

Shrinking Skins, Expanding Volumes, Energy Efficiencies and Unhealthy Side Effects

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INTRODUCTION

System's dynamics principles predict that simplistic solutions are too narrow; they may improve matters in the short term, but only make things worse for the future.¹ In examining energy efficiency practices in over the past century, it is clear that the building industry and the academy in North America have too narrowly focused on the prize of efficiency at the expense of broader health and welfare issues. This paper argues that recommendations by ASHRAE, efficient planning strategies and some passive energy strategies have significantly contributed to building designs with restricted ventilation and low skin to high volume ratios which may fundamentally erode basic human health needs for air, light and view ... not unlike tenement conditions of the late 19th century. This paper calls for a more responsible balance between the often conflicting needs for energy conservation and basic human health.

ASHRAE AND VENTILATION

Since ventilation represents 20 to 40 percent of a building's thermal load, ASHRAE in the 70's took the most obvious solution to the energy crisis by lowering ventilation standards. For example, in office buildings, ventilation was cut from 15cfm in 1977 to 5cfm in 82.^{2,3} Twenty years later, after a proliferation of articles on ventilation and sick building syndrome, the latest 1997 ASHRAE, *Fundamentals Handbook* shows its undying faith in energy efficiency when it writes the following: "Outdoor air introduced into a building constitutes part of the space-conditioning load which is one reason to *limit air exchange* rates ... to the minimum required."⁴ This demonstrates that efficiency is of central importance while human health is of secondary concern.

But air quality appears to be a fraction of what makes a building "sick." In addition to respiratory illness, simplistic efficiency strategies have lowered the quality and quantity of indoor light. Within the last 20 years, medical studies have found that today's low levels of indoor light may significantly contribute to depression, inattentive- ness, stress and compromised immunity.⁵⁻⁸ Additionally, restricted access to *outdoor* spaces may significantly increase rates of osteoporosis and cancers of the breast and prostate.^{9,10} For hospital patients, poor views due to smaller energy saving windows may slow recovery time and increase pain.¹¹

MODERN ARCHITECTURE'S TIE TO HEALTHY DESIGN

Recent environmental medical research has roots back to Vitruvius and Alberti and more recently to the mid 19th century with Florence Nightingale. Among others, she strongly recommended light — in particular sunlight—and fresh air in hospital designs in her influential 1860 book *Notes on Nursing*. In 1903, therapeutic light gained scientific validity when the Nobel Prize was given to Niels Finson for discovering the curative effects of light on tuberculosis.¹² These practices had a large impact not only on the design of buildings and cities but the fledgling movement of modern architecture as well.¹³ From this era emerged the health inspired work of Frank Lloyd Wright, Irving Gill, Rudolph Schindler, Richard Neutra and Alvar Aalto.¹⁴ All promoted the healthful incorporation of light, air and views.

VERNACULAR PROBLEMS

However, in many cases modern architecture broke with local customs and replaced opaque wall mass with thermally weak glass. By breaking cultural traditions, modern architecture appeared blind to local culture. A void in traditional forms and places resulted which vernacular architecture may have filled in post modern design images. In the late 70's, vernacular forms carried further weight due to energy efficiency. But this efficiency does not guarantee healthy living conditions. Cold weather vernaculars best show this conflict.

The igloo, wigwam and the early New England homes, although thermally responsive due to limited windows and minimized exterior walls, are typically oriented inward which may compromise basic health needs for light, air and view. For example, the early New England Colonial house is considered a climate responsive design because it's rooms gather around a dark centralized mass of fireplaces and limit window sizes to conserve heat.¹⁵ Colonists could take comfort in this type of heat, but in latitudes that rank the highest percentages of clinical winter depression (from 10 to 29 percent) orienting spaces away from natural light in the winter most likely exacerbated depression.

