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Review

Neurology and the Soul

By Oliver Sacks

WORKS DISCUSSED IN THIS ARTICLE

Remembering: A Study in Experimental and Social Psychology
by Frederick C. Bartlett
Cambridge University Press, (out of print)

Neural Darwinism: The Theory of Neuronal Group Selection
by Gerald M. Edelman
Basic Books, 400 pp., $32.95

The Remembered Present: A Biological Theory of Consciousness
by Gerald M. Edelman
Basic Books, 384 pp., $29.95

The Mystery of the Mind
by Wilder Penfield
Princeton University Press, 123 pp., $8.95 (paper)

The Invention of Memory: A New View of the Brain
by Israel Rosenfield, Introduction by Oliver Sacks
Basic Books, 240 pp., $9.95 (paper)

La Conscience: Une Biologie du Moi Knopf in 1991
by Israel Rosenfield
Editions Eshel (Paris, 1990); to be published in expanded form by

'A Critique of Artificial Intelligence'
by Israel Rosenfield. in *The Enchanted Loom*, edited by Pietro Corsi
Oxford University Press, 400 pp., $60.00

Man on his Nature
by Sir Charles Sherrington
Cambridge University Press, (out of print)

The Integrative Action of the Nervous System
by Sir Charles Sherrington

Cambridge University Press, (out of print)

Migraine
by Oliver Sacks
University of California Press, 290 pp., $9.95 (paper)

Awakenings
revised edition, by Oliver Sacks
HarperCollins, 448 pp., $9.95 (paper)

A Leg to Stand On
by Oliver Sacks
HarperCollins, 224 pp., $9.95 (paper)

The Man Who Mistook His Wife for a Hat and Other Clinical Tales
by Oliver Sacks
HarperCollins, 256 pp., $9.95 (paper)

Seeing Voices
by Oliver Sacks
HarperCollins, 224 pp., $8.95 (paper)

1.

There has always, seemingly, been a split between science and life, between the apparent poverty of scientific formulation and the manifest richness of phenomenal experience. This is the chasm which Goethe refers to in *Faust*, when he speaks of the grayness of theory as contrasted with the green and golden colors of life:

Grau, teurer Freund, ist alle Theorie,
Und grün des Lebens goldner Baum.

This chasm—which is smallest in physics, where we have spectacularly powerful theories of countless physical processes—is overwhelming in biology, in the study, above all, of mental processes and inner life, for these are, unlike physical existence, distinguished by extreme complexity, unpredictability, and novelty; by inner principles of autonomy, identity, and "will" (Spinoza and Leibniz speak here of *conatus*); and by a

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The magnitude of this discrepancy, as well as our almost irresistible desire to see ourselves as being somehow above nature, above the body, has generated doctrines of dualism from Plato on—doctrines clearest of all, perhaps, in Descartes, in his separation of two "essences" (*res extensa* and *res cogitans*) and in his conception of a quasi-mystical meeting point, an "organ of liaison," between the two (for him, the pineal).

Even in the work of C. S. Sherrington, the founder of modern neurophysiology, we find an explicitly Cartesian viewpoint: thus Sherrington regarded his decerebrate dogs as "Cartesian trigger-puppets" deprived of mind; he felt that physiology—at least the sort

of reflex physiology he set himself to study—needed to be free of any "interference" by will or mind; and he wondered whether these, in some sense, did not transcend physiology and might not form a separate principle in human nature. Thus looking back on a lifetime's work, he writes:

That our being should consist of *two* fundamental elements offers I suppose no greater inherent improbability than that it should rest on one only.

Wilder Penfield, the neurosurgeon who studied with Sherrington as a young man, found a lifelong interest in the exploration of "experiential seizures"—seizures in which patients would find themselves convulsed, for seconds or minutes, with a hallucinatory replay of events, scenes, perhaps music, from their past lives, scenes partly dreamlike, phantasmagoric, poetic, but with an intense and overwhelming feeling of reality. (Penfield mentions people having convulsive memories of "the action of robbers in a comic strip," of seeing people "enter the room with snow on their clothes," and of "watching circus wagons unload" when they were children.) Such hallucinatory replays, such experiential seizures, which might occur in some patients with temporal lobe epilepsy, could also be evoked, Penfield found, by stimulation of the exposed temporal lobe cortex during an operation. The whole of life in Penfield's view, at least passive, "sensory life"—the whole of a patient's experience, every sensation and feeling he ever had—was preserved exactly and totally, and recorded in the brain. Penfield uses the word "record" again and again, and sees memory, the brain's recording, as something akin to a mechanical record, or the "memory" of a computer.

"Experiential seizures," Penfield thinks, merely serve to stimulate a random segment of this memory. This is a passive (or mechanical) view of memory and the brain—and this very passivity forces Penfield into dualism too. Thus, looking back over a lifetime of work in his last book, *The Mystery of the Mind* (which he dedicates to Sherrington), he concludes that though memory and imagery, sensation and experience, are indeed "engraved" in the brain, the active faculties—will, judgment—are not in the brain, are not represented physiologically in the same way, but are "transcendent" functions irreducible to physiology.

For Penfield there is the stream of memory and consciousness, "the biological stream," and something supra-biological, "the mind (not the brain)," that watches and directs this. Thus the idea of a frontier develops:

The patient…programs his brain…. Decision comes from his mind. Neuronal action begins in the highest brain mechanisms. Here is the meeting of mind and brain. The psycho-physical frontier is here.

