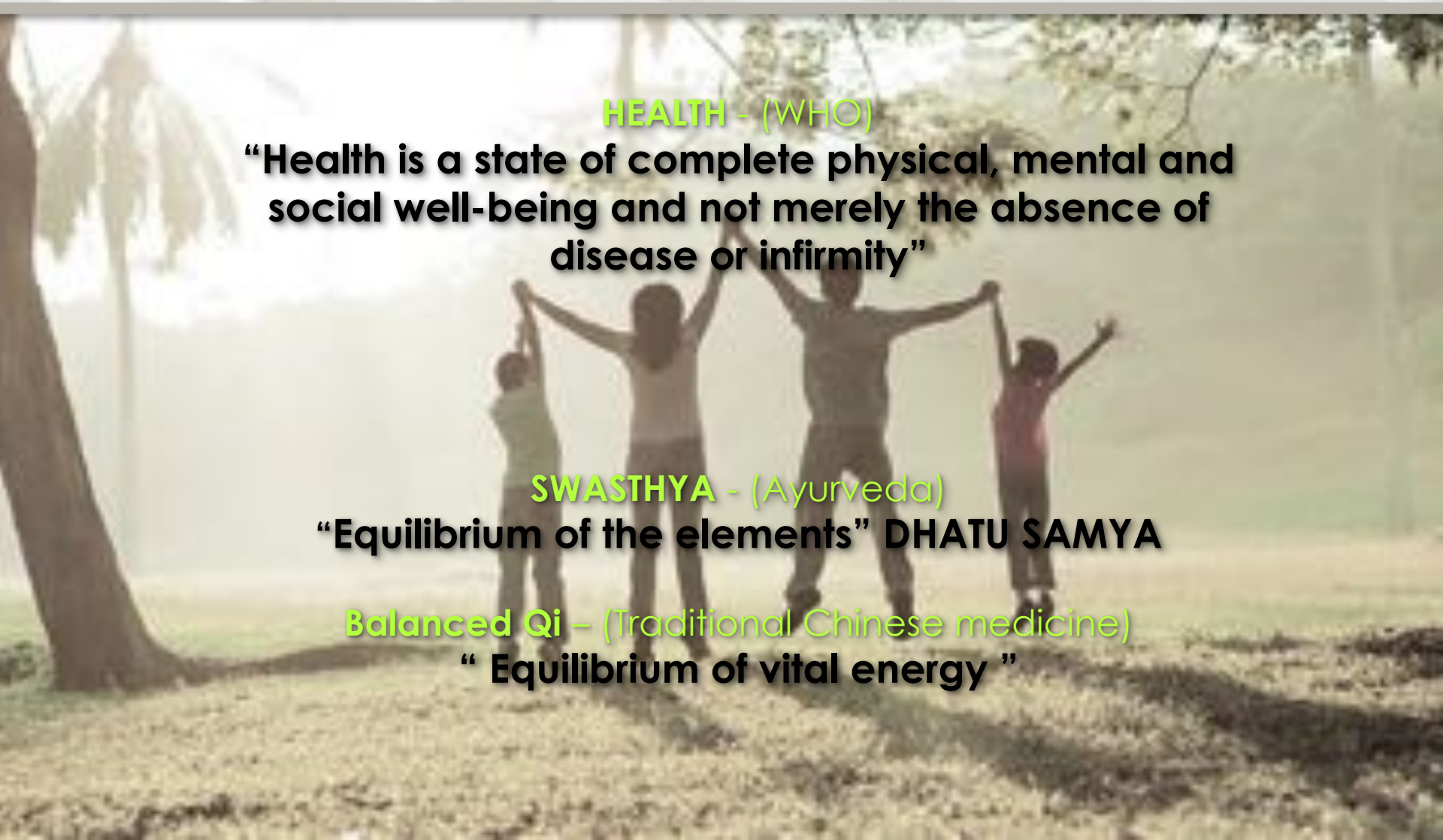
HEALTHY LIVING
& BIO-FACADES

Anuradha Sabherwal, **Stantec** | Alistair Law, **ARUP**

HEALTHY LIVING



HEALTH - (WHO)

"Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"

SWASTHYA - (Ayurveda)

"Equilibrium of the elements" DHATU SAMYA

Balanced Qi – (Traditional Chinese medicine)

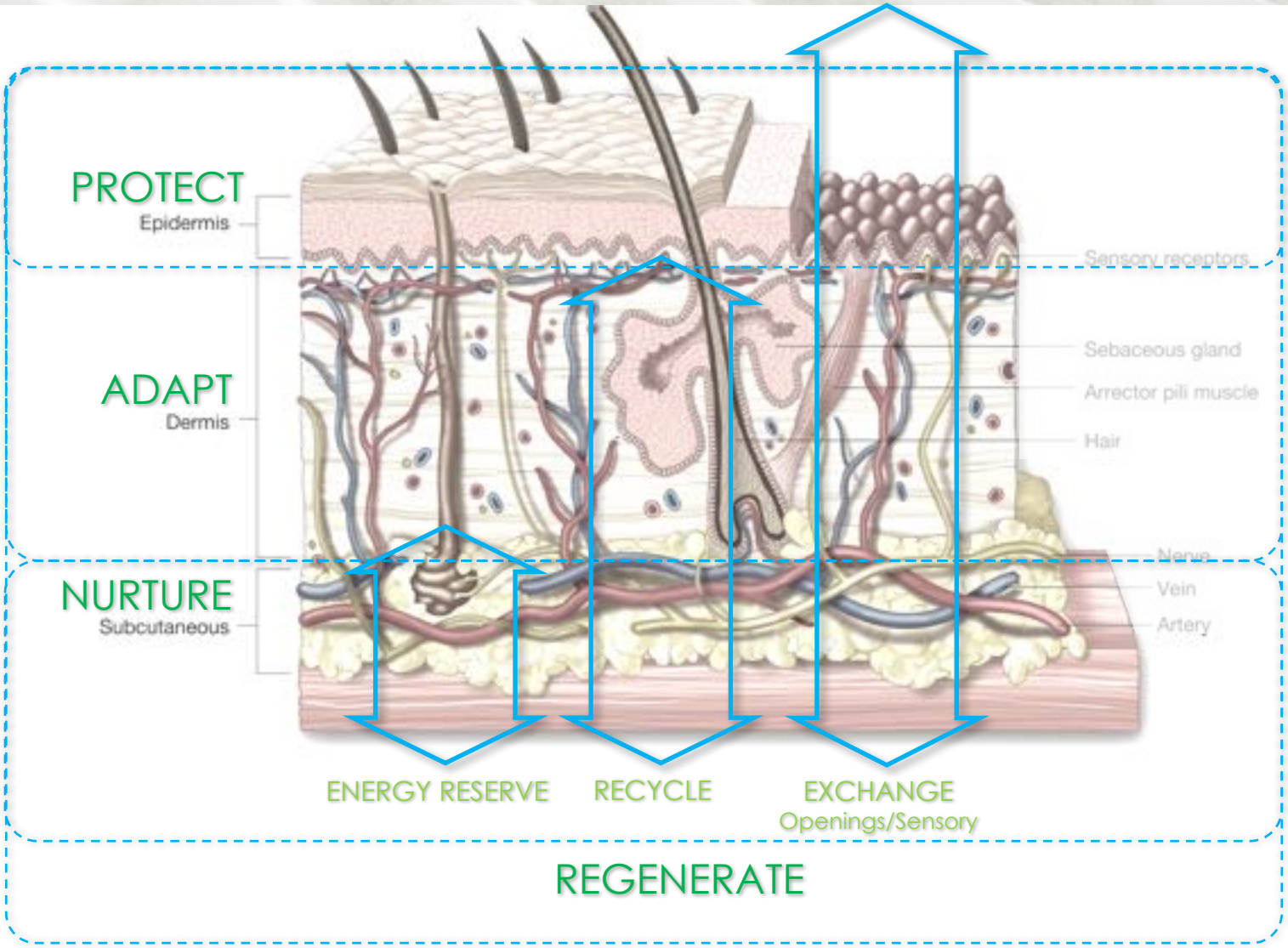
" Equilibrium of vital energy "

HEALTHY LIVING
& BIO-FACADES

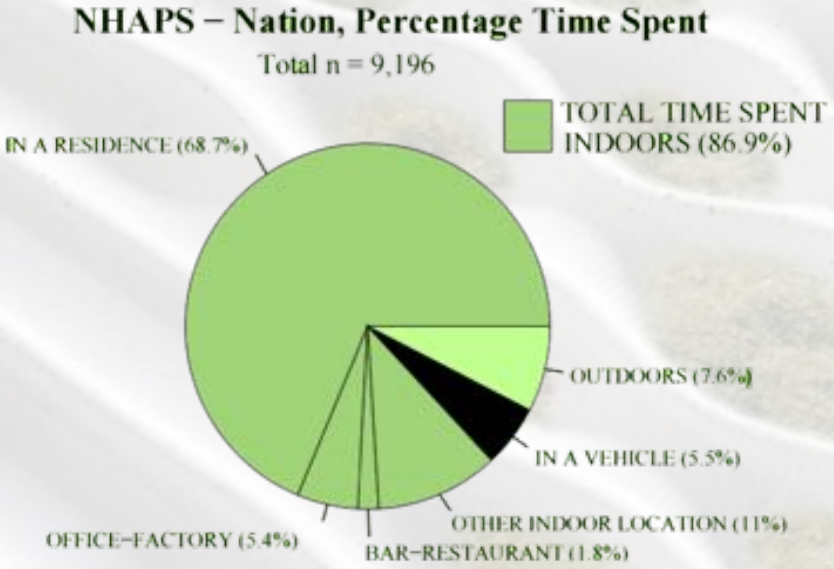
- A **Biomimetic Metaphor** for Sustainability
- How do we improve **health** and **wellbeing** in the built environment
- Biomimicking **aspects** of physiological **wellbeing**
- Concept of the "**living building skin**": A step towards 2030 Energy Goals

The Living Skin

A Biomimetic Metaphor for Sustainability



How much time do we spend indoors?



On an average day we spend **87%** of the day inhabiting buildings.

The environmental quality of these spaces directly influences our **physiology** and feeling of **wellness**.

