

"Feasible Experiments on the Possibility of Transmitting Acquired Habits by Means of Inheritance"

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Teachable
Experiments
in Heredity

Abstract for printer

Sectio[n] D

*Feasible experiments on the possibility of transmitting acquired
habits by means of inheritance.*

by Francis Galton FRS

Feasible experiments have yet to be devised that shall be accepted as crucial tests of the possibility of a parent transmitting ^a congenital aptitude to his children, which he himself possessed, ^{if not congenitally}, but merely through long & distasteful practice under the lone sort of compulsion.

The requirements are to eliminate ~~from the children~~ all possibility of parental or social teaching, ^{bring up all the descendants} in the same way, to make simultaneous experiments on many broods during many generations, and lastly, to economise time, money and labor. ~~for preoccupation~~ Their ^{poorly} with emphasis to experiment on creatures that are reared from eggs, as fowls, fishes and moths. ~~Fowls~~ The largely extending practice of hatching ~~eggs~~ eggs in incubators for commercial purposes, & the varied aptitudes of poultry make them ~~useless~~ very suitable subjects. ~~They~~ Birds are said to have ^{an instinctive} ~~instinctive~~ ^{desire} of various insects; hence ^{minuscule} insects that are really good to food, are avoided by them. To teach insects ^{and other insects} ~~insects~~ ~~to eat~~ ~~other insects~~ ~~at first~~, ~~but could be taught~~ ^{through} experience would lead them to like & to eat greedily. Similarly as regards sounds, ^{and} cries, which would frighten at first but afterwards be welcome as signals for food, &c. Would the stocks of two breeders, one of whom adopted such experiments as these & the other did not, differ in instinct after many generations? ~~Fish~~ ^(quoted by Darwin) the experiments of Moline with the pike, ^{in a trough} divided by a glass plate into two compartments, in one of which was the pike in the other were minnows, was ^{mentioned} as an example. The pike after dashing at the minnows many times, & each time being ^{chipped} & hurt by the glass plate ^{during some weeks} finally abandoned all attempts ^{to catch them} so that when the plate was removed, ~~all the time~~, the pike never ^{afterwards} ^{attempting} to attack the minnows! The question then is, whether fish reared for some generations under conditions which compelled them to adopt habits not conformable to their natures, would show any corresponding change of instinct. Of course each generation would be reared in a separate tank from its parents.

~~With the help of the author of the Selenia Illustraria~~

Moths Experiments have been made by the author to Mr. Frederic Mervin, with the Selenia Illustraria, which has two broods yearly. They ^{are being} made for quite another purpose, but have shown the ease of breeding hardy moths on a large scale, when the art of doing so is well understood. All larvae are fastidious in their diet, but it will be that certain food which they would not touch at first, ^{would} after a while be greedily eaten & be found perfect, wholesome.

Experiments on the lines suggested ought to show the proportion of cases in which acquired aptitudes ^{several kinds} are certainly, not inherited. They might also perhaps show that in a small proportion of cases they certainly are. A distinct [&] sharp limit would be fixed within which doubt remained permissible.

The object of this paper is to invite experts to discuss the details of the most appropriate experiments.



*Proof read & approved
by Prof. Galton F.R.S.*

... before you get lost
and don't move off the forest path there now so
close
late afternoon. I'll take first at twelfth

% T. Galla
Shearce Walter
Beaufort Newcastle Rose
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(A clean copy has been sent)

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Feasible experiments on the possibility of transmitting
acquired habits by means of inheritance
by Francis Galton F.R.S.



Feasible experiments have yet to be designed that shall be recognised by experts as satisfactory tests of the transmission of acquired habits. In other words, of the existence of a tendency in parents to transmit congenital aptitudes to their children to do things for which they themselves had no congenital aptitude, but ~~though~~ they had acquired an aptitude for doing under the compulsion of circumstances.

