CREATIVITY

Flow and the Psychology of Discovery and Invention

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The answer is obvious: Creativity is some sort of mental activity, an insight that occurs inside the heads of some special people. But this short assumption is misleading. If by creativity we mean an idea or action that is new and valuable, then we cannot simply accept a person's own account as the criterion for its existence. There is no way to know whether a thought is new except with reference to some standards, and there is no way to tell whether it is valuable until it passes social evaluation. Therefore, creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a sociocultural context. It is a systemic rather than an individual phenomenon. Some examples will illustrate what I mean.

When I was a graduate student I worked part-time for a few years as an editor for a Chicago publishing house. At least once a week we would get in the mail a manuscript from an unknown author who claimed to have made a great discovery of one sort or another. Perhaps it was an eight-hundred-page tome that described in minute detail how a textual analysis of the Odyssey showed that, contrary to received opinion, Ulysses did not sail around the Mediterranean.
individual, then creativity becomes a subjective phenomenon. All it takes to be creative, then, is an inner assurance that what I think or do is new and valuable. There is nothing wrong with defining creativity this way, as long as we realize that this is not at all what the term originally was supposed to mean—namely, to bring into existence something genuinely new that is valued enough to be added to the culture. On the other hand, if we decide that social confirmation is necessary for something to be called creative, the definition must encompass more than the individual. What counts then is whether the inner certitude is validated by the appropriate experts—such as the editors of the publishing house in the case of far-out manuscripts, or other scientists in the case of cold fusion. And it isn’t possible to take a middle ground and say that sometimes the inner conviction is enough, while in other cases we need external confirmation. Such a compromise leaves a huge loophole, and trying to agree on whether something is creative or not becomes impossible.

The problem is that the term “creativity” as commonly used covers too much ground. It refers to very different entities, thus causing a great deal of confusion. To clarify the issues, I distinguish at least three different phenomena that can legitimately be called by that name.

The first usage, widespread in ordinary conversation, refers to persons who express unusual thoughts, who are interesting and stimulating—in short, to people who appear to be unusually bright. A brilliant conversationalist, a person with varied interests and a quick mind, may be called creative in this sense. Unless they also contribute something of permanent significance, I refer to people of this sort as brilliant rather than creative—and by and large I don’t say much about them in this book.

The second way the term can be used is to refer to people who experience the world in novel and original ways. These are individuals whose perceptions are fresh, whose judgments are insightful, who may make important discoveries that only they know about. I refer to such people as personally creative, and try to deal with them as much as possible (especially in chapter 14, which is devoted to this topic). But given the subjective nature of this form of creativity, it is difficult to deal with it no matter how important it is for those who experience it.

The final use of the term designates individuals who, like...
Leonardo, Edison, Picasso, or Einstein, have changed our culture in some important respect. They are the creative ones without qualifications. Because their achievements are by definition public, it is easier to write about them, and the persons included in my study belong to this group.

The difference among these three meanings is not just a matter of degree. The last kind of creativity is not simply a more developed form of the first two. These are actually different ways of being creative, each to a large measure unrelated to the others. It happens very often, for example, that some persons brimming with brilliance, whom everyone thinks of as being exceptionally creative, never leave any accomplishment, any trace of their existence—except, perhaps, in the memories of those who have known them. Whereas some of the people who have had the greatest impact on history did not show any originality or brilliance in their behavior, except for the accomplishments they left behind.

For example, Leonardo da Vinci, certainly one of the most creative persons in the third sense of the term, was apparently reclusive, and almost compulsive in his behavior. If you had met him at a cocktail party, you would have thought that he was a tiresome bore and would have left him standing in a corner as soon as possible. Neither Isaac Newton nor Thomas Edison would have been considered assets at a party either, and outside of their scientific concerns they appeared colorless and driven. The biographers of outstanding creators struggle valiantly to make their subjects interesting and brilliant, yet more often than not their efforts are in vain. The accomplishments of a Michelangelo, a Beethoven, a Picasso, or an Einstein are awesome in their respective fields—but their private lives, their everyday ideas and actions, would seldom warrant another thought were it not that their specialized accomplishments made everything they said or did of interest.

By the definition I am using here, one of the most creative persons in this study is John Bardeen. He is the first person to have been awarded the Nobel prize in physics twice. The first time it was for developing the transistor; the second for his work on superconductivity. Few persons have ranged as widely and deeply in the realm of solid state physics, or come out with such important insights. But talking with Bardeen on any issue besides his work was not easy; his mind followed abstract paths while he spoke slowly, haltingly, and without much depth or interest about "real life" topics.

It is perfectly possible to make a creative contribution without being brilliant or personally creative, just as it is possible—even likely—that someone personally creative will never contribute a thing to the culture. All three kinds of creativity enrich life by making it more interesting and fulfilling. But in this context I focus primarily on the third use of the term, and explore what is involved in the kind of creativity that leaves a trace in the cultural matrix.

To make things more complicated, consider two more terms that are sometimes used interchangeably with creativity. The first is talent. Talent differs from creativity in that it focuses on an innate ability to do something very well. We might say that Michael Jordan is a talented athlete, or that Mozart was a talented pianist, without implying that either was creative for that reason. In our sample, some individuals were talented in mathematics or in music, but the majority achieved creative results without any exceptional talent being evident. Of course, talent is a relative term, so it might be argued that in comparison to "average" individuals the creative ones are talented.

The other term that is often used as a synonym for "creative" is genius. Again, there is an overlap. Perhaps we should think of a genius as a person who is both brilliant and creative at the same time. But certainly a person can change the culture in significant ways without being a genius. Although several of the people in our sample have been called a genius by the media, they—and the majority of creative individuals we interviewed—reject this designation.

**The Systems Model**

We have seen that creativity with a capital C, the kind that changes some aspect of the culture, is never only in the mind of a person. That would by definition not be a case of cultural creativity. To have any effect, the idea must be couched in terms that are understandable to others, it must pass muster with the experts in the field, and finally it must be included in the cultural domain to which it belongs. So the first question I ask of creativity is not what is it but where is it?

The answer that makes most sense is that creativity can be observed only in the interrelations of a system made up of three main parts. The first of these is the **domain**, which consists of a set of symbolic rules and procedures. Mathematics is a domain, or at a finer
resolution algebra and number theory can be seen as domains. Domains are in turn nested in what we usually call culture, or the symbolic knowledge shared by a particular society, or by humanity as a whole.

The second component of creativity is the field, which includes all the individuals who act as gatekeepers to the domain. It is their job to decide whether a new idea or product should be included in the domain. In the visual arts the field consists of art teachers, curators of museums, collectors of art, critics, and administrators of foundations and government agencies that deal with culture. It is this field that selects what new works of art deserve to be recognized, preserved, and remembered.

Finally, the third component of the creative system is the individual person. Creativity occurs when a person, using the symbols of a given domain such as music, engineering, business, or mathematics, has a new idea or sees a new pattern, and when this novelty is selected by the appropriate field for inclusion into the relevant domain. The next generation will encounter that novelty as part of the domain they are exposed to, and if they are creative, they in turn will change it further. Occasionally creativity involves the establishment of a new domain: It could be argued that Galileo started experimental physics and that Freud carved psychoanalysis out of the existing domain of neuropsychology. But if Galileo and Freud had not been able to enlist followers who came together in distinct fields to further their respective domains, their ideas would have had much less of an impact, or none at all.

So the definition that follows from this perspective is: Creativity is any act, idea, or product that changes an existing domain, or that transforms an existing domain into a new one. And the definition of a creative person is: someone whose thoughts or actions change a domain, or establish a new domain. It is important to remember, however, that a domain cannot be changed without the explicit or implicit consent of a field responsible for it.

Several consequences follow from this way of looking at things. For instance, we don't need to assume that the creative person is necessarily different from anyone else. In other words, a personal trait of "creativity" is not what determines whether a person will be creative. What counts is whether the novelty he or she produces is accepted for inclusion in the domain. This may be the result of chance, perseverance, or being at the right place at the right time. Because creativity is jointly constituted by the interaction among domain, field, and person, the trait of personal creativity may help generate the novelty that will change a domain, but it is neither a sufficient nor a necessary condition for it.

A person cannot be creative in a domain to which he or she is not exposed. No matter how enormous mathematical gifts a child may have, he or she will not be able to contribute to mathematics without learning its rules. But even if the rules are learned, creativity cannot be manifested in the absence of a field that recognizes and legitimizes the novel contributions. A child might possibly learn mathematics on his or her own by finding the right books and the right mentors, but cannot make a difference in the domain unless recognized by teachers and journal editors who will witness to the appropriateness of the contribution.

It also follows that creativity can be manifested only in existing domains and fields. For instance, it is very difficult to say "This woman is very creative in nurturing" or "This woman is very creative in her wisdom," because nurturance and wisdom, although extremely important for human survival, are loosely organized domains with few generally accepted rules and priorities, and they lack a field of experts who can determine the legitimacy of claims. So we are in the paradoxical situation that novelty is more obvious in domains that are often relatively trivial but easy to measure; whereas in domains that are more essential novelty is very difficult to determine. There can be agreement on whether a new computer game, rock song, or economic formula is actually novel, and therefore creative, less easy to agree on the novelty of an act of compassion or of an insight into human nature.

The model also allows for the often mysterious fluctuations in the attribution of creativity over time. For example, the reputation of Raphael as a painter has waxed and waned several times since his heyday at the court of Pope Julius II. Gregor Mendel did not become famous as the creator of experimental genetics until half a century after his death. Johann Sebastian Bach’s music was dismissed as old-fashioned for several generations. The conventional explanation is that Raphael, Mendel, and Bach were always creative, only their reputation changed with the vagaries of social recognition. But the systems model recognizes the fact that creativity cannot be sepa-
rated from its recognition. Mendel was not creative during his years of relative obscurity because his experimental findings were not that important until a group of British geneticists, at the end of the nineteenth century, recognized their implications for evolution.

The creativity of Raphael fluctuates as art historical knowledge, art critical theories, and the aesthetic sensitivity of the age change. According to the systems model, it makes perfect sense to say that Raphael was creative in the sixteenth and in the nineteenth centuries but not in between or afterward. Raphael is creative when the community is moved by his work, and discovers new possibilities in his paintings. But when his paintings seem mannered and routine to those who know art, Raphael can only be called a great draftsman, a subtle colorist—perhaps even a personally creative individual—but not creative with a capital C. If creativity is more than personal insight and is cocreated by domains, fields, and persons, then creativity can be constructed, deconstructed, and reconstructed several times over the course of history. Here is one of our respondents, the poet Anthony Hecht, commenting on this issue:

Literary reputations are constantly shifting. Sometimes in trifling, frivolous ways. There was a former colleague of mine who, at a recent meeting of the English Department, said that she thought it was no longer important to teach Shakespeare because among other things he had a very feeble grasp of women. Now that seems to me as trifling an observation as can be made, but it does mean that, if you take this seriously, nobody’s place in the whole canon is very secure, that it’s constantly changing. And this is both good and bad. John Donne’s position was in the nineteenth century of no consequence at all. The Oxford Book of English Verse had only one poem of his. And now, of course, he was resurrected by Herbert Grierson and T. S. Eliot and he’s one of the great figures of seventeenth-century poetry. But he wasn’t always. This is true of music, too. Bach was eclipsed for two hundred years and rediscovered by Mendelssohn. This means that we are constantly reassessing the past. And that’s a good, valuable, and indeed necessary thing to do.

This way of looking at things might seem insane to some. The usual way to think about this issue is that someone like van Gogh was a great creative genius, but his contemporaries did not recognize this. Fortunately, now we have discovered what a great painter he was after all, so his creativity has been vindicated. Few flinch at the presumption implicit in such a view. What we are saying is that we know what great art is so much better than van Gogh’s contemporaries did—those bourgeois philistines. What—besides unconscious conceit—warrants this belief? A more objective description of van Gogh’s contribution is that his creativity came into being when a sufficient number of art experts felt that his paintings had something important to contribute to the domain of art. Without such a response, van Gogh would have remained what he was, a disturbed man who painted strange canvases.

Perhaps the most important implication of the systems model is that the level of creativity in a given place at a given time does not depend only on the amount of individual creativity. It depends just as much on how well suited the respective domains and fields are to the recognition and diffusion of novel ideas. This can make a great deal of practical difference to efforts for enhancing creativity. Today many American corporations spend a great deal of money and time trying to increase the originality of their employees, hoping thereby to get a competitive edge in the marketplace. But such programs make no difference unless management also learns to recognize the valuable ideas among the many novel ones, and then finds ways of implementing them.

For instance, Robert Galvin at Motorola is justly concerned about the fact that in order to survive among the hungry Pacific Rim electronic manufacturers, his company must make creativity an intentional part of its productive process. He is also right in perceiving that to do so he first has to encourage the thousands of engineers working for the company to generate as many novel ideas as possible. So various forms of brainstorming are instituted, where employees free-associate without fear of being ridiculously impractical. But the next step is less clear. How does the field (in this case, management) choose among the multitude of new ideas the ones worth pursuing? And how can the chosen ideas be included in the domain (in this case, the production schedule of Motorola)? Because we are used to thinking that creativity begins and ends with the person, it is easy to miss the fact that the greatest spur to it may come from changes outside the individual.
Creativity in the Renaissance

A good example is the sudden spurt in artistic creativity that took place in Florence between 1400 and 1425. These were the golden years of the Renaissance, and it is generally agreed that some of the most influential new works of art in Europe were created during that quarter century. Any list of the masterpieces would include the dome of the cathedral built by Brunelleschi, the "Gates of Paradise" crafted for the baptistery by Ghiberti, Donatello’s sculptures for the chapel of Ossanmichele, the fresco cycle by Masaccio in the Brancacci Chapel, and Gentile da Fabriano’s painting of the Adoration of the Magi in the Church of the Trinity.

How can this flowering of great art be explained? If creativity is something entirely within a person, we would have to argue that for some reason an unusually large number of creative artists were born in Florence in the last decades of the fourteenth century. Perhaps some freak genetic mutation occurred, or a drastic change in the education of Florentine children suddenly caused them to become more creative. But an explanation involving the domain and the field is much more sensible.

As far as the domain is concerned, the Renaissance was made possible in part by the rediscovery of ancient Roman methods of building and sculpting that had been lost for centuries during the so-called Dark Ages. In Rome and elsewhere, by the end of the thirteenth hundreds, eager scholars were excavating classical ruins, copying down and analyzing the styles and techniques of the ancients. This slow preparatory work bore fruit at the turn of the fifteenth century, opening up long-forgotten knowledge to the artisans and craftsmen of the time.

The cathedral of Florence, Santa Maria Novella, had been left open to the skies for eighty years because no one could find a way to build a dome over its huge apse. There was no known method for preventing the walls from collapsing inward once the curvature of the dome had advanced beyond a certain height. Every year eager young artists and established builders submitted plans to the Opera del Duomo, the board that supervised the building of the cathedral, but their plans were found unpersuasive. The Opera was made up of the political and business leaders of the city, and their personal reputations were at stake in this choice. For eighty years they did not feel that any proposed solution for the completion of the dome was worthy of the city, and of themselves.

But eventually humanist scholars became interested in the Pantheon of Rome, measured its enormous dome, and analyzed how it had been constructed. The Pantheon had been rebuilt by the emperor Hadrian in the second century. The diameter of its 71-foot-high dome was 142 feet. Nothing on that scale had been built for well over a thousand years, and the methods that allowed the Romans to build such a structure that would stand up and not collapse had been long forgotten in the dark centuries of barbarian invasions. But now that peace and commerce were reviving the Italian cities, the knowledge was slowly being pieced back together.

Brunelleschi, who in 1401 appears to have visited Rome to study its antiquities, understood the importance of the studies of the Pantheon. His idea for how to complete the dome in Florence was based on the framework of internal stone arches that would help contain the thrust, and the herringbone brickwork between them. But his design was not just a restatement of the Roman model—it was influenced also by all the architecture of the intervening centuries, especially the Gothic models. When he presented his plan to the Opera, they recognized it as a feasible and beautiful solution. And after the dome was built, it became a liberating new form that inspired hundreds of builders who came after him, including Michelangelo, who based on it his design for the cupola of St. Peter’s in Rome.

But no matter how influential the rediscovery of classical art forms, the Florentine Renaissance cannot be explained only in terms of the sudden availability of information. Otherwise, the same flowering of new artistic forms would have taken place in all the other cities exposed to the ancient models. And though this actually did happen to a certain extent, no other place matched Florence in the intensity and depth of artistic achievement. Why was this so?

The explanation is that the field of art became particularly favorable to the creation of new works at just about the same time as the rediscovery of the ancient domains of art. Florence had become one of the richest cities in Europe first through trading, then through the manufacture of wool and other textiles, and finally through the financial expertise of its rich merchants. By the end of the fourteenth century there were a dozen major bankers in the city—the Medici being only one of the minor ones—who were getting substantial
interest every year from the various foreign kings and potentates to whom they had lent money.

But while the coffers of the bankers were getting fuller, the city itself was troubled. Men without property were ruthlessly exploited, and political tensions fueled by economic inequality threatened at any moment to explode into open conflict. The struggle between pope and emperor, which divided the entire continent, was reproduced inside the city in the struggle between the Guelf and Ghibelline factions. To make matters worse, Florence was surrounded by Siena, Pisa, and Arezzo, cities jealous of its wealth and ambitions and always ready to snatch away whatever they could of Florentine trade and territory.

It was in this atmosphere of wealth and uncertainty that the urban leaders decided to invest in making Florence the most beautiful city in Christendom—in their words, “a new Athens.” By building awesome churches, impressive bridges, and splendid palaces, and by commissioning great frescoes and majestic statues, they must have felt that they were weaving a protective spell around their homes and businesses. And in a way, they were not wrong: When more than five hundred years later Hitler ordered the retreating German troops to blow up the bridges on the Arno and level the city around them, the field commander refused to obey on the grounds that too much beauty would be erased from the world—and the city was saved.

The important thing to realize is that when the Florentine bankers, churchmen, and heads of great guilds decided to make their city intimidatingly beautiful, they did not just throw money at artists and wait to see what happened. They became intensely involved in the process of encouraging, evaluating, and selecting the works they wanted to see completed. It was because the leading citizens, as well as the common people, were so seriously concerned with the outcome of their work that the artists were pushed to perform beyond their previous limits. Without the constant encouragement and scrutiny of the members of the Opera, the dome over the cathedral would probably not have been as beautiful as it eventually turned out to be.

Another illustration of how the field of art operated in Florence at this time concerns the building of the north and especially the east door of the baptistery, one of the uncontested masterpieces of the period, which Michelangelo declared was worthy of being the “Gate of Paradise” when he saw its heart-wrenching beauty. In this case also a special commission had been formed to supervise the building of the doors for this public edifice. The board was composed of eminent individuals, mostly the leaders of the guild of wool weavers that was financing the project. The board decided that each door should be of bronze and have ten panels illustrating Old Testament themes. Then they wrote to some of the most eminent philosophers, writers, and churchmen in Europe to request their opinion of which scenes from the Bible should be included in the panels, and how they should be represented. After the answers came in, they drew up a list of specifications for the doors and in 1401 announced a competition for their design.