MINIMIZED EXTERIORS

Taking a clue from cold weather vernacular types, Victor Olgay recommends in *Design With Climate* that designs in northern latitudes should be nearly square because of the high space to low exterior wall ratio.¹⁶ Using graphic tables he demonstrates how BTU efficiency slumps when building shapes become more elongated. However, this strategy not only limits natural light, but in large buildings it produces a multitude of interior rooms relying solely on the air conditioning system for fresh air. If the HVAC system is contaminated or broken, rooms near the core cannot open windows for temporary relief. Additionally, rooms near the core are cut-off from stress reducing views of nature.

Reyner Banham in his book *The Architecture of the Well-tempered Environment* showcased the thermal efficiency of this compaction strategy in Belfast's 1900 Royal Victorian Hospital. In contrast to the Royal Victorian, most contemporary hospital designs sported winged pavilions with natural light and patient access to garden courtyards. Air quality was assured through cross ventilation. However, the Royal Victorian eliminated inefficient patient centered courtyards and pavilion wings by compressing the scheme into a single rectangular block minimizing energy wasting exterior walls and windows. Additionally, Banham wrote that the appeal of this arrangement is minimized heat loss through a shortening of distribution ducts.¹⁷

While the Royal Victorian reduced duct runs, it also reduced circulation space. William Henman, the architect of the Royal Victorian in describing his design philosophy wrote that hospitals should be considered "health manufactories." He criticized Nightingale's concept of winged light and air pavilions because of their long circulation paths which added steps to doctors and nurses work routines. Henman further wrote that the solution was to concentrate wards which not only saved administrative time but provided a more efficient arrangement of ventilation.¹⁸ The further decline of the pavilion plan is due in part to the replacement of environmental light and air therapies to the reliability of biochemical drugs.¹⁹

Seventy eight years later, the 1978 ASHRAE Applications Handbook 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."²⁰ Energy tables also encouraged the inclusion of more energy saving interior rooms while limiting wasteful exterior rooms. But beyond the seduction of thermal and administrative efficiency, minimizing exterior walls and windows is profitable for all buildings and climates 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.

MEDICAL EVIDENCE AGAINST BUILDINGS THAT MINIMIZE EXTERIOR WALLS AND WINDOWS

However, the health risks of limiting exterior walls and windows could be substantial. In 1984 Roger Ulrich's landmark study demonstrated that window views to nature may accelerate healing and decrease pain medication in hospital patients.²¹ These views appear to relax patients. Research has found that a relaxed body increases the amount of white blood cells in the bloodstream helping to strengthen the immune system.²² Ulrich's studies are significant because the benefits of stress-reducing views may crossover to other stressful settings like schools and offices.

The importance of windows and light is further demonstrated in Lisa Heschong's 1999 study of classrooms where she found a link with higher standardized test performance levels in rooms with windows and skylights. In this study, she found that classrooms exposed to the largest window areas progressed 15% faster in math and 23% faster in reading than those with compromised windows.²³

Heschong's studies could tie into recent sleep disorder and depression research.²⁴ Inadequate indoor light as it relates to sleep disorders and anxiety could lead to higher levels of stress which raises the body's hormonal levels of cortisone and epinephrine. Both stress hormones compromise the immune system's white blood cell counts.²⁵ Inadequate levels of light as it relates to depression²⁶ can conceivably contribute to other types of immune problems. Studies conducted on depressed patients have shown that certain immune system regulators like immunoglobulins and lymphocytes can be compromised making the depressed more vulnerable to illness²⁷ and conceivably to building related illness.

One possible explanation for the link between light and depression may be evolutionary. Our brains and bodies have evolved with very high levels of outdoor light, ranging between 5,000 to 10,000-lux. It isn't until recently where we began to spend the majority of our time indoors which are roughly 10 times darker. According to sleep researcher Dr. Daniel Kripke of the University of California in San Diego, humans function normally in the wake/sleep cycle, when exposed regularly to light conditions of 1500 to 2,500-lux. However, today's indoor light measurements are 3 to 25 times lower. According to Kripke, these low levels do not fully activate the production of the brain's leading neurotransmitter, serotonin.²⁸

Serotonin is a crucial neurotransmitter which gives the brain a sense of well being. Without it, depression can result. Studies also show that those prone to violence, alcoholism and suicide demonstrate marked deficiencies of serotonin. With this evidence, the psychiatric community spawned a new breed of serotonin activators like Prozac, Paxil, Zoloft and light boxes which have nearly replaced Valium and Xanax.²⁹ So light and its relationship to serotonin could partially explain why Heschong's school children received higher scores in the daylit schools.

