SYMPOSIUM ON VARIATION XIV**

IS THE GENOME SUFFICIENT, WHERE IS THE DESIGN INFORMATION AND WHAT LIMITS VARIATION?

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Received 8 May 1991; Revised 5 September 1991

Abstract

Believers in both evolution and creation seem to assume that the genome and perhaps other physical structures of the cell are sufficient to code for all structures and systems of each organism. Persuasive evidence indicates this assumption to be erroneous. An alternative conceptual framework for genetics is proposed.

Introduction

Practically all discussion of the problem of biological design in relation to genetic information and the limits of or effective lack of limits to biological variation is conducted under the aegis of a grand unproved assumption. This assumption, made by all evolutionists and most creationists alike, is that the genome carries the total information required for the embryonic development and all of the housekeeping activities of the organism. Some have proposed that some genetic information is carried in structures other than the DNA in the fertilized cell (e. g., Sonneborn, 1970; Jones, 1982). I assert that there is compelling evidence to support the view that the genome is not sufficient, further, that the sum of physical structures in the cell is not sufficient. If this is indeed the case, the arena of discussion is changed, and the potentially achievable goals of biological research are correspondingly changed, as are also the interests of Christian biologists.

The proposal offered in this paper is highly speculative and is grounded in a Biblical theistic philosophy of science. This philosophy of science is metaphysical, but no more so than is the philosophy of materialistic monism which informs the current secular view of the questions addressed in this paper. In accord with a correct, philosophically neutral definition of science, Christian investigators and theoreticians have as much freedom to conduct their thought and research within their theistically grounded conceptual frameworks as do the secularists within their naturalistically grounded conceptual frameworks (for a discussion of the term, *conceptual framework,* see Kofahl, 1989). And in any event, both the secularists and the Christian theists should take note of the unproved assumptions underlying the current secular perspective in biology. Especially is this so if the secular assumptions fly in the face of hard scientific facts.

Is the Genome Sufficient?

The human genome contains approximately three billion nucleotide pairs (Darnell, et al., 1986, p. 138). Since the genetic alphabet is comprised of four different nucleotides, any one of which can occupy a particular position in the DNA of the genome, the maximum possible information which theoretically can be carried at one position is $I_1 = \log_2(4) = 2$ bits of information. Thus, a codon consisting of a sequence of three nucleotides should carry 2 x 3 = 6 bits of information. However, the genetic code is degenerate, because in general more than one of the 64 (i.e., 4^3) possible codons codes for each of the 20 normal amino acids is used to construct protein molecules. This degeneracy reduces to about 4.15 bits the amount of information which can be carried by one codon in the DNA (Yockey, 1974, p. 381). This means, then, that the one billion potential codons in the three billion nucleotides of the human genome can theoretically carry a maximum of 4.15 billion bits of genetic information.

The crucial question which can now be asked is: Can 4.15 billion bits of genetic information provide for the embryonic development, housekeeping, functions and reactions of every organism? To begin with it can be asserted that currently the science of molecular genetics does not provide knowledge of the location in the genome of the design information for a single biological structure or organ. Where, for example, in the genome of a bird does the information for the design of a feather reside? Nobody knows. In fact, nobody has any sure idea of what form such information would take in the DNA, or just how it would be translated into the form of the finished feather. From this we may conclude that the idea that the DNA carries the design information for the construction of the organism is nothing more than a working hypothesis. Perhaps it is a false hypothesis.

In order to bring some quantitative basis to this discussion, let us consider the neural network of the cerebral cortex of the human brain. The question of how much information is represented by the neural network of the cortex was discussed by Bremermann (1967, pp. 70-72). The cortex contains about 10 billion neurons. Each neuron may have from 100 to thousands of dendrites connecting it to other neurons. Assume that each neuron has only 100 such dendrites making connections with other neurons among the 10 billion neurons in the cortex. How many different networks then are possible for this model of the cortex? If n is the total number of neurons and m is the number of interconnecting dendrites from each neuron, the number of possible different networks is:

$$N = \left[\frac{(n-1)!}{m!(n-1-m)!}\right]^n$$

If $n = 10^{10}$ and $m = 100$, we obtain for the possible number of networks:

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**Parts I-XIII are in *CRSQ* 27:144-153; 28:18-27, 50-59, 98-108.

