



الدرس الأول: الماء

CHAPTER I: CYCLE OF WATER



A.T.INAM

CHAPTER ONE

' CYCLE OF WATER '

Allah The Almighty reveals in Qoran that all the living creatures on earth are created from water:

وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ ۖ حَتَّىٰ ۝ (١٦- الانبياء- 30)

This Qoranic Verse clearly indicates that 'Water' is base of life.

Qoran also reveals the 'Uniqueness' of water; as Allah The Almighty knows the movements of water: i) when water goes up into the sky (gaseous form), ii) when water comes down on the earth as rainy water (vapour cools down to liquid form) & iii) when water goes into the earth (earth absorbs the rainy water and retains it there in the form of 'ground water i.e. liquid form). Qoran also reveals the existence of 'solid' form water i.e. '*Ice'

يَعْلَمُ مَا يَلْجِ فِي الْأَرْضِ وَمَا يَخْرُجُ مِنْهَا وَمَا يَنْزِلُ مِنْ سَّمَاءٍ وَمَا يَرْجُ مِنْهَا ۖ وَهُوَ

الرَّحِيمُ الْغَفُورُ ۝ (22- سبا- 2)

كَمَثَلِ رِيحٍ يَبْعَاضُ أَصَابَتْ حَرَّتَ مَوْمٍ فَلَمَّوْا أَنْفُسَهُمْ فَأَهْلَكَتْهُ ۖ (4- العمرن 117)

Qoran also reveals the existence of 'water cycle'. Actually, cycle of water is a means of transport of water from big reservoirs on earth, like oceans & seas to the distant places of earth. During the process of transportation, the water is cleaned and purified. This free gift to the mankind from The Almighty Allah is a 'boon', otherwise, it is beyond the human capacity to arrange door to door supply of pure, fresh and soft water free of cost.

وَلَقَدْ صَرَّفْنَاهُ بَيْنَكُمْ لِيَتَّكِرُوا ۖ ۝ (١٩- الفرقان- 55)

* Ice Crystals

The above holy Qoranic Verse also indicate the phases of cycle of water existing in the atmosphere. The water from main reservoirs on earth, like; oceans & seas changes to vapour, as and when Allah The Almighty blows hot air. This hot air converts the liquid water into vapour i.e. gaseous form:

وَالَّذِي ذَرَوْنَآ نَالْحَمِيلِ وَمَرَّآ نَالْجَبْرِيتِ يُسْرَآ نَالْمُقْسِمِتِ أَمْرَآ
(26- الذریت-4-1)

Being lighter, the vapour is taken up to wards the sky against the gravity, where vapour takes the shape of cloud. The cloud is scattered into the different quarters of sky, when Allah The Almighty blows the air current:

وَالْمُرْسَلِتِ عُرْنَآ نَالْخَصِيفِ عَصْفَآ وَالتَّشْرِيبِ مَشْرَآ نَالْفُرْقَانِ (29- المرسلات-4-1)

This is the time when people hopes for rain. But there is no surety* since Allah The Almighty says in Qoran that no one knows exactly, when the rain will take place, till Allah The Almighty blows a special current of air, heralding the good news of rain-fall:

وَهُوَ الَّذِي يُرْسِلُ الرِّيحَ بُشْرًا بَيْنَ يَدَيْ رَحْمَتِهِ حَتَّىٰ إِذَا أَثَلَّتْ سَحَابًا ثِقَالًا
سُقْنَاهُ يُبْطِكُ مَيِّتٍ فَأَنْزَلْنَاهُ الْمَاءَ فَأَخْرَجْنَا بِهِ مِنْ كُلِّ الثَّمَرَاتِ (8- الاسراء-57)

This way vapourised water cools down and water drops fall on the earth. This way the 'cycle of water' completes by raining and quenching the thirst of dry & dead earth and heralding the good news of life to the living creatures on earth.

فَنَقْضُ الْآبَآءِ السَّمَاءِ بِمَاءٍ مُّخْصَرٍ وَمَجْرِنَا الْأَرْضَ عَيْنُونَا فَالْتَقَى الْمَاءُ عَلَىٰ أَمْرٍ قَدَرٍ (27- الفم-12)

Thus water rained takes the forms of streams, ground waters and lastly flows back to seas; the biggest water reservoir on earth.

