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Are the Effects of Use and Disuse Inherited? An Examination of the View Held by Spencer and Darwin

PREFACE

My warmest thanks are due to Mr. Francis Darwin, to Mr. E. B. Poulton (whose interest in the subject here discussed is shown by his share in the translation of Weismann's *Essays on Heredity*), and to Professor Romanes, for the help afforded by their kindly suggestions and criticisms, and for the advice and recommendation under which this essay is now published. Encouragement from Mr. Francis Darwin is to me the more precious, and the more worthy of grateful recognition, from the fact that my general conclusion that acquired characters are *not* inherited is at variance with the opinion of his revered father, who aided his great theory by the retention of some remains of Lamarck's doctrine of the inherited effect of habit. I feel as if the son, as representative of his great progenitor, were carrying

out the idea of an appreciative editor who writes to me: "We must say that if Darwin were still alive, he would find your arguments of great weight, and undoubtedly would give to them the serious consideration which they deserve." I hope, then, that I may be acquitted of undue presumption in opposing a view sanctioned by the author of the *Origin of Species*, but already stoutly questioned and firmly rejected by such followers of his as Weismann, Wallace, Poulton, Ray Lankester, and others, to say nothing of its practical rejection by so great an authority on heredity as Francis Galton.

The sociological importance of the subject has already been insisted on in emphatic terms by Mr. Herbert Spencer, and this importance may be even greater than he imagined.

Civilization largely sets aside the harsh but ultimately salutary action of the great law of Natural Selection without providing an efficient substitute for preventing degeneracy. The substitute on which moralists and legislators rely – if they think on the matter at all – is the cumulative inheritance of the beneficial effects of education, training, habits, institutions, and so forth – the inheritance, in short, of acquired characters, or of the effects of use and disuse. If this substitute is but a broken reed, then the deeper thinkers who gradually teach the teachers of the people, and ultimately even influence the legislators and moralists, must found their systems of morality and their criticisms of social and political laws and institutions and customs and ideas on the basis of the Darwinian law rather than on that of Lamarck.

Looking forward to the hope that the human race may become consciously and increasingly master of itself and of its destiny, and recognizing the Darwinian principle of the selection of the fittest as the *only* means of preventing the moral and physical degeneracy which, like an internal dry rot, has hitherto been the besetting danger of all civilizations, I desire that the thinkers who mould the opinions of mankind shall not be led astray from the true path of enduring progress and happiness by reliance on fallacious beliefs which will not bear examination. Such, at least, is the feeling or motive which has prompted me to devote much time and thought to a difficult but important inquiry in a debatable region of inference and conjecture, where (I am afraid) evidence on either side can never be absolutely conclusive, and where, especially, the absolute demonstration of a universal negative cannot reasonably be expected.

IMPORTANCE AND BEARING OF THE INQUIRY

The question whether the effects of use and disuse are inherited, or, in other words, whether acquired characters are hereditary, is of considerable interest to the general student of evolution; but it is, or should be, a matter of far deeper interest to the thoughtful philanthropist who desires to ensure the permanent welfare and happiness of the human race. So profoundly important, in fact, are the moral, social, and political conclusions that depend on the answer to this inquiry, that, as Mr. Herbert Spencer rightly says, it "demands, beyond all other questions whatsoever, the attention of scientific men."

It is obvious that we can produce important changes in the individual. We can, for example, improve his muscles by athletics, and his brain by education. The use of organs enlarges and strengthens them; the disuse of parts or faculties weakens them. And so great is the power of habit that it is proverbially spoken of as "second nature." It is thus certain that we can modify the individual. We can strengthen (or weaken) his body; we can improve (or deteriorate) his intellect, his habits, his morals. But there remains the still more important question which we are about to consider. Will such modifications be inherited by the offspring of the modified individual? Does individual

improvement transmit itself to descendants independently of personal teaching and example? Have artificially produced changes of structure or habit any inherent tendency to become congenitally transmissible and to be converted in time into fixed traits of constitution or character? Can the philanthropist rely on such a tendency as a hopeful factor in the evolution of mankind? – the only sound and stable basis of a higher and happier state of things being, as he knows or ought to know, the innate and constitutionally-fixed improvement of the race as a whole. If acquired modifications are impressed on the offspring and on the race, the systematic moral training of individuals will in time produce a constitutionally moral race, and we may hope to improve mankind even in defiance of the unnatural selection by which a spurious but highly popular philanthropy would systematically favour the survival of the unfittest and the rapid multiplication of the worst. But if acquired modifications do not tend to be transmitted, if the use or disuse of organs or faculties does not similarly affect posterity by inheritance, then it is evident that no innate improvement in the race can take place without the aid of natural or artificial selection.

