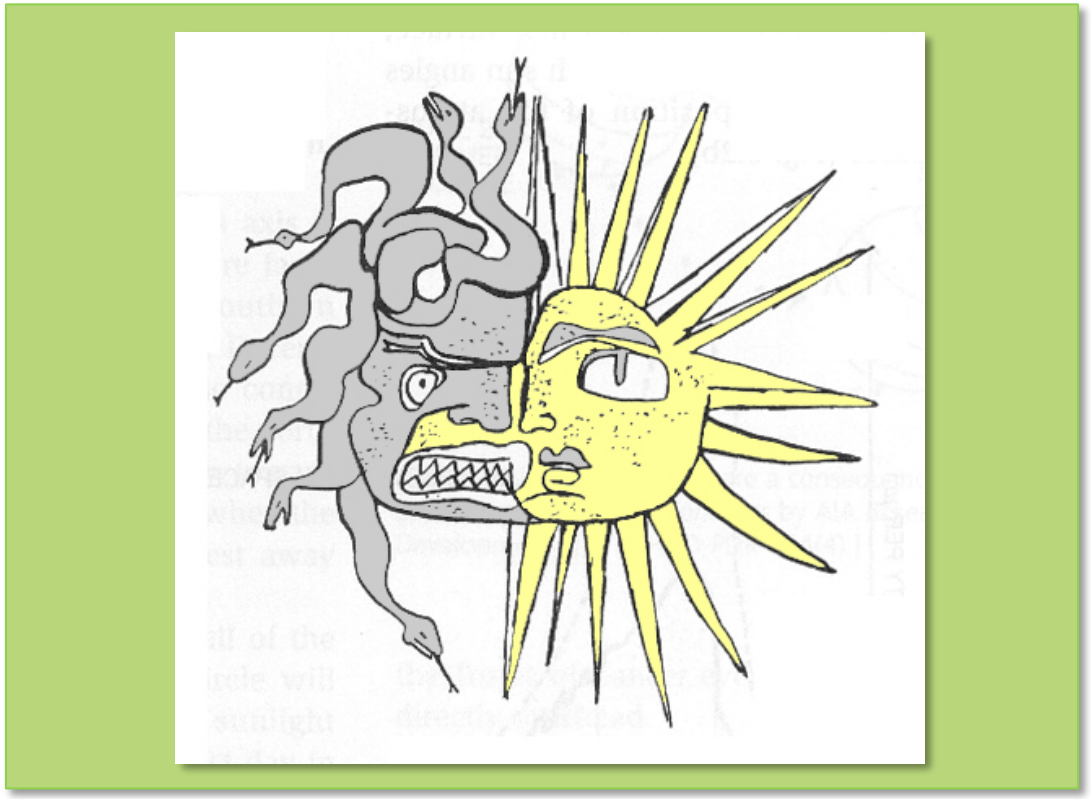
THE EVOLUTION TOWARDS CONTEMPORARY CLIMATE RESPONSIVE DESIGN



Drawing by LeCorbusier

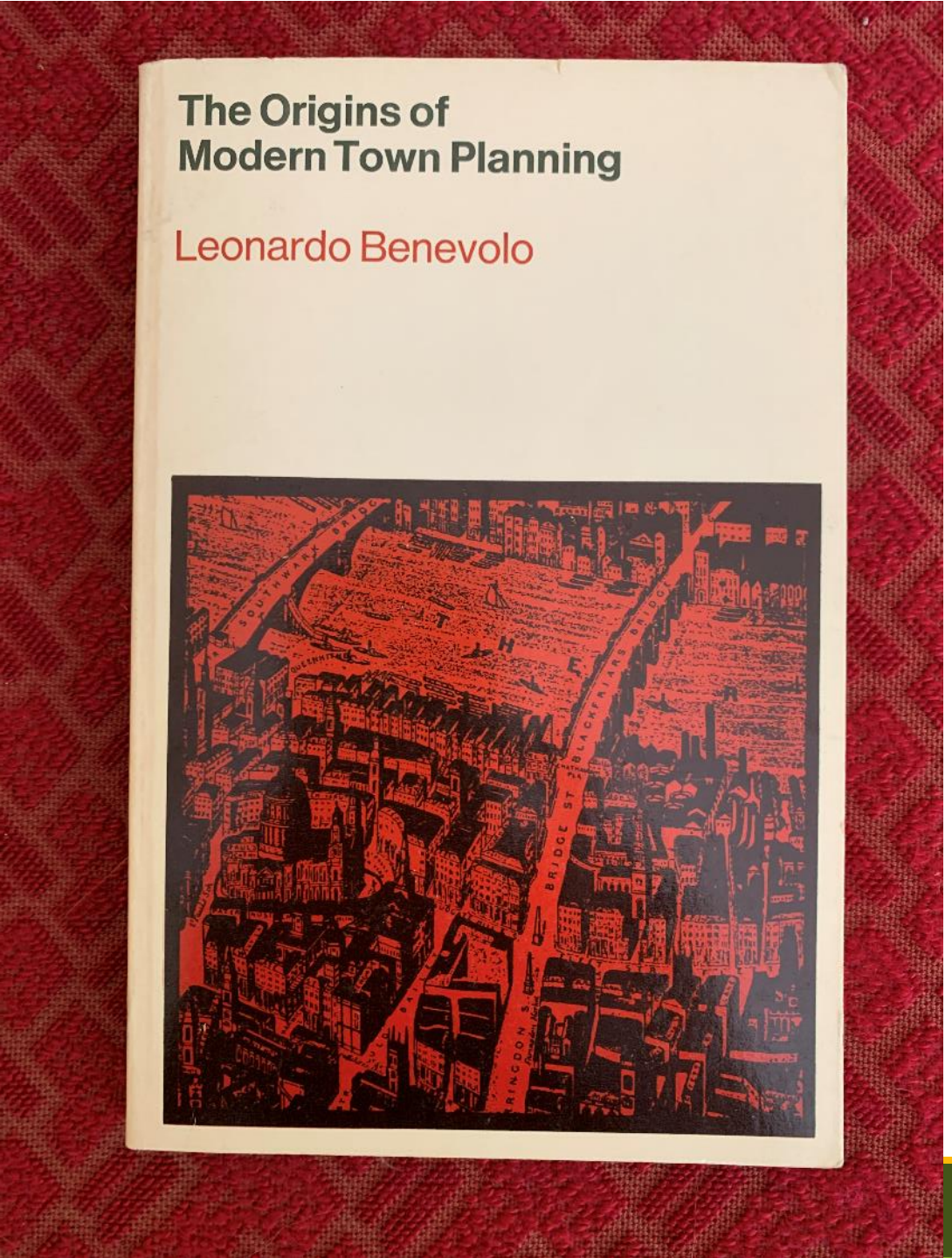
The Positive Potential of Learning From Bio-Climatic Practices

High Level Ideas:

- Did people do better with respect to **climate responsive design**
  - *Before* the interference of architects and engineers?
  - *Before* the invention of HVAC

- Was **colonialization** responsible for the eradication of successful **indigenous** building practices?

- Is **Globalization** currently responsible for taking the evolution of bad colonial practices that culminated in International Style architecture to even more places (that are climatically inappropriate)



Origins of our current climate problem

- Most of the development of North America was based on well intentioned European thinking
- Industrialized cities were generally not respectful of anything nature or climate based – there was a focus on formal layouts, organized streets, architectural styles
- Rivers were simultaneously a source of water for drinking (life), water to feed industrial processes, and the place to dump sewage
- Hard to believe but people didn't understand the basics that when you dump feces into the river, and drink that water, you might get cholera and die

Technological advances have allowed us to build anything without concern for how it should be economically/environmentally heated and cooled.

Photo: National Trust

The Glass House New Canaan Connecticut 1949, by architect Phillip Johnson who coined the term “International Style”

Conventional construction:

Boxes hooked up to life support

In Florida turn the dial one way,

in Waterloo turn it the other.

Think Building Green.com


CONNECTICUT


ARIZONA
04 20 2012


NEW MEXICO
3785


314
BCAR 2010

FLORIDA

GLOBALIZATION

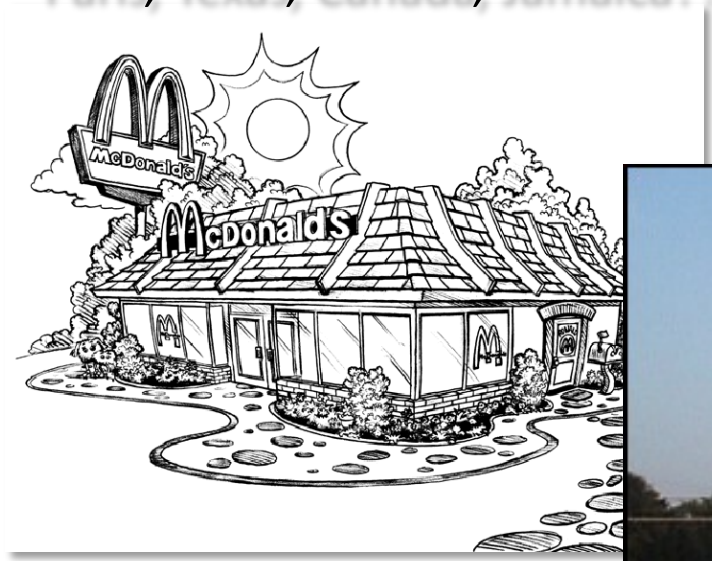
Chicago

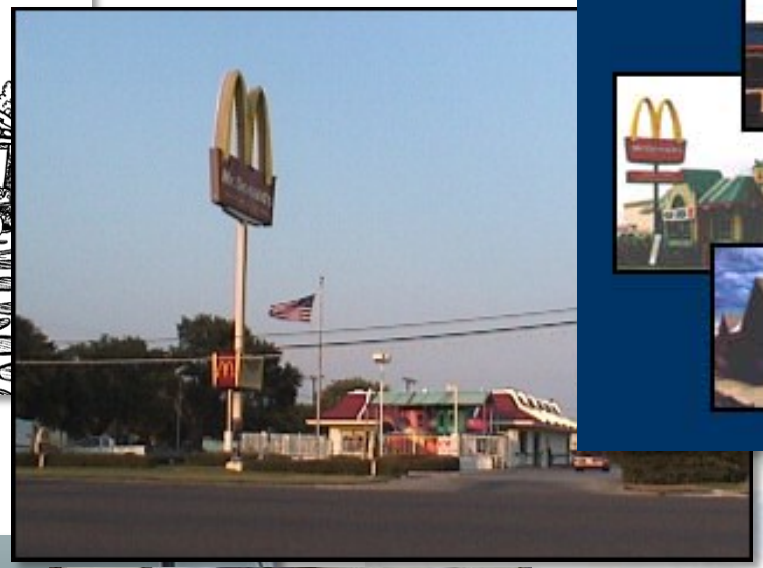
Shanghai

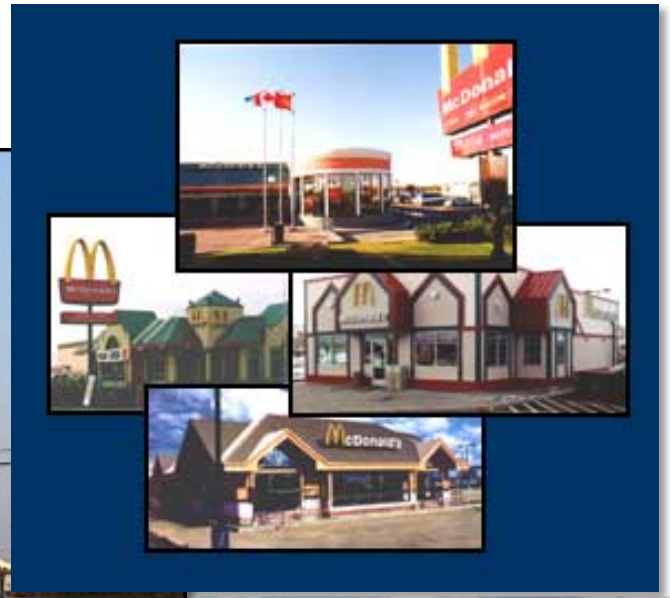
Dubai


COLD
HOT
HOTTER
GLOBALIZATION
Chicago
Shanghai
Dubai

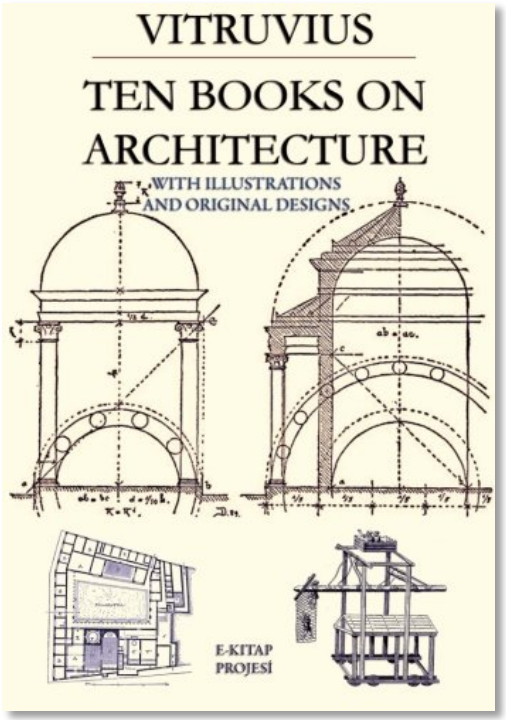
Paris, Texas, Canada, Jamaica?? Can you tell which is which??

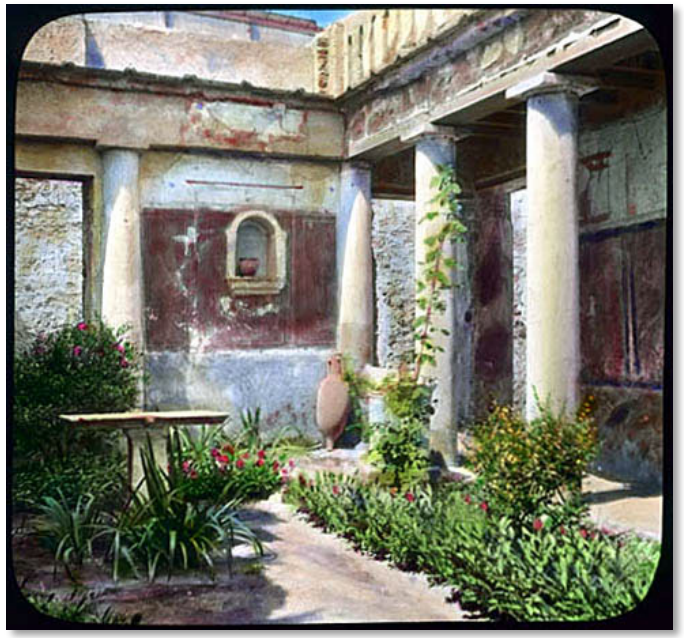






Climate Responsive Architecture





Pompeii: House of the Vettii

Tangier: inside a Medina House

"We must begin by taking note of the countries and climates in which homes are to be built if our designs for them are to be correct. One type of house seems appropriate for Egypt, another for Spain…one still different for Rome…It is obvious that design for homes ought to conform to diversities of climate."