* إِنَّ اللَّهَ عِنْدَهُ عِلْمُ السَّاعَةِ وَيُرْسِلُ الْغَيْثَ وَيَعْلَمُ مَا فِي الْأَرْحَامِ ... (21- لقمن-34)

sub chapter i

Uniqueness of Water:

Water is most important and an unique creation of Almighty Allah:

- 1) PURE & PURIFIER: Allah The Almighty says in Qoran that water is pure itself and is capable to purify the things. Therefore, generally used in 'washing' & 'bathing':

وَيُنَزِّلُ عَلَيْكُمْ مِّنَ السَّمَاءِ مَاءً لِّيُطَهِّرَكُم بِهِ ۖ (9- الانفال - ۱۱)
وَأَنزَلْنَا مِنَ السَّمَاءِ مَاءً طَهُورًا ۝ (۱۹- الفرقان - 48)

The Modern Science too, recognizes water as an 'International Solvent', since it has got the capacity to dissolve the solute like dust particles etc. in it and thus cleanse the things.

- 2) QUENCHING THIRST: Water is unique and required to quench the thirst, constitute a part of foods:

أَفَرَأَيْتُمُ الْمَاءَ تَشْرَبُونَ ۚ أَمْ أَنتُمْ أَكْثَرُ لَشْمُوءَ مِنَ الْمَرْءِ أَمْ تَحْنُ الْمُنْزِلُونَ ۝ (27- الواقعة - 68-69)
وَجَعَلْنَا بَيْنَ رَاسَيْهَا شَيْخَينِ وَاسْتَقْيَلْنَاهُم مَّاءً فُرَاتًا ۝ (29- المرسلات - 27)

Modern Science says that 80% of the humans body's content is water, therefore, human takes water with food and separately, as well.

- 3) BASE OF LIFE: Life is made from water; as Qoran says:

وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ ۖ (17- الانبياء - 35)

Modern Science also says that 'water is base of life'.

- 4) CLOUD: The liquid water changes to vapour. Vapour being lighter goes up against the gravity and forms 'cloud' above in the sky.

Current of air plays an important role in up-lifting and scattering the cloud in the atmosphere:

هُوَ الَّذِي يُرِيكُمُ الْبَرْقَ خَوْنًا وَطَمَعًا وَيُنْثِي السَّحَابَ ثِقَالًا ۝ (13-الرعد-12)

وَتَصْرِيفِ الرِّيحِ وَالسَّحَابِ الْمُسْتَخَرِّ بَيْنَ السَّمَاءِ وَالْأَرْضِ لَا يَأْتِ لِقَوْمٍ يَعْقِلُونَ ۝ (2-البقرة-164)

5) Ice (Solid): Water also exists in the form of solid i.e. 'Ice':

كَمَثَلِ رِيحٍ فِيْهَا صِرٌّ أَصَابَتْ حَرْثَ قَوْمٍ ظَلَمُوا أَنْفُسَهُمْ فَأَهْلَكَتْهُ ۖ - (4-العنكبوت-117)
وَيُنَزِّلُ مِنَ السَّمَاءِ مِنْ جِبَالٍ فِيْهَا مِنْ بَرَدٍ فَيُصِيبُ بِهِ مَنْ يَشَاءُ ... ۝ (18-النور-43)

Modern Science also observes that water is only substance that exists in all the three states of matter i.e. vapour, liquid and solid forms, on earth and this is the 'uniqueness' of water.

Now, let me discuss scientifically that what are the other factors that make water unique and wonderful:

- 1) Water is found in solid, liquid and gaseous states at the same time on earth at different temperatures.
- 2) 'Latent Heat of Fusion' and 'Latent Heat of Vaporisation' of water is unusually high.
- 3) 'Specific Heat' of water is highest among all commonly found substances.

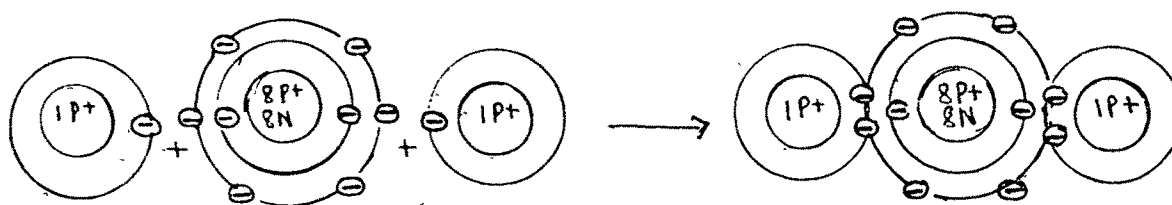
All the above 'Thermal' properties of water have important implications on weather and climate.

