individual, local race—make for genetic homogeneity or genetic heterogeneity of the species.

note 191, p. 338 : Sewall Wright, « Evolution in mendelian populations », *loc. cit.*, p. 158 :

Conditions in nature are often such as to bring about the state of poise among opposing tendencies on which an indefinitely continuing evolutionary process depends.

note 194, p. 339 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 120 :

My colleague Professor R.A. Fisher has suggested yet a third effect of the antagonism between mutation and selection. Where a mutation is common, any gene which protects the organism against its results will be favoured by selection. Thus, he thinks, mutant genes which were originally more or less dominant, become first recessive and then inactive. Meanwhile the accumulation of protective genes causes the organism to evolve. Here at last we have a suggested cause for evolution which has nothing to do with the environment on the one hand, nor with any mysterious inner urge on the other. It is, in fact, a beautifully dialectical theory.

note 195, p. 340 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 120-121 :

Nevertheless, I happen to be one of its two most determined critics, because it appears to me that, as stated by Fisher, it runs counter to certain facts. For example, mutant genes should be, but are not, more recessive in outbred than inbred species, if this theory were true.

note 196, p. 341 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 121 :

I mention this controversy in view of the widely held theory that acceptance of Marxism is an emotional cataclysm which completely ruins one's judgement. If only Fisher were a Marxist and I were not, the theory might perhaps be applicable in the case in question. As a Marxist, I hope that Fisher's general argument may have a wider validity than at present appears likely to me.

I think it is clear that the Marxist Point of view leads one to look for these creative antagonism in nature, and to investigate them when one finds them, but certainly not to accept them blindly.

note 207, p. 347 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 401-402 :

In 1937, meanwhile, Haldane published his first systematic effort to apply dialectical materialism to biology. In a paper written at the Spanish front, where he was advising the Spanish government on organizing resistance to possible chemical warfare, he attempted to give a dialectical account of evolution (Haldane 1937b). In one way the effort was remarkable. Haldane considered evolutionary theory, as understood then, in its full complexity. He tried to show that it could be fully interpreted dialectically, that is, its most fundamental principles bore a dialectical relationship to each other. In another way, however, this initial attempt, though intriguing and stimulating because of its attention to scientific detail, remained a theoretical failure. Though he paid ample lip service to Engels, Haldane's Marxism was yet nebulous - the analysis he provided owed more to second-hand Hegel than to dialectical materialism.

note 208, p. 347 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 402 :

Though materialism was implicitly - and ambiguously - assumed, Haldane was nowhere concerned with it. His attention was fixed on the dialectic, perhaps reflecting what in Marxism gave him the most intellectual difficulty during his transformation.

note 213, p. 349 : JBS Haldane, « Professor Haldane Replies », *loc. cit.*, p. 241 :

I quite agree with Dr. Lerner that the negation of a negation may mean several rather different things. Why not? If a formula is to be applicable to natural events in the spheres of physics, chemistry, biology, psychology and economics, and also to our thought about them, then it must be elastic. It is just because they cover so wide a field that the basic dialectical principles are so extremely useful on the one hand, and on the other, so hard to apply in detail without a considerable knowledge of detail.

note 214, p. 350 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 404 :

What is most remarkable about that book is not that Haldane brought the entire range of his erudition - from mathematics, physics and economics to biochemistry, genetics and evolution - to interpret existing science along what he took to be Marxist principles, but that he used those principles to speculate, in detail, about the future of science.

note 216, p. 350 : Sahotra Sarkar, « Science, Philosophy, and Politics in the Work of J.B.S. Haldane », *loc. cit.*, p. 404 :

Ultimately, the book is a failure, and its failure underscores the failure of dialectical materialism .

note 219, p.352 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 69 :

There are at least three levels at which the influence of Haldane's Marxism on his science might be explored. First, did it make him a better biologist, in a qualitative sense? [To answer this requires value judgments that are unlikely to be politically neutral.] Second, did it make him a more productive biologist, in purely quantitative terms? [Since the period of his allegiance to Marxism is at least approximately defined, one can address this question by examining his research output throughout his career; when only strictly research or theoretical publications are counted, the answer is an unequivocal "no."] Third, did Marxism detectably alter his way of doing science?

note 225, p. 353 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 73 :

When I began reading Haldane's scientific papers with an eye toward identifying ideological influences, I naively visualized strictly an internal comparison along a time line; I anticipated some validation of his claims in the form of a discontinuity of some kind in his way of defining or setting up a problem, reflecting his self-proclaimed conversion in 1937. As I reviewed the papers and their relationships with the work of Fisher and Wright, I realized

that Haldane could not be taken in isolation. neither Fisher nor Wright was a Marxist, but was it possible that population genetics itself was intrinsically dialectical, such that there is no other logical, productive approach to theory?

note 226, p. 354 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 73-74 :

Haldane's scientific output was enormous - some 500 titles- and a paper-by-paper review for political content is impossible here. Instead I will limit myself to look for any ideological benchmarks that may appear.

note 227, p. 354 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 74 :

In the first paper he constructs the simplest case, with constant selection rate, random mating, infinite population size, discrete generations, complete dominance, and perfect Mendelian segregation. He sets up a system of recurrence equations to allow one to estimate the makeup of generation n from that of generation $n-1$. In the second through fifth papers he varies single factors, gradually bringing the system closer to reality.

note 228, p. 354 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 74 :

An apologist for dialectics might argue that recurrence equations are intrinsically "dialectical." At the same time, there is an unremittingly reductionistic emphasis in the way the models are constructed. This apparent contradiction (is it dialectical?) nicely underscores the subjectivity and ambiguity inherent in claims that such-and-such is or is not dialectical. [(Struik, 1936, goes so far as to argue that all mathematics is inherently dialectical, which if true would render this discussion moot. For an example of very recent dialectical apologetics in biology see Allen, 1992, where it is argued that Darwin reasoned dialectically.)]

But not all such claims are equally subjective or ambiguous.

note 229, p. 355 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 74 :

The sixth paper (1930) treated the effects of isolation and gene flow. Gene flow is at least quasidialectical insofar as it involves opposing pressures, but recall that JBS himself had doubted openly that all processes leading to equilibrium were necessarily dialectical. The seventh paper (193 1a), however, admits of no doubts. In it, Haldane lets selection intensity vary as a function of death rate, thus "inter-penetrating" demography and genetics in a novel way. The eighth paper (193 1b) is even more dialectical. In it, he considers a case in which two genes are harmful in isolation from each other but beneficial when combined in the same individual. The result is the first in his work that corresponds easily to a Hegelian "triad."

note 231, p. 358 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 74 :

Haldane's mathematics shows dialectical traces as early as 1924, becomes more obviously dialectical by 1930, and undeniably so from 1931.

note 232, p. 359 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 74 :

In the paper "The Effect of Variation on Fitness" (1937a) he develops the mathematics of overdominance. Although this seems to be an intrinsically dialectical subject, there is no sense of ideological motivation or excitement in the paper; it is a typical Haldane theoretical paper, terse to the point of being telegraphic, and presents overdominance as merely one among several cases. "The Equilibrium between Mutation and Random Extinction" (1939) and "The Conflict between Selection and Mutation of Harmful Recessive Genes" (1940b) are similarly dialectical in content but not in style.

note 234, p. 360 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », loc. cit., p. 74 :

The facts thus far suggest that Haldane was quite right when he stated that his apprenticeship to his father had predisposed him to dialectical thinking. His conscious embrace of Marxism in 1937 - at least insofar as it influenced his scientific work - was merely an acknowledgment of a way of thinking that had been in place for a long time, albeit perhaps unconsciously.

note 239, p. 361 : Charlotte Haldane, 1950, *Truth will out*, Vanguard Press, New York, p. 37 :

We both were and had been, long before we had met, socialists [and to use the horrible cliché that, at about that period, began to pass into the language, 'left-wing intellectuals.']

note 240, p. 361 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 75 :

But the possibility remains that the dialectical character of Haldane's work reflects not only his personality, but the nature of the discipline if not of nature itself. (If Engels was right about nature being dialectical, the theory best describing and explaining nature should be dialectical, too.)

note 243, p. 362 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 75-76 :

The presence of strongly dialectical elements in both Fisher and Wright leaves little doubt that the method is well suited to the subject matter. Ideologues may then debate whether this says anything about the structure of nature.

note 244, p. 363 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 76 :

In summarv. if Haldane means conscious application of Marxism, there is little if anything in his work to validate his claim that he "found Marxism of real value in the planning of biological research." There is much to validate the alternative claim that dialectical thinking was of value to him, even before he knew he was doing it. His claims for the value of conscious Marxism can be viewed in the psychological context of the need for justification and self-assurance in the recent convert, or in the sociopolitical context of the mass-produced political rhetoric of the period, or perhaps both.

note 246, p. 363 : Arthur M. Shapiro, « Haldane, Marxism and the Conduct of Research », *loc. cit.*, p. 76 :

He was too much of a polymath and had too subtle a mind for anyone to conclude that without his Marxism he would have done this or that differently.

note 252, p. 366 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 95 :

[This Chapter has traced Haldane's philosophical development] from his Kantian idealism of the early 1920s to his Kantian agnosticism of the mid- to late 1920s, followed by his move towards Hopkins holistic materialism and then his acceptance of DM. [Throughout all of these changes] Haldane remained a holist.

note 259, p. 368 : Loren R. Graham, 1972, *Science and philosophy in the Soviet Union*, Alfred A. Knopf, New York, p.63-64 :

Looking back over the system of Soviet dialectical materialism, we see, on the most general level, that it represents a natural philosophy based on the following quite reasonable principles and opinions:

- *The world is material, and is made up of what current science would describe as matter-energy.*
- *The material world forms an interconnected whole.*
- *Man's knowledge is derived from objectively existing matter.*
- *The world is constantly changing, and, indeed, there are no truly static entities in the world.*
- *The changes in matter occur in accordance with certain overall regularities or laws.*

- *The laws of the development of matter exist on different levels corresponding to the different subject matters of the sciences, and therefore one should not expect in every case to be able to explain such complex entities as biological organisms in terms of the most elementary physicochemical laws.*
- *Matter is infinite in its properties, and therefore man's knowledge will never be complete.*
- *The motion present in the world is explained by internal factors, and therefore no external mover is needed.*
- *Man's knowledge grows with time, as is illustrated by his increasing success in applying it to practice, but this growth occurs through the accumulation of relative not absolute truths.*

The history of thought clearly shows that no one of the above principles or opinions is original to dialectical materialism, although the total is.

note 260, p. 370 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 107 :

In each model the population consists of a billiard ball universe of genes or Mendelian factors. Once the conditions for the model have been set up then it will run in a mechanistically determined manner to its conclusion. This is as true of the models of unstable and oscillating populations as of the stable ones. There is no sense of an internal dynamic to these early population models.

note 262, p. 370 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 107-108 :

I find this mechanistic emphasis in the early MT papers unsurprising. As seen above, Haldane's stated intention was to use quantitative arguments in favour of natural selection as a feasible explanation for evolution, rather than rely on purely descriptive arguments. With very little previous work on this issue it was necessary to start with the simplest cases and then move on to the more complex (Haldane 1924a: 57). For Haldane this project was also the promotion of joining Mendelism to Darwinism. Very little was known about the nature of Mendelian factors themselves apart from their location on the chromosomes (Haldane 1927c). There was little choice but to consider them as if they were the billiard balls of mechanism. This was not a problem for the neo-Kantian Haldane for whom mechanism could be useful in biology even though it was not sufficient.

