The Wayback Machine - https://web.archive.org/web/20060526225315/http://www.latrobefellow.org:80/wpindex.html

A WHITE PAPER

Prepared by John P. Eberhard, FAIA
2003-2005 Latrobe Fellow
AIA College of Fellows

NOTE: CLICK ON BOX AT BEGINNING OF SUBJECT TO SEE CONTENTS

TABLE OF CONTENTS OF WHITE PAPER

Executive Summary

Introduction

Foreword

Upheavals at the turn of the century

Inventions that changed the cities

Architecture in a "Century of Change"

The Basics of Neuroscience

Social and Behavioral Sciences

Hypotheses from ANFA workshops

Architecture Education in a "Century of Change"

2002-2003 An Advanced Concept

Click on "contents" to go to Table of Contents
Contents

EXECUTIVE SUMMARY

Prepared by
John P. Eberhard, FAIA
2003-2005 Latrobe Fellow
the AIA College of Fellows

•This Executive Summary uses the following logic:

•At the end of the 19th century there were many upheavals including seven inventions that changed cities

•Architecture began a "Century of Change"

•It is likely neuroscience knowledge will mark the end of that century

•What is neuroscience ?

•How is this related to social and behavioral science ?

•What concepts have emerged from ANFA's work so far?

•What does this mean to architecture education?

•What should it mean to the profession ?

EXECUTIVE SUMMARY

What is meant by a "White Paper."

According to the British Government (where the concept was created) *White Papers* are documents produced by the Government setting out details of future policy on a particular subject. A White Paper will often be the basis for a Bill to be put before Parliament. The White Paper allows the Government an opportunity to gather feedback before it formally presents the policies as a Bill. It contains detailed proposals for legislation, and is the final stage before the government introduces its proposals to Parliament in the form of a Bill.

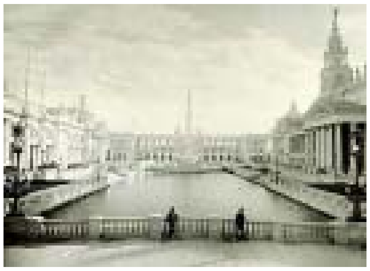
This White Paper is the culmination of the two years John Eberhard, FAIA has served as the Latrobe Fellow of the College of Fellows. When the Academy of Neuroscience for Architecture received the Fellowship and he was made the Latrobe Fellow, he outlined a two-year plan.

- The first six months were to be spent interviewing a large number of neuroscientists who live and work in the San Diego area.
- The second six months was devoted to designing an undergraduate course in neuroscience and architecture, and then conducting a series of seminars (based on the design) at the New School of Architecture & Design in San Diego.
- The third quarter was devoted to exploring the creation of interdisciplinary doctoral programs in a number of universities with both graduate architectural research programs and neuroscience programs.
- The last six months has seen a concentration on preparation of this White Paper. It will be presented to the AIA Board of Directors in their May 2005 meeting in Las Vegas. It will also form the basis for a workshop to be conducted during the Convention in Las Vegas.

In May 2003 the College of Fellows of the AIA, with Betsey Olenick Dougherty, FAIA as the Chancellor, awarded their Latrobe Fellowship to the Academy of Neuroscience for Architects (ANFA).

The San Diego Chapter of the AIA established ANFA.

EXECUTIVE SUMMARY



The visitors to the fair saw immediately that its greatest power lay in the strange gravity of the buildings themselves. No single element accounted for this phenomenon. Each building was huge to begin with, but the impression of mass was amplified by the fact that all the building were neoclassical in design, all had cornices set at the same height, all had been painted the same soft white, and all were so shockingly, beautifully unlike anything the majority of visitors ever had seen in their own hometowns.

The Devil in the White City
by Erik Larson

THE END OF AN ERA AND START OF ANOTHER

In a story called "Fair Weather" a thirteen-year-old farm girl named Rosie, who lives in central Illinois, is invited to Chicago to see the 1893 World's Columbian Exposition. She calls her visit to the *white city* "the last day of our old lives."

In more ways than she realized, Rosie was correct about the White City standing at the threshold of a new era for architecture. Perhaps the Exposition was only a harbinger of this new era and forces at work in the world were inevitably destined to change the physical fabric of urban places in dramatic ways. Perhaps it happened in Chicago because conditions were ripe for revolutionary changes in the technology of building. Perhaps it was the last day of the old life of the classic architect – trained at the Ecole de Beaux Art in Paris and a member of a distinguished gentlemen's fraternity.

As will be described in the sections of this report entitled "Inventions That Reshaped the Urban Fabric" and "Upheavals at the Turn of the Century", a new "Century of Change" was ushered in by 1900. These changes dramatically reshaped what it meant to be an architect.

More than a century later architecture stands on the threshold of another new era. The enormous body of knowledge being created by neuroscientists is about to dramatically change what it means to be a professional designer. The Century of Change had begun in 1906 with Sabine's application of physics to improve listeners' ability to hear in a Harvard auditorium -- creating what is now called the field of Acoustics. Other applications of physics and chemistry soon produced design tools for building structures and electrical systems, lighting calculations, measurement of the thermal environment, the hydraulics of plumbing systems, etc.

EXECUTIVE SUMMARY

"So gorgeous was the spectacle on the May morning of 1910 when nine kings rode in the funeral of Edward VII of England that the crowd, waiting in hushed and black-clad awe, could not keep back gasps of admiration…... Together they represented seventy nations in the greatest assemblage of royalty and rank ever gathered in one place and, of its kind, the last. The muffled tongue of Big Ben tolled nine by the clock as the cortege left the palace, but on history's clock it was sunset, and the sun of the old world was setting in a dying blaze of splendor never to be seen again."

Barbara Tuchman in her book, *The Guns of August.*

UPHEAVALS AT THE TURN OF THE CENTURY

The end of the 19th century and the beginning of the 20th century may have witnessed the greatest set of upheavals ever experienced. Not only were long reigning monarchies being replaced by new forms of government, but also everywhere in the arts and sciences dramatic changes were afoot.

Architecture was impacted not only by the White City and the enormous appeal of classic design that flowed from that, but by the rise of mavericks like Wright and Sullivan in the United States, and Le Corbusier and Gropius in Europe.

Picasso and his group of friends lived in an era of dramatic change that occurs rarely in Western history. These young men believed that they were living in an heroic age where anything was possible. They needed no accolades from society. They shared everything, including knowledge, and strove to produce art and literature that would match the incredible achievements in sciences, mathematics and technology.

The striking changes in musical style that occurred about 1900 were a turning point in the history of Western music comparable to the dramatic transformation of the early 14th and early 17th centuries. But never before had the change been so rapid, and never before had there been such a diversity of resulting styles. The experimental works of Arnold Schoenberg and Igor Stravinsky about 1910 heralded a new epoch in music.

The corpus of Einstein's paper entitled "On the Electrodynamics of Moving Bodies," the so-called relativity paper, is at first glance no different from other papers of that era. Yet first glance deceives: It was daring in both style and content. Page for page, Einstein's relativity paper is unparalleled in the history of science in its depth, breadth and sheer intellectual virtuosity. Einstein developed one of the most far-reaching theories in physics…. The 1905 theory of relativity, written in white heat in about five weeks, remains the clear turning point marking "the last day of physics as we knew it".

EXECUTIVE SUMMARY

INVENTIONS THAT RESHAPED CITIES

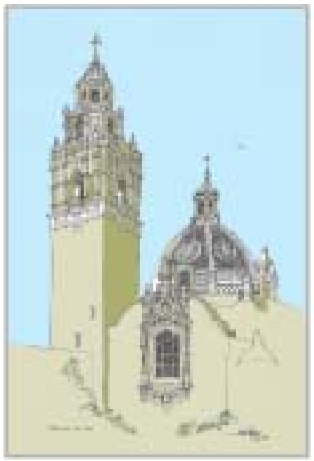
The following matrix shows the historic systems used in cities for centuries, followed by the "second generation" system that emerged at the end of the 19th century, and the basic invention that made the new system possible:

Perhaps the greatest impact on architecture in the history of the world was precipitated by seven major inventions towards the end of the 19th century. For thousands of years the pace of change in the materials and methods used to design and build the fabric of cities was slow. So quickly were these new inventions introduced that only electric lighting was considered for incorporation in the Columbian Exposition of 1893

HISTORIC METHODS	SECOND GENERATION	INVENTION or DISCOVERY
Masonry walls and timber roofs	**STEEL FRAMES** 1883 in buildings	Bessmer Process for steel (1855)
Stairways, ramps and pulleys	**ELEVATORS** Elisha Graves Otis	Safety latch for hoists (1889)
Candles, oil lamps, gas lamps	**ELECTRIC LIGHT** And generators	Light Bulb (1880)
Wood stoves and fireplaces	**CENTRAL HEAT** Furnaces & ducts	Oil Burner (1868)
Outhouses, privies, slop jars	**INDOOR PLUMBING**	Flushing valve (1878) & sewers
Messengers and Mail delivery	**TELEPHONE** Switching centers	Telephonics (1876)
Horseback and horse & carriage	**AUTOMOBILE** Henry Ford (1896)	Internal combustion engine by Daimler (1885)

What is even more remarkable than the fact that these inventions all appeared at the same period in history as the other "great upheavals" (shown on previous page), but that even after a century of change, there have been no new inventions to displace these seven. They have become integrated into architectural specifications, building codes, and engineering specialties. Dislodging them with new inventions will not be easy, even though in the largest cities in the world (only two of which are in the United States) these inventions cause enormous problems of pollution, congestion, and constant breakdowns of centralized systems.

EXECUTIVE SUMMARY



ARCHITECTURE IN A CENTURY OF CHANGE

Architecture in this paper means all of the places and spaces used by humans for living, working, learning, healing, governing, etc. This means the entire built environment, not just those special buildings designed by a few well-known architects. All of these spaces are enclosures for activities. The experiences of a child in school, a patient in a hospital, a worker in an office, a mother in her home, are all important to understand. Neuroscience stands ready to provide knowledge that will advance this understanding.

"My definition of architecture is the art of making places. It is not an artist's sculpture. It's not the art of painting. Places can be rooms or corridors. They can be porches or streets. They can be gardens, golf courses. Places are made by human beings for human habitation. And that is how you need to evaluate them."

Robert Campbell, FAIA, architecture critic, The Boston Globe

...in the making of things and buildings, we may distinguish between our own culture, which is very self-conscious about its architecture, art, and engineering, and certain other cultures which are rather unselfconscious about theirs. The features which distinguish architecturally unselfconscious cultures is that there is little thought about architecture or design as such. There is a right way to make buildings and a wrong way... Since the division of labor in such cultures is limited, specialization is rare, there are no architects, and each man builds his own house.

Christopher Alexander, in Notes on the Synthesis of Form, Harvard Press, 1964

"Architecture is a communal art, having to do with the whole man-made environment, the human city entire, rather than only the individual environment, and rather than only the individual buildings within it."

Vincent Scully, America at the Millennium, Architecture and Community

EXECUTIVE SUMMARY

We know from many studies that have been done on perception, learning and memory how the brain processes an object, in both sensory and motor terms. We know how knowledge about an object can be stored in memory, categorized in conceptual or linguistic terms, and retrieved in recall or recognition modes.
Antonio Damasio

THE BASICS OF NEUROSCIENCE

Neuroscience is the study of the brain and the mind. In the main body of this report there is a ten-page description of the basics.

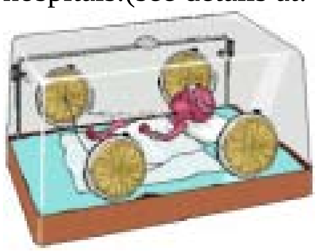
The field of neuroscience includes four areas of exploration of the brain and the mind:

- Genetic studies of the formation and plasticity of the brain
- Molecular and cellular studies of the brain
- Cognitive neuroscience studies of behavioral activities of the mind
- Systems studies of visual systems, aural systems, etc.

There are thousands of experiments now being conducted in neuroscience labs, but few of them have any direct application for architects. This is likely to change dramatically in the next decade. Some of the issues to be studied in the context of neuroscience seem clear, e.g.:

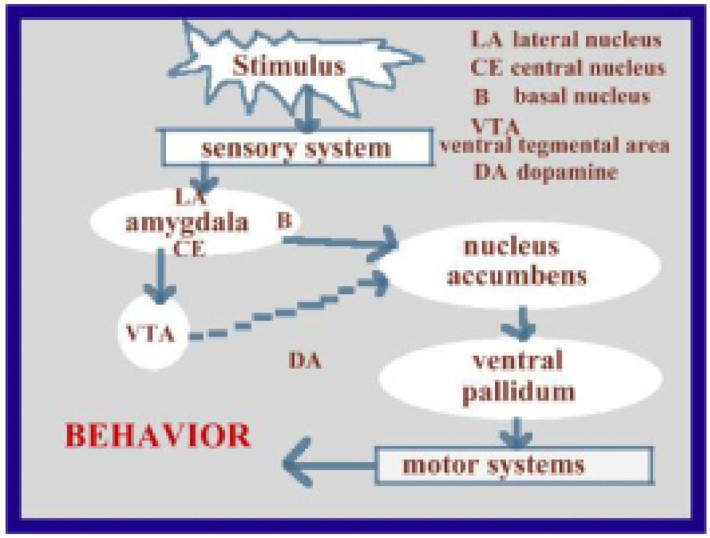
- How does the architectural setting of their school impact the cognitive ability of children?
- How do visitors to a hospital find their way in complex architectural settings?
- Why do most people who enter a church like North Christian Church in Columbus, Indiana feel a sense of awe?

An example of a previously unrecognized design issue is the work of Dr. Stanley Graven in neo-natal care units of hospitals.(see details at: www.architecture-mind.com)



This work established a direct negative impact on the brain development in infants from the normally noisy environment of these units as well as the uncontrolled lighting conditions found there. Design criteria based on the desires of nurses and doctors were often detrimental to critical development stages of premature infants.

EXECUTIVE SUMMARY



The study of aesthetics seems esoteric, unpredictable, and perhaps slightly decadent in its struggle to explain feelings and body reactions without the advantage of precise experimental methods.

Kent Bloomer and Charles Moore, *Body, Memory, and Architecture*, Yale University Press 1977

The Social and Behavioral Sciences

There is a long history of research and observation by those trained in one of the many fields associated with social and behavioral science that bears on architecture. Not all of these research results (or observations) have proven to be useful or directly relevant to those who practice architecture. However, sufficient work has been done over the past fifty years (and some earlier) that is of value, and consequently should be acknowledged as a basis for neuroscience studies. There will be no attempt to be exhaustive in exploring this subject, but a few examples are offered. An early example is:

Social Science observations are something like the observations of light before the development of the science of physics in the 19th century. The social science observations are not necessarily wrong, but they are limited. Observations of how humans interact with their environment are based on "informed suppositions" and usually careful methodology. The limit of these methods is that we know a good deal about what happens during environmental interactions, but we don't know why humans respond the way that they do. As a result of studies of the brain and the mind by neuroscientists with modern scanning equipment, it is possible to know much more about how humans "experience" their environment, about why they have such experiences, and about what might be done by designers to influence experience.

EXECUTIVE SUMMARY

There are certain hypotheses that can contribute more to basic science, could be more easily "banked" for future research and application, but not be immediately "applied" to solving problems. There are others that might be considered "clinical/architect-ural" that might be immediately appli-cable to design problems. And, there are "robust" hypo-theses that could do both.

From the writings of John Zeisel, a member of the ANFA Board

HYPOTHESES FROM ANFA WORKSHOPS

In this section of the White Paper are recorded the sixty hypotheses that have been developed in the three workshops conducted by ANFA during the past two years. Some of them are statements of what the group that created them felt to be intuitively correct. Others are clearly intellectual statements that can serve as a basis for Ph.D. and Post Doctoral experiments over the next few years.

A dictionary definition of Hypothesis is:
A proposition, or set of propositions, set forth as an explanation for the occurrence of some specified group of phenomena, either asserted merely as a provisional conjecture to guide investigation (working hypothesis) or accepted as highly probable in the light of established facts.

Normally a scientist hopes to convince himself that his initial conception (his hypothesis) is correct. If a succession of tests agrees with (or fails to falsify) this hypothesis, it is regarded as reasonable to treat the hypothesis as true, at all events until it is discredited by a subsequent test. The scientist is not concerned with providing a guarantee of his conclusion, since, however many tests support it; there remains the possibility that the next one will not. His concern is to convince himself and his critical colleagues that a hypothesis has passed enough tests to make it worth accepting until a better one presents itself.