Vitruvius, Architect 1st century BCE

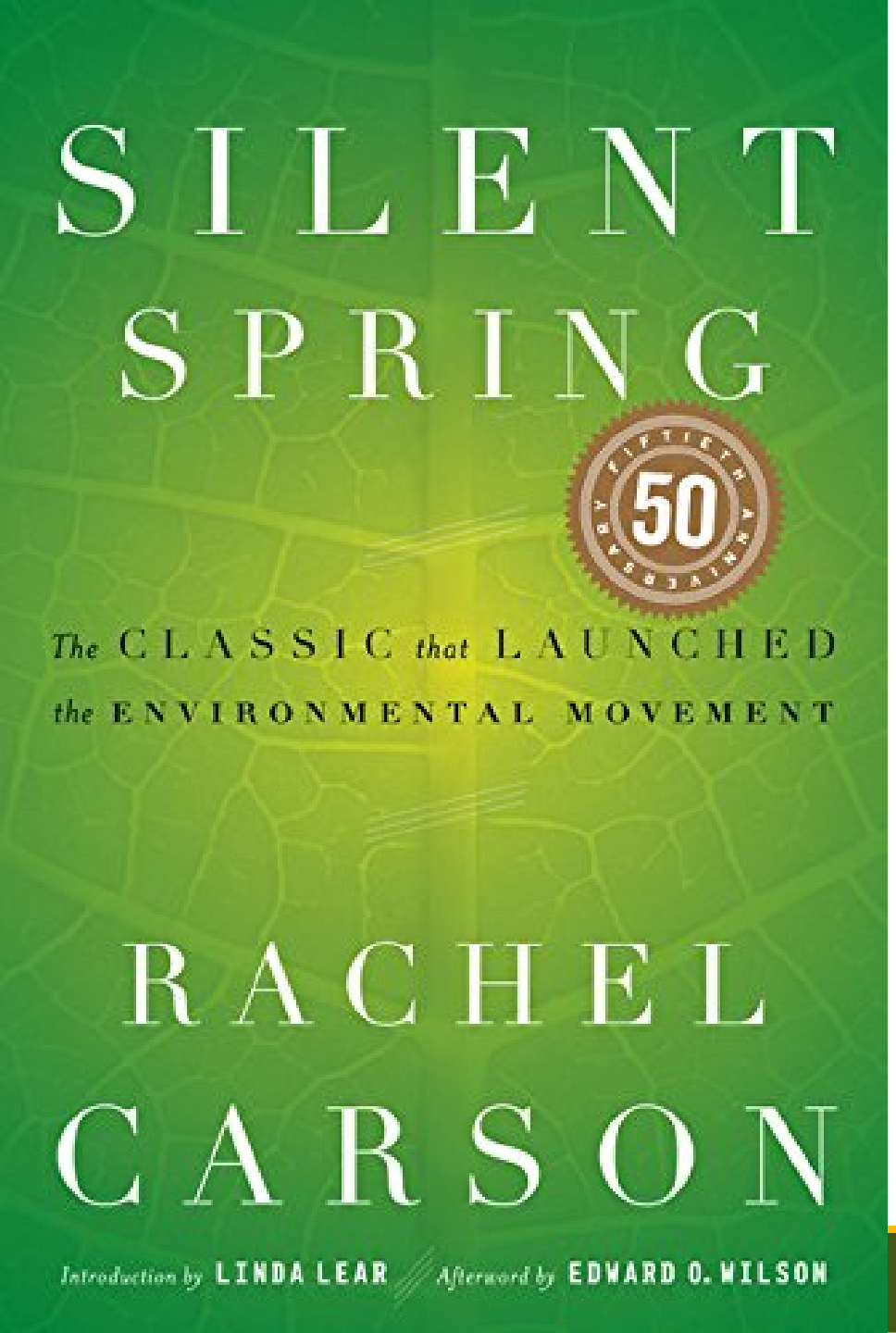
Primitive Architecture and Climate

1960

Despite meager resources, primitive people have designed dwellings that successfully meet the severest climate problems. These simple shelters often outperform the structures of present-day architects

by James Marston Fitch and Daniel P. Branch

This is the required reading that accompanies today's lecture.



1962

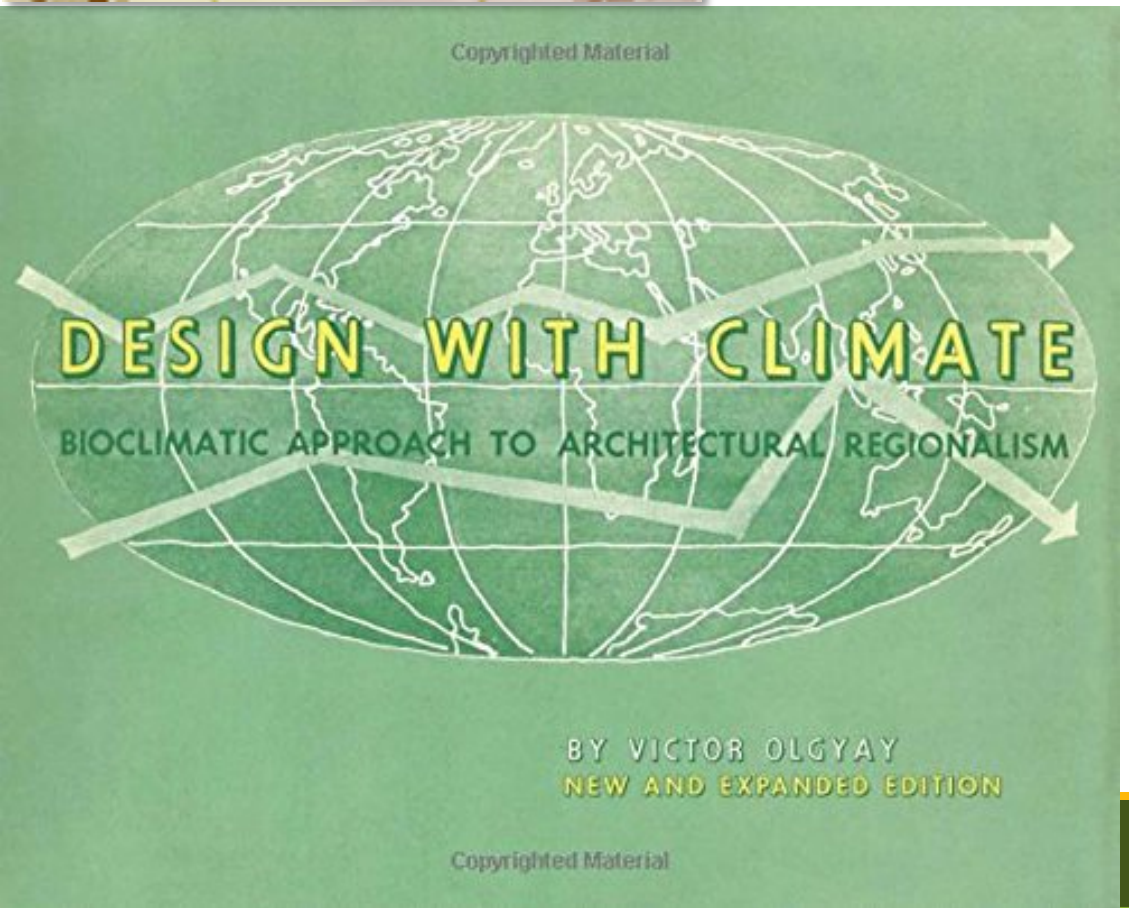
This book launched environmental consciousness in the 20th century.

Rachel Carson connected the negative health impact of DDT (pesticide) on human health.

Surprisingly before that time people didn't appreciate that you sprayed it on plants, it rained, the rainwater entered the ground, ended up in ponds, cattle drank the water, and people ingested DDT.

1963

Victor Olgyay establishes the relationship between original indigenous practices, building form, climate (based on Fitch and Branch) and *human comfort*.



2015

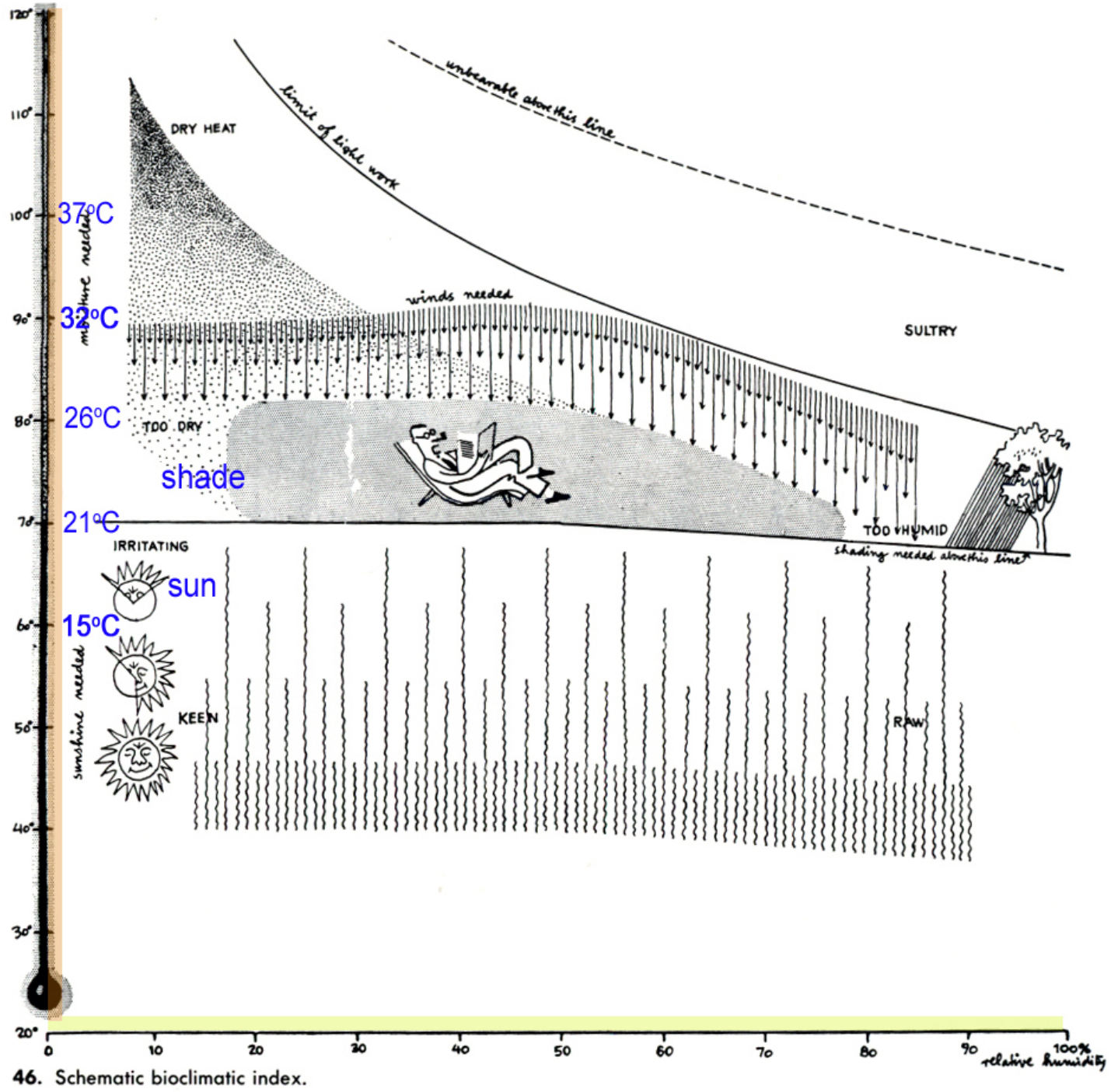
The second environmental movement demanded a reprint to the out of print original text.

Olgyay's basic ideas about climate and its relationship to **HUMAN COMFORT** were to become the basis for thinking in current sustainable design.

Victor Olgyay, 1963, introduced the concept of the **COMFORT ZONE**.

There is little point of saving energy if the building is not comfortable for the occupants.

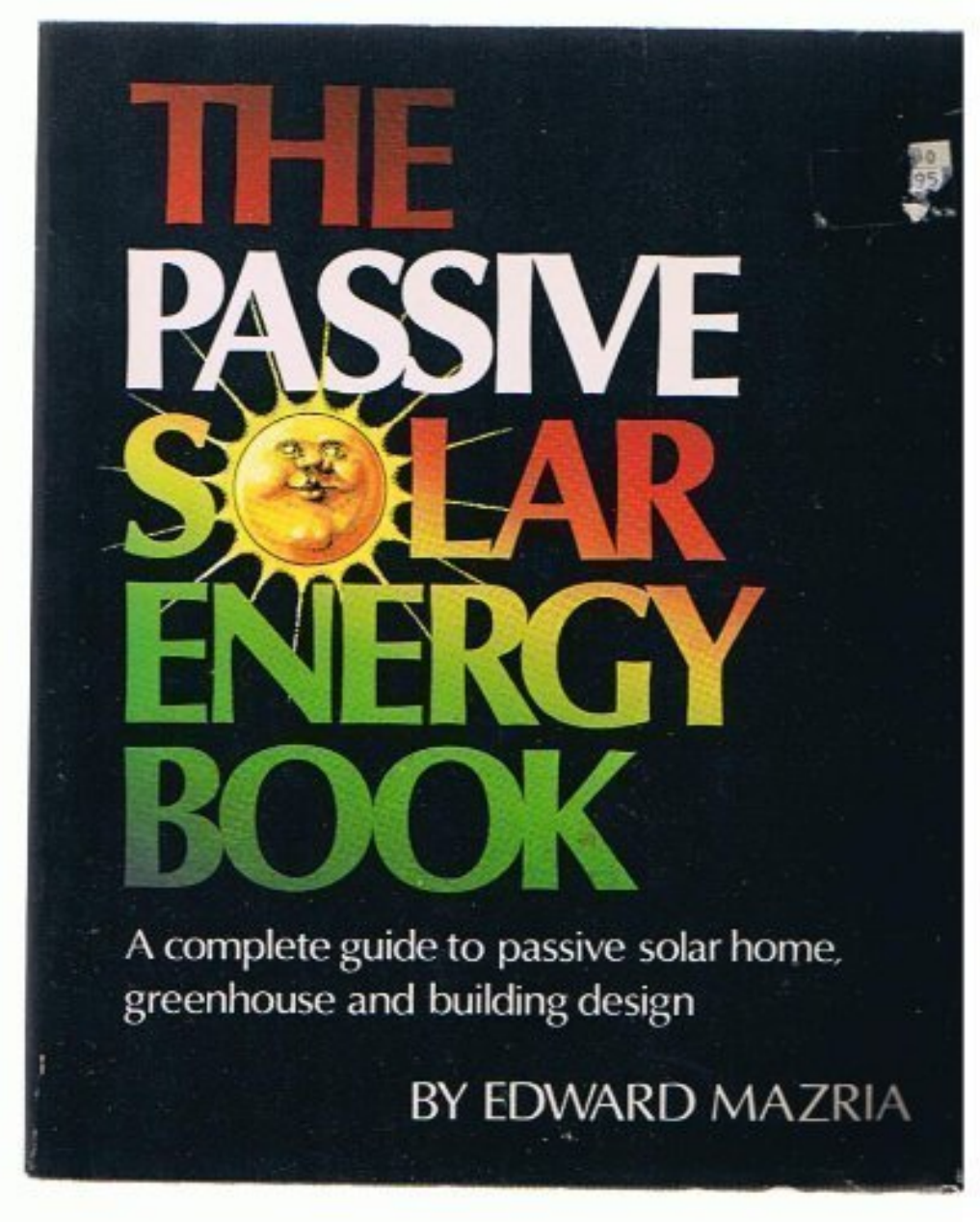
You can have reasonable comfort without heating or AC.



46. Schematic bioclimatic index.

Farnsworth House, 1945-51

Occupant thermal comfort was never a priority in highly formal projects like these. Mies didn’t even want the owner to install drapery! The windows are all sealed. No natural ventilation. No built in shading. The majority of modern buildings were constructed sealed.



