CLIMATOLOGY
LECTURE-1

Introduction to Climatology

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Syllabus

UNIT I General Introduction

- Introduction to Climatology
- Movement of earth around sun.
- Different elements of climate like: Wind, temperature, humidity, precipitation and pressure.
- Different climatic zones
- Orientation of building with respect to above mentioned elements of climate
- Effect of climate on man and shelter.

UNIT II Relation of Climate and comfort

- Macro-micro climatic effects
- Concept of comfort zone and bio-climatic chart
- Climatic evaluation by season

UNIT III Sun Control and shading devices (without calculations)

- Solar Chart (sun path diagram)
- Orientation for sun
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- Introduction and objectives of Solar Passive Design
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UNIT IV Wind control

- Orientation with respect to wind
- Wind protection devices Use of building materials with respect to climate
- Concrete; Brick; Glass; Plastics; Stone; Insulating material

UNIT V Environment and Ecology

- Basic elements of ecology
- Concepts of natural cycles in Eco-system
- Source of noise and air pollution, their effects and controls
- Use of landscape elements for micro and macro climate control
- Introduction to climate change, principle causes and effects- methods of mitigating climate change.

Contents:

- Climatology
- Climate
- Weather
- Movement of Earth around Sun
- Earth's Orbit
- Axial Tilt and Seasons
- Earth's revolution around the sun
- Latitude
- Longitude
- Altitude

WHAT IS CLIMATOLOGY?

"Study of climatic conditions of any geographic area".

WHAT IS CLIMATE?

"The average weather condition for not less than 30 years of certain geographical location"

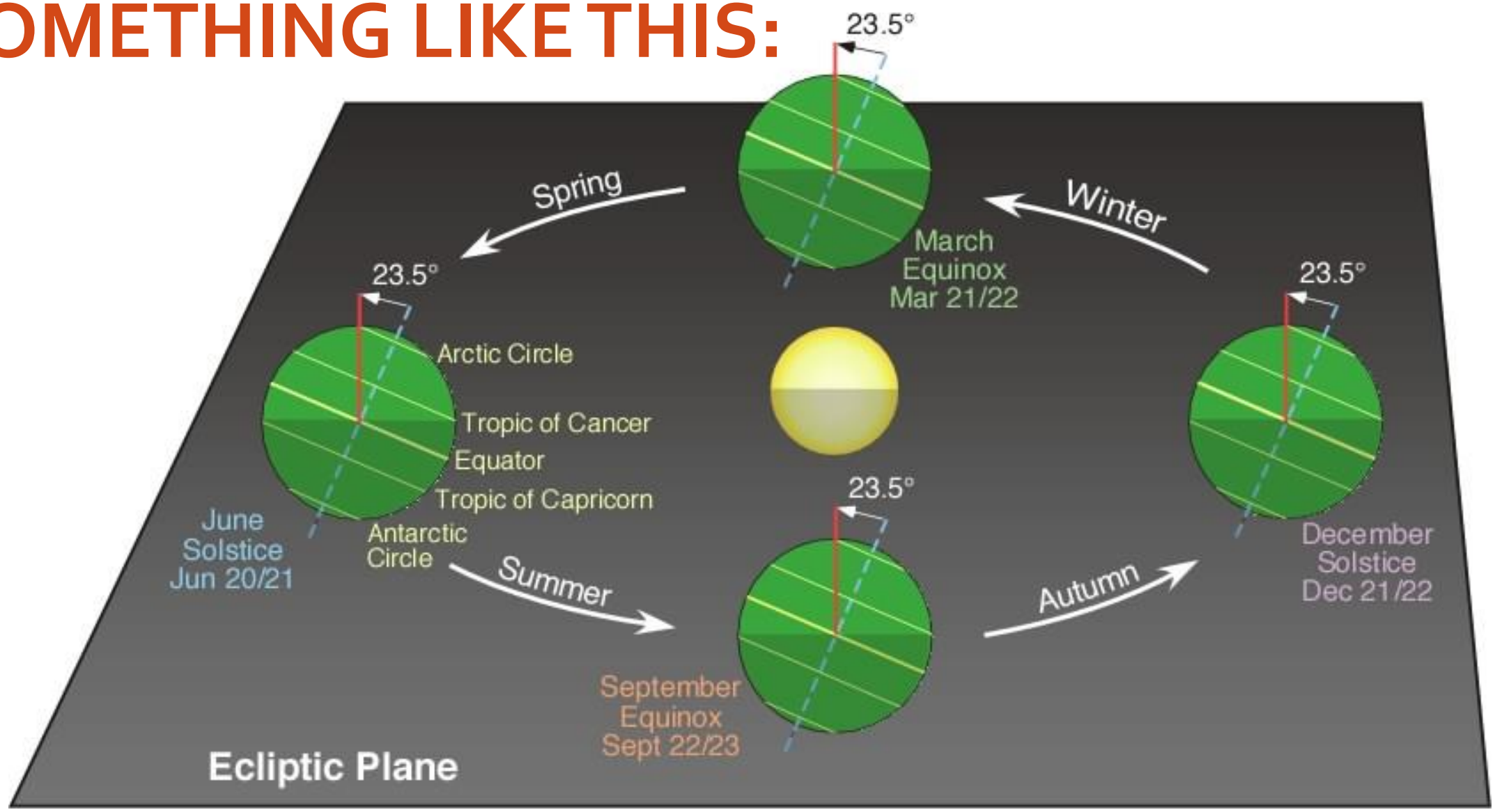
WHAT IS WEATHER?

"The momentary state of the atmospheric environment, such as temperature, humidity, wind, light, rainfall, etc., at a certain location."

MOVEMENT OF EARTH AROUND SUN:

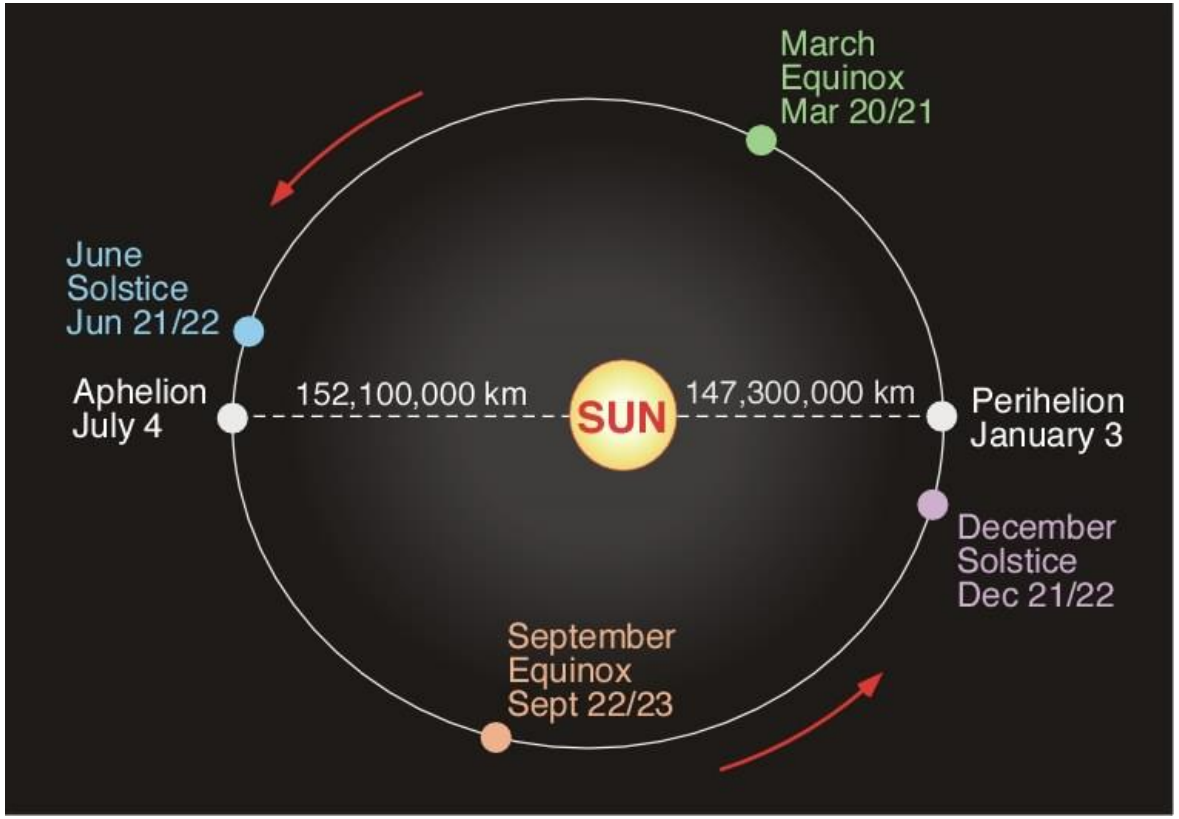
We all know that "Earth follows an elliptical orbit around the Sun, meaning it moves in an elongated, oval-shaped path."

SOMETHING LIKE THIS:



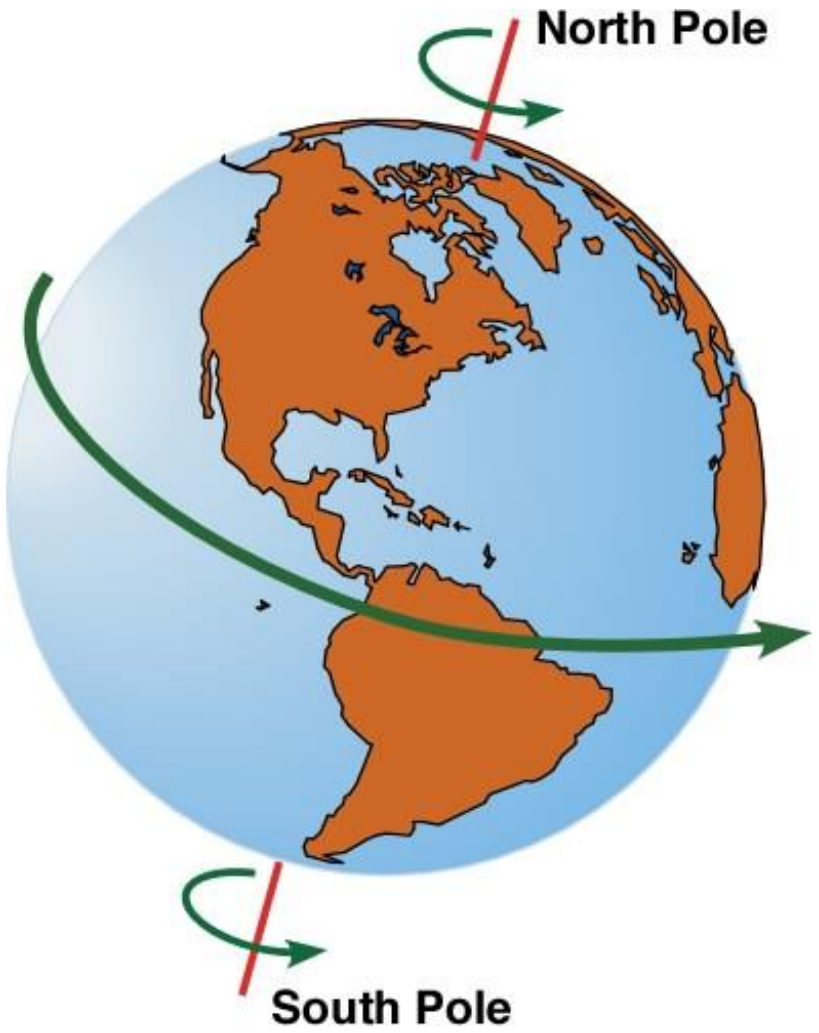
EARTH'S ORBIT:

- **Shape:** Slightly flattened circle (ellipse).
- **Size:** Earth's average distance from the Sun is about 15 crore or 150 million kilometers.
- **Perihelion:** The point in its orbit when Earth is closest to the Sun.
- **Aphelion:** The point when Earth is farthest from the Sun.

