

I may work as hard as Butler did out of ambition or a desire to make money. But unless I also enjoy the task, my mind is not fully concentrated. My attention keeps shifting to the clock, to daydreams of better things to do, to resenting the job and wishing it was over. This kind of split attention, of halfhearted involvement, is incompatible with creativity. And creative people usually enjoy not only their work but also the many other activities in their lives. Margaret Butler, in describing what she does after her formal retirement, uses the word *enjoy* in reference to everything she does: helping her husband to continue his mathematical research, writing a careers-for-women guide for the American Nuclear Society, working with teachers to get women students interested in science, organizing support groups for women scientists, reading, and being involved in local politics.

These ten pairs of contrasting personality traits might be the most telling characteristic of creative people. Of course, this list is to a certain extent arbitrary. It could be argued that many other important traits have been left out. But what is important to keep in mind is that these conflicting traits—or any conflicting traits—are usually difficult to find in the same person. Yet without the second pole, new ideas will not be recognized. And without the first, they will not be developed to the point of acceptance. Therefore, the novelty that survives to change a domain is usually the work of someone who can operate at both ends of these polarities—and that is the kind of person we call “creative.”

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THE WORK OF CREATIVITY

Is there a single series of mental steps that leads to novelties that result in changing a domain? Or, to put it differently, is every creative product the result of a single “creative process”? Many individuals and business training programs claim that they know what “creative thinking” consists of and that they can teach it. Creative individuals usually have their own theories—often quite different from one another. Robert Galvin says that creativity consists of anticipation and commitment. Anticipation involves having a vision of something that will become important in the future before anybody else has it; commitment is the belief that keeps one working to realize the vision despite doubt and discouragement.

On the other hand, in his letter of refusal, the management guru Peter Drucker lists four reasons that account for his accomplishments (in addition to the fifth, never participate in studies such as this):

- (a) I have been able to produce because I have always been a loner and have not had to spend time on keeping subordinates, assistants, secretaries, and other time-wasters; because (b) I never set foot in my university office—I do my teaching; and if students

want to see me I give them lunch; because (c) I have been a workaholic since I was 20; and (d) because I thrive on stress and begin to pine if there is no deadline. Otherwise—if I may be presumptuous: I was born like the sentry in Goethe's *Faust II*:

*Zum Sehen geboren
Zum Schauen bestellt*

("Born to see, my task is to watch")

Given how different domains are from one another, however, and given the variety of tasks and the different strengths and weaknesses of individuals, we should not expect a great deal of similarity in how people arrive at a novel idea or product. Yet some common threads do seem to run across boundaries of domains and individual idiosyncrasies, and these might well constitute the core characteristics of what it takes to approach a problem in a way likely to lead to an outcome the field will perceive as creative. Let's illustrate this process with a description of how the Italian author Grazia Livi wrote one of her short stories.

THE WRITING OF A STORY

One day Livi went to her bank to talk to a financial adviser who managed her portfolio of investments. The adviser was a woman Livi had met before; she seemed to her the epitome of a contemporary career woman bent on success and not much else, immaculately groomed, cold, hard, impatient. A person without a private life, with no dreams except money and advancement. This particular day the appointment started in the usual key: the adviser looking distant and frigid, asking questions in a dry, uninterested voice. Then a ringing phone interrupted the conversation. To Livi's surprise, as the woman turned away to take the call, her face changed—the chiseled features softened; even the hard helmet of hair became velvety—her posture relaxed, her voice became low and caressing. Livi had an immediate visual image of the person at the other end of the phone: a handsome, tanned, laid-back architect who drove a Maserati. After returning from the bank, she made a few notes to herself in a log she keeps for this purpose and then apparently forgot the incident.

Some months later, rereading the log, she saw a connection

between the entry she had made of the episode at the bank and entries she had written about a dressed-for-success woman sitting for hours in a beauty shop and other similar types she had met in the course of the past years. She was seized with a strong feeling of emotional discovery: Here was an insight about the current predicament of women—torn between contrasting demands—that could yield a true story. True not in the sense of representing what she had seen—the woman at the bank may have been talking to her mother or her child—but true to a widespread condition of our times, where many women feel that they have to be aggressive and cold to compete in the business world yet at the same time cannot give up what they think of as their femininity. So she sat down to write about a career woman grooming herself all day for a date that never comes off—and it was a terrific story. Not because of the plot, which is as old as the hills, but because the emotional currents of her character reflected so achingly and accurately the experience of our time.

Livi's story may not change the domain of literature, and hence it is not an example of the highest order of creativity. But it may well be included in future collections of short stories, because it is an excellent example of a contemporary genre. And to the extent that it expands the domain, it qualifies as a creative achievement. Is there a way to analyze what Livi did, to see more clearly what her mental processes were as she wrote the story?

The creative process has traditionally been described as taking five steps. The first is a period of preparation, becoming immersed, consciously or not, in a set of problematic issues that are interesting and arouse curiosity. In the case of Grazia Livi, the emotional quandary of modern women was something she experienced personally, as a writer trying to compete for prizes, reviews, and publications, and also as a woman trying to balance the responsibilities of motherhood with her writing.

The second phase of the creative process is a period of incubation, during which ideas churn around below the threshold of consciousness. It is during this time that unusual connections are likely to be made. When we intend to solve a problem consciously, we process information in a linear, logical fashion. But when ideas call to each other on their own, without our leading them down a straight and narrow path, unexpected combinations may come into being.

The third component of the creative process is insight, sometimes

called the "Aha!" moment, the instant when Archimedes cried out "Eureka!" as he stepped into the bath, when the pieces of the puzzle fall together. In real life, there may be several insights interspersed with periods of incubation, evaluation, and elaboration. For instance, in the case of Livi's short story, there are at least two moments of significant insight: when she saw the investment adviser transformed by the phone call, and when she saw the connection between the similar entries in the log.

The fourth component is evaluation, when the person must decide whether the insight is valuable and worth pursuing. This is often the most emotionally trying part of the process, when one feels most uncertain and insecure. This is also when the internalized criteria of the domain, and the internalized opinion of the field, usually become prominent. Is this idea really novel, or is it obvious? What will my colleagues think of it? It is the period of self-criticism, of soul-searching. For Grazia Livi, much of this sifting took place as she read through her log and decided which ideas to develop.

The fifth and last component of the process is elaboration. It is probably the one that takes up the most time and involves the hardest work. This is what Edison was referring to when he said that creativity consists of 1 percent inspiration and 99 percent perspiration. In Livi's case, elaboration consisted in selecting the characters of the story, deciding on a plot, and then translating the emotions she had intuited into strings of words.

