Environmental Surfing

Design for Human Health and Environmental Sustainability

4.1

ARCC 2019: Bridging Research & Practice May 29-June 1, 2019

Vivian Loftness, FAIA, Paul Mellon Chair in Architecture Center for Building Performance & Diagnostics Car

Carnegie Mellon University

our future is the marriage of the no tech and the hi tech, of resilience and the internet of things

What is Resiliency?

Protection from

Climate Change Natural Disasters Deadly Heat or Cold Harmful Air Devastating Damp & Mold Scary Bugs

Access to

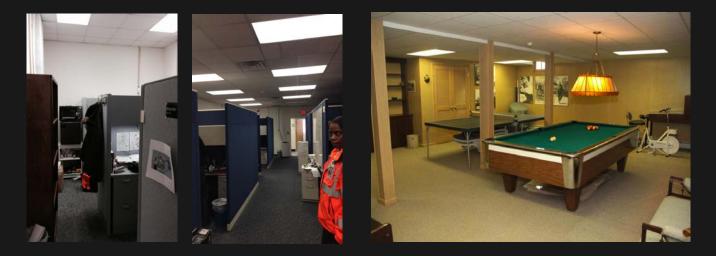
Fresh Water Food Air Tolerable Temperatures Light Sanitation Community Electricity Mobility in a net zero world



In a net zero economy, architecture must celebrate climate, culture and region, balancing deep conservation with the dynamic embrace of natural conditioning.



Deep buildings with static, dark glass facades must disappear. These buildings, by definition, lock in a chemical soup of materials and occupant activities with serious consequences for human health, from asthma, to skin and eye irritations, to reproductive health, to cancer.



Sealed and windowless workspaces and living spaces lock out the natural conditioning resources of passive solar heating, daylighting, natural ventilation and passive cooling – nature's renewables and the centerpiece of human health and environmental resiliency.

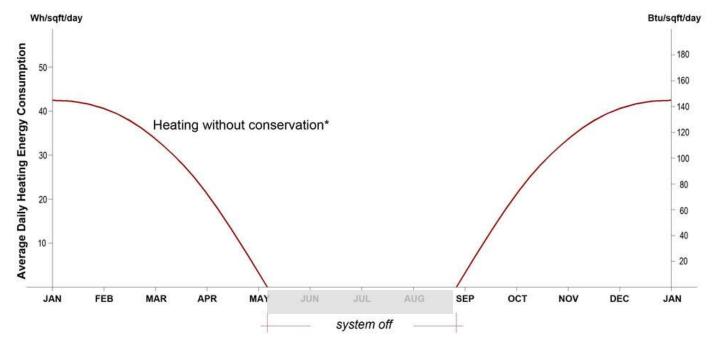


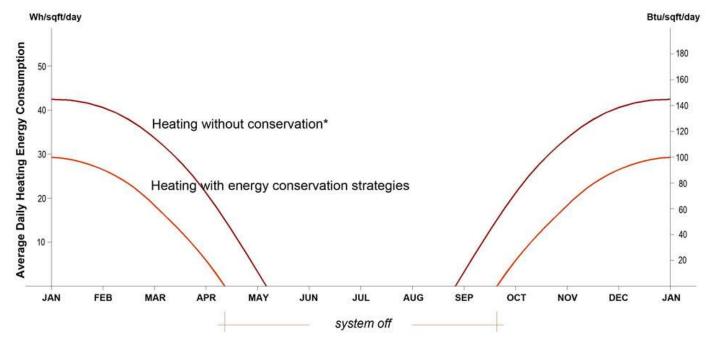
Instead, we will design for 'Environmental Surfing' maximizing natural conditioning, unique to each climate, with less energy and water resource extraction and pollution; maximizing local food and materials with less transportation and toxicity; and reducing technological complexity with just-in-time and just-where-needed technological innovation.

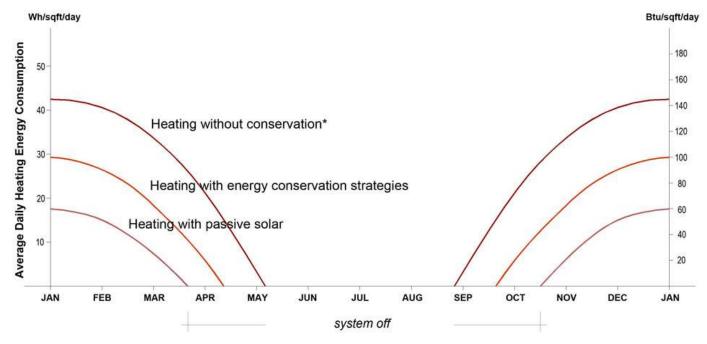
Environmental surfing for free heat



Net zero buildings will 'free roll' for 25-75% of the winter time with passive solar heating that heals and rejuvenates.





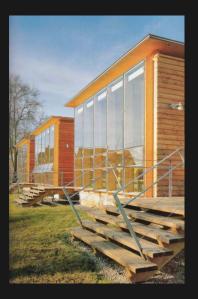




Conservation can reduce today's heating demand by 25-75%



Dennis Wedlick Architect | Hudson Passive House (PHIUS)



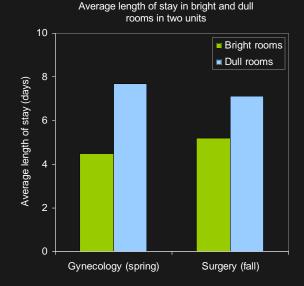
Passive solar can displace 25-75% of the remaining heating demand



Sunshine = Health

Inha University Hospital / Choi 2005 (Hospital)

In a 2005 building case study of Inha University Hospital in Korea, Choi identifies a 41% reduction in average length of stay among gynecology patients in bright sunlit rooms, as compared to those in dull rooms, in spring, and an average 26% reduction in average length of stay among surgery ward patients in bright rooms, as compared to those in dull rooms, during spring and fall.



First cost increase:\$1,0Annual health savings:\$10,ROI:1,01

\$1,000 / bed \$10,115 / bed **1,011%**

Reference: Choi, Joonho. (2005). Study of the Relationship between Indoor daylight Environments and Patient Average Length of Stay (ALOS) in Healthcare Facilities, Unpublished master's thesis, Department of Architecture, Texas A&M University. College Station, TX.

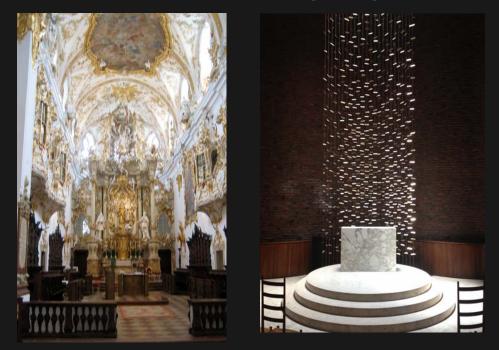
Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mello



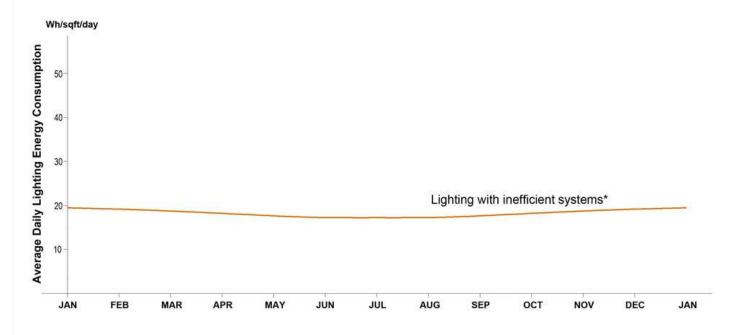


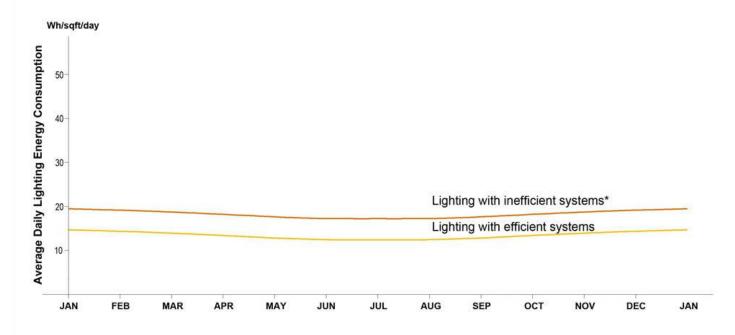
Resilient Libraries _ Passive Solar

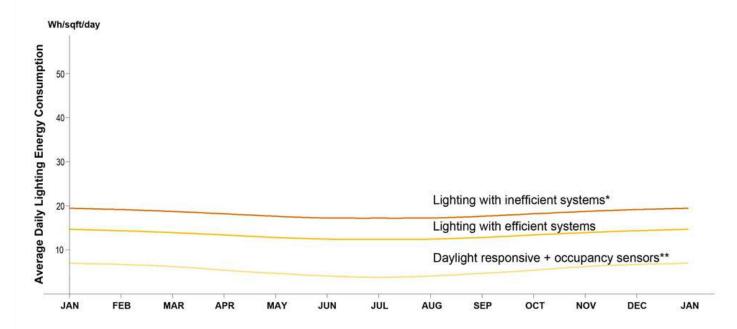
Environmental surfing for light



Net zero buildings will be designed for daylighting as the dominant light source, rediscovering the engineering and the art of effective daylight design.