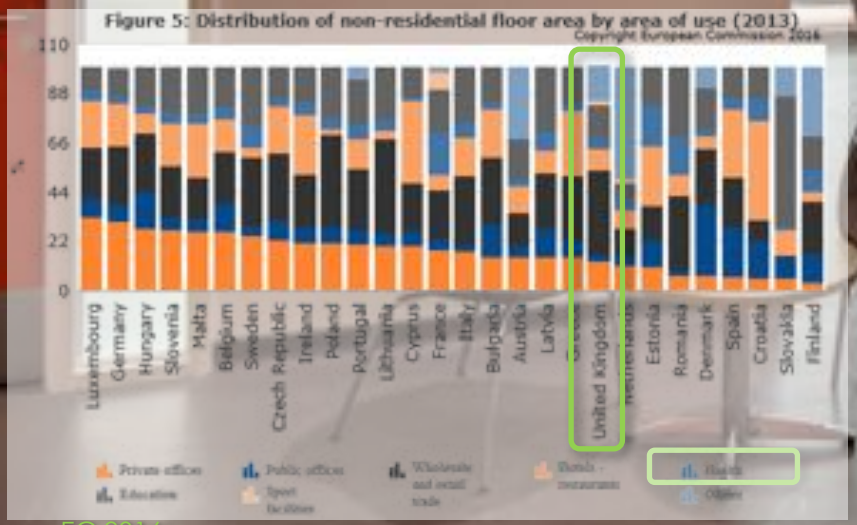


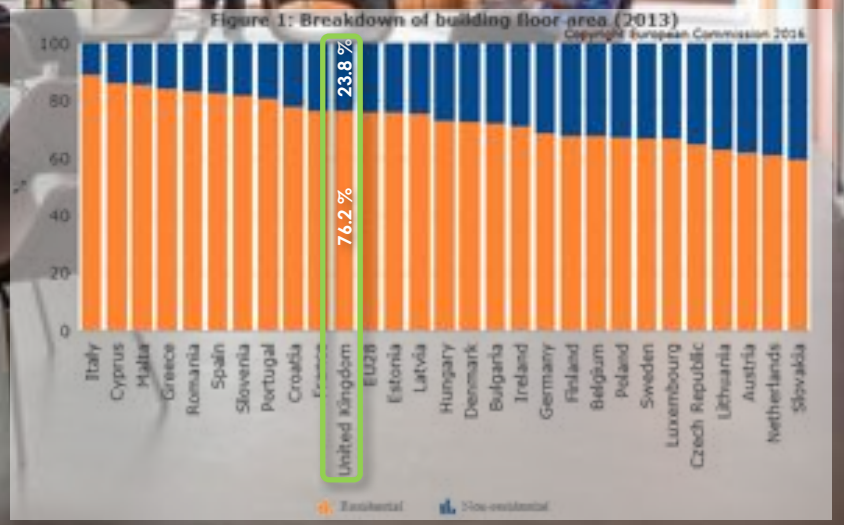

Source: National Human Activity Pattern Survey (USA)

Healthcare buildings form
4.31% of all UK non residential buildings

Non residential buildings are **1/4th** of the total UK building stock

Healthcare to "Health" "Care"





Source: EC 2016

How do we improve **health** and **wellbeing** in the built environment?

"DO LESS HARM"

"HOLISTIC HEALTH"

"NURTURING BY NATURE"

Source: UK Climate Change Risk Assessment Report 2017
Barton et al. (2010).

Green Building Practice

"DO LESS HARM"

Improve building performance

Reduce environmental impact

Improve human comfort

Sustainable design

Green energy

Net zero buildings

Source: Carbon Neutral Lab,Stantec

Health and Wellness

"HOLISTIC HEALTH"

Healthy living

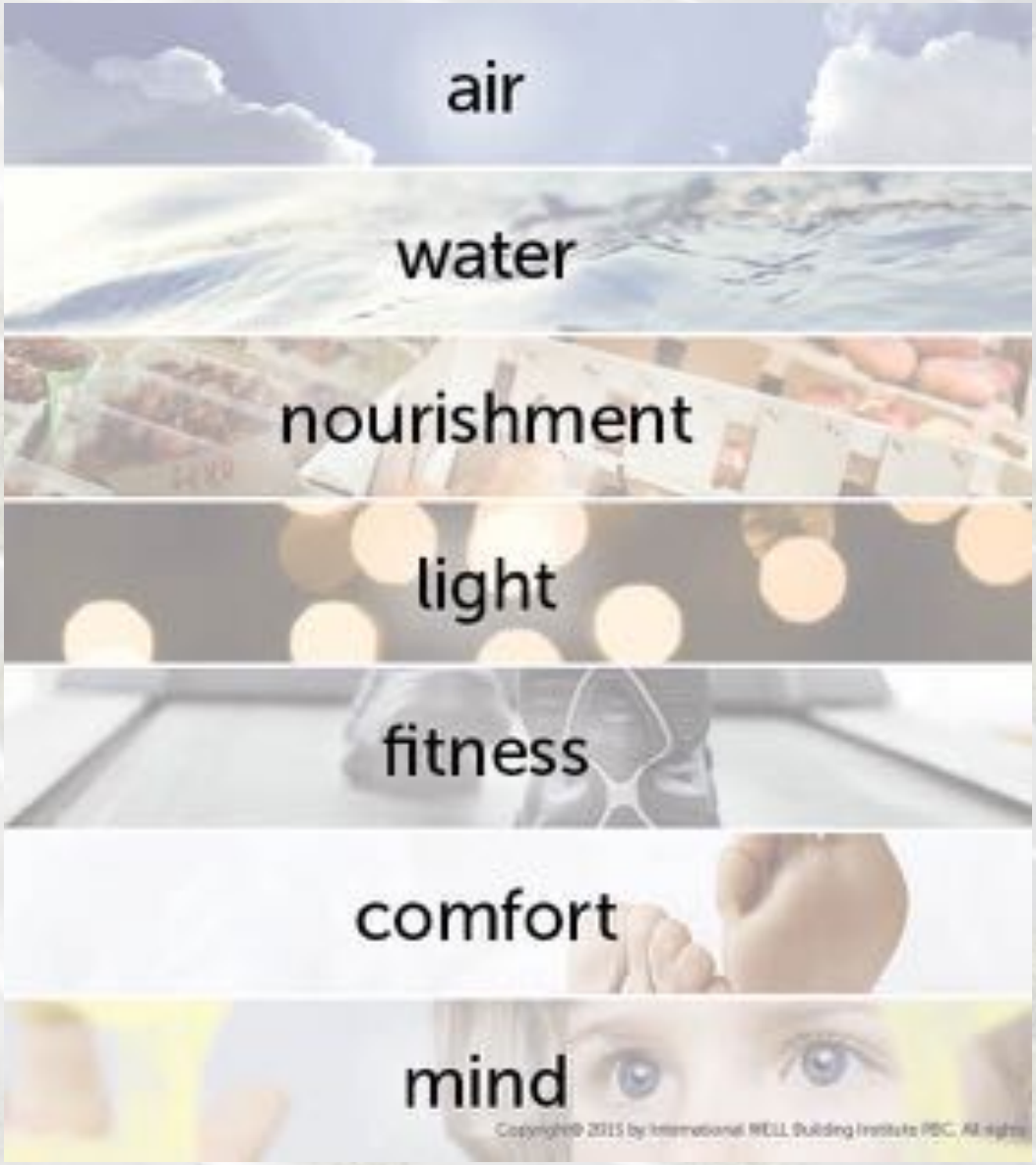
Nurture physiological wellbeing

Physical and mental comfort

"NURTURING BY NATURE"

Benefits of nature – biophilia

Learning from nature - biomimicry



How do we quantify health & sustainability?

"DO LESS HARM"

BREEAM®

LEED

greenstar

CEPAS

GREEN GLOBES

CASBEE®

BASIX®
www.basix.planning.nsw.gov.au

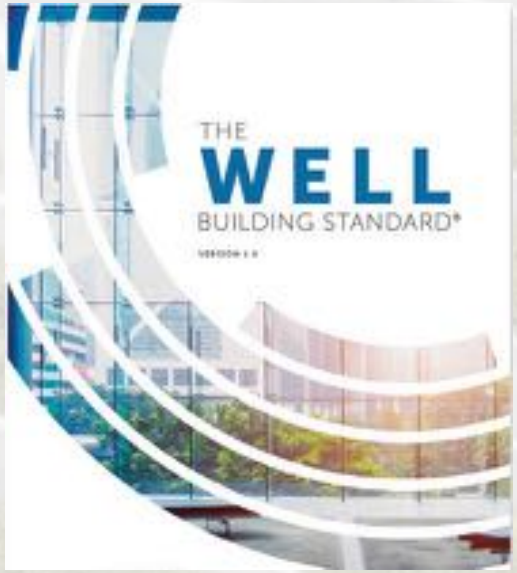
إستدامة
estidama

GSAS
GLOBAL SUSTAINABILITY ASSESSMENT SYSTEM
2009

HKGBC 香港綠色建築議會

BEAM 建築環保評估協會

"HOLISTIC HEALTH"



"NURTURING BY NATURE"

TERRAPIN BRIGHT GREEN

14 PATTERNS OF BIOPHILIC DESIGN
IMPROVING HEALTH AND WELL-BEING IN THE BUILT ENVIRONMENT

BREEAM	LEED	استدامة estidama	CASBEE	greenstar	WELL
Management	(In materials)	Integrated Development Process		Management	Air (eg. air quality monitoring) Light (eg. Circadian lighting) Comfort (eg. Ergonomics)
Health and Wellbeing	Indoor environmental quality	Liveable Buildings	Indoor environment	Indoor environment quality	
Energy	Energy and atmosphere	Resourceful Energy		Energy	(in air)
Transport	Location and transportation	(in liveable buildings)		Transport	Fitness – Active Design, incentive
Water	Water efficiency	Precious Water		Water	Water Water quality, testing, drinking water promotion
Materials	Materials and resource	Stewarding Materials		Materials	(in air)
Waste	(in materials)	(in materials, water)	Outdoor environment Biotope preservation townscape landscape local character	(in management)	(in management)
Pollution	Sustainable sites	Natural Systems		Land use & ecology Emissions	(in air & comfort)
Innovation	Innovation	Innovation		Innovation	Innovation
	Regional Priority	Design for disassembly	Quality of service Serviceability Durability Reliability Flexibility Adaptability		Mind – Altruism, Awareness, Beauty & Design, Biophilia, healthy sleep policy, family support, adaptable spaces Nourishment – Allergies, fruits and veg, nutritional info. , hygiene, serving sizes, mindful eating

A **lateral** perspective..