But this classical analytic framework leading from preparation to elaboration gives a severely distorted picture of the creative process if it is taken too literally. A person who makes a creative contribution never just slogs through the long last stage of elaboration. This part of the process is constantly interrupted by periods of incubation and is punctuated by small epiphanies. Many fresh insights emerge as one is presumably just putting finishing touches on the initial insight. As Grazia Livi was struggling to find words to describe her character, the words themselves suggested new emotions that were sometimes more "right" to the personality she was trying to create than the ones she had initially envisioned. These new feelings in turn suggested actions, turns of the plot she had not thought of before. The character became more complex, more nuanced, as the writing progressed; the plot became more subtle and intriguing.

Thus the creative process is less linear than recursive. How many

iterations it goes through, how many loops are involved, how many insights are needed, depends on the depth and breadth of the issues dealt with. Sometimes incubation lasts for years; sometimes it takes a few hours. Sometimes the creative idea includes one deep insight and innumerable small ones. In some cases, as with Darwin's formulation of the theory of evolution, the basic insight may appear slowly, in separate disconnected flashes that take years to coalesce into a coherent idea. By the time Darwin clearly understood what his theory implied, it was hardly an insight any longer, because its components had all emerged in his thought at different times in the past and had slowly connected with one another along the way. It was a thunderous "Aha!" built up over a lifetime, made up of a chorus of little "Eurekas."

A more linear account is Freeman Dyson's description of the creative process that brought him scientific fame. Dyson had been a student of Richard Feynman, who in the late 1940s was trying to make electrodynamics understandable in terms of the principles of quantum mechanics. Success in this task would mean translating the laws of electricity so that they conformed to the more basic laws of subatomic behavior. It would be a great simplification, a welcome ordering of the domain of physics. Unfortunately, while most colleagues felt that Feynman was onto something deep and important, not many could follow the few scribbles and sketches he used to prove his points, especially since he usually went from *A* directly to *Z* with no stops in between. At the same time, another physicist, Julian Schwinger, also was working on the unification of quantum and electrodynamic principles. Schwinger was in many ways Feynman's opposite: He worked slowly and methodically and was such a perfectionist that he never felt ready to claim a solution to the problem he was working on. Freeman Dyson, working in Feynman's orbit at Cornell University, was exposed to a series of lectures by Schwinger. It gave him the idea of bringing together Feynman's leaps of intuition with Schwinger's painstaking calculations and to resolve once and for all the puzzle of how the behavior of quanta related to electrical phenomena. After Dyson finished his work, Feynman's and Schwinger's theories became understandable, and the two received the Nobel Prize in physics. Several colleagues felt that if anyone deserved the prize, it was Dyson. Here is how he describes the process that led to his accomplishment:

It was the summer of 1948, so I was then twenty-four. There was a big problem which essentially the whole community of physicists was concentrated on. Physics is usually like that—there is some particularly fascinating problem that everybody is working on and it tends to be sort of one thing at a time. And at that time the big problem was called quantum electrodynamics, which was a theory of radiation and atoms, and the theory was in a mess and nobody knew how to calculate with it. It was sort of a logjam for all kinds of further developments. So somebody had to learn how to calculate with this theory. It wasn't a question of the theory being wrong, but it was somehow not decently organized, so that people tried to calculate and always got silly answers, like zero or infinity, or something. Anyhow, at that moment there appeared two great ideas which were associated with two people, Schwinger and Feynman, both of them about five years older than I was. Each of them produced a new theory of radiation, which looked as though it was going to work, although there were difficulties with both of them. I was in this happy position of being familiar with both of them and I got to know both of them and I got to work.

I spent six months working very hard to understand both of them clearly, and that meant simply hard, hard work of calculating. I would sit down for days and days with large stacks of papers doing calculations so that I could understand precisely what Feynman was saying. And at the end of six months, I went off on a vacation. I took a Greyhound bus to California and spent a couple of weeks just bumming around. This was soon after I had arrived from England, so I had never been to the West before. After two weeks in California, where I wasn't doing any work, I was just sight-seeing, I got on the bus to come back to Princeton, and suddenly in the middle of the night when we were going through Kansas, the whole sort of suddenly became crystal clear, and so that was sort of the big revelation for me, it was the Eureka experience or whatever you call it. Suddenly the whole picture became clear, and Schwinger fit into it beautifully and Feynman fit into it beautifully and the result was a theory that actually was useful. That was the big creative moment of my life. Then I had to spend another six months working out the details and writing it all up and so forth. It finally ended up with two long papers in the *Physical Review*, and that was my passport to the world of science.

It would be difficult to imagine a clearer example of the classical version of the creative process. It starts with Dyson, immersed in the field of physics, sensing from his teachers and colleagues where the next opportunity for adding something important to the domain lies. He has a privileged access to both the domain and the field—he is personally acquainted with the two central individuals involved. Having found his problem—to reconcile the two leading theories in the domain—he goes through a six-month period of consciously directed, hard preparation. Then he spends two weeks relaxing, a period during which the ideas marshaled up during the past half year have a chance to incubate, to sort out and shake together. This is followed by the sudden insight that occurs unbidden during a night bus ride. And finally another half year of hard work evaluating and elaborating the insight. The idea having been accepted by the field—in this case, the editors of *Physical Review*—it is then added to the domain. As is often the case, most of the credit for the accomplishment does not go directly to the author, but to those whose work he has built upon.

The five-stage view of the creative process may be too simplified, and it can be misleading, but it does offer a relatively valid and simple way to organize the complexities involved. Therefore, I use these categories to describe how creative people work, starting with the beginning phase, that of preparation. It is essential to remember in what follows, however, that the five stages in reality are not exclusive but typically overlap and recur several times before the process is completed.

THE EMERGENCE OF PROBLEMS

Occasionally it is possible to arrive at a creative discovery without any preparation. The fortunate person simply stumbles into a wholly unpredictable situation, as Roentgen did when he tried to find out why his photographic plates were being ruined and discovered radiation in the process. But usually insights tend to come to prepared minds, that is, to those who have thought long and hard about a given set of problematic issues. There are three main sources from which problems typically arise: personal experiences, requirements of the domain, and social pressures. While these three sources of inspiration are usually synergistic and intertwined, it is easier to consider

them separately, as if they acted independently, which in reality is not the case.

Life as a Source of Problems

We have seen that Grazia Livi's idea for a story about the conflict between career and femininity was influenced by her own experiences as a woman. From the time she was a little girl, her parents expected her two brothers to be educated and successful while Grazia and her sister were expected to grow up to be traditional housewives. Throughout her life Livi rebelled against the role cut out for her. Even though she married and had children, she resolved to become successful on her own. It is this direct experience in her own life that made her sensitive to the episodes involving career women that she jotted down in her diary.

