CASE STUDIES IN DESIGN AND ECOLOGY

Indoor Risks/Outdoor Needs

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"Yet it is obvious that productivity and efficiency have no value in themselves; they merit only as means to ends. In fact, excessive concern with productivity and efficiency interferes with the pursuit of significance.

—Rene Dubos

The inside is viewed as protective, a refuge from the chaos of the outside world. It is a comfortable place where wide fluctuations of heat, cold, rain, light and wind are kept at bay so rest, play and work can be more productive. But within the last 25 years, with the advent of sick building syndrome, building related illnesses, and recently with the threat of terror and its dissemination through television and the computer, the inside could be seen more as a trap. In *World Risk Society,* Ulrich Beck (1999) is incomplete when he points out that "pollution follows the poor" for contamination from VOC and chemical off-gassing, or the thought of anthrax dumped in a central air handler, appears blind to class. In fact, third world peasants may have the advantage because the greater part of their day is outdoors where the quality of light and air often benefits the body.

According to the American Lung Association (2002), approximately 90 percent of American's time is spent indoors. Many factors have lured us inside which has slowly severed an important biological connection with the outdoors. These factors include planning efficiencies that aid administrative productivity and energy conservation, as well as inventions of comfort, entertainment and information exchange. This separation is first noticeable with the mechanical efficiencies of the industrial revolution; picks-up momentum with the inventions of both the automobile and air conditioning and worsens further with simplistic energy conservation measures borne from the Middle East oil embargo. The paper surveys a brief history of key technological events and planning guidelines that hastened the inside/outside split and how the medical and architectural communities each responded. The paper then outlines recent medical research on the necessity of outside air and light for normal bodily functions.

HISTORICAL CONTEXT

The industrial revolution shifted vast populations towards the indoor economies of the city, away from the outdoor economies of herding and agriculture. Although peasants may have slept in dank dark hovels, the majority of their workdays were spent outdoors. The move to the city brought new illnesses borne from poor sanitation, and the scarcity of light and fresh air. From a lack of light came rickets for the young. Tuberculosis became a disease easily spread by cramped tenements, shadowy narrow streets and the lack of adequate sewage disposal. Tuberculosis sanitariums counteracted by locating outside the city where fresh air and sunlight were abundant. Outdoor areas such as decks for sunbathing and exercise were integral parts of the hospital plan. Taking a cue from sanitariums and the Environmental Health Movement of the 19th century, Frank Lloyd Wright and Richard Neutra's work among others strove to bring-in fresh air and light in their designs. The 19th century environmental health movement reached its architectural climax with Neutra's Lovell Health House, with its sanitary materials and abundance of operable windows for fresh air and light. The design afforded a variety of opportunities for outdoor activities such as sunbathing, exercise and sleeping.[1] However, in the 1940's Becker (1985) points out that antibiotics like penicillin and sulfanilamide replaced light and air therapies due to reliability and efficient administration.

On an urban level, several strategies brought the light and fresh air of the countryside back inside the city. The planning schemes of John Nash, Ebenezer Howard, and LeCorbusier wove the countryside into the city in a piecemeal way, while Wright scattered the city around the countryside. Wright's vision proved more prophetic in America, but its drawback results in homeowners spending an inordinate amount of time inside the automobile. Today, a suburbanite can enter their car in the morning from a garage, drive 30 stressful miles to a parking garage at work and repeat the process back home without stepping outside. With America's build-up of auto traffic, foot travel was largely ignored resulting in inhospitable urban pedestrian environments.

To a certain extent, Jane Jacobs in the 60's, Christopher Alexander in the 70's and the New Urbanists in the 80's reacted against automobile centered sprawl and attempted to restore a proper indoor/

outdoor balance by giving back the street and city to the pedestrian. Jane Jacob's activism against Robert Moses's neighborhood crushing freeway and housing projects, along with her book *The Death and Life of Great American Cities* helped planners see the value of streets and sidewalks that belonged more to the pedestrian, than the automobile. Following in the 70's, Christopher Alexander's book *A Pattern Language* has given a refined set of socially motivated of tools for reclaiming the outside areas next to the building edge. The book's "patterns" or chapters entitled: "Four Story Limit," "Small Parking Lots," "Positive and Negative Space," "Building Edge," "Arcades," "Six Foot Balcony," "Window Seat," "Courtyards that Live," and "Wings of Light" are a few strategies which allow occupants to be more neighborly and comfortable within or near the light and air of the outdoors.