The hypotheses summarized in the main report are "butt-ups", attempts to use neuroscience methods to impact the experience-based intuitions of professional designers.
Three areas are covered:
1. The design of healthcare facilities
2. The design of sacred places
3. The design of K-6 classroom spaces.

Reports for each of these workshops are also available on the ANFA website: **www.ANFArch.org**

EXECUTIVE SUMMARY

ARCHITECTURE EDUCATION IN A CENTURY OF CHANGE

The Flexner Report dramatically changed the medical profession in 1914. It established the concept of teaching clinics in which doctors in training were exposed to real patients with real diseases. Teaching clinics also became the institutional setting for introducing new technology and new medications on an experimental basis. They are, today, the primary setting for medical research and medical student's experience with real patients.

It would seem wise for the architectural profession to take steps to establish teaching clinics for architects in training who would be exposed to real clients (and users). These teaching clinics could be used to introduce new knowledge and to conduct experiments of future value.

Neuroscience projects for Studio-Clinical Studies

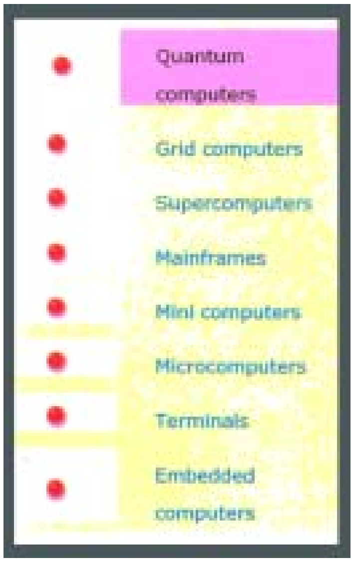
The following paragraphs provide preliminary ideas for clinical studies that might be done in collaboration with architectural firms and student teams, working with neuroscience PhD students. Such clinical studies, with real children, could be added to the knowledge base used in the design of the schools.

1. The impact of light on cognitive ability. Investigate the impact of daylight as it impacts interconnectedness and interactions of the visual areas of the brain. Consideration of both daylight and artificial light on cognition would be included.
2. The acoustic environment of the classroom. Sound waves reaching the auditory cortex in young children require special attention in order for them to select the voice messages from their teacher and enhance aural perception for learning. Neuroscience studies could help explain why this is so.

"Studio has come to define design education, and yet that has not always been so. For most of the history of architectural education, students worked alongside architects on the job site or in the office, as apprentices. Architectural education emerged from the craft guilds that arose in Europe in the 12th century, which served as the major way of organizing the work, exerting control over membership, workplace conditions, markets, and relations to the state. The craft guilds also determined who could join, and the length of apprenticeship, the dues and fines members had to pay, the means of production, the pace and hours of work, and who could practice in what market. There was little separation between work and education, and between design and construction."

Thomas Fisher, Dean College of Architecture and Landscape Architecture, University of Minnesota

EXECUTIVE SUMMARY



The AIA Technology in Architectural Practice (TAP) Knowledge Community serves as a resource for AIA members, the profession, and the public in the deployment of computer technology in the practice of architecture. TAP monitors the development of computer technology and its impact on architecture practice and the entire building life cycle, including design, construction, facility management, and retirement or reuse.

AN ADVANCED CONCEPT

For thirty years computers have been used in architectural practice. In the beginning computer use was dominated by word processing applications of specifications and correspondence, with some applications for relatively simple math computations of structural or HVAC designs. As the technology of computers became more sophisticated their use as "drafting machines" was introduced. By the end of the 80's software was available that made it possible to prepare reasonable 3-D views of designs.

By the end of the 90's the architectural drawings produced by computers were sophisticated enough that most offices had completely switched to computer-based systems for producing working drawings. Graduates of architectural schools are expected to enter the employment market with computer skills. Consulting engineers can exchange databases with their architectural clients, enabling much easier interfaces.

It seems likely that the next phase of development in electronic media will be systems that support conceptual thinking. These are likely to be based on Quantum Computers (more fully explained in full report). How the concepts will be represented and communicated in order to serve as guides for the realization of the object(s) conceived could be the result of research in neuroscience and quantum computers. It is more than likely that such representations will not be the traditional working drawings used by architects today.

Thus neuroscience holds promise of changing the technology of practice as well as the knowledge base of architecture.

A WHITE PAPER
Prepared by John P. Eberhard, FAIA
2003-2005 Latrobe Fellow
AIA College of Fellows

Introduction to White Paper

The “White City” at the Columbian Exposition of 1893 marked the “last day of our old lives” and the beginning of a Century of Change for architects as well as the general population.

The Century of Change was ushered in by upheavals in painting, music, science, medicine, and world governments as well as architecture.

The Century of Change also began with a remarkable period of invention and innovation, which produced a technological revolution in the fabric of cities.

The Century of Change in architecture began with a few mavericks like Wright and Sullivan. In the 1920s and 30s with the rise of the Bauhaus in Germany and then the movement of its leaders into architectural education in the United States there was a sharp departure from classical architecture to what became known as “Modern.” By the end of the century, architectural schools across the world had changed to teaching Modern design and the technical courses needed for incorporating the new building technologies. Classic architecture was relegated to history courses.

One major innovation was introduced into practice during this century—the electronic computer. What began in the 1970s as a method of preparing specifications and contracts soon became the drafting tool of choice. By the end of the century, three-dimensional representations of design produced by computer-based systems were common practice. The profession of architecture and architectural schools, at the beginning of this new century, will find themselves with a whole new opportunity.

In the last decade of the 20th century, as the result of a suggestion by Dr. Jonas Salk, neuroscience was introduced to the architectural community. Social and behavioral scientists have shown what happens as humans experience an architectural setting. Neuroscience shows promise of eventually providing evidence of why they have such experiences.

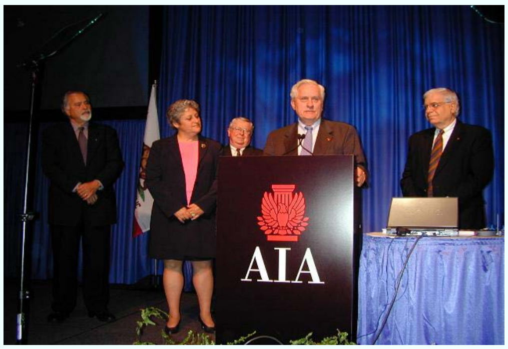
ANFA was established in 2003 by the San Diego Chapter of the AIA to explore neuroscience on behalf of the architectural community. In the past two years progress has been made. A number of workshops have produced more than sixty hypotheses that are ready to be tested in neuroscience laboratories.

This White Paper concludes with a number of advanced concepts of what could be explored in this coming century.

Click on "contents" to go to Table of Contents for White Paper
Contents

A WHITE PAPER
Prepared by John P. Eberhard, FAIA
2003-2005 Latrobe Fellow
AIA College of Fellows

Forward to White Paper



Author: Betsey Olenick Dougherty, FAIA
2004 Chancellor, AIA College of Fellows

Few opportunities for volunteer professional society leadership are as rewarding as that of Chancellor of the College of Fellows of the American Institute of Architects. The AIA College of Fellows is a select group of members that have been nominated, juried, and elevated to Fellowship within AIA by their peers. Not satisfied to rest upon their laurels, this group is the steward of the largest endowed research grant within the architectural profession, The Latrobe Fellowship.

Following 10 years of membership as an AIA Fellow, service on the Executive Committee of the College begins with a nomination and election to a four-year term. Each of four officers rises through the positions to become Chancellor. The result is an evolutionary, continuous process that is led by a handful of capable, experienced people. The level of commitment and deliberation is impressive, as is the vision for the future of the architectural profession.

Previous studies have been critical of the interface between architectural practice and education, and have questioned the attention given to the serious research of architecturally related subjects. After much consideration, the College of Fellows Executive Committee elected to consolidate a previous small grants program into the significant Latrobe Fellowship, named after Benjamin Henry Latrobe. Latrobe (1764-1820) is credited with being the first professional architect in the United States, and the co-designer of the U.S. Capitol Building in Washington, D.C. His legacy provides the spirit and inspiration for the research fellowship named in his memory.

The Academy of Neurosciences for Architecture is the second Latrobe recipient, following Kiernan and Timberlake of the University of Pennsylvania. John Paul Eberhard, FAIA, serves as the Latrobe Fellow. I had the distinct pleasure of serving on the first round jury, and placing John's name, along with others, on the short list to be forwarded to the second and final round jury. In their wisdom, the jury selected John and his vision for The Academy of Neuroscience for Architecture. His work coincided with my tenure as 2004 Chancellor of the AIA College of Fellows.

One of the first products of John Eberhard's work says it all. It is a CD entitled "Beyond Intuition." In this CD, the argument is made that architects have an intuitive sense of the value of beauty, of light, of air, of color, and of the impact that the physical environment has upon human activity. John's premise is that the potential to scientifically explore brain activity as a response to the built environment could show

rich rewards. Imagine the impact upon the value of good design if it can be scientifically proven that it promotes learning, healing, and human interaction.

I have always measured design by its ability to lift the human spirit. As an architect, I have marveled at the wonders of nature, and have devotedly assumed the great responsibility of designing carefully and gently upon the land. Each architectural project is an opportunity to enhance the built environment and to support and promote the quality of life. Sustainability teaches us to use resources wisely. Programmatic responsiveness ensures that a building will function well for its intended purpose. Inherent flexibility in building design and in the design of engineered building systems will allow buildings to change over time to extend their useful life. The application of the tenants of Neuroscience will determine the quality of human activity by potentially stimulating neurons within the brain. To contemplate the implications of this research is staggering.

The following White Paper encapsulates the past two years of research into the topic of neuroscience and how it can impact architectural design. It is my sincere belief that the conclusion of this work to date marks the beginning, and not the end, of research into this topic. The College of Fellows takes great pride in having supported the initiation of this effort in earnest. It is my hope that the value of this work is universally recognized, and that it will continue.The impact of spatial perception and reception upon human activity should become an inherent consideration in the process of architectural design and planning.

The goals for the AIA College of Fellows Latrobe Fellowship have been furthered through the quality of the work conducted by The Academy of Neurosciences for Architecture under the direction of John Eberhard, FAIA. The relationship among education, practice, and research has been enriched through collaboration with the San Diego New School of Architecture and Design, and with partnerships with the University of California at San Diego, the Scripps Institute, and the Salk Institute. An example has been set for others to follow. A rich legacy of research now grows within the architecture community and within the archives of the American Institute of Architects.

Click on "contents" to go to Table of Contents for White Paper
Contents

UPHEAVALS AT THE TURN OF THE CENTURY

Visitors to the Columbian Exposition saw immediately that its greatest power lay in the strange gravity of the buildings themselves. The Court of Honor produced an effect of majesty and beauty that was far greater than even the dream of the architects. Some visitors were so moved that immediately upon entering the Court of Honor they began to weep. The shared "absence of color" produced an especially alluring range of effects as the sun traveled the sky. In the early morning, the buildings were a pale blue and seemed to float on a ghostly cushion of ground mist. Each evening, the sun colored the building ochre and lit the motes of dust raised by the breeze until the air itself became a soft orange veil.

ARCHITECTURE

If evenings at the fair were seductive, the nights were ravishing. The lamps that laced every building and walkway produced the most elaborate demonstration of electric illumination ever attempted and the first large-scale test of alternating current.

The fair's greatest impact lay in how it changed the way Americans perceived their cities and their architects. It primed the whole of America—not just a few rich architectural patrons—to think of cities in a way they never had before… The fair taught men and women steeped only in the necessary to see that cities did not have to be dark, soiled, and unsafe bastions of the strictly pragmatic. They could also be beautiful.

By the beginning of the 20th century new mavericks roamed the world of architecture. Wright and Sullivan shook off the rules and rigors of classical "white" architecture and began to chart a new course that was to come to full bloom in the 1930s with the formation of the Bauhaus.

Science and technology produced by the end of the 19th century dramatic changes in the fabric of cities, in how products were to be manufactured, in how work was to be organized, and became the harbinger of revolutionary changes in every area of human activity.

UPHEAVALS AT THE TURN OF THE CENTURY

PAINTING

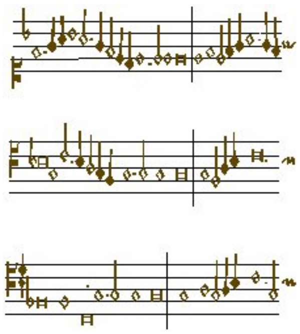
Friedrich Nietzsche's effect on young intellectuals in Spain and Europe cannot be overestimated. His call for explosive developments in art, for unhindered self-expression and for the conception of the artist "as heroic, defiant, and full of eruptive sexual energy overthrowing accepted styles," struck a resonant chord in Picasso.

Picasso and his group of friends lived in an era of dramatic change that occurs rarely in Western history. Great shifts were occurring in art, literature, and science, with even bigger ones expected. These young men believed that they were living in a heroic age where anything was possible. They needed no accolades from society. They were impoverished and had nothing to lose. They shared everything, including knowledge, and strove to produce art and literature that would match the incredible achievements in sciences, mathematics, and technology.

By mid-summer of 1907 he (Picasso) had produced *Les Demoiselles d'Avignon*, the painting that brought art into the twentieth century.

Arthur I. Miller, 2001. "Einstein, Picasso." New York, Basic Books.

UPHEAVALS AT THE TURN OF THE CENTURY



MUSIC

The striking changes in musical style that occurred about 1900 were a turning point in the history of Western music comparable to the dramatic transformation of the early 14th and early 17th centuries. But never before had the change been so rapid, and never before had there been such a diversity of resulting styles. The last decades of the 19th century witnessed what might be termed the diffusion of Romanticism, when significant departures from the current musical vocabulary appeared in the works of some nationalist composers and especially in the Impressionistic style represented in France by Claude Debussy and Maurice Ravel. The amorphous rhythmic patterns, the whole-tone scale, the concept of free relationship of adjacent harmonies, and the kaleidoscopic textures of musical Impressionism were musical manifestations of the aesthetic movements current in painting and literature.

The experimental works of Arnold Schoenberg and Igor Stravinsky about 1910 heralded a new epoch in music. The Expressionist movement—like Impressionism an aesthetic development shared by other art forms—resulted in discarding traditional harmonic concepts of consonance and dissonance and led to the development of atonality and 12-tone technique (in which all 12 tones of the octave are serialized, or given an ordered relationship). Stravinsky's revolutionary style concentrated on metric imbalance and percussive dissonance and introduced a decade of extreme experimentation that coincided with World War I, a period of major social and political upheaval.

Copyright © 1994-2001 Encyclopædia Britannica, Inc.

UPHEAVALS AT THE TURN OF THE CENTURY

The end of monarchies

What Winston Churchill once described as "the old world in its sunset" had never been captured more brilliantly than at the funeral of King Edward VII in May 1910. This was the occasion of the celebrated Parade of Kings, when more than 50 royal horsemen—a swaggering cavalcade of emperors, kings, crown princes, archdukes, grand dukes and princes—followed the slowly trundling coffin through the streets of London.

Here was a moment of supreme monarchical glory. Who, seeing this collection of royalty clattering by, could doubt that the institution of kingship was flourishing? Nothing could better have symbolized the extraordinary early 20th-century flowering of European monarchy than this spectacular parade.

Whatever the powers of these rulers—whether they were autocrats as in Russia, or virtually powerless constitutional monarchs as in Great Britain—their prestige and position remained almost intact. Few of those watching, or taking part in, Edward VII's funeral could have imagined that this blaze of splendor marked, not a royal high noon, but a royal sunset.

And on the other political front there was Lenin
If the Bolshevik Revolution (1917) is— as some people have called it—the most significant political event of the 20th century, then Lenin must for good or ill be regarded as the century's most significant political leader. His writings suggested: *Future wars were inevitable so long as imperialism existed; imperialism was inevitable so long as capitalism existed; only the overthrow of capitalism everywhere could end the imperialist war and prevent such wars in the future.* First published in Russia in 1917, Imperialism to this day provides the instrument that Communists everywhere employ to evaluate major trends in the non-Communist world.

