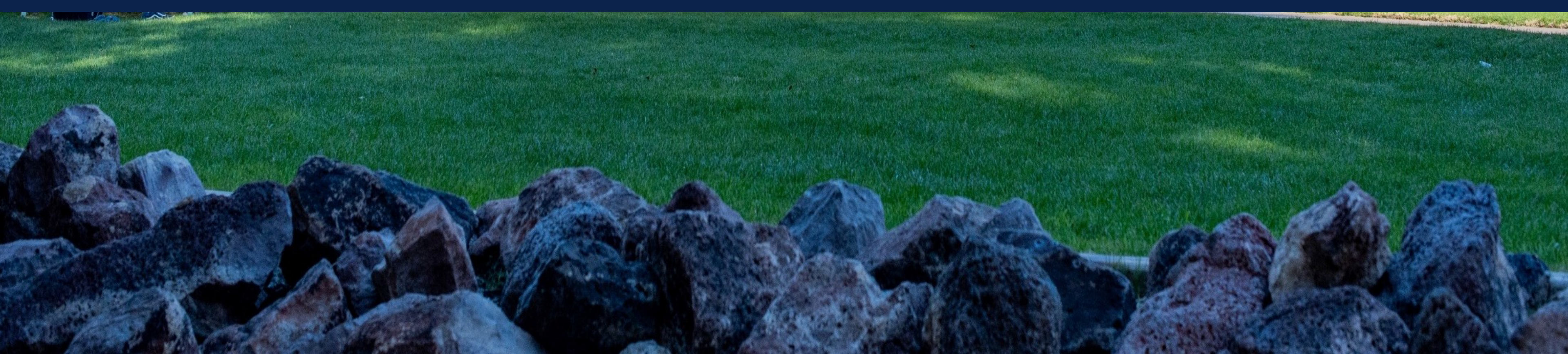
NSF NRT-InFEWS: Indigenous Food, Energy, and Water Security and Sovereignty
Presents:

Food, Energy and Water (FEWS) Learning Modules

June 2021



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MODULE INTRODUCTION:

DR. MURAT KACIRA - DIRECTOR, CONTROLLED ENVIRONMENT AGRICULTURE CENTER

MODULE 1: DINÉ FOOD SOVEREIGNTY & AGRICULTURE

JAYMUS LEE - PSM IN CONTROLLED ENVIRONMENT AGRICULTURE, UNIVERSITY OF ARIZONA

- Lecture
- Zoom Poll Question
- Jamboard (Slide 1)
- Lunch Break Discussion Prompt

MODULE 2: CONTROLLED ENVIRONMENT AGRICULTURE & GREENHOUSE DESIGN

AMY PIERCE, MS BIOSYSTEMS ENGINEERING

- Lecture
- Zoom Poll Question
- Jamboard (Slide 2)

MODULE 3: HYDROPONICS & GROWING SYSTEMS

ALEXANDRA TRAHAN, MS, ENVIRONMENTAL SCIENCE

- Lecture
- Jamboard (Slide 3)

MODULE 4: CEA PLANT NUTRITION

RUTH PANNILL, MS NATURAL RESOURCES AND ENVIRONMENT

- Lecture
- Zoom Poll Question

MODULE 5: DINÉ COLLEGE HOOP HOUSE PROJECT

JAYMUS LEE - PSM IN CONTROLLED ENVIRONMENT AGRICULTURE, UNIVERSITY OF ARIZONA

- Lecture
- Application and Review

REVIEW: INTRODUCTION TO HOMEWORK & EQUATIONS

AMY PIERCE, MS BIOSYSTEMS ENGINEERING & JAYMUS LEE - PSM IN CONTROLLED ENVIRONMENT AGRICULTURE, UNIVERSITY OF ARIZONA

THE UNIVERSITY OF ARIZONA

INDIGE-FEWSS FOOD MODULES

CONTROLLED ENVIRONMENT AGRICULTURE & GREENHOUSE DESIGN

Presented by: Amy Pierce

THE UNIVERSITY OF ARIZONA

Learning Objectives

Students will be able to...

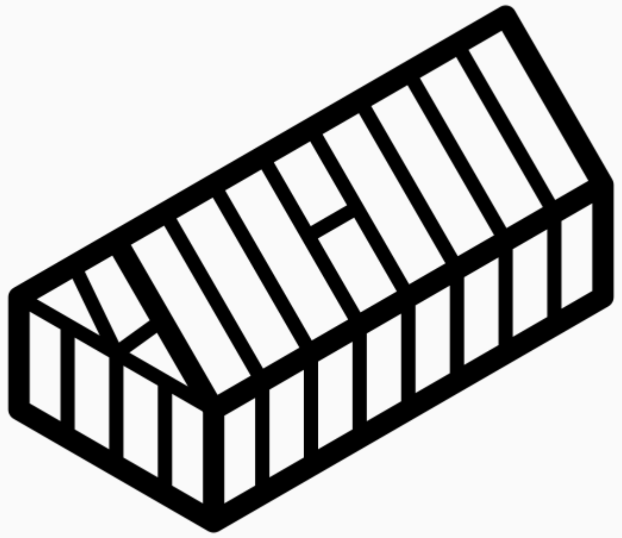
1. **Name the three most important environmental variables that should be monitored and controlled in a greenhouse.**
2. **Name and describe suitable methods for greenhouse heating and cooling.**
3. **Describe how food, water, and energy are produced and used in an off-grid greenhouse system.**

Presentation Outline:

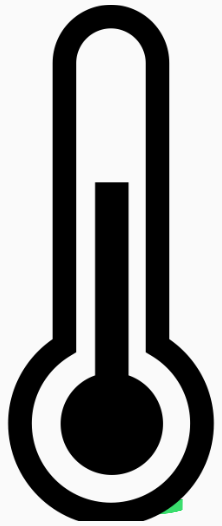
1. CEA & The Navajo Nation
2. Greenhouse Shapes & Structures
3. Heating & Cooling
4. Irrigation

Controlled Environment Agriculture (CEA)

PROVIDES PHYSICAL PROTECTION AND OPTIMAL GROWING CONDITIONS THROUGHOUT CROP DEVELOPMENT



Structure



Climate Control Systems

Irrigation Systems

Scales of Protected Cultivation

Low-Technology

Traditional Navajo Shadehouse

Low-Tunnel Plant Covering

High-Tunnel / Hoop House

High-Technology

Vertical Farm

High-Tech Greenhouse

Medium-Tech Greenhouse

Why CEA in Navajo Nation?

Solar resources are abundant, water less so

- **Greenhouses utilize free resource of the sun, protect against harsh weather, and use a lot less water for production compared to open field**

Increase Navajo food security and sovereignty

- Fresh produce closer and more affordable

Large Navajo agricultural sector already exists

- Approximately 14,500 farms on Navajo Nation (2017)
- Feed for livestock can be grown more efficiently

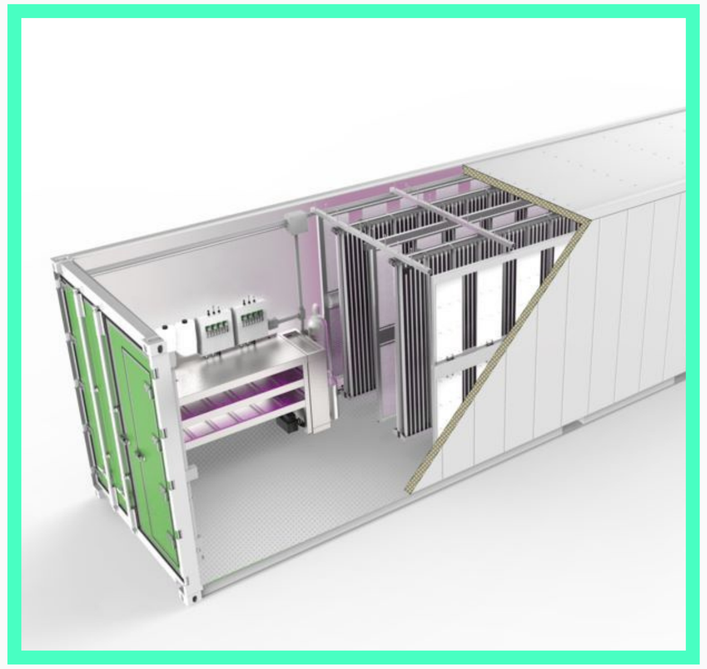
Steady, year-round employment in rising industry

- Greenhouses need people to maintain the plants and all of the greenhouse systems

Controlled Environment Agriculture

ROOFTOP AQUAPONICS FACILITY
HAGUE, NETHERLANDS

AEROFARMS
NEW JERSEY USA



FREIGHT FARM
MULTIPLE LOCATIONS

UA CEAC TEACHING GREENHOUSE
TUCSON, AZ

GREENHOUSES

INDOOR PLANT FACTORIES

ROOFTOP GROWING FACILITIES

CONTAINER FARMS

HYDROPONICS

AQUAPONICS

AEROPONICS

MYCOCULTURE

Why Greenhouses on the Navajo Nation?

