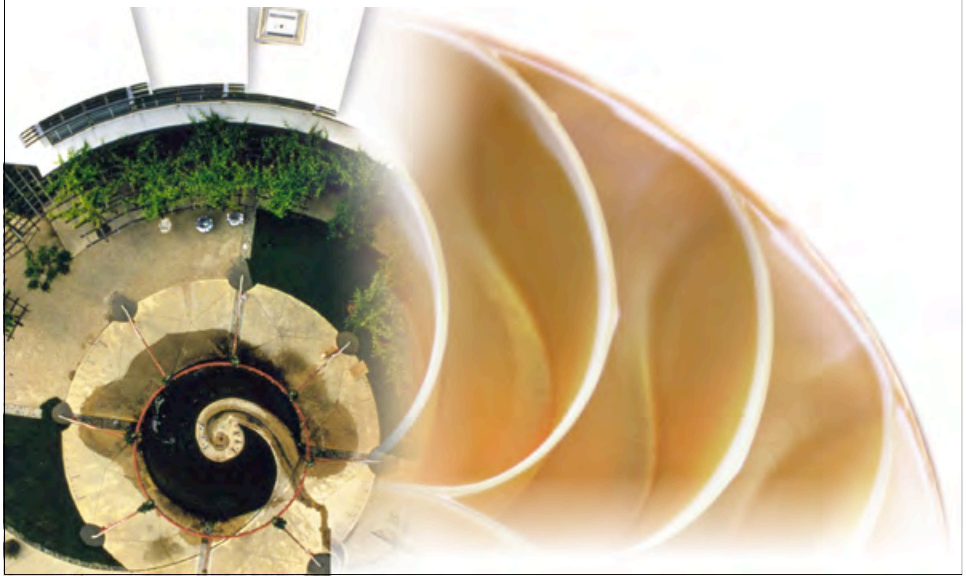
Solar Heating

ARCH 331/431 Spring 2008
Lecture 14



Seattle 2-hour temperatures

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12 midnight	37	40	42	45	50	56	60	60	56	49	42	38
2	37	39	40	43	49	54	58	58	54	48	42	37
4	36	38	39	42	47	53	56	57	53	47	41	36
6	35	37	39	41	46	52	55	56	52	46	40	36
8	36	39	40	43	48	54	57	58	54	47	41	37
10	41	44	47	51	57	62	67	67	62	54	46	41
12 noon	44	48	51	55	61	67	72	72	67	58	49	44
2	45	50	53	57	64	70	75	75	69	60	51	45
4	44	48	52	56	62	68	74	74	68	59	50	44
6	42	46	48	52	59	64	69	69	64	55	47	42
8	40	43	45	48	54	60	64	64	60	52	45	40
10	38	41	43	46	52	57	61	62	57	50	43	39

CLOSED/Heating: 66.0%
OPEN/"Sailing": 32.6%
CLOSED/Cooling: 1.4%

Balance Point = 55° F
Change-over Temperature = 75° F


European Research Institute
University of Birmingham
www.feildenclegg.com


The New Central Office
for the National Trust
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The Berrill Building
Open University
Milton Keynes

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The New Environmental Office
Building Research Establishment
(BRE)

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John Cabot City Technology
College Kingswood
Bristol
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1st place overall
University of Colorado
Washington State University
Universidad de Puerto Rico
2nd place overall
Cornell University
Canadian Solar Decathlon
Universidad Politecnica de Madrid
3rd place overall
Cal Poly
Virginia Polytechnic Institute
University of Michigan