$$N = 10^{8.42 \times 10^{12}}$$

So if brain networks are being produced at random with $n = 10^{10}$, and $m = 100$, the probability for a particular one to be formed would be:

$$p = 1/N = 10^{-8.42 \times 10^{12}}$$

This probability for the random formation of the particular network corresponds to an information content of:

$$I = -\log_2 p = \frac{-\log_{10} p}{\log_{10} 2} = 2.8 \times 10^{13} \text{ bits, i.e., 28 trillion bits.}$$

If we compare the possible 4.15 billion bits of information in the human genome with the 28 trillion bits for the neural network of the cerebral cortex, we see that the information capacity of the genome is insufficient by a factor of about 7,000. This factor becomes 140,000 if, as many geneticists believe, 95 percent of the genome's DNA is "junk." Bremermann (1967) considered a possible alleviation of this difficulty based on the fact that the cerebral cortex appears to be structured in subunits of about 10,000 neurons each. If a particular connecting dendrite needs to be targeted only to a particular subunit, rather than a single exactly specified neuron in the cortex, the number of different possible arrangements of this less specific neural network can be calculated by means of a modification of the formula for N given above:

$$N_s = \left[\frac{[(n/n_s) - 1]!}{m![(n/n_s) - 1 - m]!}\right]^n$$

where n_s is the number of neurons in a subunit, and thus n/n_s is the number of subunits;

So with $n = 10^{10}$, $m = 100$, and $n_s = 10{,}000$, we get the number of possible networks:

$$N_s = 10^{4.42 \times 10^{12}}$$

and the information content of a specific network is:

$$1, = 1.47 \times 10^{13} \text{ bits,}$$

i.e., about 15 trillion bits of information.

Thus, the information capacity of the human genome is still insufficient by a factor of about 3,500 to specify the neural network of the cerebral cortex.

Two possible solutions for this problem have been suggested. One is that the design of the neuronal network of the cerebral cortex makes repetitive use of smaller subnetworks. Thus the specification could be made by a program which calls for a certain set of specifications to be used *x* number of times. This would reduce the amount of information required for the specification. The evidence to support this concept has yet to be discovered. The idea that such a vast and global network could be repetitious enough reduces the required specification information by a factor of perhaps 1/50,000 to a fraction of 4.15 billion bits seems most unlikely. Another possible solution is that the development of the network is guided by a trial and error "learning" process. It is a fact that the development of the brain does require active use which probably coordinates with a type of "learning." This could presumably reduce the required information for specification of the brain network. But is the presumption supportable? The ability to "learn" and what to learn has to be encoded in the genome, so as to produce the marvelous working structure of the adult brain network. Again, could this reduce the required information by a factor of 1/50,000? Our ignorance prevents a numerical answer to this question, but an affirmative answer seems to demand belief in the incredible.

No mention has been made about storage in the genome of information to specify the rest of the brain, not to mention the other structures in the human body. The human brain is said to be the most complex object in the universe, but the remainder of the human body evidences a vast complexity and sophistication of high technology. Moreover, much of the structure of the body is mapped back several times on the cerebral cortex and other parts of the brain through the nervous system which mediates to the brain different mappings for the senses of touch, pain, and heat and cold, as well as for motor control. The assumption that this can all be specified by a mere four billion bits of information really seems ridiculous. If all of this information to specify in exact scientific language the designs and building instructions for the human body other than the brain were known, to store it would probably require all the libraries in the world—if indeed such description and specification is possible to us mere humans. The genome appears to be insufficient.

New Proposals

McCann (1991) offers evidence which strongly supports the view that in development from the fertilized egg cell the embryonic cells appear possessed of "skill" to "govern" and "exercise control," and that this is suggestive of "a cellular level of intelligence. " McCann uses modest, careful language. I think that we can be bolder. Taken with the information which McCann and others have advanced, the quantitative estimates given above for the insufficiency of the genome accord with the view that the intelligence required for development has to come from an external, immaterial source.

On the basis of the above facts I offer the following four-part proposal:

1. The information for the designs and construction of biological structures and in particular for those characters which define and maintain separate the originally created "kinds" (baramin) is imposed on the natural world by special divine providential power.
2. The information required for the biochemistry, metabolism, and other housekeeping processes of the organism is supplied by the genome and to some extent by other physical structures of the cell.
3. The genome provides for the genetic variation needed for the variation (microevolution) which is needed to make possible the adaptation of species to their changing environments.
4. Since the basic design information for biodesigns cannot be carried in the genome, mutations of the genome and natural selection are incapable of producing the evolutionary novelties which would be absolutely essential to make macroevolution a reality.