1. Grow year-round (independent of seasons)
2. Efficient use of resources (i.e. water, fertilizer, labor, energy)
3. Sustainable food systems: local, fresh produce and steady jobs
4. Improved independence from outside climate & pests
5. Use of nonarable and contaminated land

Greenhouse Production & Traditional Navajo Cultivation

Similarities

- Significance of place
- Practical experience and hands on
- Knowledge of planting and harvesting
- Resource-use efficiency and non-depletion
- Sustainability as a central goal

Geodesic Greenhouse on Navajo Nation

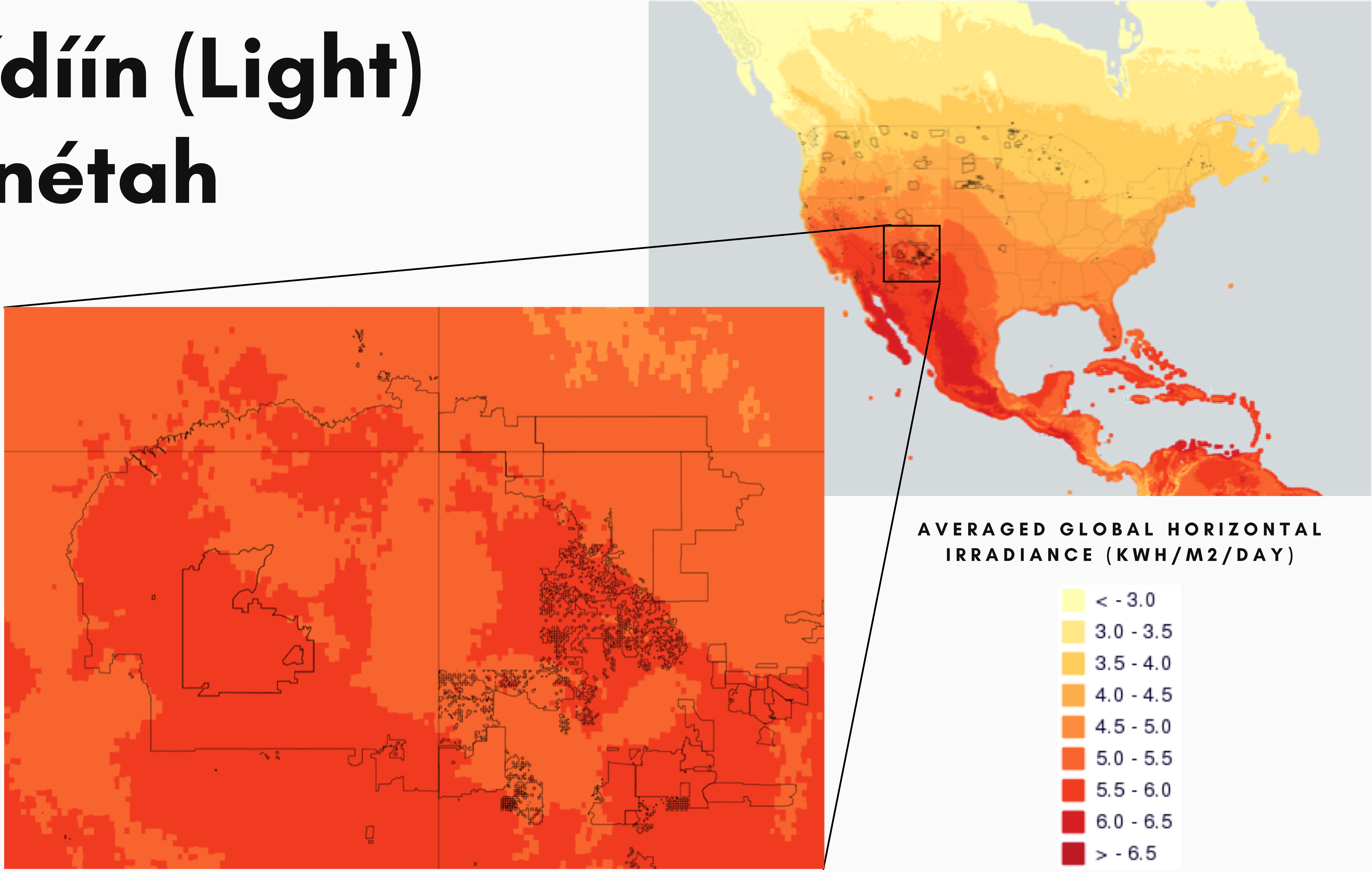
Source: Chaco Culture National Historical Park Museum Collection and Pacific Domes (1898)

Differences

- Biodiversity
- Manipulated environment
- Spirituality in traditional cultivation
- Ceremonial use of traditional foods
- Sense of place and time
- Knowledge of creation and organization
- Generational transmission of traditional knowledge


What are your cultural concerns about growing food in a greenhouse?
Answer in chat or microphone