HOSPITALS AS MANUFACTORIES: A CASE OF PRODUCTIVITY AND THE INSIDE/OUTSIDE SPLIT

Early 20th century hospital design is where it becomes clear that the values of medical *efficiency* and *productivity* are more highly valued over the *quality* of patient recovery. Florence Nightingale (1863) one of the strongest proponents of the 19th Century Environmental Health Movement, developed hospital planning methods based on pavilion wings and courtyards that brought patients ample natural light, air and views. Her concepts went largely unchallenged until the turn of the century when a new breed of British hospital designers starting with William Henman became more interested in the efficiency of Taylor management methods and centralized heat and ventilation.

Henman successfully challenged Nightingale's plans due to the inefficiency of the pavilion's circulation and lack of environmental control. Henman's prototype, the Royal Victorian Hospital in Belfast, compacted Nightingale's energy intensive pavilion wings into a "fat" warehouse mass. Henman (1896) called his hospitals "health manufactories" where the plan could facilitate time saving steps for doctors and nurses. This was in the era of Frederick Taylor's scientific management theories where time and motion studies were applied to factory production. Henman further wrote that his health manufactory solution of concentrated wards not only saved administrative time, but also provided a more efficient arrangement of ventilation by shortening duct lines. Today's hospitals of tangled hallways and disoriented patients are largely a result of Henman's ideal of administrative and HVAC efficiency. In building types other than hospitals, programmed space adjacency diagrams, inspired by Taylor's scientific management methods, often clump spaces into deep warehouse or mazes with little contact to the outside.

Additionally, Henman's efficient warehouse wards most effectively severed the inside from the outside by limiting windows and exterior walls. An argument Henman might have made in today's energy conservation context is that his scheme could save the hospital operational and construction money, for by eliminating courtyards, less energy intensive exterior wall space and windows would be needed. This could not only save in initial construction costs, but also lower energy bills due to the low thermal efficiency of exterior walls and windows.

Seventy-nine years later, the *ASHRAE 1982 Handbook Applications* also endorsed a similar compaction strategy while at the same time discouraging the use of windows. It recommended that "since the exterior load varies from 30 –60% of the total air-conditioned load...it is desirable to keep the perimeter area to a minimum." ASHRAE energy tables also encouraged the inclusion of more energy saving interior rooms with no exterior walls while discouraging wasteful energy intensive exterior rooms. But beyond the seduction of thermal and administrative efficiency, minimizing exterior walls and windows is profitable for all buildings because of its ease of planning and assembly. Compared to interior walls, exteriors require more detailing, trade coordination, building time, and energy intensive materials due to the extra effort needed to waterproof, insulate and integrate windows and doors. In short, it takes more human and embodied material energy to plan and build exterior walls.

A COMPARISON BETWEEN IN/OUTDOOR LIGHT AND AIR

From an evolutionary perspective, our bodies have evolved more in outside conditions than inside. Although the indoors is more comfortable and productive, the outdoors in many cases is healthier. Compared to inside air, which is for the most part recycled, outside air is constantly changing. Additionally, outdoor light levels are much higher which helps curb depression and facilitates the body's manufacture of vitamin D3.

In the 19th century, the lack of lack of light and fresh air inside the industrial city fostered rickets and tuberculosis. Today, asthma, which was hardly present early in the 20th century, and sick building syndrome may largely be the result of simplistically sealing the inside away from the outside.[2] Additionally, heart disease and cancer were not as common at the turn of the century for which recent medical research is suggesting may correlate with a lack of exposure to outdoor ultraviolet B light. The following medical research indicates the consequences of over exposure to indoor environments.

OUTDOOR AIR QUALITY

Strauss *et al* (1988) has shown that fungus is a major contributor to "sick building syndrome." These same fungus are found outdoors, but can easily be diluted and dispersed by a slight breeze. Inside, the

same fungus is re-circulated by central air conditioners and kept inside by airtight energy saving construction. Radon gas occurs outside as well as inside, but inside concentrations can be far higher due to recycled air, limited space and airtight construction.