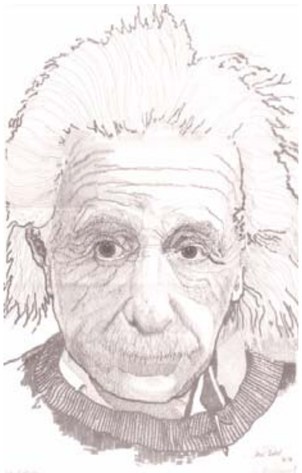
Copyright © 1994-2001 Encyclopædia Britannica, Inc.

SOCIAL/POLITCAL

"*So gorgeous was the spectacle on the May morning of 1910 when nine kings rode in the funeral of Edward VII of England that the crowd, waiting in hushed and black-clad awe, could not keep back gasps of admiration…… Together they represented seventy nations in the greatest assemblage of royalty and rank ever gathered in one place and, of its kind, the last. The muffled tongue of Big Ben tolled nine by the clock as the cortege left the palace, but on history's clock it was sunset, and the sun of the old world was setting in a dying blaze of splendor never to be seen again."*

Barbara Tuchman in her book, *The Guns of August.*

UPHEAVALS AT THE TURN OF THE CENTURY



SCIENCE

The corpus of Einstein's paper entitled "On the Electrodynamics of Moving Bodies," the so-called relativity paper, is at first glance no different from other papers of that era. Yet first glance deceives: It was daring in both style and content. Page for page, Einstein's relativity paper is unparalleled in the history of science in its depth, breadth and sheer intellectual virtuosity. Einstein developed one of the most far-reaching theories in physics….The 1905 theory of relativity, written in white heat in about five weeks, remains the clear turning point marking "the last day of physics as we knew it."

Wondering "quite spontaneously" is at the root of Einstein's highly visual thought experiments. For him, creative thinking occurred in visual imagery and words "were sought after laboriously only in the second stage." Both as a musician and a physicist Einstein was an antipositivist. In music, beyond the notes and instruments was the sublime realm where melodies floated. In physics, beyond observations and theory lay the music of the spheres, where laws of nature waited to be plucked out of the cosmos. His great breakthrough was to use organizing principles and visual imagery of thought experiments to go beyond sense perceptions and its associated form of intuition.

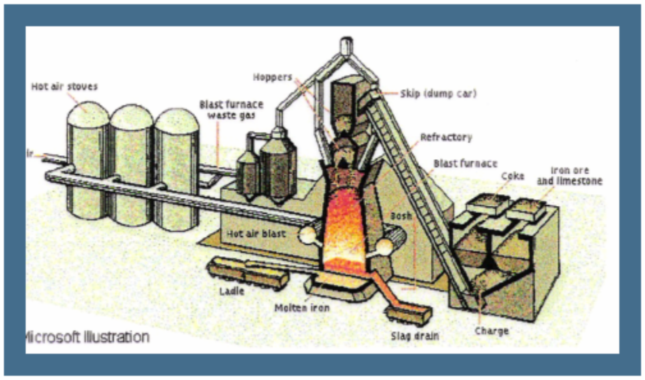
Arthur I. Miller, 2001. "Einstein, Picasso." New York, Basic Books

INVENTIONS THAT RESHAPED THE URBAN FABRIC

Perhaps the greatest impact on architecture in the history of the world was precipitated by the following set of inventions towards the end of the 19th century. For thousands of years the pace of change in the materials and methods used to design and build the fabric of cities was slow. So quickly were these inventions introduced that only electric lighting (and then only on the exterior) was incorporated in the Columbian Exposition of 1893.

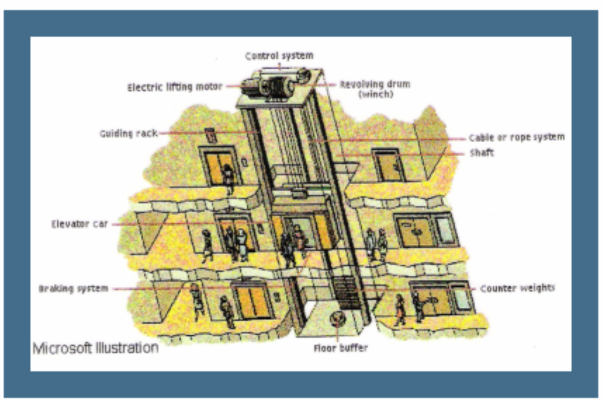
First Generation Of Urban Systems	Discovery or Primary Invention	Precursors To 2nd generation	Second Generation Of Urban Systems
Masonry walls Timber roofs Arches & domes	Smelting iron ore Bessmer Process For steel (1855)	Cast iron (1813) Wrought iron (1855) Eiffel tower (1889)	**STEEL FRAMES For buildings (1883) Home Insurance Bldg.**
Stairways Ramps & pulleys	Safety latch for Elevators/hoists Elisha Graves Otis	Mechanical lifts Hydraulic lifts	**ELEVATORS Safety device (1889)**
Candles Oil lamps	Electrical power Station (1882) Thomas Edison	Gas lights With piping	**ELECTRIC LIGHT Light bulb (1880)**
Fire in stoves Fireplaces	Oil-burner (1868) Gas burner (1902)	Steam engine Coal furnace	**CENTRAL HEAT Burner/ducts/controls (1868)**
Outhouses Privies Slop jars	Flushing valve And water closet From 1778 to 1878	Water piping (1872) Storm sewers (1875)	**INDOOR PLUMBING Toilet/water/sewer (1878)**
Messengers Mail	Telephonics Alexander G. Bell Basic patent 1876	Telegraph (1850) (Morse code)	**TELEPHONE Switching centers (1876)**
Horse & carriage Horse back Oxen	Internal Combustion Engine Gottlieb Daimler Patented 1885	Steam buggy (1865) Electric car Oil wells	**AUTOMOBILE Benz in 1893 Ford in 1896**

INVENTIONS THAT RESHAPED THE URBAN FABRIC



STEEL FRAMING

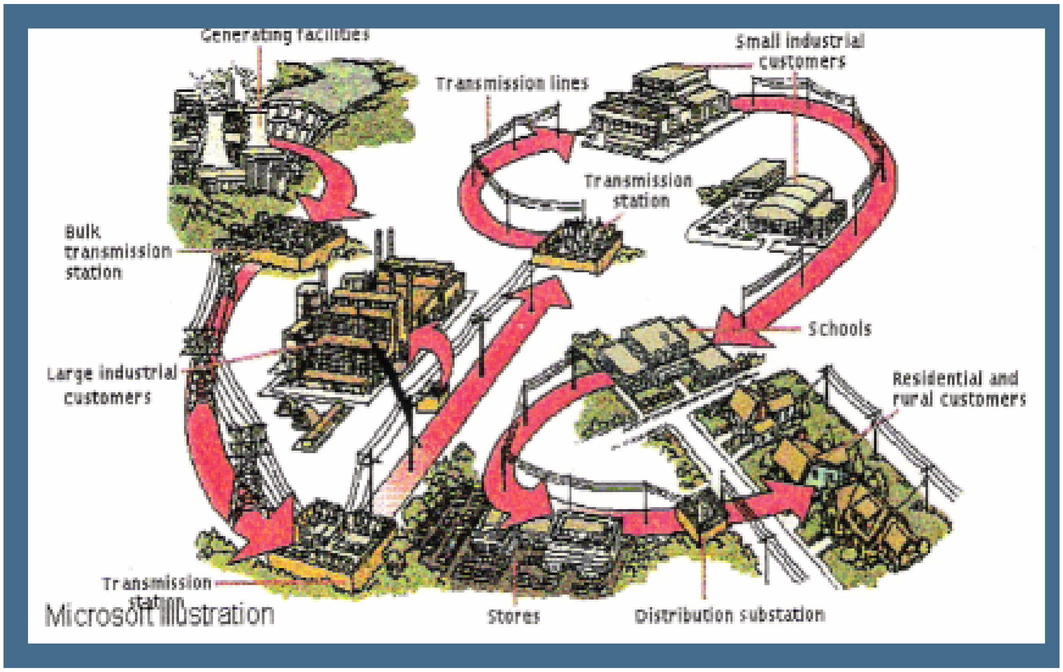
Bessmer's invention of the process for making steel was the key to making possible the introduction of steel frames for buildings. By separating the structural system from the skin of the building (as was the case with masonry construction) it became possible to build taller and taller.The Home Insurance Building in Chicago by William Le Baron Jenny is generally credited with being the first use of structural steel. By the end of the 19th century, architects would be indebted to Charles Strobel, the engineer who designed the wide-flange steel beam—the structural system of choice from 1895 on.



ELEVATORS

It would not have been practical to design buildings more than five or six floors in height if people were going to be required to use stairs to move vertically. Although Elisha Graves Otis is credited with inventing the elevator, and was the founder of the company that still carries his name, he actually invented the safety latch that made the modern passenger elevator practical. It is interesting to note that none of the buildings at the 1893 Columbian Exposition (the White City) incorporated passenger elevators although the safety latch was patented in 1889.

INVENTIONS THAT RESHAPED THE URBAN FABRIC



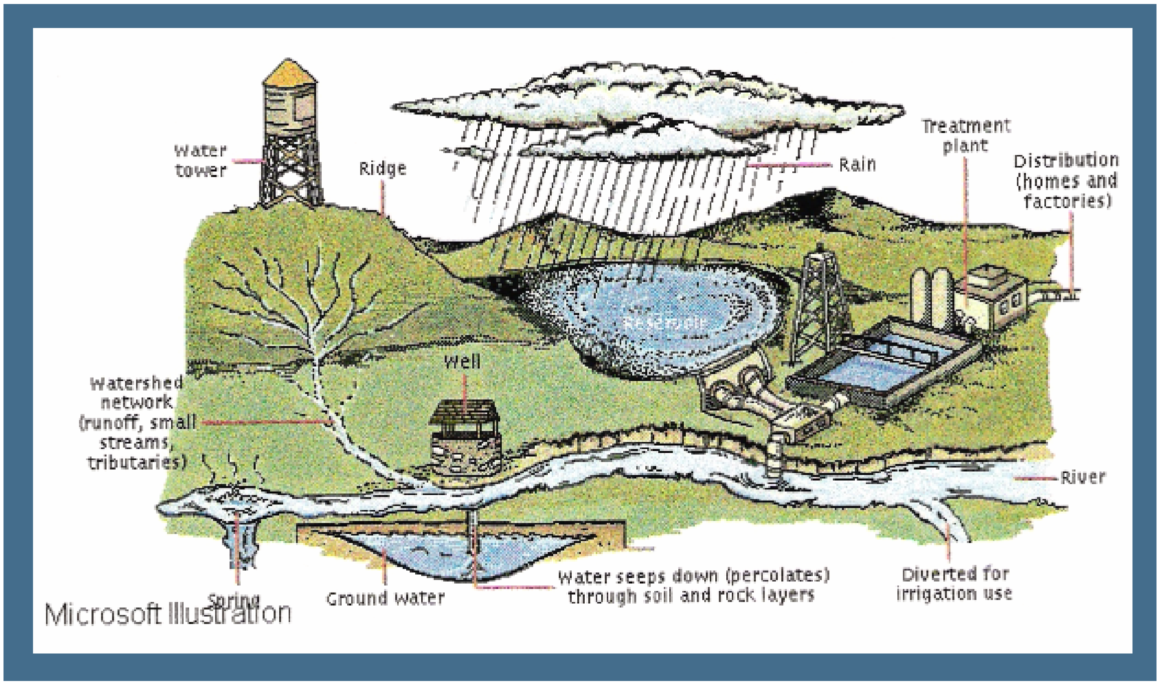
LIGHTING SYSTEMS

Daylight has been the fundamental source of light for buildings ever since glass windows became common in the 17th century. Candles made of beeswax were used by the Romans, and candles made from animal fat have been used in Europe since the Middle Ages.

With the introduction of illuminating gas early in the 19th century, including a method of distribution within cities, gas lamps became common. However, gas lamps were never very adequate sources of lighting and they were constantly seen as a fire hazard. Thomas Edison changed the technology of lighting dramatically with his invention of the light bulb in 1880. The subsequent invention of generating facilities, transmission lines, transmission stations, and wiring methods within buildings assured the domination of electric lighting from that time forward. The design of buildings with dense floor plans that prohibited the use of natural daylight (except at the outside walls) became the result of such lighting systems.

Once introduced into the building, electrical systems made a range of other devices possible, including elevators, heating and cooling units, and the telephone.

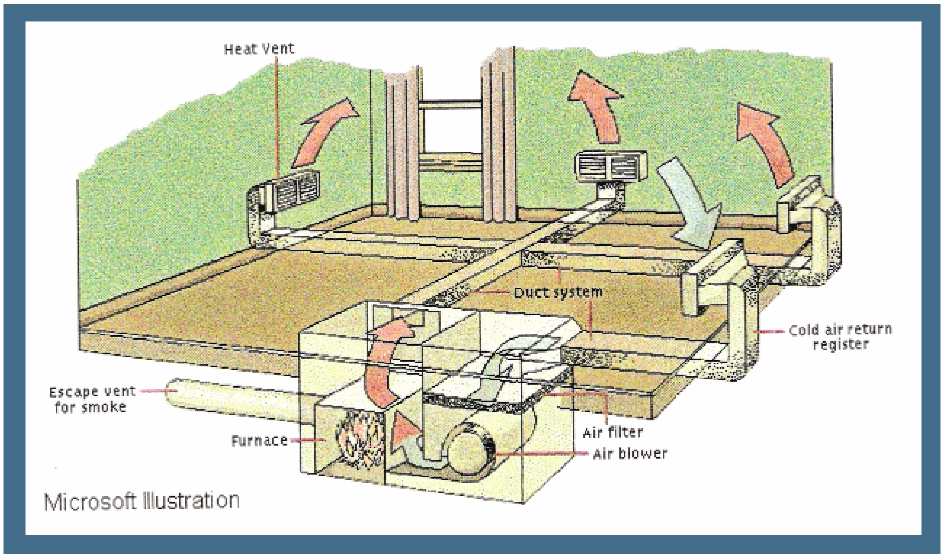
INVENTIONS THAT RESHAPED THE URBAN FABRIC



WATER AND WASTE MANAGEMENT

It was not until near the end of the 19th century that water for use in disposing of human wastes was seriously developed. As with other urban systems, there was not one invention or not a single time in history when the total system came into existence. The key invention was a flushing valve for the water closet that worked well enough to allow city water authorities to permit them to be attached to municipal water systems. Once this gap was bridged, the introduction of "indoor plumbing" into houses and commercial buildings spread at a reasonable rate. However, as late as 1940, cities the size of St. Louis still had less than 50 percent of the housing units equipped with indoor toilets. This slow rate of adoption was attributed to the cost of storage and distribution of potable water in cities.

INVENTIONS THAT RESHAPED THE URBAN FABRIC

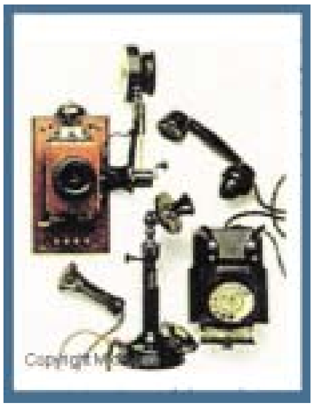


HEATING AND COOLING SYSTEMS

One of the earliest devices for heating houses was the fireplace and/or a stove in which wood or coal could be burned. Historically, in warm climates, or at those times of the year when the weather is warm, people seek to cool their buildings with natural ventilation and various shading devices.

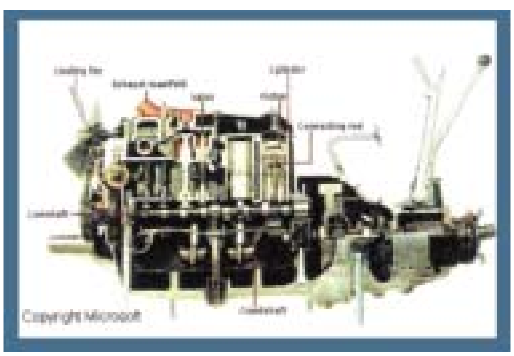
Towards the end of the 19th century, oil and gas motors became replacements for earlier steam engines, and these sources of energy began to find their way into heating systems of buildings. However, at the turn of the century, coal was the primary source of fuel, and since air pollution was not yet a concern, central furnaces and hot-water boilers became common devices for heating buildings. Toward the middle of the 20th century, electricity became an alternative energy source for heating. The rise in use of electrical heating was spurred by its cleaner operation and because cooling systems could more easily be designed around electrical compressors.

