CLOUDS AND PRECIPITATION (BY Mr. S K MANOCHA SIR)

Classification of Clouds – The clouds are divided into **ten basic types** based on slight modifications to the scheme provided by **Luke Howard**, an English naturalist in **1803**.

These ten basic types are divided into four primary cloud groups –

a. High Clouds – 1. Cirrus (Ci), 2. Cirrostratus (Cs), 3. Cirrocumulus (Cc);

b. Middle Clouds – 1. Altostratus (As), 2. Altocumulus (Ac);

c. Low Clouds – 1. Stratus (St), 2. Stratocumulus (Sc), 3. Nimbostratus (Ns);

d. **Clouds with great vertical development – 1. Cumulus (Cu), and 2. Cumulonimbus (Cb)**

Note- ***the heights of the clouds in the three categories – low, middle, and high may have their spatial and temporal variations. The types overlap, and cloud development frequently is in a state of change, so that one type may evolve into another.***

- **High Clouds** – are generally found **above 6 km**. Because of small amount of water vapour and low temperature at such altitudes, these clouds are **thin, white, and composed of ice crystals;** *these high clouds often are harbingers of an approaching weather system or* storm.
- **Cirrus** - the most common high clouds are the Cirrus (Ci), which are thin, wispy clouds blown by high winds into long streamers called **mares' tails**; generally, point to fair, pleasant weather.
- **Cirrocumulus (Cc)** – appear as small, rounded, white puffs that may occur individually or in long rows; these clouds give **"mackerel sky"** appearance.

- **Cirrostratus (Cs)** – the thin, sheet-like, high clouds that often cover the entire sky are cirrostratus; moon and sun can be clearly seen through them; these produce a **halo – a ring of light that encircles the sun or moon.**
- **Middle Clouds** - normally occur **between 2 to 6 km**; they may be either stratiform or cumuliform; these are composed of water droplets and some ice crystals.
- **Altocumulus (Ac)** appear as grey, puffy masses, sometimes rolled out in waves or bands; the appearance of these clouds on a warm, humid summer morning often portends thunderstorms by late afternoon.
- **Altostratus (As)** is a grey cloud composed of ice crystals and water droplets; these often cover the entire sky across an area; in the thinner section of the cloud, **the sun/moon may be dimly visible as a round disk ("watery appearance")**; these often form ahead of storms having widespread and relatively continuous precipitation; if precipitation falls from an altostratus, its base usually lowers and if the precipitation reaches the ground, the cloud is then classified as **nimbostratus.**
- **Low Clouds** – usually are **below 2 km;** they sometimes occur as individual clouds but more often appear as a general overcast; these clouds often are widespread and are associated with somber skies and drizzly rain; are almost always composed of water droplets (however, in cold weather, they may contain ice particles and snow).
- **Nimbostratus (Ns)** – is a dark grey, "wet" – looking cloudy layer associated with more or less continuously falling rain or snow; the intensity of this precipitation is usually light or moderate; it is easily confused with the altostratus; since these lower clouds drift rapidly with the wind, they form irregular shreds with a ragged appearance that are called **stratus fractus, or scud**.

- **Stratocumulus (Sc)** – are low lumpy clouds that appear in rows, in patches, or as rounded masses with blue sky visible between the individual cloud elements; often these appear near sunset as the spreading remains of a much larger cumulus cloud; occasionally, the sun will shine through the cloud breaks producing bands of light (called crepuscular rays) that appear to reach down to the ground.
- **Stratus (St)** – is a uniform greyish cloud that often covers the entire sky; normally, no precipitation falls from the stratus, but sometimes it is accompanied by a light drizzle.

Clouds with great vertical development – **clouds of vertical development**, **grow upward from low bases to heights of as much as 15 km;** their horizontal spread is usually very restricted; they indicate very active vertical movements in the air; the relevant types are **cumulus**, which usually indicate fair weather, and **cumulonimbus**, which are storm clouds.