From the dozens of drawings submitted the board chose five finalists—Brunelleschi and Ghiberti among them. The finalists on the short list were given a year to finish a bronze mock-up of one of the door panels. The subject was to be “The Sacrifice of Isaac” and had to include at least one angel and one sheep in addition to Abraham and his son. During that year all five finalists were paid handsome by the board for time and materials. In 1402 the jury reconvened to consider the new entries and selected Ghiberti’s panel, which showed technical excellence as well as a wonderfully natural yet classical composition.

Lorenzo Ghiberti was twenty-one years old at the time. He spent the next twenty years finishing the north door and then another twenty-seven finishing the famed east door. He was involved with perfecting the baptistery doors from 1402 to 1452, a span of a half century. Of course, in the meantime he finished many more commissions and sculpted statues for the Medici, the Pazzi, the guild of merchant bankers, and other notables, but his reputation rests on the Gates of Paradise, which changed the Western world’s conception of decorative art.

If Brunelleschi had been influenced by Roman architecture, Ghiberti studied and tried to emulate Roman sculpture. He had to relearn the technique for casting large bronze shapes, and he studied the classic profiles carved on Roman tombs on which he modeled the expressions of the characters he made emerge from the door panels. And again, he combined the rediscovered classics with the more recent Gothic sculpture produced in Siena. However, one could claim without too much risk of exaggeration that what made the
Gates of Paradise so beautiful was the care, concern, and support of the entire community, represented by the field of judges who supervised their construction. If Ghiberti and his fellows were driven to surpass themselves, it was by the intense competition and focused attention their work attracted. Thus the sociologist of art Arnold Hauser rightly assesses this period: “In the art of the early Renaissance ... the starting point of production is to be found mostly not in the creative urge, the subjective self-expression and spontaneous inspiration of the artist, but in the task set by the customer.”

Of course, the great works of Florentine art would never have been made just because the domain of classical art had been rediscovered, or because the rulers of the city had decided to make it beautiful. Without individual artists the Renaissance could not have taken place. After all, it was Brunelleschi who built the dome over Santa Maria Novella, and it was Ghiberti who spent his life casting the Gates of Paradise. At the same time, it must be recognized that without previous models and the support of the city, Brunelleschi and Ghiberti could not have done what they did. And that with the favorable conjunction of field and domain, if these two artists had not been born, some others would have stepped in their place and built the dome and the doors. It is because of this inseparable connection that creativity must, in the last analysis, be seen not as something happening within a person but in the relationships within a system.

**Domains of Knowledge and Action**

It seems that every species of living organism, except for us humans, understands the world in terms of more or less built-in responses to certain types of sensations. Plants turn toward the sun. There are amoebas sensitive to magnetic attraction that orient their bodies toward the North pole. Baby indigo buntings learn the patterns of the stars as they look out of their nests and then are able to fly great distances at night without losing their way. Bats respond to sounds, sharks to smell, and birds of prey have incredibly developed vision.

Each species experiences and understands its environment in terms of the information its sensory equipment is programmed to process.

The same is true for humans. But in addition to the narrow windows on the world our genes have provided, we have managed to open up new perspectives on reality based on information mediated by symbols. Perfect parallel lines do not exist in nature, but by postulating their existence Euclid and his followers could build a system for representing spatial relations that is much more precise than what the unaided eye and brain can achieve. Different as they are from each other, lyric poetry and magnetic resonance spectroscopy are both ways to make accessible information that otherwise we would never have an inkling about.

Knowledge mediated by symbols is extrasomatic; it is not transmitted through the chemical codes inscribed in our chromosomes but must be intentionally passed on and learned. It is this extrasomatic information that makes up what we call a culture. And the knowledge conveyed by symbols is bundled up in discrete domains—geometry, music, religion, legal systems, and so on. Each domain is made up of its own symbolic elements, its own rules, and generally has its own system of notation. In many ways, each domain describes an isolated little world in which a person can think and act with clarity and concentration.

The existence of domains is perhaps the best evidence of human creativity. The fact that calculus and Gregorian chants exist means that we can experience patterns of order that were not programmed into our genes by biological evolution. By learning the rules of a domain, we immediately step beyond the boundaries of biology and enter the realm of cultural evolution. Each domain expands the limitations of individuality and enlarges our sensitivity and ability to relate to the world. Each person is surrounded by an almost infinite number of domains that are potentially able to open up new worlds and give new powers to those who learn their rules. Therefore, it is astounding how few of us bother to invest enough mental energy to learn the rules of even one of these domains, and live instead exclusively within the constraints of biological existence.

For most people, domains are primarily ways to make a living. We choose nursing or plumbing, medicine or business administration because of our ability and the chances of getting a well-paying job. But then there are individuals—and the creative ones are usually in this group—who choose certain domains because of a powerful calling to do so. For them the match is so perfect that acting within the rules of the domain is rewarding in itself; they would keep doing what they do even if they were not paid for it, just for the sake of doing the activity.
Despite the multiplicity of domains, there are some common reasons for pursuing them for their own sake. Nuclear physics, microbiology, poetry, and musical composition share few symbols and rules, yet the calling for these different domains is often astonishingly similar. To bring order to experience, to make something that will endure after one's death, to do something that allows humankind to go beyond its present powers are very common themes.

When asked why he decided to become a poet at the age of seven, György Faludy answered, "Because I was afraid to die." He explained that creating patterns with words, patterns that because of their truth and beauty had a chance to survive longer than the body of the poet, was an act of defiance and hope that gave meaning and direction to his life for the next seventy-three years. This urge is not so very different from physicist John Bardeen's description of his work on superconductivity that might lead to a world without friction, the physicist Heinz Maier-Leibnitz's hope that nuclear energy will provide unlimited power, or the biochemical physicist Manfred Eigen's attempt to understand how life evolved. Domains are wonderfully different, but the human quest they represent converges on a few themes. In many ways, Max Planck's obsession with understanding the Absolute underlies most human attempts to transcend the limitations of a body doomed to die after a short span of years.

There are several ways that domains can help or hinder creativity. Three major dimensions are particularly relevant: the clarity of structure, the centrality within the culture, and accessibility. Say that pharmaceutical companies A and B are competing in the same market. The amount of money they devote to research and development, as well as the creative potential of their researchers, is equal. Now we want to predict whether company A or B will come up with the most effective new drugs, basing our prediction solely on domain characteristics. The questions we would ask are the following: Which company has the more detailed data about pharmaceuticals? Where are the data better organized? Which company puts more emphasis in its culture on research, relative to other areas such as production and marketing? Where does pharmaceutical knowledge earn more respect? Which company disseminates knowledge better among its staff? Where is it easier to test a hypothesis? The company where knowledge is better structured, more central, and more accessible is likely to be the one where—other things still being equal—creative innovations are going to happen.

It has been often remarked that superior ability in some domains—such as mathematics or music—shows itself earlier in life than in other domains—such as painting or philosophy. Similarly, it has been suggested that the most creative performances in some domains are the work of young people, while in other domains older persons have the edge. The most creative lyric verse is believed to be that written by the young, while epics tend to be written by more mature poets. Mathematical genius peaks in the twenties, physics in the thirties, but great philosophical works are usually achieved later in life.

The most likely explanation for these differences lies in the different ways these domains are structured. The symbolic system of mathematics is organized relatively tightly; the internal logic is strict; the system maximizes clarity and lack of redundancy. Therefore, it is easy for a young person to assimilate the rules quickly and jump to the cutting edge of the domain in a few years. For the same structural reasons, when a novelty is proposed—like the long-awaited proof of Fermat's last theorem presented by a relatively young mathematician in 1993—it is immediately recognized and, if viable, accepted. By contrast, it takes decades for social scientists or philosophers to master their domains, and if they produce a new idea, it takes the field many years to assess whether it is an improvement worth adding to the knowledge base.

Heinz Maier-Leibnitz tells the story of a small physics seminar he taught in Munich, which was interrupted one day by a graduate student who suggested a new way to represent on the blackboard the behavior of a subatomic particle. The professor agreed that the new formulation was an improvement and praised the student for having thought of it. By the end of the week, Maier-Leibnitz says, he started getting calls from physicists at other German universities, asking in effect, "Is it true that one of your students came up with such and such an idea?" The next week, calls began to come in from American universities on the East Coast. In two weeks, colleagues from Cal Tech, Berkeley, and Stanford were asking the same question.

This story could never have been told about my branch of psychology. If a student stood up in a psychology seminar at any school in the world and uttered the most profound ideas, he or she would
not create a ripple beyond the walls of the classroom. Not because psychology students are less intelligent or original than the ones in physics. Nor because my colleagues and I are less alert to our students' new ideas. But because with the exception of a few highly structured subdomains, psychology is so diffuse a system of thought that it takes years of intense writing for any person to say something that others recognize as new and important. The young student in Maier-Leibnitz's class was eventually awarded the Nobel Prize in physics, something that could never happen to a psychologist.

Does this mean that a domain that is better structured—where creativity is easier to determine—is in some sense "better" than one that is more diffuse? That it is more important, more advanced, more serious? Not at all. If that were true, then chess, microeconomics, or computer programming, which are very clearly structured domains, would have to be considered more advanced than morality or wisdom.

But it is certainly true that nowadays a quantifiable domain with sharp boundaries and well-defined rules is taken more seriously. In a typical university it is much easier to get funding for such a department. It is also easier to justify promotion for a teacher in a narrowly defined domain: Ten colleagues will willingly write letters of recommendation stating that professor X should be promoted because she is the world's authority on the mating habits of the kangaroo rat or on the use of the subjunctive in Dravidic languages. It is much less likely that ten scholars would agree on who is a world authority on personality development. From this it is easy to make the regrettable mistake of inferring that personality development is a scientifically less respectable domain than the one that studies the mating practices of the kangaroo rat.

In the current historical climate, a domain where quantifiable measurement is possible takes precedence over one where it does not. We believe that things that can be measured are real, and we ignore those that we don't know how to measure. So people take intelligence very seriously, because the mental ability we call by that name can be measured by tests; whereas few bother about how sensitive, altruistic, or helpful someone is, because as yet there is no good way to measure such qualities. Sometimes this bias has profound consequences—for instance, in how we define social progress and achievement. One of futurist Hazel Henderson's life goals is to con-

vince world governments to start computing less easily measured trends in their Gross National Product. As long as the costs of pollution, depredation of natural resources, decline in the quality of life, and various other human costs are left out of the reckoning of the GNP, she claims, entirely distorted pictures of reality result. A country may pride itself on all its new highways while the resulting auto emissions are causing widespread emphysema.

**FIELDS OF ACCOMPLISHMENT**

If a symbolic domain is necessary for a person to innovate in, a field is necessary to determine whether the innovation is worth making a fuss about. Only a very small percentage of the great number of novelties produced will eventually become part of the culture. For instance, about one hundred thousand new books are published every year in the United States. How many of these will be remembered ten years from now? Similarly, about five hundred thousand people in this country state on their census forms that they are artists. If each of them painted only one picture a year, it would amount to about fifteen million new paintings per generation. How many of these will end up in museums or in textbooks on art? One in a million, ten in a million, one in ten thousand? One?

George Stigler, the Nobel laureate in economics, made the same point about new ideas produced in his domain, and what he says can be applied to any other field of science:

The profession is too busy to read much. I keep telling my colleagues at the *Journal of Political Economy* that anytime we get an article that fifteen of our profession, of the seven thousand subscribers, read carefully, that must be truly a major article of the year.

These numbers suggest that the competition between memes, or units of cultural information, is as fierce as the competition between the units of chemical information we call genes. In order to survive, cultures must eliminate most of the new ideas their members produce. Cultures are conservative, and for good reason. No culture could assimilate all the novelty people produce without dissolving into chaos. Suppose you had to pay equal attention to the fifteen
million paintings—how much time would you have left free to eat, sleep, work, or listen to music? In other words, no person can afford to pay attention to more than a very small fraction of new things produced. Yet a culture could not survive long unless all of its members paid attention to at least a few of the same things. In fact it could be said that a culture exists when the majority of people agree that painting X deserves more attention than painting Y, or idea X deserves more thought than idea Y.

Because of the scarcity of attention, we must be selective: We remember and recognize only a few of the works of art produced, we read only a few of the new books written, we buy only a few of the new appliances being invented. Usually it is the various fields that act as filters to help us select among the flood of new information those mems worth paying attention to. A field is made up of experts in a given domain whose job involves passing judgment on performance in that domain. Members of the field choose from among the novelties those that deserve to be included in the canon.

This competition also means that a creative person must convince the field that he or she has made a valuable innovation. This is never an easy task. Stigler emphasizes the necessity of this difficult struggle for recognition:

I think you have to accept the judgment of others. Because if one were allowed to judge his own case, every one of us should have been president of the United States and received all the medals and so forth. And so I guess I am most proud of the things in which I succeeded in impressing other people with what I have done. And those would be things like the two areas of work in which I received the Nobel Prize, and things like that. So those and certain other works that my profession has liked would be, as far as my professional life goes, the things of which I’m most proud.

I have always looked upon the task of a scientist as bearing the responsibility for persuading his contemporaries of the cogency and validity of his thinking. He isn’t entitled to a warm reception. He has to earn it, whether by the skill of his exposition, the novelty of his ideas, or what. I’ve written on subjects which I thought had promise which haven’t amounted to much. That’s all right. That may well mean that my judgment wasn’t good, because I don’t think any one person’s judgment is as good as that of a collection of his better colleagues.

Fields vary greatly in terms of how specialized versus how inclusive they are. For some domains, the field is as broad as society itself. It took the entire population of the United States to decide whether the recipe for New Coke was an innovation worth keeping. On the other hand, it has been said that only four or five people in the world initially understood Einstein’s theory of relativity, but their opinion had enough weight to make his name a household word. But even in Einstein’s case, the broader society had a voice in deciding that his work deserved a central place in our culture. To what extent, for instance, did his fame depend on the fact that he looked like a scientist from Hollywood central casting? That he was persecuted by our enemies, the Nazis? That many interpreted his discoveries as supportive of the reality of values, and thus offering a refreshing alternative to binding social norms and beliefs? That while yearning to overthrow old beliefs, we also thirst for new certainties, and Einstein was said to have come up with an important new truth? Although none of these considerations bears in the least on the theory of relativity, they were all very much part of how the media portrayed Einstein—and it is these traits rather than the profundity of his theory that presumably convinced most people that he was worth including in the cultural pantheon.

Fields can affect the rate of creativity in at least three ways. The first way is by being either reactive or proactive. A reactive field does not solicit or stimulate novelty, while a proactive field does. One of the major reasons the Renaissance was so bountiful in Florence is that the patrons actively demanded novelty from artists. In the United States, we make some effort to be proactive in terms of stimulating scientific creativity in the young: science fairs and prestigious prizes like the Westinghouse, which goes to the one hundred best high school science projects each year, are some examples. But of course much more could be done to stimulate novel thinking in science early on. Similarly, some companies like Motorola take seriously the idea that one way to increase creativity is for the field to be proactive.

The second way for the field to influence the rate of novelty is by choosing either a narrow or a broad filter in the selection of novelty.
Some fields are conservative and allow only a few new items to enter the domain at any given time. They reject most novelty and select only what they consider best. Others are more liberal in allowing new ideas into their domains, and as a result these change more rapidly. At the extremes, both strategies can be dangerous: It is possible to wreck a domain either by starving it of novelty or by admitting too much unassimilated novelty into it.

Finally, fields can encourage novelty if they are well connected to the rest of the social system and are able to channel support into their own domain. For instance, after World War II it was easy for nuclear physicists to get all sorts of money to build new laboratories, research centers, experimental reactors, and to train new physicists, because politicians and voters were still enormously impressed by the atomic bomb and the future possibilities it represented. During a few years in the 1950s, the number of students in theoretical physics at the University of Rome went from seven to two hundred; the proportions were not far off elsewhere around the world.

There are several ways that domains and fields can affect each other. Sometimes domains determine to a large extent what the field can or cannot do; this is probably more usual in the sciences, where the knowledge base severely restricts what the scientific establishment can or cannot claim. No matter how much a group of scientists would like their pet theory accepted, it won’t be if it runs against the previously accumulated consensus. In the arts, on the other hand, it is often the field that takes precedence: The artistic establishment decides, without firm guidelines anchored in the past, which new works of art are worthy of inclusion in the domain.

Sometimes fields that are not competent in the domain take control over it. The church interfered in Galileo’s astronomical findings; the Communist party for a while directed not only Soviet genetics but art and music as well; and fundamentalists in the United States are trying to have a voice in teaching evolutionary history. In more subtle ways, economic and political forces always influence, whether intentionally or not, the development of domains. Our knowledge of foreign languages would be even less if the U.S. government stopped subsidizing Title IV programs. Opera and ballet would virtually disappear without massive outside support. The Japanese government is heavily invested in stimulating new ideas and applications in micro-circuitry, while the Dutch government, understandably enough, encourages pioneering work in the building of dams and hydraulic devices. The Romanian government was actively involved in the destruction of the art forms of its ethnic minorities in order to maintain the purity of Dacian culture; the Nazis tried to destroy what they considered “degenerate” Jewish art.

At times fields become unable to represent well a particular domain. A leading philosopher in our study maintains that if a young person wants to learn philosophy these days, he or she would be better advised to become immersed in the domain directly and avoid the field altogether: “I’d tell him to read the great books of philosophy. And I would tell him not to do graduate study at any university. I think all philosophy departments are no good. They are all terrible.” By and large, however, jurisdiction over a given domain is officially left in the hands of a field of experts. These may range from grade school teachers to university professors and include anyone who has a right to decide whether a new idea or product is “good” or “bad.” It is impossible to understand creativity without understanding how fields operate, how they decide whether something new should or should not be added to the domain.

The Contributions of the Person

Finally we get to the individual responsible for generating novelty. Most investigations focus on the creative person, believing that by understanding how his or her mind works, the key to creativity will be found. But this is not necessarily the case. For though it is true that behind every new idea or product there is a person, it does not follow that such persons have a single characteristic responsible for the novelty.

Perhaps being creative is more like being involved in an automobile accident. There are some traits that make one more likely to be in an accident—being young and male, for instance—but usually we cannot explain car accidents on the basis of the driver’s characteristics alone. There are too many other variables involved: the condition of the road, the other driver, the type of traffic, the weather, and so on. Accidents, like creativity, are properties of systems rather than of individuals.

Nor can we say that it is the person who starts the creative process.

In the case of the Florentine Renaissance one could just as well say
that it was started by the rediscovery of Roman art, or by the stimulation provided by the city's bankers. Brunelleschi and his friends found themselves in a stream of thought and action that started before they were born, and then they stepped into the middle of it. At first it appears that they initiated the great works that made the epoch famous, but in reality they were only catalysts for a much more complex process with many participants and many inputs.