Universidad Politecnica de Madrid

Texas A&M University

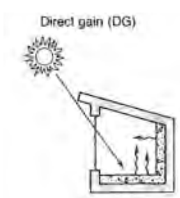
Carnegie Mellon University

University of Cincinnati

Technische Universitat Darmstadt, Germany

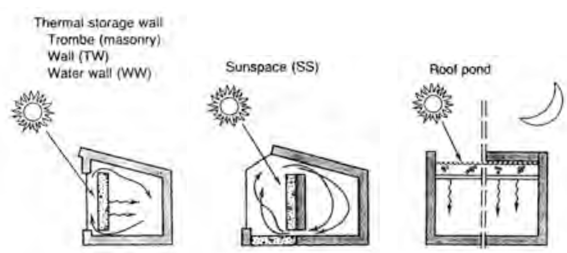
Passive Solar Systems

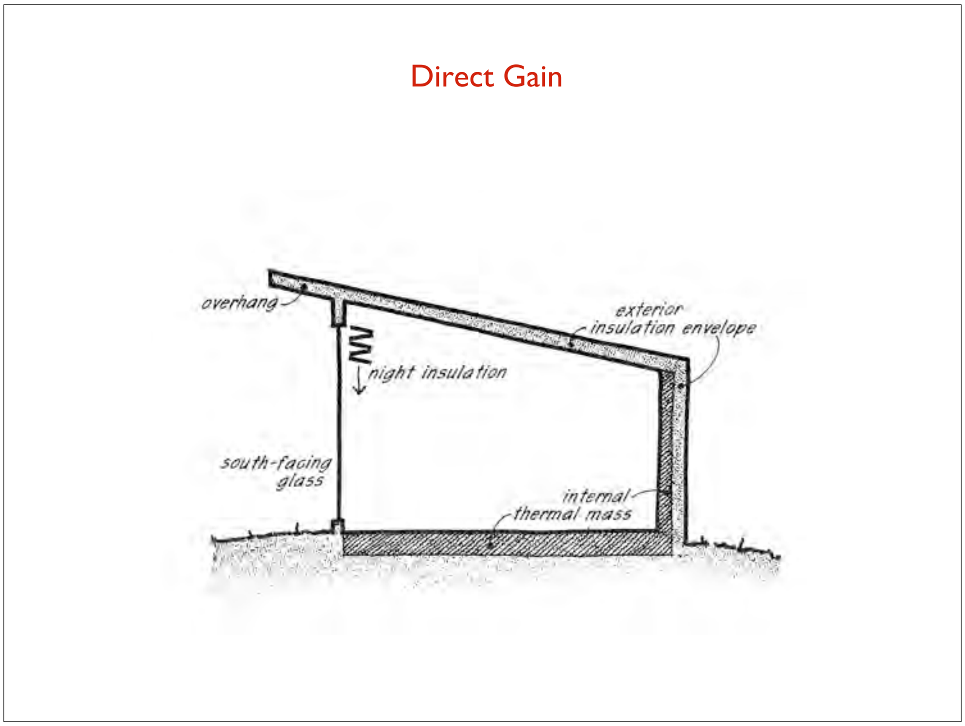
DIRECT GAIN



INDIRECT GAIN

- Trombe Wall
- Sunspace
- Roof Pond

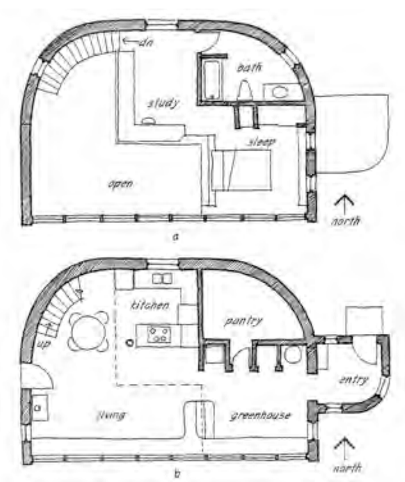


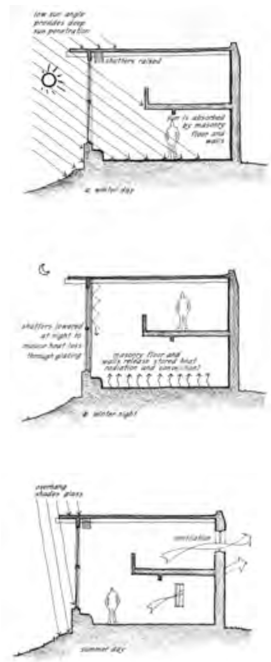

Direct Gain
overhang
exterior
insulation envelope
night insulation
south-facing
glass
internal
thermal mass