The origins of problematic elements in life experience are easiest to see in the work of artists, poets, and humanists in general. Eva Zeisel, who was considered the "dumb one" in a family that eventually included two Nobel laureates and many other outstanding male scientists, also resolved to prove herself by breaking away from traditional family interests and becoming an independent artist. Most of the creative ideas for her pottery come from a tension between two contrasting, self-imposed requirements: to make pots that conform to the human hand and are steeped in tradition, and yet can be mass-produced inexpensively by modern technology.

Poets like Anthony Hecht, György Faludy, and Hilde Domin write down daily impressions, events, and especially feelings on index cards or in notebooks, and these caches of experience are the raw material out of which their work evolves. "I had a friend, a poet called Radnòty, who wrote poems I considered atrocious," says Faludy. "And then after suffering in the concentration camps it changed him totally and he wrote wonderful verse. Suffering is not bad: It helps you very much. Do you know a novel about happiness? Or a film about happy people? We are a perverse race, only suffering interests us." He then relates how once when he was sitting in a cabin on beautiful Vancouver Island, trying to find inspiration to start a poem, he could think of nothing interesting. Finally, a set of strong images occurred to him: Five secret policemen arrive in a boat, break into the cabin, throw his books out of the window into the sea, take him five thousand miles to Siberia, and beat him mercilessly—a great

scenario for a poem, one with which the poet was unfortunately all too familiar.

The historian Natalie Davis describes the project she is working on, a book about three women of the seventeenth century, one Jewish, one Catholic, one Protestant, exploring the "sources of adventuresomeness for women":

They were all sort of me in the sense that they were all middle-aged mothers, although in one case a grandmother—which I am—and so I keep thinking that it is no coincidence that I got started on this completely different project.

The painter Ed Paschke tears off dozens of arresting images each day from magazines and newspapers and keeps these strange or funny cutouts in boxes to which he returns occasionally for inspiration. Rummaging through these icons of the times he may find one that he projects on the wall and uses as a starting point for a sardonic pictorial commentary. Another painter, Lee Nading, tears off newspaper headlines that have to do with the conflict of nature and technology—DAM ENDANGERS RARE FISH or TRAIN FULL OF GARBAGE DERAILS IN IOWA—and eventually uses one of them to inspire a canvas. To understand why Nading is particularly sensitive to this kind of event, it helps to know that he had a beloved elder brother who committed suicide just as his career was becoming successful. This brother worked at one of the most prestigious scientific research laboratories but became disillusioned with the competitiveness and the lack of concern for human consequences that he felt around him. Nading never quite forgave science for having contributed to his brother's death, and he finds in the threats posed by the fruits of science the source for his artistic problems.

Artists find inspiration in "real" life—emotions like love and anxiety, events like birth and death, the horrors of war, and a peaceful afternoon in the country. We shall see in a little while that artists are also influenced in the choice of their problems by the domain and the field. It has been said that every painting is a response to all previous paintings, and every poem reflects the history of poetry. Yet paintings and poems are also very clearly inspired by the artist's experiences.

The experiences of scientists are relevant to the problems they deal

with in a much more general, but perhaps not less important way. This has to do with the fundamental interest and curiosity the scientist brings to the task. One of the very first studies of creative scientists, conducted by Ann Roe, concluded that the chemists and physicists in her sample became interested as children in the properties of matter because the normal interests of childhood were not accessible to them. Their parents were emotionally distant, they had few friends, they were not very athletic. Perhaps this kind of generalization is drawn with too thick a brush, but the basic idea underlying it—that early experience predisposes a young person to be interested in a certain range of problems—is probably sound.

For instance, the physicist Viktor Weisskopf describes with great emotion the sense of awe and wonder he felt when, as a young man, he and a friend used to climb in the Austrian Alps. Many of the great physicists of his generation, like Max Planck, Werner Heisenberg, and Hans Bethe, claim that what inspired them to try to understand the movement of atoms and stars was the exhilaration they felt at the sight of tall peaks and the night sky.

Linus Pauling became interested in chemistry when his father, a pharmacist in turn-of-the-century Portland, let him mix powders and potions in the back of the drugstore. The young Pauling was fascinated by the fact that two different substances could turn into a third entirely different one. He experienced a godlike sense of being able to create something entirely new. By the age of seven he had read and practically memorized the enormous *Pharmacopoeia* containing the knowledge of basic elements and mixtures a pharmacist was expected to know. It was this early curiosity about how matter could be transformed that fueled Pauling's career for the next eighty years. The psychologist Donald Campbell makes the point that the difference between a scholar who comes up with new ideas and one who does not is often a difference in curiosity:

So many of my professor friends who know that they should be continuing to do research look around and find no problem that fascinates them. Whereas I have a scattered dilettante backlog of problems that I would love to work on and I feel are within reach of a solution. Many talented people can't think of anything to do that they feel is worth doing. Now, I think that I am blessed that there are trivial problems that can excite me.

Without a burning curiosity, a lively interest, we are unlikely to persevere long to make a significant new contribution. This kind of interest is rarely only intellectual in nature. It is usually rooted in deep feelings, in memorable experiences that need some sort of resolution—a resolution that can be achieved only by a new artistic expression or a new way of understanding. Someone who is motivated solely by the desire to become rich and famous might struggle hard to get ahead but will rarely have enough inducement to work beyond what is necessary, to venture beyond what is already known.

The Influence of Past Knowledge

The other main source of problems is the domain itself. Just as personal experiences produce tensions that cannot be resolved in terms of ordinary solutions, so does working within a symbolic system. Over and over, both in the arts and the sciences, the inspiration for a creative solution comes from a conflict suggested by the "state of the art." Every domain has its own internal logic, its pattern of development, and those who work within it must respond to this logic. A young painter in the 1960s had two choices: Either paint in the fashionable abstract expressionist style or discover a viable way of rebelling against it. Natural scientists in the early part of this century were confronted by the development of quantum theory in physics: Many of the most challenging problems in chemistry, biology, astronomy, as well as physics, were generated by the possibility of applying quantum theory to these new realms. Freeman Dyson's concern with quantum electrodynamics is only one example.

Gerald Holton, a physicist who later turned to the history of science, gives a lucid account of how a problematic issue in the domain can fuse with a personally felt conflict to suggest the theme for a person's lifework. As a graduate student at Harvard, Holton was immersed in the heady atmosphere of logical positivism. His teachers and fellow students were bent on demonstrating that science could be reduced to an absolutely logical enterprise. Nothing intuitive or metaphysical was admitted to this new domain. But Holton, who read about the way Kepler and Einstein had worked, started to feel that the kind of science everyone around him took for granted did not apply to some of the most celebrated scientific breakthroughs.

