Creativity
in the
R&D Laboratory

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Greensboro, North Carolina

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Dr. Stanley S. Gryskiewicz in his role as Director of the Innovation and Creativity Area at the Center for Creative Leadership is the principal organizer and developer of creativity training programs at the Center, as well as the organizer of the Center's research programs in creativity. He has been active in creativity training in the United States, Europe, and Latin America for the past seventeen years, and he has conducted research on innovation for the past eight years. Dr. Gryskiewicz holds a Ph.D. in occupational psychology from London University.

Preface

Portions of this report were presented (1) in the symposium, “Creativity in the Corporation,” in the Division of Industrial and Organizational Psychology, at the meeting of the American Psychological Association, Toronto, Ontario, Canada, August 1984; (2) in the symposium, “The Creative Process Leading to Commercial Development,” in the Division of Chemical Marketing and Economics, at the meeting of the American Chemical Society, Philadelphia, Pennsylvania, August 1984; and (3) at Creativity Week VIII, Center for Creative Leadership, Greensboro, North Carolina, September 1985.

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Introduction

The 41-year-old chemist has arrived a couple of minutes late for the interview. The manager of a top-priority project in the research laboratory of a large American chemical company, he has just left a meeting with his research team. But, clearly, he is prepared; he has read and carefully considered the interviewer's request to describe a highly creative event from his work experience. Now, as the interviewer switches on the tape recorder and repeats the request, the chemist settles back and begins to tell of an event that occurred the previous year:

> This company operates a pretty extensive program in clinical chemistry. One of the main problems we've been working on recently is urinalysis—trying to come up with an analysis system that can pinpoint very specific problems in the kidneys. The problem with our existing system was that it was not selective enough.
>
> It started with just a casual conversation between one of the lab heads—an assistant director—and myself. He mentioned that we needed something much more selective and, since I work for him, I decided to go ahead on it.
>
> I had a great deal of freedom in that environment. We were doing a lot more basic research than you often see.
>
> **Interviewer:** *Describe the characteristics and abilities of the people involved.*
>
> There were two of us working on the problem, and there was a good meld between us. The creative idea of how to do the synthesis was mine, but the creative idea of how to put it into a package and make it work in a practice system was his. It was a good interaction. Also, we both had a background in the area, and a certain amount of intuition.
>
> **Interviewer:** *What features of the work environment distinguished this event?*
>
> The way our lab is structured allows for a great deal of freedom of action. There is a great deal of responsibility for your own fate. You can go and find a project of interest to you and develop it, even if it isn't of obvious interest to the company.

> There are a lot of projects going on at one time. For example, one division may have five or six projects going. Two or three may be of real interest to the company, and the rest may be long shots. However, sometimes the long shots turn out in the long run to be the most productive.

> Basically, management kept out of it and gave up enough rope to either hang ourselves or find an answer.

This quote illustrates well several of the main themes that emerged from our interview study of 120 R&D scientists. Primary among these is the importance of freedom in promoting creativity—most notably, freedom in deciding how to best achieve the goals of a specific project. Freedom, when combined with several other features of project management, corporate culture, and the scientists themselves, can be a powerful stimulant to creativity. We will outline the major stimulants to creativity in R&D, as well as the major obstacles, and suggest ways in which managers can put this information to work for them.

Our study was designed to answer some quite simple questions: What influences creativity in R&D? and What is it about persons and their work environments that makes a difference? Our method involved asking all interviewees to tell us about two events from their work experience: one event that exemplified high creativity, and one that exemplified low creativity. Assuming that they were far more expert in their fields than we, we told the interviewees to take as creative whatever *they* judged as creative. We also said that they themselves need not be one of the central characters in the story, as long as they observed the event closely enough to be able to describe it in detail. Moreover, we asked our interviewees, in telling their stories, to describe as many details as they could remember about both the person(s) *and* the work environment surrounding the event. We did this in an effort to make our information as broad as possible and, thus, as useful as possible.

Nearly all of our 120 scientists did come to the twenty-minute interview prepared to tell the two stories—one exemplifying high creativity and one exemplifying low creativity. We felt that, by using this critical incident technique, we would be more likely to avoid the interjection of personal beliefs about creativity than if we simply asked interviewees what they thought was important for supporting or undermining creativity in organizations.

The Research Method

In our search for information about the major influences on creativity and innovation, we did a detailed content analysis of typed verbatim transcripts of these tape-recorded interviews. This content analysis proceeded in two stages. First, two coders independently read all of the transcripts and marked segments of the transcripts according to four major themes: environmental stimulants to creativity, environmental obstacles to creativity, personal qualities favorable to creativity, and personal qualities unfavorable to creativity. The coders then compared their assignments of statements to major themes, discussing any disagreements until they came to consensus. The second stage of content analysis was done by two different coders, who independently assigned statements from each of the major themes to particular subthemes (such as freedom, which was a subtheme under environmental stimulants). As in the first stage, these coders then compared the statement assignments they had made, and discussed any disagreements until they came to consensus. The overall level of agreement in the independent ratings, before any discussion, was good: 80 percent for stage 1 and 74 percent for stage 2.

Many other researchers have looked at creativity in organizations, and a good number have focused on the R&D lab. As we will show, many (though *not* all) of our major findings echo those of other researchers. In a number of ways, however, our study is unique. Most other works examining the factors influencing creativity in organizations have employed questionnaires as the major (or sole) data source (e.g., Ekvall, 1983; Ekvall, Arvonen, & Waldenstrom-Lindblad, 1983), and the same is true of most studies that have focused on creativity in the R&D lab (e.g., Andrews, 1975; Andrews & Farris, 1967; Baran, Zandon, & Vanston, 1986; Faas, 1985; Pelz & Andrews, 1966; Smeltz & Cross, 1984).

A few researchers have employed interviews as their major data source. In a methodology similar to ours, Kanter (1983) asked managers from several companies to describe their most significant job-related accomplishment of the last two years. The interviewees were not specifically selected from R&D. Each of these interviews covered a number of points that had been specified in advance, including a complete chronology of the accomplishment, conditions of initiation, acquisition and use of resources, acquisition and use of information, support, opposition, results, and rewards. An unspecified number of coders did content analysis on the interviewer's notes from each interview. As we did, these researchers had coders discuss disagreements until they came to consensus.

The interview procedure has also been used by a few researchers who have specifically examined R&D laboratories. Bailyn (1984) interviewed technical professionals at all levels of the hierarchy in a small number of American and British R&D labs. Those interviews dealt with a number of general issues surrounding the employment of scientists and technicians in corporations. Finally, Von Glinow and Kerr (1983) asked respondents to provide written answers to three specific questions about creativity: (1) Write the names of the two most creative people you know in the company, (2) describe the specific creative actions or behaviors of these people, and (3) describe the outcomes or results of the behaviors. Although this methodology does not employ oral interviews, it seems closer to the interview methods than to the written questionnaire methods. Two coders independently assigned the written comments to response categories.