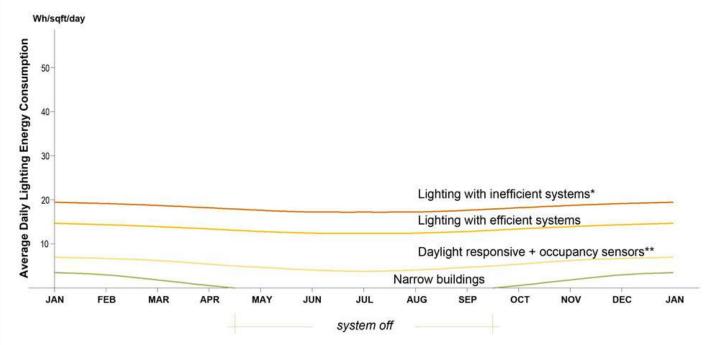






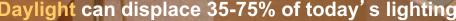
* Total annual lighting energy consumption refers to EIA-CBECS 1995 & 1999

** Monthly lighting energy profile refers to McDougall, T., Nordmeyer, K. & Klaassen, C. J. (2006). Low-Energy building case study: IAMU office and training headquarters. ASHRAE Transactions, Vol.12, pp312-320



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Daylight can displace 35-75% of today's lighting

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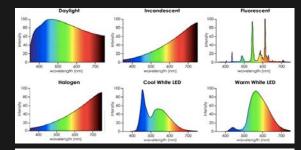
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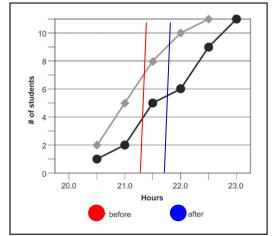
Daylight = Sleep Cycles (and Performance)

North Carolina School/ Figueiro and Rea 2012

In a 2010 study of sleep cycles of 8th grade students in the Smith Middle School in Chapel Hill, Figuero and Rea identify that student exposure to short-wavelength morning light significantly regulates their circadian clock and improves sleep times by as much as 30 min.

Wolfson and Carskadon (1998) identified that poor performing students obtained about 25 minutes less sleep per night and went to bed on average 40 minutes later on school nights than those who were good performers.





Dim Light Melatonin Onset DLMO

(after – no morning light)

Lack of short-wavelength light during the school day delays dim light melatonin onset (DLMO) in middle school students Mariana G. Figueiro and Mark S. Rea Neuro Endocrinol Lett . 2010 ; 31(1): 92–96.



Resilient Airports _ Daylight

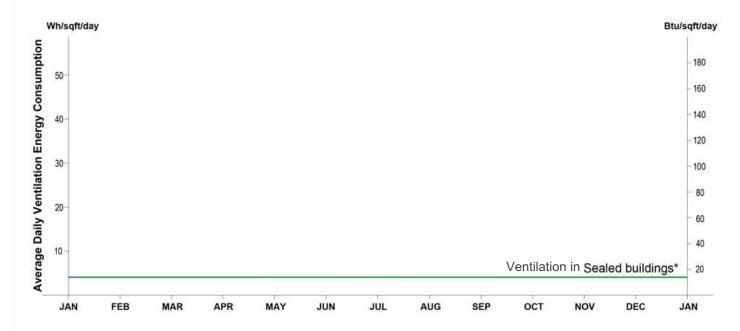


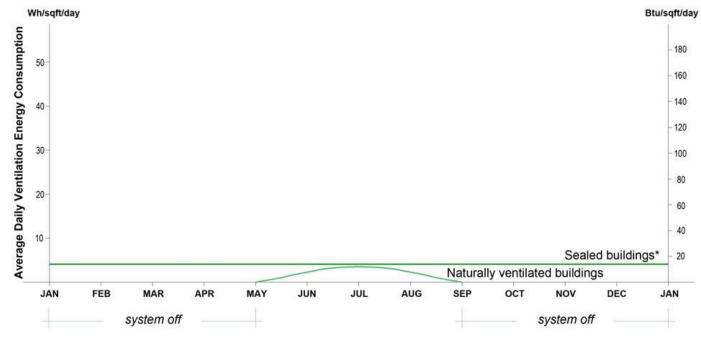


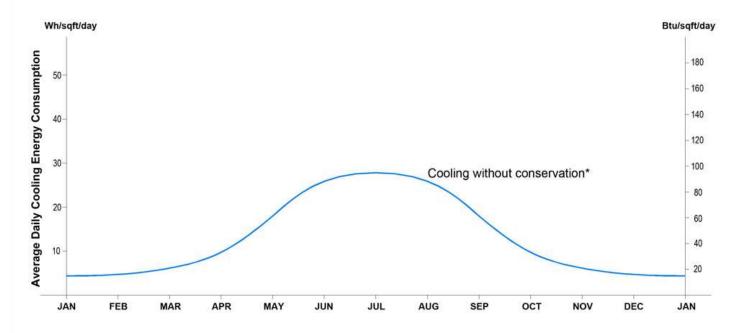
Environmental surfing for fresh air and natural cooling

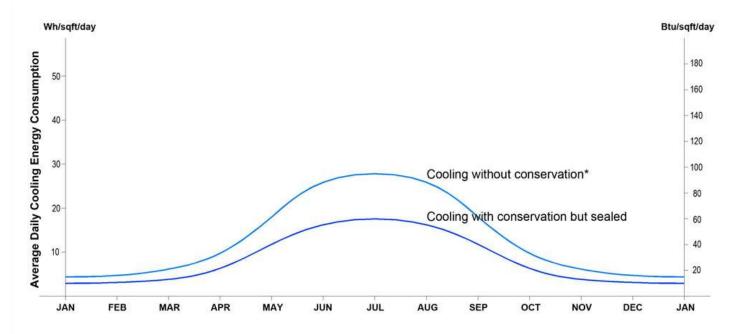


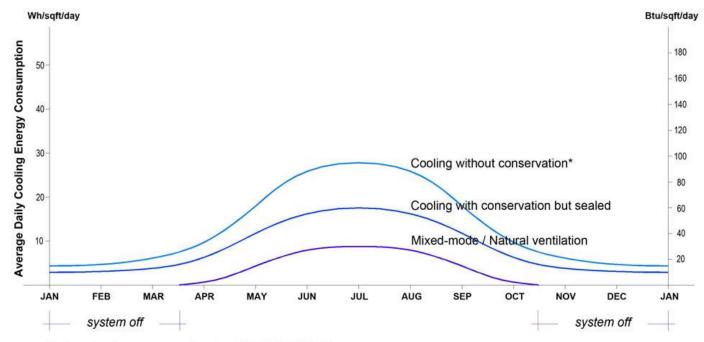
Net zero buildings will be designed for natural ventilation as the dominant ventilation strategy for every possible hour, for human health, for free cooling and for community.

