



Buildings, Climate & Site

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Review

- ◆ Buildings have value
 - Historical, Sentimental, Capital, Revenue
- ◆ Buildings protect things of value
 - Processes, Activities
 - Environment?



Review



- ◆ Buildings use significant resources
- ◆ Buildings produce large amounts of waste

Review

- ◆ Building deterioration, deficiency and inefficiency
 - Threaten that which we consider valuable
 - Increase resource use and waste production



What is Building Science?



- ◆ Making buildings work?
- ◆ The application of science and technology to solve problems related to the construction, operation, maintenance, repair and decommissioning of the built environment.

What is Building Science?

- ◆ Science & Technology
 - physics,
 - material science,
 - meteorology,
 - construction technology,
 - physiology
- ◆ Engineering analysis and design

Components of the Built Environment

- ◆ Buildings and the parts thereof
- ◆ Service infrastructure/utilities, etc.
- ◆ Distribution/transportation/traffic handling systems
- ◆ **Occupants/users/owners**
- ◆ **Providing and maintaining the built environment is the largest single industry on the planet**



Building Functions and Human Needs



- ◆ Location
 - ◆ Shelter
 - ◆ Utility
 - ◆ Comfort
 - ◆ Delight
-
- ◆ Adapted from Maslow's five-level hierarchy of human needs

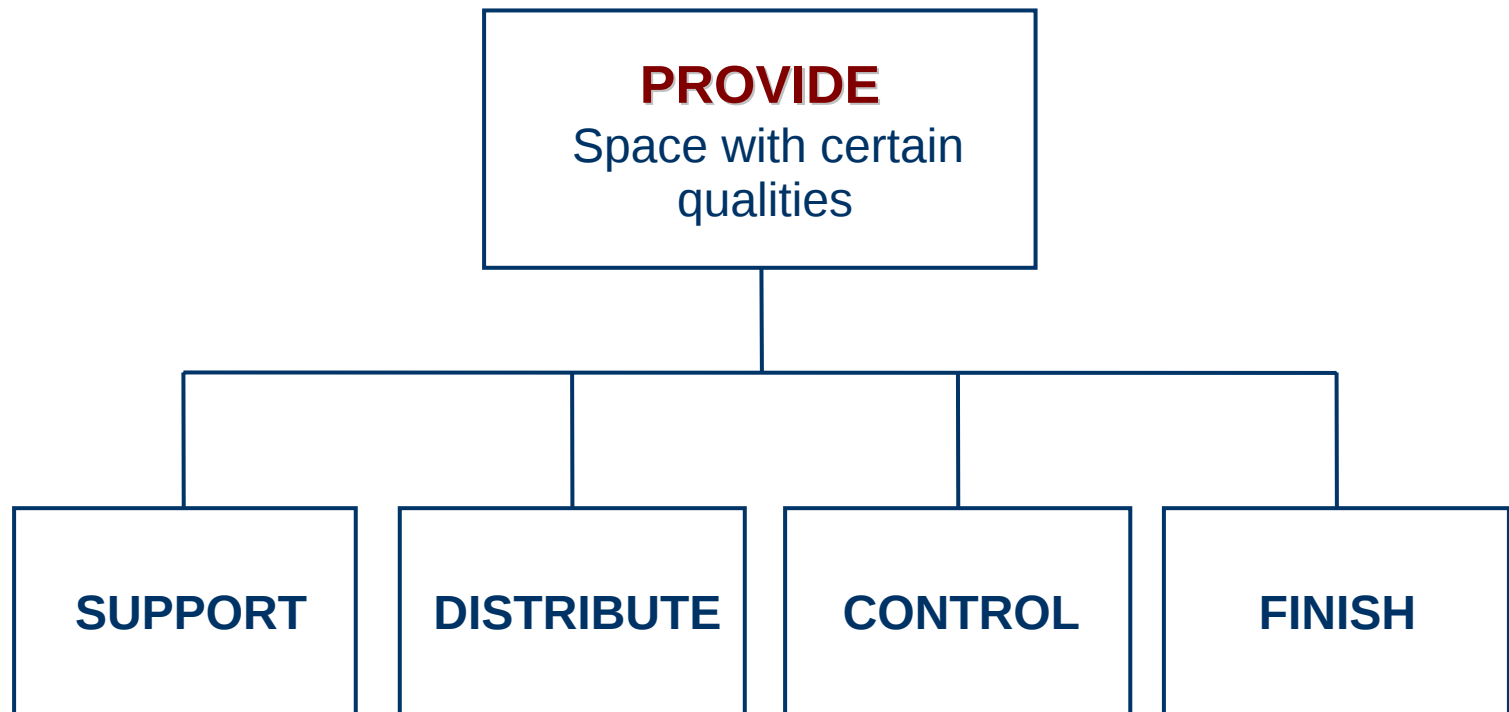
Building Functions Historical Perspective

“Durability, Convenience, and Beauty”
Vitruvius, 70 BC

“Firmness, Commodity, and Delight”
Sir Wotton, 1684

*“Provide the desired environment
for human use and occupancy”*

Building Functions



Support

- ◆ Accommodate, resist, distribute and transfer all physical loadings; normal, abnormal and accidental, such as:
 - Air pressure (wind, tornado, hurricane, explosion, etc.)
 - Ground motion (seismic, settlement, etc.)
 - Fire
 - Impact (Gravitational (dead and live loadings—both static and dynamic (vehicles, missiles, etc.))
 - Volume change (thermal, moisture, creep, shrinkage, etc.)

Distribute

- ◆ Into, within and/or out-of the building:
 - People (collection and dispersion, e.g., elevators, escalators, etc.)
 - Goods (collection and distribution, e.g., loading docks, conveyors, elevators, etc.)
 - Vehicles (distribution etc.)
 - Utilities:
 - Water (hot, cold, potable, grey, etc.)
 - Air (conditioned, compressed, etc.)
 - Gas (natural, propane, soil, gas, radon, etc.)
 - Electricity (voltage, amperage, etc.)

Control

- ◆ Into, within and/or out of the building
 - People (access and egress)
 - Animals, Birds and Insects (access, etc.)
 - Vehicles (access and egress)
 - Environment...

Control

- Environment:

- Precipitation (exclusion of rain, snow, hail, etc.)
- Solar Radiation (light, U/V, etc.)
- Heat (temperature)
- Air (humidity, odor, etc.)
- Moisture (water, water vapor)
- Sound (quality, quantity)
- Light (quality, quantity)
- Contaminants and particulates (VOC's, etc.)

Finish

- ◆ Appearance and/or suitability of all relevant faces both within and the outside of the building. Some considerations are:
 - Color, speculance, reflectance, etc.
 - Texture, pattern, relief, etc.
 - Shape
 - Proportion, etc.

