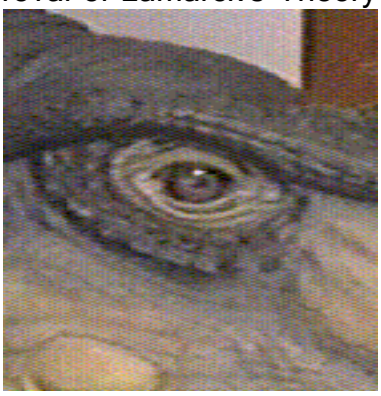
Lamarck Revisited

The Inheritance of Acquired Characteristics Gains Attention

Since the turn of the 20th century, the scientific community has widely rejected directed evolution, a theory mostly associated with the name of Jean-Baptiste Lamarck (1774-1829).Disapproval of Lamarck's Theory of Inheritance of Acquired Characteristics has not dissuaded investigators from attempting to prove that the grand old man of evolution may have been right after all. If they can do that, then the concept of humanity battling against a harsh world will be reconsidered. Evolution will graduate from a theoretical study to a practical philosophy that guides our lives.



Note: The words directed evolution, Inheritance of Acquired Characteristics, Lamarckian evolution, and adaptive mutations are expressions that have slightly different meanings to different persons. For this article the words will be used interchangeably and will have the same context.

The History

Lamarck is considered the more complete theorist of the early promoters of the Theory of Evolution that Charles Darwin later adopted and greatly expanded. Lamarck followed contemporaries in explaining evolution as a directed process and self-adapting means by which species changed their characteristics in response to environmental changes and passed the characteristics to future populations. Darwin published his Principle of Natural Selection on November 24, 1859, at the same time as did co-discoverer Alfred Russel Wallace. In Charles Darwin's words:

> *..If variations* (from mutations) *useful to any organic being ever do occur, assuredly individuals thus characterized will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance, these will tend to produce offspring similarly characterized. This principle of preservation, or the survival of the fittest, I have called Natural Selection.*

Through the remainder of the 19th century, academics of the two evolution theories competed with one another for scientific approval. Contemporary religious authorities considered them both as acadenic aberrations.

The Losing Battle of Lamarck's Supporters

Darwin's Theory of Natural Selection obtained greater scientific recognition, but Lamarck's concepts had support. German Zoologist August Weismann, while performing experiments in the late1880's to prove Lamarck right, convinced himself that Lamarck had been wrong.

Weissman concluded that the cells in mammals that determine heredity (*germline*) became isolated before birth from the cells (*soma*) that determine the growth of the mammal. No mechanism had been determined by which changes in the *soma* could affect the *germline,* or by which *soma* changes could be inherited. This phenomenal discovery, still known as *Weissman's barrier*, should have ended the discussion. However,in some animals and plants, the separation between *germline* and *soma* occur after birth. Those cases contain a possibility of *inheritance of acquired characteristics*. Weissman's conclusions only made Lamarck's supporters more eager to prove Lamarck's theories by experimentation. One of the attempts had tragic consequences.

Austrian biologist Paul Kammer claimed to have living proof that toads (Alytes), which normally mate on land, developed calloused pads in order to hold slippery mates when they became seduced to mate in water.The land toads developed pads developed after only a few generations. Charges of investigative fraud countered Kammer's claims. Paul Kammer committed suicide six months after the charges appeared and his suicide seemed to confirm the charges. The hostility of the scientific community to Lamarck's supporters, and Kammer's suicide that resulted from this hostility, diminished the ardor of Lamarck's adherents, but not in the Soviet Union.

Russian plant breeder T.D. Lysenko attemped to improve plant yields by inducing "environmental" changes during plant germination with use of a process known as vernalization. Lysenko's work is still controversial. If he had some success, it became buried in the Cold War rhetoric. Having his theories championed by a leading scientist of the Soviet Union further deteriorated Lamarck's image in the West. Lamarckians graduated to Neo-Lamarckians.

The Neo-Lamarckian challenge to Darwin's *Theory of Natural Selection* hinged on whether mutations were directed or random. Without complete knowledge of the origin of mutations, neither evolutionary theory could claim complete legitimacy. In 1943, Salvador Luria and Max Delbruk showed that cultures of bacteria grown in laboratory dishes, and which survived lethal doses by a selective agent, obeyed the theory of random mutation--the distribution of the surviving microbes could only have occurred if the bacteria had mutated before presentation of the lethal agent. The statistical distribution of survival indicated that post lethal dose mutations had not occurred. This final blow to Lamarck's concepts still did not permanently deter Lamarck's followers. It encouraged them to examine Luria's tests and devise new ones - and for good reasons--*Natural Selection* had not answered all the problems of the theory and Lamarck's theory had positive social implications that contrasted with the negative impact of Darwin's theiry..

