
WHERE IS CREATIVITY?

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.

Instead, according to the author's calculations, if one paid attention to the landmarks, the distances traveled, and the pattern of the stars mentioned by Homer, it was obvious that Ulysses actually traveled around the coast of Florida.

Or it might be a textbook for building flying saucers, with extremely precise blueprints—which on closer inspection turned out to be copied from a service manual for a household appliance. What made reading these manuscripts depressing was the fact that their authors actually believed they had found something new and important and that their creative efforts went unrecognized only because of a conspiracy on the part of philistines like myself and the editors of all the other publishing houses.

Some years ago the scientific world was abuzz with the news that two chemists had achieved cold fusion in the laboratory. If true, this meant that something very similar to the perpetual motion machine—one of the oldest dreams of mankind—was about to be realized. After a few frenetic months during which laboratories around the world attempted to replicate the initial claims—some with apparent success, but most without—it became increasingly clear that the experiments on which the claims were based had been flawed. So the researchers who at first were hailed as the greatest creative scientists of the century became somewhat of an embarrassment to the scholarly establishment. Yet, as far as we know, they firmly believed that they were right and that their reputations had been ruined by jealous colleagues.

Jacob Rabinow, himself an inventor but also an evaluator of inventions for the National Bureau of Standards in Washington, has many similar stories to tell about people who think they have invented perpetual motion machines:

I've met many of these inventors who invent something that cannot work, that is theoretically impossible. But they spent three years developing it, running a motor without electricity, with magnets. You explain to them it won't work. It violates the second law of thermodynamics. And they say, "Don't give me your goddamn Washington laws."

Who is right: the individual who believes in his or her own creativity, or the social milieu that denies it? If we take sides with the

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 neuropathology. 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 at 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 now 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 steps are 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 Orsanmichele, 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 thirteen 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 handsomely 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 Medicis, the Pazzis, 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 busily being invented. Usually it is the various fields that act as filters to help us select among the flood of new information those memes 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 relativity 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 so 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.

THREE

THE CREATIVE PERSONALITY

To 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.