Building Attributes

1. ***buildability*** or constructability
2. ***economic viability*** or cost effectiveness over both the short and longer term
3. ***viewability*** including aesthetic, cultural and other visual expectations
4. ***utility*** including fitness, flexibility and suitability
5. ***sustainability***
6. ***serviceability*** (structural and otherwise)
7. ***safety*** in relation to life, health, injury, property and economic enterprise

Building Attributes

8. ***productivity*** in relation to the major functions involved
9. ***operability***
10. ***maintainability***
11. ***repairability*** including minor and major repairs;
12. ***durability***
13. ***convertability*** in relation to modification, extension or conversion
14. ***disposability***, including recyclability



Building Types



- ◆ Function and attributes are determined by the intended use (Human Needs)
- ◆ Type of building is determined by function and attributes

Categorization of Building Type

General Use	Specific Use, Size or Shape	Nature of Building	Comment
Residential	Single (Detached) Single (Attached) Multi	Houses* Semi-detached* (2 units) Duplex*(2), Triplex*(3), Quadrplex*(4 units) Row housing*, Town homes*, etc. Apartment, Dormitory, Motel, Hotel	<4 Stories ° Low-rise >4 but <12 ° Mid > 12 ° High-rise
Service Industrial	Storage Manufacturing Mixed use/multi-purpose	Warehouse+, Cool Storage, Freezer storage Light industrial+ Production/storage/office+	Often single story (high bay) structures with, perhaps, a small mezzanine for offices and light storage.
Commercial	Retail Office Mixed use	Shop, plaza, mall Low, medium and high-rise Office/retail/residential	Notes: * Mostly designed and built without direct professional (engineering or architectural) involvement. + Smaller/simpler of these buildings can be built without direct professional involvement.
Health Educational Institutional Monumental Industrial	e.g., Hospitals, clinics, etc. e.g., Schools, colleges, universities, etc. e.g., Persons, court facilities, civic buildings, etc. e.g., Museums, galleries, monuments, etc. e.g., Medium to heavy, factories, etc.		

Buildings are Systems *of* Systems

- ◆ The systems that make up a a building can be grouped in four categories
 - Superstructure
 - Enclosure
 - Service Systems
 - Fabric

Buildings are Systems *in* Systems

- ◆ Buildings exist in a greater system that includes both the built and natural environments
- ◆ Buildings influence and are influenced by the both environments on different levels

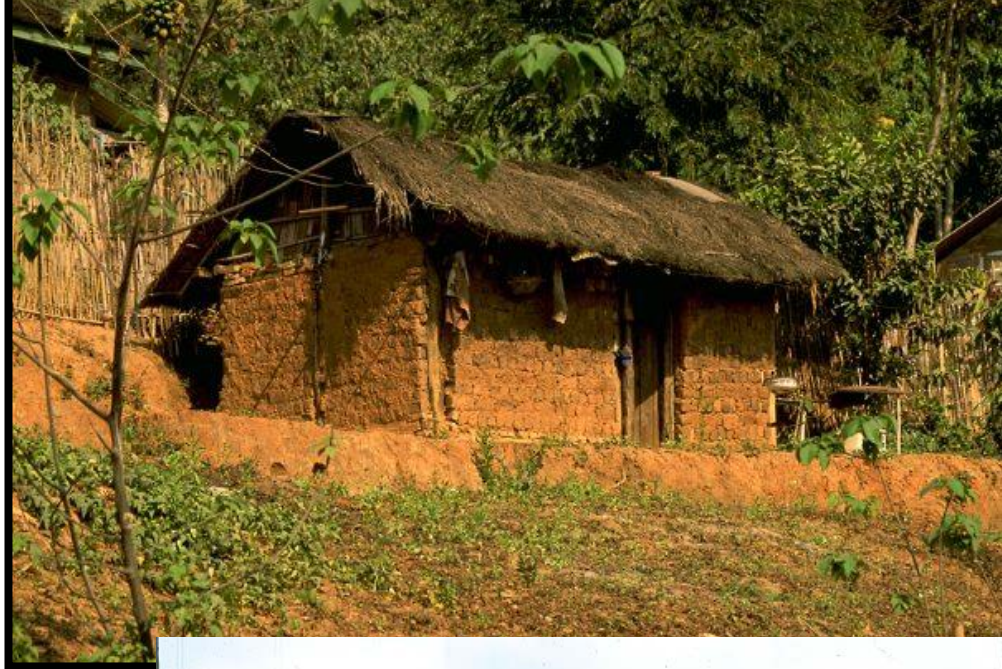


Buildings & Climate













Why such differences? Art?

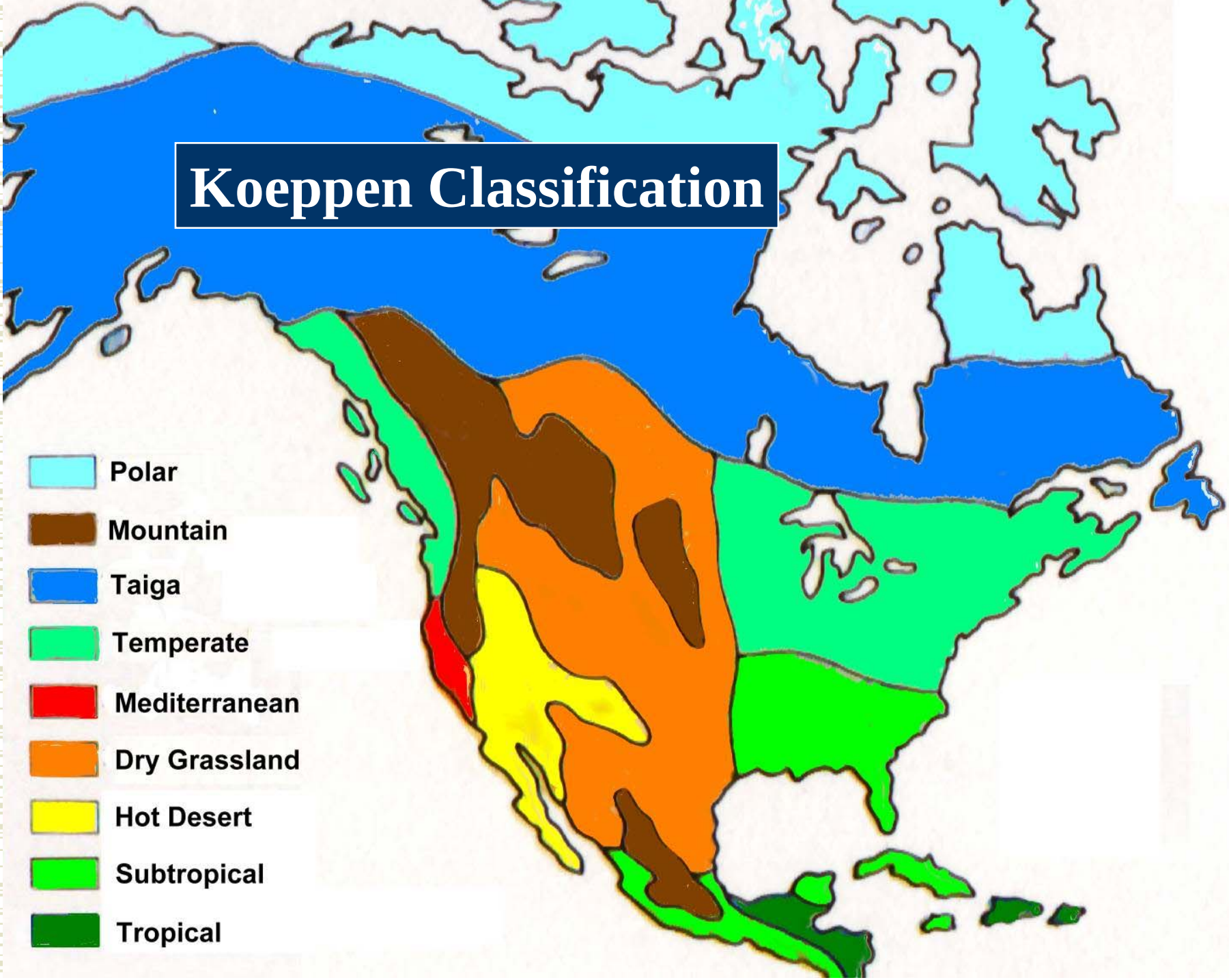
- ◆ Usually create buildings to provide an interior environment
- ◆ Must be aware of exterior environment
- ◆ Building:
 - Shape,
 - Size,
 - Orientation,
 - Glazing useall interact with building use and climate