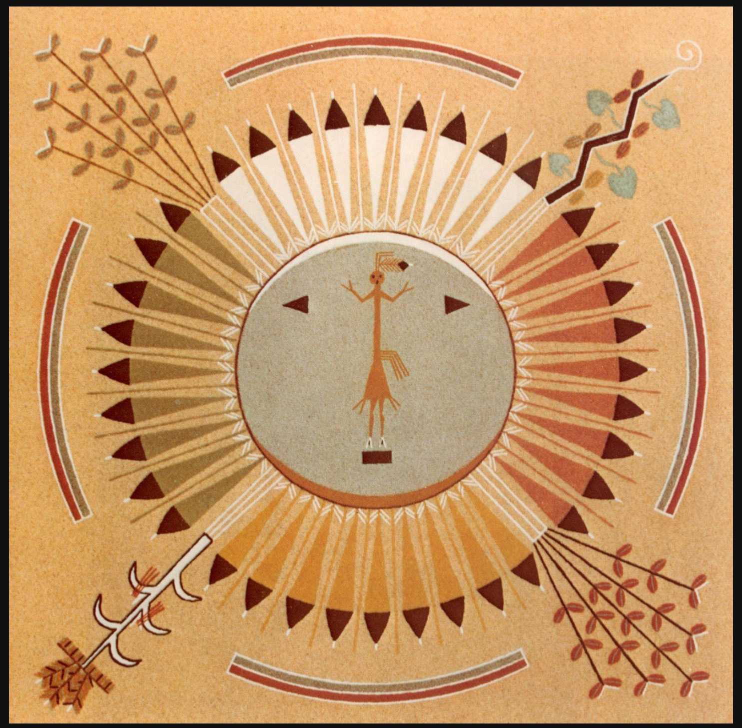
Adinídíín (Light) on Dinétah



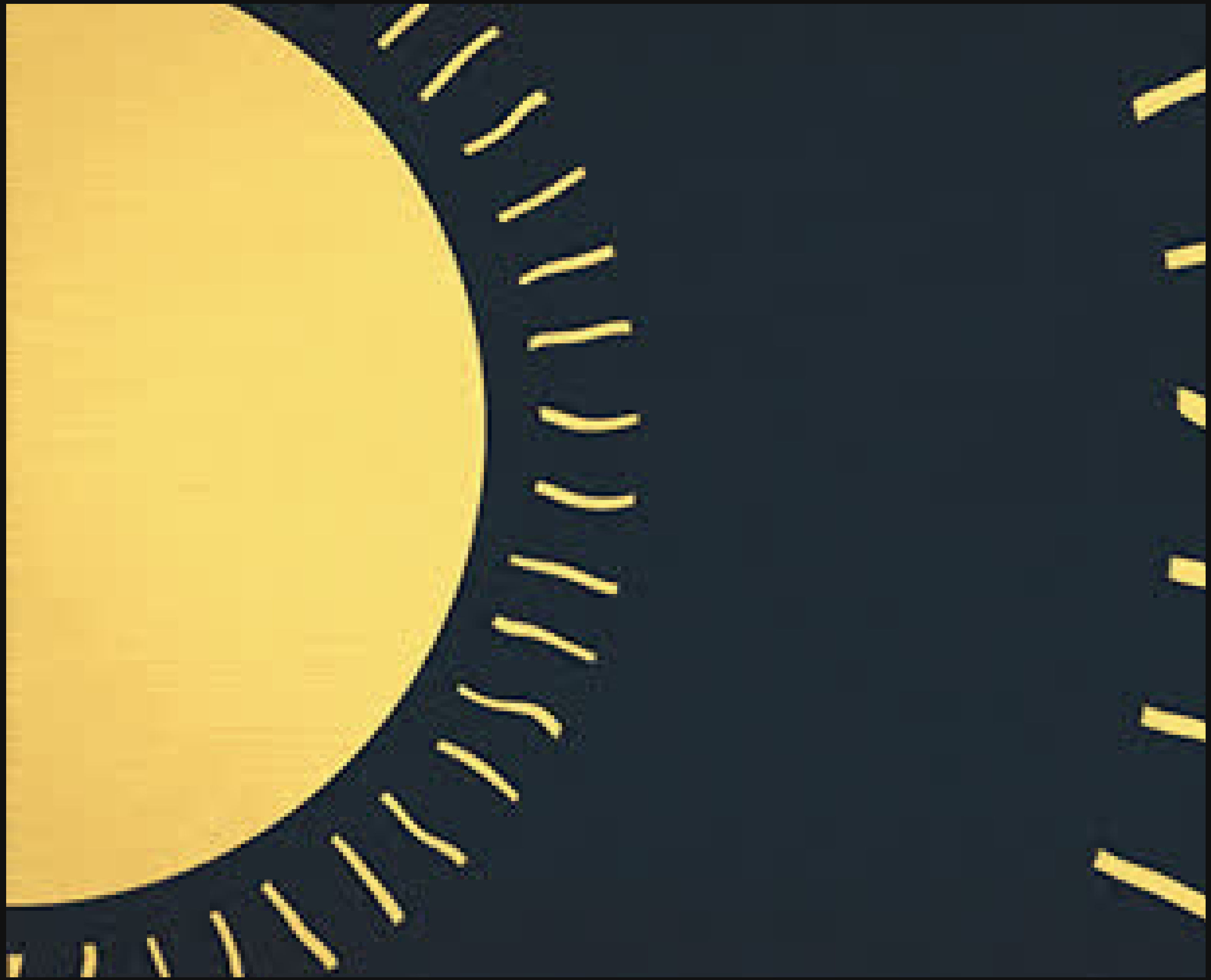
DATA TAKEN FROM NREL NATIONAL SOLAR RESOURCES DATABASE

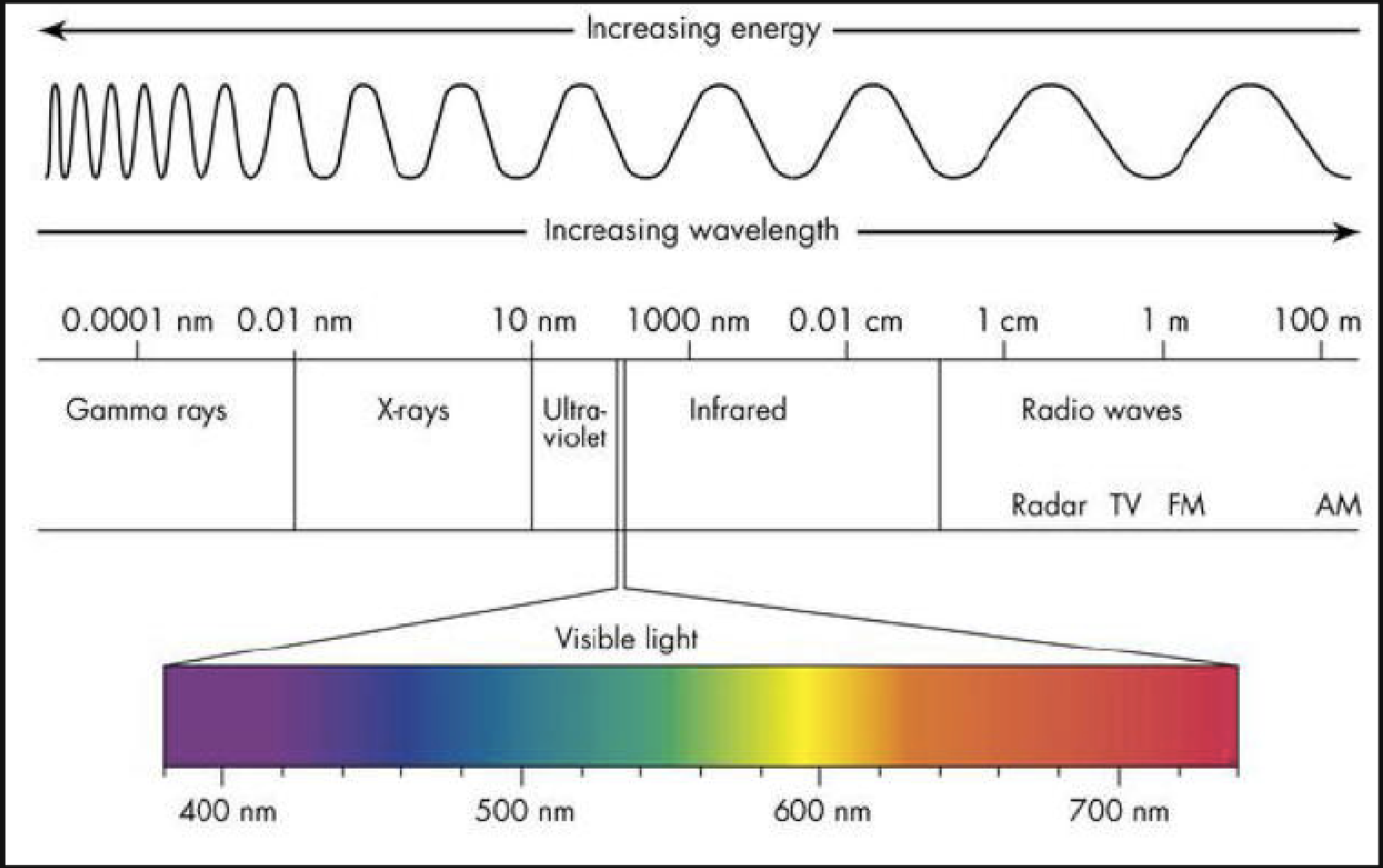
What is Adinídíín (Light)?

- Energy travels in waves – the wavelength determines the type of energy
- Shorter wavelength -> higher energy
- **Sunlight** is electromagnetic radiation emitted by the sun



What is Adinídíín (Light)?





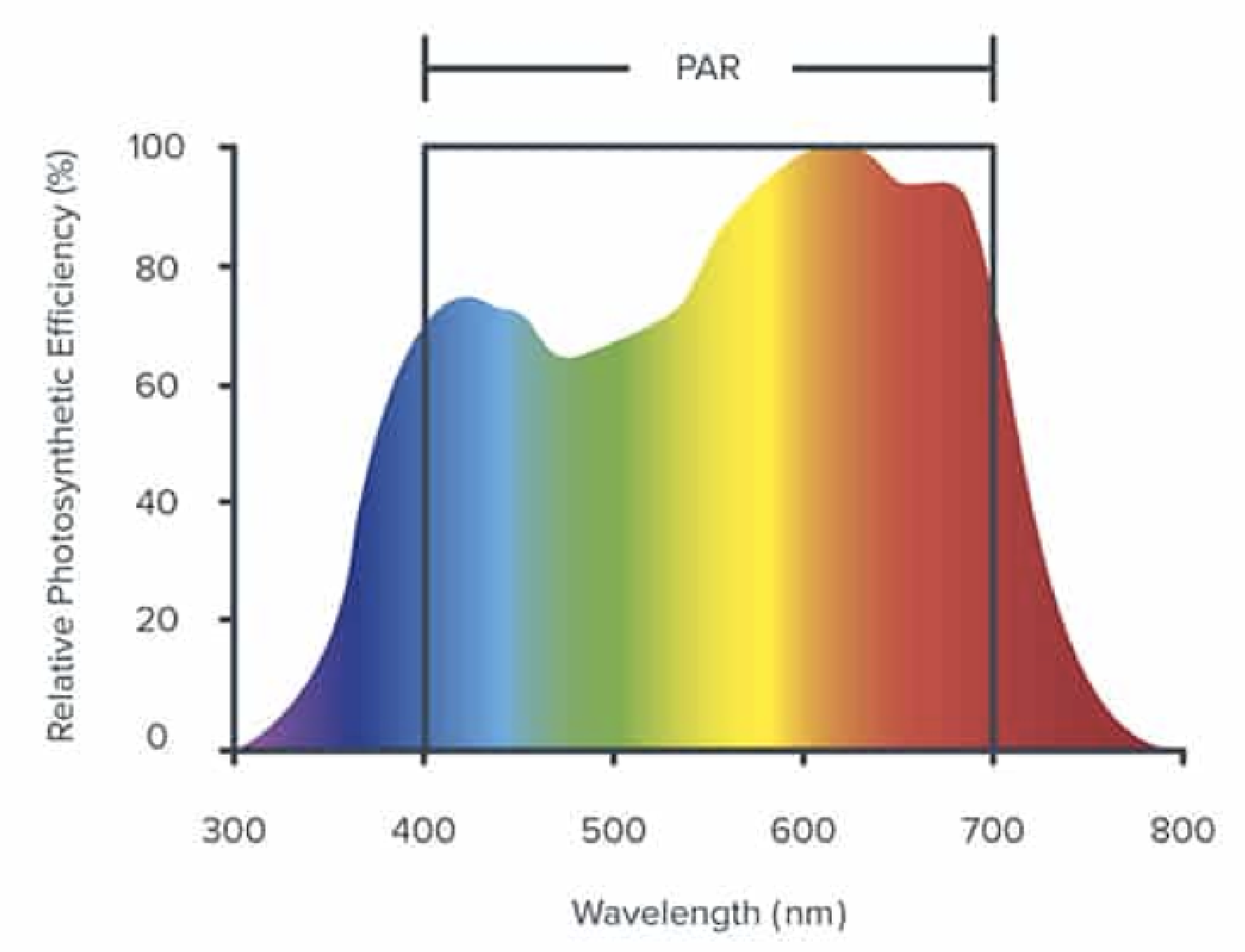
How to measure light?