Such a frontier has to be envisaged, because Penfield sees all brain action as "automatic," "reflex," or "computational"; and yet, clearly, man himself is not an automaton. Thus Penfield sums up his views:

After years of striving to explain the basis of mind on the the basis of brain-action alone, I have come to the conclusion that it is simpler…if one adopts the hypothesis that our being does consist of two fundamental elements.

The "mind," in Penfield's sense, is a ghostly thing indeed. It lacks memory, or the need for memory—"It can open the [brain's] files of remembrance in a flash." It needs none of the apparatus, the physicality, of the brain. But, Penfield tells us, though immaterial, the mind does require "energy"; and this energy is normally provided through its attachment to the living brain. And yet (and here Penfield's speculations become increasingly fantastical), the mind may have a way of surviving bodily death. It may do this, he thinks, by establishing a relationship, an energy flow, with the minds of the living; or with the mind of God; or with some other source of mind energy out there, in the cosmos. "When the nature of the energy that activates the mind is discovered (as I believe it will be)," Penfield concludes, "the time may come when scientists will be able

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The struggle between dualistic thinking and various forms of monism has raged since the time of Descartes, and it is far from finished at the present time. Most biologists believe in evolution (one may disregard the trivial rear guard of "creationists"); but neurologists and psychologists are sometimes less rational in their thought, and may exempt "mind" from the scientific considerations they otherwise entertain, and claim it for a special, privileged status. Thus Lord Adrian (who shared the Nobel Prize for physiology with Sherrington) wrote in 1966, "As soon as we let ourselves contemplate our own place in the picture, we seem to be stepping outside the boundaries of natural science." (Penfield quotes this sentiment with approval, at the very start of *The Mystery of the Mind*, adding, "I agree with him.") Sherrington's great pupil J. C. Eccles, also a Nobel prize winner in physiology, has been an emphatic dualist from the start of his career, and indeed entertains notions remarkably similar to Descartes's except that for Eccles it is the synapse (not the pineal gland) that "transduces" between brain and mind.[2]

It was in regard to Sherrington, Adrian, Penfield, and Eccles (and a host of others whose names are less well known) that Carol Feldman, a philosopher, once asked me, "Why do all you neurologists go mystical?" I agreed that this was a fascinating question, but that there were many exceptions (myself included). Hughlings Jackson, a friend and follower of Darwin and often called the father of neurology, believed in, and spent his life trying to explore, "the physiology of mind." Whatever dualistic exceptions there may have been, it has always been the central effort of neurology to exempt nothing from the domain of natural science, to try to develop a physiology of mind.

Clinical neurologists, it should be said, even if they lack the genius of Sherrington, Eccles, or Adrian, may nevertheless have a somewhat better record here, for they have daily to face the richness of human life, the complexity of the phenomenal world; whereas a physiologist can spend a life with spinal preparations and decerebrate animals, in a world of nerve potentials, synapses, and reflexes—such a life may fail to be a corrective to dualism, may even foster its mystical development.

Barbara McClintock, the geneticist, often spoke of "a feeling for the organism" as the first and crucial necessity for a biologist. It is easy to get lost in the details of genetics or molecular biology, or in the details of neurophysiology, and to forget, or lose, this feeling for the organism. This is less so, perhaps, for the physician than for the "pure" scientist, for the physician must confront, must have a feeling for, the total being of his

patients—not merely as an ethical, Hippocratic necessity, but because, otherwise, he may find himself unable to treat them.

There is a tendency in neurology and pathology to talk about "the lesion," to see the process and end of medicine as delineating, and "treating," the lesion. But the effects of a lesion, of any dys-function, cannot help ramifying throughout the economy of the organism, and so force one to consider the organism as a whole:

2.

The first patients I saw when I finished my training were patients with migraine. My first thoughts were that migraine was a simple pathology, or pathophysiology, which would require a pill, a medication, and that the beginning and end of medicine was to make the diagnosis and to give the pill. But there were many patients who shook me. One in particular was a young mathematician who described to me how every week he had a sort of cycle. He would start to get nervous and irritable on Wednesday, and this would become worse by Thursday; by Friday, he could not work. On Saturday he was greatly agitated, and on Sunday he would have a terrible migraine. But then, toward afternoon, the migraine would die away. Sometimes, as a migraine disappears, the person may break out in a gentle sweat; he may pass pints of urine. It is almost as if there is a catharsis at both physiological and emotional levels. As the migraine and the tension drained out of this man, he would feel himself refreshed, renewed, he would feel calm and creative, and on Sunday evening, Monday, and Tuesday, he did original work in mathematics. Then he would start getting irritable again.

When I "cured" this man of his migraines, I also "cured" him of his mathematics. Along with the pathology, the creativity also disappeared, and this made it clear that one had to inspect the economy of the person, the economy of this strange cycle of illness and misery each week culminating in a migraine and then followed by a wonderful transcendent sort of health and creativity. It is not sufficient just to make a diagnosis of migraine and give a pill. One has to inquire into the entire human drama that surrounds the attacks, to explore what they might mean in a particular person. One has to take not

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The second group of patients I encountered were those I describe in my book *Awakenings*. As a student I had vaguely heard of the great sleeping sickness, the *encephalitis lethargica*, which had become a worldwide pandemic in the 1920s; but it was only in 1966, when I arrived at a hospital in New York, that I saw for the first time the full, and almost unimaginable, depth and strangeness of the states that this might bring about. When I came to the hospital, I found some eighty patients who were, for the most part, completely "frozen," frozen in strange statuesque attitudes—and some of them had been in this state for forty years. Many of them had curious "crises" at times, in which their frozenness would be replaced by sudden spasmodic activity, "forced" movements, "forced" behaviors, compulsions of every kind.

