Building Science for Architects

Introduction

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Why Do Architects Need to Understand Building Science?

Q: What is Building Science?

A: The study of heat flow, air flow and moisture flow through the building enclosure

The requirements for our buildings have changed

- We live in a society where every citizen deserves healthy, affordable, comfortable and durable homes and where the population is steadily increasing
- We demand more comfort and control of our interior environments than we used to so will not tolerate conditions that we used to tolerate
- We have a limited supply of energy (Hubbard's Curve) and so we have to think about energy conservation

What is different about the way we build today?

- We have added thermal insulation
- Tigher Building Assemblies
  - We have gone from board sheathing to sheet goods, reducing air leakage into and out of assemblies
- We have removed active chimneys and replaced them with power vented sealed combustion furnaces.
- We have become an air conditioning society (and that requires ducted air distribution systems)
- We have more new products to deal with, and these new products are getting combined in new ways

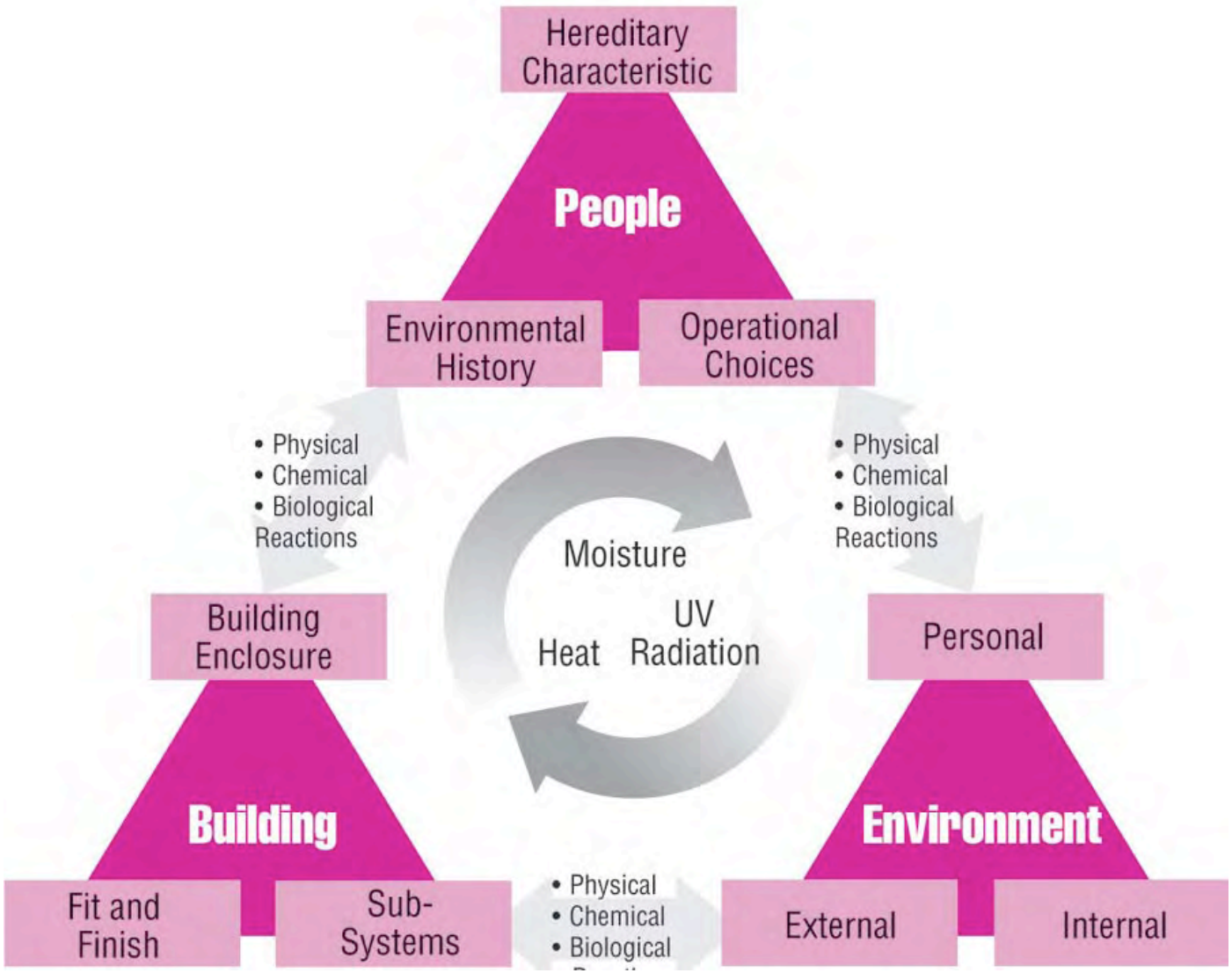
What Happens When Buildings Don't Work?

- We waste energy
- We waste materials
- People are uncomfortable
- Conditions are unsafe
- Conditions are unhealthy
- Components or systems fail

Your Environmental Separator

- At the most basic level a building provides shelter - shelter from the elements as well as from other dangers.
- Its' function is to separate the inside from the outside as required by the local environment and the wishes of its occupants.
- A building creates an interior environment that is different from the exterior environment – it is an environmental separator.
- This interior environment should be controllable by the occupants in a manner that meets their needs.