David Wright House
Santa Fe, New Mexico

David Wright House

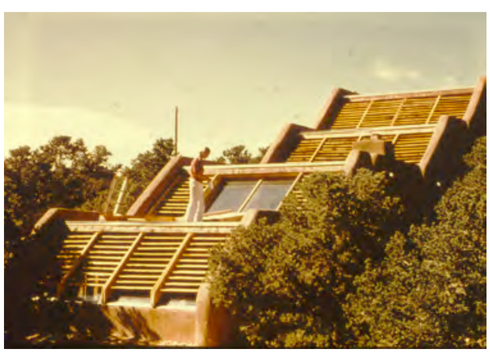
Santa Fe, New Mexico





Karen Terry House

Santa Fe, New Mexico



Quiz 5 Slide 1 answers

1. Name the three fundamental criteria for Passive Solar Design.

1. **Insulation**
   - Keep the Heat In and Cold Out
2. **Glass**
   - Window Area and Solar Access
3. **Mass**
   - Heat Capacity and Quantity of Materials
   - Location and Distribution of Materials

Slide 2 answers

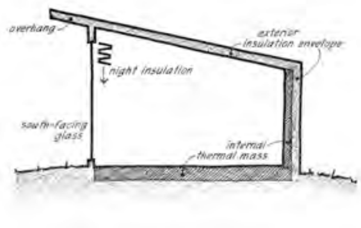
Material	Specific Heat BTU/lb °F	Density lb/ft³	VHC BTU/ft³ °F
Water	1.0	62.0	62.0
Concrete	0.20	120.0	24.0
Steel	0.12	489.0	58.7
Wood	0.50	27.0	13.5

4. [T] F For a given temperature change, a **cubic foot** of water will store (or liberate) more energy than a **pound** of concrete.
   TM of 1 ft^3 water = **62** BTU/°F; TM of 1 ft^3 concrete = **24** BTU/°F

5. T [F] For a 10°F temperature increase (or loss), a **pound** of steel will store (or liberate) more energy than a **pound** of concrete.
   TM of 1 lb steel = **1.2** BTU; TM of 1 lb concrete = **2.0** BTU

6. [T] F 1 **cubic foot** of water contains more thermal mass (TM = BTU/°F) than 100 **pounds** of concrete.
   TM of 1 ft^3 water = 62 BTU/°F; TM of 100 lbs concrete = 20 BTU/°F

Slide 3 answers



7. What is the Thermal Mass inside small "test" room having the following materials?

Floor: 6" concrete (40 ft^3)

Walls: 4" concrete (60 ft^3)

Thermal Mass (TM) = 24 BTU/ft^3 °F x 100 ft^3

= **2,400 BTU/°F**

8. How much energy is stored in this room when the temperature of the entire room rises by 10°F?

Q = 2,400 BTU/°F x 10°F = **24,000 BTU**

Mass

Thermal Mass = SH x Density x Volume

VHC

(Mass = Density x Volume; VHC = SH x Density)

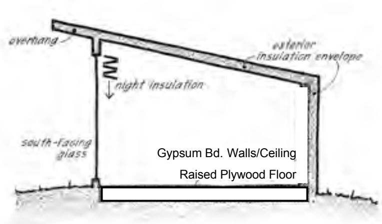
Q = TM x dT

Material	Specific Heat BTU/lb °F	Density lb/ft^3	VHC BTU/ft^3 °F
Concrete	0.20	120.0	24.0
Air	0.24	.075	.018

