The Wonderful Mistake

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The greatest single achievement of nature to date was surely the invention of the molecule of DNA. We have had it from the very beginning, built into the first cell to emerge, membranes and all, somewhere in the soupy water of the cooling planet three thousand million years or so ago. All of today's DNA, strung through all the cells of the earth, is simply an extension and elaboration of that first molecule. In a fundamental sense we cannot claim to have made progress, since the method used for growth and replication is essentially unchanged.

But we have made progress in all kinds of other ways. Although it is out of fashion today to talk of progress in evolution if you use that word to mean anything like improvement, implying some sort of value judgment beyond the reach of science, I cannot think of a better term to describe what has happened. After all, to have come all the way from a system of life possessing only one kind of primitive microbial cell, living out colorless lives in hummocks of algal mats, to what we see around us today—the City of Paris, the State of Iowa, Cambridge University, Woods Hole, the succession of travertine-lined waterfalls and lakes like flights of great stairs in Yugoslavia's Plitvice, the horse-chestnut tree in my backyard, and the columns of neurones arranged in modules in the cerebral cortex of vertebrates—*has* to represent improvement. We have come a long way on that old molecule.

We could never have done it with human intelligence, even if molecular biologists had been flown in by satellite at the beginning, laboratories and all, from some other solar system. We have evolved scientists, to be sure, and so we know a lot about DNA, but if our kind of mind had been confronted with the problem of designing a similar replicating molecule, starting from scratch, we'd never have succeeded. We would have made one fatal mistake: our molecule would have been perfect. Given enough time, we would have figured out how to do this, nucleotides, enzymes, and all, to make flawless, exact copies, but it would never have occurred to us, thinking as we do, that the thing had to be able to make errors.

The capacity to blunder slightly is the real marvel of DNA. Without this special attribute, we would still be anaerobic bacteria and there would be no music. Viewed individually, one by one, each of the mutations that have brought us along represents a random, totally spontaneous accident, but it is no accident at all that mutations occur; the molecule of DNA was ordained from the beginning to make small mistakes.

If we had been doing it, we would have found some way to correct this, and evolution would have been stopped in its tracks. Imagine the consternation of human scientists, successfully engaged in the letter-perfect replication of prokaryotes, nonnucleated cells like bacteria, when nucleated cells suddenly turned up. Think of the agitated commissions assembled to explain the scandalous proliferations of trilobites all over the place, the mass firings, the withdrawal of tenure.

To err is human, we say, but we don't like the idea much, and it is harder still to accept the fact that erring is biological as well. We prefer sticking to the point, and insuring ourselves against change. But there it is: we are here by the purest chance, and by mistake at that. Somewhere along the line, nucleotides were edged apart to let new ones in; maybe viruses moved in, carrying along bits of other, foreign genomes; radiation from the sun or from outer-

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space caused tiny cracks in the molecule, and humanity was conceived.

And maybe, given the fundamental instability of the molecule, it had to turn out this way. After all, if you have a mechanism designed to keep changing the ways of living, and if all the new forms have to fit together as they plainly do, and if every improvised new gene representing an embellishment in an individual is likely to be selected for the species, and if you have enough time, maybe the system is simply bound to develop brains sooner or later, and awareness.

Biology needs a better word than "error" for the driving force in evolution. Or maybe "error" will do after all, when you remember that it came from an old root meaning to wander about, looking for something.

EXTENDING IDEAS

- Read *The Double Helix* by James Watson or *Rosalind Franklin* by Anne Sayre and write an essay describing your view of how a major discovery was made. Include the nature of the approach, the importance of collaborative work, and the roles that luck or imagination might have played.

ON THE JOB

CRIMINALIST The courtroom was completely silent. The most important piece of evidence linking Jason Benton to the attempted murder of a state university student had been placed before the jury. That evidence came from forensic science, the practical application of science and medicine to law.

On a warm day in autumn, Missy, a freshman in college, was at a campus party with her roommate and decided to leave early and walk back to the dormitory alone. When her roommate returned, it was obvious that Missy had not made it back. After retracing the path that Missy was assumed to have taken home, her roommate and other friends found her lying just off the road, obviously terrified and suffering from severe trauma. She was coherent and said that she had been mugged and beaten on her way home. When police arrived, she described that her attacker had grabbed her from behind. She never clearly saw his face but she recalled that he had spoken with an angry stutter and a foreign-sounding accent. Because of the stutter and accent, the police suspected a well-known, recently paroled criminal, Jason Benton, and they picked him up for questioning.

A forensics team that included the state's senior criminalist immediately studied the area for evidence, finding little. But, Missy had scratched her attacker and got some of his skin beneath her fin-