Just a Little Bit Unnatural

Roald Hoffmann

Chemists, those master builders of molecules, have an interesting way of playing with the natural/unnatural borderline. Here is one recent example, involving DNA and RNA. Both of these crucial biopolymers utilize the construction module of a sugar called ribose. Ribose *(fig. 1)* is a pentose, meaning that the sugar has five carbons. Four of these form a five-membered ring with one oxygen; the fifth carbon is outside the ring. But more common on earth than pentoses is another group of sugars, the six-carbon hexoses. Glucose *(fig. 2)*, fructose, starch, cellulose all contain this molecular motif.

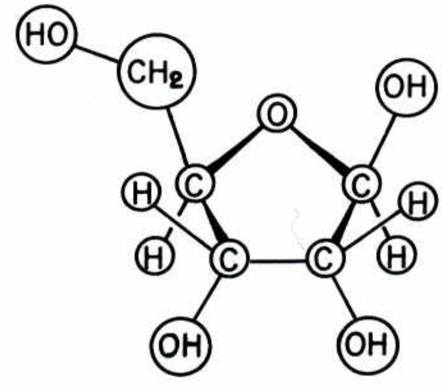

FIG. 1 Ribose, a pentose.

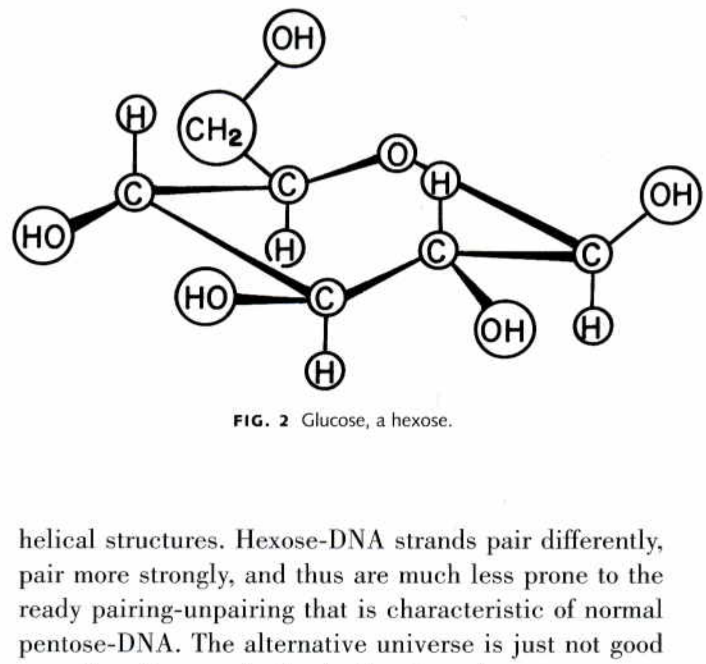

FIG. 2 Glucose, a hexose.

So here's the question, posed by Alfred Eschenmoser of the Federal Institute of Technology in Zurich, a question in tone much like those asked at a Passover seder: "Why, then, did Nature choose pentoses and not hexoses as the sugar building blocks of nucleic acids?"[1]

The Swiss chemist answers this question about the natural world by synthesizing unnatural molecules. He and his able co-workers build up an entire alternative universe—changing the sugars, hooking them together to a polymer by the same phosphates that form the normal DNA chain, adding on the same bases that DNA uses to carry the genetic code. Eschenmoser and his co-workers do what nature chose not to do: build a "hexose-DNA" *(fig. 3)*; normal RNA and DNA are pentose nucleic acids *(fig. 4)*.

The alternative world in their hands, the chemists look for differences. These are easy to find. The beauty and efficient replication properties of the pentose-DNA universe (natural, that of our world) derive from the bases being cradled within a helix and perpendicular to its axis. This, in turn, can be traced to the angle at which the bases B come off the sugar, relative to the way the sugar ring enters the chain. But notice how in the hexose-DNA universe (unnatural, even more so that of our world) the bases are attached at a very different angle. Computer modeling and experiment show that the hexose-DNA does not form helical structures. Hexose-DNA strands pair differently, pair more strongly, and thus are much less prone to the ready pairing-unpairing that is characteristic of normal pentose-DNA. The alternative universe is just not good enough, so it seems, to do what has been done.