Direct Gain

Example 1.1

How hot does it get inside a small "test" room (9'deep x 16' wide x 8' high) located in Seattle on a typical day in July:



Thermal Mass contained inside this building:

Floor: 3/4" plywood	80 BTU/°F
Walls/Ceiling: 1/2" gyp. bd.	150 BTU/°F
Air: (1152 ft^3) x (.018 BTU/ft^3 °F)	21 BTU/°F
Thermal Mass (TM) =	**251 BTU/°F**

Incoming solar energy through a south window in July:

Q_{sun} (July - Table C.15, "VS")	1299 BTU/ft^2
Shading Coefficient	x .86
Window Area (8' x 16')	x 128 ft^2
Q_{in} (energy entering room) =	**142,993 BTU**

Q = TM x dT

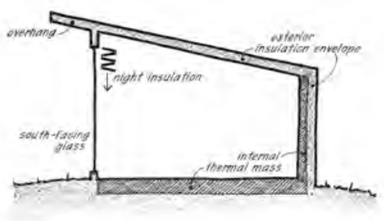
dT = Q / TM

dT = 142,993 BTU / 251 BTU/°F = 570 °F

Direct Gain

Example 1.2

Replace raised plywood floor with a slab-on-grade, and replace the back wall with concrete:



Thermal Mass contained inside this building:

Concrete floor and walls	2,400 BTU/°F
Walls/Ceiling: 1/2" gyp. bd.	120 BTU/°F
Air: (1152 ft³) x (.018 BTU/ft³ °F)	21 BTU/°F
Thermal Mass (TM)	= **2,541 BTU/°F**

Incoming solar energy through a south window in July:

Q_{sun} (July - Table C.15, "VS")	1299 BTU/ft²
Shading Coefficient	x .86
Window Area (8' x 16')	x 128 ft²
Q_{in} *(energy entering room)*	= **142,993 BTU**

Q = TM x dT

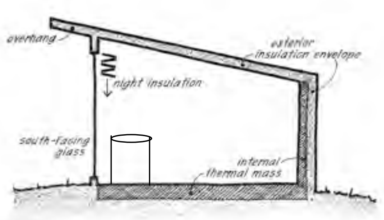
dT = Q / TM

dT = 142,993 BTU / 2,541 BTU/°F = 56 °F

Direct Gain

Example 1.3

Add 6 - 50 gallon barrels of water:



Thermal Mass contained inside this building:

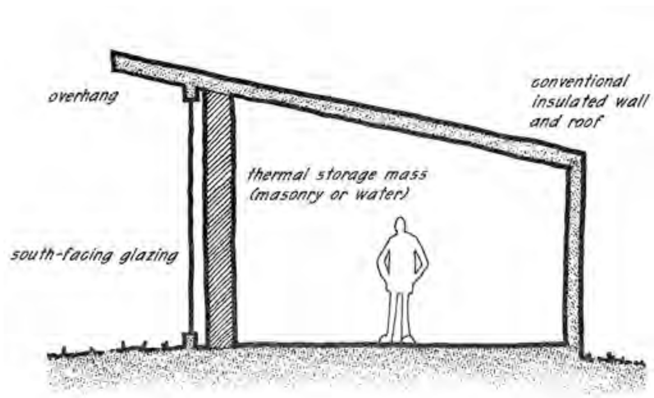
6 x 50 gal.x8 lb/galx1 BTU/lb°F	2,400 BTU/°F
Concrete floor and walls	2,400 BTU/°F
Walls/Ceiling: 1/2" gyp. bd.	120 BTU/°F
Air: (1152 ft³) x (.018 BTU/ft³ °F)	21 BTU/°F
Thermal Mass (TM)	= **4,941 BTU/°F**

Incoming solar energy through a south window in July:

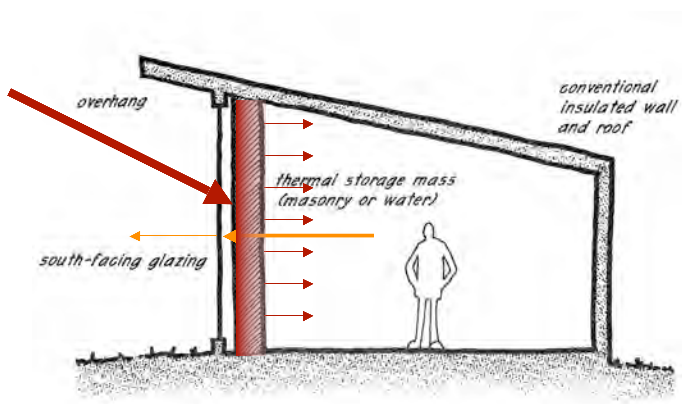
Q_{sun} (July - Table C.15, "VS")	1299 BTU/ft²
Shading Coefficient	x .86
Window Area (8' x 16')	x 128 ft²
Q_{in} *(energy entering room)*	= **142,993 BTU**

dT = 142,993 BTU / 4,941 BTU/°F = 30 °F

Indirect Gain
Mass Wall

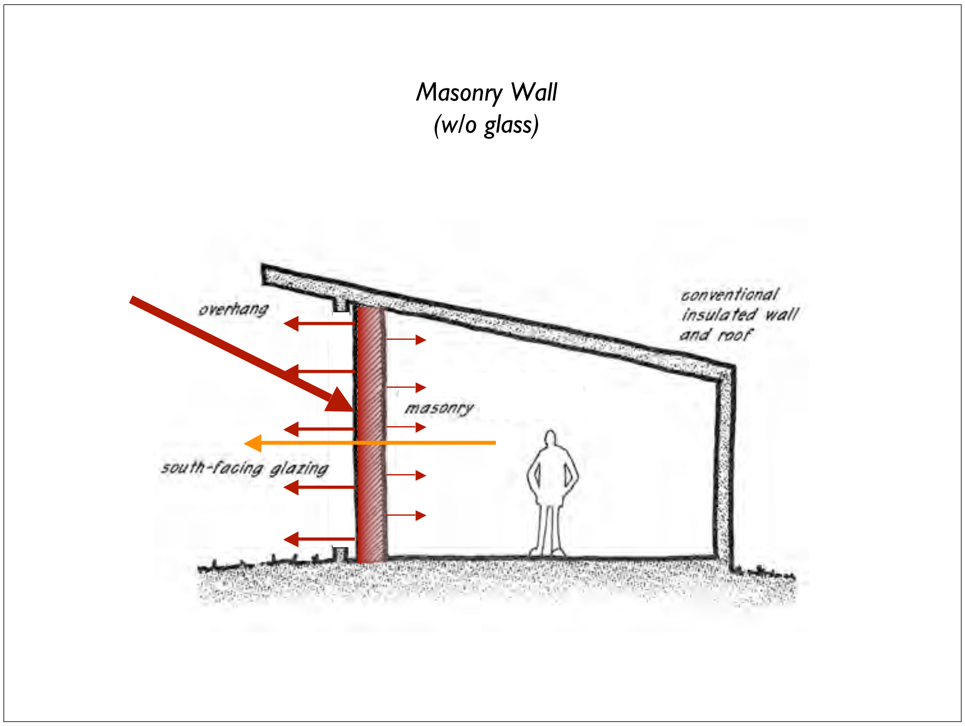