*Amount of heat required to raise the temperature of 1 gram of substance by 1 Celcius, is termed as 'specific heat'.

- 4) Unique Molecular Structure of Water. Apart from water's unique thermal properties, its Molecular Structure is also unique.

Water is made of two Hydrogen Atoms and one Oxygen atom. These atoms are bonded together by sharing 'electrons'. Each Hydrogen atom share 'one' electron with 'eight' electrons of Oxygen atom, as shown below:

Electronic Configuration of Water Molecule:



The Electronic Configuration of Water Molecule indicates that Oxygen atom has a stronger attraction for 'share electron' from Hydrogen atom than do the Hydrogen atoms. This sort of attraction exists because, Hydrogen-Oxygen-Hydrogen atoms describe a '105' degree angle: A 'charge separation' develops within molecule; i.e. a negatively charged Oxygen region and positively charged Hydrogen region. A molecule that exhibits such a separation of positive and negative charges is called **di-polar**.

Opposite charge attracts like a tiny magnet, therefore, the Di-Polar molecules of water remain linked together.

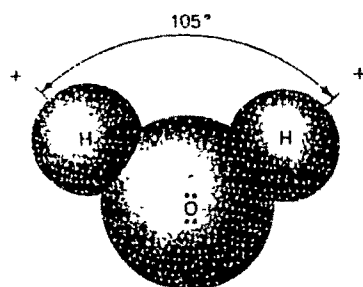
DI-POLAR STRUCTURE OF WATER MOLECULE

FIGURE
The dipolar structure of the water molecule.

HYDROGEN BONDING:

The Negative Pole (O) of one molecule of water is attracted to the Positive Pole (H) of another water molecule. This special attractive 'force' among neighbouring water molecules is known as 'Hydrogen Bonding'.

A single water molecule forms Hydrogen Bonds in three directions, because, each atom (H-O-H) of water molecule is 'potential' site for Bonding.

Hydrogen Bonding inhibits changes in the 'Kinetic' activity of individual water molecules, e.g. when heat is added to water, the resulting increase in Kinetic Molecular Activity and corresponding rise in the temprature; unusually small. That is why, water exhibits anomalously high 'Specific Heat'. Therefore, abnormally greater amount of heat is required to 'melt' and 'boil' the water.

Due to stabilizing effect of Hydrogen Bonding, great amount of heat is required to change the phase of water. To change water from 'solid' phase to 'liquid' phase, 'heat energy' is required to break the 'Hydrogen Bonds'.

The relative strength of 'Hydrogen Bond' dictates an un-usual high 'Latent Heat of Fusion'* of water. All Hydrogen Bonds do not break when water changes from 'Ice' to 'liquid'. Many small 'clusters' of bonded molecules persist into liquid phase.

Considering greater amount of heat is required for water to vaporise (i.e. boiling), during this process all Hydrogen Bonds must break. For this reason, water's 'Latent Heat of Vaporization**' is considerably greater than its 'Latent Heat of Fusion***'.

In solid and liquid phases 'Di-polar Water Molecules' are linked by Hydrogen Bonds. Hydrogen Bond; means 'water' is thermally more stable than other substances.

*Heat released when water changes from 'liquid' state to 'solid' state, is known as 'The Latent Heat of Fusion'(80 cal/gm).

**Heat required to change the water phase from 'liquid' to 'Gas' i.e. 'vapour' (500 to 600 cal/gm - depending on temprature of water).is known as 'Latent Heat of Vaporization'.

***Heat required to change the water phase from 'Solid' to Liquid' is known as 'Latent Heat of Melting' (80 cal/gm)

Please over to page # 28, regarding the Qoranic details of reservoirs of water on earth.

sub chapter ii

Reservoirs of Water on Earth:

Previously, I have discussed that water is unique and wonderful substance that Almighty Allah has bestowed us on the earth. In this sub chapter, I view the possibility of water availability on the earth.