There are several reasons why artists might find a special affinity for such creative play with the molecules of nature. Here is one: A strong bond between good chemistry and good art is that of craftsmanship, and the very special respect for the work of mind and hands together. For real creation and not just theory or criticism. What a difference between writing about a painting and starting to paint it, between writing about a molecule (as I've done above), and

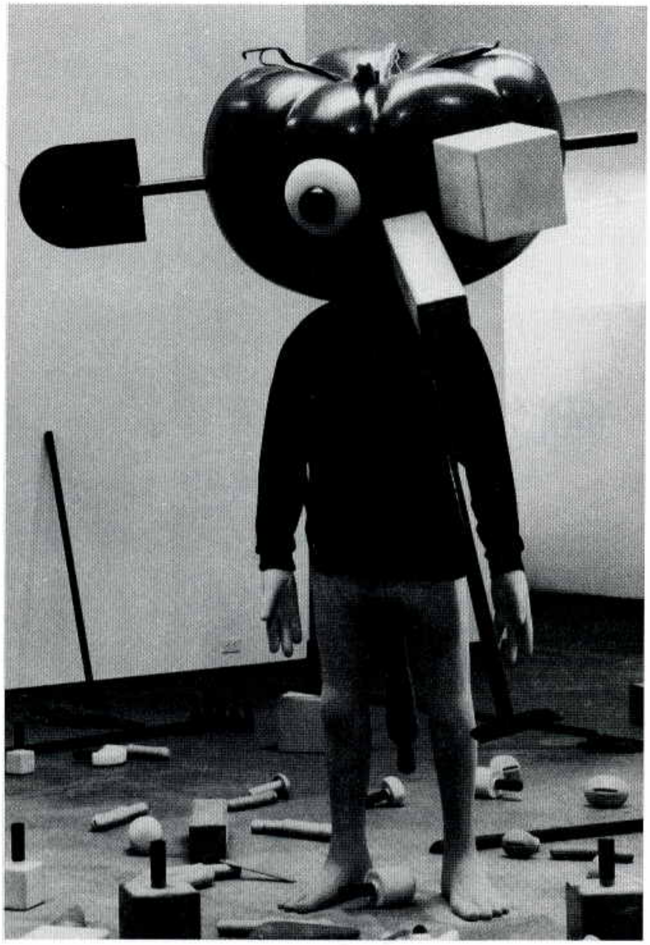

FIG. 9 Paul McCarthy, *Tomato Heads*, 1994, fiberglass, aluminum, urethane rubber, cloth, plexiglass, 84 × 60 × 46 inches. Rosamond Felson Gallery and Douglas M. Parker Studio, New York.

In *The Magic Mountain* Thomas Mann used the device of the chest X ray to reveal the inner person. His protagonist in the Swiss sanitorium, Hans Castorp, cherishes the X ray of Frau Chauchat as the essence of her personhood.[17] Similarly, artists like Clarke draw inspiration from scientific discoveries and use them to look beneath the visible world, to reveal the essential nature of observable things. But science has also been a source of Surreal fantasies and dystopic, even apocalyptic, visions, as many artists have cast themselves as social critics.

The DNA art of the 1990s reflects these various patterns in the historical intersection of science and art. In attributing cultural powers to a biological entity—in accepting the premises of genetic essentialism—some of the artists I have described use molecular metaphors to probe underlying truths. But others are raising questions that are more broadly troubling with the ascendance of genetics as an explanatory science. Can the self be reduced to a molecular entity? Can persons—human beings, in all their social, historical, and moral complexity—be equated with their genes? If the premises of genetic essentialism are accepted as a basis for social policy, what will be the social implications? Such questions, captured by artists and illustrators, worry