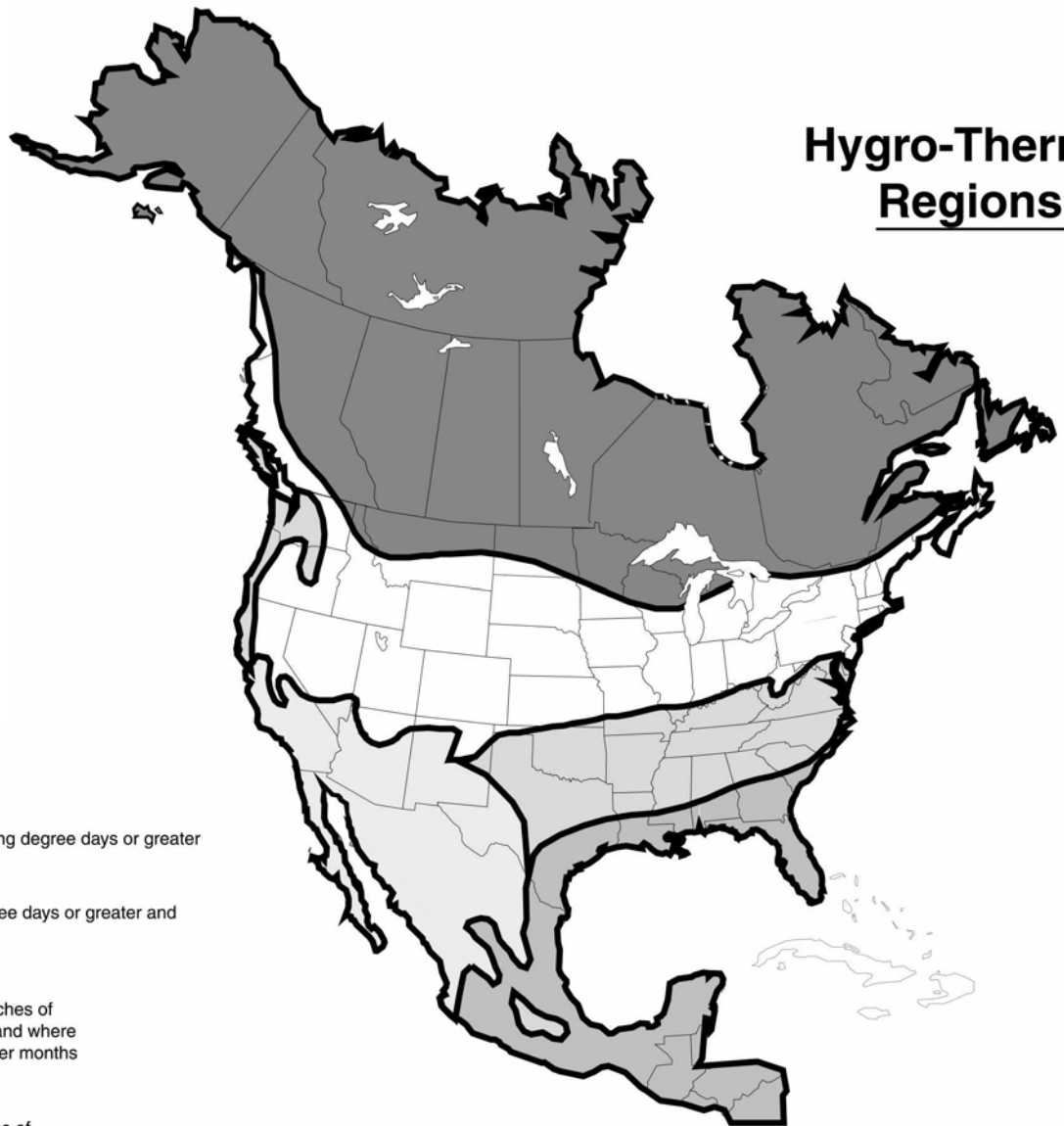
Climate Parameters

- ◆ Temperature
- ◆ Humidity
- ◆ Sun
- ◆ Rain
- ◆ Wind

Koeppen Classification

- 
- A map of North America illustrating the Koeppen climate classification system. The map uses various colors to delineate different climate zones across the continent. A legend on the left side of the map provides the key for these colors.
- Polar
 - Mountain
 - Taiga
 - Temperate
 - Mediterranean
 - Dry Grassland
 - Hot Desert
 - Subtropical
 - Tropical

Hygro-Thermal Regions



Legend

Severe-Cold

A severe-cold climate is defined as a region with approximately 8,000 heating degree days or greater

Cold

A cold climate is defined as a region with approximately 4,500 heating degree days or greater and less than approximately 8,000 heating degree days

Mixed-Humid

A mixed-humid climate is defined as a region that receives more than 20 inches of annual precipitation, has approximately 4,500 heating degree days or less and where the monthly average outdoor temperature drops below 45°F during the winter months

Hot-Humid

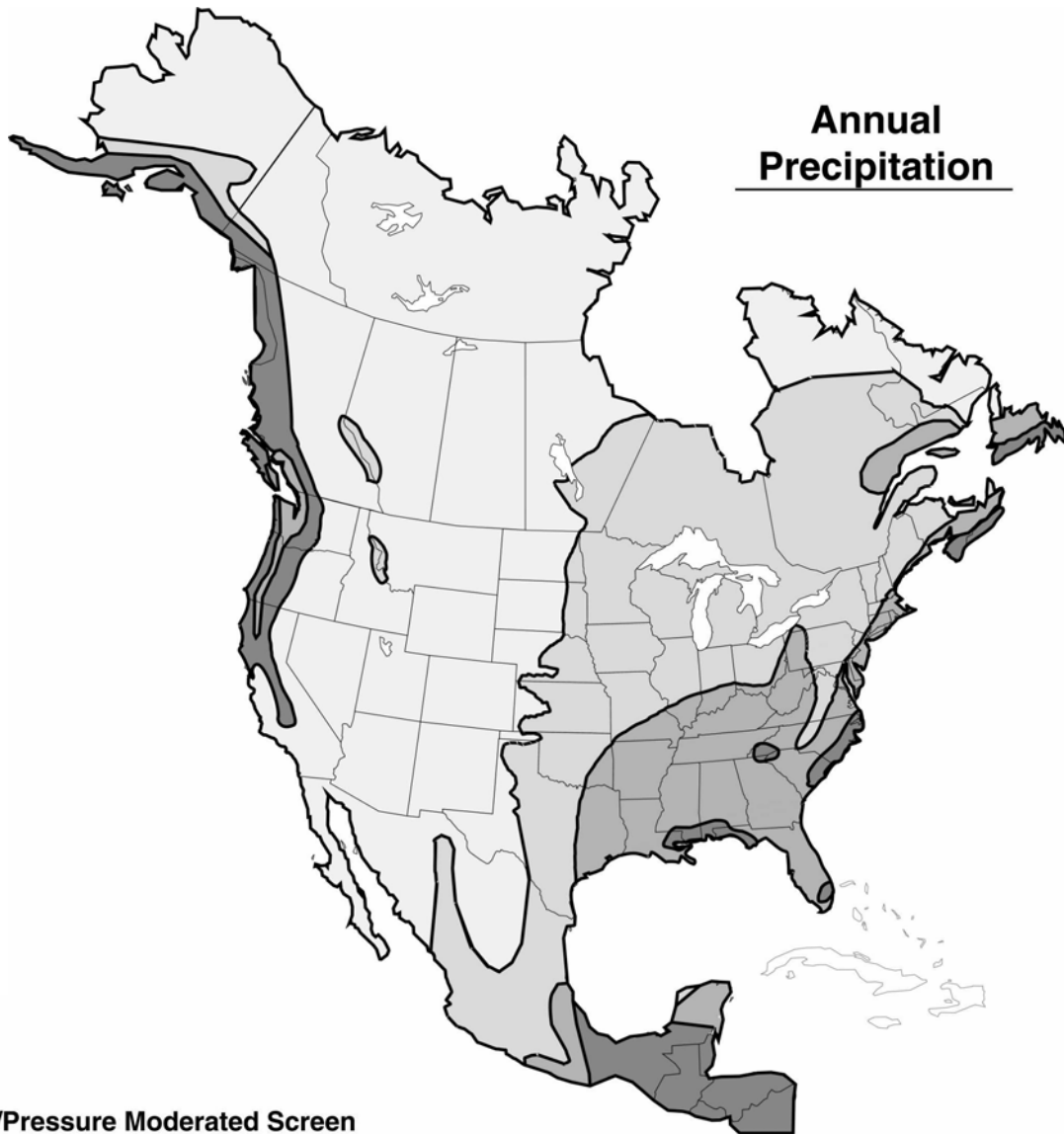
A hot-humid climate is defined as a region that receives more than 20 inches of annual precipitation and where the monthly average outdoor temperature remains above 45°F throughout the year*

