Postharvest technologies for the developing world

Forum on postharvest practices
UC Washington Center

Michael Reid, UC Davis

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USAID FROM THE AMERICAN PEOPLE

HORTICULTURE INNOVATION LAB

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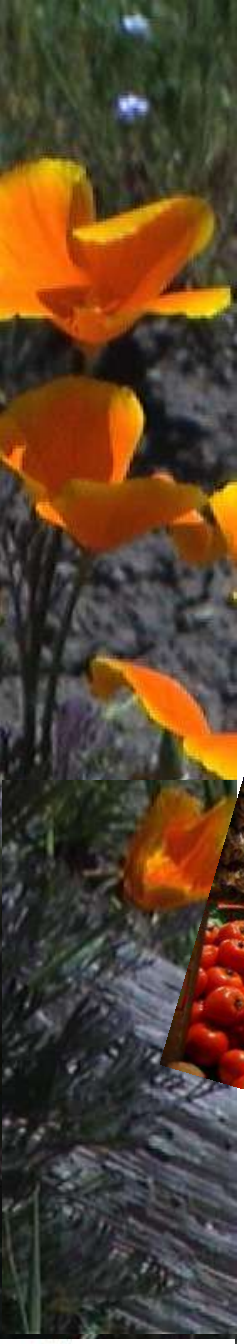
Food supply depends on better postharvest technology

- Losses are high
  - Perishables > 30%
  - Grains 10 – 20%



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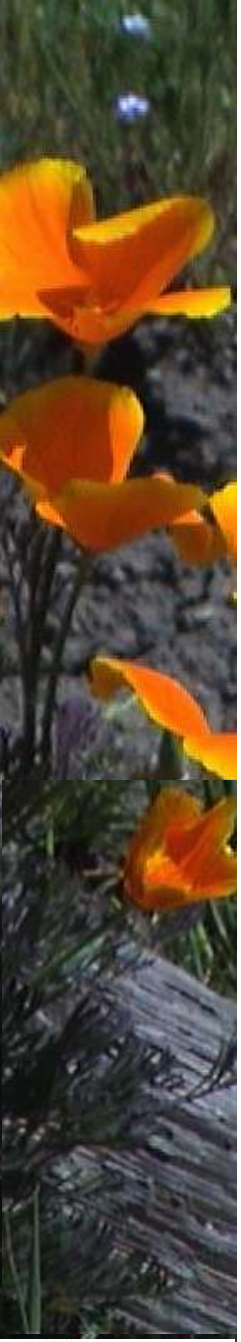

Postharvest opportunities

- Germplasm manipulation
- Innovations in cooling
- Electronics, communication and robotics
- Improved packaging
- Innovative marketing

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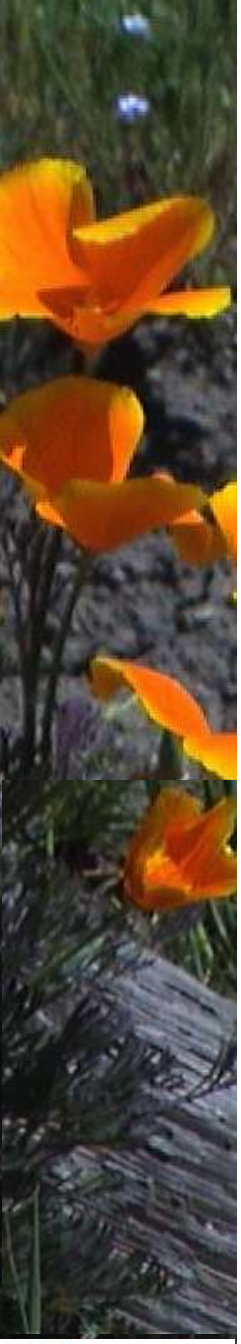

Germplasm manipulation

- Many of the issues relating to postharvest losses of horticultural crops in the developing world can be addressed using molecular tools,

BUT

- The information resulting from the application of the tools of modern biology to plants has only sparingly been applied to horticultural crops, and hardly at all to postharvest improvement

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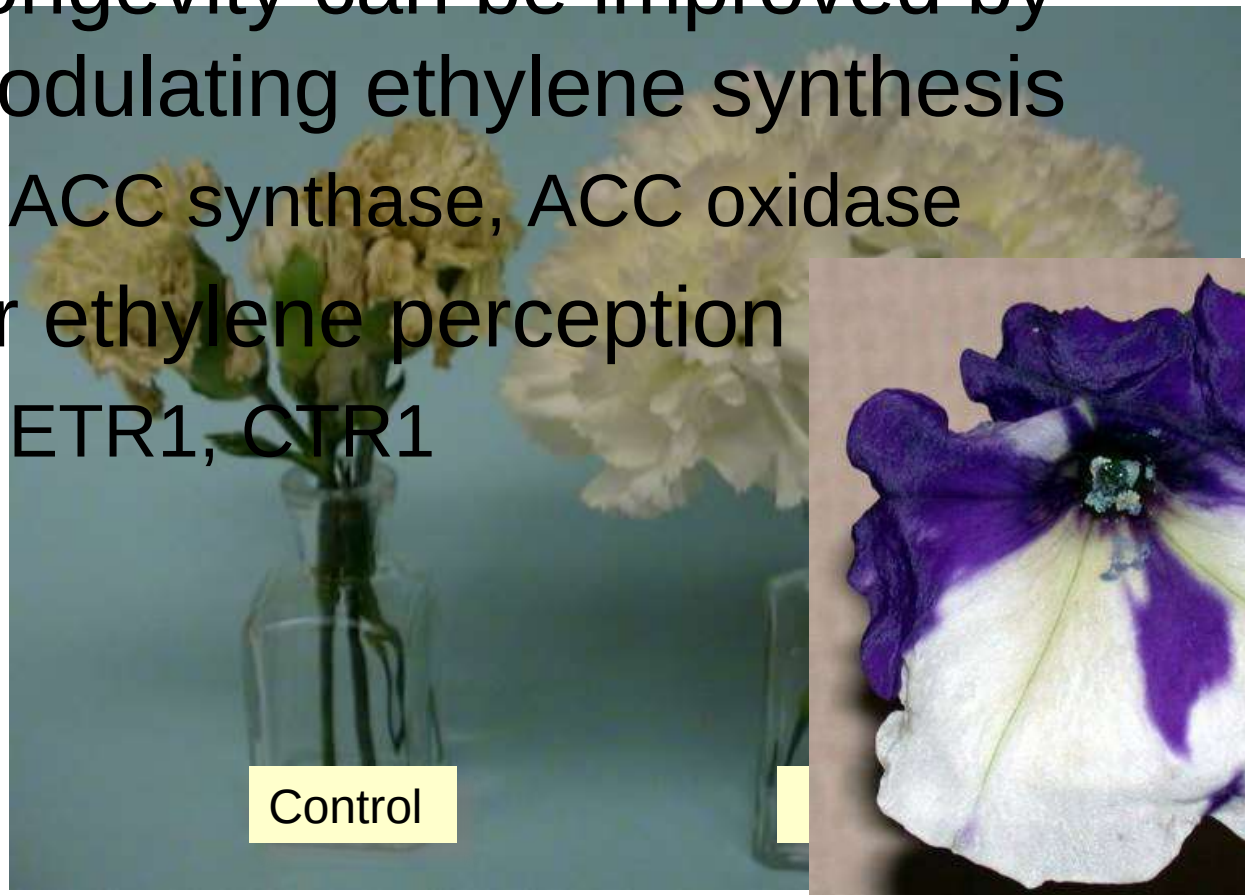
Example: *Postharvest life*

- Postharvest life of many fruits and flowers is regulated by ethylene
- Longevity can be improved by modulating ethylene synthesis
  - ACC synthase, ACC oxidase
- Or ethylene perception
  - ETR1, CTR1



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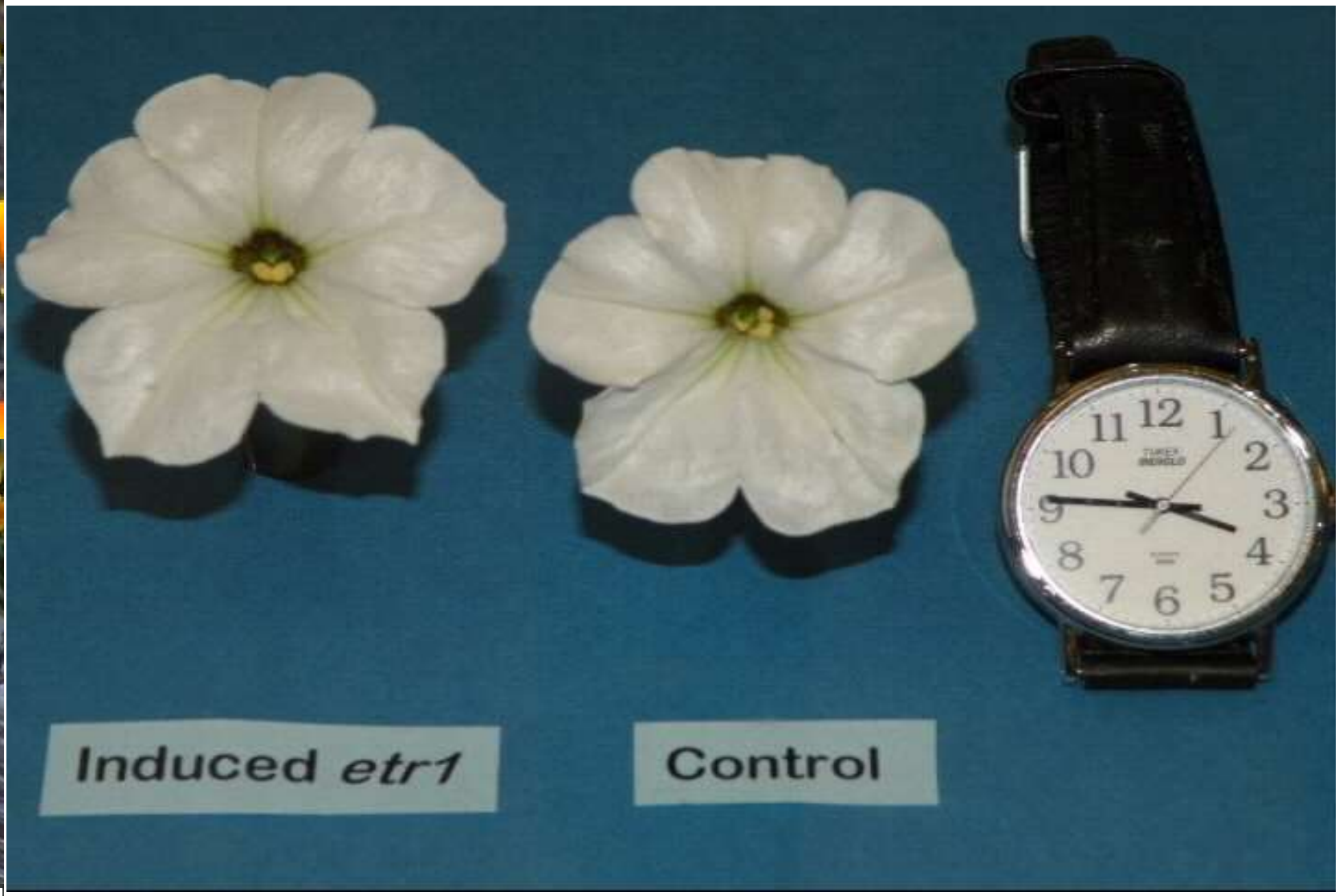
Induced ethylene resistance



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Shelf life and quality of ‘Charentais’ melons is greatly improved by biotechnology

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Other biotech targets

Better-flavored varieties

- Heirloom, high flavor cultivars have poor postharvest characteristics
- Use biotech to improve flavor of modern cultivars, or the postharvest performance of heirloom varieties

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Arctic apples

- Modified to inhibit browning and retain crispness

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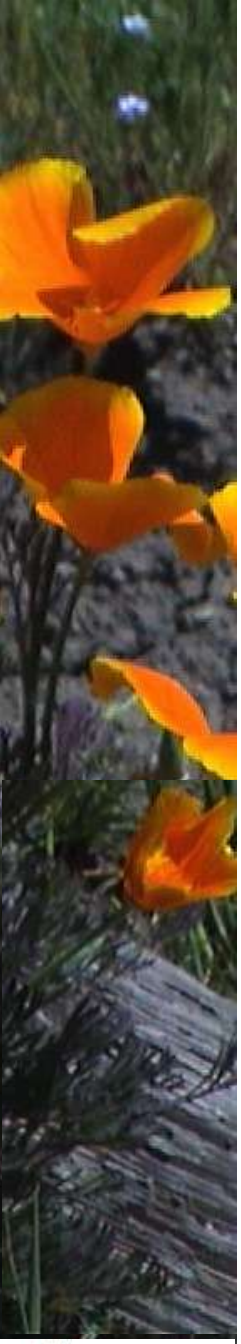
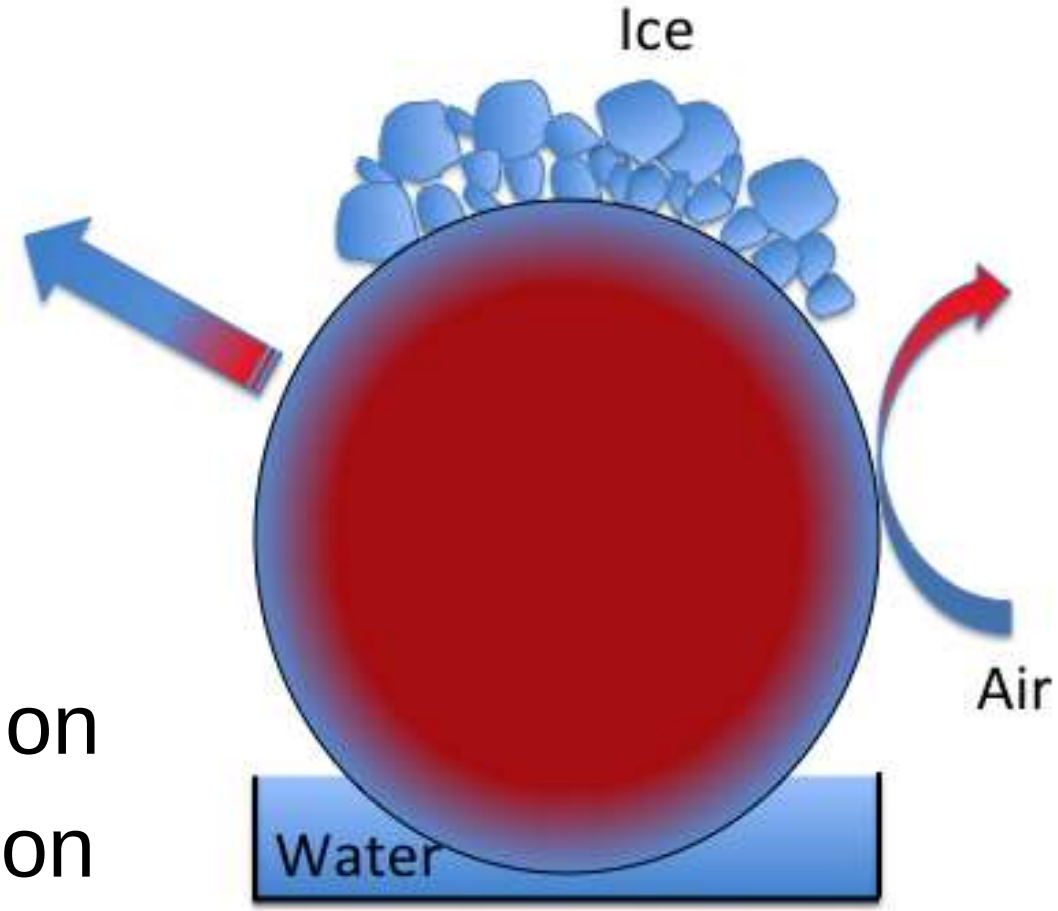
Other tempting targets