I discovered that these models don't quite work, that you do not in fact have built into usual accounts of the scientific process the kind of presuppositions that these people were very fond of. It was not true, for example, that the way to think about science is to think in terms of protocol sentences, and verification theory of meaning, and all of those things that were very dear to them. But these presuppositions were the things that the best of them were willing to put their money on, their reputation, their time, their very life, and stick with it even against the evidence for a while. They were enchanted with an idea for which there was in fact no proof. I had to really struggle with that.

And it is at that point that I found the idea of a *thematic proposition*, that some people are imbued with prior thematic ideas which would survive a period of disconfirmation. And that was not part of the logic of positivism or empiricism at all.

Holton describes the genesis of his own intellectual problem as a conjunction of personal interest and a sense that something was askew in the intellectual environment:

Your research project gets defined partly by some internal fascination for which one cannot account in any detail, preparation that is unique because of the life history of that person, luck, and something to work against. That is, something that you are dissatisfied with that other people are doing.

An intellectual problem is not restricted to a particular domain. Indeed, some of the most creative breakthroughs occur when an idea that works well in one domain gets grafted to another and revitalizes it. This was certainly the case with the widespread applications of physics' quantum theory to neighboring disciplines like chemistry and astronomy. Creative people are ever alert to what colleagues across the fence are doing. Manfred Eigen, whose recent work involves the attempt to replicate inorganic evolution in the laboratory, is bringing together concepts and experimental procedures from physics, chemistry, and biology. The ideas coalesced in part from conversations over the years with colleagues from different disciplines—whom he invited to informal winter meetings in Switzerland.

A large majority of our respondents were inspired by a tension in their domain that became obvious when looked at from the perspective of another domain. Even though they do not think of themselves as interdisciplinary, their best work bridges realms of ideas. Their histories tend to cast doubt on the wisdom of overspecialization, where bright young people are trained to become exclusive experts in one field and shun breadth like the plague.

And then there are people who sense problems in "real" life that cannot be accommodated within the symbolic system of any existing domain. Barry Commoner, trained as a biophysicist, decided to step out of the formalities of the academic approach and confront such issues as the quality of water and the disposal of garbage. His problems are defined by real-life concerns, not disciplines.

Well, I established a pretty good reputation in biochemistry and biophysics. In the beginning all of the papers were published in academic journals. But in various ways and for various reasons I moved more and more in the direction of doing work that was relevant to real world problems. And every now and then a paper of mine will appear in an academic journal, but that's just by accident.

As the generation of World War II scientists began to get older, the academic world became very isolated from the real world. Academic work was discipline dictated and discipline oriented, which is really pretty dull, I think.

The prevailing philosophy in academic life is reductionism, which is exactly the reverse of my approach to things, and I'm not interested in doing it.

This is a typical reaction against a domain becoming too confining and its members mistaking the symbolic system in which they operate for the broader reality of which it is a part. Commoner's feelings may be similar to those that young scholars in Byzantium must have felt when the church councils spent so much time debating how many angels could dance on the head of a pin. When a field becomes too self-referential and cut off from reality, it runs the risk of becoming irrelevant. It is often dissatisfaction with the rigidity of domains that makes great creative advances possible.

Of course, a person cannot be inspired by a domain unless he or

she learns its rules. That is why everyone we talked to, whether artist or scientist, emphasized over and over the importance of basic knowledge, of thorough familiarity with the symbolic information and the basic procedures of the discipline. György Faludy can recite long stretches of verse by Catullus that he memorized in Latin sixty years ago; he has read all the Greek, Chinese, Arabic, and European poetry that he has been able to find. He translated more than fourteen hundred poems from around the world to master his craft, even though his own powerful poems are simple, discursive, and based on personal experience. In science, mastery of the basic symbolic tools is equally important. Practically everyone echoes what Margaret Butler tells high school students:

The message that we were trying to get [across] is that if you do not know what you want to be, at least take science and math. Especially math, so that when you get into college if you change your mind and you like science or math more, or you find that you want to get into it, then you will have the background that is needed. Many women find later on that they do not have the background [mathematics] because they copped out early on.

You cannot transform a domain unless you first thoroughly understand how it works. Which means that one has to acquire the tools of mathematics, learn the basic principles of physics, and become aware of the current state of knowledge. But the old Italian saying seems to apply: *Impara l'arte, e mettila da parte* (learn the craft, and then set it aside). One cannot be creative without learning what others know, but then one cannot be creative without becoming dissatisfied with that knowledge and rejecting it (or some of it) for a better way.

The Pressures of the Human Environment

The third source of ideas and problems is the field one works in. All through life, a creative person is exposed to the influence of teachers, mentors, fellow students, and coworkers, and later in life to the ideas of one's own students and followers. Moreover, the institutions one works for and the events of the wider society in which one lives provide powerful influences that can redirect one's career and channel a person's thinking in new directions.

Indeed, if we look at creativity from this perspective, personal experience and domain knowledge may pale in comparison with the contribution of the social context to determine which problems one tackles. What an artist paints is a response not only to the classic canon of art but also to what others are painting right now. Scientists don't learn only from books or experiments they conduct but also from seminars, meetings, workshops, and journal articles reporting what is happening, or about to happen elsewhere. Whether one follows the crowd or takes a different path, it is usually impossible to ignore what takes place in the field.

Many people are introduced to the wonders of a domain by a teacher. There is often a particular teacher who recognizes the child's curiosity or ability and starts cultivating his or her mind in the discipline. Some creative persons have a long list of such teachers. The critic and rhetorician Wayne Booth says that each year in school he idealized a different one and tried to live up to that teacher's expectations. In his case, as in several others, the changes from one career direction to the other—from engineering to English—occurred in response to the quality of the teachers encountered.

For some, the introduction to the domain comes later. John Gardner started college intending to become a writer but found in the psychology departments of Berkeley and then Stanford an intellectual community that satisfied his curiosity as well as his desire for congenial company.

The field is paramount for individuals who work primarily in an organizational context. John Reed of Citicorp must constantly interact with several groups in order to assimilate the information that he needs to make difficult decisions. About twice a year he meets for a few days with the half-dozen heads of the national banks of Germany, Japan, and so on to exchange ideas about future trends in the world economy. At more frequent intervals he has similar meetings with the CEOs of General Motors, General Electric, or IBM. Even more often, he meets with the key executives of his own corporation. His inner network consists of about thirty people whom he trusts to provide the input he needs to navigate a multibillion-dollar corporation through constantly changing times. Reed spends at least half of his mornings talking on the phone or in person with members of this network and never makes a major decision involving the company without conferring with at least some of them.

