The Islamia University of Bahawalpur

Department of Entomology

University College of Agriculture & Environmental Sciences

E-mail: entomology@iub.edu.pk, Ph: 062- 062-9255471, Fax: 062-9250232

Instructor: Dr. M. Aslam Farooqi

Email ID: aslam_farooqi1770@yahoo.com

ENT-505 **Insect Ecology** **3(2-1)**

Syllabus For Final Term Examination

BIOTIC FACTORS:

- *Biotic components* are the *living things that shape an ecosystem*.
- A biotic factor is any living component that affects another organism, including animals that consume the organism in question, and the living food that the organism consumes.
- Biotic factors include human influence.
- Biotic components usually include: *Producers*, i.e. autotrophs: e.g. plants; they convert the energy (from the sun, or other sources such as hydrothermal vents) into food, *Consumers*, i.e. heterotrophs: e.g. animals, *insects*; they depend upon producers for food, *Decomposers*, i.e. detritivores: e.g. fungi and bacteria; they break down chemicals from producers and consumers into simpler form which can be reused.
- The following are biotic factors which affect the insect behavior, growth, dispersal, distribution and finally their population.

  1. Food
  2. Other organisms

FOOD:

- Each insect species has certain natural food requirements for the completion of its life cycle.
- Under normal conditions, there is happy adjustment between host and particular species of insects. But in the event of sudden increase in population, the density of population becomes too high to be supported by food availability in the area. Hence, competition for food as well as space will be there.
- The quality and quantity of the food influences, survival, multiplication, growth and development and longevity of insect's species.

Classification of insects based on food requirements:

Omnivorous insects	Feed on both plants and animals	Wasps and Cockroaches
Carnivorous insects	Feed on other animals, as parasites and predators	Predatory Lady bird beetles, Mantids, *Trichogramma spp. Bracon spp.*
Herbivores insects	Feed on living plants	Crop Insect Pests
Polyphagous	Feed on wide range of cultivated and wild plants	Locusts, Grasshoppers, Cutworms (*Spodoptera litura*), Borers (*Helicoverpa armigera*)
Oligophagous	Feed on plants belong to one family	Cabbage butterfly *Pieris brassicae,* Diamond backed moth *Plutella xylostella*
Monophagous	Feed on a single species of plants	Paddy stem borer *Scirpophaga incertulas,* Brinjal epilachna beetle, *Epilachna vegintioctopunctata*
Saprophytic insects	Feed on decaying plants	Fruit fly *Drosophila,* and cecidomyiid flies
Scavengers	Feed on dead organic matter	House flies, Scarabaid beetles

OTHER ORGANISMS:

Inter-Specific Associations:

1. ***Symbiosis****:* Inter-relations between organisms of different species which live in close and long-term union without harmful effects in known as symbiosis, and each member is known as *symbiont*. One insect feeds on the food collected by another insect of the same species eg: white ants, wasps, bees etc. Symbiotic relations may be categorized into mutulistic (useful), commensalitic (useful) and parasitic (harmful) relations.

2. ***Commensalism:*** One insect is benefitted by living on or inside of another insect without injuring the other is known as commensalism, and it usually uses lives on the waste or surplus food of its host. The benefitting insect is called *commensal* while the other one is called host. Eg. Gall-forming insects. When commensal uses its host as a means of transport, the phenomenon is termed as *phoresy*. Eg: blister beetles attach to legs and hairs of bees. *Telenomus beneficiens* (a parasite) attach themselves to the anal tuft hairs of rice stem borer females (*Scirpophaga incertulas*) for their transport, and this parasite parasitizes the freshly laid eggs.

Mutualism: When the association benefits both the symbionts, it is known as mutualism. Eg: Ants and Aphids, Termites and flagellate protozoans in their guts, Crow on cattle to pick up ticks and mites.

Harmful Associations:

Parasites and predators are those that live at the expense of other living organisms.