All of these patients clearly had a "syndrome" that affected movement and will in extraordinary ways. And yet no two patients were the same: over and above the generic similarities, the syndrome, or its expression, was different in each patient. When

Constantin von Economo had originally described these postencephalitic syndromes in 1917, he recognized three major types, based on the distribution of inflammatory lesions in the brain. But as the years passed, these syndromes grew more and more complex, and more and more subtypes had to be perceived, until finally there were as many "subtypes" as individuals. Postencephalitic syndromes became individual, became "personalized," as they evolved, and in a way that defeated classical pathological explanation; for the particular dispositions and experiences of the individual, it became evident, were gradually drawn in, over the years, to lend a personal coloring to the syndromes that developed.

Smith Ely Jelliffe, both a physiologist and a psychoanalyst by training, was very sensitive to this double character; he described in detail how post-encephalitic respiratory disorders which he encountered gradually became forms of respiratory "behavior," and how in general postencephalitic syndromes and crises, by embedding more and more of the patient's personality and experience, exemplified the "structuralization of identity."[1]

Thus one postencephalitic patient cited by Jelliffe would, at the beginning of an attack, make a movement as if to catch a ball. This was very puzzling until it was learned that his first attack, many years before, had occurred while he was playing cricket. Someone had hit the ball, and the ball was coming toward him. He went to catch it, and in that moment he could not let go of the ball, and he found himself transfixed in that position. Thereafter, each time he had an attack, it would be ushered in by a replay of this moment that the ball was coming toward him and he had to catch it. Here, although one knows something of the physiology of these attacks, a knowledge of this crude physiology is not enough. One needs a knowledge of the personal history—in this case, that the first attack had come in a cricket match many years before. This fascinated me very much, because one saw here how movements and scenes from a person's experience could be embedded in his physiology: how his physiology itself could evolve, could become "personalized."

It became evident to me, even before these patients were "awakened," that what seemed an impersonal or even depersonalizing disease had, in fact, a strong quality of the personal, and could not be understood without reference to the personal. It was not merely humanly, or ethically, necessary to see these patients as individuals; it was

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In the summer of 1969 it became possible to give these patients a new "awakening" drug, L-DOPA, and with it, in that summer, they were released from their decades-long symptoms and syndromes, and became startlingly, wonderfully, alive. Then, in the fall, all sorts of problems appeared—recurrences of old symptoms, new symptoms of all sorts, sudden oscillations between states of immobility and excitement. Some of these setbacks, it was evident, had simple physiological causes: 90 percent or more of the motor-regulatory systems of the brain had been devastated, and the relatively few regulatory cells left were being overstimulated, and exhausted, by the drug. But this, it was equally evident, was not the whole of the matter: some patients with the grossest physiological damage did relatively well, and other patients, with less organic damage, did very badly.

One such patient (Rose R.), for example, was deeply nostalgic, and when she was "awakened" to 1969 she found it intolerable: "I can't bear it," she said, "everything is gone. Everything which meant anything has vanished and gone." And her "awakening" had a deeply anachronistic quality: she spoke of figures from the 1920s as if they were still alive; she had mannerisms, turns of phrase that had been obsolete for forty years, but that still seemed entirely current and contemporary to her. She said, "I *know* it's 1969, but I *feel* it's '26. I *know* I'm sixty-four, but I *feel* I'm twenty-one." And she added, "I can't bear the present time—all this television, trash, nonsense. None of it means anything to me." And, perhaps in accordance with this state of mind, she suddenly ceased to respond to L-DOPA, and reverted again to the catatonic state she had been in for forty years; nor were we ever able again, by chemical means, to make any change in her condition.

Another patient (Miron V.), who at first did very badly on L-DOPA, swinging unpredictably between stupor and frenzy, did far better, ceased to swing, when he found his family, who had been cut off from him for years, and when, additionally, we were able to set up a cobbler's bench and last in the hospital, so that he could resume the work he had once loved and which had been essential in giving him a sense of purpose and identity. Bringing these back—work and love, meaning—"centered" him, gave him back a firm base of identity and health, and alleviated the violent physiological oscillations he had been having.

Whatever went wrong on the ward or in their inner lives would instantly throw these patients into physiological problems of all sorts. Thus there was a sudden access of tics, crises, recurrent Parkinsonism, etc., in September 1969, when a new hospital director abruptly dissolved the patient community, forbade visiting, and instituted a new, repressive regime; and whatever went right, humanly and morally, would as promptly serve to alleviate these problems (as with Miron V.). I had, as I had had with my migraine patients, a sense of complete psychophysical transparency or continuity, of the physical and the mental dissolving into each other—never a sense of two elements or realms. "Awakening," it became clear, was not just a matter of a chemical, but of

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We had at first thought in narrow, chemical terms, believing that it would be sufficient to animate the patients chemically with L-DOPA, and then let them go. But L-DOPA, it was soon clear, was only the beginning. What was then necessary, after the first excitement had come and gone, was "reality," the sense of a real life, an identity; it was necessary for them to find or make a life with purpose and meaning and individuality and dignity.