Hot-Dry/Mixed-Dry

A hot-dry climate is defined as a region that receives less than 20 inches of annual precipitation and where the monthly average outdoor temperature remains above 45°F throughout the year;

A mixed-dry climate is defined as a region that receives less than 20 inches of annual precipitation, has approximately 4,500 heating degree days or less and where the monthly average outdoor temperature drops below 45° during the winter months

**Annual
Precipitation**



Exposure

Extreme		Over 60" Pressure Equalized Rain Screen/Pressure Moderated Screen
High		40" - 60" Rain Screen/Vented Cladding/Vented Drainage Space
Moderate		20" - 40" Drainage Plane/Drainage Space
Low		Under 20" Face Seal



Climate Zone



- ◆ Vernacular experience indicates the type of building appropriate
 - Vernacular cant help us much with large buildings
- ◆ Primary Determinants for Buildings

Climate Zone

Climate Zones:

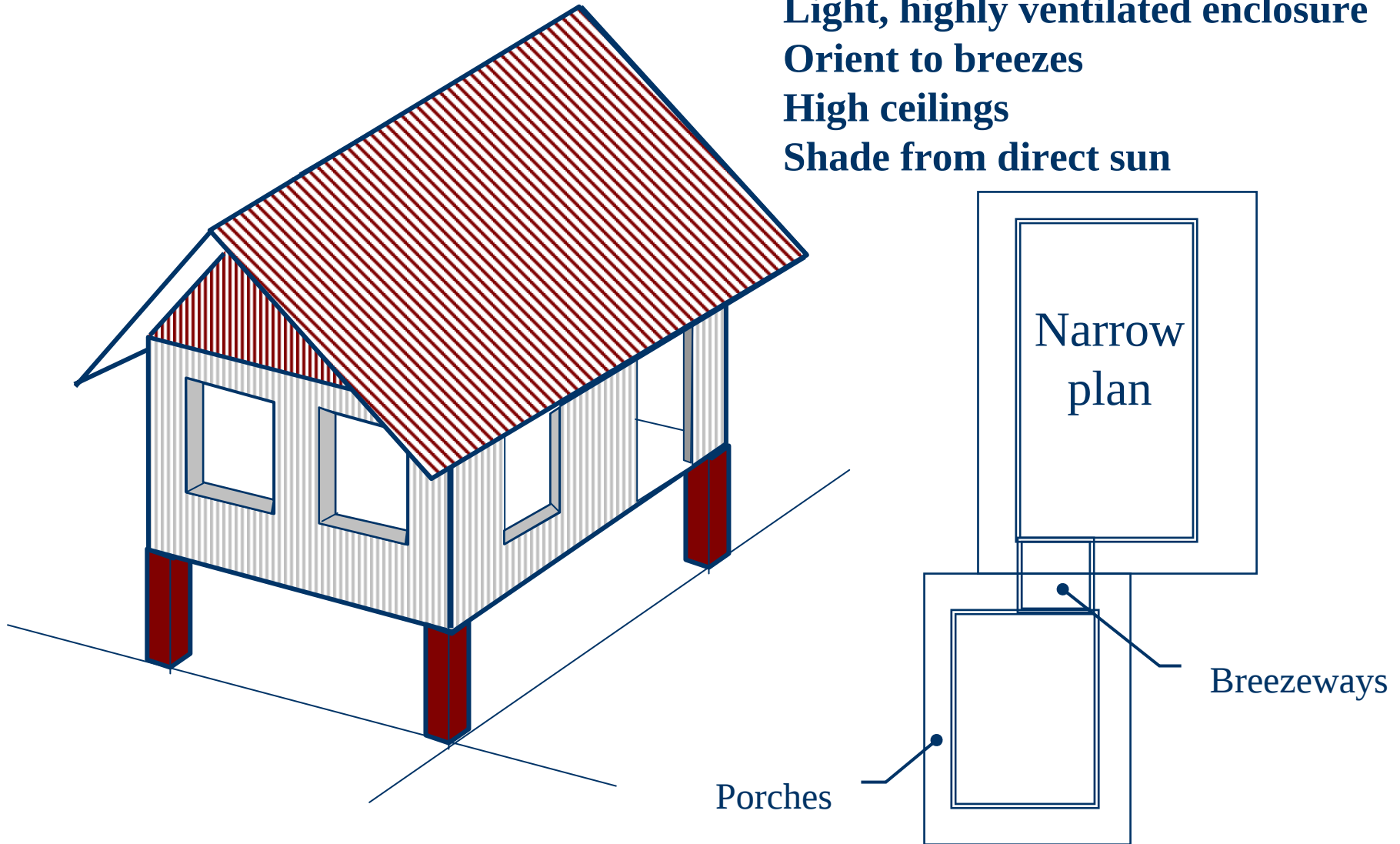
- Hot-Humid
 - Hot-Arid
 - Mixed
 - Cold-Humid
 - Cold-Dry
- ◆ Different strategies are used for each

