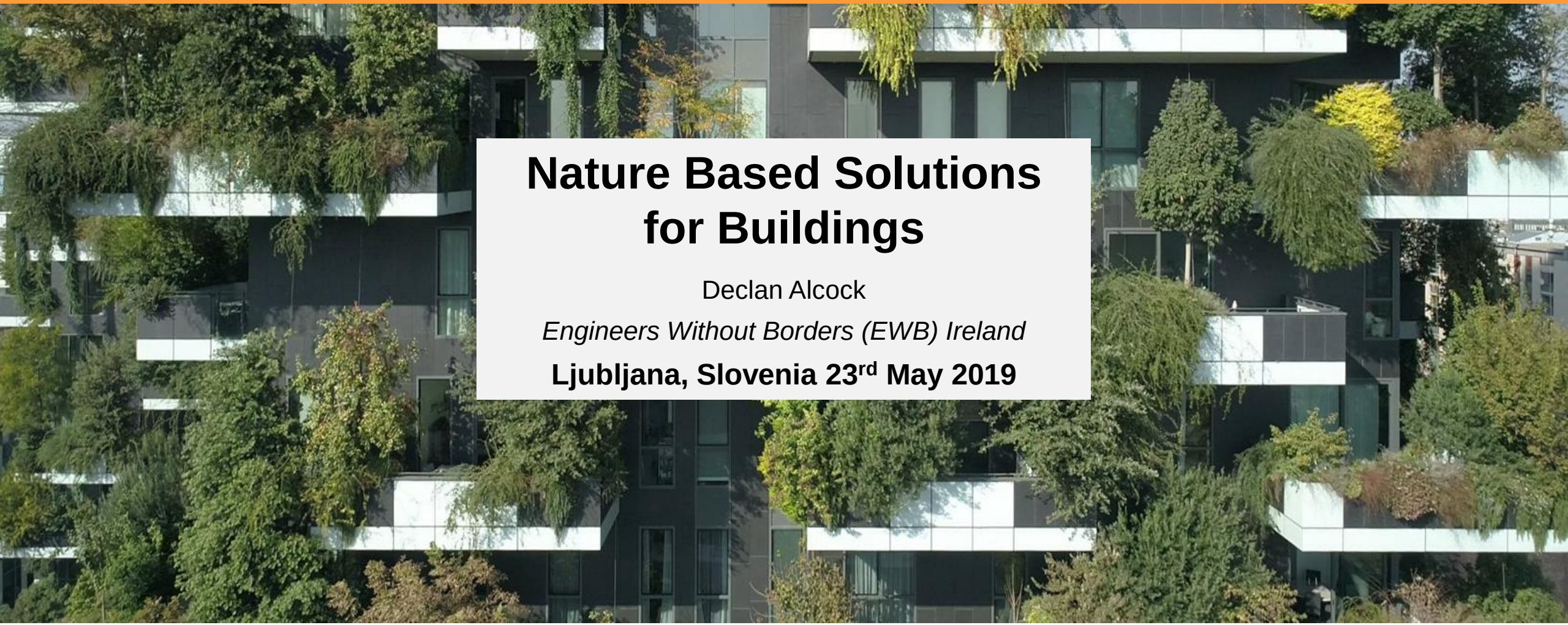
ARC

ACHIEVING RESILIENT CITIES & COMMUNITIES

Integrating Nature Based Solutions for Resilience

11 SUSTAINABLE CITIES AND COMMUNITIES



Nature Based Solutions for Buildings

Declan Alcock

Engineers Without Borders (EWB) Ireland

Ljubljana, Slovenia 23rd May 2019

Development Technology in the Community (DTC) Research Group

engineers without borders ireland

LIMNOS

SOLID GROUND
A GLOBAL ADVOCACY CAMPAIGN OF HABITAT FOR HUMANITY

This project is funded by the European Union

OLLSCOIL TEICNEOLAÍOCHTA BHAILE ÁTHA CLIATH
TU DUBLIN
TECHNOLOGICAL UNIVERSITY DUBLIN

Climate Change Mitigation

Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas emissions

UNFCCC COP 21

- Buildings offers one of the most ***cost-effective and economically beneficial paths for reducing energy demand and associated GHG emissions***

- Many solutions are available, and the ***economic, health, and social benefits of sustainable buildings are significant***, and have been demonstrated

EU Context

Buildings are central to the EU's energy efficiency policy, as they account for;

- 40% of final energy consumption
- 36% of CO2 emissions

Energy efficiency in the building sector has an important contribution to both;

- Energy security
- 2030 framework for climate and energy policy

Energy Security

53% of the EU-28's energy comes from countries outside the EU.

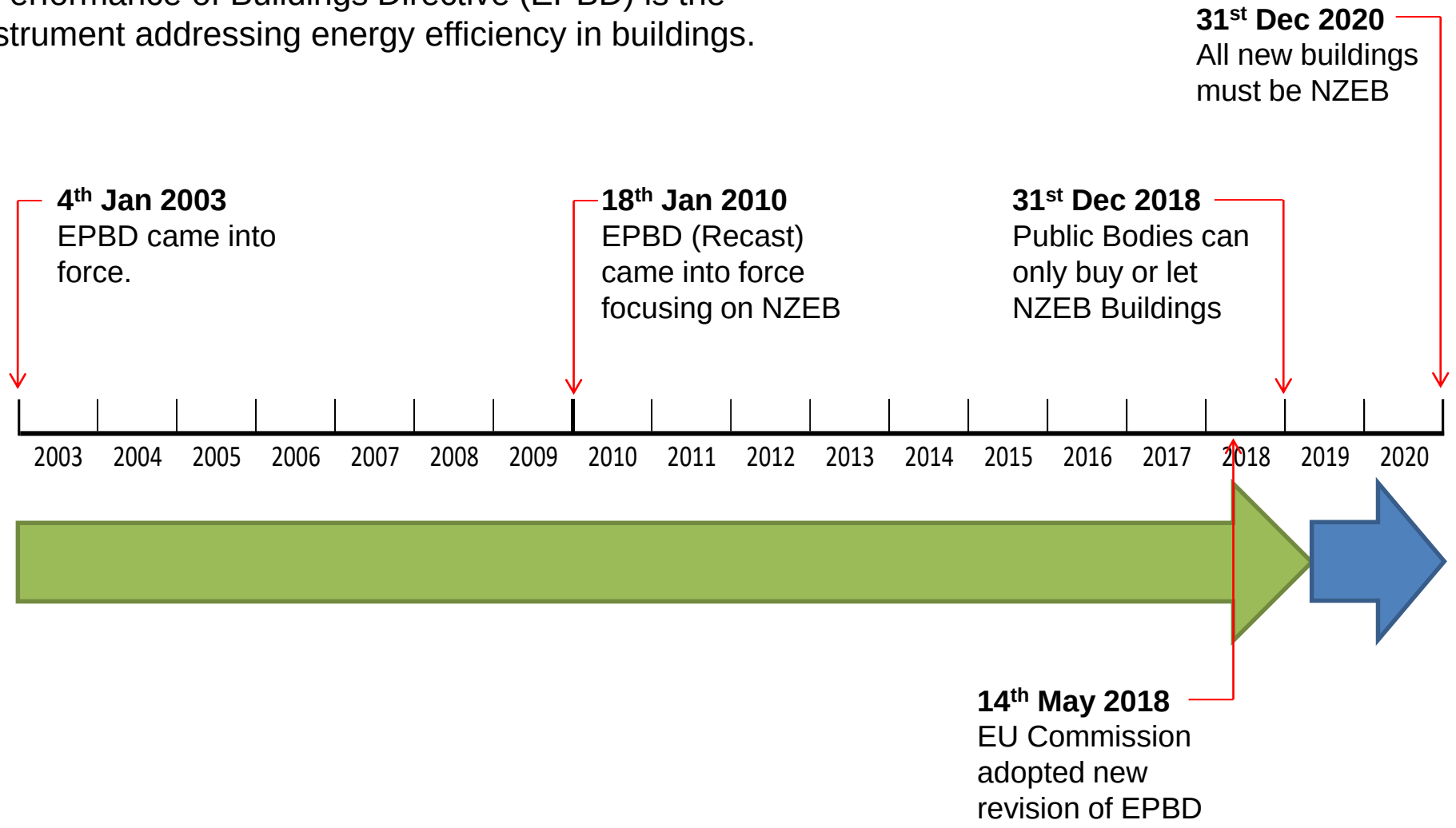
This costs more than €1billion per day, and this has been rising over recent decades.

- 90% of its crude oil
- 66% of its natural gas
- 42% of its coal and other solid fuels

Source: European Commission

European Energy Policy

The Energy Performance of Buildings Directive (EPBD) is the main legal instrument addressing energy efficiency in buildings.



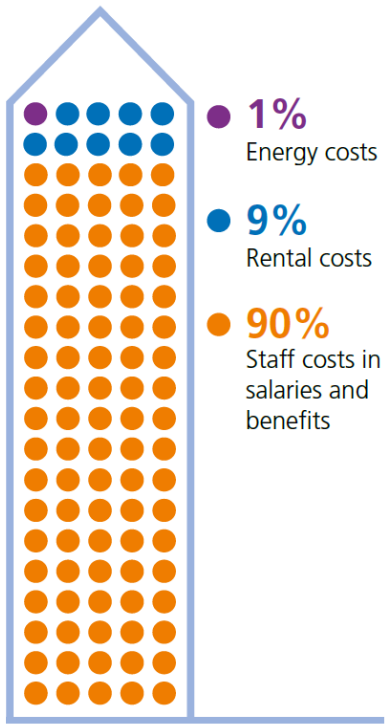
The Business Case for Green Building

People spend 90% of their time in buildings;

- The physical built environment, including things like temperature, lighting & air quality directly impacts health and wellbeing
- Staff costs are approximately 90% of business running costs
- Better staff health and wellbeing has a significant impact on reducing costs and therefore improving business performance
- Low carbon, resource efficient and environmentally sensitive buildings can enhance the health, wellbeing of building users

That is a very strong element of the business case for green buildings.