For those who suffer from Seasonal Affective Disorder (SAD), high intensity lamps of 10,000-lux adequately relieve winter depression. However, these lamps along with typical interior lights lack the full spectrum of daylight. Incandescent light lacks outside levels of blue while cool white fluorescent has a very high level of yellow (which is the most effective color for raising blood pressure). Both light sources are foreign to what our brain evolved with. Some researchers have deemed this imbalance as "mal-illumination" referring to the different color spectrums as essential nutrients.³⁰ The lack of blue light, which is missing in incandescent and marginal in many fluorescent lights is known to activate the para-sympathetic nervous system which helps the body to relax and digest food properly.³¹ This is congruent with further studies showing blue as lowering blood pressure and heart rates.³² Additionally, blue light is also linked with the suppression of melatonin which makes us drowsy.³³ From this evidence, it appears that the higher levels of blue light found in the sky not only relaxes the body, but keeps the mind alert. This evidence may also explain why Heschong's schoolchildren performed better with windows and skylights.

Additionally, today's lighting standards may also contribute to anxiety and depression because current standards focus on low minimum light levels for *visual comfort* and task efficiency which is far below Dr. Kripke's recommendations. Current levels range from 300-lux for classrooms and computer stations to 500-lux for offices,³⁴ ... four to seven times less than the vastly higher, minimum level of 2000-lux recommended for normal bodily function and serotonin production.

THE HEALTH BENEFITS OF OUTDOOR LIGHT AND AIR

In addition to the high levels of outdoor light, medical research is now claiming that the *lack* of outdoor full-spectrum light could be responsible for a number of maladies that go far beyond sleep disorders and depression. Because lifestyles today are typically spent indoors, studies are showing a relationship between a lack of outdoor light and higher rates of osteoporosis, jaundice, breast cancer, ovarian cancer, colon cancer, large bowel cancer and prostate cancer. Most of this research is sponsored by science based foundation grants and is reported in hard scientific medical journals.^{35, 36} Sunlight induced ultraviolet B light and its production of vitamin D3, a sunshine not dietary induced hormone, helps bones and the immune system absorb calcium. Although dietary vitamin D can be metabolized into vitamin D3, the process is only 60% effective.³⁷ The combination of calcium and vitamin D 3 not only helps form strong bones and teeth, but also may help to regulate the body's immune system for which bones play an integral part.³⁸ This contribution to the immune system has resulted in a multitude of promising studies since the '80's that show strong links to ultraviolet light and its role in combating heart disease and cancer.^{39, 40} Reinforcing this research is a number of surprising studies that show lower rates of both cancer and heart disease in global areas and times of the year where the sun shines strongest. (higher altitudes, lower latitudes, arid climates and during the summer)^{41, 42, 43} Although windows block out most ultraviolet light, thus eliminating Vitamin D3 production, this prompts the need for more accessible and comfortable outside areas.

Not only is the outdoors a source of high amounts of full-spectrum light, but in many cases, fresh air. Compared to outside air, recycled indoor air in most sick buildings has higher concentrations of fungus. According to asthma researcher Dr. Cynthia Jumper of Texas Tech's Health Science Center, sick indoor air conditions may be linked to upper and lower respiratory illnesses. Asthma in children has risen dramatically since the 70's energy crisis where today 1 in 20 children are afflicted. Dr. Jumper speculates that tightly sealed buildings and lower ventilation standards are a major contributor.⁴⁴ As pointed out by Dr. Jumper's colleagues, Dr. Danny Cooley and Dr. David Strauss in their research of 94 buildings in 48 states, the fungi which is responsible for building related illnesses, and sick building syndrome has significantly higher concentrations inside. As a result, these researchers use outdoor air as a baseline for measuring normal fungus levels.⁴⁵ Because outside air is continuously moving, it can in most cases easily disperse harmful fungus and gasses.