Hot-Humid Climate

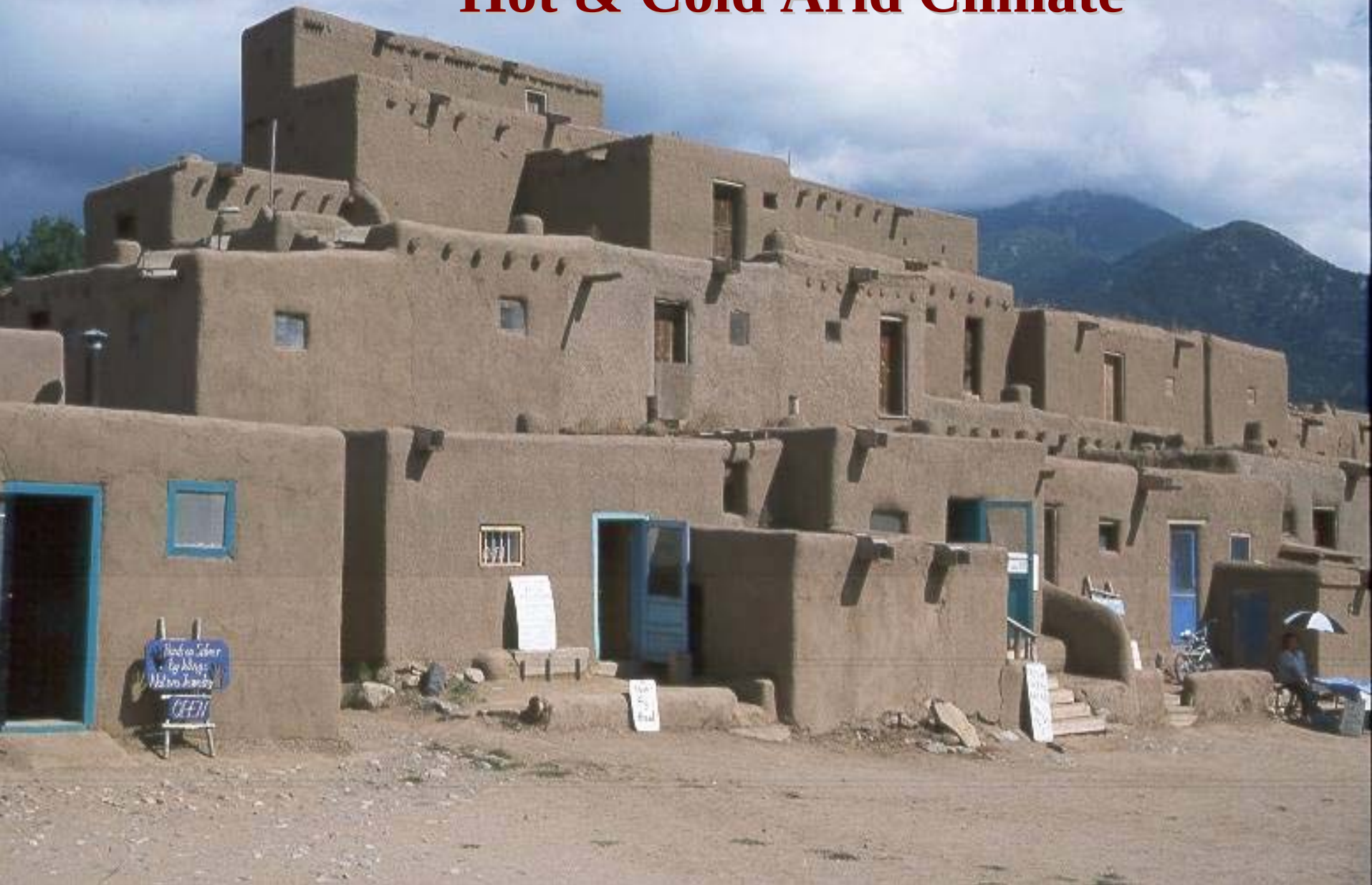


Hot-Humid

Light, highly ventilated enclosure
Orient to breezes
High ceilings
Shade from direct sun



Hot & Cold Arid Climate



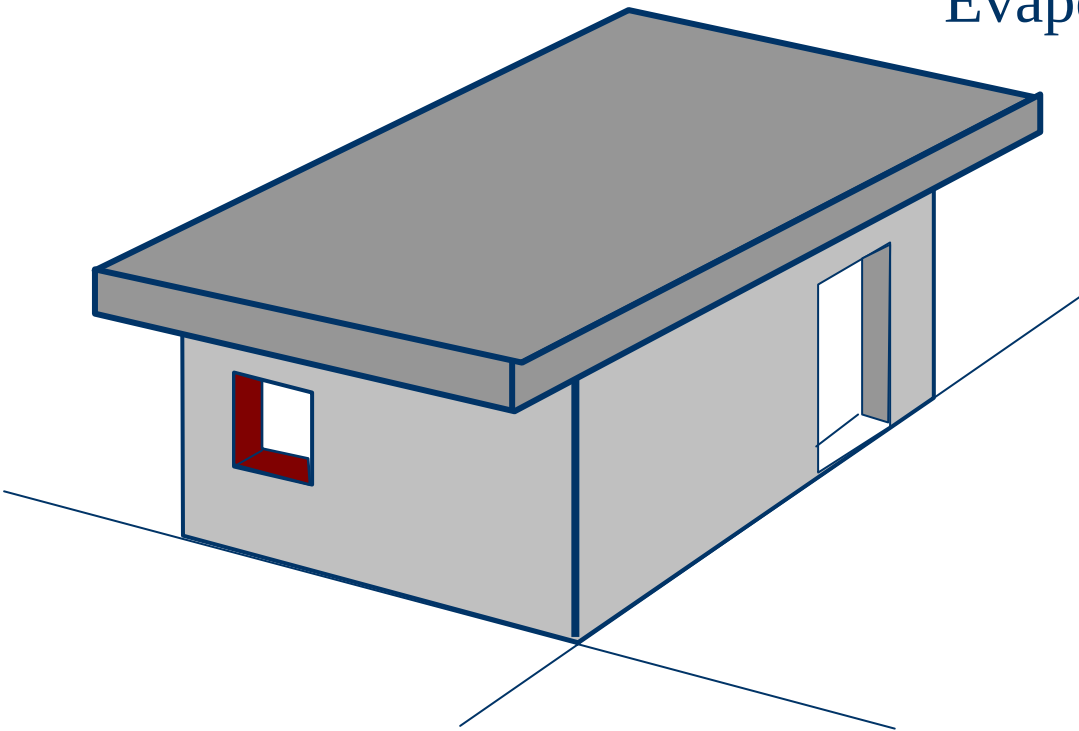
Arid Climate (Hot and Cold)