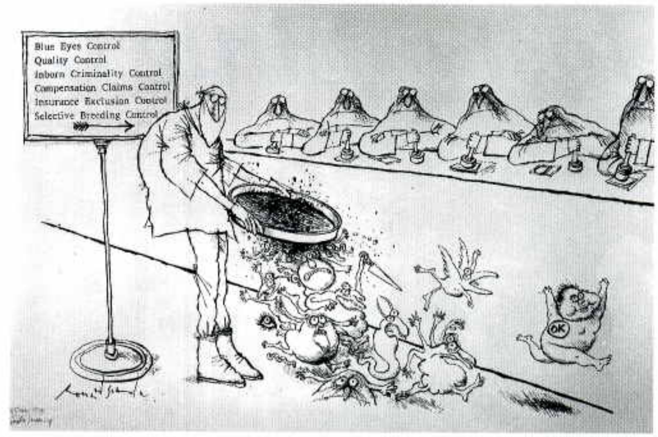

FIG. 10 Ronald Searle, *The Double-Edged Helix*, 1994, ink on paper, 8½ × 11 inches. Private collection.

many scientists as well.[18] For the social and ethical meaning of genetics—the implications of the belief in genetic essentialism—will become increasingly critical as scientific advances in molecular biology change the way we regard human behavior and how we shape our social codes ▬

Notes

Ellen Levy generously provided material and advice that have helped to shape this paper.

1. Miller's work appeared in an exhibition called *Genus Memorialis: Imitations of Immortality* at Horodner Romley Gallery, New York, February 1993.

2. See Dorothy Nelkin and Susan Lindee, *The DNA Mystique: The Gene as a Cultural Icon* (New York: W. H. Freeman, 1995), which is about representations of DNA in verbal metaphors and popular stories.

3. Kevin Clarke, in Alan Jones, "Kevin Clarke," *Tema Celeste* 40 (Spring 1993): 72–73.

4. Suzanne Anker's work was exhibited in a show called *Wonderful Life* at Dooly Le Cappeline Gallery, New York, December 1991.

5. Photographs are in the Jane H. Baum Gallery, New York. See also Nancy Burson, *Faces* (Santa Fe: Twin Palms, 1993).

6. Jones, "Kevin Clarke," 73.

7. For discussion and documentation of these frequently used metaphors, see Nelkin and Lindee, *DNA Mystique*, chap. 1.

8. Moore's work is exhibited at Sperone Westwater, New York. *Niagara* appeared in the 1995 Whitney Biennial. See Faye Hirsch, review of Frank Moore at Sperone Westwater, *Art in America* 81 (April 1993): 131–32.

9. Nick Downes, cartoon in *Science* 238 (November 9, 1987): 772.

10. See Daniel J. Kevles and Leroy Hood, eds., *The Code of Codes: Scientific and Social Issues in the Human Genome Project* (Cambridge: Harvard University Press, 1992).

11. Zittel's construction was exhibited at the New Museum of Contemporary Art, New York, 1994.

12. Nicholas Rule's painting appeared in an exhibition called *Gene Culture: Molecular Metaphors in Visual Art* at Fordham College, New York, January 1995, curated by Suzanne Anker.

13. Laurel Katz's work is exhibited at Postmasters Gallery, New York.

14. Ronald Searle, "The Double-Edged Helix," in Dorothy Nelkin, "The Double-Edged Helix," *New York Times*, February 4, 1994.

15. Mark Evanier and Will Meugniot, *DNAgents*, Eclipse Enterprises Series, November 1992, cover.

16. Stuart Goldenberg, cartoon in the *New York Times*, September 16, 1990.

17. I want to thank Vera Zolberg for calling my attention to this example.

18. A working group on the ethical, legal, and social implications of genetic research has been established as part of the Human Genome Project and receives from 3 to 5 percent of its total funds.

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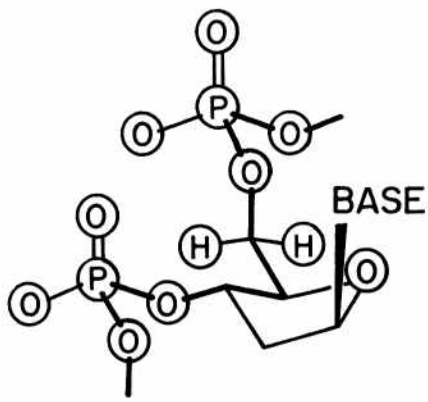

FIG. 3 A segment of hexose-DNA.