Each of the previous methods used has its own particular merits. Questionnaires, for example, allow for clear statistical comparisons of data gathered relatively easily from a large number of respondents. Moreover, both closely structured interviews and questionnaires allow researchers to examine the specific factors in which they are interested.

The methodology we used also has its own unique merits. We used detailed content analysis, done by independent coders working with verbatim transcriptions, in order to maximize the accuracy of the data we will present. Most important, however, is the question that we asked interviewees. As noted earlier, we asked them to describe in detail two critical incidents in order to minimize the probability that they would simply tell us their personal theories about what influences creativity. We asked for two incidents (high and low creativity) in order to look at both sides of the coin: factors that stimulate creativity and factors that block it. Moreover, the loosely structured interview question allowed for maximum flexibility and range in responses; interviewees could tell us all the details they recalled from the critical incidents, thus perhaps bringing up things that we as researchers would not think to ask for. Finally, because this was an oral interview, we could probe for elaboration and clarification of the answers.

Thus, our study is unique in (a) its examination of the whole possible range of factors influencing creativity in R&D (b) through detailed content analysis of verbatim transcripts (c) of semi-structured interviews (d) that dealt with two opposite critical incidents. We believe that this particular approach allowed us to uncover an unusually wide range of factors in our study, as well as a number of factors that had not been pinpointed by previous research.

Major Themes in the Interviews

The types of things our interviewees talked about fell into four major categories. Rank-ordered by frequency, they are: (1) environmental stimulants to creativity, (2) environmental obstacles to creativity, (3) favorable personal qualities, and (4) unfavorable personal qualities. In our system, “environmental factors” are any factors outside of the problem-solvers themselves (including other people) that seem to consistently influence creativity positively, as in the high creativity stories, or negatively, as in the low creativity stories. “Personal qualities” are any factors of ability, personality, mood, etc., within the problem-solvers themselves that seemed to consistently influence creativity either positively or negatively. We found that environmental factors were mentioned much more frequently than personal qualities, in both the high and the low creativity stories. Because this finding appeared in both the high and low creativity stories, and because a large percentage of the stories did not involve the interviewee as a central character (a problem-solver), we feel that this preponderance of environmental factors cannot be dismissed as a simple attributional bias.

Does this mean that, in an absolute sense, environmental factors account for more of the variance in creative output than individual-difference factors? Not necessarily, and not even probably. Certainly, at a gross level, personal factors such as general intelligence, experience in the field, and ability to think creatively are the major influences on output of creative ideas. But, assuming that hiring practices at major corporations select for individuals who exhibit relatively high levels of these personal qualities, the variance above this baseline may well be accounted for primarily by factors in the work environment. Frank Andrews (1975), a pioneer in studying R&D creativity, used a similar explanation to deal with his own data: “. . . social and psychological factors may so affect the translation of creative ability into innovative performance that there is not general effect which one can describe or identify” (p. 124).

Our data did yield some general effects of person factors, however. What are the personal qualities of scientists that appear to consistently influence creativity in the R&D lab? What is that baseline beyond which the environment appears to play such a critical role? To answer these questions, we will collapse information obtained on both the favorable and unfavorable personal qualities to present a picture of the creative R&D scientist.

Personal Qualities of Creative R&D Scientists

The personal qualities of the scientists described by our interviewees—both the positives and the negatives—can be summarized into five categories, as outlined in Table 1 (see page 7). We will briefly describe each of these with illustrative quotes from the interviews. In these descriptions, we will refer to the problem-solvers in the high creativity stories as “high creativity scientists,” and the problem-solvers in the low creativity stories as “low creativity scientists.”

Intrinsic Motivation

The single most frequently mentioned characteristic of scientists involved in highly creative work was intrinsic motivation—being motivated primarily from *within*, from the scientist’s own interest in the work itself, and not from external pressures. This included a number of aspects: being self-driven, excited by the work itself, enthusiastic, attracted by the challenge of the problem, having a sense of working on something important, and a belief in or commitment to the idea. The importance of this intrinsic motivation, self-reliance, or internal locus of control in the creativity of persons within organizations has been found by some other researchers, including Pelz and Andrews (1966), Ekvall (1983), and Smeltz and Cross (1984). These qualities are also similar to the dedication, intense involvement, and commitment to work that some researchers have found in successful R&D scientists (e.g., Kerr, Von Glinow, & Schriesheim, 1977; Pelz & Andrews, 1966). Finally, our findings fit well with recent experimental research demonstrating a link between intrinsic motivation and creativity (cf. Amabile, 1983).

Forty percent of our participants mentioned some aspect of self-motivation as a positive influence on creativity.

> I find that having an idea, putting something together, testing an idea, experimenting . . . all that is just very exciting.

> A person has to be somewhat self-motivated. The person has to have an inner drive. . . . People have to feel that they are contributing.

> What’s important to me is feeling that I’ve done something that’s made a difference, seeing that something I’ve worked on has turned into a product in the market. It’s not getting pats on the back from my own management in the organization, but having the self-satisfaction of seeing my work come to something,

Table 1
Personal Qualities of Creative R&D Scientists

N.B.: These categories are listed in order of the frequency with which they were mentioned in the interviews.

Intrinsic Motivation
Being self-driven, excited by the work itself, enthusiastic, attracted by the challenge of the problem, having a sense of working on something important, and a commitment to the idea; *not* being apathetic; *not* being motivated only by money, recognition, or external directives.

Ability and Experience
Having special problem-solving abilities and tactics for creative thinking; having talent and expertise in the particular area; having broad general knowledge and experience in many fields; being highly intelligent.

Risk-orientation
Being unconventional, unafraid to take risks, attracted to challenge; *not* being inflexible or unwilling to do things differently.

Social Skill
Having good rapport with others, being a good listener and a good team player, being broad-minded or open to others' ideas; having political savvy.

Other Qualities
Individual: having persistence, curiosity, energy, and intellectual honesty; being naive or unbiased by preconceptions about the problem.
Group: a positive group synergy arising from the combination of individual members' abilities and personalities.

> feeling that I have made a contribution to the profits of the company and to the availability of new products to consumers.
>
> People felt ownership of the problem; they felt responsible for it.