When we asked creative persons what explains their success, one of the most frequent answers—perhaps the most frequent one—was that they were lucky. Being in the right place at the right time is an almost universal explanation. Several scientists who were in graduate school in the late 1920s or 1930s remember being among the first cohorts to be exposed to quantum theory. Inspired by the work of Max Planck and Niels Bohr, they applied quantum mechanics to chemistry, to biology, to astrophysics, to electrodynamics. Some of them, like Linus Pauling, John Bardeen, Manfred Eigen, Subrahmanyan Chandrasekhar, were awarded Nobel Prizes for extending the theory to new domains. Many women scientists who entered graduate school in the 1940s mention that they wouldn't have been accepted by the schools, and certainly they wouldn't have been given fellowships and special attention from supervisors, except for the fact that there were so few male students left to compete against, most of them having gone to war.

Luck is without doubt an important ingredient in creative discoveries. A very successful artist, whose work sells well and hangs in the best museums and who can afford a large estate with horses and a swimming pool, once admitted ruefully that there could be at least a thousand artists as good as he is—yet they are unknown and their work is unappreciated. The one difference between him and the rest, he said, was that years back he met at a party a man with whom he had a few drinks. They hit it off and became friends. The man eventually became a successful art dealer who did his best to push his friend's work. One thing led to another: A rich collector began to buy the artist's work, critics started paying attention, a large museum added one of his works to its permanent collection. And once the artist became successful, the field discovered his creativity.

It is important to point out the tenuousness of the individual contribution to creativity, because it is usually so often overrated. Yet one can also fall in the opposite error and deny the individual any credit. Certain sociologists and social psychologists claim that creativity is all a matter of attribution. The creative person is like a blank screen on which social consensus projects exceptional qualities. Because we need to believe that creative people exist, we endow some individuals with this illusory quality. This, too, is an oversimplification. For while the individual is not as important as it is commonly supposed, neither is it true that novelty could come about without the contribution of individuals, and that all individuals have the same likelihood of producing novelty.

Luck, although a favorite explanation of creative individuals, is also easy to overstate. Many young scientists in Linus Pauling's generation were exposed to the arrival of quantum theory from Europe. Why didn't they see what this theory implied for chemistry, the way he saw it? Many women would have liked to become scientists in the 1940s. Why did so few take the opportunity when the doors to graduate training were opened to them? Being in the right place at the right time is clearly important. But many people never realize that they are standing in a propitious space/time convergence, and even fewer know what to do when the realization hits them.

**INTERNALIZING THE SYSTEM**

A person who wants to make a creative contribution not only must work within a creative system but must also reproduce that system within his or her mind. In other words, the person must learn the rules and the content of the domain, as well as the criteria of selection, the preferences of the field. In science, it is practically impossible to make a creative contribution without internalizing the fundamental knowledge of the domain. All scientists would agree with the words of Frank Offner, a scientist and inventor: "The important thing is that you must have a good, a very solid grounding in the physical sciences, before you can make any progress in understanding." The same conclusions are voiced in every other discipline. Artists agree that a painter cannot make a creative contribution without looking, and looking, and looking at previous art, and without knowing what other artists and critics consider good and bad art. Writers say that you have to read, read, and read some more, and know what the critics' criteria for good writing are, before you can write creatively yourself.
An extremely lucid example of how the internalization of the system works is given by the inventor Jacob Rabinow. At first, he talks about the importance of what I have called the domain:

So you need three things to be an original thinker. First, you have to have a tremendous amount of information—a big database if you like to be fancy. If you're a musician, you should know a lot about music, that is, you've heard music, you remember music, you could repeat a song if you have to. In other words, if you were born on a desert island and never heard music, you're not likely to be a Beethoven. You might, but it's not likely. You may imitate birds but you're not going to write the Fifth Symphony. So you're brought up in an atmosphere where you store a lot of information.

So you have to have the kind of memory that you need for the kind of things you want to do. And you do those things which are easy and you don't do those things which are hard, so you get better and better by doing the things you do well, and eventually you become either a great tennis player or a good inventor or whatever, because you tend to do those things which you do well and the more you do, the easier it gets, and the easier it gets, the better you do it, and eventually you become very one-sided but you're very good at it and you're lousy at everything else because you don't do it well. This is what engineers call positive feedback. So the small differences at the beginning of life become enormous differences by the time you've done it for forty, fifty, eighty years as I've done it. So anyway, first you have to have the big database.

Next Rabinow brings up what the person must contribute, which is mainly a question of motivation, or the enjoyment one feels when playing (or working?) with the contents of the domain:

Then you have to be willing to pull the ideas, because you're interested. Now, some people could do it, but they don't bother. They're interested in doing something else. So if you ask them, they'll, as a favor to you, say: "Yeah, I can think of something." But there are people like myself who like to do it. It's fun to come up with an idea, and if nobody wants it, I don't give a damn. It's just fun to come up with something strange and different.

Finally he focuses on how important it is to reproduce in one's mind the criteria of judgment that the field uses:

And then you must have the ability to get rid of the trash which you think of. You cannot think only of good ideas, or write only beautiful music. You must think of a lot of music, a lot of ideas, a lot of poetry, a lot of whatever. And if you're good, you must be able to throw out the junk immediately without even saying it. In other words, you get many ideas appearing and you discard them because you're well trained and you say, "that's junk." And when you see the good one, you say, "Oops, this sounds interesting. Let me pursue that a little further." And you start developing it. Now, people don't like this explanation. They say, "What? You think of junk?" I say, "Yup. You must." You cannot a priori think only of good ideas. You cannot think only of great symphonies. Some people do it very rapidly. And this is a matter of training. And by the way, if you're not well trained, but you've got ideas, and you don't know if they're good or bad, then you send them to the Bureau of Standards, National Institute of Standards, where I work, and we evaluate them. And we throw them out.

He was asked what constitutes "junk." Is it something that doesn't work, or—

It doesn't work, or it's old, or you know that it will not gel. You suddenly realize it's not good. It's too complicated. It's not what mathematicians call "elegant." You know, it's not good poetry. And this is a matter of training. If you're well trained in technology, you see an idea and say, "Oh, God, this is terrible." First of all, it's too complicated. Secondly, it's been tried before. Thirdly, he could have done it in three different easier ways. In other words, you can evaluate the thing. That doesn't mean that he wasn't original. But he simply didn't do enough. If he were well trained, if he had the experience I had, and had good bosses and worked with great people, he could say this is not really a good idea. It's an idea, but it's not a good idea. And you have arguments with people. And you say, "Look, this is not a good way. Look at the number of parts you're gluing together. Look at the amount of energy it'll take. This is really not good." And the guy says, "But to me it's new." I
say, "Yup, to you it's new. It may be new to the world. But it's still not good."

To say what is beautiful you have to take a sophisticated group of people, people who know that particular art and have seen a lot of it, and say this is good art, or this is good music, or this is a good invention. And that doesn't mean everybody can vote on it; they don't know enough. But if a group of engineers who work on new stuff look at it and say, "That's pretty nice," that's because they know. They know because they've been trained in it.

And a good creative person is well trained. So he has first of all an enormous amount of knowledge in that field. Secondly, he tries to combine ideas, because he enjoys writing music or enjoys inventing. And finally, he has the judgment to say, "This is good, I'll pursue this further."

It would be very difficult to improve on this description of how the systems model works after it is internalized. Drawing on over eighty years of varied experience, Rabinow has distilled with great insight what is involved in being a creative inventor. And as his words suggest, the same process holds for other domains, whether poetry, music, or physics.

T
o be creative, a person has to internalize the entire system that makes creativity possible. So what sort of person is likely to do that? This question is very difficult to answer. Creative individuals are remarkable for their ability to adapt to almost any situation and to make do with whatever is at hand to reach their goals. If nothing else, this distinguishes them from the rest of us. But there does not seem to be a particular set of traits that a person must have in order to come up with a valuable novelty. What John Reed, the CEO of Citicorp, who has thought quite a lot about such things, says about businesspeople could be applied to creative persons in other domains as well:

Well, because of my job, I tend to know the guys who run the top fifty, one hundred companies in the country, and there's quite a range. It has little to do with the industry. It's funny, there is a consistency in what people look at in businesspeople, but there's no consistency in style and approach, personality, and so forth. There is not a consistent norm with regard to anything other than business performance.
Personality type, style. There are guys who drink too much, there are guys who chase girls; there are guys who are conservative, do none of the above; there are guys who are very serious and workaholics; there are guys who—it's quite amazing, the range of styles. You're paid to run companies, they watch quite carefully as to results. But there's an amazing lack of consistency on any other dimension. How you do it seems to be a wide-open variable. There isn't a clear pattern, tremendously different personality types. And it doesn't seem to run by industry either.

The same is true for scientists: What leads to an important discovery doesn't matter as long as you play by the rules. Or for artists: You can be a happy extrovert like Raphael, or a surly introvert like Michelangelo—the only thing that matters is how good your paintings are judged to be. This is all well and true; yet at the same time it is somewhat disappointing. After all, to say that what makes a person creative is his or her creativity is a tautology. Can we do any better? We don't really have very sound evidence, let alone proof, but we can venture some rather robust and credible suggestions.

Perhaps the first trait that facilitates creativity is a genetic predisposition for a given domain. It makes sense that a person whose nervous system is more sensitive to color and light will have an advantage in becoming a painter, while someone born with a perfect pitch will do well in music. And being better at their respective domains, they will become more deeply interested in sounds and colors, will learn more about them, and thus are in a position to innovate in music or art with greater ease.

On the other hand, a sensory advantage is certainly not necessary. El Greco seems to have suffered from a disease of the optic nerve, and Beethoven was functionally deaf when he composed some of his greatest work. Although most great scientists seem to have been attracted to numbers and experimentation early in life, how creative they eventually became bears little relationship to how talented they were as children.

But a special sensory advantage may be responsible for developing an early interest in the domain, which is certainly an important ingredient of creativity. The physicist John Wheeler remembers being interested in "toy mechanisms, things that would shoot rubber bands, Tinkertoys, toy railroads, electric light bulbs, switches, buzzers." His father, who was a librarian, used to take him to New York State University, where he left John in the library office while he lectured. John was fascinated by the typewriters and other machines, especially hand calculators: "You pushed a button down and turned a crank, and how the thing worked, that intrigued me immensely." When he was twelve, he built a primitive calculator that had gears whittled out of wood.

Without a good dose of curiosity, wonder, and interest in what things are like and in how they work, it is difficult to recognize an interesting problem. Openness to experience, a fluid attention that constantly processes events in the environment, is a great advantage for recognizing potential novelty. Every creative person is more than amply endowed with these traits. Here is how the historian Natalie Davis selects what historical projects to focus on:

Well, I just get really curious about some problem. It just hooks in very deeply. At the time I don't know why necessarily it is that I invest so much curiosity and eros into some project. At the time, it just seems terribly interesting and important for the field. I may not know what is personally invested in it, other than my curiosity and my delight.

Without such interest it is difficult to become involved in a domain deeply enough to reach its boundaries and then push them farther. True, it is possible to make one creative discovery, even a very important one, by accident and without any great interest in the topic. But contributions that require a lifetime of struggle are impossible without curiosity and love for the subject.

A person also needs access to a domain. This depends to a great extent on luck. Being born to an affluent family, or close to good schools, mentors, and coaches obviously is a great advantage. It does no good to be extremely intelligent and curious if I cannot learn what it takes to operate in a given symbolic system. The ownership of what sociologist Pierre Bourdieu calls "cultural capital" is a great resource. Those who have it provide their children with the advantage of an environment full of interesting books, stimulating conversation, expectations for educational advancement, role models, tutors, useful connections, and so on.

But here too, luck is not everything. Some children fight their way
to the right schools while their peers stay behind. Manfred Eigen was captured by Russian troops at age seventeen and taken to a prisoner-of-war camp at the end of World War II, because he had been drafted to serve in an antiaircraft unit two years earlier. But he was determined to get back to studying science, even though he had had to leave high school at fifteen and never finished his studies. He escaped from the POW camp, walked back across half of Europe, and made a beeline for Göttingen, for he had heard that the best faculty in physics was reassembling there after the ravages of the war. He reached the city before the university actually had a chance to open but was admitted later with the first cohort of students, even though he lacked a high school diploma. Caught up in the ascetic postwar dedication to scholarship, led by the most knowledgeable teachers, surrounded by other equally dedicated students, he made quick progress. A few years later he received his doctorate and in 1967 the Nobel Prize. It is true that in early childhood Eigen could draw on substantial cultural capital, because his family had been musical and intellectually ambitious. Nevertheless, few people tossed by fate so far outside the circle of knowledge found their way back to its center as quickly and surely as he did.

Access to a field is equally important. Some people are terribly knowledgeable but are so unable to communicate with those who matter among their peers that they are ignored or shunned in the formative years of their careers. Michelangelo was reclusive, but in his youth was able to interact with leading members of the Medici court long enough to impress them with his skill and dedication. Isaac Newton was equally solitary and cantankerous, but somehow convinced his tutor at Cambridge that he deserved a lifetime tenured fellowship at the university, and so was able to continue his work undisturbed by human contact for many years. Someone who is not known and appreciated by the relevant people has a very difficult time accomplishing something that will be seen as creative. Such a person may not have a chance to learn the latest information, may not be given the opportunity to work, and if he or she does manage to accomplish something novel, that novelty is likely to be ignored or ridiculed.

In the sciences, being at the right university—the one where the most state-of-the-art research is being done in the best equipped labs by the most visible scientists—is extremely important. George Stigler describes this as a snowballing process, where an outstanding scientist gets funded to do exciting research, attracts other faculty, then the best students—until a critical mass is formed that has an irresistible appeal to any young person entering the field. In the arts, the attraction is more to the centers of distribution, now primarily New York City, where the major galleries and collectors are located. Just as a century ago aspiring young artists felt they had to go to Paris if they wanted to be recognized, now they feel that unless they run the gauntlet of Manhattan they don’t have a chance. One can paint beautiful pictures in Alabama or North Dakota, but they are likely to be misplaced, ignored, and forgotten unless they get the stamp of approval of critics, collectors, and other gatekeepers of the field. Eva Zeisel’s work received the imprimatur of the art establishment after her ceramics were shown by the Museum of Modern Art. The same is true of the other arts: Michael Snow spent ten years in New York City to catch up with the field of jazz music, and writers have to make connections with the agents and publishers there.

Access to fields is usually severely restricted. There are many gates to pass, and bottlenecks form in front of them. Writers who want to catch the attention of an editor long enough to have their work read have to compete with thousands of similarly hopeful writers who have also submitted their manuscripts. The editor typically has only a few minutes to dedicate to each writer’s work, assuming he or she even glances at the submission in the first place. Getting a literary agent to sell the manuscript is no solution either, since a good agent’s attention is as difficult to get as that of an editor.

Because of these bottlenecks, access to a field is often determined by chance or by irrelevant factors, such as having good connections. Students applying to good universities in some disciplines are so many and have such excellent credentials that it is difficult to rank them in any meaningful way. Yet the openings are few, so a selection must be made. Hence the joke that the admissions committee throws all the application folders down a long stairway, and the students whose files travel farthest get admitted.

The Ten Dimensions of Complexity

Access to the domain and access to the field are all well and good, but when are we going to deal with the real characteristics of creative
persons? When do we get to the interesting part—the tortured souls, the impossible dreams, the agony and the ecstasy of creation? The reason I hesitate to write about the deep personality of creative individuals is that I am not sure that there is much to write about, since creativity is the property of a complex system, and none of its components alone can explain it. The personality of an individual who is to do something creative must adapt itself to the particular domain, to the conditions of a particular field, which vary at different times and from domain to domain.

Giorgio Vasari in 1550 noted with chagrin that the new generations of Italian painters and sculptors seemed to be very different from their predecessors of the early Renaissance. They tended to be savage and mad, wrote the good Vasari, whereas their elders and betters had been tame and sensible. Perhaps Vasari was reacting to the artists who had embraced the ideology of Mannerism, the style ushered in by Michelangelo near the end of his long career, which relied on interesting distortions of figures and on grand gestures. This style would have been considered ugly a hundred years earlier, and the painters who used it would have been shunned. But a few centuries later, at the height of the Romantic period, an artist who was not more than a little savage and mad would not have been taken very seriously, because these qualities were de rigueur for creative souls.

In the 1960s, when abstract expressionism was the reigning style, those art students who tended to be sullen, brooding, and antisocial were thought by their teachers to be very creative. They were encouraged, and they won the prizes and fellowships. Unfortunately, when these students left school and tried to establish careers in the art world, they found that being antisocial did not get them very far. To get the attention of dealers and critics they had to throw wild parties and be constantly seen and talked about. Hence a hecatomb of introverted artists ensued: Most were selected out, ending up as art teachers in the Midwest or as car salesmen in New Jersey. Then the Warhol cohort replaced the abstract expressionists, and it was young artists with cool, clever, flip personalities who projected the aura of creativity. This, too, was a transient mask. The point is that you cannot assume the mantle of creativity just by assuming a certain personality style. One can be creative by living like a monk, or by burning the candle at both ends. Michelangelo was not greatly fond of women, while Picasso couldn't get enough of them. Both changed the domain of painting, even though their personalities had little in common.

Are there then no traits that distinguish creative people? If I had to express in one word what makes their personalities different from others, it would be complexity. By this I mean that they show tendencies of thought and action that in most people are segregated. They contain contradictory extremes—instead of being an “individual,” each of them is a “multitude.” Like the color white that includes all the hues in the spectrum, they tend to bring together the entire range of human possibilities within themselves.

These qualities are present in all of us, but usually we are trained to develop only one pole of the dialectic. We might grow up cultivating the aggressive, competitive side of our nature, and disdain or repress the nurturant, cooperative side. A creative individual is more likely to be both aggressive and cooperative, either at the same time or at different times, depending on the situation. Having a complex personality means being able to express the full range of traits that are potentially present in the human repertoire but usually atrophy because we think that one or the other pole is “good,” whereas the other extreme is “bad.”

This kind of person has many traits in common with what the Swiss analytic psychologist Carl Jung considered a mature personality. He also thought that every one of our strong points has a repressed shadow side that most of us refuse to acknowledge. The very orderly person may long to be spontaneous, the submissive person wishes to be dominant. As long as we disown these shadows, we can never be whole or satisfied. Yet that is what we usually do, and so we keep on struggling against ourselves, trying to live up to an image that distorts our true being.

A complex personality does not imply neutrality, or the average. It is not some position at the midpoint between two poles. It does not imply, for instance, being wishy-washy, so that one is never very competitive or very cooperative. Rather it involves the ability to move from one extreme to the other as the occasion requires. Perhaps a central position, a golden mean, is the place of choice, what software writers call the default condition. But creative persons definitely know both extremes and experience both with equal intensity and without inner conflict. It might be easier to illustrate this conclusion in terms of ten pairs of apparently antithetical traits that are
often both present in such individuals and integrated with each other in a dialectical tension.