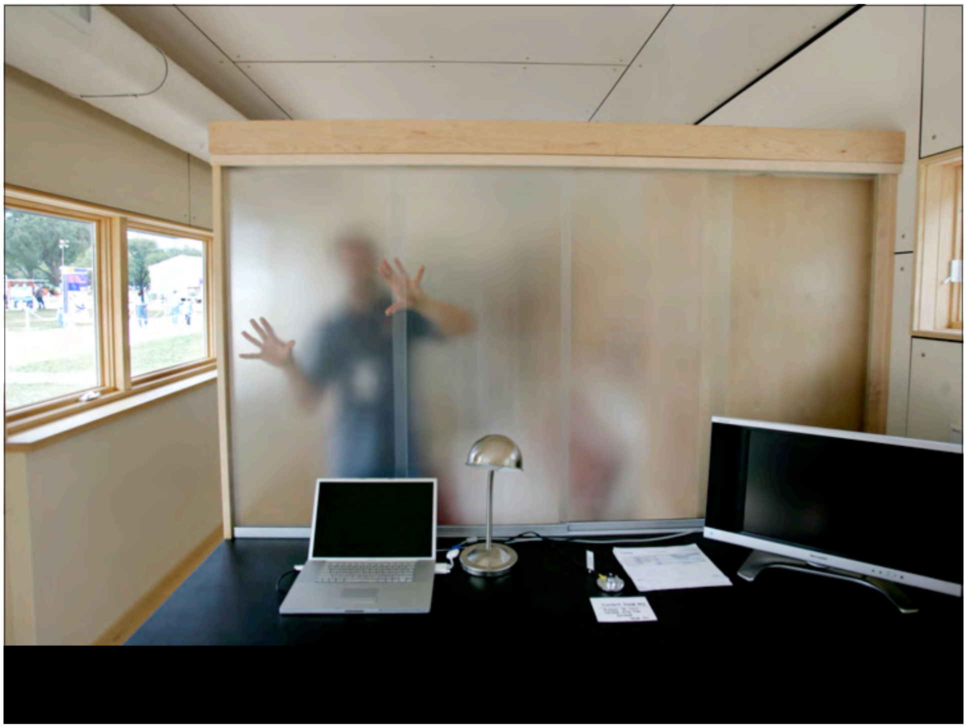
Indirect Gain
Mass Wall



Thermal Resistance of Concrete: **r = .1** (°F ft² h/BTU - in)

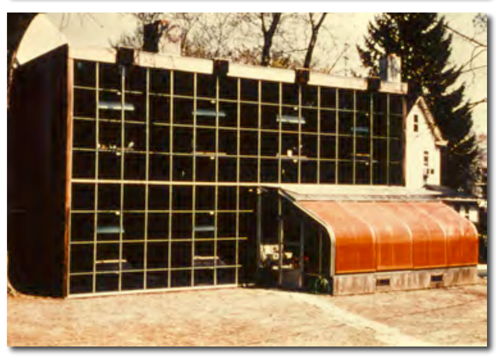
10-inch thick concrete wall: **R = 1** (°F ft² h/BTU)


Masonry Wall
(w/o glass)
overhang
conventional
insulated wall
and roof
masonry
south-facing glazing