Typical business operating costs[1]



10% Variation

A 10% variation applied equally to each cost has a far from equal impact

+/– 0.1%
Energy costs

+/– 0.9%
Rental costs

+/– 9.0%
Staff costs

Source: World Green Building Council

The Business Case for Green Building

Commercial Property;

Certified Buildings (LEED, BREEAM, WELL etc.) are more attractive to clients;

- Retain their value (higher sales price & rental rates)
- They are more marketable
- Improved employee satisfaction and retention
- Improved employee productivity
- Improved working atmosphere/comfort helps in staff retention
- They have lower operating costs
- They have lower energy costs

Principles of Green Building

Sustainable Site

Optimise land use and development to reduce adverse impacts and minimize the building's ecological footprint

Energy Efficiency

Establish performance targets for intended use, occupancy and other energy operations for new construction and renovation projects

Water Efficiency

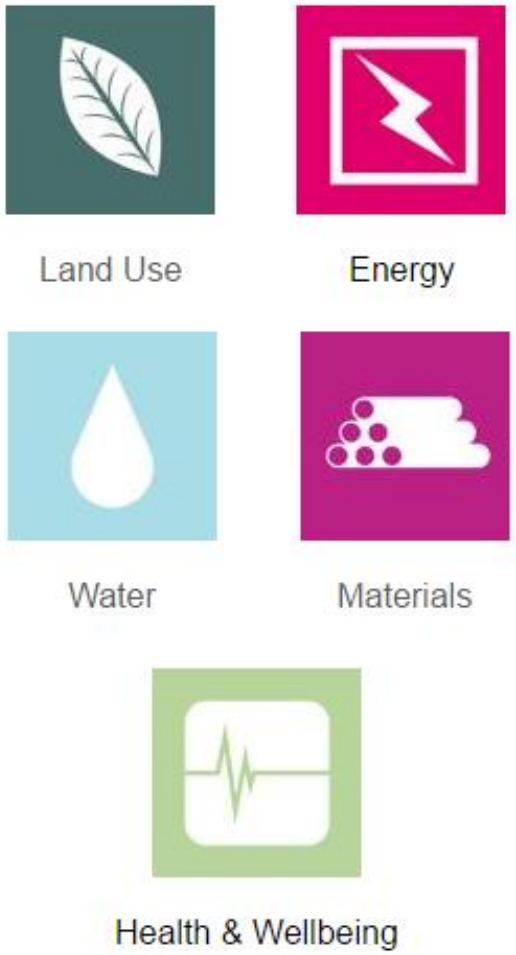
Decrease demands for fresh water and reduce the generation of wastewater through optimized landscaping, integrated rainwater catchments, gray water recycling, and wastewater treatment systems

Building Materials

Use sustainable construction materials and resources

Healthy Indoor Environmental Quality

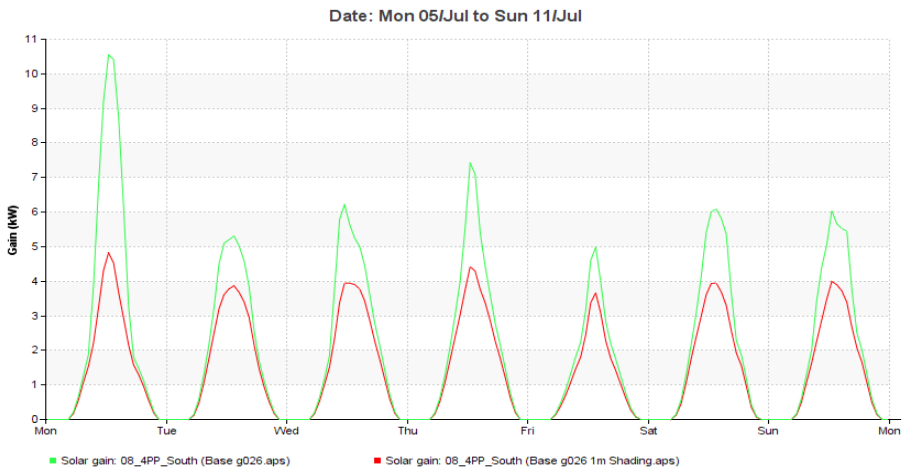
Enhance sustainable communities through ventilation and thermal comfort, moisture control, daylighting, and indoor air quality

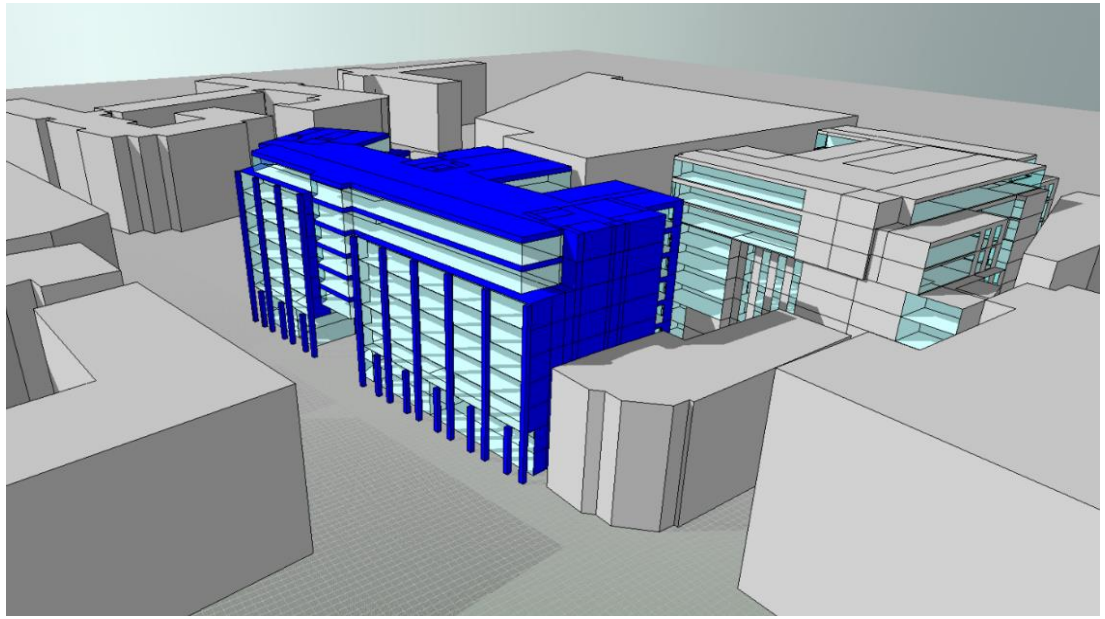


Principles of Green Building

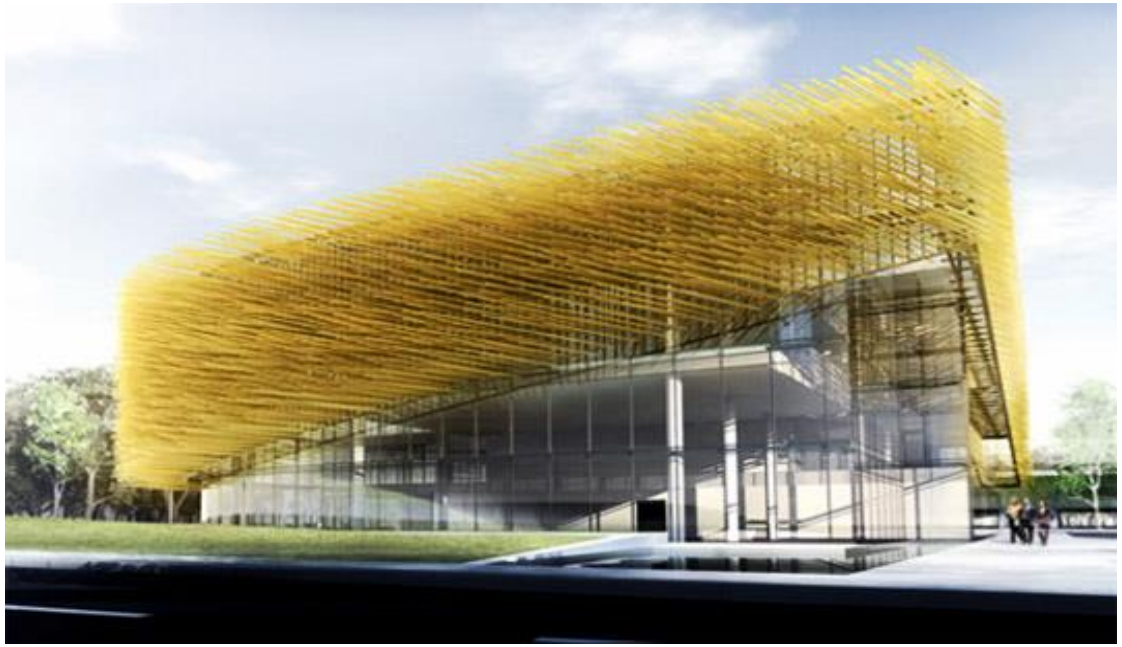
Passive Solar Design

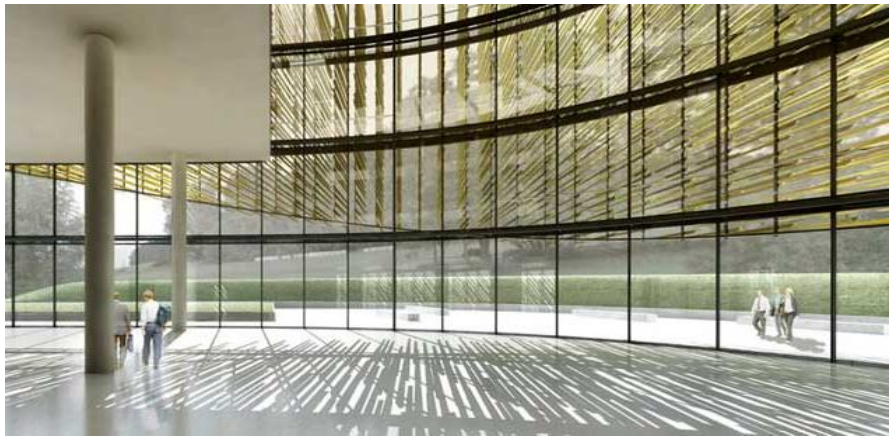
- Utilise solar gains in winter to reduce heating
- Avoid overheating in summer
- Improve thermal comfort of building users
- Reduce energy consumption and CO2 emissions





Principles of Green Building



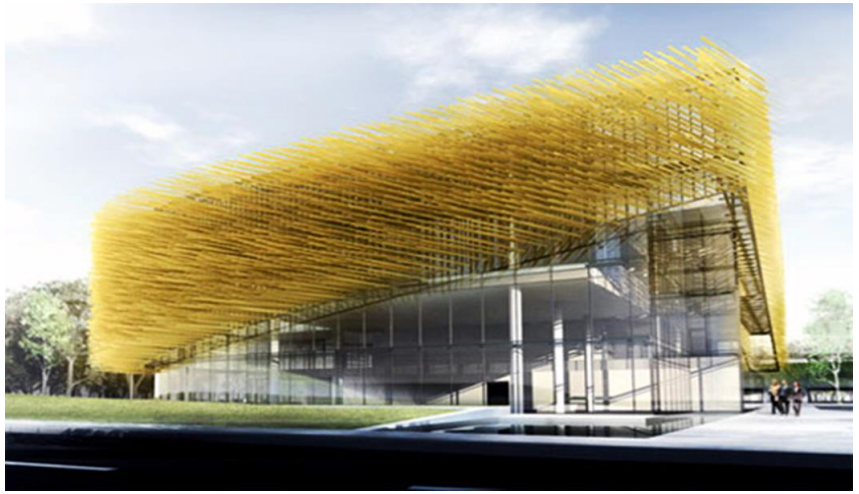


Solar Shading

- Anodised aluminium fins, cantilevered from vertical support brackets on all four façades of the building
- On the South West façade they act as a large scale brise soleil
- Early morning and winter sunlight can enter the building while in high summer sun is excluded

Source: Moxon Architects.