The Problems with Natural Selection

Luria's and Delbruk's successful investigations removed one doubt from the *Theory of Natural Selection*--that random mutations could improve a species chance of survival. The Darwinians had no more doubts in their beliefs. Over the years, a lesser recognized group of evolutionists demanded answers to their questions:

(1) Why haven't the fossil remains displayed intermediary stages of growth expected from the gradual changes of *Natural Selection?*
(2) How can the unpredictable nature of random mutations provide a suitable mechanism for the development of complex systems such as the nervous system, eye and armed weapons in animals, such as sprays?
(3) Do a sufficient number of generations exist to adapt to the slow changes predicted by random mutations and evolve to the human species as it exists today?
(4) Does a slight superiority of a positive, but still not obvious benefit of a particular mutation, mean that mating will proceed quickly enough to capture the benefits of the mutation? Can't it more easily lag into obscurity?

Darwin realized some of these limitations to his theory. He addressed them with care, but not with final authority. Other evolutionists have shown that nervous system and eye developments have a variety of intermediate patterns in the animal world and a gradual evolution of these systems is entirely possible. Neo-Darwinist Stephan Jay Gould, who did not have total acceptance from other neo-Darwinists, proposed a Theory of Punctured Equilibrium--evolutionary changes occur in short and quick bursts. Using this theory, the lack of fossil records and incomplete number of generations become lesser limitations to Darwin's theory. Some evolutionists still felt their questions had not been satisfactorily answered and must be eventually explained. The perception that limitations remained in the *Theory of Natural Selection* prompted these evolutionist to find a more complete scientific theory of evolution. Their more complete theory did not

attempt to contradict *Natural Selection*. It attempted to complement it and strengthen its acceptance.

The Social Elegance of Directed Evolution

Scientific fulfillment was not the only reason driving the Neo-Lamarckians. *Directed evolution* pleases social reformers. *Natural Selection* angers them.

- Darwin speaks of competition. Lamarck speaks of cooperation.
- Darwin represents survival of the fittest. Lamarck speaks of the species making itself fit.
- *Natural selection* makes humankind a pawn of random mutations that indirectly determine its fate. *Inheritance of acquired characteristics* has humankind more directly involved in its fate.
- *Natural Selection* is harsh, cruel and insensitive. *Inheritance of acquired characteristics* is optimistic, soothing and sensitive.
- *Natural Selection* has not shown practical applications. *Inheritance of acquired characteristics* promises practical applications that can benefit humankind.
- *Random mutations* can be lethal. *Adaptive mutations* are not lethal.

The Attempted Proofs of Directed Evolution

Many experiments have been performed with to prove directed evolution. Only a few of them will be mentioned, and most of them have their critics and alternative explanations.

Epigenetic inheritance systems, in which the phenotype (observed appearance of an organism) that expresses cell information is modified by environmental stress, have been noticed as modified phenotypes appearing in subsequent generations.

In 1988, a team of Harvard biologists under the leadership of Joseph Cairns challenged the previous experiments performed by Luria and Delbruck in 1943. The early experiments seemed to prove that all mutations occurred randomly and none could be directed. Cairns group reasoned that in the earlier investigations the bacteria had been given too lethal a dose. They died before they could develop and propagate self-directed mutations.

The Harvard experimenters used bacteria that could not grow in a specific environment because they lacked a working gene for an enzyme needed to metabolize the only available food. By genetic engineering, the bacteria were given versions of the necessary gene in which the coded message was, in effect, scrambled and therefore useless. Most, if not all, the bacteria failed to grow. After a few days they began thriving, feeding and reproducing. The distribution of bacteria colonies that survived showed that many bacteria had unscrambled the code and performed self-directed mutations that corrected the deficiency.