Parasites:

- Parasite is one, which attaches itself to the body of the other organism, either externally or internally, and gets nourishment and shelter, at least for shorter duration or for the entire life-cycle.
- The organism which is attacked by the parasites is called host.
- *The phenomenon of obtaining nourishment at the expense of the host to which parasite is attached is called parasitism.*

Parasites can be grouped based on:

Site of Parasitisation/attack		
Ecto-parasites	This attacks its host from outside of the body of the host. The mother parasite lays its eggs on the body of the host and after the eggs are hatched, the larvae feed on the host by remaining outside only.	Head louse: *Epiricania melanolenca, Epipyrops spp.* on sugarcane fly
Endo-parasites	This enters the body of the host and feeds from inside. The mother parasite either lays its eggs inside the tissues of the host or on the food materials of the host to gain entry inside	Braconoids & Ichnemonoids *Apanteles flavipes* on jowar stem borer
Stage of the Host		
Egg parasite	Attacks egg stage of the host	*Trichogramma spp.*
Early larval parasite	Attacks early larval stage	*Apanteles spp.*
Mid larval parasite	Attacks mid larval stage	*Bracon hebetor*
Late larval parasite	Attacks late larval stage	*Gonozus nephantidis*
Pre-pupal parasite	Attacks pre-pupal stage	*Elasmus nephantidis*
Pupal parasite	Attacks pupal stage	*Tetrastichus Israeli* *Trichospilus pupivora* *Stomatocerus spp.*
Duration of the attack		
Transitory parasite	It is not a permanent parasite (completing all stages of its life cycle on the same host), but transitory which spends few stages of its life cycle in one host and other stages on some other species of hosts, or as free living organism	Braconoids and Ichneumonoids
Permanent	Which spends all the stages of its life cycles on the same	Head louce

Parasite	host	
Degree of parasitisation		
Obligatory parasite	Parasite which can live only as a parasite and cannot live away from the host even for short period	Bird lice and Head louse
Facultative parasite	Parasite, which can live away from the host at least for shorter period	Fleas
Food Habits		
Monophagous (Host-Specific)	Which has only one host spp and cannot survive in another spp	*Gonizus nephantidis* on *Opisina arenosella*
Oligophagous	Which has very few hosts (more than one spp.) and hosts are closely related	*Isotoma javensis* on sugarcane and sorghum borers
*Ploy**phagous*	Which has number of widely different host species	*Bracon spp. Apanteles Spp.* on lepidopteran caterpillars

CONCEPT OF BALANCE OF LIFE:

- The population of an insect or any organism may be defined as the number of individuals of particular species existing in a particular area at a time.
- The population never remains constant for long, but tend to oscillate all the time about a theoretical optimum for the species.
- Balance of Life or population balance or natural balance in nature is the maintenance of a more or less fluctuating population density of an organism, over a given period of time within certain definite upper and lower limits by the action of biotic and abiotic factors.
- Several theories have been put forward to explain fluctuations in numbers and they differ widely; Nichloson's Theory, Theory of Andrewwartha and Birtch, Milne's Theory, Chitty's Theory, Pimental's Theory.
- In their efforts to analyze the factors determining the population increase of a species, some ecologists have tried to calculate an animal's maximum capacity (biotic potential) to increase in the absence of any environment. *Chapman* (1928) carriedout some lab experiments on the population increase of the flour beetles and *gave the concept of biotic potential which he defined as the mean maximum rate of reproduction in a given period of time under given conditions*. Later, Lotka, Birtch, Andrew wartha and Birth, mentioned another terminology, *intrinsic rate of increase / the rate of natural increase / innate capacity for increase (rm), which can be defined as the maximal rate of increase attained at any particular combination of temperature, moisture, and quality of food and so on*.

Factors contributing to increase the insect population:

- Any organism will multiply enormously if the environment is optimum.
- Different organisms multiply at different rates.
- Hence, it is well known that every organism has an inherent capacity to survive, reproduce and multiply in numbers.
- The extent to which a species can multiply in a given period of time, if no adverse factors interfere is called its *biotic potential*, which is known as *maximum reproductive power.*
- *Chapman* (1928) introduced this concept.
- *The biotic potential is the innate capacity to increase in populations*, depends on: Biotic Potential (BP): $p(fs)^n$, where
  p = Initial Population f = Fecundity
  s = Sex Ratio
  n = Number of generations/year or per given time or unit time

1. *Initial Population (p):* The more the initial population of an organism, the more its progeny.
2. *Fecundity (f)*: It is the average number of eggs laid by a female in its life. The more the fecundity, the more will be the resultant population.