Furthermore Haldane did not think that studies in genetics would shed light on the nature of the gene: this was the task of biochemistry. He commented that

"just as the internal structure of atoms was elucidated by physicists rather than chemists, it is probable that the inner nature of the gene is a problem for the biochemist rather than the geneticist"

note 265, p. 372 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 108-109 :

These writings exhibit a sense of internal dynamics to a population that is missing from the earlier MT papers and can be treated as a cluster under the themes of semi-isolated communities and metastable populations.

note 266, p. 372 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 108-109 :

Haldane gave the example of a population containing genotype AABB with occasional mutations of A and B to a and b respectively. Occasionally a section of this population becomes temporarily isolated from the main population (Haldane 1931c: 138). The genotype aabb subsequently becomes the "stable type," ie the majority, of this semi-isolated community. When this community re-gains contact with the main population one of three outcomes are possible. Firstly, aabb becomes "swamped by hybridisation" with AABB. Secondly, "aabb may possess or develop characters which render meeting with AABB rare." Thirdly, "metastability" may occur.

note 267, p. 373 : JBS Haldane, 1931, « A mathematical theory of natural selection, Part. VIII. Metastable populations », *Proceedings of the Cambridge Philosophical Society*, Vol. 27, p. 139 :

Chromosome changes may occur to cause close linkage of A and B when the populations are crossed. Thus if the loci of A and B are in the same chromosome an inversion of the portion containing them will lead to their behaving as a single factor on crossing. In this case if K is positive the whole species will be transformed into the type aabb. A species which is liable to transformations of this kind may be called metastable. Possibly metastability is quite a general phenomenon, but it is only rarely that the circumstances arise which favour a change of the type considered.

note 268, p. 373 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 109-110 :

So Haldane strongly suspected that many species (and populations) were of a metastable nature. A change in the genetic composition of species and populations was due as much to the internal nature of the species as it was to a change in environmental conditions. In other words, the internal structure of the population (in this case, linkage possibilities) contains the potential for change. A change in the conditions (external factors) under which the population exists can allow this potential to be realised.

note 269, p. 373 : JBS Haldane, 1931, « A mathematical theory of natural and artificial selection, Part. VII. Selection intensity as a function of mortality rate », *Proceedings of the Cambridge Philosophical Society*, Vol. 27, p. 135 :

This is in full accordance with the views of Bidder, who points out that, where "cataclasm" occasionally destroy the vast majority of a species, characters which are useless or worse under normal conditions may be selected.

note 270, p. 374 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 114-115 :

After a gap of three years Haldane combined the ecological work on semi-isolated communities and cataclasm with his genetical speculation on the internal metastable nature of populations to explain how a population equilibrium could be disturbed. These developments took him away from his earlier work in which the nature of the equilibrium was little more than 'given.' "Stable" or "unstable" equilibria had referred simply to tracking the rise and fall of a gene's frequency in a population. In a similar vein, disturbances had simply been dealt with by tracking gene frequencies by the use of mathematical models (including MT5). By 1930 Haldane had added the ecological picture with cataclasm, and was emphasising the potential 'switch' from disadvantageous to advantageous and vice versa in gene function.

note 272, p. 375 : JBS Haldane, « Professor Haldane Replies », *loc. cit.*, p. 239 :

I recently published the first serious estimate of the rate of mutation of a human gene. I did this after I had been compelled, when writing an essay on "The Present State of the Theory of Natural Selection" for Gosizdat (one of the Moscow publishing houses), to try to state the Mendelian theory of evolution in dialectical terms. Some five years earlier, I had discussed the equilibrium (or near equilibrium) between mutation and selection in mathematical terms. The intellectual effort of doing so had exhausted me, and it was not until (thanks to Engels) I could state the situation verbally, that I saw how this approximate equilibrium gave the key to many surprising facts, including the frequency of hemophilia in human populations.

note 273, p. 376 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 116 :

Although not explicitly stated by Haldane in "Spontaneous Mutation" (1935), his newly enhanced mutation-selection model was central to his calculation of the spontaneous mutation rate of the gene for human haemophilia (a sex-linked condition). This can be seen through his comments concerning balance or equilibrium. His professed aim was to "attempt to show that most large human populations are in approximate equilibrium as regards haemophilia, selection being balanced by mutation" (my emphasis) (spontaneous mutation, p. 318). Haldane showed mathematically that if this balance or "approximate equilibrium"

existed then a large population of haemophilia genes must be “effectively wiped out per generation. The same number must be replaced by mutation” (Haldane 1935a: 318). In other words, as selection constantly eliminated haemophilia genes then mutation replaced them in the same number and a dynamic equilibrium was maintained.

note 274, p. 376 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 119 :

Although a ‘technical’ paper the presentation of “Spontaneous Mutation” displays a more developed sense of the relationship between mutation and selection. Instead of merely giving formal recognition to (or glossing over) the relationship Haldane was now able to apply his understanding of the relationship to a practical (or concrete) issue in a way that previously was missing in his pronouncements on mutation–selection. His more defined model of “approximate” equilibrium, with its ‘fruitful tension’ between mutation and selection, was central to his arguments for calculating the rate of spontaneous mutation. This model entailed mutation and selection attempting to push the frequency of a gene in opposite directions. Formulations such as

$$\frac{2\mu + v}{1 - f.}$$

were the mathematical expression of this concept.

note 276, p. 377 : JBS Haldane, « A discussion on theory of natural selection », *loc. cit.*, p. 69 :

The fact that Natural Selection has a primary role in stabilizing species makes more plausible its secondary role in determining which evolutionary paths they will take among the very vast number which mutation renders possible.

note 277, p. 377 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 120-121 :

Selection acted as ‘eliminator’ to help keep a population in equilibrium. When the population was disturbed selection could ‘switch’ to ‘chooser.’ At the very least this is highly suggestive of a unity of opposites in which ‘eliminator’ and ‘chooser’ are complementary aspects of the same process. They are opposites in the sense of ‘selection-as-eliminator’ acts to avoid change (to maintain stability in a population or species) whereas ‘selection-as-chooser’ acts to disrupt the stability of the population or species, resulting in a ‘new’ population or species.

note 278, p. 378 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 121 :

By 1930 he already had the broad outline of his model for evolutionary change – a population in equilibrium until disturbed by a variety of factors (especially ecological impact leading to semi isolated communities or previously disadvantageous characters suddenly becoming advantageous due to a drastic change in environmental conditions). Yet he did not explicitly express the ‘switch’ between selection as ‘eliminator’ and ‘chooser,’ or the “balance” between mutation and selection, until 1935 and 1936. Was his increasing knowledge of DM helping him to identify the nature of these processes? The mutation–selection balance could be construed as a unity of opposites, a principle he was excited about in “Quantum Mechanics” (1934) a year earlier than “Spontaneous Mutation” (1935).

note 280, p. 379 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 119 :

Instead of merely giving formal recognition to (or glossing over) the relationship Haldane was now able to apply his understanding of the relationship to a practical (or concrete) issue in a way that previously was missing in his pronouncements on mutation–selection.

note 283, p. 380 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 128 :

In 1935 Haldane had used his mutation–selection concept simply to ascertain whether a human population was in “approximate” equilibrium for haemophilia. As seen in this section, by 1939 he was using his concept to explain the shift from one equilibrium to another, as well as the nature of the equilibrium itself.¹ From his post 1935 work with Bell, and the cluster of papers from 1939 and 1940 it can be seen that Haldane was using his mutation–selection concept as a research tool, both in theory development and as an aid to research programme design.

note 284, p. 380 : Andrew J. Hammond, *JBS Haldane and the Attempt to Construct a Marxist Biology*, p. 183 :

I have also argued that Haldane used DM's law of the unity of opposites a year later in his mutation–selection theory. This theory paved the way to a productive research programme. [In the case of his theory of disease and evolution I have argued that he may have used DM to identify or arrive at various elements and synthesise them into a new theory. Once again, he pointed out possible research programmes from this theory.] In part this can be seen as using DM to ‘filter’ data and theories. This method would have been particularly useful to Haldane. He read as widely as possible on developments in biology to make use of this knowledge in his work. Perhaps DM gave him a philosophical framework (or organising principle) by which to filter large quantities of data and theories. [This would certainly appeal to the philosophical monist Haldane with his desire for an over-arching theory unifying all aspects of the universe.] Evidence that he may have used DM as such a framework can be found in his ongoing emphasis on the unity of opposites [(including his comment on biochemistry in 1954). Finally, I have argued that Haldane may have used DM to reinterpret and embellish his theory of the origins of life. In this highly speculative case he may have used DM in his own theorising (eg in “Quantum Mechanics” and extending Milnes’ theory) and as a filter.] My overall conclusion to my study is that DM may not have ‘directly’ influenced Haldane’s daily research but a good case can be made for DM indirectly affecting his practice through its use in theory design and as a filter.

note 297, p. 387 : JBS Haldane, *The Marxist Philosophy and the Sciences*, p. 45 : cf. note 180, chapitre 5.

note 303, p. 390 : JBS Haldane, « the effect of variation on fitness », *loc. cit.*, p. 340 :

At any gene locus in a population there are a number of possible conditions which may be listed as follows :

1. *Equilibrium*
 - a. *Equilibrium between genes whose effect on fitness is of the order of their mutation rates or smaller.*
 - b. *Equilibrium due to greater fitness of heterozygotes than homozygotes.*
 - c. *Equilibrium due to the constant production by mutation of genes lowering fitness and thus eliminated by selection.*
 - d. *Equilibrium due to exogamy.*
 - e. *Equilibrium due to inhomogeneous environment, etc.*
2. *State of Change*
 - a. *Decrease in frequency of a gene lowering fitness.*
 - b. *Increase in frequency of a gene lowering fitness.*

note 304, p. 391 : JBS Haldane, « The spread of harmful autosomal recessive gene in human populations », *loc. cit.*, p. 232 :

It is well known that the frequency of a number of abnormalities is higher among persons whose parents are relatives than among the population in general. Some of these abnormalities are definitely known to be due to recessive genes. Certain of these genes, for example those for amaurotic idiocy and ichthyosis foetalis, are lethal. Others, such as the extreme forms of deafness, retinis pigmentosa and so on, were probably sublethal to primitive men, and presumably lower the fitness of homozygotes to-day. The question arises as to whether existing populations are in equilibrium for such genes.

note 305, p. 392 : JBS Haldane, « The spread of harmful autosomal recessive gene in human populations », *loc. cit.*, p. 233 :

[On the other hand,] α , the coefficient of inbreeding, has certainly diminished during historical time. Two thousand years ago the population of northern Europe consisted largely of small endogamous communities, and three thousand years ago this was also true of southern Europe. Even in the last century the value of α has probably diminished in most countries, owing to increases both in urbanization and in rural transport. We shall therefore consider the effect of a sudden diminution in the value of α .

note 306, p. 392 : JBS Haldane, « The spread of harmful autosomal recessive gene in human populations », *loc. cit.*, p. 235 :

We can now sketch the effect of civilization on recessive sublethals. In the primitive condition we have a number of small nearly endogamous communities, and therefore a high value of α . They are in approximate equilibrium. At any given moment some of these communities have a high frequency of a particular recessive gene, and homozygotes are fairly common. Thus albinism is very common in a few primitive tribes, oligophrenia in a certain rural district of north Sweden [(Sjögren, 1935). Other similar communities are quite free from such genes, but in a group of such communities the frequency of recessive phenotypes is high enough to balance mutation, though the gene frequency is low.]

As a consequence of civilization these small communities are merged in larger towns and states. The frequency of homozygotes falls sharply. But mutation is no longer balanced by selection, and the gene frequency increases slowly. This process is now going on. [A community which takes to inbreeding again after several thousand years of civilization will probably produce lethal and sublethal recessives in great number. The danger is, however, less acute than appears at first sight, since modern populations are probably mostly descended from inbred rural communities of the mediaeval and ancient world, rather than from outbred urban communities.]