The importance of intrinsic motivation is also highlighted in the described characteristics of scientists involved in the low creativity events. There, being *unmotivated* was the single most frequently cited negative personal characteristic, mentioned by 36 percent of our interviewees: not being challenged by the problem, lacking courage in attacking a difficult problem or overcoming environmental obstacles, having a pessimistic attitude toward the likely outcome of the project, being overly cautious and unwilling to take risks, complacent, unhappy about work, or simply lazy. Similarly, a number of interviewees mentioned the negative characteristics of being motivated primarily by *external* factors such as money or recognition.

> We had no inherent interest in finding the answer.
>
> The people had trouble gaining the spark or the necessary enthusiasm for the project.
>
> The people were quite good in general. If there was a fault, it was not wanting to make waves in the face of a management directive.

The negative impact of external motivation on an individual's creativity, which we found in our research, seems similar to Pelz and Andrews' (1966) finding that ambition to rise in status within the organization negatively predicts a scientist's creativity.

Ability and Experience

Many of the remarks made by our interviewees in their descriptions of scientists, in both the high and low creativity events, concerned special cognitive skills, general knowledge, or expertise within the specific field. In fact, 38 percent of the participants mentioned special cognitive abilities in the high creativity scientists, 33 percent mentioned expertise in the specific field, 18 percent mentioned having diverse experience in many fields, and 13 percent mentioned general brilliance. Not surprisingly, many other researchers have found expertise, intelligence, and experience to be positive contributors to a scientist's creativity (e.g., Ekvall, 1983; Kerr, Von Glinow, & Schriesheim, 1977; Pelz & Andrews, 1966; Von Glinow & Kerr, 1983). Interestingly, however, in a finding similar to ours, Andrews (1975) discovered that, among the entire list of positive qualities of creative R&D scientists, sheer brilliance did not figure very prominently.

> Good problem-solving abilities were important, as well as the ability to take an idea from one field and extend it into another. That is really what led to the identification of this new process.
>
> One person in the group has been in the company for 20 years and has a great deal of experience.

> One of the people working on the project was familiar with another new technique that was just being recorded in the literature and that had a foreseeable influence on the stuff we were doing.

> The individual who was responsible is a senior research associate with the company. He has a broad range of experience. He was creative because he was able to draw on virtually every aspect of his previous experience.

In the stories of low creativity, a *lack* of skill or experience was mentioned by 24 percent of the participants. this finding has not been explicitly documented in the R&D creativity literature, perhaps because previous researchers have not looked so directly at specific instances of *low* creativity. Some of the remarks made by our interviewees:

> I couldn't be very creative there because I lacked the ability and knowledge in the area.

> He got bogged down in the details. He spent time analyzing things that were intuitively obvious, and worrying about the process in a too-narrow point of view. He could not connect what he worked on to making the system better or understanding it better.

Risk-orientation

Scientists who were the key problem-solvers in the high creativity stories were often described by our interviewees as courageous in taking risks. Risk-taking, long documented as important in the general creativity literature, has also been found by at least one other team of researchers looking specifically at R&D (Von Glinow & Kerr, 1983). Over one-third of our interviewees mentioned risk-orientation, including a wide range of qualities: has unconventional attitudes, thoughts, or style; deviates from the usual path; doesn't just adapt; doesn't do the standard thing; is risk-oriented; takes chances; is not overly cautious; is rebellious or brash; is courageous; is attracted to challenge; is willing to take risks with ideas and money.

> In this group, people were not afraid to step over the boundary lines. Because this is a frontier-type of chemistry, your mind-set has to be such that you can accept that your results are going to be new, and that you won't know exactly what to do with them.

The opposite characteristic, being inflexible or overly cautious in one's thinking, has not previously been highlighted in the literature on R&D creativity. This quality was mentioned by 22 percent of our interviewees in their descriptions of low creativity scientists:

> They were afraid to try something new.

> My own preconceptions served as an obstacle.

Social Skill

There is very little mention of a scientist's social skill in previous research on R&D creativity. However, 18 percent of our participants mentioned the positive role of social skill in the high creativity scientists, perhaps because such skill allowed the scientist access to the ideas and insights of other people. Positive social and political skills included having good rapport with others, being a good listener and a good team player, and being broad-minded or open to others' ideas.

> You need a willingness to interact with your peers and exchange ideas. This includes respecting the input you get.

In parallel with these results, about 7 percent of our interviewees mentioned a lack of social or political skill in the low creativity scientists:

> They didn't make enough effort to lower the barriers and improve communication and act like a group.

Other Qualities

A number of other qualities of individual scientists and groups of scientists appeared in these interviews. Although over 40 percent of our interviewees mentioned some personality traits, no one single personality trait was mentioned by a very large percentage. The traits most frequently mentioned were persistence, curiosity, energy, and honesty. Some of these, particularly persistence and energy, have been found by other researchers (Daft & Becker, 1978; Von Glinow & Kerr, 1983).

> I followed up on his suggestion and studied the unrelated system and began to see how their approach could be successfully applied to my problem. From there, it was just a matter of being persistent and hammering out the details.

> I was very dogmatic about working on what I thought was important, which turns out to be what *was* important, so management started backing off and giving me some freedom.

Many of the other qualities we discovered have not been explicitly documented in previous empirical work. For example, 30 percent of our interviewees described qualities of the *group* of scientists working on a highly creative project, qualities that arose from the special combination of talents, backgrounds, and/or personalities of the individuals in the group. Among the qualities included here were trust, free communication, good teamwork, being diverse, flexible, and self-reliant as a group, being mutually helpful, and taking a fresh perspective.

> There were a number of good things about the group. We had similar abilities, but different backgrounds—different ways of looking at the problem. Also, we had mutual respect for each other's abilities and a willingness to listen, but not hang on someone's idea—to say, well, that's a good idea, but here are some problems . . .

Finally, one quality of individual high creativity scientists that we discovered, though not mentioned by very many interviewees (13 percent), was still prominent enough to deserve inclusion in the list of positive personal qualities. This is *naiveté*, being naive or new to the field in some way and, as a result, not being biased by preconceptions or bound by old ways of doing things.

