SOCIAL DESIGN

The Link Between Facility Design, Organization Design, and Corporate Strategy

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1.

INTRODUCTION

The Productivity of Knowledge Work

"The application of knowledge to work created developed economies by setting off the productivity explosion of the last hundred years. ... Increasing the productivity of manual workers in manufacturing, in farming, in mining, in transportation, can no longer create wealth by itself. The Productivity Revolution has become a victim of its own success. From now on, what matters is the productivity of non-manual workers. And that requires applying knowledge to knowledge."[1]

Peter Drucker

The shift from the industrial economy to the emerging knowledge economy is deeply reflected in the new way of creating value: applying knowledge to knowledge. As knowledge resides uniquely in the human mind, only knowledge workers can use existing knowledge or create new knowledge. Hence, during the last twenty years a new kind of worker, the knowledge worker, has emerged at the leading edge of this phenomenon.

Now that knowledge work is widely recognized as a most important source of value for organizations and for society as a whole, a great deal of exploration is under way to determine what conditions best support optimum productivity for knowledge workers.

One of the most important factors that influences the productivity of knowledge is the place in which work occurs, a physical facility that generally takes the form of an office building, a home office, or a research laboratory.

A survey of the field reveals that we are now in the midst of a tremendous evolution in the design of these facilities. And many of these new facilities share a significant quality. As their designs have been motivated by persistent beliefs in the importance of interaction for the productivity of knowledge workers, new concepts intended to promote interaction are being tested in numerous building projects.

Thus, the purpose of this report is to explore some of the most important concepts and trends concerning the relationship between facility design, interaction, and the productivity of knowledge.

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SOCIAL DESIGN

The concept of "social design" as used in the title of this report refers to the widespread belief that interactions between knowledge workers provide an important spark for their creativity, and thus for their productivity as well.

Nearly everyone has had the experience of a chance conversation that opens new insights which later prove to be important. Because this experience is so widespread, it is almost universally accepted as true even though scientific evidence to support the linkage between interaction and creativity is little known. In fact, science now explains a great deal about why there is a tremendous difference between interacting face to face and all other forms of interaction. A summary of the key ideas is presented in Part 5: Science and Social Design.

Economics is also an important factor in any discussion about creativity and productivity. In 1987, Morgan Stanley economist Stephen Roach identified a phenomenon he labeled "the productivity paradox."[2] What he discovered was that although American companies spent trillions of dollars on information technology (IT) in the 1970s and 80s, the productivity of the office workers using that IT equipment did not improve.
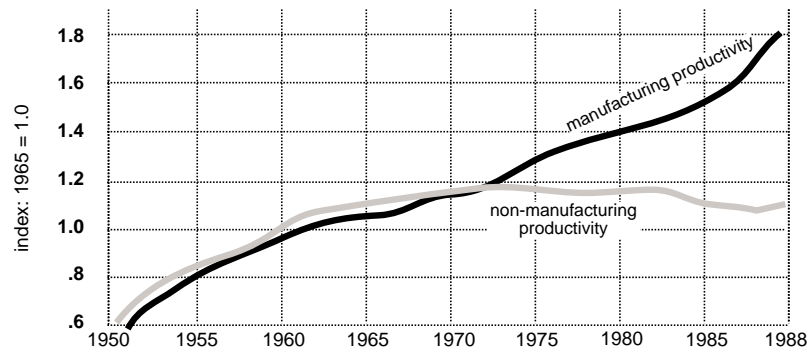
The Productivity Paradox[3]

Since productivity improvements are the fundamental reason for investment, as well as the basis for increasing the wealth of any society, Roach's finding is very significant. To some degree, it calls into question the IT strategy of nearly every American firm, and projecting the trend forward in the worst case could portend a precipitous decline in America's position in the global economy.

These issues have significance in many fields in addition to architecture, among them education and training, the design of work processes, and the design of organizations.

The focus in this report is in reference to the discipline of architecture, as through the practice of architecture buildings and urban spaces are created to support rich person-to-person interactions. Could it be that architecture is as relevant to the productivity of knowledge-dependent organizations as computers are? Given historical patterns of investment, this is a radical proposition.

Or is it? An informal survey conducted in preparing this report revealed that hundreds of American companies are now or have recently invested literally billions of dollars in new facilities for their knowledge workers. Furthermore, the designers of nearly all of these facilities have given considerable attention to the factors supporting human interactions, and have included in these buildings new features that specifically promote many different forms of interactions.

The term "social design" therefore refers to that aspect of architecture which takes as a priority the creation of environments for effective and positive human interaction, and in the end asks the question:

Can better buildings make for a better quality of interaction?

The subtitle, "The Link Between Organization Design, Facility Design, and Corporate Strategy," describes the strategic opportunity that facility design offers to corporate leaders. Organizations are subject to design just as much as buildings are, and as you will discover below, organizational innovations can spawn new and ingenious approaches to architecture. Since the design of both facilities and organizations are entirely complementary with one another, these two aspects of design can literally define and reinforce effective corporate strategy in this age of "intellectual capital."

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3.

THE KEY THEMES

There are few work environments more complex than the research laboratory, and none that better exemplify the complex issues surrounding knowledge work.

In a typical laboratory, knowledge workers (who are generally scientists, engineers, and technicians) design and conduct experiments whose purpose is to create useful new knowledge. This knowledge is expected to be valuable to a company or organization. It may be knowledge of the uncharted physical world of chemistry or biology, or knowledge about the behavior of man-made products, or knowledge about how people interact with each other and with physical artifacts.

The number of scientists and engineers doing all this work is steadily increasing, and in fact it was recently noted that 90% of all the scientists who ever lived are still alive, and still working.[4] Partly as a result of their aggregated work, the role of knowledge itself has become a central fact of our economy, and as a result we care more and more about the insights that scientists and engineers generate in their labs.

From the perspective of the architect, it turns out that the design of research laboratories is quite a difficult problem. Numerous factors must be taken into account, some of which require conflicting or contradictory responses. Hence, it is the architect's job to find the best balance between these factors, taking into consideration the client's needs, culture and organization.

The most immediate issue is that in a typical lab facility, researchers work in two different settings, the lab itself as well as their separate offices. Ideally, these two work locations should not be too far from one another, but they also should not be isolated from other offices and labs so that researchers can easily interact. Then again, there are cost considerations which suggest that separating lab and office functions is more cost-efficient.

And what is the client's view of interaction? Is there a belief that optimizing interaction is critical, and if so what building features are most effective at promoting interaction? Or is the preference of the researchers to have a lot of private space? And if so, will the company try to force interaction anyway?

An interesting aspect of the interaction question shows up in the design of larger facilities. Building complexes meant for thousands of people are commonly used by large companies to bring their key knowledge workers into proximity of each other, and the key questions inherent in designing these complexes go beyond architecture and into the domain of urban design.

Since the urban experience is focused precisely on fostering safe and enriching interactions between people, the field of urban design may be as relevant for one floor of one building, as it is for "company towns" of 3000 people, as it is for communities of tens of thousands or millions. Numerous references to urban design, both literal and metaphorical, are mentioned in the projects reviewed for this report, because in the end the way we interact with each other in the context of any built environment raises the same issues and possibilities regardless of population size.

Among the other questions strongly influencing architects and their clients are those of future use. Labs change occupants, uses, needs, and configurations with great regularity. How will this need for flexibility be reflected in the overall design? More flexibility may require greater up-front investment. Is the capital available?

In addition there are requirements driven by the shape of a building site, the number of people who are going to use a particular facility, expectations for future expansion, and local codes.

And there is a timing question. How much of a hurry is the client in? This factor, it turns out, drives responses to many of the other issues. As one pharmaceutical executive put it, "In our business, time is more important than money," meaning that in their environment of intense competition, getting to market quickly may be much more important to the long-term viability of a company that what it cost to do the development work of a particular drug or to build the building in which the development work is to be done.

At Procter & Gamble, this has led to the development of a management philosophy referred to as, "Kill'em quick!"[5] This is the practice of stopping development activity as soon as it becomes clear that a project is stalled, and immediately shifting resources to more promising areas.

In this intense competitive environment, the architect and the client must decide which facility variables to optimize, and which are secondary. In most of today's new facilities, companies are opting to optimize for interaction.

The roots of these questions go back many decades. In 1977, Tom Allen, Professor of Organizational Psychology and Management at MIT's Sloan School of Management, wrote what is still the definitive book on interaction in the laboratory, *Managing the Flow of Technology.* [6] The book presents the results of many years of research into the factors affecting human interaction in the R&D process.

One of the key discoveries of Allen's work is a graph showing the probability of interaction between two people as a function of the distance between their offices.

**"The probability that two people will communicate as a function
of the distance separating them"**
Adapted from: Tom Allen, Managing the Flow of Technology
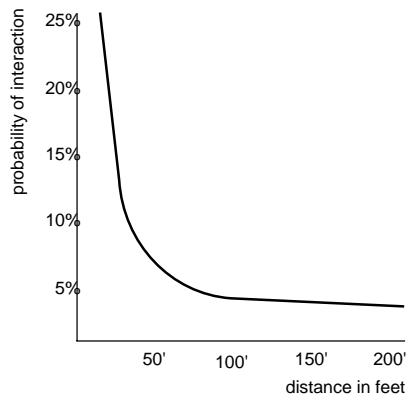
Once the importance of face-to-face interaction is accepted as a design goal for an R&D lab, the obvious implication of this research is that everyone should be no more than 100 feet away from everyone else. This is, of course, quite impossible in organizations with more than about a hundred people. Nevertheless, there are strategies that can be applied to optimize interactions, and Allen explores many of them in his book.

