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"Please Come to My Laboratory for Better Coffee, Fresh Orange Juice, . . . Conversation"

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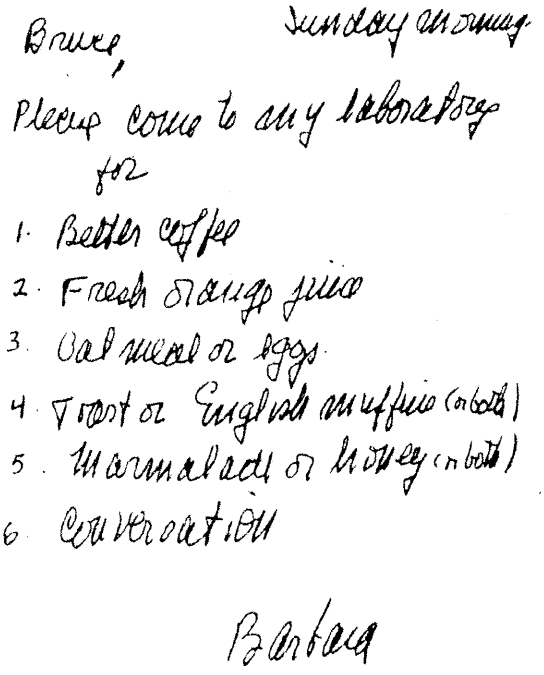
I cannot remember exactly when I first met Barbara McClintock. I have spent so many profitable hours in her large laboratory room at Cold Spring Harbor Laboratory that, in my memory, many of our meetings have been joined together, as if they were part of the same visit. Barbara once reported to one of my students about me that she had "never met anyone with so little sense of space or time." This statement, made by a person with remarkable gifts for observation, is now engraved on the back of a gift watch from my laboratory; it could certainly explain my complete failure as an historian.



Note from Barbara, sent May 1978, while at Cold Spring Harbor Laboratory.

My own excuse for the memory lapse is that Barbara has not changed at all in the 20 years that she and I have been friends. As I write this, I have just returned from yet another 5 hours of intense conversation with Barbara. This visit was different only because, knowing that I would be writing this brief tribute to her, I asked Barbara questions designed to refresh my memory about past discussions. Whenever we retouched old topics, she rekindled the same intense excitement about science that drew me to her 20 years ago. As before, I left exhilarated. Why? An attempt to answer this question for myself inspires this essay.

Although apparently not attracted to the professional literature of neurobiology, Barbara is fascinated by the brain and what she views as the three-dimensional nature of all thought processes: the dispersed manner in which information is stored, how we sift through this information to come up with interesting new associations and ideas, and how this processing continues "automatically" without our conscious involvement. Many of her opinions about the above topics have been derived from observations of her own mind, which, like most of the rest of biology, Barbara has examined closely and with consummate skill.

In the case of the brain, it is obvious that a large network of complex interactions between many different individual elements (nerve cells) creates something that is very much more profound than the sum of its parts—for example, human consciousness, including the joy that comes from certain types of understanding. Barbara's life has been intimately connected to this fact in several ways. First and foremost, for 70 years she has devoted herself to using her mind to analyze complex patterns, armed with the realization, already clear to her as an undergraduate at Cornell, that she was uniquely gifted at being able to derive new understandings from such efforts.

Barbara is by far the most "inner-directed" person whom I have met. To me, she seems to want nothing more from life than the tremendous pleasure she derives from making new connections, and exercising old ones, in her mind. For about 45 years, this pleasure came from intense, full-time scientific investigation, most of it on the maize (corn) plant. Year after year, 10 months of meticulous planning would culminate in six 7-day weeks of 24-hour days, caring for 3000–5000 carefully crossed maize plants. These efforts led to her pioneering discovery and analysis of transposable elements, for which she was awarded the 1983 Nobel prize for Medicine or Physiology. This physically demanding life-style ended shortly before I met Barbara. But for as long as I have known her, Barbara has derived the same type of pleasure from reading and analyzing the work of others, which is done with nearly the same intensity that she applied to her maize work. Her reading provides her tremendous opportunities for discovery because Barbara carefully selects information for storage, and then lets the new data "reverberate" throughout a carefully prepared mind. The result is often a new connection or insight concerning the nature of living systems—a new node in the very large network of biological information that Barbara has been developing and nurturing for the past 70 years.