- the puffy **cumulus (Cu)** cloud takes on a variety of shapes, but most often it looks like a piece of floating cotton with sharp outlines and a flat base; cumulus clouds that show only slight vertical growth are called **cumulus humilis** and are associated with fair weather; therefore, these clouds are called “fair weather cumulus”; ragged-edge cumulus clouds that are smaller than cumulus humilis and scattered across the sky are called **cumulus fractus**; when the growing cumulus resembles a head of cauliflower, it becomes a **cumulus congestus**, or **towering cumulus (T cu)**; precipitation that falls from a congestus is always showery.
- If a cumulus congestus continues to grow vertically, it develops into a huge **cumulonimbus (Cb)** – a thunderstorm cloud; it grows from a low base (maybe 600 m) and its top may extend upward to the tropopause, over 12000 metres higher; it

may occur as an isolated cloud or as part of a line or "wall" of clouds; there is a tremendous amount of energy released by condensation; these clouds have lightning and thunder.

Colur and Clouds

- When sunlight bounces off a surface at the same angle at which it strikes the surface, we say that the light is reflected, and call this phenomenon reflection. There are various constituents of the atmosphere, however, that tend to deflect solar radiation from its path and send it out in all directions. The radiation reflected in this way is said to be scattered. Scattered light is called diffuse light. When we look at a cloud, it appears white because countless cloud droplets scatter all wavelengths of visible sunlight in all directions. As a cloud grows larger and taller, more sunlight is reflected from it and less light can penetrate all the way through it. In fact, relatively little light penetrates a cloud whose thickness is 1000 metres. Since little sunlight reaches the underside of the cloud, little light is scattered, and the cloud base appears dark. At the same time, if droplets near the cloud base grow larger, they become less effective scatterers and better absorbers. As a result, the little amount of visible light that does reach this part of the cloud is absorbed rather than scattered, which makes the cloud appear even darker. These same cloud droplets may even grow large and heavy enough to fall to earth as rain.

- **Clouds are also important because of their influence on radiant energy. They receive both insolation from both above and terrestrial radiation from below, and then either absorb, reflect, scatter, or reradiate this energy. The function of clouds in the global energy budget is important.**

FORMS OF PRECIPITATION: Several forms of precipitation may result from the **Collision-Coalescence and Ice Crystal formation processes**. The form that results depends primarily on – ***temperature of air and its degree of turbulence***. The main forms of precipitation are:

1. Rain – It consists of drops of liquid water **(0.5 mm to 6 mm in diameter**). **It is the most common and widespread form of precipitation.** Most rain is the result of condensation and precipitation in ascending air that has a temperature above freezing, but some results from the thawing of ice crystals as they descend through the warmer air.

- Meteorologists often make a distinction among "rain," which goes on for a relatively long time; "showers," which are relatively brief and involve large drops; and "drizzle," which consists of very small drops and usually lasts for some time.
- ***Most of the rain that falls over middle latitudes results from melted snow that formed from the ice-crystal process.***
- **Virga** – Occasionally, the rain falling from a cloud never reaches the surface because the low humidity causes rapid evaporation. As the drops become smaller, their rate of fall decreases, and they appear to hang in the air as a rain streamer. These evaporating streaks of precipitation are called **virga**.

2. Drizzle – a spray like rain (drops <0.5 mm in diameter). These fall at a slow pace. It is generally associated with low and stratus clouds. It reduces visibility.

3. Snow – One of the solid forms of precipitation – ice crystals, small pellets, or flakes. It is formed when water vapour is converted directly to ice without an intermediate water stage.

Snow is usually dry and powdery. It appears white as snow crystals reflect light in all directions.

- When ice crystals and snow-flakes fall from high cirrus clouds they are called **fallstreaks**. Fallstreaks behave in much the same way as virga. As the ice particles fall into drier air, they usually sublimate (that is, change from ice into vapour). Fallstreaks when moved horizontally by winds, appear as dangling white streamers.
- **Blizzard** is a weather condition characterized by low temperatures and strong winds bearing large amounts of fine, dry, powdery particles of snow, which can reduce visibility to only a few metres.

4. Sleet – In general, the term is applied to a mixture of rain and snow. In the US, sleet refers to small raindrops that freeze during descent and reach the ground as small pellets.