When he applied the lessons from the proximity graph to the design of the laboratory, Allen recommended this floor plan to a company that was developing a new laboratory.

"Configuration for the new laboratory facility"
Adapted from: Tom Allen, Managing the Flow of Technology
not to scale
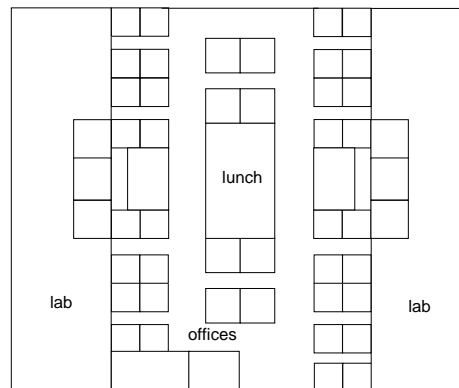
Subsequent analysis showed significant improvement in communication between many groups using the facility (as well as an unintended consequence of reduced communication between occupants of this lab and the rest of the organization). The concepts discovered and developed by Allen remain strongly influential, as we will see below.

Another key theme discussed in the report is the psychology of shared spaces. Cultural norms about privacy and individual behavior become very important when work spaces are shared. The greater the sharing, of course, the more poignant the issue is likely to be. In some cases, a great deal of effort has been needed to handle the psychological needs of people who had not been accustomed to working in shared spaces.

Another topic worth noting is a dual shift in the practice of chemistry that has both organizational and architectural consequences. Over the last decade, a great deal of research in chemistry that had been done manually by scientists and technicians working in labs has gradually become automated through the use of new equipment and methods. As a consequence, it isn't necessary for researchers to be in their labs as much as in the past.

Toxicity is also an issue. As the toxicity of lab chemicals has become better understood in recent decades, the goal of spending less time in the lab has been accepted as a way to reduce toxic exposure.

These shifts have interesting manifestations. One is that when you visit a chemistry lab today, you rarely find anyone there. Nancy Escano of Dowler-Gruman Architects notes that some clients find this troubling. Among her many client companies, those led by older executives who were accustomed to spending a great deal of time in labs tend to favor optimizing the design of new facilities around lab usage, while younger executives tend to optimize for the offices. The difference of focus can lead to dramatically different end results.

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The facilities described in this report accommodate from 200 to 3600 people, a wide range of scales that encompass very different kinds of problems. The firms using them compete in a range of industries, including four in pharmaceuticals, two in biotech, one in polymer chemicals, and two in software.

Interestingly, although they face very different issues and concerns in the marketplace and in many aspects of the design of their facilities, the issues of function as it relates to interaction, creativity, and productivity turned out to be nearly identical, and the creativity that they and their designers display is a pleasure to experience.

4.

FACILITY DESCRIPTIONS

Genentech South San Francisco Campus

W.L. Gore & Associates Elkton Cluster

Procter & Gamble Heath Care Research Center

Chiron Corporation Life Science Center

Glaxo Wellcome Inc. US R&D Headquarters

Inhale Therapeutic Systems Headquarters

Hewlett Packard RSI Team Space

Alza Corporation Mountain View Campus

Sun Microsystems Menlo Park Campus

GENENTECH
South San Francisco,
California

Process Science Center
Size: 160,000 square feet
Employees: 160
Architect: FLAD and Associates, Madison, Wisconsin
Date: 1995

Founders Research Center
Size: 275,000 square feet
Employees: 300
Architect: SRG, Portland, Oregon
Date: 1993

The Company
Genentech is a biotechnology company located in South San Francisco, California. Reflecting the company's growth over the decades since its founding, the company's campus consists of many buildings that were built at different times. This progression shows the evolution of laboratory designs from the earlier buildings to the latter ones, and offers many insights into lab configurations.

As with the other companies described here, Genentech believes that informal communication improves the possibility of doing something new and innovative. This belief has significant influence on the design of Genentech's facilities, although no effort has been made to measure the effectiveness of random interactions.

For example, the location of offices, toilets, mail rooms, copiers, coffee machines, and stairways within individual buildings is intended to force interactions by bringing people to these shared spaces and functions.

In addition, special "interaction spaces" have been used in many facilities, with varying degrees of success. Subsequent observations at Genentech (and confirmed at Sun Microsystems, as described below) revealed that the psychology of these spaces can be complex.

In the Process Science Center, comfortable spaces for informal interaction were located at the end of long hallways, with the idea that people could easily see if anyone else was using the space. However, the easy visibility had the opposite of the desired effect, and the rooms are rarely used. It

turns out that in Genentech's intense corporate culture, people feel guilty if they are seen relaxing, so the very visibility of the interaction space makes it unusable. It was clear in retrospect that the space would have been used much more if it was more private.

The difficulty Genentech has had in designing effective interaction spaces led facility manager Scott Hoag to observe that, "A lot of people can tell you what interaction space is not. Few people can tell you what it is."

Privacy is also a theme in laboratory design at Genentech. In the most recently-designed building, although labs are shared they are configured to give considerable privacy.
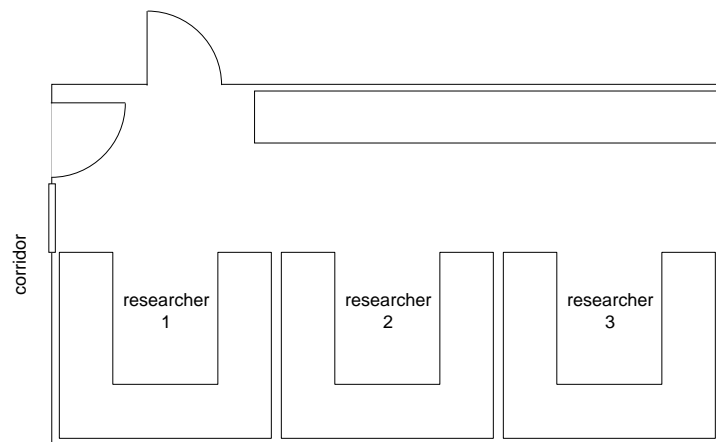
Genentech
Typical Laboratory Floor Plan
not to scale

Genentech's labs are also built with as much modularity as possible to make it easy to change uses and to remodel.

Although somewhat different in their aesthetics, the two recent building considered here have very similar lab configurations. Each has two long corridors with research labs along the exterior, support labs between, and offices at the ends of the structure. There is no separate set of corridors for materials and equipment.

		labs		offices		labs	
offices		lab support		admin support		lab support	
		labs		offices		labs	
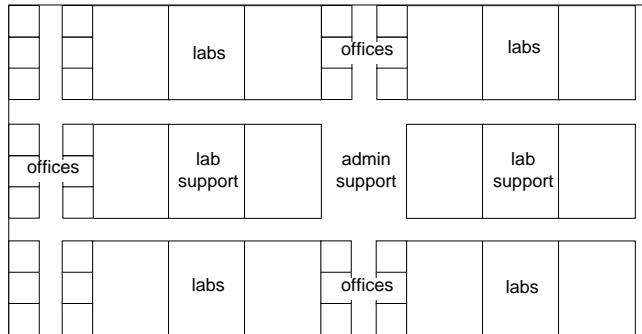
Genentech
Typical Laboratory Wing
not to scale

An interesting side note is Genentech's use of music. Money is included in the construction budget to pay for a stereo system for each new lab. As you move from one lab to another throughout the company one encounters a wide variety of music.

In all of Genentech's buildings, the issue of crowding is continually an issue. The growth of the company combined with changing research activities and functions constantly creates pressure to reconfigure spaces, and often to add more people.

In one building, this meant that spaces designed as conference rooms quickly became offices, resulting in a definite lack of meeting space.

But crowding is not an entirely bad thing. During the design phase for a new building, an R&D director drew a graph correlating "researcher happiness" with "laboratory crowding".
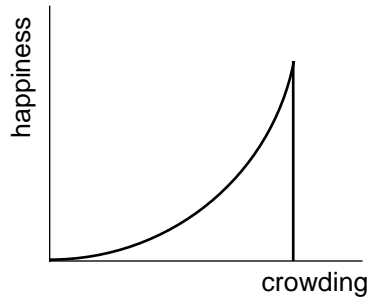
Although the threshold may vary for each individual, there was general agreement that such a threshold did indeed exist, beyond which further crowding quickly leads to reduced happiness. Since Genentech believes that the "right" crowding correlates with productivity, determining the right degree is critical.

This graph also illustrates an interesting consequence of architecture that often affects start-up companies. Hoag observes that when start-up companies finally become successful enough to move out of the garage or skunkworks and into nice, new facilities, they lose something important that cannot be replaced. Many of these companies never achieve their potential that they showed in the crowded conditions of the skunkworks.

Another interesting phenomenon discovered at Genentech is the value of being naive. Early on, the relatively inexperienced Genentech staff worked with a relatively inexperienced architect and came up with innovative solutions to facility problems that they realize they might not have the courage to attempt now.

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W.L. GORE & ASSOCIATES

Elkton Cluster
Elkton, Maryland

Size: Facilities range in size from 70,000 to 214,000 square feet per facility, including office and plant space; 17 facilities in cluster. Office space is about 20 - 30% of the square feet in each facility.
Employees: 150 - 200 people per facility; 2600 in the cluster
Architect: Internal team with consultants
Date: Ongoing

The Company

W.L. Gore & Associates was founded by research chemist Bill Gore in 1958, when he left DuPont to pursue his interest in polytetrafluoroethylene (PTFE, known commercially as Teflon), a versatile polymer that had great promise for many applications.