Another organizational approach is represented by Robert Galvin, president of Motorola. Galvin sees his company as a gigantic creative enterprise, with more than twenty thousand engineers anticipating trends, reacting to them with new ideas, creating new products and processes. He sees his own job as orchestrating all this effort, being a role model for everyone else. In cases when the responsibility is to lead a group of people in novel directions, work is usually dictated not by a symbolic domain but by the requirements of the organization itself. It could be said for them, to borrow Marshall McLuhan's phrase, that the medium is the message; what they accomplish within their organizational structure *is* their creative accomplishment.

Scientists also mention the importance of particular research institutions. The Bell Labs, the Rockefeller Institute, and the Argonne National Laboratories are some of the places that have allowed young scientists to pursue their interests in a stimulating and supportive environment. Not surprisingly, many of them feel strong loyalties to such institutions and are more than willing to follow their research policies. Many a Nobel Prize was won by tackling problems that arose out of such institutional contexts.

New ideas are also generated when someone attempts to create a new organization or perhaps a new field. Manfred Eigen founded an interdisciplinary Max Planck Institute in Göttingen to replicate experimentally evolutionary forces in the laboratory. George Klein built up the tumor biology research center at the Karolinska Institute in Stockholm, and employs a large cadre of Ph.D.'s. Initiatives of this sort not only allow the principal investigator to pursue his or her research but also make it possible for a new discipline to emerge. If the lab is successful, entirely new sets of problems are opened up for investigation, and with time a new symbolic system—or domain—may develop.

Finally, some creative individuals attempt to form entirely new organizations outside the pale of accepted scientific, academic, or business institutions. Hazel Henderson dedicates most of her time to developing groups that will further her vision; she sees herself as the progenitor of innumerable special interest groups united in their ecological consciousness. Similarly, Barry Commoner has purposefully positioned his center in a no-man's-land where he can move unfettered by the pressures of academic or political conformity. When John Gardner founded Common Cause, he insisted on financing it

only through small independent contributions so as to avoid the major influences that come with large donations. By creating new forms of association, these individuals hope to see new problems emerge, leading to solutions that couldn't be attempted through old ways of thinking.

But organizations are embedded in larger human groups and broader historical processes. An economic depression or a change in political priorities will stimulate one line of research and send another into oblivion. According to George Stigler, the Great Depression is what sent him and many of his colleagues to study economics in graduate school. The availability of nuclear reactors built to support World War II projects stimulated many bright students to major in physics. György Faludy spent many years in concentration camps for writing one poem critical of Joseph Stalin.

Wars are notorious for affecting the direction of science, and, indirectly, of the arts as well. Let's take psychology as an example. The domain of mental testing, including the whole concept of the IQ test and its uses, owes much of its success to the U.S. Army's need to have a way of selecting recruits for World War I. Afterward the testing technology was transported into the field of education, where it has achieved a prominence that many educators find disturbing. Creativity testing owes its existence to World War II, when the air force commissioned J. P. Guilford, a psychologist at the University of Southern California, to study the subject. The air force wanted to select pilots who in an emergency—the unexpected failure of a gear or instrument—would respond with appropriately original behavior, saving themselves and the plane. The usual IQ tests were not designed to tap originality, and hence Guilford was funded to develop what later became known as the tests for divergent thinking.

As mentioned earlier, World War II was especially beneficial for women scientists. Several said that they probably would not have been admitted to graduate school if so many men had not been drafted and the graduate departments had not been looking desperately for qualified students. After graduating, these same women found jobs in government-sponsored research labs involved with the war effort, or the later attempts to keep up scientific superiority fueled by the Cold War. Margaret Butler fondly recalls the early postwar years at Argonne, where she became involved with the birth

and the infancy of computer science. Those were exciting times, when outside historical events, technological advances, and new scientific discoveries fused into a single stimulus to work hard and tackle important problems.

The influence of historical events on the arts is less direct but probably not less important. It could be argued, for instance, that the breakaway from classical literary, musical, and artistic styles that is so characteristic of the twentieth century was an indirect reaction to the disillusion people felt at the inability of Western civilization to avoid the bloodshed of World War I. It is no coincidence that Einstein's theory of relativity, Freud's theory of the unconscious, Eliot's free-form poetry, Stravinsky's twelve-tone music, Martha Graham's abstract choreography, Picasso's deformed figures, James Joyce's stream of consciousness prose were all created—and were accepted by the public—in the same period in which empires collapsed and belief systems rejected old certainties.

The Egyptian writer Naguib Mahfouz has spent many decades chronicling imaginatively the forces that are tearing apart the ancient fabric of his culture: colonialism, shifting of values, social mobility that creates new wealth and new poverty, and the changing roles of men and women. His ideas originate:

in the process of living. We learn to get on with life even before we think of writing about it. There are particular events that sink deeper into our heart than others. My concerns were always political. Politics attracts me very much. Politics, interpersonal relationships, and love. The oppressed people in society. These were the sort of things that attracted me most.

For Nina Gruenberg, associate editor and editorial columnist for the elite opinion-making weekly *Die Zeit*, unfolding world events provide a constant stream of problematic issues. Her challenge is to grasp the essential elements of the human conflicts involved, the sociocultural context in which the drama is played out, and then to report concisely her personal impression of the events. In the weeks prior to being interviewed, she had been in Texas covering the World Economic Summit, in London for the NATO summit, and in Russia for a meeting between German chancellor Helmut Kohl and Russian president Mikhail Gorbachev.

You know, I run a weekly newspaper, and normally I am very proud Wednesday mornings after the newspaper is out of the machinery, and it's ready and fresh, and I am satisfied with the piece I did. The last time I was very satisfied was after Chancellor Kohl went to the Caucasus and talked with President Gorbachev. This was on Monday, and we returned on Monday evening. I came back here to Hamburg on Tuesday morning, and by that evening the article had to be written. It was the end, it was the event of the week, and so I had to do an article which seemed to me and to all of my colleagues very important. But I was very tired and exhausted. And so I had really some difficulty in getting it done my way and in concentrating. And after that, the next morning, I was very happy!

The creative process starts with a sense that there is a puzzle somewhere, or a task to be accomplished. Perhaps something is not right, somewhere there is a conflict, a tension, a need to be satisfied. The problematic issue can be triggered by a personal experience, by a lack of fit in the symbolic system, by the stimulation of colleagues, or by public needs. In any case, without such a felt tension that attracts the psychic energy of the person, there is no need for a new response. Therefore, without a stimulus of this sort, the creative process is unlikely to start.