This, it might be said, is true of us all, but it was especially clear in these neurologically damaged patients, who had so little of the normal resilience the rest of us have, and so great a tendency to disintegrate physiologically. These patients had an exaggerated need to find ways of centering and organizing their so greatly disturbed physiology. Thus studying them, in their extremity, made clearer what is needed and sought by us all.

One such way of "centering," of recalling a self, the active powers of a self, from the abyss of pathology, can be given by music, by art of all kinds. In Parkinsonism, in

postencephalitic syndromes, patients become deeply inert. *Inert*, etymologically, is the privative of *art*: indeed, the word was originally *inart*. And one of the cures for inertia is art: thus one would see patients completely frozen, unable to take a single step, without inner impulse or activity, but almost miraculously able, in the presence of music, to walk, to dance, to move and talk normally.

One such postencephalitic patient, a former music teacher, said she had been "demusicked" by her disease; but, even before L-DOPA, she would suddenly recover herself, albeit briefly, if she was "remusicked" ("You are the music while the music lasts"—Eliot). Other patients would suddenly "come to"—that is, recover their lost mobility and initiative and will and identity—if one engaged them in play: playing ball, playing cards, any sort of play.

Art and play, and drama and rite, had a therapeutic power as strong as L-DOPA, as strong as any drug; but, it was clear, these worked in a different way. They worked, one felt, *to evoke a self*, and not in some partial and mechanical way. "The arts are not drugs," wrote E.M.Forster. "They are not guaranteed to act when taken. Something as mysterious and capricious as the creative impulse has to be released before they can act."

3.

These were some of the observations, some of the considerations, which forced themselves on me when, as a young doctor in the 1960s, I first began to see patients. But every experience since, every other sort of patient, has served to confirm these basic observations. I have seen innumerable patients with Tourette's syndrome who suffer from violent convulsive tics and compulsions of all sorts. Many of them, interestingly, are musicians, or athletes, or actors; and in the act of making music, of batting a ball, of acting, of performing, they may completely cease to be Tourettic. *Concentration* acts as a "cure," albeit a temporary one, for Tourette's.[4] This is so for Parkinsonism as well. In Korsakov's syndrome, a profound impairment of memory caused by alcohol-induced damage to certain systems of the brain, the patient may be unable to remember anything, to hold together, for more than a few seconds. I describe one such patient, Jimmie, "The Lost Mariner," in *The Man Who Mistook His Wife for a Hat*. But Jimmie, so lost, so disconnected, so disoriented most of the time, would "come together" completely during the rite of Mass, would be enabled through its "organic" coherence and continuity—with every moment referring to every other, every moment filled with meaning—to recover, if transiently, his own continuity. He became, at this

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When I first started seeing patients, my thinking was mechanical, physiological. But it soon became clear that I needed always to address myself to the individual person and to his needs, and that I could not understand what was going on without this. More and more I started to think of medicine as not just treating the lesion, or the disease. One has to treat the lesion, but one has, equally, to pay attention to the entire individual. This is not only ethically so, but it seems to me to be scientifically so as well. Physiology and neurology and neuroscience themselves need the concept of the individual. The great Russian neuropsychologist A.R. Luria himself used to feel this very strongly. He liked

to quote Karl Marx's definition of science as "the ascent to the concrete," and he felt that getting historical details, getting an idea of the full richness of a life and the full consciousness of a life was quite necessary if one were to treat any patient. And he felt, by the same token, that an impersonal case history had to be replaced by a deep and essentially personal biography. Luria was himself always at this intersection of biology and biography, both as a physician and as a writer. Indeed, in his first letter to me, Luria was at pains to distance himself from "connectionism, associationism, and the dry, mechanical thinking of my friend Fred Skinner," and to insist upon the *historical* genesis of higher cerebral functions, the fact that one needs for their understanding "a new, *historical* biology."

Implied in all this is the necessity for an adequate concept of the individual and of mind, a concept of how individual persons grow and become, and how their growing and becoming are correlated with their physical bodies. Dualistic approaches prevent us from developing such a concept. The body remains, resolutely, a "machine," with the mind divorced from it, as a sort of "ghost" (Gilbert Ryle speaks of "the ghost in the machine"). Spinoza, by contrast, took a more open approach, saying that if we knew more of the body, of its complexity, its delicacy, its subtlety, its potential, and above all, of its capacity to interact and develop, we would have less and less need, or no need, to invoke any extra, incorporeal essence or principle. "No one," writes Spinoza in the *Ethics*, "has hitherto laid down the limits of the body;…no one has as yet been taught by experience what the body can accomplish solely by the laws of nature;…no one hitherto has gained such an accurate knowledge of the bodily mechanism, that he can explain all its function;…the body can, by the sole laws of its nature, do many things which the

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But it is only now, three centuries later, that we are beginning to glimpse the level of neurobiology that is needed; and it is only now that it has become possible, in tentative terms, to bring this new knowledge into fruitful contact with a new theory, and attempt for the first time a neurobiological theory of the individual, explaining how a human being perceives, learns, enriches himself, becomes himself.