Gore was right about the polymer's potential, and the company he founded is now a global, multi-billion dollar leader with 6500 people. The key innovations at Gore continue to be based on polymer chemistry, as well as innovative approaches to organization. For example, people who work at Gore are called associates rather than employees, since Gore believed that structured organizations and titles conflicted with the emergence of natural leadership. Nor do associates have titles, as these are seen as barriers to communication.

Facilities Design

Facility design at Gore is driven by company founder Bill Gore's belief that 200 was the maximum number of people you could know personally in a work place. Since it was important to him to maintain the family feeling in which everyone knew everyone else, a typical Gore facility holds no more than 200 people per shift.

For a small start-up company that's probably not a big deal, but for a global firm of 6,500 people, this model has significant influence on organization and facilities strategy.

To achieve economies of scale, Gore develops clusters of buildings designed for teams of up to 200. In the northern Delaware region of Newark-Elkton, 17 facilities of an average of 150 persons each are located in rural settings within 10 miles of each other, supporting a total population of about 2600 people. While most people spend their time at one location, some associates drive from place to place for meetings.

Innovation at the company is intentionally focused on the teams housed in each building, so a great deal of R&D is mixed in with the regular operation of each plant.

Gore's technical community includes associates who are located in the various buildings, so a monthly technical meeting is held among all the facilities in the cluster. Each month, people from one facility present their work and activities so that others are updated on technical and business issues pertaining to the entire cluster.

Floor Plan
Befitting the rural setting, the typical office is not a formal environment. Office spaces are very open to encourage informal communication. Workstations are arranged in standardized cubicle clusters called "villages," an obvious urban design metaphor that seems to fit the informal organizational style of the company very well.

Considerable care is paid to ergonomic factors. For example, a superior acoustic ceiling tile was found in Sweden, so that's what Gore uses. (It's called "Ecophon.") In addition, large skylights are used bring natural light to the center of the office space.

Most facilities are one story structures, as this is thought to support better communication, with layouts that are straightforward. A typical new facility in this cluster has plant and warehouse space built in an "L" shape, with an office space at the joint so that it's easy to get from the plant floor to the offices.
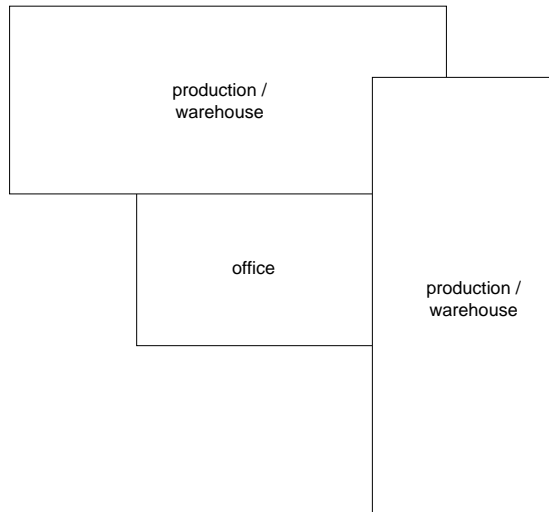
W.L. Gore & Associates
Elkton Cluster
Typical Site Plan
not to scale

Whereas it used to be that a facility was 50,000 to 60,000 square feet, increasing automation in manufacturing and warehousing has led to an increase in size. New plants are an average of 200,000 square feet for every 200 people. Of these, about 80 people are located in office spaces of about 38,000 gross square feet, which include common areas, conference rooms, and cubicles.

Facility Development Model
Gore's internal construction group manages the development process, and makes long term agreements with contractors to support good communication and fast construction. It generally takes 12 to 18 months from breaking ground to moving into a new facility. Since the company has grown about 20% per year, the need for new facilities has been constant.

Since new facilities are built in anticipation of future needs, assumptions must be made about the eventual use of a building when a new project starts. In one case, the proposed use for a building under construction changed three times during the construction process before any users actually moved in.

Often new buildings are only partially occupied at the beginning so that there will be room for additional people as a team grows.

With a clear organizational philosophy and a definite focus on the emergence of natural leadership, the intent of Gore buildings is to reflect the organization rather than driving it. In this they clearly succeed very well.

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PROCTER & GAMBLE
**Health Care Research Center
Suburban Cincinnati,
Ohio**

Size: 1.3 million square feet
Employees: Eventually 2500 people
Architect: CUH2A, Princeton, New Jersey
Date: Initial phases completed in 1994; subsequent phase in 1999.

The Company
Procter & Gamble (P&G) is well known as a world leader in consumer products for laundry and cleaning, beauty care, food and beverage, and health care. 1997 sales were about $35 billion.

The Facility
In 1986, Procter & Gamble started design and development of a new Health Care Research Center (HCRC). In 1994, eight years and about $280 million later, the initial 1.3 million square-foot facility was competed for about 1500 people. In February 1999, a new Pharmaceutical wing was completed and another 650 people moved in.

The intent of the HCRC is to accelerate the development of new P&G products in the health care field, including both pharmaceutical and over-the-counter medications and products. The method of achieving the goal, as with most other facilities explored in this report, is to encourage and support interaction, in the belief that interactions between researchers are critically important to the success of a research process. In particular, this facility is designed to encourage teamwork across scientific disciplines.

The first impression you get when you approach the facility is of its size: it's enormous. Perched on the side of a hill, the massive tan building is covers a vast area. Once inside, you realize that this is, by intent, a small city unto itself. A project as enormous and costly as this one offers numerous opportunities to force, encourage or support interaction, making it a fascinating case study in social design.

The intent to maximize interaction between people is evident in many aspects of the project's design, from the overall layout of the parts of the building on the site, to the configuration of each of the many research wings of the building, to the design of each laboratory unit.

Overall Layout

The building consists of five major elements, each housing a different function.

- The "Discovery" wing houses basic research
- The "Development" wing houses applied development
- The Pharmaceutical wing houses the pharmaceutical work
- The central utilities wing houses power, heating, and warehousing of materials.
- A central spine connects the other wings and houses support services such as the main entrance, large conference facilities, library, and cafeteria.
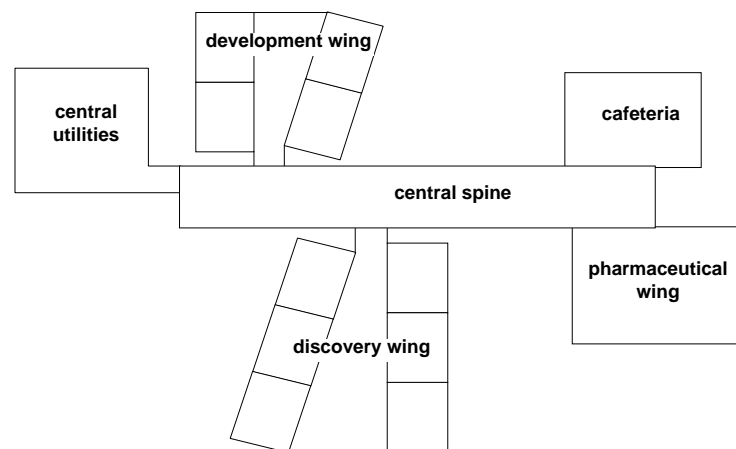
Procter & Gamble
Health Care Research Center
Site Plan
not to scale

Since most of the services are located on the central spine, it is intended that people will randomly cross paths there. The cafeteria, a key place for random meeting, is located at one end of the long central hallway and one floor down. People coming from most of the building must walk a long distance and then descend the escalator, so they inevitably see each other by the dozens during the lunch hours.

To encourage people to remain in the facility all day long, many retail services are available near the cafeteria, including a sundries shop, bank, laundry, shoe repair, and post office.

Discovery and Development Research Wings Design
Both the Discovery and Development Wings are shaped like wedges, with
the narrow ends connecting to the central spine. Since there's no shortage
of land on this site, one immediately wonders why. Again the strategy
of forcing people to encounter one another seems to be the explanation.
To get from anywhere in these wings to the central spine, and then to the
building's shared services and cafeteria, you must pass through the single
opening where you're likely to meet colleagues again.

Since P&G research indicated that people are more likely to interact in
spacious hallway, the hallways throughout both wings are exceptionally
wide.

Similarly, the lack of stairs and elevators throughout the building
is explained by research which shows that people interact more on
escalators than on stairs or elevators. Hence, movement vertically
between the three floors of each wing is done on escalators. Since there
are (intentionally) fewer escalators than one might expect, people are even
more likely to see others while their moving up and down between floors.

By the way, you might wonder why three floors. Tom Allen's research
provides an answer, as he concludes that, "for communication purposes,
a research manager should limit his laboratory to a single-story square
building as long as the required floor space is less than 10,000 square
meters [100,000 square feet]. Above that area, the building should have at
least three floors."[7]

The Laboratory "Brick" Concept
The laboratory spaces also display a specific social design intent. They
have been designed around the concept of a standard laboratory unit
called a "brick." The research wings of the building consist of 11 bricks
each, stacked on the 3 floors.

The configuration of the typical brick also appears to be derived from Tom
Allen's work. Although this was not confirmed by Procter & Gamble, it
would seem that Allen's concepts have been adopted quite literally in the
design of the HCRC bricks.

