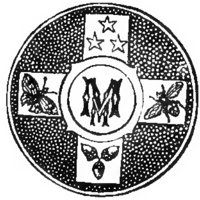
COMPARATIVE LONGEVITY.



ON

COMPARATIVE LONGEVITY

IN MAN

AND THE LOWER ANIMALS

BY

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PREFACE.

A PRIZE was recently offered in the University of Oxford for an Essay on Longevity, and was awarded to the little treatise now published. In the following pages the scope proposed in the subject given for the essay, viz. 'The Comparative Longevity of different species of lower Animals and the Longevity of Man in different states of Civilization,' has been adhered to. The subject does not admit of very satisfactory treatment from a scientific point of view, and is accordingly one which probably few persons would have selected to write upon, unless under special circumstances, such as were present in this case. At the same time, Longevity is a subject of great popularity, and hence the facts and arguments herein set forth may, it is hoped, interest the public. One result which I hope to attain, by the favour of those who may read my pages, is the accumulation of an increased number of really trustworthy facts bearing on the questions raised. I venture to beg all those who have it in their power to communicate such facts to me, to do so.

E. R. L.

MELTON HOUSF, HAMPSTEAD,

December 18, 1869.

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EX VIRIBUS VIVIMUS.

AN ESSAY ON THE COMPARATIVE LONGEVITY OF DIFFERENT SPECIES OF LOWER ANIMALS, AND THE LONGEVITY OF MAN IN DIFFERENT STATES OF CIVILIZATION.

1. *Introductory.*

THE periodic phenomena observable in organisms have always a special interest for students of Nature on account of the extreme obscurity of their relations, as well as from the practical importance which they possess for mankind. There is probably but small room for doubt that ultimately the various recurring periods of death, of reproduction, of sleep, of hybernation, of gestation, of puberty, are all related to or derive their origin from those great astronomical cycles of change in the relative positions of sun, moon, and earth—which we know as year, month, and day. Whilst in some of the periodic phenomena of organisms this relation is clear and direct, in others it is obscured by the introduction of most complex factors, which do not permit us to trace in the majority of organisms the operation of the astronomical cause. The duration of life[1] is vastly influenced by varying conditions in various organisms, but the prime factor in all cases is the influence of changing day and night, of alternate winter and summer, or wet and dry season.[2] How this influence is modified by the creation of correspondences between organisms and their surroundings, or how, in the words of the philosophy of evolution, new factors have arisen in the progressive development of organisms by the law of the survival of the fittest, is to be the subject of enquiry in this essay.

Although it is vain (with present knowledge) to expect to gain a complete insight into those agreements between beings and their environment, of which the duration of life is one, yet certain facts and considerations have been pointed out which go

[1] The great importance which man attaches himself to long life, gives the enquiry into longevity in animals a greater importance than it deserves as a physiological or philosophical question. The varying *intensity* of life in different species, and the *average mortality* of a species, are more clearly influential quantities in nature than the possible length of life. Time does not appear in the organic world as an easily recognisable factor, for though in life as in levers what is lost in power is gained in time, it is difficult to distribute the amount of life of any given species rightly between intensity and length.

[2] In other words, astronomical cycles have furnished the unit for organic cycles. The cyclical character has been as it were impressed upon organic matter, by the great cycles of the universe. No further implication is intended in the text.

far towards enabling us so to do. From the time of Aristotle onwards, observers and philosophers have accumulated facts and multiplied speculation on the causes of longevity: the field is a well-trodden one, and for many years to come any increased knowledge of it must be looked for rather from the examination of long-acquired facts and their re-arrangement, than from new or unexpected observations[1] by individual workers.

2. *Writers on Longevity, and general Sources of Information.*

In consequence of the general nature of the enquiry proposed in this essay, we have little in common with those who in former ages have enlarged upon the possible means of prolonging human life; nor are we concerned specially with those questions as to the possible and extreme periods of man's tenure of existence, which to-day occupy the attention of many literary men of an antiquarian or curious turn of mind. In the writings of these men we cannot expect to find more than one limited class of facts bearing on comparative longevity; and in too many cases the facts so called are not supported by scientific evidence. In a recent article in

[1] It will be seen below how vast an amount of enquiry has yet to be made, as to length of life in animals and men. No single individual can do much in this matter in less than a lifetime.

the 'Quarterly Review,'[1] and still more lately in the 'Fortnightly Review,'[2] admirable *résumés* are given of what is known and has been supposed with regard to this possibility of human life—a subject to which the term 'longevity' has had its meaning narrowed, but one which will here be treated subordinately. It will be unnecessary therefore to refer further to authorities on this question, until their opinions are discussed. Naturalists and philosophers, including Aristotle, Bacon, and Haller, have incidentally given expression to opinion as to the causes of the varied tenure of life of organisms; but naturally the later writers have had a larger number of facts to deal with, and have been able to bring a sounder scientific knowledge to bear on the problem than those who preceded them. The treatise of Bacon, entitled 'Historia Vitæ et Mortis,' contains a most admirable enquiry into the causes of longevity. The question is attacked from every side, and the most ingenious hypotheses, with regard to animals and men, are suggested and discussed with that order and precision which belong to the great philosopher. At the same time, it must be admitted that, in Bacon's time, strange traditions and superstitions held men's minds, and that he actually, who shewed the means

[1] January, 1868. Also see Sir Henry Holland's able Essay on 'Human Longevity' in the 'Edinburgh Review,' 1857, hereafter referred to again.

[2] April, 1869.

by which we have become free from such impediments, was to a considerable extent affected in this way. The account of the ages attained by various species of birds and animals, given by Bacon, is very extensive, and his remarks upon each case valuable. These are referred to hereafter; but his statements with regard to various cases of human longevity are less trustworthy, as well as his discussion of the value of inunction, of smelling fresh earth on waking, and other curious devices for prolonging life: little reliance, moreover, can be placed on the strange connections between longevity and personal qualities and characteristics, such as hairiness and temper, which Bacon enumerates. This treatise, however, is well worth the study of those interested in the subject, if only as a collection of strange fancies. Bacon's conclusions set forth in the thirty-two canons at the close of his treatise, explain variations in longevity as due to variations in the density of the 'vital spirits,' and other causes affecting these spirits. The work of the Prussian physician, C. F. Hufeland, entitled 'The Art of Prolonging the Life of Man,' published in the beginning of this century, is to a great extent founded on Bacon's work, from whom most of his facts are derived. The advance in science during a century and a half, enabled him to treat the subject in a less metaphysical style than Bacon could; at the same time, his philosophy is one which has now in its turn become antiquated. Hufeland endeavours, by an examination of the various leases of life in the vegetable and animal world and their connected conditions, to discover what will favour and what will combat the prolongation of life in man; and the latter part of his work is a recommendation of temperance and regularity in the exercise of the various functions, such being the lesson derived from his general study. At the outset of his enquiry Hufeland observes, 'Is it then impossible to penetrate the intimate nature of this sacred flame (life), and to learn to distinguish what will feed it from what will diminish it? I know how rash is the enterprise I have undertaken. I am about to approach a sanctuary from which so many presumptuous men have had to depart abashed and confused, and of which Haller himself, the favoured confidant of Nature, has said that no mortal can penetrate therein.' Hufeland had no cause to regret his enterprise, for though he did not accomplish his task, which indeed he could not hope to do, he has shewn an excellent path, which it remains for others to improve and extend.

The general conclusions Hufeland arrived at are as follows. He says, 'The duration of life depends then, in general, on the following circumstances. 1st. It depends on the quantity of vital force contained in the body. . . . 2nd. Life consumes and destroys not only vital force, but also the organs; the destruction of life ought then to occur later in a body endowed with vigorous organs than in one in which the organs are delicate. . . . Thus, a certain solidity of general organisation and a suitable condition of the vital organs are the second condition on which length of life depends. 3rd. The consumption (of vital force and of organs) may be more or less rapid, consequently its duration, or, what amounts to the same thing, that of life, may be, other things being equal as regards forces and organs, shorter or longer, according as the act of destruction operates with more or less intensity. 4th. Finally, since the reparation of losses is the principal means of counteracting consumption, a body which has the most perfect means of regeneration, both internal and external, will endure a longer time than one not provided with these means. In a word, the duration of life in a being depends on the sum of the vital forces which it possesses, on the greater or less consistence of its organs, on the rapidity or the slowness of its consumption, and on the perfection or imperfection of regeneration.'[1]

The only criticisms on these views which it is at present useful to make, is that they involve certain ideas which have become modified with the advance of science, and hence require to be adapted to present knowledge. In the sequel it will be seen how far they differ or agree with modern conclusions.

[1] Hufeland observes in one passage, 'The more imperfect the organisation the longer the life,' after describing the prolongation of life in plants by pruning. His own facts are sufficient to refute this as a general law. The truth is the very opposite of this.

A second work on Longevity, which treats of the general subject, and which therefore has an interest for the present enquiry, is that of the late P. Flourens, who was perpetual secretary to the Academy of Sciences of Paris, and Professor of Comparative Physiology at the Museum of Natural History. Flourens' work is devoted to human longevity in its first part, and in this connection he considers the longevity of other mammalia in order to answer this question, Is there any sure characteristic in animals from which we may infer their length of life? He gives the supposed age of several mammals, and the age at which the epiphyses of their bones are supposed to become united throughout the skeleton, and from this comparison he comes to the conclusion that in mammals and man the period of life is five times that of the period of growth,—a very neat and valuable rule to aid us in examining the question of the causes of longevity, were there a real foundation for it in fact.[1] The data used by M. Flourens are, however, very few and of small credibility, whilst such as they are, they do not bear out his law of an exact quintuple ratio. The suggestion of fixing by the junction of the osseous epiphyses the period of growth, is nevertheless one of great practical value.

In a work entitled, 'Life, its Nature, Varieties and

[1] Buffon had previously supposed a ratio of 7 to 1 as that of the length of life to length of growth.

Phenomena,' Mr. Leo H. Grindon has discussed what he terms the various leases of life in plants and animals, using the data and inferences of Bacon, Hufeland, and Flourens to a very large extent, but adding some which are of value. The relation of length of life to bulk, intensity, and fertility, which have been more or less clearly apparent to all who have thought on the matter from early times, are briefly set forth, and apparent exceptions to the laws enunciated are attributed to special design on the part of the Creator, to serve the special requirements of the exceptional organism, or of some other organism dependent on it.

Lastly, in regard to works, the volumes of Mr. Herbert Spencer must be mentioned. For whether we accept the new philosophy of Evolution, so marvellously born of Mr. Darwin's theory of the Origin of Species, or cling to an older belief, the fitness of things to their conditions, the correspondences of organisms to their environment, so ably set forth in Mr. Spencer's grand work, must enter into our theory of Nature. It may be a fair boast of the evolutionist that the founder of his philosophy has been led by the course of his speculations to trace a closer connection, a more complete adaptation of living things to their wants than the teleologist ever even hinted at, much as such a close connection would have added to the consistency of his theory of design. In his 'Principles of Biology,' Mr. Spencer, in the chapters on Genesis and on Multiplication, establishes certain laws of correspondence, which, together with the facts he so adequately cites, have the closest bearing on the antecedents of longevity. Nevertheless it is to be noted that the term 'longevity' is not once used in these chapters, nor is the duration of individual life discussed directly at all. Did the nature of this essay permit, it would be perhaps the most satisfactory way of treating the question of longevity, to assume the contents of Mr. Spencer's volumes and to write a last chapter on the Duration of Individuals. This is not, however, the form which it is deemed right to adopt upon the present occasion, though frequent reference to and use of the views of this most eminent philosopher will be made.

Having dismissed the subject of books, let us consider for a moment the nature of the data which are available with regard to the duration of life. We shall find that the paucity and uncertainty of observations on this class of facts is something really extreme. Lord Bacon, in his 'Historia Vitæ et Mortis,' makes a remark which is true to this day:—'De diuturnitate, et brevitate vitæ in animalibus tenuis est informatio, quæ haberi potest; observatio negligens; traditio fabulosa; in cicurribus vita degener corrumpit; in sylvestribus injuria cœli intercipit.'[1] To begin with man himself, we have sta-

[1] Montagu's edition, 1828, vol. x. p. 134.

tistics, individual assertions, general impressions, experiment. It might be supposed that statistics would furnish very valuable evidence on this matter; but, in the first place, it is only within certain European areas and a part of America that statistics relating to age are prepared, and the qualifications to which these are subject, from the shifting of population, are of a very complex character; further, there is a remarkable personal equation in the observers, who are at the same time the subjects of the enquiry into age, which it seems almost impossible fairly to estimate. Men do not tell the truth as to their age, either from ignorance or from deceitfulness. The ill-educated and the aged are specially likely to make false statements from ignorance, whilst that 'vanity which never grows old'[1] affects equally the statements of old and young.

Individual assertions, taken alone and apart from the correction which the average of a vast number must ensure, are of course still less to be depended upon, and for the same reasons. General impressions, such as are imparted to us by travellers, by poets, and even historians, are of very small value when they relate to the duration of life, where it is so easy to confuse wear and one of its factors age. Experiment of what will ensure long duration of life in himself has been too rarely tried by man to make this class of evidence of any scientific value, whilst amongst

[1] Buffon.

animals man seems never to have selected or endeavoured to produce longevity, probably because of its uselessness; had he done so, we might hope for some valuable facts from his experiments.

With regard to observations on the length of life of other animals, the certain knowledge is very small, only that tenure of life which is very brief being easily observed.[1] The greatest uncertainty or even ignorance prevails as to the duration of life of even the commonest mammals, birds, and fishes; in most cases it seems only possible to say that it is not less than a certain period. This of course furnishes a limited means of comparison. A writer in the 'English Cyclopædia'[2] says: 'Of the age to which the horse would naturally arrive, it is impossible to say anything satisfactory. Many have exceeded thirty, and some of them even forty, but from ill usage and over-exertion the majority come to their end before they have seen nine or ten years.' M. Flourens gives exceedingly wide ranges for many mammals in his book above noted, whilst it is obvious, if we consider the position of many wild animals, such as the larger

[1] We may naturally suppose that if we are ignorant with regard to man to the extent above shewn, still more *à fortiori* shall we be ignorant as to wild animals, to none of which has statistical examination been applied, nor probably can be in any but the rarest cases. It is clear, since animals do not carry the number of the years of their proper life marked on their bodies, like any of those specific characters which are structural, we can only form guesses as to this period from individual cases.

[2] C. Knight's 'English Cyclopædia,' Article 'Horse.'

carnivora, most birds, reptiles, fishes, and aquatic animals, that any suppositions as to their duration of life can rest on but few facts. In reply to enquiries, Mr. Charles Darwin writes that he has no information with regard to the longevity of the nearest wild representatives of our domesticated animals, nor notes as to the longevity of our quadrupeds.[1] Mr. Thomas Bell, the author of most valuable works on 'British Quadrupeds,' 'British Reptiles,' and 'British Crustacea Podophthalmia,' in reply to special enquiry, writes that the opportunities of observation are few, and the results necessarily uncertain as to length of life in Reptiles and Crustacea.[2] Dr. Gunther, of the British Museum, a most able ichthyologist and naturalist, remarks, in a letter in reply to enquiries,—'There is scarcely anything positive known of the age and causes of death of various fishes.' So, too, in Mr. Yarrell's works little is said of duration of life; whilst in Mr. Gwyn Jeffreys' admirable treatise on the British Mollusca a similar absence of knowledge with regard to those animals is admitted. The Insects form a remarkable exception, since in a great number of them the duration of life is well known.[3]

[1] Mr. Darwin very kindly furnished me with a note relative to the age of certain birds, which is quoted in the Table of Statements, which follows.

[2] He, however, gives two facts which are mentioned in the Table of Statements.

[3] Only comparatively 'well known,' however, for the relative duration of life in different species of insects, involving a matter of months and days, is not known.

Of still lower forms of life there is as little knowledge in most cases as in the higher forms. The Vegetable division of organisms among its higher and terrestrial members furnishes ample data; the ages of trees, shrubs, and such like forms appear to be well ascertained, but those whose condition and structure is diversified by aquatic habitat, leave us as much in ignorance as do similarly inaccessible animals.

Here, then, before entering on this enquiry, whilst but looking out on the road, we see how few are the guide-posts—how small the assurance we can have of taking the right turning. When that immense engine of scientific observation, which is wielded by statisticians, has been fairly and fully applied to the human species and to such of the many and varied forms of animal life as may be possible, not only so as to determine length, but other quantitative phenomena [1] of life also, then we may hope to see the problem, about to be discussed, definitely and clearly investigated by inductive methods.

[1] Such are the time of gestation, incubation, metamorphosis, of hybernation, of sleep, of growth, the amount of deaths and births at various ages, of food consumed, of force exerted—phenomena, none of which can be measured or determined by isolated cases, but require, like longevity, the examination of vast numbers to give true results, varying as they may do in the individuals of a species.

A. Longevity in Organisms generally.

3. *Longevity defined.*

It is very necessary to have a clear perception of the meaning of the principal terms involved in the consideration of the duration of life. By 'longevity' must be understood the length of time during which life is exhibited in an individual.[1] Unless we introduce the term 'individual,' and assign to it a definite meaning, we become involved in numerous difficulties when making a comparison of the length of life in different species of organic beings. However important in a zoological sense the definition of 'individual' may be which regards the various forms and existences appertaining to a species between ovum and ovum, as the individual of that species, for physiological purposes, such a definition cannot be accepted. The whole product of a fertilized germ, whilst it no doubt, in many cases, agrees with all requirements as a definition of the individual of a species, is yet, in many other cases, open to much

[1] Though longevity is thus limited on the present occasion, in accordance with the ordinary usage of the term, it is only right to remind the reader that there is a vastly important and most interesting aspect of longevity which has been but little written on or considered as yet, and which it is to be regretted we cannot now enter upon. The longevity of races and species (as such) is the subject to which allusion is made: in connection with the Darwinian theory and struggle for existence, the longevity of species will prove a most fertile field of research.

objection. In the Vertebrata, in Mollusca, in most Insects, such a definition is unobjectionable; but when we consider the numerous examples of asexual reproduction we are led into difficulty. 'It seems a questionable use of language to say that the countless masses of *Anacharis alsinastrum* which, within these few years, have grown up in our rivers, canals, and ponds are all parts of one individual.'[1] And yet, as this plant does not seed in England, these countless masses, having arisen by asexual multiplication, must be so regarded, if the above definition be accepted. In the Hydrozoa are we to ascribe the same amount of individuality to those forms which give rise to separate polypidoms by the separation of budded offspring, as to those to which these remain attached, to form a compound polypidom? The same difficulty occurs with the lower Annelids and Vermes, with Aphis, and such asexually proliferous insects, and with multiaxial plants whose buds are capable of separation and the initiation of distinct existences. An illustration of the perplexity into which the above definition of the individual would lead us in regard to the question of longevity is furnished by such compound organisms as are known among the Actinozoa. 'Ehrenberg judges that certain enormous corals which he saw in the Red Sea, and parts of which are still tenanted by working polypes, were alive in the time of the Pharaohs, and have been growing and enlarging

[1] Spencer.

ever since. Others of equally vast age have been observed in the waters of tropical America.'[1] If we regard the whole product of the fertilized germ as an individual, then we must conclude that these corals have a longevity of more than 3000 years, though we well know that countless generations of asexually-produced polyps have succeeded one another in these great coral masses. Without further discussing the question here, we may adopt Mr. Spencer's view, that there is no possible definition of individual which is absolutely unobjectionable. 'Individualities merge and are distributed, in such cases as fusion and fission, which renders the estimation of their longevity a matter of great indefiniteness, and we shall find it most agreeable to all the facts in issue, to consider as individuals all those wholly or partially independent organized masses which arise by multicentral and multiaxial development that is either continuous or discontinuous.'[2]

The period of life which we must compare in different species is then that presented by individuals as above defined. We have not to consider the life of *attached* gemmæ, nor of *unlaid* ova. Such life is not the life of distinct individuals. Thus then, for our purpose, all parts of a tree, as long as they remain attached to the original axis, are but one individual. But we have to consider and compare the duration

[1] Leo Grindon: 'Life,' &c. p. 99.