- Ethylene-independent ripening
- Ch
- Le



Innovative cooling methods



- Conduction
- Convection
- Radiation

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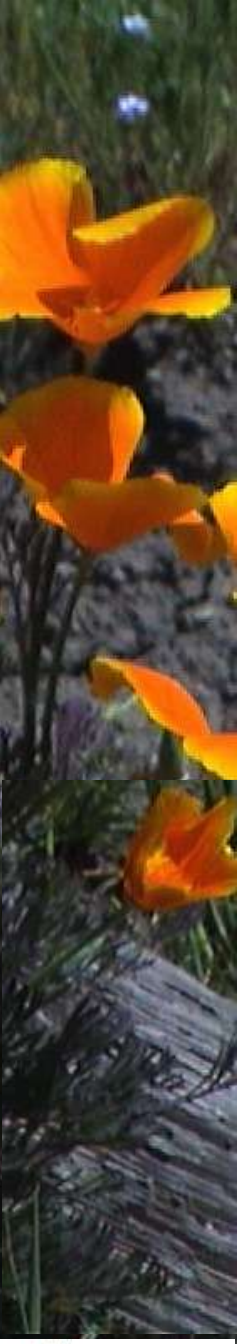
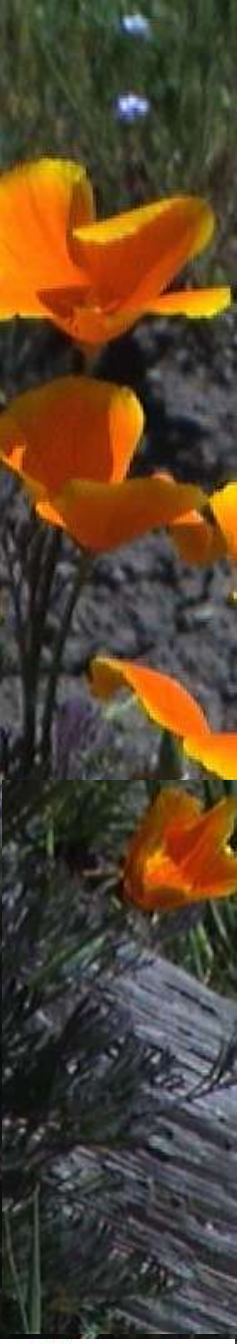


Product type determines cooling method

- Can be cooled with water or ice
  - Root vegetables
  - Mature fruits
- Must be cooled with air
  - Flowers
  - Leafy vegetables
- Cannot be cooled with ice
  - Chilling-sensitve crops
    - Tropical and sub-tropical fruits and vegetables



Packaging affects cooling choice

- Water tolerant
  - Wooden boxes
  - Returnable plastic crates
  - Waxed fiberboard cartons
- Water intolerant
  - Fiberboard boxes
  - Packs containing paper

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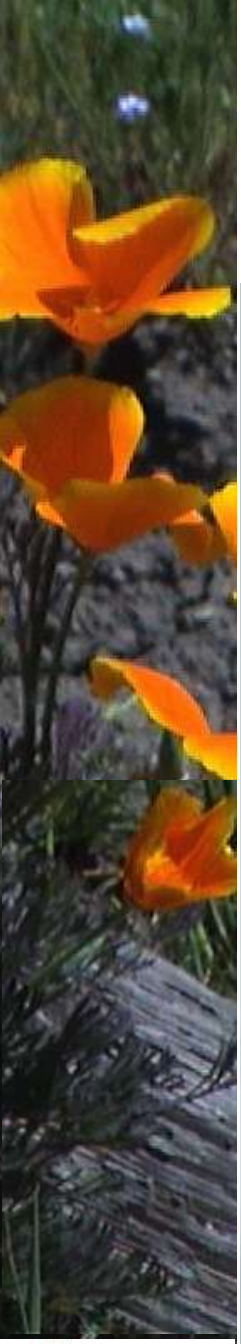

Cooling sources?

- Availability of electricity
- Availability of ice
- Availability of water
  - Volume
  - Sanitation
  - Temperature

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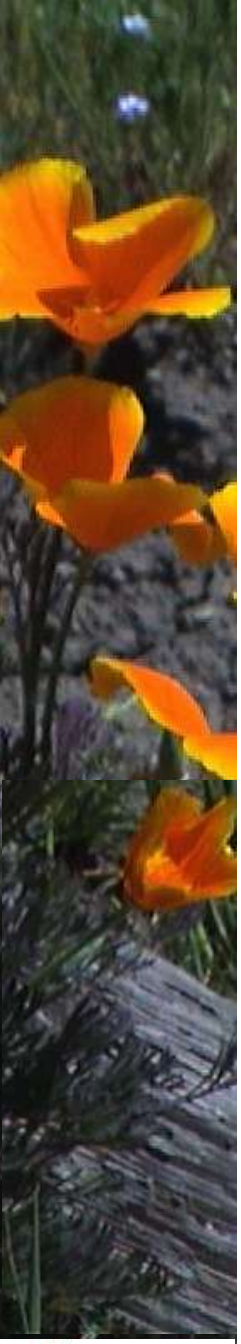
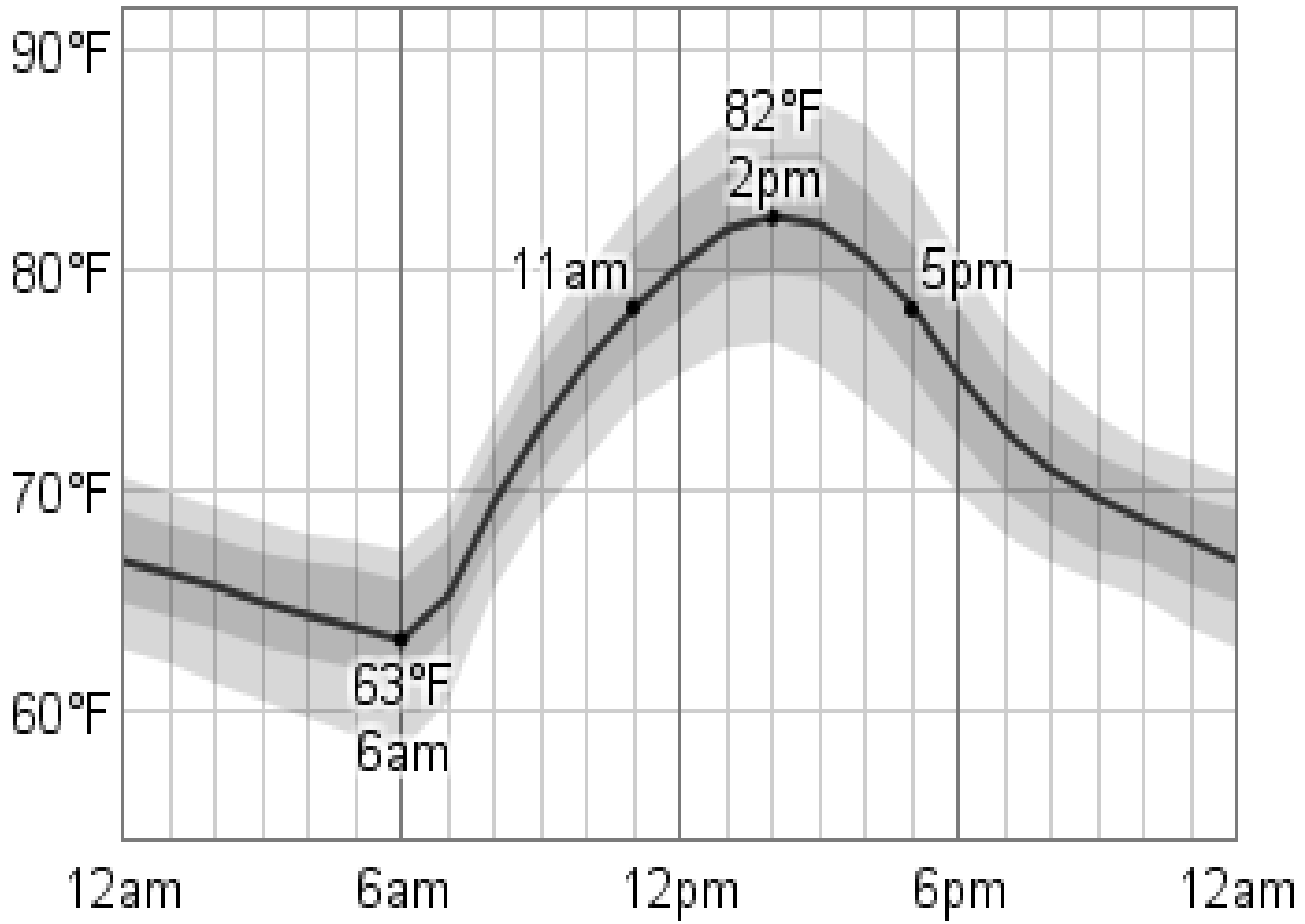


What is the temperature variation – daily, annual?



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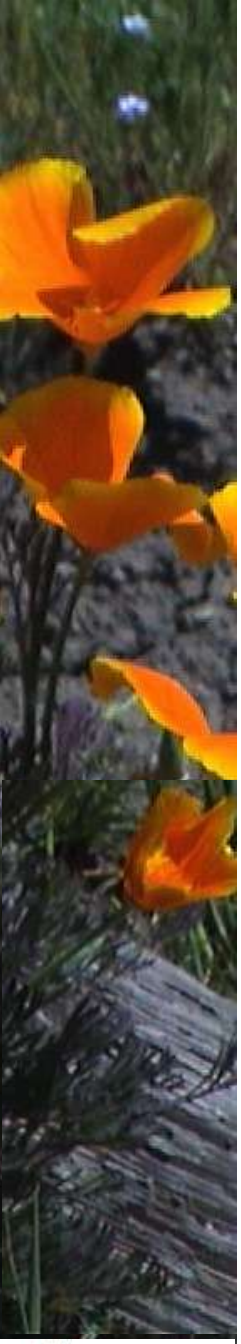
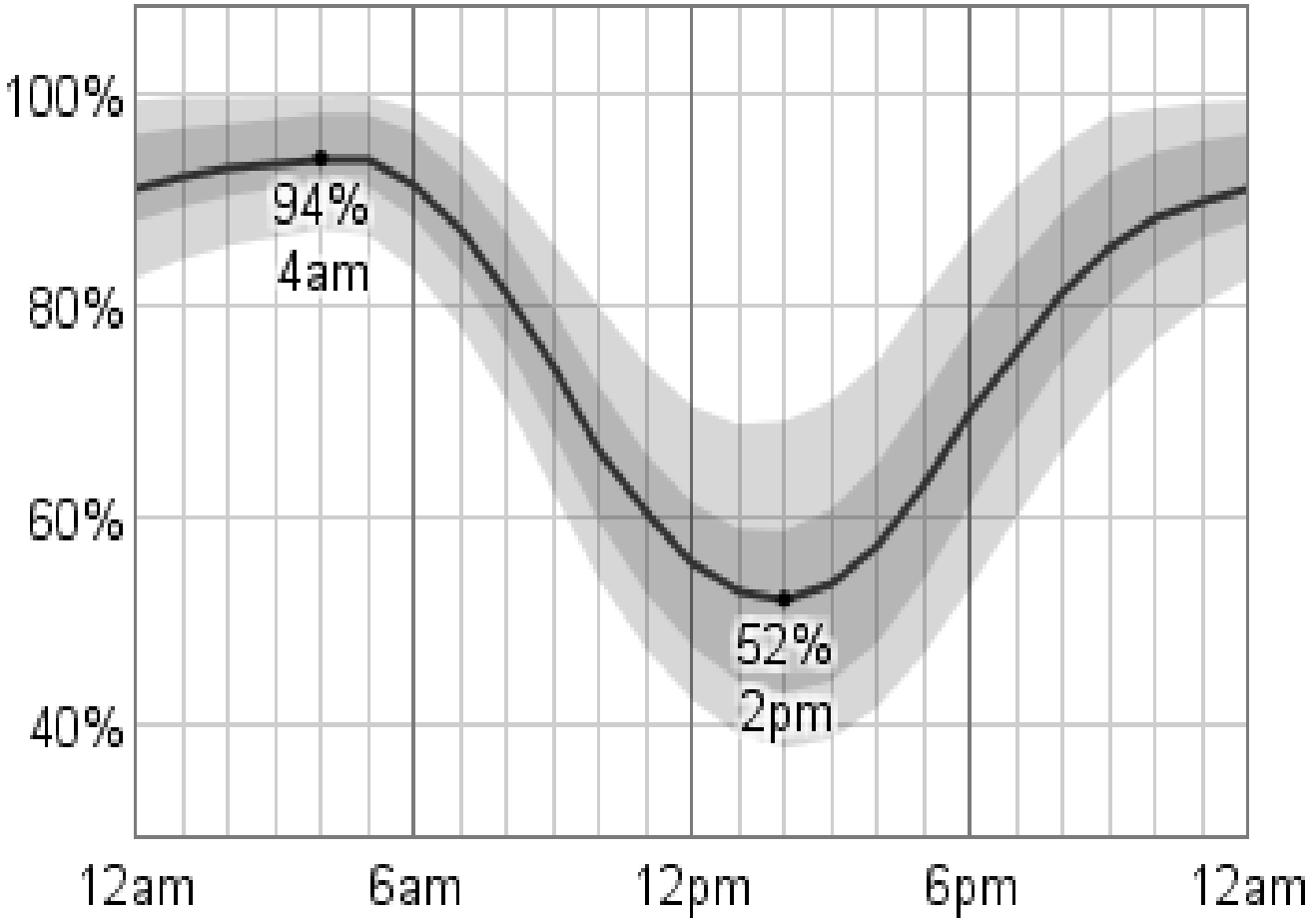


What is the daily humidity variation?