Each of the 22 bricks consists of 2 long laboratory sections. For flexibility, these labs are modular and relatively uniform. Although there are slight differences in functionality provided to chemistry and biology labs (more air circulation is needed in chemistry labs), they are generally quite similar and can be converted to different uses at minimal time and cost.
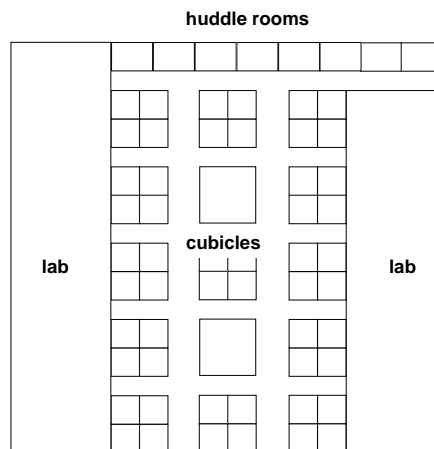

Procter & Gamble
Health Care Research Center
Typical Lab Brick Floor Plan
not to scale

For safety and efficiency, a separate system of service elevators and hallways keeps the flow of materials away the flow of people. This is a typical feature in many new facilities, and it introduces another design constraint that must be balanced with other requirements.
Users noted that the shift to robotic chemistry described above has already been a factor in the HCRC facility, as some labs have been refitted with robotic capacities.

Between the two lab sections are cubicle work stations for the 50 or so people, and in the center there are various meeting and conference spaces for the teams using the brick.
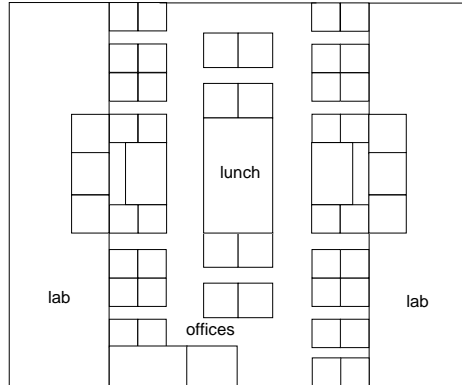
"Configuration for the new laboratory facility"
Adapted from: Tom Allen, Managing the Flow of Technology
not to scale

Many aspects of this design represents a revolution for P&G. In the past researchers had their own private labs and private offices. Now they share labs, and they may also share equipment and glassware.

Since the wall between the labs and offices is glass, people can look in from the offices and see experiments that their colleagues are running.

The users of any particular brick are generally expected to be the people from many disciplines working together on project teams, and may include the most senior researchers as well as associate researchers, technicians, and administrative support.

If people aren't in the lab, they may be in their cubicles. Private offices are also gone, and one of the most interesting features of the design is that each person is allocated a 64 square foot cubicle, regardless of rank. The cubicles are open, reflecting the conscious intent of the P&G to remove obstacles and barriers. In fact, one of the few complaints offered about the entire facility was the lack of privacy in the cubicles, and the high level of visual and auditory distraction caused by others in the space. Although the facility does have a white noise system, it does not seem to be adequate.

There was also a complaint about glare and reflection on computer screens caused by the building's lighting system, over which individuals in their own cubicles have no control. When we visited, P&G was about to test large umbrellas like those used at outdoor restaurants to see if that would control the glare problem.

As with the labs, the modularity of the cubicles also supports flexibility. When a project team completes its work, it is easy to relocate any individual to a new cubicle and to move all of their equipment and papers.

The lack private offices creates a need for more meeting space, which is addressed by providing an assortment of different kinds of meeting rooms in each brick. "Huddle rooms" hold about 5 people, and there are also other conference and meeting rooms of various sizes. Asked to identify the critical success factors in the building, one researcher commented, "Make sure you have enough huddle rooms."

In making the adjustment from their former work environment to the HCRC, it was noted that one side effect with the new openness and the profusion of interactions was a problem of "over communication." Given so many more opportunities to communicate than they had in their prior work environments, people were communicating too much, and they had to learn when to and when not to.

This huge building and the enormous amount of money that P&G has invested in it offers a unique approach to facilities design. What makes it even more interesting is that it will take many years before the results of the investment are known. New drugs take many years to develop, and market share in the health care industry tends to shift gradually, so it may be a decade or more before we know if this building has achieved its intended purpose.

CHIRON CORPORATION
Life Science Center
Emeryville, California

Size: 260,000 square feet
Employees: 500
Architect: Flad & Associates, Madison Wisconsin and Legoretta Arquitectos, Mexico City
Date: 1998

The Facility

When biotechnology leader Chiron Corporation decided to redevelop its Life Science Center facility in Emeryville, California, the company brought together Flad Associates, an American architecture firm specializing in laboratory design together with internationally recognized Mexican designer Ricardo Legoretta. The result is a building that combines a refined and dramatic sense of aesthetics with a number of strategies designed to maximize interaction between researchers.

It's also an award-winning facility, having just been named *R&D Magazine's* 1999 "Lab of the Year."

The facility is specifically designed to be a "social building," one that encourages and supports many different kinds of person-to-person interactions.

Some of those strategies include:

- An enormous, central atrium to give the building a friendly and open feel.
- Wide stairways to make it easy to get from floor to floor.
- Wide hallways to support casual interactions.
- Lots of social spaces throughout the building.
- Numerous "huddle rooms," small meetings rooms easily available for spontaneous, informal interaction.
- Labs and offices with lots of glass so that others can see who's there and might be available to talk.
- Labs located at the exterior of the building for natural light, and shared support services located at the interior of the building.

To encourage people to use these social features, the typical office has been reduced to an 8 foot x 10 foot module. Notes Chiron's Ed Bailey, Senior Director of Corporate Facilities and Engineering, "In the larger offices that we have in our other buildings, everybody has a meeting space. We've taken that meeting space out and put it into the huddle room, which is more open for everyone to use. Your office becomes your private space. Putting more people into the building and giving them smaller private spaces only works if you have a lot of social interactive space."

These smaller offices also save money. Reducing the space allocation by only 50 square feet per person saved millions in construction costs, and that money was then reallocated to aesthetic and social amenities.

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GLAXO WELLCOME
**US R&D Headquarters
Research Triangle
Park, North Carolina**

Size: 1.5 million square feet
Employees: 2500
Architect: Kling Lindquist, Philadelphia
Date: 1991

The Facility

Glaxo Wellcome's US R&D headquarters is located on what was originally a 70 acre site, and is now 500 acres in Research Triangle Park, North Carolina. With 2500 employees and more than 1.5 million square feet in this facility alone, the project's driving issue is not only shared labs and cubicles, but rather how a facility can be at once enormous, humane, and flexible.

In the belief that scale, configuration and aesthetics are critical factors affecting the productivity of researchers, architect Binh Vinh has focused the project on bringing natural light into neighborhood clusters of offices and labs. "My research tells me that a neighborhood should be no more than 40 people. Above that number it becomes too large. Each neighborhood has center like a small town plaza or village green, a place where people can gather and exchange ideas and be together."

Vinh's own experience confirms the work of Tom Allen when he notes that, "People don't want to walk more than about 100 feet to find someone else." To support good communication the neighborhoods are connected with a 'main street' to form a larger community. Adds Vinh, "If we organize the buildings on a human scale, we can maintain the relationship of neighborhoods and communities so everyone can feel like they belong. They belong to the group, they belong to the company, belong to the corporation, and belong to the goals and objectives that they set out to do." In the end, the goal is provide, "an environment in which they can interact and enhance their creativity."

But in a large facility, and even a small one, people find themselves many hundreds of feet away from one another. Hence, the Glaxo facility is designed so that all of the buildings are interconnected in a looping snowflake pattern. At the major nodes where the buildings meet, support spaces contain shared services to draw people together. Nodes include formal conference rooms, informal team rooms, coffee, vending, lavatories, and copiers, as well as administrative and managerial support.

Researcher Dan Sternbach was part of the team that worked with the Vinh in the design process. He believes that the nodes bring people together from different departments, and notes that in fact this building design was selected in part because it, "seemed to be the best compromise between interaction and actually accommodating a large group."

Since the facility was completed in 1991, the experience of the intervening years gives a true picture of the building's performance. Sternbach worked in the completed facility for a while before moving on to another Glaxo building. "The people corridor that connects all the offices actually forces people to walk by everybody else's office. That's good for communication. You know when people are in and you can stop buy their offices. Where I am now we have no idea whether the people next door are in or have been gone for a week. The whole argument about proximity means a lot when you're collaborating with people."

This is quite important in a field like chemistry, where visualizing the molecule is critical to progress. Sternbach says that, "Chemists require a lot of graphical communications - they're usually showing someone else molecules. It's not text information. A year ago we switched our email system to one with a lot more forgiving to sending graphics, which also made a big improvement in the communication. Before that, it was certainly very important that you could talk to a chemist and write something on a board, and these boards were in the same corridors that the people were moving through. That also was a way for people to communicate, and cause other people to stop and look at the board and say, 'Hey, I've seen that.' That is an integral part of the building that we could communicate through the graphical language that chemists use."

But even with the improvement in email, "nothing replaces two people standing at the board and drawing things, which is the way we communicate a lot. It's an interactive situation where when somebody's drawing something up the other guy says, 'Well that reminds me of this thing.' As soon as you try to do that by email it takes more time. You can do some of it that way but it's probably you get the same conversation that would happen in a day versus 20 minutes because of the give and take that goes on."