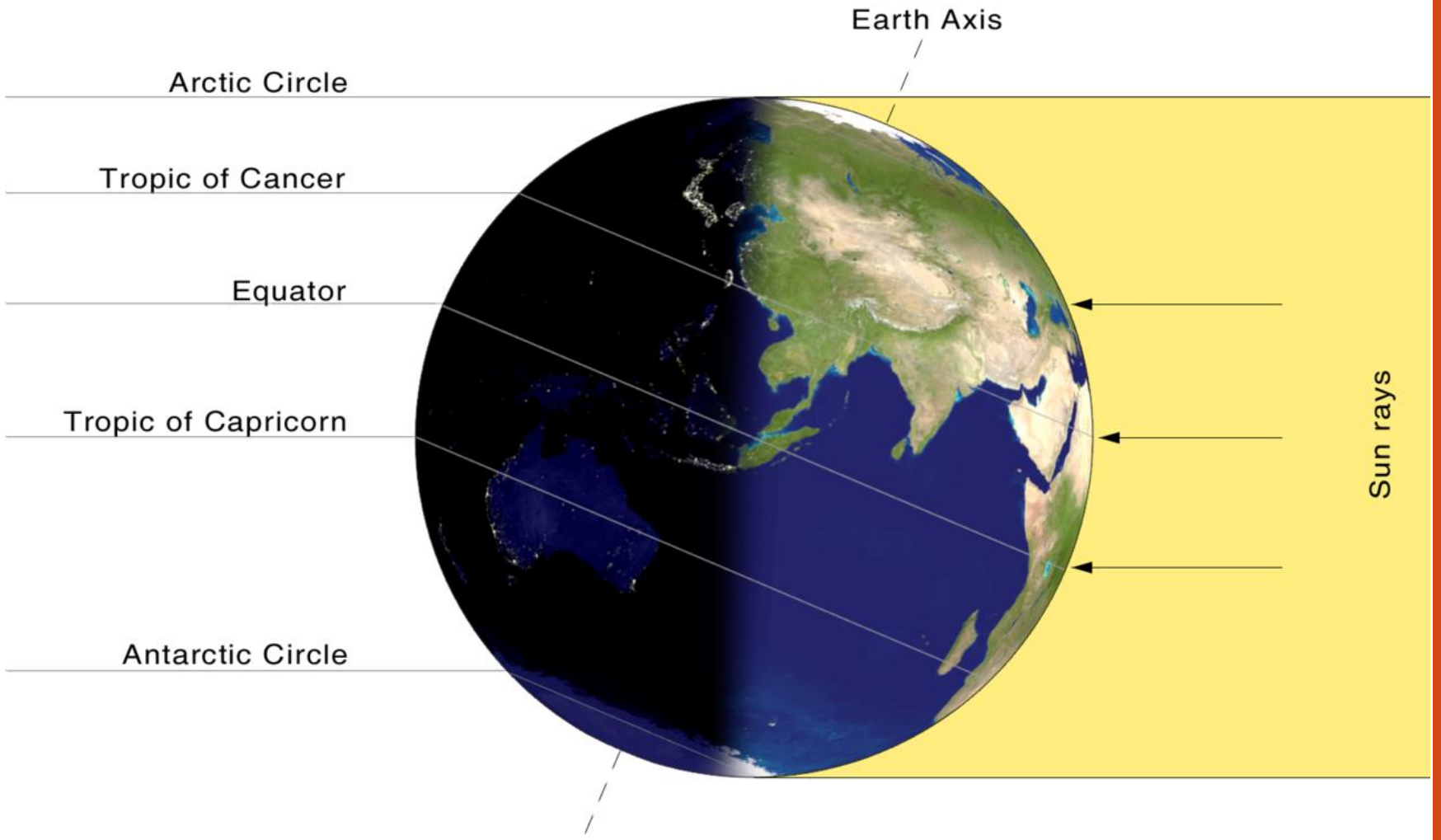


AXIAL TILT AND SEASONS:

- Earth's axis is tilted at approximately 23.5 degrees relative to its orbit around the Sun.
- It is the primary reason we experience changing seasons.
- When the Northern Hemisphere is tilted toward the Sun, it's summer there, and the Southern Hemisphere experiences winter.
- When the Southern Hemisphere is tilted toward the Sun, the opposite occurs.



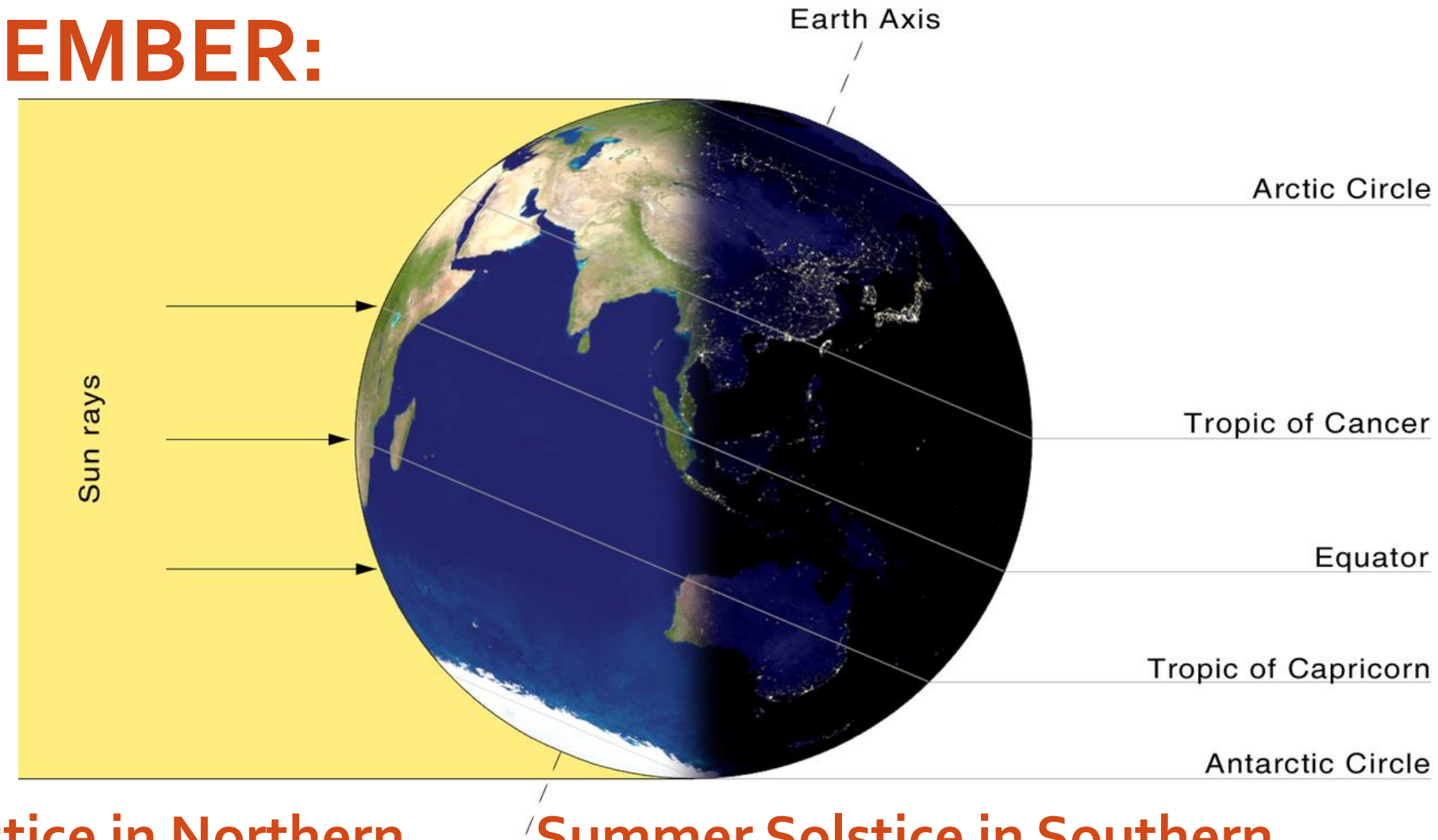
21st JUNE:



Summer Solstice in Northern Hemisphere

Winter Solstice in Southern Hemisphere

21st DECEMBER:



Winter Solstice in Northern Hemisphere

Summer Solstice in Southern Hemisphere

EARTH'S REVOLUTION AROUND THE SUN:

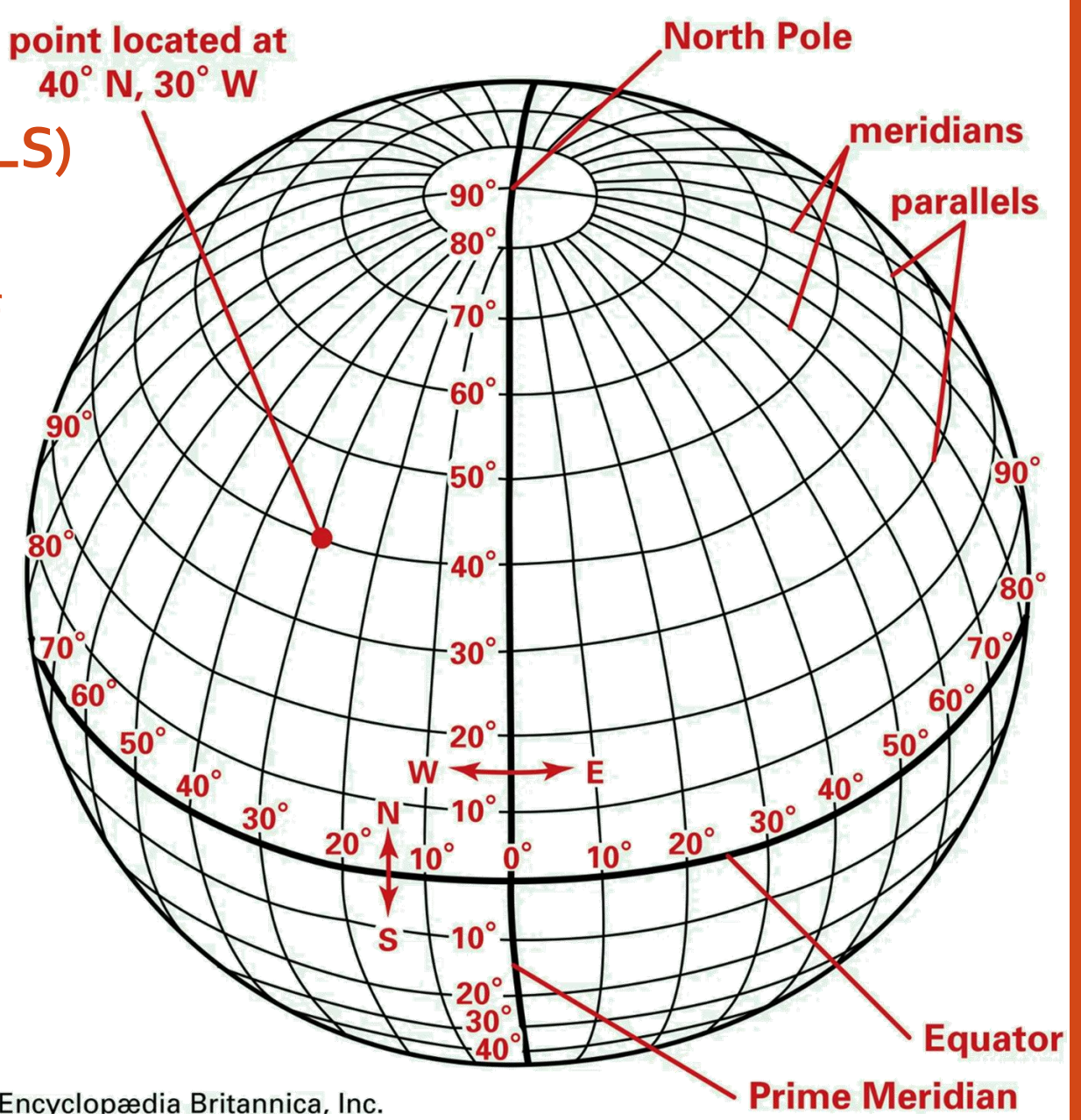
- It takes roughly 365 days and 6 hours for Earth to complete one orbit, defining a year.
- Leap years are introduced to account for the extra fraction of a day. (6 hours X 4 = 24 hours ~ 1 day)

Rotation and day-night cycle:

- Earth also spins on its axis.
- As Earth rotates, different parts of the planet are exposed to the Sun's light, creating day and night.
- This rotation takes about 24 hours, defining a day.

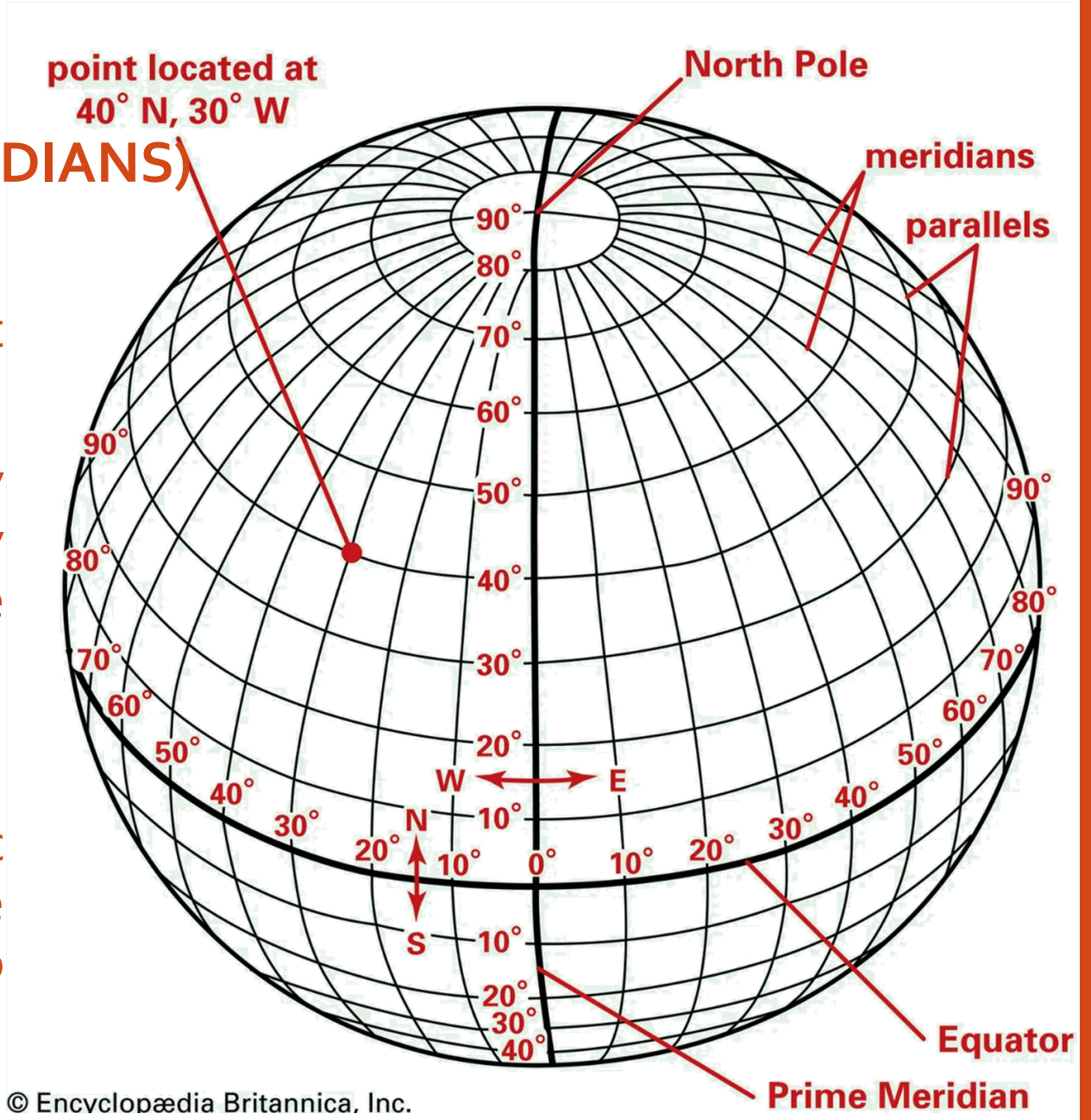
LATITUDE: (aka PARALLELS)

- Latitude is the measurement of distance north or south of the Equator.
- It is measured with 180 imaginary lines that form circles around Earth east-west, parallel to the Equator.
- These lines are known as parallels.
- A circle of latitude is an imaginary ring linking all points sharing a parallel.



LONGITUDE: (aka MERIDIANS)

- Longitude is the measurement east or west of the prime meridian.
- Longitude is measured by imaginary lines that run around Earth vertically (up and down) and meet at the North and South Poles.
- These lines are known as meridians.
- Each meridian measures one arc degree of longitude. The distance around Earth measures 360 degrees.

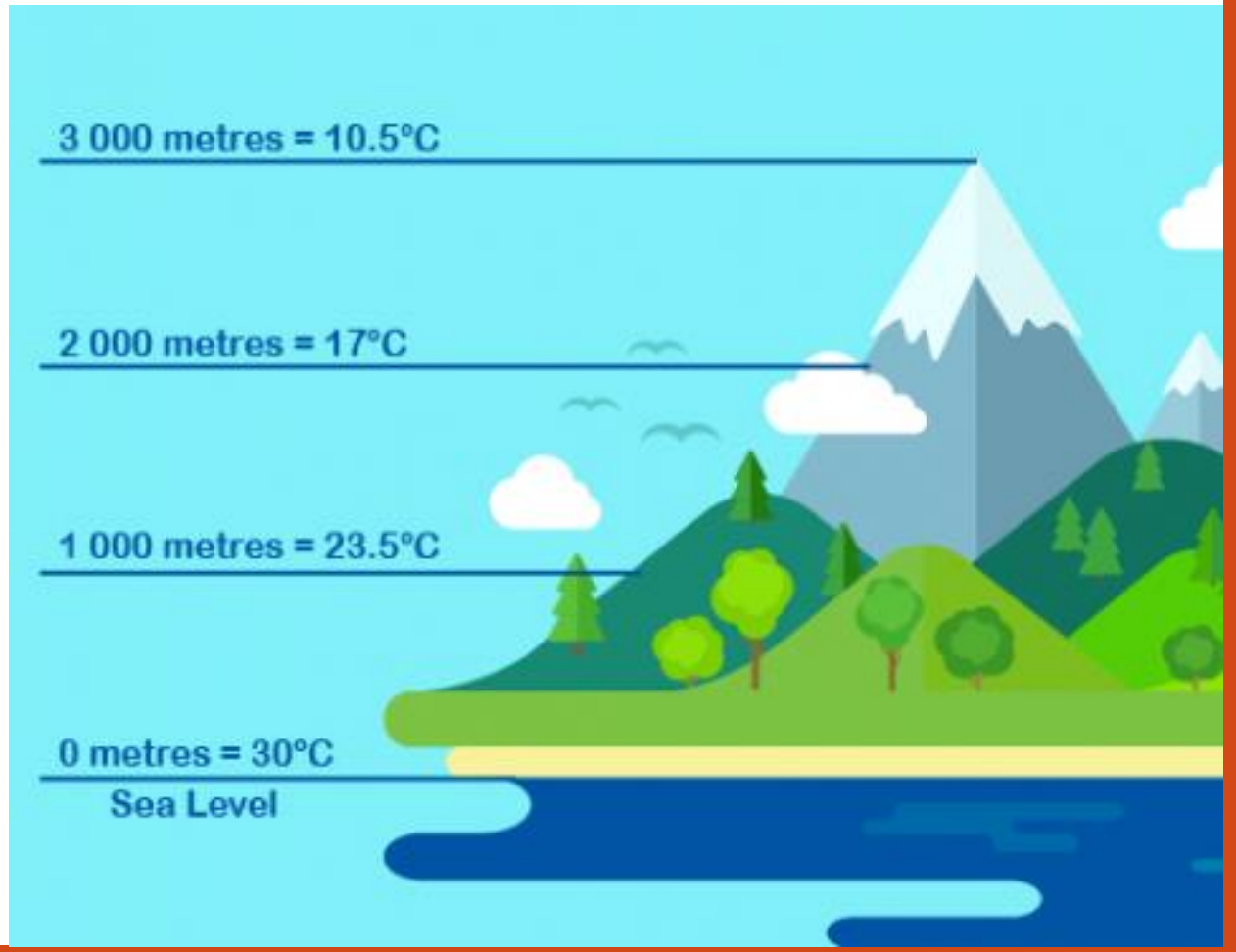


ALTITUDE: (aka ELEVATION)

Altitude is the "height above sea level" of any place.

Impact on climate:

- As altitude increases, temperatures generally decrease.
- This is known as the lapse rate, where the temperature drops about 2°C per 300 meters of altitude gain.
- Higher altitudes often have cooler, more temperate climates, while lowland areas tend to be warmer.