Herbert Spencer maintains that the effects of use and disuse *are* inherited in kind, and in his *Factors of Organic Evolution*[1] he has supported his contention with a selection of facts and reasonings which I shall have the temerity to examine and criticize. Darwin also held the same view, though not so strongly.

[1] Which originally appeared in the *Nineteenth Century* for April and May, 1886.

And here, to prevent misunderstanding, I may say that the admiration and reverence and gratitude due to Darwin ought not to be allowed to interfere in the slightest degree with the freest criticism of his conclusions. To perfect his work by the correction of really extraneous errors is as much a sacred duty as to study and apply the great truths he has taught.

SPENCER'S EXAMPLES AND ARGUMENTS

DIMINUTION OF THE JAWS IN CIVILIZED RACES

Mr. Spencer verified this by comparing English jaws with Australian and Negro jaws at the College of Surgeons.[2] He maintains that the diminution of the jaw in civilized races can *only* have been brought about by inheritance of the effects of lessened use. But if English jaws are lighter and thinner than those of Australians and Negroes, so too is the rest of the skull. As the diminution in the weight and thickness of the walls of the cranium cannot well be ascribed to disuse, it must be attributed to some other cause; and this cause may have affected

[2] *Principles of Biology*, § 166, footnote. The English jaws are somewhat lighter than the Australian jaws, though I could not undertake to affirm that they are really shorter and smaller. In the typical skulls depicted on p. 68 of the official guide to the mammalian galleries at South Kensington, the typical Caucasian jaw is very much larger than the Tasmanian jaw, although the repulsively obtrusive teeth of the latter convey the contrary idea to the imagination. Mr. Spencer's assumption that the ancient Britons had large jaws appears to me erroneous. (See Professor Rolleston's *Scientific Papers and Addresses*, i. p. 250.)

the jaw also. Cessation of the process by which natural selection[3] favoured strong thick bones during ages of brutal violence might bring about a change in this direction. Lightness of structure, facilitating agility and being economical of material, would also be favoured by natural selection so far as strength was not too seriously diminished.

Sexual selection powerfully affects the human face, and so must affect the jaws – as is shown by the differences between male and female jaws, and by the relative lightness and smallness of the latter, especially in the higher races. Human preference, both sexual and social, would tend to eliminate huge jaws and ferocious teeth when these were no longer needed as weapons of war or organs of prehension, &c. We can hardly assume that the lower half of the face is specially exempt from the influence of natural and sexual selection; and the effects of these undoubted factors of evolution must be fully considered before we are entitled to call in the aid of a factor whose existence is questioned.

After allowing for lost teeth and the consequent alveolar absorption, and for a reduction proportional to that shown in the rest of the skull, the difference in average weight in fifty European and fourteen Australian male jaws at the College of

[3] Romanes, Galton, and Weismann have made great use of this principle in explaining the diminution of disused organs. Weismann has given it the name of *Panmixia*, —*all* individuals being equally free to survive and commingle their variations, and not merely selected or favoured individuals. See his *Essays on Heredity*, &c., p. 90 (Clarendon Press).

Surgeons turned out to be less than a fifth of an ounce, or about 5 per cent. This slight reduction may be much more than accounted for by such causes as disuse in the individual, human preference setting back the teeth, and partial transference of the much more marked diminution seen in female jaws. There is apparently no room for accumulated *inherited* effects of ancestral disuse. The number of jaws is small, indeed; but weighing them is at least more decisive than Mr. Spencer's mere inspection.