INVENTIONS THAT RESHAPED THE URBAN FABRIC



TELEPHONE

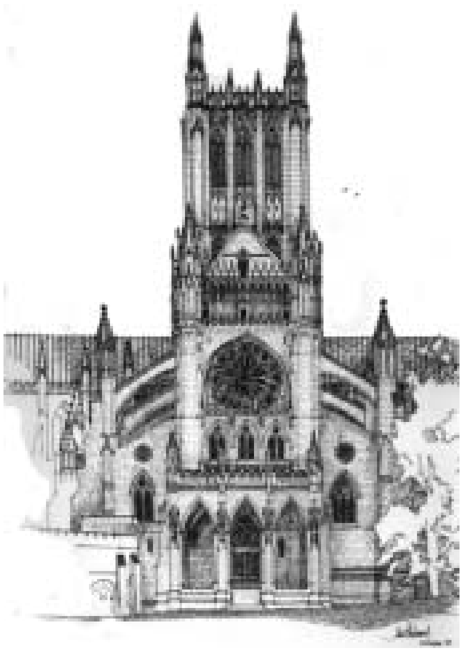
The early telephones were all derived from the basic patent Alexander Graham Bell obtained in 1876. While working on sound transmission for the deaf, he discovered that steady electric current could be altered to resemble the vibrations made by the human voice. Once the instrument was invented, an urban system of telephone switching centers, wires, relays, etc. were put in place. It can be argued that the modern office building with thousands of workers connected to each other was made possible by the telephone



INTERNAL COMBUSTION ENGINE

It was the invention of the internal combustion engine by Gottlieb Daimler in 1885 that made the automobile possible. Henry Ford and Benz applied this invention to a horseless carriage, and organized production companies to make such cars, but they relied on others to find oil wells, develop the petroleum products and distribute them as fuel. Designing and building roads to support the operation of automobiles became an important step in creating a personal means of transportation still dominant today. The design of large metropolitan areas is dependent on effective interfacing with this personal transportation network.

ARCHITECTURE



Architects should be creators of places within space

My friend Dr. Robert Schuller says that God created space and that it is everywhere around us. Man creates places by separating out a part of space to house some human purpose. A few years ago, in a letter to the editors of the New York Times, the staff of Project for Public Spaces suggested:

Both inside and outside the formal boundaries of architecture there is today a tremendous energy being devoted to rethinking how buildings, streets, and green spaces shape our lives, our communities, our economy, our democracy, and our sense of ourselves. The distinguishing feature of this new direction in design is the subtle but significant shift from the "project" to the "place." This small recalibration in focus delivers an enormous change in results. When creating a place becomes the goal, then important questions about what happens all around and throughout the building or development move to the forefront. It's a step away from the 20th Century vision of the architect's work as an isolated triumph of aesthetic devotion (even fetishism) to a more inclusive 21st Century idea of the designer as part of a vibrant, messy, exhilarating process of creating a living, breathing community.

Making this leap from project to place has profound implications for the profession. Architects lose the Howard Roark supremacy in setting out how things shall be. Ideas, decisions, and even inspiration will come from a wider assortment of sources, including people who live there, work there, or visit there. And a number of disciplines must be drawn upon to create places that meet the various needs of people using them.

This section on Architecture will explore developments during the Century of Change, and what neuroscience may mean to continued development in the 21st century.

ARCHITECTURE

Lutheran Church, Newport, RI
by Eberhard in 1957

The birth of modern architecture hinged on the recognition of a deep historical discontinuity. About 1900 the arch-itectural avant-garde severed this bond. The immense spectrum of historical styles, which had been so passionately researched and churned by the nineteenth century in its troubled pursuit of architectural relevance, was now recognized as antithetical or, at best, irrelevant to architectural Modernism.

Marvin Trachtenberg and Isabelle Hyman in their book: "Arch-itecture from Prehistory to Post-modernism"

Changes at the end of the 19th century

As the result of the great upheavals that occurred towards the end of the 19th century, and the enormous impact of the White City, architecture was both on the edge of revolution and a move to preserve tradition. Firms like McKim, Mead and White moved effectively (and skillfully) to exploit the general publics response to the White City. By far the largest number of buildings designed and built between 1900 and 1950 were traditional in style if not in technology. The basic inventions that changed the fabric of the city—steel frames, elevators, electric lighting, indoor plumbing, central heating, the telephone, and the automobile—made it possible to design and build taller and taller structures in the dense central city. But they did little to change the preferred styles of architecture by the public. When I began to design churches in 1955 my "contemporary" design solutions were a hard sell. Most congregations wanted either Colonial or Gothic designs. In fact, at the turn of the 21st century that was still true.

For those architects who were prepared to break with the past, there were a few venturesome clients. Frank Lloyd Wright and Louis Sullivan in the United States; Le Corbusier, Walter Gropius, and Mies van der Rohe in Europe succeeded. These architects, and their associates, believed in breaking with the past and moving into new intellectual and stylistic domains. While not as successful in completely revolutionizing architecture as Picasso and his friends were in changing painting or Einstein in changing science, or Lenin in changing the social-political base of Russia, they were vehement in their pronouncements and convictions.

ARCHITECTURE

The Bauhaus 1925-26

On the example of Gropius' ideal, modern designers have since thought in terms of producing funcational and aesthetically pleasing objects for mass society rather than individual items for a wealthy elite.

Encyclopedia Britannica

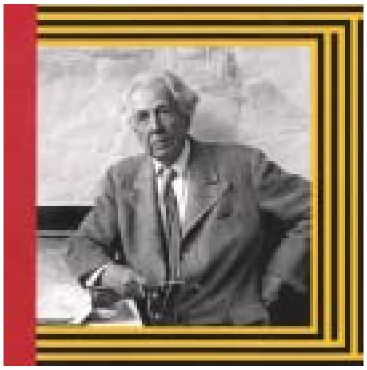
Le Corbusier wrote in 1923:

Architecture finds itself confronted with new laws. Construction has undergone innovations so great that the old "styles," which still obsess us, can no longer clothe it; the materials employed evade the attention of the decorative artist. There is so much novelty in the forms and rhythms furnished by the constructional methods, such novelty in arrangement and in the new industrial programs, that we can no longer close our minds to the true and profound laws of architecture which are established on mass, rhythm and proportion: the "styles" no longer exist, they are outside our ken; if they still trouble us, it is as parasites. If we set ourselves against the past, we are forced to the conclusion that the old architectural ode, with its mass of rules and regulations evolved during four thousand years, is no longer of any interest; it no longer concerns us: all the values have been revised; there has been revolution in the conception of what Architecture is.

The Bauhaus was founded by Walter Gropius in 1919 to teach students equally in art and in technically expert craftsmanship. A severe but elegant geometric style carried out with great economy of means has been considered characteristic of the Bauhaus. It had far-reaching influence. Today, in almost every school of architecture, students learn about the fundamental elements of design based on the Bauhaus model.

When Gropius came to head the Harvard School of Architecture in1937, the philosophy of the Bauhaus became fully integrated into the education for architects. The revolutionary idea the Bauhaus introduced included the very idea of changing architectural education by sweeping away the old and introducing the new found freedom of creating unique solutions—no matter how shallow the intellectual basis for doing so.

ARCHITECTURE



It is hard to realize how strange his work must have seemed in early 1902, how unlike anything else and how totally out of step with prevailing taste, how offensive even to conventional neighbors on those suburban lots who considered his houses so peculiar they called them "harems." He maintained throughout his life that he was the sole inventor of modernism. He took an adversarial stand against the Interna-tional style.

Ada Louise Huxtable in her book: Frank Lloyd Wright

Frank Lloyd Wright

By birth, background, and temperament, Wright was uniquely suited to the radical cultural climate of his youth. His early years intersected with a revolution in the arts, a time of exalted creativity and fervent artistic reform devoted to the overthrow of the established order and the rejection of the models of the past.

What Wright does not admit to or even hint at in his autobiography are the other ideas and models that shaped the nature of his art. To maintain his Olympian position as the self-described inventor of Modern architecture, he could admit to no other interest or influence, or acknowledge any work but his own. Wright was an active participant in the intellectual ferment and creative inquiry that prefigured modernism in the arts. While he carefully denied it, he was in touch with every new development, every contemporary current, and every innovation here and in Europe, through books, magazines, direct observation, and professional contacts abroad.

The straightedge, the triangle, and the compass were his tools; the intriguingly complex patterns of circles, squares, triangles, and hexagons that these tools produced made up his preferred design vocabulary. The passage of the century and the advent of minimalism and computer-aided geometry have dimmed the radical edge of Wright's work; seen in context, and by his contemporaries, it was shockingly unconventional.

Those who change the course of art use any means to convince the world that it needs something it neither anticipates nor understands and rarely wants. Although he never ceased to make the claim that he was modernism's sole inventor, champions of the International style, who moved from Europe to become the intellectual avant-garde in the United States in the 1930s, would relegate him to the twilight of its beginnings.

ARCHITECTURE

This Orange County Government Center in Goshen N.Y. designed by Paul Rudolph in 1963, it likely to be demolished soon. The citizens of this community consider it the ugliest building in town. Baby boomers in Goshen and elsewhere have made their preferences for traditional architectural style clear.
Fred A. Bernstein, in the October 31, 2004 New York Times.

Peabody Terrace, by Sert

After 1950

In the ’40s, the world of architecture education went through a dramatic transformation. School after school discarded their past practice of using the Beaux Art approach (borrowed from the French at the end of the previous century) and adopted “modern design” or “contemporary architecture” as their theme. Often this was done “overnight”—stopping the old process at the end of the spring semester and beginning the new the following fall. During the transition stage many of the same faculty continued to teach design studios. By the decade of the ’50s, there were no architecture schools left in the United States where students studied the classic orders. This was to have a profound effect on the shape of the profession for the balance of the century.

Architectural projects designed in the 1960s seem almost uniformly to have been poorly done. Perhaps it was the rapid change introduced in the schools of architecture and the accompanying emphasis on unique new designs that were shorn on their classic heritage and forced into cost conscious solutions by the clients. Some of the ’60s buildings photograph well (like the illustration shown here), but they did not work very well. They leaked, they were badly lighted, and they seemed most often to make poor use of color.

An example of ’60s problems is Sert’s 1964 ode to Modernism (Peabody Terrace in Cambridge, Mass.) that won praise from fellow architects, but was considered a tall and brutal monument for many who live in the area. For this community, it’s not just about the dull, gray concrete, or the 22-story towers, or the way the buildings turn their back on the neighborhood streets. They take sun from the street so that neighboring houses are colder and darker. Forty years later it was renovated at great expense.

ARCHITECTURE

To walk into the woods of Eureka Springs, Ark., with sun dappling the trees, to hear the birds, to absorb the fresh scent of pine needles on the forest floor as they are softly crushed beneath your feet is to begin a journey of joy.
To enter this chapel with its intricate crown of wooden trusses is to experience the frozen music of architecture at its most sublime.

Eberhard in AAF News Dec. 1996

There began to emerge from the 1970s a number of buildings that were considered special. The Thorncrown chapel by Fay Jones in 1979 is one of the best. It received the highest number of votes from the membership of the AIA when asked to rate the best designed building in the U.S. Almost four million people have visited this little chapel on the hillside, testimony to the appeal of its special qualities.

The nation had come through the harrowing experiences of the Vietnam War, accompanied by massive student demonstrations on college campuses—often led by architecture students. A crisis in our supply of fossil fuel energy precipitated an interest in energy conserving designs, as well as designs based on "passive" energy sources (sun and wind). Schools of architecture turned from a 1960's concern with how architecture could be married to social purposes to creative designs that were "energy conscious".

By 1980, it became clear that the first cycle of architectural Modernism, which began in the 1890s, was "finished as a living movement capable of further growth." After the mid-1970s, this new avant-garde style tended to call itself Post-Modernism. Ultimately this new movement was rooted in the resistance to Modernism during the first three decades of the century. Simply because a score of progressive architects repudiated historicism at the turn of the century should not mislead us into thinking that the rest of the world followed. Far from it. The bulk of the new buildings designed around the world were new building types (technologically) in traditional facades.

If there was one building type that brought out the best in early twentieth-century traditionalism, it was the skyscrapers of New York City. While the eight technical inventions mentioned earlier were necessary for the skyscraper to be realized, the architectural character of the buildings could still hark back to a traditional vocabulary. The Chicago Tribune's Gothic detail was a prime example.

ARCHITECTURE

The most powerful figure of American Second Modernism is Philip Johnson, the reigning dean of American Architecture.

Trachtenberg and Hyman in their book "Architecture" written in 1986

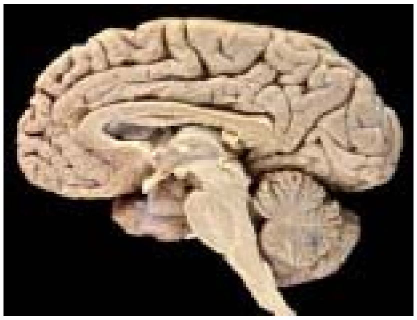
The AT&T Building

In 1978, AT&T commissioned Philip Johnson and his partner John Burgee to design their world headquarters building in New York City. The project was revealed to the howls of architectural critics, who regarded it as a joke. The building was clad in granite and was 647 feet tall—36 oversize stories. It looked like a colossal Chippendale highboy cabinet. Trachtenberg and Hyman (in their 1986 book) say, "It seems futile, and perhaps irrelevant, to ask if there is any purpose to all of this beside heady public entertainment. Johnson is inscrutable about it, admitting to the desire for a sense of monumentality out of his huge granite machinery, a 'passion for greatness'."

This passion of corporate leaders for greatness, when harnessed to architects with large egos, has continued to produce ever taller and bolder monuments around the world. As of 1998, the tallest building in the world was in Malaysia—the Petronas Towers**,** twin skyscrapers in Kuala Lumpur that were the world's tallest twin towers. Standing 1,483 ft (452 m) high, they were designed by the Argentinian-American architect Cesar Pelli. Completed in 1997, they surpassed Chicago's Sears Tower as the record-holding tallest structure; they themselves were surpassed by Taipei 101 in 2003.

The average citizen of the world must wonder at the need for taller and taller buildings to support corporate "passions for greatness" when the vast number of buildings—those designed by architects and those that are "just built"—are more humble and often relegated by architecture critics to the status of "background" buildings. It would seem worthy of a profession that aspires to greatness to seek ways to enhance the quality of all buildings in order to follow Jonas Salk's admonition to become admired ancestors for future generations. This paper argues that a knowledge base derived from neuroscience research shows promise of enabling this aspiration.

THE BASICS OF NEUROSCIENCE



Human Brain

The human brain is what makes humans capable of painting the Sistine Chapel, designing the Vietnam Memorial, reading, writing, and playing Chopin. It is a truly astonishing and magnificent kind of "wonder-tissue," as the philosopher Dennett puts it. Whatever self-esteem justly derives from our accomplishments does so because of the brain, not in spite of it.

Patricia Smith Churchland, in her book Brain-Wise, MIT, 2002

The human brain has three major structural components: the large dome-shaped cerebrum (top), the smaller somewhat spherical cerebellum (lower right), and the brainstem (center). Prominent in the brainstem are the medulla oblongata (the egg-shaped enlargement at center) and the thalamus (between the medulla and the cerebrum).

Oxford Scientific Films/London Scientific Films

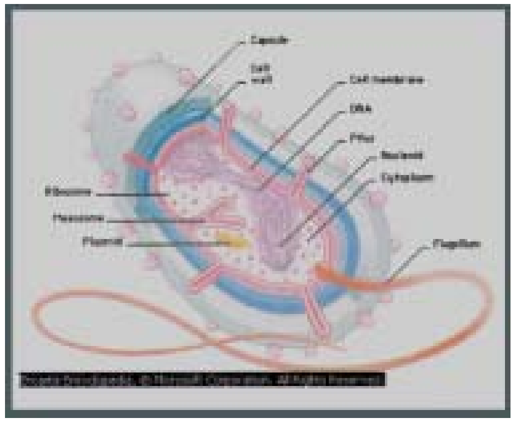
The brain is composed of more than 100 billion cells contained in various components. The cortex—that folded "thirty inch square *napkin* with six layers"—looking like cauliflower, contains ten billion neurons held in place by ninety billion glial (Greek word for glue) cells. Neurons differ in size and shape, in their chemistry, and in the design of the networks to which they contribute. On the next page, neurons are discussed in more detail.

