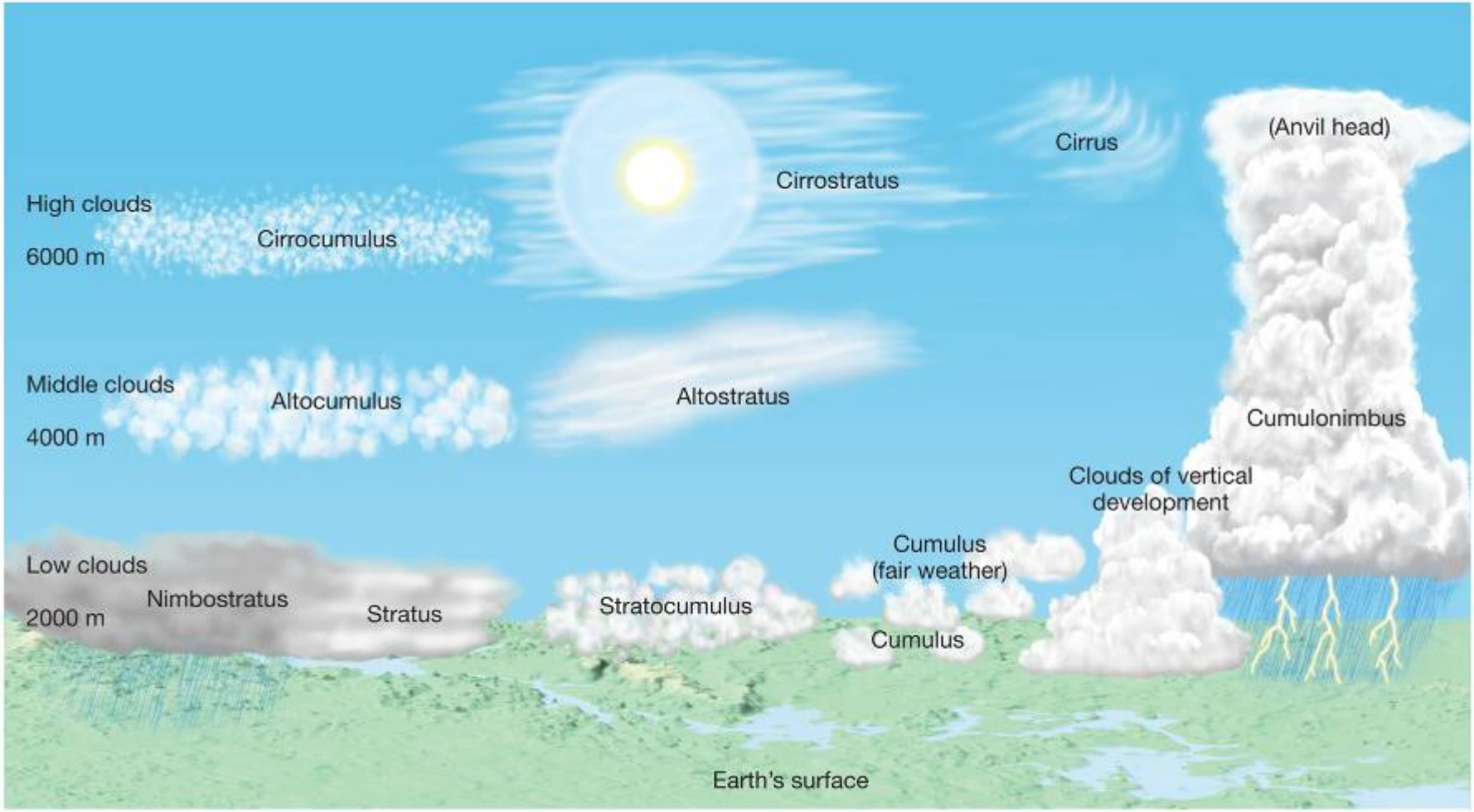
Chapter 5
Forms of Condensation and Precipitation

The Atmosphere 10e

Lutgens & Tarbuck
Power Point by Michael C. LoPresto



Cloud Types

TABLE 5-1 Basic cloud types

Cloud family and height	Cloud type	Characteristics
High clouds—above 6000 m (20,000 ft)	Cirrus (Ci)	Thin, delicate, fibrous ice-crystal clouds. Sometimes appear as hooked filaments called "mares' tails" (cirrus uncinus; Figure 5–3a).
	Cirrostratus (Cs)	Thin sheet of white ice-crystal clouds that may give the sky a milky look. Sometimes produces halos around the Sun and Moon (Figure 5–3b).
	Cirrocumulus (Cc)	Thin, white ice-crystal clouds. In the form of ripples or waves, or globular masses all in a row. May produce a "mackerel sky." Least common of high clouds (Figure 5–3c).
Middle clouds—2000–6000 m (6500 to 20,000 ft)	Altocumulus (Ac)	White to gray clouds often made up of separate globules; "sheepback" clouds (Figure 5–4a).
	Altostratus (As)	Stratified veil of clouds that is generally thin and may produce very light precipitation. When thin, the Sun or Moon may be visible as a "bright spot," but no halos are produced (Figure 5–4b).
Low clouds—below 2000 m (6500 ft)	Stratus (St)	Low uniform layer resembling fog but not resting on the ground. May produce drizzle.
	Stratocumulus (Sc)	Soft, gray clouds in globular patches or rolls. Rolls may join together to make a continuous cloud.
	Nimbostratus (Ns)	Amorphous layer of dark gray clouds. One of the chief precipitation-producing clouds (Figure 5–5).
Clouds of vertical development	Cumulus (Cu)	Dense, billowy clouds often characterized by flat bases. May occur as isolated clouds or closely packed (Figure 5–6).
	Cumulonimbus (Cb)	Towering cloud, sometimes spreading out on top to form an "anvil head." Associated with heavy rainfall, thunder, lightning, hail, and tornadoes (Figure 5–7).

(a)

Cirrus Clouds

(b)

Cirrostratus

(c)

Cirrocumulus

(a)

Altocumulus

(b)

Altostratus

Nimbostratus

Cumulus Clouds

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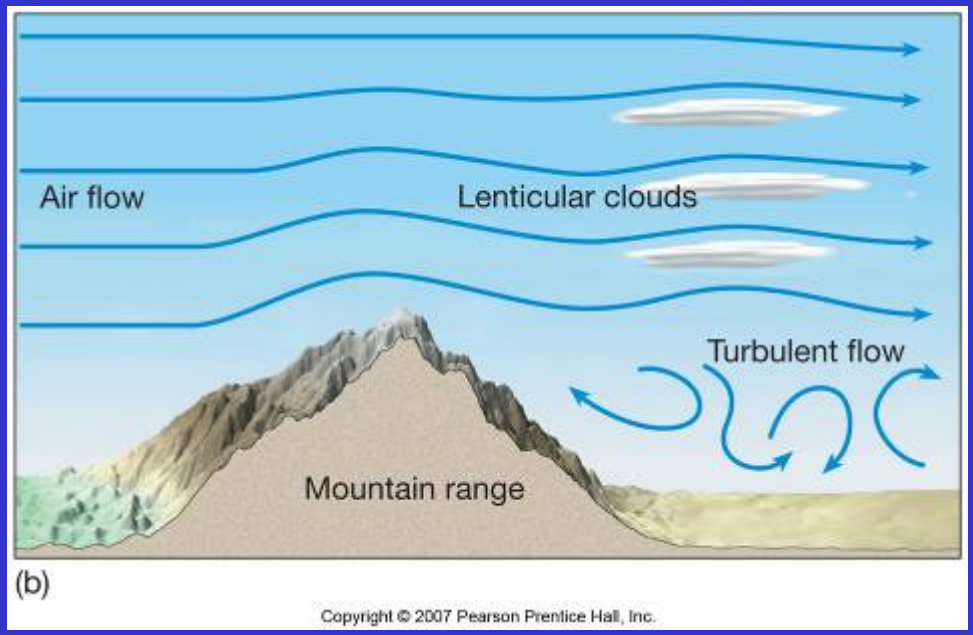
Aircraft Contrails