- A single moth of *Earias vitella* (bhendi fruit borer) lays about 200eggs/female, and completes life cycle in a month. If a pair of fruit borer adults is reared under most favourable conditions, after one month, 200 adults will come out (eg.100 males+100 females), and these can lay 20,000 eggs (200 eggs/female X 100 females). After 2 months, all these 20,000 adults can lay 2,000,000 eggs (200eggs/female X 10,000 females), and if you keep on calculating for one year, the number of adults of fruit borer would be 2,000,000,000,000,000,000,000,000. If a single moth can produce this much, and if all the adults are spread over earth like a blanket, they can cover 24.32 cms above earth surface. *But, in reality, only a fraction of progeny completes life cycle due to environmental resistance*.

- Some insects like white ants reproduce very fast.
- Mustard aphids have 40 generations/year.
- A pair of housefly can produce from April-Aug to an extent of $191010X10^{15}$ populations. Theoretically they can cover 14m deep layer on the earth.
- A pair of *Drosophila* is allowed to produce; the progeny can cover the entire sub-continent and Burma.

3. *Sex ratio (s)*: It is the ratio of females to the total population and is represented by:

$$\text{Sex Ratio (S)} : \frac{\text{Number of Females}}{\text{Number of Males+Females}}$$

4. *Number of generation per unit time (n)*, or a year: Obviously, the greater the number of generations/year, the larger the population.

- Mustard aphids (*Lipaphis erysimi*) have over 40 generations a year.

Factors tending to reduce the insect populations:

- Full expression of the biotic potential of an organism is restricted by *environmental resistance*, any factor that inhibits the increase in number of the population. These factors include unfavourable climatic conditions; lack of space, light, or a suitable substrate; deficiencies of necessary chemical compounds or minerals; and the inhibiting effects of predators, parasites, disease organisms.
- In nature, powerful factors like abiotic and biotic working against the increase in insect populations. These biotic and abiotic factors are known as *constituents of environmental resistance*, which always tend to destroy a considerable proportion of insect life. The effect of physical and biological factors in preventing a species from reproducing at its maximum rate is called as *environmental resistance.*
- The proportion of the population which is normally eliminated as a result of *environmental resistance* is known as *normal coefficient of destruction*, which can be expressed by the formula:

$Qn = 1 - (1/S)^n/fn$, where

Q = coefficient of destruction

n = number of generations per year or unit time s = sex ratio, when the population is taken as 1 f = fecundity

Habitat vs Niche

Habitat (Location of an organism)

- A habitat is a place where a particular animal or plant species lives where a plant or animal can get the food, shelter and space to live.
- A habitat, is all aspects of the area (physical location) in which an organism lives, includes:
  - Biotic factors
  - Abiotic factors

Niche (Profession or ecological role of an organism)

- An ecological niche includes all of the factors that a species needs to survive, stay healthy, and reproduce and its ecological function (the location and **ROLE** of an organism).
  - Biotic factors
  - Abiotic conditions

  + Species behavior

25

Habitat vs Niche

Organisms often share a habitat, but rarely fill the exact same niche!

- Species can share habitats and resources.
- Each organism has its own way of gathering food, reproducing and avoiding predators.
- Competition occurs when two species use resources in the same way.
- Competitive exclusion keeps two species from occupying the same niche.
- Competitive exclusion has different outcomes.
  - One species is better suited to the niche and the other will either be pushed out or become extinct.
  - The niche will be divided.
  - The two species will further diverge.

Habitat vs Niche

Competitive exclusion

- No two different species can share the same niche but can have similar niches. This is because of competition for same resources like food.
- The extinction or eviction of a population is due to direct competition with another species for a same resource.
- This could also cause one species to be evicted from the niche which would allow survival of both species.