The differences between Anglo-Saxon male jaws and Australian and Tasmanian jaws are most easily explained as effects of human preference and natural selection. We can hardly suppose that disuse would maintain or develop the projecting chin, increase its perpendicular height till the jaw is deepest and strongest at its extremity, evolve a side flange, and enlarge the upper jaw-bone to form part of a more prominent nose, while drawing back the savagely obtrusive teeth and lips to a more pleasing and subdued position of retirement and of humanized beauty. If human preference and natural selection caused some of these differences, why are they incompetent to effect changes in the direction of a diminution of the jaw or teeth? And if use and disuse are the sole modifying agents in the case of the human jaw, why should men have any more chin than a gorilla or a dog?

The excessive weight of the West African jaws at the College of Surgeons is partly *against* Mr. Spencer's contention, unless he assumes that Guinea Negroes use their jaws far more than the Australians, a supposition which seems extremely improbable.

The heavier skull and narrower molar teeth point however to other factors than increased use.

The striking variability of the human jaw is strongly opposed to the idea of its being under the direct and dominant control of so uniform a cause as ancestral use and disuse. Mr. Spencer regards a variation of 1 oz. as a large one, but I found that the English jaws in the College of Surgeons varied from 1·9 oz. to 4·3 oz. (or 5 oz. if lost teeth were allowed for); Australian jaws varied from 2 oz. to 4·5 oz. (with *no* lost teeth to allow for); while in Negro jaws the maximum rose to over 5½ oz.[4] In spite of disuse some European jaws were twice as heavy as the lightest Australian jaw, either absolutely or (in some cases) relatively to the cranium. The uniformity of change relied upon by Mr. Spencer is scarcely borne out by the facts so far as male jaws are concerned. The great reduction in the weight of *female* jaws *and skulls* evidently points to sexual selection and to panmixia under male protection.

I think, on the whole, we must conclude that the human jaws do not afford satisfactory proof of the inheritance of the effects of use and disuse, inasmuch as the differences in their weight and shape and size can be more reasonably and consistently accounted for as the result of less disputable causes.

[4] Inclusive in each case of fixed strengthening wire weighing about a sixteenth of an ounce or less.

DIMINISHED BITING MUSCLES OF LAP-DOGS

The next example, the reduced biting muscles, &c., of lap-dogs is also unsatisfactory as a proof of the inheritance of the effects of disuse; for the change can readily be accounted for without the introduction of such a factor. The previous natural selection of strong jaws and teeth and muscles is reversed. The conscious or unconscious selection of lap-dogs with the least tendency to bite would easily bring about a general enfeeblement of the whole biting apparatus – weakness of the parts concerned favouring harmlessness. Mr. Spencer maintains that the dwindling of the parts concerned in clenching the jaw is certainly not due to artificial selection because the modifications offer no appreciable external signs. Surely hard biting is sufficiently appreciable by the person bitten without any visual admeasurement of the masseter muscles or the zygomatic arches. Disuse during lifetime would also cause some amount of degeneracy; and I am not sure that Mr. Spencer is right in *entirely* excluding economy of nutrition from the problem. Breeders would not over-feed these dogs; and the puppies that grew most rapidly would usually be favoured.

CROWDED TEETH

The too closely-packed teeth in the "decreasing" jaws of modern men (p. 13)[5] are also suggestive of other causes than use and disuse. Why is there not simultaneous variation in teeth and jaws, if disuse is the governing factor? Are we to suppose that the size of the human teeth is maintained by use at the same time that the jaws are being diminished by disuse? Mr. Spencer acknowledges that the crowding of bull-dogs' and lap-dogs' teeth is caused by the artificial selection of shortened jaws. If a similar change is really occurring in man, could it not be similarly explained by some factor, such as sexual selection, which might affect the outward appearance at the cost of less obvious defects or inconveniences?

Mr. Spencer points to the decay of modern teeth as a sign or result of their being overcrowded through the diminution of the jaw by disuse.[6] But the teeth which are the most frequently overcrowded are the lower incisors. The upper incisors are less overcrowded, being commonly pressed outwards by the lower arc of teeth fitting inside them in biting. The lower incisors are correspondingly pressed inwards and closer together. Yet the upper incisors decay – or at least are extracted – about twenty

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[5] References of course are to *Factors of Organic Evolution*.

[6] P. 13; and *Nineteenth Century*, February, 1888, p. 211.

times as frequently as the closely packed lower incisors.[7] Surely this must indicate that the cause of decay is not overcrowding.