Barry G. Hall, an evolutionary biologist at the University of Rochester, NY, damaged cell DNA by two different forms of genetic damage. Mutations that might occur to repair either of the damages were not sufficient to benefit the cell. Both damages required repair for any benefit. In one of two 1991 experiments, which are too complicated and lengthy to describe in this space, he showed that the cells repaired themselves by producing the correct mutations at a rate billions of time sooner than if chance alone had caused the changes. (Washington Post, April 20, 1992, p.A3)

Note: Both of these investigations were criticized as lacking effective controls, and ascribed to known physiological processes. Subsequent work by Hall with more controlled experiments eventually led to experimentally verified acceptance. (Johannes Wirz, Progress towards complementarity in genetics, Elemente der Naturwissenschaft, 64(1), 37-52 1996)

Epigenetic changes, which are alterations in gene expression, can be passed from mother cells to daughter cells. However, it had not been shown that subsequent generations inherited the same properties. Evidence is accumulating that the epigenetic changes are not erased. This phenomenon has been observed in plants, fruits and yeast. (Was Lamarck just a little right? Michael Balter, Science, April 7, 2000)

Geneticist Enrico Coen and others at the John Innes Centre in Norwich, U.K. reported that a mutant version of the toadflax plant (flowers radial rather than bilateral) was due to an epimutation in which a gene was not expressed. The gene state and and the flower characteristic were inherited by subsequent generations of toadflax plants. (Nature, September 9, 1999)

Inherited epigenetic changes have also been observed in mammals.

Mohan Raizada at the University of Florida in Gainesville, Florida and others inserted a therapeutic gene into a modified virus, and delivered the gene into the hearts of rats that are predisposed to high blood pressure. These rats and two subsequent generations were protected from hypertension.
"Our data support the notion that the AT1R-AS is integrated into the parental genome and is transmitted to the offspring. The proposed germ-line transmission of the AT1R-AS is consistent with previous reports demonstrating the integration of retroviral vector and its germ-line transmission in other systems." (Permanent Cardiovascular Protection From Hypertension by the AT1 Receptor Antisense Gene Therapy in Hypertensive Rat Offspring, Circulation Research. 1999;85:e44.)

Philosopher Eva Jablonka and Biologist Marion J. Lamb present a detailed study of *'epigenetic inheritance'* and multiple inheritance systems in their book: Epigenetic Inheritance and Evolution--The Lamarckian Dimension. On P. 26 they state:

> *In recent years, molecular biology has shown that the genome is far more fluid and responsive to the environment than previously supposed. It has also shown that information can be transmitted to descendants in ways other than through the base sequence of DNA.*

On Page 27, they further state:

> *The nature of different types of heritable variation is now beginning to receive closer attention, and there is a growing realization not only that some DNA variations can be environmentally induced, but also that there are non-DNA heritable variations that play a crucial part in development.*

Breaking Weismann's Barrier

Until now, no mechanism for inheritance of acquired characteristics has been demonstrated in vertebrates. Nevertheless, means for acquired characteristics to cross Weismann's barrier have been theorized and presented. Molecular biologists Edward J. Steele, Robyn A. Lindley and Robert V. Blanden, who work at different Australian research centers, have been active for many years in investigating the immune system's adaptive processes and have tried to apply a similar analogy to an *inheritance of acquired characteristics.* On P. 166 of their book titled: Lamarck's Signature, they present one scheme:

> *The 'Somatic Selection Theory' predicts the germline transmission of acquired somatic mutations of antibody V-region genes. It could be affected via the agency of the enzyme reverse transcriptase (copying RNA into DNA) plus the ubiquitous, naturally occurring endogenous RNA retroviruses (produced by lymphocytes) acting as 'gene shuttles' ferrying mutated V-region gene sequences into germ cells. This would then be followed by the physical integration of this somatically derived genetic information into the germline DNA so as to replace a pre-existing gene sequence.*

Other Indications of Lamarckian Evolution

The gradual changes that occur from random mutations in individuals of a species dictate that *Natural Selection has abrupt but* slow evolutionary changes. Lamarck's hypothesis predicts that characteristics change in large populations and therefore have a more rapid evolution. Recent studies have concluded that evolutionary changes can be quick.

- According to Megan Higgie and colleagues at the University of Queensland, Australia, a type of male fruit fly altered within just nine generations the chemical signals it puts out to attract females in its species.
- Andrew P. Hendry and colleagues at the University of Massachusetts, learned that just after only 13 generations, sockeye salmon developed distinctly different sizes depending on whether they spawned in a river or lake.
- Ruth Shaw, University of Minnesota, and University of California researchers, David N. Reznick and F.H. Rodd captured guppies from two downstream pools and placed them in pools upstream of waterfalls. In the downstream pools the guppies had been plagued by large predators but in the upstream pools, only small predators were around. After four years, these guppies began reaching maturity. They quickly adapted to their new and less threatening surroundings by growing larger and by producing fewer offspring.