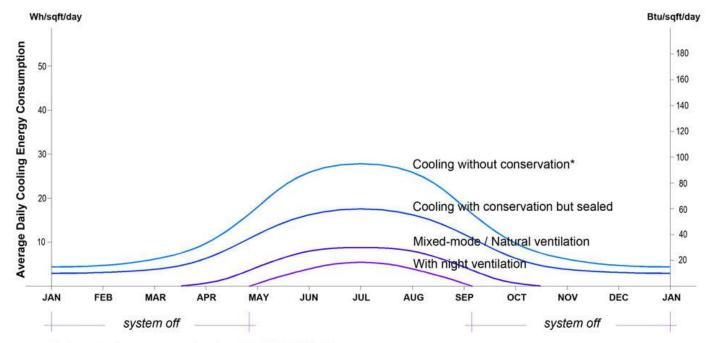














Shade can displace an additional 20-40% of today's cooling



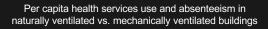
Natural ventilation can displace 20-40% of today's cooling and 70% of ventilation

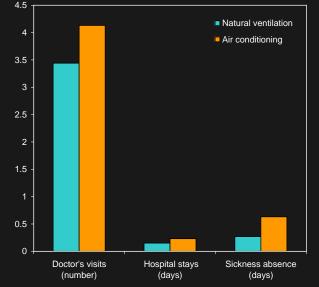
Natural Ventilation = Health + Individual Productivity

Preziosi et al 2004

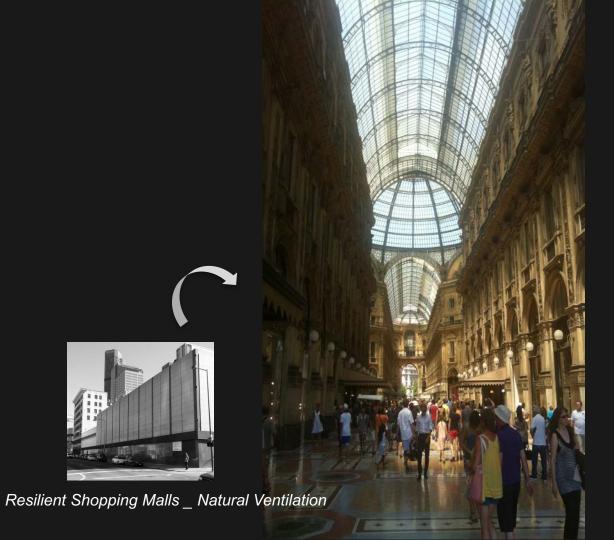
In a 2004 multiple building study of professional middle-aged women in France, Preziosi et al identify a 57.1% reduction in sickness absence, a 16.7% reduction in medical services use (doctor visits), and a 34.8% reduction in hospital stays among subjects with natural ventilation in their workplace, as compared to those with air conditioning.

First cost increase: Annual health savings: Annual productivity savings: **ROI:** \$1,000 / employee \$181 / employee \$85 / employee 27%





Preziosi P., S. Czerniichow, P. Gehanno, and S. Hercberg (2004) Workplace airconditioning and health services attendance among French middle-aged women: a prospective cohort study. International Journal of Epidemiology, 33(5), pp.1120-1123. Carnegie Mellon University Center for Building Performance ABSIC BIDS™







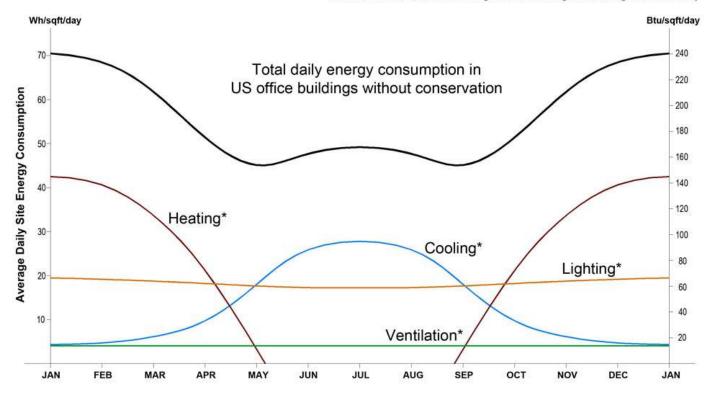




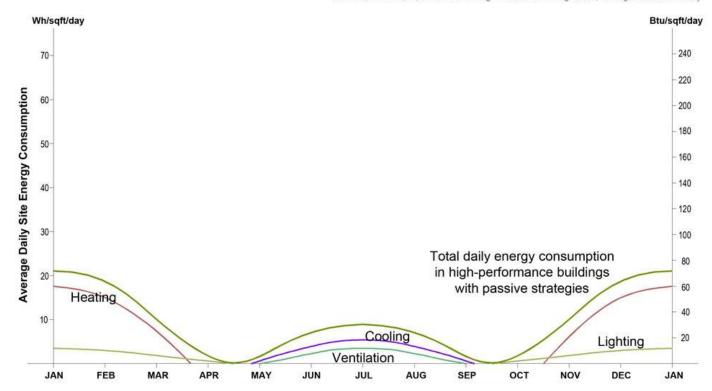


Resilient Churches _ Night Ventilation

Loftness, V. & Hua, Y., Center for Building Performance & Diagnostics, Carnegie Mellon University



* Total annual heating, cooling, ventilation and lighting energy consumption refers to EIA-CBECS 1995 & 1999

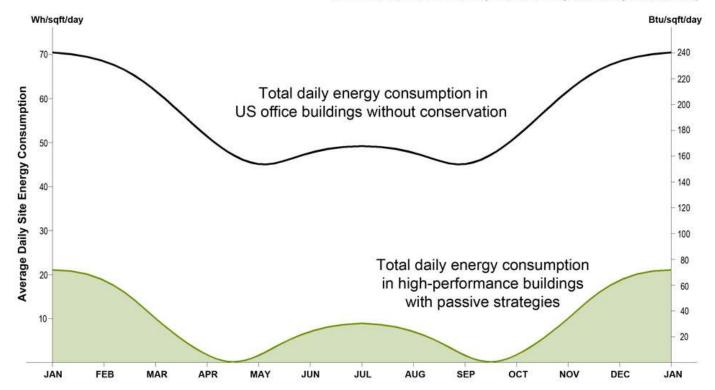


Loftness, V. & Hua, Y., Center for Building Performance & Diagnostics, Carnegie Mellon University

Wh/sqft/day Btu/sqft/day 240 70-- 220 Average Daily Site Energy Consumption Total daily energy consumption in 60 - 200 US office buildings without conservation 180 50-160 - 140 40-- 120 30-100 80 20-60 40 10 20 JUL JUN AUG SEP ост NOV DEC FEB APR MAR MAY JAN JAN

Loftness, V. & Hua, Y., Center for Building Performance & Diagnostics, Carnegie Mellon University

Loftness, V. & Hua, Y., Center for Building Performance & Diagnostics, Carnegie Mellon University



Energy

Net zero energy Passive House Embodied energy Renewable energy GHG and Atmospheric Pollutants

The Realm of Sustainability in the Built Environment

Site

Net zero land **Ecological footprint Urban growth boundaries Cool communities Transit oriented development**

Ecodistricts[™]

AIA COTE

top ten

Thermal quality **Visual quality** Acoustic quality **Air quality**

IEQ

Biomimicry

Biophilia

Human Health

Permaculture Fitwel™

WELL[™] Active Design Guidelines[™]

LEED[™]

Living Building Challenge[™]

Water Net Zero Water

Grey water Black water Storm water

2030[™]

Materials

Durability

Red list Declare

EPD/HPD

Net zero energy Passive House Embodied energy Renewable energy

Energy

GHG and Atmospheric Pollutants

DfD[™] Design for Disassembly

Cradle to Cradle[™]/ Upcycle[™]

UNEP Sustainable Dev. Goals[™]

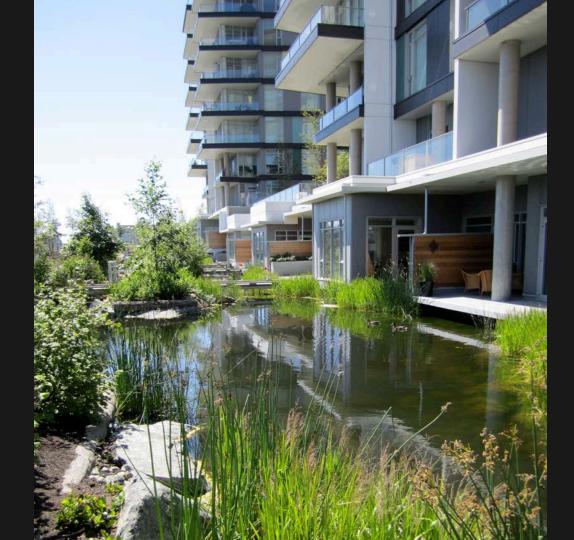
Social Equity

Tiny House, Pocket House Equitable Infrastructures QOL Technologies Smart Homes, Offices, Classrooms, Cities

Sustainable Green Regenerative Resilient

Erich Fromm used Biophilia to describe the pscyhological orientation of being attracted to all that is alive and vital.

EO Wilson and Stephen Kellert In the Biophilia Hypothesis described the links that human beings instinctively seek with other living systems.