The lateness and irregularity of the wisdom teeth are sometimes supposed to indicate their gradual disappearance through want of room in a diminishing jaw. But a note on Tasmanian skulls in the *Catalogue of the College of Surgeons* (p. 199) shows that this lateness and irregularity have been common among Tasmanians as well as among civilized races, so that the change can hardly be attributed to the effects of disuse under civilization.

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[7] Tomes's *Dental Surgery*, pp. 273-275. Tomes observes that it is as yet uncertain in what way civilization predisposes to caries. But he shows that caries is caused by the lime salts in the teeth being attacked by *acids* from decomposing food in crevices, from artificial drink such as cyder, from sugar, from medicine, and from vitiated secretions of the mouth. It is evident that in civilized races natural selection cannot so rigorously insist on sound teeth, sound constitutions, and *protective alkaline* saliva. The reaction of the civilized mouth is often acid, especially when the system is disordered by dyspepsia or other diseases or forms of ill-health common under civilization. The main supply of saliva, which is poured from the cheeks opposite the upper molars, is often acid when in small quantities. But the submaxillary and sub-lingual saliva poured out at the foot of the lower incisors and held in the front part of the jaw as in a spoon, "differs from parotid saliva in being more alkaline" (Foster's *Text Book of Physiology*, p. 238; Tomes, pp. 284, 685). One observer says that the reaction near the lower incisors is "never acid." Hence (I conclude) the remarkable immunity of the lower incisors and canines from decay, an immunity which extends backwards in a lessening degree to the first and second bicuspids. The close packing of the lower incisors may assist by preventing the retention of decaying fragments of food. Sexual selection may promote caries by favouring white teeth, which are more prone to decay than yellow ones. Acid vitiation of the mucus might account both for caries and (possibly) for the strange infertility of some inferior races under civilization.

BLIND CAVE-CRABS

The cave-crabs which have lost their disused eyes but *not the disused eye-stalks* appear to illustrate the effects of natural selection rather than of disuse. The loss of the exposed, sensitive, and worse-than-useless eye, would be a decided gain, while the disused eye-stalk, being no particular detriment to the crab, would be but slightly affected by natural selection, though open to the cumulative effects of disuse. The disused but better protected eyes of the blind cave-rat are still "of large size" (*Origin of Species*, p. 110).

NO CONCOMITANT VARIATION FROM CONCOMITANT DISUSE

It is but fair to add that these instances of the cave-crab's eye-stalk and the closely-packed teeth are put forward by Mr. Spencer with the more immediate object of proving that there is "no concomitant variation in co-operative parts," even when "formed out of the same tissue, like the crab's eye and its peduncle" (pp. 12-14, 23, 33). It escapes his notice, however, that in two out of his three cases it is *disuse*, or *diminished use*, which fails to cause concomitant variation or proportionate variation.

THE GIRAFFE, AND NECESSITY FOR CONCOMITANT VARIATION

Having unwittingly shown that lessened use of closely-connected and co-operative parts does not cause concomitant variation in these parts, Mr. Spencer concludes that the concomitant variation requisite for evolution can only be caused by altered degrees of use or disuse. He elaborately argues that the many co-ordinated modifications of parts necessitated by each important alteration in an animal are so complex that they cannot possibly be brought about except by the inherited effect of the use and disuse of the various parts concerned. He holds, for instance, that natural selection is inadequate to effect the numerous concomitant changes necessitated by such developments as that of the long neck of the giraffe. Darwin, however, on the contrary, holds that natural selection alone "would have sufficed for the production of this remarkable quadruped."[8] He is surprised at Mr. Spencer's view that natural selection can do so little in modifying the higher animals. Thus one of the chief arguments with which Mr. Spencer supports his theory is so poorly founded as to be rejected by a far greater authority on such subjects. All that is needed is that natural

[8] *Origin of Species*, pp. 198-9; *Variation of Animals and Plants under Domestication*, vol. ii. p. 328 footnote, also p. 206.

selection should preserve the tallest giraffes through times of famine by their being able to reach otherwise inaccessible stores of foliage. The continual variability of all parts of the higher animals gives scope for innumerable changes, and Nature is not in a hurry. Mr. Spencer, however, says that "the chances against any adequate readjustments fortuitously arising must be infinity to one." But he has also shown that altered degree of use does not cause the needed concomitant variation of co-operative parts. So the chances against a beneficial change in an animal must be, at a liberal estimate, infinity to two. Mr. Spencer, if he has proved anything, has proved that it is practically impossible that the giraffe can have acquired a long neck, or the elk its huge horns, or that any species has ever acquired any important modification.