[2] 'Principles of Biology:' Spencer, vol. i. p. 207.

of life of all separated and independent organized masses: the branch is part of the individual tree while it is attached thereto; but if it be removed when young and grafted or bedded, it is a new individuality and has its own longevity. So with the bedded polyps or worm-segments: whilst attached, they have but one individuality; when thrown off or disunited by the death of their common parent or axis, they are distinct individualities. Though not fully satisfactory, such seems to be the fittest use of the word 'individual' in relation to our subject.

Certain difficulties are also involved in the term 'life.' For, whilst in this essay it is beside the subject to enter into an explanation or definition of that phenomenon, we are certainly called upon to consider whether, in defining longevity as the duration of life of an individual, we regard the suspended animation of such organisms as Rotifera, Tardigrada, and some Nematodes, as also the retarded development of seeds, such as those of Egyptian wheat obtained from the most ancient monuments, as coming into consideration as instances of duration of life. The best solution which can be given of this difficulty appears to be in regarding these cases as strictly exceptional, and as being rather examples of suspension of life than of its duration. Though the conditions under which this suspension occurs may furnish some evidence as to the conditions favourable to the retention of vitality by an organism, they must be looked upon as abnormal, and not credited with a false significance. The life of a dried Rotifer is rather potential or latent life than efficient life, and it is with efficient life that our definition of longevity deals.[1] Doubtless efficient life, by approximating more closely, from time to time, or continuously, to this merely potential life, has its term extended in various cases;[2] but the normal and natural course of events must not be confounded with what is abnormal and accidental. With these qualifications, longevity may be defined as the length of duration of life of an individual. With this meaning of the term we may now endeavour to see how the longevity of various organisms may be compared.

4. *The various kinds of Longevity.*

Great as is our ignorance with regard to longevity in all that relates to accuracy and detail, yet there are a few patent facts within everyone's experience which it is well to consider at once. Firstly, various individuals enjoy various durations of life. That men, cats,

[1] Professor Owen remarks in a recent note ('Monthly Microsc. Journal,' vol. i. p. 294)—'There are organisms (Vibrio, Rotifer, Macrobiotus, &c.) which we can devitalize and revitalize—devive and revive—many times. As the dried animalcule manifests no phenomenon suggesting any idea contributing to form the complex one of "life" in my mind, I regard it to be as completely lifeless as is the drowned man whose breath and heat have gone, and whose blood has ceased to circulate.'

[2] Ex. gr. Parasitic worms which become encysted: hybernation approaches this condition in great measure.

mice, bees, and buttercups live for different periods of time, is matter of experience, and not only this, but all men do not live equally long, nor all cats, nor all bees and flowers. Hence every individual has its own longevity, if we understand that term to mean duration of life. On looking a little further, we readily discover that there is a closer agreement as to duration of life (though we cannot deal with accurate numbers) between the individuals of the same species than there is between the individuals of different species; and though the individuals of the same species exhibit great variation in their length of life, yet there is a probable duration which characterizes the species, and is the same therefore for all the individuals. We thus, then, have *individual* and *specific* longevity. But when we try to form some more definite notion of this 'specific longevity,' great difficulties have to be encountered.

By 'specific longevity' we may mean the *average longevity* of the individuals of a species, that is, the average duration of life of all the individuals born; and had we data for various organisms as we have for some groups of mankind, we should speak of this period as the expectation of life at *birth*, and could assign to it a fixed quantity, as is done for men. On the other hand, a very different term is that which we usually speak of as the 'longevity' of this or that race, family, or species. Howsoever ignorant we are of numbers in this matter, though it is even difficult to define what are the limits of the period to which we refer, yet, in speaking of 'longevity' of groups of beings, we usually mean the potential longevity—or 'lease of life,' as Mr. Grindon terms it—and do not allow the average longevity, affected as it is by disease and accident at all periods of life, to enter into our consideration.

The term 'mortality' is usually applied to the question of average longevity, and hence, in accordance with general convention, longevity may be understood to refer to potential longevity. Once for all, here it may be pointed out how slightly these quantities can affect each other, though they are to a certain extent related. Mortality has been largely studied in the case of man, and much more is known of it than of longevity in his case; but among animals and plants generally, vastly important as mortality is in regard to the necessities of life and of organisms, there is as little known as in the matter of longevity. That the average longevity of a group of individuals is but slightly related to the potential longevity, appears from these considerations. From enemies preying upon the 'young ones,'[1] or from disease, or from a severe struggle for food, or from the accidents of dispersion, vast numbers of the individuals of the group may die at a very early age; those, on the other hand, which do survive, may live to a period of time quite unaffected by the conditions which acted

[1] 'Young ones.'—Herbert Spencer.

on them in early stages of existence. Thus from great destruction of young the average longevity may be brought very low, and not indicate directly at all the potential longevity. It is clear that a very high potential longevity will materially raise the average longevity, whilst a low one will somewhat diminish it; on the other hand, the chances of life may be the better in each individual of the survivors from the fact that the average longevity has been lessened by the destruction of numbers of the weaker and unhealthy among the young. It is clear that the subject of mortality is so distinct from that of longevity that it cannot enter largely into consideration on the present occasion.

Whilst we have fixed terms to give us the means of comparing average longevities, what have we that corresponds in the case of potential longevity?

This matter has not been fixed by any authority, even in the case of man, who is indeed the only animal of which there are sufficient facts known to enable one to use in any way such a definite indication of potential longevity for comparison. Statisticians frame tables for various groups and classes of men, in which the probable[1] after-lifetime or expectation of life is calculated for any given age. The expectation of life at birth obviously indicates the

[1] Mr. Neison has proposed rather to compare the lifetime, of which there is an *equal* chance, at different ages, but this proposal has not been made use of.

average longevity of the group, but at what period of life does the expectation fairly indicate the potential longevity? It might be answered at once that, as a matter of course, the highest age attained by any individual of the group, that is, the greatest *individual* longevity, is the measure of the potential longevity of the group; but we must remember, in dealing with a large number of cases, not to mistake abnormal or exceptional cases for normal ones, and not to base conclusions for a group on such cases. In the case of man, as noted again below, this may be of less importance, but with the various organisms of the animal and vegetal kingdoms we cannot justly say that the longevity proper to a species is indicated by the greatest longevity attained by an individual of the species. In searching for some terms to be used as indicating the potential longevity where statistics are available (and where they are not, guesses and estimations based on the few existing data must take their place), the probable after-lifetime of an individual, when it has attained the average longevity of the species, might be taken arbitrarily as fixing the potential longevity of the species. But it seems better, though less precise, to use the probable after-lifetime of an individual at that age when it has passed some crisis, such as the maturity of the reproductive organs, or other similar crises, as the case may be, for the purpose of giving fixed terms of comparison as to potential longevity. It is perhaps scarcely worth while speculating as to what may best serve this purpose, since in no animal or plant are we in a position to make use of any decision on the matter, and in the case of man it will be seen that it is not much wanted. The day may, however, come when sufficient observations will have been made on lower organisms to render such a fixed point of comparison useful.

Potential longevity differs then in different species (as a glance at the statements as to longevity below will fully prove), and agrees within certain limits in individuals of the same species. Why is this? It is no doubt because the particular structure and habits of each species in some way require or entail the particular limit or lease of life. But how is this effected? Does the life of a given species receive its limit simply through the operation of the particular or specific external agencies (to which the species is born and specially constructed to meet) on each individual born? Undoubtedly this is so to a large extent. For man may take an animal lower than himself in the scale of life, or a plant, and by his care and attention, by removing the agencies to which the creature is born, and carefully substituting others, may cause it to live much longer than it could possibly do if left to its natural conditions. Thus man may take a bird, and by providing it with food, and protecting it from competition with its fellows, from accidents and enemies, from the want caused by weakness in old age, protract its life. Parrots, thus, live even one hundred years, and goldfinches twenty-three, which there is good reason to believe is far beyond their length of life when in a 'state of nature.' So lions have lived in menageries to be forty to sixty years old (Haller), being fed after the loss of their teeth and the blunting of their claws. Insects have been so kept for three or four years; and many plants by attention are made perennial or biennial, whereas in natural conditions they would be annual. It will probably be admitted that man has this power in many cases without further illustration.

Hence we must again qualify or analyse potential longevity as applied to species; for there is one period which is proper to the species in its normal conditions, which it cannot by any struggles of its own extend, hedged in as it is by those very conditions in relation to which it has either been created, or by which it has been evolved. There is a second period which is equally proper to a species (as far as experiments tell us), which man can make evident by removing some of the natural conditions and substituting others, which however has its limit, beyond which limit no power that is known can extend the life. The first period may be called Normal Potential Longevity, the second Absolute[1] Potential Longevity.

[1] Absolute is used for want of a better term; it is only 'absolute' within man's experience.

Man himself, in his civilized form, is continually bringing his intelligence to bear on his own longevity, thus changing conditions as no other organism can, and consequently in his case normal and absolute potential longevity are merged. It is the development of unprecedented and overpowering intelligence which interferes in the case of man, and separates him in this as in other matters so greatly from other organisms. His intelligence enables him to take many precautions with advancing years; it leads him to form communities and organizations in which the active and young protect and minister to the aged. This great peculiarity in man, and the more than specific differences of condition which his all-adapting brain renders possible in various groups of individuals with less than specific difference of structure, makes it desirable to consider him apart from the rest of the organized world in such a matter as longevity.

When man exerts the greatest care to protract the life of certain organisms, he yet finds that death will come and limit the period. There is a limit to absolute potential longevity clearly enough in many organisms, and this limit, which may be termed an inherent one, must of course act in limiting normal potential longevity. What is it that constitutes this limit, are all organisms subject to it, and how does it become inherent? It appears that in some organisms we cannot clearly say from observation that there is such an inherent limit; in fact, their *absolute* potential longevity appears to be very nearly practically unlimited; but we may suppose that it has a remote limit which is difficult to observe on account of its distant character. Such organisms are fish, molluscs, large crustacea, annelids, many trees and sea-weeds. In other organisms, on the contrary, there is distinctly observable a natural inherent limit to life, which is inevitable, however carefully injurious and destructive influences are kept off, which makes its approach felt with the advance of years, in that state which is called 'natural decay' or 'senility.' Men, other mammals and birds, some reptiles, insects, some lower invertebrata, and many plants, exhibit this condition of things very obviously. In some, as insects, and some low worms and protozoa, the action of this 'natural decay' is far more powerful than it is in the other cases, and we see these creatures dying clearly under its influence; in others it is less obvious, and hence we may suppose that in the former group, where natural decay appears to play no part, its apparent absence is merely a matter of degree, and that it is simply reduced to a minimum.

That the time of the on-coming of this period of natural decay, i. e. the limit of absolute potential longevity, varies strictly and largely in different species, and proportionately to the normal potential longevity, is difficult of absolute proof in the absence of experiment; but it will probably be admitted from common experience as to ageing, and some facts bearing on it which it is needless to particularize are given in the 'Statements as to Longevity,' below.

What we are then endeavouring to examine in various species of lower animals and in man, viz. normal potential longevity, varies in accordance with two sets of influences, the external agencies or specific 'milieu,' acting directly on individuals, and an inherent limiting agency. To the first, all organisms are severally subject; the second seems to possess a very small power in some. Both these are hereditary influences, as is implied in their truly specific character; the inherent is so by hypothesis, the external agencies are less obviously so, being indirectly inherited by the transmission of structural capacities and necessities involving the same details of life in the offspring as in the parent.

Not less hereditary is that average longevity which was spoken of as constituting the study known as 'mortality.' It, equally with potential longevity, is a specific character as truly as a tuft of feathers or an additional antennary joint, and is determined by the reciprocal relations of the 'environment' and the 'organism,' and with a constant organism it cannot vary, whilst, if the 'environment' is not constant, the organism must become a new species on the evolution hypothesis, or cease to exist on the special-creation hypothesis being no longer fitted to its conditions. The close relation of the average longevity to the welfare of the species is seen in cases where man has interfered with this quantity, as in game-preserving. Gamekeepers killed 'vermin,' i. e. hawks, weasels, foxes, &c., which were in the habit of diminishing the average longevity of the grouse, by destroying weakly birds. The vermin being destroyed, the average longevity was unduly raised, and as a consequence we had the grouse disease, which threatened the extinction of the species. Other such cases might be actually pointed to, or conjectured.[1]

We have then these three quantities of life—the normal, the absolute, and the average longevity, each one of which, in its unequal distribution, we are entitled to assume, is fitted to the requirements of the specific organism, either by special design, or by the gradual evolution of relations. By enquiring what the correspondences are, we may endeavour to frame some general propositions as to the causes affecting longevity, and thus be the better able to examine the question of man's longevity. It is seldom, on account of the small knowledge available, that the term 'absolute potential longevity' will have again to be used. In speaking of potential longevity, or longevity, henceforth, unless otherwise said, normal

[1] Such, for example, are the diseases of domesticated animals, and of civilized man himself. The incapacity of some plants and animals to become established in a new country may be attributed, in many cases to the absence of some cause—nature's sanatory police—which would check undue average longevity, and thus maintain a healthy stock.

potential longevity, or what appears to belong to that term, as above explained, will be meant.

5. *Inherent Death.*

Let us now parenthetically enquire as to this inherent cause of death—this something in the organism which, more clearly than the other structures and properties of the organism, limits life. We say, 'more clearly,' for it is impossible to regard what was ascribed to the 'milieu,' 'environment,' or 'external agencies,' without remembering that they have their correlatives in the organism itself.

How is it that absolute potential longevity is made to have a limit by heredity? How is it that natural decay is hereditary as to time and effect? The whole subject of the hereditary transmission of specific characters has been recently treated of by Mr. Darwin in his volumes on 'Animals and Plants under Domestication,' and the ingenious theory of Pangenesis started to explain and collect all these phenomena under one head. Though Mr. Darwin does not allude especially to senility, he mentions at length periodic developments agreeing as to their time of appearance in both parent and offspring. The theory of Pangenesis is thus stated: 'I assume that cells before their conversion into completely passive or "formed material," throw off minute granules or atoms, which circulate freely throughout the system, and when *supplied with proper nutriment multiply* by self-division, subsequently becoming developed into cells like those from which they were derived. They are supposed to be transmitted from the parents to the offspring, and are generally developed in the generation which immediately succeeds, but are often transmitted in a dormant state during many generations, and are then developed. Their development is supposed to depend on their union with other partially developed cells or gemmules which precede them in the regular course of growth.' 'Gemmules are supposed to be thrown off by every cell or unit, not only during the adult state, but during all the stages of development.' (Darwin, loc. cit. vol. ii. p. 374.)

We may use this theory to explain the hereditary character of senility. The gemmules, 'when supplied with proper nutriment, multiply.' As long as there is nutriment for them they will continue to be produced, but when the superabundance of nutriment ceases, which, as we shall see, is soon after growth is quite completed, their production ceases; they are thus limited in number, and, being called upon in repair and reproduction, are gradually exhausted. But it is not necessary to have recourse to the pangenetic gemmules, which are only considered by Mr. Darwin as provisional hypotheses.[1] The

[1] Mr. Darwin does not appear to connect the gemmules with *ordinary* repair (i. e. of waste, not injury), which it would be more satis-

physiological units of Mr. Herbert Spencer, which he describes as follows,[1] will suffice as an assumption; or, indeed, we need go no further in explicitness than is involved in the assumption of 'a matter of life.' What we have to explain is why Mr. Spencer's units, or the 'matter of life,' should be limited in quantity in various organisms, so that life terminates at different periods, even when two species compared appear to have been subjected to the same external agencies. The old writers distinguished the 'vires in posse' and the 'vires in actu.' The aged, they said,

factory to do. The material character seems also some objection to these gemmules. For take the case of a polyp reproducing asexually for three thousand years. According to Mr. Darwin's supposition, involved in his explanation of Atavism and Reversion, the last generation of polyps contain gemmules from every preceding generation. The persistence of the same material gemmule, and the vast increase in the number of gemmules, and consequently of material bulk, as later generations come on, make a *material* theory difficult. Modified force-centres, becoming further modified in each generation, such as Mr. Spencer's physiological units, might be made to fit in with Mr. Darwin's hypothesis in other respects.

[1] Mr. Spencer, after describing the organic 'polarity' seen in the phenomena of repair and development, says, 'If then this organic polarity can be possessed neither by the chemical units nor the morphological units, we must conceive it as possessed by certain intermediate units, which we may term *physiological.* There seems no alternative but to suppose that the chemical units combine into units immensely more complex than themselves, complex as they are; and that in each organism, the physiological units produced by this further compounding of highly compound atoms, have a more or less distinctive character. We must conclude that in each case, some slight difference in their mutual play of forces produces a difference in the form which the aggregate of them assumes.'

had not, as the young, this under-stratum of 'vires in posse' to call upon in cases of exhaustion. 'We must never forget to insist,' says M. Reveillé Parise,[1] 'upon this fundamental principle, that the unknown force of life, *vis abdita quædam*, diminishes more and more with the progress of age.' 'Ex viribus vivimus,' said Galen.[2] A young man is commonly said to overtax his strength and to injure his *constitution* by great expenditure of force when young. The common idea expressed in these various statements of opinion is that a store of life-force or life-material exists, which the young accumulate, which increases up to a certain amount, but which ceases to do so at some period, and thenceforward dwindles. Professor Huxley has well expressed this in terms of life-material, in a lecture delivered at Edinburgh, in January, 1869. 'At any rate,' says Professor Huxley, 'the matter of life is a veritable *peau de chagrin*, and for every vital act it is somewhat the smaller. All work implies waste, and the work of life results, directly or indirectly, in the waste of protoplasm.' Is there any direct evidence of the existence of such a store of force or material as is evidently usually supposed to exist in organisms? If we look at the question from the point of view of force, it makes little difference, for force implies matter in a particular condition. It could not be maintained that one

[1] Quoted by M. Flourens, *loc. cit.*
[2] 'Method. Medend.' Lib. xi.

organism might possess a greater store of vital force or life-power than another, without there being some *material* representative of that force. Hence we must—whether taking force or matter as our text—look for some matter in the young which disappears in the old. Protoplasm, the physiological basis of life, which no doubt is the same thing as that which Dr. Beale terms 'germinal matter,' is a matter which by its increase or accumulation in an organism must increase its power—in fact, its amount of life; and, conversely, when diminished, the amount of life must be diminished. It is from the changes of this germinal matter that the formed tissues result, that repair is effected, force evolved, nutriment elaborated, secretion manufactured; and it is a matter of observation that this germinal matter is more abundant in young than it is in aged organisms. The numerous preparations of tissues, and their description by Dr. Beale, the result of his carmine process, clearly demonstrate this, and it is on all hands admitted. The quotation which follows from Mr. Paget is a fair description of that diminution of repairing power to which we shall have to refer, whilst Dr. Marshall Hall has largely detailed the decline of the vital powers in old age:—

'Some people, as they grow old, seem only to wither and dry up: sharp-featured, shrivelled, and spinous old folk, yet withal wiry and tough, clinging to life, and letting death have them, as it were, by small instalments slowly paid. Such are the "lean and slippered pantaloons," and their "shrunk shanks" declare the pervading atrophy. Others, women more often than men, as old and as ill-nourished as these, yet make a far different appearance. With these the first sign of old age is that they grow fat; and this abides with them till, it may be, in a last illness, sharper than old age, they are robbed even of their fat. These too, when old age sets in, become pursy, short-winded, pot-bellied, pale and flabby; their skin hangs not in wrinkles but in rolls; and their voice, instead of rising "towards childish treble," becomes gruff and husky.'—'Surgical Pathology,' p. 82.