Cumulonimbus

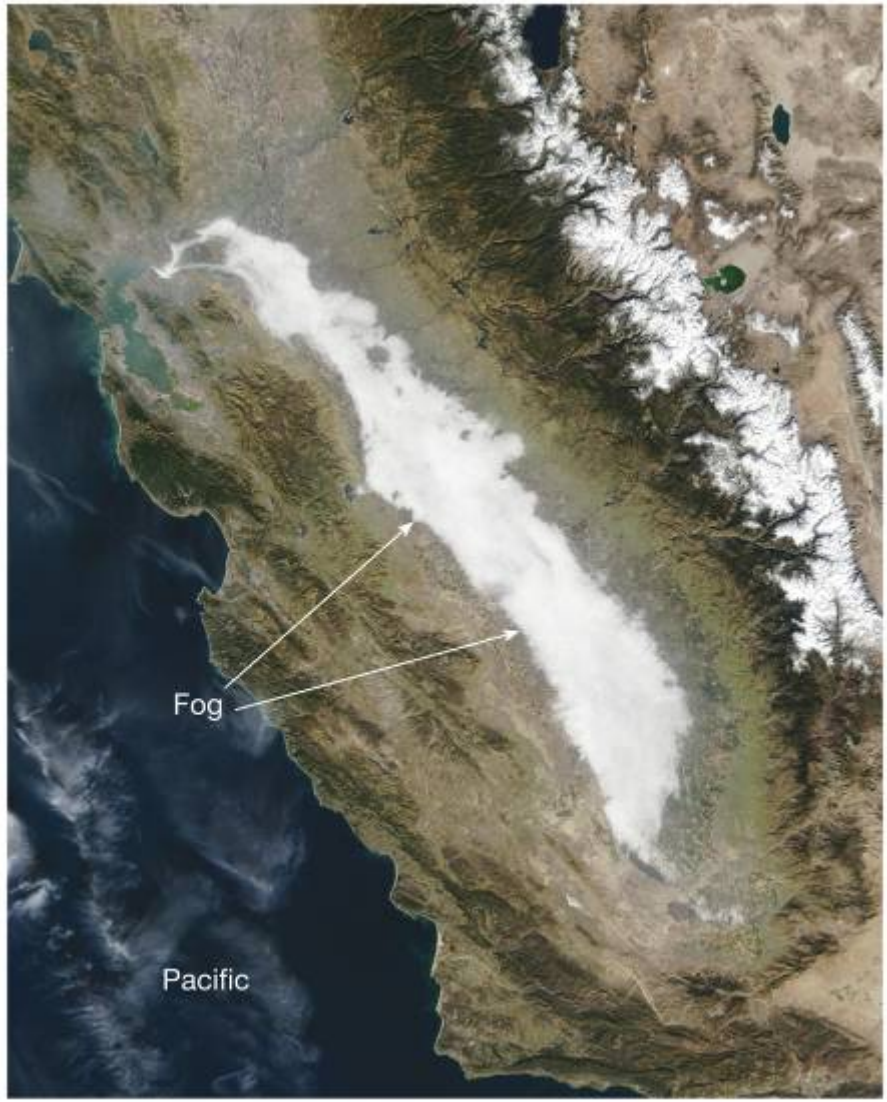
Lenticular Clouds



Types of Fog

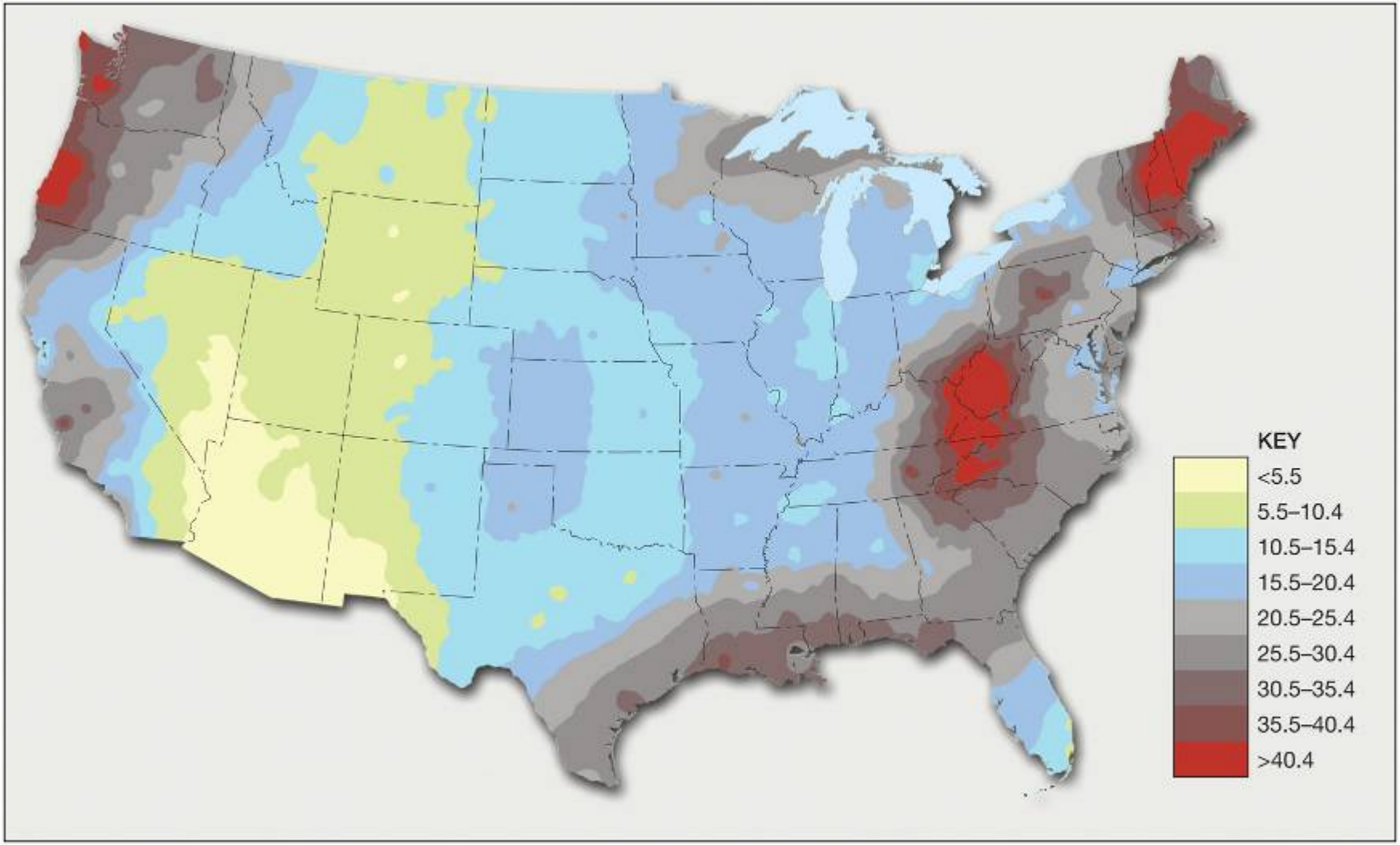
Radiation
Valley
Upslope
Advection
Evaporation
Precipitation

Valley Fog



Advection Fog

Steam Fog



Days Per Year with Heavy Fog

Forces Acting on Cloud Droplets and Raindrops

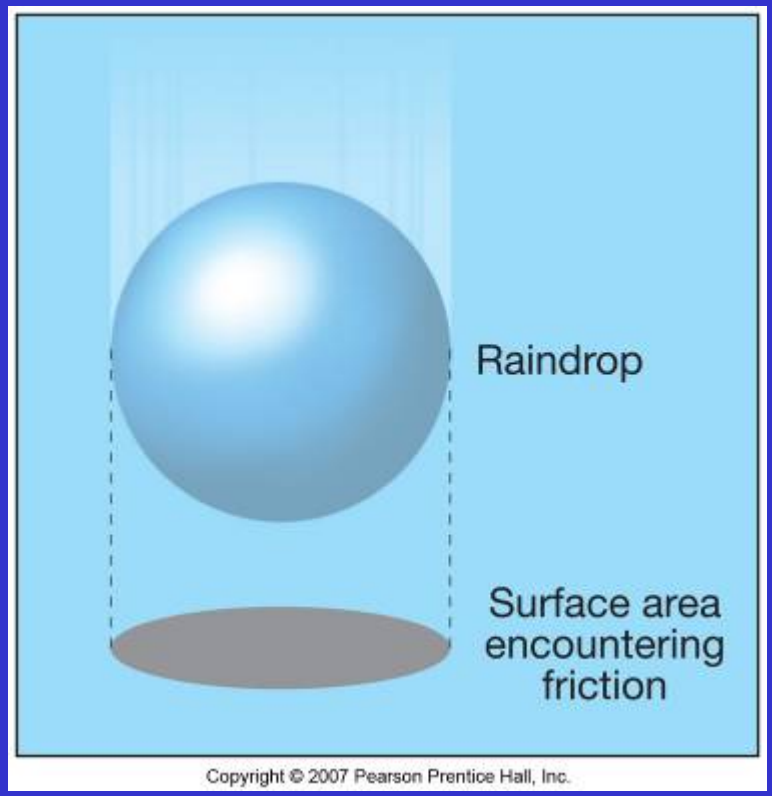
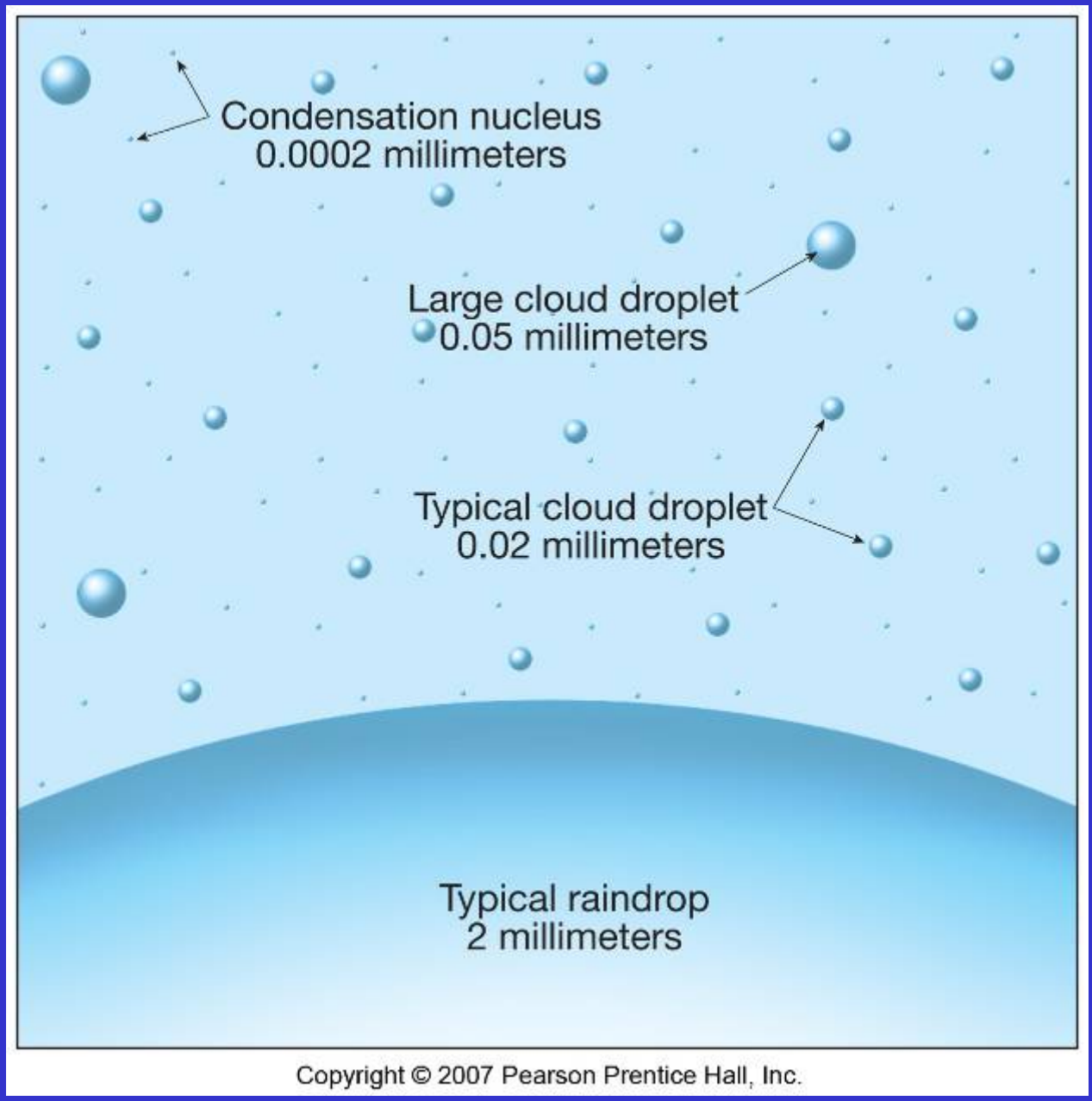


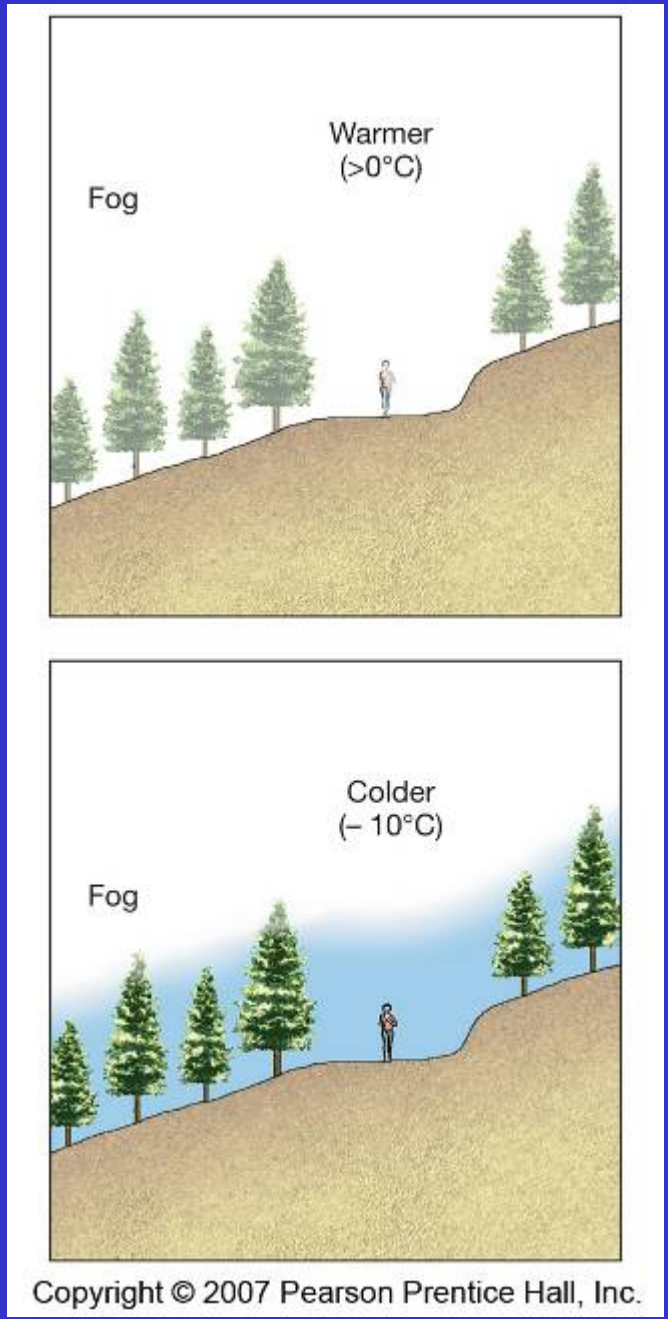
TABLE 5-A Maximum fall distance before evaporation