وَالْقَىٰ فِي الْأَرْضِ رَوَاسِيَ أَن تَمِيدَ بِكُمْ وَانْحَارَ سُبُلًا لَّعَلَّكُمْ تَعْلَمُونَ ۚ (الأنفال-14)

Allah The Almighty reveals in Qoran that He has created 'seas' the biggest possible reservoirs on the earth:

- وَمَا يَسْتَوِي الْبَحْرَانِ هَٰذَا عَذْبٌ فُرَاتٌ سَائِغٌ شَرَابُهُ وَهَٰذَا مِلْحٌ أُجَاجٌ ۚ (فاطر-22)
- مَرَجَ الْبَحْرَيْنِ يَلْتَقِيَانِ ۚ (الرحمن-27) وَسَخَّرَ لَكُمُ الْفُلْكَ لِتَجْرِيَ فِي الْبَحْرِ بِأَمْرِهِ ۚ (ابراهيم-13)

Apart from seas, Allah The Almighty has also created 'streams', the natural source of water reservoirs on earth:

- وَفَجَّرْنَا فِيهَا مِنَ الْعُيُونِ ۚ (يس-34) كَمْ تَرَكُوا مِنْ جَنَّاتٍ وَعُيُونٍ ۚ (الدخان-25)
- أَمْ مِّنْ رَّأْيَا يُغَيِّرُونَ ۚ (الشعراء-134-133)
- وَفَجَّرْنَا الْأَرْضَ عُيُونًا ۚ (القمر-27) (الشمس-12) (النمل-61)

Almighty Allah creates the other 'reservoirs', only when the rain falls:

وَنَفْتَحُ أَبْوَابَ السَّمَاءِ بِمَاءٍ مُّثَمَرٍ ۖ وَفَجَّرْنَا الْأَرْضَ عُيُونًا فَالْتَقَى الْمَاءُ عَلَىٰ أَمْرٍ قَدْ قُدِرَ ۚ (الشمر-27) (النمل-12) (نوح-12)

In the above Qoranic Verse Allah The Almighty reveals that streams are created from the water just rained and thus cycle of water completes when the rainy water which was actually evaporised from the reservoir, again reaches to the same.

There are 'سَبْعُ الْمَاءِ' which Almighty Allah creates when rain falls:

أَلَمْ تَرَ أَنَّ اللَّهَ أَنْزَلَ مِنَ السَّمَاءِ مَاءً فَسَلَكَهُ يَنَابِيعٌ فِي الْأَرْضِ ۚ (الزمر-23)

The following Qoranic Verse indicates that ground beneath the earth is also the source of water i.e. 'Under-ground Water Reservoir':

وَالْأَرْضُ بِمَنِّ ذَٰلِكَ دَحْيَاهُ ۖ أَخْرَجَ مِنْهَا مَآءَهَا وَمَرْعَاهَا (30- النزعت - 30,31)
 حَتَّىٰ لَشَجَرْنَاهَا مِنَ الْأَرْضِ يَنْبُوعًا ۚ أَرْتَكُونَ لَكَ جَنَّةٌ مِّنْ نَّخِيلٍ وَعِنَبٍ وَقَدْجَرٍ ۚ لَّا تَحْرُكُهَا فَجِيرًا ۚ
 Allah The Almighty reveals in Qoran that rainy water is sweet,

soft and pure water. It may remain sweet and soft water and get accumulated as a 'soft water reservoir' on the earth. On the other hand Allah The Almighty may change this sweet, soft and pure water into salty, hard and impure water:

• أَمَرْنَا بِتَمْرِ الْمَاءِ الَّذِي شَرَبْتُمْ ۖ وَأَنْتُمْ أَنْزَلْتُمُوهُ مِنَ الْمُنِّ أَمْ تَحْسِبُ الْمُنَّ لَوْنًا ۚ
 لَوْ نَشَاءُ جَعَلْنَاهُ أُجَاجًا فَلَوْلَا تَشْكُرُونَ (27- الواقعة - 68-70)

'River' is also a kind of water reservoir, which Allah The Almighty creates on earth. The existence of River is also the result of 'rain fall':

وَسَقَرْنَا لَهُمُ الْأَنْهَارَ (13- إبراهيم - 32)
 • وَأَرْسَلْنَا السَّمَاءَ عَلَيْهِمْ مِزَّ رِازٍ ۖ وَجَعَلْنَا الْأَنْهَارَ تَجْرِي مِّنْ تَحْتِهِمْ ۖ (7- الأنعام - 6)
 • وَهُوَ الَّذِي مَتَّ الْأَرْضَ وَجَعَلَ فِيهَا رِوَادٍ ۖ وَجَعَلَ فِيهَا أَنْهَارًا ۖ (13- السجدة - 17)
 • وَأَنْزَلْنَا مِنَ السَّمَاءِ مَآءً ۖ يَخْتَلِفُ فِي الْأَرْضِ ۖ وَإِنَّا عَلَىٰ زُحُفٍ
 بِهِ لَقَبِيرُونَ (18- المؤمنون - 18) وَأَتْرَكْنَا الْبَحْرَ رَهْوًا ۖ (25- الرعد - 24)
 • وَهَدَيْنَا الْأَنْهَارَ تَجْرِي مِّنْ تَحْتِهَا ۖ أَفَلَا يَتَذَكَّرُونَ (25- الزخرف - 51)