Principles of Green Building



Features	Trees	Aluminium Fins
Solar Shading	✓	✓
Prevent Glare	✓	✓
Good Daylight	✓	✓
Reduce Heat	✓	✓
Improve Air Quality	✓	-
Improve Biodiversity	✓	-
Environmental Impact	-	✓
• Extraction	-	✓
• Processing	-	✓
• Smelting	-	✓
• Manufacturing	-	✓
• Transport	-	✓

Buildings as Climate Modifiers

The Purpose of a Building

From earliest times buildings, or shelters, aimed to mitigate the worst climatic extremes of hot, cold, wind and rain

As a result they can be termed **“Climate Modifiers”.**

Different approaches developed to the problem of trying to remain depending on the local climate and the raw materials available to builders

We can learn how best to avoid adverse climatic effects and how to capitalise on beneficial aspects of the climate by studying indigenous buildings

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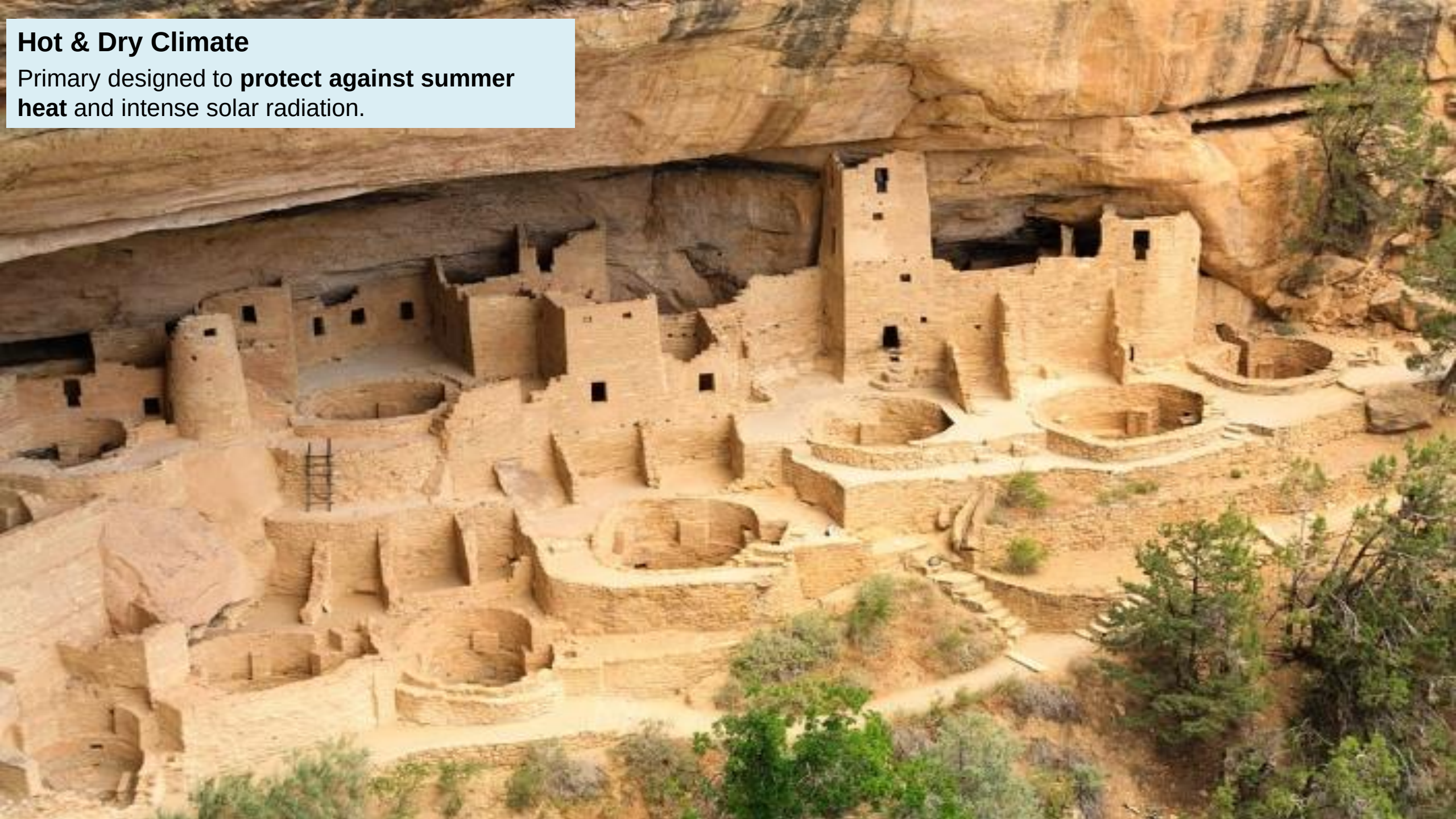
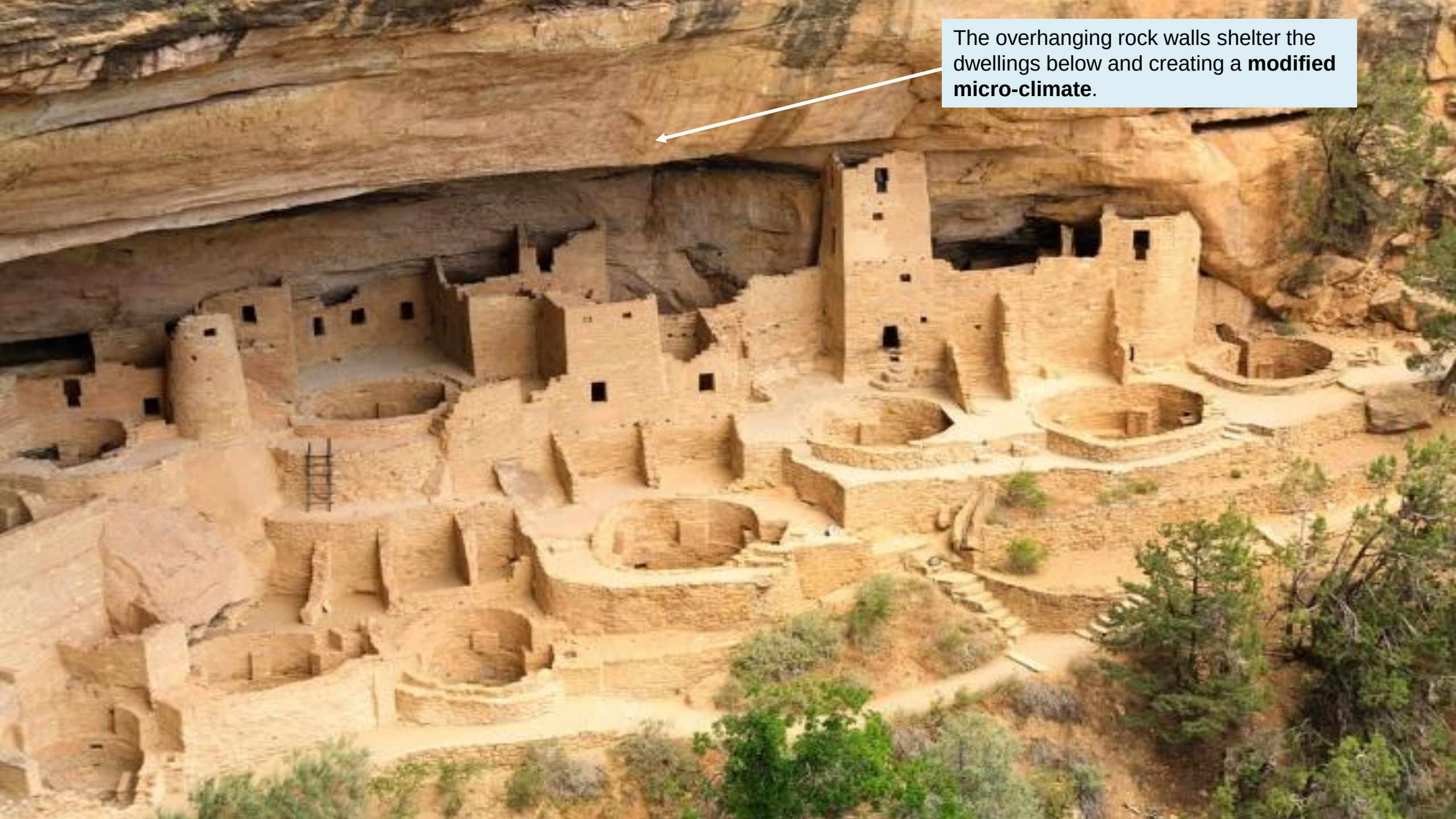
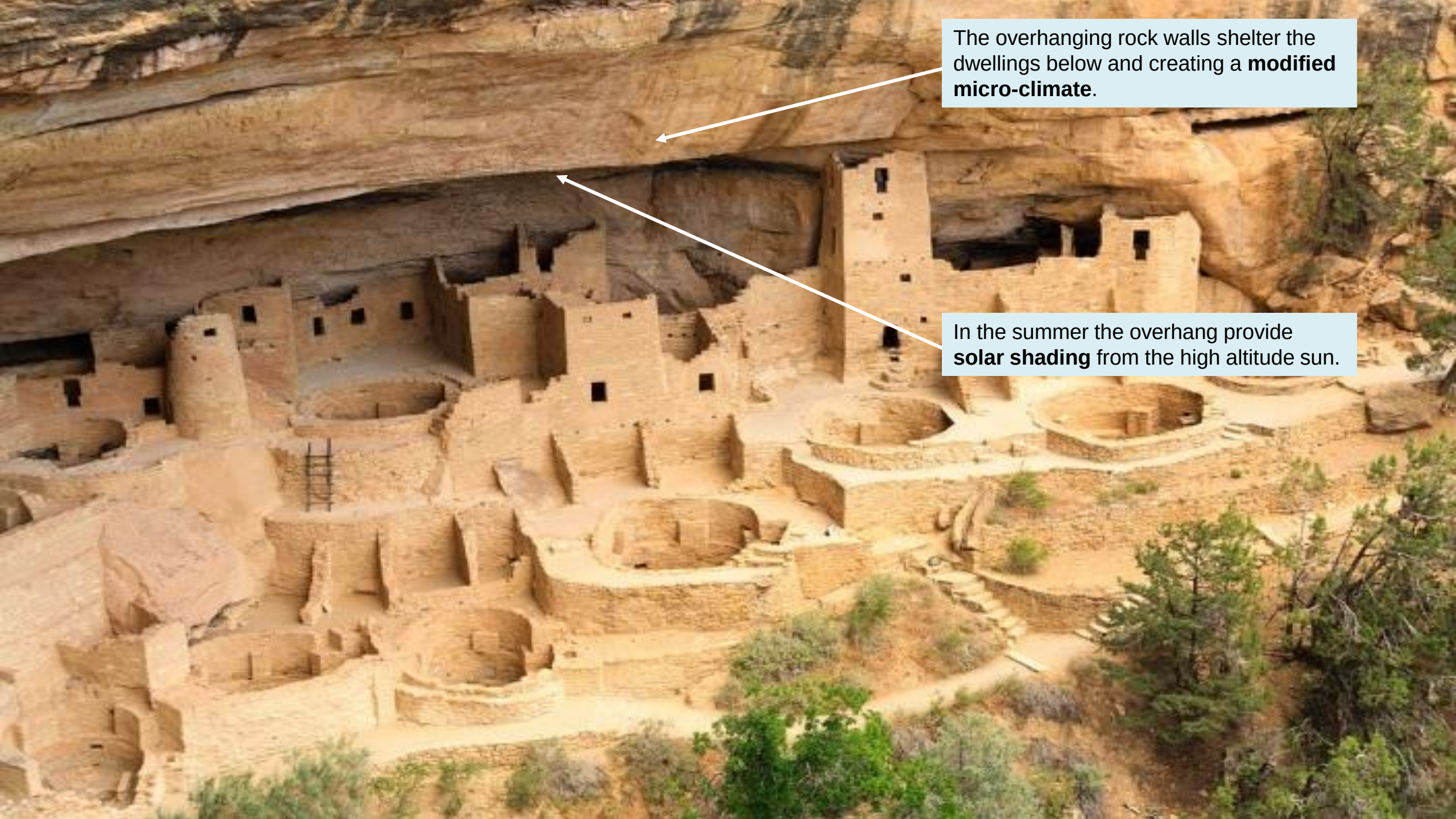
Hot & Dry Climate

Primary designed to **protect against summer heat** and intense solar radiation.