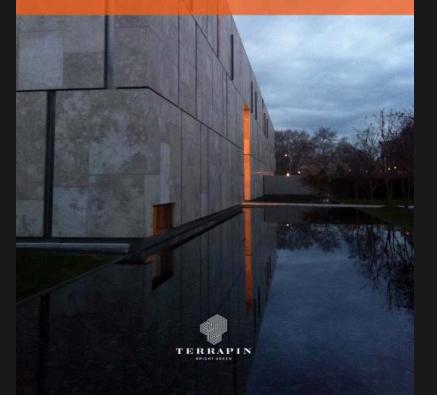


KELLERT'S BIOPHILIC DESIGN ELEMENTS & ATTRIBUTES



ratios and scales

14 PATTERNS OF BIOPHILIC DESIGN



WELL [®] Features	Parallel Patterns of Biophilic Design
54 Circadian Light Design	[P6] Dynamic & Diffuse Light
76 Thermal Comfort	[P4] Thermal & Airflow Variability
79 Sound Masking	[P2] Non-Visual Connection with Nature [P5] Presence of Water
82 Individual Thermal Control	[P4] Thermal & Airflow Variability
83 Radiant Thermal Comfort	[P4] Thermal & Airflow Variability
88 Biophilia I – Qualitative	 [P1] Visual Connection with Nature [P5] Presence of Water [P6] Dynamic & Diffuse Light [P7] Connection with Natural Systems [P8] Biomorphic Forms & Patterns [P9] Material Connection with Nature [P11] Prospect [P12] Refuge [P13] Mystery [P14] Risk/Peril
89 Adaptable Spaces	[P2] Non-Visual Connection with Nature [P12] Refuge
99 Beauty & Design II	 [P1] Visual Connection with Nature [P6] Dynamic & Diffuse Light [P8] Biomorphic Forms & Patterns [P10] Complexity & Order [P11] Prospect [P13] Mystery
100 Biophilia II – Quantitative	[P1] Visual Connection with Nature[P5] Presence of Water[P7] Connection with Natural Systems



Emerging Biophilic Research

Natural Ventilation Views Daylight Sunshine Thermal Variability – Alliesthesia Access to Nature – Active Design

Sounds of Nature Smells of Nature Sensory Feel of Nature Natural Materials Nature's Complexity and Order Craft – the Human Hand Art – Nature's Imagery Community Dynamics of Time and Place

Vivian Loftness, FAIA, LEED Fellow

Center for Building Performance & Diagnostics Carnegie Mellon University

In a 2006 multiple building study of 54 elementary schools, Shaughnessy et al identify a 14.4% improvement in standardized math test scores in classrooms with a ventilation rate higher than 4.5 l/sperson, as compared to classrooms with a ventilation rate-lower than 2.25 l/s-person.

First cost increase: Annual funding gain: Annual energy cost increase: Net savings: ROI: \$13 / student \$158 / student \$2 / student \$156 1200%

Increase Outside Air



First cost increase: Annual energy cost increase: Annual health savings: Annual productivity savings: ROI: \$800 / employee
\$8 / employee
\$17 / employee
\$106 / employee
14%

In a 2002 controlled experiment, Kaczmarczyk et al identify a 23.5% reduction in headache symptoms when workers are provided with individually-controlled task air systems supplying outdoor air, as compared to a conventional mixing ventilation system.



Provide Task Air

In a 2004 multiple building study in France, Preziosi et al identify a 57.1% reduction in sickness absence and a 16.7% reduction in doctor visits among workers with natural ventilation in their workplace, as compared to those with air conditioning.

> First cost increase: Annual health savings: Annual productivity savings: **ROI:**

\$1,000 / employee \$181 / employee \$85 / employee **27%**

Open Windows



In a 1996 controlled experiment and meta-analysis, Wyon identified that providing individual temperature control over a range of 6° C (10.8° F) results in performance improvements of 2.7% on thinking and decision-making tasks, 7% on typing tasks, and 3.4% on skilled manual tasks.



First cost increase:\$800 / employeeAnnual productivity savings:\$1,035 / employeeROI:129%

Give Back Temperature Control



Nature is dynamic but indoor environments are static?

we design light that never varies from 500 lux, air temperature that never varies from 72F air speed designed to be undectable at <.3 ft/sec

The concept of alliesthesia encourages the deliberate introduction of temperature drifts, air movement, and thermal asymmetries; it precludes an isothermal, steady-state heat balance approach, and requires a fundamentally new understanding of thermal perception. (Parkinson & de Dear 2015).

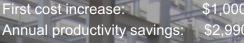
we could mechanically vary the temperature.....



or we could just turn off the HVAC and celebrate natural conditioning?

In a 2003 study of the SMUD Call Center, Heschong et al identify a 6% to 7% faster Average Handling Time for employees with seated access to views through larger windows with vegetation content from their cubicles, as compared to employees with no view of the outdoors.

Maximize Views



RO

\$1,000 /employee \$2,990 /employee





Make Daylight Dominant



\$1,000 / bed

1,000%

\$10,000 / bed / year

First cost increase:

ROI:

Annual health savings:

In a 2005 study of 89 patients undergoing elective cervical and lumbar spinal surgery at Montefiore Hospital in Pittsburgh, PA, Walch et al identify a 22% reduction in analgesic medication use after surgery among patients in bright, sunny rooms, as compared to patients located in dim rooms.

First cost increase: Annual health savings: **ROI:** \$1,000 / bed \$28 / bed **3%**



Celebrate Sunshine



what is the magic of daylight and sunshine?

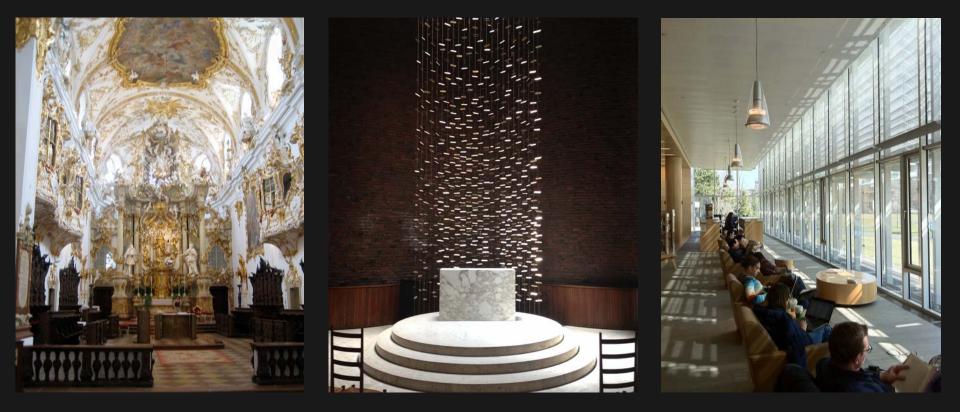


cool light stops melatonin production

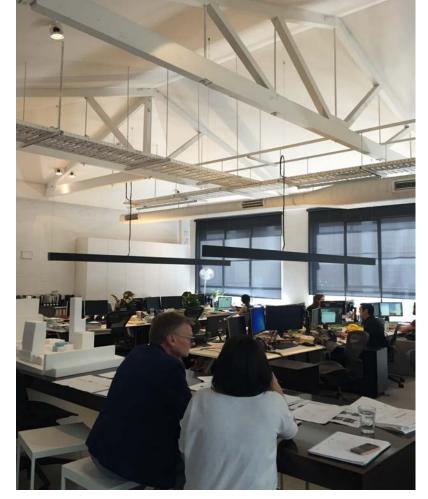
warm light starts melatonin production



We could mimic daylight variability (and shut out nighttime blue light from IT)...



or we could just turn off the lights and celebrate daylight and dark?



In a 1998 multiple building study in Germany, Çakir and Çakir identify a 19% reduction in headaches for workers with separate task and ambient lighting, as compared to workers with ceiling-only combined task and ambient lighting.

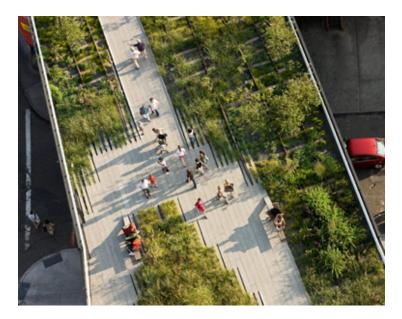


First cost increase: Annual health savings: Annual productivity savings: ROI:

\$314 /employee \$14 /employee \$87 /employee

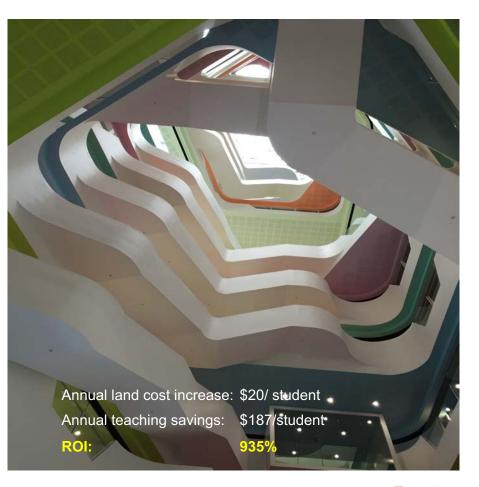
Separate Ambient and Task Light





In a 2004 Chicago field study of 17 children professionally diagnosed with ADHD, Kuo and Faber Taylor et al identified a 17% improvement in performance (digit span backwards test) after a 20 minute walk in a park as compared to built urban settings.