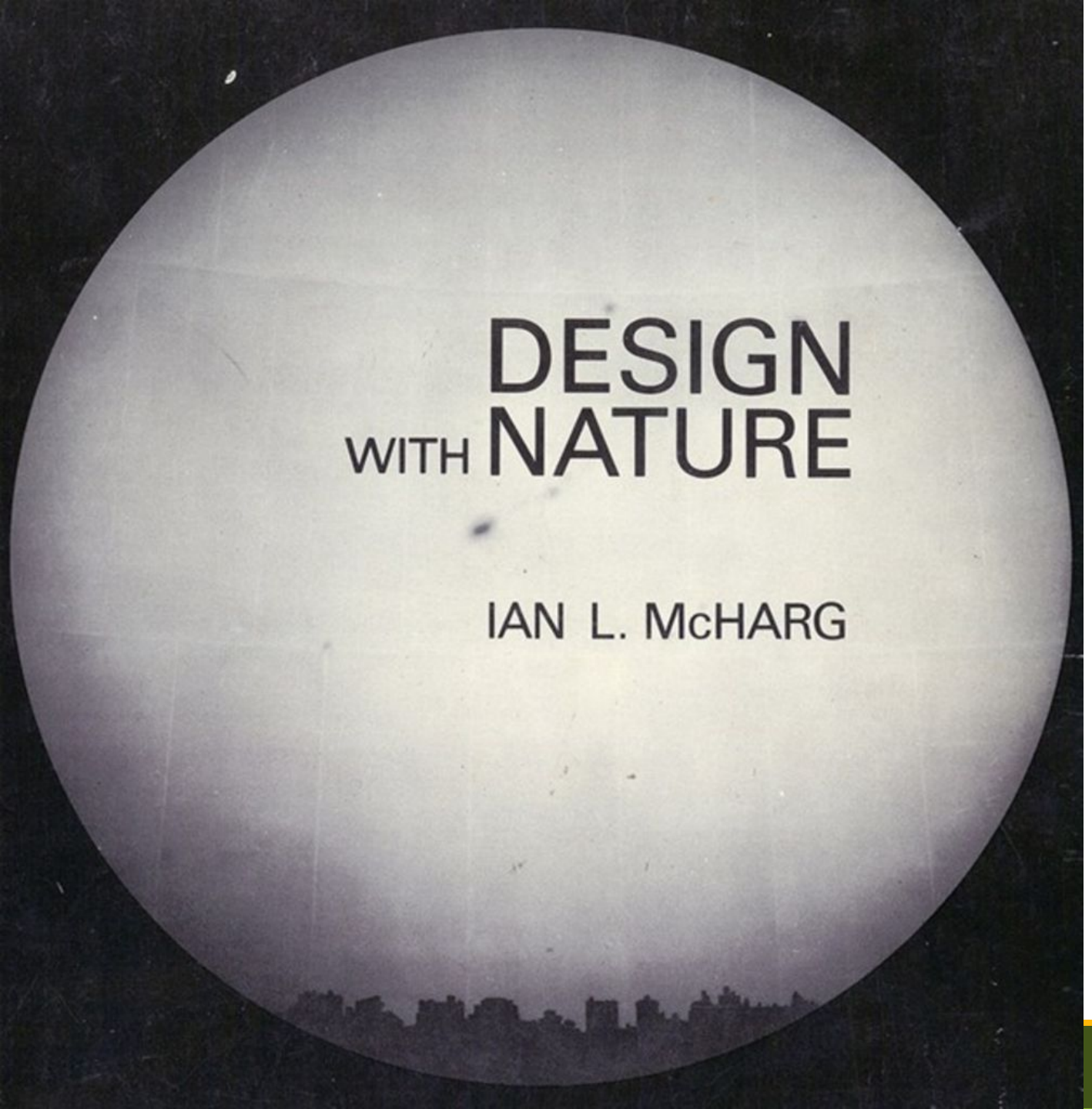
1979

The 1970s saw a surge in interest in the design of solar responsive buildings. Edward Mazria' book became the basis of work in this area.

2009

Mazria founded architecture2030 and challenged all architects to design to zero carbon operating energy by the year 2030.

https://architecture2030.org/



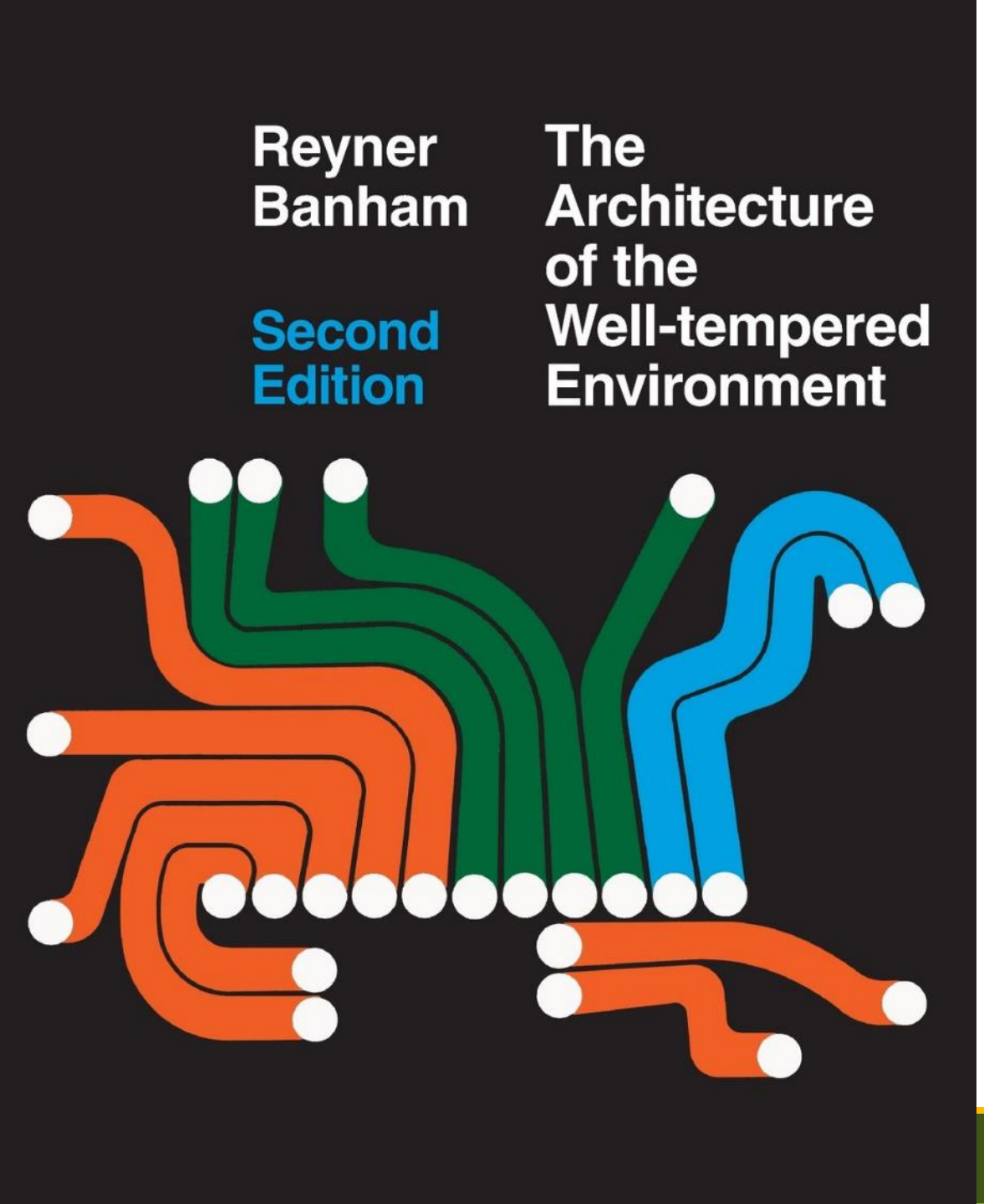
1969

Ian McHarg looks at the relationship of landforms to planning decisions.

Works against the modern notion of eradicating the landscape.

1995

The out of print book is resurrected as its ideas become the basis of current sustainable practices in development ideas.

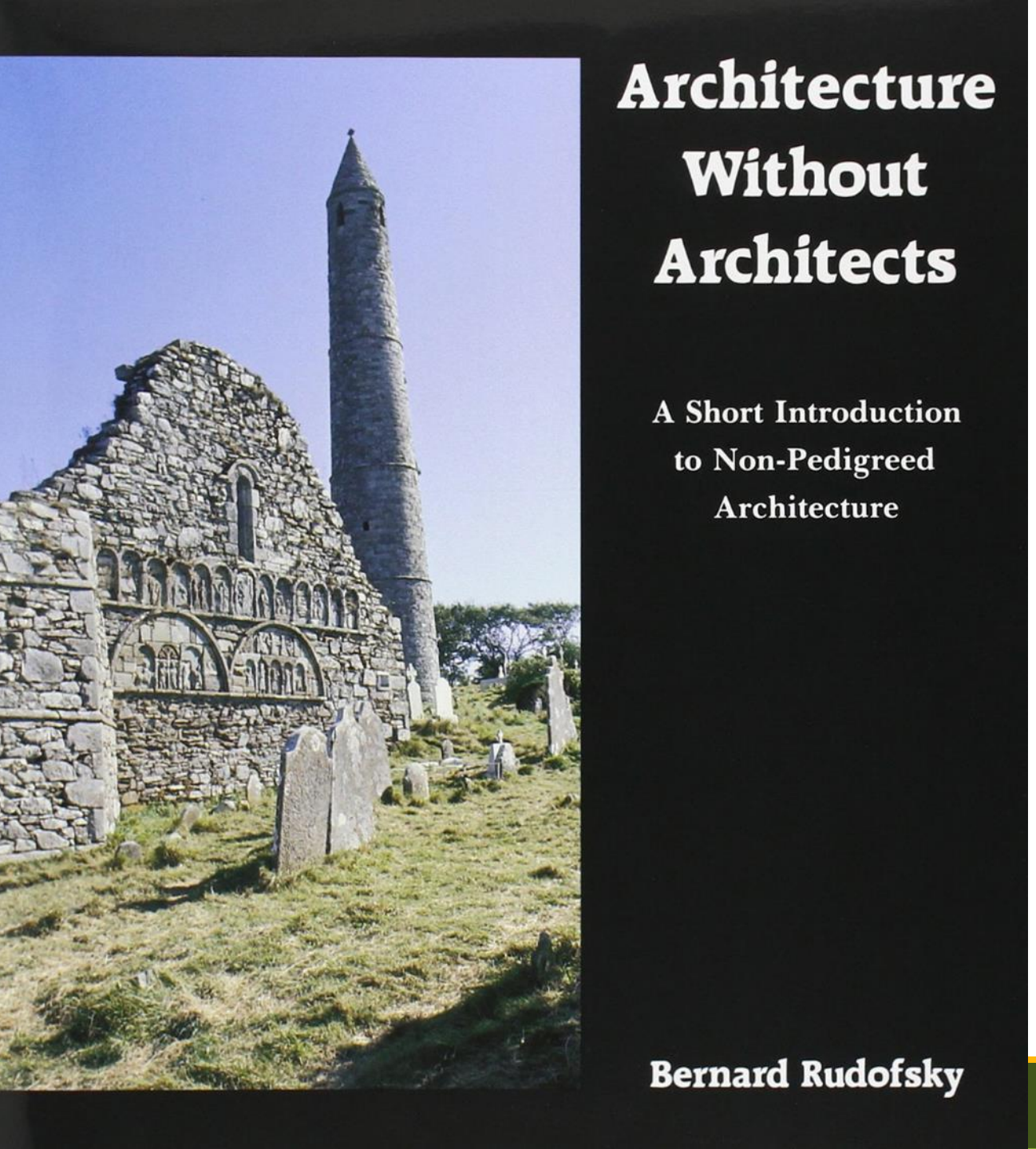


1984

This important text looked at the failure of Modern Architecture as it became reliant on mechanical heating and cooling systems.

The abandonment of good building practices that had environmental benefits.

Reyner Banham was a highly respected writer and so had a lot of influence.

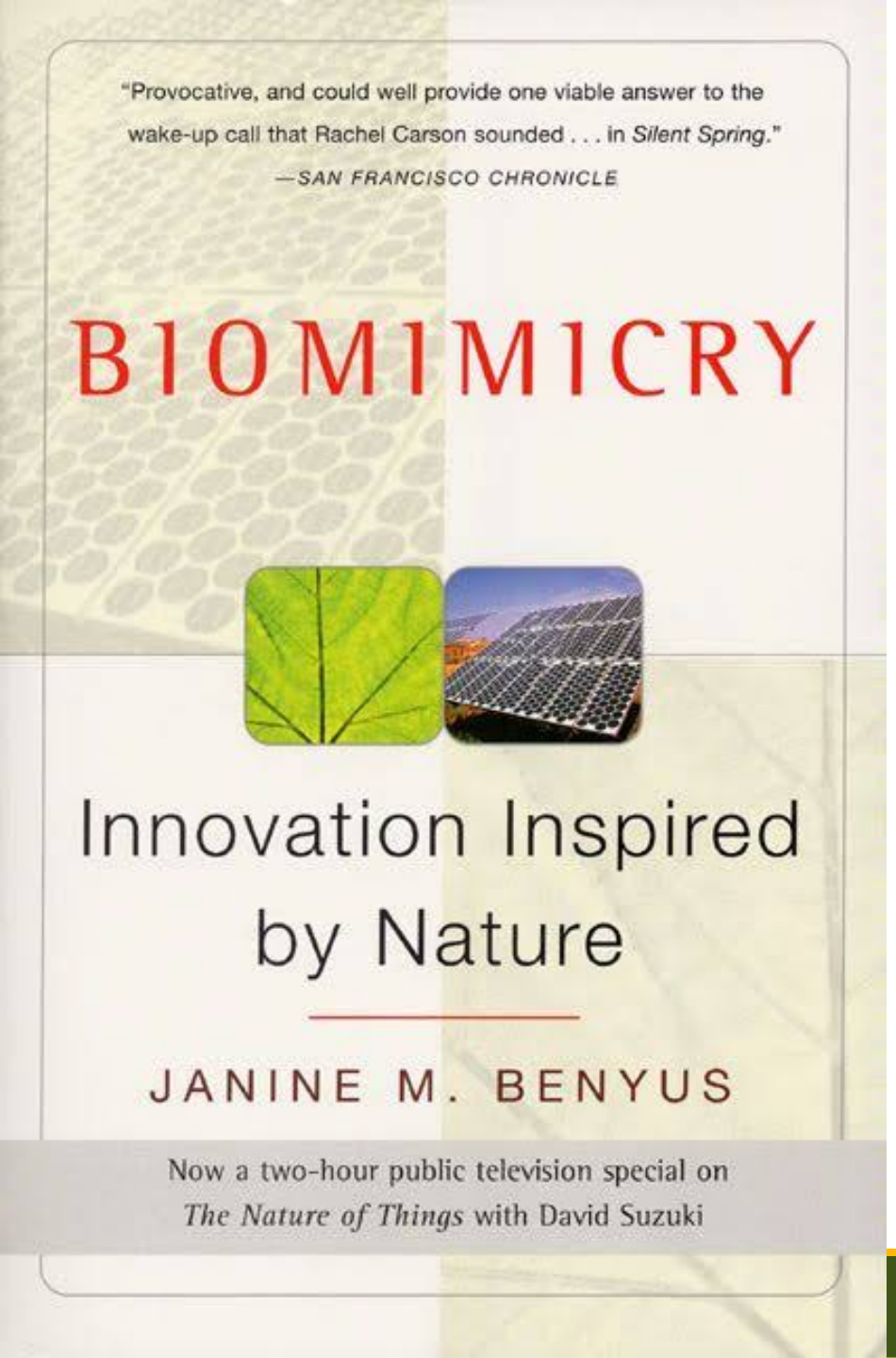


1987

This seminal text looked at historic architecture from around the world.

It didn't have an environmental focus, necessarily, but was looking at building practices that were less formally driven.

Buildings that relied on local materials, ideas and skills.