CLIMATOLOGY
LECTURE-2

Elements of Climate

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Syllabus

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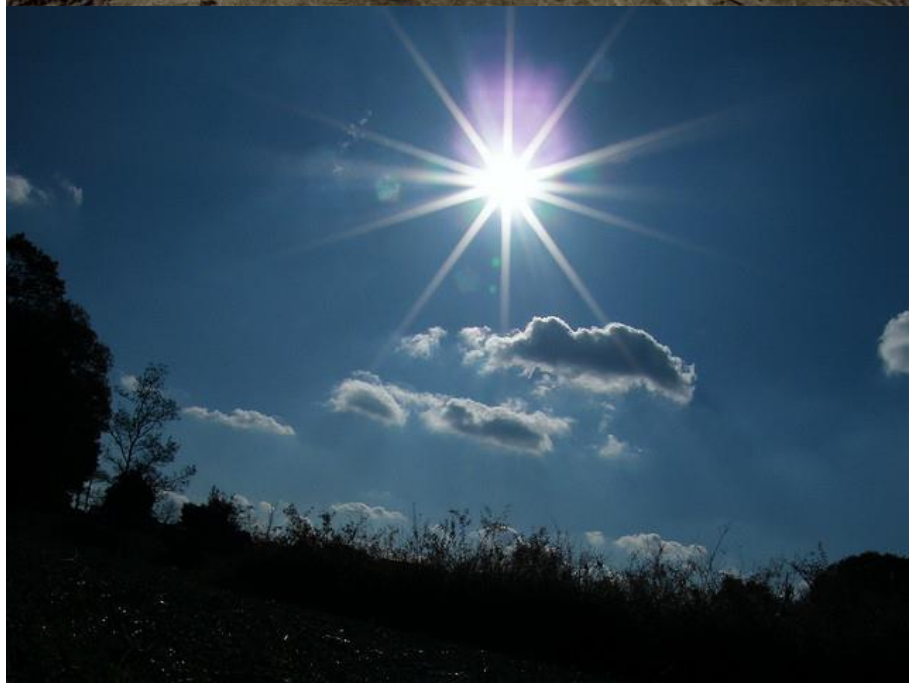
Contents:

Different elements of climate like:

- Wind
- Temperature
- Humidity
- Precipitation
- Pressure.

ELEMENTS OF CLIMATE:

- TEMPRATURE
- PRECIPITATION
- HUMIDITY
- WIND
- PRESSURE



TEMPRATURE:

- A temperature is an objective comparative measure of hot or cold.
- The temperature of the air is measured in degrees Celsius (DC), most often with a mercury thermometer.
- The dry-bulb or 'true air temperature' is a value taken in the shade, the thermometer being mounted inside a louvered wooden box, known as the 'Stevenson screen' at a height of 1·20 to 1·80 m above the ground.

Stevenson screen:

Humidity:

- The amount of water vapor in the air.
- The humidity of air can be described as absolute humidity (AH), i.e. the amount of moisture actually present in unit mass or unit volume of air, in terms of grams per kilograms (g/kg) or gram per cubic meter (g/m^3).
- Relative humidity is the ratio of the actual amount of moisture present, to the amount of moisture the air could hold at the given temperature expressed as a percentage:
- RH = (AH /SH) x100 (%)

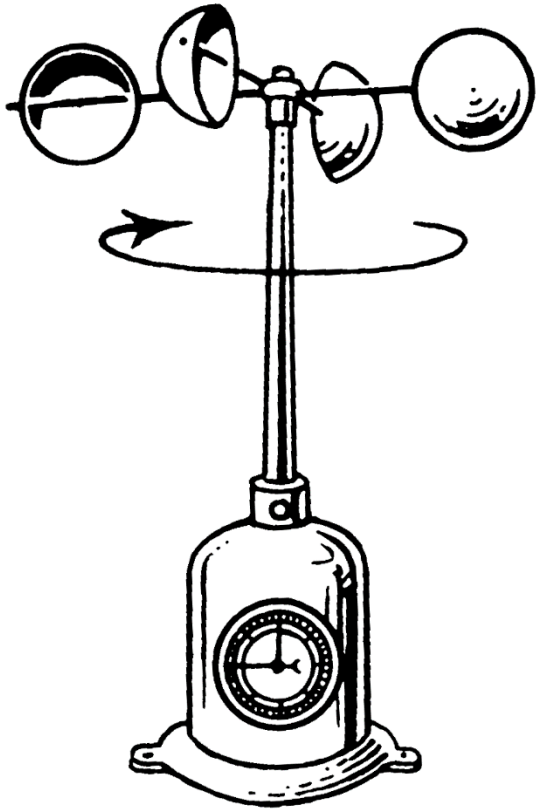
Precipitation:

- Precipitation is the collective term used for rain, snow, hail, dew and frost that is, for all forms of water deposited ('precipitated') from the atmosphere.
- It is measured by rain-gauges.
- It is expressed in millimeter per a time unit (mm/month, mm/day).

Wind:

- Wind velocity is measured by C1 cup-type or propeller anemometer, or by a Pitot tube (similar to the air-speed meters of aero-planes),
- Its direction is measured by a wind vane.
- Free wind velocities are normally recorded in open flat country at a height of 10m.
- Measurements in urban areas are often taken at a height of between 10 and 20 m to avoid obstructions. Velocities near the ground are a good deal lower than the free wind speed.

Anemometer :



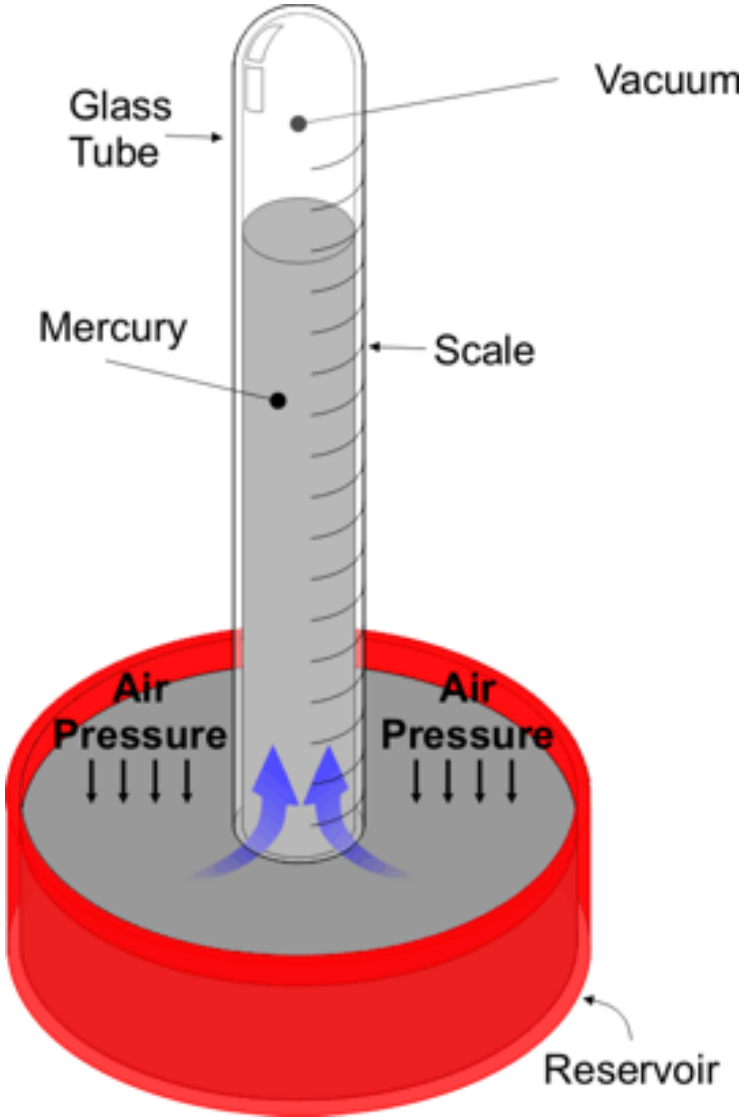
Wind vane:

Pressure:

- Air Pressure is the result of the pressure created by the weight of the air in the Earth's atmosphere. It is also called a barometric pressure, named after the instrument used to measure air pressure.
- Although it may not be visible, air has weight since it is not empty. It is filled with small particles of nitrogen, oxygen, argon, carbon dioxide and a few other gases.
- The weight of the particles in the air creates pressure due to the gravitational force of the Earth. Since more air is present above the air close to the ground, air pressure is the highest on the planet's surface and decreases as altitude increase.

Barometer:

- Barometer- A tool used to measure air pressure in inches of mercury or millibars (mb).



CLIMATOLOGY
LECTURE-3

Climatic Zones

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Climate Classification:

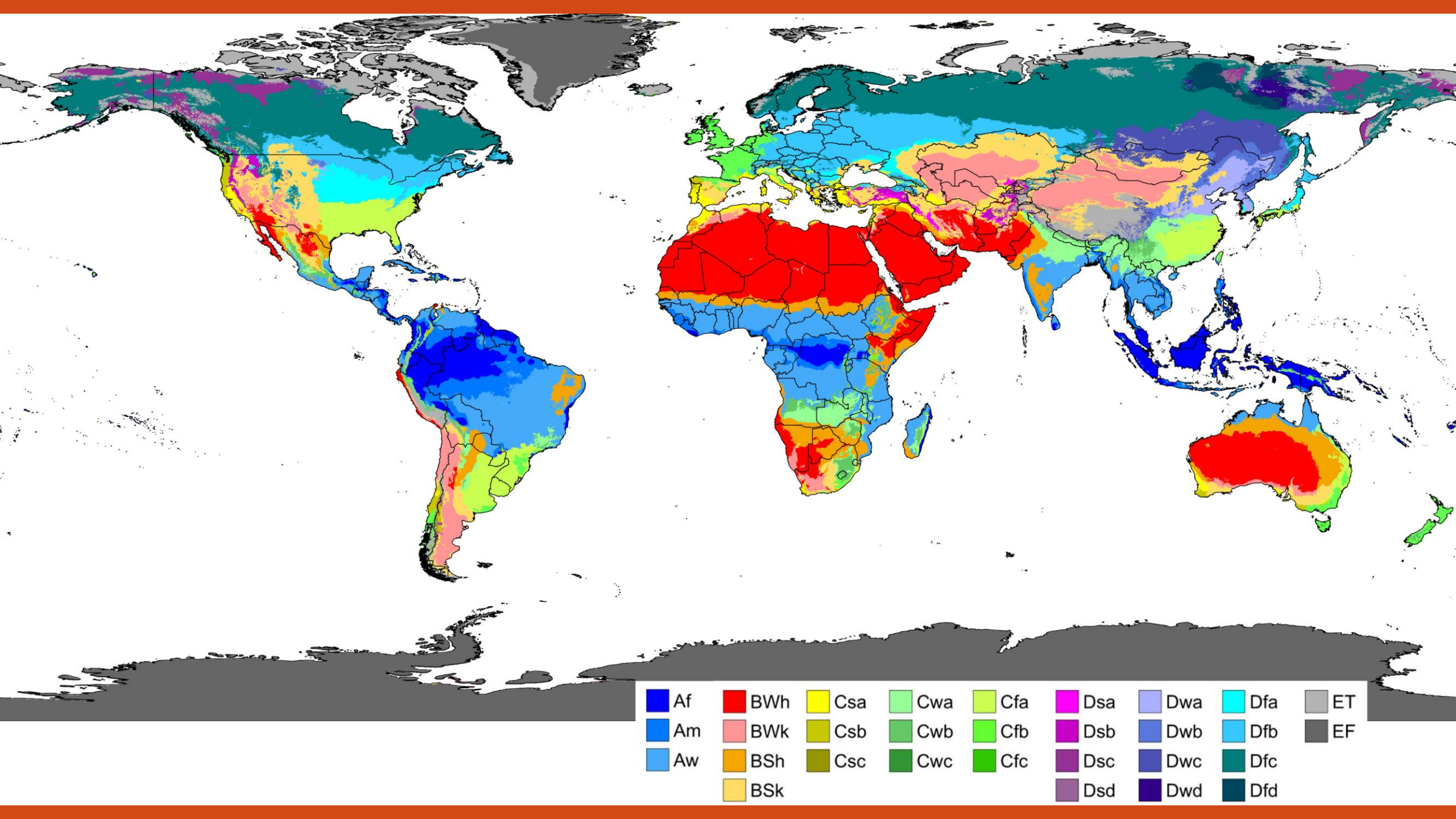
- The **Köppen climate classification** is one of the most widely used climate classification systems.
- It was first published by German-Russian climatologist **Wladimir Köppen** (1846–1940) in 1884, with several later modifications by Köppen, notably in 1918 and 1936.
- Later, German climatologist **Rudolf Geiger** (1894–1981) introduced some changes to the classification system, which is thus sometimes called the "***Köppen–Geiger climate classification".***