The brain is about the size of a coconut, the shape of a walnut, the color of raw liver, and has the consistency of chilled butter. It has two hemispheres, each covered by the thin gray tissue of cortex. These two halves are bound together by a band of fibers called the *corpus callosum* that provides a continuous transfer of information between them. The responses of the two halves to incoming information are so rapid that a seamless perception of the world is formed and there is a single stream of consciousness. The left hemisphere is calculating, communicative, and capable of conceiving and executing complicated plans (such as plans of buildings). The right brain is considered gentle, emotional, and more at one with the natural world.

Imagine the brain, that shiny mound of being, that mouse-gray parliament of cells, that dream factory, that petit tyrant inside a ball of bone, that huddle of neurons calling all the plays, that little everywhere, that fickle pleasuredrome, that wrinkled wardrobe of selves stuffed into the skull like too many clothes into a gym bag.

Diane Ackerman at the start of her book "An Alchemy of Mind"

THE BASICS OF NEUROSCIENCE



BASIC CELLULAR ARCHITECTURE

Cells
The brain and the body of all living creatures are composed of cells, most of which reproduce themselves every six months or less.

The human body and brain are composed of cells. Each cell contains membranes, a cytoskeleton, organelles, mitochondria, and a nucleus that contains our genes. These cells are formed over the 40 weeks of gestation by the embryo.

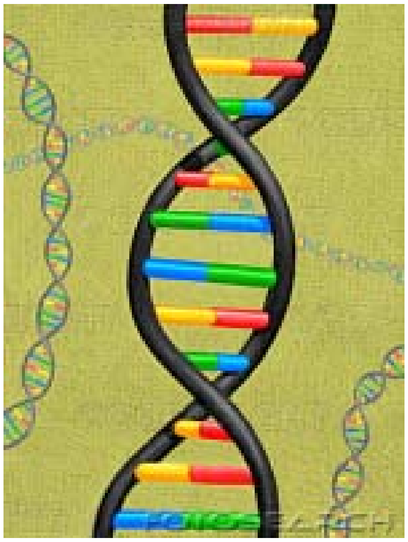
DNA provides instructions for forming proteins from amino acids. Some proteins are structural while others are enzymes made within the factory.

As the human body takes shape in the womb, populations of cells enter different streams of development: one is destined to give rise to the lungs, another to muscle, a third to the kidneys and bladder, etc.

The busy metabolism of the nervous system requires a rich circulation with lots of blood vessels and blood cells (the meniges and the ependyma).

The first structure for the brain begins to form during the third week of life, and continues over the next eight months as cells are generated by the division of progenitors (popularly called “stem cells”) that migrate into position and begin forming networks by connecting with other neurons. Unlike computers that are designed around an operating system, there is no master planner for this, it just happens as the nervous system organizes it own intricate structure.

THE BASICS OF NEUROSCIENCE



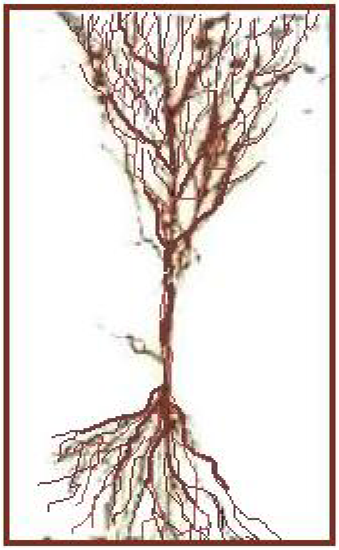
The Human Genome Project promises to provide no less than the operating instructions for a human body. The DNA is each neuron is a key item in structuring the brain.

GENETICS

Each strand of DNA consists of 3.2 billion “letters”—A or C or G or T—(representing the molecules adenine, cytosine, guanine, and thymine). A gene is an instruction, like the directions in a bead-weaving kit, but written in terms of molecules. In humans, 99.9 percent of our genes are identical in each of us. Only 80 of the 80,000 genes of our total make-up distinguish us from one another. Each triplet of letters (representing three molecules) instructs special machinery inside the cell to grab onto a particular amino acid. When enough amino acids are assembled you have a protein—for example, a protein that can cause depression.

Genes are not to be seen separately from the environment that turns them on and off. Genes are essential, but depend on their environment. Thus, genes may be equipped to turn on an experience of something that is well-proportioned, but to be turned on one has to be in a well-proportioned environment—such as an architectural setting. Genetic scientists hope to learn which genes turn on when a song is learned or a memory formed.

BASICS OF NEUROSCIENCE

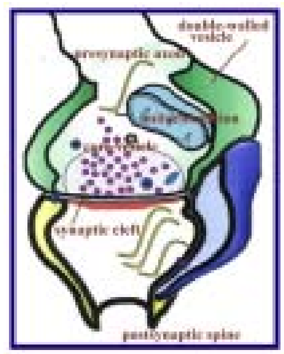


Neurons

I think of the brain as a set of networks nested like Russian dolls. In the innermost level there are billions of neurons that compose the inner network. The outermost network is made up of the communicating, inter-acting set of brains that compose a human society. The links in the outer network result from the fact that our brains can report on some aspects of their own working and can also interpret similar reports received from other brains.

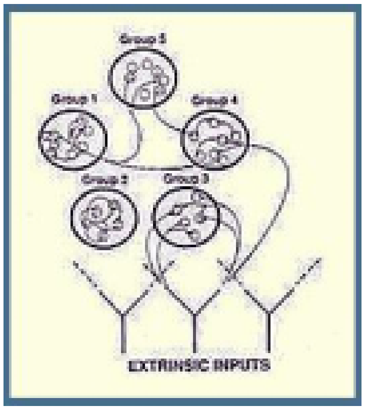
Horace Barlow,
Cambridge University

Each of the ten billion neurons in the brain's cortex consist of three parts: 1)The dendrites (branches at the top) whose electrical signals are transmitted between neurons like the wind blowing through the trees. 2) The axon (the trunk) that receives electrical signals from the dendrites. Once sufficient charges have accumulated to trigger it, a chemical reaction inside the axon is passed along its length to release neurotransmitters from 3) the synapses (the roots). Strictly speaking the synapse is a very tiny gap that exists between the ends of the "roots" of the neuron and "receptors" on other neurons.



Neurotransmitters are bundles of chemicals that carry messages from a neuron to one or more other neurons. These message can result in pleasurable or painful sensations. For example, the sensations associated with people who enjoy nicotine or caffeine products.
The simplest network in the brain grows rapidly to become highly complex. However, the brain is designed to reject the reproduction of unneeded, too complicated networks, and to replicate those networks that are beneficial. New neural connections are made every time our senses record incoming messages and, as a result, lets old records fade away. Neuronal groups that are retained are kept in a "secondary repertoire" to be used again when a similar experience happens. Each time a neuronal group is reactivated, however, it is slightly changed before it returns to the repertoire. As a result we never experience exactly the same thing twice.

BASICS OF NEUROSCIENCE



NGS Theory

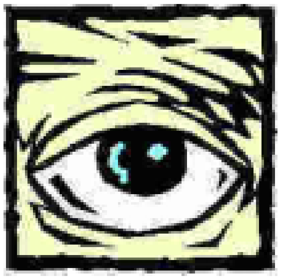
The brain operates as a selective system. This is the key concept behind NGS – neuronal group selection. The brain is organized into collections of neurons during the time humans are in the embryo stage. The selective system of the brain links together hundreds (even thousands) into "neuronal groups." Once these neurons are inter-connected they function as a unit.

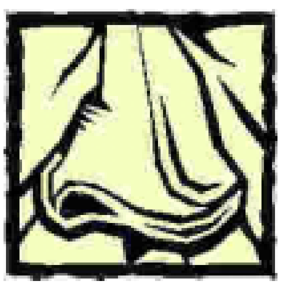
Dr. Gerald Edelman in his book Neural Darwinism

The NGS theory makes three fundamental claims:

1. The diversity of neuronal groups is created during the development stage (while we are still embryos) because of the random and highly variable manner of connecting neurons to each other. This randomness is what happens during evolution when cells which were essentially all the same, occasionally develop new varieties (what Edelman calls "epigenetic") No master plan dictated that this variation be created... it just happened. The resulting diversity of "repertoires" (a structured collection of neuronal groups) is such that no two individuals are likely to have identical connections between brain regions.
2. A second selective process occurs during the life of an individual after they are born (the postnatal stage). As we "behave" in the new environment into which we have been born some of the connections between neuronal groups are strengthened and some are weakened. As a result, new combinations of particular groups taken from the primary repertoire are associated with signals from the outside world. These new formations create a set of "secondary repertoires" consisting of functional groups likely to be used in response to our future behavior.
3. Edleman uses a concept he calls "reentrant signaling" to explain how our brains modify the secondary repertoires as we evolve. He suggests that our neuronal "maps" begin to link collections of secondary repertoires and tie them to specific events and places in response to the signals our brains receive from the outside world. The synaptic mechanism (remember this is the chemical signals sent between neurons) is then tied to memory, implanting some of the selected neuronal groups in a way that allows their particular variation to be used again in a future selection of similar events.

BASICS OF NEUROSCIENCE





Our contact with the world is through our senses, and through our mind's perception of what the senses tell us. We attempt to bring order to our environment to enable us to use it and enhance our satisfaction.
Stuart L. Knoop and Robert J. Worsing thesis while students at CMU.

Perception by the senses

In addition to the five senses commonly understood to be the basis for perception—seeing, hearing, smelling, tasting, and touch—there is a special sense called "proprioception." This sixth sense provides us with an awareness of the position of limbs, our posture, and equilibrium.

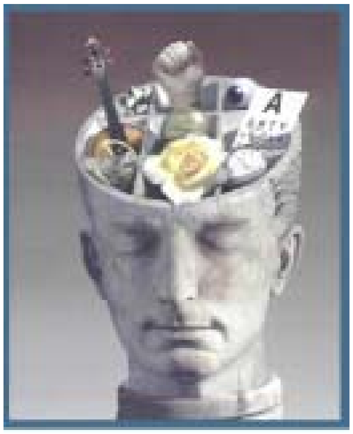
These six senses provide us with basic perception. But, these perceptions become invested with meaning when the brain processes them against our memories. Thus perception will transform mere patterns of light into objects we recognize and use, or people we know, or architectural settings we have experienced before.

All sensory stimuli enter the brain as streams of electrical pulses created by neurons firing, domino-fashion, along a certain route. This is all that happens. There is no reverse transformer that turns electrical activity back into light or shows pictures in the back of our head. What makes one stream of electrical pulses turn into vision and another into smell depends on which neurons in the cortex are stimulated.

For example, sight begins when light passes through the cornea and falls on the thousands of cells that make up the retina. These cells then transform the light into electrical impulses that are transmitted along the optic nerve to the visual cortex and separated into six visual areas.

1. The V1 area that "maps" processes from the other five on to the general scan it has produced;
2. The V2 area that adds the stereo effect of 3-D to create form;
3. The V3 area that deals with depth and distance;
4. The V4 area that is the primary color sensor;
5. The V5 area that detects motion;
6. The V6 area that deals with the exact location of an object in the field of vision.

BASICS OF NEUROSCIENCE



All of our memory, inherited from evolution and available at birth or acquired through experience, in short, all our memory of things, or the property of things, or persons and places, of events and relationships exists in dispositional form, waiting to become an explicit image or action.

Antonio Damasio in his book, "The Feeling of What Happens"..

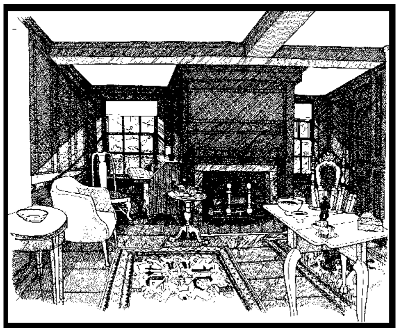
Memory

All of the appendages of the brain collaborate with the cortex in the processing of recording and recalling time and space events. Memory can be considered as "the ability to repeat a performance." Unlike memory in a computer, brain-based memory is inexact, but is capable of broad generalization. Our brains properties of inexactness, association, and generalization all derive from the fact that our memory records are selective—not everything we experience ends up as a record. And, many things that we experience are saved in "non-declarative" memory. For example, riding a bicycle, or mastering the skill of drawing. These background memories do not provide information in a form that we recall consciously—they are needed in real time as we use them.

There are four types of remembering that are usually associated with learning and thinking:
1. **Recollection** that involves the reconstruction of events or facts on the basis of partial clues
2. **Recall** that is the active and unaided remembering of something from the past
3. **Recognition** that is the ability to correctly identify previously encountered stimuli as familiar
4. **Relearning** material that is familiar but is easier to learn a second time be recovering it from memory.

Although much has been learned, we still know relatively little about how and where memory storage occurs. We know which brain systems are important for different kinds of memory, but we do not know where the various components of memory storage are actually located. We know almost nothing about how an earlier experience of an architectural setting is retrieved from memory, or what happens as the experience is gradually forgotten, or why it is so easy to confuse a memory with a dream or with something we have only imagined. And yet, as architects imagine solutions to the design of buildings, their memories of past experiences play a significant role.

BASICS OF NEUROSCIENCE



The mind uses one of the brain's most sophisticated capacities called "working memory" to figure out common problems such as where the furniture in a familiar room is located.

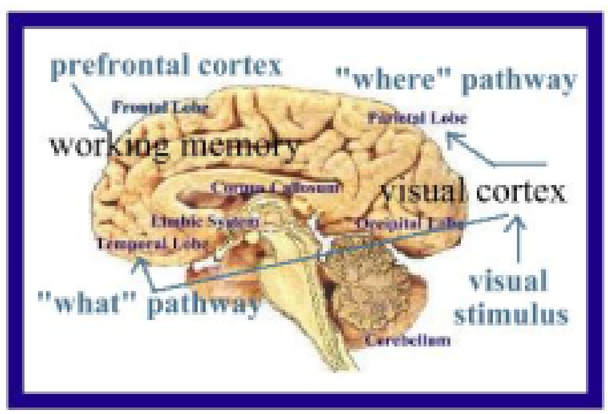
Joseph LeDoux in his book, Synaptic Self

Working memory

Working memory underlies our ability to hold a conversation, play a board game like chess, or find our way by looking at a map. It also contributes to special human endeavors, such as composing music, solving math problems, or designing a building.

The information in our working memory is what we are currently thinking about or paying attention to, with added overlays from long term memory.

The maintenance of visual information in working memory appears to depend crucially on information transfer over synaptic pathways between specialized areas of the visual cortex and the prefrontal region that tell the prefrontal cortex "what" is out there and "where" it is located. The prefrontal cortex, in turn, instructs the visual areas to attend to and stay focused on those objects and spatial locations that are being processed in working memory. These activities contribute to functions used for planning, problem solving, and controlling behavior.



Like the Wizard of Oz, these executive processes work behind the scene of consciousness.

BASICS OF NEUROSCIENCE

There are issues of "artificiality" (artificial means things that are designed and made by man as distinct to being found in nature) which are different than those encompassed by science (something known as the result of rational hypothesis formation followed by extensive experimentation). Those who practice as design professionals are concerned with how things "ought to be." Scientists are concerned with how and what things are as they are found in nature.

Herbert Simon in his book, The Sciences of the Artificial.

The Sciences of the Artificial

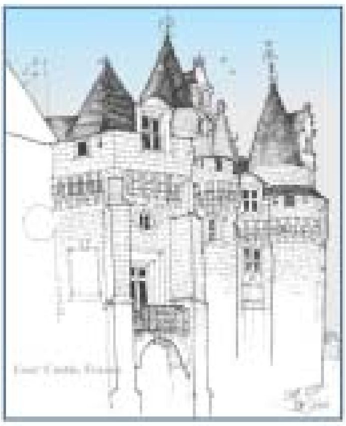
When an artifact (e.g., a clock) is designed, it has an inner environment (how it is organized and how it operates) and it is placed in an outer environment (the surroundings in which the clock operates). If the inner environment is appropriate to the outer environment (or visa versa), then the artifact will meet its goals (the designer will have succeeded in making something that is as it ought to be). For example, if the clock is intended to serve as a chronometer on board a ship it will not only have to have an inner design which records time, but it will have to operate in an environment in which the rocking of the ship is tolerated. It took many centuries before a "chronometer" was designed (which used a metal spring) making it possible to keep time on board a ship.