Habitat vs Niche

Fundamental niche

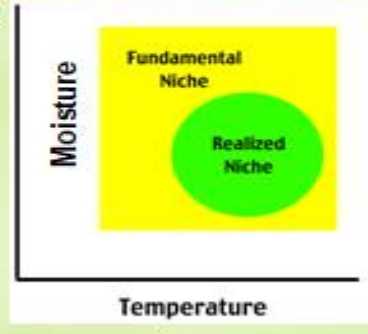
- The niche that an organism could theoretically occupy.

Realized niche

- The niche that an organism actually occupies which could be less extensive (smaller) than the fundamental niche.

Niches Diversity

- Predators increase niche diversity by decreasing the population size of their prey species which allows more resources for other species in that niche.
- Keystone predator is a predator that promotes a great niche diversity in its habitat
- Abiotic factors also contribute to niche diversity. These include temperature changes and moisture.



AGROECOSYSTEM VS NATURAL ECOSYSTEM

- Natural ecosystem is closed, or at least, unmanaged ecosystem
  - Closed ecosystem—all elements recycled through ecosystem—not often pure closed ecosystems anymore—humans frequently involved
- Agroecosystem is an open ecosystem, or managed ecosystem:
  - Producer moves plants, animals, environmental factors (fertilizers, feed) in & out of ecosystem
  - Will not continue on its own without management
  - If left alone, would progress toward closed ecosystem, but probably not the same as original ecosystem before agriculture without human input again

Comparison of natural and agricultural ecosystems

Natural ecosystem	Agricultural ecosystem
Solar energy only – no additional energy input	Solar energy plus **energy from food (labour) and fossil fuels** (machinery and transport)
Lower productivity	**Higher productivity**
More species diversity (Polyculture)	Less species diversity (Monoculture)
More genetic diversity within a species	Less genetic diversity within a species
Nutrients are recycled naturally within the ecosystem with little addition from outside	Natural recycling is more limited and supplemented by the addition of artificial fertilisers
Populations are controlled by natural means such as competition and climate	Populations are controlled by both natural means and by use of pesticides and cultivation
Natural community	Managed community

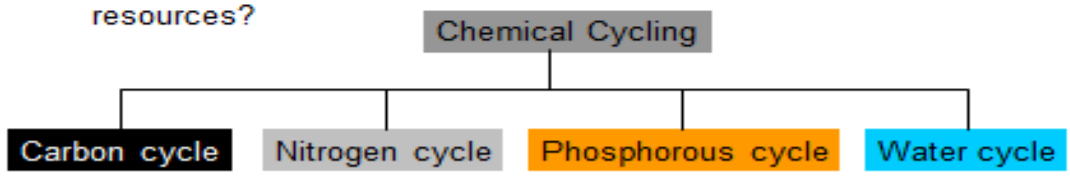
Energy Flow in ecosystems

Overview: Chemical Cycles

Biogeochemical cycles_____

The various material circuits, which involve both the nutrient and physical components of an ecosystem.

Carbon, **N**itrogen, **P**hosphorous and Water are needed by every organism on Earth. **C** is needed to build organic molecules. **N** is needed for nucleic acids. **P** is needed for energy molecules. Water is needed to maintain life. How does every organism on Earth have access to these limited resources?

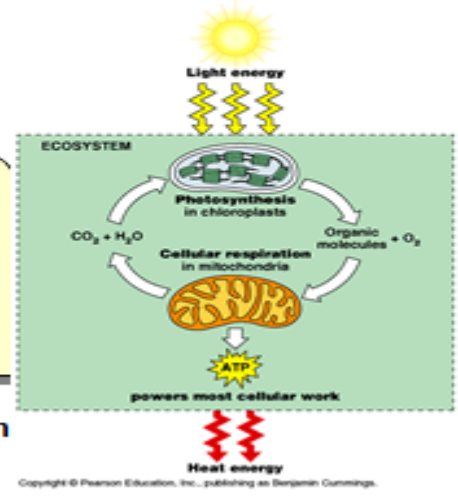


Energy Flow in ecosystems

Carbon/Oxygen Cycle

The Carbon cycle reflects the connected processes of photosynthesis and cellular respiration.