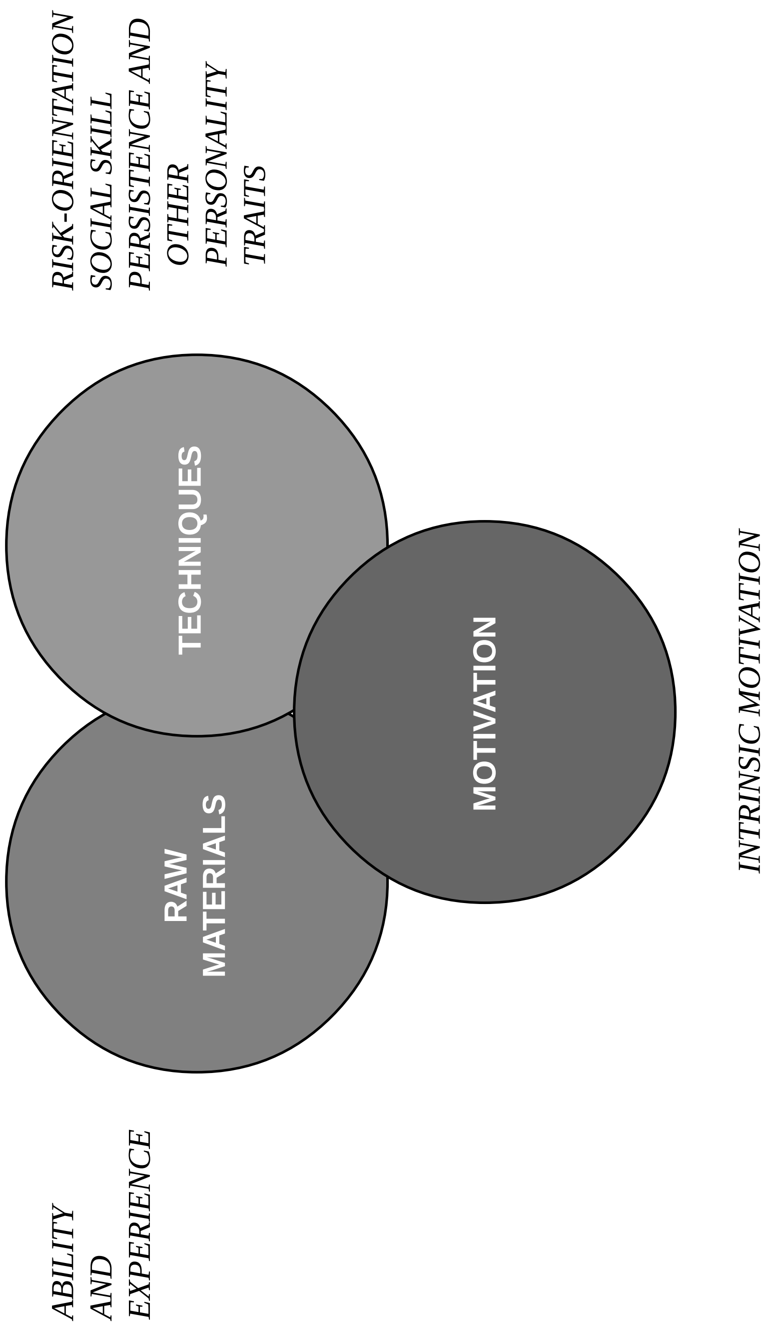
> Which of my characteristics contributed to creativity here? Ignorance.
> I had no preconceptions or prejudices. I was rather naive.

Summary: Personal Qualities

We have presented a great many personal qualities of R&D scientists that consistently enhance creativity (i.e., appear in high creativity events) or consistently undermine creativity (i.e., appear in low creativity events). Many of these qualities replicate the findings of other researchers; some have not been previously highlighted. Because of the large number of personal qualities that appear to play a role in R&D scientists' creativity, we feel it is important to find a model for summarizing and conceptually categorizing this information. We present such a model in Figure 1 (see page 12). The three essential components for creativity in an R&D scientist (and, probably, in other fields as well), appear to be: (1) Raw materials—the basics on which the scientist can draw in producing creative work. These include all those factors that we grouped

Figure 1

SUMMARIZING THE PERSONAL QUALITIES OF CREATIVE R&D SCIENTISTS



under Ability and Experience. (2) Techniques—the attitudes and approaches that the scientist applies in using those raw materials. These include all those factors that we grouped under Risk-orientation, Social Skill, and Other Qualities. (3) Motivation—the intrinsic motivation to become deeply involved with the task at hand, using those techniques and raw materials in creative ways. The strength of the first two components tells us what a scientist *can* do, but the motivation component tells us what that scientist *will* do.

Perhaps the most important finding of our research is that these personal qualities of R&D scientists—particularly intrinsic motivation—can be strongly affected by the particular work environments in which they find themselves. We now turn to a consideration of which environmental factors influence R&D creativity, and which of those seem to have the strongest impact.

The Environment for Creativity in R&D

Both the positive features of work environments, which were present in the high creativity events, and the negative features of work environments, which were present in the low creativity events, can be summarized into seven categories, as outlined in Table 2 (see page 14). As in our discussion of the personal qualities of creative R&D scientists, we will briefly describe each of these with illustrative quotes from the interviews. Throughout, it will become clear how these environmental factors can exert a powerful influence on the creativity motivation of individual scientists—and, to some extent, even on the development of their skills.

Freedom

The most frequently mentioned environmental feature surrounding the high creativity events was freedom—freedom in deciding what to do or, more frequently, *how* to do one's work; a sense of control over one's work and one's ideas; a freedom from having to meet someone else's constraints; a generally open atmosphere. Over 74 percent of our participants mentioned freedom or control at least once.

> Management did not believe that there was a solution to the problem; that's why they assigned me. I was new in the field, and since they didn't believe anyone could solve it, they didn't want to waste their senior experience. As a consequence, I was left alone more so than is normal. And since I didn't know the problem couldn't be solved, with this kind of freedom, I just went ahead and solved it!

Table 2
The Environment for Creativity in R&D

N.B.: These categories are listed in order of the frequency with which they were mentioned in the interviews.

Freedom
Freedom in deciding what to do or, more frequently, *how* to do one's work; a sense of control over one's work and ideas; a freedom from having to meet someone else's constraints; a generally open atmosphere.

Encouragement
Management enthusiasm and support for new ideas and new ways of doing things; an absence of destructive criticism and excessive fear of evaluation.

Resources and Time
Access to appropriate resources, including facilities, information, funds, and people; sufficient time to solve problems in new ways.

Recognition
Appropriate, constructive feedback on one's work, along with appropriate recognition and rewards.

Challenge
A sense of challenge arising from the nature of the problem, a sense of pressure arising from outside competition or realistic time urgency.

Other Features of Project Management
Ability to set clear overall goals while allowing operational freedom; ability to gain political support for the project, shelter the group from outside pressures and distractions, and serve as a good role model; ability to match the right person to the right job; ability to foster good project-team communication.

Other Features of Organizational Climate
A generally cooperative and collaborative atmosphere within and between divisions, with good communication throughout; a good mechanism for considering new ideas in the organization; neither an overemphasis on tangible rewards for employees *nor* an insufficient, unfair distribution of rewards and recognition; a minimization of red tape and formalized procedures; a minimization of political problems within the organization.