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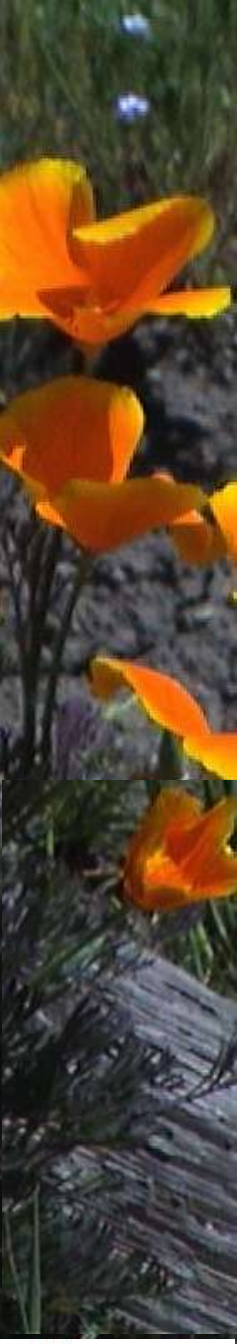
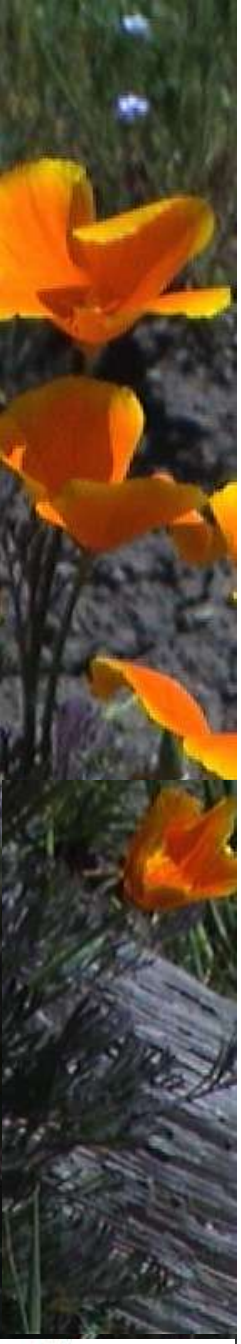


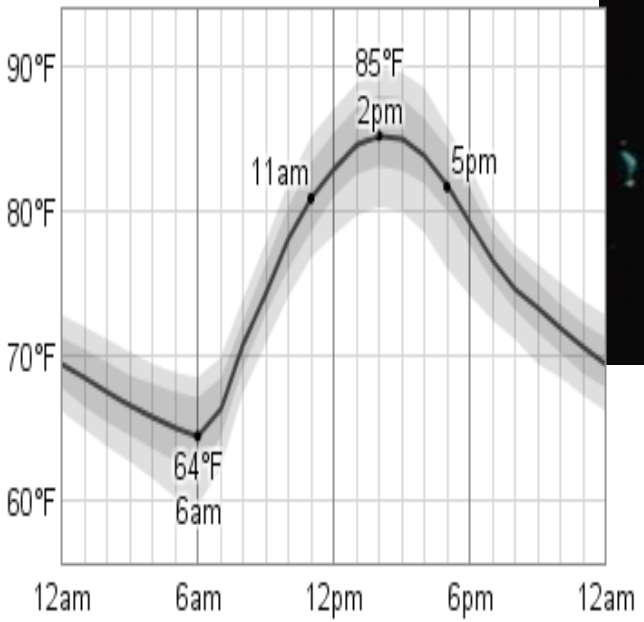
Choosing cooling methods

- The ‘no-brainers’
  - –Harvest at the coolest time of the day
  - –Including during the night
  - –Shade after harvest
    - Mist under the shade, if possible



Cooling starts in the field

- Night-time harvest?



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Shade reduces heat gain and water loss

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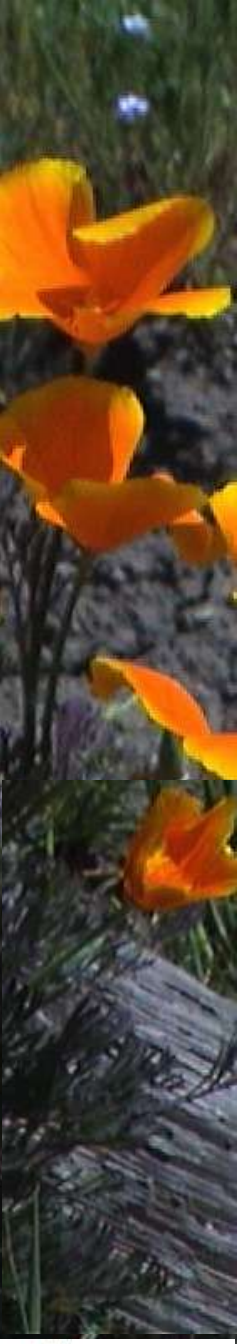

Strategies for inexpensive cooling

- Use cool media
  - –Night-time air
    - Radiation?
  - –Cold water
    - From well, river, or lake
    - Cooled with ice
  - –Ice
  - –Ice/water slurry

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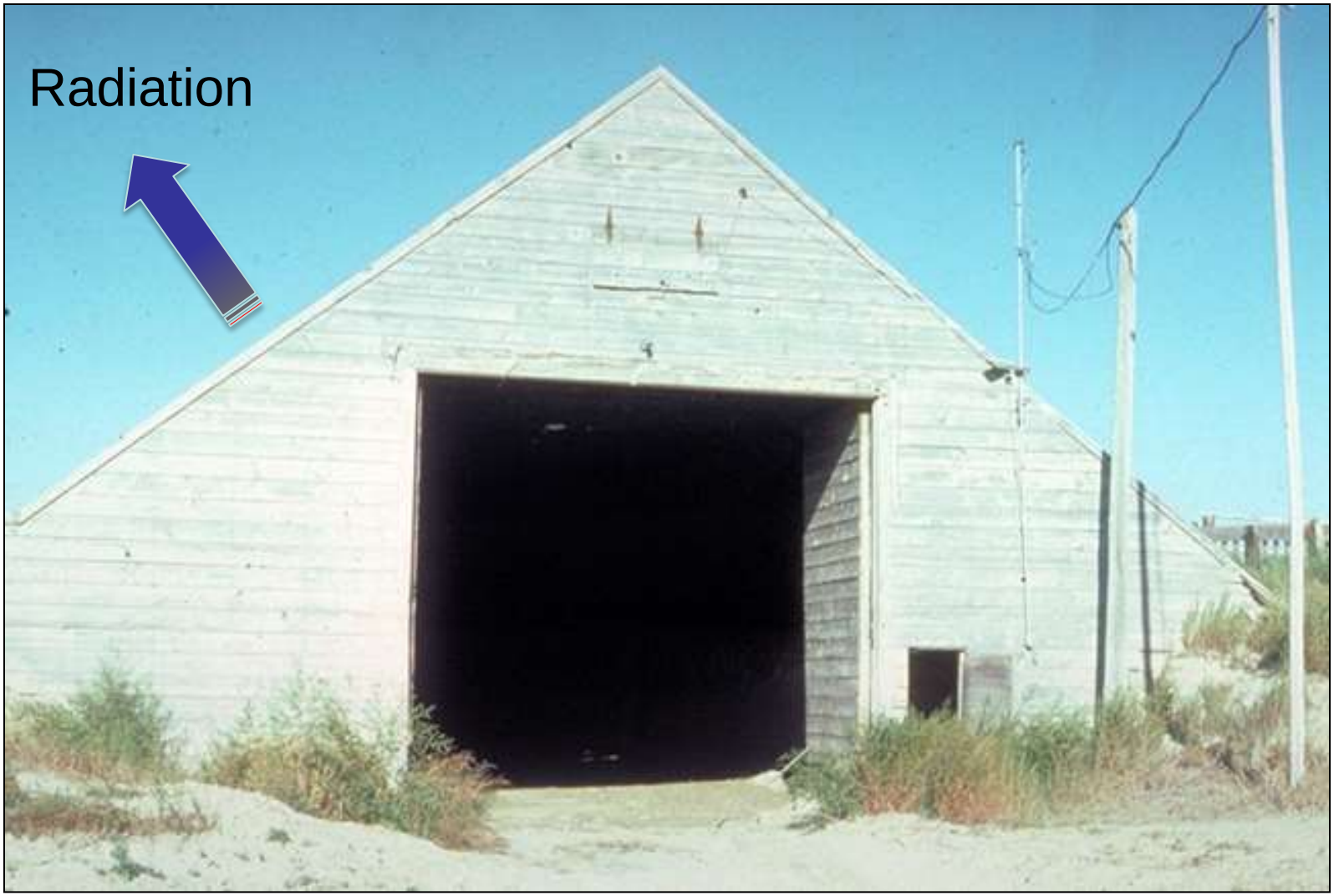
Night-air storage



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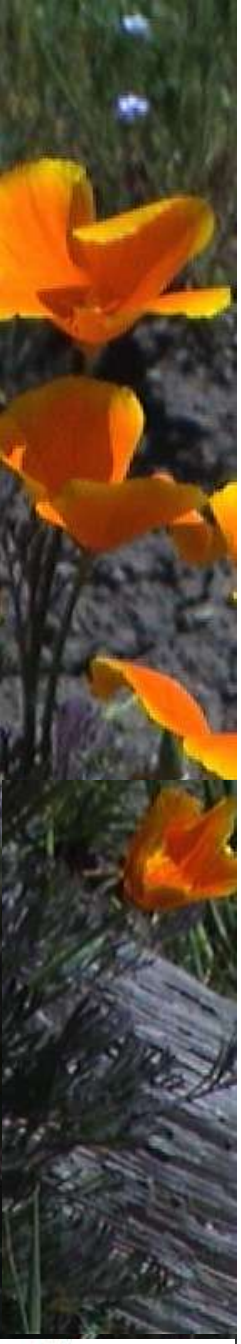
Cooling with ice



Ice solidifies and creates an insulating space around the product

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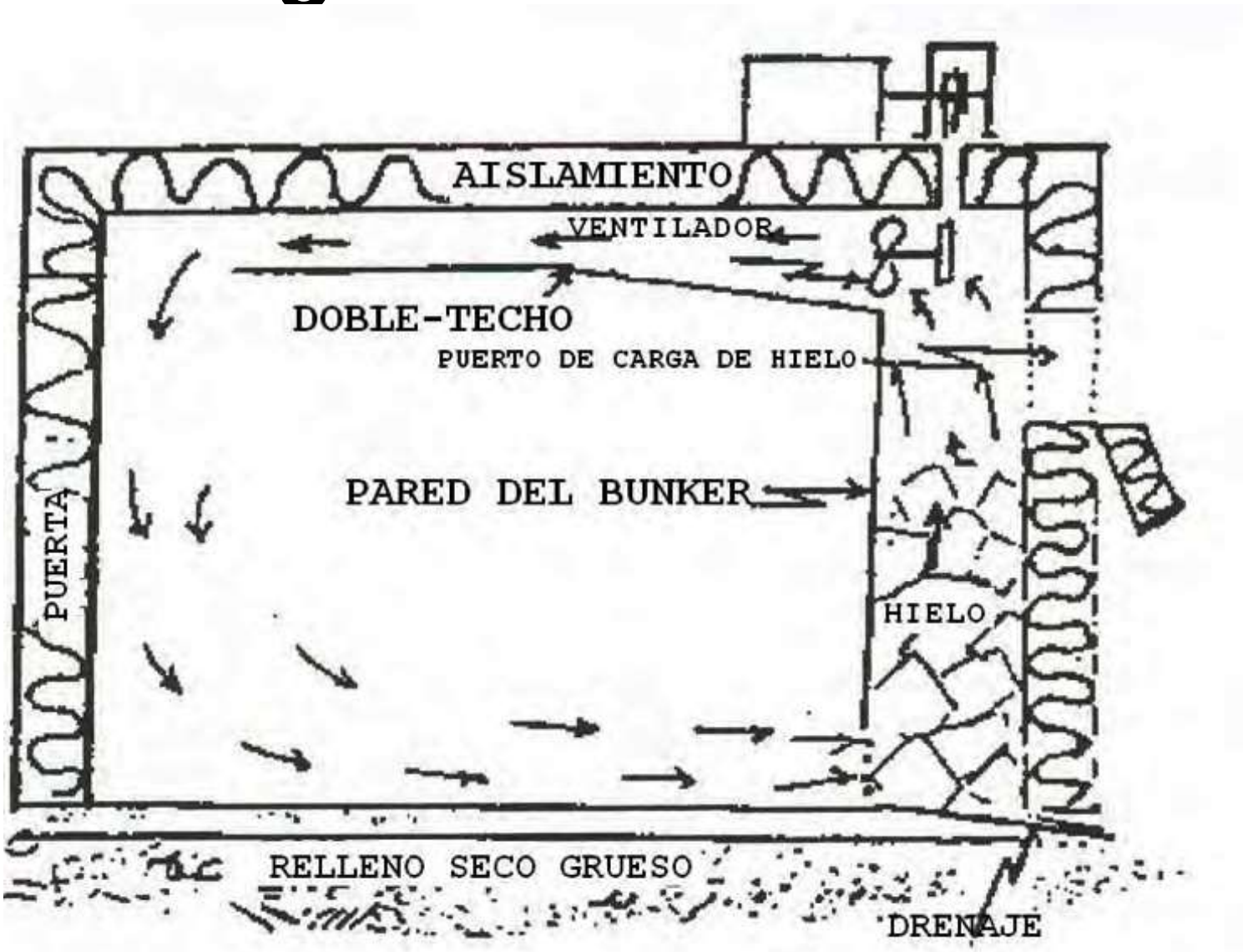
Cooling with an ice bank