1. Producers convert inorganic carbon dioxide into organic molecules.
2. Consumers eat the producers.
3. Consumers breathe out CO_2 which is reused by the autotrophs.



Since photosynthesis generates oxygen the oxygen cycle is coupled with the carbon cycle.

Energy Flow in ecosystems

Nitrogen cycle

Certain prokaryotes **fix Nitrogen in the atmosphere into ammonia** which other bacteria convert into nitrites and nitrates.

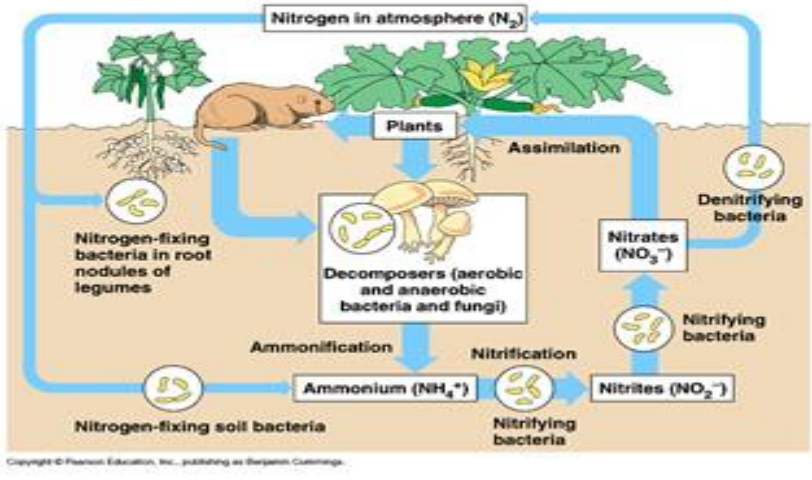
Plants absorb **ammonia** and **nitrates** and convert them into **proteins** that can be passed onto the food chain.

Detritivores reduce **dead plants, animals and their products into ammonia** which can be reused by plants or deposited in the soil.

Nitrogen in the soil is returned to the atmosphere in the form of **free nitrogen by denitrifying bacteria** for prokaryotes to fix again.

Energy Flow in ecosystems

Nitrogen cycle



Energy Flow in ecosystems

Phosphorous cycle

Phosphorous from rocks leaks into the soil by sediment runoff.

Phosphorous is added to the soil as phosphate.

Plants absorb the phosphate.

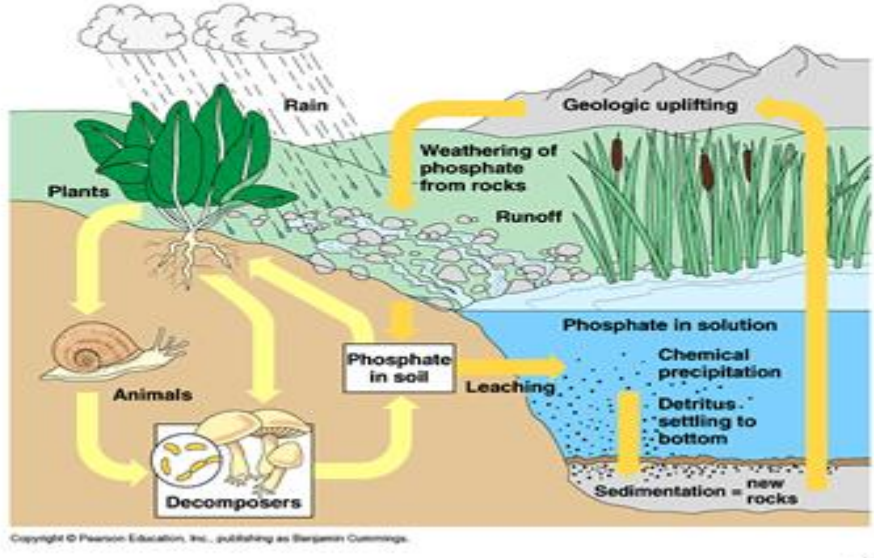
Animals eat the plants.