This was not a subject that could be investigated experimentally until the 1950s; physiology, up to this time, was still of a classical, Sherringtonian sort, concerned with reflex action, nerve potentials, and low-level integrations in the spinal cord and brain. Such research used "preparations" of various kinds (nerve muscle preparations, spinal animals, decerebrate animals, anesthetized animals, etc.). It was not until the 1950s that it became possible to make continuous recordings from single neurons in the intact and living animal, to start gaining an idea of the actual neuronal correlates of perception, attention, learning, etc.—a sense of the brain as actively constructing, actively creating "mental" representations and models. Some neurologists—above all, Henry Head and Kurt Goldstein, much earlier in the century—had already had a clear vision of the brain as creative and categorical; but there was no physiological support of such views.

The first single-unit recordings in the 1950s, and the revolutionary work of David Hubel and Torsten Wiesel in the 1960s, showed how the visual cortex started to build up complex constructions. This early work studied only the simplest situations: how cats, for example, discriminated vertical and horizontal lines. By the 1970s, under Otto

Creutzfeldt in Göttingen, situations closer and closer to "real life" were being studied—how individual neurons, in different parts of the brain, responded to actual scenes, or pictures, or music.[7] A new synthesis, a new theory of the nervous system, based on the new data of neuroscience, a vision of a sort unimaginable before 1950, was now becoming possible. And in 1978 such a theory was put forward by Gerald Edelman, with his concept of neural Darwinism, or neuronal group selection. Edelman postulated that it was not individual neurons but rather *groups* of neurons, interacting throughout the brain, that formed the neural correlate of perception.

This view has received spectacular confirmation in the very recent work of the physiologists Charles Gray and Wolf Singer, who have shown that widely separated columns of cells in the visual cortex of cats oscillate in synchrony in response to particular objects, but show no such synchronization if the stimuli are unrelated. They show that the perception of objects depends on the cooperative interaction of many neuronal groups in a coherent temporal pattern, precisely as Edelman had postulated. Therefore they conclude, the results "provide experimental support for a central postulate of Edelman's group selection theory."[8] Further, they give us good reason to go back to the almost-forgotten work of Head and Goldstein, who felt, on clinical grounds, that neurological syndromes could only be understood if the primary function of the brain was seen as one of creating categories, abstractions, and generalizations. With this we seem to recapture a richness of view that has largely vanished from the

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There have always been mechanical views of the nervous system: in the seventeenth century, Leibniz compared it to a mill; in the nineteenth century, it was often compared to a telephone exchange. In this century, it is usually compared to a computer. This model sees the brain as a glorified machine, as an immensely intricate but relatively fixed set of nervous connections, programmed to carry out different sets of nervous operations, like a Turing machine fed instructions and information. But, as Edelman points out, the world is not labeled, it does not feed us instructions and information, and there is much to indicate that, in higher nervous systems at least, there is not all that much "programming" built in. In place of such a "functionalist" theory, Edelman proposes a selectionist one: he stresses that our brains are not identical at birth (even in identical twins), that they display wide variations in a way that is incompatible with their functioning as Turing machines but that is eminently adapted for their development in individual directions. It is indeed precisely the variation that counts. The world does not have a predetermined structure: our structuring of the world is our own—our brains create structures in the light of our experiences.[9]

The units of selection, for Edelman, are neuronal groups in the brain, perhaps a million of these, with between 500 and 10,000 neurons each. (By a happy coincidence Edelman's first theorizing was published jointly with a paper by the neurophysiologist Vernon Mountcastle, who was one of the first to show that such groups of neurons did exist anatomically in the brain.)[10] These neuronal groups are richly connected to one another, as well as to receptors for vision, hearing, touch, etc.

Faced with the necessity of survival, for making order, in a teeming and chaotic world—"a booming, buzzing chaos," as William James called it—the brain is highly

plastic and adapts itself at each moment.[11] The infant, the human infant at least, is born into chaos, at least so far as complex perceptions and cognitions go. The infant immediately starts exploring the world, looking, feeling, touching, smelling, as all higher animals do, from the moment of birth. Sensation alone is not enough; it must be combined with movement, with emotion, with action. Movement and sensation together become integrated to form a "category," a coherent brain response, a category which is the antecedent of a "meaning." Subsequent explorations—feeling the same object at different times, in different contexts—are never quite the same, so that the initial category is revised, recategorized, and re-recategorized, again and again. Given this incessant recategorization, no perception, no image, no memory, one would expect, would ever be precisely repeated or the same.[12] Yet through this structuring and restructuring, the infant, the growing individual, constructs a self and a world.

It is recorded of Mozart, whose musical memory was one of the most accurate ever known, that if he was asked (after some astonishing improvisation) to "play it again," he never would, never *could*, play it precisely again, but would always come up with some new variation. Mozart, in this sense, may have been a failure as a recording machine,

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In each human being, things are constantly shifting in their significance, as is the underlying neurophysiological response. Neuronal groups are organized into sheets of brain tissue, called maps, which respond to different kinds of external stimuli—auditory, visual, and tactile—as well as to one another. Every neuronal map, every part of the brain, is dynamically or, in Edelman's term, "re-entrantly" connected with every other, evolving and integrating itself in continuous "cross-talk." The groups within the maps "speak" back and forth to one another until a coherent response is established, creating categories of things and events, to build up a picture of the world, an "inner world," at once generalized and completely individual.