PRESENTED AND DISCOVERED PROBLEMS

Problems are not all alike in the way they come to a person's attention. Most problems are already formulated; everybody knows what is to be done and only the solution is missing. The person is expected by employers, patrons, or some other external pressure to apply his or her mind to the solution of a puzzle. These are "presented" problems. But there are also situations in which nobody has asked the question yet, nobody even knows that there is a problem. In this case the creative person identifies both the problem and the solution. Here we have a "discovered" problem. Einstein, among others, believed that the really important breakthroughs in science come as a result of reformulating old problems or discovering new ones, rather than by just solving existing problems. Or as Freeman Dyson said: "It is characteristic of scientific life that it is easy when

you have a problem to work on. The hard part is finding your problem."

Frank Offner illustrates a presented problem-solving process:

When I first was getting into aircraft, I had a best friend who introduced me to Hamilton Standard, who made propellers, now part of United Technology. He suggested that I go see them and see if I could help them, and the chief of the vibration group said to me, "Now, Frank, we have had this problem for months, we cannot figure how to get the maximum positive and the maximum negative value of the voltage and take the sum of them and figure out the total stress. We don't know how to choose a resistor. You have to have a capacitor that has to agree with the resistor, because if the resistor is too high it's too sluggish and if it's too low you lose one before you get the other." Well, before he was finished talking I knew the answer. I said, "Don't use a resistor, use a little relay and you short the capacitor . . ."

In contrast, Robert Galvin describes a problem that is discovered. His father had founded Motorola early in the century to make car radios. For several decades the business was a small one-room operation, with perhaps a dozen engineers and no large contracts, so Galvin's father worked very hard to make ends meet. In 1936 he felt that he finally could afford to take a vacation. He took his wife and young Robert on a European tour. As they traveled across Germany, the elder Galvin became convinced that sooner or later Hitler would start a war. Upon his return home, he followed up his hunch by sending Don Mitchell, one of his assistants, to Camp McCoy in Wisconsin to find out how the army passed on information among its various units.

Mitchell drove to Wisconsin, rang a bell at the gate of the camp, sat down with the major in charge, and in a short time found out that, as far as communications were concerned, the army hadn't changed at all since World War I: A phone wire was run from the front line to the back trenches. Upon being told this, Galvin's ears perked up. "Don," he is supposed to have said, "if we can make a radio that fits in a car and receives signals, can't we marry a little transmitter with it, and could we add some kind of power unit and put it into a box so someone could hold it, and he could talk from

the front trench to the back trench with radios instead of stringing out the wire?" They figured it was a good idea and went to work. By the time Hitler invaded Poland, Motorola was ready to produce what became the SCR 536, the walkie-talkie of World War II. Robert Galvin uses this story to illustrate what he means by anticipation and commitment: on the one hand, having the foresight to realize how you could contribute to the future and thereby profit from it, and on the other, to have faith in your intuition and work hard to actualize it.

Presented problems usually take a much shorter time to prepare for and to solve than discovered problems. Sometimes the solution appears with the immediacy of Offner's example. Although it may require little time and effort, a novel solution to a presented problem could change the domain in significant ways and therefore be judged creative. Even in the arts, some of the most enduring paintings of the Middle Ages and the Renaissance were ordered by patrons who specified the size of the canvas, how many figures of what kind, the amount of expensive ground lapis lazuli pigment to be used, the weight of gold foil to be used in the frame, down to the smallest detail. Bach turned out a new cantata every few weeks to satisfy his patron's demands for religious hymns. Such cases show that, when approached with a desire to come up with the best solution, even the most rigidly predefined problems can result in creative outcomes.

Nevertheless, discovered problems have a chance to make a larger difference in the way we see the world. An example is Darwin's slow development of the theory of evolution. Darwin was commissioned to travel with the *Beagle* around the coast of South America and describe the largely unrecorded plant and animal life he encountered there. This was not an assignment that required a creative solution, and Darwin did what he was expected to do. But at the same time, he became more and more interested in and then puzzled by subtle differences in otherwise similar species living in what we now would call different ecological niches. He saw the connection between specific physical traits and corresponding environmental opportunities, such as the shape of a bird's beak and the kind of food available. These observations led to the concept of differential adaptation, which in turn, after many more detailed observations, led to the idea of natural selection and finally to the concept of the evolution of species.

The theory of evolution answered a great number of questions, ranging from why do animals look so different from each other to where do men and women come from. But perhaps the most remarkable feature of Darwin's accomplishment was that these questions had not been stated in an answerable form before, and he had to formulate the problem as well as propose a solution to it. Most great changes in a domain share this feature of Darwin's work: They tend to fall toward the discovered rather than the presented end on the continuum of problematic situations.

THE MYSTERIOUS TIME

After a creative person senses that on the horizon of his or her expertise there is something that does not fit, some problem that might be worth tackling, the process of creativity usually goes underground for a while. The evidence for incubation comes from reports of discoveries in which the creator becomes puzzled by an issue and remembers coming to a sudden insight into the nature of a problem, but does not remember any intermediate conscious mental steps. Because of this empty space in between sensing a problem and intuiting its solution, it has been assumed that an indispensable stage of incubation must take place in an interval of the conscious process.

Because of its mysterious quality, incubation has often been thought the most creative part of the entire process. The conscious sequences can be analyzed, to a certain extent, by the rules of logic and rationality. But what happens in the "dark" spaces defies ordinary analysis and evokes the original mystery shrouding the work of genius: One feels almost the need to turn to mysticism, to invoke the voice of the Muse as an explanation.

Our respondents unanimously agree that it is important to let problems simmer below the threshold of consciousness for a time. One of the most eloquent accounts of the importance of this stage comes again from the physicist Freeman Dyson. In describing his current work he has this to say:

I am fooling around not doing anything, which probably means that this is a creative period, although of course you don't know until afterward. I think that it is very important to be idle. I mean, they always say that Shakespeare was idle between plays. I am not

comparing myself to Shakespeare, but people who keep themselves busy all of the time are generally not creative. So I am not ashamed of being idle.

Frank Offner is equally strong in his belief in the importance of not always thinking about one's problem:

I will tell you one thing that I found in both science and technology: If you have a problem, don't sit down and try to solve it. Because I will never solve it if I am just sitting down and thinking about it. It will hit me maybe in the middle of the night, while I am driving my car or taking a shower, or something like that.