The germinal matter which abounds more in youth than age, obviously embraces Mr. Spencer's physiological units, thus accounting for and correlating its power of general and special repair. It also must include Mr. Darwin's gemmules, and must be immensely called upon therefore in reproduction, far more largely, perhaps, than is represented by the mere bulk of the generative products. Mr. Spencer recognizes this, and alludes to the shrinking and diminution of the germinal matter in advancing life in the following passage: 'Protoplasm, which has become specialized tissue, cannot be again generalized and afterwards transformed into something else, and hence the progress of structure in an organism, by diminishing the unstructured part, diminishes the amount available for making offspring;' or, we may add, for carrying on the work of life. This same store of living matter is called upon and reduced in cases of great expenditure of force, such as are greater than the contemporaneous power of assimilation can supply; and it seems not impossible that this germinal matter may be the store from which Professor Parkes supposed a muscle to draw a supply of nitrogenous aliment in the absence of nitrogenous food, and when only carbo-hydrates and hydro-carbons had been supplied. This is consistent with what is known of the great danger of excessive exertion, especially in the absence of abundant nutriment.

The ovum is composed, in its very earliest stages, of nothing but this protoplasm.[1] As development and growth advance, it gives rise to the formed tissues, increasing itself also in bulk. But the germinal matter never increases at the same rate as the whole organism; it is always diminishing relatively to the whole, though increasing absolutely as long as growth continues. This gives us some insight into the way in which the change in the vitality of youth and age occurs.

But there is a more important action than this. What is it that limits growth? what gives the limit to size? Mr. Herbert Spencer ('Principles of Biology,' vol. i. p. 128) very fully enters into this matter, and clearly shews that *expenditure* (expenditure which uses

[1] There is not even a cell-wall, according to the recent very important researches of Dr. Edouard Van Beneden.

the matter of life, and prevents its accumulation) increases more rapidly than growth; there is not a direct agreement between the increase of the one and of the other. This appears from the following considerations. It is demonstrable that the excess of absorbed over expended nutriment must, other things being equal, become less as the size of the animal becomes greater. In similarly shaped bodies the masses vary as the cubes of the dimensions, whereas the strengths vary as the squares of the dimensions. 'Supposing a creature which a year ago was one foot high, has now become two feet high, what are the necessary concomitant changes that have taken place in it? It is eight times as heavy, but the muscles and bones have increased their power only in proportion to the areas of their cross sections; hence they are severally but four times as strong as they were. Thus, while the creature has doubled in height, and while its ability to overcome forces has quadrupled, the forces it has to overcome have *grown eight times as great.* Hence, to raise its body through a given space, its muscles have to be contracted with twice the intensity, at a double cost of matter expended.' Mr. Spencer shews that the same relation is true for the absorbing surface, which has only increased fourfold, and for the circulation of nutriment, which has to be transmitted to an enlarged periphery. Thus, then, the period of growth must be limited; thus a period must be reached when the germinal or living matter is no longer accumulated but is destroyed; thus the inherent cause of death has a structural existence. The apparent absence of inherent decay in many trees, in fish, in some reptiles, is alluded to by Mr. Spencer. He attributes it, as we have done above, to their exceedingly small expenditure; trees and plants generally exhibiting no personal expenditure at all, whilst fish and cold-blooded inert reptiles shew very little indeed. Mr. Spencer also remarks that a strict inductive confirmation of the law of increase of expenditure and of growth must not be expected, since the bodies compared, e. g. fish and mammal, are not of the same density or chemical constitution entirely.

Another circumstance co-operates with the arrival of a period of balance between the expenditure and the accumulation (and depends on that period) to influence the natural termination of life. The condition of equilibrium between expenditure and nutrition, growth having ceased, might be maintained for an indefinite time, were it not that precisely at this period a new form of expenditure, involving a very severe tax, sets in—namely, reproduction. It is when a stationary condition has been reached that we may anticipate from general laws new adjustments of the whole aggregate; whilst the changes of the more adaptable state of *growth* were in course, whilst concrete shape was being built up, discrete shapes were less likely so to be; and hence it is, when growth has ceased or nearly so, that reproduction sets in.

The effect of this additional tax is to start the organism more rapidly down the incline towards the termination of the road of life, the length of time occupied in the downward run depending no doubt on the height of the hill which has been mounted, and on the friction, inclination, and additional acceleration, if any, of the descending body. An accident on the way may bring the imaginary rider over some precipice to the bottom of the course at once, and it is little likely that he will succeed in avoiding the many dangerous corners and pitfalls which increase towards the end of the road, and finally expend the full amount of impulse in traversing the whole course.

Some organisms may continue to grow and produce young throughout their life; but the earlier reproduction is commenced, and the more rapidly it is carried on, the sooner must the increase of the organism's bulk be stopped, and so waste and death ensue. Fish, molluscs, and trees are the extreme cases of this protracted period, which was explained as due to small personal expenditure. A test of the superabundance of the matter of life is seen in the reproduction of lost parts which Salamandroid Amphibians, and also Crustacea, exhibit during a considerable period of life,[1] though it may be questioned

[1] The power is possessed by the *larvæ* only of insects.

if they possess it after their last moult, if they ever have a *last* moult. Salamanders and Crustacea belong to the same category as fish.

A second lot of organisms die at once upon the setting in of reproduction by the rapid abstraction of the matter of life contained in the eggs and sperm. The Protozoa are typical of this group, for in them the formed matter of the organism is all that remains after reproduction, the entire mass of the germinal or living matter being used in reproduction. Hence there is no after-life, no down-hill run. It is the same with insects and with annual plants; so much of the living matter is taken that they have not power to recover the loss; even assimilation is stayed. The animals of the former group of small expenditure could recover their generative loss, not being called upon simultaneously in other directions.

A third group have the procreative subtraction coming on late. It checks growth and finally stops it, but it is so moderate as to leave the organism enough living matter to go on with, and life ceases only when the living matter is so far reduced as to be unable to keep the existing structures in adequate repair, or provide sufficient material for the necessary outlays of force. Such cases are presented by mammals, birds, and possibly some trees and shrubs.

It may not be out of place here briefly to state how death may be brought about by mechanical causes and external agencies in those organisms whose period of natural decay is very remote. There is of course the chance of accident, which is greater in a long life than a short one. But there are two examples of self-adjusting, or rather self-destroying tendency in the organism, to which allusion may be made. Trees increasing in size as they grow older, expose a larger surface to the wind, whilst the roots cannot penetrate beyond the limited soil; they thus are more liable to get blown over year by year. Again, increasing as they do and being stationary in position, they encroach on each other's area, and exhaust the limits of soil and space by their united action, what is enough for one being not enough for five or six. In the case of animals, the same mechanical limit appears; where the food is diffused and taken in numerous but small mouthfuls (i. e. as in herbivorous and scavenger animals, not prædaceous animals), five small mouths will be more efficient in supporting five pounds of an animal than one big one. It is thus that the Maori fly is expelled by the smaller European house-fly. It is thus that large fish, large molluscs, large crustacea of species with diffuse food receive a limit to their life. The greater danger of all kinds involved in increased *surface* also tends to limit life in such organisms.

We have yet to ask how the exact or approximate period of natural death comes to differ in various species by heredity. We have seen how it is possible for a limit to be inherited; but how does the period so limited come to be an hereditary quantity characterizing species? How is it that it varies in animals which commence life and carry it on under very much the same conditions? The specific accidents, actions, wear and tear to which different species are severally subjected are not sufficient alone to account for the fixity of the period, though their influence is important. There is something additional, some more direct cause than these, and we must look for it in the quantitative limitation of the germinal matter itself, varying in species. If it were not so, how can we account for the fact that a cow and a sheep,[1] which start from ova so exactly identical in form and size, composed probably of equal amounts of germinal matter or protoplasm, subject as they develope to the same external influences, living perhaps side by side in the same field, yet differ in their inherited term of life, which appears to be, as nearly as can be guessed, about twenty years for the larger and twelve for the smaller ruminant? We have seen that the expenditure increases during growth more rapidly than the bulk, more rapidly *à fortiori* than the accumulation of germinal matter, which we saw did not increase even as rapidly

[1] This illustration and the arugment are borrowed from Mr. Herbert Spencer, who discusses the question of size.

as the bulk. We may regard this germinal matter as a sort of stock-in-trade with which the losing game of increasing profit or accumulation, but more rapidly increasing expenditure, has to be played. 'The rate at which a man's wealth accumulates is measured by the surplus of income over expenditure, and this, save in exceptionally favourable cases, is determined by the capital *with which he begins* business.' In the transactions of an organism we trace the same three elements. 'There is the expenditure required for the obtainment and digestion of food, there is the gross return in the shape of nutriment assimilated or fit for assimilation, and there is the difference between this gross return of nutriment and the nutriment that was used up in the labour of securing it.' As long as this is in excess, we have an increase of living matter and an increase of structure, and clearly the larger the capacity of the animal to take in food, &c., on commencing life (individual life), the larger and the *longer*[1] will be the accumulation of germinal matter by the increase of bulk (profit). Say that each year the profit doubles, whilst the expenditure trebles, with a capital at starting of 6 units, whilst the expenditure is a third of the capital, and the profit cent. per cent., or equal to the capital at starting. In the *fourth* year, with these figures, we shall find that the capital commences to diminish, the figures

[1] Mr. Spencer does not discuss time at all.

representing its condition in the same units being respectively for the four years, 7, 13, 19, and 13, whilst it descends to 1 in the fifth year. Now, for comparison, suppose 9 units as the initial capital, and the same relations of expenditure and profit, we shall find that the diminution does not commence till the *fifth* year, the growth thus continuing a year longer, the figures being 15, 24, 35, 36, and 33 respectively.

These two cases, in which the quantities are of course merely arbitrarily chosen for example, and in which the ratio of expenditure and profit as to increase is exaggerated, suffice to demonstrate the principle, which may be applied to organisms. It is because the calf at birth is a much larger animal than the lamb, having been carried longer by its parent, who from her greater size could of course give to the offspring a greater proportionate amount of living matter to commence life with, that the cow lives longer than the sheep, or rather inherits a later natural limit to life. The quality of the germinal matter and many other conditions which have to be provided for, in laying down such rules as this, by the expression 'cæteris paribus,' must always be taken into consideration.

We have, then, seen reason to think that the duration of life, after growth is completed or coming to an end, depends on the amount of living matter accumulated during growth, and that this depends on the size at birth, *cæteris paribus*. Thus it is that we may trace the rationale of that connection between time of growth, time of gestation, and potential longevity, which has been pointed out,[1] though we can see no good reason why the number 5 or any other number should express the ratio for a whole class of animals.

6. *Elements of the Life Period.*

It is obvious that by increasing the duration of any one part of the lifetime of an organism, the sum total or whole may be lengthened, and it may be useful, therefore, to consider what are the phenomena which most clearly involve periods of time for their manifestation in organisms.

They are, 1st, the period of evolution (including in this term both growth and development); 2nd, the period through which reproductive activity is spread; 3rd, the period of dissolution or decay. Any condition of existence which necessitates the lengthening or shortening of one of these periods for the requirements of the organism directly affects longevity. In the period of evolution are included the period of embryonic development, of fœtal life and incubation, the larval period, which many animals exhibit, the period of growth as indicated by osseous completion or similar perfection, or the assumption of the mature

[1] Both by Flourens and Buffon, as well as the earliest writers on longevity.

state. To the period of dissolution belong those slow senile changes, or that rapid exhaustion of power, which it is clear from the preceding section depend on the period of growth, in large measure as to their length, but which are also affected by external agencies, which will be referred to again. The period of reproductive activity is a variable quantity according to the case, in some lasting but a brief day or hour of the whole life, whilst in other organisms, for certain definite objects, it may be prolonged over a considerable time, recurring at intervals. This period does not seem to depend directly on the period of growth at all, but it is distributed to organism with regard to other and special conditions.

7. *High Individuation favours Longevity.*

Having seen, then, that the period of evolution is a very important item in longevity, since (p. 44) the period of dissolution depends directly on it, as to duration, we are in a position deductively to make the proposition that potential longevity varies with, or is favoured by, high evolution, if it be admitted that high evolution, i. e. complex structure and large bulk, both or either, are identical with evolution occupying *long time.* A few considerations will prove that this is admissible. You cannot have mere growth of bulk without time, as is obvious from general facts; the very word 'grow' implies not a sudden but a gradual acquisition of volume. We infer that a great thickness of strata, or of other such accumulations, has taken a long time to grow, measuring the time by the bulk; similarly, a large population or a large city is known to take a long time to accumulate. That complexity and interdependence of structural arrangement also implies time spent in the evolution of those arrangements, is proved from the observation of other cases of non-organic development. A language, a civilization, a city, a land-surface, the sidereal system, are universally admitted to have taken time in their growth in proportion to their complexity, in proportion to the extent of redistribution and readjustment of parts of which they bear tokens. And so we may infer that high organic complexity and high organic bulk, both involved in the term 'high evolution,' or better perhaps 'high individuation,' postulate time in proportion, and we may conclude that high individuation favours longevity.

8. *Small Expenditure favours Longevity.*

We now come to a proposition which we have already anticipated in previous paragraphs, and which has great importance, qualifying largely as it does the application of the preceding, and explaining the reason of the existence of a normal potential longevity limited in some cases abruptly by natural decay, and in other cases only remotely so. It is the influence of expenditure on longevity which really gives rise to that complication which led us to distinguish normal and absolute potential longevity. (See *antea*, p. 25.) Expenditure, which was pointed out as increasing more rapidly than the means of supplying the loss it involved, and thus limiting natural life, may be increased greatly or diminished in organisms according to their requirements, and may be so far diminished as never actually to allow that period of balance and the subsequent one of decay, which we saw occurred in one group of organisms, to come on in another.

Expenditure is of two kinds—that involved in the wear and tear of obtaining and assimilating food, and generally carrying on the life, and that involved in the propagation of the species by the elaboration or separation of living portions of the parent organisms. We may distinguish these as—(1) personal, and (2) generative expenditure; and we may affirm, that by diminishing or increasing either of these, you favour or antagonize longevity. This follows deductively from the conclusions arrived at with regard to the relation of organic structure to longevity. Expenditure of either sort uses up the matter of life, and hastens on the period of natural decay. It is observable that these two forms of expenditure are naturally, *inter se*, antagonistic, on the old principle that 'one cannot have a pie and eat it.' If personal expenditure is great, as a rule generative expenditure will be small, and *vice versâ;* and when they both exist in large (that is, large relatively to the degree of evolution) quantity, the longevity is greatly diminished. A complication introduces itself here in the fact that great personal expenditure, antagonizing longevity, accompanies high evolution rather than low—high evolution which favours longevity. The injurious influence however of the personal expenditure, possibly increased in some directions, is counteracted by diminished expenditure in other directions, which high structure brings to its possessor in the form of advantages in securing nutritious food and escaping noxious agents; and further, the increased personal expenditure tells almost invariably upon the *generative* expenditure, which is small in highly-evolved organisms, or organisms of high individuation.[1] Thus the whole average expenditure is not necessarily greater in highly-evolved organisms, like things being compared to like.

There are other minor and more direct influences affecting longevity in organisms, which may possibly be brought under the general heads of Evolution and Expenditure, but to which further reference will be made in discussing the two propositions inductively.

[1] This relation is clearly brought out in Mr. Spencer's chapters on the Antagonism of Individuation and Genesis, and of Expenditure and Genesis.—'Principles of Biology,' vol. ii.

9. *Why Longevity is thus influenced.*

Before proceeding to do this—the propositions standing thus: 'The potential longevity of a species is favoured by high individuation and by small expenditure, both generative and personal, and is antagonized by small individuation and by great expenditure, either generative or personal,' we might ask why is it that this agreement of long duration of life with high evolution and antagonism to expenditure has been instituted or has arisen in the slow development of ages? If we can see what purpose the Creator may have designed to serve by such a disposition, or by what antecedent necessities He has caused it to arise, greater probability of truth will have been deductively added to the conclusions.

The amount of a species must be directly proportionate to the amount of its accessible food. It is on this fundamental relation that the argument rests. If the relations above shewn assist in adjusting the amount of the species to the amount of its accessible food, we can understand their purpose, or how they must have arisen. Without going into detail as to other terms introduced in the argument, we may briefly endeavour to shew how such an adjustment is favoured. The argument is developed at length for the quantities, Fertility, Genesis, Individuation, Nutrition, in Mr.

Spencer's chapters on the Laws of Multiplication. The amount of the species is made up by these three factors: (1) the number born—i. e. the fertility; (2) the average longevity (affected by early death-rate and difficulties of development, see *antea*); (3) the potential longevity. If a case is taken where the amount of food is increased, or the accessibility of food increased, including in this all increased facilities in carrying on the life, you must, to maintain the balance of species and food, increase the amount of the species either by increased fertility, by increased average longevity, or by increased potential longevity. It is of the last only that we have here to speak. The relation of expenditure as antagonistic to longevity tallies with this necessity thus. Increased accessibility of food, of the means of life, clearly renders less personal expenditure necessary; less exertion is required in obtaining it, and may be less in digesting it; also less waste of material in maintaining the temperature (for that condition may be included in accessibility of food), and with this there will be, according to our proposition (p. 47) increased potential longevity. Thus the balance may be maintained through the antagonism of personal expenditure and longevity. Should increased accessibility of food produce increased generative expenditure, as it may[1]—though the potential longevity should,

[1] Mr. Spencer clearly shews this in his chapter 'Coincidence of High Nutrition and High Genesis.'

cæteris paribus, be diminished—yet that this relation is duly consistent with the requirements of the case is seen in the fact that increased generative expenditure means increased fertility; and so the equation Fertility × Average Longevity × Potential Longevity = Food × *c* is maintained; the diminished potential longevity being directly corrected by the correspondingly increased fertility. It is not necessary to shew that the correspondence is true for diminished food, since it is sufficiently obvious.

Next as to Evolution or Individuation. Increased food does not at first sight appear to go with high individuation, and thus admit of the balance in the equation being struck by the consequent increase of potential longevity. Low organisms feed on abundant and widely dispersed food, and fulfil the requirements of the equation by their increased fertility. But increased food, in the sense of more nutritious food, and more of it for each individual, does go with increased individuation, and at the same time *diminished* fertility accompanies increased individuation;[1] hence the balance has to be made up out of the other two terms, average and potential longevity, and we have seen that it is so made up by the relation of individuation and longevity, deduced above. Then as to the effect of decrease of food; by *absolute* diminution of food accessible to the species, you do

[1] This must be accepted from Mr. Spencer, who fully demonstrates that this is the case.

not get increased evolution, but rather the reverse process; on the other hand, if we may assume the theory of progressive development of species, it is by a decreased *accessibility* of food that higher evolution is brought about, new developments, fresh powers and activities, being originated to cope with the increased difficulties, and this results in such a gain to the individual,[1] that food may become more abundant to it in its improved structure than it ever was before; in this case, the species survives and becomes dominant. In this case, clearly, the apparent diminution of food becomes in reality an increase, and thus again in the equation fertility $\times$ average longevity $\times$ potential longevity $=$ food $\times c$, the change in the quantity 'food,' as well as the diminution in 'fertility' necessarily accompanying increased individuation, is counterbalanced by the increased longevity accompanying increased individuation. Difficult and deeply involved as the analysis here attempted is, and especially hard to discuss without entering into much detail (already fully treated by Mr. Spencer, but not in relation to longevity)—yet the above outline may serve to shew why it is that the relations which we have seen reason to believe, do exist for longevity, should exist.

[1] Mr. Spencer shews that the increase of individuation is greater than the increased difficulties which call it forth, and that thus there is a surplus of power to the evolved form, which may make itself seen in a greater fertility (or we may add, a greater longevity) than a direct ratio of individuation would admit.