The overhanging rock walls shelter the dwellings below and creating a **modified micro-climate**.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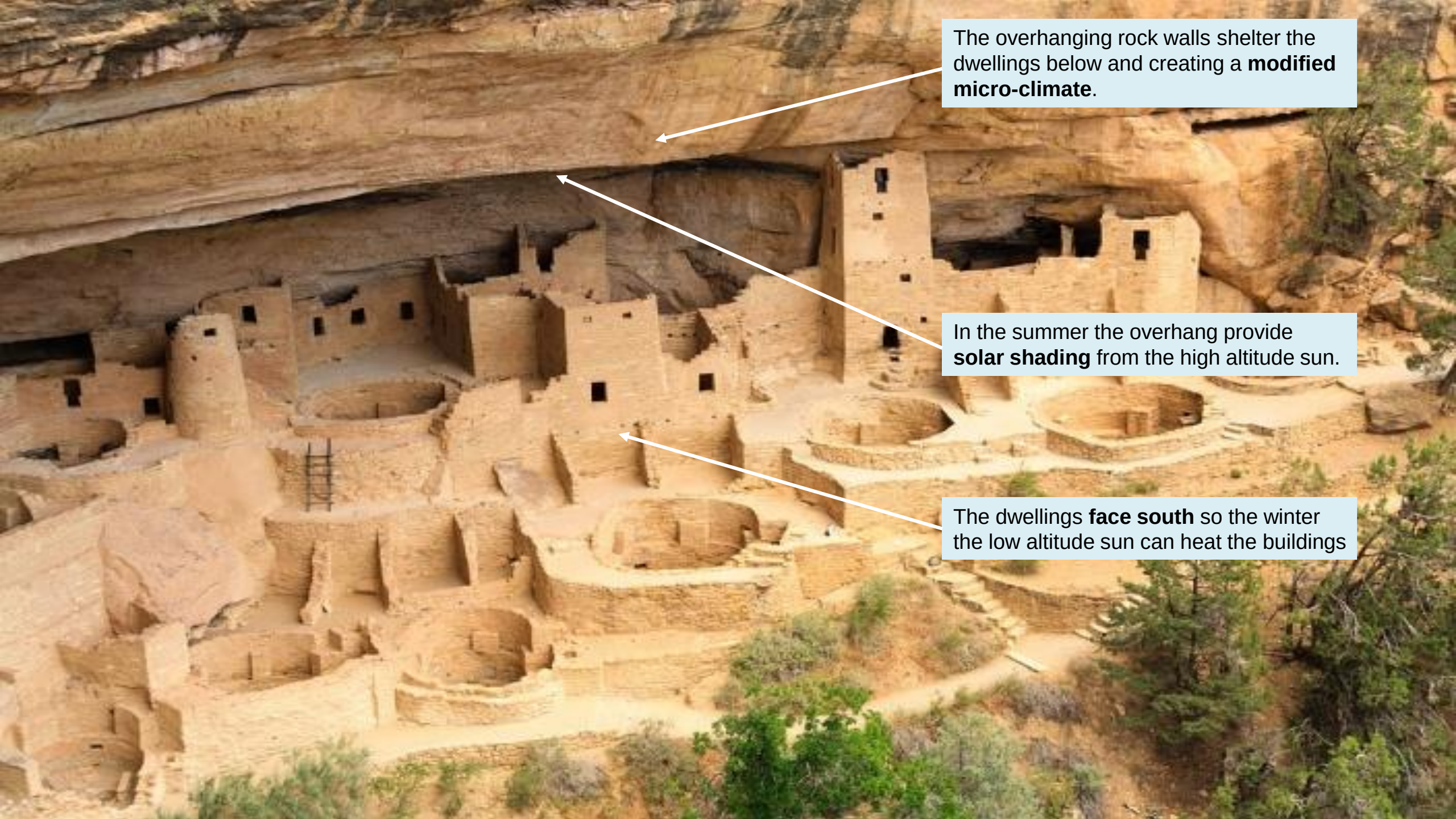
In the summer the overhang provide **solar shading** from the high altitude sun.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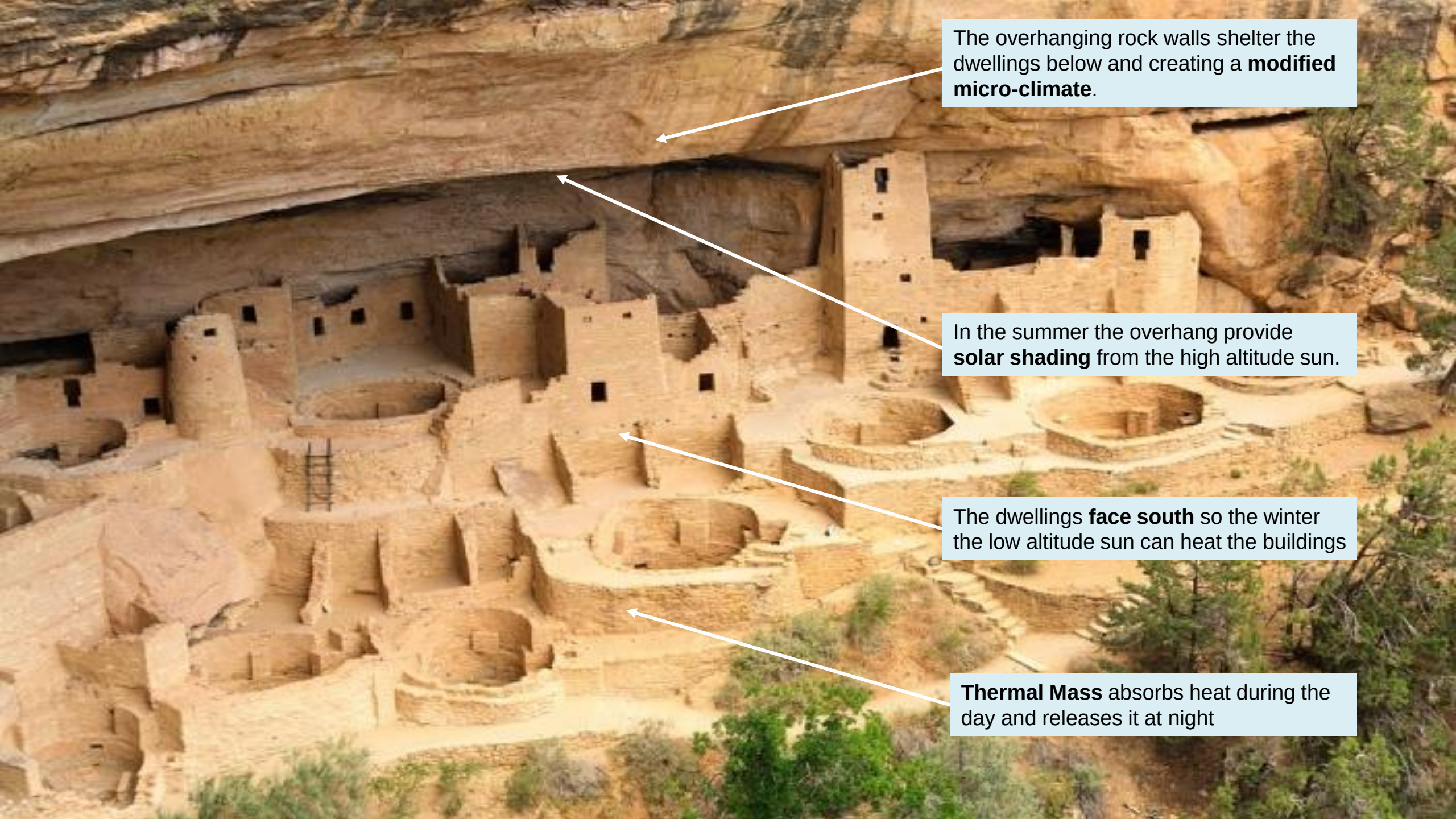