Without using the language of cognitive science, Sternbach has clearly experienced the difference between the richness of tacit knowledge generated face to face compared with the dilution of meaning that affects most online interactions.

Aesthetics plays a role, as well. To put each worker close to daylight and exterior views, the ten three-story buildings that compose the project are relatively transparent. Glaxo's Director of Construction and Commissioning Tommy Cahoon notes that features like this also play a role in helping the company to recruit the right scientists, always a top concern in a high technology company.

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INHALE THERAPEUTIC SYSTEMS
Corporate Headquarters San Carlos, California

Size: 120,000 square feet
Employees: 344
Architect: Dowler-Gruman Architects, Mountain View, California

The Facility
An intriguing example of innovation's role in an organization is Inhale Therapeutic Systems. Founded in 1990, the company is developing a way to deliver large molecule medicines into the deep lung through inhalation.

But since the product is not yet on the market, Inhale is a classic R&D-dependent company. From the outset, the company has been in a continual process of product development and testing. In the last four years alone, Inhale has raised $67 million in three public offerings and $32 million in private placement, all in the hopes of a big payoff when its technology finally hits the market.

Housed in a renovated industrial building, the company has numerous projects under way to adapt its core inhalation technology to deliver drugs owned by pharmaceutical companies including Pfizer, Lilly, Baxter, and Genzyme. Treatments for diseases as diverse as diabetes, hepatitis, multiple sclerosis, emphysema, and osteoporosis are under development.

Pfizer's insulin is a good example. Diabetics now face the burden of multiple self-injections per day, so the possibility of replacing needle injections with delivery of insulin through the lung is expected to result in a huge business, and Inhale is racing to complete clinical trials and get the product to market.

Since other companies are working to develop competitive products, time to market may be the single most significant factor in the firm's success, not to say its survival. Here time is definitely more important than money. And since Inhale's approach integrates chemical, mechanical, aerosol, and manufacturing engineering, it is clear to everyone that the sharing of knowledge between the many teams, departments and disciplines in the organization is the key to speed. Therefore, the company has adopted a unique approach that marries its organization with its facility: Both are designed to optimize knowledge sharing among teams and between disciplines.

Conventional industry practice would have put each development team in a different lab space, which could lead to reduced interaction. To support sharing between *teams*, all lab and manufacturing spaces are shared by all the teams working in a particular discipline. All the aerosol engineers working on all of Inhale's projects are working in the same space and sharing equipment, so presumably they are also sharing ideas and experiences. To make this possible, these labs are about 1400 square feet, considerably larger than conventional design practice would have provided. Learnings from any project are quickly transferred to the others.

Interestingly, this knowledge management strategy is also a very cost effective solution, and in fact Inhale's architect Nancy Escano of Dowler-Grumman points out that Inhale's space cost about 30% less than facilities her firm has designed for dozens of other pharmaceutical companies.

The configuration of office space is also designed to support learning between *disciplines*. Every one in the company, including the CEO, works in a 16 foot by 16 foot, 4-person cubicle. But instead of putting people from the same discipline together, the four people are usually from different parts of the organization. Scientists, engineers, management, administration, quality assurance, and quality control are mixed, so that in the course of their day to day work, they are exposed to the needs and concerns of each other.

For example, engineer Carlos Schuler shares a cubicle with a quality assurance manager, a scientist, and a lab technician. As Schuler puts it, "Because a QA manager also works in my cubicle, I hear him working with his colleagues on a daily basis. When I need to work with him, I already know what his requirements are."

During the course of their time together in the cubicle, informal interactions naturally lead to personal relationships that might not otherwise develop. To keep this relationship-building process alive, every six to nine months just about everybody in the company moves to a different cubicle and gets to know three new neighbors, continuing the process of building a web of relationships throughout the firm and as well as the cross- disciplinary learning process.

But there are exceptions to forced-move strategy. One team that was working on a particularly difficult technical problem sat together for two years to support a high intensity of interaction.

Since everyone works in these shared cubicles, there is a greater overall need for conference and meeting space. As a result, one meeting space is provided for every 10 people, a far greater ratio than is commonly provided in buildings of this type. Even so, the shared cubicle strategy is also effective at keeping facility costs down.

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HEWLETT PACKARD
Software Development Team Space (Reference Server Initiative) Mountain View, California

Size: 100,000 square feet
Employees: 250
Architect: Internal team + consultants
Date: 1998

The Facility

What happens when the essential architecture work on a building is done not by an architecture firm, but instead by the people who are going to work in the space? This was the issue for a team of Hewlett-Packard employees, who were given the assignment of creating their own high performance work environment.

In late 1995, Hewlett Packard's 475,000 square foot corporate headquarters in Palo Alto, Calif., was due for renovation. Since it was impossible to move everyone out of the huge building simultaneously, the renovation proceeded in stages.

But after a few departments had occupied their new space, groups scheduled for later renovation saw what was coming--and some of them didn't care for it. Instead of improved interaction, the new spaces seemed worse than the old ones, which weren't very good in the first place.

Under the leadership of Pete Karolczak, head of the Enterprise Business Systems group and Chuck Sieloff, an internal IT consultant and one of HP's knowledge-management pioneers, a 15-person project team composed of software-development staff members was given the task of designing their own space using wheeled component-system furniture. The goal was to create an environment where a team could really be a team, where rich interaction would be the norm, and where complex projects would be completed in compressed time frames. And all of this had to be done within the existing corporate guidelines for workplace density and cost-per-workstation.

A year later, the 15-person experiment was judged so successful that a new space for 30 people was developed using the principles validated from the first experiment. And now two years after that, the entire Enterprise Business Systems group of 250 people has just moved into a 50,000 square

foot building designed around the same principles. Today, all of HP's engineers, programmers, customer support staff, business analysts, and project managers involved in the group are mixed together in the space that has proven tremendously effective at promoting interaction and high productivity.

HP project manager Dorothy Heun recalls the origins of the project. "Given the need to reduce time to market and the complexity of the products we create, our projects cannot be done by people working alone. We wanted to work together in a different way."

The project team's thought process, solution, and results should interest laboratory managers and facility planners in a broad variety of research facilities where collaboration and interaction have become bywords.

Though she had no background in workplace design, Heun was given the job of arranging furniture for the prototype software development team workspace. "At first I thought they were kidding. You want me to help arrange furniture? You're joking! I was really quite surprised that they weren't. Since the project team initiative was just getting underway, projects were not fully launched and there was slack in my schedule, and so after getting over the initial shock I jumped into it. I mean, how difficult can it be to arrange furniture?"

It turned out to be a lot more difficult than she thought, and to make it worse, little help was available from the corporate facilities group. "Our facilities people were not happy that we wanted to do an experiment outside of their design," says Heun. But being untrained and left alone worked out better in the end, because "it forced us to take more responsibility for figuring out how our space affects us."

Eventually Heun made small cardboard cutouts of the furniture pieces, and settled on a design based on clusters of four to eight workstations in an open setting that she called a "pod." All the workstations in a pod surrounded a small, central team table.
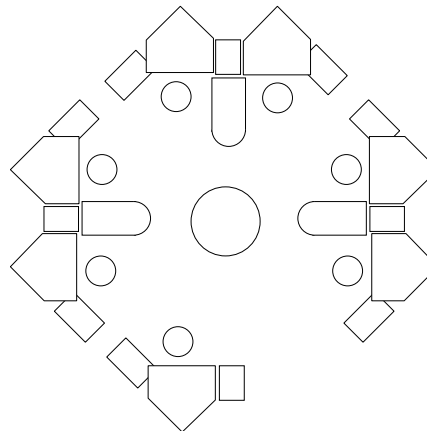
**Hewlett Packard
Pod for 7 people
Plan**
not to scale

The result was a profound change in the way the team worked. Sharing of ideas and information increased dramatically, while the time it took to bring new project team members up to speed was reduced. Heun says the design fulfills Karolczak's goal of making "impossible for people not to work as a team. Put the right people together so they collaborate intensively, and they can do wonderful things."

Intrigued with the results of the initial small-scale experiment, HP commissioned the Institute for Research on Learning (IRL), an independent research organization in Menlo Park, Calif., to use ethnography to analyze interaction patterns in the old and new environments. Sieloff says, "You can't just ask people what they want when you're trying to design an office. Inevitably when you do that, the answer is "more space and more privacy." Because that is the only thing people can control individually, that is what they ask for. We felt that if we wanted to change the way people thought about space we'd have to use an ethnographic approach."

Ethnography—the systematic study of human cultures--deals with unspoken factors that seem to be critical to both creativity and productivity. The goal of the IRL study, notes Sieloff, was "to prove that these experiments made sense. We were definitely going against the mainstream of this already-defined multiyear project for the building. We felt that in order to change the strategy, we would have to have to present some convincing evidence."

Adds Heun, "Plus we didn't have any words to describe what we were doing. We had an awareness that this environment was impacting how we worked together and how we collaborated, but we couldn't describe it and we couldn't make it concrete. It was just more of a feeling that we had from experience. But none of us had any background in this, and we didn't understand really how we were interacting together differently. We just felt that it was different. IRL helped us to put some clear terminology to it."

IRL researchers found that the new spaces supported more frequent, more spontaneous interactions. Perhaps the most significant finding was that collaborations in the experimental spaces lasted three times longer and occurred twice as frequently as those in traditional environments. In addition, the need for team meetings was almost entirely eliminated. Heun says, "Everybody is already aware of everything that is going on. If we do need to meet, we can just turn around in our chairs. No time is lost."