Humans have the ability to "learn" about problem-solving. They can learn special techniques for certain kinds of problems (such as geometry) and practice to become proficient at others (such as designing clocks). Experiments with human learning strategies have shown that many times it is necessary for someone to teach us how to solve problems (i.e. we are not likely to invent geometry all by ourselves).

Even though only rough estimates have been made, it appears that true professionals (from chess masters to architects) store about 50,000 chunks of specialized knowledge in LTM. It takes about 10 years to acquire this many chunks (moving them at the rate of five to fifteen seconds each), and it seems to be the case that even the most talented people require a decade to reach top professional proficiency.

The process of problem solving by constantly alternating references to memory, then to written documents, and then to what has been recorded on a drawing leads to what Simon calls "productions."

BASICS OF NEUROSCIENCE



Sleeping Beauty Castle

We all know what consciousness is: it is what you lose when you fall into a deep dreamless sleep and what you regain when you wake up. But this glib statement does not leave us in a comfortable position to examine consciousness scientifically.

Gerald Edelman in his book: Wider than the Sky

Consciousness

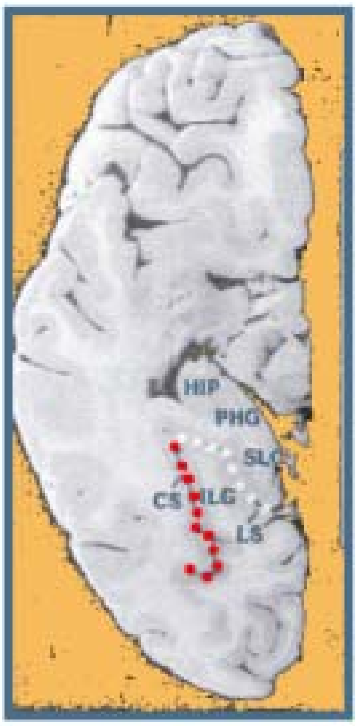
Primary consciousness is the state of being mentally aware of things in the world, of having mental images in the present. It exists primarily in the remembered present. In contrast, high-order consciousness involves the ability to be conscious of being conscious, and it allows the recognition by a thinking subject of his or her own acts and affections. It is accompanied by the ability in the waking state explicitly to recreate past episodes and to form future intentions. At a minimum level it requires semantic ability, that is, the mastery of whole system of symbols and grammar.

Adam Zeman says, “We have seen, in a number of languages, that words for consciousness stem from a root referring to ‘knowledge.’ This makes a good deal of sense. Being awake—our first sense of consciousness—is a precondition for acquiring knowledge of all kinds. Once awake, we usually come by knowledge through experience—the second sense of consciousness. The knowledge we gain is then ‘conscious’ in the third sense—we are conscious of what we know.”

We ourselves are numbered among the things of which we can have knowledge: such knowledge is the fruit of self-consciousness. Human beings gradually come to realize that they are subjects—of experience.

Colin McGinn has another argument, “Consciousness indubitably exists, and it is connected to the brain in some intelligible way, but the nature of this connection necessarily eludes us.” He says we should at least consider the possibility that we are running up against our cognitive limits. Our understanding surely has bounds. I maintain that the perennial puzzlement surrounding consciousness and its relation to the body is an indication that we are on the edge of what we can make comprehensible to ourselves. There is no product warranty inscribed on our brains reading, “this device is guaranteed to solve any problem it can formulate.”

BASICS OF NEUROSCIENCE



Recent research has shown that there are "voxels"(collections of neurons) in the right lingual sulcus of the ventral temporal lobe of the visual cortex that have the function of recognizing buildings.

A special sector of the brain

Using functional MRI, scientists at University of Pennsylvania tested the hypothesis that there exists a cortical region specialized for the perception of buildings. A region straddling the right lingual sulcus was identified that possessed the functional correlates predicted to be a specialized area for buildings.

They wished to rule out several alternative explanations that might be offered for apparent building selectivity, so they conducted several experiments. Experiment 1 identified candidate building areas in which the fMRI signal was greater during the perception and recognition of buildings than during the perception and recognition of faces or general inanimate objects.

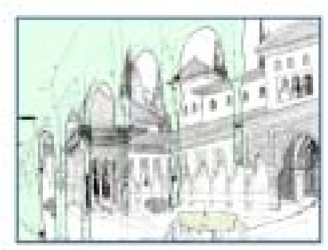
They ruled out (in other experiments) the possibility that the voxels were responding to building textures (as contrasted to whole buildings), or that other large objects like taxis or refrigerators would evoke the same response. They eventually concluded that this region of the brain is predisposed to develop representations of stimuli commonly used for the purposes of orientation. This could include large natural terrain features, hallways, and rooms as well as buildings.

Nancy Kanwisher at MIT has done similar experiments

using photos of various houses and comparing brain responses to the houses versus faces.

Dr. Aguirre of the University of Pennsylvania believes these voxels were given this role during the period in history when we were hunter-gatherers. He says that humans who have brain lesions in this area have no ability to use buildings for way-finding in urban spaces. They have to use other objects like park benches, mail boxes, plants, etc. to learn and follow a path.

SOCIAL AND BEHAVIORAL SCIENCES



Constructing a model of perception around environmental information does not take into account the contribution of the body to personal and cultural memories. We do not aggressively seek out architectural form… we experience such satisfaction by desiring and dwelling in it.

Kent Bloomer and Charles Moore in their book: Body, Memory, and Architecture.

The limits of social science

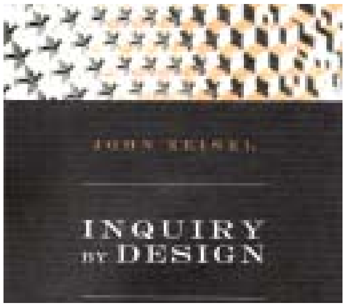
Social Science observations are something like the observations of light before the development of the science of physics in the 19th century. The social science observations are not necessarily wrong, but they are limited. Observations of how humans interact with their environment are based on "informed suppositions" and usually careful methodology. The limit of these methods is that we know a good deal about what happens during environmental interactions, but we don't know why humans respond the way that they do.

As a result of studies of the brain and the mind by neuroscientists with modern scanning equipment, it is possible to know much more about how humans "experience" their environment, about why they have such experiences, and about what might be done by designers to influence experience. We are still in the early stages of these developments, but the direction seems clear.

Past research by social and behavioral scientists has often been incorporated in text books that are used in schools of architecture. Members of EDRA (Environmental Design Research Associates) have continued to meet and publish new findings.

The next four pages are brief excerpts from three persons whom I consider to be among the key pioneers in advancing our understanding of human experience with architecture.

SOCIAL AND BEHAVIORAL SCIENCES



John Zeisel

John is a member of the Board of Directors of ANFA, and a founding member of EDRA, who wrote one of the key texts in this field. The text is called "Inquiry by Design."

It has been described by one reviewer as:

A lively, non-technical explanation of how to integrate research and design and how to carry out research on people and groups that is useful to designers. The book explains how to tailor sociological, psychological, and anthropological methods for the study of environment behavior issues such as how to prevent tourists from getting lost in a city or how to build low-income housing projects that will not be vandalized. Social scientists, designers, architects, and planners will appreciate this practical account of how and when, in programming, design reviews, and evaluation, to undertake environment behavior research.

It has been used as a text in many architecture schools. In the near future a new edition of the book will be published with a new section on neuroscience. In the foreword I was asked to write for this edition, I include the following observation:

> Architects have known intuitively the value of their design decisions on the quality of human experiences. Social and behavioral scientists have added an overlay of research that sharpens our understanding of how design impacts these experiences. Now it is going to be possible to use neuroscience research to answer the critical question of why this happens. Why do patients in a hospital respond better to certain colors? Why is the cognitive ability of children in a classroom impacted by background noise? Why do Alzheimer's patients respond positively to sunlight?

I added the caution that it will be more than a decade before architects will have a knowledge base that more precisely defines the design criteria for architectural places and instruments that can more accurately measure how well these criteria are met.

There are certain hypotheses that can contribute more to basic science, could be more easily "banked" for future research and application, but not be immediately "applied" to solving problems.
There are others that might be considered "clinical/architec-tural"that might be immediately appli-cable to design problems.
And, there are "robust" hypotheses that could do both.

From the writings of John Zeisel

SOCIAL AND BEHAVIORAL SCIENCES

Individuals require an <u>understanding</u> of the environment they are experiencing, the <u>competence</u> to deal with it, and the needed <u>control</u> abilities. When social or inter-personal factors render this urban world threatening to the individual—as the result of unemployment, inter-racial conflicts, or other frustrations—the urban setting may be abandoned, and no single building will be able to make the urban setting satisfactory.

Harold M. Proshansky

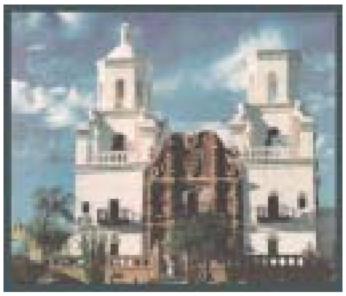
Harold was one of the early social science scholars. Based at City University of New York, he studied in detail how individuals dealt with the physical world in which they found themselves, and how their self-identity was used to form a concept of "place-identity."

Place-identity is a sub-structure of our self-identity consisting of a broadly based understanding about the physical world in which each person lives, works, worships, etc. The recognition that we store in memory (dispositional space) includes images, feelings, attitudes, values, preferences, meanings, and concepts of what behavior is appropriate to the setting. At the core of these memories is our personal environmental past, which includes the places, spaces and their properties, which have served each person's biological, psychological, social, and cultural needs.

He proposed that there were three factors underlying the influence of architectural settings:

1. *The physical setting of the home, school and neighborhood dominate the physical world of the child. A child is totally immersed in these settings. It is in these settings that the child learns some of his or her most significant social roles such as what is expected of a person because of their sex, family relationships, peer group pressures, ethnic group expectations, etc.*
2. *In each of these roles a particular architectural setting has properties that influence what is expected of that child in that setting. For example: sex role differences will have been reflected in how rooms are allocated among siblings, how the rooms are decorated, and what activities are considered appropriate in one's personal space.*
3. *In each setting a child must learn the environmental skills necessary to use them, change them if necessary, and consequently derive satisfaction from them. Environmental understanding, competence, and control all begin to emerge in the child's adaptation to each physical setting for each of his or her roles.*

SOCIAL AND BEHAVIORAL SCIENCES



My main task has been to show that there is a deep and important underlying structural correspondence between the pattern of a problem and the process of designing a physical form that answers the problem.

Christopher Alexander

Christopher Alexander

In his landmark book***, Notes on the Synthesis of Form,*** Alexander sets out his conclusion in his epilogue (see his words in the left column). Because Alexander, is first and foremost, a mathematician, he develops in this book an extremely complex mathematical approach to dealing with design in the "self-conscious" process. For example, he says:

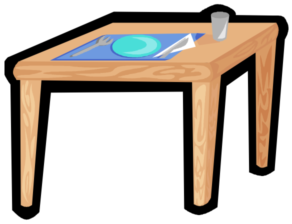
Any design problem of practical interest and complexity will probably contain at least as many as 100 variables, and will therefore have 2^{100} or roughly 10^{30} (1,000,000,000,000,000,000,000,000,000,000) different subsets of variables.

As we have learned from neuroscience, our brain's cerebral cortex deals with this sort of complexity on a subconscious basis, but there is no way to do so consciously. Alexander proposes a combination of "common sense" ways of selecting variables that are most important and joining them in mathematical subsets. Some of the interesting ideas he introduces to his readers along the way include the idea of "fit":

In our own lives, where the distinction between good and bad fit is a normal part of everyday social behavior, if a man appears in 18th century clothes we would say his costume does not fit our time…Thus even in everyday life the concept of good fit, though positive in meaning, seems very largely to feed on negative instances; it is the aspects of our lives which are obsolete, incongruous or out of tune that catch our attention.

… in the making of things and buildings, we may distinguish between our own culture, which is very selfconscious about its architecture, art, and engineering, and certain other cultures which are rather unselfconscious about theirs (such as the Mission church shown on this page, whose architect is unknown). The features which distinguish architecturally unselfconscious cultures is that there is a right way to make buildings and a wrong way...Since the division of labor in such cultures is limited, limitied specialization is rare, there are no architects, and each man builds his own house.

SOCIAL AND BEHAVIORAL SCIENCES



Social Science Methods

Observations by
Dr. Alton Delong
Professor of Interior Design
University of Tennessee

Under the dining room table is a favorite place for children to play. Such space provides an opportunity for a small child to have a space that "fits" their size.

DeLong has observed that in such spaces children speed up their sense of time.

Neuroscience could potentially help us understand "why" this is so.

Scale relationships are transparent, that is we don't "see" them, nor are we aware of how they might affect our behavior and us.

It may well be that the most important, and direct, impact of design on our behavior is through our sense of time and of timing.

Design in the "hidden dimension" and the "silent language" that we all pay attention to without knowing we are doing so.

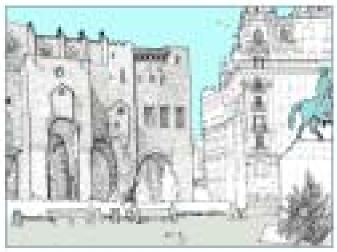
Playing video games on a 7-inch screen was 12-15 percent better than on a 23-inch screen (the game was Pong played by teenagers).

Smaller scale space speeds up children's entering into complex play – significantly.

Children and adults have different time scale relationships (their brain's sense of time as contrasted to the time of the "clock on the wall") in the same space—the child's timing is slower.

Placing children in smaller spaces speeds up their sense of "brain" time, i.e., they can do more per second of "clock on the wall" time than when they are in a larger space.

HYPOTHESES FROM WORKSHOPS



In this section of my White Paper, I will summarize the various hypotheses that have been developed in the three workshops conducted by ANFA during the past two years. More than 60 hypotheses are reproduced here. Some of them are more or less statements of what the group that created them felt to be intuitively correct—but open to verification. Others are clearly intellectual statements that can serve as a basis for PhD and post-doctoral experiments over the next few years.

If we allow discoveries in neuroscience and cognitive science to butt up against old philosophical problems, something very remarkable happens. We will see intuitions surprised and dogma routed. We will find ourselves making sense of mental phenomena in neuro-biological terms.

Patricia Smith Churchland in her book Brain-Wise.

A dictionary definition of Hypothesis is:
A proposition, or set of propositions, set forth as an explanation for the occurrence of some specified group of phenomena, either asserted merely as a provisional conjecture to guide investigation (working hypothesis) or accepted as highly probable in the light of established facts.

Normally a scientist hopes to convince himself or herself that an initial conception (the hypothesis) is correct. If a succession of tests agrees with (or fails to falsify) this hypothesis, it is regarded as reasonable to treat the hypothesis as true, at all events until it is discredited by a subsequent test. The scientist is not concerned with providing a guarantee of the conclusion, since, however many tests support it; there remains the possibility that the next one will not. The concern is to convince himself or herself and critical colleagues that a hypothesis has passed enough tests to make it worth accepting until a better one presents itself.

Herb Simon, in his great book *The Sciences of the Artificial* says:

"Those who practice as design professionals are concerned with how things "ought to be" (or might be) in order to achieve a goal. Scientists are concerned with how and what things are as they are found in nature." Consequently, Simon argued for a science of the artificial (made by man not found in nature) based on "empirical theory" (based on experiences as contrasted to experiments)."

The hypotheses summarized here are "butt-ups," attempts to use scientific methods to impact the experience-based intuitions of professional designers.