10. *Inductive.*

We may now endeavour to see how far observation supports the deductive hypothesis that longevity is favoured by high individuation, and small expenditure, both personal and generative. And here again we must allude to the profound ignorance in which we are as to the exact potential life-period, by whatever standard it be given, of any animal. Those which we have under observation we influence abnormally, and those which we have not under observation we know little about. We must then, as well as we can, make allowance for abnormal influences, and depend largely on general impressions. A list of statements as to the longevity of different groups of organisms is hereto appended, derived from the works of many authors, and from private sources of information. It is by no means a satisfactory accumulation of data, but it is believed that under present circumstances nothing better can be drawn up.[1] Lord Bacon's chapter on the same subject is added in full, in order that the reader may appreciate the state of knowledge in his time as to the question. It will be seen from many of his remarks that he had the notion that bulk favours longevity, and that personal and generative expenditure antagonize it.

[1] Any *trustworthy* additions to these statements will be very acceptable to me.

Statements as to Duration of the Individual in Organisms.

ANIMALS.

PROTOZOA.—Cause of death is the breaking up of the whole living substance into generative particles, or its division into two or more new individualities. Persistence of life unknown in nearly all cases.

Protomyxa aurantiaca—a Moneron—is stated by Haeckel to take from 4 to 6 days in the process of division. (Monogr. of Monera. Quarterly Journal of Microsc. Science, 1869.)

Amœba probably takes longer.

Infusoria have been seen to divide every half hour. (H. Spencer.)

Zoothamnium—a Vorticellidon—every 2 hours. (Brightwell.)

* *Spongilla fluviatilis* dies yearly, leaving reproductive masses, the so-called seeds.

CŒLENTERATA (Polyps).—Some appear to die annually or on reproduction, others continue to live and grow till mechanical causes bring death.

* *Hydra viridis* reproduces sexually in the autumn and dies.

* *Actinia mesembryanthemum* has been living 42 years in an aquarium. (Sir John Dalyell and Dr. Flemming.)[1]

Compound Hydrozoa live for a much longer period than one year.

Compound Actinozoa also; but the masses of coral in the Red Sea, estimated by Ehrenberg to be 3000 years old, do not indicate the longevity of simply a tertiarily aggregated individual, but of many generations of asexually produced individuals whose parent stocks have died time after time.

ECHINODERMATA, from the great variation in size of mature specimens of the same species, are inferred to die only from mechanical or accidental causes. No observations on record.

[1] A letter from Mr. C. W. Peach informs me that 'granny,' as this Actinia is called, is still alive and well, in spite of once being accidentally buried in white-wash.

VERMES (Worms).—*Turbellaria*, unknown longevity; they have more than a year's life.

Parasitic forms have interposed periods of quiescence (encysted Tœnia solium and Trichina), but die on reproduction.

* *Rotifera* die yearly or half-yearly in some cases consequent on reproduction.

ANNULATA (Ringed Worms).—None but a mechanical limit to life is apparent. From the rate of growth and size, many years of life are inferred for *Lumbricus*, *Eunice*, *Aphrodite*, and *Amphinome*. The smaller but not the larger Oligochæta die in winter after reproducing sexually.

CRUSTACEA.—The larger forms (*Decapoda* and some *Schizopoda*, also *Merostomata*), from their great range of adult size, are inferred to continue growth long after sexual maturity, and no period of natural decay is known to be reached.

Smaller forms; many die annually, in the same way as Rotifera.

* *Cheirocephalus diaphanus* developes from the egg, reproduces, and dies in 2 to 3 months. (Observed by the writer.)

* *Cancer pagurus*, of great size, was observed with adherent Cirrhipedia, which must have become attached subsequently to the last moult, and have taken some years in their own growth. (Communicated by Thomas Bell, Esq., F.R.S.)

INSECTA.—The Imago, as a rule, lives part of a year—from 6 months to a few hours—dying on reproduction. The length of life of the larva varies greatly in closely allied forms, from 4 years or more to a week. (Coleoptera, Diptera.)

* *Rose-chafer* (Scarabæus auratus) was kept and observed 4 years in larva and 2 years in imago. (Leo Grindon, 'Life, its Nature,' &c.)

* *Vanessa Cardui*, usually observed to die at the end of the year, was kept by a lady 3 or 4 years. (Rev. J. G. Wood.)

? *Mantis religiosa* is said to attain 8 years of life. (Leo Grindon, *loc. cit.*)

Butterflies which escape copulation are known to hybernate and live a second year, or part of it, as imagines.

* *Flea*, 9 months in imago. A man is now in London with performing fleas, and he finds that 9 months is a very great age for them to attain.

MYRIAPODA—ARACHNIDA.—The large forms are supposed to live longer than Insects, but this idea may be due to the absence of metamorphosis.

MOLLUSCOIDA.—?

MOLLUSCA (Snails and Mussels) are in the same case as large Crustacea as to long growth, and absence of observed period of decline. No observations. [The same Limpet might probably be observed for many years.] It is known from the rate of growth of the shell that some Mollusca must live 20 years or more.

FISH.—Great variation in sizes of adults (from 10 to 100 lbs.) of the same species. They are not *known* to get feeble as they grow old, and many are known *not* to get feebler.

* *Carp*,[1] 150 years old, and lively (seen by Buffon in pond of Comte de Maurepas). The same fish were seen by Duhamel.

? *Pike*, 267 years old—if a ring with the following inscription which was attached to it be genuine:—'I am the fish which was first of all put into this lake by the hands of the Governor of the Universe, Frederick the Second, the 5th of October, 1230.' It weighed 350 lbs., and was 19 feet long. Its skeleton was exhibited at Manheim. Taken in Suabia, at Halibrun, in 1497. (Gesner, quoted by Yarrell.)

* —— 90 years old. (Pennant, quoted by Yarrell.)

Muræna, 60 years old, in the Roman vivaria. (Pliny, quoted by Bacon and Hufeland.)

Salmon of sufficient size, according to their rate of growth, to lead one to infer 100 years as age, are recorded by Yarrell.

AMPHIBIA.—The fish-like forms may agree with fish in their longevity. The Batrachia appear to have a period of senility and decay.

* *Sieboldia maxima* has been in the Zoological Gardens for 10 years.

? *Toad*, 36 years. (Smellie, quoted by L. Grindon, *loc. cit.*)

? *Frog*, 12–16 years. (Grindon, *loc. cit.*)

[1] Carp were observed by Yarrell to weigh 6 lbs. at 10 years; the largest he could ascertain the weight of was 18 lbs. The rate of increase is probably not uniform, diminishing with age, but never ceasing entirely.

REPTILES.—Some are believed to grow as long as they live, are very slow in growth, very long-lived, and very variable in average adult size; e.g. Chelonia and Crocodilia; others, as the Lacertilia, are much more constant in size, and are believed to be shorter-lived.

Crocodiles, some of the sacred crocodiles of India, have been known since the Conquest.

* *Tortoise*, from the Galapagos, was inferred to be 175 years old from its rate of growth in the Zoological Gardens, London. (Grindon.)

* *Tortoise*, from the Cape, which had been in the Governor's garden for 80 years; it was believed to be 200 years old. (Communicated by T. Bell, Esq., F.R.S.)

BIRDS.—Their growth is limited; they appear to get feeble at a certain age, varying in species, and like mammals may die of 'old age.'

* *Parroquet*, 120 years old at death, lived at Florence for 100 years in a noble family. (Fontenelle, quoted by Flourens, 'Human Longevity,' trans. by C. Martel.)

* *Parrot*, ? sp. 120 years old at death, lived in the family of Mr. W. for 80 years; it was said to be 40 when brought to Mr. W.'s great-grandfather. (Communicated.)

? *Goose*, 100 years. (Willoughby.)

? *Falcon*, large species, 162 years, from inscription on an attached ring. It was brought from the Cape in 1772. (Hufeland, 'The Art of Prolonging Life.')

? *Raven*, 180 years. (Buffon.)

The following seven facts were communicated by Mr. Darwin:—

* *Saxicola sialis*, for 10 years and more was observed to build its nest in same spot. ('Amer. Jour. Sci.' vol. 30, p. 81.)

* *Muscicapa fusca*, 9 years; same observation.

* *Turdus*, for a longer period.

* *Falco borealis*, 12 years.

* *Starling*, for 8 years the same lame specimen was observed by Eckmark.

* *Kestrel*, for 6 years the same specimen was seen.

* *Goldfinch*, lived 23 years in confinement. (Montagu.)

BIRDS (*continued*).

?	*Pelicans* and *Herons*,	40–50 years.	(L. Grindon, 'Life, its Nature.')	
	Hawks	30–40 years.	,,	,,
?	*Peacocks*	20 years.	,,	,,
	Goldfinches . . .	,,	,,	,,
?	*Blackbirds* . . .	,,	,,	,,
?	*Pheasants* . . .	,,	,,	,,
?	*Pigeons*	,,	,,	,,
?	*Nightingales* . .	15 years.	,,	,,
*	*Domestic Fowls* . .	10 years.	,,	,,
?	*Thrushes*	8–9 years.	,,	,,
?	*Wrens*	2–3 years.	,,	,,

Mr. Grindon does not give his authority for these ages. It will be seen that he differs from Bacon as to the ages of some birds and mammals.

MAMMALS.—The general cause of death is the same as for birds.

? *Greenland Whale*, 300–400 years, inferred from the growth of the Baleen. (Grindon, *loc. cit.*)

? *Dolphin*, 30 years. (Bacon.)

* *Elephant* (Asiatic), 120 years. (De Blainville.)
150 years. (Flourens.)
? 200 years. (Buffon.)
200 years. (Aristotle.)
500 years. (Sunt qui.)

* —— At 30 years the epiphyses were not joined. ('Philos. Trans.' Everard Home.)

Rhinoceros and *Hippopotamus*, 70–80 years. (Grindon.)

Horse, 25 years. (Flourens.) But the Bishop of Metz had one that lived to be 40 years old.

—— 9 or 10 years for most, but some live to 40 years. ('Engl. Cyclop.' article *Horse*.)

—— 20 years. (Bacon.)

Horse and *Ass*, 25–30 years. (Grindon.)

* *Mule*, is longer-lived than these. (Bacon.)

? *Camel*, 40 years. (Flourens.) May live to 100 years. (Aristotle.)

—— 50 to 100 years. (Bacon.)

? *Ox*, 15–20 years. (Flourens.)

Bull, 16 years. (Bacon.)

MAMMALS (*continued*).

? *Sheep* and *Goat*, 12 years. (Grindon.)
—— less than the Bull. (Bacon.)
Pig, 20 years. (Bacon.)
Stag,[1] 30-40 years. (Flourens.)

? *Lion*, 20 years. (Flourens.) Haller saw one in a menagerie at 40 years of age which died at 50. Grindon gives 9–10 years as the life of the lion in menageries; longer when wild.

? *Leopard*, *Bear*, *Tiger*, 25 years. (Grindon.)

* *Dog*, 10–12 years. (Flourens.) Some to 20, 23, or 24 years. One was 34 years with a correspondent of the writer.

* *Cat*, 9–10 years. Some to 18 years. (Flourens.) Mr. T. W. Danby had a cat which died at the age of 18 years; it had long been unable to move, except very slowly; it walked across a room for milk and died. (Communicated by T. W. Danby, Esq.)

Rabbit, 8 years. (Flourens.)
——— 7 years. (Bacon.)
Guinea Pig, 6–7 years. (Flourens.)
Man, Fuegian, 45–50 years.
Civilized, 70-80 years. (The Book of Psalms.)
English, 75.5, average age at death of those dying at 51 and upwards. (Farr.)

VEGETALS.

PROTOPHYTA, as with PROTOZOA.

Euglena divides so rapidly as in a single night to colour a pool green.

Diatoms, some species divide in 24 hours at certain seasons. (Smith's 'British Diatomaceæ.')

Protococcus nivalis reddens a district in a single night, so rapid is the shifting of individuality by reproductive self-division.

[1] 'Hesiod,' says Pliny, 'attributes to the rook nine times our life, to the stag four times the life of the rook, and three times the life of the stag to the raven.' Γενεά is the word used by Hesiod, and *ætas* by Pliny. Aristotle remarks, in the 'History of Animals,' lib. vi. ch. xxix, 'What is related of the longevity of the stag rests upon no foundation: the duration of gestation and growth of the young stag indicates anything but a long life.'

FUNGI live from 7 to 15 days. (Grindon.)
Polypori are perennial.

ALGÆ.—*Fuci* and other large forms are perennial.
Delesseria sanguinea is annual.

LICHENES.—?

PHÆNOGAMS.—The majority in severe climates are annuals. Mignonette is a shrub in Barbary, and Palma Christi is a tree in India.

Shrubs live 4 to 5 years.

Odoriferous shrubs live 10 or more years. (Hufeland, loc. cit.) e.g. Sage, Balm, Lavender.

Trees with soft wood, e g. Poplar and Willow, live 50 years. (Hufeland.)

Fruit trees, 60 years. (Hufeland.)

In the following list, given by Mr. Grindon, the age is estimated by rings of supposed annual growth, which is not a quite trustworthy method:—

? Cercis	300 years.	? Oriental Plane	1000 years.
? Elm	335 „	? Lime	1100 „
? Ivy	450 „	? Spruce	1200 „
? Maple	516 „	? Oak	1500 „
? Larch	576 „	? Cedar	2000 „
? Orange	630 „	? Schubertia	3000 „
? Cypress	800 „	? Yew	3200 „
? Olive	800 „	? Taxodium	4000–5000 „
? Walnut	900 „	? Adansonia	„ „

In the preceding statements the authorities are given. In many cases, the supposed age is only an inference and not an observation at all. This is especially the case with the ages given by Flourens, who made them suit his theory of quintuple ratio. A query is put against the most doubtful and an asterisk against the most soundly based of the statements made.

We now present Lord Bacon's statements on the subject, which we have transcribed from a well-known translation of his works. Truth and error are strangely mixed in this interesting summary.

'Touching the length and shortness of life in living creatures, the information which may be had is but slender, observation is negligent, and tradition fabulous. In tame creatures their degenerate life corrupteth them, in wild creatures their exposing to all weathers often intercepteth them; neither do those things which may seem concomitants give any furtherance to this information (the greatness of their bodies, their time of bearing in the womb, the number of their young ones, the time of their growth, and the rest), in regard that these things are intermixed, and sometimes they concur, sometimes they sever.

1. Man's age (as far as can be gathered by any certain narration) doth exceed the age of all other living creatures, except it be of a few only, and the concomitants in him are very equally disposed, his stature and proportion large, his bearing in the womb nine months, his fruit commonly one at a birth, his puberty at the age of fourteen years, his time of growing till twenty.

2. The elephant, by undoubted relation, exceeds the ordinary race of man's life, but his bearing in the womb the space of ten years is fabulous; of two years, or at least above one is, certain. Now his bulk

is great, his time of growth until the thirtieth year, his teeth exceeding hard, neither hath it been observed that his blood is the coldest of all creatures; his age hath sometimes reached to two hundred years.

3. Lions are accounted long livers, because many of them have been found toothless, a sign not so certain, for that may be caused by their strong breath.

4. The bear is a great sleeper, a dull beast, and given to ease, and yet not noted for long life; nay, he hath this sign of short life, that his bearing in the womb is but short, scarce full forty days.

5. The fox seems to be well disposed in many things for long life; he is well skinned, feeds on flesh, lives in dens, and yet he is noted not to have that property. Certainly he is a kind of dog, and that kind is but shortlived.

6. The camel is a long liver, a lean creature, and sinewy; so that he doth ordinarily attain to fifty, and sometimes to a hundred years.

7. The horse lives but to a moderate age, scarce to forty years, his ordinary period is twenty years, but perhaps he is beholden for this shortness of life to man; for we have now no horses of the sun that live freely, and at pleasure, in good pastures; notwithstanding the horse grows till he be six years old, and is able for generation in his old age. Besides the mare goeth longer with her young one than a woman, and brings forth two at a burthen more rarely. The

ass lives commonly to the horse's age, but the mule outlives them both.

8. The hart is famous amongst men for long life, yet not upon any relation that is undoubted. They tell of a certain hart that was found with a collar about its neck, and that collar hidden with fat. The long life of the hart is the less credible, because he comes to his perfection at the fifth year, and not long after his horns (which he sheds and renews yearly) grow more narrow at the root, and less branched.

9. The dog is but a short liver, he exceeds not the age of twenty years, and, for the most part, lives not to fourteen years; a creature of the hottest temper, and living in extremes, for he is commonly either in vehement motion, or sleeping; besides, the bitch bringeth forth many at a burden, and goeth nine weeks.

10. The ox likewise, for the greatness of his body and strength, is but a short liver, about some sixteen years, and the males live longer than the females: notwithstanding they bear usually but one at a burden, and go nine months; a creature dull, fleshy, and soon fatted, and living only upon herby subtances, without grain.

11. The sheep seldom lives to ten years, though he be a creature of a moderate size, and excellently clad; and, that which may seem a wonder, being a creature with so little a gall, yet he hath the most curled coat of any other, for the hair of no creature is

so much curled as wool is. The rams generate not before the third year, and continue able for generation until the eighth. The ewes bear young as long as they live. The sheep is a diseased creature, and rarely lives to his full age.

12. The goat lives to the same age with the sheep, and is not much unlike in other things, though he be a creature more nimble, and of somewhat a firmer flesh, and so should be longer lived; but then he is much more lascivious, and that shortens his life.

13. The sow lives to fifteen years, sometimes to twenty; and though it be a creature of the moistest flesh, yet that seems to make nothing to length of life. Of the wild boar or sow we have nothing certain.

14. The cat's age is betwixt six and ten years; a creature nimble and full of spirit, whose seed (as Ælian reports) burneth the female; whereupon it is said, that the cat conceives with pain, and brings forth with ease. A creature ravenous in eating, rather swallowing down his meat whole than feeding.

15. Hares and coneys attain scarce to seven years, being both creatures generative, and with young ones of several conceptions in their bellies. In this they are unlike, that the coney lives under ground, and the hare above ground. And, again, that the hare is of a more duskish flesh.

16. Birds, for the size of their bodies, are much

lesser than beasts; for an eagle or swan is but a small thing in comparison of an ox or horse, and so is an ostrich to an elephant.

17. Birds are excellently well clad, for feathers, for warmth and close sitting to the body, exceed wool and hairs.

18. Birds, though they hatch many young ones together, yet they bear them not all in their bodies at once, but lay their eggs by turns, whereby their fruit hath the more plentiful nourishment whilst it is in their bodies.

19. Birds chew little or nothing, but their meat is found whole in their crops, notwithstanding they will break the shells of fruit and pick out the kernels; they are thought to be of a very hot and strong concoction.

20. The motion of birds in their flying is a mixed motion, consisting of a moving of the limbs, and of a kind of carriage, which is the most wholesome kind of exercise.

21. Aristotle noted well touching the generation of birds (but he transferred it ill to other living creatures), that the seed of the male confers less to generation than the female, but that it rather affords activity than matter; so that fruitful eggs and unfruitful eggs are hardly distinguished.

22. Birds (almost all of them) come to their full growth the first year, or a little after. It is true, that their feathers in some kinds, and their bills in others,

show their years; but for the growth of their bodies it is not so.

23. The eagle is accounted a long liver, yet his years are not set down; and it is alleged, as a sign of his long life, that he casts his bill, whereby he grows young again; from whence comes that old proverb, the old age of an eagle. Notwithstanding perchance the matter may be thus, that the renewing of the eagle doth not cast his bill, but the casting of his bill is the renewing of the eagle; for, after that his bill is grown to a great crookedness, the eagle feeds with much difficulty.