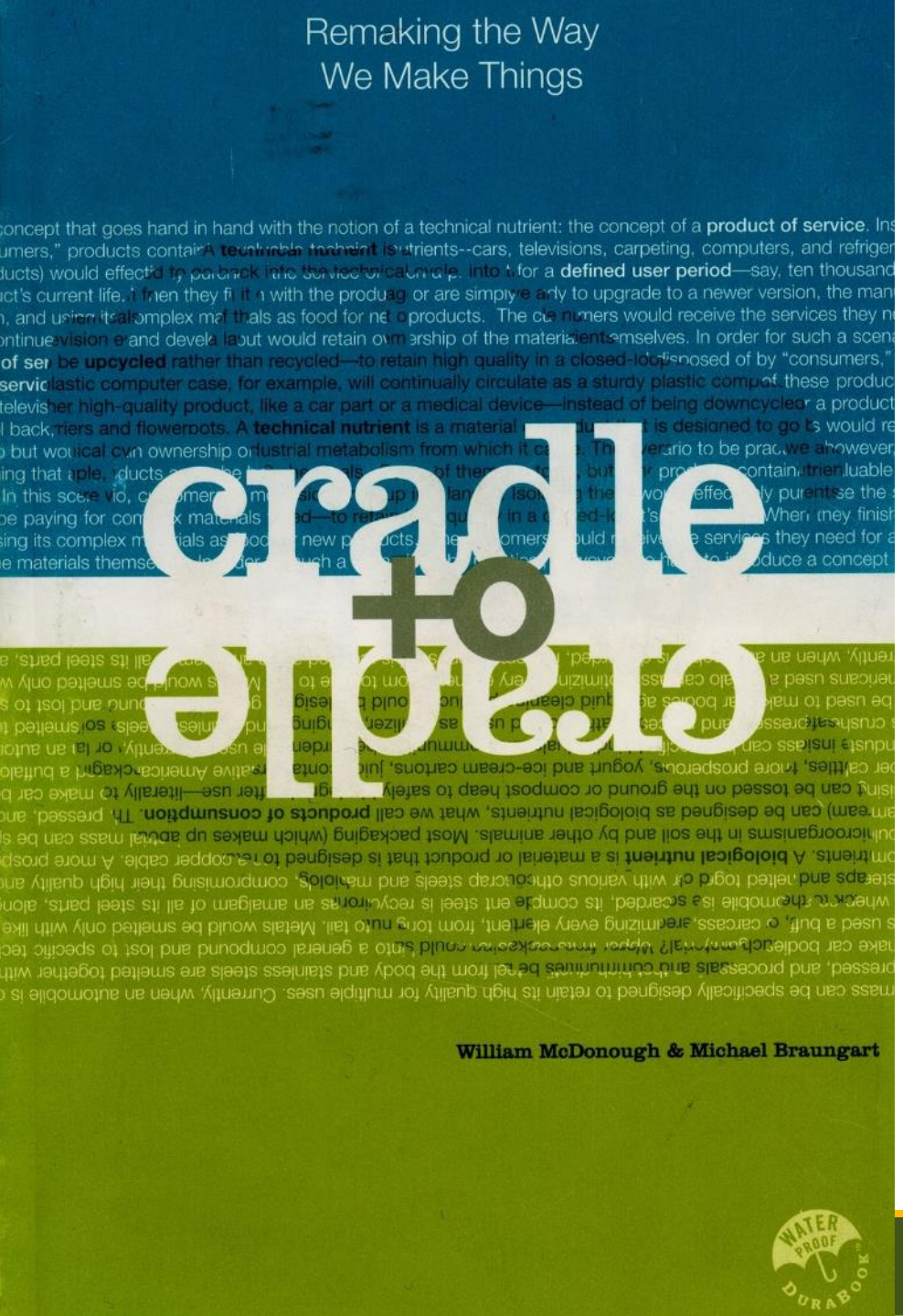


1997

Janine Benyus introduces the concept of Biomimicry.

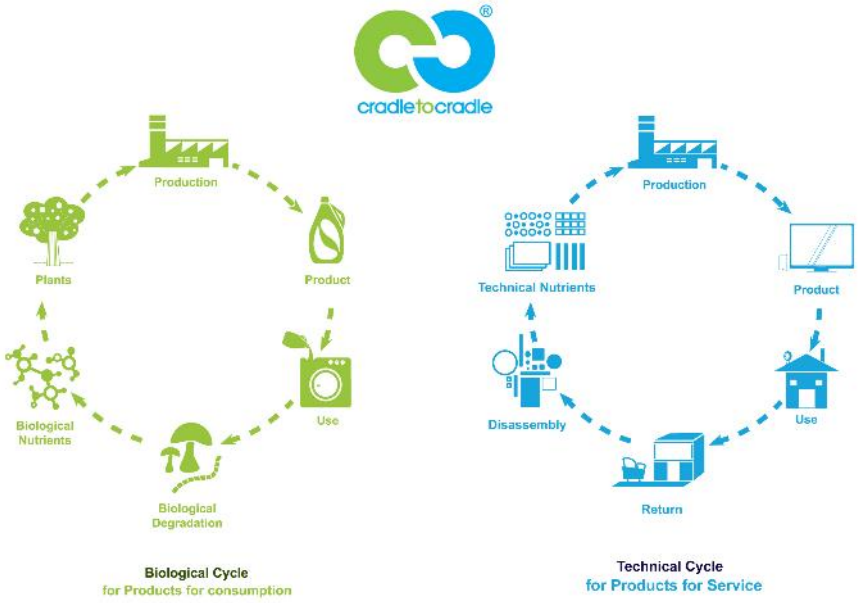
The larger idea is that nature has already solved so many problems that people/technology struggles to solve.

If we closely examine how nature does things, we can figure out how to adapt these functions to our own fabricated objects.



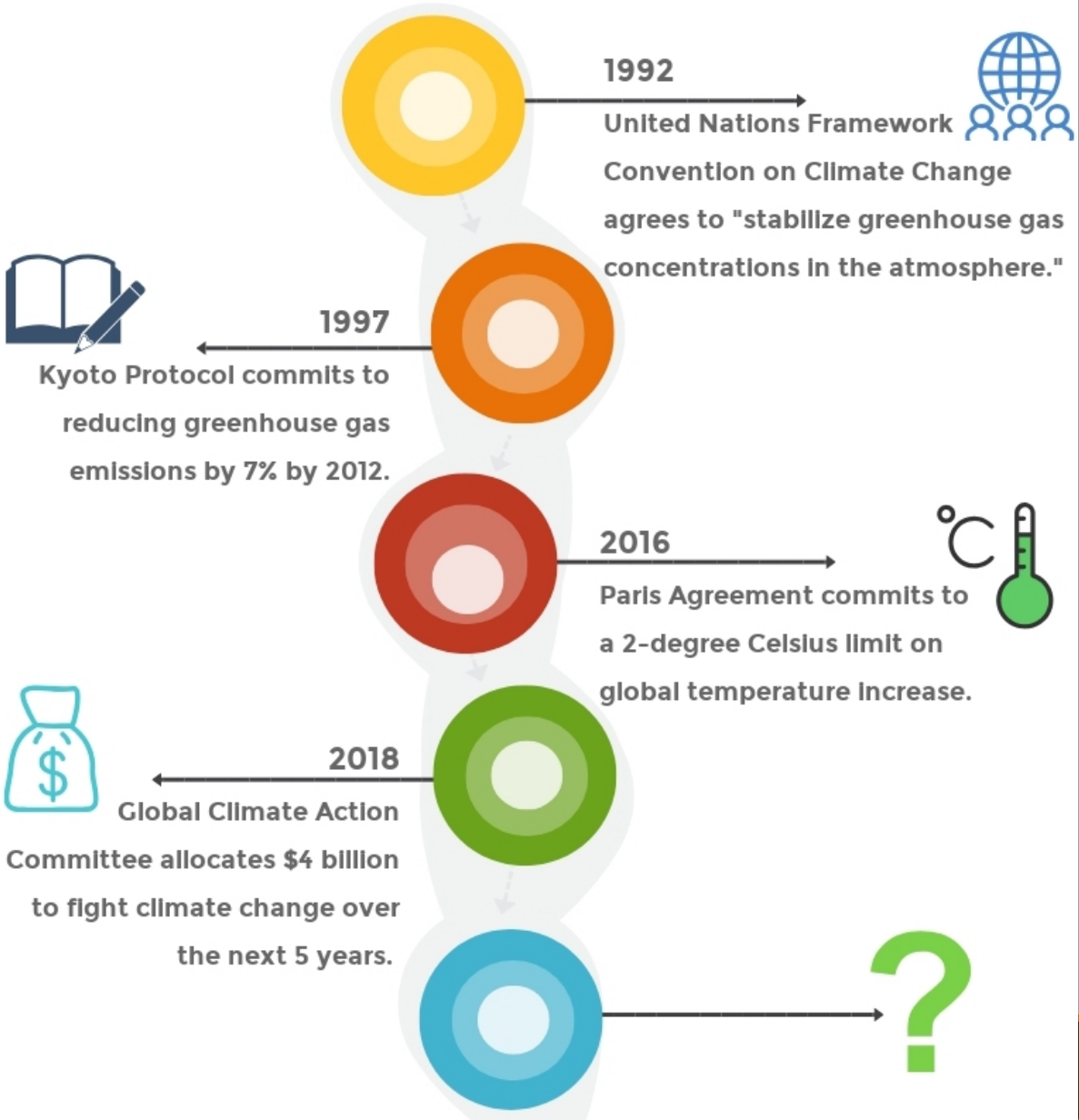
2002

William McDonough and Michael Braungart put for the idea that instead of objects being inevitable trashed, that we can change the way we make things to make use of waste to make new objects. All materials have value and all are limited in availability.



Climate Agreements

A brief history



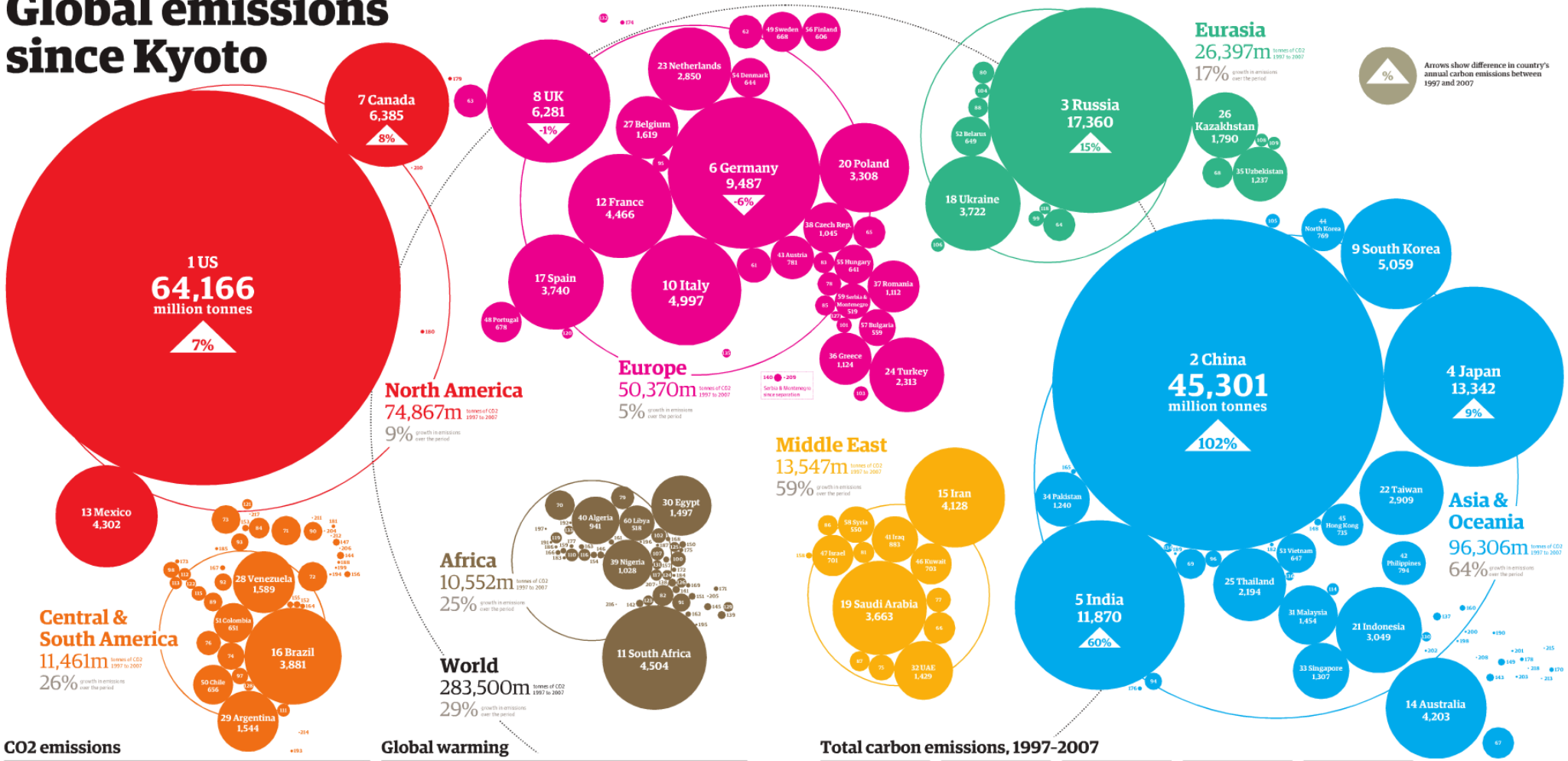
Many efforts have been made to get the countries of the world working to slow down climate change

None have been very effective

Much of the disagreement lies in disparity in population density, poor vs rich countries, developed vs developing countries

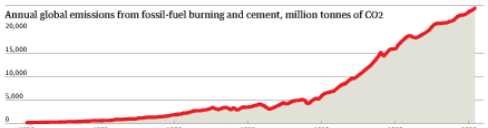
Developing countries do not think it fair to thwart their “progress” towards having lifestyles equal to developed countries.

Global emissions since Kyoto



CO2 emissions

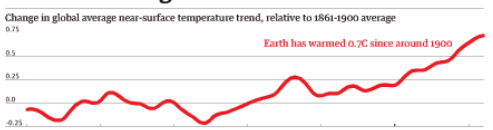
Annual global emissions from fossil-fuel burning and cement, million tonnes of CO2



SOURCE: WORLD RESOURCES INSTITUTE 2006 (FROM STERN REPORT)

Global warming

Change in global average near-surface temperature trend, relative to 1861-1900 average



SOURCE: BROHAN ET AL. 2006 (FROM STERN REPORT)

Total carbon emissions, 1997-2007

Rank	Country	Million tonnes '97-07	Percent change '97-07
1	United States	64,166	7
2	China	45,301	103
3	Russia	17,360	15
4	Japan	13,342	9
5	India	11,870	60
6	Germany	9,487	-6
7	Canada	6,385	8
8	United Kingdom	6,281	-1
9	South Korea	5,059	31
10	Italy	4,997	9
11	South Africa	4,504	17
12	France	4,466	5
13	Mexico	4,302	30
14	Australia	4,203	27
15	Iran	4,128	69
16	Brazil	3,881	23
17	Spain	3,740	54
18	Ukraine	3,722	3
19	Saudi Arabia	3,663	41
20	Poland	3,308	41
21	Indonesia	3,049	29
22	Taiwan	2,909	47
23	Netherlands	2,850	9
24	Turkey	2,313	51
25	Thailand	2,194	40
26	Kazakhstan	1,790	81
27	Belgium	1,619	4
28	Venezuela	1,589	27
29	Argentina	1,544	27
30	Egypt	1,497	43
31	Malaysia	1,454	54
32	United Arab Emirates	1,429	55
33	Singapore	1,307	54
34	Pakistan	1,240	54
35	Uzbekistan	1,237	89
36	Greece	1,124	18
37	Romania	1,112	45
38	Czech Republic	1,045	3
39	Nigeria	1,028	19
40	Algeria	941	25
41	Iraq	883	37
42	Philippines	794	17
43	Austria	781	13
44	North Korea	769	4
45	Hong Kong	735	80
46	Kuwait	703	49
47	Israel	701	30
48	Portugal	678	16
49	Sweden	668	14
50	Chile	656	20
51	Colombia	651	7
52	Belarus	649	16
53	Vietnam	647	104
54	Denmark	644	-14
55	Hungary	641	-6
56	Finland	606	6
57	Bulgaria	559	-2
58	Syria	550	33
59	Serbia & Montenegro	519	24
60	Libya	518	24
61	Switzerland	497	0
62	Norway	475	3
63	Ireland	456	29
64	Azerbaijan	420	29
65	Slovakia	420	8
66	Qatar	420	76
67	New Zealand	400	16
68	Turkmenistan	387	171
69	Bangladesh	375	93
70	Morocco	370	41
71	Puerto Rico	364	46
72	Trinidad & Tobago	362	81
73	Cuba	345	-21
74	Peru	327	28
75	Oman	277	102
76	Ecuador	249	37
77	Belarus	249	58
78	Croatia	234	36
79	Tunisia	223	27
80	Panama	209	10
81	Jordan	186	53
82	Angola	185	71
83	Slovenia	184	3
84	Dominican Republic	181	54
85	Bosnia & Herzegovina	170	97
86	Lebanon	169	40
87	Iceland	166	80
88	Lithuania	164	8
89	Panama	148	16
90	Virgin Islands, US	148	99
91	Zimbabwe	137	-33
92	Netherlands Antilles	127	-3
93	Jamaica	126	24
94	Sri Lanka	124	46
95	Luxembourg	115	41
96	Burma	113	98
97	Bolivia	112	73
98	Guatemala	108	72
99	Armenia	100	48
100	Kenya	98	68
101	Macedonia	97	46
102	Sudan	92	306
103	Cyprus	90	41
104	Latvia	90	35
105	Mongolia	83	25
106	Moldova	77	-12
107	Cameroon	74	8
108	Kyrgyzstan	70	-22
109	Tajikistan	68	42
110	Ivory Coast	69	31
111	Uruguay	68	41
112	Honduras	63	105
113	El Salvador	64	37
114	Brunei	61	178
115	Costa Rica	61	63
116	Ghana	61	82
117	Gabon	55	-23
118	Georgia	53	-6
119	Senegal	53	64
120	Gibraltar	47	41
121	Bahamas	45	44
122	Nicaragua	45	68
123	Botswana	44	40
124	Congo (Brazzaville)	42	50
125	Ethiopia	42	313
126	Tanzania	41	118
127	Albania	40	118
128	Paraguay	35	29
129	Mauritius	30	73
130	Papua New Guinea	28	75
131	Equatorial Guinea	26	185
132	Iceland	25	23
133	Mauritania	24	-8
134	Nepal	23	78
135	Malta	12	11
136	Cambodia	11	111
137	Guam	10	-44
138	Congo (Kinshasa)	10	-35
139	Reunion	10	48
140	Serbia	10	--
141	Zambia	9	9
142	Namibia	9	113
143	New Caledonia	9	67
144	Martinique	8	22
145	Madagascar	8	100
146	Benin	7	170
147	Guadeloupe	7	29
148	Macau	7	57
149	Fiji	6	144
150	Djibouti	5	-4
151	Mozambique	5	108
152	Suriname	5	36
153	Haiti	5	26
154	Togo	5	300
155	Guyana	4	44
156	Barbados	4	-4
157	Uganda	4	84
158	Palestine	4	837
159	Guinea	3	13
160	Wake Island	3	-1
161	Niger	3	12
162	Swaziland	3	24
163	Burkina Faso	3	18
164	French Guiana	3	18
165	Afghanistan	3	-42
166	Sierra Leone	3	37
167	Aruba	2	44
168	Eritrea	2	-33
169	Malawi	2	41
170	French Polynesia	2	48
171	Seychelles	2	83
172	Rwanda	2	22
173	Belize	2	123
174	Faroe Islands	2	39
175	Somalia	2	36
176	Maldives	2	157
177	Mali	2	28
178	American Samoa	1	6
179	Greenland	1	16
180	Bermuda	1	26
181	Antigua & Barbuda	1	33
182	Laos	1	16
183	Liberia	1	54
184	Burundi	1	3
185	Cayman Islands	1	41
186	Guinea-Bissau	1	30
187	Central African Republic	1	13
188	Saint Lucia	1	87
189	Gambia	1	18
190	U.S. Pacific Islands	1	3
191	Gambia	1	51
192	Western Sahara	1	23
193	Antarctica	1	16
194	Grenada	1	43
195	Lesotho	1	35
196	Chad	1	39
197	Cape Verde	1	115
198	Solomon Islands	1	38
199	St Vincent & Grenadines	1	43
200	Nauru	1	14
201	Samoa	1	29
202	East Timor	1	--
203	Tonga	1	46
204	Saint Kitts & Nevis	1	87
205	Comoros	1	43
206	Dominica	1	47
207	Sao Tome & Principe	1	60
208	Vanuatu	0	59
209	Montenegro	0	--
210	St Pierre & Miquelon	0	46
211	Virgin Islands, British	0	75
212	Montserrat	0	75
213	Cook Islands	0	58
214	Falkland Islands	0	38
215	Kiribati	0	84
216	Saint Helena	0	112
217	Turks & Caicos Islands	0	--
218	Niue	0	47

