

Double helix

The double helix 50 years on: models, metaphors, and reductionism

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Bioethics should update its conception of the gene

The 25th of April marks the 50th anniversary of the publication in *Nature* of the letter by James Watson and Francis Crick announcing their solution to the structure of deoxyribose nucleic acid (DNA).¹ By that time, much was known about the role of chromosomes in inheritance, the contribution of DNA to chromosome structure, and the chemistry of DNA.² The gene concept itself was also well established by then; the principal scientific problem became to specify what genes were in molecular terms and how they functioned in the cell during ordinary function and cell division.

The importance of the solution of the structure of DNA was twofold. First, it gave insight into finding a mechanism for DNA replication, as the authors recognised in this famous sentence:

It has not escaped our notice that the specific pairing we have postulated immediately suggests a copying mechanism for the genetic material.³

Second, it showed how Erwin Schrödinger's suggestion that genetic information could be represented as a one dimensional aperiodic crystal could actually work in material terms.^{4,5}

It has been argued that the cultural power of the Watson/Crick model of DNA turns on two things. Firstly, there is the beautiful and memorable image of the double helix itself, which has become as instantly recognisable a symbol as the Coca Cola bottle or the sign of the Cross.^{6,7} This symbol has become a metonym for life itself. Secondly, there is the image of the processes of life being somehow governed by a very long string of instructions, coded with an elementary letter code, ACGT.^{8,9} According to this image, life is seen as reducible to a superficially very simple material basis, analogous to message transmission in information theory or a sort of computer programme. Even attempts to loosen this image of exact determination of life processes by the string of instruction—through likening genes to blueprints or to cookbook recipes—do not stray too far from this image.¹⁰ Biologists themselves recognise this, and some attempts have

been made recently to discuss this in philosophical and public fora—but these lack the power of the simple image.^{11,12} The Watson/Crick image of DNA is a *model* for understanding certain aspects of biological inheritance, which has proved to be highly effective over the past 50 years in both science and society.^{13,14}

Since 1953, this model has been elaborated and complicated. Attention to the functioning of the cell as a biochemical system and to developmental processes in embryogenesis, cell differentiation, and cancer biology has led biologists to move away from consideration of DNA as a “master molecule” which “acts” to direct the functioning of the cell.¹⁵ The information theoretic notion of the gene in the cell remains dominant in much discussion of “genethics”, yet this is arguably no longer central in cell biologists’ thinking about the gene.¹⁶

Simple ideas of genetic determination of traits still govern much of bioethicists’ thinking about what genes do, and how.¹⁷ We greatly underestimate the ways in which different conceptions of the gene have different conceptual structures, explanatory force, and types of evidential support in evolutionary biology, molecular biology, embryology, and clinical medicine.^{18,19,20} When challenged about reductionism or talk of “genes for” we become more subtle, but subtlety is hard to keep up!^{21,22} In this, the influence of the Human Genome Project on bioethics has been most unfortunate, in that it has concentrated our attention on one, rather narrow, if hugely time and resource consuming, approach to understanding the nature of the gene.²³ The thought that by printing out the genetic code we will understand the whole programme, while not taken seriously even by the architects of the Human Genome Project, continues to dazzle many of us.²⁴ More generally, the idea of chromosomal structure as a programme has a structure as a metaphor which disposes us to think in mechanical and deterministic terms about how cells, bodies, and lives develop.

It is high time to review the history of “genethics” since 1953, to revisit our own ideas of what 1953’s papers mean for us today, and to challenge the unhelpful and simplistic notions of genetic causation

which we have inherited. Only then can we effectively understand, challenge, or defend contemporary developments in sequencing, gene therapy, association studies in medicine, psychology, and criminology, and pharmacogenetics. Molecular biology has moved on, and so should we. Our use of scientific models in ethics should both keep up with the models in play in current science, and grasp their limits.

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