Climate Classification:

- The ***Köppen climate classification*** divides climates into **five** main climate groups, with each group being divided based on seasonal precipitation and temperature patterns.
- The five main groups are-
  1. A (tropical)
  2. B (arid)
  3. C (temperate)
  4. D (continental)
  5. E (polar)
- Köppen designed the system based on his experience as a botanist, his main climate groups are based on what types of vegetation grow in a given climate classification region.

Climate Classification:

1st	2nd	3rd
A (Tropical)	f (Rainforest) m (Monsoon) w (Savanna, dry winter) s (Savanna, dry summer)	
B (Dry)	W (Arid Desert) S (Semi-Arid or steppe)	h (Hot) k (Cold)
C (Temperate)	w (Dry winter) f (No dry season) s (Dry summer)	a (Hot summer) b (Warm summer) c (Cold summer)
D (Continental)	w (Dry winter) f (No dry season) s (Dry summer)	a (Hot summer) b (Warm summer) c (Cold summer) d (Very cold winter)
E (Polar)		T (Tundra) F (Ice cap)


Af
Am
Aw
BWh
BWk
BSh
BSk
Csa
Csb
Csc
Cwa
Cwb
Cwc
Cfa
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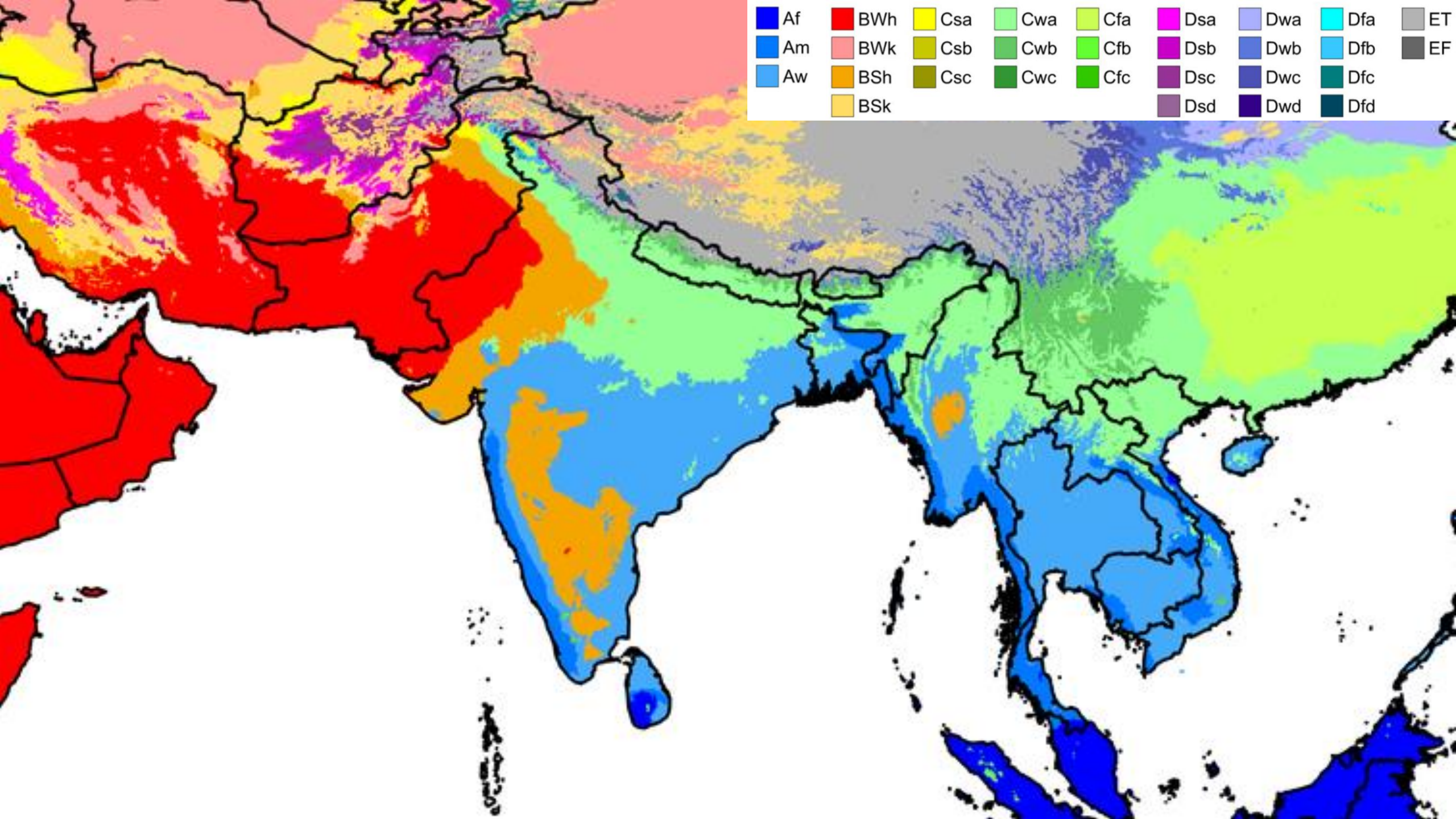
Af
Am
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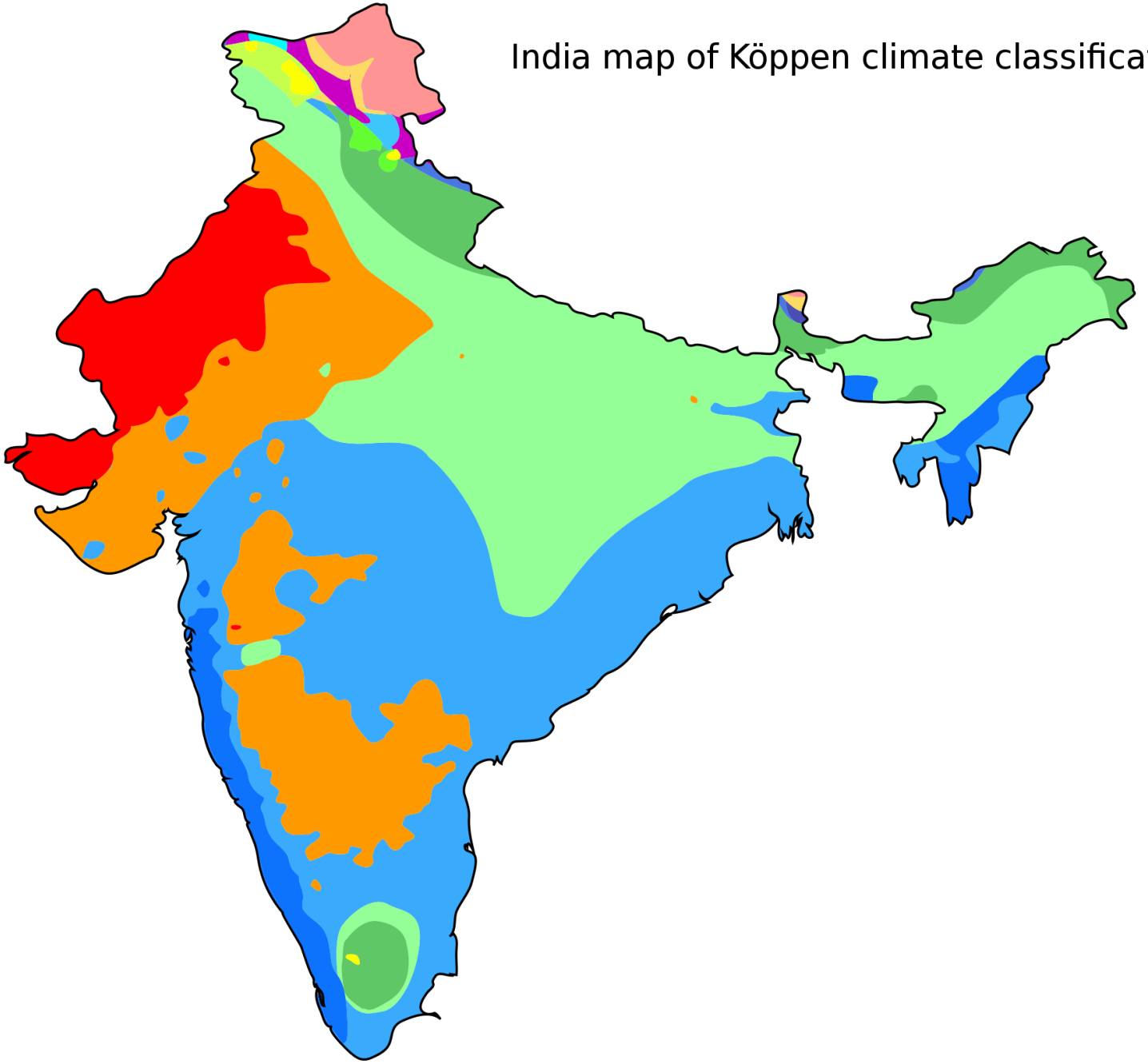
India map of Köppen climate classification



- Monsoon climate (Am)
- Tropical savanna climate (Aw)
- Warm desert climate (BWh)
- Warm semi-arid climate (BSh)
- Cold desert climate (BWk)
- Cold semi-arid climate (BSk)
- Warm mediterranean climate (Csa)
- Humid subtropical climate (Cwa)
- Humid subtropical climate/ Subtropical oceanic highland climate (Cwb)
- Oceanic subpolar climate (Cwc)
- Warm oceanic climate/ Humid subtropical climate (Cfa)
- Temperate oceanic climate (Cfb)
- Temperate continental climate/ Mediterranean continental climate (Dsb)
- Cool continental climate/ Subarctic climate (Dwc)
- Cold continental climate/ Subarctic climate (Dwd)
- Warm continental climate/ Humid continental climate (Dfa)
- Temperate continental climate/ Humid continental climate (Dfb)