This evolution of self, this active growth and learning and becoming of the individual, is made possible by "selection," the strengthening of connections within neuronal groups in accordance with the individual's experiences (and needs and beliefs and desires). This process of selection cannot arise, cannot even start, unless there is movement—it is movement that makes possible all perceptual categorization. The clearest example of this in my own experience was with a patient called Madeleine, whom I described some years ago ("Hands," in *The Man Who Mistook His Wife for a Hat*). This patient, a congenitally blind woman with cerebral palsy, was unable to read Braille, unable to perceive anything with her hands even though they had normal elementary sensation (sense of touch, pain, heat, etc.) and normal muscular power. She had never used her hands, having been treated from birth as a cripple, and carried around bodily. They remained, despite neurological intactness, motionless and useless.

By a ruse we managed to get her to reach out, to use her hands (she was in her sixtieth year) and to recognize her first object, which happened to be—a bagel. This marked a spectacular change in her: it marked her birth as a "motor individual" (Sherrington's term for the person who emerges through acts). It also marked her first manual perception, and thus her birth as a potentially complete "perceptual individual" too. The development of perceptual power, with her new and now free use of the hands, was now

extremely rapid—this was made possible with the brain's power of generalization and categorization—so that within a month she had moved from recognizing a bagel to recognizing a whole perceptual world. She did not have to recognize a million things separately, but could rank them in categories of ever-ascending range. But she showed no hint of these powers for her first sixty years, when her hands remained passive, motionless, and "useless."[13]

It is characteristic of a creature, in contrast to a computer, that nothing is ever precisely repeated or reproduced; that there is, rather, a continual revision and reorganization of perception and memory, so that no two experiences (or their neural bases) are ever precisely the same. Experience is ever-changing, like Heraclitus' stream. This streamlike quality of mind and perception, of consciousness and life, cannot be caught in any mechanical model—it is only possible in an *evolving* creature.

Darwin provided a picture of the evolution of species; Edelman has provided a picture of the evolution of the individual nervous system, as it reflects the life experience of each individual human being. The nervous system adapts, is tailored, evolves, so that experience, will, sensibility, moral sense, and all that one would call personality or soul becomes engraved in the nervous system. The result is that one's brain is one's own. One is not an immaterial soul, floating around in a machine. I do not feel alive, psychologically alive, except insofar as a stream of feeling—perceiving, imagining, remembering, reflecting, revising, recategorizing runs through me. I am that stream—that stream is me.

This is totally different from Hume's denial of identity and his reduction of mental life to nothing but "a bundle or collection of different sensations, which succeed each other with an inconceivable rapidity, and are in a perpetual flux and movement."[14] We are not incoherent, a bundle of sensations, but a *self*, rising from experience, continually growing and revised. The brain is not a bundle of impersonal processes, an "It," with the "mind," the "self," hovering mysteriously above it. It is a confederation,[15] an organic unity, of innumerable categorizations, and categorizations of its own activities, and from these, its self-reflection, there arises consciousness, the Mind, a metastructure (as Creutzfeldt says) built upon the real worlds in the brain.

In his last letter Goethe wrote, "The Ancients said that the animals are taught through their organs; let me add to this, so are men, but they have the advantage of teaching their organs in return." Through experience, education, art, and life, we teach our brains to become unique. We learn to be individuals. This is a neurological learning as well as a spiritual learning, so that finally neurology and the soul do come together completely in a way which dignifies neurology, and which is no indignity to the soul.[16]

Notes

[1] It is important that the thinking developed in Penfield's last book (he died in 1976, the year after it was published) be seen not as some eccentric late development but as being of a piece with thoughts and tendencies he had entertained most of his life. His dualism, his speculations on the relation of brain and mind, seem to have started when he was a youthful student under Sherrington and saw a cat with its cerebral hemispheres removed, a cat reduced to a "mindless automaton." (Sherrington himself had a similar epiphany, when he saw a decorticate dog in Goltz's lab forty years before.) In the

Thayer lectures in 1950—when he was in the midst of his experimental work—Penfield speculated that "mind may be of a different and distinct *essence*."

[2] John C. Eccles, *Evolution of the Brain: Creation of the Self* (Routledge, 1989).

[3] Smith Ely Jelliffe, *Psychopathology of Forced Movements and the Oculogyric Crises of Lethargic Encephalitis* (The Nervous and Mental Disease Publishing Company, 1932).

[4] In Tourette's syndrome, as in the post-encephalitic syndromes, one must conceive a host of excited subcortical and cortical points, in complete functional isolation from each other and from the brain as a whole, and firing in a random, meaningless, and uncoordinated way, a phantasmagoria of fireworks in the neurological sky. Pavlov spoke of such "pathological points" in the cortex, and their "complete functional isolation at the aetiological moment." Concentration of attention, at the moment that it is achieved, by focusing the organism's will and perceptions and actions upon a single aim, serves to cohere these otherwise uncoordinated, autonomous cerebral points, to subordinate them—and to subordinate the whole brain (or vast areas of it)—into a single functional unity. There is good electroencephalographic evidence for this sort of unification—I often saw it in the striking effects of playing music, or imagining it, in the EEGs of my post-encephalitic patients, which would be suddenly transformed from gross irregularity or convulsiveness into a rhythmic state, and a state of synchronization.

[5] Another patient of mine had extensive frontal lobe damage, rendering him completely "flat" emotionally, seemingly incapable of any normal feeling. But he loved music (country music especially), and when he sang, as he sometimes did spontaneously, he would come alive in the most remarkable way, as if the music could give him, transiently, what his cortex had lost.