Pyranometer: a sensor that converts the global solar radiation it receives into an electrical signal that can be measured

Photosynthetically Active Radiation (PAR)

400 – 700 nm wavelengths (visible range)

Plants use these wavelengths to conduct photosynthesis!



We measure PAR using a quantum sensor

Light Availability in the U.S.

Daily Light Integral (DLI)

= accumulated PAR over the course of the day

Higher DLI means **more light for photosynthesis**

Plant	DLI (mol/(m^2 day))
Seedlings/cuttings	6-8
Small herbs	10-12
Butterhead lettuce	14-16
Cucumber	20-30
Eggplant	20-30
Tomatoes	22-30

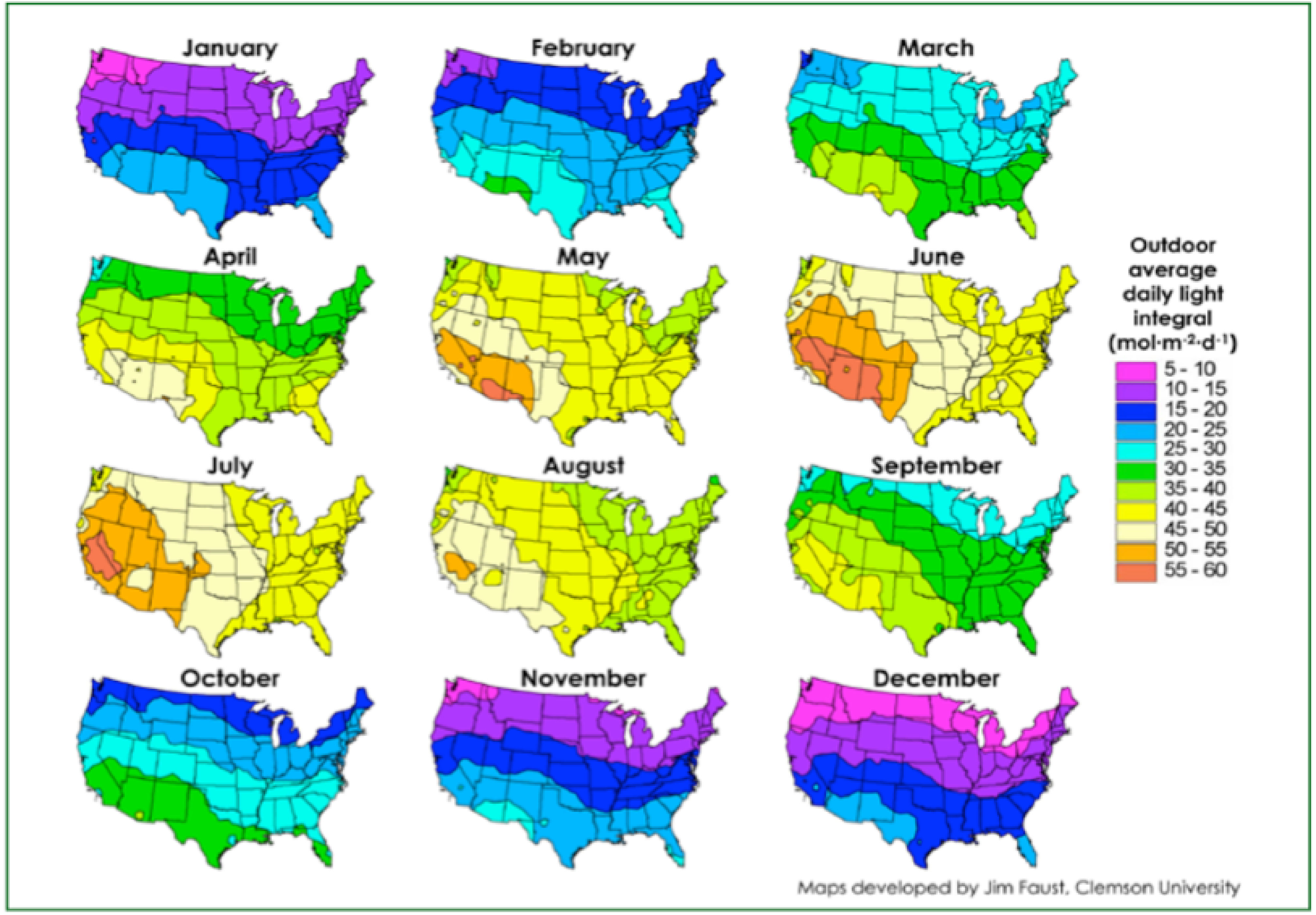


Figure 1. *Maps of monthly outdoor DLI throughout the United States.*

Source: Mapping monthly distribution of daily light integrals across the contiguous United States (Pamela C. Korczynski, Joanne Logan, and James E. Faust; Clemson University, 2002)

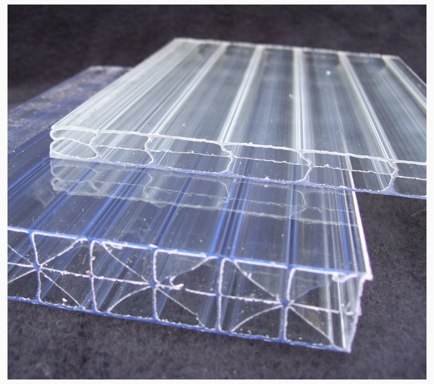
Greenhouse Design: Covering (Glazing)

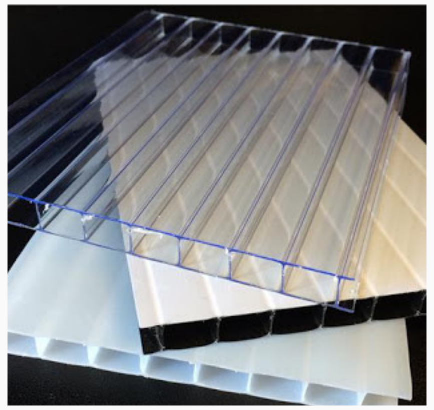
TODAY WE ARE LOOKING AT:

- Glass
- Polyethylene
- Polycarbonate
- Acrylic

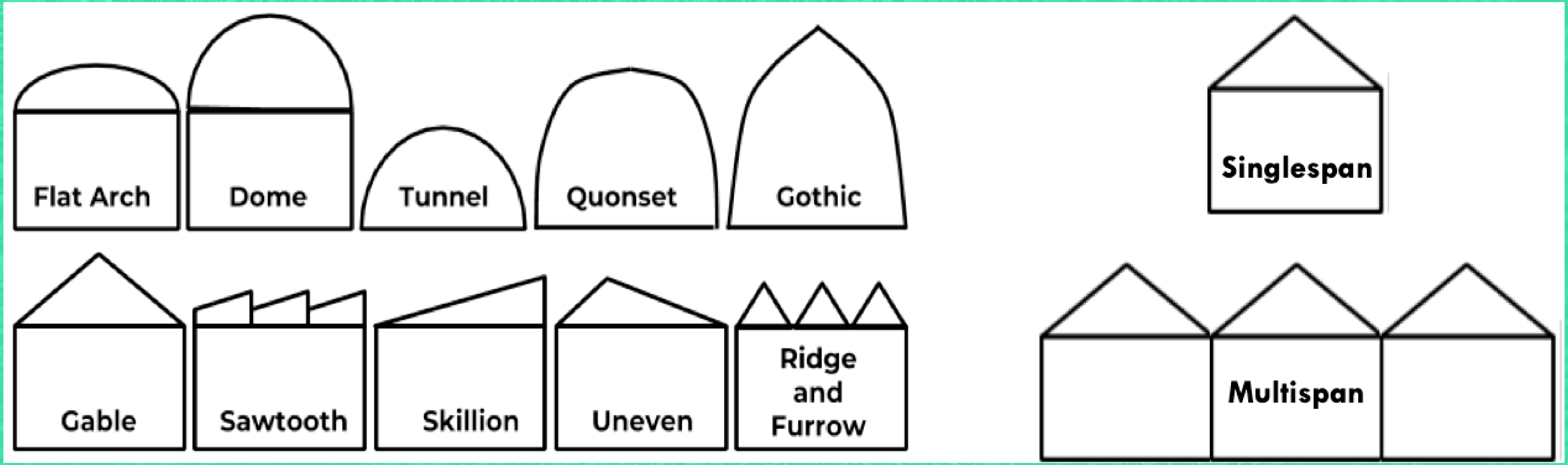
Covering Material	PAR Transmittance (%)	Infrared Transmittance (%)	UV Transmittance (%)	Durability (years)
Glass	90	<3	70	30+
Polyethylene (Double)	<80	50	48	3-4
Polycarbonate	83	<3	18	8-10
Arcrylic (Twin wall)	86	<5	44	20+