> This was not something that was imposed on them, but a problem that they generated themselves. . . . In order to get creativity, you can have large, well-defined time targets for the overall project, but the individual targets for the parts have to be left to the people to feel they have control over it.

This last quote illustrates an important qualification concerning the role of freedom in promoting R&D creativity. A great many previous researchers have found that freedom generally does promote creativity (e.g., Andrews, 1975; Andrews & Farris, 1967; Ekvall, 1983; Kanter, 1983; King & West, 1985; Pelz & Andrews, 1966; Peters & Waterman, 1982; Steiner, 1965; West, 1986). However, many have also found that complete freedom can be as detrimental to creativity as a complete *lack* of freedom. Andrews and his colleagues (Andrews, 1975; Andrews & Farris, 1967; Pelz & Andrews, 1966) have shown repeatedly that what they call “coordination” is just as important as freedom—a coordination of overall team efforts by the supervisor. This notion is quite similar to that proposed by Bailyn (1984). She defines “strategic autonomy” as “the freedom to set one’s own research agenda” (p. 7), and suggests that this autonomy should rest strictly with the research manager. She defines “operational autonomy” as “the freedom, once a problem has been set, to attack it by means determined by oneself, within given organizational resource constraints” (p. 7), and suggests that this is the autonomy so crucial to the creativity of individual R&D scientists. Our own research findings confirm this: the overall goals for a project must be firmly set by management and clearly communicated to the project team, but members of the team should be allowed as much autonomy as possible in deciding how to accomplish those goals.

Previous researchers have not found explicit evidence of the detrimental effects that constraint, or a lack of such freedom, can have on R&D creativity. But such evidence was abundant in our data. The most frequently mentioned single environmental factor in the low creativity events was constraint, defined as a lack of freedom in deciding what to do or how to do one’s work. Over 48 percent of our participants mentioned this obstacle.

> That was a low creativity situation because they wanted me to follow a particular path without adding any of my input into it. If you want to use your creativity, you can’t be told the exact way something should be done.

This quote clearly illustrates the negative impact of this particular factor—constraint—on this particular individual's intrinsic motivation to do creative work.

Encouragement

Encouragement and support of ideas has appeared prominently as a positive influence in previous research on organizational creativity (e.g., Baran, Zandon, & Vanston, 1986; Daft & Becker, 1978; Ekvall, 1983; Steiner, 1965). This positive factor, mentioned by 47 percent of participants, included three major points in our categorization scheme: management enthusiasm for, interest in, and commitment to a particular research idea or to new ideas in general; an orientation toward risk and acceptance of failure on the part of management; and an atmosphere without destructive criticism or excessive concern over evaluation. This encouragement and enthusiasm, this innovative vision, seemed to be most effective if it came from the highest levels of the organization.

> We wrote up a proposal to use this technique. It was submitted to the management in our division, where it got support. Then we reported about this work in meetings with other divisions, and there was a lot of interest. People wanted us to start right away.

> The project was a risk, so a willingness to gamble money was important.

> What helped here was people feeling secure—having an environment where they could say anything and not feel dumb.

The *opposite* of encouragement took several different forms that proved destructive to creativity. The most prominent of these, mentioned by 39 percent of our interviewees in their low creativity stories, can be termed "organizational indifference"—a lack of psychological support within the organization, a lack of faith in the project, a general apathy or complacency toward research.

> From the beginning, the concept really lacked any innovative thought. It was a defensive strategy; instead of looking for a concept that would be one step beyond what was currently available, we settled for coming out with something that was a "me too" product.

Evaluation pressure, mentioned by 33 percent of our interviewees, can also be considered as opposite to the kind of encouragement that is conducive to creativity.

Such pressure takes several different forms: inappropriate evaluation to feedback procedures, unrealistic expectations, pressure to produce something (anything) appropriate, and a general concern about criticism and external evaluation of work.

> Management had a very heavy hand and essentially over-reviewed the project.

A third factor that can undermine the encouragement to be creative is an overemphasis on the status quo within the organization, particularly at the highest levels. Comments about this factor, coming from 26 percent of our interviewees, concerned the reluctance of managers (and sometimes peers in other divisions) to change their mode of thought or operation. Instead, there was an emphasis on keeping things the same, not wanting to take risks, avoiding controversial ideas, and taking a generally conservative course.

> I'm disappointed in the outcome, even though the project was a good one. The problem was an overemphasis on the status quo; there's so much momentum in the organization to keep things going the way they are that it is almost impossible to turn that around.

A few other researchers have found negative effects of these factors. For example, Havelock (1970) describes the negative impact of "resistance to innovation" within the organization, and Kanter (1983) describes the effect of frequent threatening evaluation. However, most previous research reports do not give such factors the prominence that they clearly display in our interviewees' descriptions of low creativity events.

Resources and Time

The high creativity events described by our interviewees were quite consistently marked by a sufficiency (though not necessarily an abundance) of resources, including facilities, information, funds, and people—stimulating people both within and outside of the work group. These events were also marked by a sufficiency of time to think creatively about the project. Fifty-two percent of our interviewees mentioned sufficient resources, and 33 percent mentioned sufficient time.

> Something very important was the support provided. There was an allocation of people and capabilities throughout the organization. It was possible to get lots of diverse information.

> He was insulated from day-to-day fire fighting, so that he was able to step back and take the time to think of this process and develop it over several months.

As might be expected, a lack of resources (mentioned by 33 percent of our interviewees) and a lack of sufficient time (also mentioned by 33 percent) were important undermining factors in the low creativity events.

> Our main problems were time-sharing of the production process, and limited resources generally.

> There was pressure to get the product produced quickly. It was a long-range product, but this is a short-range company.

Perhaps because they have considered time and resources to be obvious prerequisites for creative work, and have not explicitly looked for their role, previous researchers have not highlighted these factors in their data reports.

Recognition

Despite the lay person's stereotype of scientists as loners, content to labor in isolation and happy to be left alone, it is clear that creative scientists not only tolerate but actually need feedback on their work, and the subsequent recognition of their creative efforts as well as their creative successes. This is a fact that previous researchers have documented well (e.g., Ashford & Cummings, 1985; Kanter, 1983; Peters & Waterman, 1982). Thirty-five percent of our interviewees described recognition or appropriate feedback as conducive to creativity.

> It was good to hear management say, you made a good discovery this month, and we are going to show it to top management, and you are going to be there to make the presentation. The pat on the back, the recognition, felt good.

Challenge

Creative researchers and theorists have long suggested that creativity results when a certain kind of tension is felt within the individual. In our own results, we found that certain kinds of pressure could actually enhance creativity in R&D scientists. The most notable type of pressure in the high creativity events was a sense of challenge, arising either from the intriguing nature of the problem itself or from the urgent needs of the organization. Challenge, which has been noted by other researchers (e.g., Ekvall, 1983; Pelz & Andrews, 1966), was mentioned by 22 percent of our interviewees.