The dwellings **face south** so the winter the low altitude sun can heat the buildings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In the summer the overhang provide **solar shading** from the high altitude sun.
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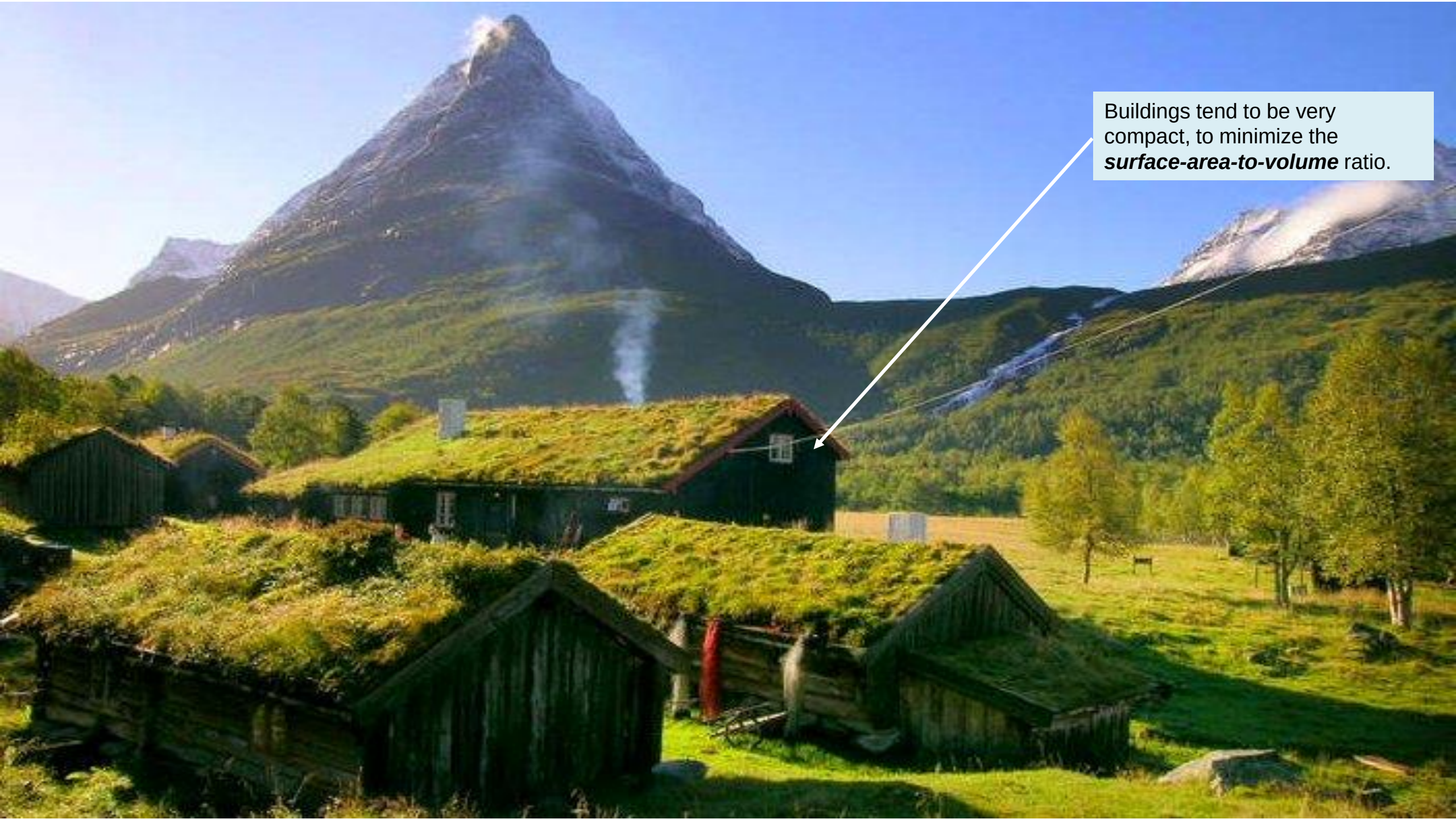
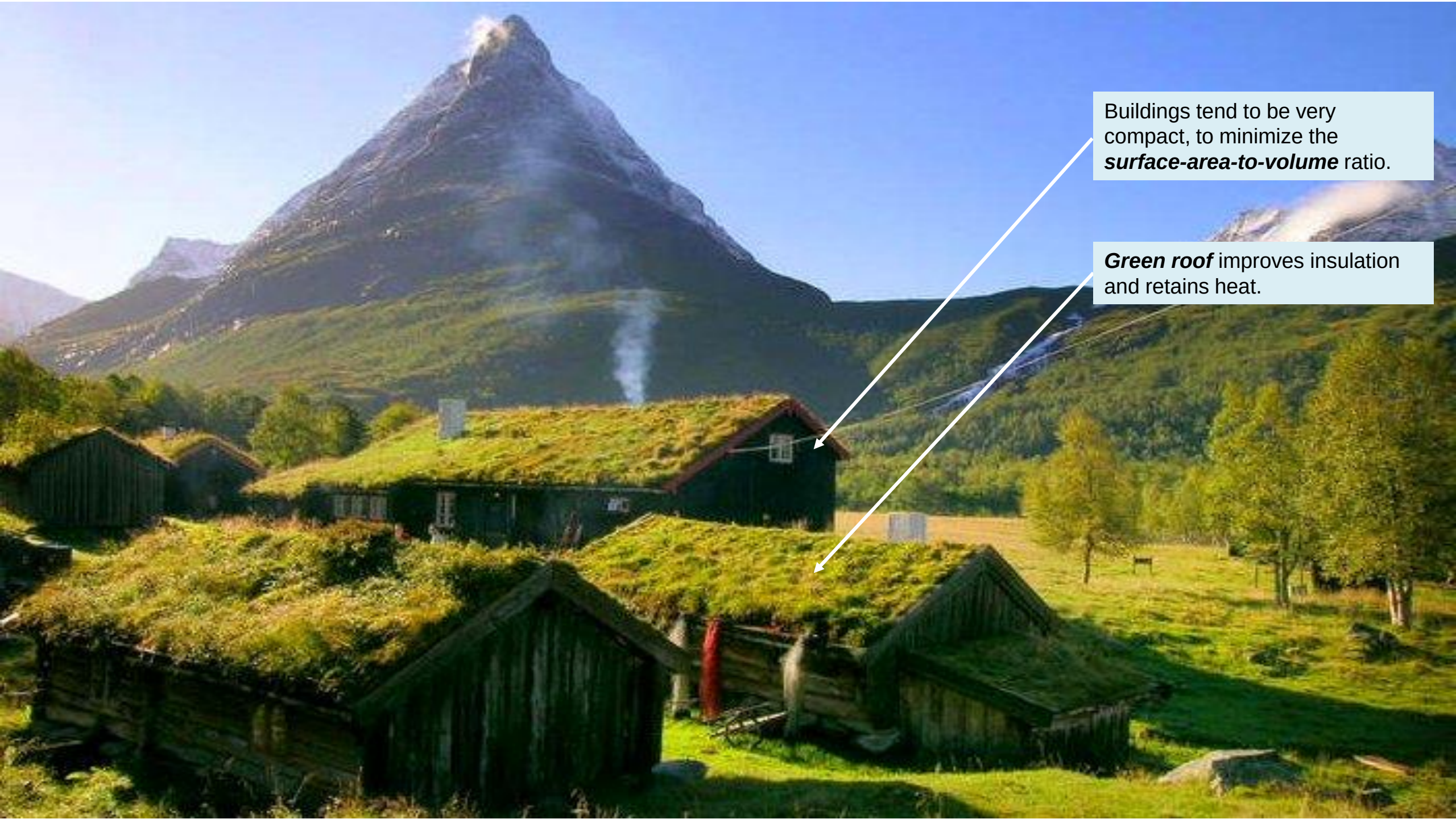
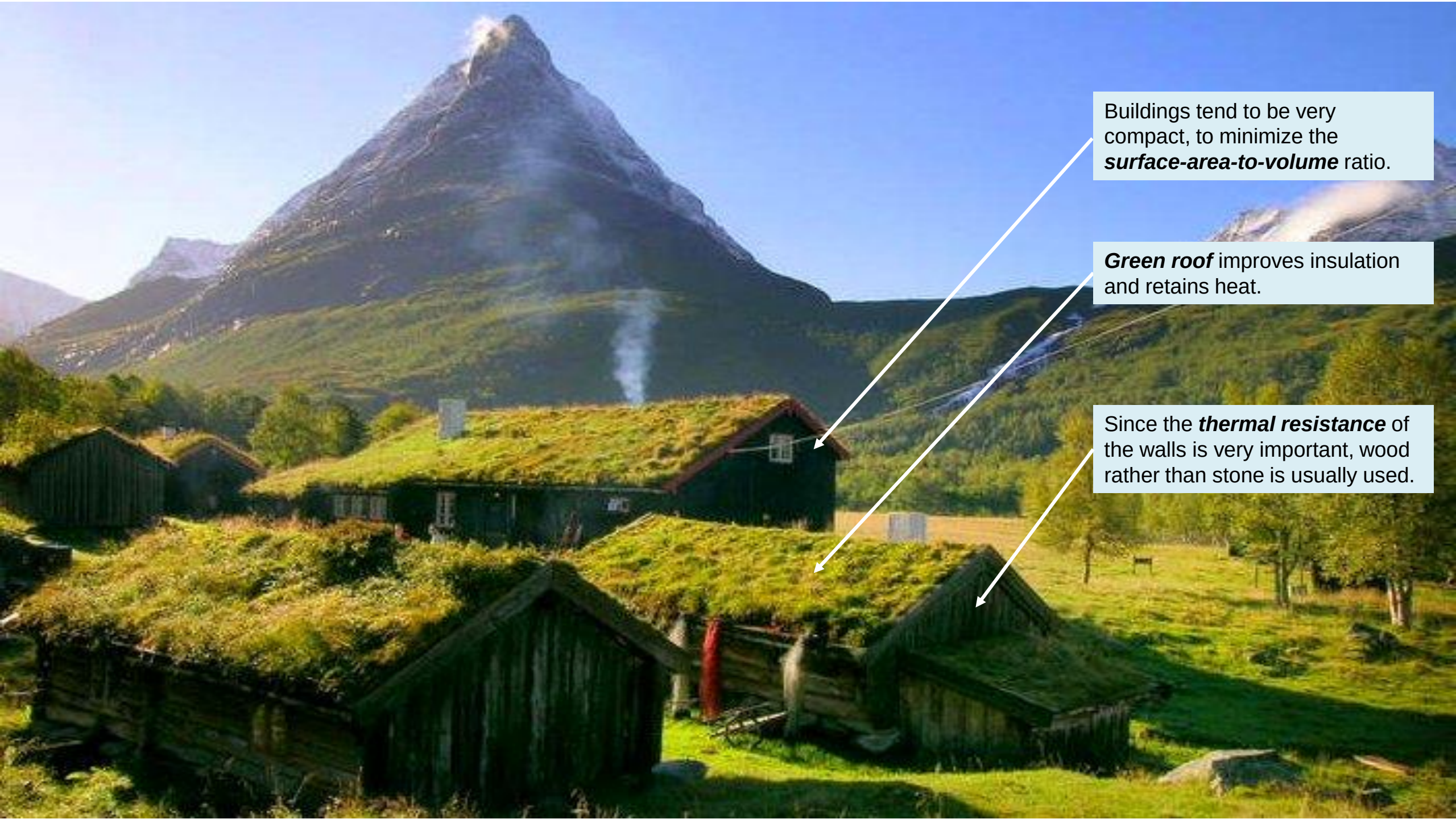
Thermal Mass absorbs heat during the day and releases it at night