Climate of India:

Climate type	Region	Annual rainfall
Amw (Monsoon type with short dry winter season)	Western coastal region, south of Mumbai	over 300 cm
As (Monsoon type with dry season in high sun period)	Coromandel coast = Coastal Tamil Nadu and adjoining areas of Andhra Pradesh	75 – 100 cm [wet winters, dry summers]
Aw (Tropical Savanah type)	Most parts of the peninsular plateau barring Coromandel and Malabar coastal strips	75 cm
BShw (Semi-arid Steppe type)	Some rain shadow areas of Western Ghats, large part of Rajasthan and contiguous areas of Haryana and Gujarat	12 to 25 cm

Climate of India:

Climate type	Region	Annual rainfall
BWh (Hot desert type)	Most of western Rajasthan	less than 12 cm
Cwg (Monsoon type with dry winters)	Most parts of the Ganga Plain, eastern Rajasthan, Assam and in Malwa Plateau	100 – 200 cm
Dfc (Cold, Humid winters type with shorter summer)	Sikkim, Arunachal Pradesh and parts of Assam	~200 cm
Et (Tundra Type)	Mountain areas of Uttarakhand The average temperature varies from 0 to 10°C	Rainfall varies from year to year.
E (Polar Type)	Higher areas of Jammu & Kashmir and Himachal Pradesh in which the temperature of the warmest month varies from 0° to 10°C	Precipitation occurs in the form of snow

Climate Zones in India:

- India possesses a large variety of climates ranging from extremely hot desert regions to high altitude locations with severely cold conditions similar to northern Europe.
- Within India it is possible to define six regions with distinct climates. The six climates are normally designated as
  1. Hot and Dry,
  2. Warm and Humid,
  3. Moderate,
  4. Cold and Sunny,
  5. Cold and Cloudy and
  6. Composite.
- The criteria of allocating any location in India to one of the first five climate zones are that the defined conditions prevail for more than six months.
- In cases where none of these categories can be identified for six months or longer, the climatic zone is called Composite.
- On this basis, ***Bansal and Minke, 1988***, originally produced the ***Climatic Zones in India Map*** by evaluation of the mean monthly data from 233 weather stations, and then delineating the six climatic zones.

Criteria of Bansal et al. [1]			Criteria of SP 7: 2005 [9]		
Climate	**Mean monthly temperature (°C)**	**Relative humidity (%)**	**Climate**	**Mean monthly maximum temperature(°C)**	**Relative humidity (%)**
Hot and dry	>30	<55	Hot and dry	>30	<55
Warm and humid	>30	>55	Warm and humid	>30 >25	>55 >75
Moderate	25-30	<75	Temperate	25-30	<75
Cold and cloudy	<25	>55	Cold	<25	All values
Cold and sunny	<25	<55			
Composite	This applies, when six months or more do not fall within any of the above categories		Composite	This applies, when six months or more do not fall within any of the above categories	

CLIMATOLOGY
LECTURE-4

Man and Comfort

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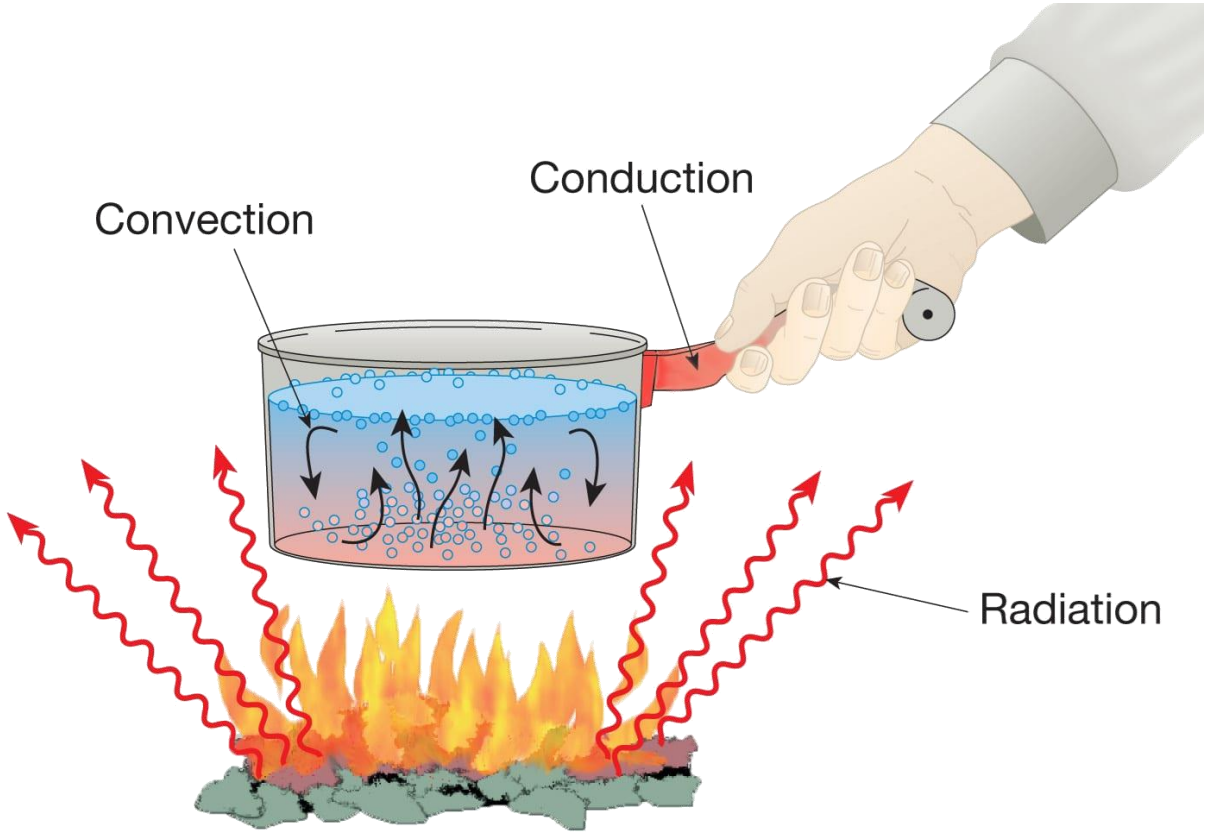
Contents:

Heat Transfer:

- **Conduction:** Transfer of Heat from object to another by method of direct contact.
- **Convection:** Transfer of heat through a fluid (liquid or gas) caused by molecular motion.
- **Radiation:** Energy that is radiated or transmitted in the form of electromagnetic waves.



Human Comfort:

- Comfort is best defined as the absence of discomfort.
- People feel uncomfortable when they are too hot or too cold, or when the air is odorous and stale.
- Positive comfort conditions are those that do not distract by causing unpleasant sensations of temperature, air drafts, humidity, or other aspects of the environment.
- Ideally, in a properly conditioned space, people should not be aware of equipment noise, heat, or air motion.
- The feeling of comfort—or, more accurately, discomfort—is based on a network of sense organs: the eyes, ears, nose, tactile sensors, heat sensors, and brain.

What is Thermal Comfort?

- According to ASHRAE "thermal comfort is that condition of mind, which expresses satisfaction with the thermal environment i.e. the condition when someone is not feeling either too hot or too cold."
- Human body is a machine which consumes food i.e. calories intake to function or perform any work.
- The human body will release excess heat into the environment, so the body can continue to operate.
- The heat transfer is proportional to temperature difference.

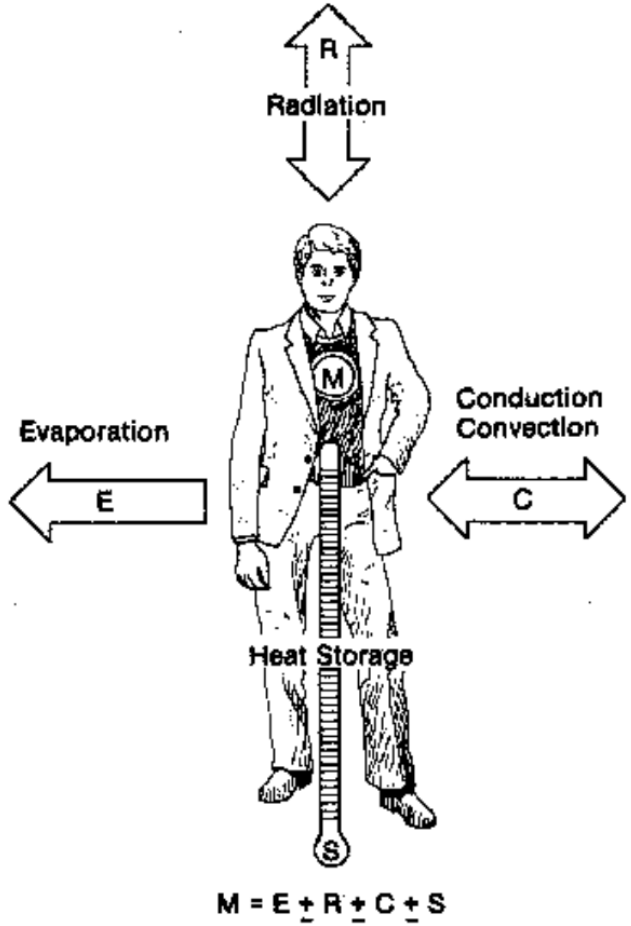
What is Thermal Comfort?

- In cold environments, the body loses more heat to the environment and in hot environments the body does not release enough heat. Both the hot and cold scenarios lead to discomfort.
- The body is in a state of thermal equilibrium with its environment when it loses heat at exactly the same rate as it gains heat.
- Mathematically, the relationship between the body's heat production and all its other heat gains and losses is:

$$\text{Heat production} = \text{heat loss}$$

or

$$M = E \pm R \pm C \pm S$$



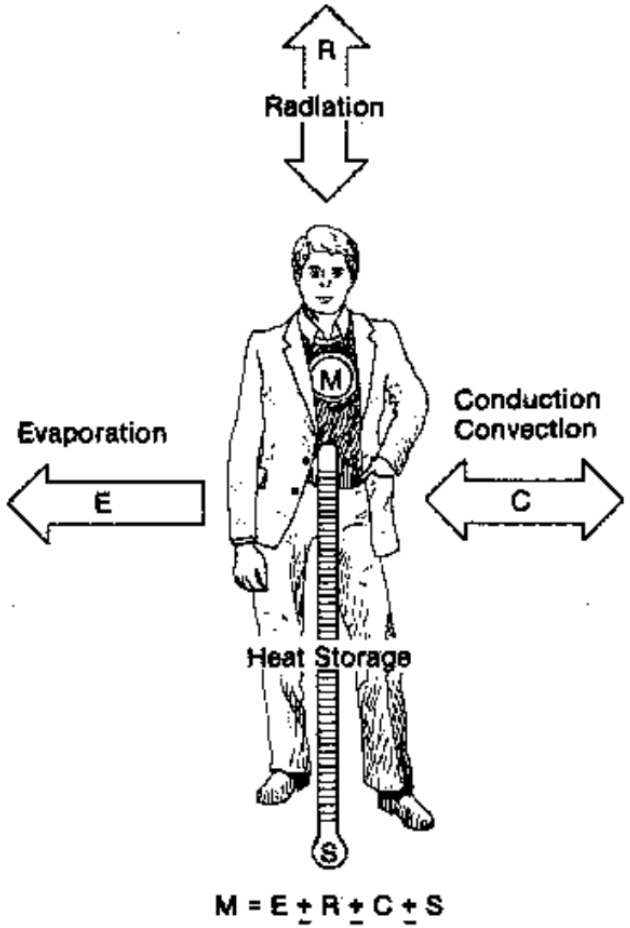
What is Thermal Comfort?