Allah The Almighty again describes in Qoran that the existence of 'under-ground water reservoir' is also due to the water obtained from rain fall. The earth is capable to absorb some part of rainy water, which remains 'preserved' beneath the earth. Allah The Almighty may utilize this water during 'recycle' process, as a result rain falls and water flows in front of you:

قُلْ أَرَأَيْتُمْ إِنِ اصْبَحَ مَاؤُكُمْ غَوْرًا فَمَنْ يَأْتِيكُمْ بِمَآءٍ مُّهِينٍ (29- المائدة - 40)
 (15- بني اسرائيل - 99)*

In this Qoranic Verse Allah The Almighty says that existence of water reservoirs are: i) in the 'sky'; i.e. in the form of 'cloud', that is why it rains, ii) beneath the 'earth'; in the liquid form, which human obtains by digging the earth and utilises it, and iii) in between the earth and sky; i.e. the 'vapours' which is found in the air as its content, when ground water vaporises and goes up in the sky to form cloud:

• الْحَمْدُ لِلَّهِ الَّذِي لَهُ مَا فِي السَّمُوتِ وَمَا فِي الْأَرْضِ ۖ يَعْلَمُ مَا يَلْجِ فِي الْأَرْضِ وَمَا

يَخْرُجُ مِنْهَا وَمَا يَنْزِلُ مِنَ السَّمَاءِ وَمَا يَخْرُجُ مِنْهَا ۖ (سبا - 22 - سبا - 1-2)

يَعْلَمُ وَمَا يَخْرُجُ مِنْهَا ۖ (الحديد - 27 - الحديد - 4)

Again Qoran reveals that Almighty Allah knows the existence of water on the earth, in the sky, suspended in between the earth and sky and very deep beneath the earth. And Allah The Almighty knows which is a secret and hidden from our eyes.

لَهُ مَا فِي السَّمُوتِ وَمَا فِي الْأَرْضِ وَمَا يَنْصُرُهُمَا وَمَا تَحْتَ الثَّرَى ۖ (طه - 6 - طه - 7)
وَأَنْ تَجْعَلَ بِالْقَوْلِ فَائِةً يَخْلُمُ السَّرَّاءَ وَخَفَى ۖ

O! non-believers, why do not you worship The Almighty Allah, Who brings out the hidden things* of skies and earth:

الَّذِي يُخْرِجُ الْخَبَّ وَفِي السَّمُوتِ وَالْأَرْضِ... (الزلزال - 25)
أَرْكُضْ بِرِجْلِكَ هَذَا مُغْتَسَلٌ بَارِدٌ وَشَرَابٌ ۖ (ص - 42 - ص - 23) وَإِذَا سَأَلَكَ مُوسَى لِقَوْمِهِ فَقُلْنَا...

Allah The Almighty creates 'streams' on earth when rain falls:

أَنْزَلَ مِنَ السَّمَاءِ مَاءً فَسَالَتْ أَوْدِيَةٌ بِقَدَرِهَا... (الرعد - 13 - الرعد - 17) نَجْعَمَاعَيْنِ تَبْرِينِ
وَفَجَّرْنَا الْأَرْضَ عُيُونًا فَالْتَفَتِ الْمَاءُ عَلَى أَمْرٍ قَدْ قُدِرَ (القمر - 27 - القمر - 12) (الرحمن - 50)

*Specially the water through a genuine system i.e. 'cycle of water'.

**When Allah The Almighty instructs Hz Ayub a.s. to hit the earth with his leg & water erupted out of earth. ... (البقرة - 60)

Now, let me view the scientific aspects regarding the possible water reservoirs on earth.