Sustainability

Green Technology
Physical comfort
Active & Passive Design
Energy & Waste **reduction**
On site **regeneration**
Ecological enhancement

Natural Balance

Self **regulation/ Feedback** Mechanism
Natural **Rhythms**
Adaptations to Stimuli
Homeostasis / Equilibrium
Self Sustainable – Energy & Waste
Circular ecosystem

Wellness

Healthy Living
Happiness & productivity
Physiological comfort
Benefits of **Nature**

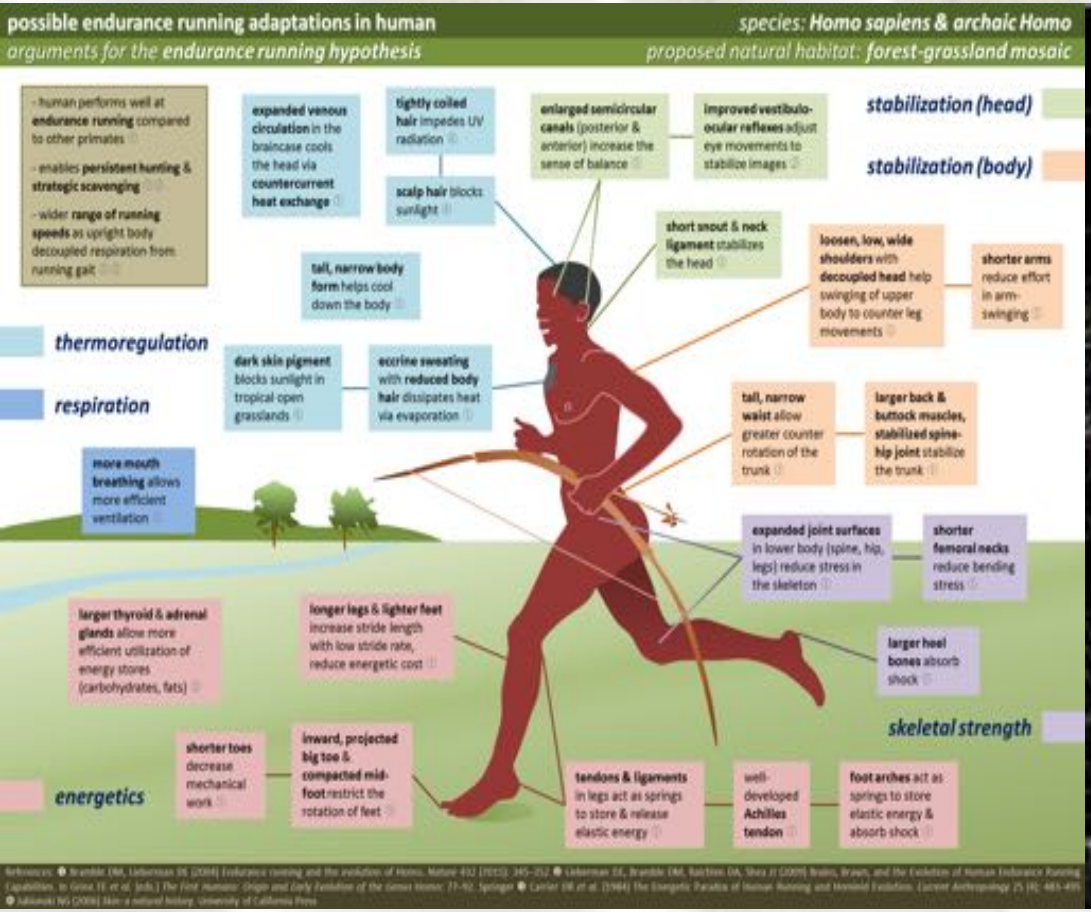
*"What if every time I started to invent something I asked '**How would nature solve this**?'"*

Source: Janine Benyus, Biomimicry Institute

Survival of the **Fittest**

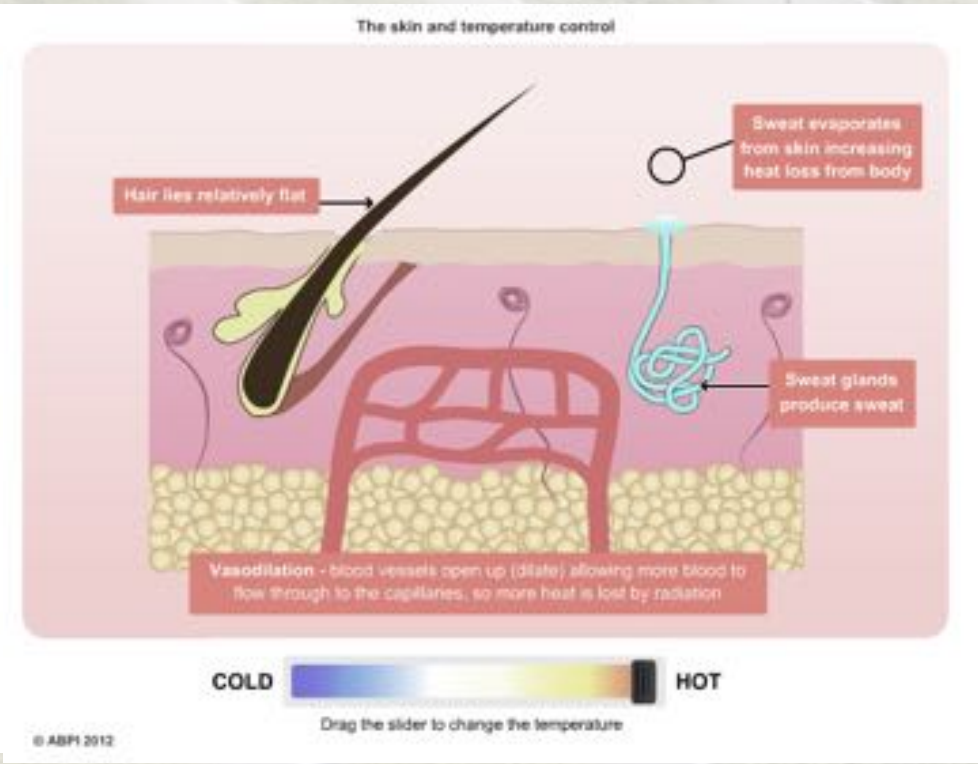
"***If buildings were animals*** *considered over evolutionary time scales, the species which* ***survived*** *would be those which lived in the environment of the planet with the* ***least effort,*** *and the least expenditure of energy* ***to maintain life.***"

Source: Intelligent skins, 2002



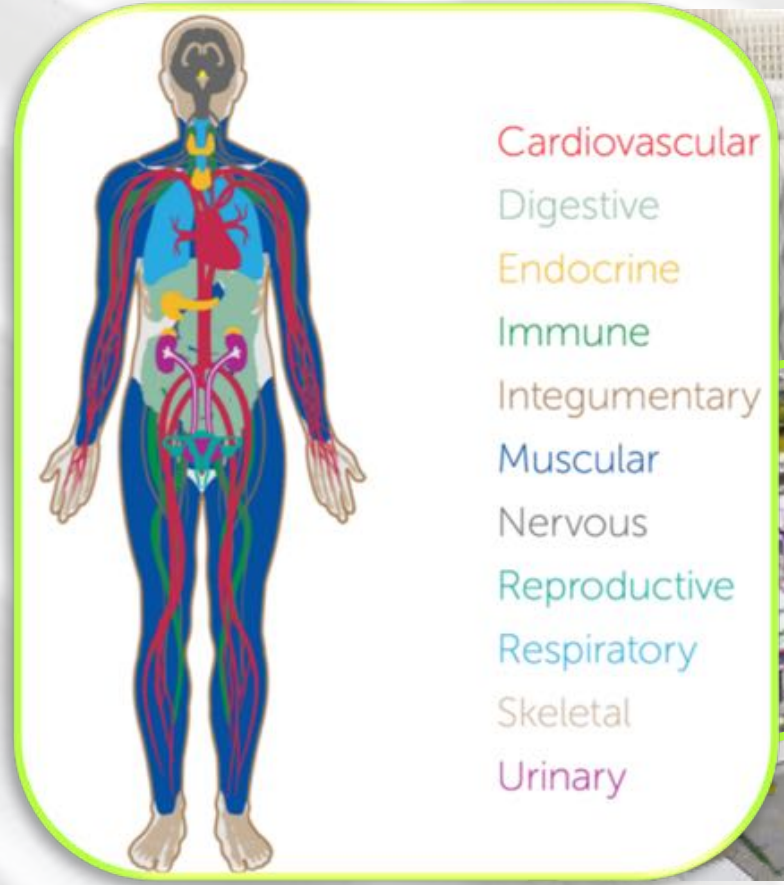
Tropism & Adaptation

Natural morphology expresses metabolism and leads to adaptation to seasonal variations in light and heat, exchange of gases, transportation of energy, and for structural stability.