- **Sleet and Freezing Rain** – As snow falls into warmer air, it begins to melt. As it falls through the deep subfreezing surface layer of air, the partially melted snowflake or cold raindrops turn back into ice, not as a snowflake, but as a tiny ice pellet called sleet.
- When raindrops strike on a cold object, the drops spread out and almost immediately freeze, forming a thin veneer of ice. This form of precipitation is called **freezing rain, or glaze**. If the drops are small (less than 0.5mm in diameter), the precipitation is called freezing **drizzle.**
- **Glaze** – Glaze is rain that turns to ice the instant it collides with a solid object. Raindrops fall through a shallow layer of subfreezing air near the ground. Although the drops do not freeze in the air (i.e. they do not turn into sleet), they become supercooled while in this cold layer and are instantly converted to an icy surface when they alight. This is a coating of ice which forms when rain falls on to a ground

surface, the temperature of which remains below freezing-point. This thick coating of ice makes both pedestrian and vehicular travel hazardous as well as breaks tree limbs and transmission lines.

- When small supercooled cloud or fog droplets strike an object whose temperature is below freezing, the tiny droplets freeze, forming an accumulation of white or milky granular ice called **rime**.
- When a sheet of ice covering a road surface or pavement appears relatively dark, it is often referred to as **black ice**. Black ice commonly forms when light rain, drizzle, or supercooled fog droplets come in contact with surfaces that have cooled to a temperature below freezing. Black Ice refers to the thin coating of transparent ice on roadways, sidewalks and parking lots – it is hard to see, can build up quickly and is extremely dangerous to both pedestrians and drivers.

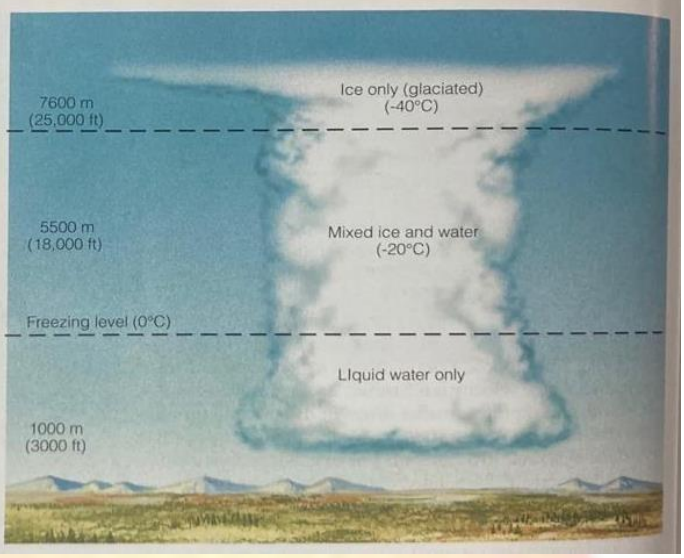
5. Hail – The precipitation form with the **most complex origin** is hail. It consists of either small pellets or larger lumps of ice. Hailstones are usually composed of roughly concentric layers of clear and cloudy ice. The cloudy portions contain numerous tiny air bubbles among crystals of ice, whereas the clear parts are made up of large ice crystals. Hail is produced in **cumulonimbus clouds** as a result of vertical air currents. A hailstone normally continues to grow whether it is rising or falling, providing it passes through portions of the cloud that contain supercooled droplets.