How long a period of incubation is needed varies depending on the nature of the problem. It may range from a few hours to several weeks and even longer. Manfred Eigen says that he goes to sleep every night mulling some unresolved problem in his mind, some experimental procedure that does not work, some laboratory process that is not quite right. Miraculously, when he wakes up in the morning he has the solution clearly in mind. Hazel Henderson jogs or does gardening when she runs dry of ideas, and when she returns to the computer they usually flow freely again. Elisabeth Noelle-Neumann needs plenty of sleep, otherwise she feels that her thoughts become routine and predictable. Donald Campbell is very clear about the importance of letting ideas make connections with each other without external distractions:

One of the values in walking to work is mental meandering. Or if driving, not to have the car radio on. Now I don't think of myself as necessarily especially creative, but this creativity has to be a profoundly wasteful process. And that mental meandering, mind wandering and so on, is an essential process. If you are allowing that mentation to be driven by the radio or the television or other people's conversations, you are just cutting down on your exploratory, your intellectual exploratory time.

These short periods of incubation, usually having to do with a "presented" problem, tend to result in minuscule, perhaps imperceptible, changes in the domain. Examples of somewhat longer periods

of incubation are the few weeks Freeman Dyson spent in California sight-seeing and not thinking consciously at all about how to reconcile Feynman and Schwinger's theories. In general, it seems that the more thorough the revolution brought about by the novelty, the longer it was working its way underground. But this hypothesis is difficult to verify. How long did Einstein's theory of relativity incubate? Or Darwin's theory of evolution? Or Beethoven's ideas for the Fifth Symphony? Because it is impossible to determine with precision when the first germs of these great works appeared in the minds of their authors, it is also impossible to know how long the process of incubation lasted.

The Functions of Idle Time

But what happens during this mysterious idle time, when the mind is not consciously preoccupied with the problem? There are several competing explanations of why incubation helps the creative process. Perhaps the best known is an offshoot of psychoanalytic theory. According to Freud, the curiosity at the roots of the creative process—especially in the arts—is triggered by a childhood experience of sexual origin, a memory so devastating that it had to be repressed. The creative person is, one who succeeds in displacing the quest for the forbidden knowledge into a permissible curiosity. The artist's zeal in trying to find new forms of representation and the scientist's urge to strip away the veils of nature are really disguised attempts to understand the confusing impressions the child felt when witnessing his parents having sex, or the ambivalently erotic emotions toward one of the parents.

But if the secondary creative process is to drain effectively the repressed primary interest, it has to dip occasionally below the threshold of consciousness, where it can connect again with its original libidinal source. This is presumably what happens during the period of incubation. The content of the conscious line of thought is taken up by the subconscious, and there, out of reach of the censorship of awareness, the abstract scientific problem has a chance to reveal itself for what it is—an attempt to come to terms with a very personal conflict. Refreshed by having been able to commune with its true source, the subconscious thought can then reemerge in consciousness, its disguise back in place, and the scientist can continue his or her research with renewed vigor.

Many creative people use a watered-down version of this account to explain their own work and often drop hints as to the probable libidinal origin of their interests. It is difficult to know what to make of such intelligence. Often it turns out that the artists or scientists who are most convinced that in their works they are attempting to resolve a childhood trauma are those who have spent many years in therapy and have been well socialized into Freudian ideology. It could be that analysis helped them uncover the repressed sources of their curiosity. Or it could be that it helped them come up with an interesting explanation for what is mysterious about their experiences—an explanation, however, that may have little basis in reality.

In any case, although a psychoanalytic approach might explain some of the motivation for a person to engage in the process of discovery, it provides very little guidance as to why a vacation in California yielded Dyson the key to quantum electrodynamics. The transformation of libido in such a case is so spectacularly implausible as to lack credibility.

Cognitive accounts of what happens during incubation assume, like the psychoanalytic ones, that some kind of information processing keeps going on in the mind even when we are not aware of it, even when we are asleep. The difference is that cognitive theories do not posit any direction to subconscious thought. There is no trauma at the center of the unconscious, seeking resolution through disguised curiosity. Cognitive theorists believe that ideas, when deprived of conscious direction, follow simple laws of association. They combine more or less randomly, although seemingly irrelevant associations between ideas may occur as a result of a prior connection: For example, the German chemist August Kekulé had the insight that the benzene molecule might be shaped like a ring after he fell asleep while watching sparks in the fireplace make circles in the air. If he had stayed awake, Kekulé would have presumably rejected as ridiculous the thought that there might be a connection between the sparks and the shape of the molecule. But in the subconscious, rationality could not censor the connection, and so when he woke up he was no longer able to ignore its possibility. According to this perspective, truly irrelevant connections dissolve and disappear from memory, while the ones that are robust survive long enough to emerge eventually into consciousness.

The distinction between serial and parallel processing of informa-

tion may also explain what happens during incubation. In a serial system like that of an old-fashioned calculator, a complex numerical problem must be solved in a sequence, one step at a time. In a parallel system such as in advanced computer software, a problem is broken up into its component steps, the partial computations are carried out simultaneously, and then these are reconstituted into a single final solution.

Something similar to parallel processing may be taking place when the elements of a problem are said to be incubating. When we think consciously about an issue, our previous training and the effort to arrive at a solution push our ideas in a linear direction, usually along predictable or familiar lines. But intentionality does not work in the subconscious. Free from rational direction, ideas can combine and pursue each other every which way. Because of this freedom, original connections that would be at first rejected by the rational mind have a chance to become established.

The Field, the Domain, and the Unconscious

At first sight, incubation seems to occur exclusively within the mind; what's more, within the mind's hidden recesses where consciousness is unable to reach. But after a closer look, we must admit that even in the unconscious the symbol system and the social environment play important roles. In the first place, it is obvious that incubation cannot work for a person who has not mastered a domain or been involved in a field. A new solution to quantum electrodynamics doesn't occur to a person unfamiliar with this branch of physics, no matter how long he or she sleeps.

Even though subconscious thinking may not follow rational lines, it still follows patterns that were established during conscious learning. We internalize the knowledge of the domain, the concerns of the field, and they become part of the way our minds are organized. It is often not necessary to perform an experiment to know that something won't work: Theoretical knowledge can predict the outcome. Similarly, we can predict what our colleagues will say if we express publicly certain ideas. When we sit alone in our study and say that an idea won't work, what we may be saying is that none of the people whose opinions matter will accept it. These internalized criteria of the domain and the field do not disappear when the thought process goes underground. They are probably less insistent

than when we are aware of what we are doing, but they still shape and control how combinations of ideas are evaluated and selected.