Design for Active and Fit





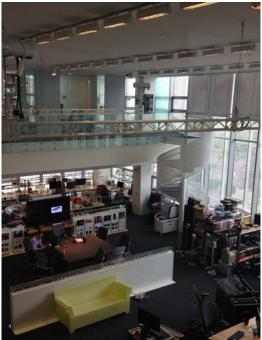
First cost increase:\$84 / studentAnnual O&M cost increase:\$5 / studentAnnual productivity savings:\$176 / student

In a 2000 study of 14 schools in Georgia, Tanner identifies a statistically significant relationship between the quality and functionality of a school's outdoor space and students' academic achievement, with a 7% increase in standardized test scores for each one-point improvement in rating of outdoor space on a scale from 1-10.

Ensure Access to Nature



Unknowns? Sounds of Nature Smells of Nature Sensory Feel of Nature Natural Materials Nature's Complexity and Order Craft – the Human Hand Art – Nature's Imagery Community Dynamics of Culture, Time and Place





Support Community & Collaboration





What about tough climates?

What about complex buildings?

Mixed mode is the perfect alliance of passive conditioning with just the right level of active technology to make the thermal, air quality, visual, and acoustic environment healthy and productive.

The distributed task controls for thermal, air quality, light, shade and views are the **Internet of Things (IoT)**, designed to ensure humans are in the loop.

Integrated design practices are central to delivering high performance buildings with mixed mode conditioning, and the internet of things with humans in the loop, to ensure human and environmental resiliency.



GHD Theater - Daylit & Naturally Ventilated Theater, University of Queensland Australia (Richard Kirk, Hassell)



Bullitt Center Daylit & Naturally Ventilated Offices, Seattle (Miller Hull, PAE Eng)

Mixed Mode: Daylight & Electric Light



H.E.B. Retail in Texas (Lake Flato and Arup) Natural Cooling + A.C. (Side by Side & Changeover)



Terry Thomas Offices in Seattle (SmithGroup and DPR) Natural Cooling only with demand controlled ventilation



Mixed Mode: Natural Cooling & Mechanical



Walgrens Retail in Illinois (Camburus, GI Energy) Natural Ventilation + A.C. (Changeover)



The Leala Hotel in Kovalam India (Charles Correa) Natural Ventilation + A.C. (Side by Side or Zoned)



Mixed Mode: Natural Ventilation & Mechanical



The sixth floor "Garden in the Sky" is used frequently for formal and informal meetings and events.

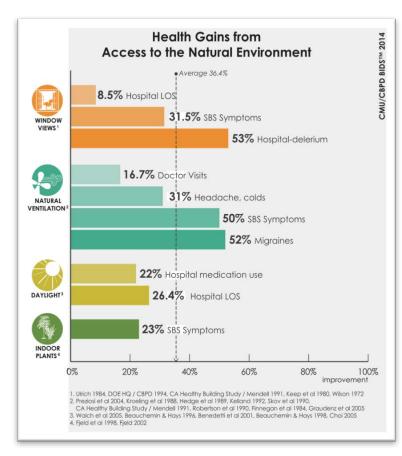
Ng Teng Fong Hospital in Singapore (Studio 505, HOK, CPG Eng) Natural Cooling 70% patient rooms, each bed with garden

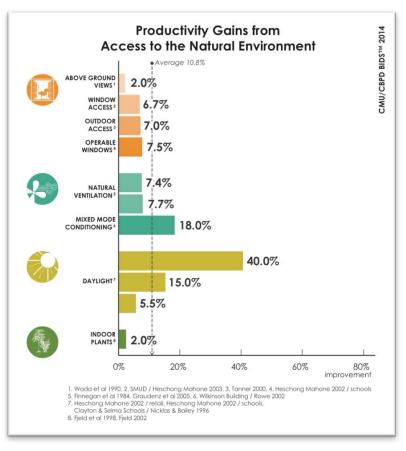


Institute of Building Research Offices in Shenzhen, China (Ye Qing) Natural Cooling + A.C. (Changeover)



Mixed Mode: Outdoor & Indoor Work/Learn/Play/Heal





environmental surfing for access to nature, light, air & natural cooling for environmental sustainability, human health and productivity.

The Triple Bottom Line of Daylighting

Profit

Energy conservation Real estate value



People

Performance at Task Sleep Well-being & Motivation Headache Reduction Pain Reduction Faster Recovery Reduced Bacteria/Mold Resiliency



Costs of buying and managing new inverted venetian blinds				
100,000 sqft building	Per sq. ft.	Per employee		
Cost of new inverted blinds (for baseline building with 40% window wall ratio)	\$5.65	\$300		
Cost of annual FM/Training costs	\$0.25	\$50		
First cost for the investment	\$5.90	\$350		
Initial Investment costs for a 100,000 sq. ft. building (for 1/3 baseline building perimeter area)	\$180,000			

what is the triple bottom line?

1 st Financial Capital savings	-	
	Per sq. ft.	Per employee
Lighting Energy savings (20%)	\$0.14	\$28
Cooling Energy Savings (20%)	\$0.45	\$9
Annual 1 st bottom line savings	+\$0.18 +\$37	
. JI (Financial)	12%	
Payback Period	8 years	
Cumulative 15-year Net Present Value	\$ 46,650	

2. Financial + Natural Capital savings		
Environmental benefits from energy savings of:	0.55 kWh	110 kWh
Air pollution emissions (SO _x , NO _x , PM, CH4)	\$0.01	\$2
CO ₂ reductions	\$0.01	\$1
Water savings	\$0.002	\$0.4
Annual 2 nd bottom line savings	+\$0.02	+\$3.4
Cumulative ROI (Financial + Environmental)	13%	
Payback Period	7.5 years	
Cumulative 15-year Net Present Value	\$ 50,850	

\$2.02	\$405
+\$2.02	+\$405
190%	
7 months	
\$ 735,400	
	+\$2.02 19 7 m





Window for Every Patient!

CPG A+E Studio 505 & HOK Vipac Acoustics







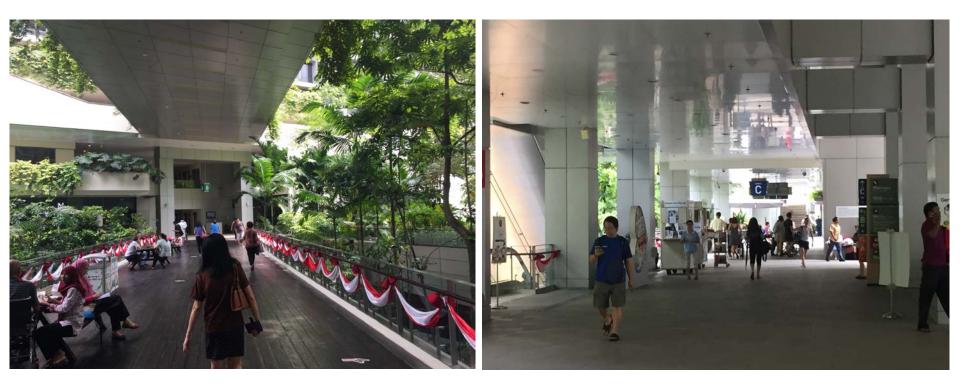
Experiencing Biophilia in Hospitals

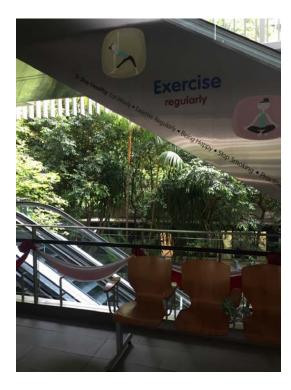


Khoo Tech Puat Hospital (KTPH) Singapore



Biophilic experience from car, bus or bike arrival through open air lobby to a Central Courtyard Oasis