Drop diameter (μm)	Maximum fall distance (m)
2500	280,000
1000	42,000
100	150
10	0.033
0	0.0000033



Size of Raindrops Compared to Cloud Droplets

Fog at Warmer and Cooler Temperatures



Bergeron Process

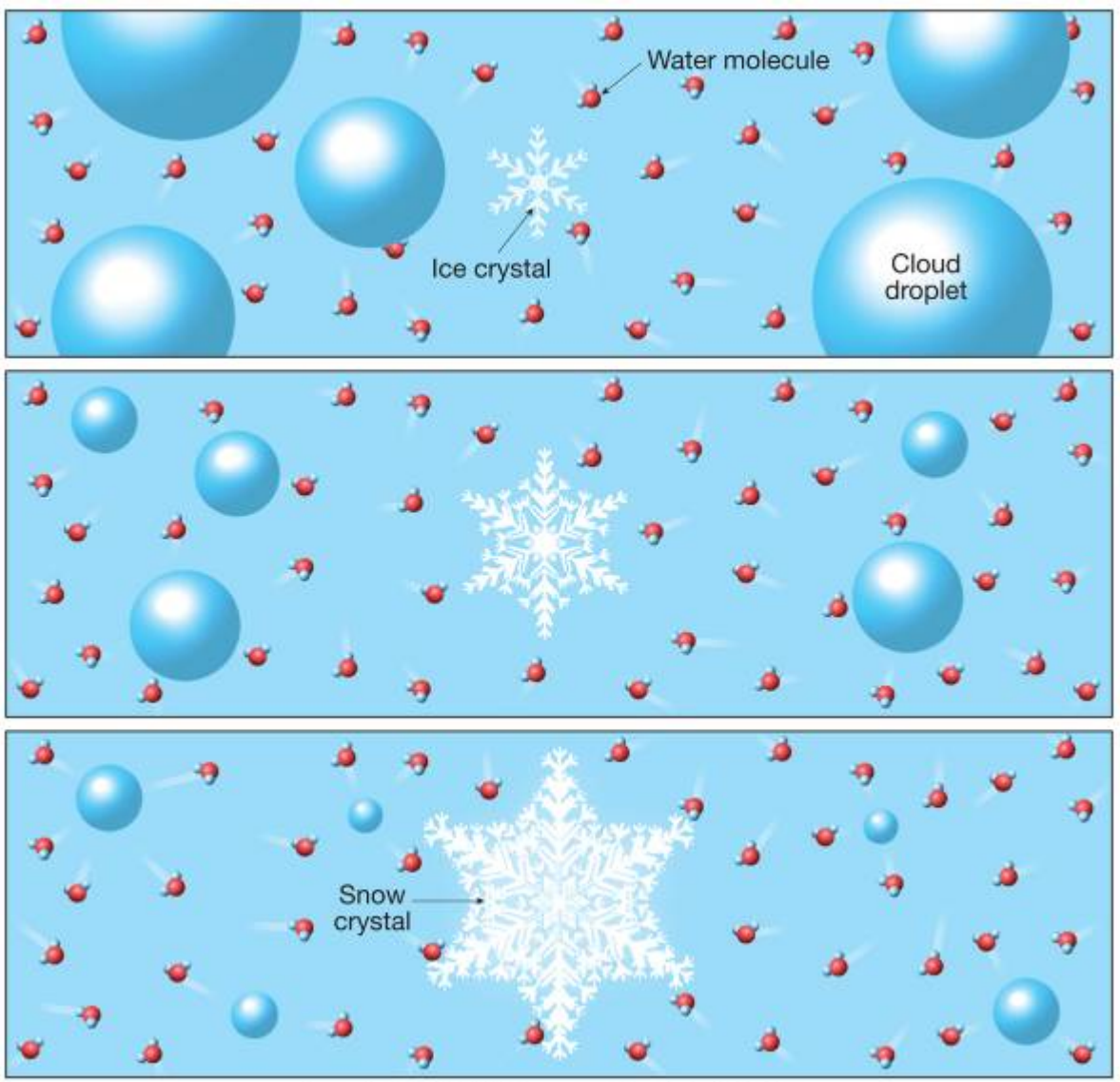
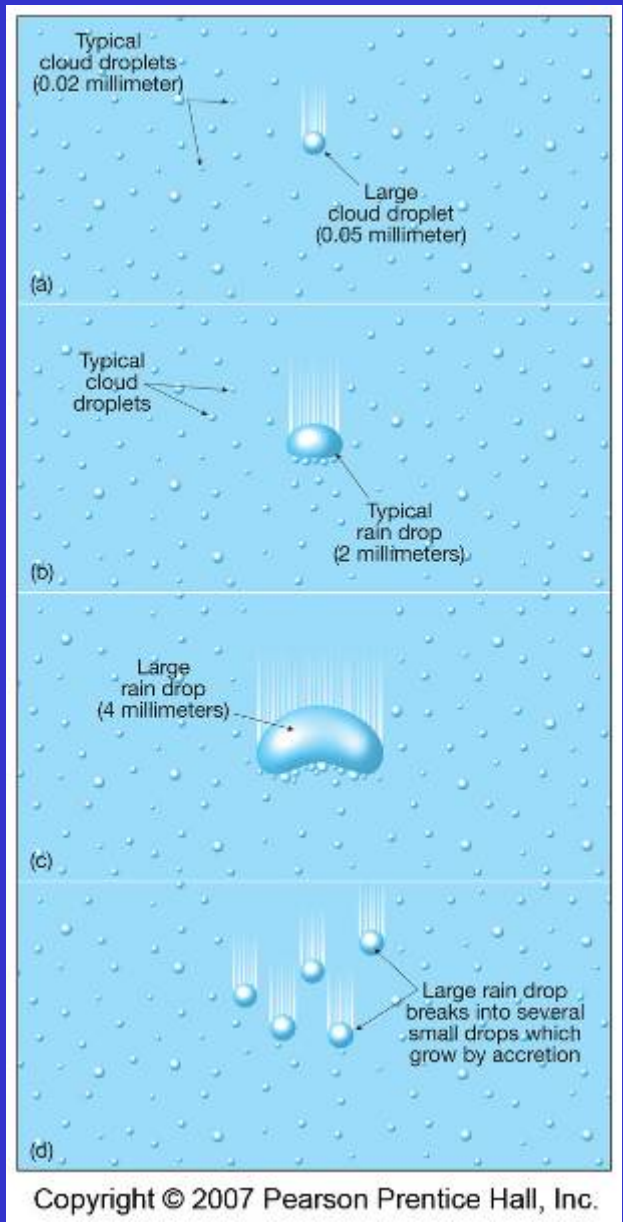
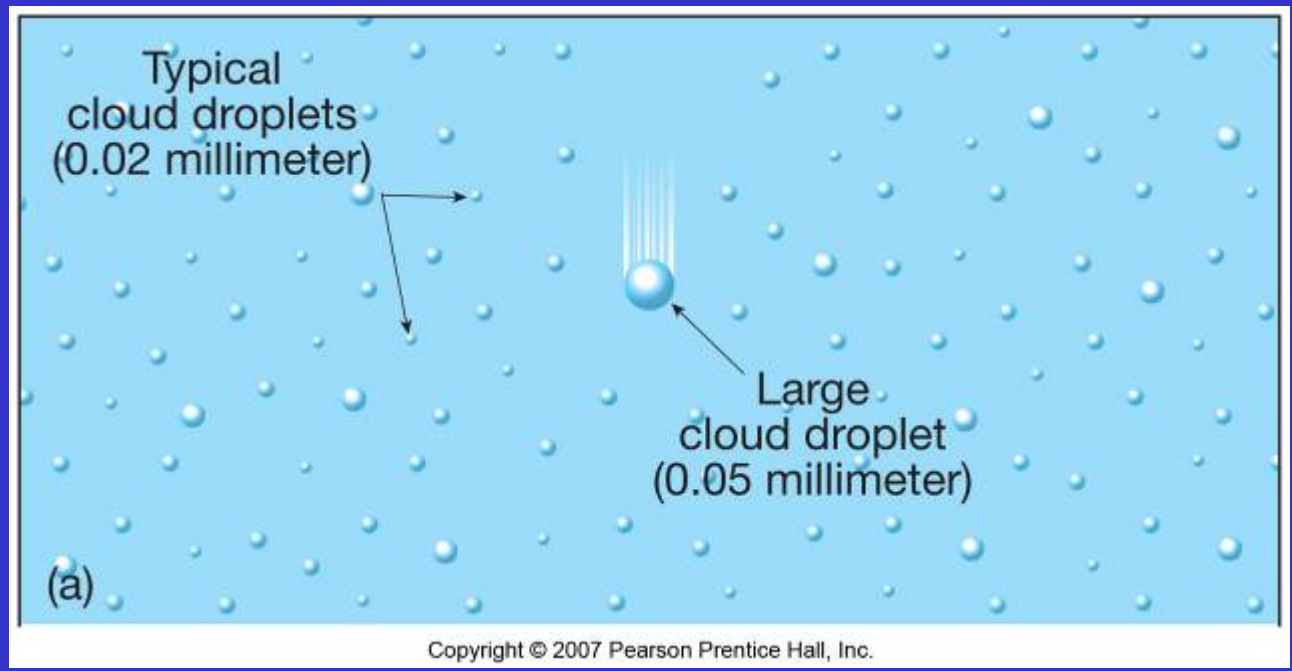


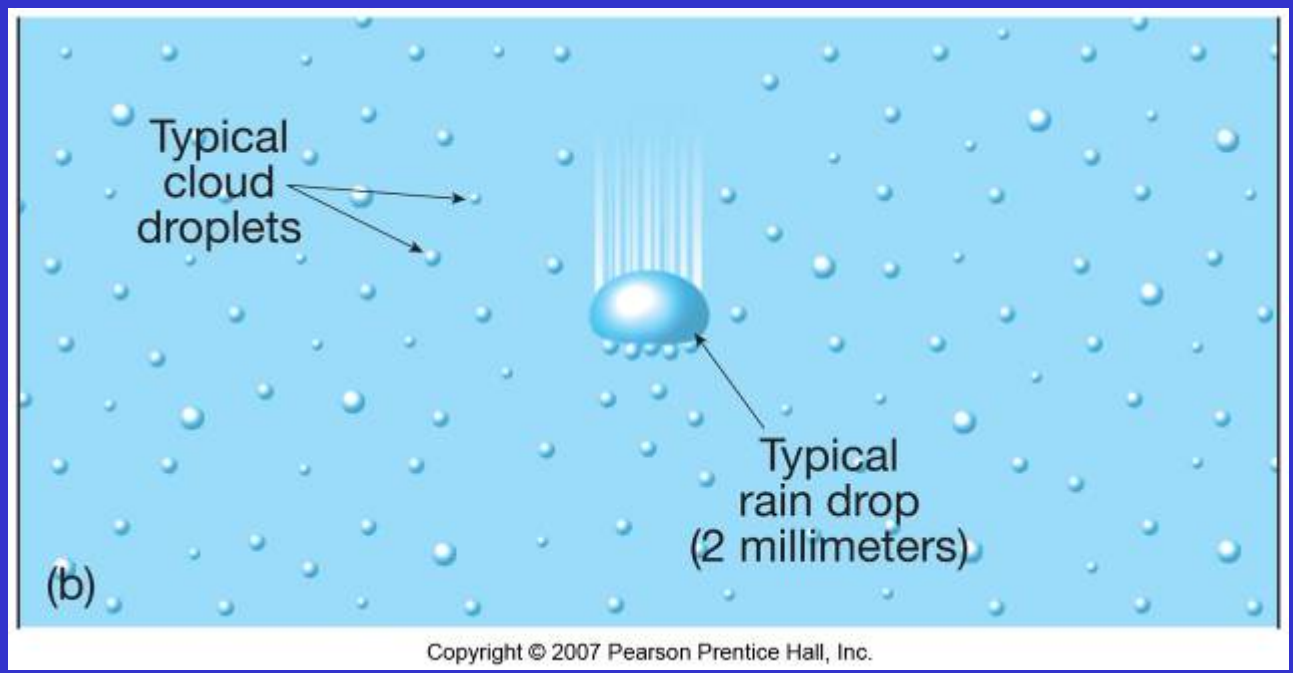
TABLE 5-2 Relative humidity with respect to ice when relative humidity with respect to water is 100 percent