The data is the latest available compiled by the Environment Information Administration, part of the US Department of Energy. Although newer data is available from other sources, the EIA is the only credible source of carbon emissions for every country in the world.

The key issues at Copenhagen

1 Cut carbon in rich world

Scientists say cuts of 25-40% by 2020 are needed, relative to 1990 levels, rising to 80-95% by 2050. Developed countries have grown rich on fossil fuels and still emit vast amounts of CO2 per person, so have a responsibility to make deepest cuts.

2 Curb carbon in developing world

Emissions from fast-growing economies such as China and India are surging, yet their citizens have small carbon footprints and millions live in poverty. So they'll argue they need to be allowed to pollute for a while yet as they improve their citizens' lives.

3 Pay the price for climate change

All agree that the poorest nations need urgent aid, having done nothing to pollute the atmosphere. It will also cost a lot to create the clean technology essential for slashing global emissions. In both cases, rich nations will be expected to pick up the tab.

4 Keep tabs on funds and emissions

Poorer nations want to continue Kyoto's top-down approach, with clear responsibilities placed on rich countries. Developing nations also want climate funds distributed by the UN, whereas developed countries would prefer the World Bank.

5 Slow the speed of deforestation

About 17% of the carbon emitted by human activity comes from razing forests. But paying people not to fell trees soon becomes complex... Who really owns them? Were they actually going to be chopped down? How do you verify the whole process?

6 Clean technology

Paying for clean technology is just the start, as the products and services required must be developed and deployed rapidly and efficiently all over the globe. But nations differ on whether a strong international body is needed, or just an advisory one.

Checklist of success

- ☐ Rich nations commit to a combined reduction in greenhouse gases of 25-40% by 2020. **Chance of success: Middling**
- ☐ Developing nations commit to a 15-30% cut on the emissions levels expected in 2020. **Chance of success: Good**
- ☐ Richer nations commit to funding poorer ones, and clean technology, to tune of $200bn+ per year. **Chance of success: Low**
- ☐ Deal done on who monitors countries' carbon emissions and distributes the money. **Chance of success: Low**
- ☐ Agreement which delivers cash to forested nations, meaning far fewer trees are cut down. **Chance of success: Good**
- ☐ Deal that delivers a radical overhaul in the deployment of clean technology. **Chance of success: Fair**

The summit in numbers

15,000
Number of delegates expected to attend official Copenhagen summit

40,500
Tonnes of carbon dioxide predicted to be emitted by those delegates while at the summit

700,000
Cost in euros of replacing outdated brick kilns in Bangladesh, paid for by Danish government to offset those emissions

$62m+
Estimated cost to Danish government of staging the event

65%
Minimum proportion of food and drink provided to delegates that will be organic

DATA: SIMON ROGERS, GRAPHIC: PAUL SCRUTTON

The Global Warming Pie

These values look at Secondary **Energy Use** by Sector in Canada (2006)
(*energy used by the final consumer i.e. operating energy*)

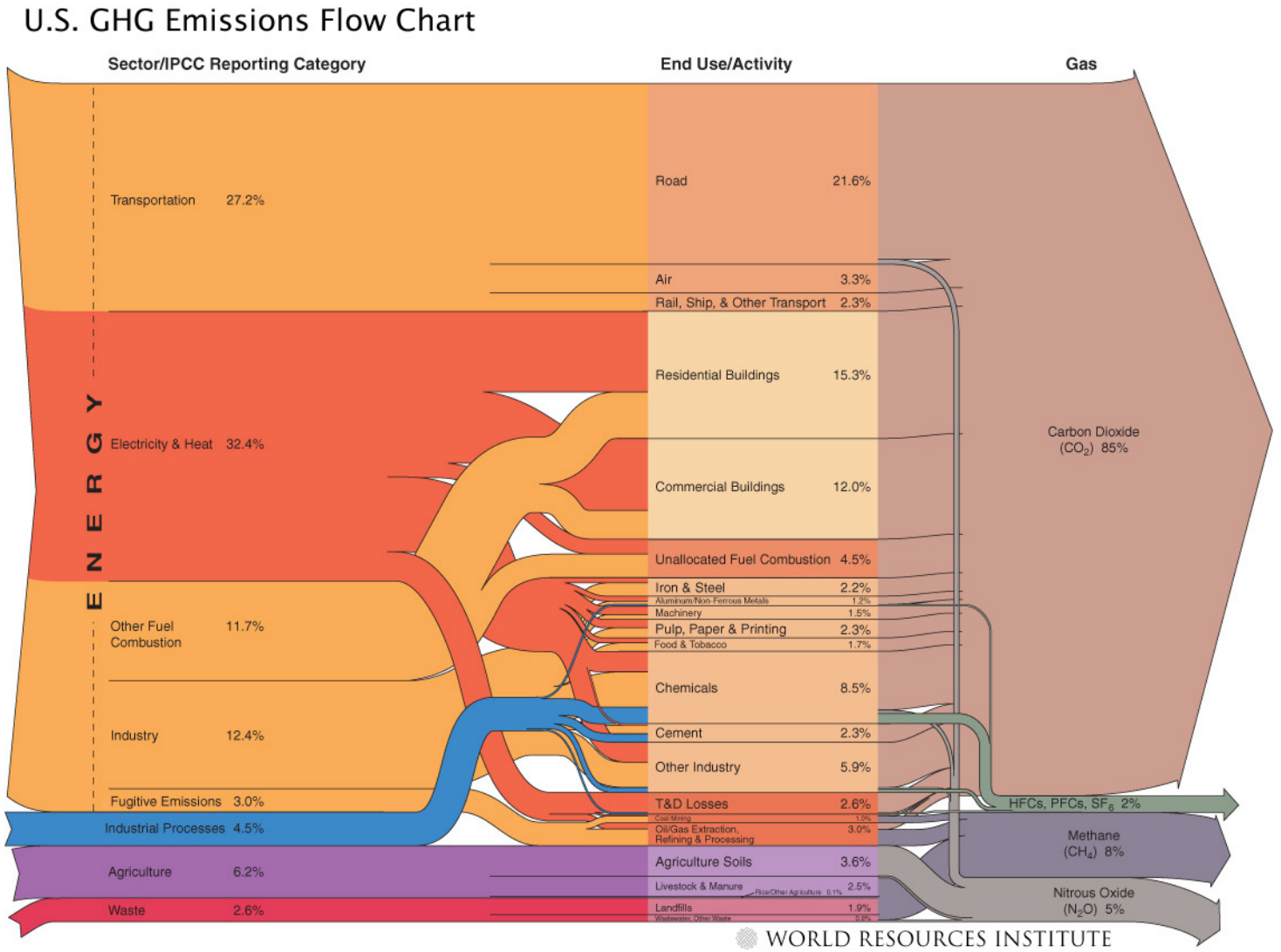
Buildings and the layout of our urban environments are responsible for climate change.

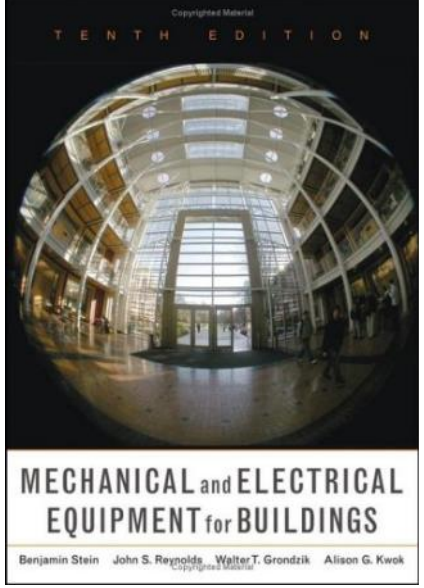
Engineers and architects are the professionals that must learn and apply better ways of designing buildings to reduce their greenhouse gas emissions

This means reducing their operating energy requirements and dependence on fossil fuels

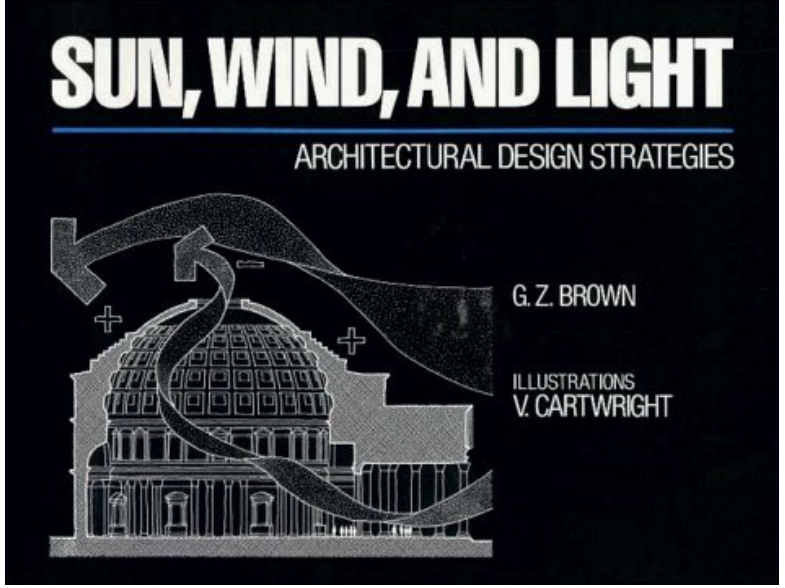
Ecological justice: it is the poor and marginalized that are the worst impacted by climate change. Desertification, floods, extreme weather events.

Emissions and their Sources

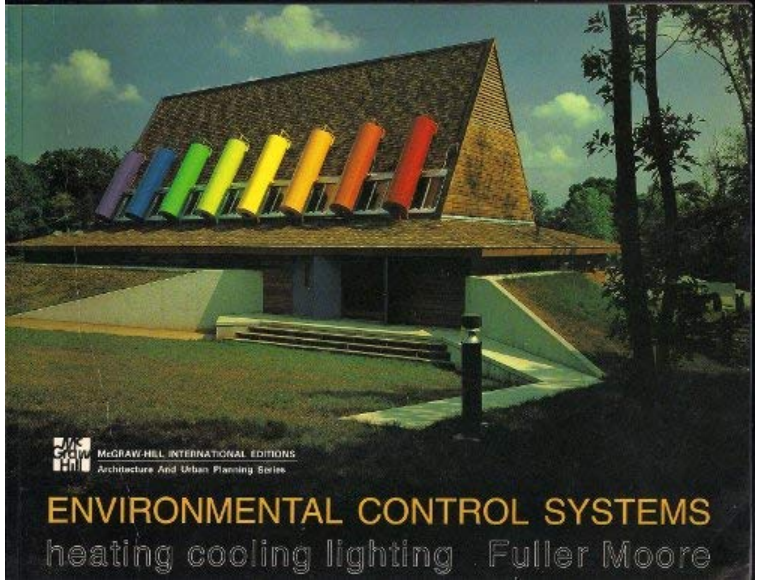




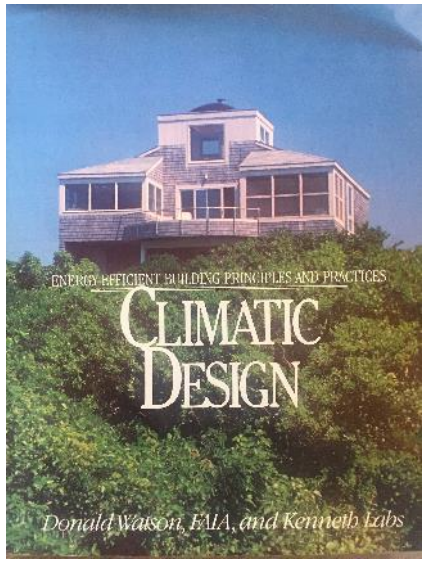
1980



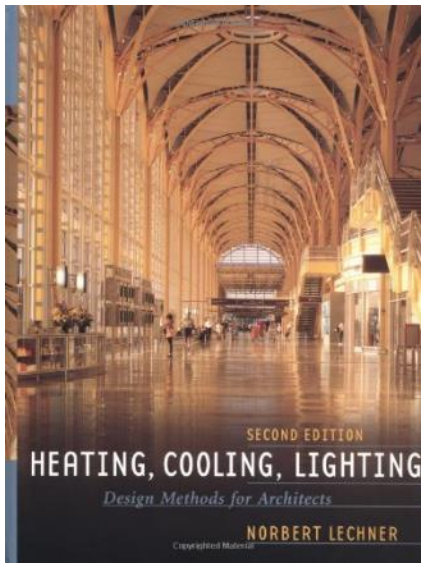
1985



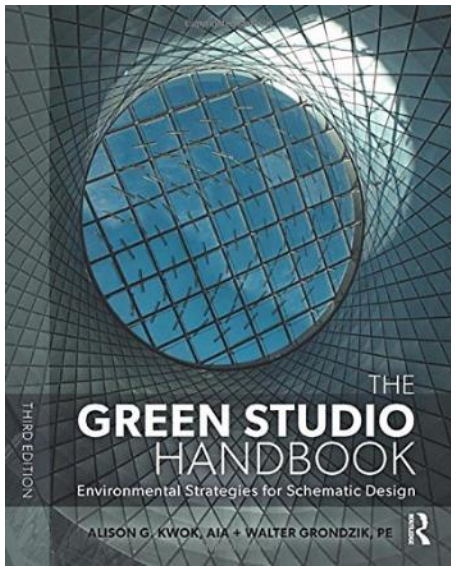
1993



1983



1991



2006

SOCIETY OF BUILDING SCIENCE EDUCATORS

All of these authors are colleagues.
They work at different universities.
I am friends with all of them through my work with SBSE.