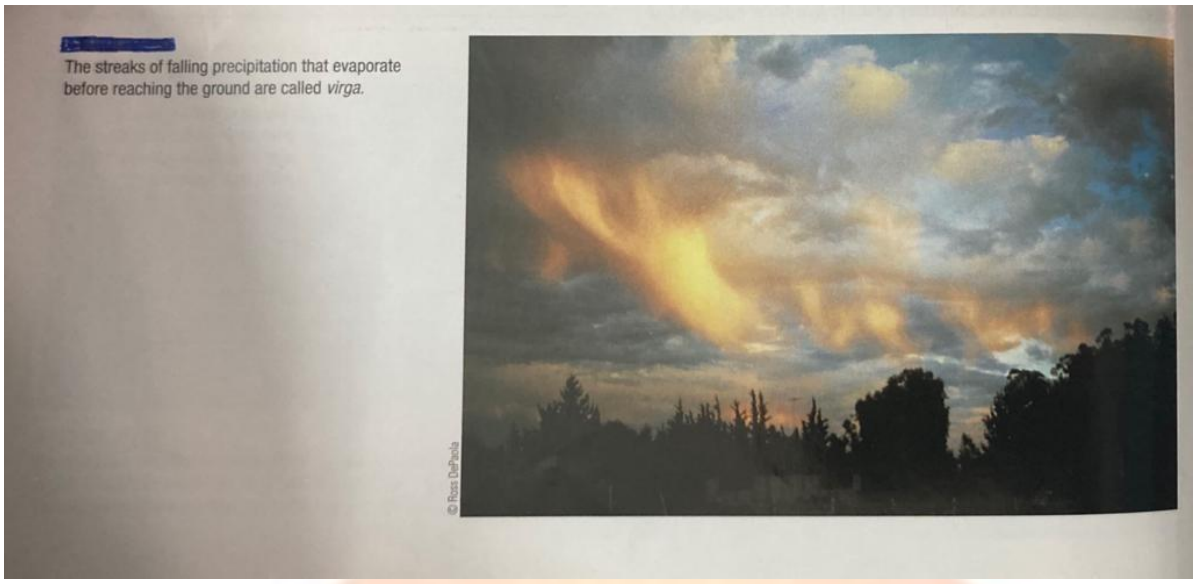
- As the cumulonimbus cloud moves along, it may deposit its hail in a long narrow band (often several kilometres wide and about 10 kilometres long). Known as **hailstreak.**

Approximate Height of Cloud Bases above the Surface for Various Locations

CLOUD GROUP	TROPICAL REGION	MIDDLE LATITUDE REGION	POLAR REGION
High Ci, Cs, Cc	20,000 to 60,000 ft (6,000 to 18,000 m)	16,000 to 43,000 ft (5000 to 13,000 m)	10,000 to 26,000 ft (3000 to 8000 m)
Middle As, Ac	6500 to 26,000 ft (2000 to 8000 m)	6500 to 23,000 ft (2000 to 7000 m)	6500 to 13,000 ft (2000 to 4000 m)
Low St, Sc, Ns	surface to 6500 ft (0 to 2000 m)	surface to 6500 ft (0 to 2000 m)	surface to 6500 ft (0 to 2000 m)

The distribution of ice and water in a cumulonimbus cloud.





The dangling white streamers of ice crystals beneath these cirrus clouds are known as *fall-streaks*. The bending of the streaks is due to the changing wind speed with height.