The relative freshness of outdoor air, the opportunity to view natural scenes and the anticancer properties of sunshine vitamin D-3 overshadow the danger of outdoor light's link with melanoma. Although abusive exposure to ultraviolet light (as demonstrated in the 1970's suntan fad) has been linked with melanoma, there is contrary evidence that significant *lack* of sunlight may also contribute to skin cancer.⁴⁶ Additionally, the hands and face which are regularly exposed to the sun, seldom develop melanoma; it is the torso and legs which are not normally exposed, that develop melanoma.⁴⁷ Cancer researcher Dupont Guerret, MD admits in his book *Melanoma Prevention, Detection and Treatment* that: "mild exposure to the sun is not harmful to most people. Indeed, it may have beneficial effects... it has been reported that the sort of mild continual sun exposure that produces a bit of a tan, but no burn may even protect you from melanoma."

CONCLUSION

It is often written that energy efficiency *is* healthy. On a global level this may be true, but on a more human biological level, the two are often at odds. In the United States, often times, energy efficiency takes first priority while health needs take a distant second. This may be a result of our educational values and standards.

For example, the National Architectural Accreditation Board's accreditation criteria writes of the *understanding* of human ecology, but it is written within the narrow context of energy efficiency. The word "health" is briefly written once, but it is cliched in that it is written within its usual context of "health, safety and welfare." To further water-down it's impact, it is written within the same sentence as property rights and subdivision ordinances.

If a new energy crisis emerges, new regulations are inevitable. If again, energy strategies are too simplistic and not meaningfully paired with human health needs, then history may repeat itself in the form of unhealthy, but efficient designs. From a biological point of view, recent light, air and view research suggests a shift in educational values and perhaps legislation. Perhaps this will change the rules of thumb of energy efficient design to more rigorously include basic human needs.

There are not a lack of good role models for there are a few firms in North America that strive for this difficult balance between health and energy. Additionally, Europe (Germany in particular) appears to legislate both energy and health needs successfully. Through these role models and medical research, perhaps the profession can assess the environment more like physicians and less like efficiency engineers. Through this re-assessment, possibly a more balanced vision of sustainability can emerge.

NOTES:

¹Peter Senge, *The Fifth Discipline*, (New York, Doubleday 1990)

²ASHRAE *Hand book, 1977 Fundamentals*, (Atlanta, ASHRAE 1977)

³ASHRAE *Handbook, 1982 Fundamentals*, (Atlanta, ASHRAE 1982)

⁴ASHRAE *Handbook, 1989 Fundamentals*, (Atlanta, ASHRAE 1989)

⁵Norman Rosenthal, *Seasons of the Mind*, (New York, Bantam, 1989)

⁶Lisa Hescong, "Daylighting In Schools: An Investigation into the Relationship between Daylighting and Human Performance. (Condensed Report submitted to the Pacific Gas and Electric Company, 1999)

⁷R. Kuller and C. Lindstern, "Health and Behavior of Children in Classrooms with and without Windows," *Journal of Environmental Psychology* 12, (1992) pp 305-317

⁸F. Holwich and B. Dieckhues, "The Effect of Natural and Artificial Light via the Eye on the Hormonal Metabolic Balance of Animal and Man," *Ophthalmologica* 180, No. 4 pp188-197

⁹Michael Holick, "The Role of Sunlight in Providing Vitamin D for Bone Health," in M. Holick and E. Jung's *Biologic Effects of Light 96*, (New York, Walter D. Gruyter and Co, 1997)

¹⁰Michael Holick, "Historical and New Perspectives in M. Holick and E. Jung (eds) *The Biologic Effects of Light 98*, (Norwell Mass, Kluwer Academic Publishers, 1999)