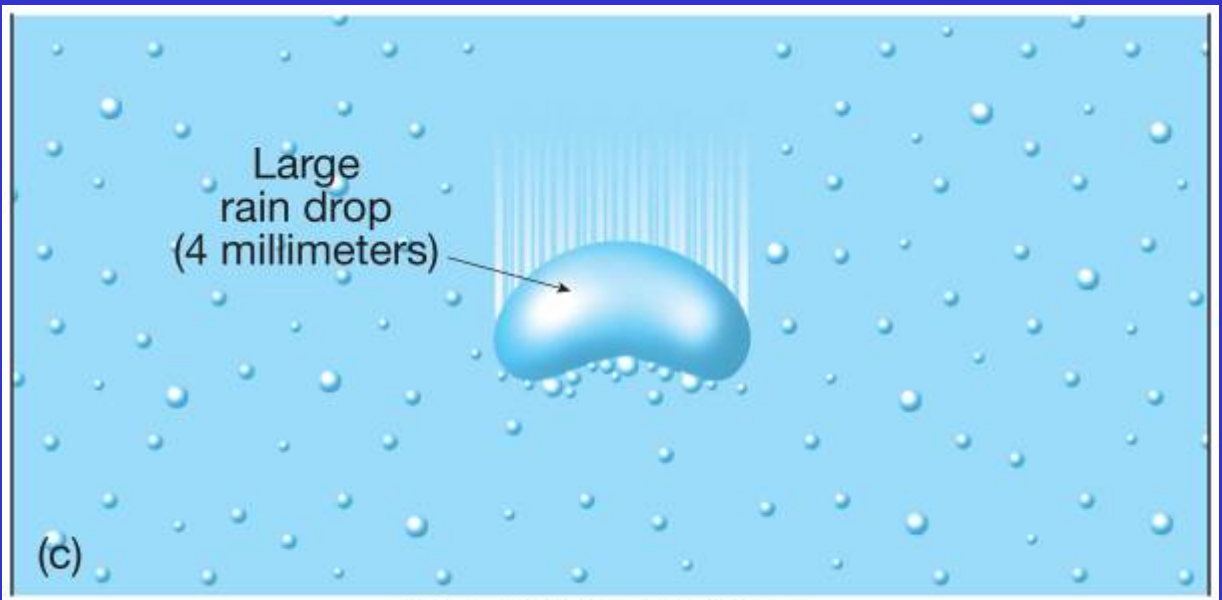
	Relative humidity with respect to:	
Temperature (°C)	**Water**	**Ice**
0	100%	100%
−5	100%	105%
−10	100%	110%
−15	100%	115%
−20	100%	121%



The Collision-Coalescence Process







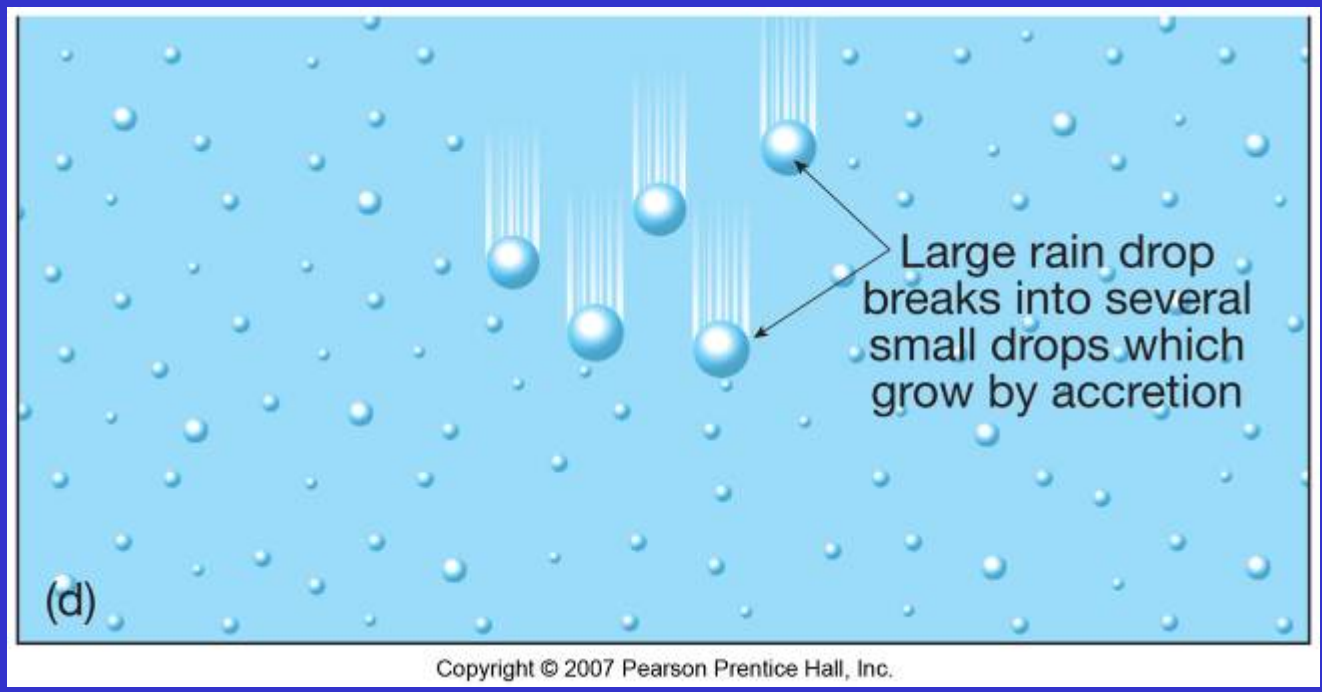
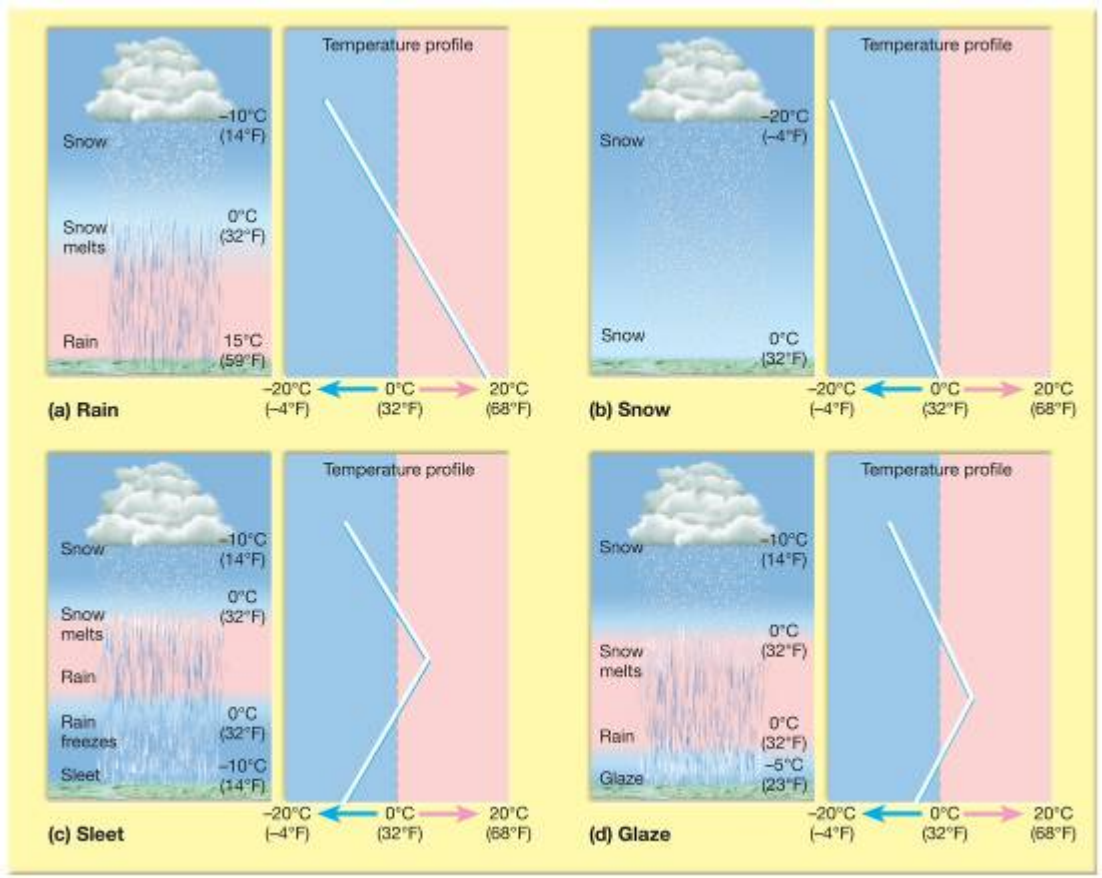