[6] A particularly interesting discussion of Spinoza's monistic views of mind and body has been provided by Stuart Hampshire in "A Kind of Materialism" in his collection *Freedom of the Mind and Other Essays* (Princeton University Press, 1971). Spinoza does not see "Mind" and "Body" as two essences, as Descartes does, but as the two *modes* ("Thought" and "Extension") in which the body/mind, the individual, exists. Similarly, he says, we must have two autonomous modes of description—physical (physiological) and mental (psychological)—neither can ever be replaced by the other. Thus he allows, as we must, a dualism of *description*, but not a dualism of essence or substance.

[7] See, for example, Otto D. Creutzfeldt, "Brain, Perception, and Mind," in *Visual Perception: The Neurophysiological Foundation* (Academic Press, 1990); and "Impasses and Fallacies of the Brain-Mind Discussion," in *Experimental Brain Research*, Supp. 9 (Berlin-Heidelberg: Springer-Verlag, 1984).

[8] Charles M. Gray and Wolf Singer, "Stimulus-specific neuronal oscillations in orientation columns in cat visual cortex," *Proceedings of the National Academy of Science*, Vol. 86 (March 1989), pp. 1698–1702.

[9] Such structuring, or construction, occurs at two levels in our brains: a lower level which is innate, universal, and automatic, such as the mechanism Edwin Land and

Semir Zeki have described for constructing or computing color in our worlds (see Sacks and Wasserman, "The Colorblind Painter," *The New York Review*, November 19, 1987); and a higher level, for the construction of *categories*, categories which extend from the perceptual to the moral (though it could be said that even the sensation of color is a categorization, albeit one fixed by the strictest physical and physiological constraints, e.g., the three narrow wavebands of frequency to which the retina differentially responds. Thus all of us arrive at the same categorizations—"red" is red for all of us, for monkeys too).

The brain is first, and in its simpler functions, a sort of computer; in its higher functions, it is a categorizing machine—an apparatus for constructing categories in the light of experience. This construction of complex categories—or "meanings"—is a relatively recent event; it does not seem to occur in fishes or amphibia, but only in mammals, birds, and possibly reptiles—an evolutionary emergence of relatively recent occurrence. A frog's reaction to a fly seems relatively automatic, a question of "feature detection" and reflex reaction. A frog's brain does not have to *create* categories—a "world"; it does not have to struggle to achieve a perceptual judgment. No doubt a frog's brain categorizes a fly—as small, black, moving, edible, etc.—but this categorization seems to be innate, programmed in the nervous system (certainly insects, with their tiny brains, and complex behaviors from the start, seem to be entirely "hard-wired"). A new way of doing things, a new complexity of perception *based on experience*, seems to have arisen perhaps 100 million years ago, in the late Jurassic or the Cretaceous periods. It was not yet "intelligence," or "consciousness," or "mind," but was, perhaps, the crucial forerunner of all these.
It has been suggested that dreaming is a way of dealing with new events and emotions, recategorizing them, processing them, so that they can be integrated and used by the brain. It is interesting that dreaming, or that form of sleep in which dreaming occcurs (REM sleep), does not occur in the Echidna or platypus, but only emerged with the evolution of marsupials. Certainly it seems to have evolved in vertebrates at about the same time as complex perceptual categorization.

[10] G.M. Edelman and V.B. Mountcastle, *The Mindful Brain* (MIT Press, 1978).

[11] One of the most remarkable examples of a radical adaptation to experience is to be found in children who are native users of sign language (I describe this in detail in *Seeing Voices*). Such children become intensely visual—develop great physiological enhancements of visual perception, visual imagery, visual memory, and visual-cognitive powers—as they acquire a visual language (Sign). Visual functions which are normally lodged in the right cerebral hemisphere cross over and get relocated in the (more analytic) left hemisphere; and, most remarkable of all, cerebral cortex which is normally auditory in function is "reallocated," and completely turned over, to visual processing. Deaf signers thus develop, under the spur of experience, radically new forms of neural organization, neural mappings, which allow them to categorize the world in a quite novel way. This would be wholly impossible if the circuits of the cerebral cortex were fixed and programmed in advance. What we see is that the opposite is true, that huge areas of the cerebral cortex are plastic at birth, open to a great range of possible developments, the actual development depending on the experience of the child. Such a process of development can be accounted for by the theory of neural group selection.

[12] That this is indeed the case was shown in brilliant experimental studies by Frederick Bartlett, the psychologist, and described in his remarkable early book, *Remembering* (1932). Bartlett himself refused to use the noun "memory," and always insisted on using the active verb "remembering." In his experiments, subjects were shown a scene, or told a tale, and asked to remember and describe what they had seen or heard; and typically their rememberings would deviate, with further tellings, farther and farther from the original, though always in a significant (sometimes creative) and personal way. In Bartlett's words,

Remembering is not the re-excitation of innumerable fixed, lifeless and fragmentary traces. It is the imaginative reconstruction, or construction, built out of the relation of our attitude towards a whole active mass of organized past reactions or experience, and to a little outstanding detail which commonly appears in image or in language form. It is thus hardly ever really exact, even in the most rudimentary cases of role recapitulation, and it is not at all important that it should be so.
There are elements of imaginative reconstruction in Penfield's patients—their memory-fragments become mixed with current experiences and states of mind, and contain an improvised and dreamlike quality (this is obvious when the original accounts are critically reviewed, as has been done by Israel Rosenfield in *The Invention of Memory*)—yet, by and large, they are not reconstructions, but "fixed, lifeless and fragmentary traces." Far from being normal, as Penfield conceives, convulsive memories must be seen as grossly abnormal—unintegrated, cut off from the main, preserved in a strange and unnatural fixity. They are not exemplars, as Penfield would have us think, of normal memory, but illustrations of the opposite, of the total breakdown of normal, Bartlettian remembering.