¹¹Roger Ulrich, "View Through a Window May Influence Recovery from Surgery," *Science* 224 (1984) pp 420-21

- ¹²Michael Holick, "The Biological Effects of Light, Historical and New Perspectives" in M. Holick and E. Jung (eds) *The Biologic Effects of Light 98*, (Norwell Mass, Kluwer Academic Publishers, 1999)
- ¹³James Ross, "The Impact of the 19th Century Public Health Movement on American Architecture." (Unpublished paper delivered at the 1995 Annual Meeting of the Society of Architectural Historians, Seattle)
- ¹⁴FL. Wright, *The Natural House*, (New York, Horizon Press, 1954) Wright scorned the unhealthful qualities of basements due to lack of fresh air and light. Irving Gill, "New Ideas About Concrete Floors" *Sunset Magazine* December (1915) Gill wrote about the sanitizing qualities of his concrete floors. R. M. Schindler, "Care of the Body" *Los Angeles Times* March 14 and April 11, (1926) Schindler wrote in place of Dr. Lovell on air quality issues. Richard Neutra, *Survival Through Design*, (New York, Oxford Press, 1954), Neutra wrote on various health related design issues. Alvar Aalto's Pamio Sanitarium included design features that allowed beds and easy therapeutic access to outdoor sun, air and views of nature. Aalto also designed splash minimizing sinks and chairs that allowed for patients to sit at such an angle as to make breathing easier.
- ¹⁵C. Moore, G. Allen and D. Lyndon. *The Place of Houses*. (New York, Holt, Rinehart and Winston, 1974) p. 71
- ¹⁶Victor Olgay, *Design With Climate* (Princeton, NJ. Princeton Univ. Press, 1973) pp. 88-89
- ¹⁷Reyner Banham, *The Architecture of the Well-tempered Environment*. (London, The Architectural Press. 1969)
- ¹⁸Henman, William, "The Construction of Hospitals," *JRIBA*, 1896-7 pp. 333-43
- ¹⁹Marni Barnes and Clare Cooper-Markus, "Research Report Applying the Therapeutic Benefits of Gardens" *Journal of Healthcare Design*. (Vol. VIII, 1996)
- ²⁰ASHRAE *Handbook 1982 Applications*, (Atlanta, ASHRAE) p. 6.3
- ²¹Roger Ulrich, "View Through a Window May Influence Recovery From Surgery" *Science* 224 (1984) pp 420-21
- ²²Hans Selye, *The Stress of Life*, (New York, McGraw Hill. 1956)
- ²³Lisa Hescong, "Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance," (Report submitted to: The Pacific Gas and Electric Company, August 20 1999) p.2
- ²⁴Daniel Kripke, "The Uses of Bright Light in an Office Practice" in S. Poceta and M. Mitler (eds) *Sleep Disorders: Diagnosis and Treatment*. (Totowa, NJ, Humana Press. 1998)
- ²⁵R. Parsons, "The Potential Influences of Environmental Perception on Human Health" *Journal of Environmental Psychology*, 11 (1991) pp 1-23
- ²⁶N. Rosenthal, D. Sack, J Gillin, et al: "Seasonal Affective Disorder: A Description of the Syndrome and Preliminary Findings with Light Treatment," *Arch Gen Psychiatry* 41 (1984) pp 72-80
- ²⁷Fredric Goodwin and Kay Redfield Jamison, *Manic Depressive Illness* (New York, Oxford Univ. Press, 1990) Reports that depression studies have shown that one of the immune systems regulation devices, Prostaglandin, is shown to be elevated in depressed patients. T. Kronfoiz and W. Nascallah, "Leukocyte Regulation in Depression and Schizophrenia." *Psychiatry Res* 13: (1984), pp. 13-18 Research finds that depressed patients have less circulating lymphocytes. Delist e al., A. King and S. Targum, "Serum Immunoglobulin Concentration in Patients Admitted to an Acute Psychiatric In-Patient Service." *British Journal of Psych.* 145 (1984) pp 661-665 Research finds that the level of immunoglobulins are lower in those suffering from depression than in normal people.