Consumers excrete feces or decomposers break down the wastes, which drains by run-off to the oceans.

The oceans deposit the phosphorous onto rocks.

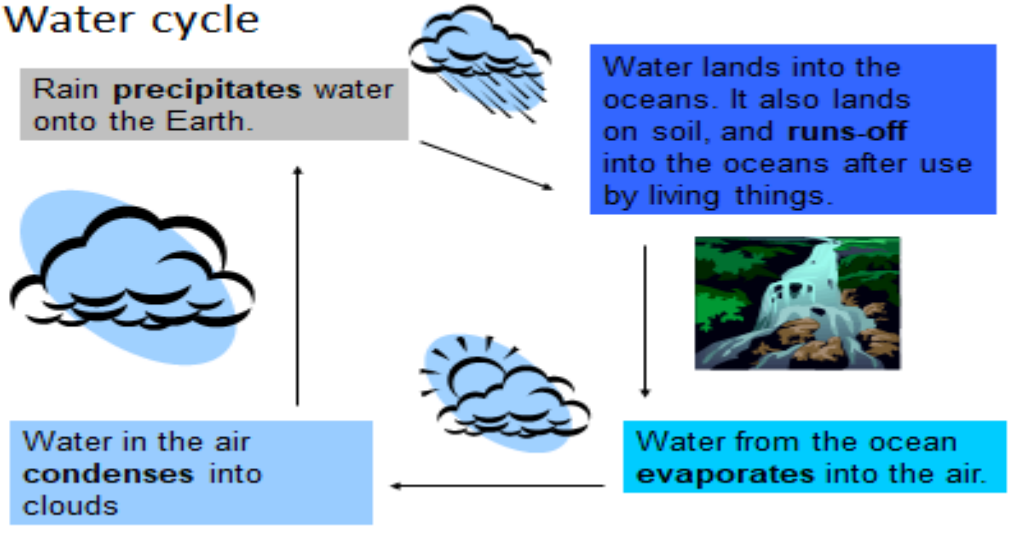
Energy Flow in ecosystems

Phosphorous cycle



Energy Flow in ecosystems

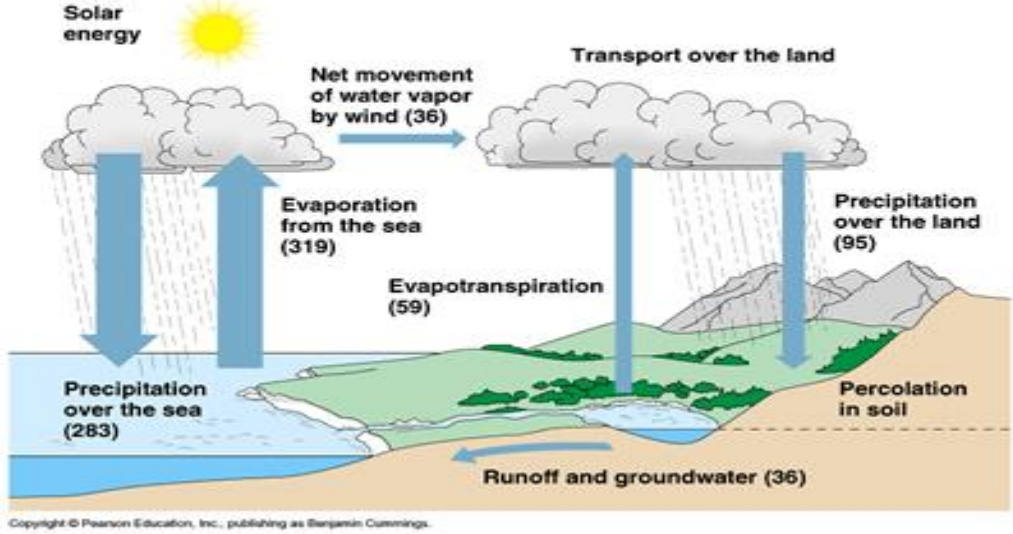
Water cycle



Water moving through a plant is called **Transpiration**

Energy Flow in ecosystems

Water cycle



Questions: Chemical cycles

Which cycle has a chemical which become deposited on rocks?