$$\text{Heat production} = \text{heat loss}$$

or

$$M = E \pm R \pm C \pm S$$

- M = metabolic rate
- E = rate of heat loss by evaporation, respiration, and elimination
- R = radiation rate
- C = conduction and convection rate
- S = body heat storage rate



Factors affecting thermal comfort:

A. Personal Factors:
B. Age.
C. Gender.
D. Level of health.
E. Acclimatisation.
F. Psychological state.

- Environmental Factors:

1. Air Temperature:

- It is the dry bulb temperature
- Its an important factor
- Low temperature makes people feel cold
- High temperature makes people feel hot
- Comfort can be achieved (between 16 -28 degree Celsius)

2. Mean Radiant Temperature

- Its radiation to and from an enclosed surface
- Measured with globe thermometer
- Calculated from globe temperature using
  - Air temperature
  - Velocity
- Comfort is achieved if
  - Globe temperature is between (16 -28 degree Celsius)
  - Difference between dry and mean radiant temperature is not less than 5 degree Celsius

3. Air velocity

- Air velocity helps on the body by
  - Increasing heat loss during sweating
  - Enhancing evaporation of sweat; causing cooling
- Velocity of up to 0.1 metre per second may lead to a feeling of stuffiness indoors
- Velocity of 0.1 to 1.0 m/s are comfortable indoors.
- Velocity above 1.0 m/s leads to discomfort.
- For Outdoors,
  - wind speeds of up to 2. 0 m/s can help achieve comfort (when the humidity is high)
  - Wind speeds of over 5. 0 m/s lead to considerable discomfort.

4. Relative Humidity

- When humidity is low
  - The air is dry
  - Sweating is more effective for body cooling
- When humidity is high
  - The air is damp and clammy
  - Sweating no longer cools the body effectively
- Thermal comfort is achieved between 20%-75% Relative Humidity

5. Metabolic rate

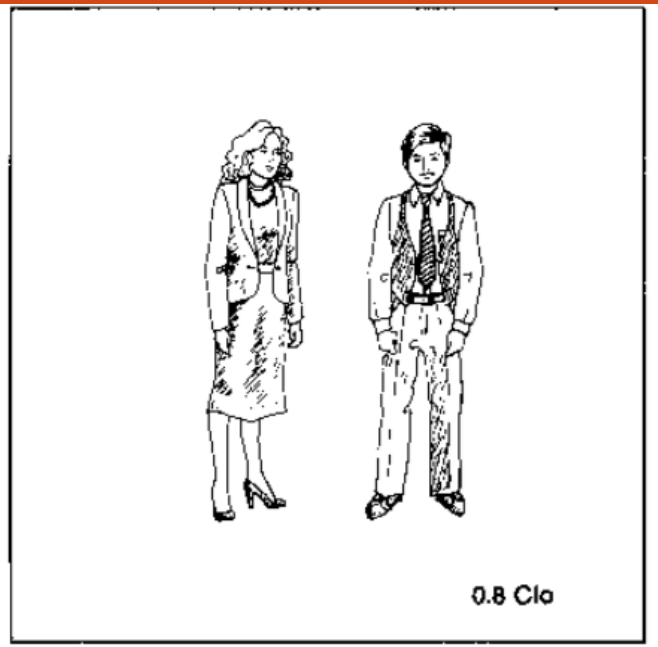
- People have different metabolic rates that can fluctuate due to activity level and environmental conditions.
- The Activity represents the metabolic rate
- The higher the activity, the more heat is produced by the body
- Metabolic rate is measured in W/m^2 and its unit is Met.
- 1 met = 58.2 W/m^2, which is equal to the energy produced per unit surface area of an average person seated at rest.

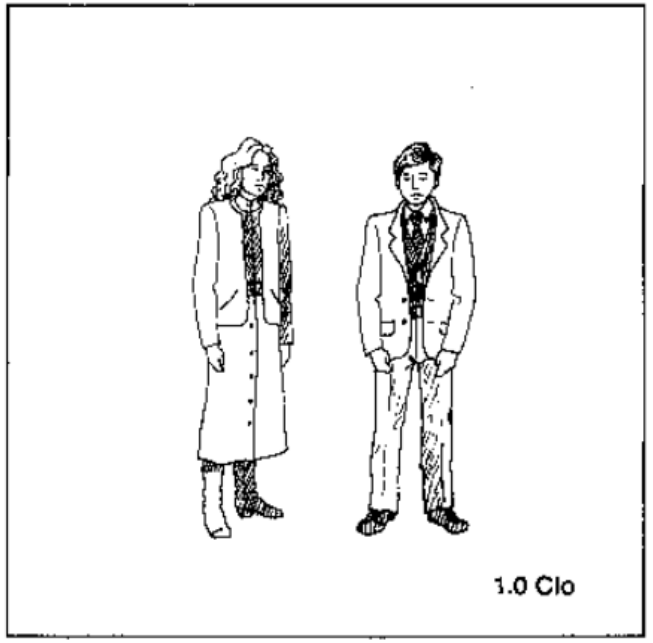
Activity	Metabolic Rate in Met Units[a]
Resting	
Sleeping	0.7
Reclining	0.8
Seated, reading	0.9
Office Work	
Seated, writing	1.0
Seated, typing or talking	1.2 to 1.4
Seated, filing	1.2
Standing, talking	1.2
Drafting	1.1 to 1.3
Miscellaneous office work	1.1 to 1.3
Standing, filing	1.4
Walking (on Level Ground)	
2 mph (0.89 m/s)	2.0
3 mph (1.34 m/s)	2.6
4 mph (1.79 m/s)	3.8
Domestic Work	
Shopping	1.4 to 1.8
Cooking	1.6 to 2.0
House cleaning	2.0 to 3.4
Washing by hand and ironing	2.0 to 3.6
Carpentry	
Machine sawing, table	1.8 to 2.2
Sawing by hand	4.0 to 4.8
Planing by hand	5.6 to 6.4
Miscellaneous Work	
Watch-repairing, seated	1.1
Lifting/packing	1.2 to 2.4
Garage work (e.g., replacing tires, raising cars by jack)	2.2 to 3.0
Vehicle Driving	
Car	1.5
Motorcycle	2.0
Heavy vehicle	3.2
Aircraft flying, routine	1.4
Instrument landing	1.8
Combat flying	2.4
Leisure Activities	
Stream fishing	1.2 to 2.0
Golf, swinging and walking	1.4 to 2.6
Golf, swinging and with golf cart	1.4 to 1.8
Dancing	2.4 to 4.4
Calisthenics exercise	3.0 to 4.0
Tennis, singles	3.6 to 4.6
Squash, singles	5.0 to 7.2
Basketball, half court	5.0 to 7.6
Wrestling, competitive or intensive	7.0 to 8.7

6. Clothing

- Clothing, through its insulation properties, is an important modifier of body heat loss and comfort.
- Clothing insulation can be described in terms of its clo value. The clo value is a numerical representation of a clothing ensemble's thermal resistance.
- The value of 1 clo = 0.155 $m^2°C/W$.
- A heavy two-piece business suit and accessories have an insulation value of about 1 clo, while a pair of shorts is about 0.05 clo.
- A person without any clothes is said to be having 0 clo value.