1. Creative individuals have a great deal of physical energy, but they are also often quiet and at rest. They work long hours, with great concentration, while projecting an aura of freshness and enthusiasm. This suggests a superior physical endowment, a genetic advantage. Yet it is surprising how often individuals who in their seventies and eighties exude energy and health remember a childhood plagued by illness. Heinz Maier-Leibnitz was bedridden for months in the Swiss mountains recovering from a lung ailment; György Faludy was often ill as a child, and so was the psychologist Donald Campbell. Public opinion analyst Elisabeth Noelle-Neumann was given no hope of survival by her physicians, but a homeopathic cure so improved her health that thirty years later she works harder than any four persons half her age. It seems that the energy of these people is internally generated and is due more to their focused minds than to the superiority of their genes. (Although it must be said that some respondents, such as Linus Pauling, answered "good genes," when asked to explain what accounted for their achievements.)

This does not mean that creative persons are hyperactive, always "on," constantly churning away. In fact, they often take rests and sleep a lot. The important thing is that the energy is under their own control—it is not controlled by the calendar, the clock, an external schedule. When necessary they can focus it like a laser beam; when it is not, they immediately start recharging their batteries. They consider the rhythm of activity followed by idleness or reflection very important for the success of their work. And this is not a biorhythm they inherited with their genes; it was learned by trial and error, as a strategy for achieving their goals. A humorous example is given by Robertson Davies:

Well, you know, that leads me to something which I think has been very important in my life, and it sounds foolish and rather trivial. But I've always insisted on having a nap after lunch, and I inherited this from my father. And one time I said to him, "You know, you've done awfully well in the world. You came to Canada as an immigrant boy without anything and you have done very well. What do you attribute it to?" And he said, "Well, what drove me on to be my own boss was that the thing that I wanted most was to be able to have a nap every day after lunch." And I thought, What an extraordinary impulse to drive a man on! But it did, and he always had a twenty-minute sleep after lunch. And I'm the same. I think it is very important. If you will not permit yourself to be driven and flogged through life, you'll probably enjoy it more.

One manifestation of energy is sexuality. Creative people are paradoxical in this respect also. They seem to have quite a strong dose of eros, or generalized libidinal energy, which some express directly into sexuality. At the same time, a certain spartan celibacy is also a part of their makeup; continence tends to accompany superior achievement. Without eros, it would be difficult to take life on with vigor; without restraint, the energy could easily dissipate.

2. Creative individuals tend to be smart, yet also naive at the same time. How smart they actually are is open to question. It is probably true that what psychologists call the g factor—meaning a core of general intelligence—is high among people who make important creative contributions. But we should not take seriously the lists that used to be printed on the sidebars of psychology textbooks, according to which John Stuart Mills must have had an IQ of 170 and Mozart an IQ of 135. Had they been tested at the time, perhaps they would have scored high. Perhaps not. And how many children in the eighteenth century would have scored even higher but never did anything memorable?

The earliest longitudinal study of superior mental abilities, initiated at Stanford University by the psychologist Lewis Terman in 1921, shows rather conclusively that children with very high IQs do well in life, but after a certain point IQ does not seem to be correlated any longer with superior performance in real life. Later studies suggest that the cutoff point is around 120; it might be difficult to do creative work with a lower IQ, but beyond 120 an increment in IQ does not necessarily imply higher creativity.

Why a low intelligence interferes with creative accomplishment
is quite obvious. But being intellectually brilliant can also be detrimental to creativity. Some people with high IQs get complacent, and, secure in their mental superiority, they lose the curiosity essential to achieving anything new. Learning facts, playing by the existing rules of domains, may come so easily to a high-IQ person that he or she never has any incentive to question, doubt, and improve on existing knowledge. This is probably why Goethe, among others, said that naïveté is the most important attribute of genius.

Another way of expressing this dialectic is by the contrasting poles of wisdom and childishness. As Howard Gardner remarked in his study of the major creative geniuses of this century, a certain immaturity, both emotional and mental, can go hand in hand with deepest insights. Mozart comes immediately to mind.

Furthermore, people who bring about an acceptable novelty in a domain seem able to use well two opposite ways of thinking: the convergent and the divergent. Convergent thinking is measured by IQ tests, and it involves solving well-defined, rational problems that have one correct answer. Divergent thinking leads to no agreed-upon solution. It involves fluency, or the ability to generate a great quantity of ideas; flexibility, or the ability to switch from one perspective to another; and originality in picking unusual associations of ideas. These are the dimensions of thinking that most creativity tests measure and that most workshops try to enhance.

It is probably true that in a system that is conducive to creativity, a person whose thinking is fluent, flexible, and original is more likely to come up with novel ideas. Therefore, it makes sense to cultivate divergent thinking in laboratories and corporations—especially if management is able to pick out and implement the most appropriate ideas from the many that are generated. Yet there remains the nagging suspicion that at the highest levels of creative achievement the generation of novelty is not the main issue. A Galileo or a Darwin did not have that many new ideas, but the ones they fastened upon were so central that they changed the entire culture. Similarly, the individuals in our study often claimed to have had only two or three good ideas in their entire career, but each idea was so generative that it kept them busy for a lifetime of testing, filling out, elaborating, and applying.

Divergent thinking is not much use without the ability to tell a good idea from a bad one—and this selectivity involves convergent thinking. Manfred Eigen is one of several scientists who claim that the only difference between them and their less creative colleagues is that they can tell whether a problem is soluble or not, and this saves enormous amounts of time and many false starts. George Stigler stresses the importance of fluidity, that is, divergent thinking on the one hand, and good judgment in recognizing a viable problem on the other:

I consider that I have good intuition and good judgment on what problems are worth pursuing and what lines of work are worth doing. I used to say (and I think this was bragging) that whereas most scholars have ideas which do not pan out more than, say, 4 percent of the time, mine come through maybe 80 percent of the time.

3. A third paradoxical trait refers to the related combination of playfulness and discipline, or responsibility and irresponsibility. There is no question that a playfully light attitude is typical of creative individuals. John Wheeler says that the most important thing in a young physicist is “this bounce, which I always associate with fun in science, kicking things around. It’s not quite joking, but it has some of the lightness of joking. It’s exploring ideas.” David Riesman, in describing the attitude of “detached attachment” that makes him an astute observer of the social scene, stresses the fact that he always “wanted at the same time to be irresponsible and responsible.”

But this playfulness doesn’t go very far without its antithesis, a quality of doggedness, endurance, perseverance. Much hard work is necessary to bring a novel idea to completion and to surmount the obstacles a creative person inevitably encounters. When asked what enabled him to solve the physics problems that made him famous, Hans Bethe answered with a smile: “Two things are required. One is a brain. And second is the willingness to spend long times in thinking, with a definite possibility that you come out with nothing.”

Nina Holton, whose playfully wild germs of ideas are the genesis of her sculpture, is very firm about the importance of hard work:
I'll tell anybody you're are a sculptor and they'll say, "Oh, how exciting, how wonderful." And I tend to say, "What's so wonderful?" I mean, it's like being a mason, or being a carpenter, half the time. But they don't wish to hearken that because they really only imagine the first part, the exciting part. But, as Khrushchev once said, that doesn't fry pancakes, you see. That germ of an idea does not make a sculpture which stands up. It just sits there. So the next stage, of course, is the hard work. Can you really translate it into a piece of sculpture? Or will it be a wild thing which only seemed exciting while you were sitting in the studio alone? Will it look like something? Can you actually do it physically? Can you, personally, do it physically? What do you have by way of materials? So the second part is a lot of hard work. And sculpture is that, you see. It is the combination of wonderful wild ideas and then a lot of hard work.

Jacob Rabinow uses an interesting mental technique to slow himself down when work on an invention requires more endurance than intuition:

Yeah, there's a trick I pull for this. When I have a job to do like that, where you have to do something that takes a lot of effort, slowly, I pretend I'm in jail. Don't laugh. And if I'm in jail, time is of no consequence. In other words, if it takes a week to cut this, it'll take a week. What else have I got to do? I'm going to be here for twenty years. See? This is a kind of mental trick. Because otherwise you say, "My God, it's not working," and then you make mistakes. But the other way, you say time is of absolutely no consequence. People start saying how much will it cost me in time? If I work with somebody else it's fifty bucks an hour, a hundred dollars an hour. Nonsense. You just forget everything except that it's got to be built. And I have no trouble doing this. I work fast, normally. But if something will take a day gluing and then next day I glue the other side—it'll take two days—it doesn't bother me at all.

Despite the carefree air that many creative people affect, most of them work late into the night and persist when less driven individuals would not. Vasari wrote in 1550 that when the Renaissance painter Paolo Uccello was working out the laws of visual perspec-

tive, he would walk back and forth all night, muttering to himself: "What a beautiful thing is this perspective!" while his wife kept calling him back to bed with no success. Close to five hundred years later, physicist and inventor Frank Offner describes the time he was trying to understand how the membrane of the ear works:

Ah, the answer may come to me in the middle of the night. My wife, when I was first into this membrane stuff, would kick me in the middle of the night and say, "Now get your mind off of membranes and get to sleep."

4. Creative individuals alternate between imagination and fantasy at one end, and a rooted sense of reality at the other. Both are needed to break away from the present without losing touch with the past. Albert Einstein once wrote that art and science are two of the greatest forms of escape from reality that humans have devised. In a sense he was right: Great art and great science involve a leap of imagination into a world that is different from the present. The rest of society often views these new ideas as fantasies without relevance to current reality. And they are right. But the whole point of art and science is to go beyond what we now consider real, and create a new reality. At the same time, this "escape" is not into a never-never land. What makes a novel idea creative is that once we see it, sooner or later we recognize that, strange as it is, it is true.

This dialectic is reflected by the way that, many years ago, the artists we studied responded to so-called projective tests, like the Rorschach or the Thematic Apperception Test. These require you to make up a story about some ambiguous stimuli, such as inkblots or drawings, that could represent almost anything. The more creative artists gave responses that were definitely more original, with unusual, colorful, detailed elements. But they never gave "bizarre" responses, which normal people occasionally do. A bizarre response is one that, with all the goodwill in the world, one could not see in the stimulus. For instance if an inkblot looks vaguely like a butterfly, and you say that it looks like a submarine without being able to give a sensible clue as to what in the inkblot made you say so, the response would be scored as bizarre. Normal people are rarely original, but they are sometimes bizarre. Creative people, it seems, are original without being bizarre. The novelty they see is rooted in reality.
Most of us assume that artists—musicians, writers, poets, painters—are strong on the fantasy side, whereas scientists, politicians, and businesspeople are realists. This may be true in terms of day-to-day routine activities. But when a person begins to work creatively, all bets are off—the artist may be as much a realist as the physicist, and the physicist as imaginative as the artist.

We certainly think of bankers, for example, as having a rather pedestrian, commonsense view of what is real and what is not. Yet a financial leader such as John Reed has much to say that dispells that notion. In his interview, he returns again and again to the theme that reality is relative and constantly changing, a perspective that he thinks is essential to confronting the future creatively:

I don’t think there is such a thing as reality. There are widely varying descriptions of reality, and you’ve got to be alert to when they change and what’s really going on. No one is going to truly grasp it, but you have to stay truly active on that end. That implies you have to have a multifaceted perspective.

There is a set of realities that exist at any moment in time. I always have some kind of a model in my mind as to what I think is going on in the world. I’m always tuning that [model] and trying to get different insights as I look at things, and I try to relate it back to what it means to our business, to how one behaves, if you will.

I don’t mean by saying there isn’t anything in the center. I just think we can look at it [reality] in so many different ways. Right now, in my business, banks are deemed to be successful based on capital ratios. Ten years ago there was no concept of the “capital ratio.” I failed totally to understand the impact of the savings and loan crisis on Congress, the regulators, and the industry. The world I’m living in today bears little resemblance to the world I lived in ten years ago, with regard to what was thought to be important. So we have defined a reality, which as I say is not empty, but it’s close to being empty.

Like anybody else, I was slow to recognize the new reality. Knowing these kinds of things turns out to be awfully relevant, because your degree of freedom get taken away if you’re off base. I went through a massive adjustment to play a game that was different from the one you saw before. But it’s a changing reality. I know goddamn well that these capital ratios are not sufficiently robust to be long-term, decent leading indicators of things, and five years from now the people who worry about how to price bank stocks are not going to be focusing on those. I describe success as evolutionary success.

What Einstein implied about art and science reappears in this account of banking: It is an evolutionary process, where current reality becomes rapidly obsolete, and one must be on the alert for the shape of things to come. At the same time, the emerging reality is not a fanciful conceit but something inherent in the here and now. It would be easy to dismiss Reed’s visionary view as the romancing of a businessman who has had too many encounters with reality. But apparently his unorthodox approach works: A recent issue of Newsweek announced: “John Reed might be excused a little fruiting... . Since his darkest days three years ago he’s quietly produced a stunning 425 percent return for investors who bought Citicorp shares.” And one commentator adds that the overseas investments Reed made were considered junk five years ago, whereas now they are seen as a hot stock. “Nothing’s changed but the perception,” the financial expert says, echoing Reed’s take on the reality of the market.

5. Creative people seem to harbor opposite tendencies on the continuum between extroversion and introversion. Usually each of us tends to be one or the other, either preferring to be in the thick of crowds or sitting on the sidelines and observing the passing show. In fact, in current psychological research, extroversion and introversion are considered the most stable personality traits that differentiate people from each other and that can be reliably measured. Creative individuals, on the other hand, seem to express both traits at the same time.

The stereotype of the “solitary genius” is strong and gets ample support also from our interviews. After all, one must generally be alone in order to write, paint, or do experiments in a laboratory. As we know from studies of young talented people, teenagers who cannot stand being alone tend not to develop their skills because practicing music or studying math requires a solitude they dread.
Only those teens who can tolerate being alone are able to master the symbolic content of a domain.

Yet over and over again, the importance of seeing people, hearing people, exchanging ideas, and getting to know another person's work and mind are stressed by creative individuals. The physicist John Wheeler expresses this point with his usual directness: "If you don't kick things around with people, you are out of it. Nobody, I always say, can be anybody without somebody being around."

Physicist Freeman Dyson expresses a fine nuance the opposite phases of this dichotomy in his work. He points to the door of his office and says:

Science is a very gregarious business. It is essentially the difference between having this door open and having it shut. When I am doing science I have the door open. I mean, that is kind of symbolic, but it is true. You want to be, all the time, talking with people. Up to a point you welcome being interrupted because it is only by interacting with other people that you get anything interesting done. It is essentially a communal enterprise. There are new things happening all the time, and you should keep abreast and keep yourself aware of what is going on. You must be constantly talking. But, of course, writing is different. When I am writing I have the door shut, and even then too much sound comes through, so very often when I am writing I go and hide in the library. It is a solitary game. So, I suppose that is the main difference. But then, afterward, of course the feedback is very strong, and you get a tremendous enrichment of contacts as a result. Lots and lots of people write me letters simply because I have written books which address a general public, so I get into touch with a much wider circle of friends. It's broadened my horizons very much. But that is only after the writing is finished and not while it is going on.

John Reed builds the alternation between inner-directed reflection and intense social interaction into his daily routine:

I'm an early morning guy. I get up at five always, get out of the shower about 5:30, and I typically try to work either at home or at the office, and that's when I do a good bit of my thinking and priority setting. I'm a great lister. I have twenty lists of things to do all the time. If I ever have five or five minutes I sit and make lists of things that I should be worrying about or doing. Typically I get to the office about 6:30. I try to keep a reasonably quiet time until 9:30 or 10:00. Then you get involved in lots of transactions. If you are chairman of the company it's like being a tribal chief. People come into your office and talk to you.

Even in the very private realm of the arts the ability to interact is essential. Nina Holton describes well the role of sociability in art:

You really can't work entirely alone in your place. You want to have a fellow artist come and talk things over with you—"How does that strike you?" You have to have some sort of feedback. You can't be sitting there entirely by yourself and never show it. And then eventually, you know, when you begin to show, you have to have a whole network. You have to get to know gallery people, you have to get to know people who work in your field who are involved. And you may want to find out whether you wish to be part of it or not be part of it, but you cannot help being part of a fellowship, you know?

Jacob Rabinow again puts into clear words the dilemma that many creative individuals face:

I remember once we had a big party and Gladys [his wife] said that I sometimes talk to a different drummer. In other words, I'm so involved in an idea I'm working on, I get so carried away, that I'm all by myself. I'm not listening to what anybody says. This sometimes happens. That you've got a new idea and you feel that it's very good and you're so involved that you're not paying attention to anybody. And you tend to drift away from people. It's very hard for me to be objective. I don't know. I'm social, I like people, I like to tell jokes, I like to go to the theater. But it's probably true that there are times when Gladys would have liked me to pay more attention to her and to the family. I love my children, they love me, and we have a
wonderful relationship. But it could be that if I were not an
inventor but had a routine job, I'd spend more time at home and
I'd pay more attention to them, and the job would be something
that I wouldn't like to do. So maybe people who don't like their
jobs love their home more. It's quite possible.

Creative individuals are also remarkably humble and proud at
the same time. It is remarkable to meet a famous person whom
you expect to be arrogant or supercilious, only to encounter self-
deprecation and shyness instead. Yet there are good reasons why
this should be so. In the first place, these individuals are well aware
that they stand, in Newton's words, "on the shoulders of giants." Their
respect for the domain in which they work makes them aware of the long line of previous contributions to it, which puts
their own into perspective. Second, they also are aware of the role
that luck played in their own achievements. And third, they are
usually so focused on future projects and current challenges that
their past accomplishments, no matter how outstanding, are no
longer very interesting to them. Elisabeth Noelle-Neumann's
answer to the question "Looking back on all your accomplish-
ments, which one would you say you are most proud of?" is typi-
cal:

I never think of what I am proud about. I never look back,
extcept to find out about mistakes. Because mistakes are hard to
remember and to draw conclusions from. But I only see danger
in thinking back about things you are proud of. When people
ask me if I am proud of something, I just shrug and hope to get
away as soon as possible. I should explain that my way is always
to look ahead, all my pleasant thoughts are about the future. It
has been this way since I was twenty years old. I start every day
fresh. The most important thing for me is to keep up the
research institute, to keep up empirical research.

Despite her great accomplishments and reputation in the field,
neuropsychologist Brenda Milner tells of being very self-critical
and of having enormous self-doubts about being creative. The
Canadian artist Michael Snow attributes the restless experimenta-
tion that led him to so many successes to a sense of confusion and
insecurity he has been trying to dispell.

Another indication of modesty is how often this question was
answered in terms of the family rather than the accomplishments
that made a person famous. For instance, Freeman Dyson's answer
was: "I suppose it is just to have raised six kids, and brought them
up, as far as one can see, all to be interesting people. I think that's
what I am most proud of, really." And John Reith's: "Oh, God,
That's real... I suppose being a parent. I have four kids. If you
had to say what has both surprised and given you a lot of pleasure,
I'd say that I'm close to my kids and I enjoy them, and I never
would have guessed that that would be as much fun as it's turned
out to be."