It is almost needless to say that this is one of the most important problems that vex the student of heredity at the present day, and perhaps the most difficult of solution. But it is only of late that its difficulty has become generally appreciated. Thanks especially to the searching criticism of Prof. Weissmann, grave doubts have fallen on the adequacy of the data upon which the popular belief is based of the ~~inheriting~~ ^{transmitting} ~~acquired~~ faculties ~~the now less more clearly than before, the evidence which is confined~~ ^{shows no more than this namely} ~~which is confined~~ when a parent has acquired some particular aptitude his children are often found to inherit that aptitude, ~~is insufficient to guide our judgement~~. If the evidence goes no further than this, it is fatally incomplete; if we know no more than that the parent ~~acquired~~ ^{had} the aptitude ~~for~~ it may well be, that the parent was himself congenitally gifted with a disposition that made the acquirement a pleasure, and with a capacity that made it easy. In this case all that the children ^{may} have inherited ^{so much the} ~~and the congenital gifts of the parent,~~ ^{as of the parents} ~~which in many cases~~ ^{especially} developed through imitation or tradition. The question is whether a parent who had no peculiar congenital aptitude, but who acquired a peculiar aptitude under the compulsion of circumstances which led to the practice ~~and~~ ^{enabled} by long practice ^{under the compulsion of} circumstances, is thereby rendered capable of transmitting a peculiar congenital aptitude to his children than he himself possesses.

When dealing ~~useful~~ ^{with} ~~in making experiments~~ ^{the} ~~selection~~ ^{many} ~~experiments~~ ^{first} is to completely eliminate the influence upon the children of parental education and of social tradition. The next requirement is uniformity of nurture ^{of an almost all-acting character} ~~which~~ ^{Thirdly} ~~ought to carry on processes of experiment~~ ^{be made} ~~simultaneous experiments~~ ^{on} ~~in~~ ^{very} many different families ^{large} ~~and~~ ^{lastly} ~~to be carried out in order~~ ^{and naturally} ~~influence~~ ^{in time, labour and money.} All these points with great emphasis to the selection ^{for experiments} of such creatures only as are ably reared from eggs. ^{and} ~~birds~~ ^{insects} ~~seem~~ especially suitable, partly on account of the variety of their aptitudes; but moths ^{small}, fish and even frogs might perhaps be utilised. Plants, ^{being} ~~this~~ ^{definitely in what we understand by} ~~aptitudes~~ ^{hardly} mental faculties, ~~not~~ come under consideration.

Fowls. The art of hatching in incubators is now so well understood and so largely practised for commercial purposes, whether any and what very simple experiments might be regularly carried on chicken hatched in incubators (at small cost) during the process of rearing them. I (say) do not profess to do more than suggest certain general ideas for discussion in the hopes that they may be ultimately moulded into a practically useful shape. The particular example that I will now give must be looked upon in that light only, namely, as an illustration of what is wanted and of what seems in a general way to be feasible, and as a matured and definite proposal. The example is as follows:-

Certain mimetic insects which are in reality good and desirable food, are avoided by certain birds, some say instinctively, on account of their superficial resemblance to other insects which are averse to the taste or dangerous from their ~~distress~~ stings. It might be possible to find such mimetic insects that are instinctively avoided by fowls and that at the same time can be easily reared. These would be given to the chicken (who would at first beaccustomed to eat them and had learnt to like them). Then

it would be a matter of observation open to any one to determine whether the stock of a breeder reared under these conditions for several generations, showed any signs of their instinctive avoidance of these insects being tested when they were first presented to them. The whole of the stocks of some breeders being submitted to this experiment and those of other breeders being left alone, a comparison between the two could always be made between them.

Though ~~such~~ this particular experiment may perhaps not prove feasible, its description will serve as an example of what should be aimed at. Namely, to teach the poultry to welcome some particular signal for food or other desirable end, ~~which was at first instinctively unwelcome to them~~. Considering the terror (at hearing certain cries) that fowls are said to show instinctively, it is quite conceivable that sound signals might be an effective ~~means~~ means of experiment.

However the ~~first~~ ^{very early} step before ~~conducting~~ ^{describing} determining a course of experiment, should certainly be to observe more carefully than has hitherto been done, the degree of aversion or of pleasure that newly hatched fowls ~~may~~ ^{really} show to each of a variety of sight and of sound signals. ^{and without reference to the species} Numerous statements have been made (It is quite possible that very little may be correctly ascertained), and that the experiences & associations of thought in these young things may play a larger part than we are aware of, in the interpretation placed by chickens even of a few days old, on the sight and sound signals by which they are guided.