High mass - moderate temperature

Few or shaded windows

Overhangs for solar shade

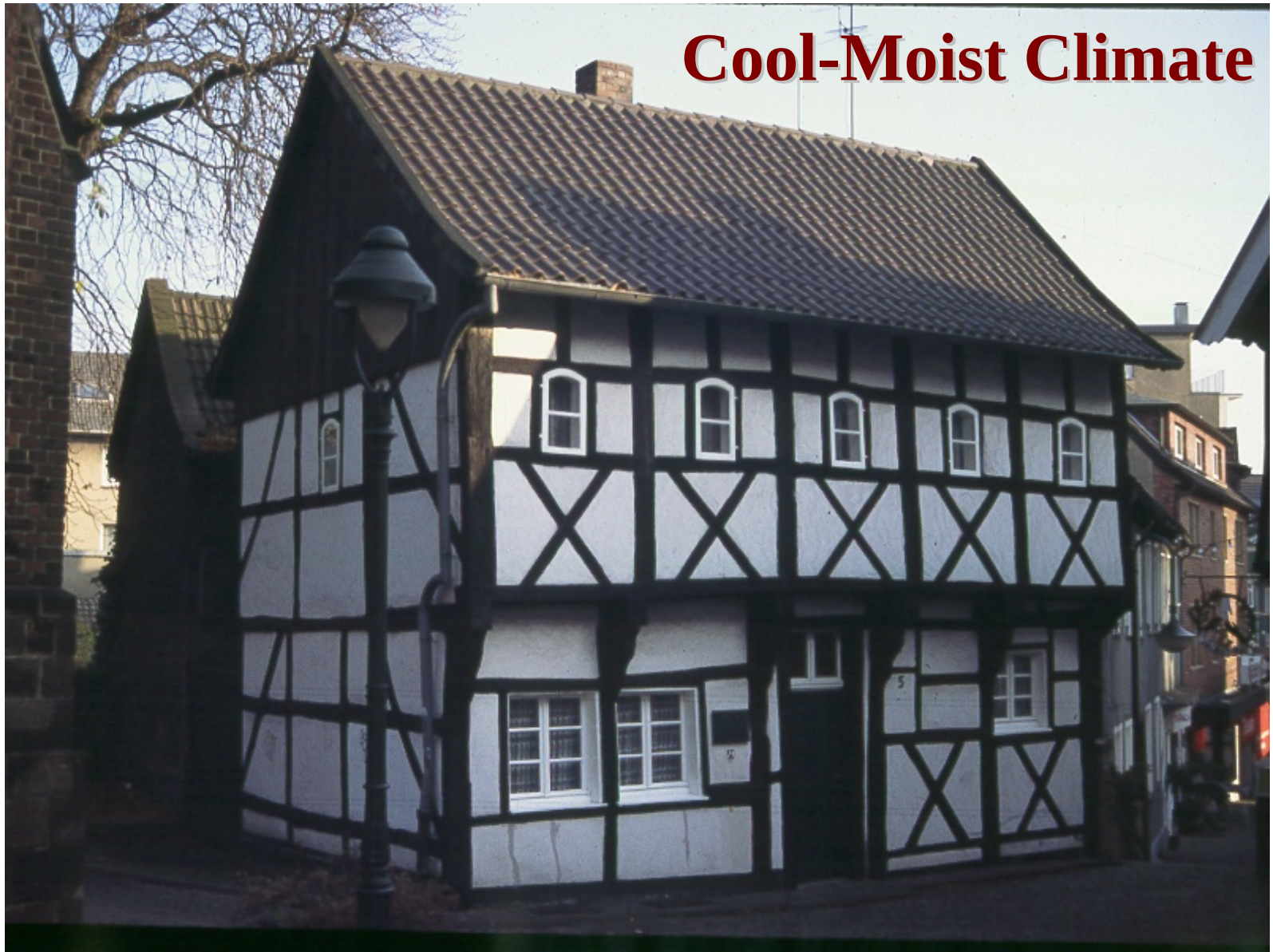
Evaporative cooling / solar chimney



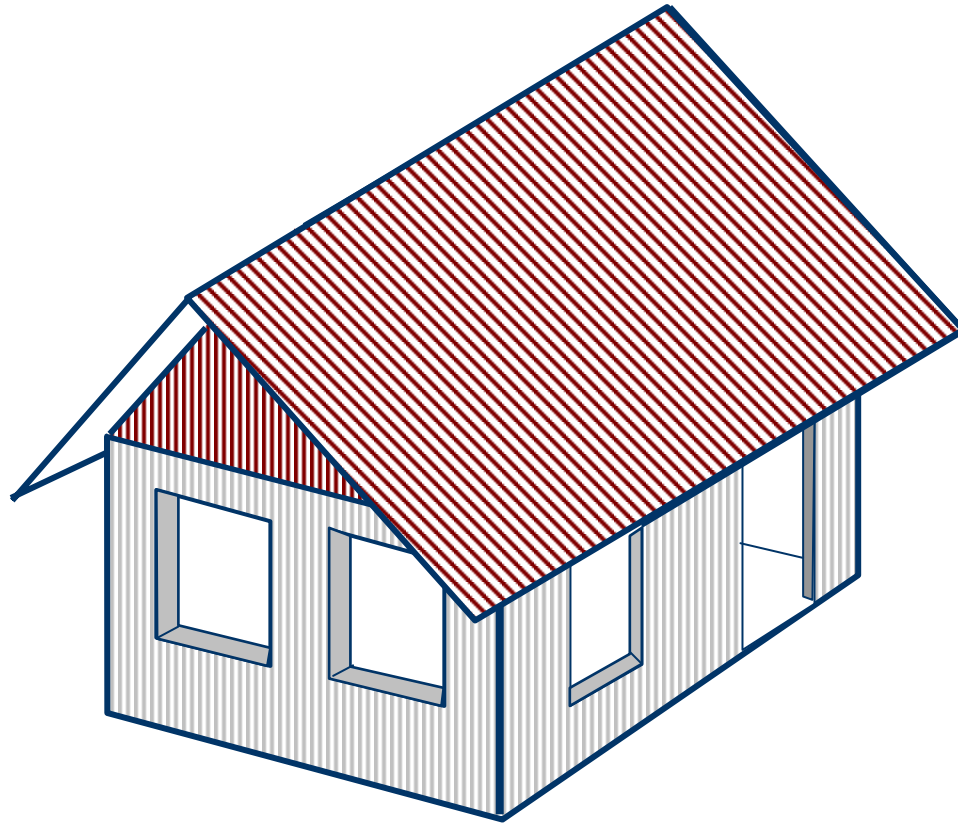
Towns:Narrow
Streets

Stocky
Plan

Cool-Moist Climate



Cool-Moist



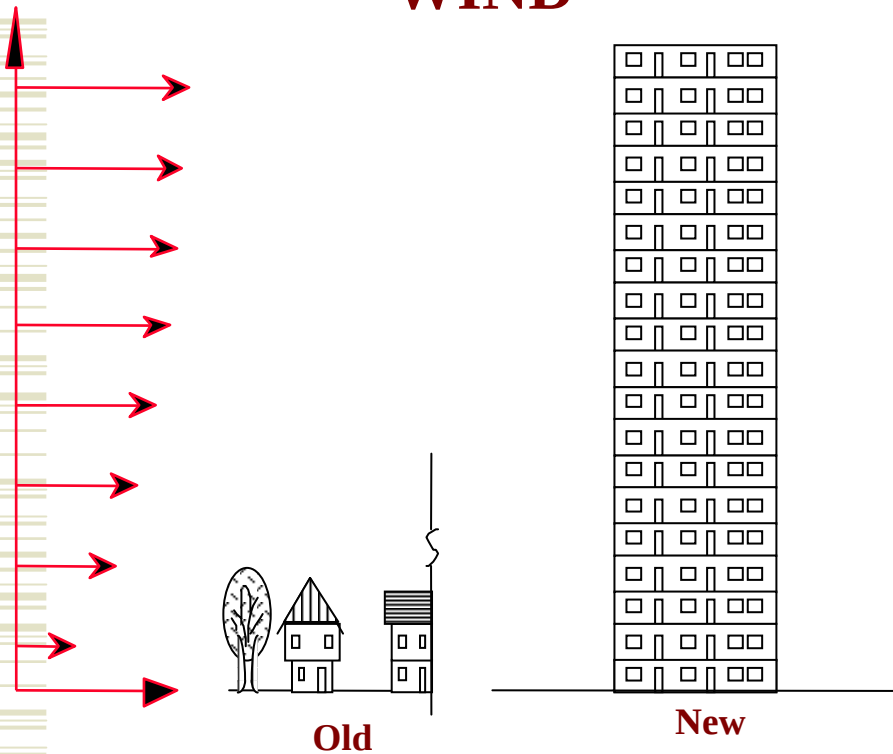
Collect sun in winter
Shade sun in summer
Shelter from rain
Shelter from winter wind