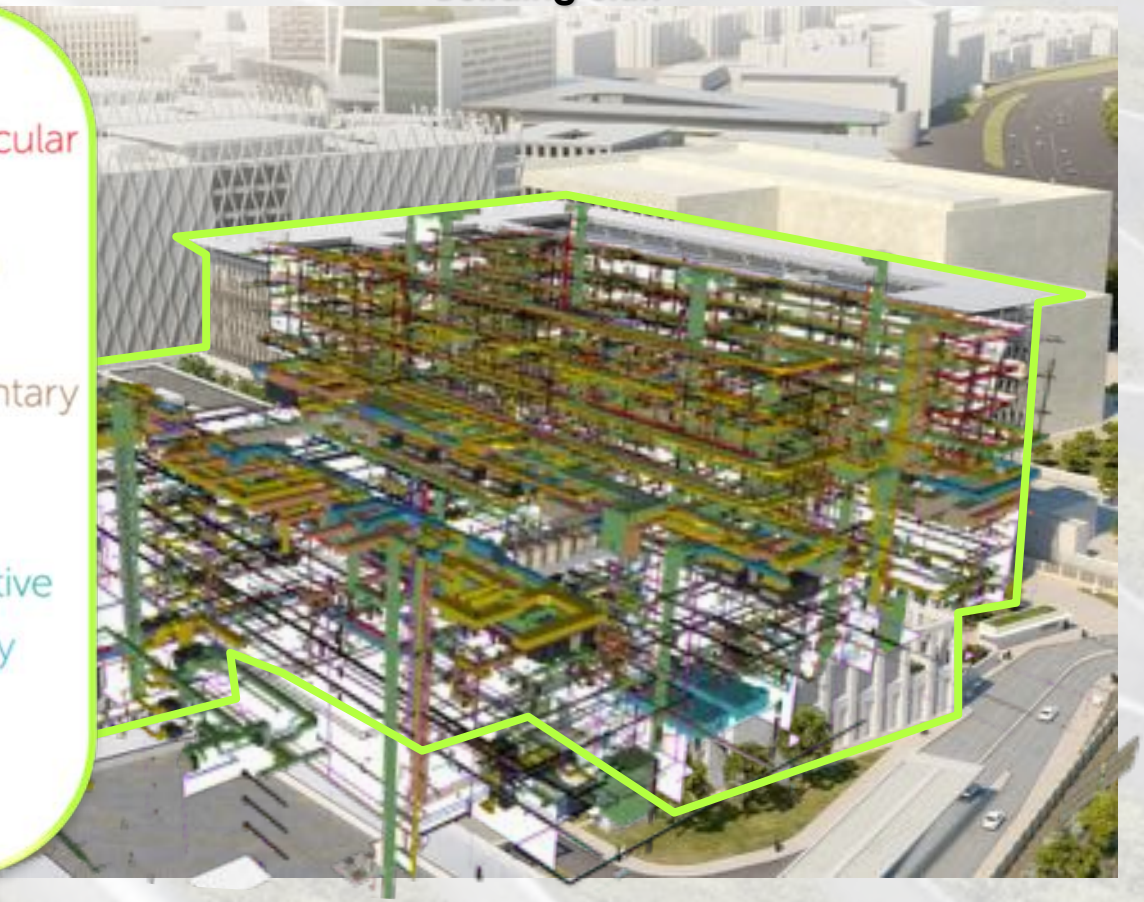


Human Health and Building Health

Human Skin

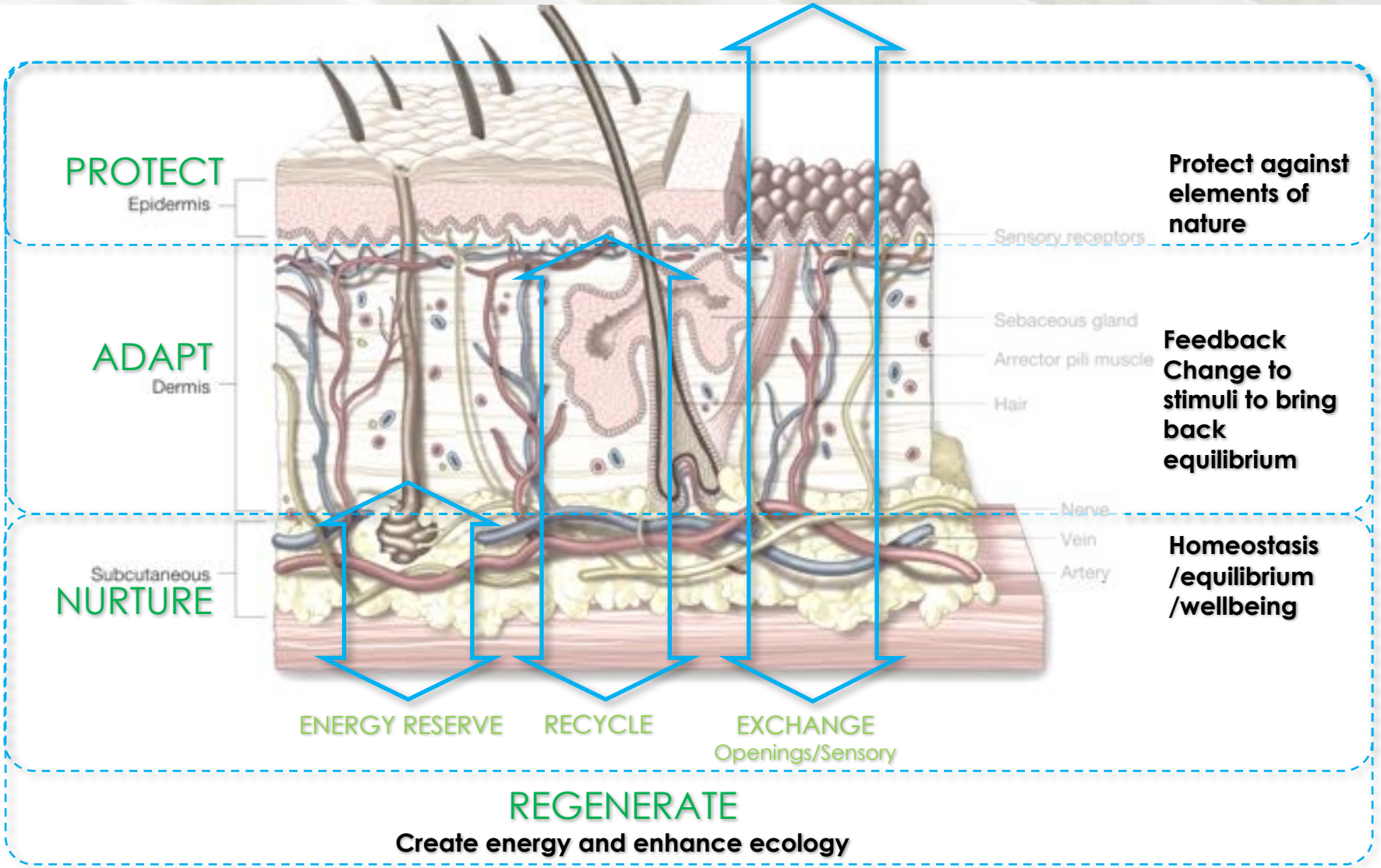


Building Skin



The Living Building Skin

A bio-mimetic design concept

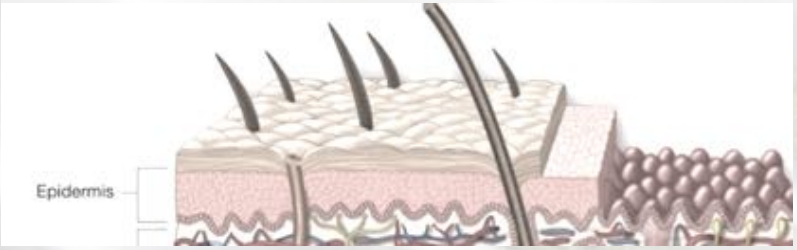


Biomimicking aspects of physiological wellbeing

Protect

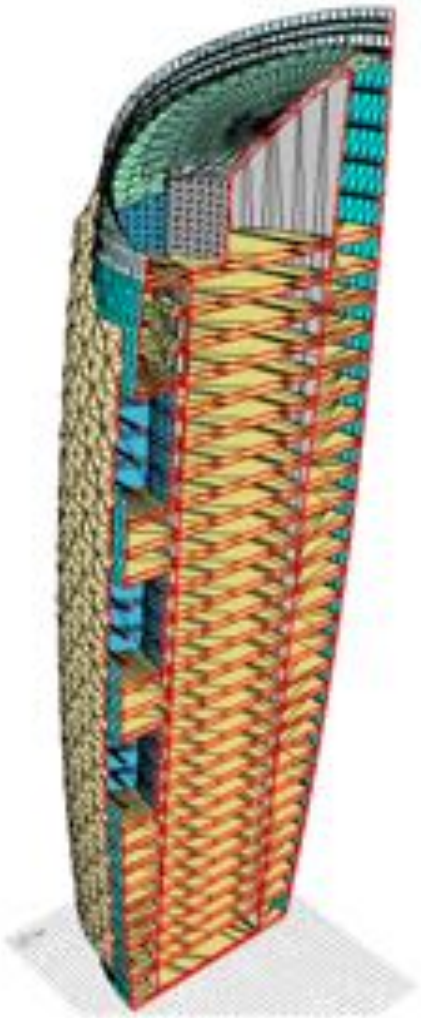
Protect against elements of nature

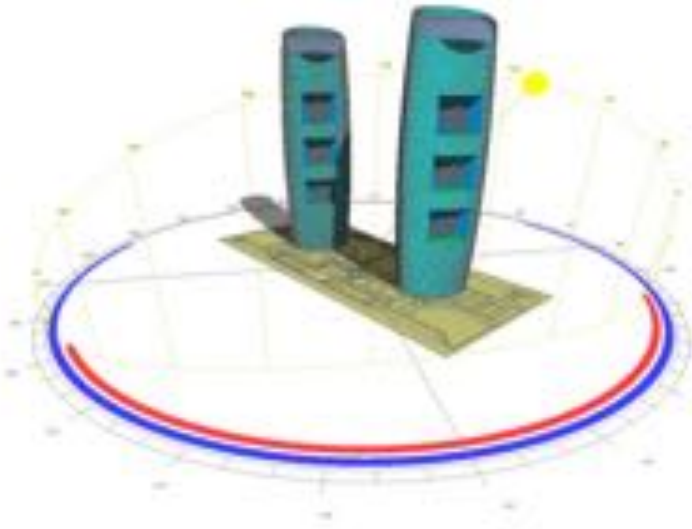
Biomimicking the Skin	Living Building Skin Aspect
Hair on epidermis protects from external elements	Sun shades; Wind & Rain protection; Filtration
Skin pigment to protect from UV	Glazing tints
Water resistant yet breathable, perspiration	Moisture control, Breathable membranes
Dermis fat cells protects from thermal fluctuations	Thermal control; Adaptive insulation; Phase change
Immune & nervous system sensitivity	Good air quality; Air tightness
Protection from injury & infection	Impact protection; Pollution protection

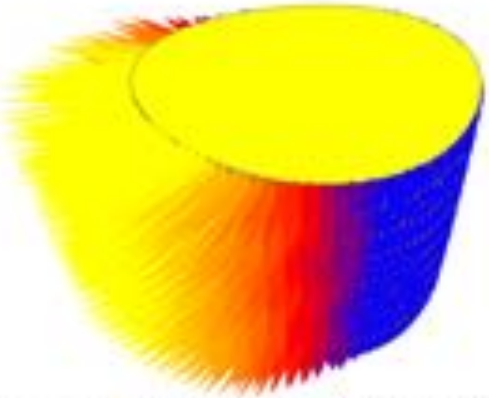


Responsive Facade (Shade) - Al Bahar Tower, Abu Dhabi

"The mashrabiya will reduce solar gain by 50% and improve lighting conditions inside by using a lighter tinted glass"