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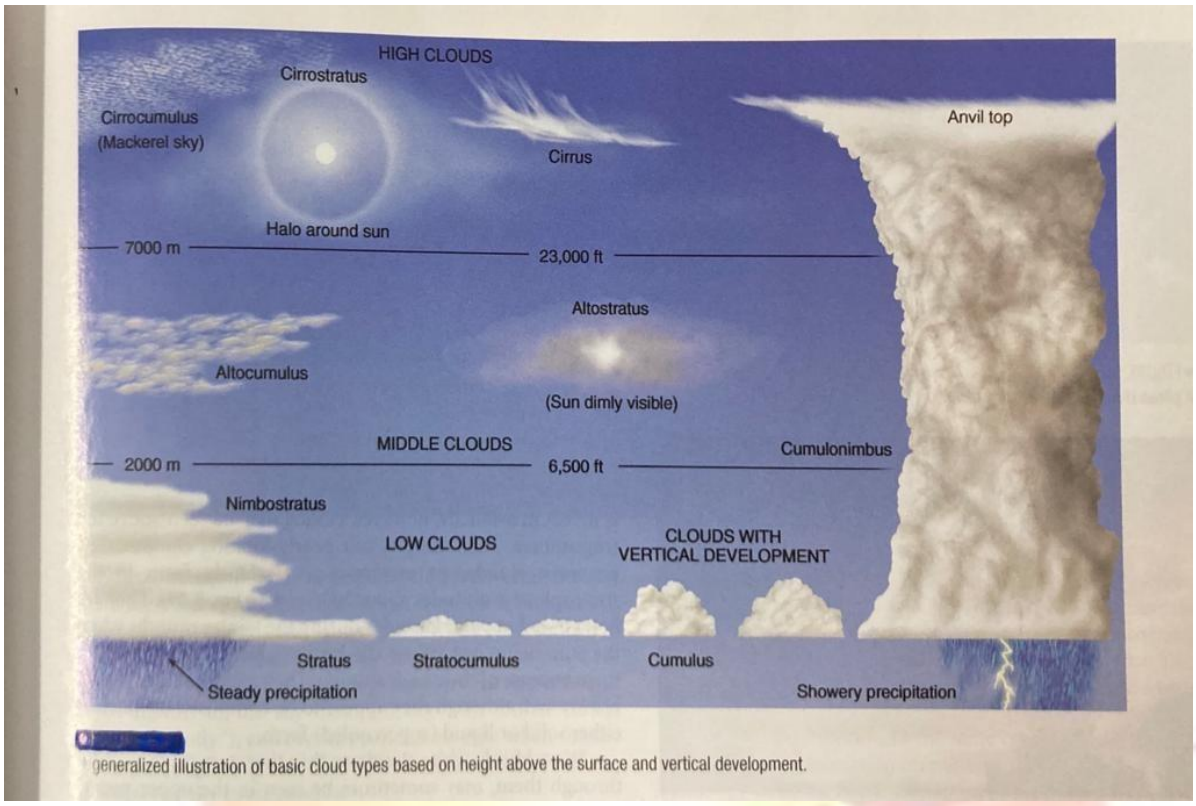
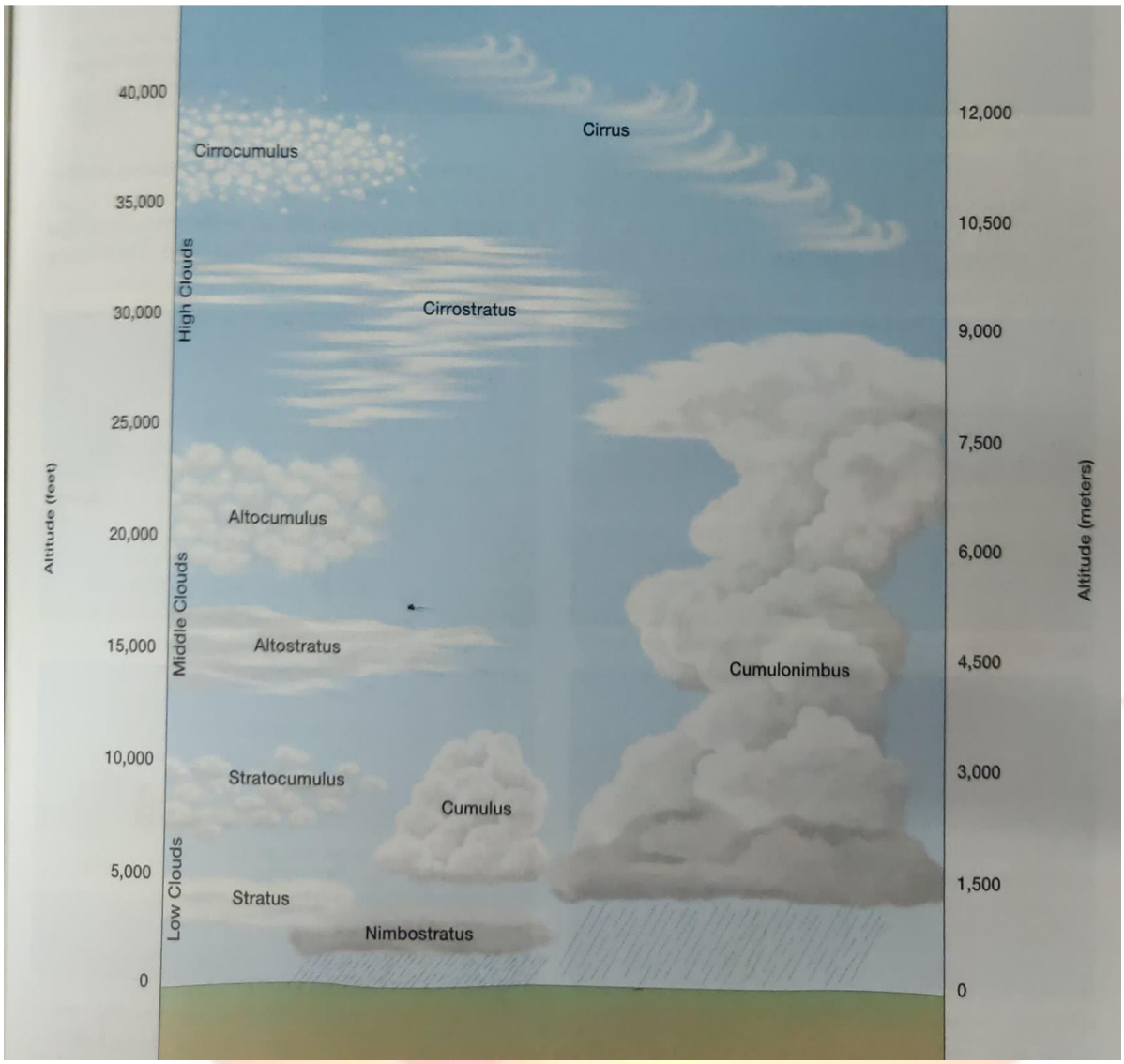