Which cycle provides the basis of organic molecules?

Which cycle requires the help of bacteria?

Weather Instruments

A **THERMOMETER** measures the air temperature. Most thermometers are closed glass tubes containing liquids such as alcohol or mercury. When air around the tube heats the liquid, the liquid expands and moves up the tube. A scale then shows what the actual temperature is.

A **BAROMETER** measures air pressure. It tells you whether or not the pressure is rising or falling. A rising barometer means sunny and dry conditions, while a falling barometer means stormy and wet conditions. An Italian scientist named Torricelli built the first barometer in 1643.

A **SLING PSYCHROMETER** measures relative humidity, using the cooling effect of evaporation. Two thermometers are used in a sling psychrometer. Wet the cloth of one of the thermometers and swing the psychrometer around a few times. Water evaporates from the cloth, causing the temperatures on that thermometer to be lower than the other.

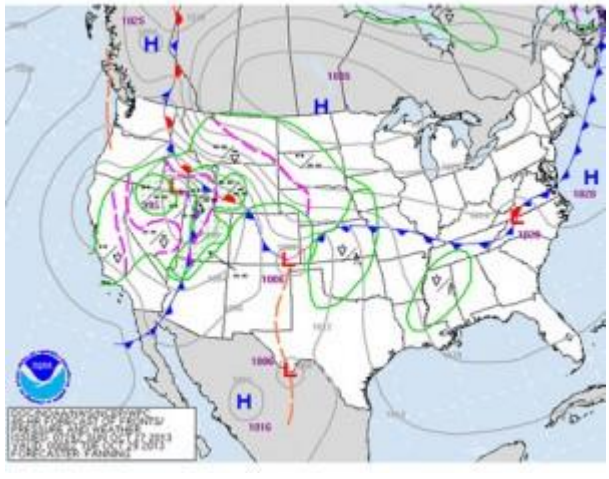
A **RAIN GAUGE** measures the amount of rain that has fallen over a specific time period. One millimetre of measured precipitation is the equivalent of one litre of rainfall per metre squared.

A **WIND VANE** is an instrument that determines the direction from which the wind is blowing.

An **ANEMOMETER** measures wind speed. The cups catch the wind, turning a dial attached to the instrument. The dial shows the wind speed.

A **WIND SOCK** is a conical textile tube, which resembles a giant sock, designed to indicate wind direction and relative wind speed.

WEATHER MAPS indicate atmospheric conditions above a large portion of the Earth's surface. Meteorologists use weather maps to forecast the weather.



A **HYGROMETER** measures the water vapor content of air or the humidity.

A **WEATHER BALLOON** measures weather conditions higher up in the atmosphere.

- **Exosphere**: 700 to 10,000 km (440 to 6,200 miles)
- **Thermosphere**: 80 to 700 km (50 to 440 miles)
- **Mesosphere**: 50 to 80 km (31 to 50 miles)
- **Stratosphere**: 12 to 50 km (7 to 31 miles)
- **Troposphere**: 0 to 12 km (0 to 7 miles

A **COMPASS** is a navigational instrument for finding directions.

WEATHER SATELLITES are used to photograph and track large-scale air movements. Then meteorologists compile and analyze the data with the help of computers.

Photometer: A **photometer**, generally, is an instrument that measures light intensity or the optical properties of solutions or surfaces. Photometers measure:

Optical properties: The **optical properties** of a material define how it interacts with light.

Photometers usually measure:

Illuminance: In photometry, **Illuminance** is the total luminous flux incident on a surface, per unit area.

Scattering of light: Scattering is a general physical process where some forms of radiation, such as light, sound, or moving particles, are forced to deviate from a straight trajectory by one or more paths.

Reflection of light: Reflection is the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated.

Fluorescence: Fluorescence is the emission of light by a substance that has absorbed light or other electromagnetic radiation.