[13] My own most dramatic confirmation of the need for movement, as well as sensation, came in 1974, when, following an injury and surgery to my left leg, I had to have it immobilized and encased in a cast and was not allowed to use it for a period of fifteen days. This led to a drastic alteration of "body-image" (Head's term) and "body-ego" (Freud's term). The leg itself no longer felt like "mine," not like flesh, not coherent, not like a real object at all. "I" now ended at the hip, on the left side, with no sense subjectively of where the leg had previously been. With the absence of movement, and of the information activity would provide, the brain could no longer make a categorization of the leg, as "me" or even "body," and my body-image had contracted, and (so to speak) sealed itself over seamlessly, leaving no trace, no place, no space, for a leg.

Nothing showed me more clearly than this experience the dynamic nature of the body image: how it could not sustain itself a something static, but had rather continuously to be constructed, brought up to date, revised. The rapid revision of body-image with this change in the periphery is very similar to what has been found experimentally, in monkeys, by Michael Merzenich—viz. that following an injury, or change of sensation in a finger, the brain mappings (of the hand) showed rapid reassembly and alterations, a rapid "recategorization" of the hand. When I came to write of my own injury (*A Leg to Stand On* was written in the 1970s, though only published in 1984), I did not know either of Merzenich's findings, or of Edelman's theory, and could not make sense of what had happened to me. But it was, of course, no more and no less than such a swift recategorization of body-image as they describe. It was only on the fifteenth day after

my injury, when I was able to *move* my leg, that it come back to me as a real object, as part of my current body image as, once again, *me*.

[14] Hume's image, so inapplicable to the normal mind, may be more apt as a description of the dis-integrated mind, such as may occur in Korsakov's and, convulsively, in Tourette's, in which temporal and historical continuity has been lost. Such Humean disintegrations (and violations of continuity) may also occur in dreaming and delirium. A similar disunity of memory also occurs in Luria's Mnemonist, whose brain threw out millions of images, never integrated with his personal life, images which (in Luria's words) formed an "It" not an "I."

The incontinent tendency to mimicry in Touretters (see Sacks, "Tics," *The New York Review*, January 29, 1987), like the excessive sensory concreteness of the Mnemonist's memory-images, testifies to a failure in the abstracting and categorizing powers of the brain here (or rather, a short-circuiting of these powers by the precipitate quality of imagery or mimicry). Here too one must mention idiot savants and autist artists, with their uncanny ability to reproduce, with almost "photographic" fidelity, any pattern or scene they have seen, or any string of numbers or tune they have once heard, yet to miss the meaning, to be unable to generalize or theorize. There is an element of the wonderful, the prodigious, in such powers—but they smack of the primitive and the pathological, too.

Much pathology, indeed, can be reinterpreted in terms of disunity and disintegration, as being (what Edelman would call) "diseases of categorization" or "diseases of consciousness." Perhaps the simplest example of this is a phantom limb, a fixed and motionless image of the lost limb, sometimes fixed in the exact position in which it was lost—one such patient of mine chopped off his extended index finger by accident, and twenty years later still suffered from a an intrusive phantom finger still rigidly extended in the position it once had. Such a phantom is, in effect, a fossil memory, like a still photo preserved from the past—an image which can no longer be integrated into the normal, ever-changing, dynamic body-image, but has been marooned, a relic of the past, in an unnatural and strange fixity. Bits of memory, of experience, may get similarly isolated, and thence-forth present themselves intrusively and reiteratingly—as in Penfield's patients, but also as in cases of psychic trauma and neurosis ("The hysteric suffers from reminiscences," as Freud says). As for Jimmie and Rose, these are the most tragic of all, for they are in their entirety marooned, fixed in the past, the stream of consciousness frozen, not updated in decades. The treatment of such "diseases of consciousness" is clear—one must reintegrate the isolated, frozen fragments of memory, and bring them back into the present, into the ongoing stream of being, into becoming integral parts of the ongoing "I" (but this may be impossible, of course, if too gross a pathology is involved).

[15] I use the term "confederation" in a totally different sense from Marvin Minsky, the father of artificial intelligence, in his important book, *The Society of Mind* (Simon & Schuster, 1987). For Minsky this "society" is one of mechanical addition and linkage, as of innumerable lifeless modules in a computer, whereas the "confederation" I speak of is intensely alive, and has an organic and personal and historical unity. Minsky denies "self" and "freedom of the will"; I see them as central in any theory of brain/mind.

[16] In preparing this article I have been assisted by discussions with Pietro Corsi, Otto Creutzfeldt, Gerald Edelman, Ralph Siegel—and, most especially, Israel Rosenfield. To

these and many others I owe illumination and insights, though my opinions—and

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Letters

January 17, 1991: Gregory Ludwig, JAMES SACKSIFIED
December 6, 1990: Oliver Sacks, NEUROLOGY AND THE SOUL