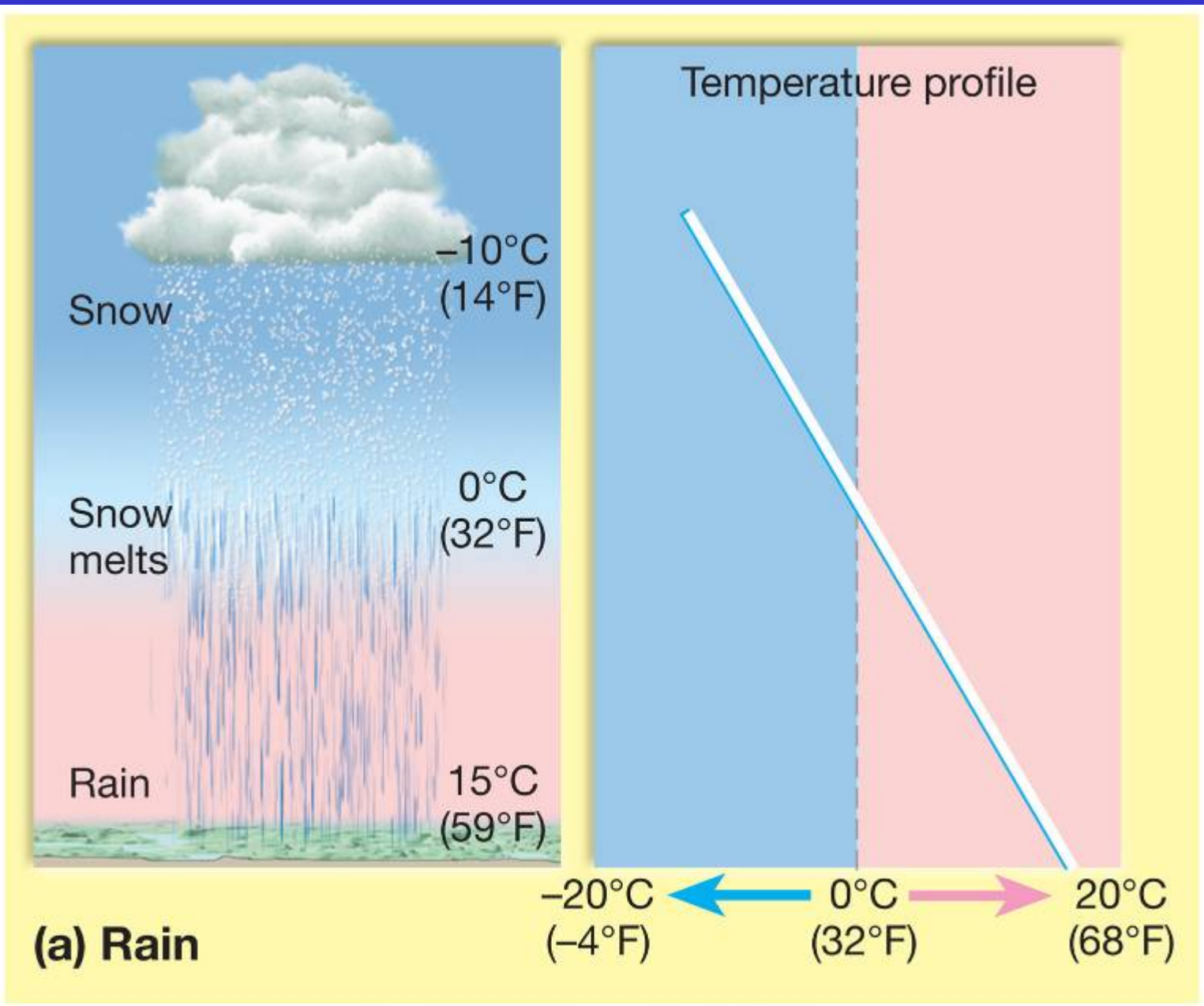
TABLE 5-3 Fall velocity of water drops

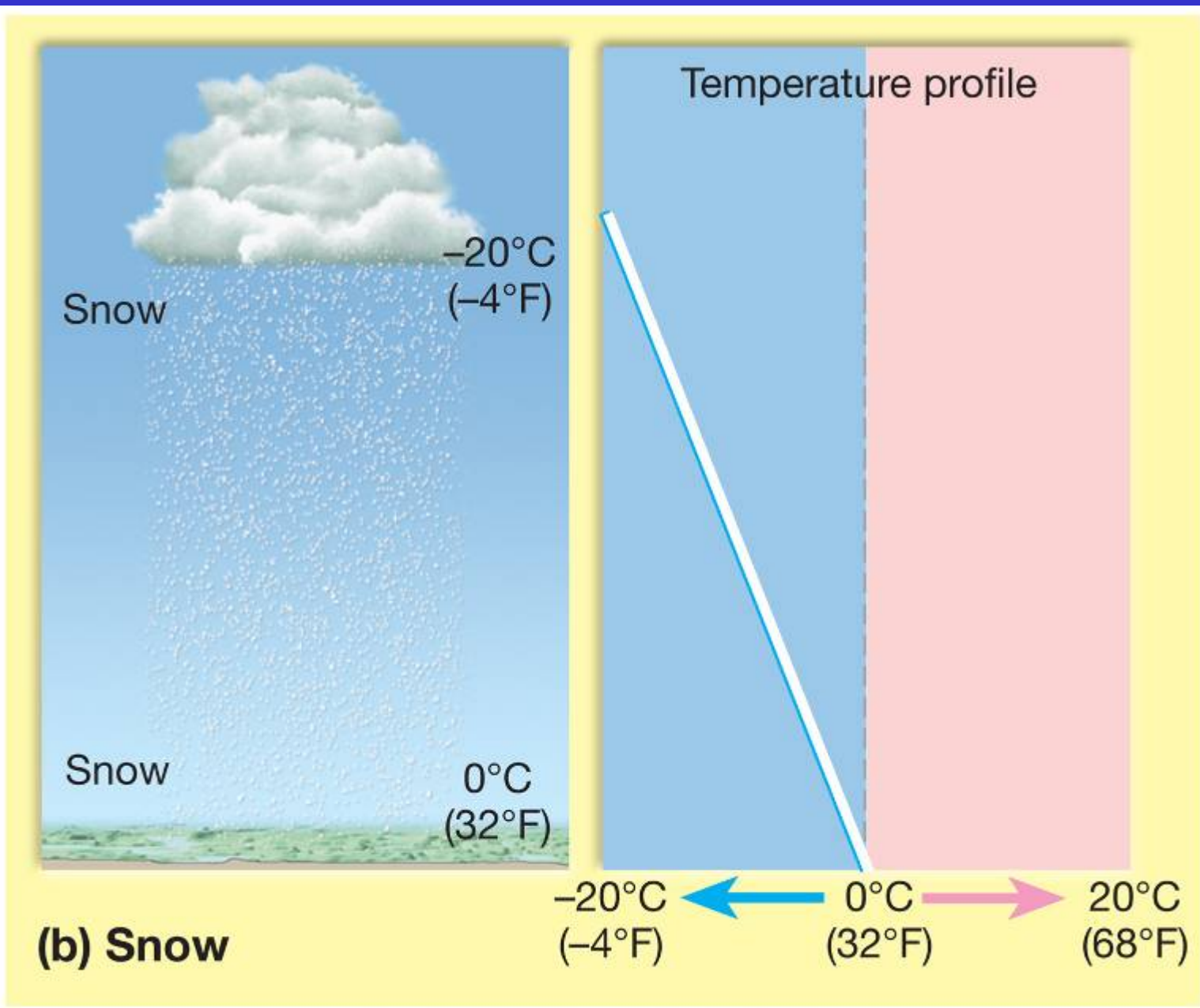
Types	Diameter (millimeters)	Fall velocity (km/hr)	Fall velocity (miles/hr)
Small cloud droplets	0.01	0.01	0.006
Typical cloud droplets	0.02	0.04	0.03
Large cloud droplets	0.05	0.3	0.2
Drizzle drops	0.5	7	4
Typical rain drops	2.0	23	14
Large rain drops	5.0	33	20

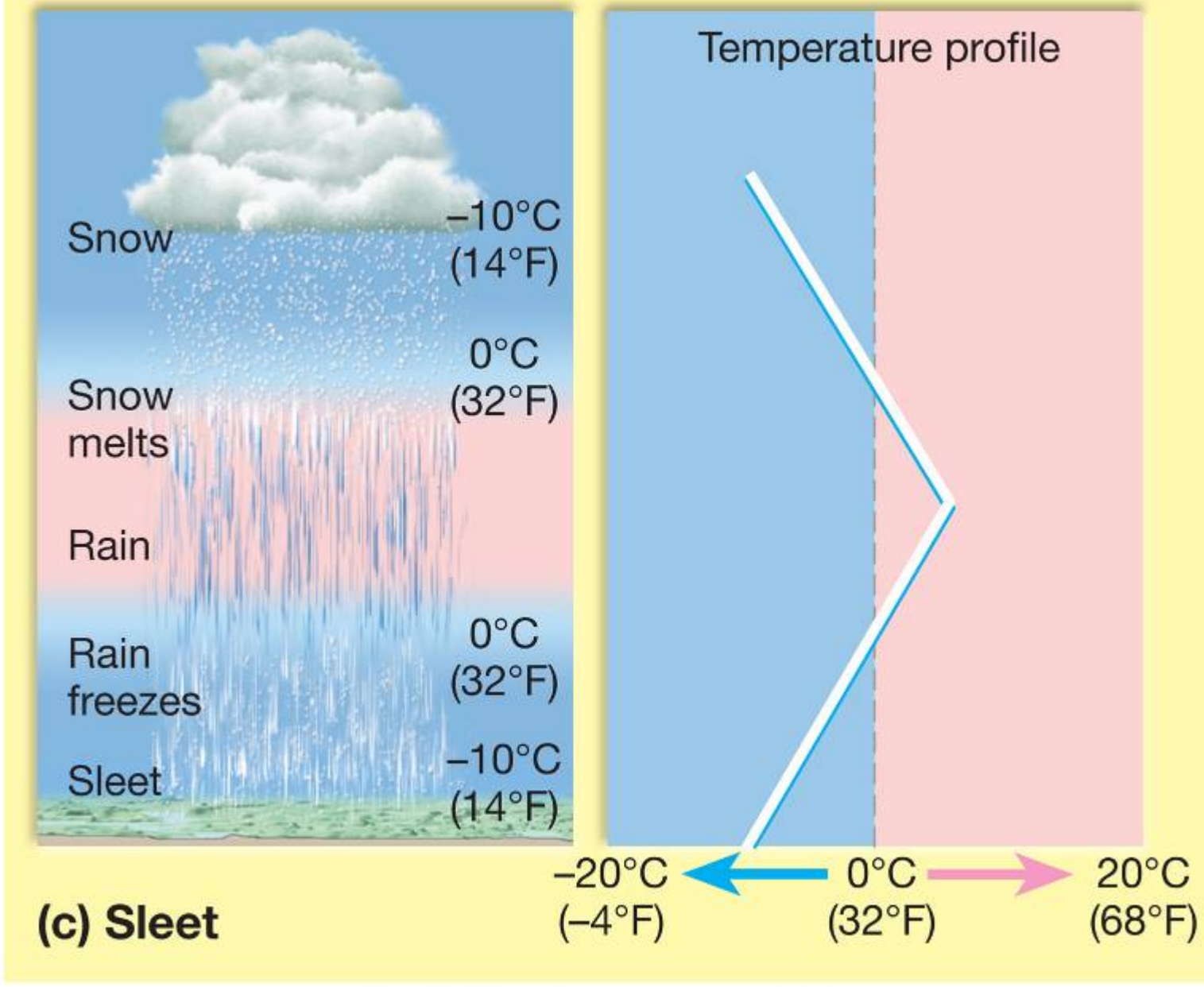
Data from Smithsonian Meteorological Tables