Covering Material	U (BTU hr^{-1} ft^{-2} F^{-1})=1/R	R Value
Single (double) glass	1.15 (0.7)	0.87 (1.43)
Single (double) poly	1.15 (0.7)	0.87 (1.43)
Double poly + thermal screen	0.3 – 0.5	3.3-2.0
Double layer polycarbonate	0.6	1.67
Double layer acrylic	0.6	1.67



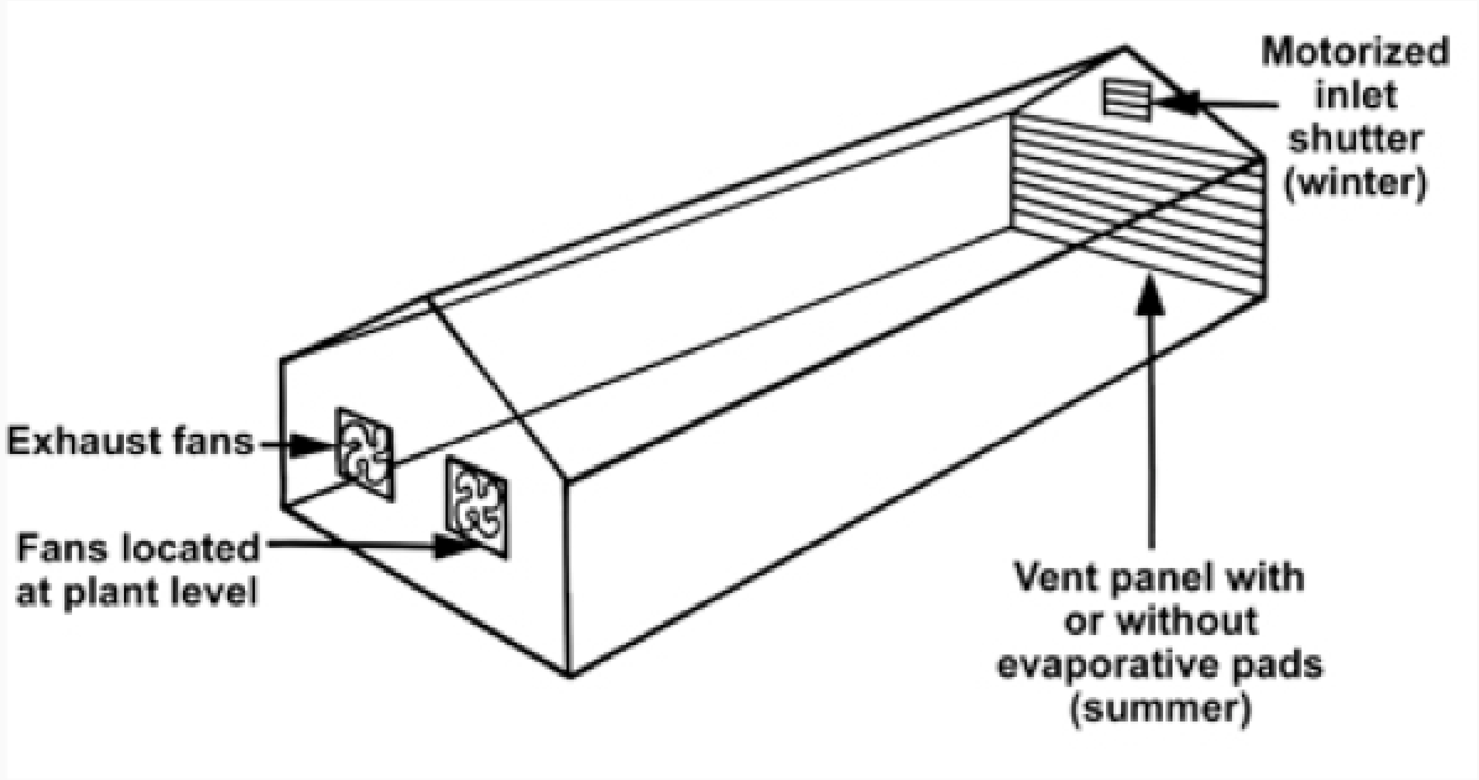


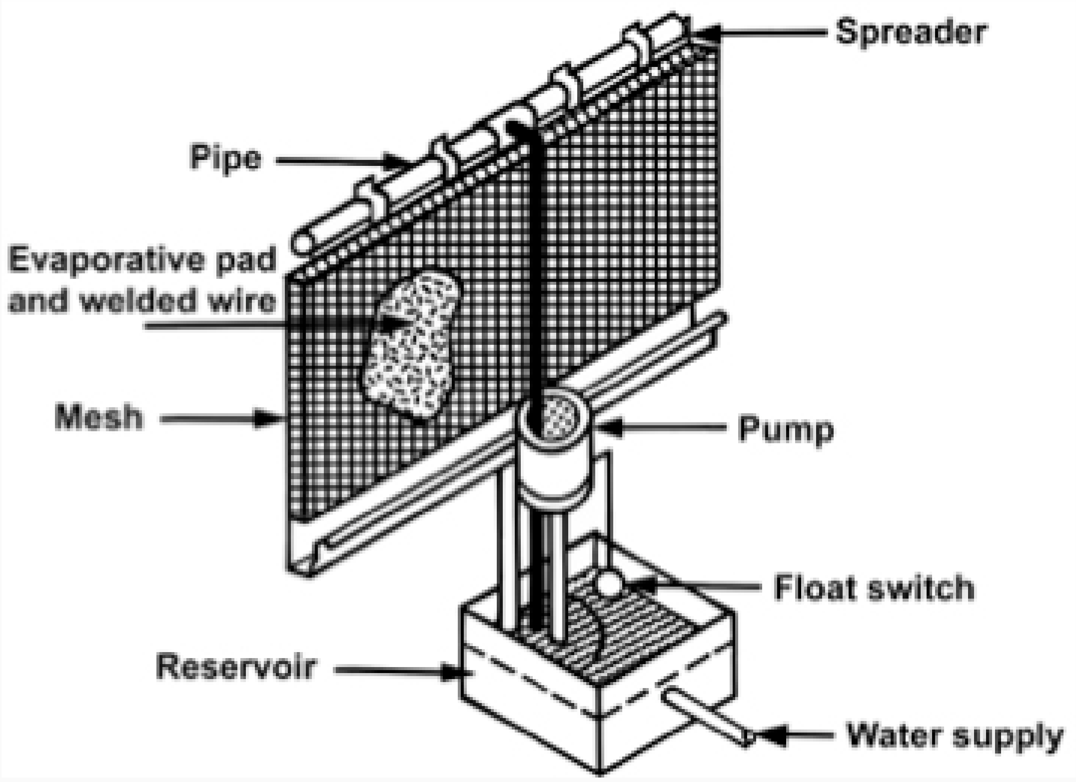
Greenhouse Shapes and Styles