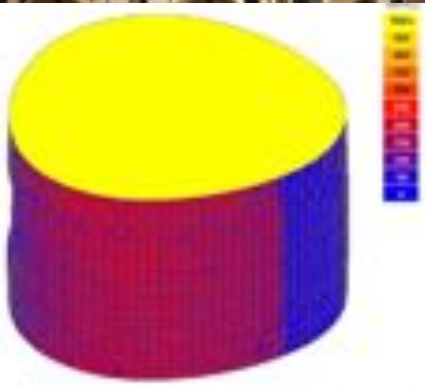






Summer, 9am – total solar radiation on the façade without Mashrabiya

Summer, 9am – view from the sun. 3D model with Mashrabiya



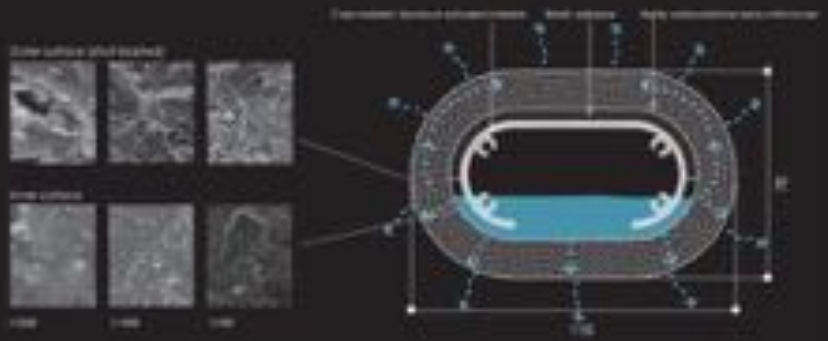
Summer, 9am – view from the sun. Solar radiation on the façade with the Mashrabiya

PV solar cells | solar shades | double skin/stack effect | natural circulation | protective/shaded form | hexagonal structure | shading effect | solar energy

Bio-skin - Sony Building, Osaka.
The surface temperature of the building enclosure can be reduced by as much as 12°C and its micro-climate by 2°C.

A primitive, but new technology:
Circulation of rainwater through perous ceramic tubes

ELEVATION

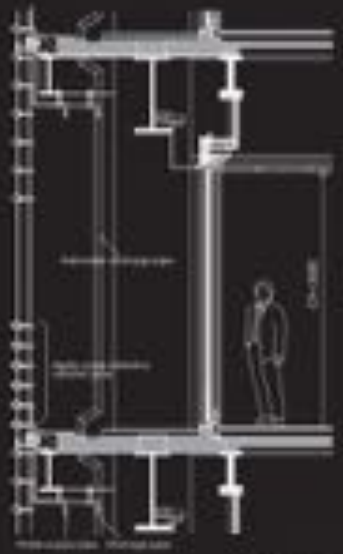


PHOTOMICROGRAPH

LOUVER SECTION

Porous ceramic pipes are made with soil. The rainwater collected from the surface of the rooftop and stored in the underground storage tank is pumped up and circulated through out the pipes that are connected in a **system** form. The rainwater penetrates the porous ceramic and then evaporates from the pipe surface, thereby cooling the surrounding air.

Restoring water circulation:
Revitalizing urban water retention capability



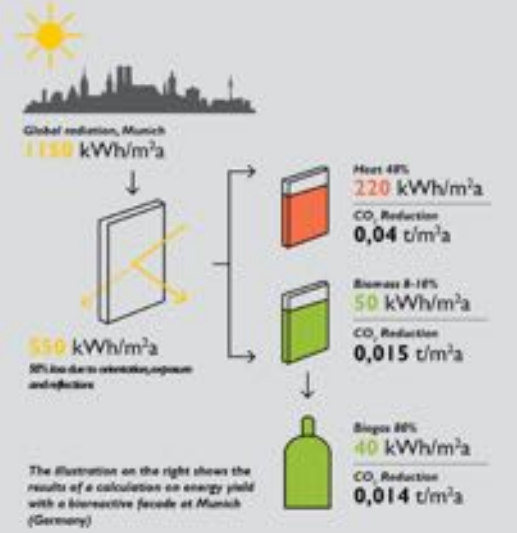
DETAIL 1:75

JOINT DETAIL

WATER CYCLE IN THE BUILDING

WATER CYCLE IN THE CITY

Rainwater is not discharged into sewerage immediately, but is retained in the outer surface of the building for evaporation. Excess water is impregnated in the soil of the planter as much as possible. This will result in the normalization of the water cycle and reduction in load on the sewage infrastructure in the urban environment.

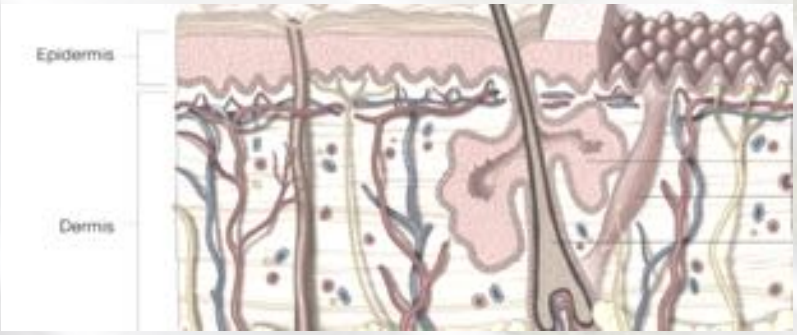

Global radiation, Munich
1150 kWh/m²a
550 kWh/m²a
Heat 48%
220 kWh/m²a
CO₂ Reduction
0,04 t/m²a
Biomass 8-18%
50 kWh/m²a
CO₂ Reduction
0,015 t/m²a
Biogas 80%
40 kWh/m²a
CO₂ Reduction
0,014 t/m²a
The illustration on the right shows the results of a calculation on energy yield with a bioreactive facade at Munich (Germany)

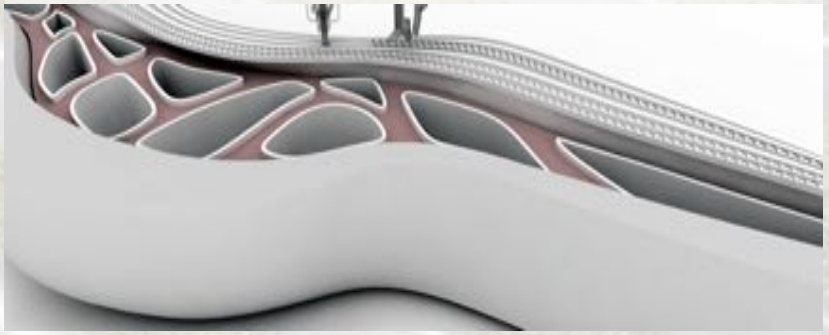
Biomimicking aspects of physiological wellbeing

Adapt

Change to seasonal stimuli to bring back equilibrium

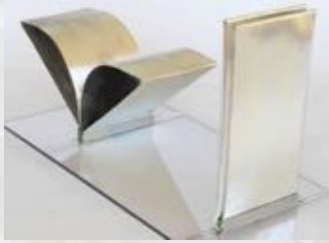
Biomimicking the Skin	**Living Building Skin Aspect**
Produce vitamin D with sunlight	Daylight modulation; Glare control
Blood vessels provide nutrition	Passive Comfort; Green facades;Urban farms
Feedback regulation for Physiological Adaptation	Comfort Conditions Adaptation, Climatic Sensors
Pores open and close for temperature and moisture regulation	Moisture and Ventillation Adaptation





Homeostatic Façade (Thermal & solar control)
New York, Decker and Yeadon

A dielectric elastomer that uses electricity to change shape. The electricity deforms the squiggles, expanding them when it's hot and sunny and contracting them when it's cold.



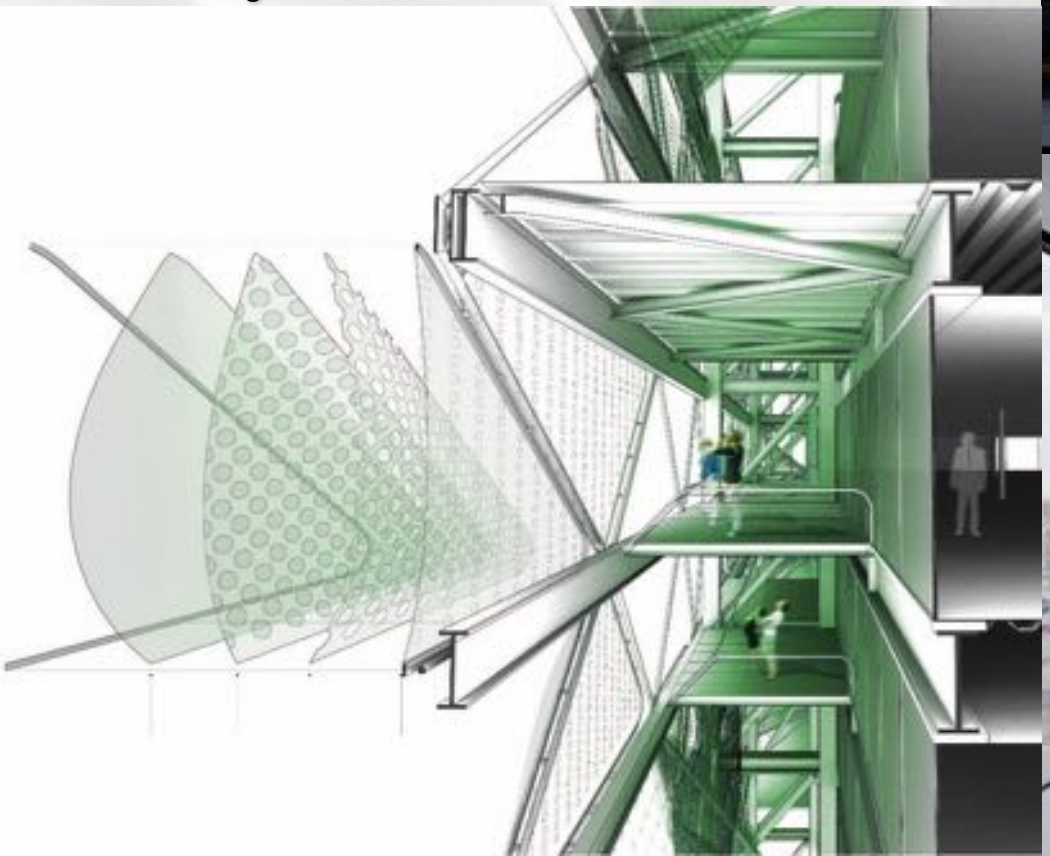
Inflatable skin - Media ICT building, Barcelona
Cloud 9, 2011