Moths. If a proper species of moth be selected, too brood can be reared in each year without difficulty. The moths that ~~now~~ are ^{now} being reared for me, for quite another inquiry, are the Selene Illustraria, and I have ~~already~~ many healthy in the fifth generation, thanks primarily to the care of Mr. F. Merrifield, and more lately to Tufts Richardson, and now to Mr. Welldon also. It is worth considering whether experiments analogous to those suggested in respect to fowls, are worth making upon the larvae of moths. The Larvae are fastidious as to their diet, but larvae ~~and~~ other food ^{apparently} exist that they refuse at first to touch, ~~but~~ ^{though} afterward feed greedily upon it without any harm to health. It would be ~~very~~ instructive to gather the experience of moth breeders on this point, and doubtless the breeders of silk worms have abundance of appropriate information.

Fish. The fish that inhabit waters previously unvisited by anglers are readily caught at first by a baited hook, but they soon become wary. The most guileless among them are ~~caught~~ ^{and killed} ~~and~~ ^{extinguished} ~~they~~ ^{live} comes to an end, while the terror ~~exists~~ ^{exists} by each newly hooked and floundering fish helps to educate the survivors ^{in education} to the fear of latent danger. How far this ^{acquired} ~~read~~ may ~~be~~ assume the form of an hereditary fear of man, remains to be proved. I presume that some of the smaller ~~species~~ ^{fish} admit of being easily reared ^{in multitude} ~~when~~ ^{each} new generation, being hatched in a ^{separate} ~~receptacle~~ newly cleaned out for them. So that there shall ~~be~~ ^{be} no education ^{of the members} ~~of the~~ last me any previous generation.

A classical experiment by Motiers shows the possibility of impressing a conviction on the mind of a fish that is afterwards retained with tenacity. He prepared a long trough full of water and divided it into two compartments by a strong plate of clear glass, set crossways. He placed a live pike in one compartment and live minnows in the other. The pike soon made a dash at the minnows, not seeing the interposed glass, against which his snout struck ~~painfully~~, and he was thrown back baffled and presumably somewhat hurt. Again he tried, and again with the same result. Being a stupid sort of fish, he continued ^{after three trials} ~~doing~~ at intervals during a month and then ^{he} ~~wholly~~ desisted. The idea had become at last fairly hammered into his head, that the minnows were invariably protected, and that it was both a useless and painful act for him to attempt to seize them. At this stage of the experiment, the partition was removed, and the pike thenceforward made no further attempt on the lives of the minnows.

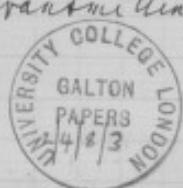
But what would his descendants have done under similar circumstances? Would they be taught ^{a little} more ~~more~~ ^{quickly} than their parent had been? This little anecdote is offered merely to show the sort of experiment at which we should aim, namely the successful imposition of an originally uncongenial habit.

It now remains

now let us consider ~~whether~~ how far the sort of information that such experiments ^{as these} could afford would settle the question of dispute. It ~~would~~ assign limits to reasonable doubt, it would tell us that the number of times in which an acquired habit was inherited to any sensible degree ^{after some specified number of generations} did certainly not exceed so and so per cent. It might also tell us that the number certainly did exceed some lesser number per cent. We could ~~not~~ hope to prove that acquired habits ^{are} never inherited, but it is possible that we may ^{might find} ~~it~~ ^{in any appreciable degree} ~~that they were not heritable even after~~ ^{after a large number of generations} ~~extremely~~ ^{small degrees}. This seems to have been done in the case of many artificial mutilations. But as the loss of a limb belongs to a very different order of ~~things~~ ^{causes} to the loss of an instinct, it would be dangerous to conclude that what ^{is} found to occur in the one case would necessarily occur in the other. It therefore appears to me that the probability experiments along the lines I have suggested, on creatures reared from eggs, and away from their parents, are well worth considering. It is only through the hard compilation of unquestionable facts, that we are likely to forego the wholesome moral doctrine that the self denials and ~~hard~~ tools of the parent will earn for his children a happier nature than he himself has been gifted with, that they will craignitally ^{naturally} ~~more~~ ^{less} ~~their~~ ^{than he} faults was, to deny themselves ^{harmful} pleasure as are harmful, and to work ^{generally} ~~more generally~~ than he was naturally disposed to do, ^{In the} good of others. ^{So far} ~~but~~ ^{of the question in itself} ^{to a large extent} ~~therefore~~ ^{and} ~~talky about~~, but it is one to be solved by a direct appeal to experiment and observation. The possibility of a child inheriting ^{peculiarities} aptitudes that the parent has acquired against the grain of his nature ^{cannot be forced by a direct appeal to experiment} ~~is a most important question~~ ~~in itself~~ ~~and~~ ^{to be firmly} ~~the object of this memoir is to obtain~~ the opinion of experts as to the most feasible ~~way~~ ~~of solving~~ ^{the purpose of} experiments for ~~solving~~ ^{the purpose of} it.