Precipitation Types and Their Temperature Profiles

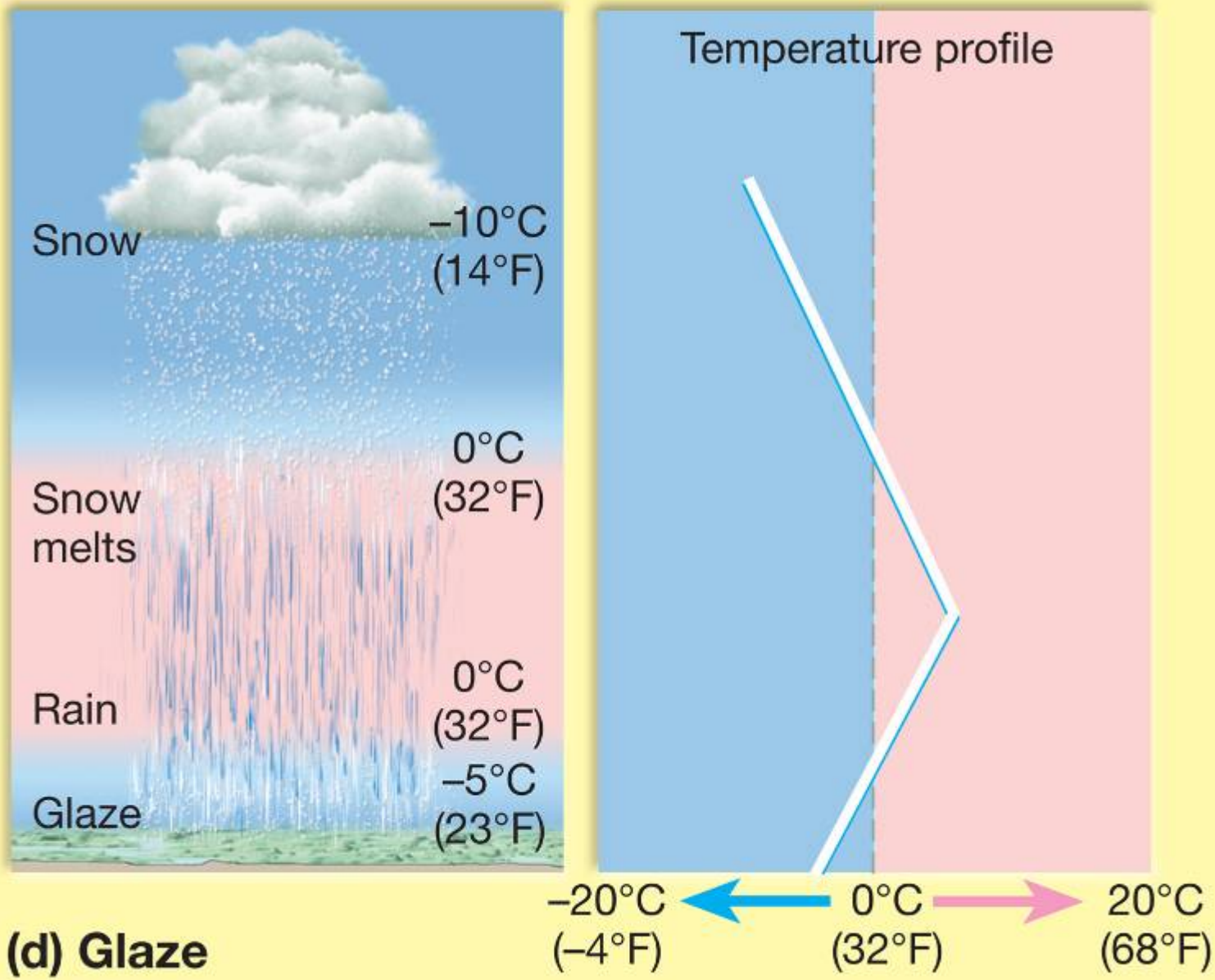








(c) Sleet



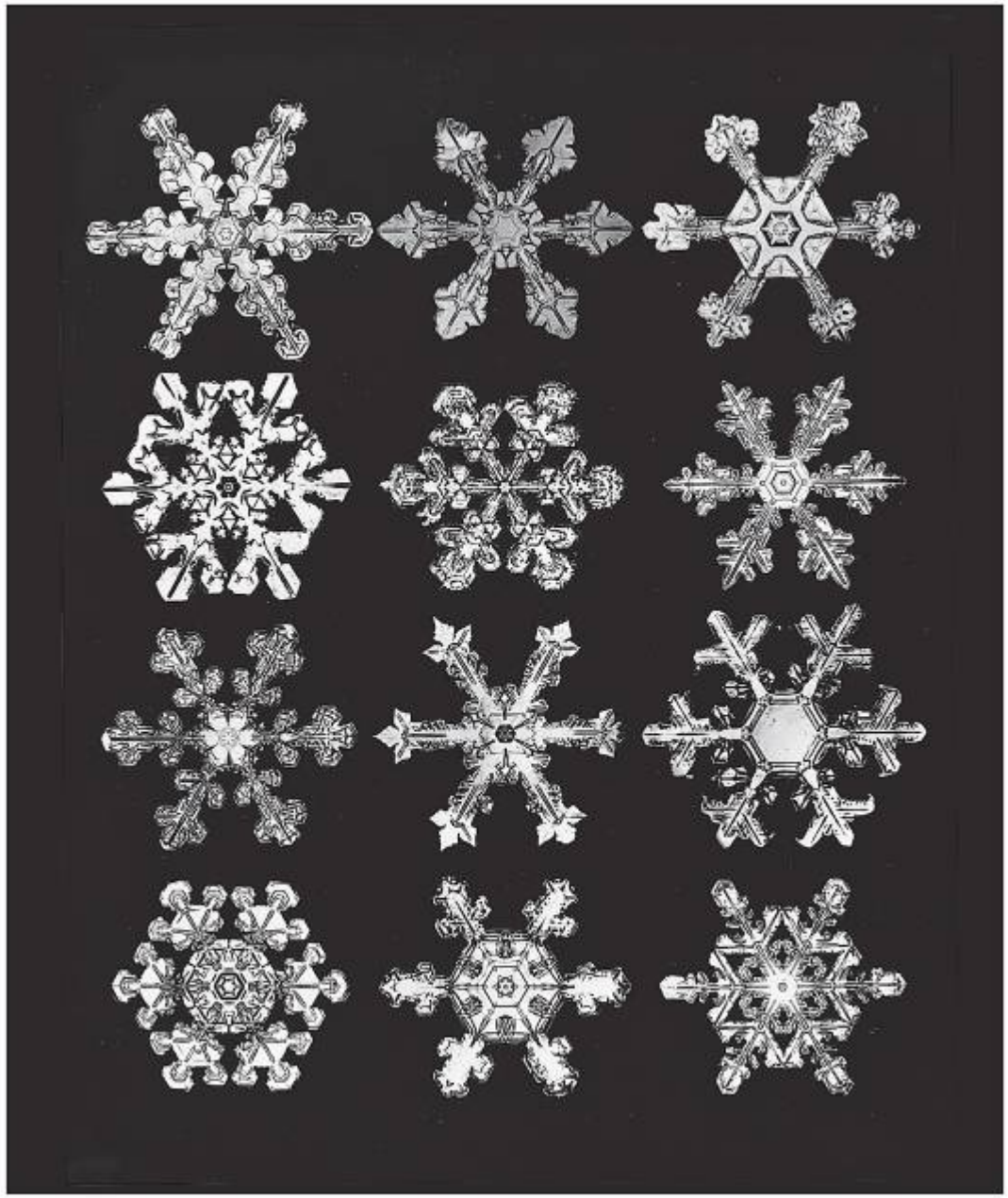
(d) Glaze

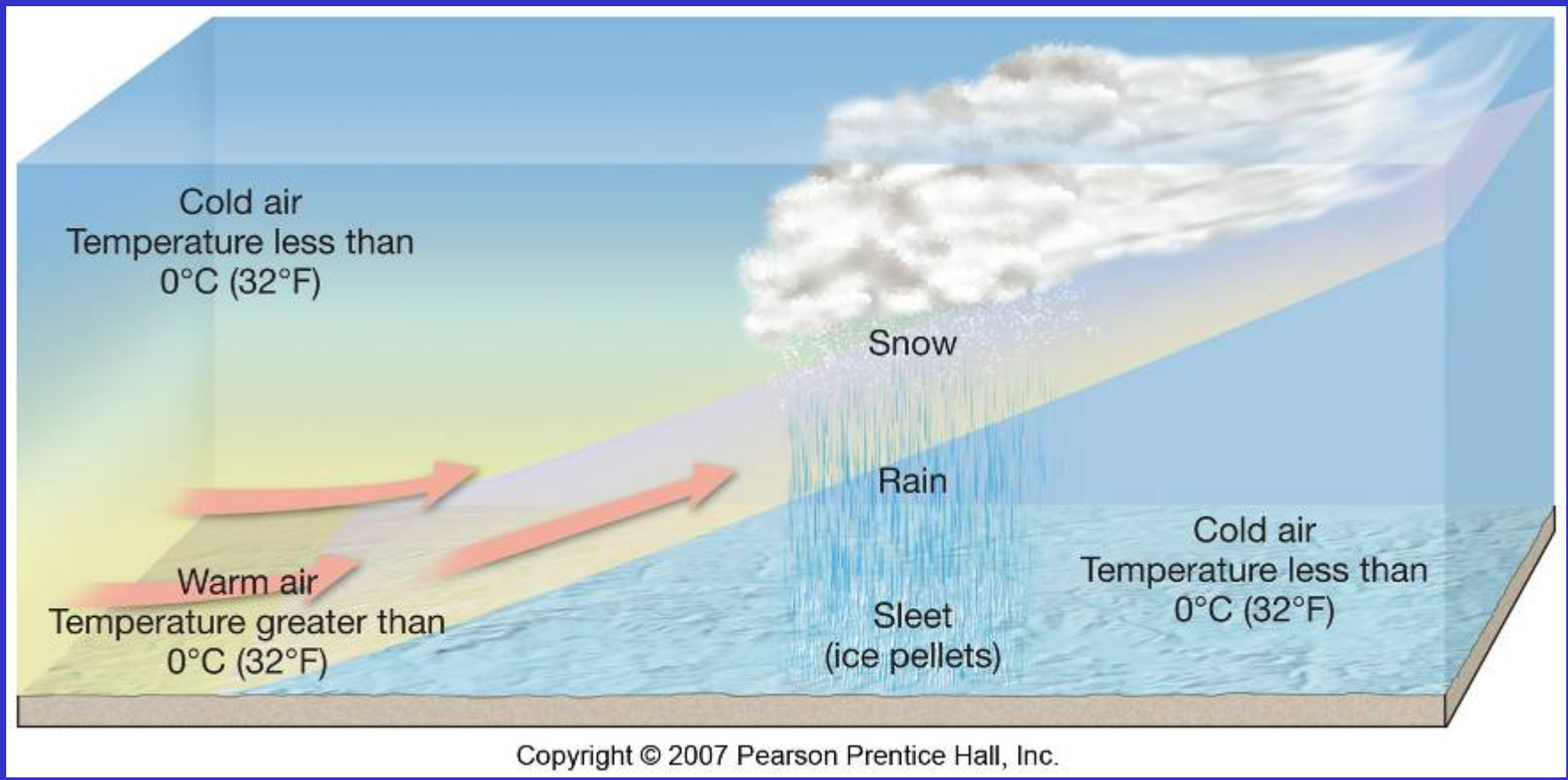
TABLE 5-4 Types of precipitation

Type	Approximate size	State of water	Description
Mist	0.005 to 0.05 mm	Liquid	Droplets large enough to be felt on the face when air is moving 1 meter/second. Associated with stratus clouds.
Drizzle	Less than 0.5 mm	Liquid	Small uniform drops that fall from stratus clouds, generally for several hours.
Rain	0.5 to 5 mm	Liquid	Generally produced by nimbostratus or cumulonimbus clouds. When heavy, size can be highly variable from one place to another.
Sleet	0.5 to 5 mm	Solid	Small, spherical to lumpy ice particles that form when raindrops freeze while falling through a layer of subfreezing air. Because the ice particles are small, any damage is generally minor. Sleet can make travel hazardous.
Glaze	Layers 1 mm to 2 cm thick	Solid	Produced when supercooled raindrops freeze on contact with solid objects. Glaze can form a thick coating of ice having sufficient weight to seriously damage trees and power lines.
Rime	Variable accumulations	Solid	Deposits usually consisting of ice feathers that point into the wind. These delicate frostlike accumulations form as supercooled cloud or fog droplets encounter objects and freeze on contact.
Snow	1 mm to 2 cm	Solid	The crystalline nature of snow allows it to assume many shapes, including six-sided crystals, plates, and needles. Produced in supercooled clouds where water vapor is deposited as ice crystals that remain frozen during their descent.
Hail	5 mm to 10 cm or larger	Solid	Precipitation in the form of hard, rounded pellets or irregular lumps of ice. Produced in large convective, cumulonimbus clouds, where frozen ice particles and supercooled water coexist.
Graupel	2 mm to 5 mm	Solid	Sometimes called "soft hail," graupel forms as rime collects on snow crystals to produce irregular masses of "soft" ice. Because these particles are softer than hailstones, they normally flatten out upon impact.