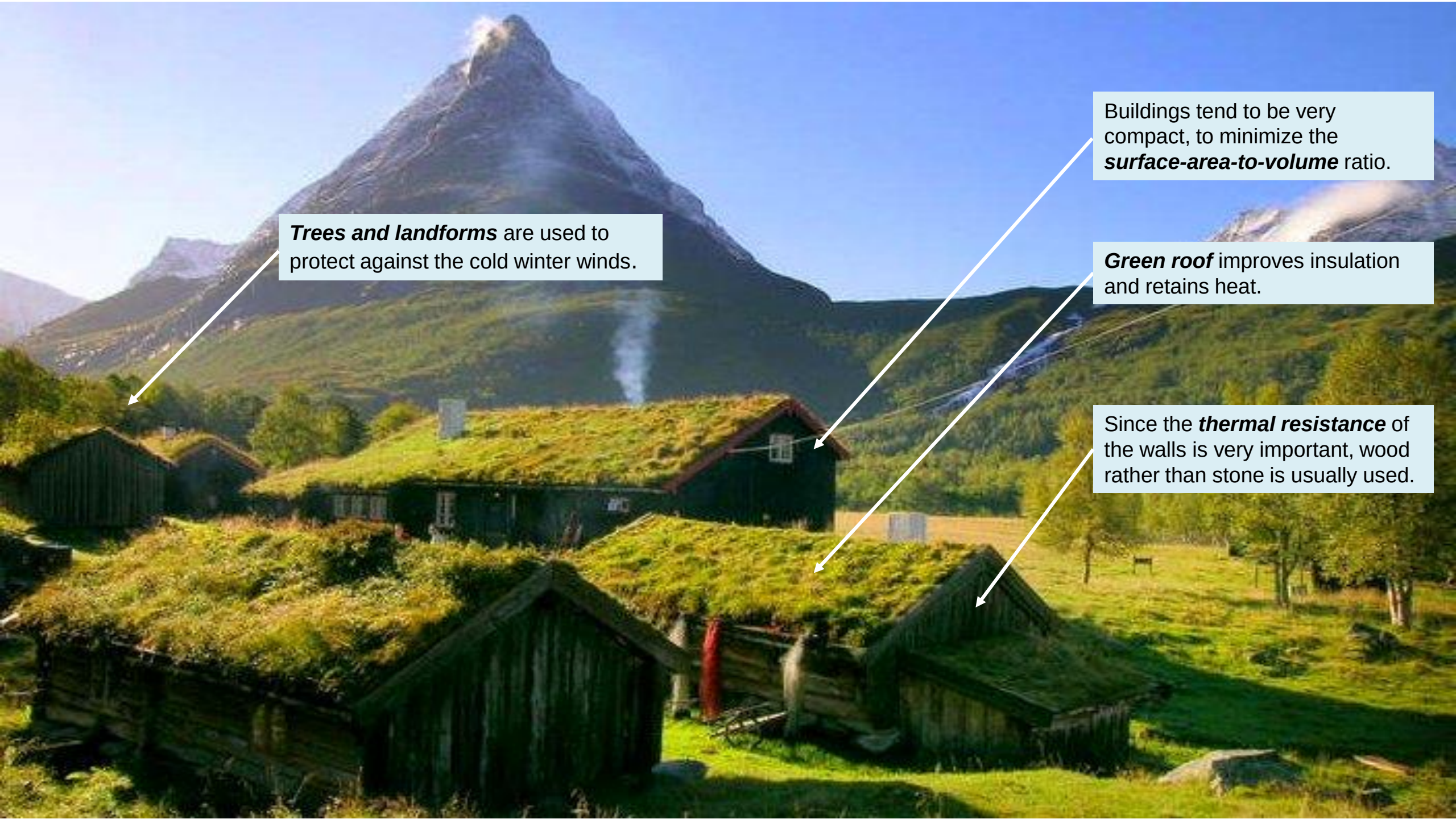
Cold Climate

The emphasis is on **heat retention**


Buildings tend to be very compact, to minimize the ***surface-area-to-volume*** ratio.


Buildings tend to be very compact, to minimize the ***surface-area-to-volume*** ratio.
Green roof improves insulation and retains heat.


Buildings tend to be very compact, to minimize the ***surface-area-to-volume*** ratio.
Green roof improves insulation and retains heat.
Since the ***thermal resistance*** of the walls is very important, wood rather than stone is usually used.


Buildings tend to be very compact, to minimize the ***surface-area-to-volume*** ratio.
Trees and landforms are used to protect against the cold winter winds.
Green roof improves insulation and retains heat.
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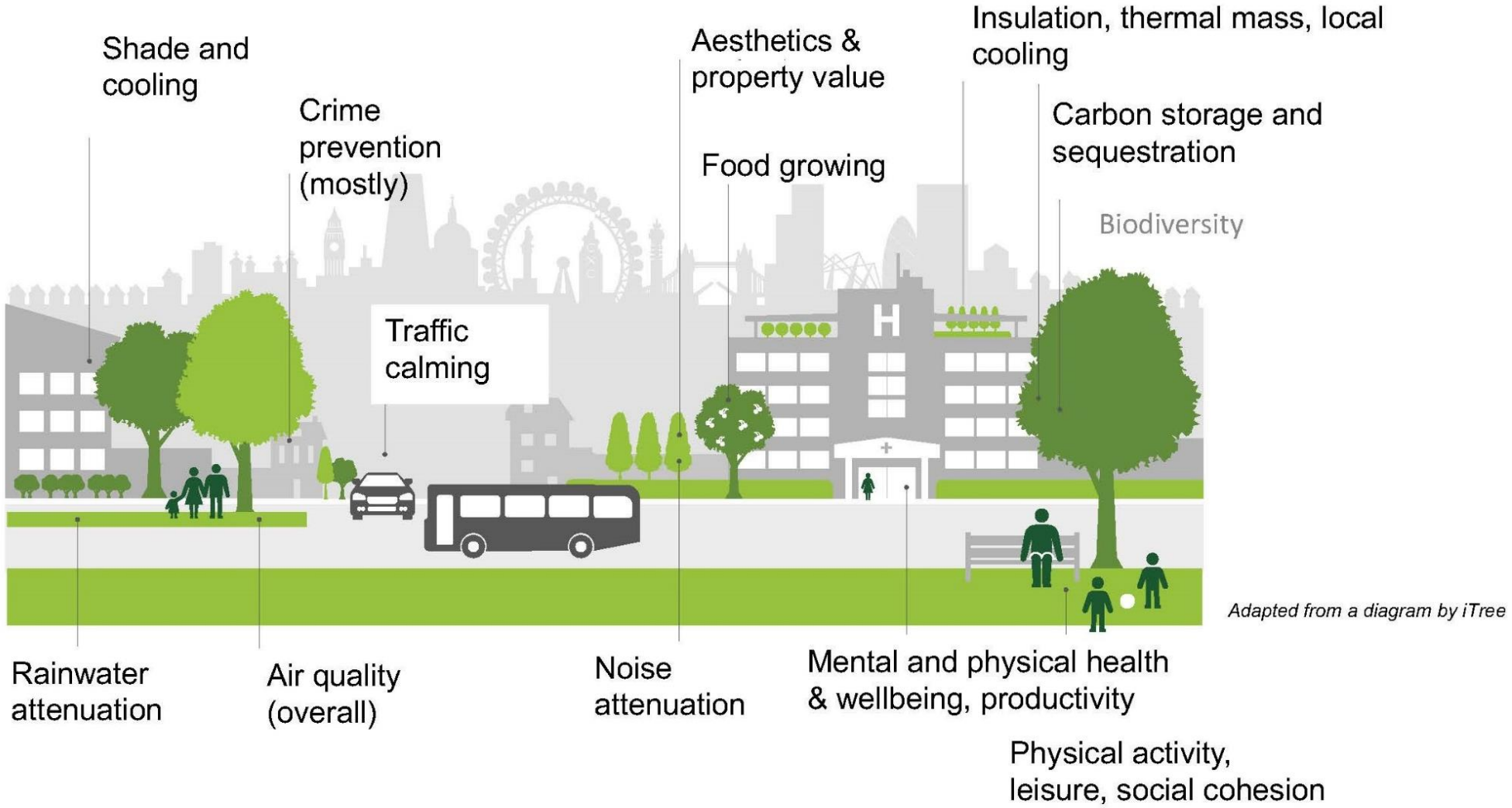
Benefits of Green Infrastructure



Adapted from a diagram by iTree

Benefits of Green Infrastructure

Green roofs, roof gardens, balcony gardens, green facades / walls in buildings, results in:

- Reduces the Urban Heat Island Effect
- Improving air quality
- Absorbing CO2 emissions
- Sustainable drainage
- Reducing noise pollution
- Enhancing urban biodiversity by providing habitats
- Reduced heating and cooling costs saving energy and CO2 emissions
- Protects roof materials from exposure to UV and damage caused by expansion and contraction
- Provides a connection with nature and improves health & wellbeing

Benefits of Green Infrastructure

Climate Change Adaptation

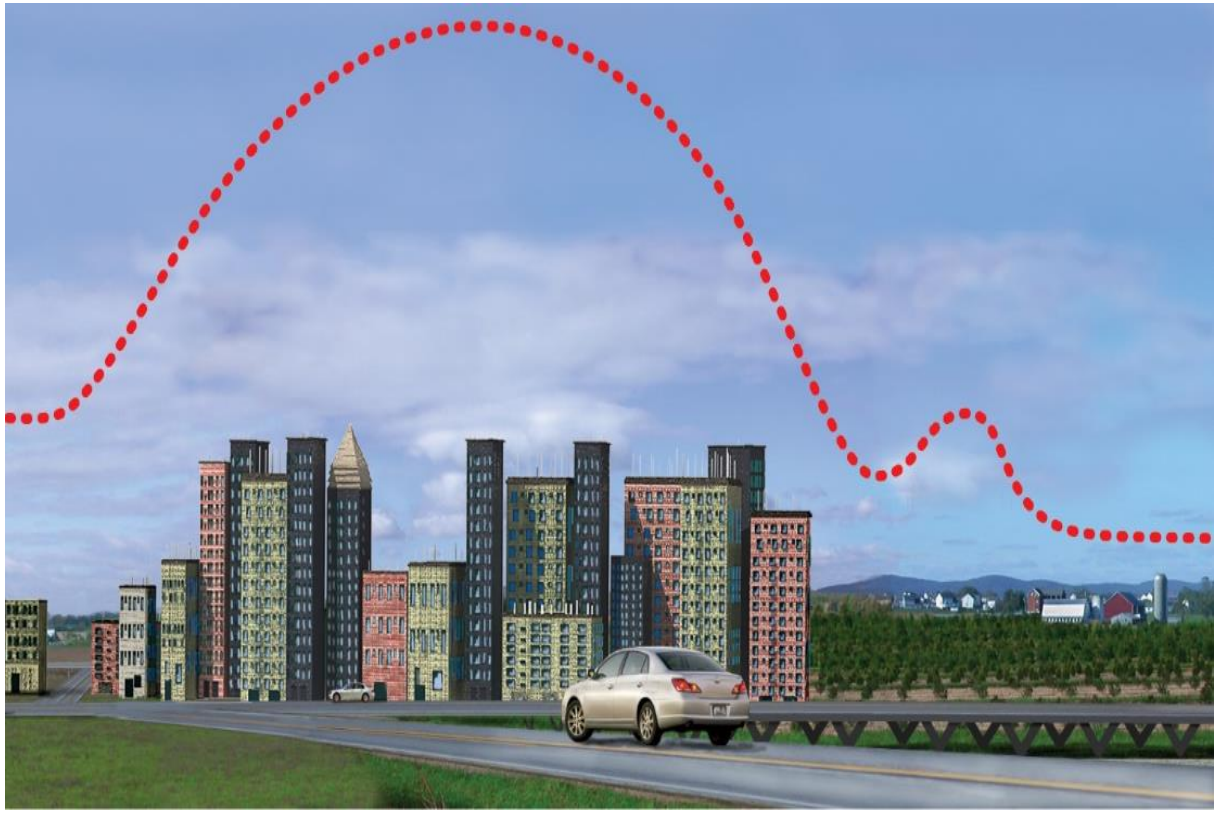
Urban Heat Island

Cities use a lot of concrete for buildings, asphalt for roofs, footpath, roads etc. which absorbs and retains solar radiation

Urban surfaces can convert up to 95% of the solar radiation into heat and in large cities this can result in a 4°C variation between the city and surrounding areas