Site/Microclimate

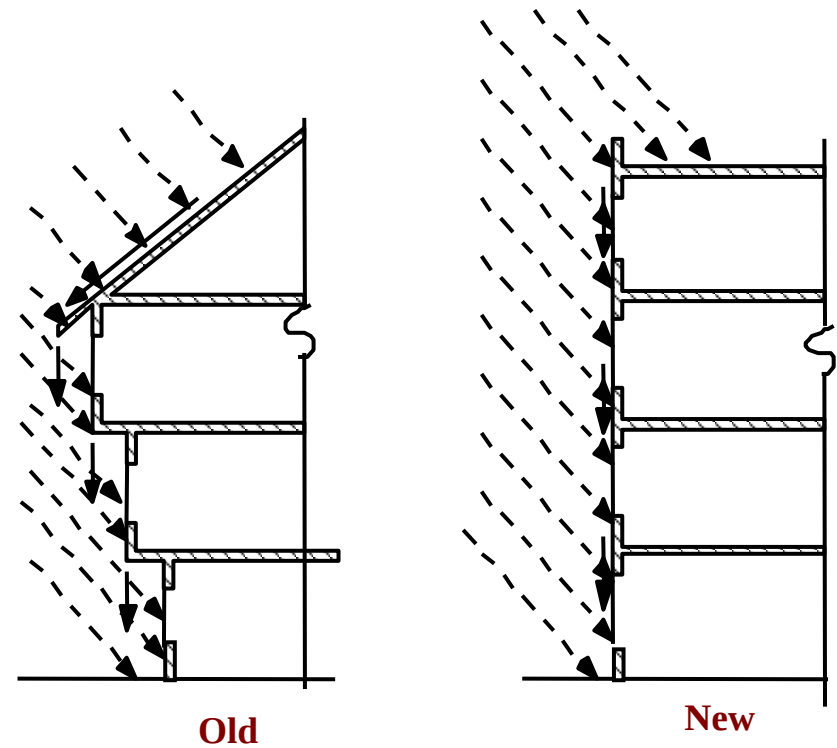
- ◆ Can be modified
- ◆ Great savings & improved comfort possible
- ◆ SUN - heating or shade, solar chimney
- ◆ WIND - cooling or ventilation
- ◆ TOPOGRAPHY - hill top versus valley
- ◆ PLANTING - sun, rain, wind protection
- ◆ Ponds, reflective snow, etc
- ◆ Orientation

Gradients

WIND

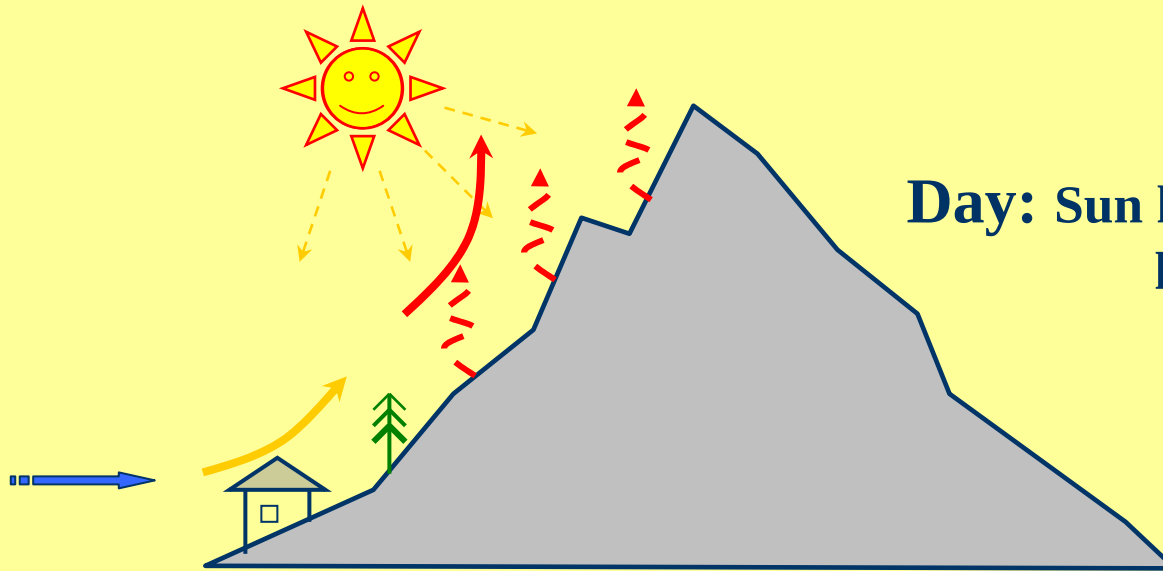


RAIN/SUN



Overhangs - Surface - Drainage - Shelter





Day: Sun heats ground, ground heats air, hot air rises



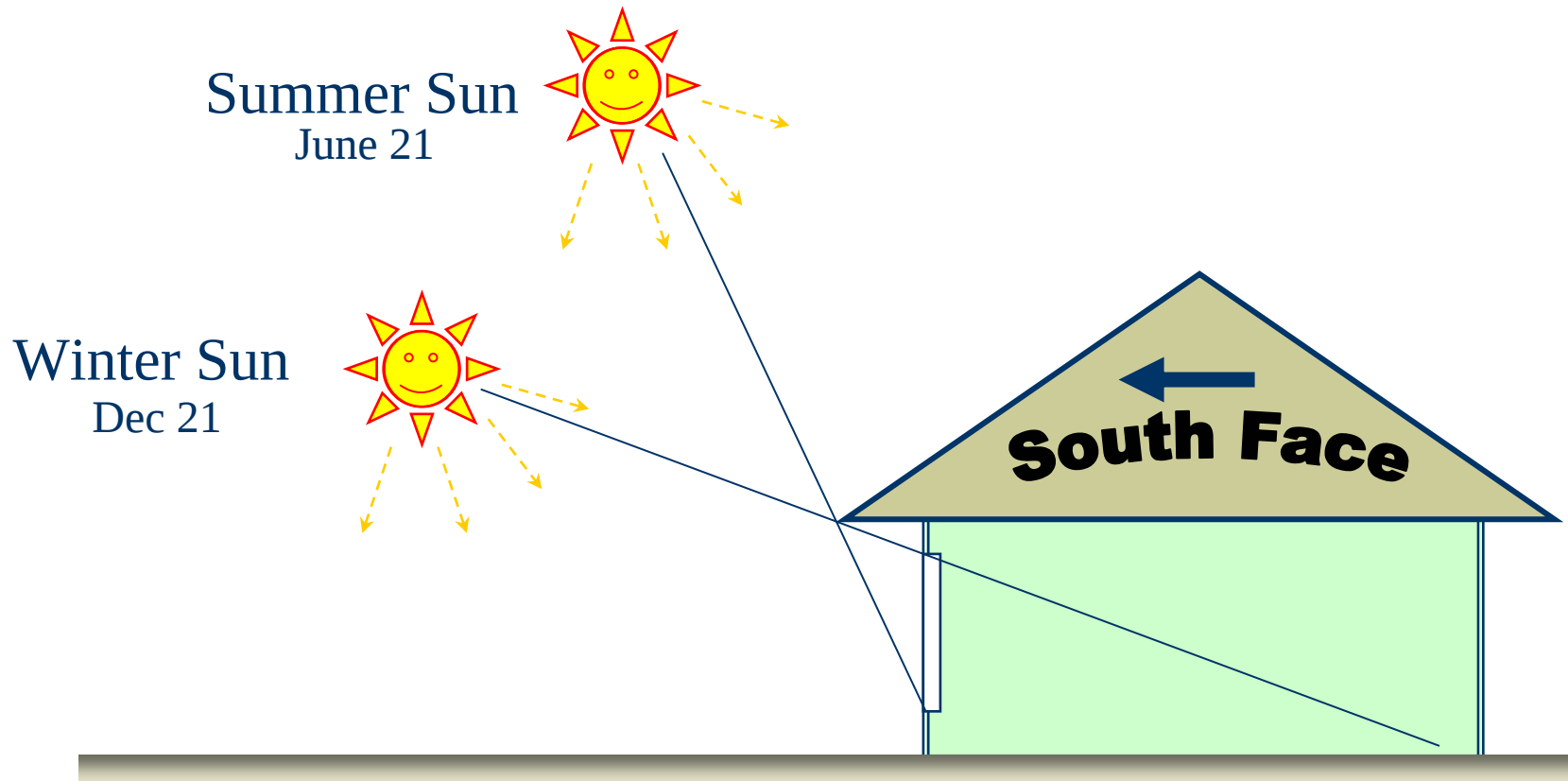
Night: ground and air cools to night sky, cold air falls