Biophilia & Active Design

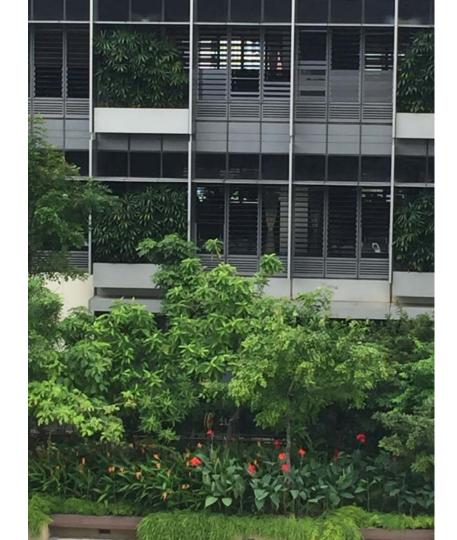


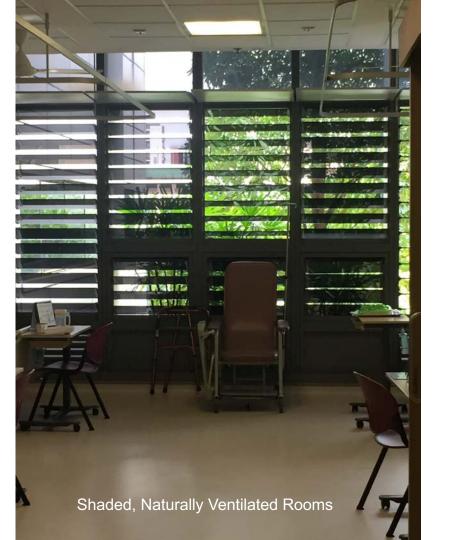




Shaded Mixed Mode Hospital Rooms (Air Conditioning or Natural Ventilation)

Shaded, Naturally Ventilated Rooms









Shaded Mixed Mode Hospital Rooms (Air Conditioning or Natural Ventilation) Central Courtyard Oasis with Emergency Shelter Wing





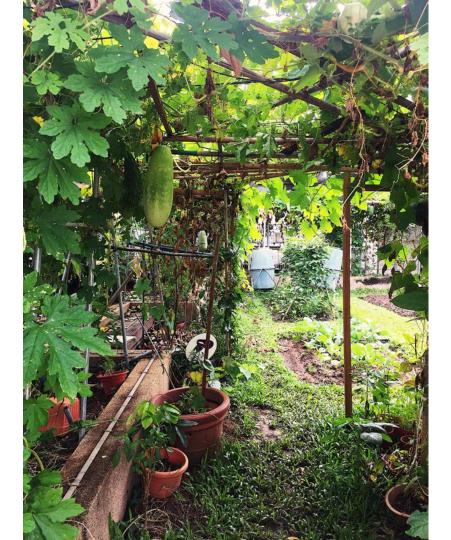


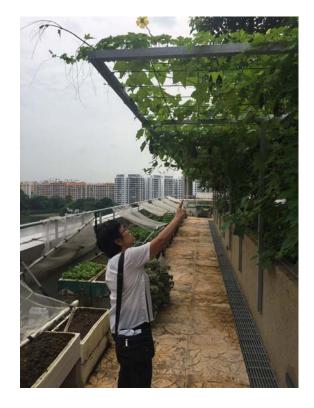
Biophilic Naturally Ventilated Restrooms





PV Shaded Mechanical Plant leaves 50% of the Rooftop free For Production Gardens





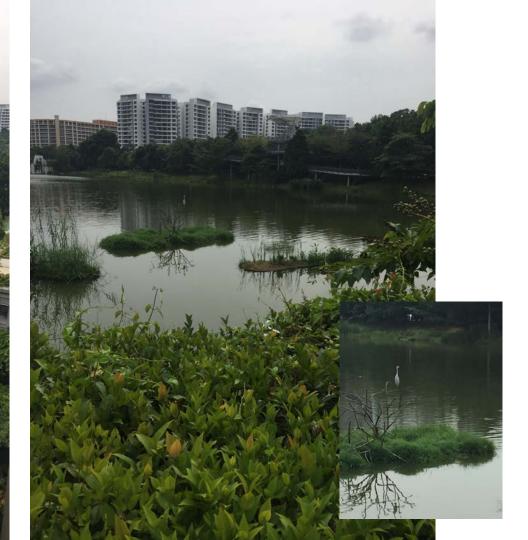
With a volunteer staff, the 80 year old director provides one meal a week from on-site gardens, and therapeutic programs for the patients and community





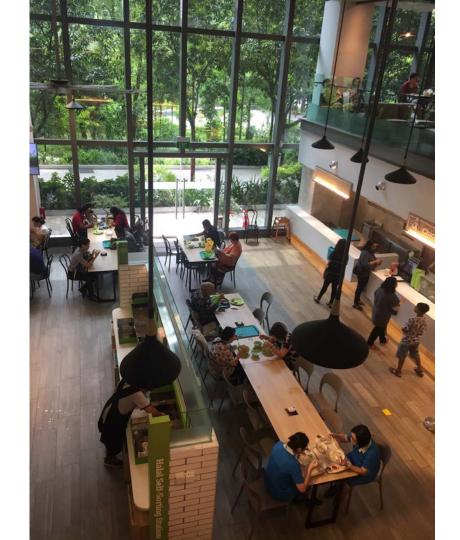


Walk from the Courtyard Oasis to the Reservoir Loop for a serious 5 km program...





...or visit the garden of plants that "heal, thrill and kill" with a stop for lunch at the community restaurant



Butterflies Sighted In Khoo Teck Puat Hospital































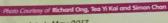












Last updated: May 2017



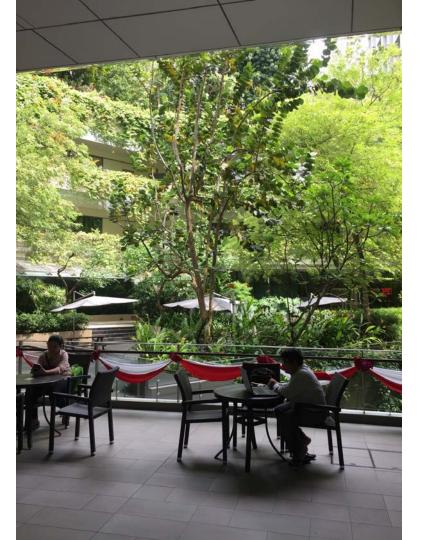






Khoo Tech Puat Hospital (KTPH)

designed for the health and well-being of the entire community



THE SPHERES | AMAZON Seattle, WA

John Savo, AIA Principal nbbj Dale Alberda, AIA Principal nbbj

#StephenKellertAward

Amazon Spheres

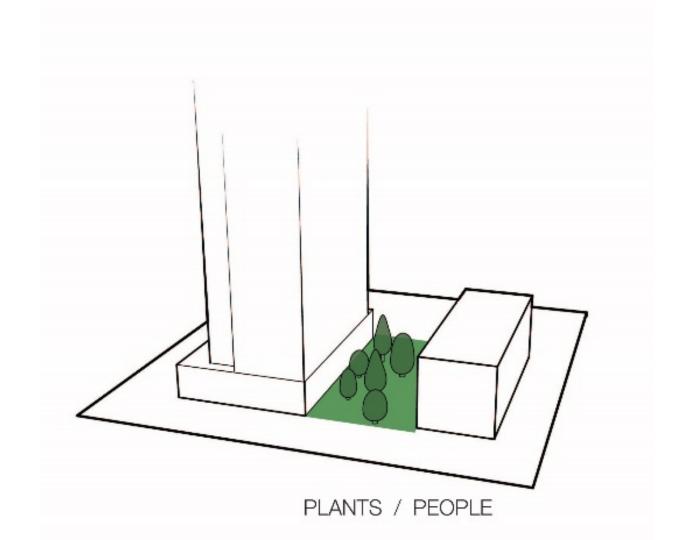
Stephen Kellert Biophilic Desig Award Ceremony

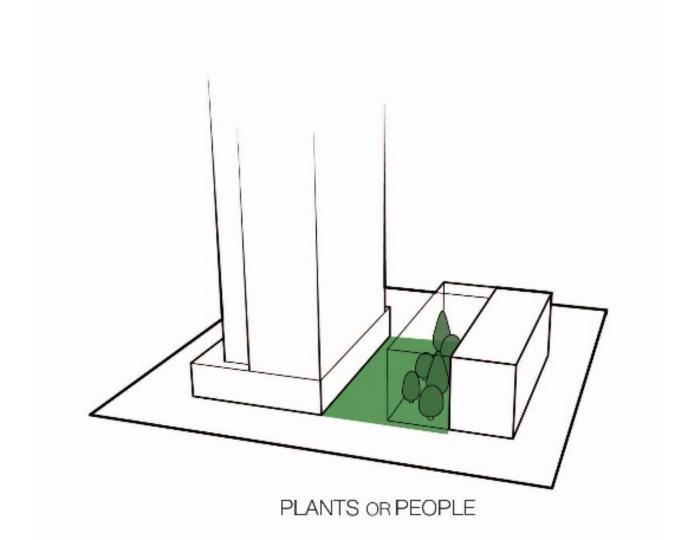
NO.