Mr. Wallace, in his *Darwinism*, answers Mr. Spencer by a collection of facts showing that "variation is the rule," that the range of variation in wild animals and plants is much greater than was supposed, and that "each part varies to a considerable extent independently" of other parts, so that "the materials constantly ready for natural selection to act upon are abundant in quantity and very varied in kind." While co-operative parts would often be more or less correlated, so that they would tend to vary together, coincident variation is not necessary. The lengthened wing might be gained in one generation, and the strengthened muscle at a subsequent period; the bird in the meanwhile drawing upon its surplus energy, aided (as I would suggest) by the strengthening effect of increased use in the individual. Seeing that artificial

selection of complicated variations has modified animals in many points either simultaneously or by slow steps, as with otter-sheep, fancy pigeons, &c. (many of the characters thus obtained being clearly independent of use and disuse), natural selection must be credited with similar powers, and Mr. Wallace concludes that Mr. Spencer's insuperable difficulty is "wholly imaginary."

The extract concerning a somewhat similar "class of difficulties," which Mr. Spencer quotes from his *Principles of Biology*, is faulty in its reasoning,[9] though legitimate in its conclusion concerning the increasing difficulty of evolution in proportion with the increasing number and complexity of faculties to be evolved. But this increasing difficulty of complex evolution is only overcome by *some* favourably-varying individuals and species – not by all. And as the difficulty increases we find neglect and decay of the less-needed faculties – as with domesticated animals and civilized men, who lose in one direction while they gain in another. The increasing difficulty of complex evolution by natural selection is no proof whatever of

[9] Mr. Spencer weakly argues that an advantageous attribute (such as swiftness, keen sight, courage, sagacity, strength, &c.) cannot be increased by natural selection unless it is "of greater importance, for the time being, than most of the other attributes"; and that natural selection cannot develop any one superiority when animals are equally preserved by "other superiorities." But as natural selection will simultaneously eliminate tendencies to slowness, blindness, deafness, stupidity, &c., it *must* favour and improve many points simultaneously, although no one of them may be of greater importance than the rest. Of course the more complicated the evolution the slower it will be; but time is plentiful, and the amount of elimination is correspondingly vast.

use-inheritance[10] except to those who confound difficulty with impossibility.

[10] I venture to coin this concise term to signify *the direct inheritance of the effects of use and disuse in kind*. Having a name for a thing is highly convenient; it facilitates clearness and accuracy in reasoning, and in this particular inquiry it may save some confusion of thought from double or incomplete meanings in the shortened phrases which would otherwise have to be employed to indicate this great but nameless factor of evolution.

ALLEGED RUINOUS EFFECTS OF NATURAL SELECTION

Mr. Spencer further contends that natural selection, by unduly developing specially advantageous modifications without the necessary but complex secondary modifications, would render the constitution of a variety "unworkable" (p. 23). But this seems hardly feasible, seeing that natural selection must continually favour the most workable constitutions, and will only preserve organisms in proportion as they combine general workableness with the special modification. On the other hand, according to Mr. Spencer himself, use-inheritance must often disturb the balance of the constitution. Thus it tends to make the jaws and teeth unworkable through the overcrowding and decay of the teeth – there being, as his illustrations show, no simultaneous or concomitant or proportional variation in relation to altered degree of use or disuse.