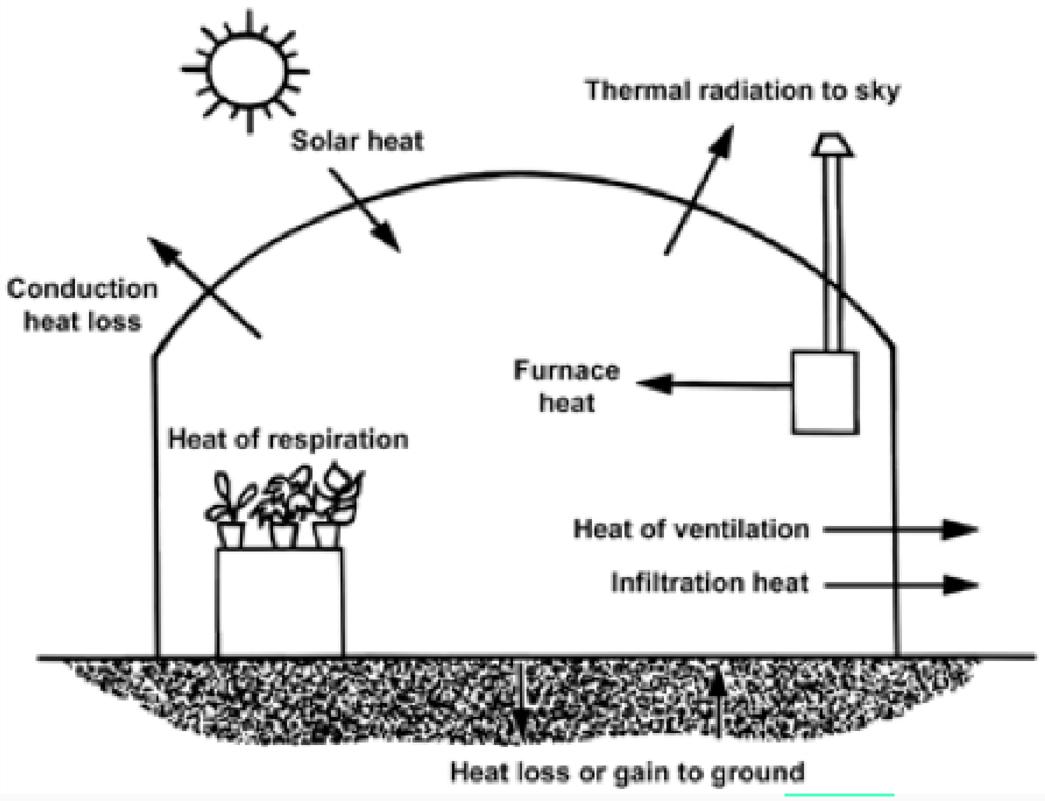


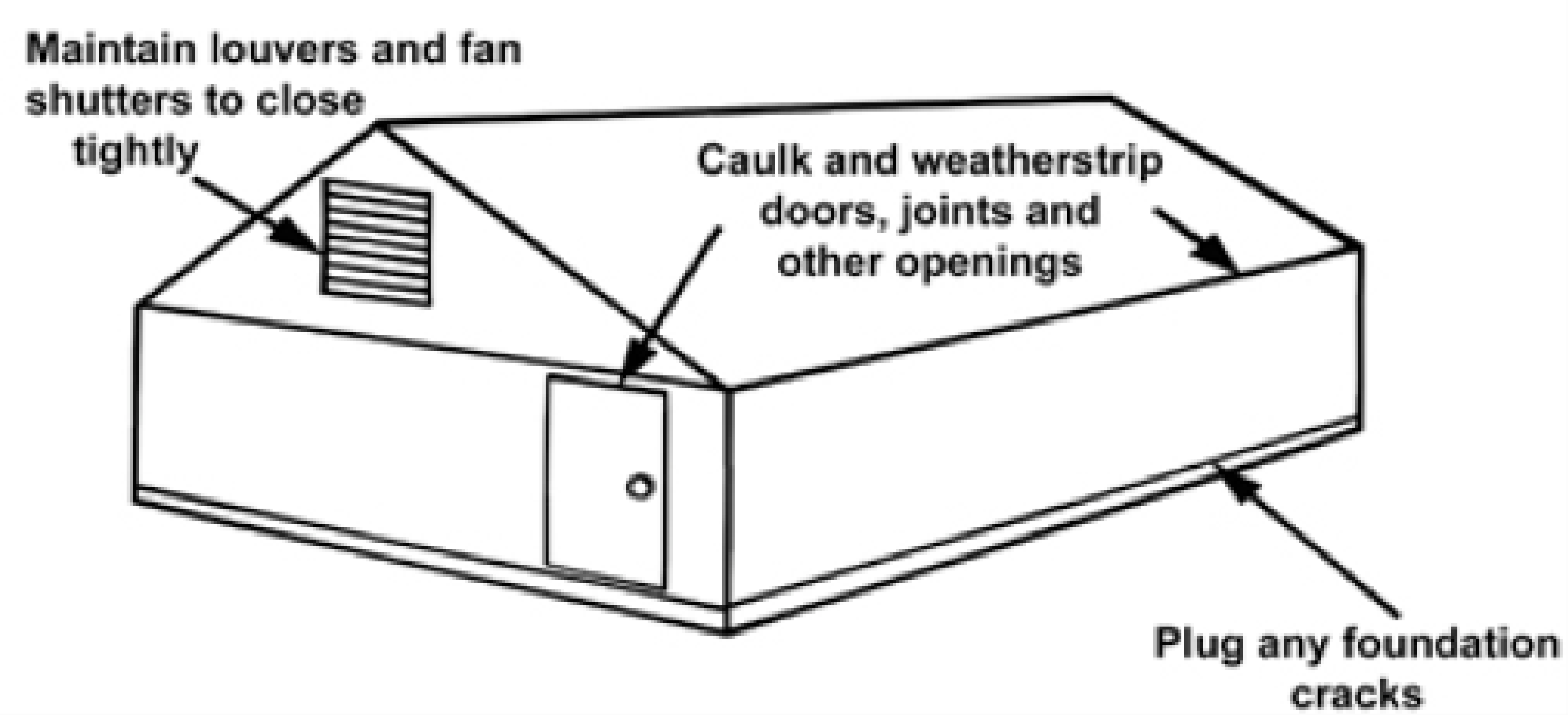
Hortitech Greenhouse: https://www.greenhouseht.com/greenhouse-frames

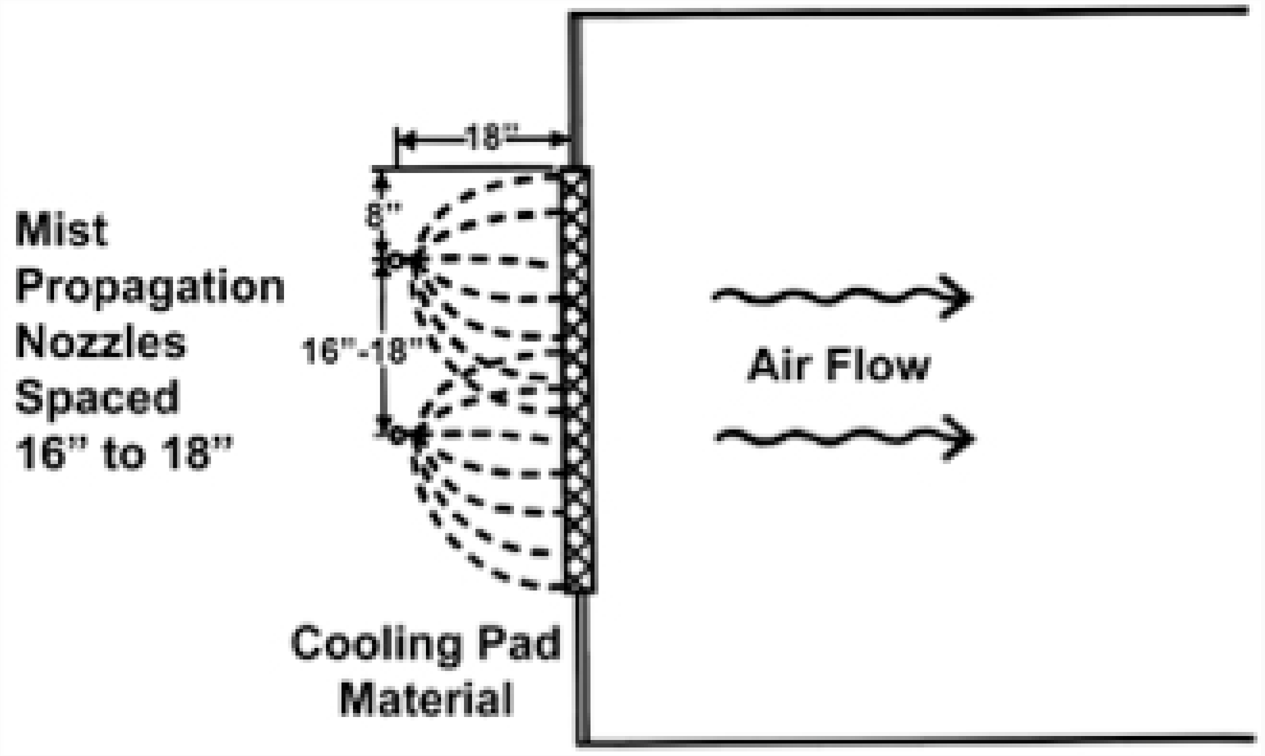
GREENHOUSE DESIGN: HEATING, COOLING, VENTILATION











https://extension.uga.edu/publications/detail.html?number=B792&title=Greenhouses:%20Heating,%20Cooling%20and%20Ventilation