Compared to the inside, the outside has higher levels of negative ions, which Sulman (1976) reported to produce feelings of well being. Although the research for negative ions' effect on well being and performance is still debatable, the evidence that negative ions effectively clean the air and curb depression is reasonably established. This was discovered by accident when Michael Terman used a negative ion machine as a placebo for a light therapy study on depression. To his surprise, the ion machine also helped alleviate depression. This has led to further studies by Terman (1998) where both negative ions and light therapy are used together.

Compared to the inside, negative ion levels outside are vastly higher. Outside, negative ion levels are roughly 3000 per cubic centimeter while inside, levels are far lower (roughly 200 per cubic centimeter) (Ivker, 2001) Indoors, the friction of air moving through air conditioner units, and from computer and TV screens strip the air of negative ions and give the air a more positive charge. Negative ion machines could be seen to restore the balance, but unfortunately most of the devices overcompensate by producing too many negative ions (Ivker) or produce ozone which irritates the respiratory tract. (Cutler) The machines can also cause high levels of dust to collect on the walls and ceilings providing food for fungus. From this, it appears the best way to attract the right amount of negative ions is to open a window or step outside.

OUTDOOR LIGHT QUALITY

According to those who treat depression and sleep disturbances, people are more prone to mood swings and loss of sleep when the brain is does not receive enough light during the day. Bright light therapy, used by both depressives and those who suffer from sleep difficulties, are treated with roughly 2500 –10,000 lux of light for 20 to 60 minutes a day...preferably in the morning.[3] These high levels are commonly found in the winter outdoors, not indoors, because office lighting standards of 500 lux are 5 to 30 times lower. According to Dr. Kripke (2001) of the UC San Diego center for sleep research, the brain needs at least an hour of 1500 to 2500 lux a day to regularize sleep and curb depression. Giradin *et al* found that even those who live in balmy San Diego on average do not go outside enough to receive healthy levels of light.

Additionally, outdoor light contains ultraviolet B (UV-B) rays, which stimulates the cholesterol in our skin to produce vitamin D-3. Inside, Jackson (1995) found that UV-B rays are blocked by windows. Outside, the face and hands can produce enough vitamin D-3 for 15 minutes a day. (Liberman) which acts as a catalyst for our body's most plentiful mineral, calcium which is not only essential for bone formation and the prevention of osteoporosis, but is necessary for proper muscle and nerve functioning. (*Harrison's Principles of Internal Medicine*) Recent anti-cancer research by Tangpricha (2002) suggests that D-3 regulates calcium which helps regulate cell growth. Without vitamin D, most of the calcium in our diet would pass through the body.

As an essential nutrient for proper muscle functioning, calcium is also used by the body's most critical muscle, the heart. Weishaar (1987) discovered that Vitamin D-3 receptors are found on the heart and smooth muscles in veins and arteries to facilitate blood circulation. Epidemiological research by Krause (2001) supports this theory where he has found that those populations that receive the most sunlight, (those nearest the equator and the lower latitudes of the United States) have lower blood pressure than those who receive less sunlight in higher latitudes.

Holick (1999) reports that the immune system is also believed to benefit from outdoor UV-B light for lab studies indicate vitamin D-3 increases antibody responses. Lorentie (1976) reports that Vitamin D deficient patients have recurrent respiratory tract infections which could partially explain why colds, flues and pneumonia commonly occur in the winter where a substantial decline of UV-B occurs in latitudes above 35 degrees.[4]

Calcium and vitamin D-3 also appears to regulate cell growth. Without D-3, cells mutate uncontrollably, or produce cancerous growth. Tangpricha (2001) found that the 1ahydroxylase enzyme, which is a part of vitamin D made in the kidney and colon, has been shown to help regulate calcium homeostasis in cell growth. Epidemiological research by Waterhouse (1996) supports a similar anti-cancer role for outside light, for his statistics show that those who live closer to the equator and lower latitudes of the United States are less afflicted by cancer, (most kinds)[5] than those who live in the upper latitudes. Latitudes that show exceptions are Japan and Scandinavia, which consume high Vitamin D-2 fish diets. This same research casts doubt on the accepted theory that UV-B light is the main cause of melanoma skin cancer.