^{In the present time}
^{we are no longer satisfied in idling holding their belief and a preaching and ^{containing} about it}
^{as if it were true. So far ^{that} been the case,}
^{unquestionably. There is the evidence that it is so, and the balance of probability seems ^{to be firmly}}
^{the other against its truth being true. But the question may still be an open one, and can only}
^{be solved by a direct appeal to experiments &}

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Feasible experiments have yet to be designed that shall be recognised by experts as satisfactory tests of the hereditary transmission of acquired habits. In other words, of the existence of a tendency in parents to transmit congenital aptitudes to their children to do things for which they themselves had no congenital aptitude, though they had acquired an aptitude for doing them under the compulsion of circumstances.

It is almost needless to say that this is one of the most important problems that vex the student of heredity at the present day, and perhaps the most difficult of solution. But it is only of late that its difficulty has become generally appreciated. Thanks especially to the searching criticism of Professor Weissmann, grave doubts have fallen on the adequacy of the data upon which the old popular belief is based, of the possibility of inheriting ^{purely} acquired faculties. We now see more clearly than before, the insufficiency of all evidence that shows no more than this, namely when a parent has acquired some particular aptitude there are many instances in which his children are found to inherit that aptitude. Whenever the evidence goes no further than this, it is fatally incomplete; for it may well be that the parent was himself congenitally gifted with a disposition that made the process of acquirement a pleasure ^{to him}, and with a capacity that made it easy. In this very common case, the children may have inherited no more than the congenital gifts of the parents, & not the acquired ones, and these will frequently be developed in early life through imitation or tradition. Such instances as these, give no help to solve the question whether a parent who had no peculiar congenital aptitude, but who acquired a peculiar aptitude through long practice enforced by circumstances, is thereby enabled to transmit to his children a stronger congenital aptitude than he had himself possessed.

~~When~~ ^{for} devising experiments to solve this difficult problem, many stringent requirements must be regarded. The first is complete to eliminate the influence of parental education and of social tradition from the children. Another is uniformity of nurture. Thirdly we ought to carry on experiments of an almost self acting character on many different stocks, simultaneously, and during many generations. We must do this without fear of the results of our experimental being biased through the influence of any form of natural or artificial selection. Lastly we have to economise in time, labour and money.

All these requirements taken together, point with great emphasis to the selection of such creatures only as are artificially reared from eggs, for the purpose of experiment. Fowls seem especially suitable, partly on account of the variety of their aptitudes; bat-moths, small fish, and even frogs might perhaps be utilised. Plants, from their deficiency in mental faculties, hardly come under consideration.

Fowls. The art of hatching in incubators is now so well understood and is so largely practised for commercial purposes, that it is very well worth considering whether any and what very simple experiment might be regularly carried on at small cost, on chickens hatched in that way. I do not profess to do more than suggest certain general ideas for discussion, in the hope that they may be ultimately moulded into a practically useful shape. The particular example about to be given, must be looked upon in that light only, namely as an illustration of what is wanted, and of what seems in a general way to be feasible, and by no means as a matured and definite proposal. The example is as follows—

Certain mimetic insects which are in reality good and desirable food, are avoided by certain birds, some say instinctively, on account of their superficial resemblance to other insects which are acrid to the taste or dangerous from their stings. It might be possible to find mimetic insects that are instinctively avoided by fowls, and ~~which~~ at the same time can be easily reared. These would be given to the chicks who would at length learn to eat them greedily. Then it would be a matter of observation to determine whether the stock of a breeder, reared under these conditions for several generations, showed lessened signs of an instinctive abhorrence avoidance of these insects when first presented to them. The whole of the stocks of some breeders being submitted to this experiment and those of others being left alone, comparisons could always be made between them.

Though this particular experiment may not prove feasible, its description will serve as an example of what should be aimed at. Namely to teach the poultry to welcome some particular signal for food or other desirable end, which signal was at first instinctively unwelcome to them. Considering the terror that fowls are said to show instinctively at hearing certain ones, it is quite conceivable that sound signals might be effective means of experiment.