0.2 Clo

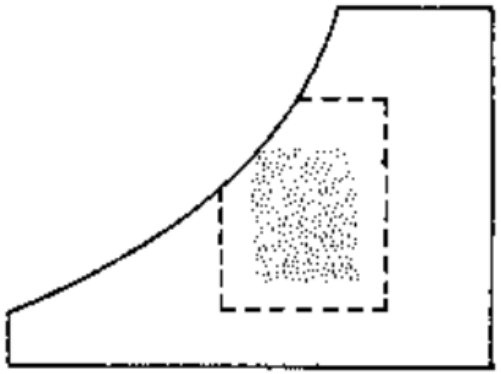

0.8 Clo


1.0 Clo

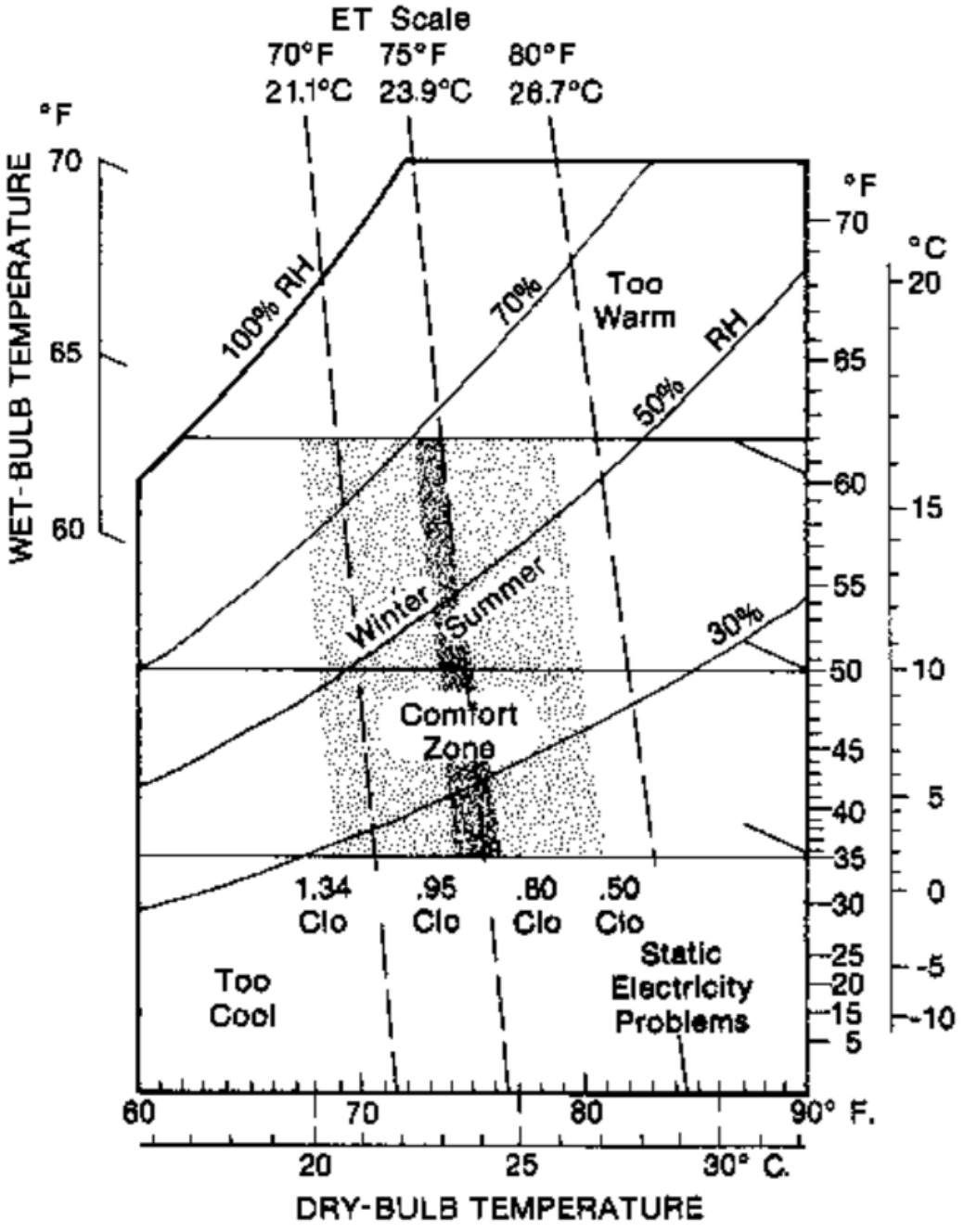

3.0 Clo

Men		Women	
Clothing	**clo**	**Clothing**	**clo**
Underwear		Underwear	
Sleeveless	0.06	Girdle	0.04
T-shirt	0.09	Bra and panties	0.05
Briefs	0.05	Half slip	0.13
Long underwear, upper	0.10	Full slip	0.19
Long underwear, lower	0.10	Long underwear, upper	0.10
		Long underwear, lower	0.10
Shirt		Blouse	
Light, short sleeve	0.14	Light, long sleeve	0.20
long sleeve	0.22	Heavy, long sleeve	0.29
Heavy, short sleeve	0.25	Dress, light	0.22
long sleeve	0.29	Dress, heavy	0.70
(Plus 5% for tie or turtleneck)			
Vest, light	0.15	Skirt, light	0.10
Vest, heavy	0.29	Skirt, heavy	0.22
Trousers, light	0.26	Slacks, light	0.10
Trousers, heavy	0.32	Slacks, heavy	0.44
		Sweater	
Sweater, light	0.20	Light, sleeveless	0.17
Sweater, heavy	0.37	Heavy, long sleeve	0.37
Jacket, light	0.22	Jacket, light	0.17
Jacket, heavy	0.49	Jacket, heavy	0.37
Socks		Stockings	
Ankle length, thin	0.03	Any length	0.01
thick	0.04	Panty hose	0.01
Knee high	0.10		
Shoes		Shoes	
Sandals	0.02	Sandals	0.02
Oxfords	0.04	Pumps	0.04
Boots	0.08	Boots	0.08
Hat and overcoat	2.00	Hat and overcoat	2.00

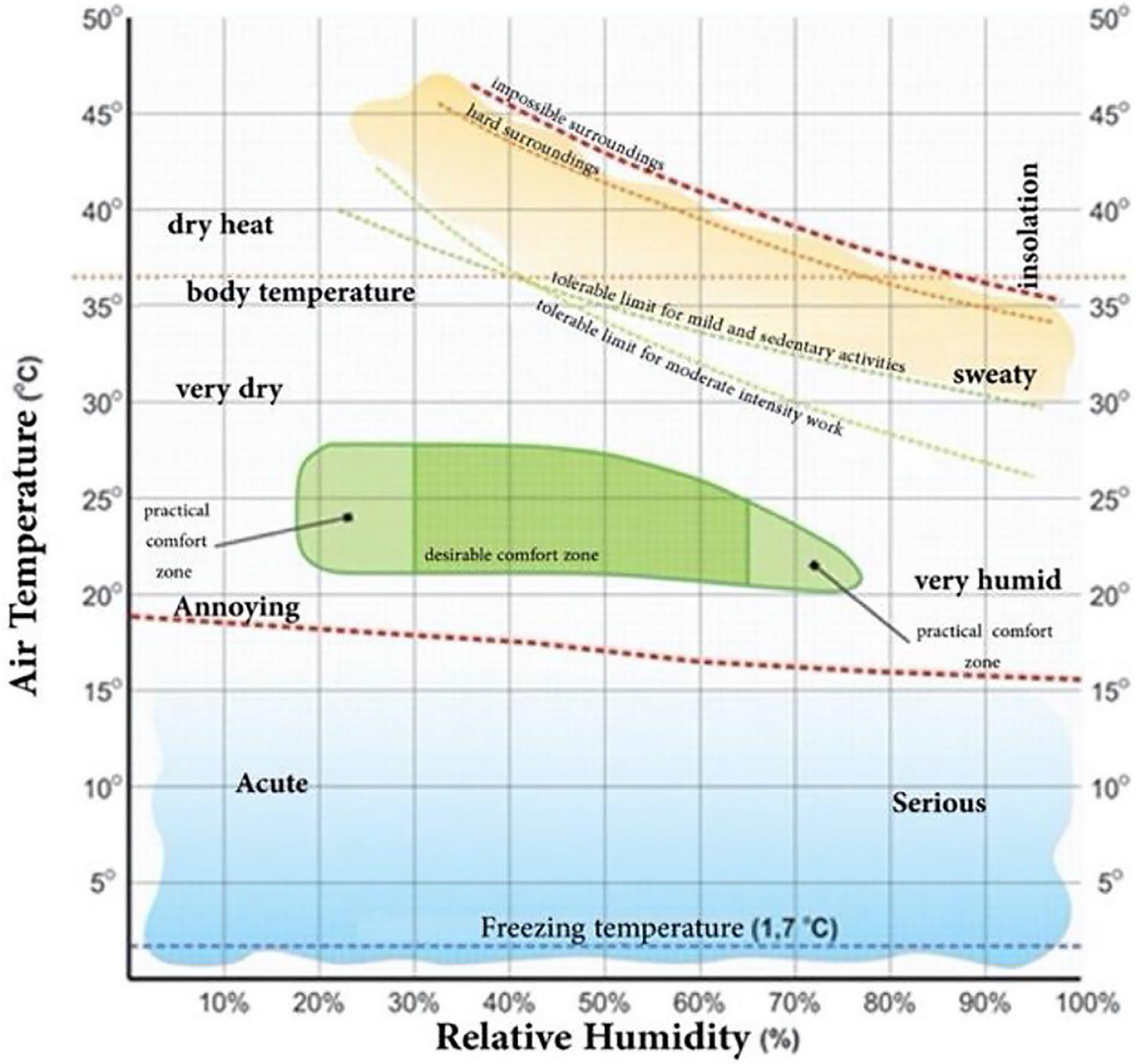
The Comfort Chart



Psychrometric Chart
Location Key



Victor Olgay's Bio-climatic Chart



Other factors:

Indoor Air quality:

- Human comfort can also be affected by the quality of ventilation in a building.
- Ventilation is necessary in buildings to remove 'stale' air and replace it with 'fresh' air, as well as to prevent overheating.
- We all breathe air to live and if it is polluted or carries airborne diseases we can fall ill as a result.
- Airborne hazards such as carbon monoxide or longer-term indoor threats like radon release are sometimes a problem but the toxic fine combustion particles mainly from traffic emissions and some power stations are the major health risk to the public at large.

Other factors:

Visual comfort

- Visual comfort is also an important factor that involves the provision of natural light, external views, reduction of glare and so on.

Noise nuisance

- Comfort can also be negatively influenced by the amount and type of noise in a building.
- Noise nuisance is excessive noise or disturbance that may have a negative effect on health or the quality of life, e.g. being able to hear the occupants of a neighbouring house through the walls.

Other factors:

Ergonomics

- Ergonomics is particularly related to the design of workplaces, products and systems to best fit those who use them.
- The aim of effective ergonomics is to apply learnings about human abilities and limitations to improve interaction with environment and products, and prevent or limit the risk of illness or injury.

CLIMATOLOGY
LECTURE-5

Macro and Micro Climate

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Syllabus

UNIT I General Introduction

- Introduction to Climatology
- Movement of earth around sun.
- Different elements of climate like: Wind, temperature, humidity, precipitation and pressure.
- Different climatic zones
- Orientation of building with respect to above mentioned elements of climate
- Effect of climate on man and shelter.

UNIT II Relation of Climate and comfort

- Macro-micro climatic effects
- Concept of comfort zone and bio-climatic chart
- Climatic evaluation by season

UNIT III Sun Control and shading devices (without calculations)

- Solar Chart (sun path diagram)
- Orientation for sun
- Internal and external sun protection devices
- Natural lighting
- Introduction and objectives of Solar Passive Design
- Passive solar heating and cooling

UNIT IV Wind control

- Orientation with respect to wind
- Wind protection devices Use of building materials with respect to climate
- Concrete; Brick; Glass; Plastics; Stone; Insulating material

UNIT V Environment and Ecology

- Basic elements of ecology
- Concepts of natural cycles in Eco-system
- Source of noise and air pollution, their effects and controls
- Use of landscape elements for micro and macro climate control
- Introduction to climate change, principle causes and effects- methods of mitigating climate change.

Contents:

Macro Climate:

- Macro climate refers to the broader climate patterns of a large geographic region, like a city, country, or continent.
- It involves long-term weather patterns, including average temperatures, precipitation, and seasonal variations.

Factors Influencing Macro Climate:

- **Latitude:** Distance from the equator affects the amount of sunlight a region receives, leading to temperature variations.
- **Ocean Currents:** Oceans moderate climate by absorbing and releasing heat. Regions near coastlines are influenced by ocean currents.
- **Wind Patterns:** Global wind patterns, like the trade winds and westerlies, distribute heat and moisture across the planet, affecting climate.

Importance of Macro-Climate in Architecture:

- **Regional Planning:** Architects need to understand the macro climate of a region to plan cities and towns effectively. This knowledge helps in designing infrastructure that can withstand the typical weather conditions of the area.
- **Energy Efficiency:** Knowledge of macro climate guides architects in designing energy-efficient buildings. For instance, in colder regions, designs might focus on maximizing sunlight exposure for natural heating.
- **Sustainable Architecture:** Understanding macro climates is crucial for sustainable architecture. Architects can implement passive design strategies based on regional climate patterns to reduce energy consumption.

Micro Climate:

- Micro climate refers to the climate of a small, localized area, such as a garden, park, building, or street.
- It focuses on the atmospheric conditions within a specific space, considering factors like temperature, humidity, wind patterns, and sunlight exposure.

Factors Influencing Micro Climate:

- **Topography:** Elevation and slope of the land affect sun exposure and wind patterns.
- **Vegetation:** Trees and plants influence humidity, provide shade, and impact local wind patterns.
- **Built Environment:** Buildings, roads, and other structures can create micro climates by blocking wind or reflecting sunlight.

Importance of Micro-Climate in Architecture:

- **Site Analysis:** Architects analyze micro climates to understand how specific locations are affected by environmental factors. This knowledge helps in optimal site selection for buildings.
- **Design Considerations:** Different micro climates require unique design considerations. For instance, buildings in urban areas might face heat island effects, whereas coastal areas might have high humidity and salt exposure.
- **User Comfort:** Architects use micro climate data to design spaces that provide comfort to occupants. Proper ventilation, shading, and insulation techniques are employed based on micro climate analysis.