Conclusions

The first part of the above proposal is not a scientific hypothesis, for it incorporates the empirically

untestable principle of supernatural influence on nature. It is actually a metaphysical concept which is an element in a Christian conceptual framework for research in genetics. Parts 2 and 3 are long-established elements of the standard universally accepted perspective in biology, so they also are elements in a Christian conceptual framework for genetics. Part 4 is a logical conclusion which follows from parts 1 through 3. Valid scientific research in genetics can be carried on within the framework provided by the above four-part proposal. It is not a scientific hypothesis but, using Popper's words, it is "*a metaphysical research programme*— a possible framework for testable scientific hypotheses." (Popper, 1976, p. 168)

I predict that all biological data can be accommodated to the four-point proposal presented in this paper. Kuznetsov's research provides evidence for cellular mechanisms which block the translation of mutated genes (1991). Such mechanisms could serve as a barrier to macroevolutionary changes, as Kuznetsov suggests. They could also, however, simply serve to preserve the viability of the cells from generation to generation, macroevolution by mutation and natural selection being impossible for the reason asserted in parts 1 and 4 of my proposal above. The study of embryonic development over the past two decades, largely in *Drosophila,* has led to some understanding of the participation of DNA in development (Chisaka, et al., 1991; Gould, et al., 1990). The DNA homeobox genes and particular gene mutations have been shown to influence aspects of segmentation during development. However, the source of the designs and instructions for the construction of complex structures still eludes researchers. The fact that a particular mutation may cause a leg to replace an antenna or to appear in this segment or that one does not reveal the source of the design of the leg or antenna. John Maddox (1988) questioned the meaning of it all:

> Is molecular biology running into a dead end? . . . Future historians may think it odd that so much should have been learned about the molecules on which life depends while so little has been understood about their functions, or . . . life itself.

Biology still needs God the Creator who is also the sovereign Lord and Sustainer of all His creatures. Vitalism*-of a supernatural kind as taught in the Bible—is not an inviable concept in biology. It has its proper place in the conceptual framework of Christian research scientists. Let there be more research by Christians who have this fundamental spiritual and philosophical commitment. But let us always be careful not to confuse divinely revealed truth, which does not change, with scientific knowledge which is perpetually subject to change.

"... You take away their breath, they die and return to their dust. You send forth Your Spirit, they are created . . ." Psalm 104:29-30

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*Readers may be interested in a brief discussion of vitalism that appeared in the Quarterly. Armstrong, H. L. 1984. Vitalism: A neglected weapon? *CRSQ* 21:78; Reply to Wolfe. *CRSQ* 22:49; Reply to Edwords, *CRSQ* 22:95-96; Edwords, F. 1985. Problem with creationism? *CRSQ* 22:95: Wolpe. S. T. 1985. Dooyeweerd on mechanism vs. vitalism. *CRSQ* 22:48-49.

Man, I believe, is a created being; there is a sacred essence in him. Man is on this planet in consequence of a mighty plan—of whose outlines we may gain faint intimations—and his life is used to further a vast purpose—of which we are given an occasional clue. If man is indeed a created being, and the members of a society act upon their belief that such is their nature, they will begin to frame political theories consonant with their convictions. They will erect political structures designed to safeguard the sacred essence in each person; the law will attempt to maximize each person's opportunity to realize his earthly goals. Believing that God wills men to be free, such a society will regard any trespass on the true liberty of even the lowliest individual to be a thwarting of some intent of the Creator. The deep conviction that each human being is a person and not a thing will generate ideas of equal, inherent rights; and this central dogma will exert pressure on personal attitude and conduct, on government and law, on every level of the free society, to bring all into harmony with the key belief that man is a created being.

But suppose man is not a created being. Suppose the human being is not a person, but a thing. If the universe is simply brute fact, mindless and meaningless; reducible in the final analysis to mass and motion—then man is a thing just like any other item in the catalogue of the planet's inhabitants. Suppose we assume—as do many of our contemporaries—that man is the chance product of the random movement of material particles. Man's haphazard appearance on a fifth rate planet is, then, a fluke; he just happened to occur, as the accidental by-product of physical and chemical forces. He's merely a part of nature, like every other species on the planet. Except that the human species is more foolish than the rest, and has a great gift for make-believe which renders its continued existence problematic!

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