A very early step before seriously considering any course of experiment should certainly be to observe more carefully than has I believe, hitherto been done, the degree of aversion or of pleasure that newly hatched fowls really show to each

of a variety of sight and of sound signals, and their individual differences in these respects. It is quite possible, that though numerous statements have been made, very little may have been correctly ascertained and that experience and associations may play a larger part than we are aware of, in the interpretation placed by chickens even of a few days old, on the sight, and sound ^{and other} signals by which they are guided.

Moths. If a proper species of moth be selected, two broods can be reared in each year without difficulty. The moths that are now being reared for me for quite another inquiry, are the Selenia Illustraria, ^{and}. I have already many healthy broods in the fifth generation, thanks primarily to the care of Mr F. Merrifield, and now to Miss Birdham and Mr Welldon also. It is worth considering whether experiments analogous to those suggested in respect to fowls, are worth making upon the larvae of moths. Larvae are fastidious in their diet, but leaves and other food apparently exist, that they refuse at first to touch though they afterwards feed greedily upon it without any harm to health. It would be instructive to gather the experiences of moth-breeders on this point, and doubtless the rearers of silk-worms have abundance of appropriate information.

Fish. The fish that inhabit waters previously unvisited by anglers, are readily caught by a baited hook, but they soon become wary. The most quieless of them are the first who are captured, and their breed is extinguished, while the survivors are educated to the fear of latent danger by each newly hooked and floundering fish. How far this acquired dread may assume the form of an hereditary instinct, remains to be proved. I presume that some of the smallest species of fish admit of being easily reared in multitudes. The members of any generation on which observation is desirable ~~being~~ would be hatched in a separate receptacle, newly cleaned out for them, so that they shall receive no education from members of any preceding generation.

A classical experiment by Möbius shows the possibility of impressing a emotion on the mind of a fish, that is afterwards retained with tenacity, and ought to be transmitted by inheritance if the transmission of such acquired convictions be possible. He prepared a long trough full of water and divided it into two compartments by a strong plate of clear glass, set crossways. He put a live pike into one compartment and live minnows in the other. The pike seeing the minnows through the glass, but not seeing the glass itself, soon made a dash

at them. His snout struck heavily against the interposed glass, and he was thrown back baffled and presumably somewhat hurt. Again he tried, and again with the same result. Being a stupid sort of fish, he continued to make these frantic dashes at intervals during a month, and then he suddenly and wholly desisted. The idea had become at last fairly hammered into his brain, that the minnows were invincibly protected and that it was both a useless and painful act for him to attempt to seize them. At this stage of the experiment Möbius removed the glass partition, but the fish thenceforward made no further attempt on the lives of the minnows. What would the descendants of that fish have done under similar circumstances? Would they be taught a little more quickly than he had been? This little anecdote is offered merely to show the sort of experiment at which we should aim, namely, the successful importation of an originally uncongenital habit.

It now remains to consider how far the information that such experiments as these could afford, would settle the question of the possibility of transmitting hereditarily any habit that may have been acquired. It ought to assign limits to reasonable doubt. We should learn that the number of times in which an acquired habit was inherited to any sensible degree after some specified number of generations, could certainly not exceed so and so per cent. We might also learn that it certainly did exceed some lesser number. ~~We cannot prove any negative~~ and therefore cannot hope to prove that acquired habits are never inherited, but we may perhaps find no case of their being inherited in any appreciable degree, even after many generations. This seems to have been already done in the case of many artificial mutilations. But as the loss of a limb belongs to a different order of events to the loss of an instinct, it would be dangerous to conclude that what has been found to occur in the one case would necessarily occur in the other. It therefore appears to me that the possibility of experiments along the lines I have suggested, on creatures reared from eggs and away from their parents, are well worth considering. It is only through the hard compulsion of unquestionable facts, that we are likely to forego the wholesome moral doctrine that the self-denials and toils of the parent will earn to his children a happier nature than he had himself been gifted with. That they will be congenitally more disposed than he was to deny themselves harmful pleasures, and to work generously for the good of others. It must be recollect ed that we are no longer justified in idly holding this comfortable belief, and in preaching about it as if it were unquestionably true.

So far from this being the case the balance of probability seems strongly against its truth. But the question is not yet solved. The possibility of a child inheriting even the simplest aptitudes that the parent has acquired against the grain of his nature, can only be determined by a direct appeal to suitable experiments. The object of this memoir is to obtain the opinion of experts as to the most feasible experiments for the purpose
