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In his letter on *Science and Judaism* of 1962<sup>1</sup> the Lubavitcher Rebbe Shlita writes: "If you are still troubled by the theory of evolution, I can tell you without fear of contradiction that it has not a shred of evidence to support it."

Such a statement comes as a shock to those of us who have been indoctrinated since our school-days with the notion that evolution is a scientific fact. Most of us retain that notion throughout our life and it is only the few who become involved in advanced study and research in evolutionary theory who have the opportunity to examine the foundations on which it is built.

## A Statistician Looks at Neo-Darwinism

by Prof. Avraham M. Hasofer

### *A Statistician Looks at Neo-Darwinism*

Having been involved for several years in that research, I feel it my duty to come out and share my conclusions with the public at large, at a time when much confusion exists about this subject.

A substantial part of what I would like to say has already been covered by Dr. L.M. Spetner's excellent articles which appeared in B'OR HA'TORAH number two, and to which I refer the

<sup>1</sup> Carmell, A. and Domb, C. (eds.) *Challenge: Torah Views on Science and its Problems*, Jerusalem-New York: Feldheim Publishers, 1976, pp. 142-49.

reader. The remarks below are to be taken as complementary to his.

### *What is the Theory of Evolution?*

The Theory of Evolution discussed in modern biology books invariably means neo-Darwinist theory, which purports to explain the appearance of the diverse life-forms existing on earth. According to this theory, plants and animals have descended from simple ancestors far back in the history of the earth. The mechanism by which new species appear consists of two steps:

- (a) the appearance of new features through mutations;
- (b) natural selection, which ensures that beneficial mutations will survive and be passed on to the offspring.

### *What are the Criteria for a Scientific Explanation?*

The question arises: does neo-Darwinism satisfy the accepted criteria of a scientific explanation?

There are many scientific theories which purport to explain observable facts. Let us consider a typical example: the perturbations of the orbit of the planet Uranus. It was suggested by the astronomers Adams and Leverrier that the perturbations were due to the attraction of a hitherto unobserved planet. Using Newtonian mechanics, they proceeded to calculate the expected position of the unknown planet. The latter was then observed by Galle in 1846, at the very position which had been predicted by calculation.

This example illustrates two basic criteria for a scientific explanation:

(a) The proposed cause must be observed to exist.

(b) It must be possible to show *quantitatively* that the proposed cause explains the observed effect through the use of accepted theory.

Observation of the cause and the effect then provides a confirmation of the theory used in the calculation as well. Thus the observation of Neptune provided confirmation of Newtonian mechanics, on which the calculations were based.

Sometimes, however, the proposed cause is unobservable, as in the case of the electronic theory of electricity. In that case, it is absolutely imperative that the cause should quantitatively predict the effect through the use of accepted theory.

### *Does Neo-Darwinism Satisfy the Criteria?*

The answer to this question is emphatically "no". In fact, the proposed causes have never been observed:

(a) *A new species has never been observed descending from another.*

(b) *A crucial aspect of the proposed mechanism of evolution is the appearance of mutations which are beneficial in some environments. However, a beneficial mutation has never been observed. This fact is usually well camouflaged in texts which support evolution. Examples of selection of a particular advantageous feature abound. But close examination of the facts invariably reveals that the advantageous feature could well have been there all the time. There is no evidence that a mutation has occurred.*

One very popular case study quoted by Darwinists is that of the peppered moth (*Biston betularia*) in Great Britain. In the past, there were many light-colored moths that blended with the lichen growing on trees. As industry spread, the lichen disappeared, and the dark (melanic) form of the moth became predominant. This predominance has been attributed to the adaptive advantage of the dark form which is better camouflaged against predators when it settles on soot-blackened tree bark.

The operation of natural selection in this case has been amply established by observation and experiment. But it has never been established that the melanic form of the moth appeared through mutation. The more cautious writers such as Ruse<sup>2</sup> do not make such a claim.

But in the *Encyclopaedia of Nature and Science*<sup>3</sup> under the article "Evolution", we read: "Until about 100 years ago, nearly all the peppered moths were white. . . Occasional black individuals appeared as the result of a mutation. . ."