We may then expect a slow increase for some thousands of years, in the frequencies of rarer recessive conditions.

note 309, p. 393 : JBS Haldane, « The theory of the evolution of dominance », *loc. cit.*, p. 373 :

In a population which is mainly self-fertilized the majority of non-lethal mutant genes are present in homozygotes and very few in heterozygotes. The intensity of selection for dominance must therefore be less than in outbred species. Since, however, dominance is often commoner in inbred than outbred species, Fisher's theory appears to stand in need of modification.

note 315, p. 396 : JBS Haldane, « The theory of a cline », *loc. cit.*, p. 283 :

The method would, however, be reliable if adequate data were available, and it is hoped that the possibility of using them may stimulate their collection. An ideal set of data would include the following:

- (1) Data on the frequency of different phenotypes over the area covered by the cline, especially near any conspicuous boundary.*
- (2) Data on the genetics of the character concerned. It is however to be noted that if a clear-cut difference is due to a single gene substitution, it makes very little difference whether this gene is dominant or recessive, [since for a given intensity of selection the interquartile range is only 37% longer in the region where recessives are favoured than in that where dominants are favoured.]*
- (3) Evidence that mating is at random, or an estimate of the homogamy. [This again is unimportant, since complete homogamy will only slightly increase the intensity of the cline, bringing it to the level characteristic for two different species.]*
- (4) Data on migration, [designed to give the mean square distance m^2 migrated per generation, and evidence that migration is random in direction, and independent of phenotype.]*
- (5) Data over a number of years, to test whether the frequencies and migration rates are fairly stable.*

note 316, p. 400 : JBS Haldane, « A mathematical theory of natural and artificial selection. Part I », *loc. cit.*, p. 19 :

A satisfactory theory of natural selection must be quantitative. 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 transmutations. In any given case we must specify:

- (1) The mode of inheritance of the character considered,*
- (2) The system of breeding in the group of organisms studied,*
- (3) The intensity of selection,*
- (4) Its incidence (e.g. on both sexes or only one), and*
- (5) The rate at which the proportion of organisms showing the character increases or diminishes.*

It should be possible to obtain an equation connecting (3) and (5).

note 317, p. 405 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 337 :

There is good reason to believe, with Darwin, that natural selection has played a very important part in evolution. The great interest of the evolutionary process has tended to divert attention from the action of natural selection in stabilizing species in their existing monomorphic or polymorphic facies. Yet this latter phenomenon is easily observable.

note 318, p. 405 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 337 :

On the other hand, the evolutionary process is exceedingly slow. Forms usually change little in 100,000 years. Now Haldane (1924) showed that a dominant character causing an increase of 0.1 per cent in the fitness of its carriers would increase of 0.1 per cent to one of 99 per cent in a random mating population in 23,400 generations.

note 319, p. 406 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 338 :

[However,] in what follows we shall deal entirely with populations in equilibrium. Every species observed with sufficient care has been found to include members less fit than the average and whose lack of fitness is heritable. Their number in a sufficiently large population is approximately constant, and in spite of selection does not diminish, either because the gene or chromosomal abnormality responsible for them are continually being replenished as the result of mutation, or because they are advantageous in a different combination. We shall here discuss the effect of such deleterious genes on the fitness of the species.

note 320, p. 406 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 338-339 :

We must first define fitness. This is easiest in a hermaphrodite organism. We can say that the fitness of any particular genotype (or group of genotypes) is half the mean number of progeny left by an individual of that genotype. Progeny due to self-fertilization are counted twice over. Certain conventions are necessary. Obviously, individuals must be counted at the same stage of the life-cycle, e.g. at birth or maturity. [Also when determining our average fitness we must take arithmetic means in space, but geometric means in time. Thus if two organisms have 18 and 2 progenies, respectively, their mean fitness is 5, not 3. And in an organism with two generations per year, the autumn generation being 5 times as numerous as the spring population, the mean fitness of the spring population is 5, of the autumn population 1/5, their mean being unity, the geometric mean, not 2.6, the arithmetic mean.]

If we take the generation as our unit of time, the natural logarithm of the fitness is the Malthusian parameter as defined by Fisher (1930). Fisher took the year as his unit; and where generations are not sharply defined an astronomical unit is preferable to a biological. [In such a case the precise mathematical theory (Norton 1928, Haldane 1926) is rather complicated. However our general conclusions are unaffected by the complications.]

*In a bisexual organism a correction must be made for the sex-ratio. And in a polymorphic population with several exogamous genotypes [(e.g. a plant with trimorphic heterostylism)] the matter is further complicated. [An example of the necessary computations is given by Fisher (1935) in the case of *Lythrum Salicaria*.] However, unless a mutant gene or chromosomal abnormality affects the sex-ratio no complication of this type occur in the case of animals.*

note 321, p. 407 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 339-340 :

It is clear that the mean fitness of all members of a species must always be very close to unity, if we average over any length of time. If the fitness were 1.01 the population would increase 20,959 times in 1,000 generations. In almost all species the mean fitness over 1,000 generations must vary from unity by far less than one per cent.

note 322, p. 407 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 340 :

But in any species some genotypes have a fitness less than unity, ranging from zero in the case of lethal genes and genes causing complete sterility. So it is clear that the fitness of the standard type containing no deleterious genes must exceed unity. A population composed of such a type would of course increase until, owing to its pressure on the means of subsistence, the fitness was again reduced to unity.

note 323, p. 408 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 340 : cf. note 303 du chapitre 5.

note 324, p. 408 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 340 :

There will also be equilibrium due to a combination of causes. E.g. heterozygous forms such as the thrum primrose which are kept in existence by exogamy may also be per se fitter than homozygotes. And equilibrium 1(a) shades into 1(b) and 1(c) imperceptibly.

note 325, p. 409 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 340 :

Equilibria of types a, b, d and e may give rise to polymorphism. Type c will give a number of abnormalities, each much rarer than the normal type, but the population as a whole will be monomorphic, except for sexuality and results of equilibrium due to other causes. We shall now investigate equilibria due to this cause.

note 326, p. 410 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 340-341 :

New genes constantly arise by mutation. It is well known that most mutant types are less fit than the normal in the wild state, even if they are more so in abnormal conditions such as domestication. It is a priori obvious that it must be so. For a gene with any appreciable mutation frequency must have appeared many times in the past [(except perhaps in species such as the elephants or Sequoia gigante with very few individuals)]. Hence if it produced an increase of fitness, it would already have spread through the population.

note 327, p. 411 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 341 :

It is, however, hardly justifiable to describe such abnormal genes as pathological in all cases, [although they may be so.] In the first place, they may lead to increased fitness in a different environment. [Thus Sax (1926) found that bean plants from recessive white seeds were more fertile than their sisters from coloured seeds in good years, less so in bad years when the environment was presumably more like that of wild plants.] Secondly, several abnormal genes together may increase fitness, as Haldane (1931) and Wright (1931) have pointed out. If so the standard or normal type is not the fittest type in the population. Nevertheless, the fittest type will not spread, since the abnormal genes generally occur one at a time, thus lowering fitness, and only rarely all together.

note 328, p. 411 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 341 :

It is at once clear that in equilibrium such abnormal genes are wiped out by natural selection at exactly the same rate as they are produced by mutation. It does not matter whether the gene is lethal or almost harmless. In the first case, every individual carrying it, or if it is recessive, every individual homozygous for it, is wiped out. In the second the viability or fertility of such individuals may only be reduced by one-thousandth. In either case, however, the loss of fitness to the species depends entirely on the mutation rate and not at all on the effect of the gene upon the fitness of the individual carrying it, provided this is large enough to keep the gene rare. This conclusion will be proved in detail [for the four individual cases].

note 343, p. 420 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 348 :

This may be taken as a rough estimate of the price which the species pays for the variability which is probably a prerequisite for evolution.

note 344, p. 420 : JBS Haldane, « The effect of variation on fitness », *loc. cit.*, p. 348 :

[In other words,] if we could achieve the aim of negative eugenics and abolish all genes (including autosomal recessives, most of which can not even be detected at present) which seriously lower fitness in our present environment, we might expect a gain in fitness of the order of 10 per cent, though this might lower our capacity for evolution in a changed environment.

note 346, p. 424 : JBS Haldane, « A Dialectical Account of Evolution », *loc. cit.*, p. 477 :

Naturally enough, biologists to whom dialectical materialism means nothing, or means a weapon of the abominable Marx, cannot understand how harmful mutations can be a condition of evolutionary progress. They therefore deny them any importance.

note 354, p. 428 : JBS Haldane, « The spread of harmful autosomal recessive genes in human populations », *loc. cit.*, p. 235 : cf. note 306 du chapitre 5.

Chapitre 6 :

note 388, p. 446 : Karl Pearson, 1930, *The Life, Letters and Labours of Francis Galton (Volume Three)*, p. 441 :

Francis Galton to his scientific colleagues was courteous, generous and marvellously humble. To his relatives and close friends he was sympathetic, helpful and always full of fun. His wonderful patience with an invalid wife, and after her death his splendid loyalty to her memory, can only be lightly touched on here.

note 392, p. 447 : Michael Bulmer, « The development of Francis Galton's Ideas on the Mechanism of Heredity », *loc. cit.*, p. 264 :

*Galton's ideas about heredity fell into three phases: (1) his attempt to demonstrate the inheritance of human mental abilities, in particular in *Hereditary Genius* (1869), and to distinguish between the effects of nature and nurture in the history of twins, (2) his experiments on pangenesis and his physiological theory of heredity in the 1870s, and (3) his subsequent construction of a purely statistical theory of heredity, leading to the techniques of regression and correlation and to the law of ancestral heredity.*

note 396, p. 447 : Daniel J. Kevles, *In the Name of Eugenics*, p. 4 :

Galton's hereditary analysis proceeded from the premise that reputation – especially the kind that earned a place in a dictionary of eminence – truly indicated ability, that the lack of it just as reliably bespoke the absence of ability, that neither outcome depended upon social circumstance.

note 398, p. 448 : Francis Galton, *Hereditary Genius*, p. 37 :

Is reputation a fair test of natural ability? It is the only one I can employ—am I justified in using it? How much of a man's success is due to his opportunities, how much to his natural power of intellect?

note 399, p. 448 : Francis Galton, *Hereditary Genius*, p. 42-43 :

To recapitulate: I have endeavoured to show in respect to literary and artistic eminence:

- 1. That men who are gifted with high abilities — even men of class E— easily rise through all the obstacles caused by inferiority of social rank.*
- 2. Countries where there are fewer hindrances than in England, to a poor man rising in life, produce a much larger proportion of persons of culture, but not of what I call eminent men.*
- 3. Men who are largely aided by social advantages, are unable to achieve eminence, unless they are endowed with high natural gifts.*

note 405, p. 450 : Francis Galton, *Inquiries into human faculty and its Development*, p. 1 :

Since the publication of my work on Hereditary Genius in 1869, I have written numerous memoirs, [of which a list is given in an earlier page, and which are scattered in various publications.] They may have appeared desultory when read in the order in which they appeared, but as they had an underlying connection it seems worth while to bring their substance together in logical sequence into a single volume. [I have revised, condensed, largely re-written, transposed old matter, and interpolated much that is new; but traces of the fragmentary origin of the work still remain, and I do not regret them. They serve to show that the book is intended to be suggestive, and renounces all claim to be encyclopedic. I have indeed, with that object, avoided going into details in not a few cases where I should otherwise have written with fulness, especially in the Anthropometric part.] My general object has been to take note of the varied hereditary faculties of different men, and of the great differences in different families and races, to learn how far history may have shown the practicability of supplanting inefficient human stock by better strains, and to consider whether it might not be our duty to do so by such efforts as may be reasonable, thus exerting ourselves to further the ends of evolution more rapidly and with less distress than if events were left to their own course.

note 406, p. 451 : Francis Galton, *Inquiries into human faculty and its Development*, p. 17 :

The science of improving stock, which is by no means confined to questions of judicious mating, but which, especially in the case of man, takes cognisance of all influences that tend in however remote a degree to give to the more suitable races or strains of blood a better chance of prevailing speedily over the less suitable than they otherwise would have had.

note 407, p. 451 : Francis Galton, *Inquiries into human faculty and its Development*, p. 220 :

To sum up in a few words. The chief result of these Inquiries has been to elicit the religious significance of the doctrine of evolution. It suggests an alteration in our mental attitude, and imposes a new moral duty. The new mental attitude is one of a greater sense of moral freedom, responsibility, and opportunity; the new duty which is supposed to be exercised concurrently with, and not in opposition to the old ones upon which the social fabric depends, is an endeavour to further evolution, especially that of the human race.

note 408, p. 452 : William R. Greg, 1868, « On the failure of 'Natural Selection' in the case of Man », *Fraser's Magazine*, Vol. 68, p. 362 :

Legislation and philanthropy are improving the condition of the masses, but they are more and more losing the guidance and governance of the masses. Wealth accumulates above, and wages rise below; but the cost of living augments with both operations, till those classes — the stamina of the nation — which are neither too rich nor too poor to fear a fall, find marriage a hazardous adventure, and dread the burden of large families. Medical science is mitigating suffering, and achieving some success in its warfare against disease; but at the same time it enables the diseased to live. It controls and sometimes half cures the maladies that spring from profligacy and excess, but in so doing it encourages both, by stepping in between the cause and its consequence, and saving them from their natural and deterring penalties. It reduces the aggregate mortality by sanitary improvements and precautions; but those whom it saves from dying prematurely it preserves to propagate dismal and imperfect lives. In our complicated modern communities a race is being run between moral and mental enlightenment and the deterioration of the physical constitution through the defeasance of the law of natural selection;— and on the issues of that race the destinies of humanity depend.

note 409, p. 453 : Francis Galton, *Inquiries into human faculty and its Development*, p. 219 :

When we begin to inquire, with some misgiving perhaps, as to the evidence that man has present power to influence the quality of future humanity, we soon discover that his past influence in that direction has been very large indeed. It has been exerted hitherto for other ends than that which is now contemplated, such as for conquest or emigration, also through social conditions whose effects upon race were imperfectly foreseen. There can be no doubt that the hitherto unused means of his influence are also numerous and great.

note 412, p. 454 : Francis Galton, *Inquiries into human faculty and its Development*, p. 219 :