Warmer air in urban areas increases at night as heat is released from infrastructure

As temperatures increase mitigating UHI will become more important in the future



Benefits of Green Infrastructure

Climate Change Adaptation

Two methods to reduce urban temperatures;

- Increase the amount of vegetation in urban areas.
- Increase the reflectivity of surfaces

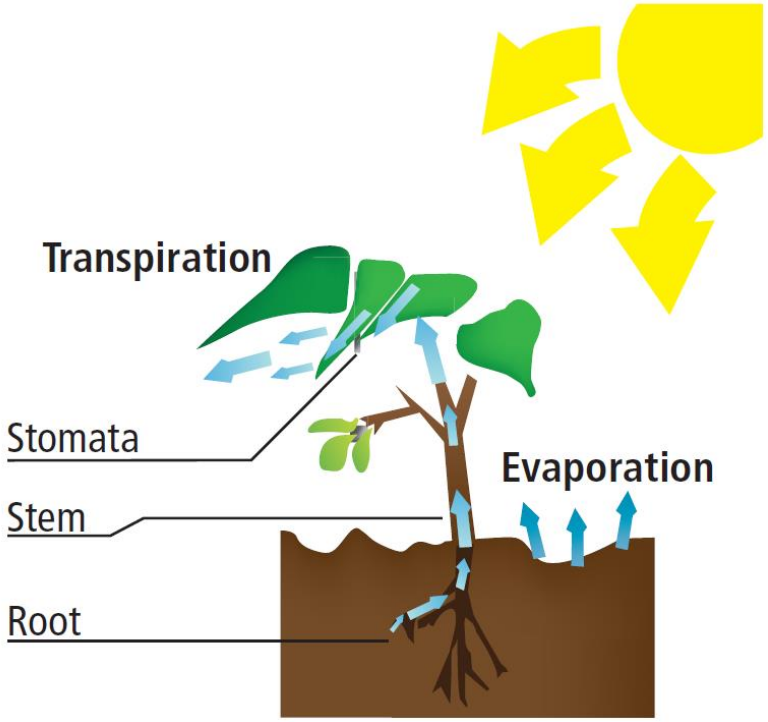
.

Evapotranspiration

- Evaporation - water evaporates from the soil, plants, and bodies of water into the surrounding air
- Transpiration - water content is lost as vapour through plant leaves
- Evapotranspiration helps to humidify and cool the surrounding air

Albedo

Green roofs have a very high albedo (reflectivity) which reflects solar radiation rather than absorbing it



Benefits of Green Infrastructure

Climate Change Mitigation

Approximately 75% of existing buildings are inefficient, with very little renovated each year. This has a large impact on energy usage and production of carbon dioxide;

- Poorly insulated roofs result in overheating of spaces beneath them during the summer
- Green Roofs reduce the need for air conditioning in the summer and heating in the winter
- In addition green roofs and photovoltaic panels are complementary technologies that improve each other's performance
- The cooler ambient temperatures increase the PV efficiency, and the green roof benefits from the areas of shade

Benefits of Green Infrastructure

Air Quality

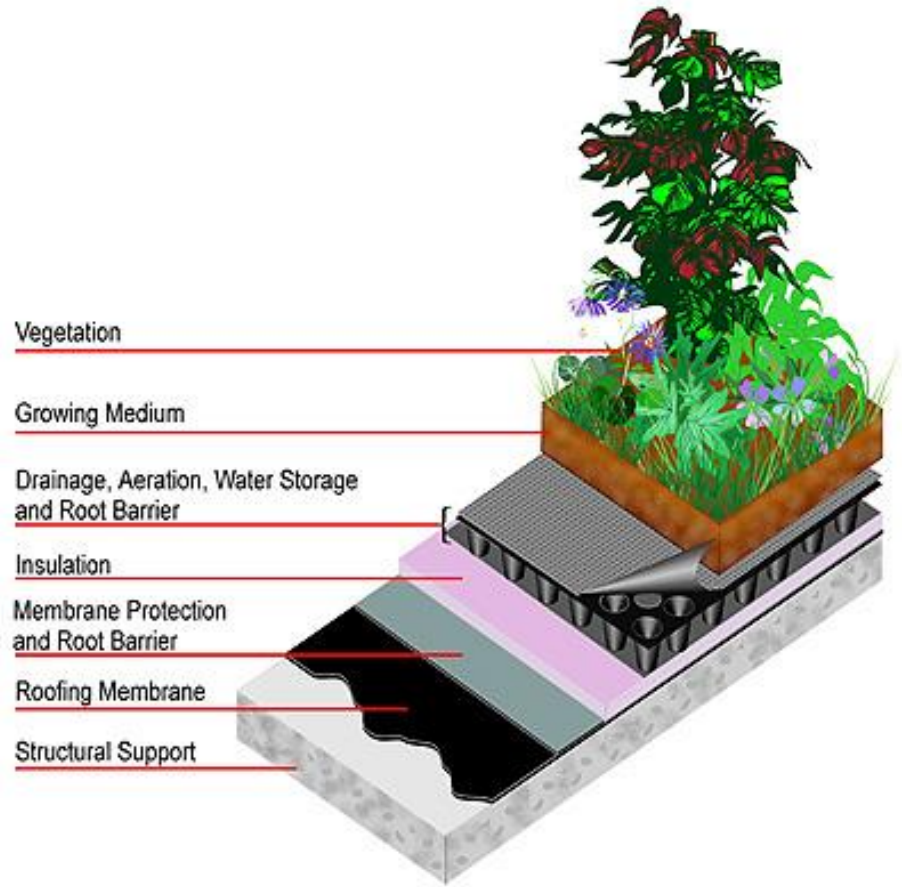
- Plants reduce carbon dioxide in the atmosphere and produce oxygen
- Green roofs reduce the heat island effect, which is the main cause of ozone production
- Plant roofs remove heavy metals, airborne particles and volatile organic compounds
- Being absorbed into the green roof system these polluting particles do not enter the water system through surface run off leading to improvement in water quality

Benefits of Green Infrastructure

Sustainable Urban Drainage

Peak flow rates and total run-off volume of rainwater from the roof are significantly reduced compared to a conventional roof.

- By storing rainwater Green Roofs can reduce annual run-off from roofs by at least 50% contributing to urban drainage and flood alleviation schemes.
- The rate of release following heavy rainfall is slowed, reducing the problems associated with storm surges.
- They are much easier to retrofit in the existing urban environment than most other SUDS components.



Benefits of Green Infrastructure

Noise Reduction

Living Walls have the benefit of reducing the sound level within buildings and outdoors.

They are often used to combat noise pollution such as that caused by city traffic.

<u>However</u> very little research has been done to quantify this.

- The foliage of the plants is known to refract, reflect, and absorb acoustic energy.
- Laboratory test found that a modular green wall system reduced sound levels by 15 decibels (dB).
- In comparison thermal double-glazing can reduce noise by 30 dB.

Georgian Architecture Dublin (1714 – 1830)

engineers without borders ireland

Benefits of Green Infrastructure

Economic Benefits

- Reduce energy required to heat and cool buildings, reduces energy costs
- Protects materials from damage reducing maintenance and repair costs
- Improve health & wellbeing of building occupants, reducing business costs and healthcare costs.

Vertical Forests

Bosco Verticale Milan

Architect Stefani Boeri

Hosts 800 trees, 4,500 shrubs and 15,000 plants

Equivalent of 20,000 square meters of forest.

Construction of a microclimate, produces humidity, absorbs CO2 and dust particles and produces oxygen.

Bosco Verticale Milan

Source: www.stefanoboeriarchitetti.net

Biophilic Design

Biophilic design integrates natural elements into the built environment thereby creating positive feelings such as calmness and satisfaction
Kellert S.R, Heerwagen J.,Mador M., (2008)

Direct Experience of Nature

- Light, air, water, plants, weather, landscapes and ecosystems

Indirect Experience of Nature

- Images of nature, natural materials, naturalistic colors, shapes and forms

Experience of Space and Place

- Cultural and ecological attachment to place, mobility and wayfinding etc.

Biophilic Design in Offices

IMPACT FLOWS THIS WAY

ENVIRONMENTAL	EXPERIENTIAL	ECONOMIC
1. Lighting 2. Indoor Air Quality 3. Thermal comfort 4. Acoustics 5. Interior layout 6. Look & feel 7. Active/Inclusive design 8. Integration of nature 9. Amenities	Perception of the working environment	1. Absenteeism 2. Staff turnover 3. Revenue breakdown 4. Medical costs 5. Medical complaints 6. Physical complaints

Offices with natural light, materials, and vegetation have been found to increase productivity, improve morale, and reduce absenteeism.
This has financial implications for businesses.

Biophilia in Healthcare Buildings

Patients

Research shows that patients given a view of nature, or access to gardens, spent less time in the hospital compared to those who did not.

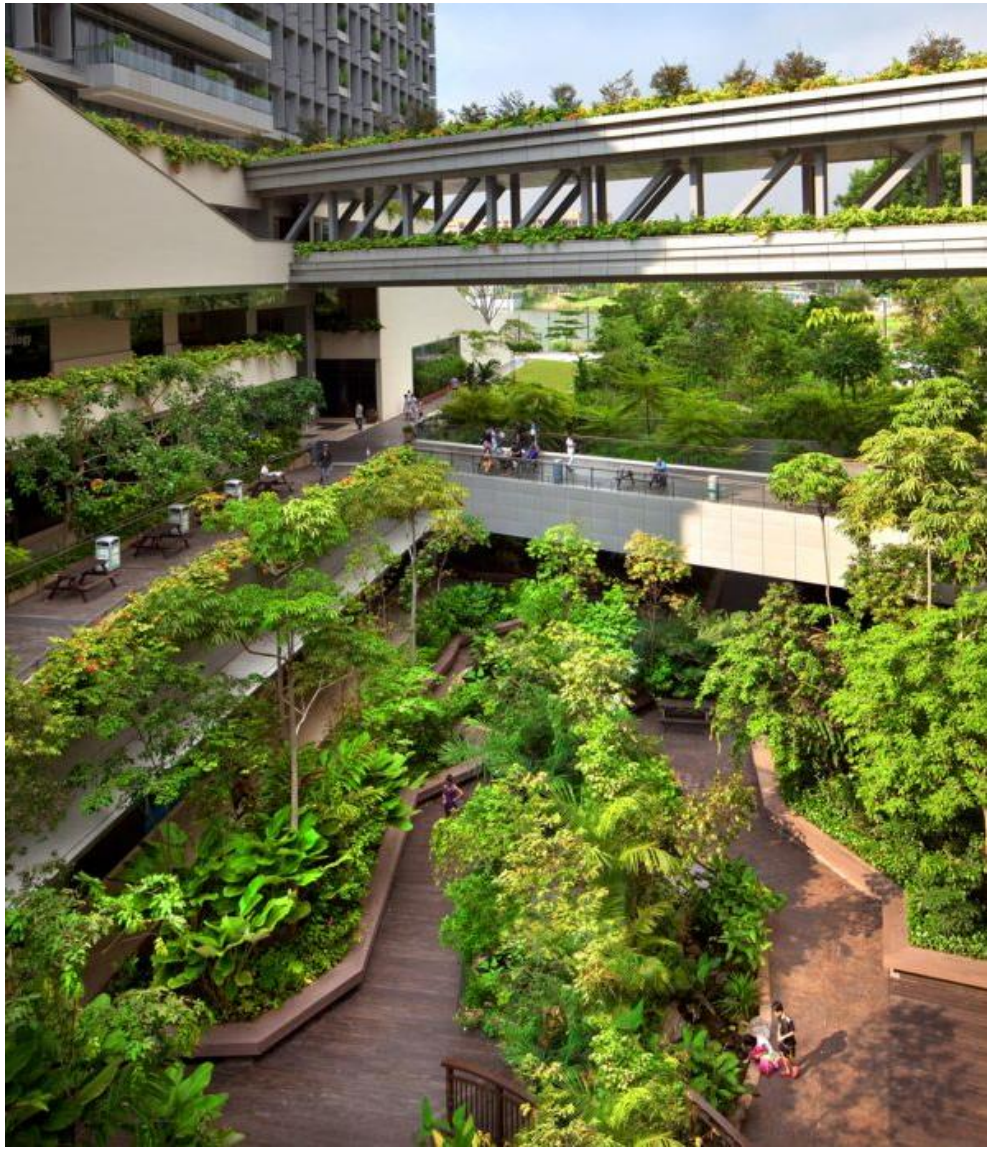
- On average, patients whose windows overlooked a scene of nature were spent 8.5% less time in recovery (Ulrich,1984).
- 95% of all people visiting inpatients, surveyed across four independent hospitals, reported feeling more relaxed, less stressed and more able to cope with the situation (Marcus & Barnes, 1995).