In fact, the most probable explanation of the origin of the dark variety is that it had existed all the time but only as a very small proportion of the population, possibly because the allele responsible for the black color also offered some other selective advantage. Such a situation is referred to in the literature as genetic polymorphism and is very widespread.<sup>4</sup>

One situation where the mutation rate was artificially increased is the Bikini atoll after the atomic bomb tests. Large numbers of mutations were observed in the fauna and the flora, all invariably deleterious.

It is to be emphasized that cases of natural selection abound. But even the

most extreme evolutionists have not claimed that natural selection without mutations has led to the appearance of new species.

The only way to redeem the mutation aspect of neo-Darwinism is to show by calculation that, although beneficial mutations have not been observed, they *could* have occurred during geological times.

#### *The Probability of Beneficial Mutations*

Until about twenty years ago, it was not possible to perform any numerical calculations in relation to the occurrence of beneficial mutations, because the mechanism of occurrence of mutations was not well-enough understood.

With the discovery of the chemical composition of chromosomes, it has become possible to put numerical values on the probability of appearance of a beneficial mutation. To my knowledge, the first time such a calculation was published was in L.M. Spetner's paper in the *JOURNAL OF THEORETICAL BIOLOGY* in 1964.<sup>5</sup> A simplified version was subsequently published by myself.<sup>6</sup>

Spetner interpreted the results of the calculations in terms of speed of trans-

<sup>2</sup> Ruse, M. *Darwinism Defended: a Guide to the Evolution Controversies*, Reading, Mass.: Addison Wesley, 1982.

<sup>3</sup> "Evolution" in *Encyclopaedia of Nature and Science*, London: McDonald Co., 1974.

<sup>4</sup> Ford, F.B. *Ecological Genetics*, London: Methuen, 1964.

<sup>5</sup> Spetner, L.M. "Natural Selection: an Information-transmission Mechanism for Evolution", *JOURNAL OF THEORETICAL BIOLOGY*, vol. 7, 1964, p. 412.

<sup>6</sup> Hasofer, A.M. "A Simplified Treatment of Spetner's Natural Selection Model", *JOURNAL OF THEORETICAL BIOLOGY*, vol. 11, 1966, pp. 338-42.

mission of information from the environment to the living organism. This interpretation was further extended by him in the IEEE TRANSACTIONS ON INFORMATION THEORY in 1968.<sup>7</sup> It was reiterated in a paper published two years later in NATURE.<sup>8</sup>

Briefly, the results of the calculation indicated that the probability that even one beneficial mutation would have occurred within the most generous allocation of geological time is so low that it is unreasonable to assume that it had occurred. Further details of the calculation will be given later on.

As has been mentioned above, Spetner's calculation has been available in published form since 1964. In view of the central importance of this problem to evolutionary theory, one would have expected a flurry of attempts to produce alternative calculations which would make the situation more palatable. But there have been no attempts at all! A few weeks ago I made a thorough search of the *Science Citation Index* to find out whether any answers to Spetner had been published. There were none.

My own contacts and discussions with biologists have confirmed the fact that no plausible calculation has been developed to support the claim that the beneficial mutations required to sustain evolution can occur with a reasonably high probability.

#### *Some Details of the Calculations*

To obtain an idea of the order of magnitude involved, we visualize the chromosomes of a living organism as made up of a string of nucleotides. A reasonable total length is about one billion nucleotides, each capable of

having one of the four bases: adenine, guanine, cytosine and thymine. The molecular mutation rate is taken to be  $3 \times 10^{-9}$  per birth per nucleotide, and we assume that mutation of one base to any one of the other three bases is equiprobable. The length of a particular locus in the chromosomes is taken to be 15 nucleotides. The total number of possible sequences is  $4^{15} = 10^9$ .

One can then calculate the mean number of births required for a beneficial mutation to occur. This depends of course on the number of nucleotide sequences which would be beneficial in a particular environment. We thus obtain the following values.

<i>Number of beneficial sequences</i>	<i>Mean number of births required</i>
10,000	$0.18 \times 10^{45}$
100,000	$0.30 \times 10^{39}$

Let us now consider the required birthrate. First we note that the most generous of geologists will allow as an upper bound of the age of the earth six billion years ( $6 \times 10^9$ ). (See for example the article on "Dating" in the *Encyclopaedia Britannica*, 1974.)