Why do we build buildings, NOW???

Initially, it was for shelter from the outside weather, and thus, survival.

THEN, people desired a certain minimum level of COMFORT, but would modify clothing or expectations as a function of the weather.

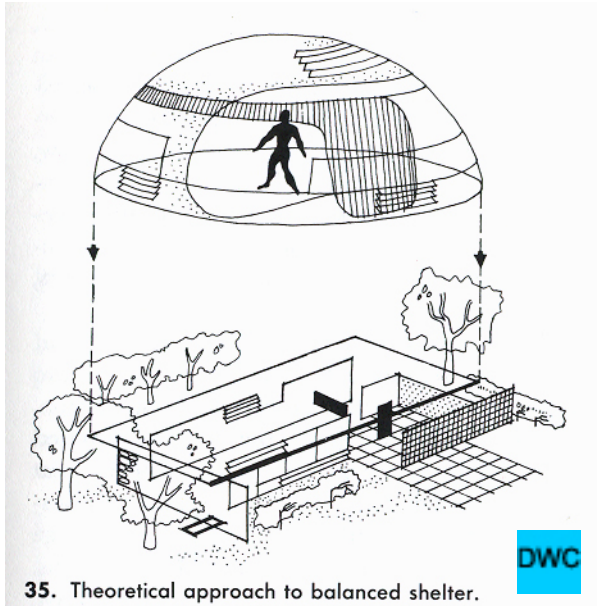
NOW, people (due to the invention of HVAC) expect to be held at a constant level of COMFORT, in spite of the weather or location (in the world).

Climate and Housing

In its most fundamental form, housing is shelter – a system of components designed to mediate the existing environments (which is less than satisfactory in some way) into a comfortable and satisfactory environment. Historically, shelter has been built

- to reduce the range of local climatic variations;
- to avoid some of the heat of the sun in hot climates,
- to conserve heat in cold climates,
- to welcome the breezes when they can provide desired cooling,
- to avoid winds when they serve to compound the problems of an already cold environments,
- to admit light in sufficient amounts for task lighting and to keep out excessive or unnecessary light.

Shelter and Environment



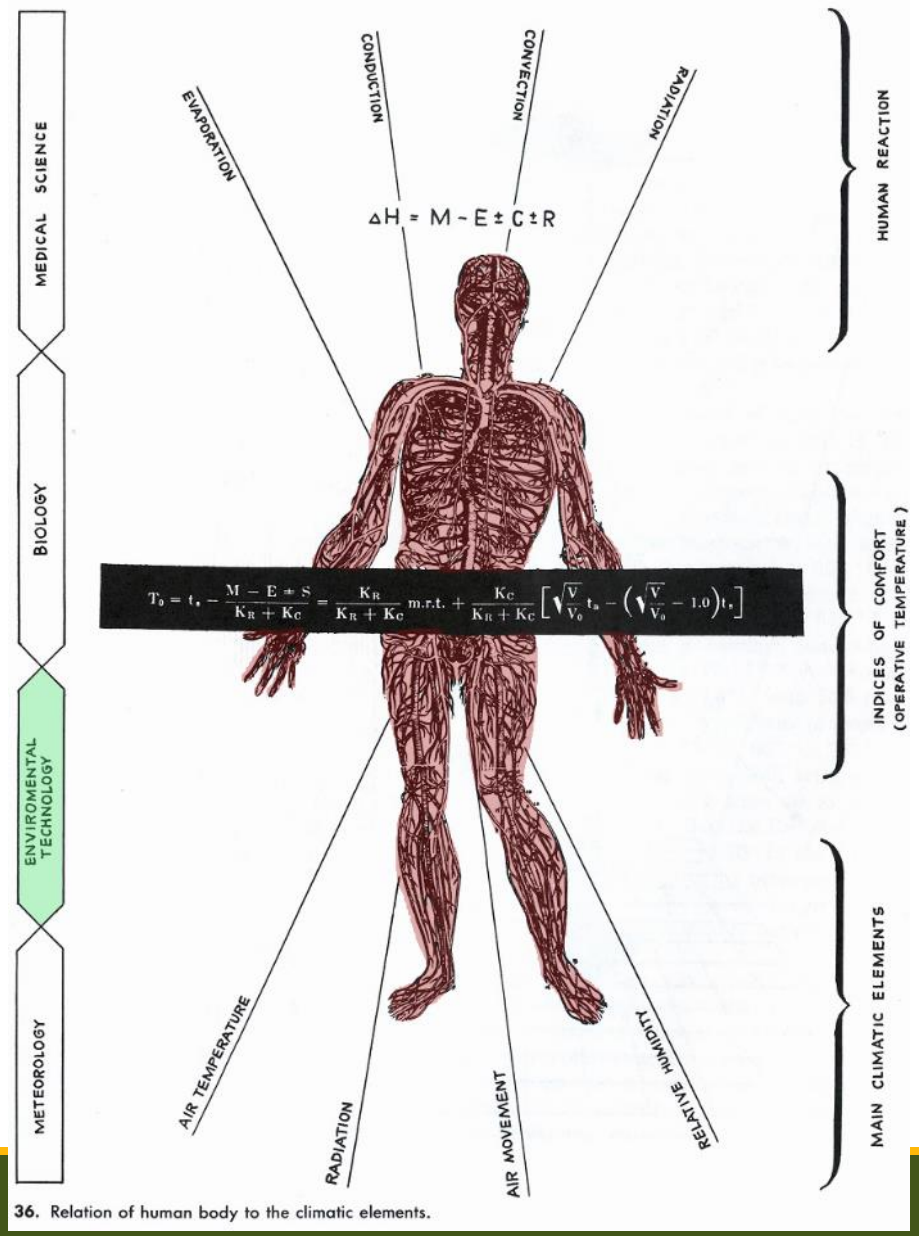
35. Theoretical approach to balanced shelter.

- Shelter is the main instrument for fulfilling the requirements of comfort. It modifies the natural environment to approach optimum conditions of livability.

- The architect and engineer's problem is to produce an environment that will not place undue stress upon the body's heat-compensation mechanism

- *It is NOW our task to make utmost use of* ***the natural means*** *available in order to produce a more healthful and livable building, and to achieve a saving in cost by keeping to a minimum the use of mechanical aids for climate control – thereby reducing demand for fossil fuels and lowering CO2 levels*

The Effects of Climate on People



36. Relation of human body to the climatic elements.

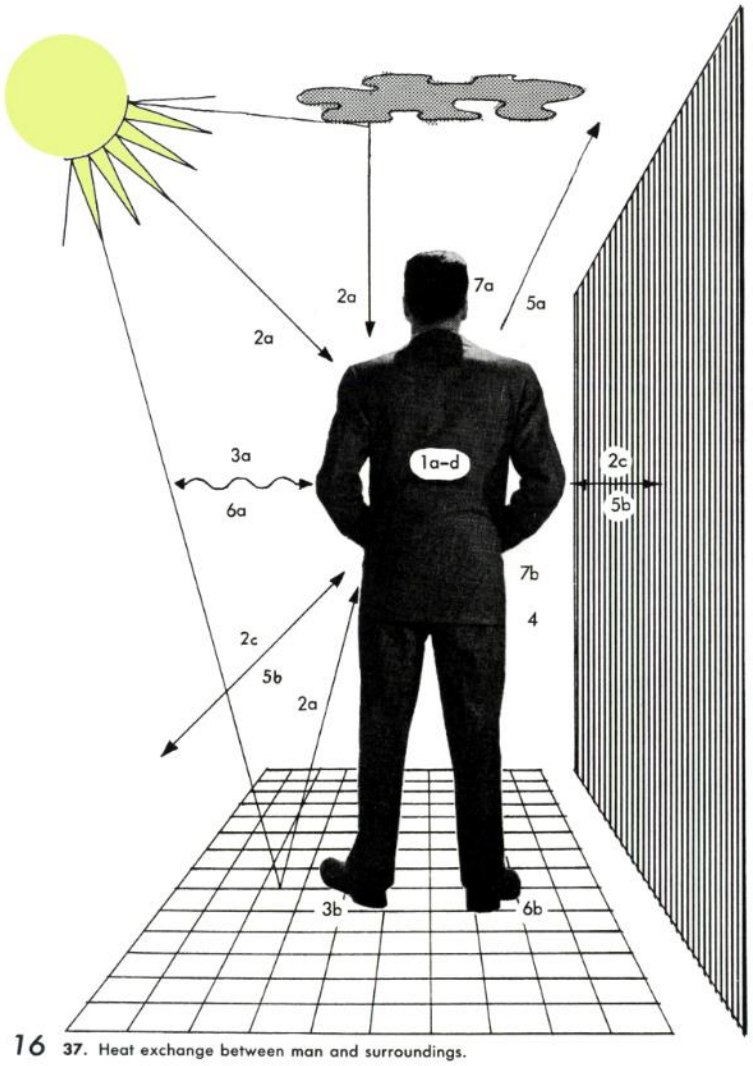
Major elements of climatic environment which affect human comfort are:

- Air temperature
- Radiation
- Air movement (Wind Speed)
- Humidity

"Thermal Comfort – that condition of mind which expresses satisfaction with the thermal environment."

ASHRAE Standard 55-66

Bodily Heat Transfer



16 37. Heat exchange between man and surroundings.

Heat Gains:

- Metabolism (conversion of food to activity and heat)
- Absorption of Radiant Energy
- Heat Conduction Toward Body

Heat Loss Through:

- Evaporation
- Conduction
- Convection (Wind Chill Factor)
- Radiation

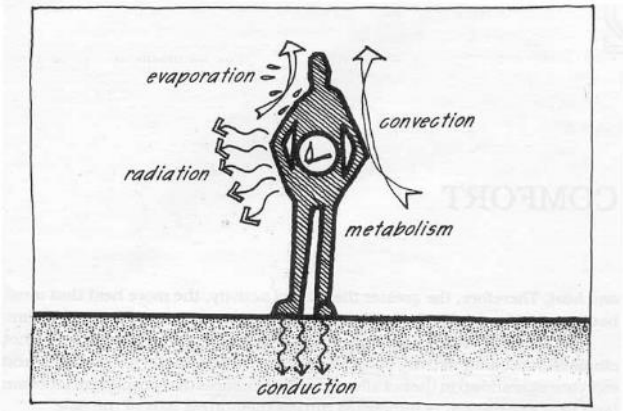
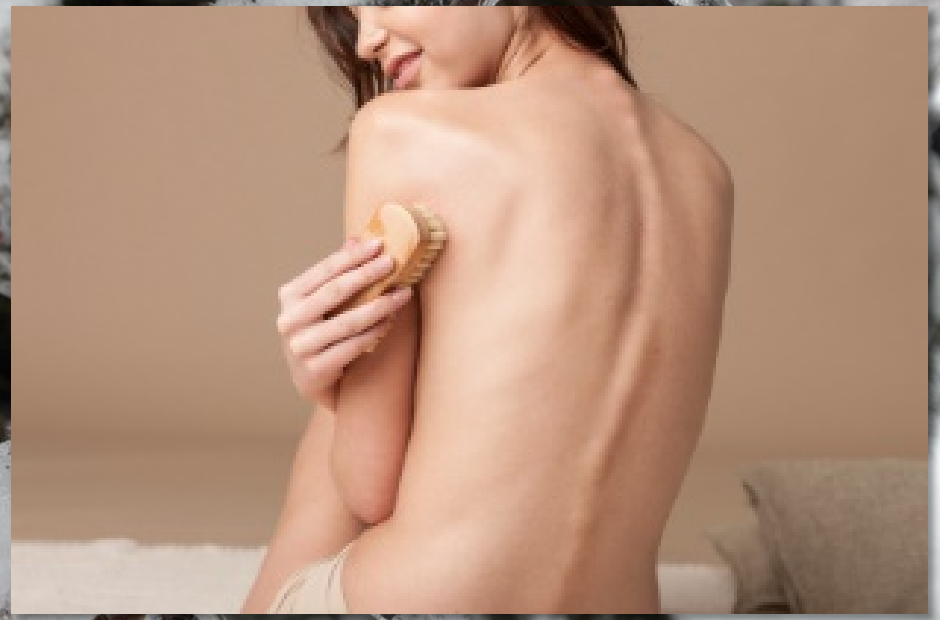


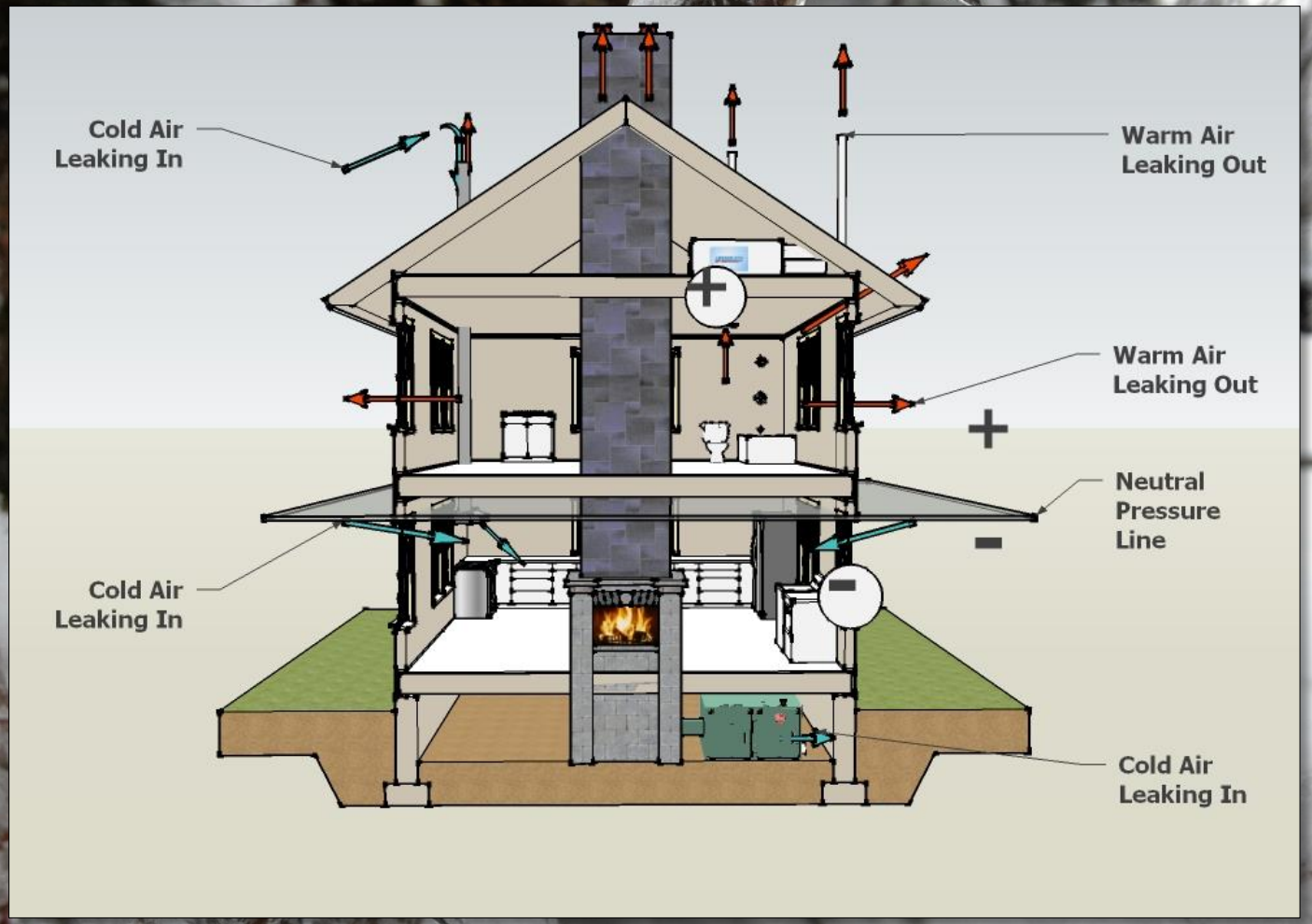
Figure 2.1: Maintaining the thermal balance by equalizing heat gain (due primarily to metabolic heat generation) and heat losses (by convection, radiation, conduction, and evaporation).