But just as one must take the concerns of the discipline seriously, one must also be willing to take a stand against received wisdom, if the conditions warrant it. Otherwise no advance is possible. The all-important tension between trusting domain knowledge yet being ready to reject it is well illustrated by Frank Offner's description of what went on in his mind as he was trying to develop the first electronic controls that eventually made possible the commercial use of jet engines:

If you understand science and a question comes up and you want to do something, then you can work out a good solution very easily. If you don't have a good scientific background, you can't. If I had looked at what other people had done before, like in the jet engines, I would have been lost. Everybody attacked it exactly the wrong way. They thought the way that I did it was impossible. [Norbert] Weiner, the mathematician—I read his book on cybernetics—that said it was impossible. But I used rate acceleration feedback, and it worked.

What Offner points out here is that a creative solution often requires using knowledge from one part of the domain to correct the accepted beliefs of the field—which are based on different conclusions derived from other parts of the same domain. In this case, cybernetic theory seemed to exclude the possibility of controls that would keep the speed of the jet engine exactly constant. But before ever seeing a jet engine, by thinking about what the controls were supposed to accomplish and then going back to basic physics, Offner came up with a design that worked and was implemented.

Creative thoughts evolve in this gap filled with tension—holding on to what is known and accepted while tending toward a still ill-defined truth that is barely glimpsed on the other side of the chasm. Even when thoughts incubate below the threshold of consciousness, this tension is present.

THE "AHA!" EXPERIENCE

Most of the people in our sample—but not all—recall with great intensity and precision a particular moment when some major prob-

lem crystallized in their minds in such a way that a solution became all but inevitable, requiring only a matter of time and hard work. For presented problems, the insight might even include the particulars of the solution. Here are two examples from Frank Offner:

It will hit me maybe in the middle of the night. It turns around somehow inside your brain. I can tell you where I was when I got the answer how to stabilize the jet control with a feedback. I was sitting on a sofa, I guess this was before I was married, at some friend's house and a little bit bored and the answer hit me, "Ah!" and I put in the derivative term.

And another one. I was going to do my Ph.D. thesis on nerve excitation. There were two sets of equations describing nerve excitation. I was going to make some experiments to see which was the right one, one made at the University of Chicago, the other in England, and I was going to see which was the more accurate. And I tried to work out the mathematics to see what kind of experiment would [be decisive]. I remember I was taking a shower when I saw how to solve that problem. I sat down to solve that problem and I found that the equations were just two ways of saying the same thing. So I had to do something else [for the thesis].

The insight presumably occurs when a subconscious connection between ideas fits so well that it is forced to pop out into awareness, like a cork held underwater breaking out into the air after it is released.

THE 99 PERCENT PERSPIRATION

After an insight occurs, one must check it out to see if the connections genuinely make sense. The painter steps back from the canvas to see whether the composition works, the poet rereads the verse with a more critical eye, the scientist sits down to do the calculations or run the experiments. Most lovely insights never go any farther, because under the cold light of reason fatal flaws appear. But if everything checks out, the slow and often routine work of elaboration begins.

There are four main conditions that are important during this stage of the process. First of all, the person must pay attention to the

developing work, to notice when new ideas, new problems, and new insights arise out of the interaction with the medium. Keeping the mind open and flexible is an important aspect of the way creative persons carry on their work. Next, one must pay attention to one's goals and feelings, to know whether the work is indeed proceeding as intended. The third condition is to keep in touch with domain knowledge, to use the most effective techniques, the fullest information, and the best theories as one proceeds. And finally, especially in the later stages of the process, it is important to listen to colleagues in the field. By interacting with others involved with similar problems, it is possible to correct a line of solution that is going in the wrong direction, to refine and focus one's ideas, and to find the most convincing mode of presenting them, the one that has the best chance of being accepted.

The historian Natalie Davis describes how she feels during the last stage of the creative process, when all that is left is the writing up of the results of her research:

If I didn't have affect in a project, if I had lost it or maybe it didn't last too long, it would lose its spark. I mean, I don't want to do something that I have lost my love for. I think that everybody is perhaps that way, but I am very much that way. It is hard to be creative if you are just doing something doggedly. If I didn't have curiosity, if I felt that my curiosity was limited, then the novelty part of it would be gone. Because it is the curiosity that has often pushed me to think of ways of finding out about something that people thought you could never find out about. Or ways of looking at a subject that have never been looked at before. That's what keeps me running back and forth to the library, and just thinking, and thinking, and thinking.

Barry Commoner describes the last phases of his work, when he has to write things down, or communicate them to an audience:

Some of the work is extremely hard from the point of view of creating a clear statement. For example, in one of my books I wrote a chapter on thermodynamics designed for the lay public. That probably went through fifteen drafts. It was the most difficult writing I ever had to do, because it's a very difficult subject to put

into ordinary lay terms. And that's one of the things I've done I'm most proud of. I've had engineers tell me that for the first time they had a clear picture of thermodynamics from it. So I enjoy that a great deal. I enjoy communicating. Same with speaking. I do a lot of speaking. And I really enjoy seeing the audience paying attention—listening, understanding it.

One thing about creative work is that it's never done. In different words, every person we interviewed said that it was equally true that they had worked every minute of their careers, and that they had never worked a day in all their lives. They experienced even the most focused immersion in extremely difficult tasks as a lark, an exhilarating and playful adventure.

It is easy to resent this attitude and see the inner freedom of the creative person as an elite privilege. While the rest of us are struggling at boring jobs, they have the luxury of doing what they love to do, not knowing whether it is work or play. There might be an element of truth in this. But far more important, in my opinion, is the message that the creative person is sending us: You, too, can spend your life doing what you love to do. After all, most of the people we interviewed were not born with a silver spoon in their mouth; many came from humble origins and struggled to create a career that allowed them to keep exploring their interests. Even if we don't have the good fortune to discover a new chemical element or write a great story, the love of the creative process for its own sake is available to all. It is difficult to imagine a richer life.

 FIVE

THE FLOW OF CREATIVITY

Creative persons differ from one another in a variety of ways, but in one respect they are unanimous: They all love what they do. It is not the hope of achieving fame or making money that drives them; rather, it is the opportunity to do the work that they enjoy doing. Jacob Rabinow explains: "You invent for the hell of it. I don't start with the idea, 'What will make money?' This is a rough world; money's important. But if I have to trade between what's fun for me and what's money-making, I'll take what's fun." The novelist Naguib Mahfouz concurs in more genteel tones: "I love my work more than I love what it produces. I am dedicated to the work regardless of its consequences." We found the same sentiments in every single interview.

What is extraordinary in this case is that we talked to engineers and chemists, writers and musicians, businesspersons and social reformers, historians and architects, sociologists and physicians—and they all agree that they do what they do primarily because it's fun. Yet many others in the same occupations don't enjoy what they do. So we have to assume that it is not *what* these people do that counts but *how* they do it. Being an engineer or a carpenter is not in itself