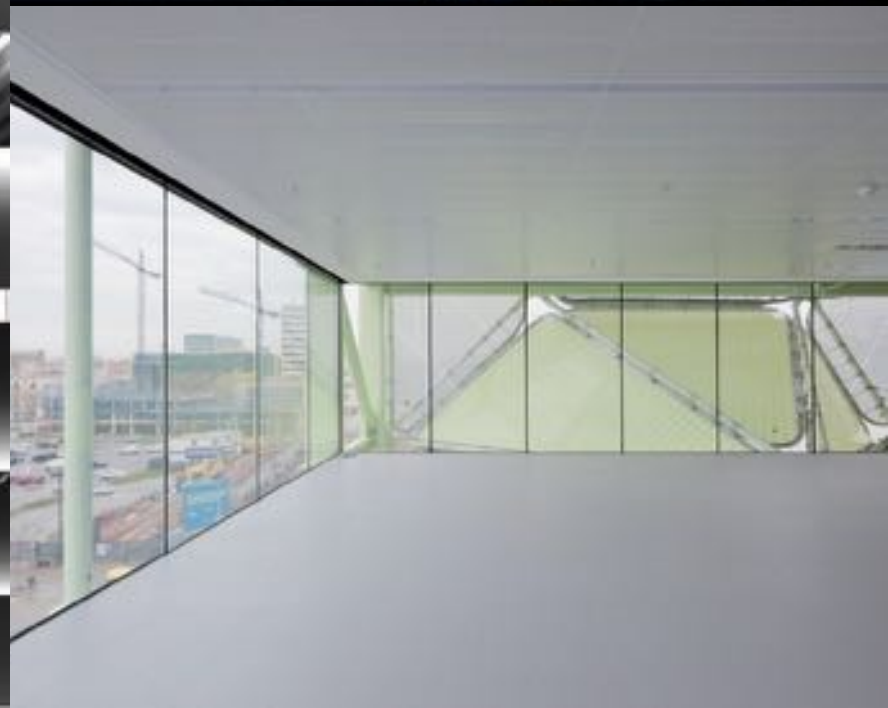
Temperature controlling ETFE skin that inflates and deflates to regulate interior climate.

The project's photovoltaic roof, ETFE skin, rainwater recycling, and district cooling makes it almost net zero, reducing carbon emissions by 95%.

In summer, the membrane acts as a sunscreen, filtering heat and UV rays by 85%. The filter is created by inflating the chambers with a fog-like Nitrogen mix, which block solar rays and creates cooling shade.

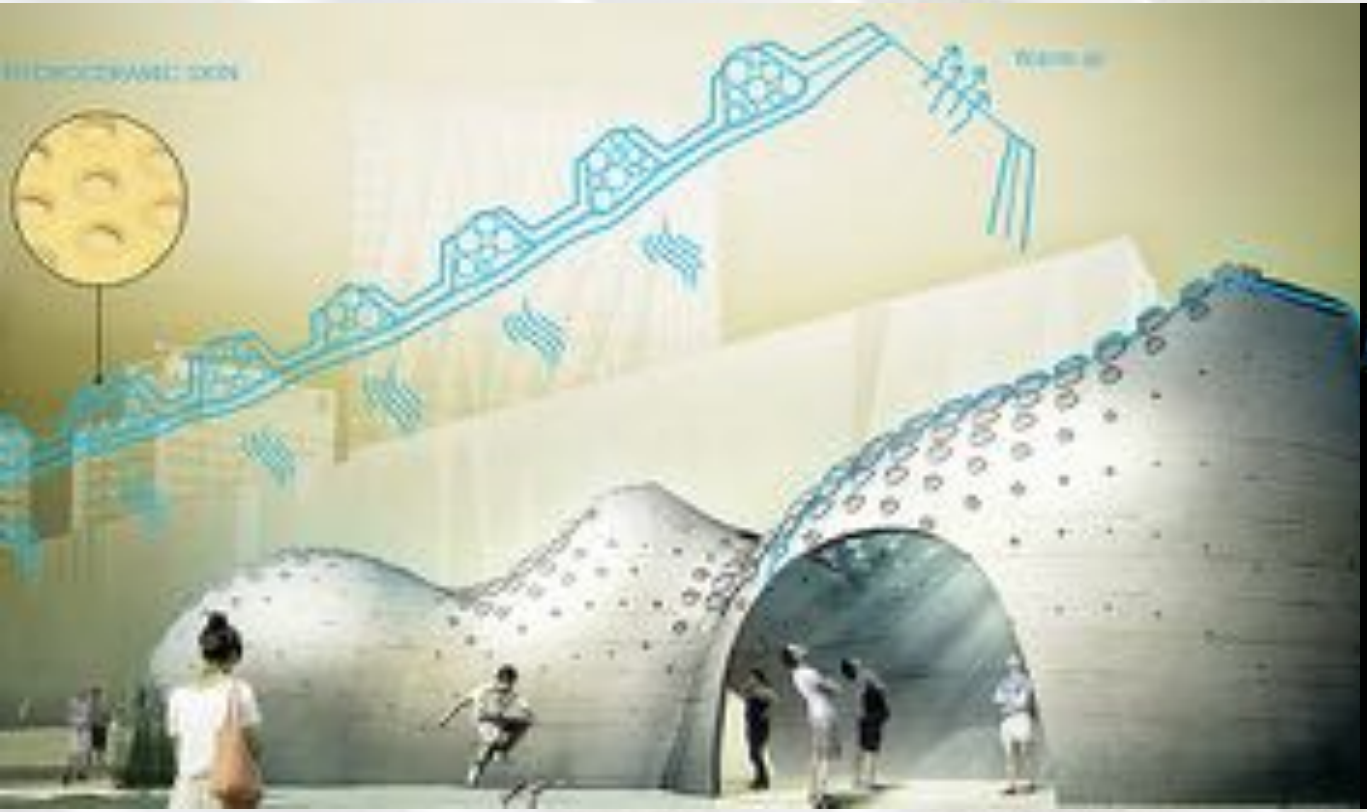
In winter, the membrane opens to soak up solar rays, maximizing the transmission of light and heat to the interior.





Adaptive Insulation - Phase Change Materials /Nano Cellular Foam/Aerogels

- An insulation able to modulate their thermal conductivity
- Capable of transferring/blocking desirable/undesirable heat and moisture control as required
- Reduce energy use
- Improve indoor environmental quality.



Biomimicking aspects of physiological wellbeing

Nurture

Homeostasis /equilibrium /wellbeing

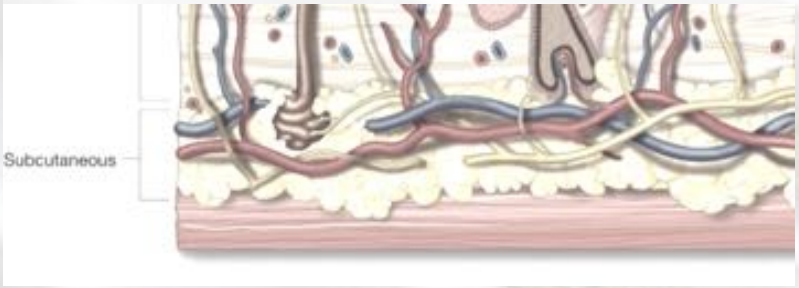
Biomimicking the Skin

Survival - Regulate body comfort by adapting to seasonal external stimuli.

Health & physiological wellbeing

Stretch surface area for growth/fat cells stores

Nurture with Nature



Living Building Skin Aspect

Seasonal Indoor comfort modulation; Bioclimatic Active & Passive Design

Wellness Design Standards – High quality internal environments

Adaptive Insulation; Seasonal thermal adptations

Green building envelope; Biophilic seasonal change; Green materials

Hygroscopic Anisotropy (Moisture control)
Department for Form Generation and Materialization (Achim Menges), HfG, Offenbach, Germany, 2006/2012

"Once exposed to changes in relative humidity, the 9 veneer composite patches swell or shrink and thus facilitate the opening and closure of each local component resulting in different degrees of porosity across the surface, which is both a structure and responsive skin.

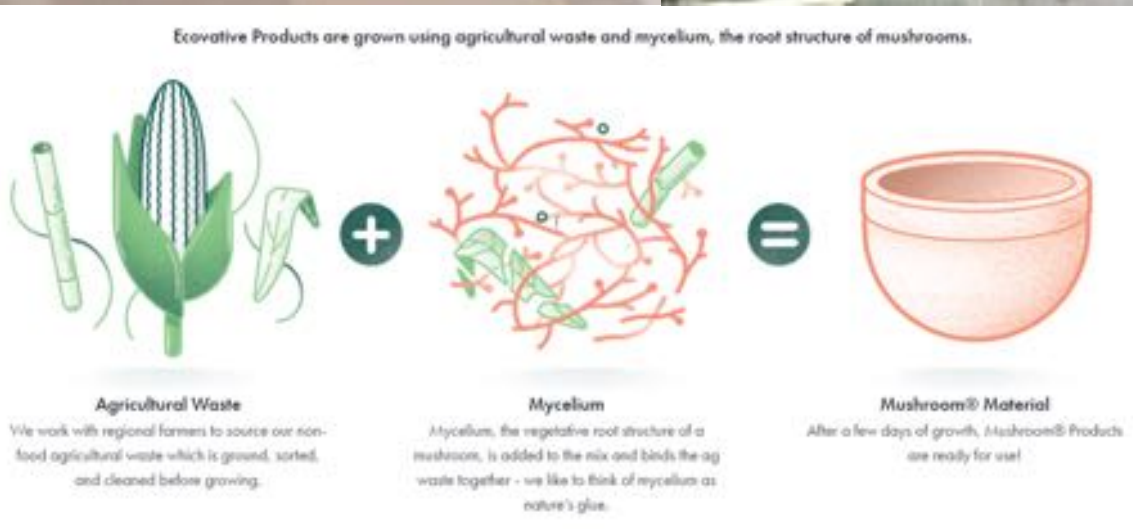
This high level of integration of form, structure and material performance enables a direct response to environmental influences without the need for additional electronic or mechanical control."

Green Building Envelope (Wellness through Biophilia)

ARUP

Mushroom Materials for insulation **(cyclical economy)**
Ecovative/ Greensulate

A biodegradable, ecologically sustainable material that is grown in the shape needed and can promote an environmentally sound cyclical economy.