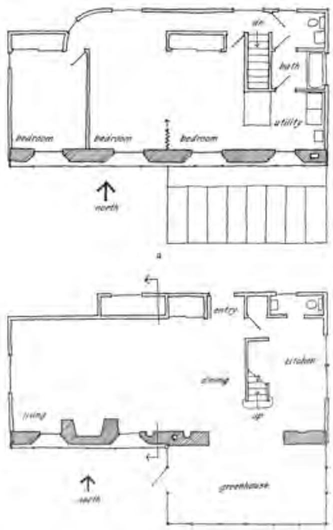
Kelbaugh House

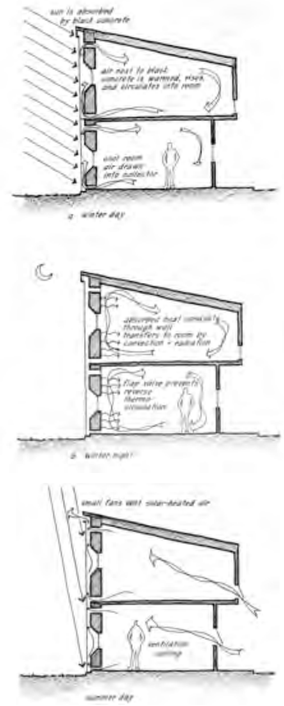
Princeton, New Jersey



Kelbaugh House

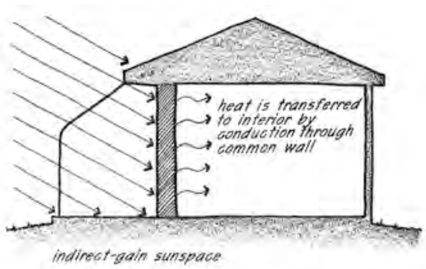
Princeton, New Jersey

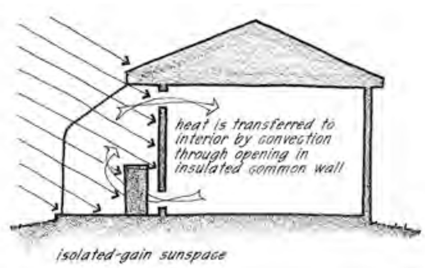




Indirect Gain

Sunspace



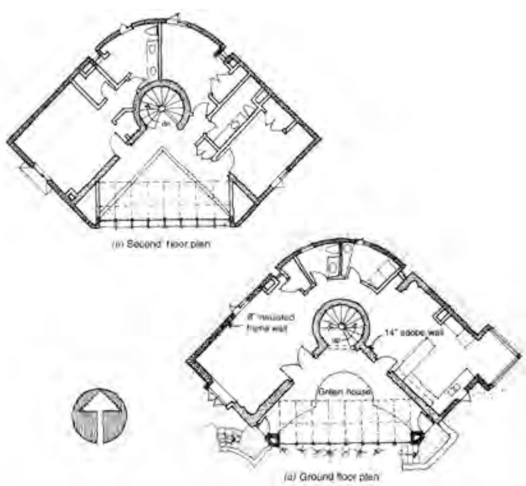


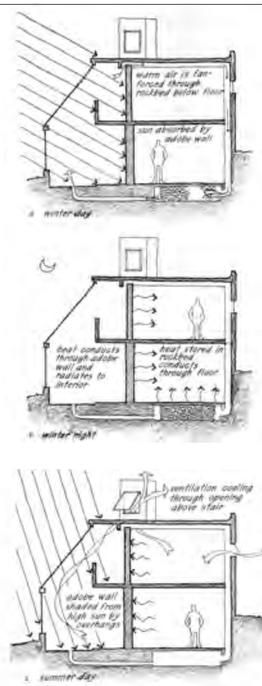
Balcomb House

Santa Fe, New Mexico

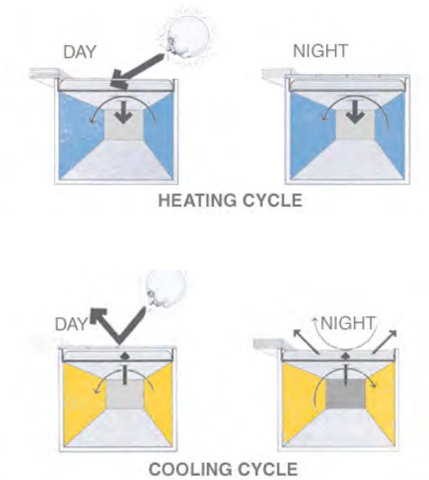
Balcomb House

Santa Fe, New Mexico





Indirect Gain
Roof Pond



Skytherm House • Harold Hay
Atascadero, California

La Verda Compound
Santa Fe, New Mexico

Stockbrand Residence
Albuquerque, New Mexico

MAZRIA ODEMS DZUREC

Mt. Airy Library
Mt. Airy, North Carolina

Trust Pharmacy
Grants, New Mexico

MAZRIA ODEMS DZUREC