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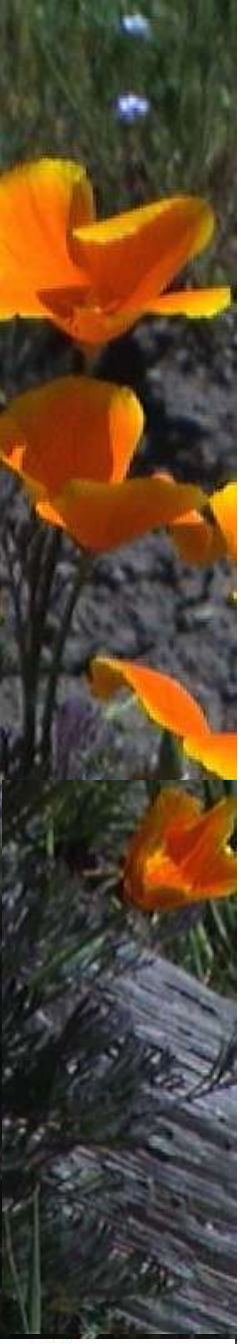
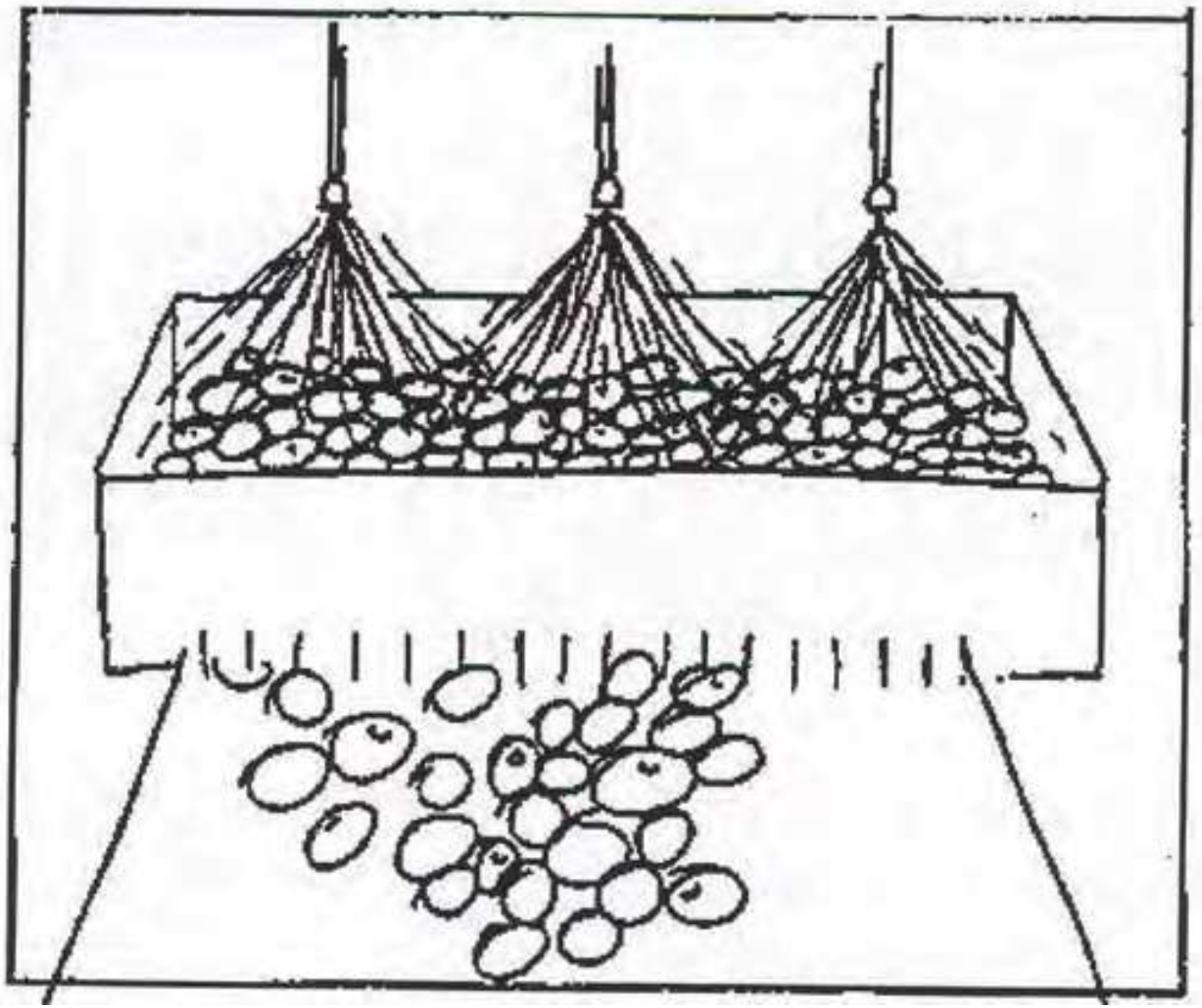


Cooling with water

Shower-type hydrocooler



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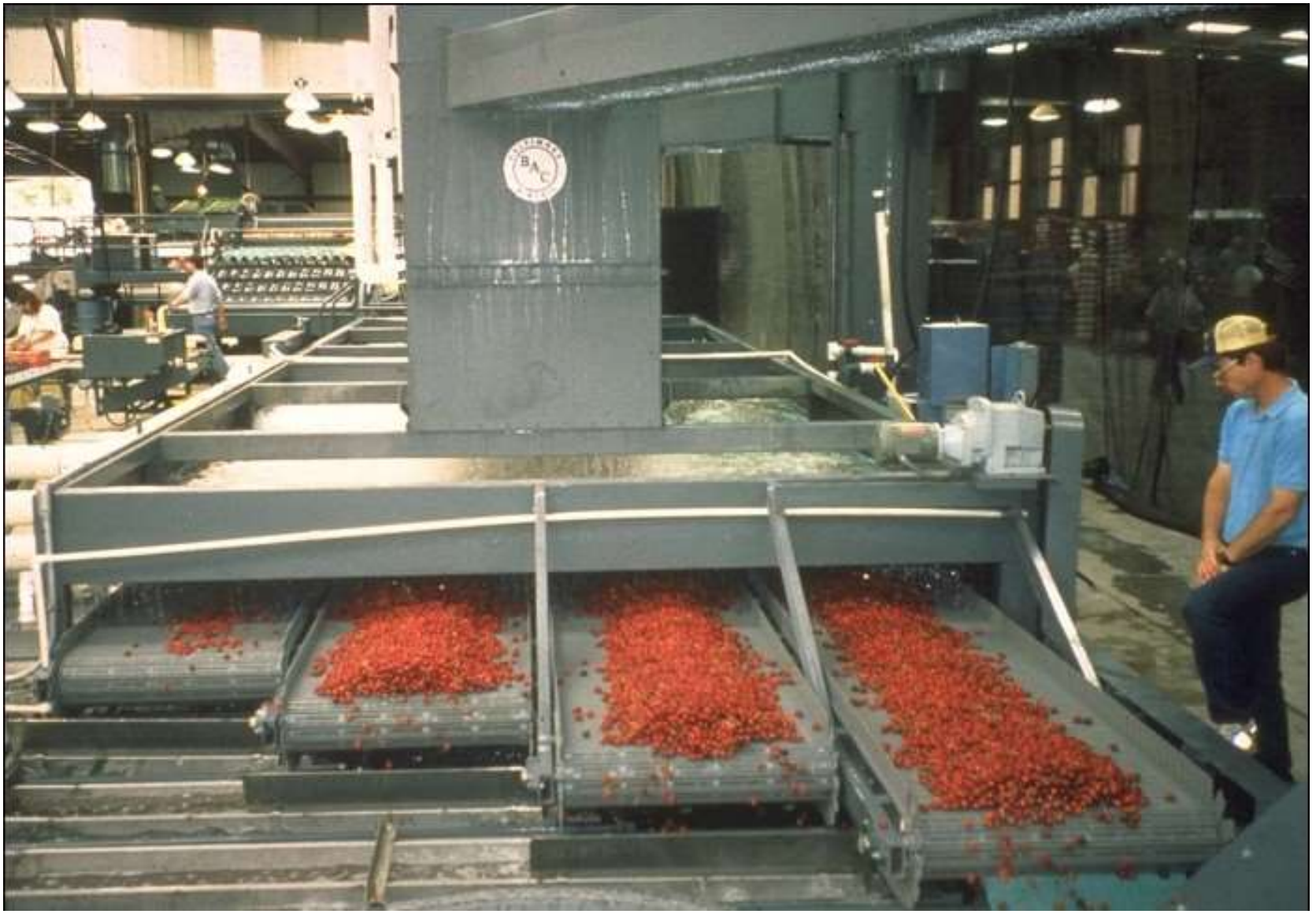

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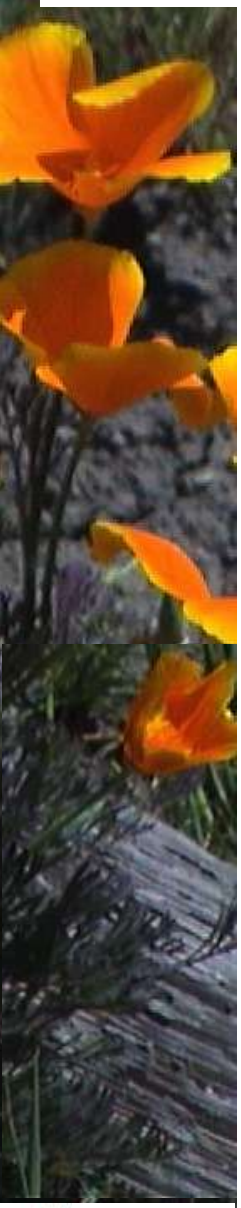
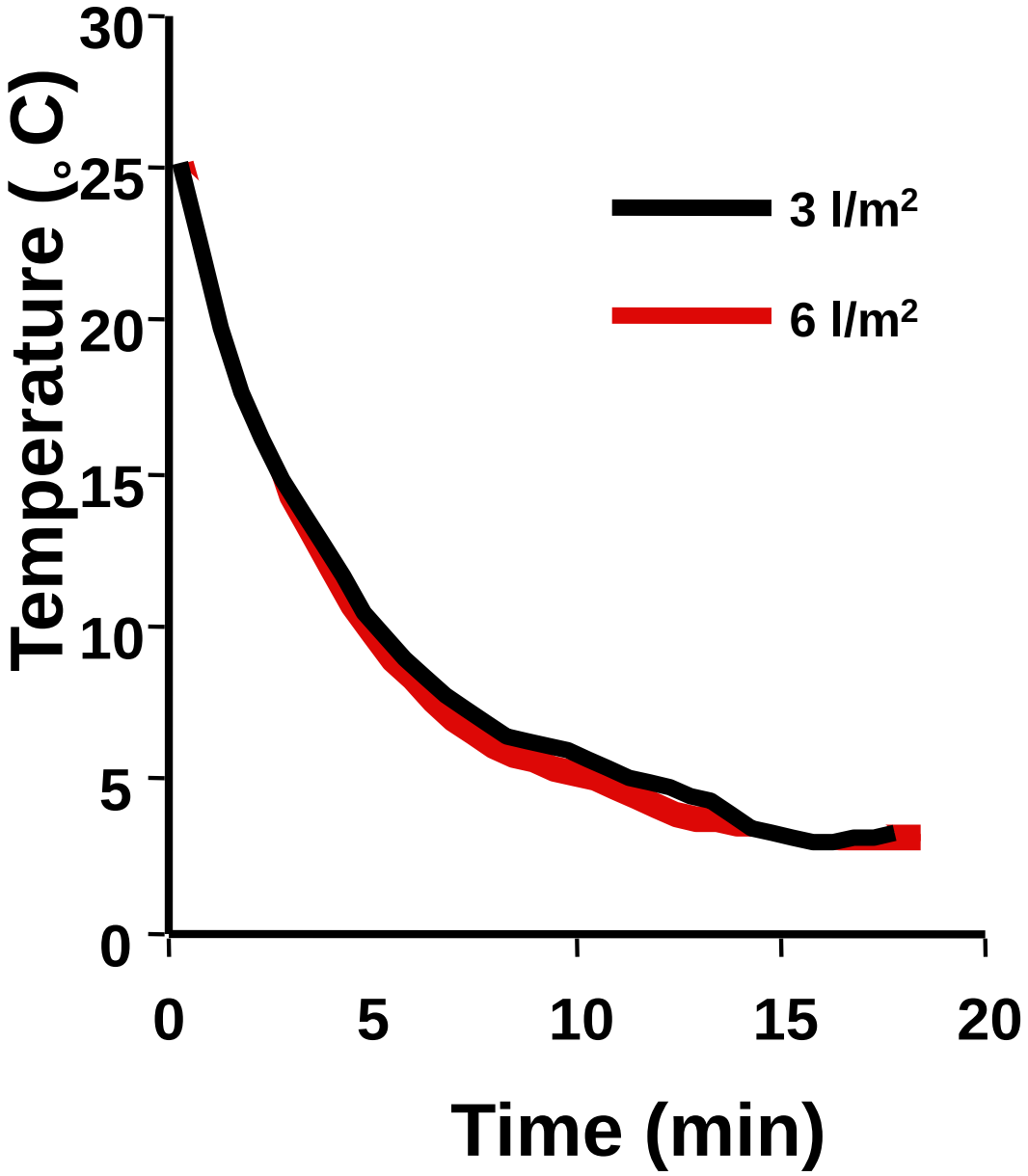
Cooling of cherries





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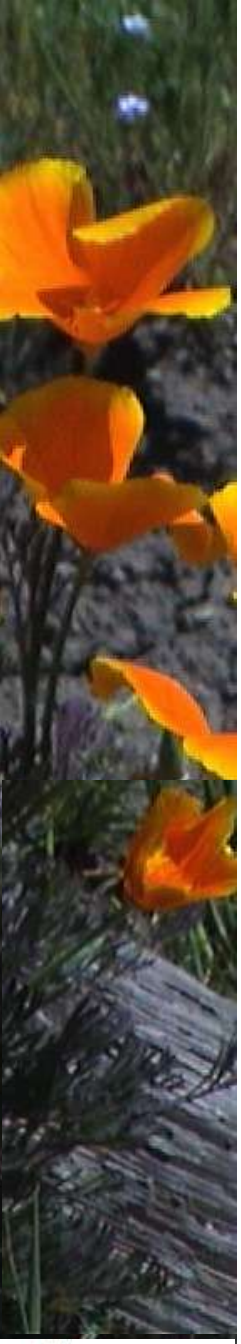
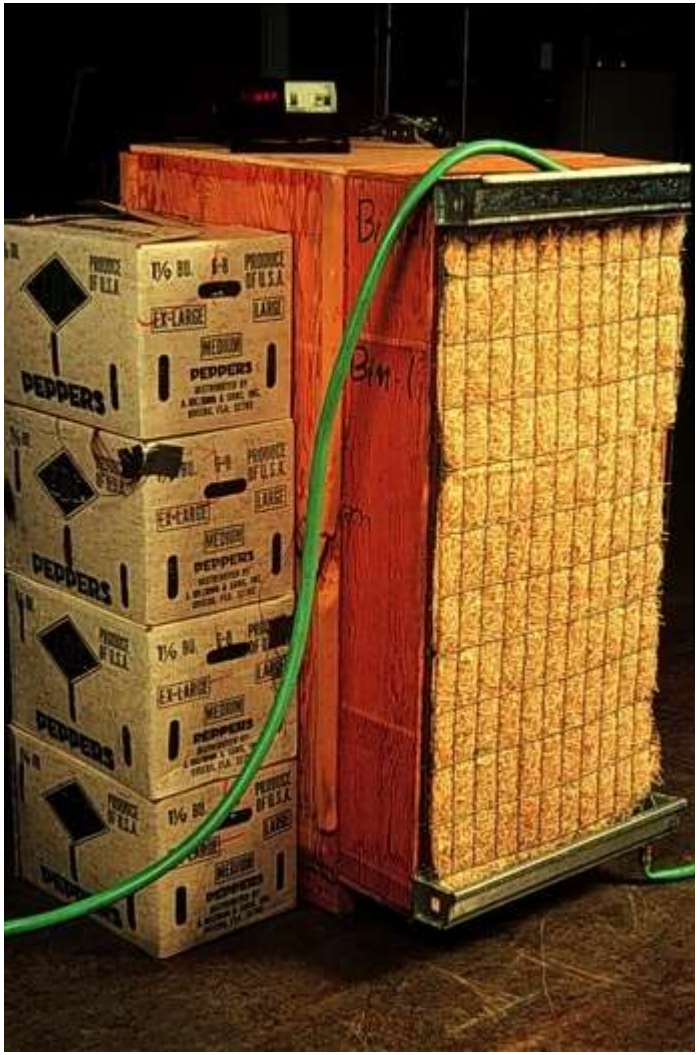


Evaporative cooling

- Conversion of 1 L of water to vapor absorbs 540 kcal
- Enough to cool 50 kg of product from 20° C to 10° C