An Evolutionist Summarizes Lamarck's Contributions

C.H. Waddington, a reknowned evolutionist, provided an answer to the environment's influence on the evolution path by tracing his development as an evolutionist in his book: *The Evolution of an Evolutionist.* Although he worked during the decades of the 50's and 60's, and before current thoughts and experiments, his words still have meaning today.

Early in his career, he praised Lamarck. On P.38:

> *Evolutionary theories had, of course, been put forward some time before Darwin wrote Origin of Species. The most famous of these earlier discussions is that associated with the name of Lamarck. It has suffered a most surprising fate. Lamarck is the only major figure in the history of biology whose name has become to all extents and purposes, a term of abuse. Most scientists' contributions are fated to be outgrown, but very few authors have written works which, two centuries later, are still rejected with an indignation so intense that the skeptic may suspect something akin to an uneasy conscience. In point of fact, Lamarck has, I think, been somewhat unfairly judged.*

Waddington offered that evolution should consider an adaption process that is influenced by the environment. On P. 24

> *The reigning modern view is that, in nature, the direction of mutational change is entirely at random, and that adaptation results solely from the natural selection of mutations which happen to give rise to individuals with suitable characteristics. I want to argue that this theory is an extremist one, and that, in essaying to account for adaptation, it neglects to call to its aid the doctrines emerging in other fields of modern biology.*

In a later article Waddington explained the doctrines of modern biology that perform the adaptation process. He termed the process *genetic assimilation* and relied on natural selection for transferring the adaptation to future generations. On P. 91:

> *The process of genetic assimilation is one by which a phenotypic character, which initially is*

produced only in response to some environment influence, becomes, through a process of selection, taken over by the genotype, so that it is formed even in the absence of the environmental influence which had at first been necessary.

Genetic assimilation is brought about by the operation of orthodox genetic and embryological principles. It depends on two main types of fact: (a) that the capacity of an organism to be modified in response to an environmental stress is under genetic control and can be altered by selection; and (b) that development processes exhibit a balance between tendencies to be modified by the environment and tendencies to resist modification.

Where Lamarckian Evolution is Today

If *directed evolution* could be proven, then its knowledge and acceptance would greatly affect all mankind.

Inducing agents might be used to direct the immune system to rapidly develop permanent antibody solutions to diseases and carry these solutions to subsequent populations. Genetic engineering would include Lamarck's concepts, giving it a more positive approach and making it more aware of treacherous and possible damaging effects. Agriculture could take advantage of environmental manipulation of plant life. The latter investigation has already been explored in the Soviet Union with varying and controversial success.

Despite the intensive investigations of Lamarck's theories and claims made from them, Lamarck's *Inheritance of Acquired Characteristics* has only mildly interested the scientific community. One reason is that all of *Natural Selection* has been widely accepted and its dogmas have become an integral part of the academic community. The leaders of laboratories, institutions and universities have a clear interest in maintaining a status quo in evolutionary thinking. But that isn't the major reason.

The major reason is that Lamarck's followers have investigated for decades and have not found a '*Killer App'*, a revelation that will totally excite rather than mildly interest the scientific community. They have not located '*the smoking gun'* that sufficiently derails the intensive preoccupation with *Natural Selection* and permits an intensive examination of a complementary approach to evolution. Proponents of *Natural Selection* note that environment might influence the genes, but maintain that *Natural Selection* determines the appearance of acquired characteristics in future generations.

Acceptance of Lamarck's hypothesis of *Inheritance of Acquired Characteristics* has one additional implication: If humankind is able to respond to the environment and direct its evolution, then the questions concerning *Natural Selection* will be answered. The intervention of a higher authority in the evolutionary process will become superfluous. The last nail in the coffin of creationism will be hammered.

Relevant Literature:

Lamarck's Signature-- How Retrogenes are Changing Darwin's Natural Selection Paradigm, Edward J. Steele, Robyn A. Lindley, Robert V. Blanden, Perseus Books, 1998.

Epigenetic Inheritance and Evolution--The Lamarckian Dimension, Eva Jablonka and Marion J. Lamb, Oxford University Press, 1995.

The Evolution of an Evolutionist--C.H. Waddington, Cornell University Press, 1975.

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