ADVERSE CASE OF NEUTER INSECTS

Mr. Spencer also holds that most mental phenomena, especially where complex or social or moral, can only be explained as arising from use-inheritance, which becomes more and more important as a factor of evolution as we advance from the vegetable world and the lower grades of animal life to the more complex activities, tastes, and habits of the higher organizations (preface, and p. 74). But there happens to be a tolerably clear proof that such changes as the evolution of complicated structures and habits and social instincts *can* take place independently of use-inheritance. The wonderful instincts of the working bees have apparently been evolved (at least in all their later social complications and developments) without the aid of use-inheritance – nay, in spite of its utmost opposition. Working bees, being infertile "neuters," cannot as a rule transmit their own modifications and habits. They are descended from countless generations of queen bees and drones, whose habits have been widely different from those of the workers, and whose structures are dissimilar in various respects. In many species of ants there are two, and in the leaf-cutting ants of Brazil there are *three*, kinds of neuters which differ from each other and from their male and female ancestors "to an almost

incredible degree."[11] The soldier caste is distinguished from the workers by enormously large heads, very powerful mandibles, and "extraordinarily different" instincts. In the driver ant of West Africa one kind of neuter is three times the size of the other, and has jaws nearly five times as long. In another case "the workers of one caste alone carry a wonderful sort of shield on their heads." One of the three neuter classes in the leaf-cutting ants has a single eye in the midst of its forehead. In certain Mexican and Australian ants some of the neuters have huge spherical abdomens, which serve as living reservoirs of honey for the use of the community. In the equally wonderful case of the termites, or so-called "white ants" (which belong, however, to an entirely different order of insect from the ants and bees) the neuters are blind and wingless, and are divided into soldiers and workers, each class possessing the requisite instincts and structures adapting it for its tasks. Seeing that natural selection can form and maintain the various structures and the exceedingly

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[11] *Origin of Species*, pp. 230-232; Bates's *Naturalist on the Amazons*. Darwin is "surprised that no one has hitherto advanced the demonstrative case of neuter insects, against the well-known doctrine of inherited habit, as advanced by Lamarck." As he justly observes, "it proves that with animals, as with plants, any amount of modification may be effected by the accumulation of numerous, slight, spontaneous variations, which are in any way profitable, without exercise or habit having been brought into play. For peculiar habits confined to the workers or sterile females, however long they might be followed, could not possibly affect the males and fertile females, which alone leave any descendants." Some slight modification of these remarks, however, may possibly be needed to meet the case of "factitious queens," who (probably through eating particles of the royal food) become capable of producing a few male eggs.

complicated instincts of ants and bees and wasps and termites in direct defiance of the alleged tendency to use-inheritance, surely we may believe that natural selection, unopposed by use-inheritance, is equally competent for the work of complex or social or mental evolution in the many cases where the strong presumptive evidence cannot be rendered almost indisputable by the exceptional exclusion of the modified animal from the work of reproduction.

Ants and bees seem to be capable of altering their habits and methods of action much as men do. Bees taken to Australia cease to store honey after a few years' experience of the mild winters. Whole communities of bees sometimes take to theft, and live by plundering hives, first killing the queen to create dismay among the workers. Slave ants attend devotedly to their captors, and fight against their own species. Forel reared an artificial ant-colony made up of five different and more or less hostile species. Why cannot a much more intelligent animal modify his habits far more rapidly and comprehensively without the aid of a factor which is clearly unnecessary in the case of the more intelligent of the social insects?

ÆSTHETIC FACULTIES

The modern development of music and harmony (p. 19) is undeniable, but why could it only have been brought about by the help of the inheritance of the effects of use? Why are we to suppose that "minor traits" such as the "æsthetic perceptions" cannot have been evolved by natural selection (p. 20) or by sexual selection? Darwin holds that our musical faculties were developed by sexual preference long before the acquisition of speech. He believes that the "rhythms and cadences of oratory are derived from previously developed musical powers" – a conclusion "exactly opposite" to that arrived at by Mr. Spencer.[12] The emotional susceptibility to music, and the delicate perceptions needed for the higher branches of art, were apparently the work of natural and sexual selection in the long past. Civilization, with its leisure and wealth and accumulated knowledge, perfects human faculties by artificial cultivation, develops and combines means of enjoyment, and discovers unsuspected sources of interest and pleasure. The sense of harmony, modern as it seems to be, must have been a latent and indirect consequence of the development of the sense of hearing and of melody. Use, at least, could never have called it into existence. Nature favours and develops enjoyments to a certain extent, for they subserve self-preservation and sexual

[12] *Descent of Man*, pp. 573, 572, and footnote.