At the same time, of course, no matter how modest these indi-
viduals are, they know that in comparison with others they have
accomplished a great deal. And this knowledge provides a sense of
security, even pride. This is often expressed as a sense of self-
sufficiency. For instance, medical physicist Rosalyn Yalow mentioned
repeatedly that all through her life she never had any doubts about
succeeding in what she started out to do. Jacob Rabinow concurs:

"There's one other thing that you do when you invent. And that is
what I call the Existence Proof. This means that you have to
assume that it can be done. If you don't assume that, you won't
even try. And I always assume that not only it can be done, but I
can do it." Some individuals stress humility, others self-sufficiency,
but in actuality all of the people we interviewed seemed to have a
good dose of both.

Another way of expressing this duality is to see it as a contrast
between ambition and selflessness, or competition and cooperation.
It is often necessary for creative individuals to be ambitious and
aggressive. Yet at the same time, they are often willing to subordi-
nate their own personal comfort and advancement to the success of
whatever project they are working on. Aggressiveness is required
especially in fields where competition is acute, or in domains
where it is difficult to introduce novelty. In George Stigler's words:

Every scholar, I think, is aggressive in some sense. He has to
be aggressive if he wants to change his discipline. Now, if you
get a Keynes or a Friedman, they are also aggressive in that they
want to change the world, and so they become splendid public
figures as well. But that's a very hard game to play.
Brenda Milner claims that she has always been very aggressive verbally. John Gardner, statesman and founder of several national grassroots political organizations, describes well both the peaceful and aggressive instincts that coexist within the same person:

I was the president of the Carnegie Corporation. I had a very interesting life, but not a lot of new challenges, not a tumultuous life. I was well protected. When I went to Washington I discovered a lot of things about myself that I didn’t know. I discovered that I liked politicians. I got along well with them. I enjoyed dealing with the press, as much as anyone can enjoy dealing with the press. And then I discovered that I enjoyed a political fight, which was about as far away from my self-image as you can get. I’m a very peaceful person. But these things come out. Life pulls them out of you, and as I say, I’m a slow learner, but in my midfifties I learned some interesting things.

Several persons mention that in the course of their careers motivation has shifted from self-centered goals to more altruistic interests. For instance, Sarah LeVine, who started out as an anthropologist and then became a fiction writer, has this to say:

Up until quite recently, I used to think of production only for the greater glory of myself, really. I don’t see it that way at all anymore. I mean, it’s nice if one gets recognition for what one does, but much more important is to leave something that other people can learn about, and I suppose that comes with middle age.

7. In all cultures, men are brought up to be “masculine” and to disregard and repress those aspects of their temperament that the culture regards as “feminine,” whereas women are expected to do the opposite. Creative individuals to a certain extent escape this rigid gender role stereotyping. When tests of masculinity/femininity are given to young people, over and over one finds that creative and talented girls are more dominant and tough than other girls, and creative boys are more sensitive and less aggressive than their male peers.

This tendency toward androgyny is sometimes understood in purely sexual terms, and therefore it gets confused with homosexuality. But psychological androgyny is a much wider concept, referring to a person’s ability to be at the same time aggressive and nurturant, sensitive and rigid, dominant and submissive, regardless of gender. A psychologically androgynous person in effect doubles his or her repertoire of responses and can interact with the world in terms of a much richer and varied spectrum of opportunities. It is not surprising that creative individuals are more likely to have not only the strengths of their own gender but those of the other one, too.

Among the people we interviewed, this form of androgyny was difficult to detect—no doubt in part because we did not use any standard test to measure its presence. Nevertheless, it was obvious that the women artists and scientists tended to be much more assertive, self-confident, and openly aggressive than women are generally brought up to be in our society. Perhaps the most noticeable evidence for the “femininity” of the men in the sample was their great preoccupation with their family and their sensitivity to subtle aspects of the environment that other men are inclined to dismiss as unimportant. But despite having these traits that are not usual to their gender, they retained the usual gender-specific traits as well. In general, the women were perfectly “feminine” and the men thoroughly “masculine,” in addition to having cross-gender traits.

8. Generally, creative people are thought to be rebellious and independent. Yet it is impossible to be creative without having first internalized a domain of culture. And a person must believe in the importance of such a domain in order to learn its rules; hence, he or she must to a certain extent be a traditionalist. So it is difficult to see how a person can be creative without being both traditional and conservative and at the same time rebellious and iconoclastic. Being only traditional leaves the domain unchanged; constantly taking chances without regard to what has been valued in the past rarely leads to novelty that is accepted as an improvement. The artist Eva Zeisel, who says that the folk tradition in which she works is “her home,” nevertheless produces ceramics that were recognized by the Museum of Modern Art as masterpieces of contemporary design. This is what she says about innovation for its own sake:
This idea to create something different is not my aim, and shouldn't be anybody's aim. Because, first of all, if you are a designer or a playful person in any of these crafts, you have to be able to function a long life, and you can't always try to be different. I mean different from different from different. Secondly, wanting to be different can't be the motive of your work. Besides—if I talk too much let me know—to be different is a negative motive, and no creative thought or created thing grows out of a negative impulse. A negative impulse is always frustrating. And to be different means not like this and not like that. And the "not like"—that's why postmodernism, with the prefix of "post" couldn't work. No negative impulse can work, can produce any happy creation. Only a positive one.

But the willingness to take risks, to break with the safety of tradition, is also necessary. The economist George Stigler is very emphatic in this regard:

I'd say one of the most common failures of able people is a lack of nerve. They'll play safe games. They'll take whatever the literature's doing and add a little bit to it. In our field, for example, we study oligopoly, which is a situation in which there are two sellers. Then why not try three and see what that does. So there's a safe game to play. In innovation, you have to play a less safe game, if it's going to be interesting. It's not predictable that it'll go well.

9. Most creative persons are very passionate about their work, yet they can be extremely objective about it as well. The energy generated by this conflict between attachment and detachment has been mentioned by many as being an important part of their work. Why this is the case is relatively clear. Without the passion, we soon lose interest in a difficult task. Yet without being objective about it, our work is not very good and lacks credibility. So the creative process tends to be what some respondents called a yin-yang alternation between these two extremes. Here is how the historian Natalie Davis puts it:

I am sometimes like a mother trying to bring the past to life again. I love what I am doing and I love to write. I just have a
great deal of affect invested in bringing these people to life again, in some way. It doesn't mean that I love my characters, necessarily, these people from the past. But I love to find out about them and re-create them or their situation. I think it is very important to find a way to be detached from what you write, so that you can't be so identified with your work that you can't accept criticism and response, and that is the danger of having as much affect as I do. But I am aware of that and of when I think it is particularly important to detach oneself from the work, and that is something where age really does help.

10. Finally, the openness and sensitivity of creative individuals often exposes them to suffering and pain yet also a great deal of enjoyment. The suffering is easy to understand. The greater sensitivity can cause slights and anxieties that are not usually felt by the rest of us. Most would agree with Rabinow's words: "Inventors have a low threshold of pain. Things bother them." A badly designed machine causes pain to an inventive engineer, just as the creative writer is hurt when reading bad prose. Being alone at the forefront of a discipline also makes you exposed and vulnerable. Eminence invites criticism and often vicious attacks. When an artist has invested years in making a sculpture, or a scientist in developing a theory, it is devastating if nobody cares.

Ever since the Romantic movement gained ascendance a few centuries ago, artists have been expected to suffer in order to demonstrate the sensitivity of their souls. In fact, research shows that artists and writers do have unusually high rates of psychopathology and addictions. But what is the cause, what is the effect? The poet Mark Strand comments:

There have been a lot of unfortunate cases of writers, painters, who have been melancholic, depressed, taken their own lives. I don't think it goes with the territory. I think those people would have been depressed, or alcoholic, suicidal, whatever, even if they weren't writing. I just think it's their characterological makeup. Whether that characterological makeup drove them to write or to paint, as well as to alcohol or to suicide, I don't know. I know there are an awful lot of healthy
writers and painters who have no thoughts of suicide. I think it’s a myth, by and large. It creates a special aura, a frailty, around the artist to say that he lives so close to the edge. He’s so responsive to the world around him, so sensitive, so driven to respond to it, it’s almost unbearable. That he must escape either through drugs or alcohol, finally suicide, the burden of consciousness is so great. But the burden of consciousness is great for people who don’t—you know—want to kill themselves.

It is also true that deep interest and involvement in obscure subjects often goes unrewarded, or even brings on ridicule. Divergent thinking is often perceived as deviant by the majority, and so the creative person may feel isolated and misunderstood. These occupational hazards do come with the territory, so to speak, and it is difficult to see how a person could be creative and at the same time insensitive to them.

Perhaps the most difficult thing for a creative individual to bear is the sense of loss and emptiness experienced when, for some reason or another, he or she cannot work. This is especially painful when a person feels one’s creativity drying out; then the whole self-concept is jeopardized, as Mark Strand suggests:

Yeah, there’s a momentary serenity, a sense of satisfaction, when you come up with an idea that you think is worth pursuing. Another form of that is when you have completed, where you’ve done as much as you can with an idea that you thought was worth working on. Then you sort of bask in the glow of completion for a day, maybe. You know, have a glass or two more of wine at night because you don’t feel you have to go upstairs and look at anything again.

And then you’re beginning again. You hope. Sometimes the hiatus will last not overnight but for weeks, months, and years. And the longer the hiatus is between books that you’re committed to finishing, the more painful and frustrating life becomes. When I say “painful,” that’s probably too grandiose a term for the petty frustration one feels. But if it goes on, and on, and you develop what people call a writer’s block, it’s painful, because your identity’s at stake. If you’re not writing, and you’re a writer and known as a writer, what are you?

Yet when the person is working in the area of his or her expertise, worries and cares fall away, replaced by a sense of bliss. Perhaps the most important quality, the one that is most consistently present in all creative individuals, is the ability to enjoy the process of creation for its own sake. Without this trait poets would give up striving for perfection and would write commercial jingles, economists would work for banks where they would earn at least twice as much as they do at the university, physicists would stop doing basic research and join industrial laboratories where the conditions are better and the expectations more predictable. In fact, enjoyment is such an important part of creativity that we devote chapter 5 to the connection. Here I report a single illustration, just as a place marker, to make sure that we don’t lose sight of this essential component:

Margaret Butler is a computer scientist and mathematician, the first woman elected a fellow of the American Nuclear Society. In describing her work, like most of our respondents, she keeps stressing this element of fun, of enjoyment. In answer to the question “Of your accomplishments at work, what are you most proud of?” she answers:

Well, in my work I think that the most interesting and exciting things that I have done were in the early days at Argonne when we were building computers. We worked on a team to design one of the first computers. We developed image analysis software with the people in the biology division for scanning chromosomes and trying to do automatic karyotyping, and I think that was the most fun that I had in all of my forty-plus years at the lab.

It is interesting that this response, stressing fun and excitement, came in answer to a question about what she is most proud of in her work. Later on, she says:

I worked and worked. You work hard. You try to do your best. When we were working on the chromosome project, Jim [her husband] and I spent sometimes the whole night over there working. We would come out in the morning and the sun would be coming up. Science is very much fun. And I think women should have the opportunity to have fun.
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.”

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 siren in Goethe’s Faust II:

Zum Schen geben
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, tall, 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 slugs 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 electrodynamical 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 Liv’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 Liv 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 Radnóthy, 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. Running 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—**DA M ENDANGERES RARE FISH OF TRAIN FULL OF GARBAGE DETAINS 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 Pharmacopeia 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 shut 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 dropped 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 other artists 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 Gardener 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 evolutional 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 came 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.

C

reative 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, businessmen 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
enjoyable. But if one does these things a certain way, then they become intrinsically rewarding, worth doing for their own sake. What is the secret of transforming activities so that they are rewarding in and of themselves?

**Programmed for Creativity**

When people are asked to choose from a list the best description of how they feel when doing whatever they enjoy doing most—reading, climbing mountains, playing chess, whatever—the answer most frequently chosen is "designing or discovering something new." At first, it seems strange that dancers, rock climbers, and composers all agree that their most enjoyable experiences resemble a process of discovery. But when we think about it some more, it seems perfectly reasonable that at least some people should enjoy discovering and creating above all else.

To see the logic of this, try a simple thought experiment. Suppose that you want to build an organism, an artificial life form, that will have the best chance of surviving in a complex and unpredictable environment, such as that on Earth. You want to build into this organism some mechanism that will prepare it to confront as many of the sudden dangers and to take advantage of as many of the opportunities that arise as possible. How would you go about doing this? Certainly you would want to design an organism that is basically conservative, one that learns the best solutions from the past and keeps repeating them, trying to save energy, to be cautious and go with the tried-and-true patterns of behavior.

But the best solution would also include a relay system in a few organisms that would give a positive reinforcement every time they discovered something new or came up with a novel idea or behavior, whether or not it was immediately useful. It is especially important to make sure that the organism was not rewarded only for useful discoveries, otherwise it would be severely handicapped in meeting the future. For no earthly builder could anticipate the kind of situations the species of new organisms might encounter tomorrow, next year, or in the next decade. So the best program is one that makes the organism feel good whenever something new is discovered, regardless of its present usefulness. And this is what seems to have happened with our race through evolution.

By random mutations, some individuals must have developed a nervous system in which the discovery of novelty stimulates the pleasure centers in the brain. Just as some individuals derive a keener pleasure from sex and others from food, so some must have been born who derived a keener pleasure from learning something new. It is possible that children who were more curious ran more risks and so were more likely to die early than their more stolid companions. But it is also probable that those human groups that learned to appreciate the curious children among them, and helped to protect and reward them so that they could grow to maturity and have children of their own, were more successful than groups that ignored the potentially creative in their midst.

If this is true, we are the descendants of ancestors who recognized the importance of novelty, protected those individuals who enjoyed being creative, and learned from them. Because they had among them individuals who enjoyed exploring and inventing, they were better prepared to face the unpredictable conditions that threatened their survival. So we too share this propensity for enjoying whatever we do, provided we can do it in a new way, provided we can discover or design something new in doing it. This is why creativity, no matter in what domain it takes place, is so enjoyable. This is why Brenda Milner, among many others, said: "I would say that I am impartial about what is important or great, because every new little discovery, even a tiny one, is exciting at the moment of discovery."

But this is only part of the story. Another force motivates us, and it is more primitive and more powerful than the urge to create: the force of entropy. This too is a survival mechanism built into our genes by evolution. It gives us pleasure when we are comfortable, when we relax, when we can get away with feeling good without expending energy. If we didn't have this built-in regulator, we could easily kill ourselves by running ragged and then not having enough reserves of strength, body fat, or nervous energy to face the unexpected.

This is the reason why the urge to relax, to curl up comfortably on the sofa whenever we can get away with it, is so strong. Because this conservative urge is so powerful, for most people "free time" means a chance to wind down, to park the mind in neutral. When there are no external demands, entropy kicks in, and unless we understand what is happening, it takes over our body and our mind.
We are generally torn between two opposite sets of instructions programmed into the brain: the least-effort imperative on one side, and the claims of creativity on the other.

In most individuals entropy seems to be stronger, and they enjoy comfort more than the challenge of discovery. A few, like the ones who tell their stories in this book, are more responsive to the rewards of discovery. But we all respond to both of these rewards; the tendencies toward conserving energy as well as using it constructively are simultaneously part of our inheritance. Which one wins depends not only on our genetic makeup but also presumably on our early experiences. However, unless enough people are motivated by the enjoyment that comes from confronting challenges, by discovering new ways of being and doing, there is no evolution of culture, no progress in thought or feeling. It is important, therefore, to understand better what enjoyment consists of and how creativity can produce it.

**What Is Enjoyment?**

In order to answer that question, many years ago I started to study people who seemed to be doing things that they enjoyed but were not rewarded for with money or fame. Chess players, rock climbers, dancers, and composers devoted many hours a week to their avocations. Why were they doing it? It was clear from talking to them that what kept them motivated was the quality of experience they felt when they were involved with the activity. This feeling didn't come when they were relaxing, when they were taking drugs or alcohol, or when they were consuming the expensive privileges of wealth. Rather, it often involved painful, risky, difficult activities that stretched the person's capacity and involved an element of novelty and discovery. This optimal experience is what I have called **flow**, because many of the respondents described the feeling when things were going well as an almost automatic, effortless, yet highly focused state of consciousness.

The flow experience was described in almost identical terms regardless of the activity that produced it. Athletes, artists, religious mystics, scientists, and ordinary working people described their most rewarding experiences with very similar words. And the description did not vary much by culture, gender, or age; old and young, rich and poor, men and women, Americans and Japanese seem to experience enjoyment in the same way, even though they may be doing very different things to attain it. Nine main elements were mentioned over and over again to describe how it feels when an experience is enjoyable.

1. **There are clear goals every step of the way.** In contrast to what happens in everyday life, on the job or at home, where often there are contradictory demands and our purpose is unsure, in flow we always know what needs to be done. The musician knows what notes to play next, the rock climber knows the next move to make. When a job is enjoyable, it also has clear goals: The surgeon is aware how the incision should proceed moment by moment; the farmer has a plan for how to carry out the planting.

2. **There is immediate feedback to one's actions.** Again, in contrast to the usual state of affairs, in a flow experience we know how well we are doing. The musician hears right away whether the note played is the one. The rock climber finds out immediately whether the move was correct because he or she is still hanging in there and hasn't fallen to the bottom of the valley. The surgeon sees there is no blood in the cavity, and the farmer sees the furrows lining up neatly in the field.

3. **There is a balance between challenges and skills.** In flow, we feel that our abilities are well matched to the opportunities for action. In everyday life we sometimes feel that the challenges are too high in relation to our skills, and then we feel frustrated and anxious. Or we feel that our potential is greater than the opportunities to express it, and then we feel bored. Playing tennis or chess against a much better opponent leads to frustration; against a much weaker opponent, to boredom. In a really enjoyable game, the players are balanced on the fine line between boredom and anxiety. The same is true when work, or a conversation, or a relationship is going well.

4. **Action and awareness are merged.** It is typical of everyday experience that our minds are disjointed from what we do. Sitting in class, students may appear to be paying attention to the teacher, but
they are actually thinking about lunch, or last night's date. The worker thinks about the weekend; the mother cleaning house is worried about her child; the golfer's mind is preoccupied with how his swing looks to his friends. In flow, however, our concentration is focused on what we do. One-pointedness of mind is required by the close match between challenges and skills, and it is made possible by the clarity of goals and the constant availability of feedback.

5. **Distractions are excluded from consciousness.** Another typical element of flow is that we are aware only of what is relevant here and now. If the musician thinks of his health or tax problems when playing, he is likely to hit a wrong note. If the surgeon's mind wanders during an operation, the patient's life is in danger. Flow is the result of intense concentration on the present, which relieves us of the usual fears that cause depression and anxiety in everyday life.