The First Skin

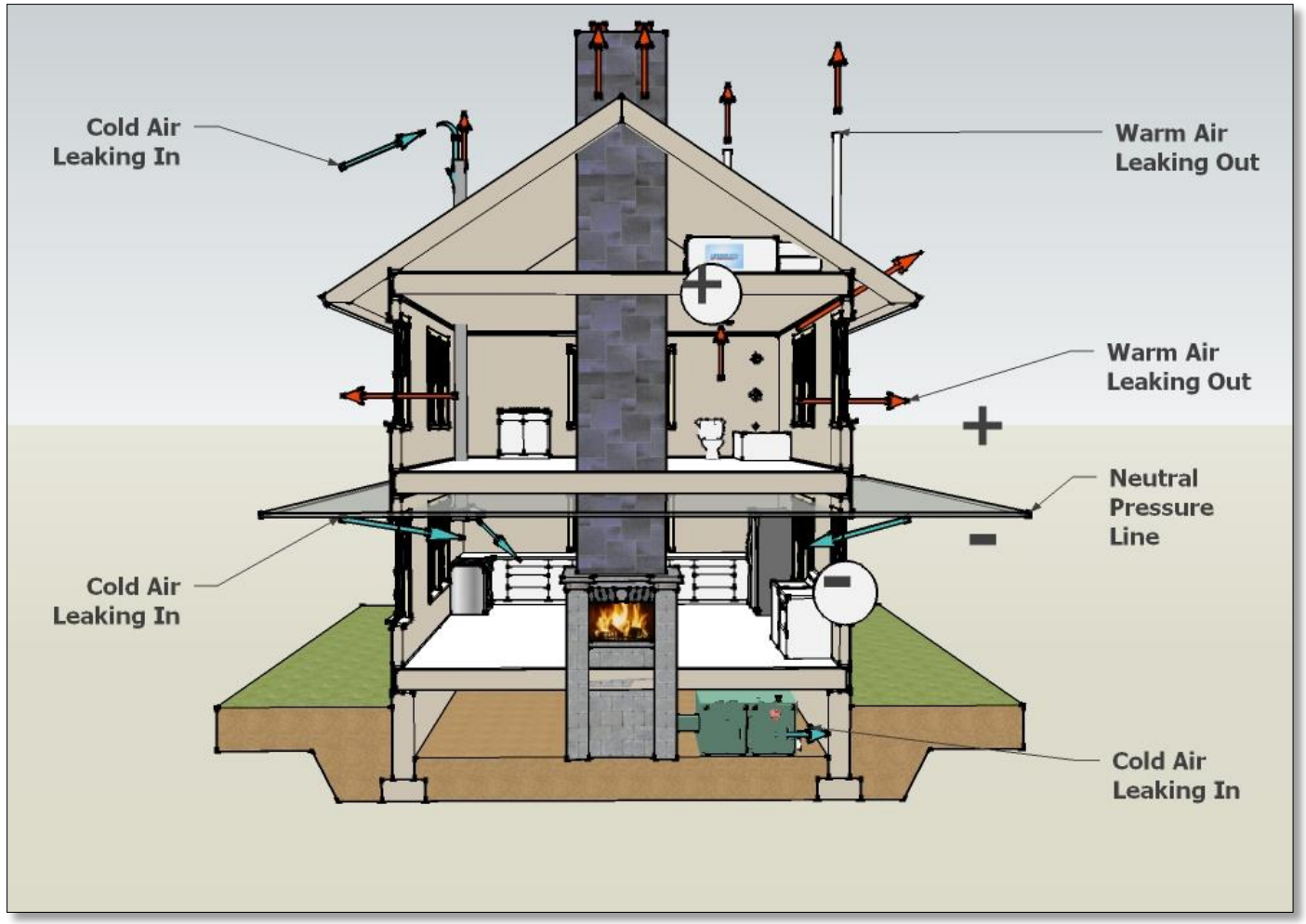


The Second Skin

The Third Skin



The Third Skin



The building envelope, aka third skin, must mediate between the environment and our second skin to make us comfortable.

The Third Skin is composed of:

#1 – opaque elements

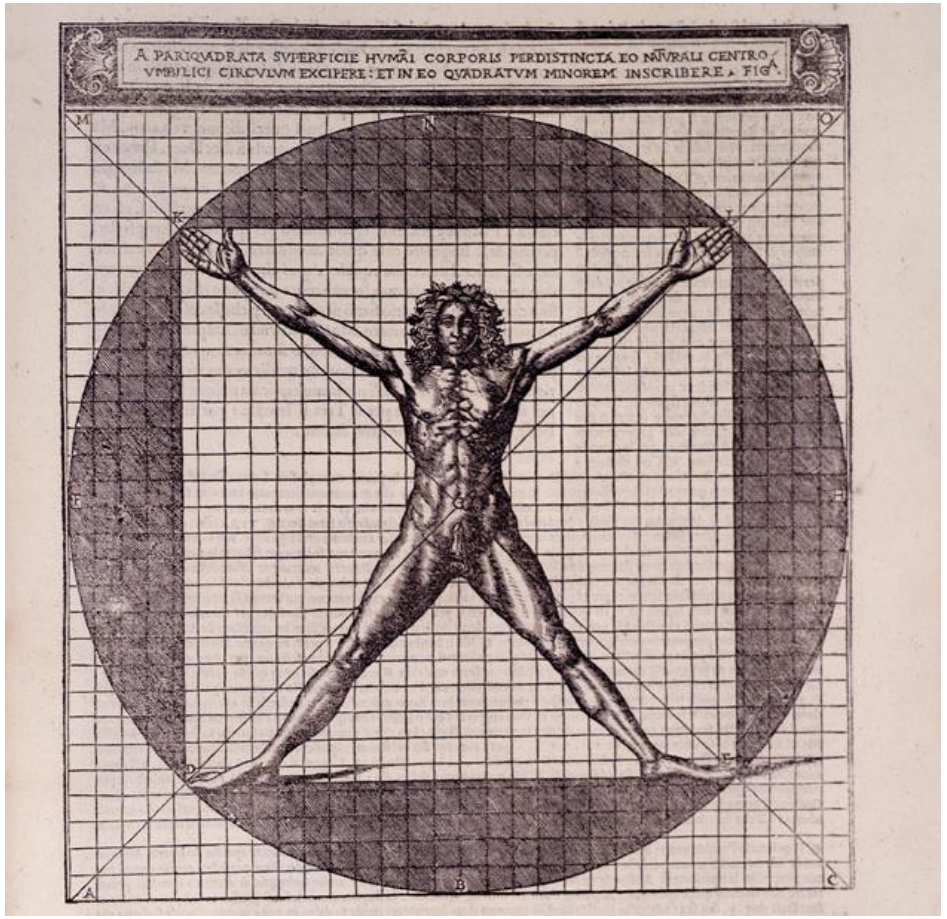
#2 – transparent elements

#3 – the details that join them

The Third Skin is supposed to:

#1 – Manage climate
(heat, cold, sun, light, breezes)
#2 – Be durable
#3 – Be sustainable
#4 – Be cost effective

#5 – Look good!



Vitruvius believed that an architect should focus on three central themes when preparing a design for a building: firmitas (strength), utilitas (functionality), and venustas (beauty).

Heat Transfer Mechanisms

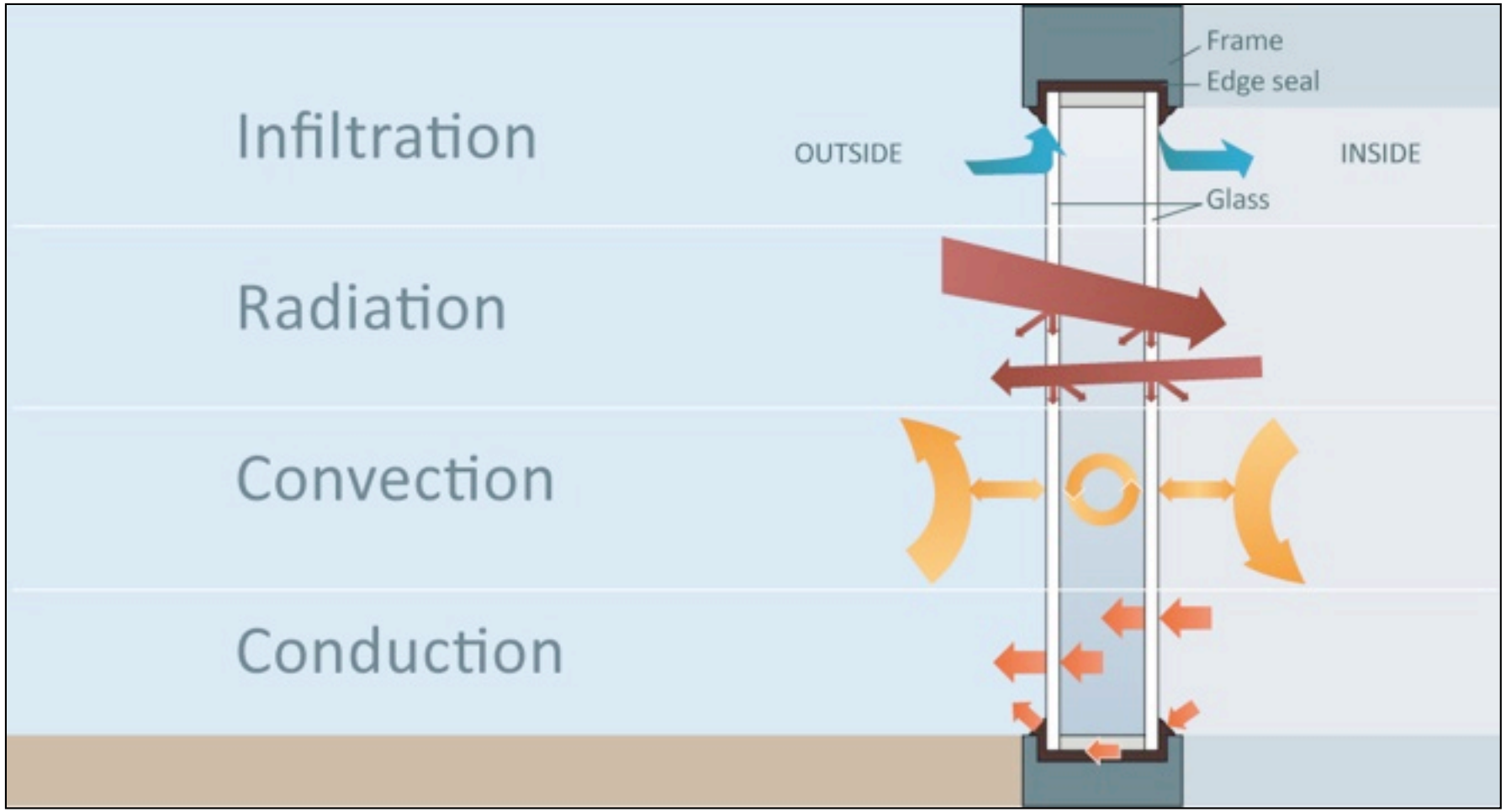
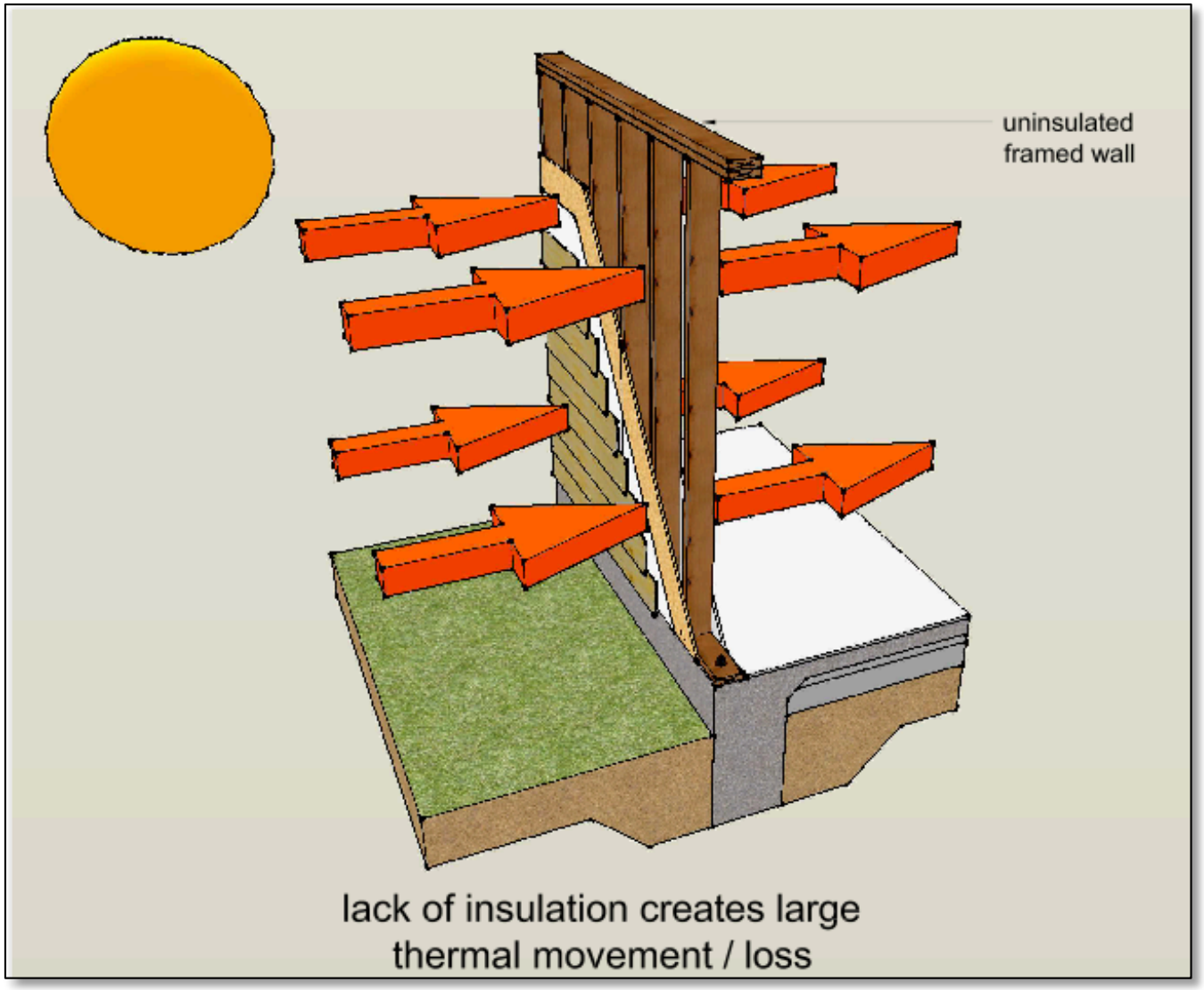