A small but significant detail was designed to ensure interaction between project team members and their managers, and it exemplifies the kind of thinking that contributes to a successful project. Typically, the managers would have been located with their teams, but in this case they are located in the back of the space. Why? To maximize their interaction with each other they sit together, and to maximize their interactions with the rest of the team, they have to walk through the entire team to get to and from their desks. Passing by multiple times each day reinforces HP's traditional "management by walking around" culture, and creates new opportunities to exchange ideas.

Since almost everyone had previously been housed in individual cubicles, the loss of privacy did require adjustment. Heun says, "People came from their point of reference up to that time, which was a cubicle. You know, you don't talk to someone about how messy their cube is--it's none of your business. For the most part, unless it's your neighbor who's got a really, really loud voice, you're not going to say anything about it. In [the pod] space, if someone's being too messy and too loud, you know it. We would notice hat people would just sit there and get really irked by it, and they'd fume about it, but they wouldn't address it. In the traditional workspace it wasn't OK to bring it up."

Pretending not to notice didn't work now, so a few months after the first team converted to the pod environment, a meeting revealed the extent of the problem of messy and noisy neighbors. As a result, explicit social protocols were developed to make it socially acceptable for an employee to alert a fellow staff member who is being too loud or too messy. With the help of the furniture vendor, the team created a small brochure explaining some simple rules for getting along in the shared space. Incoming team members are now automatically given an orientation to these social protocols.

Another key tool in the pods' successful implementation has been the cordless telephone. Sieloff says, "We learned a lot about the tremendous value of the mobile phone because one of the big resistance issues was privacy, and the core of the privacy issue is telephones.

In a cubicle environment with high partitions, you have this illusion of visual privacy, but you don't have any acoustic privacy. In the open environment, you don't have the illusion of visual privacy, so you know when you can talk or not. But the one thing you can't do anything about is when you're talking on the phone and you're tethered, you're stuck. So the mobile phone turned out to be a tremendous insight, making it very easy for people to adjust to the open space. If they got a private phone call, they could just walk away. If they want to make a private phone call, they can go somewhere else."

Yet another discovery was the value of whiteboards to support ongoing interaction. Says Heun, "We didn't have very many whiteboards in our original experiment, but now they are absolutely a must-have. We will take an idea and put it on the board. Over the course of a week I'll explain it to someone else who walks into the space, and we'll discuss it for a while, and the idea will grow. And then the other person will come back and the idea will evolve from a very brief casual discussion to a solution. We can't imagine working without whiteboards."

Heun says the new work environment has significantly boosted team productivity. "Of all of the deliverables and the products that we provide, none of it can be done by individuals. Everything can be benefited by the team approach: multiple minds coming together to create the optimum solution. We do want the teams to be the primary focal point, and not the individual."

She adds, "Everybody here is motivated. They like the collaboration, they are energized by it, projects are exciting and fun. This group has a culture, an inner drive, and I think many of us are willing to do something for this team or organization because we look at what we have to do individually within the context of the team and what the team has accomplished."

With such a success on its hands, you'd think HP managers would be falling over one another to get comparable facilities in their departments. However, three years into the experiment, that hasn't happened. HP's facilities group has become a strong supporter of the work Heun's group has done, but despite evidence of this project's success, a new HP Labs facility in England will have a more traditional office design. The researchers there were simply unwilling to give up their private spaces

Heun acknowledges the irony of the situation. "It can be frustrating to try to find groups who are willing to pursue this type of experimentation, and who can understand the impact that space has on their productivity and how they work together."

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ALZA CORPORATION
**Mountain View Campus
Mountain View,
California**

Size: 305,000 square feet
Employees: 750 people
Architect: DES Architects, Redwood City, California; Dowler-Gruman   Architects, Mountain View, California, and others.
Date: Ongoing

The Company
Established originally in 1968 in nearby Palo Alto, Alza Corporation outgrew its Palo Alto facilities many years ago, and has operated in two locations since then.

Having discovered that the morale of people working in the outlying buildings was lower because they didn't feel themselves to be part of the team, the company is in the process of consolidating its staff into a cluster of buildings in Mountain View, California by constructing three new facilities in addition to a number of existing facilities already in Mountain View.

The company's growth has taught many lessons about the process of bringing new facilities on line. For example, at one point in its growth the company needed a new building quickly. Recognizing the overwhelming importance of time to market for its products, the company chose the very expensive strategy of buying an existing building, gutting it back to the bare shell, and then rebuilding it from the inside out. Why do this rather than just build a new building? Because it would have taken two additional years to get the permits for a new one!

To end up with better buildings and to speed up the development process, Alza Facilities Director Jim Simpson and Construction Director Jim Roensch offer these suggestions:

1. One of the critical issues is for a building's designers to fully understand what users want and need. Therefore, during the design process, invite selected facility users to talk about their work and their workspace, and have the design team (including the architects) work as scribes to record what the researchers are saying. This way, the users can see if they have communicated clearly, and the designers are forced to engage in understanding the subtle dimensions of the users' experience.

2. Ask your architects to compare about what they hear from your organization with what they hear from other clients, so you get the benefit of their broader experience.

3. Ask architects to determine the price of features you're considering to provide one specific basis for determining if it's worth the price.

4. Develop relationships with the municipal officials who will be approving and inspecting construction so that they will be converted from "watch dogs" to "people who help you solve problems."

5. Construction and FDA validation is done simultaneously so that all required documentation is developed during the construction process. While the contractor must allocate time and effort to do this, the overall savings in time and cost make it worthwhile.

6. Have the contractor write the initial maintenance specification for the building, rather than the maintenance staff. This way it will be based on manufacturers' specifications, and will define the level of maintenance needed to enforce contractors' warranty requirements.

7. Given the volatility of the biotech industry, build modular labs that can quickly be converted from one function to another.

SUN MICROSYSTEMS
Menlo Park Campus

Size: 1.2 million square feet
Employees: 3600
Architect: Exteriors: Backen, Arrigoni & Ross, San Francisco
           Interiors: Bottom Duvivier, Redwood City
Date: 1997

The Facility

A new Sun Microsystems facility in Menlo Park, California was designed to bring 3600 Sun employees much closer together than they had ever been before.

The internal Sun organization responsible for facilities is called, interestingly, "Workplace Effectiveness." Based on their own research, this team concluded that buildings of 120,000 to 130,000 square feet, and housing 350 to 500 people are about the right size. This led to a requirement for eight separate buildings.

Urban Design

The typical Silicon Valley approach for a campus setting of eight such buildings would have dispersed the buildings more or less evenly on the site, with each surrounded by its own parking. Instead of doing that, Sun chose to create what is in effect an urban village, and recognizing that density matters in the best urban settings, the eight buildings are clustered to define the perimeter of a large interior plaza consisting of a series of linked courtyards that function as outdoor rooms. Filled with an abundance of flowers, trees, fountains, and shrubs, the various courtyards are intentionally different sizes. The reason? Sun manager Eric Richert notes that "Uniformly large spaces are uniformly unused."

Environmental factors were carefully taken into account. The site is adjacent to the San Francisco Bay, where the brisk prevailing winds are from the north much of the year. Therefore, taller, three-story buildings and walls connecting them define a wind break on the northern side of the complex, while the shorter two-story buildings define the south perimeter let more sunlight into the urban courtyards. The long interior street is not wide so that wind doesn't get down to the ground level, and it is oriented for maximum sun exposure.

By intent, the street is not straight, but rather curves gently so that spaces unfold as you walk along.
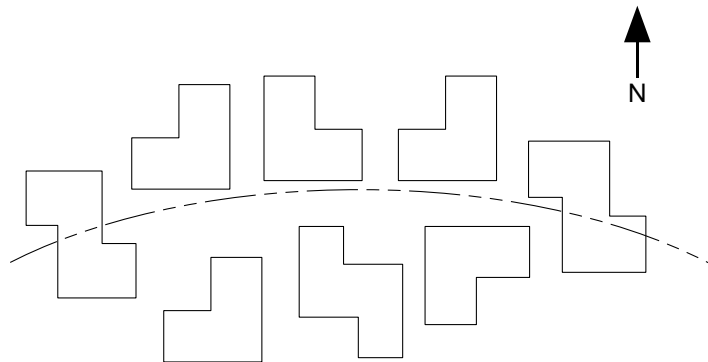
Sun Microsystems
Menlo Park Campus
Site Plan
not to scale

The results are outstanding. The spaces are beautiful, and much used. During the lunch time hours on sunny days (which are most days at this location), the courtyards are filled with people coming and going, sitting, reading, eating, and talking. During one ten-minute stroll from one end of the complex to the other, many clusters of people are observed walking and talking together. Numerous conversations and exchanges also happen spontaneously between people who happen to see one another, which leads Richert to offer another observation about how to promote interaction: "The spaces between buildings are as important as the spaces inside the buildings."

Interestingly, the campus offers not just one, but two cafeterias. The large central cafeteria is complemented by a smaller deli, so that people are not forced into the large space, but can choose a more intimate lunch.

Team Spaces
Whereas the approach to urban design for 3600 people defines the large scale, Sun also pursued innovations in the space configuration for team clusters of 15 people.

Richert and his team already knew that acoustic and visual privacy is needed for the kind of work commonly done by the company's programmers. When people were forced to work in more open cubicle environments, various strange behaviors could be routinely observed. Some people would work odd hours to avoid their colleagues, while others would block the entrances to their cubicles with piles of papers, while others would isolate themselves with headsets. (Can you spell "Dilbert?")