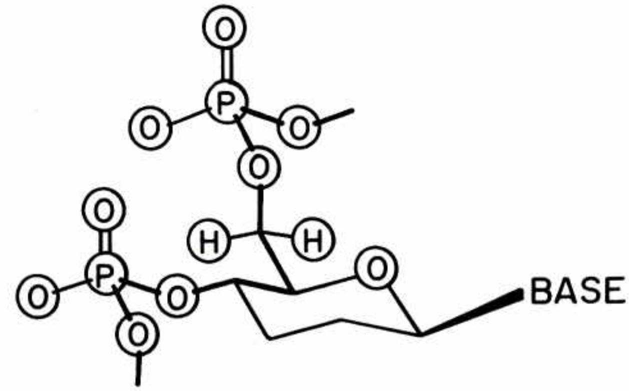

FIG. 4 A segment of pentose-DNA.

the existential act of making it! I don't mean to deny the creative element in the best criticism, that of perceiving relations where none were to be seen before. Nor do I want to downplay the role of the intellect in shaping creation. After all, I am a theoretical chemist! But there is something inherently different about beginning to carve that stone, something vital that matches measuring out the reactants and dissolving them in a solvent at the outset of a chemical reaction.

How much changes in the act of painting! And in the act of synthesizing one of Eschenmoser's pentoses. There is always a plan, but it works only part way. In each new reaction, different conditions are tried out. These may fail to produce the desired results, whereupon part of the plan is abandoned and a new way is tried. In some cases (not the pentoses), the process and its serendipitous outcome may render the original goal irrelevant. A new molecule may be built, surpassing not only what was planned, but what was imagined. The object of chemical creation, built by a process of trial and error, as a painting often is, acquires a life of its own. Laboratory science and studio art have more in common than one might think.

Another reason for science and art being drawn together: The artifactual is a natural bridge between them. The practitioner of art and science, a human being, uses his or her tools (I don't have any hangups about Lucie Ree's wheel or Caravaggio's brush being a different order of tool from Eschenmoser's students' gleaming glass flasks) to do something very similar—to shape, paint, synthesize what was not on earth before. There is no doubt that we can judge as beautiful the natural objects of this wonderful and terrible world—be they an Arizona sunset, a typhoon, the world within a lily. But that is not what art (or science) is about. To quote Igor Stravinsky (from his *Poetics of Music*, at a point where he inveighs against the idea that natural sounds are music, or that music should imitate nature):

I take cognizance of the existence of elemental natural sounds, the raw materials of music, which, pleasing in themselves, may caress the ear and give us a pleasure that may be quite complete. But, over and beyond this passive enjoyment we shall discover music, music that will make us participate actively in the working of a mind that orders, gives life, and creates. For at the root of all creation one discovers an appetite that is not an appetite for the fruits of the earth.[2]

Some reasonable people in the arts think of the activity of scientists metaphorically as the killing and dissection of a free bird, the downing of the hawk circling in the sky, carving out the trajectory of its flight. Perhaps that is so for some bad science. But how different that is from the activities sketched above—from the free, inventive, intense (and responsible) play with the genetic material that shaped the bird and you and me! What science provides—knowledge of the making of a feather, of the bird's awesome economy of energy, of its homing mechanisms—gives us alternative ways of appreciating the hawk as it flies.[3] This does not detract, in any way, from the poem, the infinite ways in which I can write a poem of that hawk. Or paint it. All knowledge enriches.

Notes

The first part of this article is adapted from Roald Hoffmann, "Unnatural Acts," *Discover*, August 1993, 21–24. I am grateful to K. C. Cole for her editorial assistance in that version.

1. Albert Eschenmoser and Max Dobler, "Warum Pentose- und nicht Hexose-Nucleinsäuren?" *Helvetica Chimica Acta* 75, no. 1 (1992): 218. For a further English language account of this beautiful work, see Albert Eschenmoser and Eli Loewenthal, "Chemistry of Potentially Prebiological Natural Products," *Chemical Society Reviews* 21, no. 1 (1993):1–16.

2. Igor Stravinsky, *The Poetics of Music* (Cambridge: Harvard University Press, 1956), 29.

3. On the natural/unnatural dichotomy in all its ramifications, see Roald Hoffmann, *The Same and Not the Same* (New York: Columbia University Press, 1995).

ROALD HOFFMANN, *Nobel Prize laureate, has a second career as a poet. He published an art/science/literature collaboration with Vivian Torrence, "Chemistry Imagined," in 1993.*