6. **There is no worry of failure.** While in flow, we are too involved to be concerned with failure. Some people describe it as a feeling of total control; but actually we are not in control, it's just that the issue does not even come up. If it did, we would not be concentrating totally, because our attention would be split between what we did and the feeling of control. The reason that failure is not an issue is that in flow it is clear what has to be done, and our skills are potentially adequate to the challenges.

7. **Self-consciousness disappears.** In everyday life, we are always monitoring how we appear to other people; we are on the alert to defend ourselves from potential slights and anxious to make a favorable impression. Typically this awareness of self is a burden. In flow we are too involved in what we are doing to care about protecting the ego. Yet after an episode of flow is over, we generally emerge from it with a stronger self-concept; we know that we have succeeded in meeting a difficult challenge. We might even feel that we have stepped out of the boundaries of the ego and have become part, at least temporarily, of a larger entity. The musician feels at one with the harmony of the cosmos, the athlete moves at one with the team, the reader of a novel lives for a few hours in a different reality. Paradoxically, the self expands through acts of self-forgetfulness.

8. **The sense of time becomes distorted.** Generally in flow we forget time, and hours may pass by in what seem like a few minutes. Or the opposite happens: A figure skater may report that a quick turn that in real time takes only a second seems to stretch out for ten times as long. In other words, clock time no longer marks equal lengths of experienced time; our sense of how much time passes depends on what we are doing.

9. **The activity becomes autotelic.** Whenever most of these conditions are present, we begin to enjoy whatever it is that produces such an experience. I may be scared of using a computer and learn to do it only because my job depends on it. But as my skills increase, and I recognize what the computer allows me to do, I may begin to enjoy using the computer for its own sake as well. At this point the activity becomes autotelic, which is Greek for something that is an end in itself. Some activities such as art, music, and sports are usually autotelic: There is no reason for doing them except to feel the experience they provide. Most things in life are exotelic. We do them not because we enjoy them but in order to get at some later goal. And some activities are both: The violinist gets paid for playing, and the surgeon gets status and good money for operating, as well as getting enjoyment from doing what they do. In many ways, the secret to a happy life is to learn to get flow from as many of the things we have to do as possible. If work and family life become autotelic, then there is nothing wasted in life, and everything we do is worth doing for its own sake.

**The Conditions for Flow in Creativity**

Creativity involves the production of novelty. The process of discovery involved in creating something new appears to be one of the most enjoyable activities any human can be involved in. In fact, it is easy to recognize the conditions of flow in the accounts of our respondents, as they describe how it feels to do the sort of things they do.
The Clarity of Goals
In certain conditions, the creative process begins with the goal of solving a problem that is given to the person by someone else or is suggested by the state of the art in the domain. Moreover, anything that does not work as well as it could can provide a clear goal to the inventor. This is what Frank Offner describes:

Oh, I love to solve problems. If it is why our dishwasher does not work, or why the automobile does not work, or how the nerve works, or anything. Now I am working on how the hair cells work, and ah... it is so very interesting. I don't care what kind of problem it is. If I can solve it, it is fun. It is really a lot of fun to solve problems, isn't it? Isn't that what is interesting in life? Especially if people say one thing and you show that they have been wrong for twenty years and you can solve it in five minutes.

Or the goal may emerge as a problem in the domain—a gap in the network of knowledge, a contradiction among the findings, a puzzling result. Here the goal is to restore harmony in the system by reconciling the apparent disparities. The physicist Viktor Weisskopf describes the enjoyment involved in this process:

Well, in science, obviously, if I understand something, you know, a new discovery, it need not be my own, a discovery of somebody else, where I say, "Aha, now I understand natural processes that I did not understand before," that is the joy of insight.

In music it is the insight into what the piece means. What it tells you, what the composer wanted to tell you, the beauty or expression or religious feelings, things like that.

For artists the goal of the activity is not so easily found. In fact, the more creative the problem, the less clear it is what needs to be done. Discovered problems, the ones that generate the greatest changes in the domain, are also the most difficult to enjoy working on because of their elusiveness. In such cases, the creative person somehow must develop an unconscious mechanism that tells him or her what to do. The poet György Faludy usually does not start writing until a "voice" tells him, often in the middle of the night, "György, it's time to start writing." He adds ruefully: "That voice has my number, but I don't have his." The ancients called that voice the Muse. Or it can be a vision, as it is for Robertson Davies:

You are always writing, and you're always fantasizing. What I find very much in my own work, though I don't know if it applies to the work of other people, is that an idea for a novel seizes me and will not let me go until I have given it careful consideration. And that is not to say that a complete story appears in my head, but very often what appears is a picture which seems somehow significant and which must be considered. Now, a great many years ago, I found that whenever I stopped thinking about something in particular, a picture kept coming up in my head. It was a picture of a street, and I knew what street it was; it was the street on which I was born in a small Ontario village. And there were two boys playing in the snow and one threw a snowball at the other.

Readers of Davies’s oeuvre will recognize in this picture the opening scene of Fifth Business, the first volume of his famous Deptford trilogy. In many ways, the writing of the book consisted in finding out what that image, charged with emotion and nostalgia, portended. The goal was to find out what were the consequences of throwing that snowball. Probably if Davies had told himself rationally that this is what the book would be about he would have thought it a trivial goal, not worth all the time and effort. But fortunately the goal presented itself as a vision, a mysterious call that he felt impelled to follow. Very often this is how the Muse communicates—through a glass darkly, as it were. It is a splendid arrangement, for if the artist were not tricked by the mystery, he or she might never venture into the unexplored territory.

Knowing How Well One Is Doing
Games are designed so that we can keep score and know how well we are doing. Most jobs give some sort of information about performance: The salesman can add up daily sales, the assembly worker can count items produced. If all else fails, the boss may tell you how well you are doing. But the artist, the scientist, and the inventor are moving on very different timelines. How do they know, day in and day out, whether they are wasting their time or actually accomplishing something?
This is indeed a difficult problem. Many artists give up because it is just too exhausting to wait until critics or galleries take notice and pass judgment on their canvases. Research scientists drift away from pure science because they cannot tolerate the long cycles of insecurity before reviewers and editors evaluate their results. So how can they experience flow without external information about their performance?

The solution seems to be that those individuals who keep doing creative work are those who succeed in internalizing the field's criteria of judgment to the extent that they can give feedback to themselves, without having to wait to hear from experts. The poet who keeps enjoying writing verse is the one who knows how good each line is, how appropriate each word chosen. The scientist who enjoys her work is the one who has a sense of what a good experiment is like and who appreciates it when a test is well run or when a report is readily written. Then she need not wait until October to see if her name is on the Nobel Prize list.

Many creative scientists say that the difference between them and their less creative peers is the ability to separate bad ideas from good ones, so that they don't waste much time exploring blind alleys. Everyone has both bad and good ideas all the time, they say. But some people can't tell them apart until it's too late, until they have already invested a great deal of time in the unprofitable hunches. This is another form of the ability to give oneself feedback: to know in advance what is feasible and what will work, without having to suffer the consequences of bad judgment. At Linus Pauling's sixtieth birthday celebration, a student asked him, "Dr. Pauling, how does one go about having good ideas?" He replied, "You have a lot of ideas and throw away the bad ones." To do that, of course, one has to have a very well internalized picture of what the domain is like and what constitutes "good" and "bad" ideas according to the field.

Balancing Challenges and Skills
The pursuit of a creative problem is rarely easy. In fact, in order to be enjoyable it should be hard, and of course so it is, almost by definition. It is never easy to break new ground, to venture into the unknown. When one starts out, the difficulties may seem almost overwhelming. Here is how Freeman Dyson describes this aspect of the process:

Well, I think that you have to describe it as sort of a struggle. I have to always force myself to write, and also to work harder at a science problem. You have to put blood, sweat, and tears into it first. And it is awfully hard to get started. I think most writers have this problem. I mean, it's part of the business. You may work very hard for a week producing the first page. That's really blood, tears, and sweat, and there is nothing else to describe it. You have to force yourself to push and push and push with the hope that something good will come out. And you have to go through that process before it really starts to flow easily, and without that preliminary forcing and pushing probably nothing would ever happen. So, I think that is what distinguishes it from just having a good time—you have a good time once you are really in the flowing phase, but you have to overcome some sort of barrier to get there. That is why I say it is unconscious, because you don't know actually whether you are really getting anywhere or not. In that phase it just seems to be unadulterated torture.

The creative person is not immune to the conflict between the two programs we all carry in our genetic inheritance. As Dyson knows, even the most creative persons must overcome the barrier of entropy. It is impossible to accomplish something that is truly new and worthwhile without struggling with it. It isn't just in competitive sports that the saying "no pain, no gain" applies. The less well defined the problem, the more ambitious it is, and the harder it is for the creative person to get a handle on it. Barry Commoner points out:

I enjoy doing things that other people won't do. Because what are they? They're usually things that are difficult and important—and that people shy away from. I have a general approach to thinking of the way in which issues develop. I'm interested in the origins of problems. And so I have a pretty good idea of where things are going, and what's important and what isn't important. And I try very hard to be at the cutting edge of problems. Very often that puts me so far out in front that people are upset about it, but that's OK.

To be able to cope with such problems, the creative person has to have a great many personality traits that are conducive to discovery
and hard work, including the ability to internalize the rules of the
domain and the judgments of the field. Commoner also gives a hint
of another skill that creative individuals develop: a personal approach,
an internal model that allows them to put the problem into a mana-
gable context. The same idea is expressed by Linus Pauling:

I think one thing that I do is to bring ideas from one field of
knowledge into another field of knowledge. And, I've often said I
don't think that I'm smarter than a lot of other scientists, but per-
haps I think more about the problems. I have a picture, a sort of
general theory of the universe in my mind that I've built up over
the decades. If I read an article, or hear someone give a seminar
talk, or in some other way get some piece of information about
science that I hadn't had before, I ask myself, "How does that fit
into my picture of the universe?" and if it doesn't fit, I ask, "Why
doesn't it fit in?"

The strategies creative individuals develop are not always suc-
cessful. They take risks, and what is risk without an occasional failure?
When the challenges become too great for the person to cope with,
a sense of frustration rather than joy creeps in—at least for a while.
Our interview with John Reed took place a few years after Citicorp
was bloodied in the market; its shares lost a great deal of their value
almost overnight. Reed blamed himself for not foreseeing the con-
tingency that caused the loss. As a result, at the time he felt that some
of the fun had gone out of his job. What used to be spontaneous
turned into hard work; he had to force himself to be more of an
accountant than a builder and leader; and the new skill he had to
acquire required unfamiliar discipline.

The Merging of Action and Awareness
But when the challenges are just right, the creative process begins to
hum, and all other concerns are temporarily shelved in the deep
involvement with the activity. Here is Dyson again, describing how it
feels after the initial struggle is over:

I always find that when I am writing, it is really the fingers that
are doing it and not the brain. Somehow the writing takes charge.
And the same thing happens of course with equations. You don't
really think of what you are going to write. You just scribble, the
equations lead the way, and what you are doing is sort of architec-
tural. You have to have a design in view, in which you design a
chapter, or a proof of a theorem, as the case may be. Then you
have to put it together out of words or out of symbols as the case
may be, but if you don't have a clear architecture in mind then the
thing won't end up being any good. The trick is to start from both
ends and to meet in the middle, which is essentially like building a
bridge. That seems to me the way that I think, anyhow. So the
original design is somehow accidental and you don't know how it
comes into your head. It just sort of happens, maybe when you are
shaving or taking a walk, then you sit down and actually work
through and that is when the hard work is done. And that is very
largely a matter of putting pieces together, finding out what works
and what doesn't.

Barry Commoner uses similar terms to describe the almost auto-
matic quality of the flow experience when writing, expressing the
feeling of merging action and awareness through the image of the
flowing ink and the flowing of ideas:

I write with this pen [he removes a fountain pen from his breast
pocket and holds it up]. And it's very clear to me that my ability to
think and write at the same time depends on the flow of ink. The
thing I enjoy most is the flow of my own ideas and getting them
down on paper. I will not write with a ballpoint pen, because it
doesn't really flow. That's why I use a fountain pen. And only a
fountain pen that really works very well.

The novelist Richard Stern gives a classic description of how it
feels to become lost in the process of writing and to feel the rightness
of one's actions in terms of what is happening in that special world of
one's own creation:

At your best you're not thinking. How am I making my way
ahead in the world by doing this? No. You're concentrated on your
characters, on the situation, on the form of the book, on the words
which are coming out. And their shape. You've lost ... you're not
an ego at that point. It's not competitive. It's ... I would use the
word pure. You know that this is right. I don’t mean that it works in the world, or that it adds up, but that it’s right in this place. In this story. It belongs to it. It’s right for that person, that character.

Avoiding Distractions
Many of the peculiarities attributed to creative persons are really just ways to protect the focus of concentration so that they may lose themselves in the creative process. Distractions interrupt flow, and it may take hours to recover the peace of mind one needs to get on with the work. The more ambitious the task, the longer it takes to lose oneself in it, and the easier it is to get distracted. A scientist working on an arcane problem must detach himself from the “normal” world and mam with his mind in a world of disembodied symbols that now you see, now you don’t. Any intrusion from the solid world of everyday reality can make that world disappear in an instant. It is for this reason that Freeman Dyson “hides” in the library when he’s writing and why Marcel Proust used to seclude himself in a windowless room lined with cork when he sat down to write À la recherche du temps perdu. Even the slightest noise could break the thread of his teetering imagination.

More serious health, family, or financial problems could occupy the mind of a person so insistently that he or she is no longer able to devote enough attention to work. Then a long period of drought may follow, a writer’s block, a burnout, which may end a creative career. It is this kind of distraction that Jacob Rabinow talks about:

Freedom from worry is one thing—that you don’t have any problem of health or sickness in the family or something that occupies your mind. Or financial worries, that you’re going crazy about how you’re going to pay the next bill. Or children’s worries, or drugs or something. No, it’s nice to be free of responsibility. That doesn’t mean you have no responsibility to the project, but to be free of other things. And you’re not likely to be an inventor if you’re very sick. You’re too busy with your problems, too many pains.

Many of our respondents were thankful to their spouses for providing a buffer from exactly these kinds of distractions. This was especially true of the men; the women sometimes mentioned pointedly that they also would have liked to have had a wife to spare them from worries that interfered with their concentration on work.

Forgetting Self, Time, and Surroundings
When distractions are out of the way and the other conditions for flow are in place, the creative process acquires all the dimensions of flow. Here it is described by the poet Mark Strand:

Well, you’re right in the work, you lose your sense of time, you’re completely enraptured, you’re completely caught up in what you’re doing, and you’re sort of swayed by the possibilities you see in this work. If that becomes too powerful, then you get up, because the excitement is too great. You can’t continue to work or continue to see the end of the work because you’re jumping ahead of yourself all the time. The idea is to be so... so saturated with it that there’s no future or past, it’s just an extended present in which you’re, uh, making meaning. And dismantling meaning, and remaking it. Without undue regard for the words you’re using. It’s meaning carried to a high order. It’s not just essential communication, daily communication; it’s a total communication. When you’re working on something and you’re working well, you have the feeling that there’s no other way of saying what you’re saying.

He captures precisely the sense of flowing along this extended present and the powerful sense of doing exactly the right thing the only way it could be done. It may not happen often, but when it does the beauty of it justifies all the hard work.

Creativity as Autotelic Experience
This then brings us back to where we started this chapter and the observation that all of the respondents placed the joy of working ahead of any extrinsic rewards they may receive from it. Like most of the others, the psychologist Donald Campbell gives unambiguous advice to young people entering the field:

I would say: “Don’t go into science if you are interested in money. Don’t go into science if you will not enjoy it even if you
do not become famous. Let fame be something that you accept graciously if you get it, but make sure that it is a career that you can enjoy. That requires intrinsic motivation. And try to pick a setting in which you can work on the problems that intrinsically motivate you even if they are not exciting to others. Try to have the situational setting so that you can enjoy that work intrinsically, even if you are out of step with the time."

Scientists often describe the autotelic aspects of their work as the exhilaration that comes from the pursuit of truth and of beauty. What they seem to describe, however, is the joy of discovery, of solving a problem, of being able to express an observed relationship in a simple and elegant form. So what is rewarding is not a mysterious and ineffable external goal, but the activity of science itself. It is the pursuit that counts, not the attainment. Of course this distinction is to a certain extent misleading, because without occasional successes the scientist might become discouraged. But what makes science intrinsically rewarding is the everyday practice, not the rare success. This is how Subrahmanyan Chandrasekhar, the Nobel laureate physicist, describes his own motivation:

There are two things about me which people generally don’t know. I’ve never worked in anything which is glamorous in any sense. That’s point number one. Point number two: I have always worked in areas which, during the time I have worked on them, did not attract attention.

The word success is an ambiguous word. Success with respect to the outside? Or success with respect to oneself? And if it is a success with respect to the outside, then how do you evaluate it? Very often outside success is irrelevant, wrong, and misplaced. So how can one talk about it? Externally, you may think I am successful because people write about some aspects of my work. But that is an external judgment. And I have no idea as to how to value that judgment.

Success is not one of my motives. Because success stands in contrast to failure. But no worthwhile effort in one’s life is either a success or a failure. What do you mean by success? You take a problem and you want to solve it. Well, if you solve it, in a limited sense it is a success. But it may be a trivial problem. So a judgment about success is not something about which I’ve ever been serious about in any sense whatever.

Certainly all of these people seem to have heeded their own advice. None pursued money and fame. Some became comfortably wealthy from their inventions or their books, but none of them felt fortunate because of it. What they felt fortunate about was that they could get paid for something they had such fun doing and that in the bargain they could feel that what they did might help the human condition along. It is indeed lucky to be able to justify one’s life with words such as those of C. Vann Woodward, who explains why he writes history:

It interests me. It is a source of satisfaction. Achieving something that one thinks is important. Without such a consciousness or motivation it seems to me that life could be rather dull and purposeless, and I wouldn’t want to attempt that kind of life. Of complete leisure, say, of having absolutely nothing to do that one felt was worth doing—that strikes me as a rather desperate situation to be in.

**Flow and Happiness**

What is the relation between flow and happiness? This is a very interesting and delicate question. At first, it is easy to conclude that the two must be the same thing. But actually the connection is a bit more complex. First of all, when we are in flow, we do not usually feel happy—for the simple reason that in flow we feel only what is relevant to the activity. Happiness is a distraction. The poet in the middle of writing or the scientist working out equations does not feel happy, at least not without losing the thread of his or her thought.

It is only after we get out of flow, at the end of a session or in moments of distraction within it, that we might indulge in feeling happy. And then there is the rush of well-being, of satisfaction that comes when the poem is completed or the theorem is proved. In the long run, the more flow we experience in daily life, the more likely we are to feel happy overall. But this also depends on what activity provides flow. Unfortunately, many people find the only challenges
they can respond to are violence, gambling, random sex, or drugs. Some of these experiences can be enjoyable, but these episodes of flow do not add up to a sense of satisfaction and happiness over time. Pleasure does not lead to creativity, but soon turns into addiction—the thrill of entropy.