> We were put in a situation where people said it couldn't be done; other companies had turned down the offer. . . . So there was a challenge. That challenge gave us our motivation.

Once again, we see the impact of an environmental factor on personal motivation.

Although they were not mentioned frequently (only 12 percent of our interviewees brought them up), some other sorts of pressure within the work environment—such as time pressure or competition—were occasionally cited in the high creativity events. Our participants' comments seem to suggest that, rather than being a pressure applied by some external force, this conducive type of pressure is internally generated, and is perceived as another kind of challenge; the individual or team feels driven to prove that they can meet the challenge of an urgent situation:

> This was not something that was imposed on them, but a problem that they generated themselves. There were no specific deadlines, but a sense of urgency that was internalized.

> The marketplace is competitive, and therefore we feel compelled to compete.

Just as often as competition could stimulate creativity, however, it seemed to undermine creativity too. Fourteen percent of our interviewees mentioned competition between groups or individuals who might have been working together or even should have been working together:

> We had two groups trying to achieve the same thing. This fostered competition. It became a win-lose situation, and we all ended up losing.

The negative effects of this sort of *internal* competition have also been uncovered by Kanter (1983) in her study of innovative and noninnovative people.

Other Features of Project Management

Obviously, all of the factors we have described thus far make for good project management: freedom, encouragement, allocation of resources and allowance of sufficient time, recognition and feedback, and positive pressure. But our interviewees also mentioned a great many other features of project management that can influence creativity. Altogether, 65 percent mentioned some feature of good project management in the high creativity stories, and 37 percent mentioned some feature of poor project management in the low creativity stories. Although no single one of these other features was mentioned with particularly high frequency, some do stand out. For example, many participants cited the ability of the project manager to set clear goals and provide a coherent problem definition for the group—in other words, to effectively use strategic autonomy (Bailyn, 1984):

> As the manager of this successful project, I gave the people involved a clear idea of what the end product was going to be. I attempted to get each person involved in those aspects that were in their expertise, and I asked them how they would go about doing it. I let people set their own goals and manage their own business.

As might be expected, the absence of this skill often showed up in the descriptions of project managers for the low creativity events:

> Our project suffered because goals weren't being set; it's hard to work without certain goals in mind. The supervisor wasn't good at making decisions.

Good project managers also show an ability to gain political support for the project, shelter the group from outside pressures and distractions, and serve as a good role model. Often, the technical expertise of the project manager can be important; some projects seem to have derailed because the manager was scientifically incompetent and didn't really understand what was going on. Another important aspect of good project management is the ability to match the right person to the right job, and adjust management styles depending on the individual being supervised. Finally, a successful project manager must also foster good communication within the project team. Many of these features of good project management are similar to those reported by Andrews (1975).

Other Features of Organizational Climate

An organization that supports creativity has, as part of its climate, the positive factors we have already presented: freedom, encouragement, allocation of sufficient resources and allowance of sufficient time for creativity, appropriate recognition for creative work, and some degree of positive pressure. According to the event descriptions given by our interviewees, however, there are a number of other features of organizational climate that play a role. Altogether, 42 percent of the interviewees mentioned some other organizational factor as a positive in the high creativity stories, and 62 percent mentioned some other organizational factor as a negative in the low creativity stories. Although no one single factor stands out with a particularly high frequency, some are more noticeable than others. One crucial point, for example, seemed to be the necessity of having a mechanism within the organization for considering new ideas:

> What encouraged me? The company had set up an innovation office (or research proposal system) that was promoted by division management and recognized by people on the bench as something worthwhile to get interested in.

Another important positive was a generally cooperative and collaborative atmosphere within and between divisions, with good communication throughout . . .

> Having the other scientists to talk to is important. When it came time to introduce the product, he had support from different areas . . . which enhanced its coming into the marketplace.

. . . and the absence of such a collaborative atmosphere can severely hamper creativity:

> When we bring an idea to manufacturing, we have to overcome the NIH syndrome—Not Invented Here.

Several other researchers have cited the important roles of good communication and collaboration (Ekvall, 1983; Kanter, 1983; Pelz & Andrews, 1966; Rothwell, 1977; Steiner, 1965), as well as mutual trust and confidence within the organization (Ekvall, 1983; Ekvall, et al., 1983).

One of the most striking organizational factors named as a detriment to creativity was the reward system—either too much emphasis on rewards, or insufficient or unfair distribution of rewards (including recognition for good work):

> The problem is that there is a tendency to drive people toward management—that is the way to move up—and no drive to keep them in the technical side. There is a dual ladder system, but it is clearly not an equitable situation. One ladder is shorter than the other.

> Rewards have an effect on creativity. I would not like to be put in a situation where you are told you will get this reward if you get this particular job done.

Our reading of our participants' remarks about reward systems leads us to conclude that R&D scientists *do* feel that they are in an organization that provides extrinsic rewards equitably and generously following good work, but having a particular, tangible reward offered for a particular job can undermine that intrinsic motivation we discussed earlier. We feel that Pelz and Andrews (1966) summarized this phenomenon best: ". . . the research director must give close attention to the whole system of rewards—both intrinsic and extrinsic. He must live with the paradox that extrinsic rewards cannot be relied on to motivate achievement, but that when achievement occurs, the extrinsic rewards should be consistent. And possibly the very provision of them will stimulate further achievement" (p. 139).

As noted by several other researchers (Kanter, 1983; Zaltman, Duncan, & Holbeck, 1973), overly formal and complex structures, procedures, and communication channels within the organization can be detrimental to creativity.

> Here, instead of ideas really flowing, we have a more formal presenting of ideas. You wait until you have a complete package of information and then present it to a formal meeting after you understand things.

> The structure I'm working in is not matrix management, but matrix mismanagement. I am reporting to too many different organizations and I seem to be a part of too many different organizations all at once.

A number of participants mentioned political problems within the organization, and, perhaps partly as a result of those problems, the lack of a mechanism for encouraging and developing new ideas. Finally, some of the negative organizational factors were quite general, referring to the physical plant or to methods of doing business within the organization.

> Very often these days creativity is something that management wants to buy, and they hope they will hire someone who will get bolts out of the blue. But the problem is, you've got to put your work in and understand the system. People aren't allowed to stay in a job long enough to develop the skills that will allow them, if they have creativity, to take the next step.