Heating

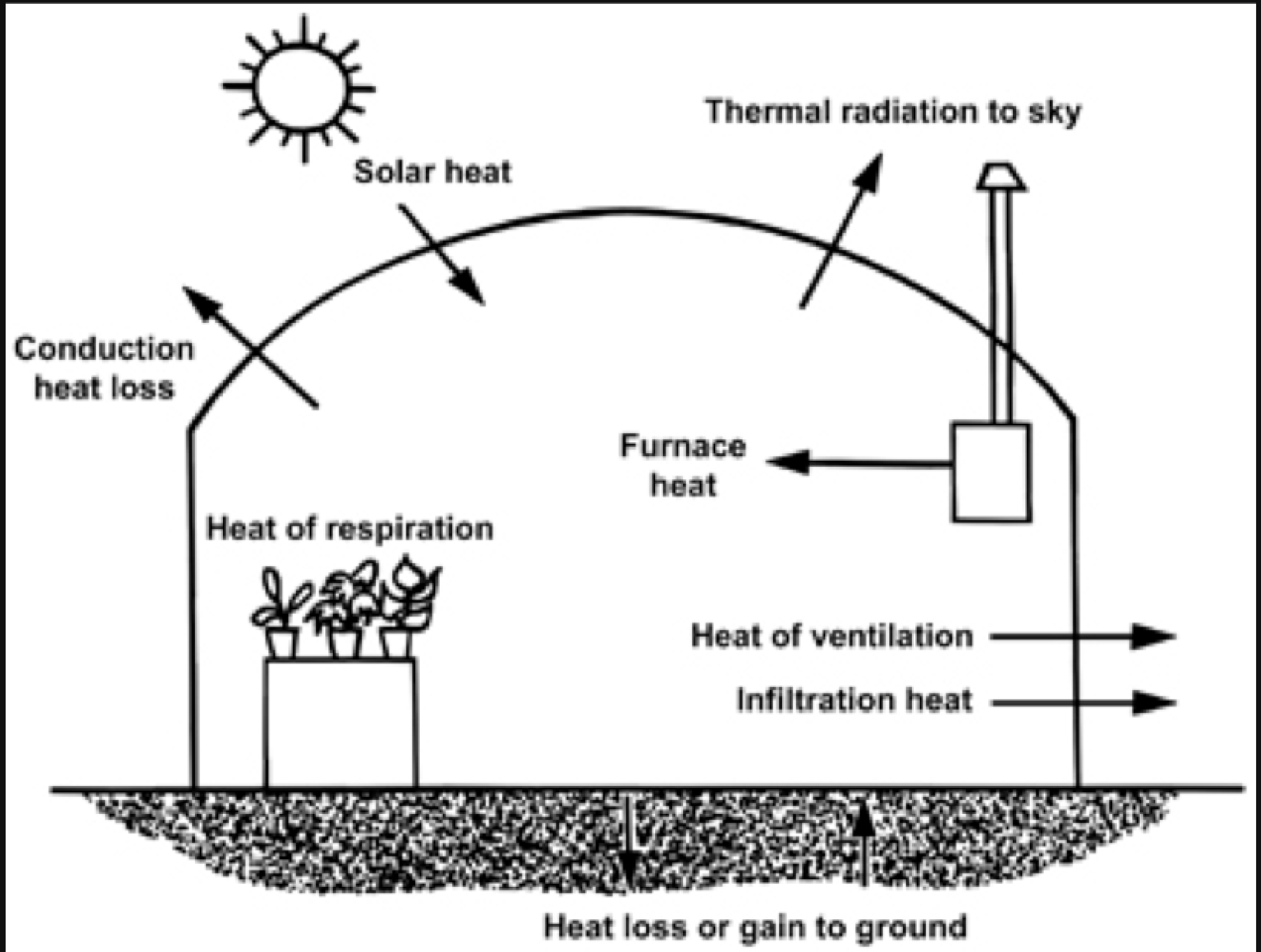
Greenhouse Energy Balance

$$Q_{greenhouse} = \sum Q_{in} - \sum Q_{out}$$

$$Q_{greenhouse} = Q_{heater} - Q_{conduction}$$

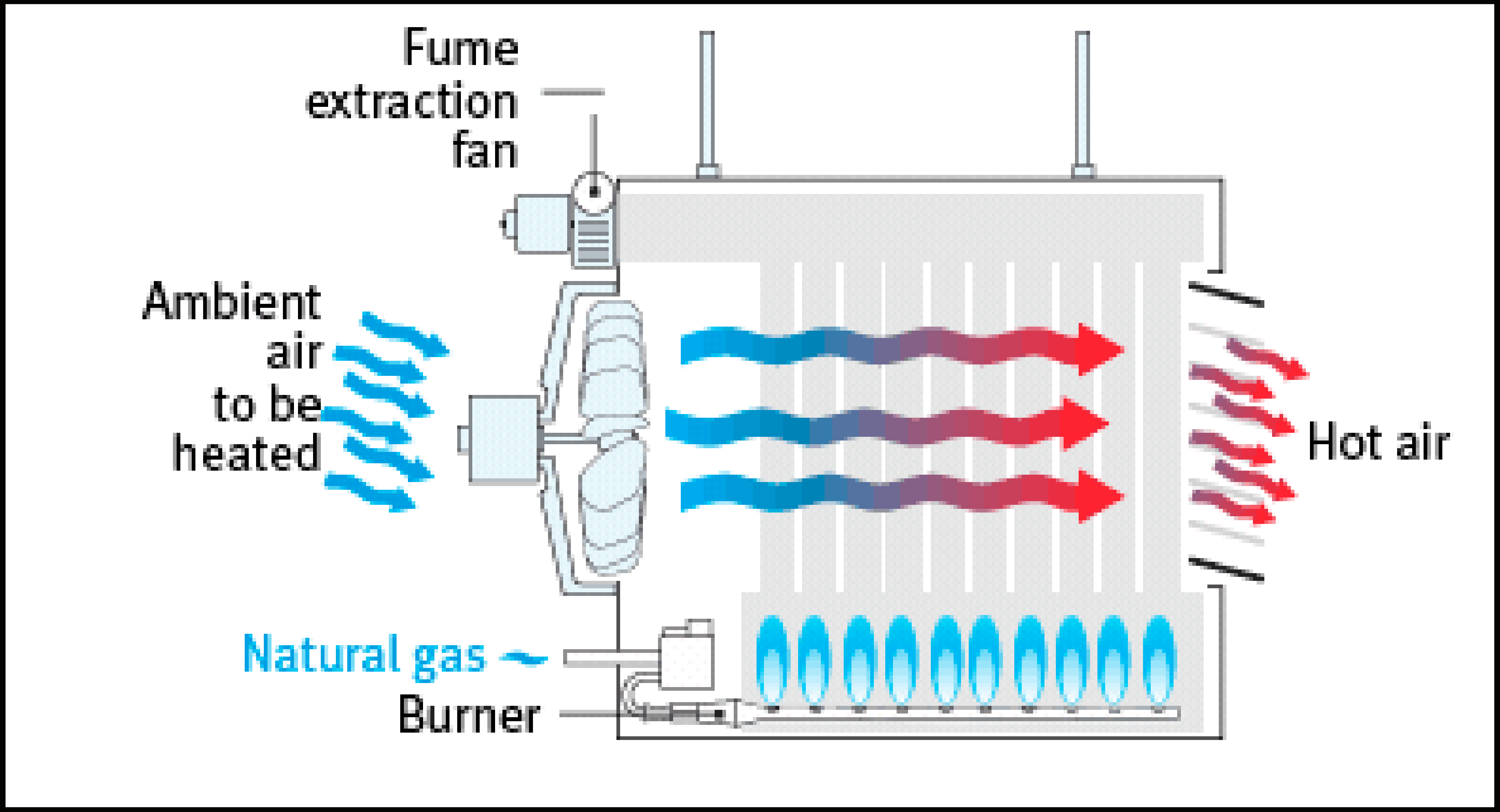
$$Q_{heater} = Q_{conduction}$$

$$Q_{conduction} = U\ A\ (T_{in} - T_{out})$$



U = heat transfer coefficient of the covering material in BTU/(hr °F ft^2)