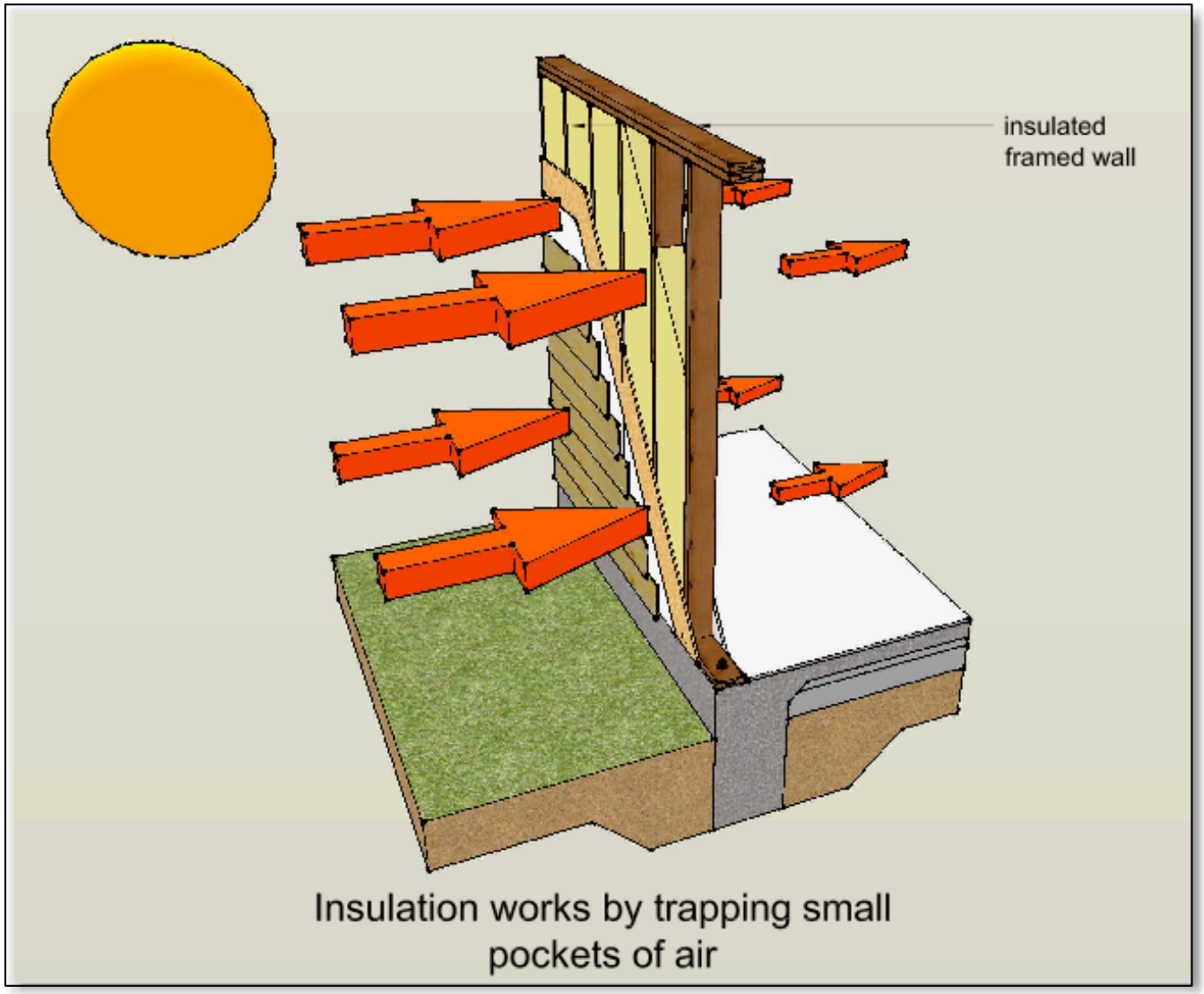
Image courtesy of Collette/Baker-Laporte

Insulation & Thermal Conductivity

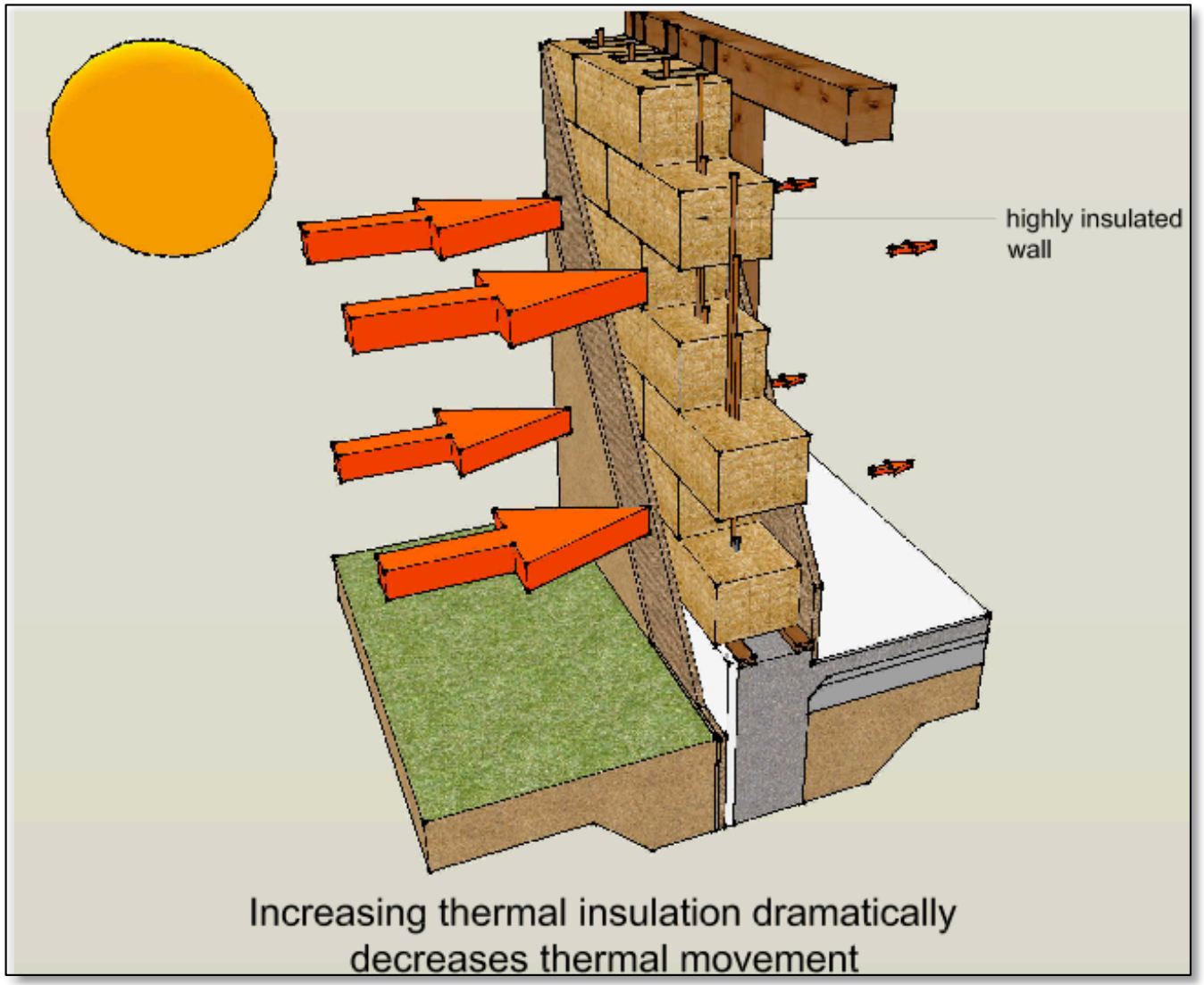


Cold climate design focuses greatly on insulating the building envelope and sealing up to prevent losses due to air leakage.

Insulation & Thermal Conductivity



Insulation & Thermal Conductivity



fiberglass

polystyrene

Sheep’s wool

Insulation is the only real way to keep the heat in. Some types are more environmentally friendly than others.

The Comfort Zone

The Comfort Zone refers to the range of temperature conditions of air movement, humidity and exposure to direct sunlight, under which a moderately clothed human feels “comfortable”.

This will be different for **Indoor** versus **Outdoor** conditions.

This will be different for different cultures and climate conditions - what are people used to??

We need our buildings to not only create comfortable indoor environments, but also pleasing and useful spaces outside of our buildings.

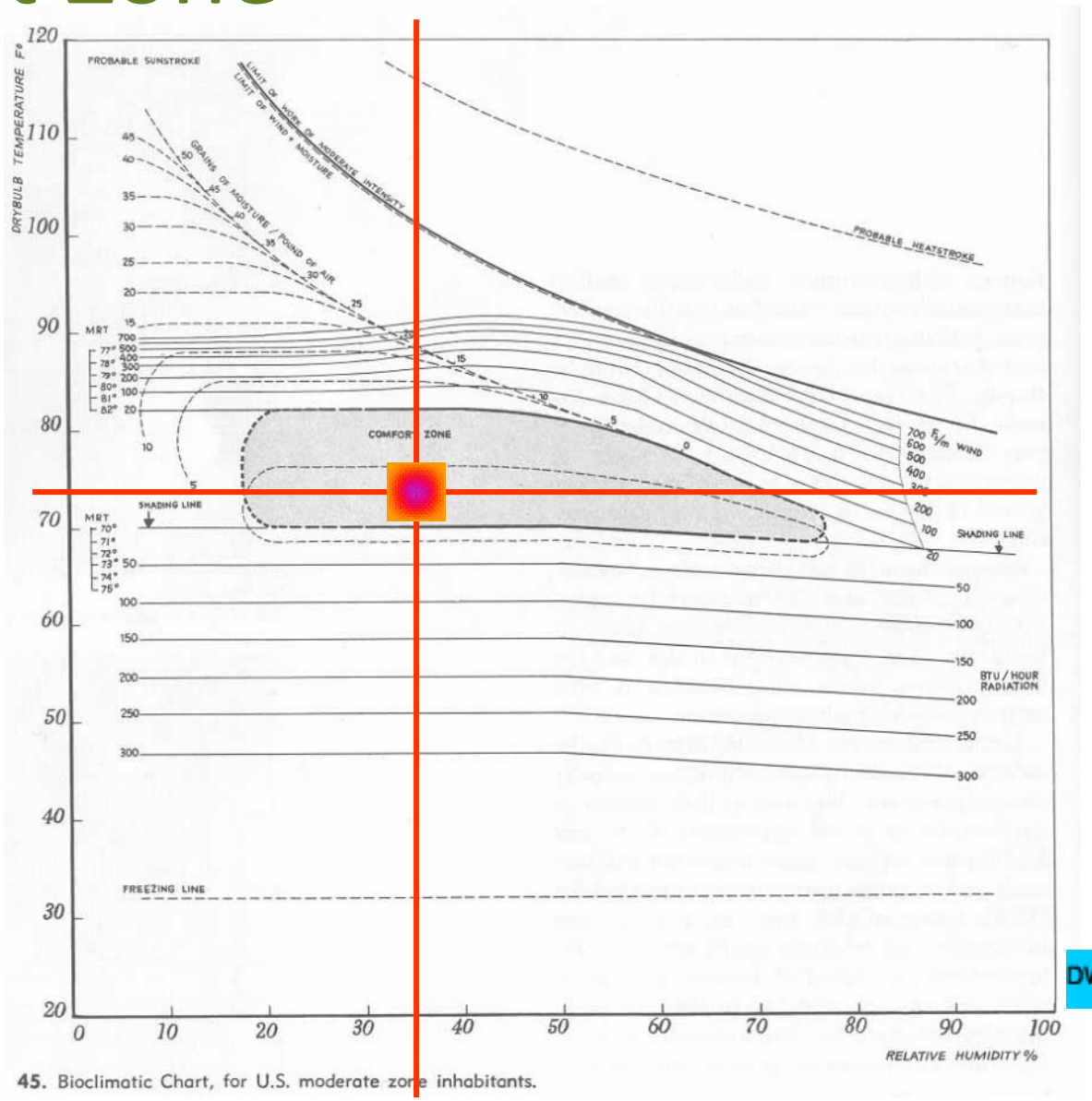
In a hot climate, where do people choose to sit?

Conversely when it is cold, people sit in the sun.

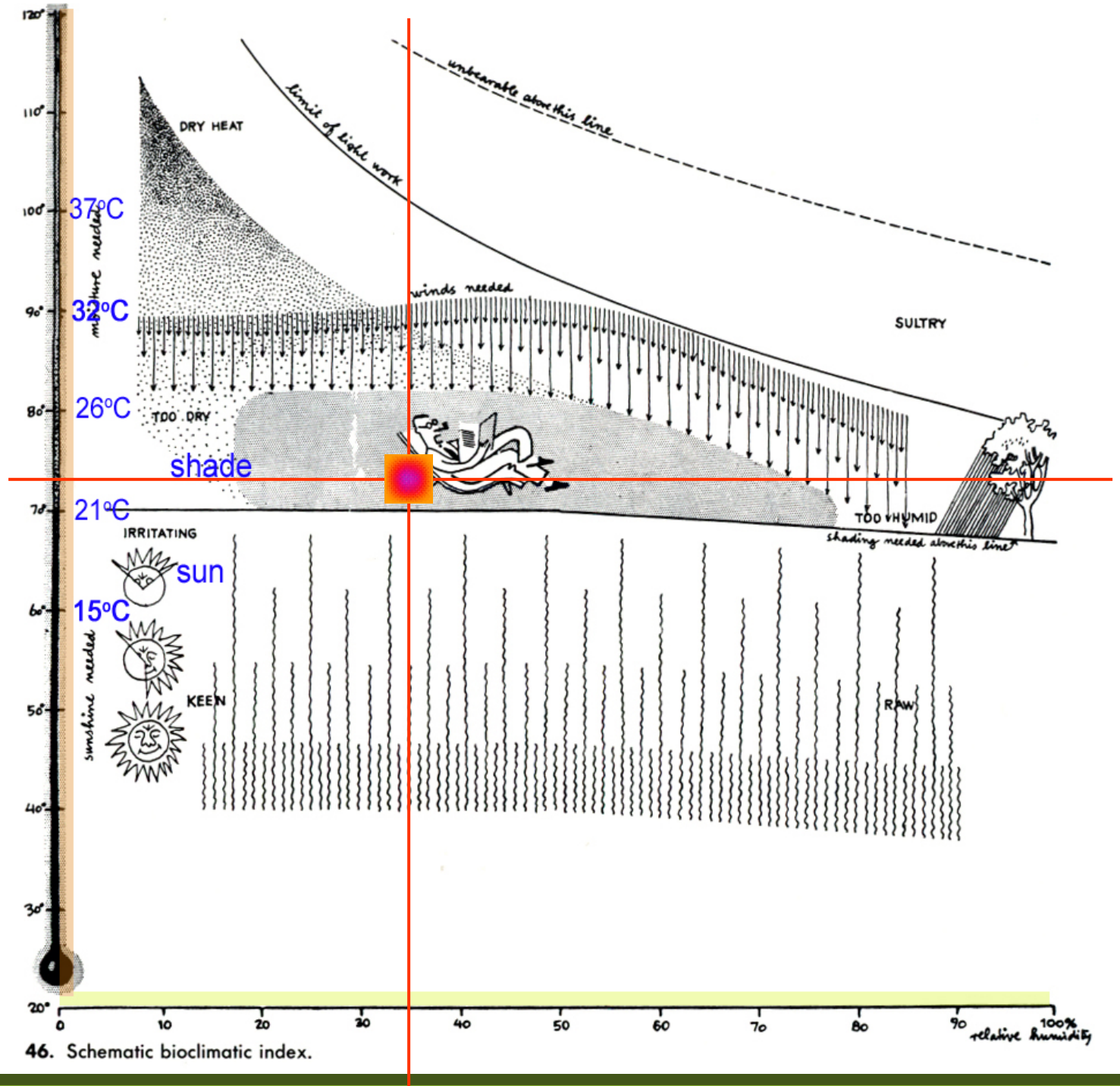
The Comfort Zone

The comfort zone is the kidney shaped area that defines the range of conditions within which North Americans express no *great* objection.

However, the intersecting red lines show the temp and RH that we strive have been accustomed to striving for in our *interior* environments, winter, summer, Arctic, Florida!

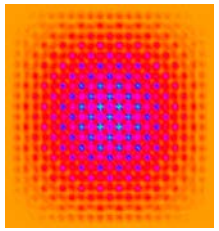


45. Bioclimatic Chart, for U.S. moderate zone inhabitants.

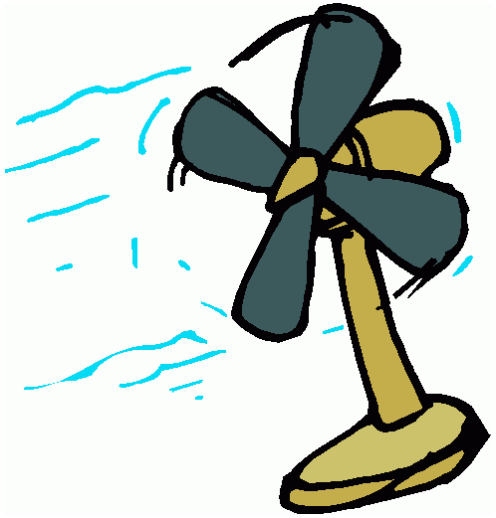


This adaptation is from "Design with Climate" by Victor Olgyay, first published in 1963.

One of the biggest adjustments that must be made in trying to design buildings with less dependency on mechanical heating and cooling, is the *adaptation of human expectations* to have their environments held at a constant Temperature and Relative Humidity.



23C 35%RH



All indoor temp and RH that falls outside of 23C 35%RH normally has called for mechanical and electrical intervention!!

i.e. $$$ and fuel and CO2 emissions