Because of the aversion to cubicles, individual offices were the norm for this project. In a part of one building that was intentionally experimental, different space configurations intended to promote increased interaction were tested. Groups of 16 individual offices were arranged adjacent to small meeting rooms, with the hope that teams would uses these rooms for increased collaboration. To accommodate the space for these meeting rooms within the overall planning budget, all individual offices were reduced from 8' x 12' (96 square feet) to 8' x 10' (80 square feet).
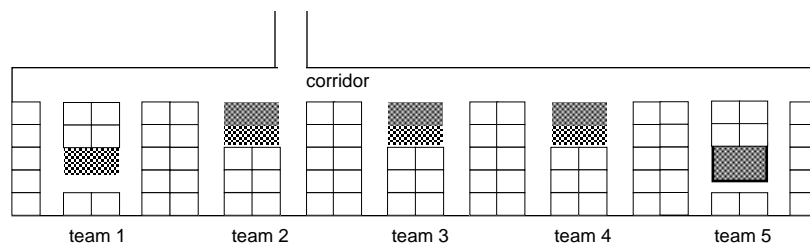
Sun Microsystems
Menlo Park Campus
Experimental Team Space Plan
not to scale

Three different kinds of meeting rooms were tested: large open spaces adjacent to a major hallway (teams 2, 3 and 4), an interior space enclosed with glass walls (team 5), and an interior space not enclosed, but defined simply by the adjacent offices (team 1)

The results were revealing because the three different configurations of the meeting rooms proved to be used much differently. Contrary to expectations, the rooms that were most private were used most, while the meeting rooms that did not provide privacy were used least.

In fact, respect for privacy is so strong that when people were talking in one of the meeting rooms, they would immediately stop if they noticed that they were disturbing anyone in the adjacent offices. Therefore, meeting spaces that had easily moveable walls were most effective because a wall could immediately positioned between those conversing and those in offices, and everyone's privacy was protected.

It's interesting to note that unless a building is studied in detail, the important facts about its use may not be evident. Sun has learned, however, that "in the design of team spaces, details make a huge difference."

This attention to detail is evident in many ways. One example is the doors to the private offices. Each door is glass, floor to ceiling. The glass has been etched to give privacy inside. But instead of being etched uniformly, the pattern gradually shifts from being translucent at the bottom graduating to clear at the ceiling. More light gets in this way, and the space is more interesting visually without sacrificing privacy.

These lessons are being applied in a new facility Sun is building for 1800 people in Massachusetts. The ratio of one meeting space for every 15 people has been adopted as a standard for many of the facility's occupants, so the buildings have 70 of these small meeting spaces in addition to a standard complement of conference and training rooms.

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5.
SCIENCE AND SOCIAL DESIGN

We talked with dozens of people in the process of researching this report. Nearly all of them discussed the importance of interaction in the research process, and most of them presented examples showing how their particular facilities were specifically designed to support it. But none of them admitted to either having done or even being aware of research explaining or quantifying the role of interaction in knowledge work. While the persistence and uniformity of these beliefs are impressive, there is clearly a gap.

However, there is a growing body of scientific knowledge about knowledge, and although this is not the place for a detailed presentation of this work, it is important to review some of the key concepts that have come to be recognized in recent years.

A good beginning point for exploring science about interaction is to examine the difference between explicit and tacit knowledge. While explicit knowledge can be shared through verbal and written expression, tacit knowledge is that which we feel, experience, and believe, but which we may not be able to (i.e., probably cannot) articulate.

The many nuances of the difference between these two forms of knowledge is beautifully explained in Ikujiro Nonaka and Hirotaka Takeuchi's book *The Knowledge-Creating Company*.[8] They point out that while Westerners tend to value explicit knowledge most highly, there is great appreciation for tacit knowledge among the Asian cultures, and this has contributed enormously to the success of Japanese companies during recent decades.

In the design of their products, Japanese companies pay careful attention to the tacit factors pertaining to how products are used, including the feel of a product in your hands and its ease of operation.

A simple example of tacit factors in design is the key used to open and start a car. Today it is an accepted standard of Japanese cars that a single key both opens and starts the car. Since the key is symmetrical, it works facing either direction, which assures 100% success with the key in the lock or the ignition. In contrast, GM still provides two different keys, and neither is symmetrical. Hence, fumbling at random in the dark, the GM driver has only a 25% chance to get the right key in the lock correctly.

Why is this tacit knowledge? Because if you ask 100 drivers of Japanese or GM cars, 98 probably aren't aware of this detail even though they experience its consequences many times each day. Point out the difference and ask again on a dark and stormy night, and you can be sure that the drivers of the Japanese cars are happy with their choice.

And why is there tacit knowledge at all? Why does so much of our experience lie beyond our conscious awareness? For an answer to this question we must turn to physiology and cognitive science. Studies of the human brain reveal that the sensory organs generate information at a prodigious rate, as the combined channel capacity of the nerves associated with the eyes, ears, skin, taste and smell systems is on the order of eleven million bits of data per second. Meanwhile, conscious perception lags considerably behind at a paltry forty bits per second.[9] This means that the brain is processing approximately 300,000 times more information than consciousness is aware of.

Knowledge, however, is more than sensory data. It is also the complex concepts that we synthesize from sensory data. The field of cognitive science addresses this issue, and calls to our attention the fact that most of our concepts also remain at the tacit level (although it does so using slightly different terminology). George Lakeoff puts it very simply: "One of the most fundamental results in cognitive science, one that comes from the study of commonsense reasoning, is that most of our thought is unconscious - not unconscious in the Freudian sense of being repressed, but unconscious simply in that we are not aware of it. We think and talk at too fast a rate and at too deep a level to have conscious awareness and control over everything we think and say. We are even less conscious of the components of thoughts - concepts. When we think, we use an elaborate system of concepts, but we are not usually aware of just what those concepts are like and how they fit together into a system."[10]

Since the gap between tacit and explicit processing is so great at both the sensory and conceptual levels, we begin to understand why face to face interaction is so dense and so important. Nuances of tone, inflection, timing, cadence, body language, attention, smell, and facial expression are all richly present in any encounter, while they are captured only partially - if at all - in interactions via telephones and computers. From our own

experiences, we know that these factors contribute enormously to the completeness of exchange, to our ability to communicate effectively with one another. This is not to say that telephones and computers do not have their uses, but it does say clearly that there is something unique about encountering each other in the flesh.

And what of the common experience of interaction leading to new insight? Physiology and cognitive science also tell us that the brain in general and the memory in particular work by association,[11] and that interacting with one another stimulates new associations, new connections that sometimes lead to breakthrough concepts. Face to face interactions also enable people to share experiences, which means sharing tacit knowledge and in the process creating new tacit and explicit knowledge. From this process we get the title of James Burke's best-selling study of innovation called *Connections*,[12] which we also call "creativity."

But since so much of what we discussing takes place unconsciously, how would you know what is actually happening? You would have to turn some of that tacit knowledge into explicit knowledge, which you could do by studying the behavior of people in their labs and offices. Professionals who study the behavior of human cultures practice a branch of anthropology called "ethnography," and indeed ethnography is just what many on the leading edge of organization design are now doing. [13]

It turns out that ethnographic methods are as useful for studying tribesmen in New Guinea as computer programmers in Palo Alto because they expose the important tacit factors embedded in interactions. One firm leveraging ethnography is GVO, a product design firm that uses ethnography to expose new markets that neither their clients nor their clients' competitors have yet recognized. Another is the Institute for Research on Learning, which uses ethnography to help companies like HP design new buildings, and to help educators design new school curricula.

Among the key insights that workplace ethnographers have found is that there is frequently a huge difference between what people say they do and what they actually do in their jobs. This issue is important to architects because when they design buildings, they rely on what their clients tell them. If a client, out of ignorance or inawareness, tells them wrongly, chances are the resulting building will end up wrongly as well.

Ethnographers have also developed some very useful theories about the behavior of people in organizations and how they develop new knowledge. A concept originated at the IRL called "communities of practice" tells us that new knowledge emerges in work groups as they gradually transform the tacit experiences of doing their particular jobs into explicit shared methods and practices.[14] These very methods and practices define a group as a community, and provides the de facto context in which their knowledge base grows and develops. It is through the progressive transformation of tacit knowledge into explicit knowledge by means of interaction that these groups become increasingly productive and add increasing value.

All of the foregoing validates the intuitive proposition that interaction is critical to the productivity of knowledge work, and also suggests many useful areas of study and investigation to further pinpoint architectural and organizational opportunities.

If we put all of this together, we compose a picture that looks something like this: Many factors contribute to the sense of richness we experience in human interaction, and not all of them are conscious. Through such interactions we literally build new knowledge although we probably are not fully conscious of this as it occurs.

In the early 1990s the National Research Council addressed many of these issues in their response to the productivity paradox. Their study, published in 1994, embraced the linkage between interaction and productivity, and suggested that increasing the number and ways through which people could work together was the remedy.[15] The report further pointed out that since computer technology in offices tends to support only very simple one-to-one linkages, it may not have much effect on productivity.

We can summarize the tacit aspect of this discussion by replaying a comment from the report on Glaxo Wellcome. Chemist Dan Sternbach notes that, "Nothing replaces two people standing at the board and drawing things, which is the way we communicate a lot. It's an interactive situation where when somebody's drawing something up the

other guy says, 'Well that reminds me of this thing.' As soon as you try to do that by email it takes more time. You can do some of it that way but the same conversation would probably happen in a day versus 20 minutes because of the give and take that goes on."