Although it is known that melanoma may result from *excessive and chronic* exposure to the sun, Garland's (1990) work demonstrates that those who work outdoors may be less inclined to melanoma than office workers who do not regularly work outside. Additionally, according to Holick (1996) those who develop melanoma contract it most on parts of the body that are not exposed to the sun such as the torso and thigh, than on exposed areas such as the arms and face. While UV-B may be responsible for other skin cancers, age spots and wrinkles, these are not as life threatening as melanoma.

CONCLUSION

It is clear from medical research that the outdoors has many desirable health elements not found indoors. Precedence for buildings that relate strongly to the outdoors can be found in the architecture inspired from the 19th Century Environmental Health Movement. The pedestrian based planning principles laid down by Jacobs, Alexander and the New Urbanists clearly give people a greater opportunity to linger outside. However, these ideas need further exploration because they have for the most part reacted to the automobile and other social factors, not specifically to health issues. Additionally, the entertainment venues of TV and computer, which require glare free dark interiors, compete effectively with outdoor recreation. From this it is clear that the design ecology of today's interiors, although productive, needs to expand its criteria to issues of broader sustainability. Indoor ecologies should either mimic outdoor conditions or relate more effectively to the outside.

REFERENCES

Alexander, Christopher, S. Ishikawa, and Murray Silverstein. New York, Oxford University Press, 1977.

American Lung Association Web Page "Facts about Air Quality, (accessed Feb. 7, 2002) available from www.alaw.org/air_quality, 2002

ASHRAE Handbook 1982 Applications, Atlanta, ASHRAE p. 6.3

Barnes, Marni and Clare Cooper-Markus "Research Report: Applying the Therapeutic Benefits of Gardens" *Journal of Healthcare Design 8* (1996)

Beck, Ulrich, *World Risk Society,* Malden, MA, Polity Press, 1999, p. 5

Becker, R. *The Body Electric,* New York, Morrow 1985

Cutler, Ellen. *Winning the War Against Asthma and Allergies,* Albany, NY, Del Mar, 1998

Dubos, Rene, *So Human an Animal,* New York, Charles Scribner and Sons, 1969, p. 179

Garland, F., M. White and E.D. Gorman *Arch Environmental Health, 45,* 1990, pp 261-267

Girardin, J. D. Kripke, W. Mason and S. Ancoli-Israel, "Relationships Among Illumination, Activity, and Sleep Patterns," in M. Holick and E. Jung's (eds.) *The Biological Effects of Light 98,* Norwell, Mass, Kluwer Academic Publishers, (1999) pp. 36- 39

Grant, W. "An Estimate of Excess Cancer Mortality in the U.S. Due to Inadequate Exposure to Solar UV-B Radiation" Abstract in *Photodermatology, Photoimmunology and Photomedicine* V.17, N. 3 (2001) p 142, Note: Soon to be published in *The Biological Effects of Light 2001,* M. Holick and E. Jung (eds.) Norwell, MA, Kluwer Academic Publishers 2002

Harrison's Principles of Internal Medicine 15th Edition Vol. I, E. Braunwald, A. Fauci, D. Kasper, S. Hauser, D. Longo, L. Jameson, (eds.) New York, McGraw Hill 2001

Henman, William, "The Construction of Hospitals," *JRIBA,,* (1896-97) pp. 333-43

Holick, M. "Factors Modifying Promotion and Progression of Melanoma," in M. Holick and E. Jung (eds.) *Biologic Effects of Light 1995,* New York, Walter de Gruyter, 1996, pp. 264-271

Holick, M . "The Biologic Effects of Light: Historical and New Perspectives, in Holick M. and E. Jung (eds.) *The Biologic Effects of Light 1998,* Norwell, MA, Kluwer Academic Publishers, 1999

Ivker, Robert and Todd Nelson, *Asthma Survival,* New York, Jeremy P. Tarcher/ Putman, 2001 pp. 72-74

Jackson, D. and M. Holick, "Most Materials used in Window Construction Prevent Ultra Violet-B Transmission and UVB-Catalyzed Pre-vitamin D Formation," in Michael Holick and Ernst Jung (Eds.) *Biologic Effects of Light 1995,* New York, Walter de Gruyter and Co, 1996

Jacobs, Jane, *The Death and Life of Great American Cities,* New York, Random House 1961