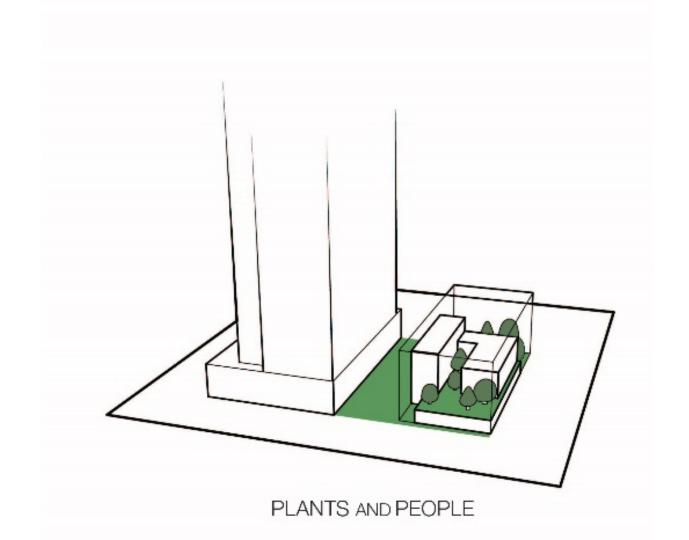
November 14, 2018

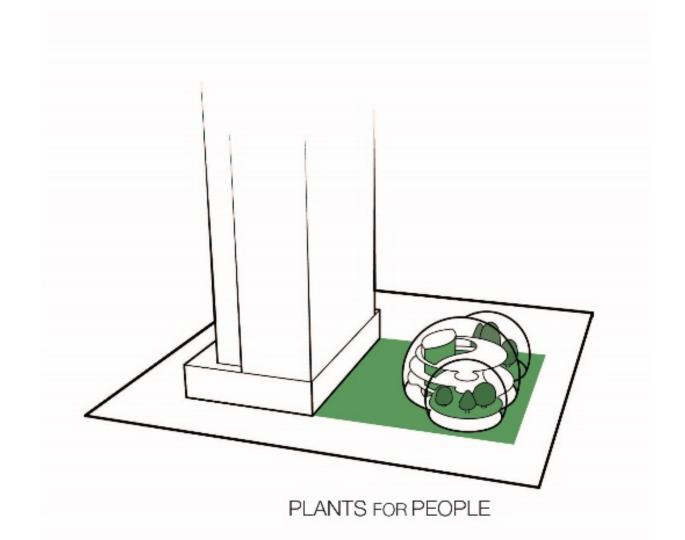


















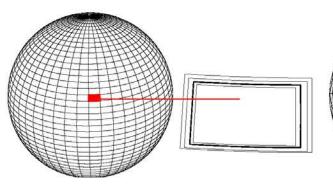
Enid A. Haupt Conservatory - Bronx, New York - 1902

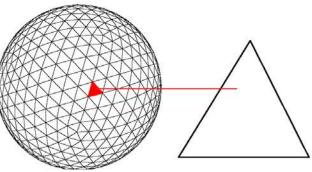


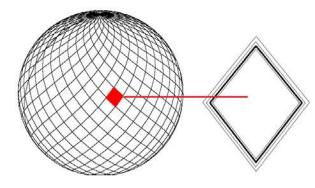
Montreal Biosphere - Montreal, Quebec - 1967



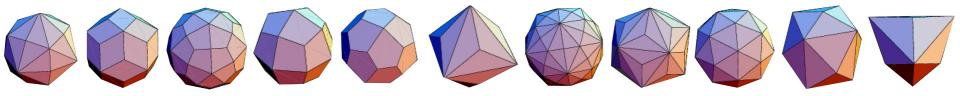
Swiss Re Headquarters - London, England - 2004

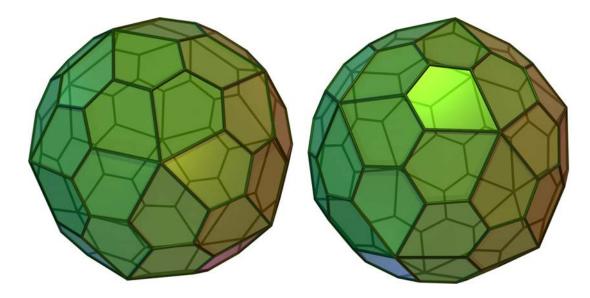


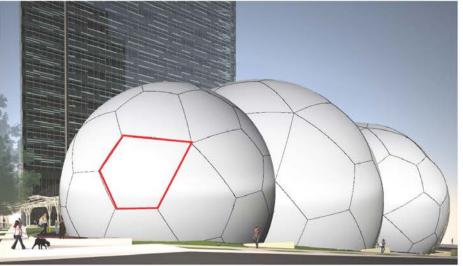








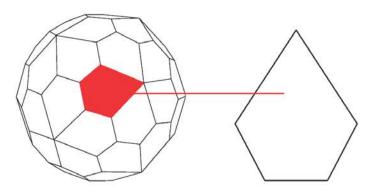


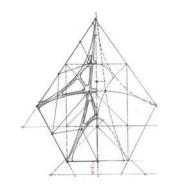


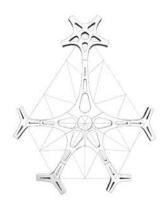
Conjoined Catalan Spheres



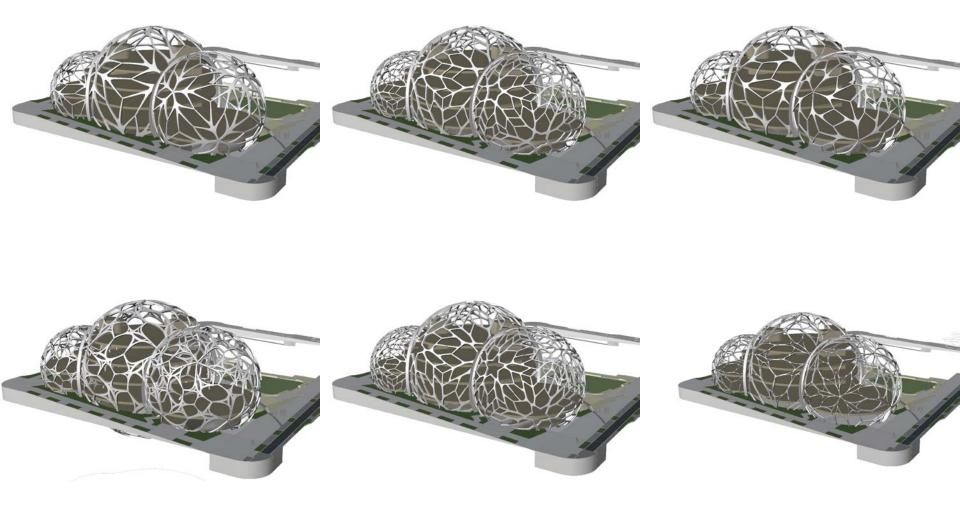
Structural Steel Catalan Module

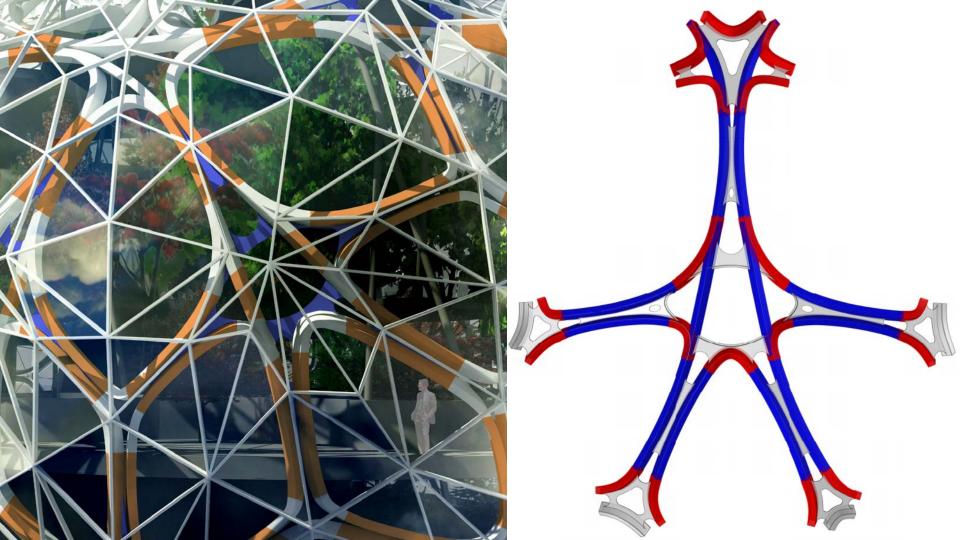






















Go Green

Neuroscience tells us:

Exposure to plants makes us less emotionally volatile and error prone; even pictures of plants have a calming effect.