and social preference in innumerable ways. But modern æsthetic advance seems to be almost entirely due to the culture of latent abilities, the formation of complex associations, the selection and encouragement of talent, and the wide diffusion and imitation of the accumulated products of the well-cultivated genius of favourably varying individuals. The fact that uneducated persons do not enjoy the higher tastes, and the rapidity with which such tastes are acquired or professed, ought to be sufficient proof that modern culture is brought about by far swifter and more potent influences than use-inheritance. Neither would this hypothetical factor of evolution materially aid in explaining the many other rapid changes of habit brought about by education, custom, and the changed conditions of civilization generally. Powerful tastes – as is incontestably shown in the cases of alcohol and tobacco – lie latent for ages, and suddenly become manifest when suitable conditions arise. Every discovery, and each step in social and moral evolution, produces its wide-spreading train of consequences. I see no reason why use-inheritance need be credited with any share in the cumulative results of the invention of printing and the steam-engine and gunpowder, or of freedom and security under representative government, or of science and art and the partial emancipation of the mind of man from superstition, or of the innumerable other improvements or changes that take place under modern civilization.

Mr. Spencer suggests an inquiry whether the greater powers possessed by eminent musicians were not mainly due to the

inherited effect of the musical practice of their fathers (p. 19). But these great musicians inherited far more than their parents possessed. The excess of their powers beyond their parents' must surely be attributed to spontaneous variation; and who shall say that the rest was in any way due to use-inheritance? If, too, the superiority of geniuses proves use-inheritance, why should not the inferiority of the sons of geniuses prove the existence of a tendency which is the exact opposite of use-inheritance? But nobody collects facts concerning the degenerate branches of musical families. Only the favourably varying branches are noticed, and a general impression of rapid evolution of talent is thus produced. Such cases might be explained, too, by the facts that musical faculty is strong in both sexes, that musical families associate together, and that the more gifted members may intermarry. Great musicians are often astonishingly precocious. Meyerbeer "played brilliantly" at the age of six. Mozart played beautifully at four. Are we to suppose that the effect of the *adult* practice of parents was inherited at this early age? If use-inheritance was not necessary in the case of Handel, whose father was a surgeon, why is it needed to account for Bach?

LACK OF EVIDENCE

The "direct proofs" of use-inheritance are not as plentiful as might be desired, it appears (pp. 24-28). This acknowledged "lack of recognized evidence" is indeed the weakest feature in the case, though Mr. Spencer would fain attribute this lack of direct proof to insufficient investigation and to the inconspicuous nature of the inheritance of the modification. But there is an almost endless abundance of conspicuous examples of the effects of use and disuse in the individual. How is it that the subsequent inheritance of these effects has not been more satisfactorily observed and investigated? Horse-breeders and others could profit by such a tendency, and one cannot help suspecting that the reason they ignore it must be its practical inefficacy, arising probably from its weakness, its obscurity and uncertainty or its non-existence.

INHERITED EPILEPSY IN GUINEA-PIGS

Brown-Séquard's discovery that an epileptic tendency artificially produced by mutilating the nervous system of a guinea-pig is occasionally inherited may be a fact of "considerable weight," or on the other hand it may be entirely irrelevant. Cases of this kind strike one as peculiar exceptions rather than as examples of a general rule or law. They seem to show that certain morbid conditions may occasionally affect both the individual and the reproductive elements or transmissible type in a similar manner; but then we also know that such prompt and complete transmission of an artificial modification is widely different from the usual rule. Exceptional cases require exceptional explanations, and are scarcely good examples of the effect of a general tendency which in almost all other cases is so inconspicuous in its immediate effects. Further remarks on this inherited epilepsy can be most conveniently introduced later on in connection with Darwin's explanation of the inherited mutilation which it usually accompanies, but which Mr. Spencer does not mention.

INHERITED INSANITY AND NERVOUS DISORDERS

Mr. Spencer infers that, because insanity is usually hereditary, and insanity can be artificially produced by various excesses, therefore this artificially-produced insanity must also be hereditary (p. 28). Direct evidence of this conclusion would be better than a mere inference which may beg the very question at issue. That the liability to insanity commonly runs in families is no proof that strictly non-inherited insanity will subsequently become hereditary. I think that theories should be based on facts rather than facts on theories, especially when those facts are to be the basis or proof of a further theory.