By helping patients recover more effectively and quickly, healthcare costs are reduced.

General government expenditure in the EU on health amounted to EUR 1080 billion or 7.0 % of GDP in 2017.

Healing Garden; Yawkey Cancer Center, Boston © Anton Grassi

Healing Through Nature



Khoo Teck Puat Hospital Singapore

Khoo Teck Puat Hospital Singapore

For Staff

Hospitals are stressful work environments. Gardens provide a positive escape from workplace pressures and recuperation from stress.

Evidence suggests that hospital gardens increase staff satisfaction with the workplace, and may help with retaining personnel.

For visitors

That connection to nature has an instinctive calming feeling and can help ease anxiety in visitors.

Source: www.cpgcorp.com.sg

Healthy Schools

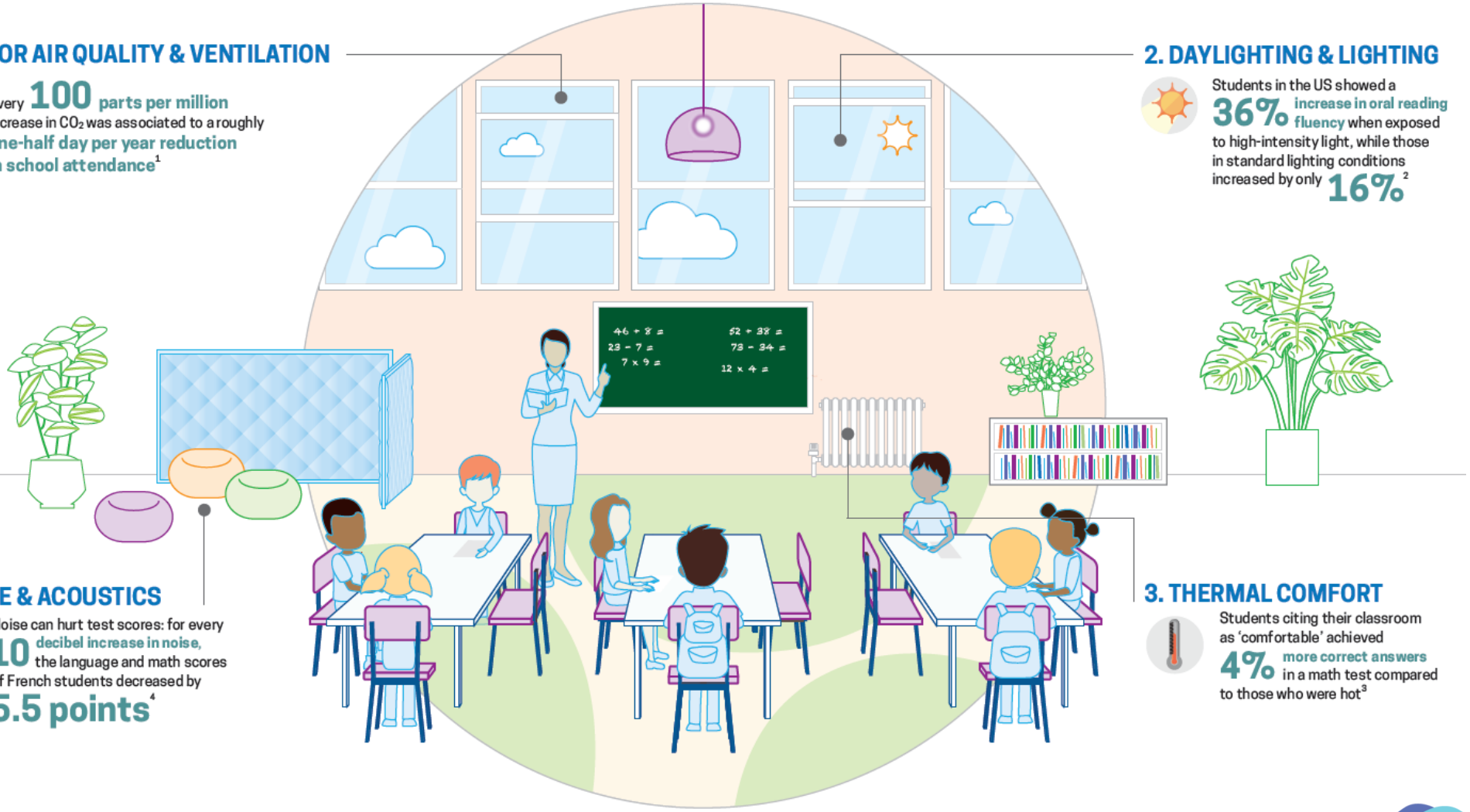
engineers without borders ireland

1. INDOOR AIR QUALITY & VENTILATION

Every **100** parts per million increase in CO_2 was associated to a roughly **one-half day per year reduction in school attendance**[1]

2. DAYLIGHTING & LIGHTING

Students in the US showed a **36%** increase in oral reading fluency when exposed to high-intensity light, while those in standard lighting conditions increased by only **16%**[2]



4. NOISE & ACOUSTICS

Noise can hurt test scores: for every **10** decibel increase in noise, the language and math scores of French students decreased by **5.5 points**[4]

3. THERMAL COMFORT

Students citing their classroom as 'comfortable' achieved **4%** more correct answers in a math test compared to those who were hot[3]

WORLD GREEN BUILDING COUNCIL

Healthy Schools

Impact on performance

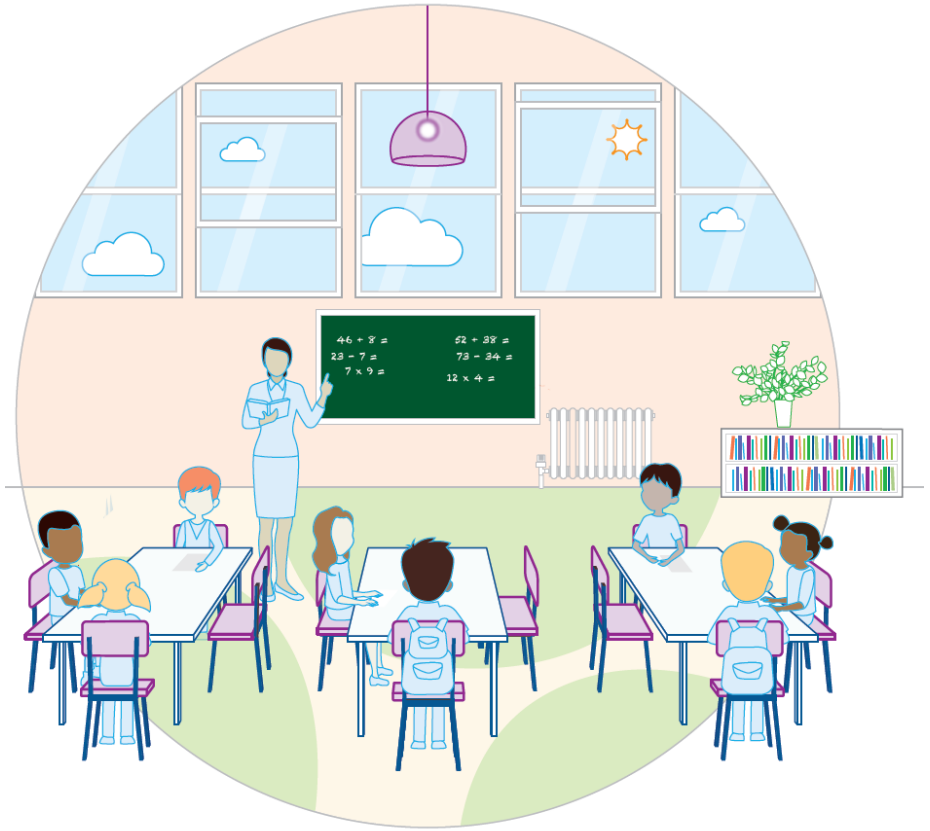
The classroom is perhaps the most influential environment for a students development outside the home.

Research shows that students in well daylight classrooms with good air quality perform better.

- Students in classes with better daylighting performed 20 - 26% better on maths & reading tests (Heschong 1999)
- Other studies noticed 10 - 25% improvements in test performance of mental function and memory recall when subjected to a view (Heschong 2003)
- Greener indoor environments could reduce allergies and asthmas by up to 25% (Fisk 2000)

Poor Indoor Air Quality (IAQ) in schools is linked to asthma in children, which in turn increases the absentee rate

As temperature and humidity increase, and attention span decreases, achievement and task-performance deteriorate



Conclusions

Modern buildings are becoming more complex however a lot can be learned from traditional bio-climatic building design;

- How best to avoid adverse climatic effects
- How to use the beneficial aspects of the climate

Integrating Nature Based Solutions in building design can provide many environmental, economic and social benefits

Ultimately buildings are for people and NBS contribute to happier, healthier building users

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Thank you

www.ewb-ireland.org

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@EWBIreland

Varming Consulting Engineers UC

IGBC IRISH GREEN BUILDING COUNCIL

Further Reading

Energy Performance of Buildings Directive
https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/nearly-zero-energy-buildings

Building the Business Case: Health, Wellbeing and Productivity in Green Offices
https://www.worldgbc.org/news-media/building-business-case-health-wellbeing-and-productivity-green-offices

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Ulrich, Roger. (2002). Health Benefits of Gardens in Hospitals.

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Fisk W: Health and productivity gains from better indoor environments and their implications for the US Department of Energy. E-Vision Conference, Washington, DC, 2000.

The Biophilic Cities Project
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