Even if we allow the wide choice of one hundred thousand beneficial mutations, and the whole span of six billion years for the one beneficial mutation to occur, we would still expect to need a yearly birthrate of  $5 \times 10^{28}$ . This is certainly totally unrealistic for any higher living organism on earth.

<sup>7</sup> Spetner, L.M. "Information Transmission in Evolution", IEEE TRANSACTIONS ON INFORMATION THEORY, vol. IT-14, no. 1, Jan. 1968, pp. 1-6.

<sup>8</sup> Spetner, L.M. "Natural Selection versus Gene Uniqueness", NATURE, vol. 226, 1970, pp. 948-49.

In fact the total area of the earth is  $5 \times 10^{14} \text{ m}^2$ . Suppose one higher organism was born each year on each square meter of the earth's surface for six billion years. Then we would still have only  $3 \times 10^{24}$  births, not even one ten-thousandth of the average number of births for one beneficial mutation to occur!

For further technical details of the above calculation see Appendix A.

One can recast the above results within the framework of the universally accepted *Neyman-Pearson Hypothesis Testing Procedure*.<sup>9</sup>

Suppose that we still allow a choice of one hundred thousand beneficial mutations, and let us assume a population with one million births per year.

The hypothesis to be tested is: "At least one beneficial mutation has occurred during the time span available to the population." If we choose a significance level of 5%, then since this probability corresponds to a number of births less than or equal to  $0.7 \times 10^{18}$ , it follows that the hypothesis must be rejected if the time span available is less than  $0.7 \times 10^{12}$  years.

Since geological data allow only  $6 \times 10^9$  years as an upper bound, the hypothesis must be rejected.

Another way of looking at the problem is through the technique of *Bayesian inference*,<sup>10</sup> which allows us to update our degrees of belief in scientific explanations in the light of new knowledge.

Suppose that initially, before the chemical structure of DNA was discovered, a biologist was 99% sure that neo-Darwinism accounted for the appearance of the diverse forms of life.

After the biologist becomes aware of the calculations presented above, he

realizes that the probability that beneficial mutations have occurred at all during geological times is far less than 0.0048. If he behaves rationally, he must then conclude that the chance that neo-Darwinism accounts for the diversity of life is far less than 32.2%. In other words, he must now be much more than 67.8% sure that the diversity of life is due to other, hitherto undiscovered causes.

For further details of the Neyman-Pearson and the Bayesian procedures see Appendix B.

Clearly the above calculations heavily understate the case against the neo-Darwinist mechanism, since the latter requires not one beneficial mutation but a very large number, probably billions. But since even *one* mutation appears improbable, so much the more a large number!

### Discussion

The calculations performed in the preceding section are based on our present understanding of the chemical coding of genetic information in the chromosomes. As explained in this paper and pointed out by Salisbury,<sup>11</sup> this understanding is quite incompatible with the concept of evolution by natural selection of adaptive genes that are originally produced by random mutations.

<sup>9</sup> Balaam, L.N. *Fundamentals of Biometry*, London: Allen and Unwin, 1972, p. 12.

<sup>10</sup> Lindley, D.V. *Introduction to Probability and Statistics from a Bayesian Viewpoint, Part I: Probability*, Cambridge, Eng.: Cambridge University Press, 1965, p. 29.

<sup>11</sup> Salisbury, F.B. "Natural Selection and the Complexity of the Gene", *NATURE*, vol. 224, 1969, pp. 342-43.

It has already been mentioned that:

- (a) A new species has never been observed descending from another.
- (b) The appearance of a beneficial mutation has never been observed.

In addition, calculations based on our present understanding of the genetic code show that the probability of the appearance of beneficial mutations in geological times is infinitesimally small. The only rational conclusion that can be drawn from all of the above is that neo-Darwinism is a speculation unsupported by fact.

It is up to the evolutionists to bolster up their case by supporting it with facts and/or *quantitative* calculations. Until they do, one must just state that, at this stage, science cannot shed any light on the mechanism of appearance of the diverse forms of life on earth because the only proper scientific attitude in the absence of evidence is to withhold judgment.

Evolutionists are well aware of the fatal weakness of neo-Darwinism in the area of mutations. Some attempt to evade it through a naive faith. For example, in the 1974 volume of the *Encyclopaedia of Nature and Science*<sup>12</sup> in the article "Evolution", we read: "Mistakes, or mutations, sometimes occur when the (genetic) instructions are being handed down to the offspring. These wrong instructions are generally harmful and the organism gains no benefit — it may even die — but the mutations sometimes result in major improvements. . . Mutations of this kind *must* have happened many times during the long course of evolution. . ."