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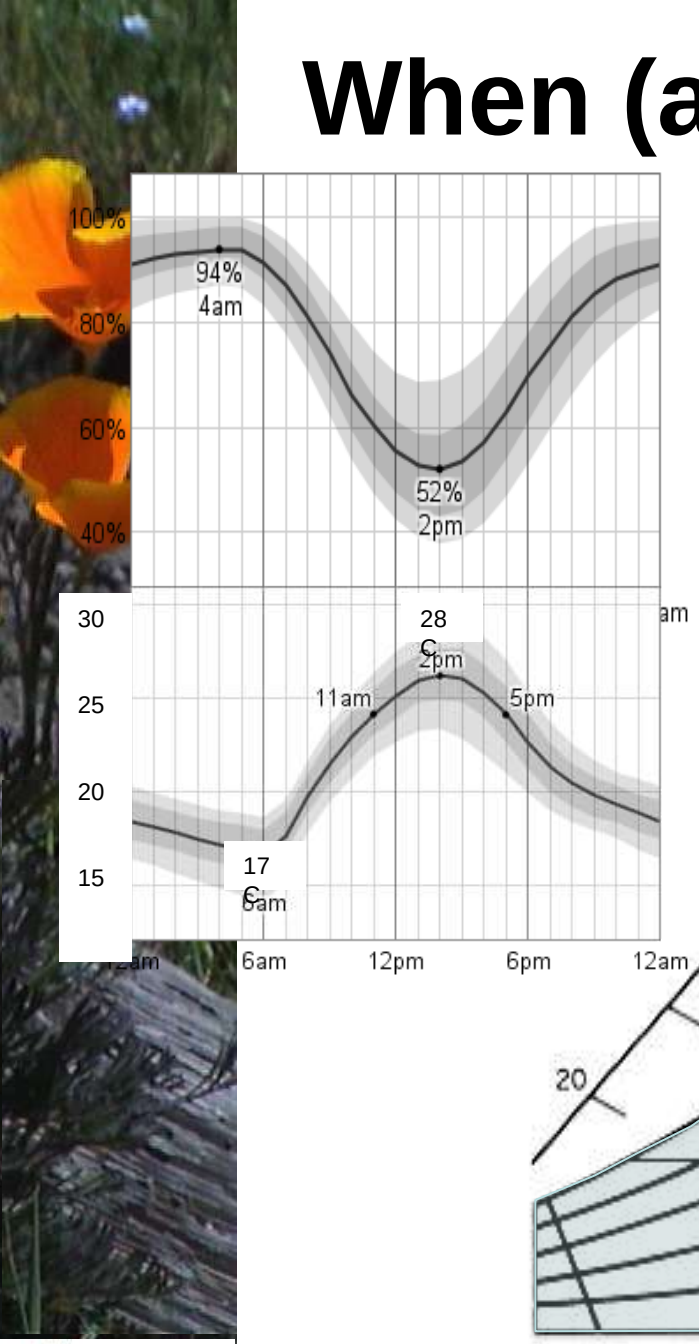
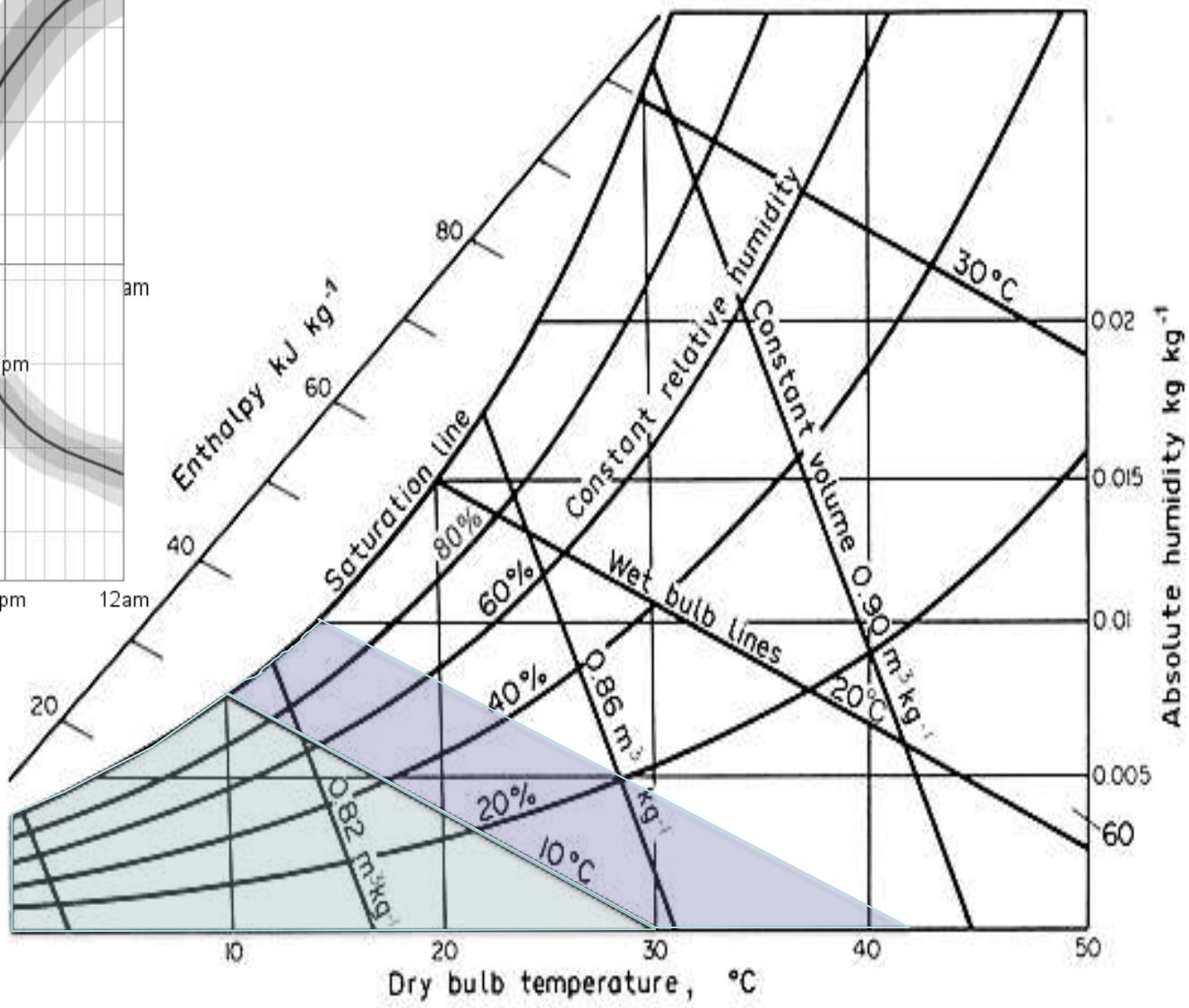
Evaporative cooling

When (and where) is it useful?





Low-tech systems for evaporative cooling

- Room with wetted charcoal walls
- The zero energy cooler

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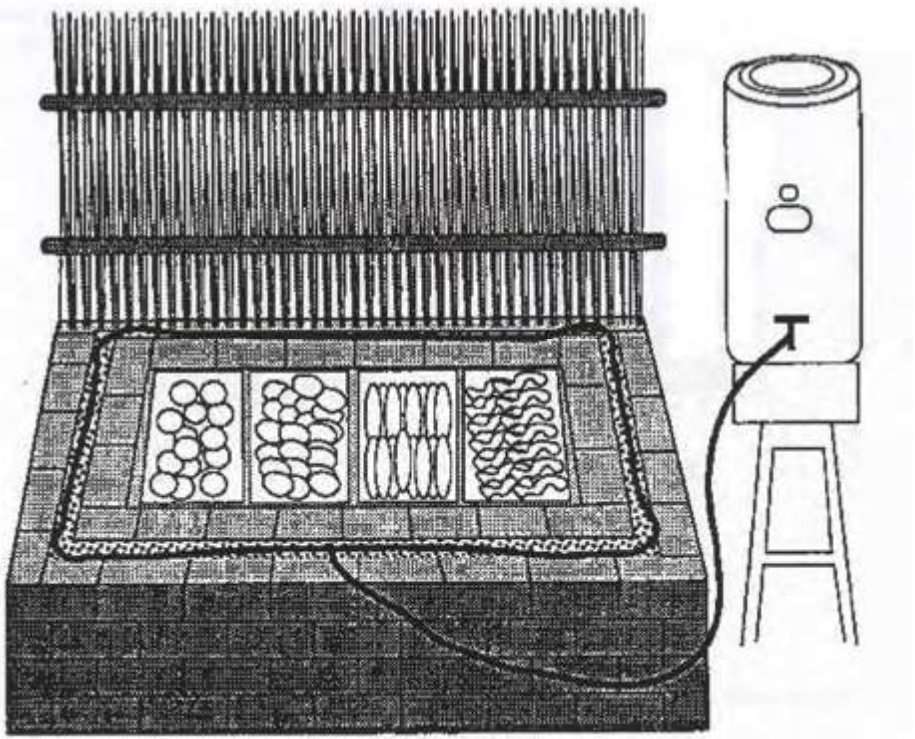
Results from India



Increases in Shelf Life Via Zero Energy Cool Chamber

CROP	SHELF LIFE (IN DAYS)		ADDED SHELF LIFE (PERCENT)
	ROOM TEMPERATURE	ZERO ENERGY COOL CHAMBER	
Banana	14	20	**43%**
Carrot	5	12	**140%**
Cauliflower	7	12	**71%**
Guava	10	15	**50%**
Lime	11	25	**127%**
Mango	6	9	**50%**
Mint	1	3	**200%**
Peas	5	10	**100%**
Potato	46	97	**111%**

Source: Adapted from Roy. n.d. "On-farm storage technology can save energy and raise farm income." Presentation.

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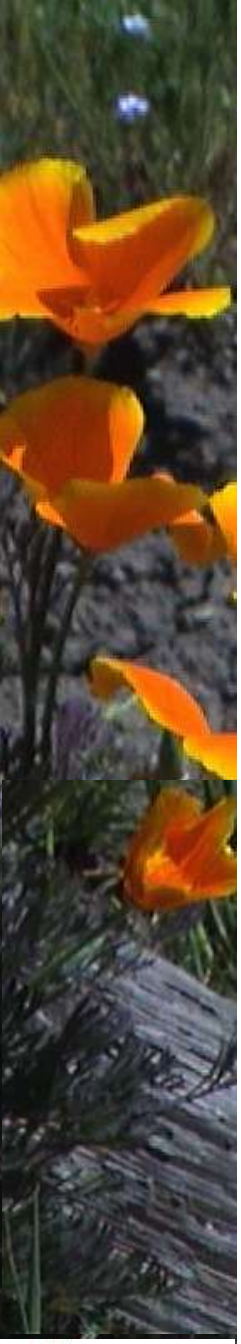
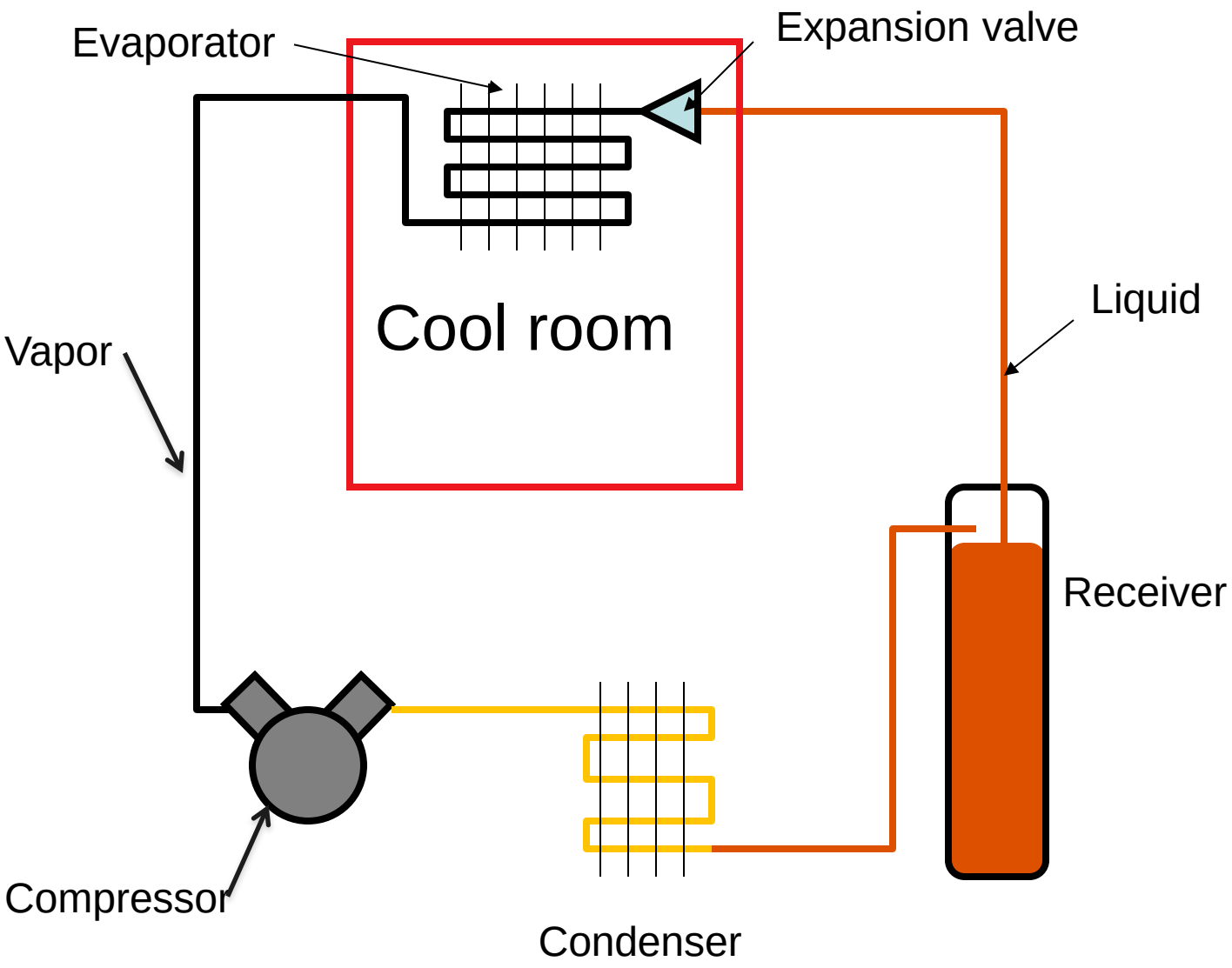


Mechanical refrigeration



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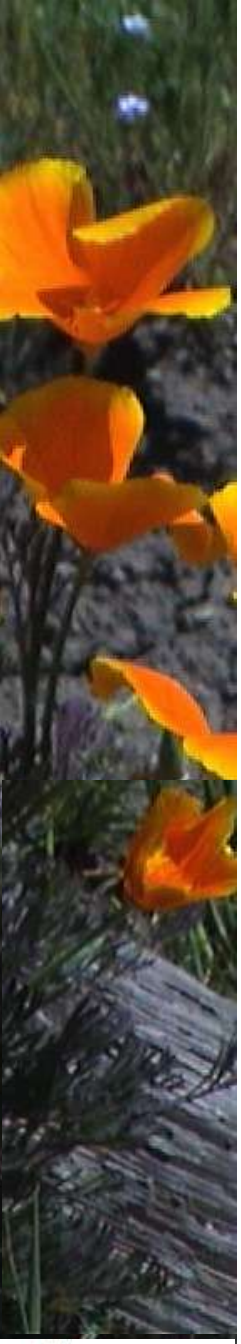
Mechanical refrigeration