24. Vultures are also affirmed to be long livers, insomuch that they extend their life well near to a hundred years. Kites likewise, and so all birds that feed upon flesh, and birds of prey, live long. As for hawks, because they lead a degenerate and servile life for the delight of men, the term of their natural life is not certainly known; notwithstanding amongst mewed hawks some have been found to have lived thirty years, and amongst wild hawks forty years.

25. The raven likewise is reported to live long, sometimes to a hundred years. He feeds on carrion, and flies not often, but rather is a sedentary and melanchollic bird, and hath very black flesh. But the crow, like unto him in most things (except in greatness and voice), lives not altogether so long, and yet is reckoned amongst the long livers.

26. The swan is certainly found to be a long liver,

and exceeds not unfrequently a hundred years. He is a bird excellently plumed, a feeder upon fish, and is always carried, and that in running waters.

27. The goose also may pass amongst the long livers, though his food be commonly grass, and such kind of nourishment, especially the wild goose; whereupon this proverb grew amongst the Germans, *Magis senex quam anservivalis;* older than a wild goose.

28. Storks must needs be long livers, if that be true which was anciently observed of them, that they never came to Thebes, because that city was often sacked. This, if it were so, then either they must have the knowledge of more ages than one, or else the old ones must tell their young the history. But there is nothing more frequent than fables.

29. For fables do so abound touching the phœnix, that the truth is utterly lost, if any such bird there be. As for that which was so much admired, that she was ever seen abroad with a great troop of birds about her, it is no such wonder; for the same is usually seen about an owl flying in the daytime, or a parrot let out of a cage.

30. The parrot hath been certainly known to have lived threescore years in England, how old soever he was before he was brought over; a bird eating almost all kind of meats, chewing his meat, and renewing his bill: likewise curst and mischievous, and of a black flesh.

31. The peacock lives twenty years, but he comes not forth with his argus eyes before he be three years old ; a bird slow of pace, having whitish flew.

32. The dunghill cock is venereous, martial, and but of a short life ; a crank bird, having also white flesh.

33. The Indian cock, commonly called the turkey cock, lives not much longer than the dunghill cock ; an angry bird, and hath exceeding white flesh.

34. The ringdoves are of the longest sort of livers, insomuch that they attain sometimes to fifty years of age ; an airy bird, and both builds and sits on high. But doves and turtles are but short lived, not exceeding eight years.

35. But pheasants and partridges may live to sixteen years. They are great breeders, but not so white of flesh as the ordinary pullen.

36. The blackbird is reported to be, amongst the lesser birds, one of the longest livers ; an unhappy bird, and a good singer.

37. The sparrow is noted to be of a very short life ; and it is imputed in the males to their lasciviousness. But the linnet, no bigger in body than the sparrow, hath been observed to have lived twenty years.

38. Of the ostrich we have nothing certain ; those that were kept here have been so unfortunate, that no long life appeared by them. Of the bird ibis we find only that he liveth long, but his years are not recorded.

39. The age of fishes is more uncertain than that of terrestrial creatures, because living under the water

they are the less observed; many of them breathe not, by which means their vital spirit is more closed in; and, therefore, though they receive some refrigeration by their gills, yet that refrigeration is not so continual as when it is by breathing.

40. They are free from the desiccation and depredation of the air ambient, because they live in the water, yet there is no doubt but the water, ambient, and piercing, and received into the pores of the body, doth more hurt to long life than the air doth.

41. It is affirmed, too, that their blood is not warm. Some of them are great devourers, even of their own kind. Their flesh is softer and more tender than that of terrestrial creatures; they grow exceedingly fat, insomuch that an incredible quantity of oil will be extracted out of one whale.

42. Dolphins are reported to live about thirty years; of which thing a trial was taken in some of them by cutting off their tails, they grow until ten years of age.

43. That which they report of some fishes is strange, that after a certain age their bodies will waste and grow very slender, only their head and tail retaining their former greatness.

44. There were found in Cæsar's fishponds lampreys to have lived threescore years; they were grown so familiar with long use, that Crassus, the orator, solemnly lamented one of them.

45. The pike, amongst fishes, living in fresh water

is found to last longest, sometimes to forty years; he is a ravener, of a flesh somewhat dry and firm.

46. But the carp, bream, tench, eel, and the like, are not held to live above ten years.

47. Salmons are quick of growth, short of life; so are trouts; but the perch is slow of growth, long of life.

48. Touching that monstrous bulk of the whale or ork, how long it is weiled by vital spirit, we have received nothing certain; neither yet touching the sea-calf, and sea-hog, and other innumerable fishes.

49. Crocodiles are reported to be exceeding long lived, and are famous for the times of their growth, for that they, amongst all other creatures, are thought to grow during their whole life. They are of those creatures that lay eggs, ravenous, cruel, and well fenced against the waters. Touching the other kinds of shell fish, we find nothing certain how long they live.'—*Basil Montagu's translation of Bacon's works, 'The History of Life and Death.'*

Let us first examine the facts given above in view of the relation of high Evolution or high Individuation to longevity. It is apparent that the longest-lived animals and trees are those of high development, and not only generally, but in comparing the members of a class or order this is found to be true. Thus we see the great trees, exhibiting no doubt the greatest bulk and greatest differentiation among plants, as having the longest life. The Vertebrata, which are the highest in evolution of animals, are, as a whole, the longest lived; for the Mollusca and Crustacea and Echinodermata, though, as stated in the list, they are not known to have a definite limit of life, yet certainly do not, on the whole, exhibit anything like so great a potential longevity as the Vertebrata. Again, amongst the Vertebrata, the longest lived are found in the Mammalia; and the whale and the elephant, living respectively 300 and 150 years, are the largest, and, in this special characteristic, as highly evolved [1] as any of the class. Then, side by side, we see the whale longer lived than the elephant on account of its greater bulk; man longer lived than the chimpanzee,[2] being larger and more highly differentiated; the ox longer lived than the sheep and goat; the lion than the ox, being although not bulkier yet of higher development. So the small Rodents and Insectivora have short lives; the mouse being said to live a shorter time than larger allied forms. It would be interesting to know as to the longevity of Marsupials; whether their lower evolution tells strongly on their

[1] Mr. Herbert Spencer says, 'Principles of Biology,' vol. ii. p. 479, 'The Elephant (which though otherwise less evolved, is, in extent of integration, more evolved)' i. e. as compared with man.

[2] Mr. Alfred Wallace told the writer that he knew nothing contrary to the supposition that the orang-outang lives as long as the human inhabitants of Borneo. This shews the difficulty there is in observing in regard to the question of longevity.

longevity, or whether bulk affects it most. The large Kangaroo, were longevity regulated by bulk alone, should live longer than the sheep. The Reptiles present *inter se* the same relations; the crocodiles and chelonia, which are certainly those of greatest individuation, being longest lived. So too the Fishes, as far as facts go, the Pike being a highly evolved fish. The Sharks may be guessed from their great size to have very long lives, which confirms the rule as to high development, though of course it cannot as to bulk. That bulk and development increase together is well ascertained from general principles. The Sharks of the later Tertiary period are calculated from the size of their teeth to have measured between eighty and ninety feet in length, and may have had a proportionate longevity. Speculation might lead one to attribute enormous longevity to the gigantic extinct mesozoic Reptiles. Amongst Mollusca, the highest in evolution are the highest in longevity, if we may judge by the size and rate of growth of some Cephalopods, both recent and extinct, as compared with Conchifers and Brachiopods. The Insects *inter se* present facts supporting the truth of the proposition as to high evolution: the Coleoptera and Orthoptera, undoubtedly from their carnivorous habits (in many cases) and generally dominant character, the most highly evolved, are the longest lived, according to observation, e. g. Scarabæus and Mantis.

Amongst Birds, the most striking case is seen in the exceeding longevity, which is well ascertained, of Parrots. They are undoubtedly the very highest of Birds in development, and they live probably the longest. The facts as to age do not however relate to their normal potential longevity, we have to guess that from the experiment in abnormal conditions.

Next, as to generative expenditure.[1] Since this generally and clearly increases with diminished evolution, it is not difficult to establish the contrast between it and high longevity, as a general rule. The Protozoa and Protophyta are exceedingly prolific, an Infusorian being calculated to produce 268 millions in the course of a single month (Paramecium): another 170 billions in four days, and their duration of life is correspondingly of the shortest. Insects are exceedingly prolific, and hence, in spite of their high evolution, very short-lived. Many insects deposit 300,000 ova, but, what is a more important item of consideration, they deposit an enormous bulk relatively to their living matter. Compare the not far distant but inferior Annelids, and they are seen to be

[1] It does not appear worth while to consider asexual and sexual genesis separately, where so little is to be said. But it does appear from the facts that asexual genesis is less severe a tax, and therefore less inimical to longevity than sexual genesis. Thus Chætogaster and other worms live and reproduce asexually in abundance, but at length sexual genesis occurs and they die. It is in those cases where asexual genesis partakes of the nature of growth rather than germ-production that it is least severe in its effect on longevity.

longer lived, for though in most cases possessing large genital organs, they do not deposit their ova or sperm so early or so rapidly as the Insects. The Vertebrata are by no means prolific (except fish), and at the same time are longer-lived than Invertebrata.

Fish are long-lived, in spite of considerable generative expenditure,[1] the explanation lying in the diminished personal expenditure involved in their aquatic life. This, too, affects greatly the case of Annelids just quoted. Amongst Birds it is easy to point out that smaller broods go with a greater longevity: thus the Eagle has but one or two eggs, the common Owl four or five; Finches two broods of five in a season, and the Wrens and Tits eight to fifteen; and these, as appears from our list above, stand in the same order as to longevity. It is very difficult indeed to find particular cases in which the direct action of generative expenditure on longevity is apparent, for it affects other quantities before longevity, or its action is counteracted by fluctuations in these quantities, as,

[1] The bulk of the ova and sperm in fish is not so large as the *number* of the ova lead one to think; and moreover, as a rule, they give no parental attention, which is a most important item of generative expenditure. In those fishes which do, e. g. Pipe-fish, Hippocampus, and Arius of the Amazons, the bulk and number of the ova is immensely reduced.

This item of parental attention is what in the case of man and other animals tends much to balance the male and female generative expenditure, for the male feeds both mother and young for a considerable time by his *exertion;* hence the female's expenditure of *substance* is in some degree balanced.

for example, in personal expenditure and degree of evolution. One ought to compare organisms which are alike in these two last quantities. In trees, we may take the pear, apple, and such fruit-trees, and we find that they are excessive in their reproductive expenditure, and short-lived as compared with other trees which agree (as do all Vegetals) in the absence of personal expenditure, and are of equivalent individuation. In animals[1] we may best compare experimental cases: thus we find that animals used for breeding, and made to breed early, are less long-lived than those which are not so used.[2] There are, besides, two important cases to compare, viz. mules which are born incapable of reproducing, and animals which have been operated upon. With regard to the Mule, Bacon states that it lives longer than either the Horse or the Ass, which confirms the hypothesis that generative expenditure antagonizes longevity. But as to the results of operations, it appears that, as in cases of forced abstinence, a disturbing element is introduced by the interference with the proper functions and nutrition of the animal. The principle of Treviranus, 'that every organ is as an excreting gland to the rest of the body' must be remem-

[1] The case of Actinia is alluded to farther on. Its longevity is an example where small generative expenditure, either asexual or sexual, entails long duration of the individual.

[2] This statement is derived from general assertions and needs confirmation.

bered, and we can comprehend that by the removal of generative glands no advantage as to longevity would accrue to the organism, but perhaps great injury, whilst the abeyance of normal functions will equally not prevent that nutrition of the organs and their growth, which is a great part of the tax of generative expenditure. At the same time, both castrated organisms, and those restrained from the sexual act, gain in the possible absence of nervous excitement, which has 'a relatively enormous costliness,'[1] and by not losing the simple weight of the emitted generative product. It does not appear from facts, that castrated animals are longer-lived than those normal, neither amongst men nor lower animals, nor that celibates, male or female, among either men[2] or lower animals, have a large if any advantage.

Passing on to personal expenditure, we find more numerous facts in the list to support our deductions. Aquatic animals, generally, have less personal expenditure than terrestrial animals; they are supported in the water, the temperature fluctuates little, their

[1] Spencer.

[2] It is exceedingly difficult to make estimation as to male celibates; the *unmarried* have a considerably higher death-rate at ages below fifty among males than the married, but there are not statistics to shew that of the numbers surviving there is a less expectation of life than among the married, or widowers. It is impossible to be assured of the strict abstinence of any group of men. Amongst women the oldest are widows, but the relative ages of marriage of males and females, and the numbers of married and unmarried affect these numbers vastly, and their influence *cannot* yet be eliminated.

food is abundant, for waters 'team with life' truly more than the atmosphere. Terrestrial animals, whilst supporting themselves mostly on the ground, live in the air, and in very few cases is their food to be found abundantly in this medium, and accordingly their expenditure in getting food is greater. Thus among Vertebrata, the Whale is long-lived, the Crocodiles and Chelonians are long-lived, the Salamandroids and the Fish. It does not appear certain that the Batrachia (Frogs and Toads) are shorter lived than the Salamandroids; their terrestrial habits involve greater expenditure, but their very much higher individuation may counterbalance this. Among Invertebrata, the Mollusca are long-lived; the Pulmonata less so than the branchiate Gasteropods. Paludina and Lymnæus living in the same pond differ thus in age,[1] whilst no land Mollusc is as large (and therefore probably from what we have seen as long-lived) as many hundreds of aquatic (marine) species.

The aquatic Arthropods (Crustacea), excluding the minuter forms, are most broadly contrasted with the terrestrial Insects, Myriapods, and Arachnids, in respect of length of life, as we have before mentioned, and set forth in the list. Descending lower, we find no terrestrial groups to compare.[2]

[1] As far as the writer's observations go, Lymnæus lives four years, and Paludina seven or eight.

[2] There is the terrestrial leech, and there are the terrestrial Planariæ, or ground Flukes, the longevity of which is not ascertained.

Reptiles living in hot countries, and feeding on large masses of food at intervals, have small expenditure and live long. The higher Reptiles are the most sluggish and inert of any animals in proportion to their degree of development; and hence, their expenditure being small and their development high, we should expect them to exhibit great longevity, which they do. A very instructive contrast is afforded by Birds and Reptiles, which are so closely allied in structure. The active, expending Birds are short-lived as compared with such Reptiles as the Tortoise and Crocodile.

Echinoderms, being exceedingly sluggish, living on the most easily obtainable food, in many cases, viz. the organic matter diffused in sand, live longer than would be expected from their comparatively low place in the scale of life. Actinia, which is also almost like a vegetal as to absence of personal expenditure, as are other sedentary cœlenterates, owes its great longevity to a relatively high evolution, in respect of *integration.* It buds never (or rarely), and breeds sexually but little.

The parasitic worms and crustacea might be expected to have a great longevity from the total absence of personal expenditure; but here, as in many plants, there is enormous generative expenditure, which shortens life, the small percentage of those born which ever get into the happy conditions of a stomach or gill, being the reason for this great generative outlay. Most of these forms die on reproduction. Tænia does not die at once, because of its tertiary aggregation; that is to say—it is separated into a number of joints, which, one by one, come to maturity and die, whilst new joints continue to grow from the head.

These are some of the most striking inductive verifications which the collected statements furnish; others are to be found by a further examination of the list.

11. *Other Relations of Longevity.*

There seem to be some minor modifications of the terms 'evolution' and 'expenditure' which affect longevity, and which do not strike us at once as coming under those heads, and yet are very plainly influential in the result. How difficult it is to get clear views in the intricacies of such a problem as the one before us, we may let Mr. Spencer say, who shews, in his chapter on the Inductive Verification of the Laws of Multiplication, the frequency of complications which can only be dealt with by the use of the phrase 'cæteris paribus' as a continual qualification.

Animals which feed on large masses of food, of great concentration—as, e. g. other animals, or special fruits and portions of trees—are longer lived than those feeding on diffused and widely-spread food, as the lower sorts of vegetable growth and decaying material. This we see in the greater length of life of carnivorous and frugivorous animals as compared, *cæteris paribus*, with herbivorous and garbage-eaters. This reduces itself to a case of evolution and bulk; for in the first group it is an advantage to be large and highly endowed, to be swift and powerful, and to secure the whole mass by one effort. In the second group, five mouths will take in more nutriment than one, it being equally diffused; and hence it is better for a given bulk of the species to be divided into five small individuals than retained in one large one. Where the acquisitive power increases more nearly with the bulk, as in vegetals, such a distinction does not hold. It is in accordance with this relation of bulk to food that insects which feed on widely-spread vegetable juices, or similarly wide-spread garbage, are shorter lived than the birds which prey on the insects, or than other insects which are carnivorous; and that the lower animals, generally feeding as they do on diffused food, are shorter lived. Thus the frugivorous apes are longer lived than other animals similar to them in many other matters which are not fruit-eaters; carnivora generally than herbivora, in the various classes and orders, *cæteris paribus*.

Another apparently important influence in longevity is what Mr. Spencer calls 'tertiary aggregation.' This is obviously only a form of increased evolution. Mr. Spencer supposes that what has been somewhat unaccountably called *vegetative* repetition—for it is quite as truly animal or animative repetition—is an arrested production of zooids by budding; that it is, in fact, a merging of many individualities in one. This, we see, in many cases, like being compared with like, is accompanied by increased longevity. The Tænia which exhibits this tertiary aggregation in a loose sort of way continues to develope from the attached head, and to protract its individual duration of life long after sexual organs have ripened and death followed in the separated proglottides. In the closely-allied Trematodes (flukes), in which the individuality is that of a secondary aggregate, death follows reproduction; as also in the Nematodes, which live in similar conditions, and are structurally allied to the other parasitic worms. In vegetals we find the same relation holding good, the multiaxial plants being the long-lived, the uniaxial the short-lived. That tertiary aggregation only has this accompaniment as long as it implies an increased comparative evolution, is seen in the fact that the Mollusca and Vertebrata, supposed to be secondary[1] aggregates, are longer lived than many tertiary aggregates; whilst similarly the relation of expenditure to longevity considerably qualifies the influence of tertiary aggregation. The Annelids of high tertiary aggregation, i. e. of many segments (e. g. Lumbricus and marine forms), are

[1] That is aggregates compounded of primary aggregates; primary aggregates being simply cells.

much longer lived than the Naids and Chætogaster,[1] with few segments and one year of life. So, too, the Echinoderms are tertiary aggregates, and consequently have long life as compared with simple Vermes. Tertiary aggregation acts in aiding longevity like the construction in five compartments of the *Great Eastern* steam-ship, if one is injured and lost, the others can go on without it, or even one may survive by itself. The question of tertiary aggregation brings us very near again to the discussion of individuality, which is not within our scope. Remembering what was said at the outset as to this, it is clear that tertiary aggregation acts by merging many individualities into one, and thus improving the chance of continued life.

Social organization is a sort of tertiary aggregation, in that newly-produced individuals do not separate from but remain attached to the preceding generation, supporting and ministering to the life of the older constituents. Thus it is with civilized man. He is supported in old age by the younger generations; the hope of, and confidence in, such support which the younger individuals have, being the strongest bond of society.

[1] Naids and Chætogaster are continually giving rise to new segments, which separate and become new individuals. How long the life of one original ancestor may be thus carried on by means of division is not known; but it is probably not for the immense period supposed by some writers; for, when sexual organs develope, the worm ceases to bud, and dies.

Mere size acts in plants and animals both, in rendering them less susceptible to the cold of the wet season, or the winter, and thus protracts life.

The production of woody fibre in plants is a condition of longevity, and anything directly favouring this may extend life. It enables the plant to resist breakage by wind or other violence, and protects it from cold. Thus bulbs continue the individual life of an annual flower for many years, and thus the trunks and branches of trees and shrubs live, whilst the leaves and flowers die.[1] Obviously the influence on age of the development of wood is but a part of the law of relation of evolution and longevity; but it is a special correlation, of very wide application.