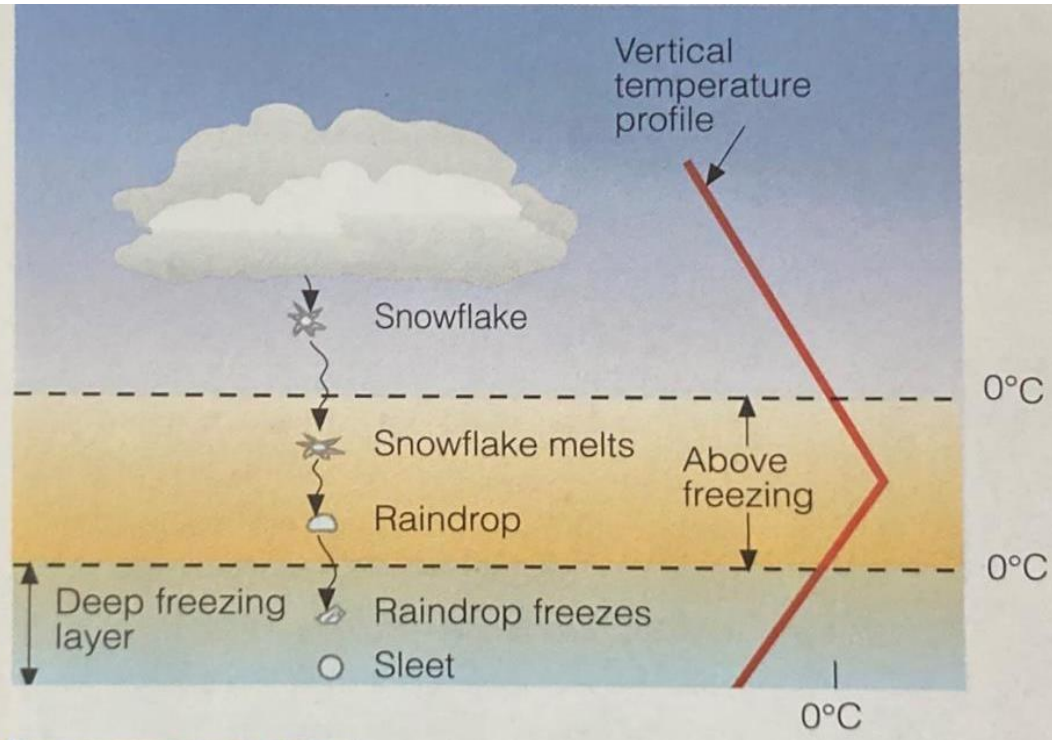
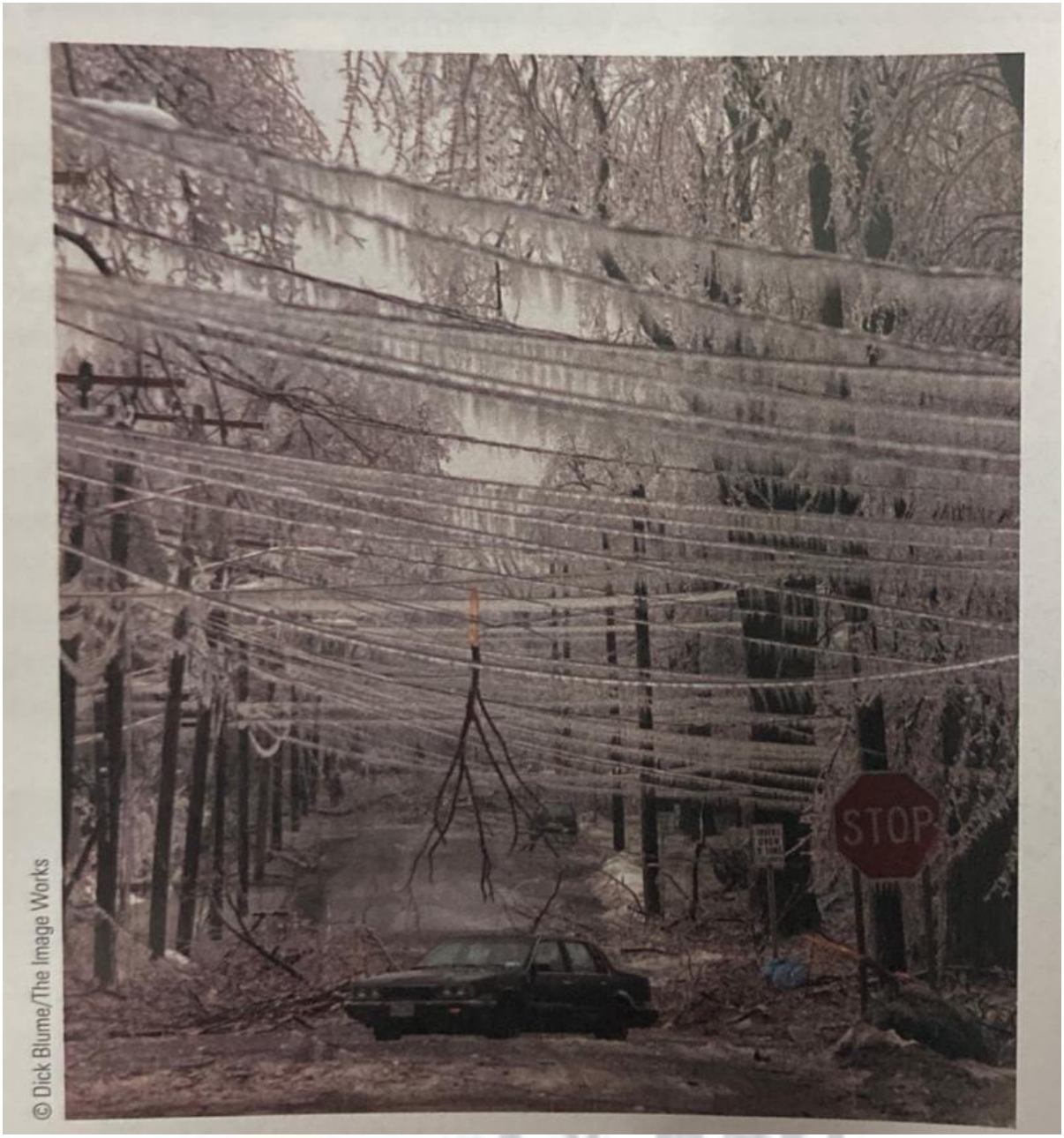