Krause, R., J. Dobberke, M. Buehring, W. Hopfenmueller, T.C. Chen and M.F. Holick, "The Role of Ultraviolet Irradiation on Blood Pressure Regulation and on Cardiovascular Risk" Abstract in *Photodermatology, Photoimmunology and Photomedicine,* Vol. 17, Number 3, (June 2001). Note: Paper soon to be published in M. Holick and E. Jung (eds.) *The Biological Effects of Light 2001,* Norwell, MA, Kluwer Academic Publishers 2002

Kripke Daniel, phone interview by author, recorded on notepad, Lubbock Texas, May 25, 2001

Liberman, Jacob. *Light, Medicine of the Future,* Santa Fe, NM: Bear and Company, 1991

Lorentie, F, Fontan G, Jara, P Casas, C, Garcia-Rodreguez MC, Ojeda JA, "Defective neurophil motility in hypovitaminosis D rickets. Acta Paediatr Scand 1976; 65: 1976, pp. 695-699

Nightingale, F. *Notes on Hospitals,* 3rd edn., enl.., London, Longman, Green, 1863

Palm, T.A. "The Geographic Distribution and Etiology of Rickets," *Practitioner 45,*1890, pp. 270-342

Strauss, David, Cooley, Danny, Wong, Wing and Cynthia Jumper, "Correlation Between the Prevalence of Certain of Fungi and Sick Building Syndrome," *Occupational Environmental Medicine 55,* (1998), pp. 579-584

Sulman, F.G. *Health, Weather and Climate, Perspectives in Medicine, #7,* S. Karger: Basel, New York, 1976.

Tangpricha, V., J. N. Flanagan, L. W. Whitlatch, C. C. Tseng, T.C. Chen M. S. Lipkin, P.R. Holt, and M.F. Holick, "The Presence of 25-Hydroxyvitamin D-1ahydroxlase in Normal and Malignant Colon Tissue. Abstract in *Photodermatology, Photoimmunology and Photomedicine,* Vol. 17, Number 3, June (2001). Note: Full paper soon to be published in M. Holick and E. Jung (eds.) *The Biological Effects of Light 2001,* Norwell, MA, Kluwer Academic Publishers 2002

Terman M., and J.S. Terman. "A controlled trial of timed bright light therapy and negative air ionization for treatment of winter depression." *Archives of General Psychiatry.* 55, (1998) pp. 875-882

Waterhouse, J., C. Muir and P. Shanmugarantnmam: "Cancer Incidence in Five Continents" Schwartz, G. "Prostate Cancer and Vitamin D Hypothesis," in Holick, M and E. Jung (eds.) *The Biologic Effects of Light 1995,* New York, Walter de Gruyter, 1996

Weishaar, F. and Simpson R. "Involvement of Vitamin D3 with Cardiovascular Function II: Direct and Indirect Effects" *American Journal of Physiology 253* (1987) E675- E683

NOTES

[1]Because of the benign outdoor conditions, Southern California, Arizona and New Mexico at the turn of the 20th century were considered Health Meccas for many Easterners who suffered from various ongoing winter illnesses . Irving Gill and John Gaw Meem were two architects who left the East Coast for health reasons and re-gained their strength in the outdoor conditions of New Mexico and Southern California.

[2]Dr. Cynthia Jumper who specializes in the treatment and research of asthma and the author of this paper have taken part in three, day long indoor air quality roundtable discussions between 1997 and 1999 at the Texas Tech Health Sciences Center where Dr. Jumper has given the results of her asthma research and her views on the dramatic rise in asthma since buildings began to be hermetically sealed.

[3]Typically, the brain has an excess of the neurotransmitter melatonin in the morning hours for which bright light effectively suppresses.

[4]Notes taken at the 2001 Biological Effects of Light Conference in Boston where Dr. Michael Holick in his keynote address reported from his research that Boston received inconsequential amounts of UV-B light in the winter months from November to February and then speculated that areas above 35 degrees north latitude probably did not receive enough UVB in the winter. Colds, Flues and Pneumonia speculation by the author.

[5]Grant's epidemiological research has found that stomach cancer is more commonly found in Southern Texas. Speculation is that the Hispanic diet, which consists of spicy food, contributes to the higher stomach cancer rates. (Grant)