Virga

Snow Crystals

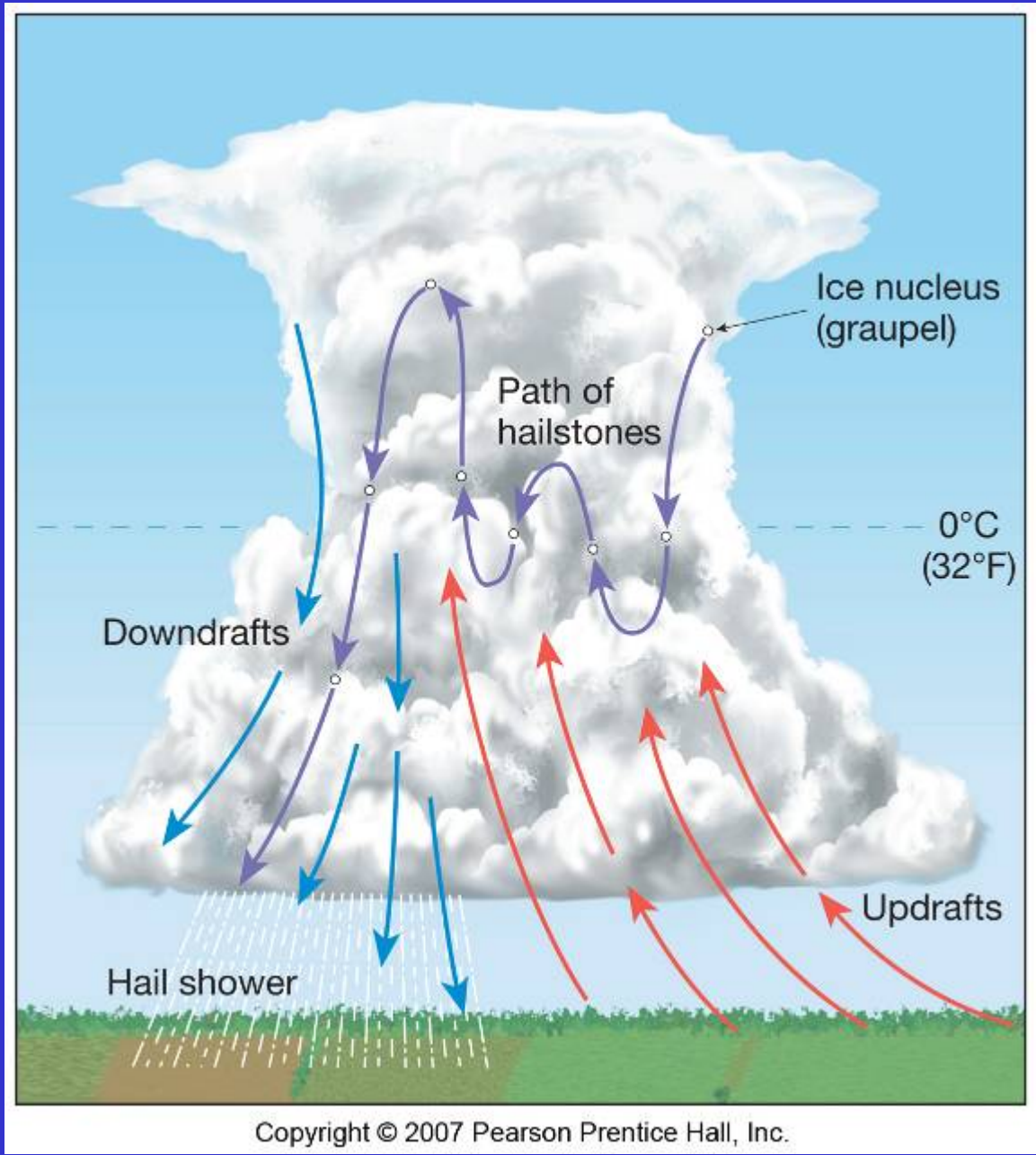




Formation of Sleet

Glaze

Formation of Hail

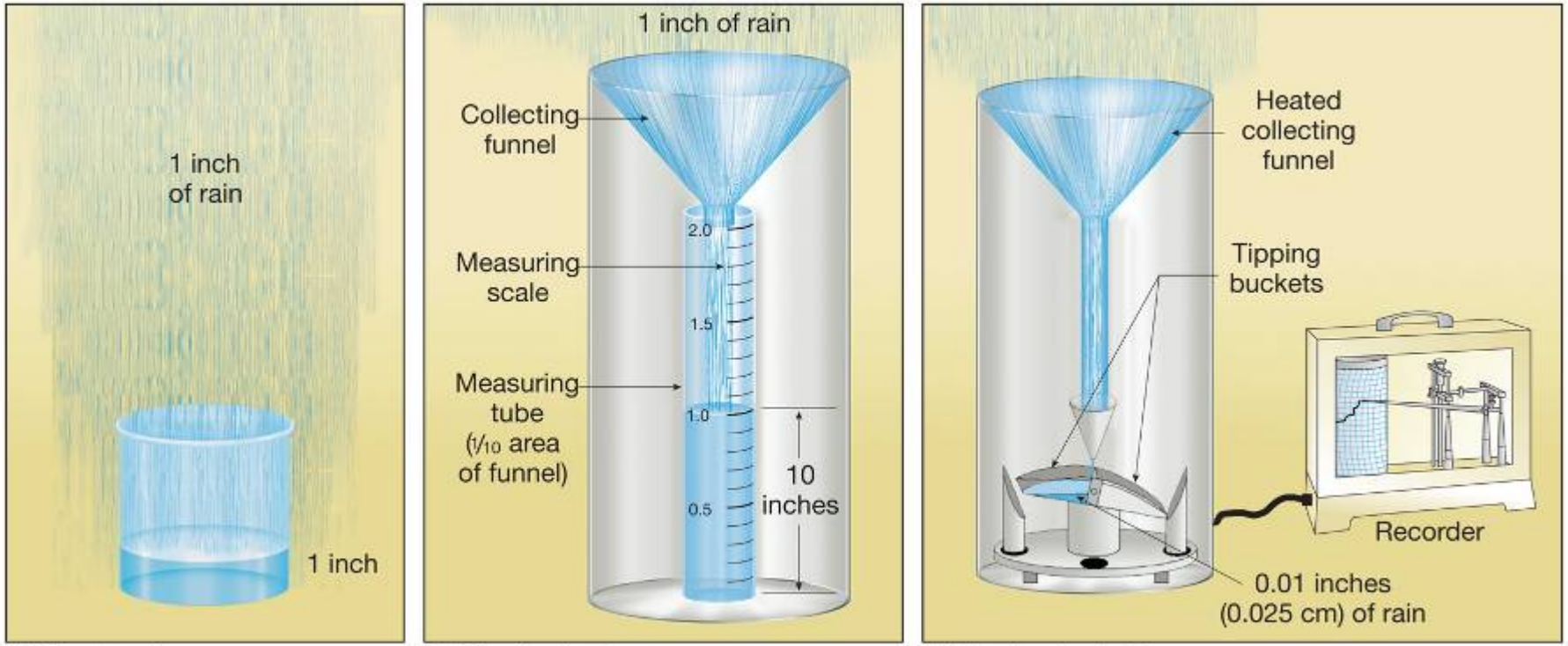


Hailstone
Cross section

Hail
Damage

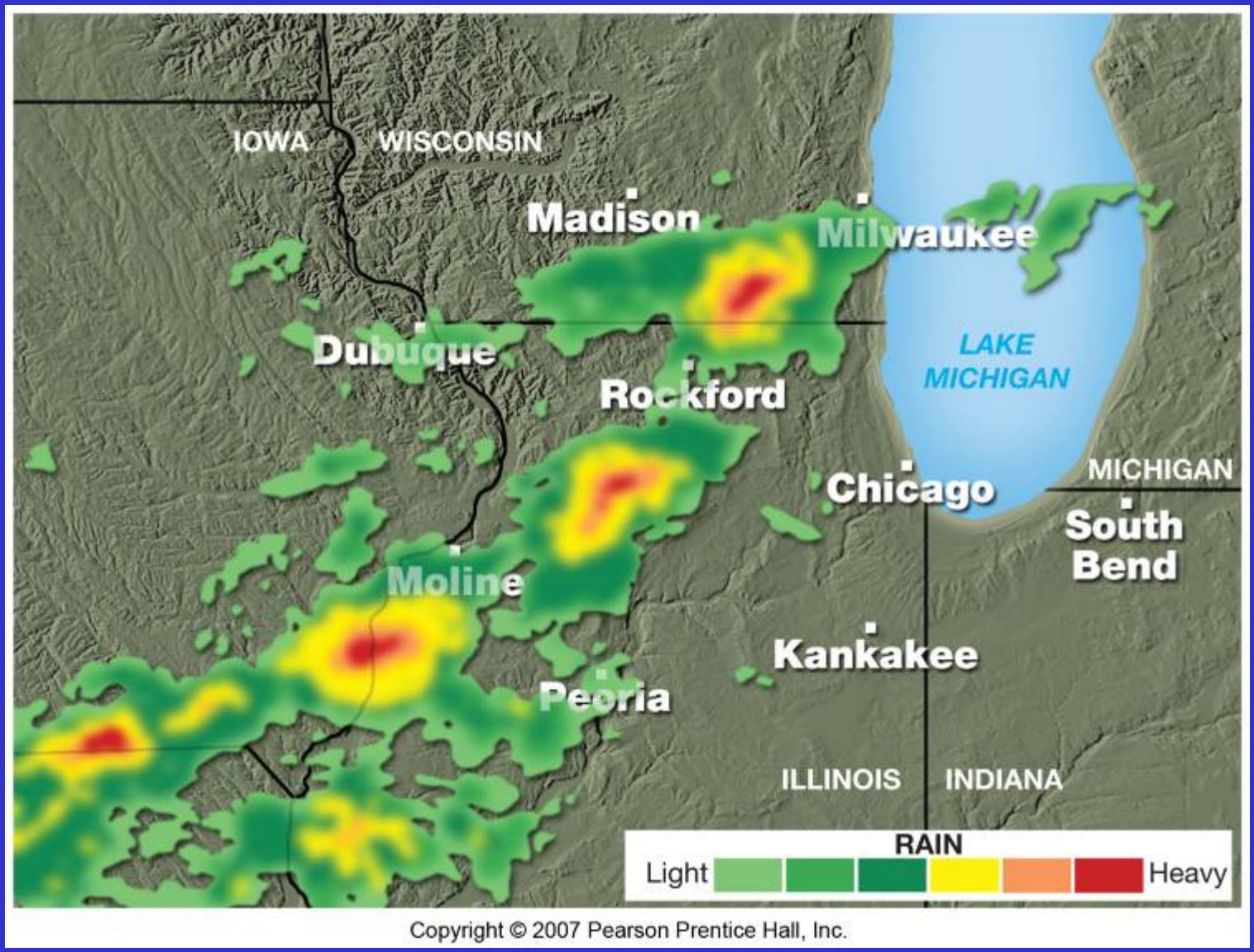
Rime

Precipitation Measurement



(a) Simple rain gauge (b) Standard rain gauge (c) Tipping–bucket gauge

Rain gauge
with
metal slats
to
minimize
"under-catch"
in
windy
conditions



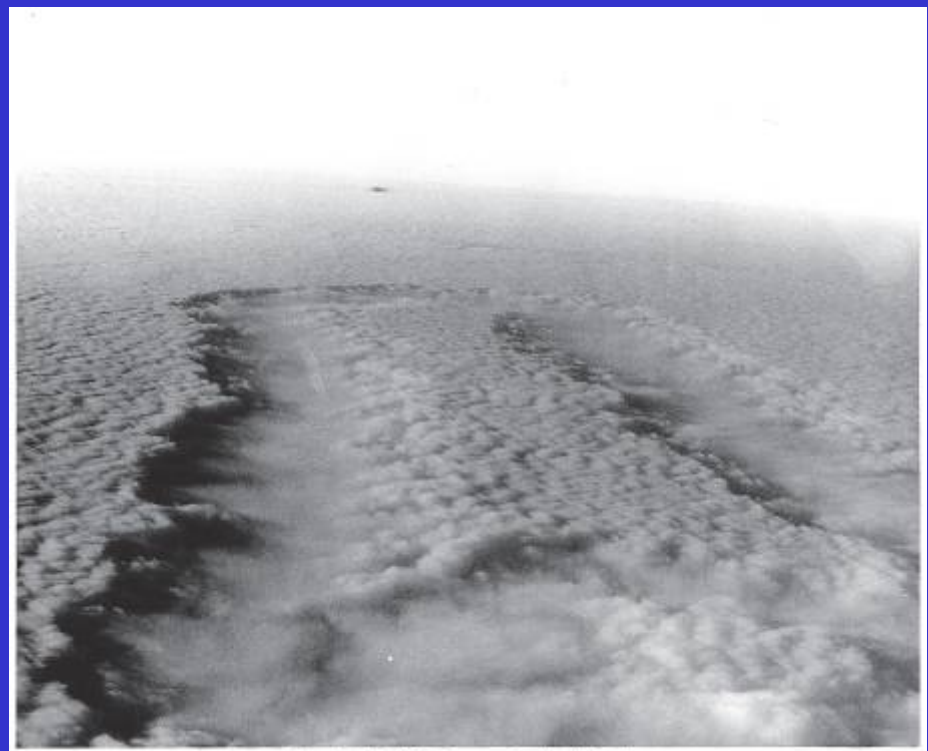