Mr. Spencer also points out that he finds among physicians "the belief that nervous disorders of a less severe kind are inheritable" – a general belief which does not necessarily include the transmission of purely artificially-produced disorders, and so misses the point which is really at issue. He proceeds, however, to state more definitely that "men who have prostrated their nervous systems by prolonged overwork or in some other way, have children more or less prone to nervousness." The following observations will, I think, warrant at least a suspension of judgment concerning this particular form of use-inheritance.

(1) The nervousness is seen in the *children* at an early age, although the nervous prostration from which it is supposed

to be derived obviously occurs in the parent at a much later period of life. This change in time is contrary to the rule of inheritance at corresponding periods; and, together with the unusual promptness and comparative completeness of the inheritance, it may indicate a special injury or deterioration of the reproductive elements rather than true inheritance. The healthy brain of early life has failed to transmit its robust condition. Is use-inheritance, then, only effective for evil? Does it only transfer the newly-acquired weakness, and not the previous long-continued vigour?

(2) Members of nervous families would be liable to suffer from nervous prostration, and by the ordinary law of heredity alone would transmit nervousness to their children.

(3) The shattered nerves or insanity resulting from alcoholic and other excesses, or from overwork or trouble, are evidently signs of a grave constitutional injury which may react upon the reproductive elements nourished and developed in that ruined constitution. The deterioration in parent and child may often display itself in the same organs – those probably which are hereditarily weakest. Acquired diseases or disorders thus appear to be transmitted, when all that was conveyed to the offspring was the exciting cause of a lowered vitality or disordered action, together with the ancestral liability to such diseases under such conditions.

(4) Francis Galton says that "it is hard to find evidence of the power of the personal structure to react upon the sexual

elements, that is not open to serious objection." Some of the cases of apparent inheritance he regards as coincidence of effect. Thus "the fact that a drunkard will often have imbecile children, although his offspring previous to his taking to drink were healthy," is an "instance of simultaneous action," and not of true inheritance. "The alcohol pervades his tissues, and, of course, affects the germinal matter in the sexual elements as much as it does that in his own structural cells, which have led to an alteration in the quality of his own nerves. Exactly the same must occur in the case of many constitutional diseases that have been acquired by long-continued irregular habits."[13]

[13] *Contemporary Review*, December, 1875, p. 92.

INDIVIDUAL AND TRANSMISSIBLE TYPE NOT MODIFIED ALIKE BY THE DIRECT EFFECT OF CHANGED HABITS OR CONDITIONS

Mr. Spencer finds it hard to believe that the modifications conveyed to offspring are not identical in tendency with the changes effected in the parent by altered use or habit (pp. 23-25, 34). But it is perfectly certain that the two sets of effects do not necessarily correspond. The effect of changed habits or conditions on the individual is often very far from coinciding with the effects on the reproductive elements or the transmissible type. The reproductive system is "extremely sensitive" to very slight changes, and is often powerfully affected by circumstances which otherwise have little effect on the individual (*Origin of Species*, p. 7). Various animals and plants become sterile when domesticated or supplied with too much nourishment. The native Tasmanians have already become extinct from sterility caused by greatly changed diet and habits. If, as Mr. Spencer teaches, continued culture and brain-work will in time produce lessened fertility or comparative sterility, we may yet have to be careful that intellectual development does not become a species of suicide, and that the culture of the race does not mean its extinction – or at least the extinction of those most susceptible of culture.

The reproductive elements are also disturbed and modified in innumerable minor ways. Changed conditions or habits tend to produce a general "plasticity" of type, the "indefinite variability" thus caused being apparently irrelevant to the change, if any, in the individual.[14]

[14] See *Origin of Species*, pp. 5-8. "Changed conditions induce an almost indefinite amount of fluctuating variability, by which the whole organization is rendered in some degree plastic" (*Descent of Man*, p. 30). It also appears that "the nature of the conditions is of subordinate importance in comparison with the nature of the organism in determining each particular form of variation; – perhaps of not more importance than the nature of the spark, by which a mass of combustible matter is ignited, has in determining the nature of the flames" (*Origin of Species*, p. 8).

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