So the link between flow and happiness depends on whether the flow-producing activity is complex, whether it leads to new challenges and hence to personal as well as cultural growth. Thus we might conclude that all our respondents must be happy, because they do enjoy their work, and their work is certainly complex. But there are further complications to consider. For instance, what if a person enjoyed being a physicist for thirty years, and then found out that his work resulted in a nuclear device that killed millions of people? How would Jonas Salk have felt if his vaccine, instead of saving lives, had been used by others for biological warfare? Certainly these are not idle questions in today’s world, and they suggest that it is possible for complex activities that produce flow to cause long-range unhappiness. Yet when all is said and done, it is much easier to be happy when one’s life has been enjoyable.

Flow and the Evolution of Consciousness

There are many things that people enjoy: the pleasures of the body, power and fame, material possessions. Some enjoy collecting different beer bottles, and a few even enjoy causing pain to themselves or to others. Strangely enough, even though the means to obtain it are widely different, the resulting feeling of well-being is very much the same. Does that mean that all forms of enjoyment are equally worth pursuing?

Twenty-five centuries ago, Plato wrote that the most important task for a society was to teach the young to find pleasure in the right objects. Now Plato was conservative even for his times, so he had rather definite ideas about what those “right things” were that young people should learn to enjoy. We are much too sophisticated in this day and age to have strong feelings in the matter. Yet we probably agree that we would feel better if our children learned to enjoy cooperation rather than violence; reading rather than stealing; chess rather than dice; hiking rather than watching television. In other words, no matter how relativistic and tolerant we have become, we still have priorities. And we do want the next generation to share those priorities. Finally, many of us suspect that the next generation will not preserve what we value unless they now enjoy it to some extent.

The problem is that it is easier to find pleasure in things that are easier, in activities like sex and violence that are already programmed into our genes. Hunting, fishing, eating, and mating have privileged places in our nervous system. It is also easy to enjoy making money, or discovering new lands, or conquering new territories, or building elaborate palaces, temples, or tombs because these projects are in synchrony with survival strategies established long ago in our physiological makeup. It is much more difficult to learn to enjoy doing things that were discovered recently in our evolution, like manipulating symbolic systems by doing math or science or writing poetry or music, and learning from doing these things about the world and about ourselves.

Children grow up believing that football players and rock singers must be happy and envy the stars of the entertainment world for what they think must be fabulous, fulfilling lives. Asked what they would like to do when they grow up, most of them would choose to be athletes and entertainers. They don’t realize until much later, if at all, that the glamour of those lives is vulgar tinsel, that to be like them leads anywhere but to happiness.

Neither parents nor schools are very effective at teaching the young to find pleasure in the right things. Adults, themselves often deluded by infatuation with fatuous models, conspire in the deception. They make serious tasks seem dull and hard, and frivolous ones exciting and easy. Schools generally fail to teach how exciting, how mesmerizingly beautiful science or mathematics can be; they teach the routine of literature or history rather than the adventure.

It is in this sense that creative individuals live exemplary lives. They show how joyful and interesting complex symbolic activity is. They have struggled through marshes of ignorance, deserts of disinterest, and with the help of parents and a few visionary teachers they have found themselves on the other side of the known. They have become pioneers of culture, models for what men and women of the future will be—if there is to be a future at all. It is by following their example that human consciousness will grow beyond the limitations
of the past, the programs that genes and cultures have wired into our brains. Perhaps our children, or their children, will feel more joy in writing poetry and solving theorems than in being passively entertained. The lives of these creative individuals reassure us that it is not impossible.

Even the most abstract mind is affected by the surroundings of the body. No one is immune to the impressions that impinge on the senses from the outside. Creative individuals may seem to disregard their environment and work happily in even the most dismal surroundings: Michelangelo contorted on his scaffold below the Sistine ceiling, the Curies freezing in their shabby Parisian lab, and an infinitude of poets scribbling away in dingy rented rooms. But in reality, the spatiotemporal context in which creative persons live has consequences that often go unnoticed. The right milieu is important in more ways than one. It can affect the production of novelty as well as its acceptance; therefore, it is not surprising that creative individuals tend to gravitate toward centers of vital activity, where their work has the chance of succeeding. From time immemorial artists, poets, scholars, and scientists have sought out places of natural beauty expecting to be inspired by the majestic peaks or the thundering sea. But in the last analysis, what sets creative individuals apart is that regardless of whether the conditions in which they find themselves are luxurious or miserable, they manage to give their surroundings a personal pattern that echoes the rhythm of their thoughts and habits.
of action. Within this environment of their own making, they can forget the rest of the world and concentrate on pursuing the Muse.

BEING IN THE RIGHT PLACE

The great centers of learning and commerce have always acted as magnets for ambitious individuals who wanted to leave their mark on the culture. From the Middle Ages onward, master craftsmen traveled all over Europe to build cathedrals and palaces, attracted now by the wealth of one city, then by that of another. Milanese stonemasons built fortresses for Teutonic knights in Poland; Venetian architects and painters went to decorate the courts of the tsars of Russia. Even Leonardo, that paragon of creativity, kept serving one master after another depending on whether duke, pope, or king could best finance his dreams.

The place where one lives is important for three main reasons. The first is that one must be in a position to access the domain in which one plans to work. Information is not distributed evenly in space but is clumped in different geographical nodes. In the past, when the diffusion of information was slower, one went to Göttingen to study some branches of physics, to Cambridge or Heidelberg for others. Even with our dazzling electronic means for exchanging information, New York is still the best place for an aspiring artist to find out firsthand what's happening in the art world, what future trends other artists are talking about. But New York is not the best place to learn oceanography, or economics, or astronomy. Iowa might be the place to learn creative writing or etching, and one can learn things about neural networks in Pittsburgh that one cannot learn anywhere else.

People in our sample often moved to places where information of interest was stored: Subrahmanyan Chandrasekhar took a boat from India to study physics at Cambridge; Freeman Dyson joined Richard Feynman at Cornell; Nina Holton went to Rome to learn bronze casting techniques. Sometimes it is not the person who chooses the place to further his or her knowledge: The opportunities for learning that a place offers capture the person's interest, and involvement with the domain follows. Brenda Milner happened to be in Montreal when the neurophysiologist D. O. Hebb started to teach at McGill University. She was so impressed by his seminars that both she and her husband changed the direction of their research, and she became one of the pioneers of the field. Margaret Butler found herself at the Argonne National Laboratories when computers were first put to use in biochemical research, and her lifelong interest in this domain was started by the opportunity to be a pioneer in this area. Rosalyn Yalow became interested in nuclear medicine because she happened to be where the instruments that made such studies possible were available. Of course, it is not that knowledge is stored in the place; rather it resides in an institution, a local tradition, or a particular person who happens to live in that place. To learn to cast bronze it helps to see how the old Italian craftsmen do it, and if one wanted to learn psychology from Hebb, one just had to go to Montreal.

The second reason why a place may help creativity is that novel stimulation is not evenly distributed. Certain environments have a greater density of interaction and provide more excitement and a greater effervescence of ideas; therefore, they prompt the person who is already inclined to break away from conventions to experiment with novelty more readily than if he or she had stayed in a more conservative, more repressive setting. The young artists who were drawn to Paris from all over the world at the end of the last century lived in a heady atmosphere where new ideas, new expressions, and new ways of living constantly jostled one another and called forth further novelty. The novelist Richard Stern describes how an artist may depend on such variety for his inspiration:

I yearned to go abroad when I was young, reading Hemingway, Fitzgerald, and so on. And once I went there it was extremely exciting for me to become a new personality, to be detached from everything that bound me, noticing everything that was different. That noticing of difference was very important. The languages, even though I was no good at them, were very important. How things were said that were different, the different formulas. Extremely exciting to me. The first time I went abroad, I was twenty-one, I began to keep the journal which I've still kept. I would keep it mostly not to go a little nuts—because there's so much that comes in. If I can get it down, then I don't have to worry about it. So being abroad has been very important in that way too.
For a theoretical physicist like Freeman Dyson, the stimulation of colleagues in neighboring offices is indispensable. Science, even more than art, is a collective enterprise where information grows much faster in “hot spots” where the thought of one person builds on that of many others. And then there are places that inhibit the generation of novelty. According to some, universities are too committed to their primary function, which is the preservation of knowledge, to be very good at stimulating creativity. Here Anthony Hecht comments on the pros and cons of this position from a poet’s perspective, but his argument applies to other domains as well:

There have been a number of poets in modern times who’ve said poets who teach in the academies end up being dry as dust, unimaginative and without daring and all that sort of stuff. I don’t think that’s true. The academy is neutral; it can, if you want to let it, curtail your imagination, but it doesn’t have to. It’s a place where you do a certain kind of work and live with certain kinds of people. The kind of people that you live with are pretty good on the whole. They’re interesting, quirky, imaginative, idiosyncratic, lively, controversial. And I find that pleasant. I know this would not be the case if I were in a business organization where everybody’s trying much more eagerly to conform.

Finally, access to the field is not evenly distributed in space. The centers that facilitate the realization of novel ideas are not necessarily the ones where the information is stored or where the stimulation is greatest. Often sudden availability of money at a certain place attracts artists or scientists to an otherwise barren environment, and that place becomes, at least for a while, one of the centers of the field. When in the 1890s William R. Harper was able to convince John D. Rockefeller, flush with dollars made in the oil fields, to part with a few million to start a university in the cornfields south of Chicago, he almost immediately attracted a number of leading scholars from the Northeast who flocked to the wilderness and established a great center of research and scholarship. Eighty years later the same phenomenon repeated itself farther west, when oil money made it possible for the University of Texas to attract a new generation of intellectual leaders to Austin. Oil is just one source of financial lure that greases the movement of academic fields from one place to another. After luminaries settle down in a particular place, it becomes difficult for young people with similar interests to resist their attraction. George Stigler, member of a department that has collected more Nobel Prizes in economics than any other in the world, explains some of the reasons why this is so:

The intellectual atmosphere in which you are determines a lot how you work. And Chicago in economics has been a virile, challenging, aggressive, and political environment. You’re surrounded by able colleagues who are quite willing to embarrass you a little if you’re doing something that’s foolish or wrong but are quite willing to help you, too, on things that have promise, so that it’s an extremely helpful environment.

The career of John Bardeen is typical. He went to graduate school at Princeton, where he became the second doctoral student of Eugene Wigner, a distinguished theoretical physicist who was awarded the Nobel Prize in 1963. Not surprisingly, many of Wigner’s students also became leaders in the field. Bardeen then went to work at the Bell Research Laboratories, where many of the bright young physicists were being hired. This is how he describes the atmosphere there:

Bell Labs had a really outstanding group in solid-state theory. The way the organization was designed, they didn’t have a theoretical group as such, but the theorists had their offices in close proximity so that they could talk readily with one another but they’d report to different experimental groups. So there was very close interaction between theory and experiment, and most papers were coauthored jointly by theorists and experimentalists. And that was a very exciting time to be there because there was a great enthusiasm for applying quantum theory to make new materials for the telephone system.

While working at Bell Labs, Bardeen developed the theory of semiconductors, which eventually led to the revolutionary invention of transistors. (For this work, he and two colleagues received the Nobel Prize in 1956.) Then Bardeen left for the University of Illi-
nois, where he became fascinated by superconductivity, which promised to fulfill the medieval dream of the *perpetuum mobile*, the frictionless machine that in principle might go on working forever. In 1957 he contributed to a theory that became the benchmark in that domain, and for that he shared the 1972 Nobel Prize with two new colleagues. This is how he explains why he moved from Bell Labs:

One reason I left to come to the University of Illinois in 1951 is that I thought that superconductivity was a just purely theoretical thing with no practical applications and it would be better to work on it in an academic environment. And Fred Seitz, who was the first student of Eugene Wigner's in Princeton, a good friend of mine for many years, had come from Carnegie Tech, now Carnegie-Mellon, with some of his coworkers to establish a group in solid-state physics at the University of Illinois. And I thought, if I came here with the group that was already present, they'd have a very strong effort in solid-state physics here. And that was true. It would attract the outstanding graduate students from places like Cal Tech and MIT; if they wanted to study solid-state physics their professors would send them out here as the best place to go.

In sciences and in the arts, in business and in politics, location matters almost as much as in buying real estate. The closer one is to the major research laboratories, journals, departments, institutes, and conference centers, the easier it is for a new voice to be heard and appreciated. At the same time, there is a downside to being near the centers of power. No one is more aware of this than Donald Campbell, whose warnings about the dangers young scholars run by being immersed too soon in a competitive, high-pressure environment are relevant beyond the confines of academia:

I do think that environments make a difference. And the assistant professorships at Big Ten universities in psychology, where you have to produce five papers a year for five years to make tenure, are far less ideal than the British system in which a Francis Crick need not publish for years and years, yet still be kept in the system on the basis of interpersonal esteem. So much less pressure and much greater freedom to explore and try out things without fear of failing.

People are responding to these conditions adaptively, and they are getting out the five papers a year for five years. But their freedom to be creative is being reduced by the pressure for quickness and number, and so is their ability to write a whole manuscript.

Look, you have two job offers, both of them have reasonable teaching loads. In one job you are going to be under high publish-or-perish pressure. In the other job you are going to feel adequate and under less pressure. Obviously the two universities have different national esteem levels. Which job would you take? I say clearly take the one where you will be free of tenure anxiety and be free to explore intellectually.

As with so many other things we have learned from these people's lives, there is no recipe for deciding, once and for all, which place is most suitable for the development of creativity. Certainly moving to the center of information and action makes sense; occasionally, it may even be indispensable. In certain domains there is really only one place in the world where one can learn and practice. But there might be disadvantages to being where the action, and therefore the pressure, is most intense. Where is the right place to be? Unfortunately, there is no single answer. Creativity is not determined by outside factors but by the person's hard resolution to do what must be done. Which place is best depends on the total configuration of a person's characteristics and those of the task he or she is involved in. Someone who is relatively more introverted may wish to perfect his act before stepping before the limelight. A more extroverted person may enjoy competitive pressures from the very beginning of her career. In either case, however, choosing the wrong environment will probably hinder the unfolding of creativity.

**Inspiring Environments**

I wrote the first draft of this chapter in a small stone cell, seven feet square, with two French windows looking out over the eastern branch of Lake Como, in northern Italy, near the foothills of the Alps. The cell was inhabited by hermit monks about five hundred years ago, and it is built over a chapel dedicated to Our Lady of
Monserrat. An earlier version of the chapel slid into the lake a long time ago. Now, from its windows, between the dense branches of laurel, oak, cedar, and beech trees, I can see, below the rocks on which the chapel is perched, the huge body of the lake rippling toward the south, like a fabulous dragon straining to break its chains.

The walls of the cell are covered with graffiti left by earlier occupants of this secluded haven. They too had the good fortune of having been selected by the Rockefeller Foundation to spend a month at the Villa Serbelloni, in the hope that the grand views, the panoramic paths through the forests, and the romantic ruins would inspire in them fresh bursts of scholarship. "Hundreds of trails, / Thousands of pines, / Limitless are the views" goes a haiku-like verse scratched by a Harvard visitor. "Generations of guests, / Ten thousand experiences, / Attained of resonant harmony." "Sun on the waters" begins an entry from UCLA, "the waves aglitter, / birds in the branches, / the trees awitter; / bells of Bellagio—a new day's birth. Scholars in the Chapel: Heaven on earth!" Another verse, this time from Sussex University in England, ends: "... our graffiti, / Make grateful, / if grotesque entreat, / That in this tree-encircled chapel, / We taste the tree of learning's apple."

There is ample precedent for such hopes. After all, the village of Bellagio, where the Villa Serbelloni stands, has been visited through the centuries by the likes of Pliny the Younger, Leonardo da Vinci, and the poets Giuseppe Parini and Ippolito Nievo—who once wrote from Sicily that he "would gladly exchange a month in Palermo for twenty-four hours in Bellagio"—all of whom sought to refresh their creativity in its magical atmosphere. "I feel that all the various features of Nature around me... provoked an emotional reaction in the depth of my soul, which I have tried to transcribe in music" wrote Franz Liszt during his stay here.

And from the highest points of the villa one can see at least three other similar enclaves across the lake: the Villa Monastero, formerly a convent for nuns from good families, where Italian physicists now repair to meditate and discuss quarks and neutrinos; the Villa Collina, once the private retreat of German chancellor Konrad Adenauer, now a place for German politicians to congregate; and the Villa Vigoni, built by a patriotic count of the Napoleonic era, now used for conferences that bring together Italian and German scien-

tists. The air of these mountains, the smell of the azaleas, the shimmering reflection of old church spires in the fjordlike branches of the lake, are supposedly conducive to the creation of beautiful paintings, gorgeous music, and deep thoughts.

Nietzsche chose to write Thus Spoke Zarathustra in the coolness of the nearby Engadine; Wagner loved to write his music in a villa in Ravello overlooking the hypnotic blue Tyrrhenian Sea; Petrarch was inspired to write his poetry in the Alps and in his villa near the Adriatic; the European physicists of the early part of this century seem to have had their most profound ideas while climbing mountains or looking at the stars from the peaks.

The belief that the physical environment deeply affects our thoughts and feelings is held in many cultures. The Chinese sages chose to write their poetry on shanty island pavilions or craggy gazebos. The Hindu Brahmins retreated to the forest to discover the reality hidden behind illusory appearances. Christian monks were so good at selecting the most beautiful natural spots that in many European countries it is a foregone conclusion that a hill or plain particularly worth seeing must have a convent or monastery built upon it.

A similar pattern exists in the United States. The Institute for Advanced Studies in the physical sciences at Princeton and its twin for the behavioral sciences in Palo Alto are situated in especially beautiful settings. Deer tiptoe through the immaculate grounds of the Educational Testing Services headquarters, and the research and development center of any corporation worth its salt will be situated among rolling meadows or within hearing range of thundering surf. The Aspen conferences unfold in the hearty, thin air of the Rockies, and the Salk Institute sparkles over the cliffs of La Jolla like a Minoan temple; the idea is that such a setting will stimulate thought and refresh the mind, and thus bring forth novel and creative ideas.

Unfortunately, there is no evidence—and probably there never will be—to prove that a delightful setting induces creativity. Certainly a great number of creative works of music, art, philosophy, and science were composed in unusually beautiful sites. But wouldn't the same works have issued forth even if their authors had been confined to a steamy urban alley or a sterile suburban spread? One cannot answer that question without a controlled experiment, and given the fact that creative works are by definition unique, it is difficult to see how a controlled experiment could ever be performed.
However, accounts by creative individuals strongly suggest that their thought processes are not indifferent to the physical environment. But the relationship is not one of simple causality. A great view does not act like a silver bullet, embedding a new idea in the mind. Rather, what seems to happen is that when persons with prepared minds find themselves in beautiful settings, they are more likely to find new connections among ideas, new perspectives on issues they are dealing with. But it is essential to have a "prepared mind." What this means is that one enters the situation with some deeply felt question and the symbolic skills necessary to answer it, nothing much is likely to happen.