I also showed that a powerful influence might flow from a public recognition in early life of the true value of the probability of future performance, as based on the past performance of the ancestors of the child. It is an element of forecast, in addition to that of present personal merit, which has yet to be appraised and recognised. Its recognition would attract assistance in various ways, impossible now to specify, [to the young families of those who were most likely to stock the world with healthy, moral, intelligent, and fair-natured citizens.] The stream of charity is not unlimited, and it is requisite for the speedier evolution of a more perfect humanity that it should be so distributed as to favour the best-adapted races. I have not spoken of the repression of the rest, believing that it would ensue indirectly as a matter of course; but I may add that few would deserve better of their country than those who determine to live celibate lives, through a reasonable conviction that their issue would probably be less fitted than the generality to play their part as citizens.

note 418, p. 456 : Francis Glaton, 1909, « Forwards », *Eugenics Review*, Vol. 1, p. 1-2 :

The Eugenics Review emphatically disclaims rivalry of any form with the more technical publications issued from time to time from the Eugenics Laboratory of the University of London now located at University College. There are two sorts of workers in every department of knowledge – those who establish a firm foundation, and those who build upon the foundation so established. The foundation of Eugenics is, in some measure, laid by applying a mathematico-statistical treatment to large collections of facts, and this, like engineering deep down in boggy soil, affords little outward evidence of its bulk and importance. The superstructure requires for its success the co-operation of many minds of a somewhat different order, filled with imagination and enthusiasm; it does not require technical knowledge as to the nature of the foundation work.

note 430, p. 461 : Hermann J. Muller, 1935, *Out of the Night*, Vanguard Press, New York, p. ix-x :

In fact, it may be admitted that “Eugenics”, in the sense in which most of us are now accustomed of thinking of it, has become a hopelessly perverted movement. Beyond imposing some slight limitation on the numbers of most grossly defective, it would be, with its present methods and outlook, powerless to work any positive change for the good. On the other hand, it does incalculable harm by lending a false appearance of scientific basis to advocates of race and class prejudice, defenders of vested interests of church and state, Fascists, Hitlerites and reactionaries generally. Even the least unreasonable of the professional spokesmen of this modern “Eugenics” have taken no clear stand against the atrocities recently proposed and carried out in its name.

Thus it is high time for those who seek the real biological upbuilding of humanity to repudiate this perverted kind of “Eugenics”, and to devote themselves to furthering the economic, social, and intellectual changes which alone will afford the means of eventually undertaking a real biological upbuilding. At the same time, Those already engaged in the social struggle may gain some additional stimulus in noting the dependence of even the biological battles upon their efforts.

note 432, p. 461 : Diane B. Paul, « Eugenics and the Left », *loc. cit.*, p. 578 :

*Muller’s twin enthusiasms for socialism and eugenics prompted his emigration to the Soviet Union in 1934. There he worked with N.I. Vavilov at the Institute of Genetics in Moscow and completed *Out of the Night* which he presented, along with an effusive letter of personal appeal, to Stalin. Not only his choice of recipients but his timing could not have been worse since genetics had already come under severe attack as inextricably linked to eugenics, and eugenics to the old social order.*

note 436, p. 462 : Julian Huxley, « Eugenics and Society », *loc. cit.*, p. 31 :

We eugenicists must no longer think of the social environment only in its possible dysgenic or non-eugenic effects, but must study it as an indispensable ally. Changes in social environments are needed both for the adequate expression of eugenic progress, and as a mean for its realization.

note 438, p. 463 : Hermann J. Muller, *Out of the Night*, p. 90 :

[But] despite the present-day confusion of the environmental, and even of the social, with the genetic, and the attempt to set up false hereditary categories, there is certainly a genetic side also to the problem of human behaviour. That is, there can be no doubt that mankind must be highly variable in regard to genes which determine the original physical basis of emotional and temperamental as well as more purely intellectual traits.

note 443, p. 465 : « Social Biology and Population Improvement », *loc. cit.*, p. 521 :

The question "How could the world's population be improved most effectively genetically?" raises far broader problems than the purely biological ones, problems which the biologist unavoidably encounters as soon as he tries to get the principles of his own special field put into practice. For the effective genetic improvement of mankind is dependent upon major changes in social conditions, and correlative changes in human attitudes. In the first place, there can be no valid basis for estimating and comparing the intrinsic worth of different individuals, without economic and social conditions which provide approximately equal opportunities for all members of society instead of stratifying them from birth into classes with widely different privileges.

note 444, p. 466 : « Social Biology and Population Improvement », *loc. cit.*, p. 521 :

The second major hindrance to genetic improvement lies in the economic and political conditions which foster antagonism between different peoples, nations and 'races'. The removal of race prejudices and of the unscientific doctrine that Appendix 1 113 good or bad genes are the monopoly of particular peoples or of persons with features of a given kind will not be possible, however, before the conditions which make for war and economic exploitation have been eliminated. This requires some effective sort of federation of the whole world, based on the common interests of all its peoples.

note 445, p. 466 : « Social Biology and Population Improvement », *loc. cit.*, p. 521 :

Thirdly, it cannot be expected that the raising of children will be influenced actively by considerations of the worth of future generations unless parents in general have a very considerable economic security and unless they are extended such adequate economic, medical, education and other aids in the bearing and rearing of each additional child that the having of more children does not overburden either of them. As the woman is more especially affected by childbearing and rearing, she must be given special protection to ensure that her reproductive duties do not interfere too greatly with her opportunities to participate in the life and work of the community at large. These objects cannot be achieved unless there is an organization of production primarily for the benefit of consumer and worker, unless the conditions of employment are adapted to the needs of parents and especially of mothers, and unless dwellings, towns and community services generally are reshaped with the good of children as one of their main objectives.

note 446, p. 467 : « Social Biology and Population Improvement », *loc. cit.*, p. 521 :

A fourth prerequisite for effective genetic improvement is the legalization, the universal dissemination, and the further development through scientific investigation, of ever more efficacious means of birth control, both negative and positive, that can be put into effect at all states of the reproductive process –as by voluntary temporary or permanent sterilization, contraception, abortion (as a third line of defence), control of fertility and of the sexual cycle, artificial insemination, etc. Along with all this the development of social consciousness and responsibility in regard to the production of children is required, and this cannot be expected to be operative unless the above-mentioned economic and social conditions for its fulfillment are present, and unless the superstitious attitude towards sex and reproduction now prevalent has been replaced by a scientific and social attitude. This will result in its being regarded as an honour and a privilege, if not a duty, for a mother, married or unmarried, for a couple, to have the best children possible, both in respect of their upbringing and of their genetic endowment, even where the latter would mean an artificial –though always voluntary –control over the process of parenthood.

note 448, p. 468 : « Social Biology and Population Improvement », *loc. cit.*, p. 521 :

Before people in general, or the State which is supposed to represent them, can be relied upon to adopt rational policies for the guidance of their reproduction, there will have to be, fifthly, a far wider spread of knowledge of biological principles and of recognition of the truth that both environment and heredity constitute dominating and inescapable complementary factors in human wellbeing, but factors both of which are under the potential control of man and admit of unlimited but interdependent progress. Betterment of environmental conditions enhances the opportunities for genetic betterment in the ways above indicated. But it must be also understood that the effect of the bettered environment is not a direct one on the germ cells and that the Lamarckian doctrine is fallacious, according to which the children of parents who have had better opportunities for physical and mental development inherit these improvements biologically, and according to which, in consequence, the dominant classes and people would have become genetically superior to the underprivileged ones.

note 449, p. 469 : « Social Biology and Population Improvement », *loc. cit.*, p. 521 :

The intrinsic (genetic) characteristics of any generation can be better than those of the preceding generation only as a result of some kind of selection, that is, by those persons of the preceding generation who had a better genetic equipment have produced more offspring, on the whole, than the rest, either through conscious choice, or as an automatic result of the way in which they lived. Under modern civilized conditions such selection is far less likely to be automatic than under primitive conditions, hence some kind of conscious guidance of selection is called for to make this possible, however, the population must first appreciate the force of the above principles, and the social value which a wisely guided selection would have.

note 450, p. 470 : « Social Biology and Population Improvement », *loc. cit.*, p. 521-522 :

Sixthly, conscious selection requires, in addition, an agreed direction or directions for selection to take, and these directions cannot be social ones, that is, for the good of mankind at large, unless social motives predominate in society. This in turn implies its socialized organization. The most important genetic objectives, from a social point of view, are the improvement of those genetic characteristics which make (a) for health, (b) for the complex called intelligence, and (c) for those temperamental qualities which favour fellow-feeling and social behaviour rather than those (to-day most esteemed by many) which make for personal 'success', as success is usually understood at present.

note 451, p. 470 : « Social Biology and Population Improvement », *loc. cit.*, p. 522 :

A more widespread understanding of biological principles will bring with it the realization that much more than the prevention of genetic deterioration is to be sought for, and that the raising of the level of the average of the population nearly to that of the highest now existing in isolated individuals, in regard to physical wellbeing, intelligence and temperamental qualities, is an achievement that would –so far as purely genetic considerations are concerned –be physically possible with a comparatively small number of generations. Thus everyone might look upon 'genius,' combined of course with stability, as his birthright. As the course of evolution shows, this would represent no final stage at all, but only an earnest of still further progress in the future. The effectiveness of such progress, however, would demand increasingly extensive and intensive research in human genetics and in the numerous fields of investigation correlated therewith.

note 452, p. 471 : « Social Biology and Population Improvement », *loc. cit.*, p. 522 :

This would involve the co-operation of specialists in various branches of medicine, psychology, chemistry and, not least, the social sciences, with the improvement of the inner constitution of man himself as their central theme. The organization of the human body is marvelously intricate, and the study of its genetics is beset with special difficulties which require the prosecution of research in this field to be on a much vaster scale, as well as more exact and analytical, than hitherto contemplated. This can, however, come about when men's minds are turned from war and hate and the struggle for the elementary means of subsistence to larger aims, pursued in common.

note 456, p. 472 : Diane B. Paul, « Eugenics and the Left », *loc. cit.*, p. 589 :

Indeed, what is most striking about the left geneticists general - including those, like Dobzhansky and Dunn whose views were considerably more moderate - is how little they changed over the years. Circumstances changed, shifting the ground from under their position, but their own views were little affected by them.

note 486, p. 480 : Pauline Mazumdar, *Eugenics, human genetics, and human failings: the Eugenics Society, its sources and its critics in Britain*, p. 194 :

During the period of the thirties, [when he and Hogben were reforming the methods of human genetics.] Haldane was not an opponent of eugenics per se, but only of the more clearly class-biased manifestations, [such as the teachings of the Dean of St Paul's.]

note 489, p. 482 : JBS Haldane, *Daedalus or Science and the Future*, p. 41 :

To this prophecy I should reply that it proceeds from a type of mind as lacking in originality as in knowledge of human nature.

note 493, p. 482 : JBS Haldane, *Daedalus or Science and the Future*, p. 63 :

It was in 1951 that Dupont and Schwarz produced the first ectogenetic child. As early as 1901 Heape had transferred embryo rabbits from one female to another, in 1925 Haldane had grown embryonic rats in serum for ten days, but had failed to carry the process to its conclusion, and it was not till 1946 that Clark succeeded with the pig.

note 494, p. 482 : JBS Haldane, *Daedalus or Science and the Future*, p. 64-65 :

Now that the technique is fully developed, we can take an ovary from a woman, and keep it growing in a suitable fluid for as long as twenty years, producing a fresh ovum each month, of which 90 per cent can be fertilized, and the embryos grown successfully for nine months, and then brought out into the air. Schwarz never got such good results, but the news of his first success caused an unprecedented sensation throughout the entire world, for the birthrate was already less than the death rate in most civilised countries. France was the first country to adopt ectogenesis officially, and by 1968 was producing 60,000 children annually by this method.

note 495, p. 483 : JBS Haldane, *Daedalus or Science and the Future*, p. 65-67 :

As we know ectogenesis is now universal, and in this country less than 30 per cent of children are now born of woman. The effect on human psychology and social life of the separation of sexual love and reproduction which was begun in the 19th century and completed in the 20th is by no means wholly satisfactory. The old family life had certainly a good deal to commend it, and although nowadays we bring on lactation in women by injection of placentin as a routine, and thus conserve much of what was best in the former instinctive cycle, we must admit that in certain respects our great grandparents had the advantage of us. On the other hand it is generally admitted that the effects of selection have more than counterbalanced these evils. The small proportion of men and women who are selected as ancestors for the next generation are so undoubtedly superior to the average that the advance in each generation in any single respect, from the increased output of first-class music to the decreased convictions for theft, is very startling. Had it not been for ectogenesis there can be little doubt that civilisation would have collapsed within a measurable time owing to the greater fertility of the less desirable members of the population in almost all countries.

note 497, p. 483 : JBS Haldane, *Daedalus or Science and the Future*, p. 69 :

We can already alter animal species to an enormous extent, and it seems only a question of time before we shall be able to apply the same principles to our own.

note 500, p. 484 : JBS Haldane, « Eugenics and Social Reforms », *loc. cit.*, p. 190 :

[But] the growing science of heredity is being used in this country to support the political opinions of the extreme right, and in America by some of the most ferocious enemies of human liberty. And yet it seems likely that the facts, in so far as they are applicable to politics at all, would warrant conclusions of an entirely different nature from those which have so far been drawn, and which have made eugenics abhorrent to many democrats.

note 502, p. 484 : JBS Haldane, « Eugenics and Social Reforms », *loc. cit.*, p. 191 :

It is on the whole undesirable that they should beget their like; but before we begin curtailing the liberties of people already sufficiently unfortunate, we should first try to impress on them their duty to restrict their families, and to see that they have the means to do so.