Clearly, however, the explicit part needs more work. To date there is no generally accepted measurement for the quality of interactions, nor for the added specific value that is achieved by a building that effectively promotes interaction.

This holds great importance as a research topic for the future, and among the criteria that need to be examined, these four seem highly pertinent:

1. Cycle time: Is there a reduction in cycle time from initial insight to application for new ideas and new products? This could be an indication that a high-performance facility is contributing to the productivity of knowledge in an organization. (And as with all four of these points, it could also be an indication of something else positive going on.)

2. Quantity: Is there an increase in the quantity of raw ideas and products, or of refined ideas and products?

3. Quality: Is there an increase in the quality of raw ideas and products, or of refined ideas and products?

4. Staff retention and recruiting: Is there an increase in staff retention and/or increase in the ability to recruit top level staff?

All are areas where useful work could and should be done to develop and apply measurements. Perhaps many of the companies covered in the report are diligently tracking some or all of these issues, and perhaps they don't like to talk about it because the results may be one of their most closely kept secrets. One can only speculate ....

<div align="center">...</div>


6.

SUMMARY
Inventory of Ideas and Innovations

The physical environment is the setting where an organization's mission and culture intersect with the need to get work done as fast as possible. In every case we examined, getting work done fast has meant stimulating interactions between people in the hope that useful new insights and ideas will result.

As all of these projects indicate, considerable thought is being given to the role that facilities design plays in supporting (or inhibiting) interactions between people. And whether this happens on a serene 70 acre campus or in a small building, there are four dimensions in which this consistently plays itself out. These areas are closely interrelated, and although in practice they cannot be entirely separated, it is useful to see them listed separately to get a feeling for the enormous possibilities that experimentation and innovation offer in each area.

1. Organize for Interaction
2. Design for Interaction
3. Design for Flexibility
4. Design for Aesthetics.

The interrelationships can be envisioned by seeing the four themes as parts of a complete loop.
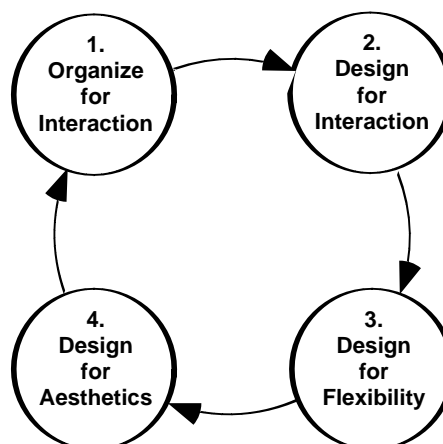
1. Organize for Interaction

It seems to be universally accepted that organizational hierarchies suppress important and desirable qualities such as innovativeness, creativity, adaptiveness, etc. Indeed, the Dilbert parody provides a steady diet of absurdity to remind us of this. In response to the painful truth behind the parody, many companies are attempting to reduce the influence of the hierarchy. Here is a list of the points covered in this report:

- Happiness curve relating researchers happiness to crowding (Genentech)

- Use of the term "associates" rather than "employees" (Gore)
- Intent to support natural leadership (Gore)
- No titles (Gore)
- Monthly technical meetings (Gore)
- Empty space in new buildings to accommodate future growth (Gore)

- Bring together all health care researchers (P&G)
- Separate discovery, development, and pharmaceutical wings (P&G)
- Provide retail services in the building to keep people on site (P&G)
- Multi-disciplinary teams in each lab brick (P&G)
- Everyone in cubicles (P&G)
- Uniform cubicle sizes (P&G)

- Shared labs by different teams within each discipline (Inhale)
- Four person cubicle mixes disciplines (Inhale)
- Everyone moves every 6 - 9 months (Inhale)

- Design by users of the space (HP)
- Ethnographic study by IRL (HP)
- Three iterations of facility experiments (HP)
- Multi-disciplinary team pods (HP)
- Manager workstations located at rear of space (HP)
- Development of explicit social protocols (HP)

- Use of white boards for development of ideas over extended periods (HP)

- Buy an existing building and gut it to save time (Alza)
- Use architects as scribes in the design process (Alza)
- Ask architects for feedback from their experience of other clients (Alza)
- Develop relationships with local enforcement officials (Alza)
- Contractor writes maintenance specification (Alza)

- Facilities group focused on achieving "Workplace Effectiveness" (Sun)

2. Design for Interaction

Facilities are designed to increase the frequency and quality of human interactions.   Here is a list of the points covered in this report:

- Offices, toilets, mail rooms, copiers, coffee machines, and stairways located to force interactions (Genentech) (Glaxo)
- Special interaction spaces (but more private ones would work better) (Genentech)
- Shared labs with some privacy (Genentech)
- Basic lab configuration with shared support spaces (Genentech)
- The value of naiveté so you don't know what you can't do (Genentech)

- Facility size at 200 people (Gore)
- Clusters of facilities (Gore)
- Workstation "village" clusters (Gore)
- Single story structures (Gore)
- "L" facility configuration (Gore)

- Force interactions in central spine (P&G)
- Locate the cafeteria at one of the building (P&G)
- Locate the cafeteria down an escalator (P&G)
- Discovery and development wings are wedge-shaped (P&G)
- Wide hallways (P&G) (Chiron)

- Escalators rather than stairs or elevators (P&G)
- Three floors (P&G)
- The lab "brick" configuration (P&G)
- Shared labs in the bricks (P&G)
- Same size cubicles for everyone   (P&G)
- "Huddle rooms" in the brick (P&G)
- Glass wall between labs and cubicles for visibility (P&G)

- Central atrium (Chiron)
- Wide stairways (Chiron)
- Lots of social spaces (Chiron)
- Many huddle rooms (Chiron)
- Lots of glass in labs and offices (Chiron)
- Labs at the exterior for natural light (Chiron)
- Reduced size of offices (Chiron)

- Buildings configured in a loop (Glaxo)
- Interaction spaces at building nodes (Glaxo)
- The people corridor (Glaxo)
- Daylight and views for everyone (Glaxo)
- Neighborhoods and main streets (Glaxo)
- Meeting spaces in neighborhoods (Glaxo)
- White boards (Glaxo)

- Labs larger than standard to accommodate many projects (Inhale)
- Four-person cubicle unit (Inhale)
- Extra meeting space (1 per every 10 people) (Inhale)

- Team space configured as a "pod" (HP)
- Manager workstations located at rear of space (HP)
- Cordless telephones (HP)
- Mobile white boards (HP)

- Building size limited to 350 - 500 people (Sun)
- Urban village configuration (Sun)
- Exterior courtyards of varying sizes (Sun)
- Orientation for wind control and sunlight (Sun)
- Two cafeterias (Sun)

- Team clusters for 15 people (Sun)
- Private offices rather than cubicles (Sun)
- Experimentation with meeting space configurations (Sun)
- Preference for more private and encloseable meeting spaces (Sun)
- Moveable walls in meeting spaces (Sun)
- Glass doors to offices with etching for privacy (Sun)

3. Design for Flexibility

Many of the features that are intended to increase interaction also serve to reduce cost by increasing the flexibility of the work environment while simultaneously reducing square footage requirements. Here are the points covered in this report:

- Lab brick provides flexibility (P&G)
- Modular cubicles provides each of making changes (P&G)

- Reduced size of offices (Chiron & Sun)

- Labs larger than standard to accommodate many projects also reduce cost (Inhale)
- Four-person cubicles reduce costs (Inhale)

- Price out proposed features in the design phase (Alza)
- FDA validation in parallel with construction (Alza)
  - Modular labs are more flexible (Alza)

4. Design for Aesthetics

Features that address aesthetics are consistently difficult to value, but managers at many facilitates cited the competition for talented individuals as one reason for the continuing effort to bring beauty to the workplace.

•••

Today's global building boom in facilities is fed by a persistent and overwhelming need to increase the productivity of researchers, and built upon strategies to increase human interaction and aesthetic appeal.

The diversity of approaches to lab design shows how difficult it is to define an ideal configuration that effectively links labs and offices together, while simultaneously supporting interactions between many researchers. In contrast, standard approaches to the design of offices are widely accepted.

As the roles of researchers continues to evolve, it has been suggested that in the future, researchers will be spending even less time in their labs, and much more time in meetings,[16] so the design of their facilities will certainly continue to evolve as well.

The concepts of urban design have a key role to play, whether the topic is a small building or a huge corporate campus. The most effective applications of urban design reveal an astonishing quantity and depth of interactions that they support.

Ethnography may be an important tool to help managers understand and influence the behavior of their organizations, and to help designers make appropriate choices in the design of complex facilities.

About 80 ideas are listed above. Since these ideas are not just being considered, but are actually being applied in one or more of these projects, it means that millions of dollars are being invested in the expectation that better results will be achieved by these various organizations.

And lest you think that this quest is strictly the province of the private sector, think again. One of the world's largest landlords is the federal government's General Services Administration (GSA), and the GSA is onto this theme as well. In partnership with Carnegie Mellon University and various industry participants, GSA's Michael Atkinson and Lois Bennett are creating an "Adaptable Workplace Laboratory" to explore the impact of the work place on worker productivity.

7.
APPENDICES

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- *Managing the Evolving Corporation* (Van Nostrand Reinhold, 1995, available from Amazon.com).

Acknowledgments

Numerous people helped in the research and preparation of this report. The author extends warm thanks to the many who are mentioned by name in the report, as well as those not identified individually.

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