Doppler Radar Display

Weather Modification

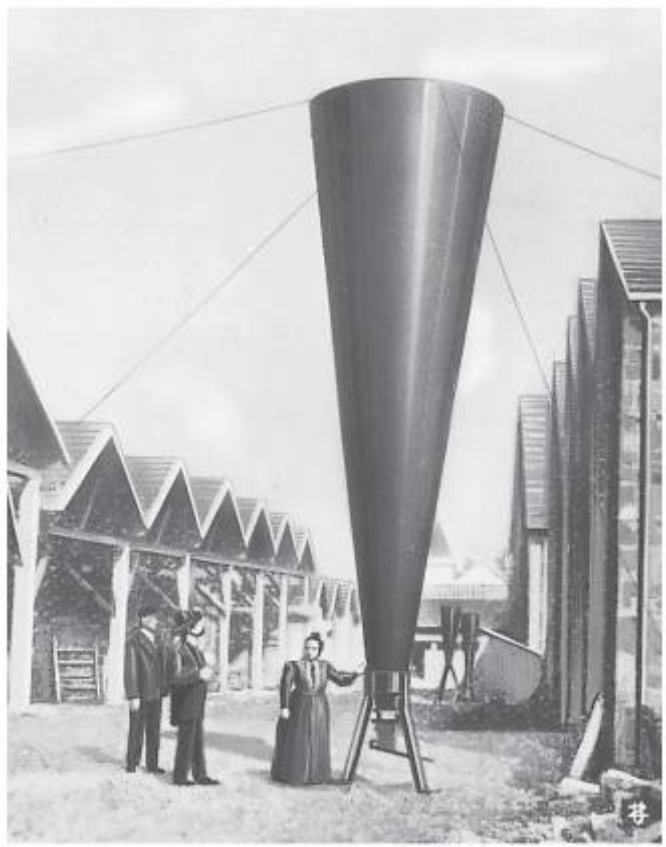
Cloud Seeding
Fog Dispersal
Hail Suppression
Frost Prevention

Cloud Seeding

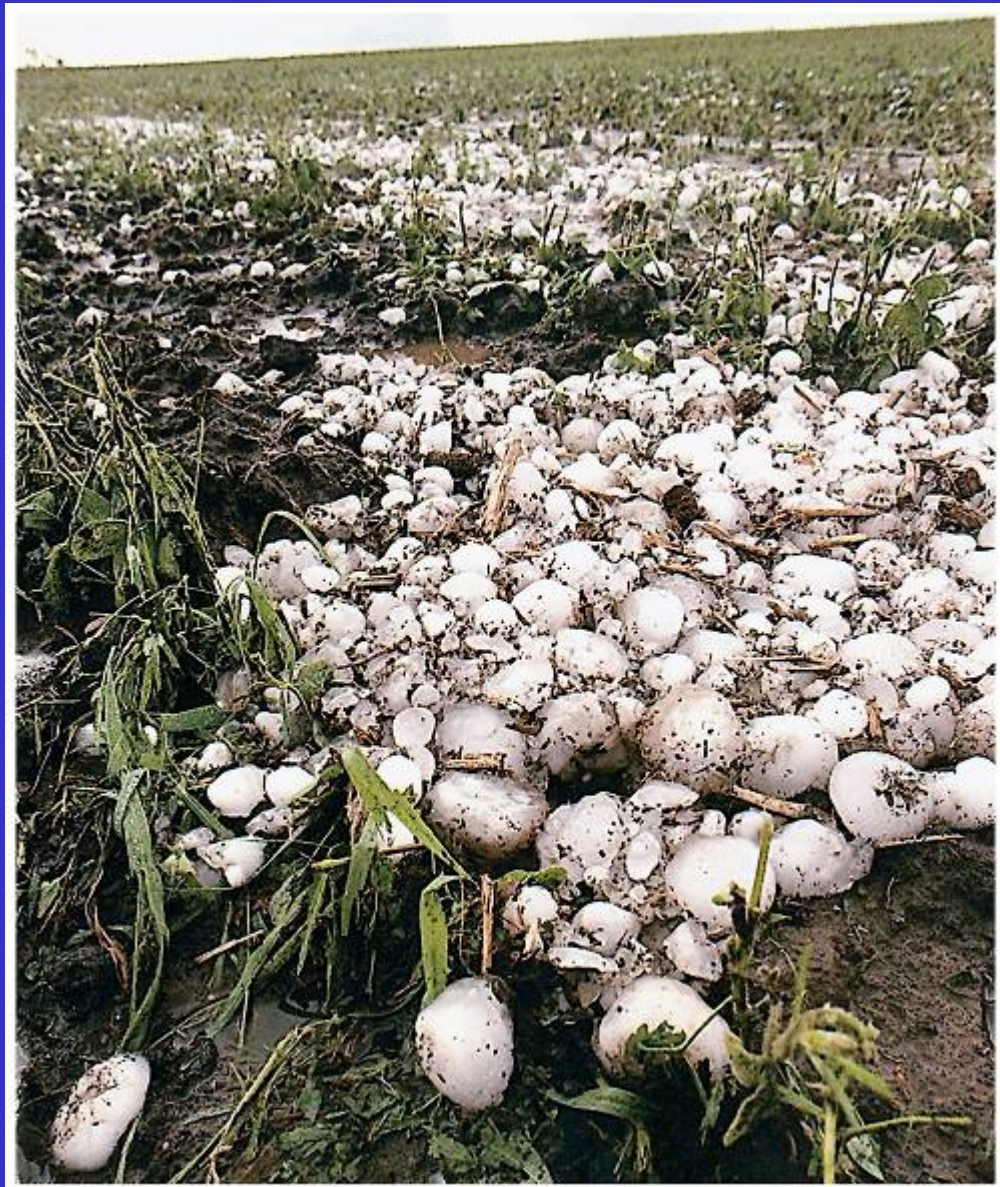
Cloud Dispersal



Hail Suppression



Hail Cannon

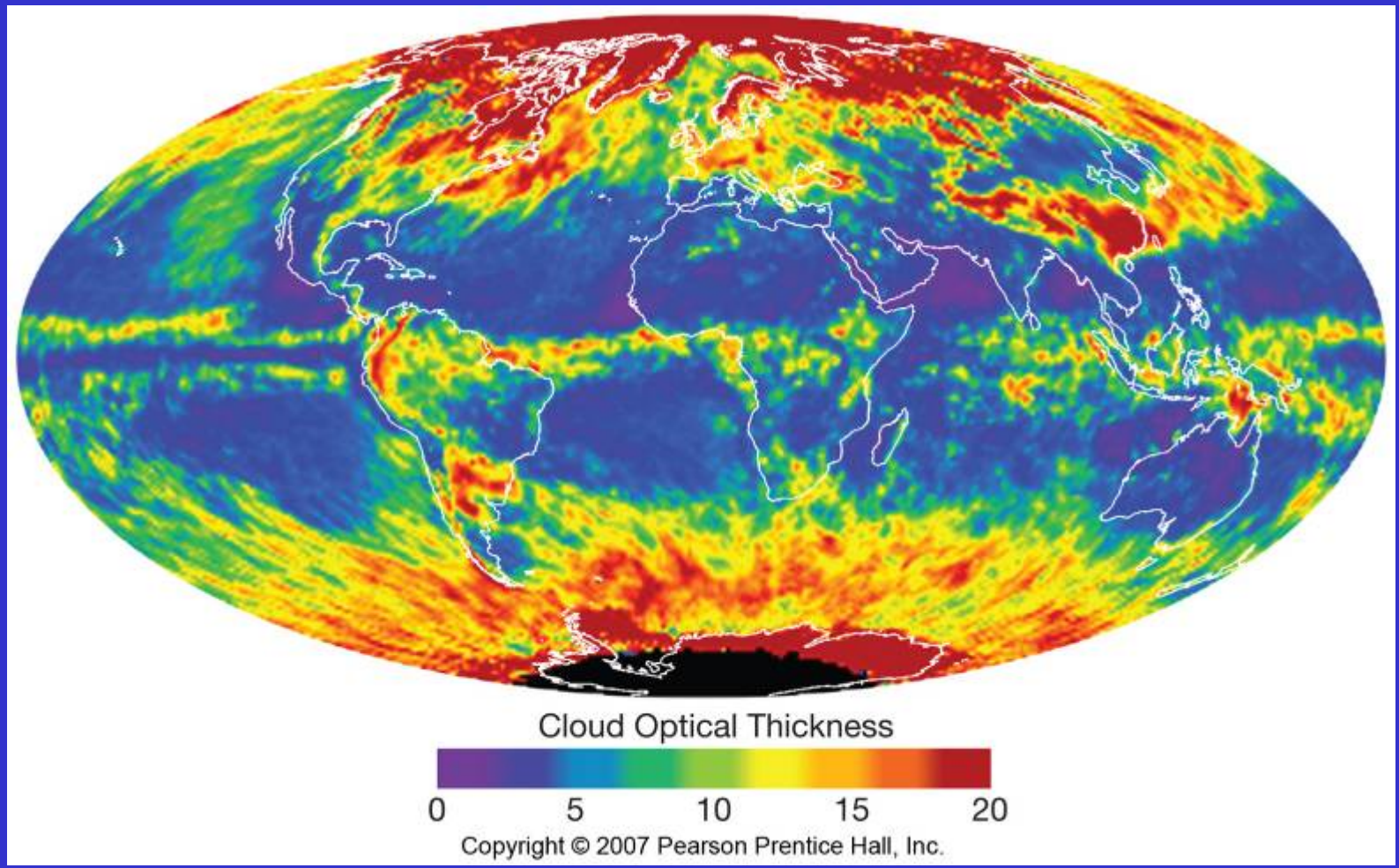


Frost Suppression

Sprinklers

Wind Machines

Orchard Heaters



Role of Clouds in the Climate System

Chapter 5

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