HYPOTHESES FROM WORKSHOPS

If exquisitely specific changes are made in the environment (perhaps a change in dimensions of a narthex) that produce a change in brain activations, it could lead to some understanding of how the brain shapes its activations in response to its environment

Sacred Spaces Workshop

The North Christian Church creates a structured rational procession. The spire informs of the destination from a distance. The landscape is very regular and structured so that one proceeds to the main entry along a single path from the parking area. However, the design is orchestrated with the endpoint undiscovered from the exterior. There is no indication of the experience one will have inside of the building. On entry to the building, one comes into the lobby, and then moves down stairs before coming back up to the worship space. Thus, even though the form of the building, its symbolism, and its iconic classic presence are clear, the layout and structure of the middle space is unfamiliar.
Some related hypotheses:

- Creation of an environment that is readily navigated can create feelings of comfort and a reduction in anxiety.
- The element of surprise can be a positive aspect of the design of worship spaces.
- The space evokes a spiritual feeling, resulting from the mystery or surprise of the arrival, that becomes a meaningful religious experience.
- It might be reasonable to hypothesize that the sequence of brain activations as one processes a place of worship brings about a spiritual feeling.

Neuroscience offers potential to inform about the cognitive process during a processional to a particular place, or possibly, the rhythm of feelings: familiarity, comfort, surprise, or awe, as one moves through architectural space. Imaging techniques may reveal the relationship of procession or higher cognitive experiences that are reported as transcendent religious experiences.

HYPOTHESES FROM WORKSHOPS

Sacred Spaces Workshop (continued)

People walking in to North Christian, almost universally experience a sense of something transcendent, whether they're approaching it for an act of worship or not, and regardless of their religious convictions. The climb into the sanctuary space gives a sense of arrival, and being in the center of the building and under a large spire. There is such a sense of "place." It's the sacred cave. It doesn't happen in every building.

- **Hypotheses**
- Perception of movement through space induces a special awareness.
- Movement during the worship experience provides special awareness.
- The sense of being in a space is enhanced by harmony/ unity of form, scale, proportion.
- There is an impact of comfort on the worship or meditation.
- There is an impact of literal and symbolic elements on the mind of the worshiper

A sacred space can be defined as a place in which a religious import has been assigned (thus the place is sacred not the experience of the visitor). A spiritual space can be defined as any place (including sacred spaces) that evokes special transcendent feelings, or connection with something larger and deeper than oneself.

How does the web of consciousness spread across our existence, experienced by so many people with so many concepts of the divine, indicate that they are present in a sacred place? How can we measure this experience?

Hypothesis:

- You are the instrument, and when tears well up in your eyes as you enter this space, you are indicating that it is sacred."

HYPOTHESES FROM WORKSHOPS

All students and teachers are negatively affected by noise and reverberation, but young students, English language learners, and students and teachers with hearing, language, or learning problems may be at a greater disadvantage

K-6 Classrooms Workshop
The basic premises were:

1. Brain development between five years and twelve years of age is significant and understood. Cognitive psychologists and neuroscientists are intrigued with how cognitive capacities change with age. They know that:
   a. Regions of primary functions (in the brain) mature first (e.g. primary motor cortex)
   b. Complex/integrative task regions mature later (e.g. temporal lobe)
   c. The superior temporal cortex, which contains association areas that integrate information from several sensory modalities, matures last.
2. There is an intuitive, but not well documented, understanding that the architectural attributes of classroom spaces affect cognitive (learning) activity.
3. Neuroscience research is likely to provide evidence to support this intuition—including the advantages of classrooms geared to stages in brain development.
4. Therefore, hypotheses are required to provide a research agenda that will bring together interdisciplinary teams to work together in creating the new knowledge needed.

Audition

Hypothesis One:
Background sounds affect reading, speech and language. The following variables are significant:

- Developmental stage of the brain
- Gender of the child
- Culture and socio-economic status of the child

Hypothesis Two:
The type of sound encountered can enhance / deter cognitive activities.

HYPOTHESES FROM WORKSHOPS

This issue is being studied right now at Salk - how light affects the circadian rhythm. These 4th types of photoreceptors are actually in the ganglion cells and don't fire up immediately, they fire up after a while and slowly ramp down after the light is off.

K-6 Classrooms Workshop (continued)

Lighting levels and spectrum of light hypotheses

The brain processes light information to visually represent the environment but also to detect changes in ambient light level. Light also acutely modulates alertness, but the cerebral correlates of this effect are unknown. When tested under brain-scanning experiments, the bright broadband polychromatic light suppresses melatonin and enhances alertness. Functional imaging revealed that a large-scale occipito-parietal attention network, including the right intraparietal sulcus, was more active in proportion to the duration of light exposure preceding the scan. Activity in the hypothalamus decreased in proportion to previous illumination.
Centre de Recherches du Cyclotron, Universite de Liege, Sart Tilman, Liege

There is a need to study the exact light level and light type. The question is whether full spectrum light is better and does it impact, enhance, and support learning? How does light level affect learning?

1. **Full spectrum light enhances learning.**
2. **Changing the cycles of light to coincide with the circadian rhythms could account for improved student performance.**
3. **Satisfactory lighting conditions vary between K-6 and K-12 schools.**
4. **There is an effective level of visual distraction for students.**
5. **Natural daylight enhances learning and health more then artificial light.**
6. **There are individual differences related to age and type of distraction.**

HYPOTHESES FROM WORKSHOPS

We want to know when and how children acquire spatial-linguistic categories, when and how they acquire the ability to negotiate frames of reference, and when and how they acquire organizational strategies to structure their verbal descriptions of space.
Dr. Nora S. Newcombe at Temple University and Janellen Huttenlocher at the University of Chicago

K-6 Classrooms Workshop (continued)

Competence within space

Spatial competence is basic to daily activities such as putting together lunch, walking to school, fitting large objects into a box of toys, using information presented in maps and diagrams, and understanding verbal descriptions of spatial materials (e.g., how to find the way to the bathroom). Thus, to understand human cognitive functioning, we must understand how children code the locations of things and navigate around their world, and how they represent and mentally manipulate spatial information…without at least tolerably close correspondence between internal representations and the actual physical world, children would not be able to find what they need, avoid what they fear, or imagine and construct tools that they use.

There is little evidence that young children lack an objective frame of reference. They may, however, find it more difficult than older children to integrate their spatial representations when a common frame of reference is not available. Fragmented spatial relations have to be related by inference and by the construction of mental models. They also are less likely than older children to use effective strategies of landmark selection and route examination to help them in navigating in unfamiliar areas.

The group agreed that "spatial competence" meant how the spatial environment would enable and positively affect learning, rather than developing competence in spatial perception.

(Continued on next page)

HYPOTHESES FROM WORKSHOPS

Hypotheses about Competence within space – page two

1. Schools should offer a hierarchy of spaces, from private to large-group, in an adaptable structure.
2. Control of the environment is essential to the teacher and the learner; manipulability of space can enable active participation of the learner.
3. The school should reflect the culture of the community; cultural relevance needs to be built in, but also flexible to reflect changing demographics so that the structure can endure.
4. Spatial transitions and flow are essential elements.
5. Appropriate scale matters to the learner/learning activity.
6. Space affects students' sense of self and others, e.g. perception of crowding.
7. A setting that evokes strong emotion may positively impact recall.
8. We may be "hardwired" to prefer certain environments that allow us to perform optimally, through restorative qualities, clarity, appropriate complexity, security, visual connection, ability to move.
9. An environment that offers balanced qualities may be most satisfying and conducive to learning, e.g. security and risk, prospect and refuge, active and quiet, social and individual, inside and outdoors.
10. When activity is intentional, learning may be stronger. Therefore, allowance for choice in activity and environment may optimize learning.

The environment may have the power to positively and effortlessly affect learning through the individual's innate ability to absorb his or her surroundings.

The major overarching assumptions or hypotheses we generated were:

Spatial qualities such as the following have a significant effect on a learner's ability to successfully complete a learning activity.

- Privacy/Distractions/Environmental stimulation
- Variety of settings/Learner choice
- Manipulability by learner
- Proportion/Shape
- Scale
- Location/Relationship

Children's interest in and sensitivity to spatial experience exists to meet specific developmental needs…

- Motor development
- Spatial cognition/mapping
- Sense of security

HYPOTHESES FROM WORKSHOPS

Competence within space – page three

The group then generated these hypotheses:

1. Sustained periods of attention will occur if children are provided the opportunity to access private spaces that limit distraction as indicated by sustained neural activity and reduced stress.

2. If a child is provided with a space that is appropriately scaled to their size, the adjusted sense of time and space leads to reduced stress, greater feelings of security and competence.

3. Sustained periods of attention will occur when a student can manipulate the environment prior to the learning task, as indicated by sustained neuronal activity and increased academic performance.

4. Sustained period of attention will occur when learners can locate themselves:
   a. In an edge space in visual context/connection with the common space, with the choice to be in either.

5. Levels of stress appropriate to high performance in learning tasks will result from environments designed to allow controlled risk-taking activities.

6. Sustained attention will occur when tasks are performed during episodic periods of major spatial contrast (experienced physically or visually).

7. Horizontal & Non-Linear (irregular) Spaces in the learning environment create lower levels of stress than vertical and linear spaces. As indicated by cortisol stress tests.

8. Sustained levels of attention are created by irregular and organic shaped spaces as indicated by increased and sustained levels of neural activity.

9. Sustained levels of attention and reduced stress will occur in certain educational activities that occur in the exterior natural environment, as indicated by increased neuronal activity and cortisol levels.

HYPOTHESES FROM WORKSHOPS

Perceived color is based on the relative activity of ganglion cells whose receptive field centers receive input from red, green, and blue cones. It appears that the ganglion cells provide a stream of information to the brain that is involved in the spatial comparison of three opposing processes: light versus dark, red versus green, and blue versus yellow.

Neuroscience, Exploring the Brain, by Bear, Connors and Paradiso – second edition

K-6 Classrooms Workshop (continued)

Color

It cannot reasonably be denied that color matters in our innate perceptions. Some things can be said about color in a psychobiological interpretation. For example, blues and greens are generally regarded as restful (in our early experiences in the savannas of Africa these colors stood for shelter, water, and vegetable food sources). here are many associations with the red as an attention-commanding color – red lights, red flags, etc. It may be that given our predilection for order that degrees of saturation in the various colors we experience provide a confirmation of expectancies.
Grant Hildebrand, University of Washington, Seattle

In addition to emotional associations, factors that affect color perception include the observer's age, mood, and mental health.People who share distinct personal traits often share color perceptions and preferences. V<u>ery young children learning to distinguish colors usually show a preference for red or orange</u>.
Reference: Encyclopedia Britannica

Hypotheses (based on visual contrast):

Ambiguity and complexity (i.e. novelty-seeking) can influence the fidelity of neural response in visual systems.

There is an optimal degree of “complexity” in the visual contrast of a learning environment.

The visual environment is capable of inducing stress in children between the ages of 6 and 12.

Developmental/maturational differences impact visual contrast & color preferences.

HYPOTHESES FROM WORKSHOPS

K-6 Classrooms Workshop (continued)

Visual Functions – stereo-acuity and depth perception

Primary Hypothesis:

There is a focal length that can provide measurable increases in attention and retention**.**

Hypothesis 1:

Outdoor environment provides opportunities for complex depth perception vs distraction

Hypothesis 2:

Learning tends to drop off at back of the room.

Hypothesis 3:

A change in the shape of classroom, away from rectangular shape, can lead to improved depth perception.

Hypothesis 4:

Dark corners contribute to difficulty with depth perception.

Good visual function at close range, particularly good stereoacuity, is significantly correlated to academic performance. Results suggest that children with attention difficulties have a characteristic inability to restrict visual attention to a limited spatial area so as to selectively process relevant information while effectively ignoring distracting information.

Kulp MT, Schmidt PP. The Ohio State University College of Optometry, Columbus, OH

HYPOTHESES FROM WORKSHOPS

Young children have problems managing their interaction with their environment, and finding their way is only one aspect of that management challenge. Some children learn best by visual/spatial clues and others learn best by auditory clues. It is generally understood in the world of education that children respond more positively to gaining rewards for doing something well than to criticism.

K-6 Classrooms Workshop (continued)

Wayfinding in Schools

Hypothesis:
Landmarks designed around images familiar to children (e.g. animal pictures) can assist in route knowledge (knowledge of the sequence of landmarks which must be followed to reach a goal).

Hypothesis:
Special designs for thresholds provide children with a sense of security and/or well-being.

Hypothesis:
Well designed wayfinding paths provide stimulation to a child's brain that is positive… i.e., the cognitive abilities are enhanced.

Hypothesis:
Children who have early experiences playing challenging computer games have increased ability to find their way in a complex setting.

Hypothesis:
Children who have been exposed to structured music while still in the womb have greater ability to deal with complex wayfinding.

Hypothesis:
Children who are in the first grade lack the neural networks required to tell other children how to find specific places in the school environment.

Hypothesis:
Children who are younger than 10, and who have more than six blocks to walk to school, have more instances of perceived dangers than those who are older.

HYPOTHESES FROM WORKSHOPS

This analysis is implicit in all the other reports of working groups (at Woods Hole), and should form the basic rational for any hypothesis development in future workshops as well.

Developed by
Dr. Esther Sternberg, MD

Woods Hole Workshop on Healthcare Facilities Design

ENVIRONMENTAL VARIABLES

TYPE

light: intensity, spectrum /color, direction, source
view: natural, interior, familiar
sound: intensity, frequency, direction /phase
smell & taste: intensity, type
touch: soft, hard, intense, etc.
proprioception: distinct – horiz./vertical /awareness

TIME

STATIC / DYNAMIC
duration, cycle, pattern, controlled, spontaneous

BRAIN PROCESSES

NEURAL SYSTEMS

SENSORY SYSTEMS (eyes, ears, smell, taste, touch, balance)
BRAINSTEM (core, survival systems)
THALAMIC /LIMBIC (emotions, stress, hormone, memory systems)
CORTICAL (learning, memory, cognitive analysis)
NEUROMUSCULAR (motor, movement)

OUTCOME MEASURES

PHYSIOLOGIC RESPONSES

CHEMICAL SYSTEMS (hormonal)
CELLULAR SYSTEMS (immunological)
MUSCULAR SYSTEMS (motor – voluntary, involuntary)
NEURAL SYSTEMS (central, peripheral, autonomic)

RECOVERY RESPONSES

LENGTH OF STAY
MEDICATION REQUIRED
INFECTION / SEVERITY

IMMUNE RESPONSES

HYPOTHESES FROM WORKSHOPS

Working Groups:
Windows
Interiors
Wayfinding
Privacy
Calming

Woods Hole Workshop on Healthcare Facilities Design

The WINDOWS **group created the following:**

Their first hypothesis:
It is hypothesized that windows influence the healing process because variations in environmental variables affect brain processes – that in turn alter outcome measures.

Their second hypothesis:
It is hypothesized that windows influence staff performance because variations in environmental variables affect brain processes that in turn alter outcome measures.

The INTERIOR ENVIRONMENTS **group created these:**

First Hypothesis:
Providing access to daylight (in a variety of ways) can:

- **Improve staff satisfaction**
- **Functional efficiency**
- **Reduce medical errors**

Sub-Hypotheses:

- **Daylight is associated with improved visual discrimination**
- **Daylight is associated with work satisfaction for nurses**
- **Daylight is associated with reduced stress levels**

Second Hypothesis
The configuration of the interior spaces (the unit) in which staff movement occurs contributes to the ability of staff to function … i.e., centralized vs. decentralized nursing stations.

HYPOTHESES FROM WORKSHOPS

Working Groups:
Windows
Interiors
Wayfinding
Privacy
Calming

Woods Hole Workshop on Healthcare Facilities Design

The WAYFINDING group created the following:

Hypothesis

- Landmarks are critical elements in wayfinding for health care facilities for occasional visitors.

Questions to Test

- Define characteristics of good landmarks (hard-wired vs learned)
- How does one locate landmarks to be most effective?
- How does one move between landmarks?
- How can landmarks be universally applied, e.g., disabled people

Experiment One

- Brain imaging using virtual spatial models in which wayfinding clues are varied.
- How to identify landmarks and select from "noisy" background? Are certain characteristics more easily and quickly recognized?
- What areas of the brain are involved? Do they vary as characteristics change?

Experiment Two

- In terms of the wayfinding-gifted vs the wayfinding-challenged, what regions of the brain can be attributed to these capabilities?
- This is an extension of Experiment One.

Experiment Three

- Does a population adept at using games where wayfinding is a part, e.g., virtual reality games or chess, become more adept at wayfinding?
- What kinds of learning reduce thresholds of landmark recognition?