Note 503, p. 485 : JBS Haldane, « Eugenics and Social Reforms », *loc. cit.*, p. 192-193 :

All investigators are agreed that mental capacity is strongly hereditary, though, as with stature, environment plays a part in its determination. Of course, two fools may produce a genius, or two dwarfs a giant, but such cases are the exception.

note 504, p. 485 : JBS Haldane, « Eugenics and Social Reforms », *loc. cit.*, p. 193 :

The Eugenics Education Society have doubtless done good work in persuading a certain number of intelligent people that it is their duty to have mere children. They have also rightly urged lessened taxation of parents of children. But many of their members have coupled this with a clamour against measures designed to ameliorate the lot of children of the poor at the expense of the rich. It is a curious policy to combat evils due to economic inequality by perpetuating that inequality.

note 505, p. 485 : JBS Haldane, « Eugenics and Social Reforms », *loc. cit.*, p. 195 :

It was only the emancipation of the negroes which saved the United States from twice its present black population. This event gave them access to alcohol, venereal disease, [and consumption].

note 506, p. 486 : JBS Haldane, « Eugenics and Social Reforms », *loc. cit.*, p. 196 :

To sum up, the rational program for a eugenicist is as follows: Teach voluntary eugenics by all means; but if you desire to check the increase of any population or section of a population, either massacre it or force it upon the greatest practicable amount of liberty, education and wealth. Civilization stands in real danger from over-production of 'undermen'. But if it perishes from this cause it will be because its governing class cared more for wealth than for justice.

note 507, p. 487 : JBS Haldane, *Heredity and Politics*, p. 7-8 :

It may well be that an increase in our knowledge will fully justify the application to man of certain measures which have led to improvements in the quality of our domestic animals. As one who is endeavouring to increase this knowledge, I can even say that I hope that it will do so.

note 508, p. 487 : JBS Haldane, *Heredity and Politics*, p. 8 :

But I believe that the facts concerning human heredity are far less simple than many people think them to be. And I hold that a premature application of our rather scanty knowledge will yield little result, and will merely serve to discredit the branch of science in which I am working.

note 509, p. 487 : JBS Haldane, *New Paths in Genetics*, p. 37 :

I cannot here discuss the many measures which have been proposed to combat this tendency. [Some of them are a naked expression of class hatred. Others, such as my colleague Fisher's support of family allowances, are not.] But none seem to me to have a very solid scientific foundation. Before this can be given I think that we shall need a very careful study of the interaction of nature and nurture in determining both the physique and the psychology of individuals.

note 510, p. 488 : JBS Haldane, « Eugenics », *loc. cit.*, p. 59 :

I am constantly being attacked from two sides for my statements on the question of eugenics, [and still more for statements which I am alleged to have made. So I think it is worth while stating my own views, if only as a basis for discussion.]

Extreme "eugenicists" say that since it is known that some people start life with a hereditary handicap, every possible step should be taken to prevent more such people being

born, and any opposition to such steps is either mere sentimentalism, or perhaps the result of orders from Moscow. Others say that any recognition of inherited differences between human beings labels me as a fascist. Once you admit that there are such differences, I am told, you justify Hitler's policy against the Jews, Poles, and Ukrainians, not to mention the numerous Germans who were murdered in the name of racial hygiene.

note 511, p. 489 : JBS Haldane, *Heredity and Politics*, p. 25-27 :

If in any branch of science we find that one quantity or quality varies as a function of several others we shall design our experiment so as to keep all but one of the independent variables approximately constant. [If, for example, we wish to ascertain the laws governing the volume of a gas we shall first keep the temperature constant while varying the pressure and so discover Boyle's law. If we keep the pressure constant, while varying the temperature, we shall discover Charles's law. If we begin by measuring the volume of gas at an arbitrary series of temperatures and pressures we shall find our work very much more difficult.]

Now we do in practice try to eliminate our variables – our differences of nature and of nurture. [I have not defined them because we shall be able to understand their essence very much more clearly when we deal with the practical methods that render them uniform.] The most obvious thing to do is to make the nurture of our various organisms as like as possible. [If we are growing a number of plants we shall see that they all have the same soil, the same amount of water and light, and that the density of plants in one part of our field is the same as in the other. With animals we shall take similar precautions. For example, we shall be particularly careful that if there is any infection all members of the population shall be equally exposed, and if we were dealing with man in an ideal experiment we should have to try to render the education and social environment of our different individuals as uniform as possible. We should then see that any difference that remained in that uniform environment were probably due to nature and not to nurture.]

I am perfectly aware that a uniform environment is an impossible ideal, nevertheless it is easy to think of characters which are very slightly affected by the environment, for instance, eye-colour in man. It is easy to think of other characters, which, although they vary considerably with the environment, may quite readily be stabilized by making the environment similar – for example, the skin color which varies a good deal according to the amount of sunlight to which a man is exposed. We may take it that during a winter in England there will not be very much sun-burn.

We see that it is possible to a large extent to eliminate one of our variables, nurture, at least when doing experimental work with plants and animals. How shall we perform a converse operation? How shall we get a population of animals or plants uniform as regards their nature, their innate qualities?

note 512, p. 489 : JBS Haldane, *Heredity and Politics*, p. 30 :

A study of pure lines teaches us that there is a certain residual variation which we cannot eliminate, even if we eliminate all differences of heredity.

note 514, p. 490 : JBS Haldane, *Heredity and Politics*, p. 32 :

The differences between these four lines are, of course, hereditary. The differences between the different rows in the diagram are environmental. If one is a rabid environmentalist one will read the table from top to bottom, a rabid eugenicist, from side to side. If one is a biologist one will read it both ways.

note 515, p. 490 : JBS Haldane, *Heredity and Politics*, p. 33 :

It is frequently asked, "What is the relative importance of nature and nurture?" That is a question to which no general answer can be given. It is obvious that if in the population of guinea-pigs no female were allowed to breed until she was six months old the differences due to nurture would be considerably reduced. If the population had contained only three lines instead of four the differences due to nature would have been diminished. It is possible, by suitable choosing of your character, your population, and your environment, to produce a population in which a given character is determined entirely by differences of nature or entirely by differences of nurture, and therefore the question has to be answered separately for any given population and any given character.

note 520, p. 494 : JBS Haldane, *New Paths in Genetics*, p. 35-36 :

The geneticist as such can only answer the question, "What will be the genetical consequences if a given eugenic law is enforced? If for example, a certain group of person is sterilized, what effect will it have on the number of persons affected with a particular abnormality in later generations?" Even this question can only be answered in a few cases yet. He cannot, as a geneticist, say what abnormalities are so undesirable as to warrant interference with parenthood. Nor can he say what measures of interference are best, whether a given group should be sterilized or segregated, whether persuasion or compulsion is to be preferred, and so on. These are ethical and political questions, and if he answers them he does so as a citizen, not a geneticist.

note 521, p. 494 : JBS Haldane, *Heredity and Politics*, p. 126-127 :

In my opinion it is impossible to arrive at any views on the problem which can at all reasonably be called unbiassed. On is inevitably biassed by political and economical opinions which are determined by facts other than one's biological knowledge. Five or six hundred years hence people may be able to judge what would have been the correct policy for their forefathers from the eugenic point of view, just as we can speak wisely on the weaknesses of feudalism. [I do not think that we are able ourselves to make such a judgment because, taking a part in the economic struggles of our own time, we cannot be as impartial as if we were considering the eugenics of domestic animals. We are part of history ourselves and we cannot avoid the consequence of being unable to think impartially. I hope, however, that I have shown that this whole problem links up with a great number of wider political questions. Ever since the time of Plato the different innate endowments of different classes have been a matter of political speculation. I do not believe that any of these eugenical schemes are likely to be of much importance because I take the view that the economic changes which we may expect in the near future will be determined by causes much more powerful than the arguments that any biologist may bring forward; and] it may be desirable that biologists should confine themselves to questions such as the inheritance of well-marked characteristics concerning which it is possible to arrive at some measure of agreement. If they do not they may prejudice large sections of society against whole fields of biological research. Just because my own views differ from those of many of my colleagues, I feel myself fully justified in giving them publicity, if only to make it clear that a consideration of human biology does not, in my opinion, justify the perpetuation of class distinctions. If this view were shared by all, or almost all, human biologists, I should be much more inclined to confine myself to the academic aspects of science, and to leave to others the discussion of its political implications.

note 522, p. 495 : JBS Haldane, *New Paths in Genetics*, p. 37 :

[Secondly,] it is far from clear what qualities are desirable. So far eugenical propaganda has been written almost entirely from the point of view of the well-to-do class. It is assumed that the innate qualities which are believed to be more frequent among them are preferable to those of the poor. It is perhaps fortunate that Communists do not hold that the children of the bourgeoisie suffer from hereditary defects, even though they think that they are brought up with undesirable ideas and prejudices.

note 523, p. 496 : JBS Haldane, *Heredity and Politics*, p. 78-79 :

Where, [as in the case of Figs 1 and 2,] the abnormal condition is due to a dominant gene that manifests itself in 100 per cent of cases and early in life, it is clear that sterilization would abolish all hereditary cases of the abnormality, leaving only those cases that are due to mutation, which in these instances would be a very small fraction of the total. Where, however, the disease is dangerous to life or alternatively lowers fertility, the proportion of all cases which is due to mutation is much larger. We see, therefore, that sterilization in the case of dominants would always be fairly effective, but that it would be least effective under those conditions where the disease is most serious.

note 524, p. 497 : JBS Haldane, *Heredity and Politics*, p. 79 :

Indeed, if we considered it important to eliminate the jaundice, it might be desirable to sterilize a certain number of people who from the point of view of health were perfectly fit.

note 525, p. 497 : JBS Haldane, *Heredity and Politics*, p. 79-80 :

But the question arises whether even in the case of dominant disease this sterilization is the most desirable course. We have six possible alternatives if we consider it desirable to eliminate such a dominant gene; (1) we might discourage the marriage of affected people and perhaps also of apparently normal carriers; (2) we might forbid it; (3) we might encourage continence either within marriage or outside it; (4) we might encourage birth-control; (5) we could try persuasion in the hope that these people would undergo voluntary sterilization; (6) we might have compulsory sterilization. Which of these alternatives is to be adopted is not, I think, a question for the biologist. It is a question of the relative value which is attached to various different goods, for example, to health on the one hand and liberty on the other.

note 526, p. 497 : JBS Haldane, *Heredity and Politics*, p. 80-81 :

The first of them is this, that whereas in the case of men it is a trivial operation, [I will not say completely safe, but no more dangerous than the extraction of a tooth, which has been known to lead to death;] in women it is a serious operation, [perhaps as dangerous as an operation for appendicitis in favourable circumstances.] It is inevitable that if a large number of women are sterilized, a certain proportion, [I do not know how large – probably less than 1 per cent –] will die as a result of the operation. [Now it is a fundamental principle of English law that a person's life must not be endangered except in order to save him from some greater danger. That is one reason why (in my opinion rightly) we forbid abortion at the mother's own request, and why we forbid a number of other procedures that endanger life and would inevitably lead to a certain loss of life.] I am not at all convinced that this principle of the sanctity of human life may not be of somewhat more importance for the State in the long run than a reduction in the number of defectives of certain kinds.

note 527, p. 498 : JBS Haldane, *Heredity and Politics*, p. 81 :

The second objection is that the demand for sterilization is a symptom of a certain state of mind which we shall have to examine later and which we may not find entirely admirable.

note 529, p. 498 : JBS Haldane, *Heredity and Politics*, p. 102-103 :