- Very efficient (heat pump)
- Commercial units are very expensive



The CoolBot

- Uses a domestic air conditioner
  - window or ‘split’ unit
- A special controller allows it to achieve low temperatures

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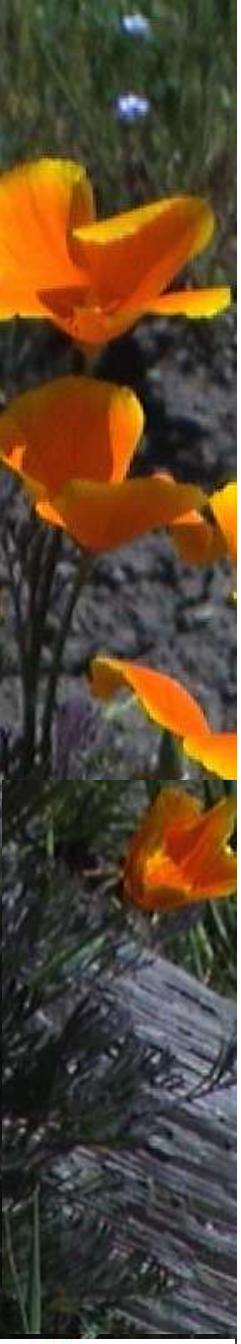
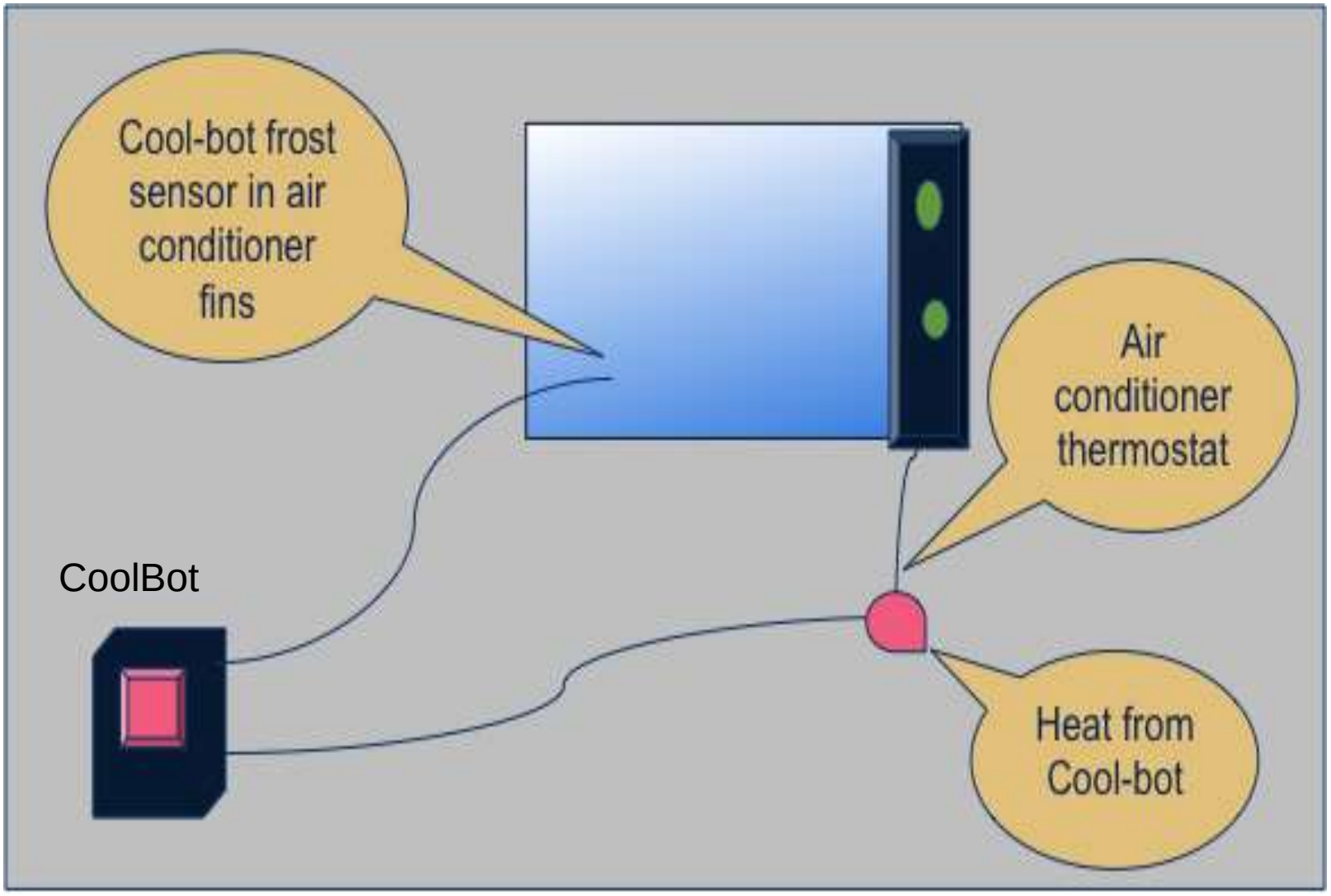


How does it work?



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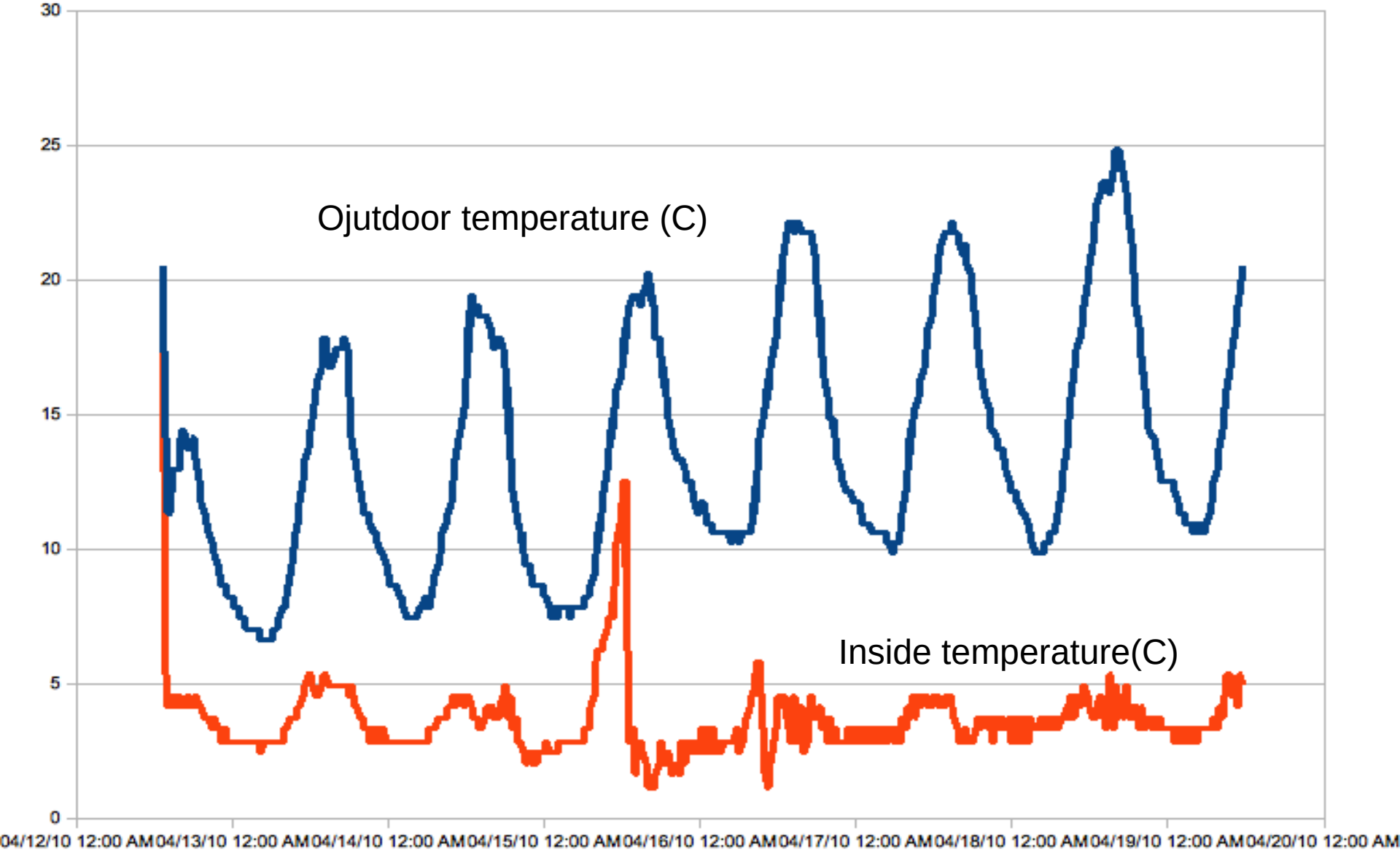
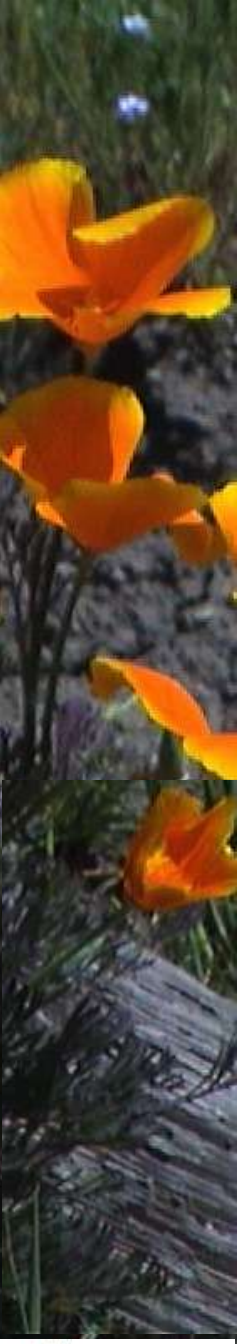
Results - UCD


30
25
20
15
10
5
0
Ojutdoor temperature (C)
Inside temperature(C)
04/12/10 12:00 AM
04/13/10 12:00 AM
04/14/10 12:00 AM
04/15/10 12:00 AM
04/16/10 12:00 AM
04/17/10 12:00 AM
04/18/10 12:00 AM
04/19/10 12:00 AM
04/20/10 12:00 AM

Construction – Bangladesh



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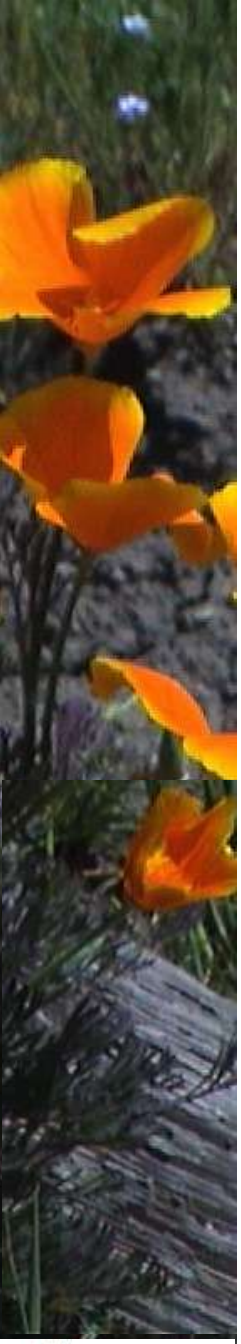

Construction alternatives

- Using the CoolBot means that the insulated room becomes the major cost of refrigerated space
- Structural insulated panels are becoming widely available and prices are falling
- We are exploring alternatives, including spray-foam and agricultural residues in hollow walls

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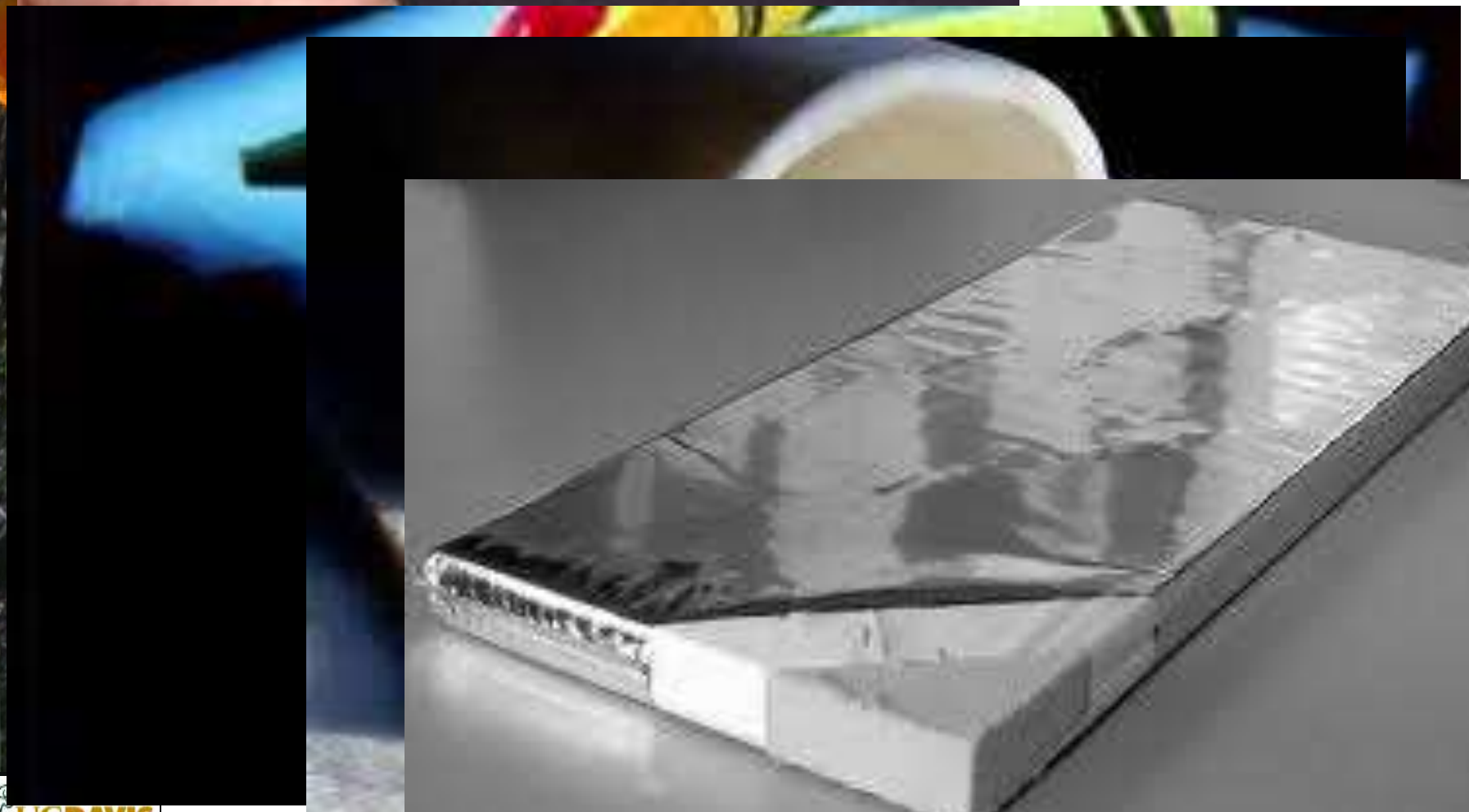
Better insulation
The promise of ‘aerogel’