As a bonus, certain plants give off antiviral, immune-boosting chemicals called phytoncides that promote health.



Seek Visual Relief

Neuroscience tells us:

Humans have an evolutionary need for private spaces that offer a sense of safety, but we also crave vistas for inspiration—a condition known as prospect refuge.

Open spaces foster creative thinking, while close confines increase focus. Specific colors have been shown to enhance or hinder these abilities.



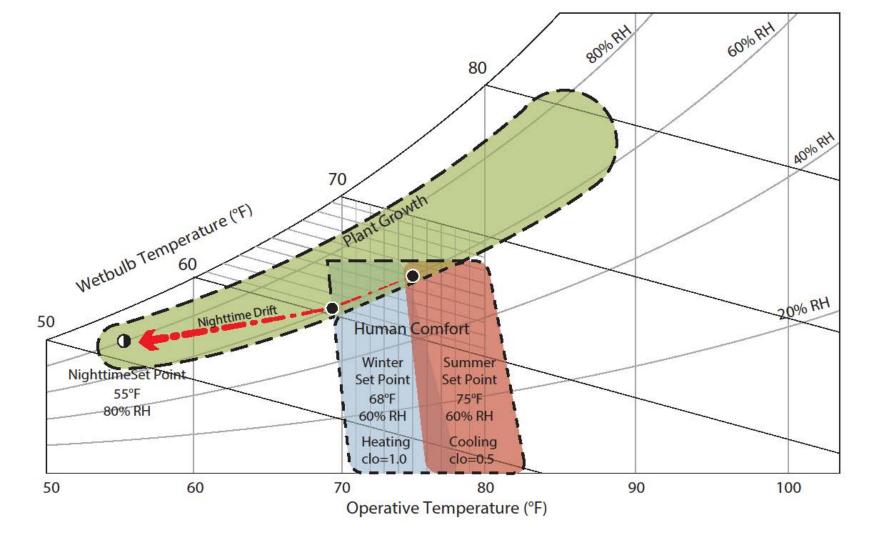
Get A Move On

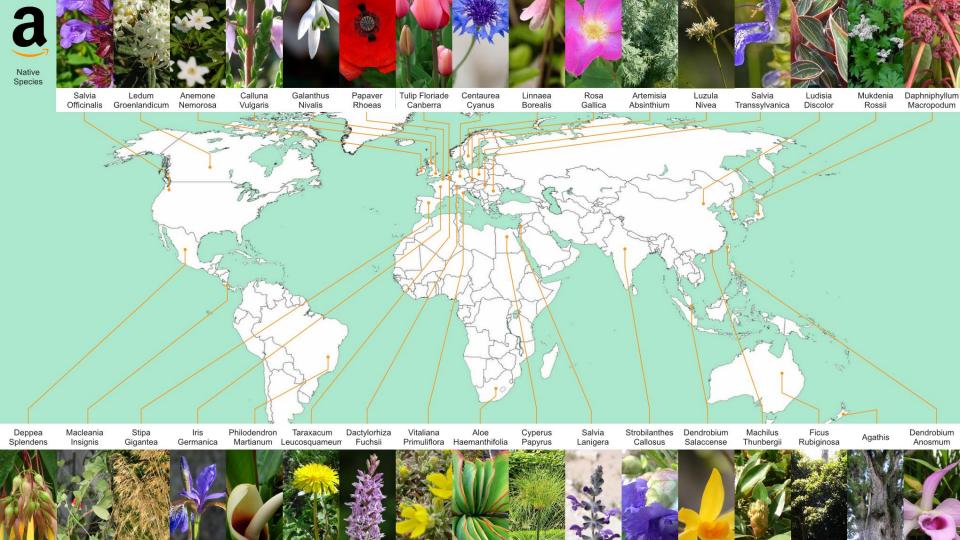
Neuroscience tells us:

Just 30 minutes of aerobic activity can boost executive function and reduce stress; outdoor exercise increases these effects.

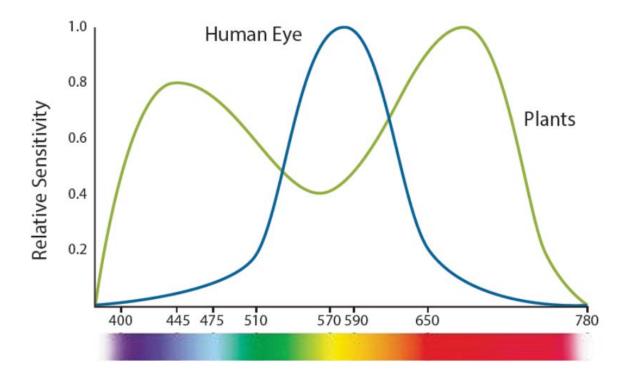
At just 1.4 miles an hour—a moderate walk—reaction time and quantitative skills improve.



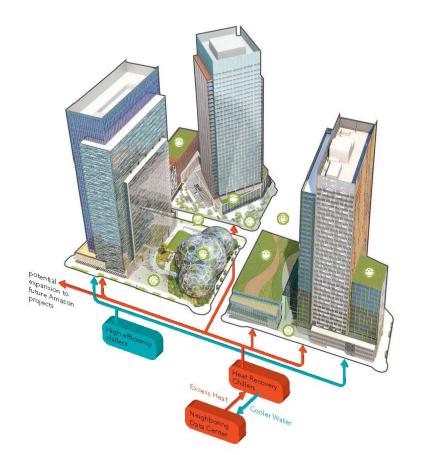


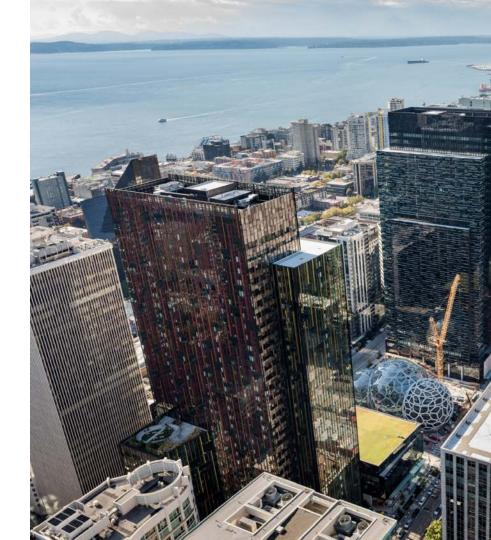


RELATIVE SENSITIVITY TO VISIBLE SPECTRUM - HUMANS vs. PLANTS

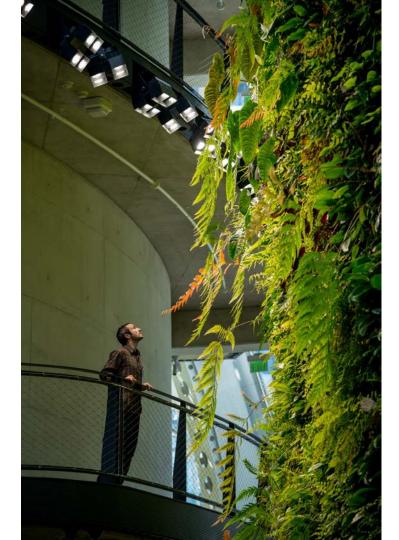


Smart Sustainability













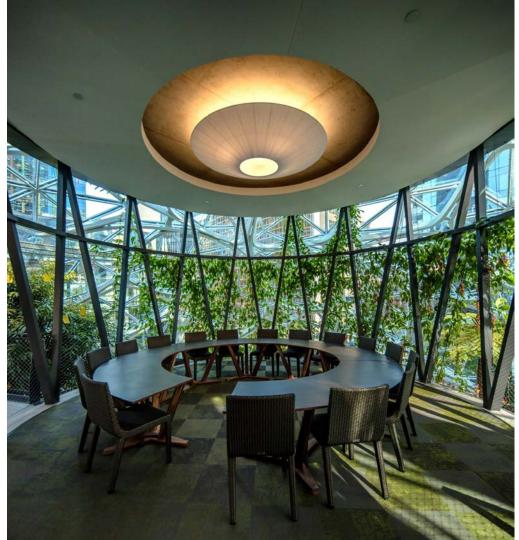


















THE SPHERES | AMAZON

ANTIS SI

Seattle, WA

4000

#StephenKellertAward



The design masters of environmental surfing will preserve, cascade, and regenerate nature's abundant resources for sheer delight; create technologies that mimic nature and regenerate without waste, displacing design that cuts us off from the environment.



The architecture produced by environmental surfing will celebrate the time of day, the seasons, and the culture that is unique to each community and to nature's creative energies, central to a resilient future.

Vivian Loftness, FAIA

PERSERVE PERSER

The Intelligent Workplace – A living laboratory at Carnegie Mellon University