We are constantly asked why sound people should be taxed to support the unsound. The answer to this is not a matter of biology. In most human societies it is regarded as a duty to help our weak or unfortunate fellows. This may be a fallacy. I do not think that it is, but I clearly cannot argue that matter here. It is of course a much harder question just how much effort should be devoted to this end. But it is at least arguable that the proposal to turn out a number of mental defectives into the bitter economic struggles of modern life, provided only that they cannot reproduce, is a step morally backwards, and an abandonment of one of the forms of behaviour which distinguish man from most other animals.

note 532, p. 501 : JBS Haldane, *Heredity and Politics*, p. 82 :

In the quite unusual pedigree of Fig. 7 several of the males had children. In the average pedigree of hæmophilia we should have to sterilize the females who are thought likely to transmit it. We could not sterilize the males because the operation would probably kill them, and nature sterilizes them already to a considerable extent by killing them off as children. We should have had, for example, to sterilize A in Fig. 10 as soon as she produced her first hæmophilic son. By doing so we should have prevented the birth of three hæmophilics and also of six normal children.

note 533, p. 501 : JBS Haldane, *Heredity and Politics*, p. 83 :

When we come to ordinary recessives we can say at once what the effects of sterilization would be. Except in cases where, as with deaf mutism, there is a tendency for recessives to inter-bred, there would be no noticeable effect in less than thirty or forty generations.

note 534, p. 501 : JBS Haldane, *Heredity and Politics*, p. 83 :

It is interesting that the only body in this country which advocates that particular form of eugenics is the Roman Catholic Church, which is opposed to other eugenic activities. It is unfortunate that it is possible on payment of a suitable sum for Catholics to obtain a dispensation to marry their first cousins.

note 535, p. 502 : JBS Haldane, *Heredity and Politics*, p. 86-87 :

I think the following proposition would be accepted by most biologists; "It is never possible, from a knowledge of a person's parents, to predict with certainty that he or she will be either a more adequate or a less adequate member of society than the majority." In a very few cases, it is true, we can predict with certainty that a given unborn child, if legitimate, will have a certain physical defect. Thus two albinos probably always produce albino children. But our knowledge of the heredity of psychological characters, desirable or otherwise, is insufficient to make predictions of this kind. We can, of course, make statistical predictions. But we do not, in my opinion, know enough to accord rights to any individual, or to deprive him or her of any rights, on the basis of ancestry only.

note 537, p. 503 : JBS Haldane, *Heredity and Politics*, p. 97 :

We are not told whether the consent would have been obtained so readily had the suggestion been made by a man who had not the power to send Hill to prison for fifteen years. Nor is it clear what test were employed to detect the mental subnormality of the Hill family. Some quite intelligent people do not appear at their best in a criminal court. The type of evidence on which Judge Holden based his eugenical activities may be inferred from his statement concerning Chris McCauley, a burglar whom he sentenced to compulsory sterilization.

"This man, about thirty-five years of age, is subnormal mentally and has every appearance and indication of immorality. He has a strain of negro blood in his veins, and has a disgusting and lustful appearance."

It is, I think, clear that Hill would not have been sterilized had he possessed an independent income. And it is unlikely that McCauley would have been, had his complexion been lighter and his appearance more in conformity with Judge Holden's aesthetic standards.

note 539, p. 504 : JBS Haldane, *Heredity and Politics*, p. 100-101 :

Finally a further problem arises. If mental defectives are to be kept permanently in an institution, there is clearly no need to sterilize them. If they are let out after sterilization, several alternatives lie before them. They may obtain employment. An acquaintance informed me that he preferred feeble-minded men to look after his pigs. Penrose writes as follows: "A striking feature of defectives or imbecile and lower (i.e. less serious) grades is their apparent incapacity for being bored with an occupation; [and provided some simple manipulation can be taught, the defective is perfectly happy in continuing the same simple manipulation for days and years without any change. This fact makes possible methods of dealing with patients who might otherwise be difficult to employ.] In a regular, even very monotonous employment they learn to be useful and worthy people."

If this statement is true, it suggests that mental defect is to a large extent a social rather than a biological problem. In a society where there was work for all, and vocational selection, places would be found for many, perhaps the majority, of people who are now regarded as feeble-minded. The large increase in recent years of the number of people certified as feeble-minded may turn out to be a result as increasingly difficulty in finding regular employment [rather than any rise in the number of people falling below a certain grade of intelligence.] In fact it may be a social and economic rather than a biological phenomena.

I am of the opinion that a man who can look after pigs or do any other steady work has a value to society, and that we have no right whatever to prevent him from reproducing his like.

note 543, p. 507 : JBS Haldane, *Heredity and Politics*, p. 116 :

Given that the environment has a certain effect we can ask ourselves whether all the differences between social classes which are measured by intelligence quotient of the children are due to environment. The answer is that they are not.

note 544, p. 507 : JBS Haldane, *Heredity and Politics*, p. 148-149 :

What I want to point out is the impossibility of getting a fair comparison in a society where the members of races are differently treated. If you take the population as a whole the conquered or exploited race will undoubtedly be handicapped; if you take a section of the

population where their economic condition are much the same you will get a very poor sample of the conquering race.

note 545, p. 508 : JBS Haldane, *Heredity and Politics*, p. 149 :

Therefore I can only close this question of the alleged superiority of whites over negroes on a note of agnosticism. I can state the view that not merely has nothing been proved, but that it is going to be exceedingly difficult to prove anything within the next few generations.

note 546, p. 508 : JBS Haldane, *Heredity and Politics*, p. 152-153 :

It is, however, necessary to emphasize the extreme degree of overlapping. One cannot identify an Indian or a negro by the type of performance which he gives. Still less can one recommend, on the basis of these studies, that negroes as such should be excluded from a particular group of careers. At most one can say that they are slightly less likely to succeed than whites or Indians. And there is no evidence as to whether their difference from other races is to be attributed to nature or nurture.

note 549, p. 509 : JBS Haldane, *Heredity and Politics*, p. 120-122 :

R.A. Fisher, [in The Genetical Theory of Natural Selection,] puts forward the view that in our existing economic system, apart from luck, there are two ways of rising in the economic scale; one is by ability, and the other by infertility. It is clear that of two equally able men – one with a single child, and the other with eight children – the one with a single child will be more likely to rise in the social scale. [He may, for example, be able to save money and buy a small shop, and later to become relatively rich. Fisher points out that this was by no means so in the past, when a large family might be an asset to an artisan working at his trade in his own house. There is no question that people tend to marry into their own economic class.] In the richer classes, according to Fisher, you have a concentration at the same time of genes making for high ability and genes making for infertility. [This result of our social system was first pointed out by Sir Francis Galton, who investigated the fertility of heiresses, an heiress being usually someone with no brother a few sisters. They were found to have fewer children than the average. He held that the extinction of noble families was largely due to the practice of marrying heiresses. Thus the genes which had been in part responsible for the rise of the founders of these noble stocks were eliminated. Wagner-Manslau reached similar conclusions from a very detailed study of the German nobility.]

Fisher hopes that this tendency may be combated by a scheme of family allowances. He believes that if wages or salaries were increased by 12 per cent for every child born the actual economic level of a family would not be lowered as a result of increasing the number of children in it.

note 550, p. 510 : JBS Haldane, *Heredity and Politics*, p. 122-123 :

It has been shown that within a given social group (eg the English or German nobility) fertility is inherited in the sense that children of fertile parents are themselves more fertile than the average. But such resemblance may be due to example and tradition rather than to a biological cause.

note 551, p. 510 : JBS Haldane, *Heredity and Politics*, p. 123 :

Once again I am inclined to regard such a proposal as possibly premature in view of our very slight knowledge of the genetical basis of those characters which are found in the "great men" whom we regard as admirable.

note 552, p. 510 : JBS Haldane, *Heredity and Politics*, p. 124 :

Nevertheless I do not regard it with horror or disgust. It seems to me a far more desirable proposal than the compulsory sterilization of large classes.

note 553, p. 510 : JBS Haldane, *Heredity and Politics*, p. 124-125 :

My own views on the differential birth-rate are extremely tentative, but they are somewhat as follows: If the rich are infertile because they are rich, they might become less so if they were made less rich. A uniform and free school system, although it might be bad from the educational point of view, would probably be good from a eugenic point of view, as parents would not restrict their families to give their children a good education. I am inclined to

believe inheritance of wealth eugenically undesirable, because it tends to make the well-to-do limit their families.

note 555, p. 512 : JBS Haldane, *Heredity and Politics*, p. 117-118 :

One might consider that the present state of the world was largely due to undue aggressiveness, that it was on the whole the more aggressive people who rose in the social scale; and that, in so far as aggressiveness was innate or dependent on innate factors, it might be desirable to humanity that those innate factors should be weeded out even at the cost of a certain sacrifice of innate factors making for intelligence. I do not think such a statement has ever seriously been made, or that the data in existence would warrant it being made; but I wish to point out that there is a possibility of a defence of the meek as being perhaps, in their way, not bad citizens.

note 557, p. 514 : JBS Haldane, « Selection against heterozygosis in man », *loc. cit.*, p. 339 :

*From the point of view of practical eugenics it is obviously futile to urge that all **rh rh** women, some 14% of the total, should be prevented or even dissuaded from marrying **Rh Rh** and **Rh rh** men who make up the remaining 86%. Nor can **rh rh** be regarded as a character to be eliminated by sterilization or otherwise. And yet the effects of the **Rh-rh** gene difference certainly account for more human deaths than any other gene difference so far known, and very possibly for more than all other known gene differences together. Hence eugenists cannot neglect it. Research on the etiology of high placental permeability is an urgent problem [which is doubtless already being tackled]. If it is largely due to a particular gene substitution, the gene in question must be much rarer than **rh**, and therefore a more suitable target for negative eugenics. Even if no systematic attempt were made to eradicate such a gene, there would be a strong case for dissuading **rh rh** women, known also to be so constituted as to be destined to form permeable placentae, from marrying **Rh Rh** or **Rh rh** men, [and at least an arguable case for compulsion]. Such women occur with a frequency of 0.7% or perhaps less.*

*Even the strongest opponent of negative eugenics might well approve of the testing of pregnant women for the presence or absence of **Rh** antigens, and further testing of **rh rh** women for the development of anti-**Rh** agglutinin. If this were present not only would it be necessary to avoid giving them transfusions from a donor carrying **Rh**, but their babies could be tested for erythroblastosis at birth, and treated, if possible, before the disease was fully developed.*

note 559, p. 516 : JBS Haldane, « The interaction of nature and nurture », *loc. cit.*, p. 205 :

We are not justified in condemning a genotype absolutely unless we are sure that some other genotype exists which would excel it by all possible criteria in all possible environments. We can only be reasonably sure of this in the case of the grosser type of congenital mental and physical defect. A moderate degree of mental dullness may be desirable for certain types of monotonous but at present necessary work, even if in most or all existing nations there may turn out to be far too many people so qualified.

In a society which were perfect from the eugenical point of view there would be no interactions of types 1 or 3; genotypes of consistently inferior performance would have been eliminated. Similarly, in a society which was optimal from the point of view of environment there would be no interactions of types 1 or 2. People would not be placed in environments where they could not do there best, at least in some respect. It follows that interactions of type 4 are the ideal at which we should aim. That is to say in the ideal society there would be a diversity of social functions and of human endowments, but no social function could be dispensed with without damage to the society, and no individual could exercise a different function without performing it less efficiently and happily than those who were actually doing so. This ideal is obviously remote and probably never fully attainable, but it is perhaps worth stating. Meanwhile our efforts should be mainly concentrated on the elimination of interactions of type 1, that is to say the elimination of environments which are unfavourable to all genotypes, and of genotypes which are inferior in all environments.

note 566, p. 521 : JBS Haldane, « The interaction of nature and nurture », *loc. cit.*, p. 199-200 :

*Many of the published results on photoperiodicity give excellent quantitative examples of type 4 interactions. For example, Hawked (1943) obtained the following results for mean weight of tubers from two clones of *Solanum andigenum* in long and short days respectively over three years. The short days were 8^{1/2} hr., the long varied from 13 to 16hr.*

	Short	Long
Clone 1108	134	37
Clone 1068	91	131

note 569, p. 523 : JBS Haldane, *Heredity and Politics*, p. 127 :

I do not believe that any of these eugenical schemes are likely to be of much importance because I take the view that the economic changes which we may expect in the near future will be determined by causes much more powerful than the arguments that any biologist may bring forward.

note 571, p. 524 : JBS Haldane, *Heredity and Politics*, p. 180 :

We must no more forget heredity when we are trying to improve environment than we must forget environment when trying to improve heredity. A complete concentration on one side of the problem can only lead to short-sighted action.

note 572, p. 526 : JBS Haldane, *Heredity and Politics*, p. 68-69 :

The phenomenon of the origin of a new gene is called mutation. We are still to some extent in the dark as to exactly what happens. We do not know whether to regard the gene as a n elementary organism which reproduces itself, or as part of the cell nucleus which is copied by some other part at each cell generation. What we can say is that the process by which the gene produces its like, whether we call it reproduction in the biological sense, or copying, is not an invariable process, that it breaks down with a certain small frequency, rarely more than once in a million cell divisions.

note 573, p. 526 : JBS Haldane, 1946, « Is Psychology a Science? », *A Banned Broadcast*, Chatto and Windus, p. 144 : cf. note 443 du chapitre 3.

note 575, p. 529 : JBS Haldane, *Heredity and Politics*, p. 180 :

In the long run the application of biology to social problems must depend on the ideals of the community, and the possibilities which its structure offers of realizing those ideals.

note 576, p. 530 : JBS Haldane, *Heredity and Politics*, p. 180-181 :

But that is only one side of the question. It is a fundamental fact first clearly pointed out by Engels, though adumbrated by Rousseau, that a number of people may all desire something and act on this desire, but that the resultant of their actions may be something which none of them wish. [This fact can be well illustrated in the field of human biology. In the middle ages most people admired the holy man, in the nineteenth century they admired the "self-made" wealthy man. But the net result of the economic system based on a genuine admiration fo holiness in the past and business ability in the present was that the holy men and women hardly bred at all, and "successful" men were less fertile than the economic failures in the slums. Thus so far as holiness and business success have a genetical basis they tend to be abolished in the societies which most admire them.]