12. *Some Experimental Evidence.*

There are some experimental proofs of the influence of generative and personal expenditure on longevity which may be now cited. By preventing plants from reproducing, that is, by cutting off their flower-buds, the gardener increases the bulk and the longevity of some plants; leaves and wood being produced in place of generative products. By change from a warm to a colder climate, this may similarly be

[1] Some persons would wish to regard tree-stems, bulbs, &c. as a kind of asexual reproductive mass, and would look upon the flowers of each year as successive generations of individuals. The compound nature of perennial plants is one of the difficulties met with in attempting to define individuality.

effected. The American aloe reproduces and dies in about five years in Mexico; in England it elaborates leaves for a hundred years before flowering. Again, the axolotl reproduces in warm Mexico as a branchiferous amphibian; in colder climates its fertility is diminished, it becomes a salamandroid before reproducing, thus lengthening life by delaying genesis. It is rarely that we can point to such cases as these, where the diminution of warmth affects sexual development. Usually it will kill the animal or plant experimented upon—as in the case of the mignonette (a shrub in Barbary), and the palma Christi (a tree in India), which both die annually in our severe climate; the longevity of the individual being in these cases diminished rather than the fertility delayed.

The two cases are interesting to compare with man, who is believed to live longest in cold countries. Like the American aloe, as is seen, when it is taken to still colder climates than our own, or like the mignonette in England, man ceases to gain in longevity when a certain limit of cold is attained. Beyond the cold of temperate regions his longevity is probably injuriously affected,[1] as is that of the palma and the mignonette in England, and that of the aloe in regions farther north. The general action of cold lies no doubt in the production of a sluggishness of the chemico-vital changes, which, if carried

[1] It is stated (Aitken's 'Medicine'), but not on statistical evidence, that the longevity of the Icelanders is greatly reduced by catarrh.

far, may destroy, but if moderated must extend, *length* of life (at the expense of *intensity*). The coldness of water, together with its diminished power of oxygenation, as compared with the atmosphere, is one of the direct causes of diminished expenditure in aquatic animals, rendering their life necessarily less intense than that of terrestrial forms, and so longer.

In keeping animals in menageries, in rearing pets and domesticated animals, man performs an experiment by diminishing personal expenditure. He frequently does the same in his own case, leading a careless, labourless existence; but there is in this as in other experiments (which are rarely so good in physiological enquiry in their results as natural comparisons) a disturbing cause, for Luxury, 'the fertile parent of a whole family of diseases,' as Galen termed her, steps in and works against the diminished expenditure. When man in his own person, or in the organisms he interferes with, so far baulks Nature's provisions that the organs become, as it were, rusty through the suspension of that personal expenditure, which is usually necessary to keep up the warmth by oxygenation, and to obtain necessary food, then he shortens rather than increases the length of life, disease attacks his victim, and death follows. This is seen exemplified in the case of domesticated animals,[1]

[1] Mr. Darwin informed the writer that he did not know of any reliable data admitting of a comparison between domestic animals and their *nearest* wild representatives (their actual wild forms being unknown in every case).

which are fattened for eating, and are believed to be short-lived in consequence. It is clearly the case in pets, such as small dogs, whose life is shortened by luxury. Hounds are the longest lived amongst dogs. On the other hand, there are cases in which man, by his care in avoiding expenditure, has lengthened his own and other animals' tenure of life; and it appears, from the little that is known, that experimental evidence does support the proposition, that longevity is lengthened by diminution of personal expenditure.

13. *Summary.*

Hence, in spite of the great complication of the case, we may conclude, on both deductive and inductive grounds, that the high or low potential longevity of different species, as a general law, is necessitated by those conditions of life which necessitate high or low individual development, as the case may be, whether of mere bulk, or complexity, or both; that it is directly subject to those conditions which cause personal expenditure to fluctuate, or which affect generative expenditure, being high when these are low, and low when these are high; that these relations interacting and contending variously according to the special case, determine the potential longevity of the various species of lower animals.

From the intricacy of these relations we may conclude that potential longevity is a very delicately balanced quantity, and that very *slight* causes may produce *great* fluctuations in it, and be almost impossible to trace; the magnitude of the result being far larger than in proportion to the magnitude of the initial cause, as is so often found to happen in Biological Science.

THE LONGEVITY OF MAN.

14. *Preliminary.*

In this part of the essay, our object is to apply the conclusions we have obtained from the study of organisms generally to the case of man, and especially to observe how far his obedience to the general law is affected by, or dependent on, the different phases of civilization which he exhibits.

Man presents the most marked contrasts with animals generally in many of the chief conditions of existence affecting longevity. Civilized man lives in societies, one of the most essential bonds of union in which is the maintenance, to a greater or less extent, by the community of the feeble. The security which the healthy and vigorous man hopes for himself, when grown old and feeble, he naturally extends to others, and thus the aged are fed and protected as the result of a specific habit or characteristic among men (the most barbarous excepted).

Further, the intellect of man renders him utterly unlike animals in much that relates to age; for whilst he grows feebler in limb, unproductive as a labourer, impotent as a warrior, in all such regards a mere burden on the species, yet the knowledge and experience stored in his great brain is of use to his younger fellow-men, and age is for that reason respected. Moreover, the *species* Homo is widely different from any other species; indeed, from the point of view of a general philosophy, it is almost erroneous to apply the term 'species' to the collective varieties of man [1] at all. For the development of the brain and of intelligence in man has really changed the whole course of Nature, supposing that the developmental course was hers. The further progress of organic beings beyond the limit reached by man (and this may be as acceptable a truth to the teleologist as to the evolutionist) can only operate through that brain, so thoroughly dominant, so all-powerful has it become. No longer are the structures of the whole organism affected by changed conditions, but of the brain alone,[2] and the result of this is that there are no *physiological species* among men. The various races and kinds of men can interbreed. It is only their intelligence, their power, knowledge, and cast of thought which largely differs, and this does

[1] The term 'polymorphism' is fairly applicable, in its zoological sense, to man as a civilized being, each unit in a society, with his special skill and special function, being comparable to such units in a polypidom or a hymenopterous colony.

[2] Other changes are exceedingly small, and are not permanent as are those of the brain.

not prevent the sperm-cell and germ-cell of two races being so developed as to unite in forming a fertile ovum.

Men exist in the most diverse conditions, not only in distant lands and varied climates, but even in the same city, in conditions so diverse, that were any other organism known, to be submitted to an equally great range of external agencies, even the most highly developed, it must either perish, or, if gradually introduced to the change, must so completely modify its structure as to become a new and distinct species. Man may be said to make his own conditions by his brain, or through it all conditions may be said to be comparatively uniform for him and for the animals which he chooses to associate with himself. Originating probably in the East, in a warm but not a tropical climate, feeding on rich and abundant fruits, he has yet gradually spread over the whole world, and does not shew any material modification of structure—no modification so great as to prevent interbreeding. When circumstances forced him to cold countries, his intelligence made him light a fire and build a house, and cover himself with the skins of other and inferior animals, which he entrapped by cunning, and whose roasted flesh served him as a substitute for the failing fruits. As necessities arose, he learned to build boats, skill of all kinds became his through his brain, and his vast knowledge was gradually acquired, and handed down from generation to generation, and passed from man to man by means of speech, which yearly grew more perfect. Meanwhile, he lived in families at first, then in tribes, and still later in societies of various kinds, which have grown, and are daily growing larger, in virtue of which the *individual* struggle for existence is, almost in the most civilized, and must be eventually entirely, abandoned, Darwin's law of survival of the fittest operating through the emulation of hundreds of varied combinations of men as wholes, instead of through the isolated struggles of the units composing them.[1]

The structural differences which have been produced in men by their distribution over the various parts of the globe, are apparent enough to the eye; perhaps seeming greater than they really are, as compared with differences amongst other individuals, by reason of our detailed knowledge of the objects compared, when they are men. But these characters of skull-form and hair-form, of complexion and hair-colour, and of size, which are what constitute the chief divergencies, other than those of the brain, among men, are not sufficiently constant in races to enable naturalists to ascertain the pedigree of the various nations of the earth, and to group their races by descent. Indeed, locality not race is what is marked by these characters. It

[1] Individual men do not struggle for existence—that is assured to them by society—they struggle to 'get on.'

is in the variety of language—a part of the intellectual development—that characters of far greater constancy and value are found.[1] Whilst the shape of the skull, the colour and such structural attributes, having assumed a certain state in a race, may rapidly change in a few generations to a totally different state,[2] language remains comparatively constant. The Circassians, who embody the ideal of beauty of the Western Europeans, are Mongolidæ in language; that is, are more closely related in descent to the Chinese and Siamese than to us. The Turk in Europe is acquiring European characteristics, losing his rounded form of head; whilst the Jew and the Ashantee are of nearer relationship to one another than either is to any of the other races named. Compare an English Jew of pure race with an African savage, and the transient character of structural character in man, such as is not brain structure, will be recognised.

It is needless to mention further the varied colour of the hair and physiognomy of Europeans; all such and many similar facts tend to shew the complete subordination of other to brain character. Hence

[1] Too great reliance must not be placed on language; for an invading race will in some cases communicate its language to the conquered, or, in other cases, adopt the language of the invaded country.

[2] The fact that the Jewish physiognomy has been traced in some African races, must be mentioned on the other side, and the certainly long persistence of the type of hair in the two great groups of smooth- and curly-haired races.

potential longevity being dependent on structure (as pointed out early in the essay), and the various races of men not exhibiting constancy in structural character, we cannot expect that the various races should exhibit anything like an approach to *specific* potential longevity.' This, too, the more so, remembering the delicacy of the quantity, and its liability to fluctuation with small influences. We have, on the contrary, every reason to believe that a man of English race and a man of Fuegian race, who by gradual change in the condition of their ancestors (for sudden change is likely to act injuriously by its mere suddenness[1]) should be living side by side, would live to the same period of time, that is, have the same potential longevity. But it is true enough that either the Fuegian would be no longer a Fuegian, for he would have abandoned the habits and conditions of life which are his peculiarities, or the Englishman would have ceased to be an Englishman by similar metamorphosis. Buffon, a man of really great insight and philosophical spirit, says:—'The man who does not die of accidental causes reaches everywhere the age of ninety or one hundred years. If we reflect that the European, Negro, Chinese, and American, the civilized man, the savage, the

[1] Dr. Kane, the American Arctic explorer, and his companions, after residing three years in a high latitude, experienced the most severe injury from the summer heat of the Northern States, and eventually Dr. Kane died from the exhaustion and prostration so produced.—'Wynn's American Statistics' (Influence of Locality on Disease).

rich, the poor, the dweller in cities and in the country, differing so much from each other in some respects, all resemble each other in having the same allotment, the same interval of time to pass from birth to death; that the variations of race, climate, food, conveniences, have nothing to do with the duration of life,—we shall discover that the duration of life does not depend on habits, customs, nor on the quality of food. Nothing can change the physical laws which regulate the number of our years.'[1] Buffon does not bring forward adequate data to support his statements, and we cannot admit the truth of his assertion in its entirety. But we have seen reason to believe that *hereditarily* the power of life in all men (within a few generations) is the same, disease, habits, and customs being dependent on external conditions, and thus longevity is rendered subject to external rather than internal causes, in the case of man; though with these varying external conditions are correlated small structural variations, which may make the longevity, in a certain sense, appear to be dependent on structure, so intimately bound up, so closely corresponding and reciprocal are structure and habit, even when dominated by such an organ as man's brain.

What we are concerned with, then, in the various kinds of man, is not variation in hereditary longevity,

[1] Vol. ii. p. 76, quoted by Flourens, p. 52.

but variation in the longevity of groups characterized by different habits, food, &c., and it is not to the race of men, but to the difference of conditions in which they live, that we must direct our attention. As was stated above, man's brain by its adapting power makes the essential conditions of life much more nearly uniform than would at first be supposed from his varied habitat, the total expenditure in procuring heat, food, safety, and in reproduction together being about the same in most races and classes. Hence we do not look for *much* difference of longevity, even in different climes and different civilizations. It is when we come to extremes, however, such as do exist, in which men are living and not adequately contending with nature by their intelligence, but are getting worsted in the struggle, that we may expect appreciable variation in longevity; the expenditure is increased in one direction without being diminished in another, and consequently the longevity suffers.[1] Thus, whilst the savages of Polynesia and of many parts of Africa,

[1] The inhabitants of Iceland are stated to rarely attain old age, comparatively few reaching the age of sixty, but I have not found any statistical proof of this assertion. ('Aitken's Medicine,' vol. ii.) In the same work the terrible condition of the inhabitants of the Pontine Marshes is described from various sources, and it is clearly shewn that men living in such malarious conditions have life greatly curtailed, becoming old and exhausted before other men have reached their prime. These cases appear to be abnormal in their conditions of life, and no evidence is forthcoming as to whether hereditary diminution of longevity is brought about by the subjection of a population to such circumstances. Probably it is.

together with the semi-civilized Mongolidæ, and the highly-civilized Iapetidæ, are, through the action of their brain power, equalised as to potential longevity by equality in respect of accessibility of food and warmth, what the barbarous gain by the diminished expenditure implied in warmth, abundance, and absence of intellectual exertion, being made up to the civilized by the higher evolution both personal and social; yet there are extremes of misery and want, of cold and of heat, to which the most degraded savages are subject, not being sufficiently intelligent to cope with these difficulties, and to which classes of men even in the most civilized communities are born and bred, not allowed by the more fortunate to receive either necessaries or education, which no doubt entail upon these savages and these classes a much diminished potential longevity.

There is then perhaps reason to admit hereditary diminution of longevity in such cases as compared with the mass, though the hereditary character will probably cease to affect the second or third generation after removal from the injurious conditions specified. The same character of temporary heredity appears in families which for some few generations are often remarkable for longevity; or, on the other hand, through disease,[1] intemperance, or other feeble-

[1] Disease may be regarded as increasing expenditure—entailing abnormal and useless expenditure, often in excess, by causing exhaustion, misdirected nutrition, &c.

ness in parentage, are equally remarkable for short life. It is in this regard (influence of disease) that the question of the average longevity or *mortality* of groups of men to their *potential longevity* deserves to be closely studied. At present, there are no data to solve the question as to the extent or nature of the influence of the one over the other, and an examination of the various life-tables given below shews that the relation is most inconstant (see p. 109 et seq.).

We may almost look upon excessively injurious conditions of existence and their effect on individuals as a definite thing comparable to a disease, being just as abnormal as in contrast with the most healthy state known to us; and we may say that no man with the *disease* 'Fuegian,' or 'Esquimaux,' or 'Australian,'[1] would have as fair a chance of long life, however favourable his circumstances, with that exception, as the man who does not labour under the disadvantage of a long ancestry of degraded savagery, and is therefore free from such disease; just as we have no hesitation in saying that a man with hereditary phthisis, scrofulous, or cancerous tendency, has not so fair a chance of long life as the healthy man. And just as in the course of a few generations the offspring of the latter may become quite healthy, so may the offspring of the former, in so far as his hereditary tendency to short life is concerned.[2]

[1] Or we may add, 'English mechanic,' or 'poverty and dirt.'

[2] Mr. Hendriks, of the Universal Life Office, informed the writer that

With these preliminary remarks on the nature of the possible variations in human potential longevity, we may proceed to some facts, and their interpretation, by means of the relations shewn to exist in all organisms for longevity.

15. *Sources of Information as to Human Longevity.*

Before making enquiry, one is apt to suppose that a good deal must be known as to the probable duration of human life; that there are, at any rate, statistics of some nations or periods of which assurance companies make use. But there are statistics and statistics,[1] and very few of the calculations relating to this matter are of real value. Besides statistics, as observed in a previous paragraph, we have general impressions either brought home by travellers or current amongst a people, and appearing in their sayings, poetry, traditions, and philosophy.

he believed himself that there is *hereditary* difference of life-tenure in various races. But he gave no facts, and probably the explanation here given of the apparent hereditary character may include all that he would contend for.

[1] Professor Huxley most truly observes that there are 'many cases in which the admitted accuracy of mathematical processes is allowed to throw a wholly inadmissible appearance of authority over the results obtained by them. Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data.'—Anniversary Address to the Geological Society, 1869.

In addition to these classes of evidence, we have experiments and observations on individuals which are of little value. Were sure post-mortem signs of yearage—not of wearage only—traceable, we might have a class of evidence from examination of dead bodies.[1] But there are no sufficiently definite signs known, though Professor Rolleston's investigation of the Anglo-Saxon interments at Frilford shews how such evidence may be of use in regard to average longevity or mortality. Cases of *individual* longevity in any race or condition of men carry little scientific value, and none that are recorded appear to assist in the discussion of the general question as to causes, but belong to the subject of abnormal longevity, of which a few words will be said before concluding. The incompetence of travellers to bring home facts as to longevity is obvious. They cannot make direct observations, or take a census of the peoples they see; hence Messrs. Wallace, Bates,[2] Darwin, Livingstone, and others, able observers as they are, give no information of use. Even in our own colonies, where civilized men are in close contact

[1] Were there any laws known, such as Buffon and Flourens have tried to lay down, of an *exact* ratio of age to growth, much might be expected in this way, and the whole enquiry facilitated.

[2] Mr. H. W. Bates informed the writer that he saw many great-grandfathers on the Amazons, but that is all the information he could afford. This kind of evidence is clearly of no use at all when we want to know to a nicety of a year what is the expectation of life of men at 50, 60 years of age, and upwards.

with the barbarians of whom we desire the knowledge, no records have been obtained. Thus, in an elaborate Report by Mr. Fenton to the Government on the natives of New Zealand, published in the 'Statistical Society's Journal,'[1] the whole statement is quite barren of any facts relating to the *longevity* of the Maoris. A kind of census is given, in which all above puberty are distinguished from all below puberty, but no greater detail than this. Even less is known of the North American Indians, the writer having consulted many authorities and made many enquiries as to these and other native races.[2] Even in China, so highly organized and civilized, nothing definite can be ascertained statistically. That acute and accomplished man, Sir John Bowring, says, 'I have no means of obtaining any satisfactory tables to shew the proportion which different ages bear to one another in China, or the average mortality at different periods of human life.'[2] The only datum which he does adduce is appended hereto with the life-tables (p. 105). Of the native population of British India, thoroughly permeated as it is by European administration, nothing is *known* relating to longevity. Englishmen who have been residents are

[1] Dr. Farr, Prof. Busk, Dr. Barnard Davis, Prof. E. A. Parkes, Dr. Lawson (of the Army Medical Department, Inspector), Prof. Huxley, Dr. Guy, Dr. Leared, Dr. Allbutt, and others, personally; besides the works of Quetelet, Wynn, Neison, Gairdner, Farr, Hendriks, many travellers, and the volumes of the Journal of the Statistical Society.

[2] Stat. Soc. Journal, vol. xx. p. 42.

of opinion that the natives of all classes have a much less potential longevity than Europeans, being very old at 60.[1] Mr. Hendriks states that the assurance companies will not take native lives at all, there being a general impression that they are bad, and a certainty that the natives lie so determinedly that no proper tables can possibly be framed.[2] From many places we have such loose and valueless statements as the following, which relates to Nova Scotia, and is the only one that need be quoted, 'its inhabitants often live to extreme age, many attaining 90 and even 100 years;'[3] a statement that could be made with equal truth and equal futility of any area within the limits of civilization.

There are some definite statements in poetic and other authors, which are of more value as reflecting the common judgment of a place, people, or time, on this question. Thus the Psalmist and the writer in Genesis give authoritative statements so far as their day and nationality; whilst Shakespeare's,

[1] It appears from the writer's special enquiries that medical army officers are of this opinion. Dr. Lawson has prepared a report for the Government on the *mortality* of natives and whites of the West African coast, but he can give no information as to longevity, except from general impression.