The Building System - Functional Relationships



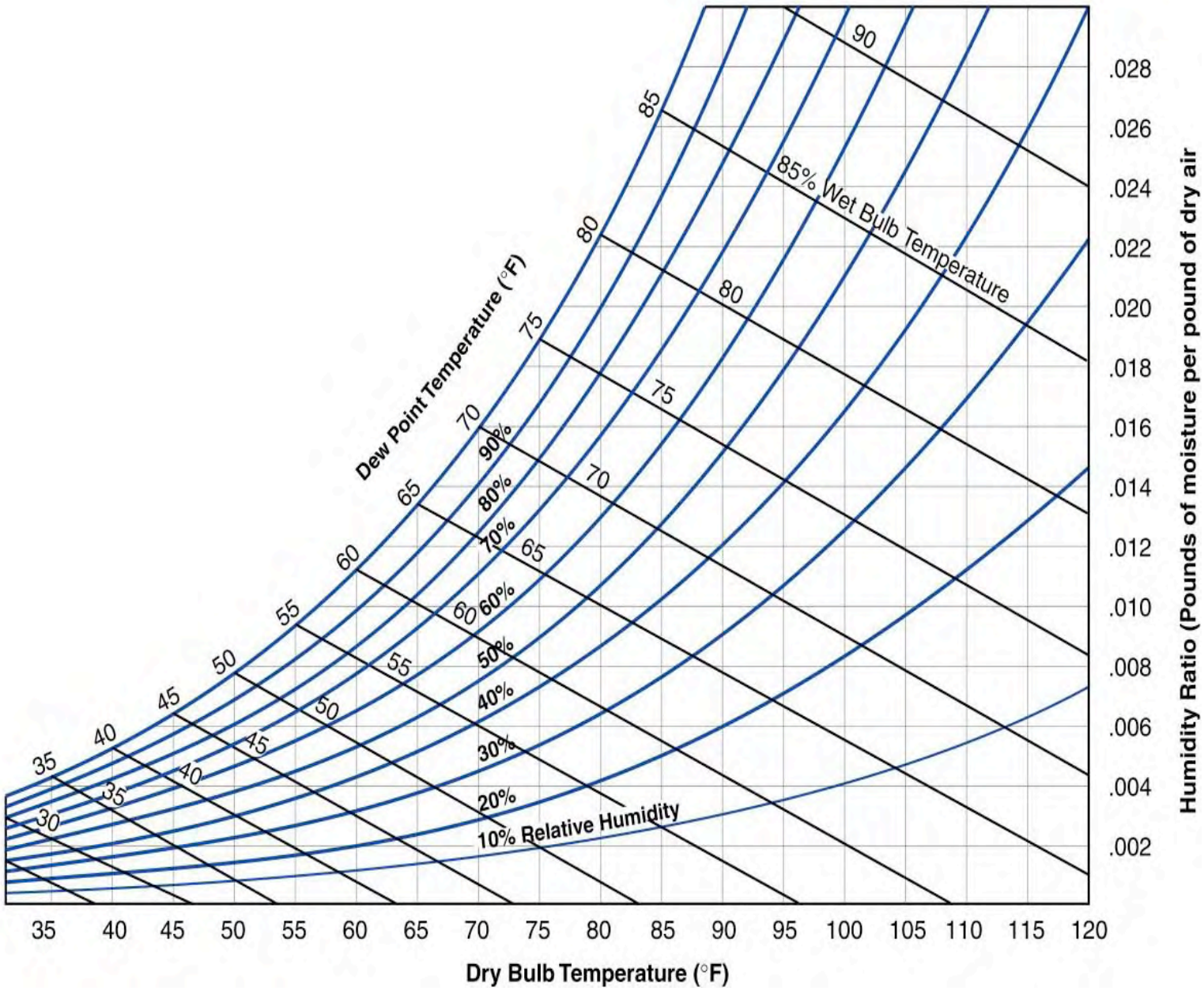
Building Science

- Building Science studies the interaction of all of these functional relationships
- It tells us how buildings actually work
- It tells us how to design them, build them, diagnose them, fix them and operate them.

Building Science

- Energy moves from higher state to lower state
  - (the second law of thermodynamics)
- Heat moves from warm to cold (thermal gradient)
- Moisture moves from more to less (concentration gradient)
- This is the thermodynamic potential
  - The psychrometric chart is a visual representation of the thermodynamic potential of water vapor

- It takes even more energy to counteract this phenomena



Building Science

- Not all forces are equal
- All are important, but some are more important than others
- Control of heat, air, moisture and radiation (HARM) stand above the rest