Solar power for cooling

- Expensive ~ $3,000
- Getting cheaper

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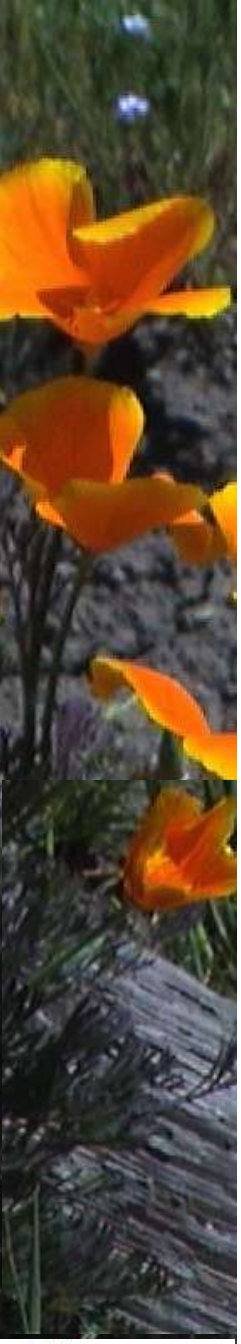
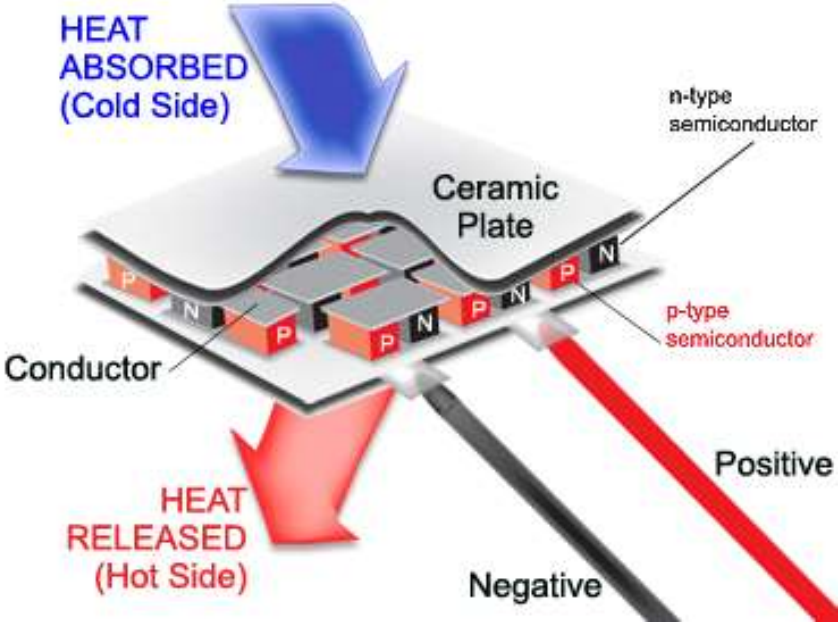


Solar refrigeration

- ‘Split unit’ coolbot room with photovoltaic panels
  - Split units use DC-inverter technology
  - Can be powered directly by PV panels
  - Lithium ion batteries for improved storage
- Peltier blocks
  - DC heat pump
  - Can give high efficiencies
- Ice-banks
  - Solar refrigeration
  - Ice ‘battery’



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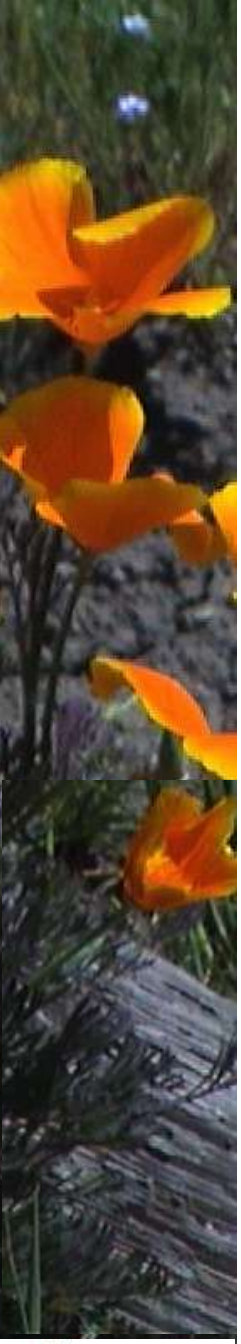
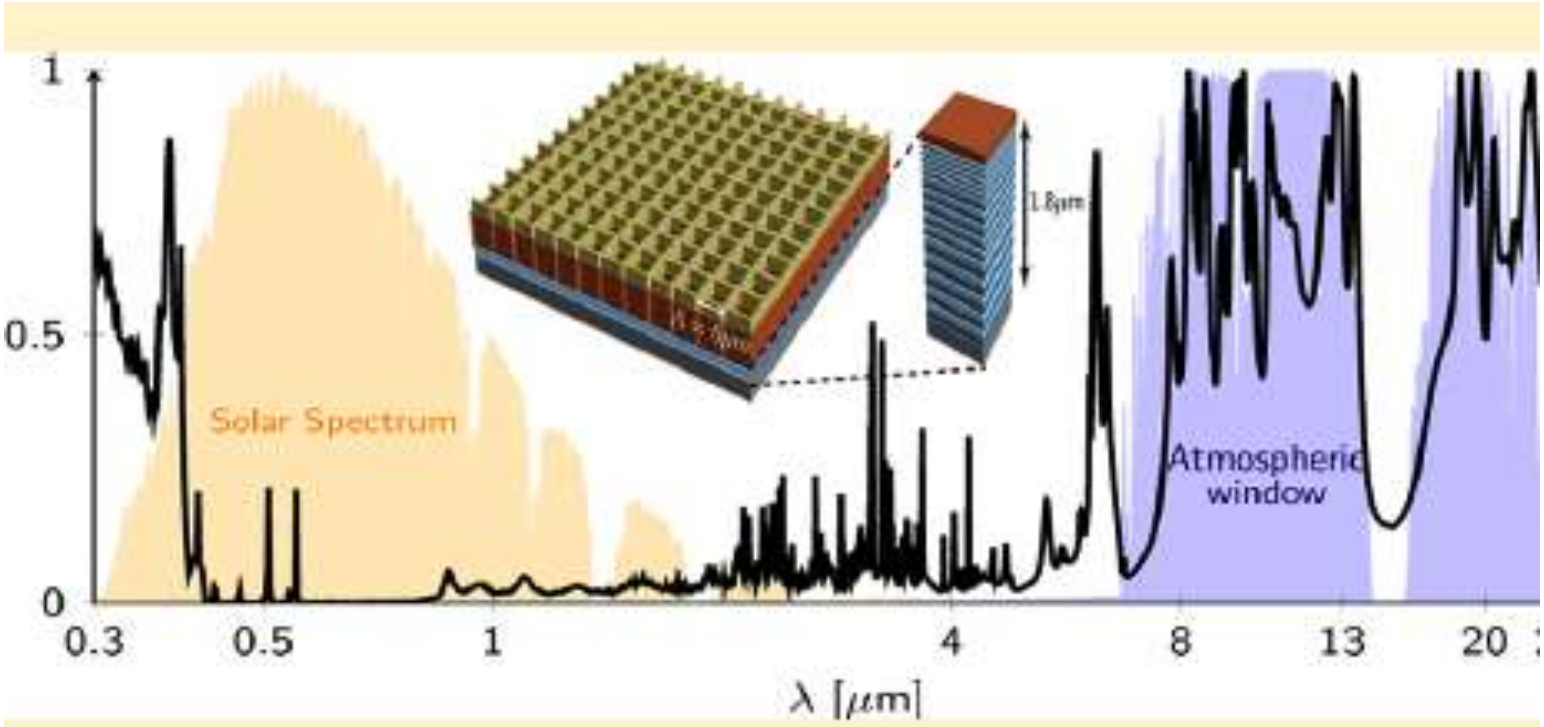


Radiation cooling?

- Utilizes a ‘window’ in the atmospheric IR absorption spectrum
- Could allow daytime cooling to the ‘night sky’



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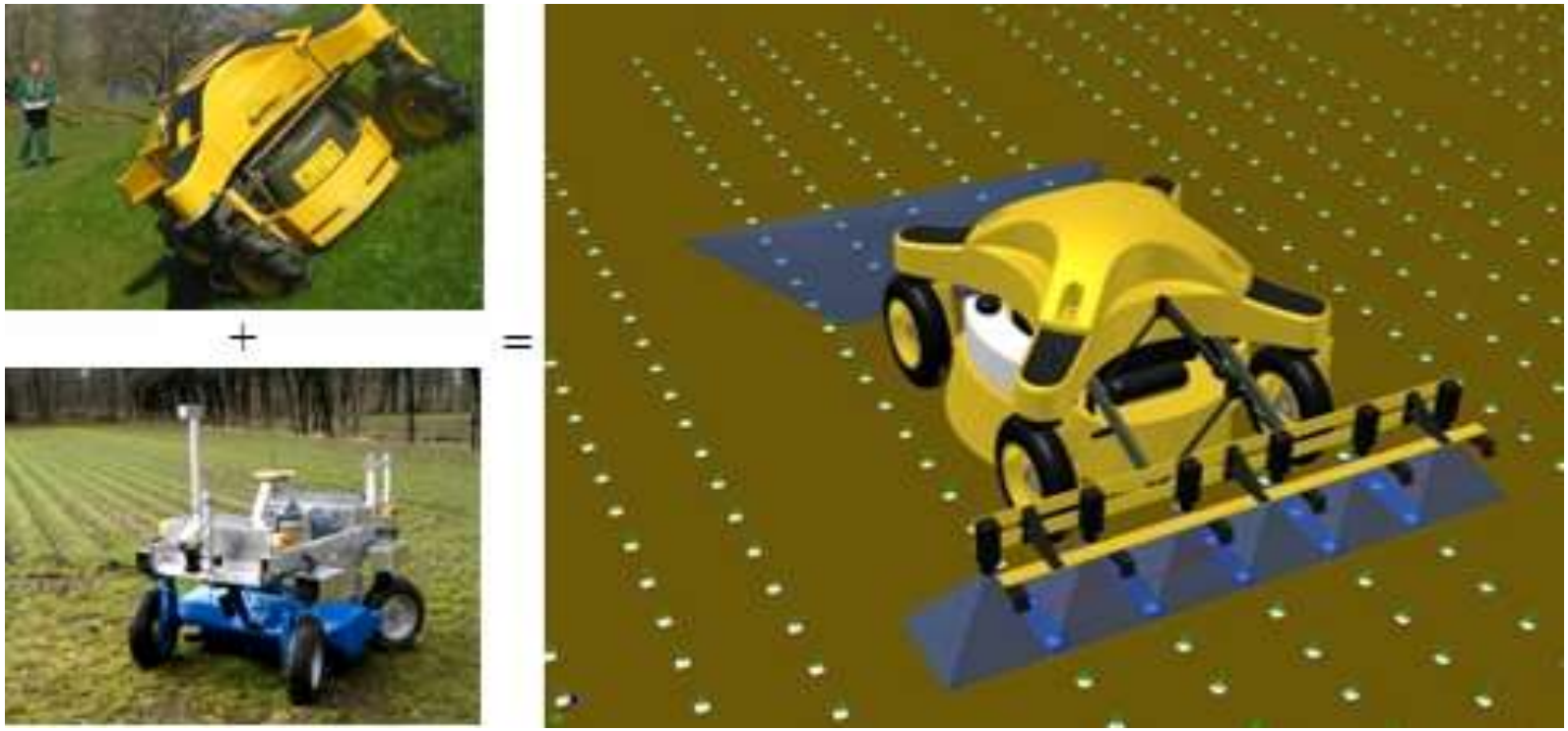
IT and robotics



Labor – a diminishing resource

- Harvesting is labor intensive. Hard, itinerant and seasonal work
- More attractive incomes and working conditions in other sectors of the economy
- Cost and availability of labor can be a major constraint even in the developing world

Robotics for harvesting
Example - strawberries

IT for assessing quality

- Non-destructive analysis
  - NIR sugar determination
  - Other taste components

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IT at harvest

- Harvest for taste
- The glove

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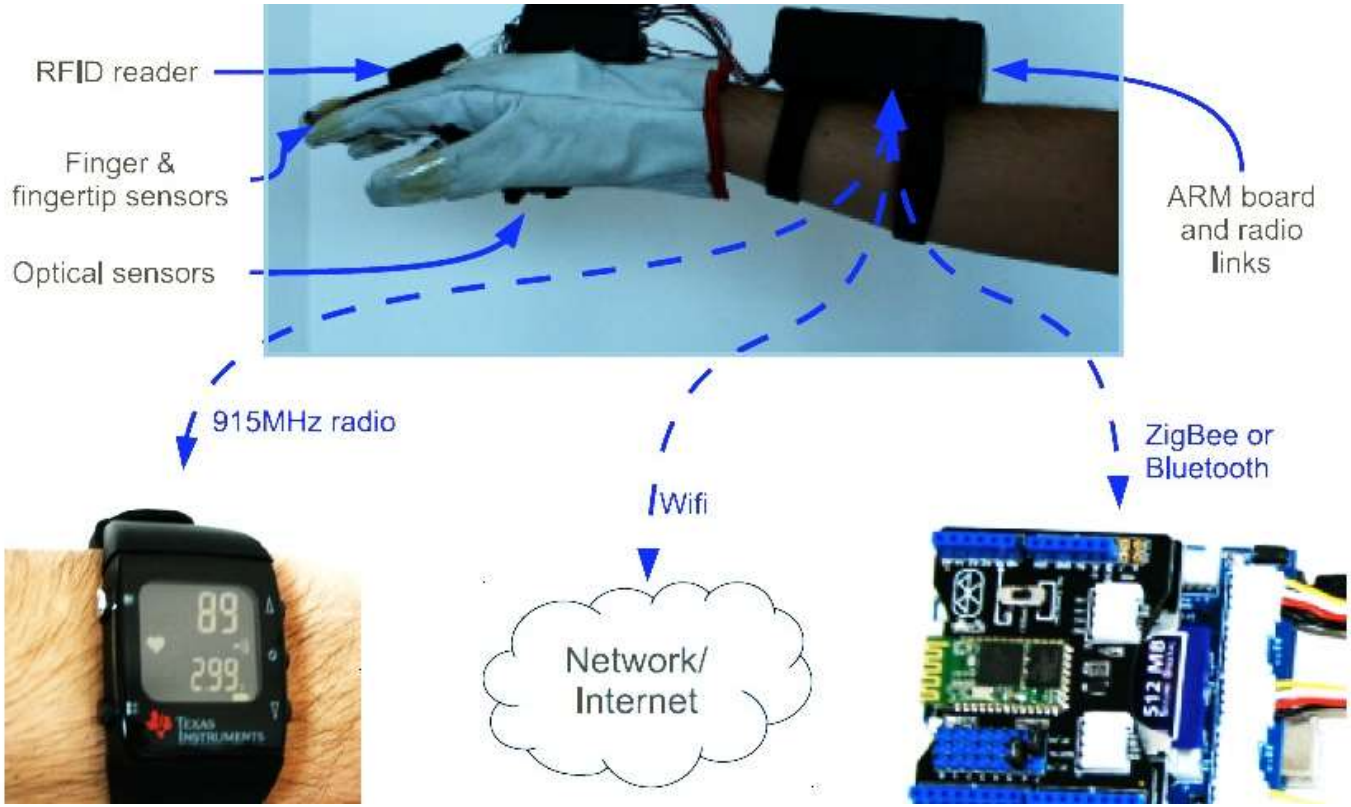
sensors
ISSN 1424-8220
www.mdpi.com/journal/sensors