Other evolutionists use purely verbal arguments, too weak to stand the test

of being reduced to real numbers. For example, Ruse<sup>13</sup> writes: "Consider a monkey, sitting at a typewriter, randomly striking the keys. *Prima facie*, the production of life by random processes seems about as likely as the monkey's typing out the whole of *Hamlet*, . . . It may not be logically impossible; but . . . it is practically impossible. Suppose, however, that every time the monkey strikes the "right" letter, it records; but suppose also that "wrong" letters get rubbed out (literally or metaphorically!). And suppose that elimination of the wrong letter is the full consequence of a "mistake": one does not lose what has already been typed. . . The typing of *Hamlet* no longer seems like anything so impossible, even by a "blind law" phenomenon, like a typing monkey. . ."

Such verbal arguments may sound plausible to a non-mathematician, but for anyone who has had experience with the huge numbers generated by combinatorial arguments, nothing short of an actual calculation will carry any weight. And all calculations made so far emphatically deny the likelihood of beneficial mutations appearing within geological times.

#### *Why is Neo-Darwinism so Popular?*

Spetner<sup>14</sup> asks: "If the evidence for evolution is as weak as I have indicated it to be, then why do the majority of biologists, most of them educated and intelligent people, still hold fast to the evolutionary doctrine. . .?"

<sup>12</sup> See footnote 3.

<sup>13</sup> Ruse, *op. cit.*

<sup>14</sup> Spetner, L.M. "The Evolutionary Doctrine", B'OR HA'TORAH, no. 2, Summer, 1982, pp. 17–25.

His answer, if I understand it correctly, is in two parts:

(a) Evolutionary doctrine provides comfort to those who do not want to be subject to the Ruler of the Universe.

(b) Biology students are intimidated by the threat of ostracism into accepting neo-Darwinism because of the large interests invested in the current view.

While these two factors are undoubtedly important, I would like to bring in a third one, which I believe to be even more fundamental, since it has its source in a basic psychological drive. This factor is highlighted by the Lubavitcher Rebbe Shlita,<sup>15</sup> in his previously quoted letter:

"The question may be asked: If the theories attempting to explain the origin and age of the world are so weak, how could they have been advanced in the first place? The answer is simple. It is a matter of human nature to seek an explanation for everything in the environment, and any theory, however far-fetched, is better than none, at least until a more feasible explanation can be devised."

#### Appendix A

In this appendix, the formula used to calculate the probability distribution of the number of births required to achieve one beneficial mutation is given. This will be followed by a discussion of the parameter values adopted.

The derivation of the formula (in a trivially different form) is given in my simplified treatment of Spetner's Natural Selection Model in the *JOURNAL OF THEORETICAL BIOLOGY*.<sup>16</sup>

Let

$N$  = number of births until a beneficial

mutation is reached.

$n$  = number of nucleotides forming a beneficial sequence. Take  $n = 15$ .

$p$  = probability of mutation of one nucleotide. Take  $p = 3 \times 10^{-9}$ .

$M$  = total number of possible sequences of length  $n = 4^n$ . If  $n = 15$ ,  $M = 10^9$ .

$m$  = number of beneficial sequences out of the  $M$  possible ones.

$P(N)$  = probability of mutating into a beneficial sequence in  $N$  births or less.

Put

$$s_k = (p/3)^k, \quad k = 0, \dots, n.$$

$$q_k = \binom{n}{k} 3^k / M, \quad k = 0, \dots, n.$$

Then

$$P(N) = 1 - \left\{ \sum_{k=0}^n q_k \exp(-N s_k) \right\}^m.$$

In the Neyman-Pearson test the following values are used:  $n = 15$ ,  $m = 100,000$ ,  $p = 3 \times 10^{-9}$ ,  $N = 0.7 \times 10^{18}$ . It then turns out that  $P(N) = 0.05$  (=5%).

If, on the other hand, we put  $N = 6 \times 10^{15}$ , representing a yearly birthrate of one million over a period of  $6 \times 10^9$  years, then  $P(N) = 0.0048$ .

The expected number of births until a beneficial mutation is obtained is calculated from  $P(N)$  by numerical summation.