Summary: Environmental Factors

As with the personal qualities of R&D scientists, we have presented a large number of environmental factors that can influence R&D creativity positively or negatively. And, as we found with the personal qualities, although many of our findings echo those of earlier researchers, some of our results have not been previously highlighted in the creativity literature. This is particularly true of the factors we found consistently in the low creativity stories—the environmental obstacles to creativity.

Perhaps so many previously overlooked factors appeared so prominently in our list of environmental obstacles simply because previous researchers have not used the method of asking specifically about instances of *low* creativity. Whatever the explanation for our new findings, we believe it is critically important for managers to be aware not only of stimulants to creativity—so that they can implement these stimulants in their management style—but also of obstacles to creativity—so that they may eliminate these elements from their management style!

Because of the large number of environmental factors that appear to play a role in R&D creativity, we find utility in the same model that we used to summarize and conceptually categorize the information on personal qualities of scientists. The model, applied to environmental factors, appears in Figure 2 (page 24). The three essential components for creativity in R&D environments (and, probably, in other environments as well) appear to be: (1) Raw materials—the basics on which R&D units can draw in producing creative work. These include all of those factors that we grouped under Resources and Time. (2) Techniques—the management skills that are conducive to creativity. This component is by far the largest; it includes all of those factors that we grouped under Freedom, Recognition, Positive Pressure, Other Features of Project Management, and Other Features of Organizational Climate. (3) Motivation—the *innovation motivation* of the organization, most clearly exemplified by upper management's vision of the company as innovative and forward-looking. This component includes most of the factors that we listed under Encouragement. Clearly, this motivation is the element that can make everything else come together. Talented people, abundant resources, and even good management skills at the lower levels of an organization will be insufficient to sustain consistent long-term creativity—unless the spark of motivation comes from the highest levels, is articulated in a clear and engaging vision, and is then constantly communicated to those who are asked to be creative.

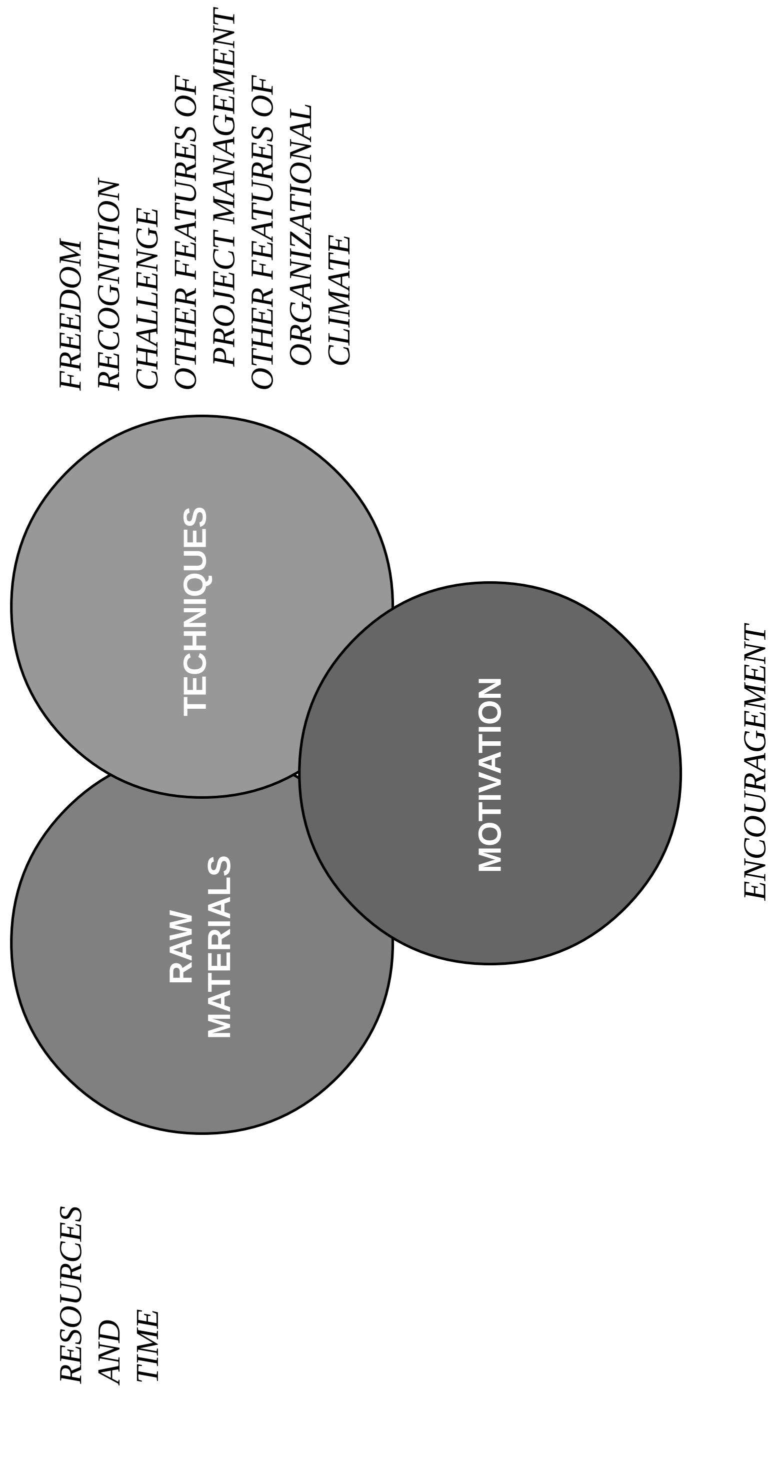
Conclusion

Managing for Creativity in R&D: The Delicate Balance

The creative process is elusive. Although researchers have had considerable success studying creative products and ideas, creative persons, and environments that promote creativity, we still know very little about the actual process of creative thinking. For that reason, it is an illusion to believe that the creative process can be "managed." R&D supervisors, and their upper-level superiors in organizations, cannot manage creativity in scientists. But they can manage *for* creativity; that is, they can

Figure 2

SUMMARIZING THE ENVIRONMENT FOR CREATIVITY IN R&D



establish work environments, organizational climates, and support systems that will allow creativity to flourish. The data we have gathered suggest that this cannot be accomplished by simply eliminating some elements from work environments—say, evaluation system—and putting others into place—say, freedom. It is more a matter of finding that delicate balance between too little and too much of each of these factors. In this concluding section, we will highlight what we feel are some of the most important points in achieving this balance of managing for creativity.

Communicating Innovation Motivation

Perhaps the most important role to be played by upper management in supporting creativity involves formulating and constantly communicating a clear vision of the organization as innovative, unafraid of risk, supportive of new ideas, and offensive (rather than merely defensive) in the marketplace. Such a vision, if it is backed up by appropriate evaluation and reward systems, as well as sufficient funding for new idea development, can provide that kind of positive encouragement to scientists that appeared so frequently in our high creativity stories.