Article

A Wearable Mobile Sensor Platform to Assist Fruit Grading

Rafael V. Aroca [1], Rafael B. Gomes [1], Rummennigue R. Dantas [1], Adonai G. Calbo [2] and Luiz M. G. Gonçalves [1,*]



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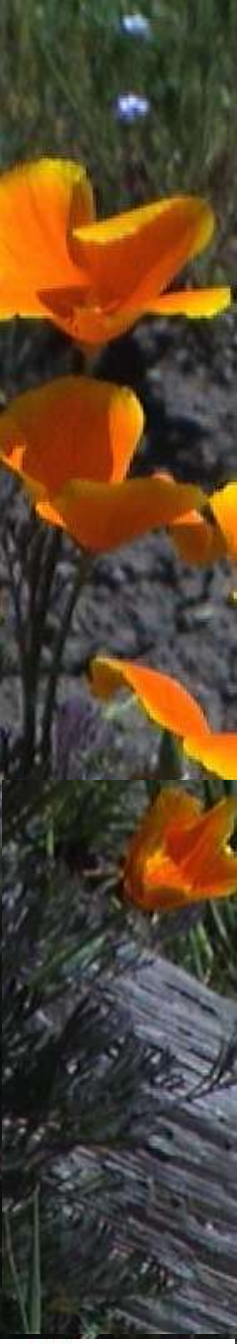
Personal postharvest

- Cell phone sensors
  - Camera (maturity, quality)
  - Audio (maturity)

Improved packaging



Smart packages

- Ripeness indicators on packages
- Flavor/taste indicators?

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Gentle packages

- Hammock pack for transporting delicate or ripened products

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Safe packages

- Most pathogens in fresh products are from other shoppers handling the produce
- Clamshell packages can protect you from your neighbors

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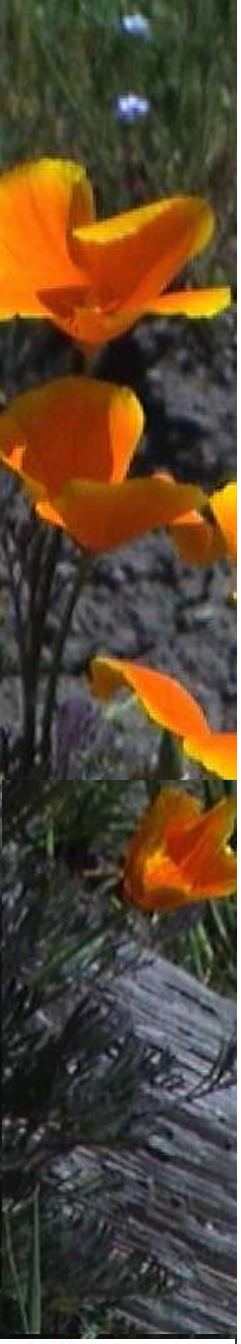

Marketing

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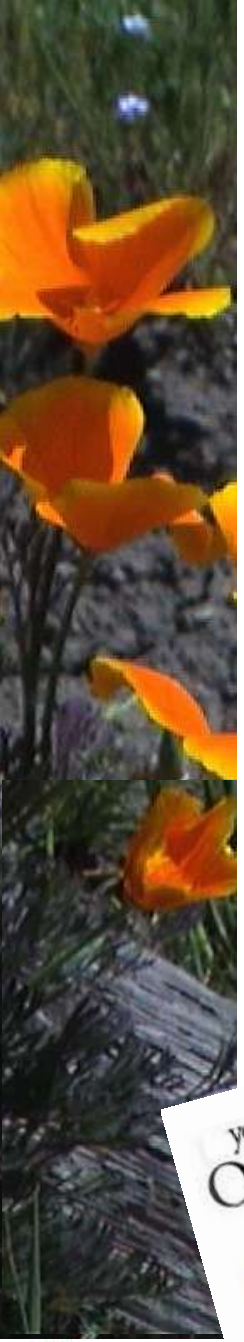
What will perishables marketing look like in 10 years?

- Webmarkets
  - Convenience, 24 hour shopping
  - Personal relationship and quality produce will drive markets
    - CSA-like
  - Refrigerated ‘slot’ in the home
- Developing world
  - Could by-pass supermarkets?



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Marketing

- Market fully mature
  - Local production/farmers' markets
  - Just-in-time supply
  - Less refrigeration
  - More frequent buys

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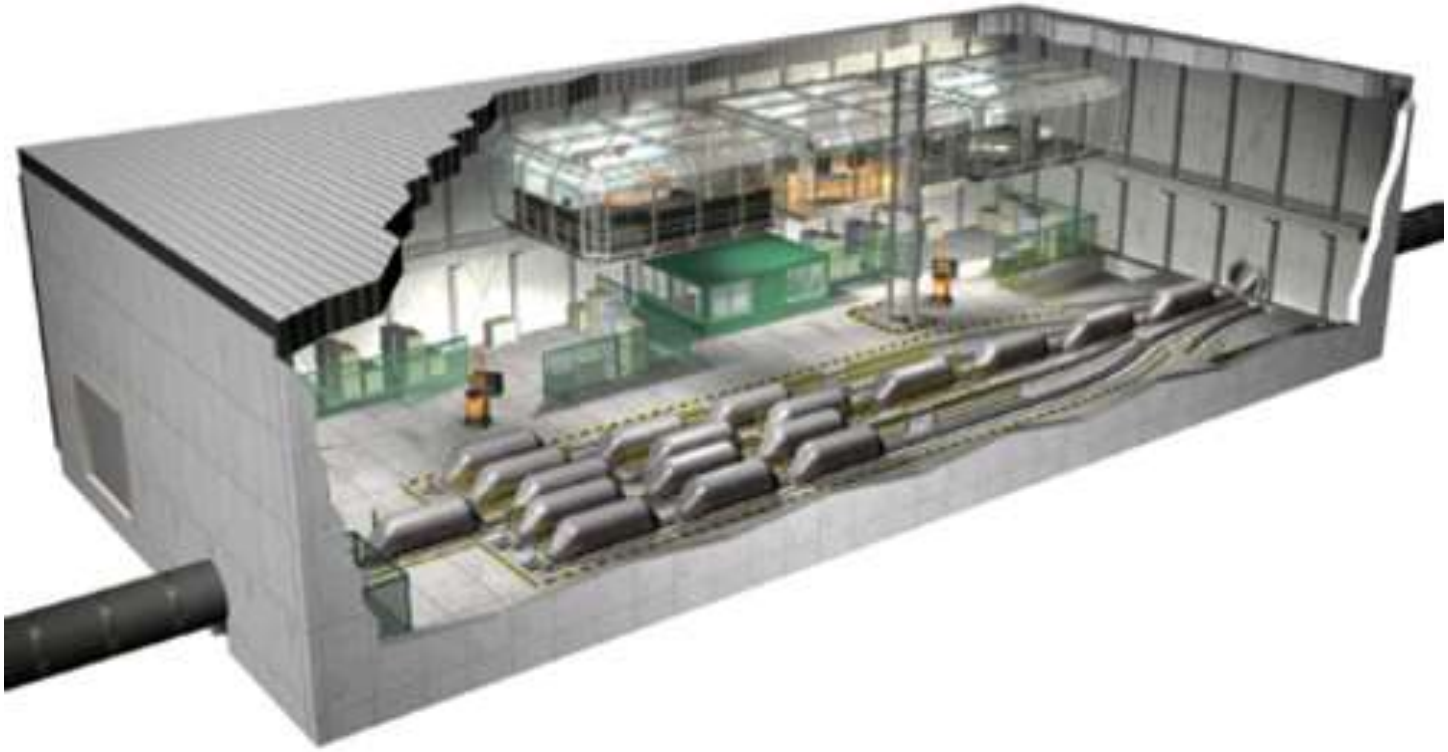
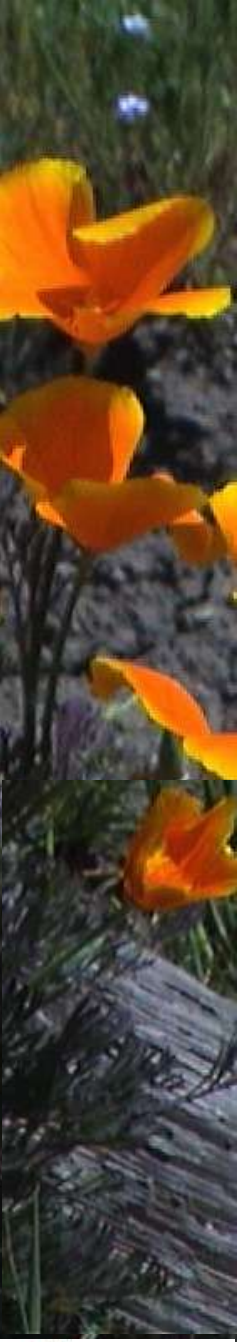
Google on-line grocery store
Groceries in 8 hours

Underground freight systems



- Urban, Interurban, intercontinental?
- Pneumatic
- Maglev



Drying

- Drying horticultural crops
  - Added value
  - Use for excess product
- Solar drying a good option
  - Cabinet dryers are commonly used

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UCD chimney dryer

- Inexpensive
- Efficient
- High air speed

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Efficient and cheap!

	Stack Dryer	Cabinet Dryer
Capital cost ($)	38.93	58.84
Fruit capacity, fresh weight (kg)	4.5	2.25
Time to dry fruit to 10% MC (11h days)	2.0	5.5
Cost per drying capacity ($/kg-day)	7.33	26.66
Average air temperature leaving dryer – ambient (°C)	15.2	9.3
Air velocity past fruit (m/s)	0.63	0.11

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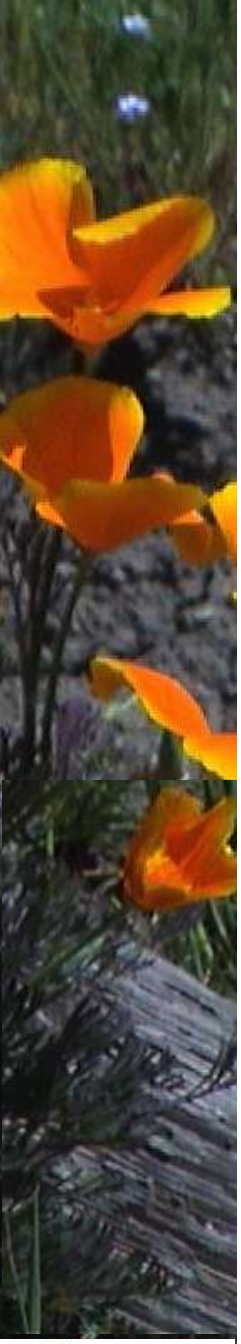

The ‘dry chain’

- Kent Bradford (UCD seed biotechnology center)
- Analagous to the cold chain
- Key for maintaining quality of stored products
  - Inhibits enzyme activity
  - Prevents insect attack
  - Prevents mold growth

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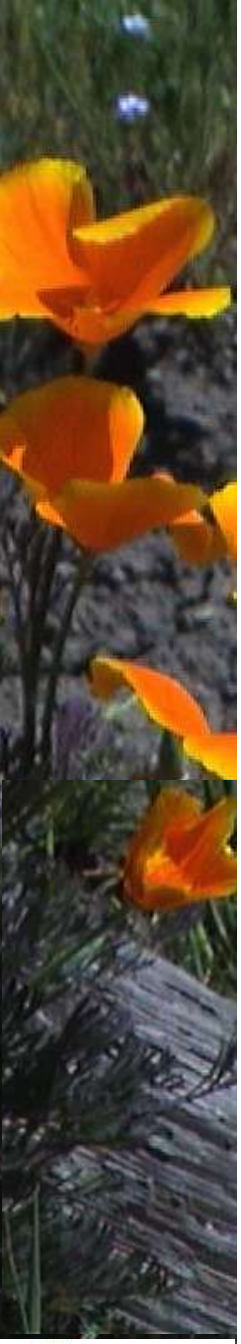

The dry chain for grains

- Typically air-dried to 15-30% moisture content
- Insect attack a major cause of loss
- Insect metabolism releases moisture, which accelerates mold and bacterial growth
  - Molds produce toxins
    - Aflatoxin, Fumonisin
- Below 12% moisture content insect attack and mold growth are prevented
- Combined with low oxygen, could eliminate the need for pesticides

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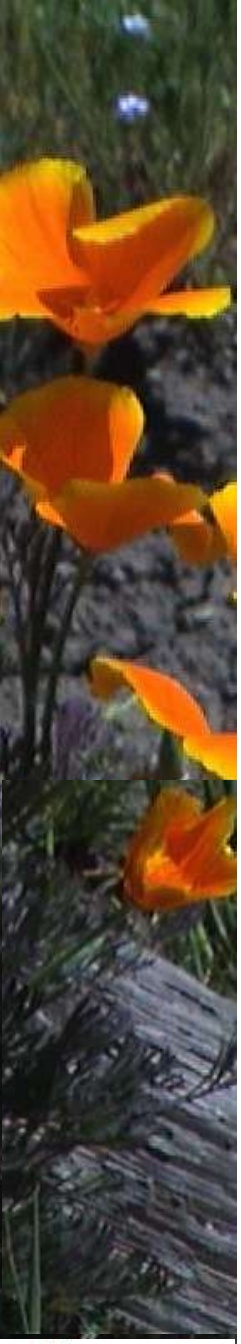

Tools for the dry chain

- Facilitated drying
  - Solar, applied heat, dehumidifiers
- Storage in sealed containers
  - Bags, drums, silos
  - With absorbers?
    - Desiccants
    - Saturated salts
- Monitoring during storage
  - Electronic - $10 - $200
  - Chemical - $0.1
    - Cobalt chloride
    - Copper-based
    - Cell-phone app

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Thanks for your interest

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