For instance, John Reed, of Citicorp, remembers two instances in his professional life, separated in time by several years, when he had been especially creative. Both of these involved recognizing the main problem his company was facing and sketching out possible solutions. As with most creative moments, it was the formulation rather than the solution of the problem that mattered most. In both cases, Reed wrote letters to himself, more than thirty pages in length, detailing the issues his company was confronting, the dangers and the opportunities of the next years, and the steps that could be taken to make the most of them. The interesting thing is that both letters were written when Reed was far away from the office, ostensibly free to relax: the first on a beach in the Caribbean, the second on a park bench in Florence. He describes how the second "letter" came about:

I write myself lots of letters. And I keep some of them. In September before the third quarter I had been kind of tired, working Saturdays and Sundays, and I had gone to Italy for a week, just to get away. I went first to Rome for a couple days, then I went up to Florence. I'd get up early in the morning, and I'd wander around, and I sat on a park bench, sort of between seven in the morning and noon, then in the afternoon I'd go visit museums and whatever. And I had a notebook, an Italian notebook, and I wrote myself long essays on what was going on and what I was worried about. And it helped me get my mind organized. Then in the afternoons I wouldn't do anything. Then at the end of the third quarter I went through the organizational changes. Just recently I pulled out my original memo and it was amazing, the degree to which I had my mind around it, the overlap must have been 80 to 90 percent [between what he wrote in Florence and what eventually was implemented].

Both "letters" were spontaneous and unpremeditated, although the issues they dealt with had been fermenting in Reed's mind for many months. Then it took several more months, after his return to headquarters, to sort out the good ideas from the bad, partly through discussions with friends and colleagues. And then several more months had to pass before ways were found to implement them. But without the "letter from the beach" and the "letter from the bench" it is doubtful that Reed could have found such a fresh perspective on the issues confronting his company.

This example still raises the question of how much the beach and the bench actually mattered. Certainly the creative solutions to Citicorp's problems would never have come about if anyone else had been sitting on them. The question is, would Reed have come up with the problem and the solution if he had stayed in his Manhattan office? While this question is unanswerable, the evidence does suggest that unusual and beautiful surroundings—stimulating, serene, majestic views imbued with natural and historical suggestions—may in fact help us see situations more holistically and from novel viewpoints.

How one spends time in a beautiful natural setting seems to matter as well. Just sitting and watching is fine, but taking a leisurely walk seems to be even better. The Greek philosophers had settled on the peripatetic method—they preferred to discuss ideas while walking up and down in the courtyards of the academy. Freeman Dyson's education at Cambridge, England, owed much less to what he heard in the classroom or read in the library than to the informal and wide-ranging conversations he had with his tutor while strolling the paths around the college. And later, in Ithaca, New York, it was through similar walks that he absorbed the revolutionary ideas of the physicist Richard Feynman: "Again, I never went to a class that Feynman taught. I never had any official connection with him at all, in fact. But we went for walks. Most of the time that I spent with him was actually walking, like the old style of philosophers who used to walk around under the cloisters." Will the new generation of physicists, crouched in front of their computer screens, have equally interesting ideas?
When ordinary people are signaled with an electronic pager at random times of the day and asked to rate how creative they feel, they tend to report the highest levels of creativity when walking, driving, or swimming; in other words, when involved in a semiautomatic activity that takes up a certain amount of attention, while leaving some of it free to make connections among ideas below the threshold of conscious intentionality. Devoting full attention to a problem is not the best recipe for having creative thoughts.

When we think intentionally, thoughts are forced to follow a linear, logical—hence predictable—direction. But when attention is focused on the view during a walk, part of the brain is left free to pursue associations that normally are not made. This mental activity takes place backstage, so to speak; we become aware of it only occasionally. Because these thoughts are not in the center of attention, they are left to develop on their own. There is no need to direct them, to criticize them prematurely, to make them do hard work. And of course it is just this freedom and playfulness that makes it possible for leisurely thinking to come up with original formulations and solutions. For as soon as we get a connection that feels right, it will jump into our awareness. The compelling combination may appear as we are lying in bed half asleep, or while shaving in the bathroom, or during a walk in the woods. At that moment the novel idea seems like a voice from heaven, the key to our problems. Later on, as we try to fit it into “reality,” that original thought may turn out to have been trivial and naïve. Much hard work of evaluation and elaboration is necessary before brilliant flashes of insight can be accepted and applied. But without them, creativity would not be what it is.

So the reason Martha’s Vineyard, the Grand Tetons, or the Big Sur may stimulate creativity is that they present such novel and complex sensory experiences—mainly visual ones, but also birdsong, water sounds, the taste and feel of the air—that one’s attention is jolted out of its customary grooves and seduced to follow the novel and attractive pattern. However, the sensory menu does not require a full investment of attention; enough psychic energy is left free to pursue, subconsciously, the problematic content that requires a creative formulation.

It is true that inspiration does not come only in locations sanctioned by the board of tourism. György Faludy wrote some of his best poems while facing daily death in various concentration camps, and Eva Zeisel collected a lifetime of ideas while imprisoned in the most notorious of Stalin’s prisons, the dreaded Ljublanka. As Samuel Johnson said, nothing focuses the mind as sharply as the news that one will be executed in a few days. Life-threatening conditions, like the beauties of nature, push the mind to think about what is essential. Other things being equal, however, it would seem that a serene landscape is a preferable source of inspiration.

Creating Creative Environments

While novel and beautiful surroundings might catalyze the moment of insight, the other phases of the creative process—such as preparation and evaluation—seem to benefit more from familiar, comfortable settings, even if these are often no better than garrets. Johann Sebastian Bach did not travel far from his native Thuringia, and Beethoven composed most of his pieces in rather dismal quarters. Marcel Proust wrote his masterpiece in a dark cork-lined study. Albert Einstein needed only a kitchen table in his modest lodgings in Berne to set down the theory of relativity. Of course, we do not know whether Bach, Beethoven, Proust, and Einstein may not have been inspired at some time in their lives by a sublime sight and spent the rest of their lives elaborating on the inspiration thus obtained. Occasionally a single experience of awe provides the fuel for a lifetime of creative work.

While a complex, stimulating environment is useful for providing new insights, a more humdrum setting may be indicated for pursuing the bulk of the creative endeavor—the much longer periods of preparation that must precede the flash of insight, and the equally long periods of evaluation and elaboration that follow. Do surroundings matter during these stages of the creative process?

Here it may be useful to make a distinction between the macroenvironment, the social, cultural, and institutional context in which a person lives, and the microenvironment, the immediate setting in which a person works. In terms of the broader context, it goes without saying that a certain amount of surplus wealth never hurts. The centers of creativity—Athens in its heyday; the Arab cities of the tenth century; Florence in the Renaissance; Venice in the fifteenth century; Paris, London, and Vienna in the nineteenth; New York in
the twentieth—were affluent and cosmopolitan. They tended to be at the crossroads of cultures, where information from different traditions was exchanged and synthesized. They were also loci of social change, often riven by conflicts between ethnic, economic, or social groups.

Not only states but also institutions can foster the development of creative ideas. The Bronx High School of Science and the Bell Research Laboratories have become legendary because of their ability to nurture important new ideas. Every university or think tank hopes to be the place that attracts future stars. Successful environments of this type provide freedom of action and stimulation of ideas, coupled with a respectful and nurturant attitude toward potential geniuses, who have notoriously fragile egos and need lots of tender, loving care.

Most of us cannot do a great deal about the macroenvironment. There is not that much we can do about the wealth of the society we live in, or even about the institutions in which we work. We can, however, gain control over the immediate environment and transform it so that it enhances personal creativity. On this score, there is much to learn from creative individuals, who generally take great pains to ensure that they can work in easy and uninterrupted concentration. How this is done varies greatly depending on the person's temperament and style of work. The important thing, however, is to have a special space tailor-made to one's own needs, where one feels comfortable and in control. Kenneth Boulding preferred to think and work in a cabin overlooking the Colorado Rockies, and he also used to get into the hot tub intermittently to gather his thoughts. Jonas Salk liked to work in a studio where, in addition to the materials he needed for writing on biology, there was a piano and an easel for painting. Hazel Henderson, who lives in a rather isolated community in north Florida to avoid the constant distractions of the urban centers, describes her daily routine:

I like to run for about two miles every morning, and I have a special place to run to, which is a very beautiful spot, just about a mile from here, where there's a beautiful salt marsh, it's looking over the city. And if you look to the left, it's just absolutely wild and beautiful. And there are my favorite blue herons and curlews

and there's fish jumping and you can feel this teeming, living activity. And then if I look this way, to the right, there's this beautiful little city with its little spires, it's very harmonious. And, you know, there is a kind of balance between the natural system and the human system.

Robertson Davies crafts his intricate fiction in a house he built fifty miles north of Toronto, on a prehistoric beach rich in fossils, "in a very nice position looking down, down the valley toward Toronto so that we can see the lights and look toward it and be glad that we're not there." The sociologist Elise Boulding has worked out almost monastic routines to help the rhythm of her creative thinking:

An early morning walk, and reflection. In that year, 1974, I spent a lot of time on my knees; I have a little prayer plot that's at the back of the hermitage. I am not sure I would do that now. In 1991 I am a different person than I was in '74. But, do a certain amount of reading, you know, like the saints and those who have been through spiritual journeys, and simply reflection. A lot of reflection, meditation. I have spent time in Catholic monasteries, and I value very much the hours of office and so on. In '74 I followed the hours of office and sang them. Again, I am not sure I would do that now. But just lots of quiet, a lot of time spent just looking out of the window at the mountains, and meditating.

In Finland many people know Pekka, an elderly Lapp whose official job is to supervise the social services in the northernmost part of the country. But Pekka also travels widely: He spends his vacations visiting Tibet to learn the beliefs and lifestyles of the monasteries, or Alaska, in search of the vanishing Inuit culture. When he is in Helsinki on government business, he is known for never sitting down until he feels that the office where the meeting is held feels right. If it does not, he will take the elevator down to the street, walk around until he finds some branches, or stones, or flowers he likes. He will bring these objects back to the office, place them here and there on the desk or file cabinets, and when he feels that the environment looks serene and harmonious, he is ready to start business. Those who have to deal with Pekka generally feel that his
improvised interior decoration also helps them to have a better meeting and come to more satisfying decisions.

Elisabeth Noelle-Neumann, an innovative and successful German scientist and businesswoman (a few years ago, in a list of the one hundred most influential women in Germany published by a business magazine, she was ranked number two), has mastered the art of personalizing her environment. Her office, in a remodeled fifteenth-century farmhouse, is furnished with graceful antiques; her home on the shores of Lake Constance is filled with books and rare objects that reflect her personality. Because she spends so much time traveling from one place to another (about fifty thousand miles every year just by car), her Mercedes 500 is another important working space. While the chauffeur drives, Noelle-Neumann reads and writes surrounded by favorite audiocassettes, bottles of mineral water, sheafs of notepaper, and bundles of ballpoint pens of various colors. Wherever she goes, she takes a familiar microenvironment with her.

To a certain extent everyone tries to accomplish something similar to what Elisabeth and Pekka do. We usually do it with our homes by filling them with objects that reflect and confirm our uniqueness. Such objects transform a house into a home. When we moved into a summer home in Montana, all it took to make the alien environment familiar was for my wife to place on the mantelpiece two colorful wooden ducks we had had for some time. With the ducks safely nesting along the wall, the empty space became immediately cozy and comfortable.

We need a supportive symbolic ecology in the home so that we can feel safe, drop our defenses, and go on with the tasks of life. And to the extent that the symbols of the home represent essential traits and values of the self, they help us be more unique, more creative. A home devoid of personal touches, lacking objects that point to the past or direct toward the future, tends to be sterile. Homes rich in meaningful symbols make it easier for their owners to know who they are and therefore what they should do.

In one of my studies we interviewed two women, both in their eighties, who lived on different floors of the same high-rise apartment house. When asked what objects were special to her in her apartment, the first woman looked vaguely around her living room, which could have passed for a showroom in a reasonably pricey furniture store, and said that she couldn't think of anything. She gave the same response in the other rooms—nothing special, nothing personal, nothing meaningful anywhere. The second woman's living room was full of pictures of friends and family, porcelain and silver inherited from aunts and uncles, books she loved or that she intended to read. The hallway was hung with framed drawings of her children and grandchildren. In the bathroom the shaving tools of her deceased husband were arranged like a tiny shrine. And the life of the two women mirrored their homes: the first followed an affectless routine, the second a varied, exciting schedule.

Of course, furnishing one's house in a certain way does not miraculously make one's life more creative. The causal connections are, as usual, more complicated. The person who creates a more unique home environment is likely to be more original to begin with. Yet having a home that reinforces one's individuality cannot but help increase the chances that one will act out one's uniqueness.

It used to be said that a man's home is his castle, in deference to the fact that at home one feels more secure and in control than anywhere else. But increasingly in our culture it could be said that a man's—and especially a woman's —car is the place where freedom, security, and control are most deeply experienced. Many people claim that their car is a "thinking machine," because only when driving do they feel relaxed enough to reflect on their problems and to place them in perspective. One person we interviewed said that about once a month, when worries become too pressing, he gets into his car after work and drives for half the night from Chicago to the Mississippi. He parks and looks at the river for about half an hour, then drives back and reaches Chicago as the dawn lights up the lake. The long drive acts as therapy, helping him sort out emotional problems.

Cars can be personalized by a variety of means: The make we buy, the color, the accessories, and the music system all contribute to an at-home feeling in a vehicle that affords both privacy and mobility. In addition to cars, offices and gardens are spaces that can be arranged to provide environments that reflect a personal sense of how the universe ought to be. It is not that there is one perfect pattern by which to order our surroundings. What helps to preserve and develop individuality, and hence enhance creativity, is an environment that we have built to reflect ourselves, where it is easy to forget the outside world and concentrate completely on the task at hand.
PATTERNING ACTIVITIES

It is not only through personalizing the material environment that we are able to enhance creative thought. Another very important way to do so is by ordering the patterns of action we engage in. Manfred Eigen, the Nobel Prize winner in chemistry, plays Mozart at the piano almost every day to take his mind off the linear track. So does the writer Madeleine L'Engle. Mark Strand walks his dog and works in the garden. Hazel Henderson, who struggles daily with the problems of the various environmental groups she helps organize, gardens and takes walks to refresh her thinking. Some ride bikes and some read novels; some cook and others swim. Again, there is no best way to structure our actions; however, it is important not to let either chance or external routine automatically dictate what we will do.

Elisabeth Noelle-Neumann rarely eats at the times other people usually eat but has her own strict schedule that fits her own needs. Richard Stern has a sort of rhythm. He imposed on time a rhythm which has enabled me to function. Function as a writer, function as a father, a husband—not always the best one—as a university professor, colleague, friend.

He goes on to specify in more concrete terms what he means by "rhythm":

My guess is that though it resembles other people's rhythms, that is, anybody who does work either has a routine or imposes on his life certain periods in which he can be alone or in which he collaborates. At any rate, he works out a sort of schedule for himself and this is not simply an external, exoskeletal phenomenon. It seems to me it has much to do with the relationship of your own physiological, hormonal, organic self and its relationship to the world outside. Components can be as ordinary as reading the newspaper in the morning. I used to do that years ago, and I stopped for years and years, which altered the rhythm of my day. One drinks a glass of wine in the evenings at certain times, when the blood sugar's low, and one looks forward to it. And then of course those hours in which one works.

Most creative individuals find out early what their best rhythms are for sleeping, eating, and working, and abide by them even when it is tempting to do otherwise. They wear clothes that are comfortable, they interact only with people they find congenial, they do only things they think are important. Of course, such idiosyncrasies are not endearing to those they have to deal with, and it is not surprising that creative people are generally considered strange and difficult to get along with. But personalizing patterns of action helps to free the mind from the expectations that make demands on attention and allows intense concentration on matters that count.

A similar control extends to the structuring of time. Some creative people have extremely tight schedules and can tell you in advance what they will be doing between three and four in the afternoon on a Thursday two months from today. Others are much more relaxed and in fact pride themselves on not even knowing what they will be doing later on today. Again, what matters is not whether one keeps to a strict or to a flexible schedule; what counts is to be master of one's own time.

Longer stretches of time show the same variable structure. Freeman Dyson and Barry Commoner believe that one should make a major career change every ten years or so to avoid becoming stale. Others seem perfectly satisfied delving deeper and deeper into a narrow corner of their domain throughout their lives. But what none of the persons we interviewed ever said was that he or she did this or that because it was the socially expected thing to do at that particular time.

So it seems that surroundings can influence creativity in different ways, in part depending on the stage of the process in which a person is involved. During preparation, when one is gathering the elements out of which the problem is going to emerge, an ordered, familiar environment is indicated, where one can concentrate on interesting issues without the distractions of "real" life. For the scientist it is the laboratory, for the businessperson the office, for the artist the studio. At the next stage, when thoughts about the problem
incubate below the level of awareness, a different environment may be more helpful. The distraction of novel stimuli, of magnificent views, of alien cultures, allows the subconscious mental processes to make connections that are unlikely when the problem is pursued by the linear logic learned from experience. And after the unexpected connection results in an insight, the familiar environment is again more conducive for completing the process; evaluation and elaboration proceed more efficiently in the sober atmosphere where the logic of the domain prevails.

However, at any point in time, what matters most is that we shape the immediate surroundings, activities, and schedules so as to feel in harmony with the small segment of the universe where we happen to be located. It is nice if this location is as fetching as a villa on Lake Como; it is a far greater challenge when fate throws you into a Siberian galag. At either extreme, what counts is for consciousness to find ways to adapt its rhythms to what is outside and, to a certain extent, to transform what it encounters outside to its own rhythms. Being in tune with place and time, we experience the reality of our unique existence and its relationship to the cosmos. And from this knowledge original thoughts and original actions follow with greater ease.

The implications for everyday life are simple: Make sure that where you work and live reflects your needs and your tastes. There should be room for immersion in concentrated activity and for stimulating novelty. The objects around you should help you become what you intend to be. Think about how you use time and consider whether your schedule reflects the rhythms that work best for you. If in doubt, experiment until you discover the best timing for work and rest, for thought and action, for being alone and for being with people.

Creating a harmonious, meaningful environment in space and time helps you to become personally creative. It may help you achieve a life that reflects your individuality, a life that is rarely boring and rarely out of control; a life that makes others realize the possibilities for uniqueness and growth inherent in the human condition. But creating such a life does not guarantee that you will be recognized as a genius, as a historically significant creative figure. To achieve historical creativity many other conditions must be met. For instance, you must be lucky, for to excel in some domains you might need the right genes, you might have to be born in the right family, at the right historical moment. Without access to the domain, potential is fruitless. How many Congolese would make great skiers? Are there really no Papuans who could contribute to nuclear physics? And finally, without the support of a field, even the most promising talent will not be recognized. But if creativity with a capital C is largely beyond our control, living a creative personal life is not. And in terms of ultimate fulfillment, the latter may be the most important accomplishment.