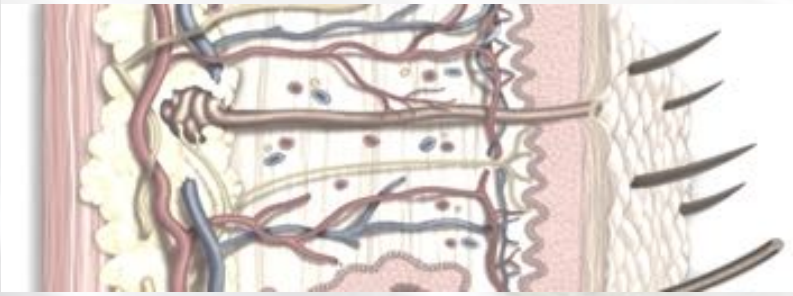


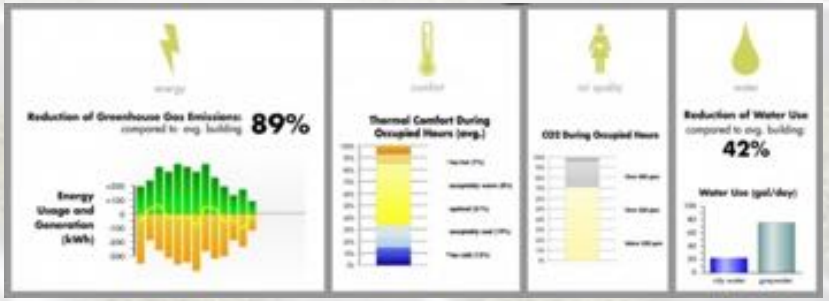
Biomimicking aspects of physiological wellbeing

Regenerate

Create energy and enhance ecology

Biomimicking the Skin	Living Building Skin Aspect
Regenerative skin	Self healing/self cleaning materials,
Spend energy from reserves, metabolism	On-site Renewable energy generation (BIPV, Wind)
Remove toxins, waste & energy recycle	Ecological enhancement, reduce pollution; Water, waste, energy, materials efficiency & recycle
Health and vitality	Cyclical economy; Green specification





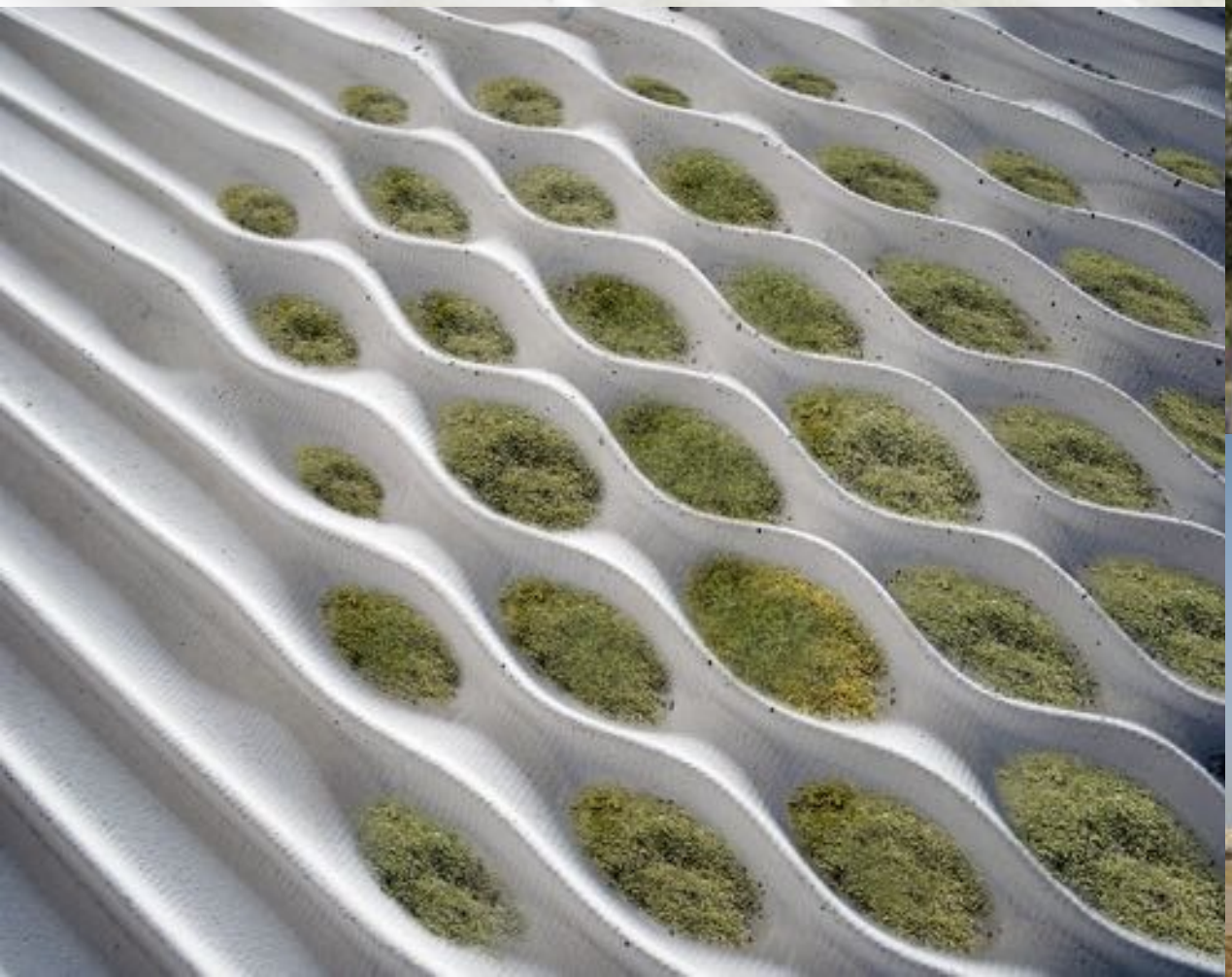
Solar Glass - BIPV

Bioreceptive Concrete (Symbiosis)

BiotA Lab, Bartlett School of Architecture,
SEED Research, 2015

A 3 layered biologically receptive concrete, favourable for microorganisms like cryptogamic cover surfaces (algae, mosses, lichens, etc.)

- The building's façade itself becomes the biological substratum for the growth of photosynthetic systems.
- It absorbs and therefore reduces atmospheric CO2
- It captures solar radiation, regulate thermal conductivity



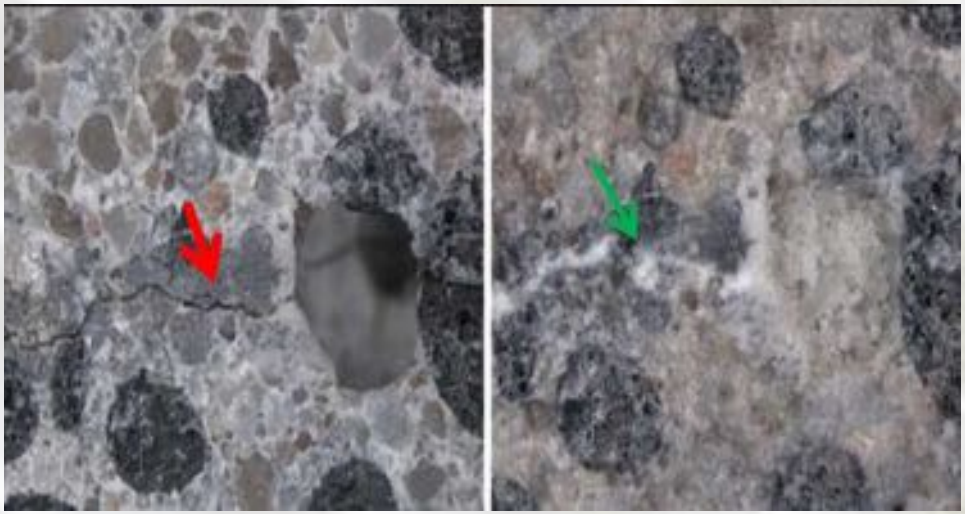
Bio Concrete (Self healing)

Syn.De.Bio, Civil Engineering & Geosciences (CEG)
Delft University of Technology, 2014

Biological materials and processes are integrated into traditional engineering materials and processes.

Self Healing concrete developed by microbiologists with special bacteria called extremophiles (because they love to live in extreme conditions) can actively produce copious amounts of limestone that can actively repair occurring cracks in a concrete structure.

This can lead to enormous savings on maintenance cost, lower demand for cement and lower CO2 emissions.



WHAT IS HAPPENING INSIDE BIO CONCRETE(MECHANISM)

❑The cracks are formed on the surface of concrete due to many reasons like shrinkage, Inadequate water for hydration ...ect,

❑The water is deliberately forced into the crack and the precursor is activated

$$Ca(C_3H_5O_2)_2 + 7O_2 \rightarrow CaCO_3 + 5CO_2 + 5H_2O$$

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$$

(carbonation)

❑The activated precursor intern induces the bacteria to react with that precursor and form a base of calcium carbonate called as limestone, the chemical equation is given above.

Environmental Design Excellence

The Crystal, London, U.K.

ARUP. LEED Platinum, BREEAM Outstanding, EPA A rated

- **90%** water self sufficient, Water Safety Plan
- 'All-electric' building, no fossil fuels used on site
- Seasonal energy storage through ground source
- All heating through Ground Source Heat Pump
- High efficiency BIPV produce **1/3rd** of all energy
- BMS control of internal environment by users
- Smart grid compatible for peak looping