HYPOTHESES FROM WORKSHOPS

Working Groups:
Windows
Interiors
Wayfinding
Privacy
Calming

Woods Hole Workshop on Healthcare Facilities Design

The PRIVACY group created the following:

Hypothesis One:
- Models of patient rooms that address patient and staff needs for privacy will have a positive impact on patient cost efficiencies.

Hypothesis Two:
- By accommodating skills achieved normally to perceive privacy within the hospital we support existing competencies in what might be a strange place. Accommodating ordinarily private acts and rituals within the hospital will foster a sense of well-being and have positive health outcomes. (Feeling of protection and well-being. Lower level of stress.)

Hypothesis Three:
- Making a variety of privacy levels available in the patient room will allow patient's visitors and clinicians greater opportunity to find privacy within the patient room. Doing so will reduce stress and improve health outcomes.

Hypothesis Four:
- Range of needs for privacy, intimacy and community is variable. Allowing for choice of place will allow for accommodation of that range. Doing so will reduce stress levels.

Hypothesis Five:
- Providing patients and clinicians with the ability to control noise levels will result in achieving greater privacy, lower stress levels and better health outcomes.

Hypothesis Six:
- Unmoderated visibility of a patient increases stress and for most patients the positive returns of greater staff observation are more than offset by increases in stress.

Hypothesis Seven:
- The places of interaction where privacy can be important are continuous throughout the experience of the hospital for patients and physicians. Providing a continuum of experience where privacy can be established will make it easier to establish privacy within the places of primary transaction.

HYPOTHESES FROM WORKSHOPS

Working Groups:
Windows
Interiors
Wayfinding
Privacy
Calming

Woods Hole Workshop on Healthcare Facilities Design

The CALMING ENVIRONMENT group created the following:

First Hypothesis

- There is a relationship between ambient lighting, the response of the circadian rhythms of the body, and the ability to sleep, which can provide a sense of calm.

Second Hypothesis

- There is an ideal space for each person that is well suited to providing a sense of calm and stress reduction.

Most Rigorous Hypothesis

- There is a hardwired set of memories (such as a hearth or a garden setting) still accessible in those with Alzheimer's disease that can provide a calming effect.

ARCHITECTURE EDUCATION

Professional architecture education has remained fairly stable for more than a century. Despite changes in ideology, as a Classical education gave way to a Modernist and then Postmodernist one, the design-oriented, studio based pedagogy has remained largely unchanged.

Thomas Fisher, Dean of the College of Architecture & Landscape Architecture at the University of Minnesota

Architecture education after a century of change

It is remarkable that after more than 100 years, the role of architecture education in universities remains mostly unchanged. As Tom Fisher suggests (in the quote on the left), this is despite the huge change in style from the classics to Modernism. Architects inside and outside of the academic community are now questioning the dominance of studio as a pedagogical method. For example:

Our best minds, including the five collateral organizations with a stake in the efficacy of architecture education, have been debating the pros and cons (re the fundamental problems surrounding architecture education) for years…The time for consensus in architecture education has come, or outside forces may force us into unanticipated or unwelcome change.

Robert Ivy, FAIA, in an editorial in 11.04 Architectural Record.

The report entitled *Building Community: A New Future for Architecture Education and Practice,* commonly called "The Boyer Report" in honor of Ernest Boyer, a leading educational thinker who authored much of the text was commissioned by the collateral architecture organizations AIA, AIAS, NCARB, NAAB, and ACSI as an independent study into the profession of architecture. Carnegie Senior Fellow Lee Mitgang co-authored the document with Boyer and presented it to the profession. The final document was formally released at the 1996 AIA Convention in Minneapolis.

The report said, in part:

Making the connections, both within the architecture curriculum and between architecture and other disciplines on campus, is, we believe, ***the single most important challenge confronting architectural programs.***

ARCHITECTURE EDUCATION

Earlier in this century the medical community began to reorganize itself, turning the general practitioner into a kind of coordinator of highly paid specialists, to whom patients with particular needs are referred. In their teaching clinics close and frequent contact was maintained between doctor and patient, while the specialists would make available the benefits of current research.

From the 02.24.04 issue of ArchVoices.

Architecture education after a century of change

In an earlier study of undergraduate education, Dr. Boyer had suggest the following:

I. Make Research-Based Learning the Standard

1. Beginning in the freshman year, students should be able to engage in research in as many courses as possible.
2. Beginning with the freshman year, students must learn how to convey the results of their work effectively both orally and in writing.
3. Undergraduates must explore diverse fields to complement and contrast with their major fields; the freshman and sophomore years need to open intellectual avenues that will stimulate original thought and independent effort, and reveal the relationships among sciences, social sciences, and humanities.
4. Inquiry-based courses should allow for joint projects and collaborative efforts.
5. **Professional schools need to provide the same inquiry-based opportunities, particularly in the early years.**
6. Provision of carefully constructed internships can turn inquiry-based learning into practical experience; internship opportunities need to be widely available.

From the report by the Carnegie Foundation's Boyer Commission
Reinventing Undergraduate Education: A Blueprint for America's Reseach Universities

There exists the potential to begin to utilize the new knowledge base emerging from neuroscience to create educational programs modeled along the lines of the teaching clinic used so well by the medical profession. We will have to first open a dialog across the universities to the disciplines working in neuroscience.

ARCHITECTURE EDUCATION

In architecture, we need to reject the avant garde's pursuit of novelty and its belief that new technology should sweep away the past, in favor of design based on enduring human values. Christopher Alexander has laid the groundwork with his theory that there are continuing patterns underlying all traditional architecture.

Charles Siegel, a writer in Berkeley, California and is the director of www.preservation.com

Architecture education after a century of change

Some architecture faculty might argue that the thesis written by students in their last year of professional education provides an opportunity for cross-disciplinary studies. While this may be a hope, it seems far from realization. For example, Stephen Verderber says:

The thesis experience has traditionally consisted of a solo performance—a purely individually based rite of passage. Functioning as a waystation, the final studio links the world of the academy to the "real" world beyond. While a required thesis project does continue to function as a viable curricular component and as a means to measure individual competency, an overarching emphasis on work produced by one individual in this annual ritual, however, tends to foster an insular, somewhat myopic worldview in the student. What is, and what is not, appropriate "territory" in the penultimate studio experience usually centers on how far one's explorations can inform one's own work as a soloist. Students are encouraged to stretch themselves intellectually, but only insofar as one can do so while working alone.

Stephen Verderber, PhD, is a professor in the School of Architecture and an adjunct professor in the Department of Health Systems Management at Tulane University.

What is being proposed in this White Paper is not just an interdisciplinary approach to the traditional architecture student thesis, but a repositioning of graduate study to a "clinical" setting. This setting would be an institutional unit created between architectural offices and academic programs in the same geographical area. Students would earn graduate credit within a "practicum" supervised by architectural faculty (with appropriate credentials to do so) and neuroscience-based faculty jointly. The professionals in practice would encourage certain clients to bring their "clinical problems" to this unit. For example, a school that is about to undergo rehabilitation of their classrooms. Or, a hospital that is planning to redesign the nurse's stations.

ARCHITECTURE EDUCATION

As an architect and educator, I am worried about the intellectual and pragmatic challenges that currently bedevil architectural practice and pedagogy. I perceive many design fallacies that permeate professional practice and studio culture at schools of architecture…. All are deeply embedded in our psyches and changing them will not be easy; reform, however, will not only ensure the survival of architecture and urbanism but also invigorate them.

Douglas Kelbaugh FAIA, Dean
A. Alfred Taubman College of Architecture + Urban Planning
University of Michigan

Architecture education after a century of change

Students who graduate with a Master's degree, based on having participated in "clinical" practice, would not only be valuable additions to the staff of firms dedicated to an advanced concept of practice, but would be candidates to advance to PhD studies that would be interdisciplinary in nature.

An indication of interdisciplinary research being supported by National Science Foundation can be seen in the titles of recently funded programs by the Directorate for Social, Behavioral & Economic Sciences:

Carnegie-Mellon University (awarded $14,898,917) to establish the Pittsburgh Science Learning Center: Studying Robust Learning with Learning Experiments in Real Classrooms.

Boston University (awarded $9,235,495) to establish a Center for Learning in Education, Science and Technology to study real-time learning autonomous systems.

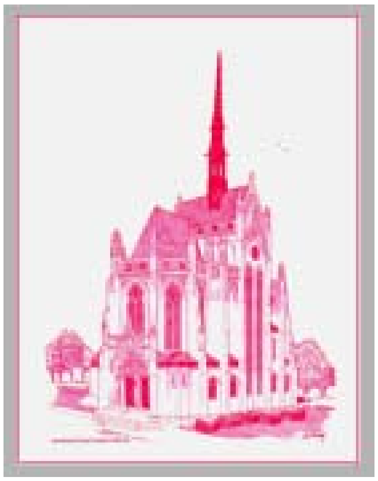
Dartmouth College (awarded $4,099,560) to establish a Center for Cognitive and Educational Neuroscience to study how education changes the brain.

The University of Minnesota, (awarded $200,838) to develop plans for an interdisciplinary center devoted to translating contemporary research on perceptual learning and brain plasticity into educational outcomes.

Florida International University (awarded $210,343) to apply a developmental framework to foster the integration of biological, psychological, and social levels of analysis to the understanding of selective attention, perceptual processing, and memory during childhood.

ADVANCED CONCEPTS

Conceptual representation in electronic media



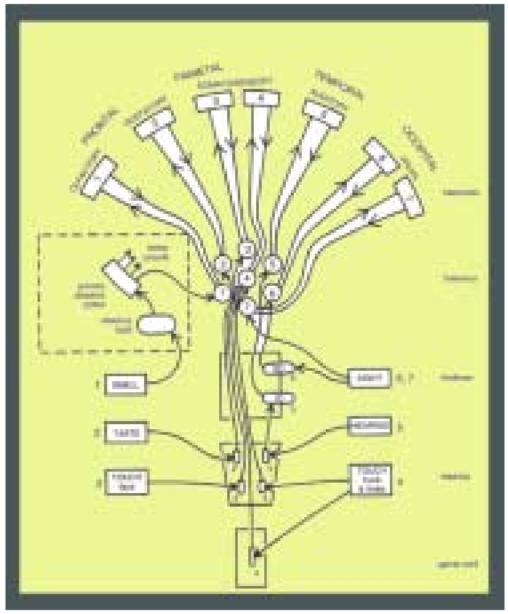
These ideas, while highly speculative, bring together four of my intellectual interests. I have practiced architecture in the traditional sense (I designed more than 100 churches before I was 30); I was an early developer of computer based systems (for the Sheraton Hotel Corporation) and an advocate for introducing computers into architecture practice; I have been a student and teacher of neuroscience since 1995; and I have been making drawings (mostly of buildings) since 1984.

I know the satisfaction of having thought about an architectural design problem for a long time and then finding it suddenly comes together as a conceptual solution (the Eureka phenomena). I am amazed at my ability to sit in front of a building and have my brain guide my hand in producing a **drawing** (like the one at the left). I am reasonably proficient in the use of computers, although it has been many years since I used one to make an architectural drawing. And, I have learned that our conceptual processes utilize working memory (in the frontal cortex of the brain), combined with the parietal lobe (vital for mathematical and spatial reasoning) and memories.

We all know what it means to conceive of an idea, or imagine an architectural design, or make a computer representation of this design. But, we may be approaching a time when neuroscience combined with quantum physics will enable us to translate our concepts directly into 3-D images for showing our clients what we "have in mind."

Conscious recognition takes place along pathways that run from the appropriate cortical sensory area to the association area that abuts it. Here, the stimulus starts to take on identity. If you're looking at an object the association areas in the lower temporal lobes begin the process of classification, starting with rough divisions like living or not living, or perhaps human or non-human. The left temporal lobe then assigns a name to it. Meanwhile, higher up in the brain in the parietal lobes, the object is fixed in space. For recognition to be complete, information is then brought in from memory stores throughout the brain to flush out the stimulus with the associations that give it meaning. "My house" becomes "my home." Finally, feedback from the limbic area is included so that perception is clothed with an emotion. "My home" is now a place of warmth, love, and shelter as well as the place to hang your hat. The process of recognition is complete.

ADVANCED CONCEPTS



"If you can think about it, it will be possible now or in the future"

Albert Einstein

What happens in our brains as we experience the world?

The **diagram** shown above indicates some of the complexity of routes which signals go through from our sense organs to the brain. It is these circuits that underlie our ability to perceive. The brain's raw material is information: the length of light waves hitting the retina; the duration of sound waves pulsing in the ear; the effect of a molecule in the olfactory canal. From this, the sensory areas of the brain create an idea of what lies outside. But that basic perception is not the brain's finished product. The final construct is a perception that is invested with meaning. The meanings we attach to our perceptions are usually useful: They transform mere patterns of light into objects we can use, people we can love, and buildings we can recognize.

All sensory stimuli, then, enter the brain in more or less undifferentiated form as a stream of electrical pulses created by neurons firing, domino fashion, along a certain route. This is all that happens. There's no reverse transformer that at some stage turns this electrical activity back into light waves or molecules. What makes one stream into vision and another into smell depends, rather, on which neurons are stimulated.

ADVANCED CONCEPTS

This type of scanning is used in the rapidly emerging medical field of diagnosing and treating a wide variety of brain disorders including Alzheimer's and Parkinson's dementias, seizures, and head trauma.

How could we study what is going on in the brain

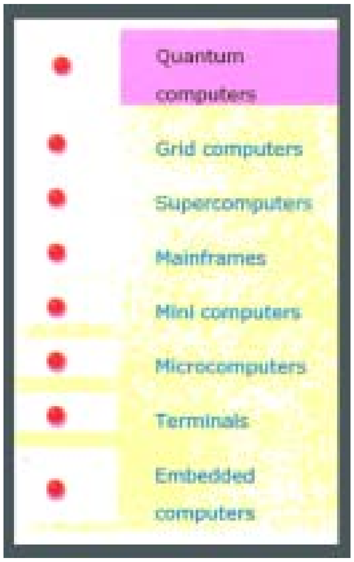
There are brain-scanning devices that can convert activities of the brain into high-resolution, three-dimensional images of brain functions.

The scanners do for brain scientists what telescopes did for early astronomers. Though the scanner technology is still in its infancy, it has already allowed scientists to peer into the brains of living, thinking human beings. Brain scientists have developed a new family of high-tech scanners that illuminate the chemistry of thought as it flashes through the living, thinking, feeling human brain.

While the scanners bear a superficial resemblance to the CATscanners presently used in many of the nation's hospitals, the differences in what they can see is dramatic. CATscanners reveal only the structure of the brain. They can detect swelling and pinpoint tumors, but the chemical machinery of thought is beyond their capabilities. The new brain-mind scanners, however, reveal those chemical reactions. They trace the mental processes of the subject as he moves, sees, hears, listens to music, meditates, or experiences emotions. The instruments are primitive yet, limited both by their resolution and by the scientists' abilities to interpret the results. But both the machines and the humans that use them are steadily becoming more sophisticated. Increasingly, the scanner laboratories are producing a cascade of discoveries that illuminate the physical basis of thought and emotion.

So, that's potentially a way to see what is going on in the brain when we imagine a solution to a design problem. The next question is what could be done with these high-resolution, three-dimensional images. How could their electronic "files" be translated into 3-D images of designs we have conceived of inside our heads?

ADVANCED CONCEPTS



The ranking of a quantum computer is as you can see at the top of the computing spectrum. Scientists predict that this will be the fastest but also the smallest computer we will know.

Advanced computer capability

Physicists around the world are engaged in a number of very large-scale projects, hoping to create a “quantum computer” – a device that utilizes the unusual and often counterintuitive laws of quantum mechanics (the framework that governs how “small” things work) to perform computations and calculations in new and sometimes very important ways. Such computers are considered to be potentially the fastest (and at the same time the smallest) computers ever known. They will be several orders of magnitude more powerful than today’s supercomputers.

A quantum computer is not simple to describe because the scientist are only developing theories and practical implementation is some time away. Optimistic researchers believe that practical quantum computers will appear in a matter of years (pessimists don’t believe the prospects are very good). The current challenge is not to build a full quantum computer right away, but to move from the experiments in which we merely observe quantum phenomena to experiments in which we *control* these phenomena.

The potential exists to utilize the quantum computer to record the electronic file of a concept in a 3-D (perhaps even a 4-D) representation of what an architect has imagined. The next step will be to download this concept into the visual (and aural) pathways of a client’s brain.