It is, or should be, the main task of politics to see that the resultant of individual desires does not run counter to those desires, that for example, a sincere desire for peace should not lead to war, either by one-sided disarmament or by the piling up of huge forces which many citizens honestly believe to be needed for defence. This is a hard enough task in the economic field. I am, indeed, one of those who think it an impossible task within the framework of our present economic system.

note 580, p. 532 : JBS Haldane, « Biology and Marxism », *loc. cit.*, p. 9-10 :

Some Marxists have reacted too strongly against the application of biological notions to mankind, and assumed that all differences between human beings are due to differences of environment. In a sense they are due to differences of ancestral environment. But they cannot, as a matter of fact, be altered in many cases, nor can we undo the past. One cannot in general make a congenitally blind man see, nor a congenitally deaf-tone man into a musician. What we can do is to build a society in which every individual will have the best possible chance of finding a useful and congenial job. More than 99 per cent of people could do something worth while. This includes many of the so-called feeble-minded, who are often well fitted for tasks which most people find monotonous.

But we know in practice, and should, I think, admit more fully in theory, that different people have very different abilities, that some are capable of making greater contributions to society than others, and this would be true even had they had equal opportunities. This does not mean that society ought to be divided into classes, nor that wages should differ greatly in different professions. If our aim is a society to which each contributes according to his abilities and receives according to his needs, we are certainly not postulating that either abilities or needs are equal.

note 581, p. 532 : JBS Haldane, « The interaction of nature and nurture », *loc. cit.*, p. 205 : cf. note 559 du chapitre 5.

Troisième partie :

Chapitre 7 :

note 65, p. 581 : Léon Trotsky, 1998 [1934] « The Second Notebook », Philip Pomper (Ed. & Trad. du russe à l'anglais), *Trotsky's Notebooks, 1933-1935*, Columbia University Press, New York, p. 102 :

Since cognition is not identical with the world (in spite of Hegel's idealistic postulation), dialectical cognition is not identical with the dialectic of nature. Consciousness is a quite original part of nature, possessing peculiarities and regularities that are completely absent in the remaining part of nature. Subjective dialectics must by virtue of this be a distinctive part of the objective dialectics – with its own special forms and regularities. [(The danger lies in the transference – under the guise of “objectivism” - of the birth pangs, the spasm of consciousness, to objective nature.)]

The dialectic of cognition brings consciousness closer to the “secrets” of nature, that is, it helps it master the dialectic of nature too. But what does the dialectic of nature consist of? Where is the boundary separating it from the dialectic of cognition [a vacillating dialectical “boundary”]?

Chapitre 8 :

note 165, p. 650 : F.S. Marvin, 1931 « Soviet Science », *Nature*, Vol. 128, p. 170 :

The file of black-bearded men who marched across the room at South Kensington at the opening meeting of the recent International Congress of the History of Science was one of its most striking features. They were delegates from Russia and had arrived from Moscow by aeroplane.

note 167, p. 651 : Gary Werskey, 1979 [1978], *The Visible College*, Holt Rinehart and Winston, New York, p. 138 :

To the public at large they would appear as scientific apologists for the coming socialist transformation of Britain. To their fellow scientists, they would become spokesmen for the emergent culture of science. But they were unable to assume either of those roles until they had seen more clearly the connections between their science and their socialism. In that respect, we are in the unusual position of knowing precisely when and where their political vision dramatically improved. It was at the Science Museum, South Kensington, on Saturday morning, 4 July 1931.

note 178, p. 655 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », *loc. cit.*, p. 69 :

The question of the relationship of the physical and biological sciences, included in the programme of the present Congress, is part of the general problem of the relationship of different systems of world outlook in the solution of the present tasks of natural science. The solution of this problem has repeatedly changed its forms, according to the particular conditions of the working experience of mankind, the condition of its material forces of production, and its socio-economic productive relations, which have been constantly changing in the course of human history.

note 179, p. 656 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », *loc. cit.*, p. 70 :

[In spite of the multiformity and variety of contradictory forces and interests functioning in capitalist conditions of production,] it is [nevertheless] not difficult to establish the predominance of the views of mechanical materialism in the period when capitalism was in its prime as an economic system, and when material culture was rapidly growing as a result

of the successes of science and technique – at the end of the XVIIIth and during the XIXth century: and the rebirth of idealistic, vitalistic and even mystical moods, in the measure of the growth of economic contradictions and the sharpening of the class struggle in bourgeois society.

note 180, p. 656 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 78 :

It is quite normal that the industrial bourgeois class, progressive in its day, saw in the consciously formulated positions of materialist radicalism a theoretical support for its struggle against the influence of the Church and the religious-idealistic ideology which served as a support for the conservative forces of feudalism. [That is why the materialist nucleus of the Darwinian theory was at first received with approval by the ideologues of the bourgeoisie, as a scientific proof and justification of the principles of free capitalist competition. And] it is just as normal that, in the measure of the growth of economic contradictions, we observe in present-day scientific literature of the bourgeois West more and more frequent attempts [to revise Darwinism, and] to return to patently idealistic and mystical conceptions.

note 182, p. 657 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 71 :

It is extremely characteristic of the endless contradiction in which modern empirical natural science has become involved that none of the theories of evolution existing in bourgeois science is able to maintain itself in the positions it selects for itself, but slides into the very positions which it was called upon to refute.

note 184, p. 657 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 71 :

[Thus neo-Lamarckianism, originally basing its objections to Darwinism on the alleged "unscientific" character of the idea of chance upon which Darwin based his theory of selection, and his attempts to provide a materialist justification for the facts of variability of organisms and their adaptations (and consequently for the whole process of formation of species) in the "direct equilibration" of the organism in relation to the influences of the outside physical surroundings,] transfers the problem of adaptation, from the sphere of the rational study of the complex relationships arising between the organism and the external milieu of its existence, into the organism itself. Thus it arrives at the vitalistic and teleological conceptions of immanent vital forces which determine the course and direction of the process of evolution.

note 185, p. 658 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 71 :

Thus, again, the "mechanico-physiological" theory of Nageli, or Berg's theory of Nomogenesis, in spite of all the efforts of the authors to prove the strictly scientific and materialist content of their constructions, arrive at essentially vitalistic ideas of the "principle of perfection," or to the idea of adaptation as the "primary physico-chemical quality of the living matter"--ideas which cannot deceive anyone by their outwardly materialist phraseology.

note 186, p. 658 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 72 :

[Thus, again,] frankly vitalistic theories, which raised the banner of struggle against the vulgar materialist conceptions of mechanism, strive to find a road to the knowledge of the nature of biological phenomena through non-cognisable and non-material forces, contrasted to the physical world. On the other hand, they are obliged to advocate "practical vitalism"--i.e., the advantage of those same mechanistic methods of research in the practical activity of the research worker. Thereby they pass to the positions of vulgar mechanism in all spheres of direct cognitive action, condemning thereby their vital forces and entelechies to the barren role of a bashful screen for our ignorance.

note 187, p. 659 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 72 :

And thus the geneticist, uncritically developing neo-Darwinist ideas of the independence of the germ-plasm of all the "physical" influences of the external surroundings, objectively arrives at the position of the autonomy of the "biological" from the "physical." Thus he descends to those very ideas of autogenesis maintained by his Lamarckian opponents, or to the conception of evolution as the result of the combinations of eternally existing genes--i.e., in fact to the negation of the very idea of evolution, as a process of the continuous unfolding of new formations in nature.

note 188, p. 659 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 73 :

From the socio-historical standpoint, these schools of thought are the result and reflection in the consciousness of the bourgeois scientist of the internal social-economic contradictions which have gripped the countries of capitalism, and express the impossibility of the further normal development of natural science, as of all sciences, in the framework of the capitalist system.

note 194, p. 662 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 80 :

The numerous attempts to revise the conceptions of mechanical materialism--unsatisfactory to the modern naturalist, but the sole conceptions with which he was familiar--without falling into the embraces of vitalism, are condemned beforehand to failure so long as the naturalist remains within the bounds of a methodology based on formal logic and of metaphysical searches for the essence of things, as isolated absolutes, irrespective of their connection and interaction with surrounding phenomena, and without taking into account those variations, that motion, which characterises the dialectical development of the whole world.

note 195, p. 662 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 73 :

To the extent that individual scientists make attempts at such philosophical generalisations, the positions set forth above reflect their inability, in virtue of the class limitations upon their general train of thought, to adopt the only correct philosophic positions of dialectical materialism.

note 196, p. 663 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 78 :

All these facts prove the socio-historical and class determinateness of scientific theories. Reflecting the state of the material forces of production and the socio-economic relations of the particular historical epoch, scientific theories express not only the actual state and level of knowledge attained by science, but also the ideological justification of the economic interests of warring groups and classes.

note 198, p. 663 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 80 :

At the same time these searches bear witness to the fact that modern natural science is undergoing a profound crisis, hindering its further normal development, and that the general level of knowledge attained is ripe for the conscious application of the dialectical method.

note 199, p. 664 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », loc. cit., p. 76 :

The necessary consequence of the above is a conclusion as to the dialectical development of matter by leaps, bound up with qualitative revolutionary changes as a result of the accumulation of quantitative changes, and the idea of the relative autonomy of the biological process, advancing not only in circumstances of interaction with the physical conditions of its surroundings, but also as a result of the development of the internal contradictions latent in the biological system itself. By this means are overcome the oversimplified mechanistic attempts to conceive of the biological process of development as the

result of only the physical influences of external surroundings, or of similar physical and physico-chemical processes inside the organism itself or its genes, [by which means, it is alleged, it is possible to explain the most complex and qualitatively peculiar phenomena of mutatory variation, and thereby the whole process of formation of species.] At the same time this standpoint also overcomes the metaphysical opposition of the biological to the physical, as an absolutely autonomous and independent principle, to the extent that this biological is considered in its indissoluble historical connection with physical phenomena [(as a higher form of motion, originating out of lower inorganic forms of motion of matter), and also its dynamic connection (metabolism).]

note 200, p; 664 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », *loc. cit.*, p. 75 :

Asserting the reality of the world existing objectively outside ourselves, dialectical materialism starts from the conviction, justified by all the practice of human activity, that our consciousness reflects not only the objective reality of the facts directly perceived by our organs of sensation, but also the constant order of the relations connecting these facts one with another.

note 201, p. 666 : B. Zavadovsky, « The “physical” and “biological” in the process of organic evolution », *loc. cit.*, p. 75 :

Establishing the fact of development, variation, motion as the basic qualities of matter, and the unity of the fundamental laws of dialectics, binding on all forms of motion of matter (the law of the unity of opposites, the law of negation of the negation, and the law of the passing of quantity into quality and vice versa), materialist dialectics at the same time emphasizes with all its force the extreme multiformity and the specific qualitative distinctions of the various forms of motion of matter, and the laws characteristic of the different stages of development of matter: and consequently the necessity of the existence of special independent sciences studying these different forms of motion.

note 214, p. 670 : J. Needham, « Foreword », *loc. cit.*, p. viii :

Here was a paradigm of the traditional history of science, so great a genius that he could not have been influenced by his environment at all, and certainly not by a sub-conscious appreciation of the needs of the society of the rising bourgeoisie of the 17th century. To suggest such a thing was, in terms of conventional thinking, almost a sacrilegious act, in any case culpable of lèse-majesté.