Building Science

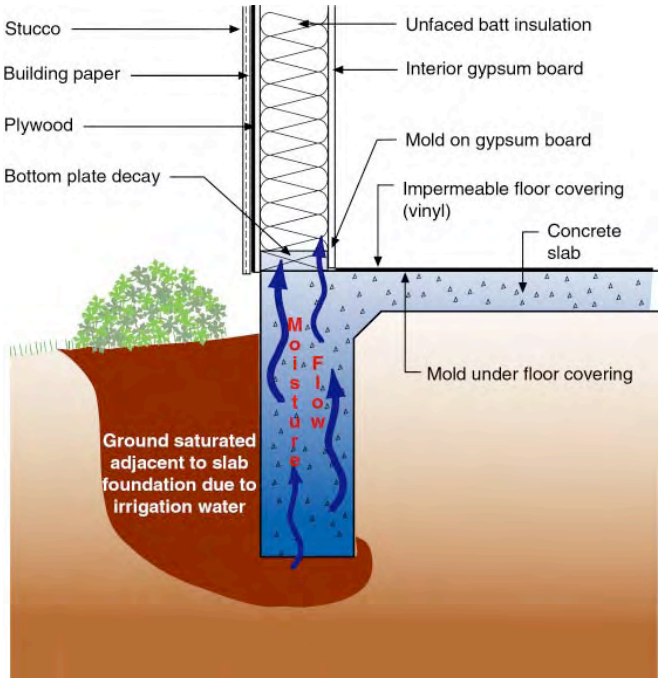
- It is a science, not an art
- There are actual physical laws that tell us how this all works.
- Everyone has opinions, but we now have the tools to answer fundamental questions on building performance
- The laws of physics always win over opinions

What does a modern building need to do?

1. Control rain and ground water
2. Control heat flow, airflow, and water vapor flow
3. Control light and solar radiation
4. Control noise and vibrations
5. Control contaminants, environmental hazards and odors, insects, rodents and vermin
6. Control fire
7. Provide strength and rigidity
8. Be durable
9. Be aesthetically pleasing
10. Be economical

Why Mold, Why Now?

- Things are staying wetter longer. And the wet things can't take it.
- The dwell time for moisture in the system is going up while the system ability to tolerate the moisture, store the moisture or redistribute the moisture is going down
- This is a rate-storage problem
- It's all about energy



Historical Perspective

- All drying requires the exchange of energy.

- Heat flow is from warm to cold.
- Moisture flow is from warm to cold & more to less.

- Old un-insulated buildings that were heated during the winter were simultaneously kiln dried and freeze dried.

- As we reduce energy flows across enclosures the drying potential is reduced.

- Adding thermal insulation reduces drying potentials. Making walls more air tight reduces drying potentials.

Reduction in Drying Potentials

- We have reduced the water vapor permeability of the linings we install on both the interior and exterior of the building enclosure.
- Polyethylene vapor barriers and vinyl wall coverings prevent walls from drying inward during the summer.
- OSB sheathings reduce outward drying and foam sheathings reduce outward drying during the winter.

Increase in Moisture and Mold Sensitivity of Construction Materials

- The moisture and mold tolerance of building assemblies is being reduced as we move down the process stream from timber to engineered materials.

- Board Lumber - Plywood - OSB - Hardboard - Particle Board - Paper

- The use of paper-faced gypsum sheathing in wet areas results in serious consequences.

Reduction in Moisture Storage and Moisture Redistribution of Building Materials

- **The moisture storage capacity of building assemblies has decreased two orders of magnitude over the past century!**

Example 2,000 square foot building

Masonry = 500 gallons of water

Wood Frame = 50 gallons of water

Steel Stud = 5 gallons of water

Three things destroy most buildings:

- Water
- Heat
- Ultra-Violet Radiation

- Of these three, control of water is the most important, followed by heat and finally followed by sunlight. Water and heat cause the vast majority of building durability problems

- A great deal of water can be transported by air. And water is often referred to as “moisture”. Hence the acronym “HARM”

Building Science

- Control of heat, air and water deals with over 80 percent of the problems faced by the construction industry.

- Heat, air, water and radiation (HARM) control are the key to building science

Building Science

H A M (heat, air, moisture)

- Heat, air and moisture control work together
- Heat control is the same everywhere
- Air control is the same everywhere
- Moisture control is different everywhere

The Rules

1. Heat Flow is From Warm to Cold
2. Air Flow is From a Higher Pressure to a Lower Pressure
3. Moisture Flow is From Warm to Cold
4. Moisture Flow is From More to Less
5. Gravity is Always Down … the earth "sucks"

Climate Dependence of Building Design

- Buildings should be suited to their environment.
- It is not desirable to construct the same manner of building in Montreal, Memphis, Mojave and Miami.
- It is cold in Montreal, it's humid in Memphis, it's hot and dry in Mojave and it's hot and wet in Miami. And that's just the outside environment.
- It is also not desirable to construct the same manner of building to enclose a warehouse, house, school, office, health club with a swimming pool, hospital or museum.
- The interior environment also clearly matters.

Firmness Commodity Delight

These are properly designed, when due regard is had to the country and climate in which they are erected. **For the method of building which is suited to Egypt would be very improper in Spain, and that in use in Pontus would be absurd at Rome**: so in other parts of the world a style suitable to one climate, would be very unsuitable to another: for one part of the world is under the sun's course, another is distant from it, and another, between the two, is temperate.

Marcus Vitruvius Pollio

c. 90 – 20 B.C.E.