generalized illustration of basic cloud types based on height above the surface and vertical development.

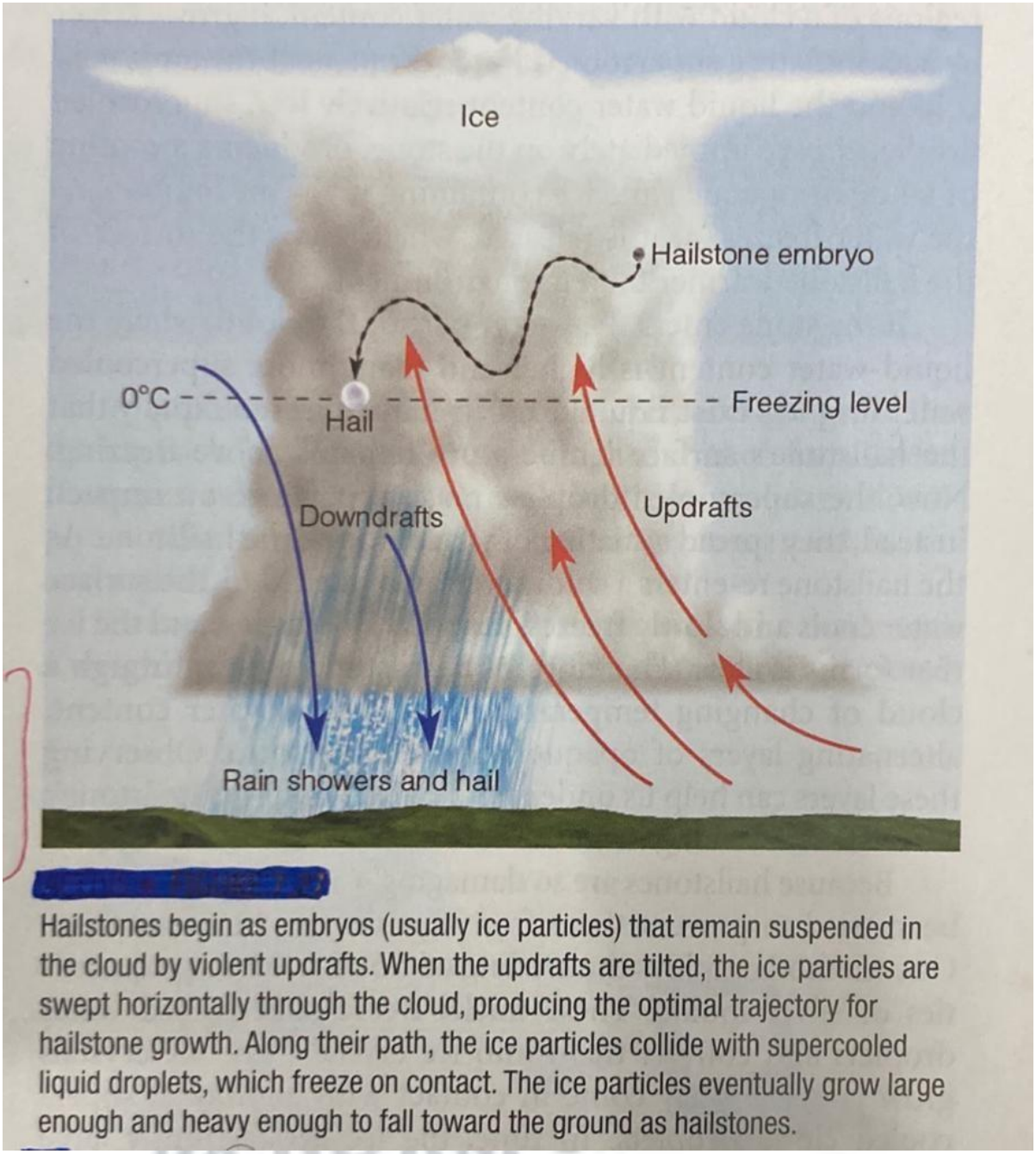




Sleet forms when a partially melted snowflake or a cold raindrop freezes into a pellet of ice before reaching the ground.



A heavy coating of freezing rain (glaze) covers Syracuse, New York, during January, 1998, causing tree limbs to break and power lines to sag.



Hailstones begin as embryos (usually ice particles) that remain suspended in the cloud by violent updrafts. When the updrafts are tilted, the ice particles are swept horizontally through the cloud, producing the optimal trajectory for hailstone growth. Along their path, the ice particles collide with supercooled liquid droplets, which freeze on contact. The ice particles eventually grow large enough and heavy enough to fall toward the ground as hailstones.