note 247, p. 684 : Pablo Huerga Melcon, « Raíces filosóficas de Boris Mijailovich Hessen: Crítica al mito del externalismo de Boris Hessen », *loc. cit.*, p. 347 :

[The article defends that] Marxism cannot analyse science externally, because social factors are considered internal to the material content of science.

note 259, p. 689 : Charles Singer, *A Short History of Biology*, p. xxviii :

He believes that the natural antidote to these evils is the proper use of the historical method in science. He believes that the way to cover any very wide scientific area is by the frank introduction of history. He believes that the proper crown of a scientific education is a general survey of the processes by which the most important current scientific ideas have reached their present state of development.

note 261, p. 690 : J.G. Crowther, *Fifty Years with Science*, p. 77 :

The subject had hitherto been pursued mainly in an antiquarian spirit. A number of the participants were elderly scientists, who had taken up the history of their subject as a pleasant diversion during their retirement, while others had worked at some historical aspect of science in their spare time; some were wealthy amateurs amusing themselves with studies in the history of science. The President of the Congress, Dr Charles Singer, who was the most eminent British historian of science, was one of the few devoting the whole of his efforts to the subject.

note 274, p. 696 : Alexander Vucinich, « Soviet Marxism and the History of Science », *loc. cit.*, p. 124 :

The 1920s were characterized by a general unsettledness on the front of Marxist studies and by a predominance of non-Marxist approaches to the theoretical and methodological questions of the history of science. The Commission on the History of Knowledge, founded by the Russian Academy of Sciences in 1921, was the primary non-Marxist center of studies in the history of science, and easily the most productive Soviet institution working in the field.

note 280, p. 698 : Alexander Vucinich, « Soviet Marxism and the History of Science », *loc. cit.*, p. 128 :

[First,] it was not only the first but also the last effort to cast a historical epoch in the development of science in the mold of classical Marxism.

note 287, p. 701 : David Joravsky, *The Lysenko Affair*, p. 228 :

In the West, Marxist theory has usually been considered the chief source of Lysenkoism, even though the most well-known Lysenkoite writings lay overwhelming stress of agricultural practice as the chief source. In these writings, arguments from Marxist theory are a minor, adventitious theme, which has been greatly exaggerated and misunderstood by Western readers.

note 302, p. 707 : Loren R. Graham, 1985, « The Socio-political Roots of Boris Hessen: Soviet Marxism and the History of Science », *loc. cit.*, p.706 :

One of the major interpretative concepts of the history of science, externalism, is historically connected to Hessen.

Hessen may not have created externalism, but he will be for ever considered one of its founders.

Chapitre 9 :

note 312, p. 712 : Harold L. Cole, Lee E. Ohanian, 2002, « The Great U.K. Depression: A Puzzle and Possible Resolution », *Review of Economic Dynamics*, Vol. 5, p. 20 :

The United Kingdom entered a major depression shortly after World War I and remained depressed through World War II. This large and persistent depression was unique among the industrialized countries. While many countries suffered depressions in the early 1930s, worldwide economic growth was rapid in the 1920s. For example, U.K. real GDP per adult fell about 1% between 1913 and 1929 while real GDP per capita in the rest of the world rose over 30% during this same period.

note 340, p. 719 : Lancelot Hogben, *Science for the Citizen*, p. vii :

Science for the Citizen is partly written for the large and growing number of intelligent adults who realize that the Impact of Science on Society is now the focus of genuinely constructive social effort. It is also written for the large and growing number of adolescents, who realize that they will be the first victims of the new destructive powers of science misapplied.

note 353, p. 722 : JD Bernal, *The Social Function of Science*, p. 415 :

Already we have in the practice of science the prototype for all common human action. The task which the scientists have undertaken – the understanding and control of nature and of man himself – is merely the conscious expression of the task of human society. The methods by which this task is attempted, however imperfectly they are realized, are the methods by which humanity is most likely to secure its own future. In its endeavour, science is communism. In science men have learned consciously to subordinate themselves to a common purpose without losing the individuality of their achievements.

note 373, p. 730 : James Eaden, David Renton, *The Communist Party of Great-Britain*, p. 7 :

The largest Communist parties began as a major faction within reformist parties – in Italy, the Socialist Party first sided with the Comintern, and only later split. In Britain, by contrast, unity was achieved by bringing together the fragments of an already-divided left.

note 375, p. 731 : James Eaden, David Renton, *The Communist Party of Great-Britain*, p. 8 :

A number of leading Communists, including J.T. Murphy, Sylvia Pankhurst, Willie Gallacher and Harry Pollitt, believed from the start that the CP would be able to push the labour Party quickly out of the way and establish itself as the major force within the British workers' movement.

note 379, p. 732 : James Eaden, David Renton, *The Communist Party of Great-Britain*, p. 14-15 :

The Minority Movement claimed 950 000 members in 1926. In order to reach this figure, any individual worker could have been counted several times. [A leading steward in a large plant might attend a conference, as the delegate of a factory, a stewards' committee, or a trades council. With triple-counting, they might claim to represent several thousand workers – less than a hundred of whom may actually have taken part in any vote.] Yet even if the claimed figure exaggerated Communist influence by a factor of ten, this would still suggest that this small party had a considerable influence in the unions, a periphery much greater than its membership.

note 384, p. 734 : James Eaden, David Renton, *The Communist Party of Great-Britain*, p. 2 :

[Second,] the British party was unduly dependent on the quality of the advice it received from seasoned revolutionaries in the Communist International. In 1920 and 1921, the role of the Comintern was generally positive. As the young Communist Party lurched from left to right, it was often the arguments of leading members of the International, including Lenin and Trotsky, which brought the British party back on track. By the middle of the decade, however, the Comintern itself had gone into decline. As the Russian Revolution degenerated from within, so the body which was set up to spread its gains across the world also declined. By 1928 or 1930, the Communist International was well on the way to becoming a fully Stalinised shell of its earlier self, and was no longer capable of leading any of its constituent parties toward a genuine revolutionary politics.

note 392, p. 736 : Kennet Newton, *The Sociology of British Communism*, p. 55 :

People with working-class occupations make up by far the largest proportion of the members of the British Communist party and always have done, even in the late 1930s when the Party attracted a large number of people with middle-class occupations.

note 393, p. 737 : Andrew Thorpe, « The Membership of the Communist Party of Great Britain, 1920-1945 », p. 786 :

There had been a small leavening of middle-class 'intellectuals' in the early days, such as William Mellor, J. T. Walton Newbold, Cecil I 'Estrange Malone, Ellen Wilkinson, and Sylvia Pankhurst. However, they were viewed with suspicion by many of their working-class 'comrades'; and most of them had departed the scene by late 1924

note 395, p. 738 : Kennet Newton, *The Sociology of British Communism*, p. 68-69 :

The Party attracted a higher proportion of middle-class members in the 1930s because of international events. While purely industrial matters drew some sections of the working class to Communism in the 1920s and 1930s, it was the Spanish Civil War and the rise of European Fascism and Nazism which led middle-class individuals to join the C.P. In the 1930s. As the international situation grew from bad to worse, so sections of the middle class shifted their political allegiance further to the left, and so also a smaller number moved far enough left to become Communists. For the first time the Party could identify itself with, even claim to lead, public opinion on a issue that was thought to be crucially important – the growth of the radical right.

note 397, p. 738 : Kennet Newton, *The Sociology of British Communism*, p. 69-70 :

[As Reinhold Niebuhr has suggested,] the intellectuals seemed to be more easily swayed by the subtleties of Marxist dogma, than the working man. In communism, particularly in the thirties, they found an approach to the world which helped towards an understanding of it, and which indicated a way in which a new and better one might be constructed.

note 403, p. 739 : JG Crowther, *The Social Relations of Science*, p. 650-651 :

[For all these reasons,] scientists cannot achieve much by independent action. [These factors have been brought into existence by social forces more powerful than the scientists. They should aim at guiding these forces, which they can influence but cannot control.] Their most effective policy is to study the general movement of social affairs, and attach themselves to those major social forces which seem to be most constructive. They can discover these only from political study and experience, so they must take some part in social affairs in order to discover whom they must support.

note 404, p. 740 : JG Crowther, *The Social Relations of Science*, p. 651-652 :

The social responsibilities of scientists seem, then, to include the following :

- 1. The exposure of errors in science, such as racialist theories, and the exposure of scientific errors in the ideas of destructive social movements.*
- 2. The organization of such intellectual criticism by cooperative effort, [so that sober fact will not be borne down by blatancy and persistence.]*
- 3. Solid demonstrations of the relations between science and social affairs, [so that scientists may be convinced of the need for their taking part collectively in social affairs, for the sake of science.]*
- 4. Descriptions of what social improvements are desirable for the advancement of science, and explanation of how science is thwarted in bad social systems, and how this thwarting is liable to produce still worse social systems. [This would include accounts of how science has declined in Fascist countries.]*
- 5. The persuasion of scientists who keep their scientific and political ideas in separate compartments to support constructive movement on the ordinary political ground of economic interest and social justice.*
- 6. The collective establishment of contacts with Cabinets and centres of government, so that no major political decision can be taken in ignorance of relevant scientific knowledge. [They should see only that politicians and the electorate are permeated by science, so that action contrary to the indications of scientific knowledge would become difficult or impossible.]*
- 7. In peace, to cooperate with all constructive social and intellectual movements, expand science, and remove the causes of war.*
- 8. In war, to consider which side is the less inimical to science, and then do what is possible to see that it is not defeated. Scientists like others, cannot be above the battle, either in politics or in war.*

note 411, p. 746 : James Eaden, David Renton, *The Communist Party of Great-Britain*, p. 186 :

[In each case] the argument was put forward that some process of working-class moderation would open up the space for a radical left government. The problem for the Communist Party was that in arguing for diminished expectations, it was attempting to occupy a political space which was already successfully inhabited by the Labour Party.

note 422, p. 753 : Ronald Clark, 1969 [1968], *J.B.S.: the Life and Work of J.B.S. Haldane*, Cowar McCann, New York, p. 134 : cf. note 338, chapitre 3.

note 425, p. 754 : Kennet Newton, *The Sociology of British Communism*, p. 69-70 : cf. note 397, chapitre 9.

note 428, p. 755 : Neal Wood, *Communism and British Intellectuals*, p. 27 :

Since 1930, only six or seven intellectuals have been elected to any single Executive Committee, usually of thirty or more members. Dutt has been joined by two intellectuals, the

party careerists, Emile Burns and James Klugmann. A handful of prominent men in their fields have been on the Executive, no doubt as a gesture to the intellectuals inside the party, and for the prestige that their names would bring outside the party: Professor J.B.S. Haldane, formerly Weldon Professor of Biometry in London University, and world renowned geneticist; Professor George Thomson, a classicist from Birmingham University; Arnold Kettle, literary historian and critic of Leeds University; Ivor Montagu, film director and producer; G.C.T. Giles, Head Master of Acton County School for Boys, and President of the National Union of Teachers; Allen Hutt, internationally known typographer, a labour historian and journalist.

note 431, p. 756 : JBS Haldane, « Genetics in the Soviet Union », *Science Advances*, p. 224-225 :

In the controversy between Vavilov and Lysenko, I would personally give Vavilov best on most points. Nevertheless, I welcome the controversy, and wish that similar debates elsewhere were given equal publicity.

note 434, p. 757 : Ronald Clark, *J.B.S.: the Life and Work of J.B.S. Haldane*, p. 203 :

[In doing so,] he contrived to get the worst of both worlds. To his Communist colleagues he was in perilous danger of backsliding and from now on began to be regarded with caution. To the rest of the world he was still the Communist apologist, defending the indefensible and, in the process, betraying those objective standards which most non-party scientists did their best to uphold.

note 435, p. 758 : Diane B. Paul, « A War on Two Fronts: J.B.S. Haldane and the Response to Lysenkoism in Britain », *loc. cit.*, p. 22 :

Hence virtually all of the party's biologists, including its eminent geneticist Haldane, were forced to fight a war on two fronts: within the party they denounced, and to the outside world they defended, Lysenko's theories.

note 440, p. 758 : JBS Haldane, 1949, « In Defence of Genetics », *The Modern Quarterly*, Vol. 4, p. 201-202 :

If this discussion were merely academic, I might well keep out of it, as others in similar positions have done. But if the views held in Marxist circles are going to be of increasing importance in Britain in the future, as they have in other countries, the situation is different. I believe that wholly unjustifiable attacks have been made on my profession, and one of the most important lessons which I have learned as a Marxist is the duty of supporting my fellow workers.