[2] A writer in the 'Statistical Society's Journal' states that *women* as a rule have an advantage in their dealings with assurance societies, which he attributes to their deceit, since they conceal diseases from the physicians, and are guided by the anticipation of coming disease to insure!

[3] Stat. Soc. Journal, vol. xvii. p. 74.

Flourens', Cabanis', the Chinese, and other divisions of the term of life indicate the writer's estimation of that period for man as he knew him.

Returning to the matter of statistics, we find that there are few countries which have kept returns, or in which the shifting nature of the population has allowed the necessary facts to be readily acquired, even amongst the most civilized; and what we notice very conspicuously is that statistics have been utterly misinterpreted, and made to furnish conclusions by faulty logic. The Northampton life-table of Price is a remarkable instance of this. And we may point to the discrepancies in some of the life-tables appended, when treating of the same classes, as further examples. It is indeed only within the last twenty years that really sound conclusions as regards longevity have been deduced from the statistics of population. In Sweden, England,[1] Belgium, Holland, and Bavaria alone are there statistics which are of sufficient value to quote. France has no sufficient returns (though the old tables, now considered untrustworthy by authorities, are given herewith), nor America,

[1] There are no facts as to Ireland at all. Mr. Hendriks, in a letter to the writer, states that he believes they are not such good lives, *primâ facie,* as English lives. A life-table for Scotland is given by Mr. Neison (*see* Tables, p. 114). Bacon, on the other hand, relates wonderful things of the 'Hiberni sylvestres,' who are, he says, very long-lived; and he mentions, amongst other customs, their frequent use of saffron as a draught. Irishmen have abandoned this potion and taken to others—and are not now so celebrated for long life.

nor other European states. Statistics are liable to error when relating, above all things, to old age; since, as men get old they lose their memory, or gain a superstitious reverence from others which induces them to lengthen their reputed age, or to allow others to do so for them. The Russian census, in which so many persons are returned as over 150 years of age, is worthless, in this regard, on account of the ignorance and superstition of the lower classes;[1] whilst the interesting comparisons which might fairly be anticipated from facts as to the negroes and whites in the United States are similarly rendered quite useless and untrustworthy. Thus the average age of those dying above 20 at Charleston appears as 47·74 for whites, and 52·56 for blacks. (Wynn, *loc. cit.*). Leaving out of the question all other interfering causes as to shifting of population, the greater age of the blacks is quite probably due to their inventive and imaginative talents. Americans tell us that the number of negroes reputed to have been 'servant to George Washington' is something extraordinary. It is clear that numerous advantages in the shape of diminished labour are to be obtained by pleading old age, or greater price than he would otherwise realize may have been gained by the slave-dealer by passing off a youth as a mature man.

[1] According to the Russian census, the age of 100 is reached by 9 persons out of every 10,000 that are born—that is, by nearly 1 in 1000. This is known to be absurd.

The Swedish life-table, constructed from the longest and most various returns, is considered the best and truest, whilst great value is also attached to the English and Belgian life-tables. The returns of assurance companies furnish some evidence as to the comparative longevity of assuring classes, and from this source we have two statements appended (see p. 106) which relate to America and Germany, and though not expressed in numbers, are sufficiently important. Some few calculations upon returns of various classes in the community have been published, which are in some cases reliable—e.g. Mr. Neison's, as to friendly societies; others are based on so few facts as to be very much smaller in value, though interesting for general comparison (e.g. Dr. Guy's observations).

16. *Statements as to the Duration of Human Life.*

A. Hebrew.

'The days of our years are threescore years and ten; and if by reason of strength they be fourscore years, yet is their strength labour and sorrow: for it is soon cut off and we fly away.'—Psalm xc. 10.

'Yet his days shall be an hundred and twenty years. . . . There were giants in the earth in those days.'—Genesis vi. 3, 4.

(The 120 years is coupled with the account of giants. It was considered exceptional by the writer of Genesis.)

B. Individual Opinion.

'When man has attained the age of forty or fifty he must know that he has reached half the term of his life.'—Cornaro (Italian).

'The man who does not die of disease reaches everywhere the age of ninety or a hundred years.'—Buffon (French).

'Non citra alterum seculum *ultimus* terminus vitæ humanæ subsistit. . . . *Annos* definire erit difficilius.'—Haller, quoted by Flourens.

'Man, being twenty years growing, lives five times twenty; that is to say, a hundred years.'—Flourens.

C. Chinese Division of Life. SIR J. BOWRING.

'*Journal of Statist. Soc.*' vol. xx. p. 42.

Age.		
10	is called	Opening degree.
20	,,	Youth expired.
30	,,	Strength and Marriage.
40	,,	Officially apt.
50	,,	Error knowing.
60	,,	Cycle closing.
70	,,	Rare bird of age.
80	,,	Rusty visage.
90	,,	Delayed.
100	,,	Age's extremity.

D. Flourens' Division of Life. (*loc. cit.* p. 24.)

Age.			
1	to 10	is called	Infancy.
10	20	,,	Adolescence.
20	30	,,	First youth.
30	40	,,	Second youth.
40	55	,,	First manhood.
55	70	,,	Second manhood.
70	85	,,	First old age.
85	100	,,	Second and last old age.

Others have divided age by periods of seven years. Dr. Farr, in the introduction to the Census of 1851, quotes various such divisions, and gives one of his own.

E. Old Men in China. SIR J. BOWRING. (*loc. cit.*)

Relief was administered in the reign of Kanghi (1657) to 373,935 indigent old men in China from various provinces. The archives of the empire shew that of this number the reputed ages were as follows:—

70 to 80	80 to 90	90 to 100	100
194,086	169,832	9,996	21

F. Shortness of German Lives.

Mr. Neison observes ('Contributions to Vital Statistics,' p. xi.) that in the returns from the Gotha Life Office, 'at the younger ages the mortality is much less than that indicated by any of the other Tables yet alluded to (English), but at the *older ages the rate of mortality is very much greater.*' Also,

G. Shortness of American Lives.

Professor Gill has obtained returns from New York Assurances 'shewing the same peculiar features in the rate of mortality described as characteristic of the Gotha Company's experience, only at the older ages the mortality is even higher than that of the other.'

The following paragraph from the 'Lancet' has come to hand while these sheets are in the press:—'The American Philosophical Society has received from Mr. Pliny Earle Chase an important contribution on the value of life in the town of Philadelphia. Mr. Chase shows that, notwithstanding the increased juvenile mortality, the Philadelphia life-tables indicate a possible life in Philadelphia of 114 years, a probable life of 33·44, and an expectation life of 35·09 years. He means by the term *possible* life, the limit sometimes obtained in a given locality; by the *probable* life, the age the probability of living beyond which is as great as that of dying before the age is attained; and by the *expectation* life he defines the average which will be attained by all who are born. In sixty-two years the average mortality was 1 in 47·836, the coloured mortality in the same period being 1 in 27·763. The ratio of still births to total births was 4·3 per cent., and to total deaths 5·8 per cent. The ratio of living births to population was 2·8 per cent., and of deaths to births, 74·5. The average natural increase was 3·3, and the increase by emigration 2·6 per cent. The main age at death was 23·57 years, and the main age of persons living was 24·29.

'But the most interesting facts in Mr. Chase's tables are those which shew how the simple mode of life of a quaker community compares with the life of a more active, or, rather, more luxurious people. He analyses the life-tables of the two communities of Philadelphia, dividing them into *Friends* and *Philadelphia*, and finds, as his results, that the Friends at the age of twelve years have a maximum vitality of 20·49 per cent. *over* their neighbours; that from twenty to sixty years of age they have a proportionate mortality of 23·37 *under* their neighbours; that their expectation of life is 24·62 per cent. higher, their probable life 43·78 per cent. more valuable, and their proportionate mortality at birth 44·70 lower than the mortality of their neighbours.

'The Quakers of Philadelphia approach thus towards the Jewish race in respect of vitality, in which they are, probably, exceptional to all other Christian communities. The lesson brings us back in thought to those peoples of whom the student's classical and great master speaks: "Plerumque tamen eam bonam contigisse ob bonos mores, *quos neque desidia, neque luxuria vitiarant.*"'

H. Savages.

Fuegians and other very degraded races are stated rarely to exceed the age of 45, being killed and eaten in some cases at that age by their children.

I. Average Age of persons of various Occupations dying at fifty-one and upwards.[1] GUY. '*Journal of Statist. Soc.*' 1846, p. 353.

England, males (Farr)	75·6	Fine Arts	71·15
Clergy	74·04	Painters (Bell)	70·96
Gentry	74·	Chemists (Thomson)	69·51
Medical men	72·95	English Literature (Chambers)	69·14
Lawyers	72·78	Male members of Royal Houses	68·54
Navy	72·62	Sovereigns of all countries	64·89
Trade and Commerce	72·32	Kings of England	64·12
Literature and Science (English)	72·10		
Aristocracy	71·69	England, females (Farr)	76·58
Army	71·58	Upper class females	76·56
Literature and Science (Foreign)	71·44	Females of Royal Houses	69·11

[1] This quantity must be carefully distinguished from 'the expectation of life' at the age of fifty-one, given in tables N to U. The 'expectation'

J. Average at Death of Sovereigns of various races dying at fifty-one and upwards. GUY. '*Journal of Statist. Soc.*' 1847, p. 68.

Emperors of Rome . . .	70·18	Czar of Russia	61·90
Moors of Spain	68·	Kings of Sweden	61·75
Caliphs of Bagdad, Egypt, &c.	76·8	„ Hungary . . .	61·
Eastern Emperors (Roman)	66·82	„ Denmark . . .	60·82
Kings of Spain	65·88	„ Poland	60·73
„ Bohemia . . .	65·16	Emperors of China and Japan	60·4
„ Bavaria . . .	65·24	Western Emperors (Rome)	60·26
„ Sicily	64·42	Kings of Wurtemberg . .	59·66
„ England . . .	64·12	Sultans of Turkey . . .	59·30
„ Saxony . . .	63·83	Kings of France	59·26
„ Portugal . . .	63·63	„ Scotland . . .	57·33
„ Savoy	62·52		

N.B.—It is noticeable that the hereditary princes are less long-lived than those who have won their position by some merit, either military or administrative.

K. Comparison of Ages at Death, of three centuries. GUY. '*Journal of Statist. Soc.*' 1859.

16th century	1500 facts gave mean of	. . . .	64·25
17th „	3400 facts „	. . . .	60·36
18th „	2800 facts „	. . . .	63·41

L. Comparative Longevity of Married and Unmarried.

A number of married persons gave mean of	. .	66·77
„ unmarried „	. .	62·00

tables are framed on more extensive data, and indicate the probable after-lifetime at a given age: hence they can only be compared *inter se*, and not with the above.

M. Comparative Longevity of more and less Distinguished Persons. GUY.

	more	less
Clergy more distinguished gave	66·42	69·49
Lawyers „ „	66·51	68·41
Medical men „ „	67·04	67·31
Literary and Scientific „	65·22	67·55
Artists „ „	64·74	65·96

N.B.—These data only admit of comparison between the terms here compared.

N. Probable after-lifetime of MALES at Age *x*, from Farr and Quetelet.

Age x.	ENGLAND. *Farr*, 1859.	BAVARIA. *Hermann.*	LOW COUNTRIES. *Baumbauer.*	BELGIUM. *Quetelet.*	SWEDEN. *Berg.*	MEAN.
0	39·91	22	31	40	48	37
10	47·05	50	49	49	50	50
20	39·48	41	40	42	41	41
30	32·76	34	33	34	33	34
40	26·06	26	25	26	25	26
50	19·54	18	18	18	18	18
60	13·53	12	12	12	12	12
70	8·45	7	7	7	7	7
80	4·93	3	3	4	3	3
90	2·84					
100	1·68					

O. Probable after-lifetime of FEMALES at Age x, from Farr and Quetelet.

Age x.	England. *Farr*, 1859.	Sweden. *Berg.*	Belgium. *Quetelet.*	Low Countries. *Baumbauer.*	Bavaria. *Hermann.*	Mean.
0	41·85	55	43	36	32	43
10	47·67	55	51	51	49	52
20	40·29	46	43	43	41	43
30	33·81	37	36	34	33	35
40	27·34	29	28	27	26	28
50	20·75	21	21	20	18	20
60	14·34	13	13	12	11	13
70	9·02	7	7	7	7	7
80	5·26	4	4	3	4	4
90	3·01					
100	1·76					

P. Probable after-lifetime for BOTH SEXES, at Age x, after Farr and Quetelet.

Age x.	ENGLAND. *Farr.*	SWEDEN. *Berg.*	BELGIUM. *Quetelet.*	LOW COUNTRIES. *Baumhauer.*	BAVARIA. *Hermann.*	MEAN.
0	45	51	42	34	27	40
10	51	53	50	50	50	51
20	43	43	43	42	41	42
30	35	35	35	34	34	35
40	27	27	27	26	26	27
50	20	19	20	19	18	19
60	13	13	13	12	12	13
70	8	7	7	7	7	7
80	4	4	4	3	4	4

Q. Probable after-lifetime at Age x, from Old and Inaccurate Sources. (Quetelet.) BOTH SEXES.

Age x.	French Annuitants. *Deparcieux.*	France. *Duvillard.*	England. *Morgan.*	England. *Milne.*	Holland. *Kerseboom.*	Sweden. *Wargentin.*	Mean.
0		20	8	41	31	33	38·5
10		43	40	53	45	49	50·3
20	40	36	34	45	38	41	42·2
30	34	29	28	36	32	33	34·5
40	27	23	23	29	26	25	26·5
50	20	17	17	21	20	19	19·2
60	14	11	12	14	14	12	12·7
70	9	6·5	8	8	8	7	7·2
80	5	3·5	4	4·6	4.5	3·5	3·7
90	2						
100	2						

R. Probable after-lifetime at Age x, from Hendriks (*Statistical Society's Journal*).

Age x.	Swedish, 1841–55. Males.	Females.	Both.	Netherlands. Males.	Females.
0	41	45·60	43·43	34·2	36·43
10	46·48	49·99	48·29	45·91	46·51
20	38·55	42·12	40·38	38·26	39·17
30	31·22	34·45	32·90	31·75	32·40
40	24·33	27·21	25·84	24·96	26·36
50	18·02	20·11	19·16	18·46	19·73
60	12·31	13·48	12·97	12·78	13·31
70	7·40	8·04	7·79	7·91	8·07
80	3·88	4·32	4·17	4·36	4·47
90	2·42	2·76	2·64	2·36	2·67
100				1·	1·

S. Probable after-lifetime at Age x, BOTH SEXES.

Scotch Lives (*Neison's Contributions*).

Age x.	RURAL.	TOWN.	CITY.
0			
10	53·05	50·74	42·63
20	44·99	42·75	34·58
30	37·78	35·03	28·63
40	30·30	27·64	22.64
50	22·89	20·74	17·38
60	16·01	13·12	13·33
70	10·65	9·13	8·76
80	5·65	5·43	4·81
90	3·22	2·76	2·35
100	·5	·5	·5

T. TABLES BASED ON LIMITED DATA AND RELATING TO SECTIONS OF THE COMMUNITY.

Probable after-lifetime at Age x for VARIOUS CLASSES in the Community, compiled from Neison's Vital Statistics, from Bailey and Day, from Hendriks, and Guy.

Age x.	Labourers. Rural Districts. (Friendly Societies.) *Neison.*	Peerage. Females. *Bailey and Day.*	Rural Distr. Males. (Friendly Societies.) *Neison.*	Healthy English Lives. Both Sexes. *Hendriks.*	Peerage. Both Sexes. *Bailey and Day.*	Peerage. Males. *Bailey and Day.*	Bakers. All Districts. (Friendly Societies.) *Neison.*	Clerks. All Districts. (Friendly Societies.) *Neison.*	Liverpool. Males. (Friendly Societies.) *Neison.*	Miners. All Districts. (Friendly Societies.) *Neison.*	Sovereigns. All Countries. *Guy.*	Persons of Intemperate Habits. *Neison.*
0		53.71		49.00	52.61	52.						
10	56.00	50 16	52.03	51.08	49.39	49.04	47.89	39.98	46.00	48.51		
20	47.90	43.48	43.89	43.45	42.21	41.46	40.02	31.83	37.95	40.67	34.3	15.55
30	40.59	36 82	37.22	36.64	35.96	35.51	32.35	27.57	30.14	33.15	27.3	13.80
40	32.76	29.93	30.09	29.64	28.86	28.33	24.47	21.85	23.15	24.92	20.9	11.62
50	25.07	23.08	22.79	22.44	21.95	21.40	19.09	16.04	17.09	17.53	15.	10.86
60	17.82	16.42	16.23	15.37	15.16	14.56	14.06	12.42	11.96	11.85	10.9	8.94
70	11.34	11.28	10.81	9.61	9.61	8.77	8 76	8.76	8.61	8.70	7.4	
80	6.95	6.92	6.69	5.51	5.45	4.58	4.81	4.80	4.80	4.80	5.	
90	3.80	4.10	3.80	3.05	3.54	1.64	2.35	2.34	2.35	2.34	3.9	
100	.5		.5				.5	.5	.5	.5	.9	

U. Calculations on a smaller Basis of Facts, by Dr. Guy (the data are derived from the 'Annual Register,' 'Peerage,' and similar sources).

Age x.	PEERAGE and BARONETAGE. Males. *Guy.*	GENTRY. Males. *Guy.*	PROFESSIONS. *Guy.*	FEMALES of these Three Classes. *Guy.*
0				
10				
20	38·5	37·3		37·
30	30·9	31·2	33·9	32·1
40	24·5	24·9	26·0	27·1
50	17·9	18·4	18·9	20·9
60	12·6	12·8	12·8	14·6
70	8·2	8·5	8·6	9·1
80	5·1	5·8	5·3	5·7
90	3·4	4·	3·2	2·8
100	1·2	1·6	0·5	0·5

17. *General Conclusions from the foregoing Statements and Tables.*

The following is a summary of the facts set forth in the pages immediately preceding and elsewhere.

1. The most degraded races have life shortened by starvation in old age, or even by suffering death at the hands of their fellows. The more civilized races protect the aged, and contribute to their longevity by care and respect.

2. Most nations speak of the ages from sixty to a hundred in language which indicates the same opinion with regard to the duration of life, e.g. Chinese, Jews, Greeks, Romans, modern Europeans. Many nations give equally traditions and accounts of excessive longevity.

3. There is an impression amongst interested observers (i.e. medical men and actuaries) that European lives, and especially English lives, are the best, that is, have the greatest probable duration.

4. Statistics shew clearly, more clearly than perhaps any other fact, that females have at all ages, *especially* in advanced periods of age, a better expectation of life than males; also that English lives are considerably better in advanced years (for a difference of one year of expectation is considerable when the whole average expectation is less than thirteen) than Dutch, French, Swedish, Belgian, or American lives.

5. English statistics tend to prove that, taking the expectation of life at sixty years of age as the criterion, the relative longevity in different classes of the community stands as follows :—Agricultural labourers in rural districts, belonging to friendly societies, with an expectation of 17·8 years of life; females of the aristocracy (peerage), with 16·42; males and females of the rural districts of Scotland, with 16·01; healthy English lives (so considered by assurance societies), with 15·37; males of the peerage, with 14·56; bakers, town and country, with 14·06; clerks, town and country, with 12·42; males in Liverpool, with 11·96; miners, with 11·85; sovereigns of all countries, with 10·9; persons of intemperate habits, with 8·94; all England (Farr), males, with 13·53 years expectation, and females with 14·34 years at the age compared, namely, sixty.[1]

6. To these may be added the observations of Dr. Guy, tending to prove that the more distinguished are less long-lived than the less distinguished members of professions, contrary to a general opinion prevalent as to the bar; that married persons are

[1] Too great reliance must not be placed on these statistics, as they are from various authorities and very variable data. Some corrections are due to circumstances, which are not stated to have been considered by the authorities who gave them: thus the males in Liverpool may appear to have a great mortality in old age, when their diminution in numbers is really due to their leaving the city. Dr. Farr informed the writer that no thoroughly reliable statistics of this kind could be obtained until the registration of births has been efficiently carried out in the localities examined for many years.

longer lived than unmarried;[1] and that the clergy, medical men, lawyers, and other classes of the community stand in the order given in § I. as to longevity.