The value  $n = 15$  for the length of the nucleotide string is based on the generally accepted fact that about three to seven amino-acids are essential for the functioning of an enzyme. Since three nucleotides are needed to code one amino-acid, the essential part of the enzyme will be coded by ten to twenty

<sup>15</sup> Carmell and Domb, *op. cit.*, p. 148.

<sup>16</sup> Hasofer, *op. cit.*

nucleotides. The number 15 is taken as an average value.<sup>17</sup>

As far as the value  $p = 3 \times 10^{-9}$  is concerned, it is near to the value calculated by Champe and Benzer,<sup>18</sup> namely  $10^{-8}$ , for T4 phage.

It is interesting to note that too high a rate of nucleotide mutation will, in fact, reduce the probability of a beneficial mutation appearing, because at the same time that the beneficial mutation must appear, the rest of the information coded in the chromosomes should remain undisturbed. Otherwise, since the immense majority of mutations are deleterious, and many are lethal, the organism would not survive.

Spetner (1964)<sup>19</sup> has made a rough calculation of the optimal mutation rate.

If

$\ell$  = number of nucleotides representing essential information without which the organism cannot survive, then the optimal value of  $p$  is approximately  $n/\ell$ .

Now the total number of nucleotides varies from  $10^7$  to  $10^{11}$ . (See Salisbury (1969) and references therein). Assuming  $\ell = 10^{10}$ , then the optimal value of  $p$  is  $1.5 \times 10^{-9}$ , a value not far from the one adopted.

Finally, as far as the value  $m = 100,000$  for the number of beneficial mutations occurring, it is to be pointed out that since the total number of possible sequences of 15 nucleotides is  $10^9$ , the above value means that one in

10,000 mutations is assumed to be beneficial, a very generous assumption in view of the fact that a beneficial mutation has never been observed to appear.

### Appendix B

#### *Neyman-Pearson Test of Hypothesis*

The distribution function of the number of years required for a population with one million births per year to produce a beneficial mutation is known. (See Appendix A.)

Choosing a level of significance  $\alpha = 5\%$ , which is the usual value in biometry, we set up a "critical region"  $0 < N < N_0$  such that  $P(N_0) = \alpha$ . As stated in Appendix A, if  $\alpha = 5\%$   $N_0 = 0.7 \times 10^{12}$ . If the geological age of the earth falls within the critical region, then the hypothesis, namely "at least one beneficial mutation has occurred in a population with one million births per year during the geological age of the earth" must be rejected.

#### *Bayesian Inference*

Let B stand for the event that life exists on earth as we see it, following the laws of genetics.

Let A stand for the neo-Darwinist theory.

Let  $A^c$  stand for all other possible explanations of the appearance of life on earth (including those as yet undiscovered).

Let  $P(A)$  stand for the probability of A (in the sense of degree of belief).

Suppose  $P(A) = 0.99$ . Then  $P(A^c) = 0.01$ .

Let  $P(B|A)$  be the likelihood that life has appeared on earth in accordance

<sup>17</sup> Salisbury, *op. cit.*, p. 343 and the references quoted therein.

<sup>18</sup> Champe, S.P. and Benzer, S. "Reversal of Mutant Phenotypes by 5-Flourouracil: an Approach to Nucleotide Sequences in Messenger RNA", PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, Washington, D.C., vol. 48, 1962, p. 532.

<sup>19</sup> Spetner (1964), see footnote 5.



with the neo-Darwinist theory.

From the calculations given in Appendix A, it appears that  $P(B|A) \ll 0.0048$ .

We let  $P(B|A^c) = 1$ , which means that there does exist a fully satisfactory explanation (possibly as yet undiscovered) of the appearance of life on earth. This reflects our basic belief in the power of science.

Then Bayes's theorem states

$$\begin{aligned} P(A|B) &= \frac{P(B|A) P(A)}{P(B|A) P(A) + P(B|A^c) P(A^c)} \\ &\ll \frac{0.0048 \times 0.99}{(0.0048 \times 0.99) + (1 \times 0.01)} \\ &= 0.322. \end{aligned}$$

Thus, even if the *a priori* probability of neo-Darwinism is 0.99, the *a posteriori* probability, after realizing the improbability of beneficial mutations occurring, is less than 32.2%.