Finding the Right People and Using Them Effectively

The most basic resource necessary to creativity in R&D is, of course, people. We (and other researchers) have found that the scientists most likely to be creative are those with strong intrinsic motivation for their work, a good background of experience and expertise, and special personality characteristics, such as risk-orientation, that can be considered “creativity skills.” Hiring decisions in R&D routinely consider the candidate’s experience and expertise carefully and may even take creativity skills into account (if only indirectly by looking for a history of creative ideas). But intrinsic motivation is too often neglected. Given the crucial importance of this characteristic, it might be wise to explicitly probe candidates for their level of personal interest in the work. Simply asking, for example, what the candidate considers his favorite projects of the past—and why—can reveal a great deal about the depth of intrinsic motivation in a particular line of work.

Motivation, combined with skill and experience, are not only important in initial hiring decisions within R&D. They are also crucial in making project assignments. Recall that one feature of good project management is the ability to match people to jobs appropriately. Assigning people to projects that capture their intrinsic motivation will vastly increase the probability of creative work. This motivation may even make up for some deficiencies in expertise. As the Nobel laureate in physics, Arthur

Schawlow, said, “The labor of love aspect is important. The most successful scientists often are not the most talented. They are the ones who are just impelled by curiosity. They’ve got to know what the answer is.”

Setting Appropriate Goals

We found, as other researchers have, that freedom is essential to the R&D scientist’s creativity. But the delicate balance required in granting freedom is especially crucial. For most projects, the manager must retain the right of “strategic autonomy,” to set the overall direction for the project. But, at the same time, that manager must allow “operational autonomy” to members of the project team, autonomy to decide on the means by which they will achieve the overall goals.

If there was sufficient time at the end of the interviews, we sometimes asked our interviewees what they see as the major factors making the difference between high and low creativity in R&D. The remarks of one of these interviewees best sums up the appropriate balance between freedom and control:

> The best managers are those who ask questions. The role of the manager is to make clear what the objective, directions, and purposes are, to set up a picture or long-term objective that a person will be working toward. Once the operation is underway, the manager should then provide an environment where a lot of questions are asked. He should be nonjudgmental—the people working on the project, or their peers, should make judgments.

Evaluating Constructively

This same interviewee, whose remarks we just quoted on appropriate managerial control, also described evaluation in a way that fits our overall findings quite well.

> Managers should make sure of the completeness of the work, and should ask about the ramifications of different procedures. Sometimes it’s necessary to ask what might be perceived as dumb questions. It should really be like peers talking to one another.

According to our results, feelings of evaluation pressure can severely curtail any risk-taking and, as a result, severely undermine creativity in R&D. However, this does not mean that an absence of evaluation will be conducive to creativity. We also found that scientists very much need to feel that their work is being paid attention to, that they are getting appropriate, constructive feedback on their work, and that their creative efforts (as well as their creative successes) are being recognized. The delicate balance in evaluation, then, comes through providing feedback that scientists see as primarily *informational* rather than primarily threatening or *controlling.* (See Deci and Ryan, 1985, for an elaboration of this important distinction between informational and controlling systems.)

Rewarding Appropriately

Rewards, too, can be perceived by the person on the receiving end as either informational or controlling. As we saw in the remarks of some of our scientists, an exclusive or primary focus on rewards—on what they can get for doing each specific job—leads to an extrinsic motivation and lower creativity. This change in motivation most likely arises because, presented in this way, rewards appear as an attempt to control behavior. But the feeling that one works in an organization with a history of generously and equitably rewarding good effort can lead scientists (and others) to see rewards as just recognition for a job well done. The balance here is between explicitly holding rewards out as carrots for specific jobs and implicitly making it clear that creative work is always recognized and rewarded in the organization.

Adjusting the Pressure

This is, perhaps, the trickiest balance of all. It seems true, from our own interviews and from the work of others, that some element of pressure or internal tension can be optimal for creativity. It is also clear, however, that too much pressure, or pressure from the wrong sources, can undermine creativity.

The key to this puzzle seems to have two parts. First, if the *other* factors conducive to creativity are in place, moderate pressure from any source might stimulate creativity. In other words, if the team is made up of individuals with the appropriate skills and motivation; if the organizational climate contains the necessary innovation motivation, appropriate evaluation and reward systems, and communication/collaboration between groups; and if the project manager sets goals appropriately, allowing sufficient freedom and protecting the project team, then a moderate amount of pressure should not undermine creativity and could, in fact, stimulate it.

The second part of the key has to do with the *type* of pressure. We found that an internal pressure can be very helpful—a pressure arising from a personal sense of challenge over a difficult problem or a desire to do something no one else has done. Also, if there is a realistic time urgency (perhaps because another organization is about to come out with a similar new product), or if there is a sense of competition against outside groups or companies, creativity can be stimulated. By contrast, however, if pressure arises solely from deadlines that appear to have been set arbitrarily by upper management or from management expectations that appear unrealistic, creativity is likely to be undermined.

The best way to achieve the desired balance of pressure, then, may be to adopt a more participative, collaborative management style where members of the project team know where the sources of pressure are, and why the pressure is necessary. Operational autonomy can go a long way toward helping them deal effectively with the pressure, too. If individual scientists are given autonomy in setting immediate project goals that respond to those pressures, potentially negative pressure may become a positive force.

A Formula for Creativity

There is none, of course. We feel that it is important to stress that the nature of creativity precludes us, or anyone, from providing a “do this, then that” formula for managers interested in promoting creativity in the R&D lab. Precisely because creativity results in new, unexpected ideas, processes, or products, its course cannot be strictly guided or planned in advance.

Although we cannot provide a clear formula for managing a creative R&D environment, we can identify the *elements* that must go into the equation. At the level of the organization, three types of elements are required: raw materials, techniques, and motivation (see Figures 1 and 2). For the individual, raw materials are ability and experience; techniques are risk-orientation, social skill, and the other personality qualities; motivation is intrinsic task motivation. For the organization, raw materials are resources in the relevant task domain; techniques are all the facets of appropriate project management and organizational management (including freedom, encouragement, recognition, and positive pressure); motivation is the motivation to innovate, that encouragement for creativity that comes from the highest levels of the organization—what we call “strategic leadership.”

We can think of these three components—raw materials, techniques, and motivation—as circles that overlap to a greater or lesser extent (as in Figures 1 and 2). Creativity in R&D should be greatest at the Creativity Intersection—that area where the skills of individuals overlap with their motivations, and where the resources and management practices of the organization overlap with a clear innovative vision.

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