18. *Interpretation by the Law.*

The interpretation of these facts in a general way, according to the law that high evolution and small expenditure favour longevity, is not difficult; but it is not possible, nor is the endeavour useful in the present state of knowledge, to explain in detail all the possible inferences.

The first two sets of facts tend to prove inductively, though the observational basis is slender, that the potential longevity of man is the same for the various races, if we exclude abnormally wretched and degraded tribes. Perhaps we should have to exclude thus the *Homo palæolithicus* of Mr. Dawkins. Keener scrutiny seems to indicate a small difference in favour of European civilization, but this is uncertain. Observations agree well with the deductive conclusions with which we started when speaking of the nature of races and varieties in the species man. The highest civilization, corresponding to the highest evolution, appears to give a somewhat increased potential longevity.

[1] Dr. Farr placed in the writer's hands a paper by him on 'The Influence of Marriage on *Mortality* in France,' which does not, however, touch on longevity.

The generally high longevity of females as compared with males in civilized communities is well established, and is fully explained in agreement with the law of diminished expenditure favouring longevity, women having undeniably less personal expenditure, and but little more generative expenditure, though such as they do have is concentrated, than men. It is noteworthy that the generative expenditure is lessened in women when the personal expenditure is increased, as is distinctly observed in the United States of America, where the women are intellectually far more active than elsewhere, and suffer, so far, from the relatively enormous costliness of nervous outlay. Thus the material of generation serves as a store which is drawn upon before the general powers involving longevity are affected in women.

The females of the English peerage present a greater contrast with the males than is observable between the sexes of any other group recorded. This conforms to the law, for in them there is the greatest difference as to expenditure, the females leading the most carefully-guarded, well-considered, and easy lives, whilst the males, especially in young life, having money at disposal, may lead irregular lives, involving great expenditure both personal and generative, leading to disease and enfeeblement, which is a direct result of misdirected expenditure. The destructiveness of intemperate habits may be seen in the column given in the life-table T. Moreover, though intemperateness is not a *vera causa* in the case of all peers, yet such men do not lead the quiet and refined lives which characterize those of the other sex in the same class, but are given to exertion of a violent and *irregular* character, possibly quite harmless morally, yet involving great expenditure from its irregularity.

The long life of the agricultural labourer belonging to a friendly society, exceeding what is termed the 'healthy English life,' is explained by the man's small personal expenditure, the absence of tax implied in the *regularity* of his daily labour, and the sobriety implied in his membership of such a society. Mr. Neison remarks ('Vital Statistics,' p. 45), 'A member of a friendly society may be regarded as a type of industry, frugality, regularity of habits, and simplicity of life.' Males of the English peerage have a higher longevity than the males of All England, but not so high as the healthy life of the insuring classes. Affluence involving less personal expenditure increases the longevity of those who enjoy it as compared to the average due to disease and intemperateness which embraces towns with all their misery and wretchedness; but it does not insure the absence of excessive and abnormal expenditure, to which indeed it directly leads, 'luxury being the parent of diseases.' It is evident from the facts given, that it is an error to quote our English peerage as the longest-lived class in Christendom, though it does not appear to be so low in the scale as Dr. Guy's observations on partial data at one time led him to believe.

Men living in towns are likely to suffer expenditure through intemperance, in addition to which they are more liable to be taxed by diseases, favoured as these are by diminished oxygenation and the close contiguity of persons. Hence we understand the low longevity of bakers, and the still lower longevity of clerks, to whose sedentary habits the tax of anxiety and mental labour is added.

The expenditure of mental labour in its highest forms as antagonizing longevity is well illustrated in Dr. Guy's comparisons of the more and less distinguished members of professions.

The small longevity of males in Liverpool is due to increased expenditure dependent on crowding, as just observed, and in a measure on the greater struggle, not for existence, but 'to get on,'—a struggle in which existence is not considered, and is in many cases lost,—which naturally occurs in the great cities.

That sovereigns (dying natural deaths) are short-lived, is explicable partly by what has been said of luxury, and partly by anxiety, both involving expenditure. It is noticeable that those sovereigns who have won and not inherited their position have been longer lived than those who have been born from a stock bred in injurious luxury for generations. This is as we should expect, such men being the strong and vigorous raised by natural selection from the masses.

The apparently higher longevity of England, as contrasted with other western European states, may be due to a somewhat higher development. Hufeland states that Danes and Englishmen are the longest-lived races, basing his opinion on the reputed cases of abnormal longevity in these countries, which are, however, of doubtful value as scientific evidence. He explained the supposed fact by the cold climate of these countries, and there may be possibly some truth in this notion, as we saw that a sluggishness of vital actions is induced by cold in the case of the American aloe; but this explanation is very doubtful. Sweden does not give a higher or as high a potential longevity (judging by the expectation of life at sixty) as England, though its climate is as cold or colder. The higher evolution or civilization of the Anglo-Saxons—or, better, Kelto-Teutons—into which not only are they born as members of a community, but which they inherit individually as a tendency, and which makes them alone able to colonize successfully, may not improbably be connected with their higher longevity. How is it, then, it may be asked, that the American branch of the race are reputed to be shorter-lived than Europeans? The subject here opened out is one of vast interest and practical importance, which we do not now propose to discuss in detail, connected as it is with that strange question of the permanence and domination of races in various regions of the earth which the facts of colonization are bringing into view at the present day. We have before given reasons for not looking for *permanency* of peculiarities in such characters as longevity in the races of mankind. Sir Charles Dilke, in his admirable sketch 'Greater Britain,' notes the disappearance of the Anglo-Saxon element and character in the Eastern United States, not only by the influx of Irish and German elements (both of which races are reputed shorter-lived than the Anglo-Saxon), but by a direct influence of the locality—an unfitness of the soil to the plant—which involves either the death or the modification of the latter. Moreover, the immigration of short-lived and unhealthy classes, and the extraordinary intensity of life, implying rapid expenditure—which has become a thoroughly American characteristic, whether from climatic or social influences, or both—must greatly diminish American longevity. To use their own expressive phrase, they are a 'go-a-head' people, and the early ageing of both male and female inhabitants of the States is an example of an individual tendency to travel fast as regards age, which is strictly dependent on, or correlated with, their activity. It is not unlikely that the small longevity of Americans—if it be a real phenomenon—is a transient attribute of the population, which, with other characteristics, will be greatly changed for what is happier and better in the future consolidation and development of that great people.

19. *Duration of Life in past Time.*

Under this heading, there is little more to be said than was contained in a celebrated but brief chapter. 'There is nothing known' of the duration of life in past time. A few years since it was the belief, based upon supposed statistical *facts*, that the potential longevity of man, that is, the expectation of life in the higher ages, was increasing and had been increasing for a hundred years. Dr. Farr has fully exposed the fallacy involved in this supposition, which was due to life-tables, erroneously constructed by Dr. Price (to whom, nevertheless, credit is due as a vital statistician), from the mortuary records of the town of Northampton. Dr. Farr has shewn that a table constructed by Price's method gives the same results to-day for Northampton as it did in the celebrated doctor's time. Moreover, the statistics of Sweden, which are very ample, extend from the middle of the eighteenth century, and furnish no indication whatever of a change. Some few facts have been adduced by Dr. Guy, which tend to shew a slight fluctuation in longevity in past centuries (see Tables K), but are really too few in number to allow of any generalization by even the most venturesome.

There is not within the cognizance of the writer a single fact of any antiquity to help us materially in the enquiry, unless it be thought that the limitation of life to seventy or eighty years in the Psalms is a smaller span than such a writer would now assign; but this supposition is not worth further consideration.

It is very well ascertained that *average* longevity has immensely increased since the middle ages in Europe; the question, however, of mortality clearly does not come within the limits of this Essay. It would be very satisfactory could some general relation between high average longevity and high potential longevity among men—i. e. small death-rate at early and late ages—be established, but the facts are conflicting, and deductive analysis renders it improbable that any constant relation does obtain, as was pointed out in treating of longevity in organisms generally.

20. *The Influence of various States of Civilization.*

We have seen that the influence of civilization cannot be fairly examined inductively, but the facts quoted, and the conclusions they offer, warrant us in supposing that a civilization of the highest order, in which the efficiency of the community and the efficiency of the component individuals is greatest—in which there is the most harmonious action, the greatest happiness for the greatest number, the least excessive expenditure with the least luxury, where regularity and temperateness are innate characteristics, will be that state of civilization most favourable to longevity. It may be supposed by some that since the tendency of civilization at present is to call out increased mental expenditure, that even when the other conditions of longevity are complied with, future men will rather lose than gain in longevity. This, however, depends upon the assumption, which we have no ground for allowing, that the structural capacity for such requirements will not increase simultaneously. There is every reason to believe that it will—that it *is* so doing. We are now in the midst of a struggle—in a transition state—which is really causing a survival of the fittest, operating chiefly through the emulation of communities, but also on individuals, and by means of this struggle greater mental power is being added to the human race. As we had occasion to remark in the case of organisms generally (quoting Mr. Herbert Spencer), increased difficulty of life-conditions necessitates increased evolution, and this is true for man's mental progress as for general structural progress. Were the evolution not always in advance of the provoking cause, we might anticipate the extinction of humanity by the excessive competition and excessive difficulties of existence which must accompany increased population. More justly, as it appears, and more hopefully, we may look forward to a time when, the whole earth being peopled, man will become finally adjusted to his conditions by the limitation of his expansion and the closer interaction of the members of the human aggregate. In that almost perfect civilization—where the greatest happiness for every individual must finally be attained—will man's longevity be extended? It does not seem improbable that this may be the case: and certainly an average longevity coincident with the potential is, under those conditions, to be looked for. Men would no longer 'die of disappointment,'[1] but would all attain eighty or a hundred years. There is no apparent reason why longevity should not increase beyond that limit, and advance with advanced evolution, and the diminished expenditure implied in more complete adjustment.[2]

[1] Buffon.

[2] It has been asserted by a writer in 'Fraser's Magazine' (September, 1869), and endorsed by another writer in the 'Spectator,' that civilization acts so as to suspend Darwin's law in the case of man—the feeble and diseased being allowed to breed, and the inferior often inheriting wealth won by no merit of their own, which could not be the case were there a free struggle for life and consorts. This is supposed to tend to shorten the life of the species, and to produce general inferiority in civilized races. But the argument is based on fallacy. As we have pointed out, man is a social animal, and the social virtues, which are urged by some persons as causes of deterioration, are the very strength of the communities in which they have been naturally and necessarily developed. That 'the individual withers, and the world is more and more,' as sung by Tennyson, is profoundly true. Natural selection operates largely on communities of men in place of individuals. That the fitter do survive, even in the case of individuals, is, however, clear enough. The diseased and feeble who propagate produce *some* healthy children, and these surely and certainly

21. *Abnormal Longevity in Man.*

A few words remain to be said on this subject from a general point of view. It has been often treated of under the head of Longevity by able writers and curious speculators. An article in the 'Quarterly Review' of January, 1868, and one in the

marry sooner and live longer than the unhealthy offspring, so that a very minimum of injury is done to the race by warding off the selective destructiveness of disease: inferiority must produce its legitimate results in spite of man's interference. Moreover, the mixing of stocks, with a *tendency* only to certain diseases, may be a source of strength, implying as it does mixture of varied constitutions. The tendency to particular diseases under given conditions is not a proof that under all conditions which may arise there will be that tendency. If the conditions are changed, as they are rapidly changed in the progress of civilization, what was weakness may become strength, a constitutional tendency to one kind of disease being associated with immunity from other kinds. Little is known on this matter; but compare the ravages of small-pox among Africans, of syphilis among Europeans. and the immunity of the Maoris from any severity under these diseases ('Fenton's Report,' *loc. cit.*). The effect of *sanatory action* in preventing the natural elimination of 'fermentable' matters from the blood (Paget) of generations is a curious subject for speculation. Zymotic diseases, if allowed to run their course unchecked in a community, kill off those individuals most imbued with this supposed fermentable matter, or remove it from those who recover from their attacks. If zymotic diseases are kept off, will not the 'fermentable matters' increase from generation to generation? It seems as though such elimination as vaccination should be adopted, together with sanatory measures, or we may accumulate a nidus in the veins of posterity. Possibly, if exempt for *great* length of time from a disease, a species may become no longer subject to it, just as two closely allied species of animal, e. g. the sheep and ox, are not subject to the same diseases, though presumably descended from a not remote common ancestor.

'Fortnightly Review' of April, 1869, contain details on this matter which it would be, on that account, superfluous to introduce here, and which, moreover, have a very restricted interest.[1] Abnormal longevity must not be confused with normal potential longevity, nor even with absolute potential longevity (see *antea*). There is a normal potential height[2] for various groups and classes of men, namely, that which they may be expected to reach, accidents of death, &c. being avoided. There is an absolute potential height, the greatest height which any one man of such a group, under the most favourable conditions, could be expected to attain; and there is the abnormal height of the giant, extending even to nine feet, and recognized as monstrous. Just so with longevity, there are three such terms possible, and there appears to be no *à priori* reason for excluding the last or

[1] I must again here draw the reader's attention to an admirable Essay by Sir Henry Holland, Bart., M.D., in the 'Edinburgh Review,' 1857. The whole question of human longevity is there discussed in a masterly way, with reference to many authorities and records not here noted. The article was brought to my notice while these pages were in the press—and I can only point out that Sir Henry, by comparison of abnormal human height and weight, is led to adopt the conclusion arrived at above—that many men have exceeded 100 years of age. He also points to the concurrence of all testimony in assigning 130 to 150 years to the most aged of various races and times. This concurrence, he considers, gives credibility to the statements. One of the last letters which Sir G. C. Lewis wrote was to Sir Henry Holland, in which he acceded to Sir Henry's view of human life sometimes exceeding 100 years.

[2] The average height, corresponding to average longevity, would be the average height of all *born*, whenever they might die.

abnormal longevity from recognition. Sir George Cornewall Lewis and others have endeavoured to throw doubt on the possibility of man's longevity exceeding 100 years. Though it has been clearly shewn that the cases of Jenkins, Parr and others, rest on no proper evidence, and are quite inadmissible as proofs of excessive longevity, yet Sir George appears to have rushed into a fanciful conclusion in arbitrarily limiting man to 100 years: the fascination of numbers has had some share in this. There are well-authenticated cases of persons who have exceeded the age of 100 years attested by the registration at baptism, which is what the opponents of man's possibly exceeding 36,500 and odd days of existence have always demanded. There is the case of Miss Baillie, sister of Dr. Baillie, of Mr. Shuldham of Marlesford Hall, who took the chair at a dinner given to his tenants on his 100th birthday, and lived two years subsequently. Of this case my friend, Mr. Cordy Jeaffreson, has been good enough to give me the following sketch:—

'The old man lived at Marlesford—not at Martlesham—famous in history for its Red Lion; and he certainly was not more than 102 years at the time of his death.

Baptized at Beccles, in Suffolk, in July 1743, William Shuldham died in May, 1845. The exact date of his birth I do not know, but I presume that it preceded his baptism long enough to entitle him to be credited with having lived into his 103rd year, the age which he is represented in obituary notices to have attained. That the above-mentioned were the dates of his baptism and death you may be confident. The celebration of the completion of his 100th year took place on July 22, 1843, when a great gathering of the gentry and humble folk of the neighbourhood feasted at Marlesford Hall, and had sports in the park. If that celebration took place on the actual anniversary day of his birth, he was some two months under 102 at his death. So that your statement may be unassailable, you had better speak only of the dates of his baptism and death, unless you make enquiries at Beccles.

William Shuldham's circumstances and habits of life were favourable to health. An energetic but not overworked man, he drove a capital business, as a country attorney, at Wickham Market and Saxmundham. A lover of country sports, he had for the greater part of his life a house in the country, first at Carlton Cross, a mile out of Saxmundham; and secondly, at Marlesford, where he built a handsome hall which, together with its small but picturesque park, may be commended as one of the best county places in the neighbourhood of Wickham Market. He retained his faculties up to his last illness, which did not cover more than a week or so, writing letters with a firm, clear hand, and managing his affairs until the last days of existence. Every successive decade of his career saw him a wealthier man. He never knew serious care: was active, and of what in *his* day of universal drunkenness was deemed temperate habits; but he was a steady port-wine drinker. His son and heir composed a song that was sung at the centenary celebration, one verse of which fairly describes his general mode of living thus:—

"Some take pills and physic, for gout or for phthisis,
Try every new nostrum for malady sore;
Some quit their home-quarters to drink foreign waters,
And yet kick the bucket the same as before;
But comfort and quiet, and temperate diet,
Will make a man healthy and wealthy and bold,
While a glass of good wine, too, will strengthen the spine, too,
And make him, like Shuldham, a hundred years old."

By referring to Davy's "Suffolk Collections," pedigree "Shuldham" (British Museum), you may ascertain that the Shuldhams were, upon the whole, given to longevity. The centenarian's grandfather completed his eighty-sixth year. The said centenarian married early in life my father's first-cousin, Mary Barber, of Boyton, who survived her husband and died considerably more than ninety years old: and the vigorous constitution and tenacity of life of these long-lived parents were transmitted in some degree to two of their offspring. The centenarian had by Mary Barber four children, William Abraham Shuldham, who lived to see his seventy-fourth year, though he suffered from epilepsy more violently than any other epileptic patient I have ever known, his fits were frequent and inordinately violent, but did not kill him till he was seventy-three: Lemuel, killed at the battle of Waterloo: Frances Mary, a married woman who died, ætat. 42, after giving birth to several children: and Louisa, a spinster, who was born December 23, 1791, and still lives a very vigorous woman for one of her years.'

I am also indebted to Mr. Cordy Jeaffreson for a notice of the case of the father of the Rev. Thomas Hart Davies, chaplain at the Dockyard, Portsmouth, in 1800. This gentleman died at *the supposed age of* 116, *but his age was afterwards investigated and found to be only* 109.

Sir Henry Holland informs me that last summer he breakfasted on the St. Lawrence, in America, with a British officer, whose commission proved him to be 104 years of age. Sir Henry also has evidence of a case in which the age of 111 years was reached.

On *à priori* grounds we have seen no reason to believe that man should not have a higher longevity than 100 years as a monstrous and abnormal phenomenon, and on this consideration we may be not indisposed to accept statements as to ages as great as 110, or even 120 years being attained, even though such an occurrence were not absolutely demonstrated and proved.

The expenditure implied in *distinction*, and the generative expenditure implied in twenty-two children, the offspring of a lady who certainly was alive in her 100th year, cannot be held to militate against the general law. These are isolated cases, where unusual vigour (i. e. abundant 'matter of life') has increased longevity and the other quantities simultaneously. There is not a sufficient number of trustworthy records of cases of high longevity to make an extended testing by them of the conclusions arrived at as to causes favouring longevity, likely to be of any real value.

In the course of what has been written, the exceedingly involved nature of the enquiry, and the absence of all but the fewest data as to comparative longevity, have been made sufficiently apparent. It is to this condition of the subject that we would gladly direct attention, as the cause of indefinite and speculative character in an essay treating of it. It is hoped that in indicating possible lines of productive enquiry, and in pointing to the more prominent and remediable gaps in information, some more practical result has been attained.

It would have been possible no doubt to carry mere speculation into greater detail than has been attempted here, as to the influences affecting longevity in man, but the facts, such as they are, seem fairly to admit of no more positive inferences than have been here given.

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SECTION I.

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