**City planning has a large
impact on the micro-climate**

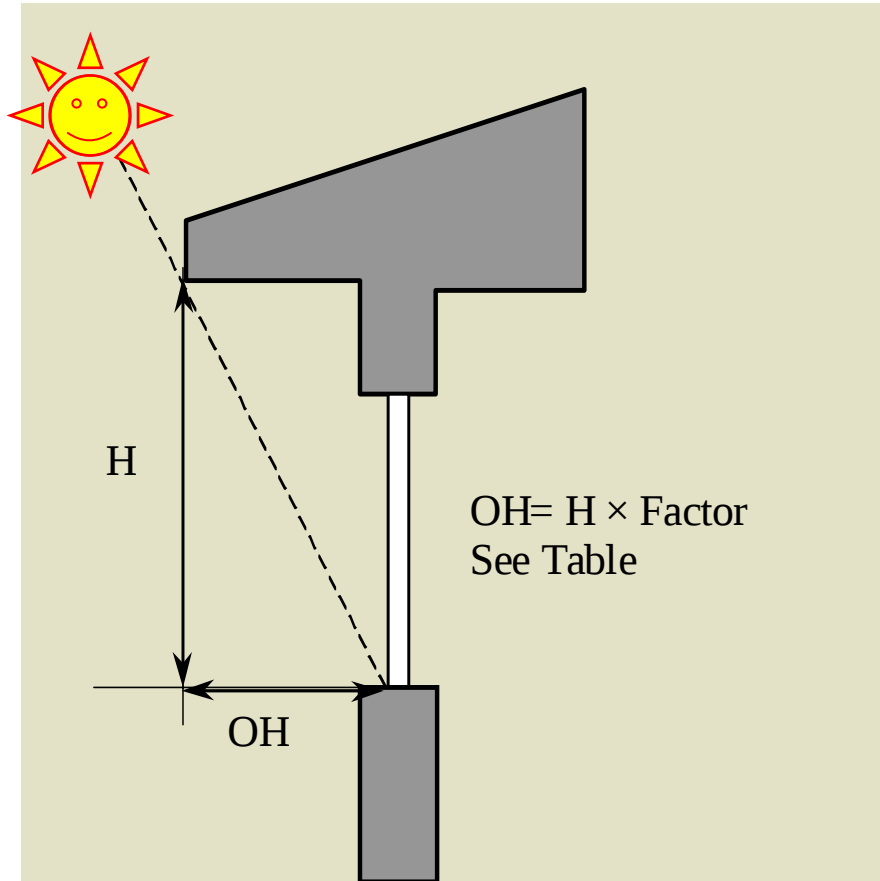


Solar Control - Shading

At high noon

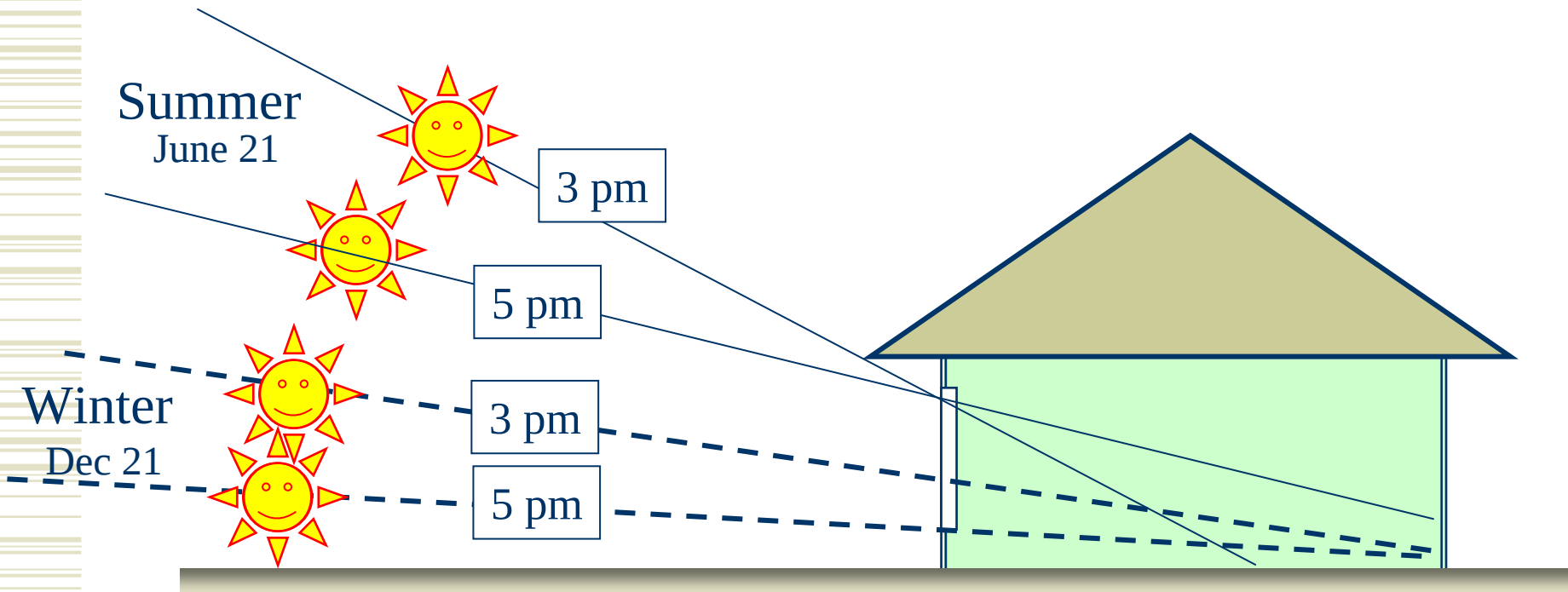


South Shading



Degrees Latitude	June 21 Only	May 10 to Aug 1
28	0.09	0.18
32	0.16	0.25
36	0.22	0.33
40	0.29	0.40
44	0.37	0.50
48	0.45	0.59

East-West Shading



Mesa Verde





Website

- ◆ University of Waterloo

Building

Engineering

Group

www.civil.uwaterloo.ca/beg

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