- ²⁸N. Okudaira and D. Kripke. "Naturalistic Studies of Human Light Exposure" *American Journal of Physiology* 245: R613-R615
- ²⁹Michael Norden, *Beyond Prozac, Brain-Toxic Lifestyles, Natural Antidotes and New Generation Antidepressants*, (New York, Regan Books, 1996)
- ³⁰John Ott, *Light and Health*, (Old Greenwich, Conn. Devin-Adir Co. 1973)
- ³¹S. Krakov, "Color Vision and the Automatic Nervous System." *Journal of the Optical Society of America*. June (1942)
- ³²H. Woolfarth, "Psychological Evaluation of Experiment to Assert the Effects of Color Stimuli Upon the Automatic Nervous System," *Excerpta Medica Neurology and Psychiatry* 2 no. 4 (1958)
- ³³R. Reiter. "Action Spectra Dose Response Relationships and Temporal Aspects of Light's Effects on The Pineal Gland." *Annals of the New York Academy of Science* 453. (1985) pp. 215-230
- ³⁴Benjamin Stein and John Reynolds, *Mechanical and Electrical Equipment for Buildings* (New York, John Wiley and Sons, 2000)
- ³⁵Full-spectrum light deprivation (in particular UVB light deprivation) and its detrimental effects on breast, ovarian, prostate and colon cancer can be found in medical journals as early as 1980 in the *International Journal of Epidemiology*. Similar studies have appeared consistently through the 90's in journals such as *Cancer Research*, *Lancet* and *Cancer Causes and Control*.
- ³⁶Michael Holick, *The Biologic Effects of Light 98*
- ³⁷Michael Holick, *The Biologic Effects of Light 95*
- ³⁸F. Holwich and B. Dieckhues, "The Effect of Natural and Artificial Light via the Eye on the Hormonal Metabolic Balance of Animal and Man." *Ophthalmologica* 180 No. 4, (1980) pp. 188 - 197
- ³⁹Holick, 95
- ⁴⁰Holick, 98
- ⁴¹R. Scragg, *Int. Journal of Epidemiology* 10 pp. 337-341
- ⁴²C. Garland, G. Comstock, F. Garland, K. Helsing, E. Shaw and E. Gorham. "Serum 25-Dihydroxyvitamin D and Colon Cancer: Eight Year Prospective Study." *Lancet* (1989) pp. 1176-1178
- ⁴³J. Waterhouse, C. Muir and P. Shanmugarantnam: "Cancer Incidence in Five Continents" Vol. IV IARC Sci Publ. Lyon (1982) Follow-up studies tracked immigrants who moved from lower to higher latitudes and visa versa and found the subjects appeared to take-on the risks associated with the new location.
- ⁴⁴Dr. Cynthia Jumper and the author have taken part in three, day long indoor air quality roundtable discussions between 1997 and 1999 at the Texas Tech Health Science Center where Dr. Jumper has given the results of her asthma research and her views on Building Related Illnesses.
- ⁴⁵David Strauss, J. Danny Cooley, Wing C. Wong and Cynthia A Jumper "Correlation Between the Prevalence of Certain Fungi and Sick Building Syndrome" *Occupational Environmental Medicine* 55 (1998) pp. 579-584
- ⁴⁶F. Garland, M. White and E. D. Gorman. *Arch Environmental Health* 45, (1990), pp 261- 267. Melanoma and other skin cancers have been linked with UV B light, but this research has shown that those whose jobs that take place mostly inside can have a higher risk of skin cancers than those whose jobs that are outside.
- ⁴⁷M. Braun and M. Tucker, "Do Photoproducts of Vitamin D Play a Role in the Etiology of Cutaneous Melanoma," In M. Holick and E. Jung (eds) *Biologic Effects of Light 95*