What has resulted from all this reading and thinking is a unique, very rich view of the world—a view that is much too rich for a simple linear readout. During one of our conversations many years ago, Barbara made an extremely interesting connection between art, thought, and language. We can all accept

that the highly intricate patterns of three-dimensional connections between the nerve cells in our brains form the physical basis for the huge collection of potential thoughts that constitute human consciousness. Barbara suggests that, even without our conscious involvement, these connections are continually being adjusted to create new, more refined arrangements—the driving force being a search for more "interesting" relationships. She views great art as an attempt to mimic the interesting relationships in our brain as a pattern of shapes and colors. The interconversion between complex three-dimensional thought processes and a much simpler two-dimensional painting is necessarily incomplete. But it can be a better representation than language, which can only provide a one-dimensional, linear readout of the actual thoughts in our heads.

This analysis made a deep impression on me for several reasons. First of all, like many scientists, I consciously search for new, interesting relationships in my own work. Where does the strong urge that motivates this search come from? As an undergraduate at Harvard, I was fascinated by a lecture on Chinese poetry by Archibald MacLeish, stressing the pleasure derived from the juxtaposition of two disparate images: poetry as "the space between two distantly related words" (MacLeish 1961). I was therefore ready to accept the notion that humans could be motivated by an attempt to form particularly pleasurable patterns of connections in our brains. Second, this view of consciousness helped to explain the pleasure that I derive from my long talks with Barbara. Although language is inadequate to express what is really in her mind, our long rambling discussions of biology produce numerous one-dimensional hints of the fascinating way in which Barbara has organized her image of the world. Reconstructing the image from these hints, like filling the space between the words of a Chinese poem, helps to explain the intellectual stimulation that often survives afterward for days.

What have I learned? When I met Barbara, I was a chemist who viewed cells as little more than a test tube full of a complex mixture of proteins and nucleic acids. Barbara therefore had a lot of biology to teach me—about the development of the maize plant, Queen Anne's lace, ladybird beetles, plant galls, stick insects, and mimicry in plants and animals, to name a few of the major topics that we have touched on. But most of all, I think that I have begun to see what Barbara means by "a feeling for the organism." Barbara looks at living cells and organisms differently than anyone else I know. From her, I have come to realize that sophisticated groups of interacting molecules can have "system properties" that are hard to decipher from the sum of the individual parts. Many of us would agree that consciousness is a qualitatively new property that emerges from a complex network of brain cells. By analogy, Barbara would argue that the result of the complex network of interactions between the many cytoskeletal proteins in the cell cytoplasm, to pick but one example, may not be understandable without new paradigms for dealing with the system as a whole. She has reached this conclusion in part from her careful observations of the global response of a living cell to a small local perturbation (McClintock 1984). More revolutionary is her analogous view of organisms. Here, the interacting units are cells instead of molecules, and included among the "system" properties that Barbara is intrigued with is the ability of tissues and organisms to rearrange from one ordered functional state to another, with only a small perturbation in the cells that form them. Such an ability would

obviously have major evolutionary implications, indicating that organisms have been formed in a way that allows mutation to cause sudden changes in their shape and other properties. Barbara is fascinated by this idea, which explains many of her particular interests in biology.

Consider plant galls, for example. Galls are abnormal outgrowths of plant tissues caused by certain parasitic insects, fungi, and bacteria (Meyer 1987). In response to a chemical signal from the parasite, the plant forms a capsule that encloses it. The structure formed by the plant is different for different parasites, can be complex, and is not part of the normal plant repertoire. Barbara takes this as evidence that the plant is preprogrammed in a way that allows its various tissues to form a variety of new and potentially useful arrangements after a change in gene expression caused by simple signals. A plasticity of this type is presumably present in organisms because it was selected for during the course of evolution: Systems of interacting cells with this property have been the favored survivors of natural selection.

In Barbara's view, a hint that animals, as well as plants, have this property comes from studies of mimicry, wherein (for example) a change in one or a few genes allows a species of butterfly to adopt the different coloration and wing patterns of an unrelated poisonous species, when it invades a geographical region containing the second species (Wickler 1968).

It would be dishonest to imply that Barbara's many friends only derive intellectual stimulation from her during their visits to Cold Spring Harbor. Barbara is also inspiring in a second way. She reminds us of the pure curiosity and excitement about science that we all experienced as young students, and she shows by her example that it is possible to maintain this curiosity throughout one's lifetime as a scientist. I return to the ever-present pile of mail to be answered and forms to be filled out much more impatient with these distractions, and ever more determined to reverse the seemingly inevitable march from scientist, to scientist-administrator, to dean. For this, no less than for all the rest, Barbara, I thank you.

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