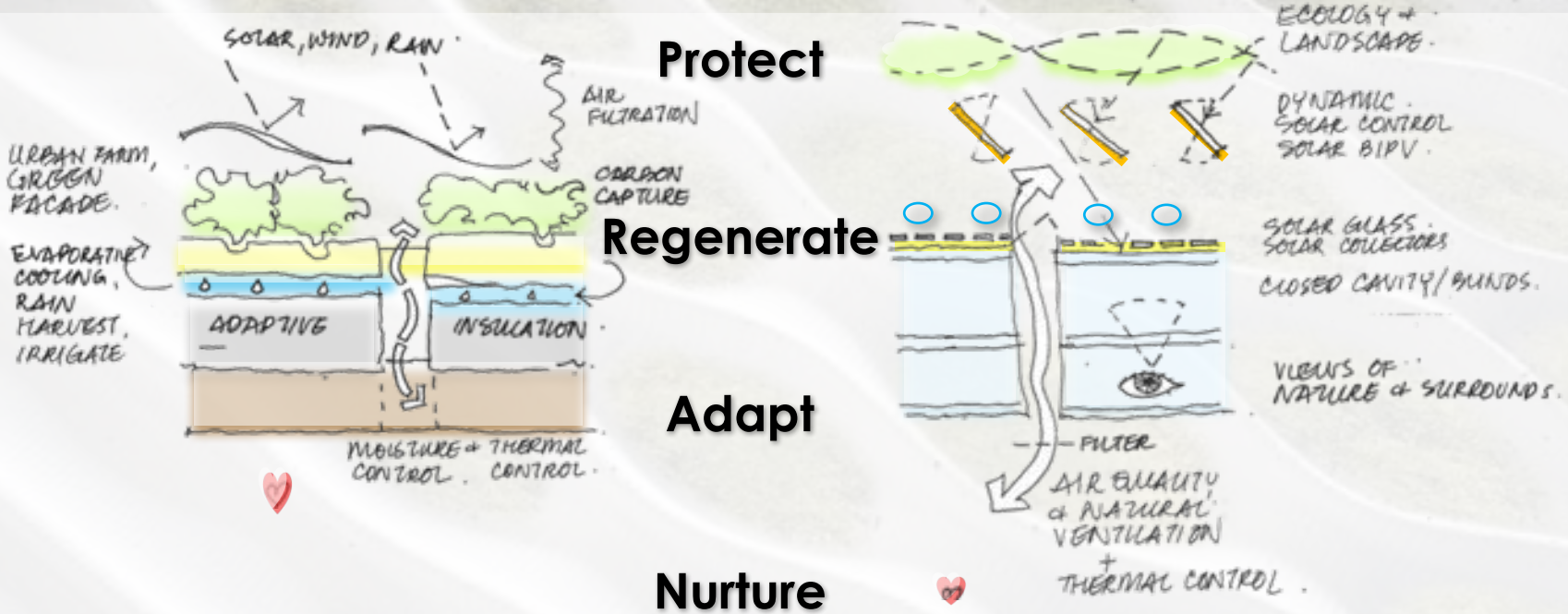
Net positive Healthy Building

Varennes Library, Montreal, Canada

Stantec. LEED Gold, 1st Institutional Net Zero Building in Canada

- Maximise daylight
- Automated Windows, air infiltration control,
- High quality insulation
- **15%** BIPV + **85%** thermal heat recovery (Passively heated air in roof void)
- **50%** reduced humidification needs
- Water based 152m deep Geothermal Wells
- Weather Station on roof connected to DALI control system
- Building uses **2%** of energy of similar buildings
- **75%** construction waste recycled
- Sustainable materials - wood

Concept of the "living building skin"



Protect

Regenerate

Adapt

Nurture

UN predicts by **2030**, 60% of the world's population will live in **urban** environments.

"Direct emissions from buildings have been **broadly flat** since 2012."

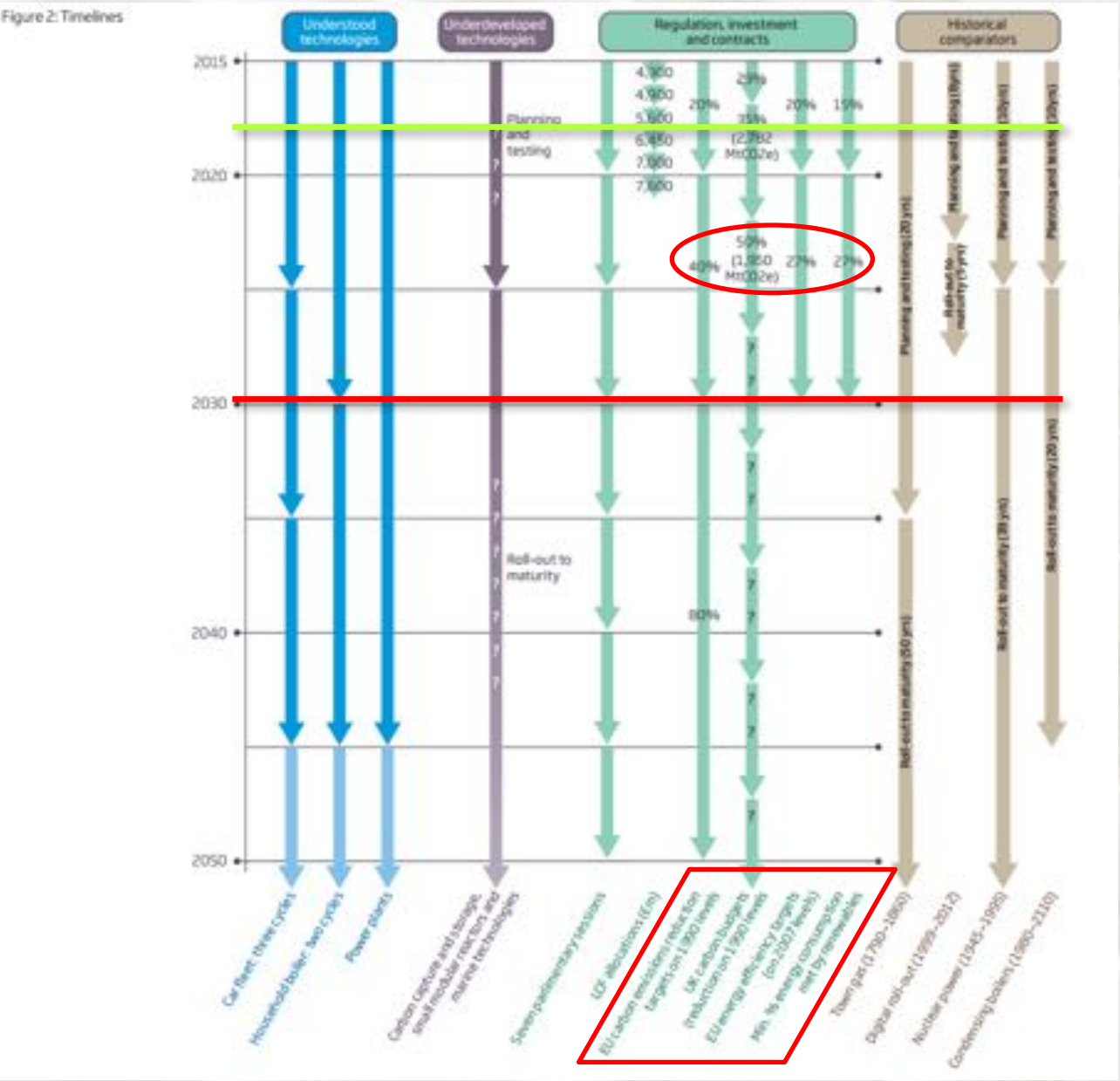
"Emissions from non-residential buildings have **shown little or no change** in recent years and increased in 2015."

Planned policies to 2020 are **insufficient** to meet required contributions for future carbon budgets."

Source: EU Energy
https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

Source: Committee on Climate Change, Progress Report 2016

What is Successful Sustainability?

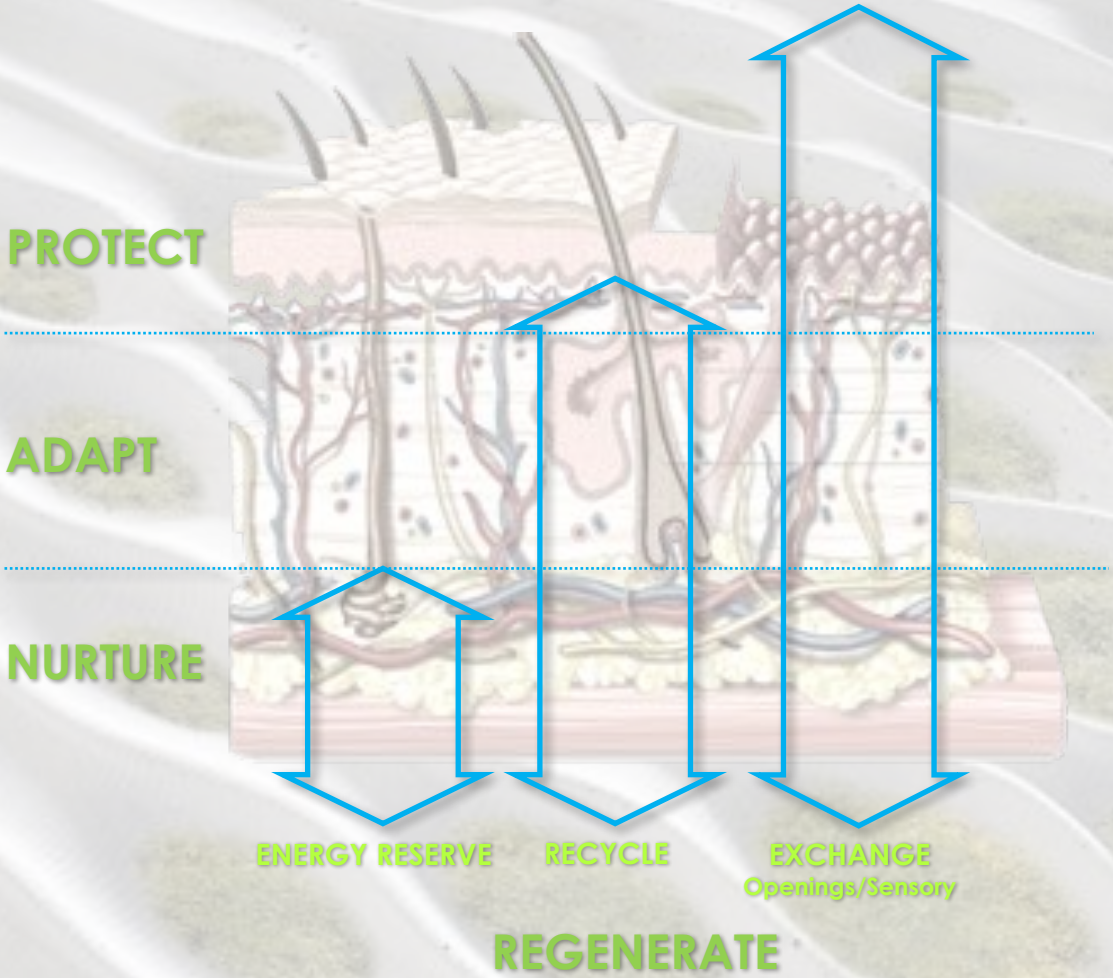


Historic technologies took **6 times longer** to reach maturity than our current expectations from technology to meet targets

Source: Critical time for UK Energy Policy, Royal Academy of Engineering, Oct 2015

“Energy is a Human Issue”

“Build Back Better” **“Transition Culture: Behavior Change”**



Thank You

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