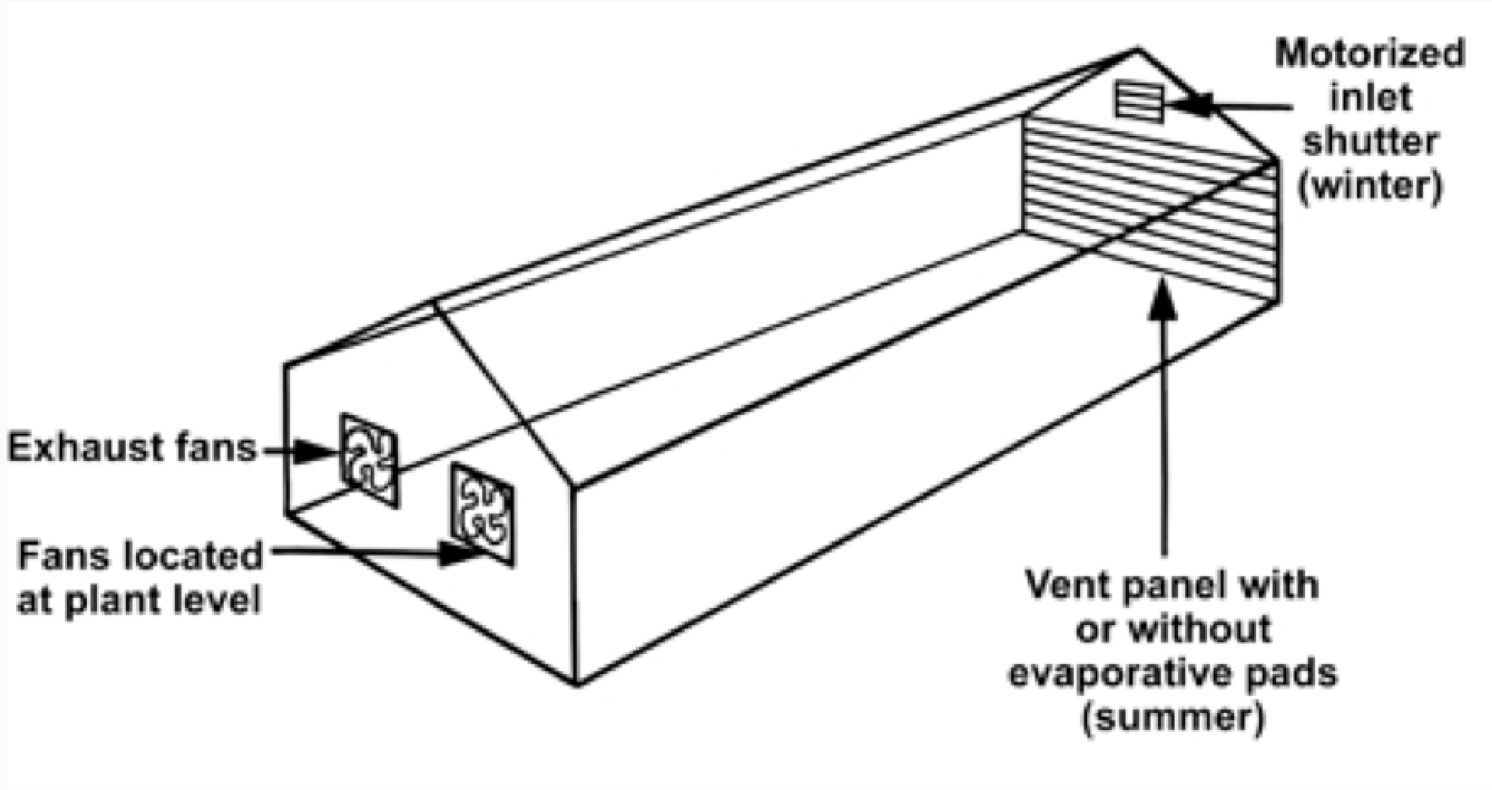
Unit Heater

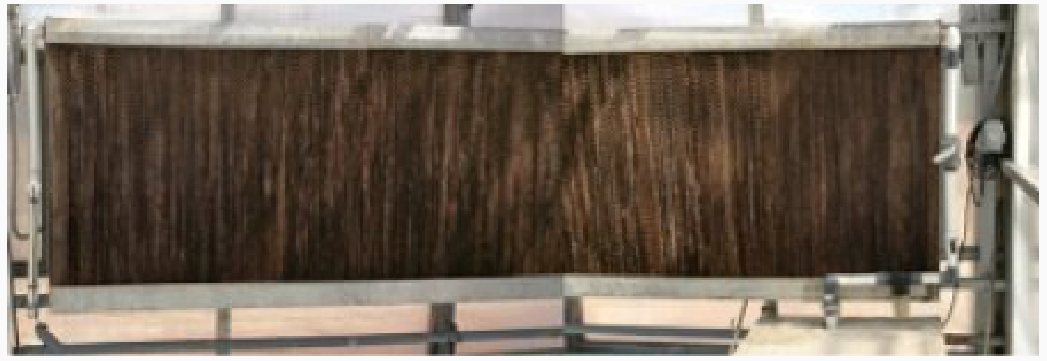

Fume
extraction
fan
Ambient
air
to be
heated
Hot air
Natural gas
Burner

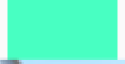
Evaporative Cooling

WHY WE USE IT:

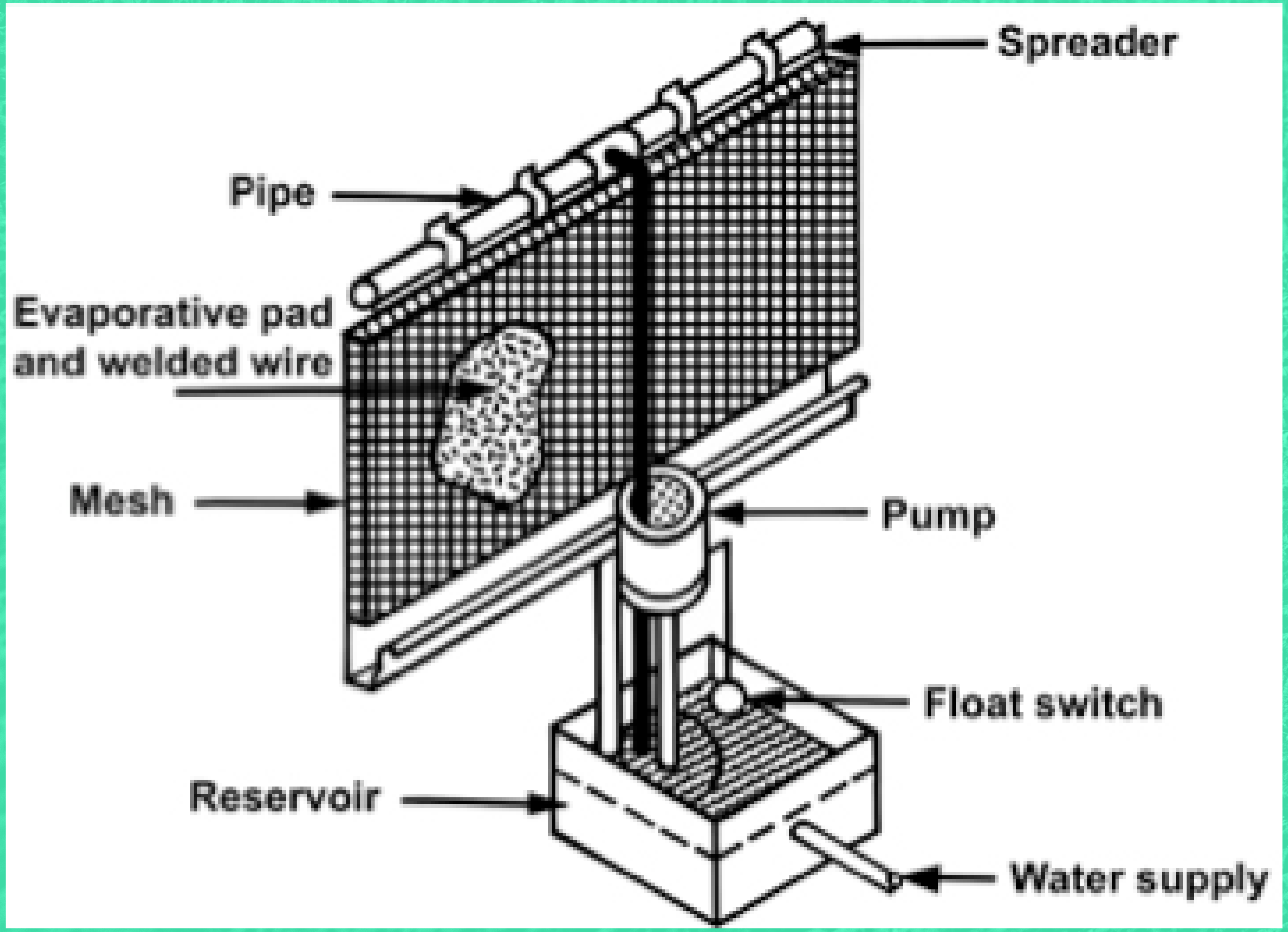
- Low energy consumption
- Dry climate







Evaporative Cooling



Climate Controller

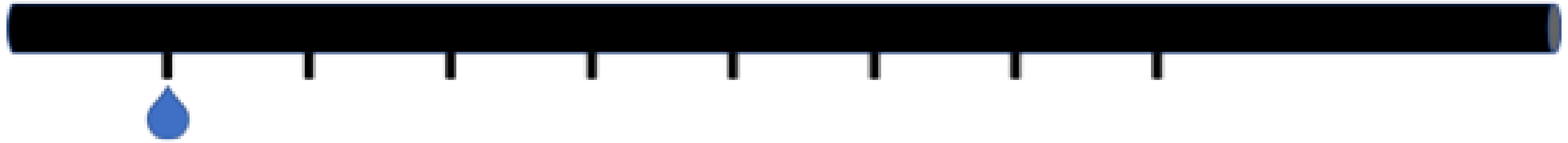
WHY WE USE IT:

- Temperature & Relative Humidity Sensors in the center of the room
- If it's too hot, too cold, or too humid, then cooling, heating, or ventilation systems are turned on

Irrigation

DRIP TAPE

DRIPPERS



MISTERS

HYDROPONIC SYSTEMS...

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RESEARCH, INNOVATION & IMPACT
Arizona Institutes for Resilience

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