Within the atmosphere, water occurs in all the three phases; a) water vapour, b) tiny ice crystals & c) water droplets as cloud. The total amount of water within the atmosphere is very small, and most of which is in the lower portion of the atmosphere i.e. 'TOROSPHERE'. Water continually cycles into the atmosphere from the reservoirs of water on the earth's surface, and water continually leaves the atmosphere and return to earth's surface as 'rain', 'snow' and other forms of 'precipitation'. On average, the residence time of water molecules in the atmosphere is about 'ten' days. This cycle is called 'Hydrologic' cycle.

HYDROLOGIC CYCLE:

'Ceaseless flow of water among the 'reservoirs', is called as Hydrologic Cycle*.

The latest scientific investigations reveal that on the earth water is distributed among Ocean, Terrestrial and Atmospheric reservoirs, as shown in the table:

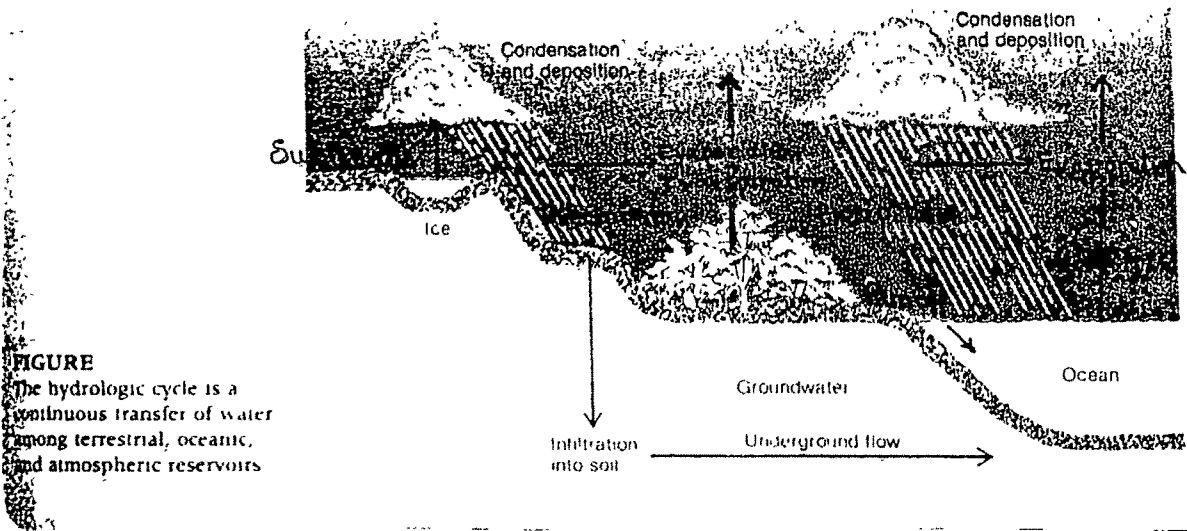
<u>RESERVOIR</u>	<u>% of Total Water on Earth</u>
World Oceans	97.2
Ice Sheets & Glaciers	2.15
Ground Water	0.62
Lakes (fresh water)	00.009
Inland seas, saline lakes	00.008
Soil Water	00.005
Atmosphere	00.001
Rivers & Streams	00.0001
Total	100.00

* (27- الحريد 4) (22- سبأ - 1,2)

Hydrologic Cycle ... continues ...

Water vaporises from sea and land to the atmosphere, where clouds are formed. From cloud water falls back in the forms of rain and snow fall on the surface of earth. Thus, rainy water is supplied to the rivers, which ultimately pours in to the sea.

All rivers run into sea, yet the sea never over-flows, because the sea water evaporates to form cloud. This natural phenomenon is actually the 'Hydrologic Cycle'.



فَفَتَحْنَا أَبْوَابَ السَّمَاءِ بِمَاءٍ مُنْهَمِرٍ وَفَجَّرْنَا الْأَرْضَ عُيُونًا فَالْتَقَى الْمَاءُ عَلَى
(أَمْرٍ قَدْ فُدِرَ) (27- القمر 11, 12)

Within the usual range of temperature & pressure on planet earth, all the three phases of water co-exist naturally. That is; 'water vapour' is in equilibrium with water's 'liquid' and 'solid' phases.

At the interface between water and air, some water molecules escape from water surface and enter the air as 'VAPOUR', while other water molecules leave the vapour phase and return to water surface as liquid.

Evaporation occurs if more water molecules enter the air than return to liquid water, and **Condensation** occurs if more water molecules return to liquid water than enter to air of atmosphere as vapour.

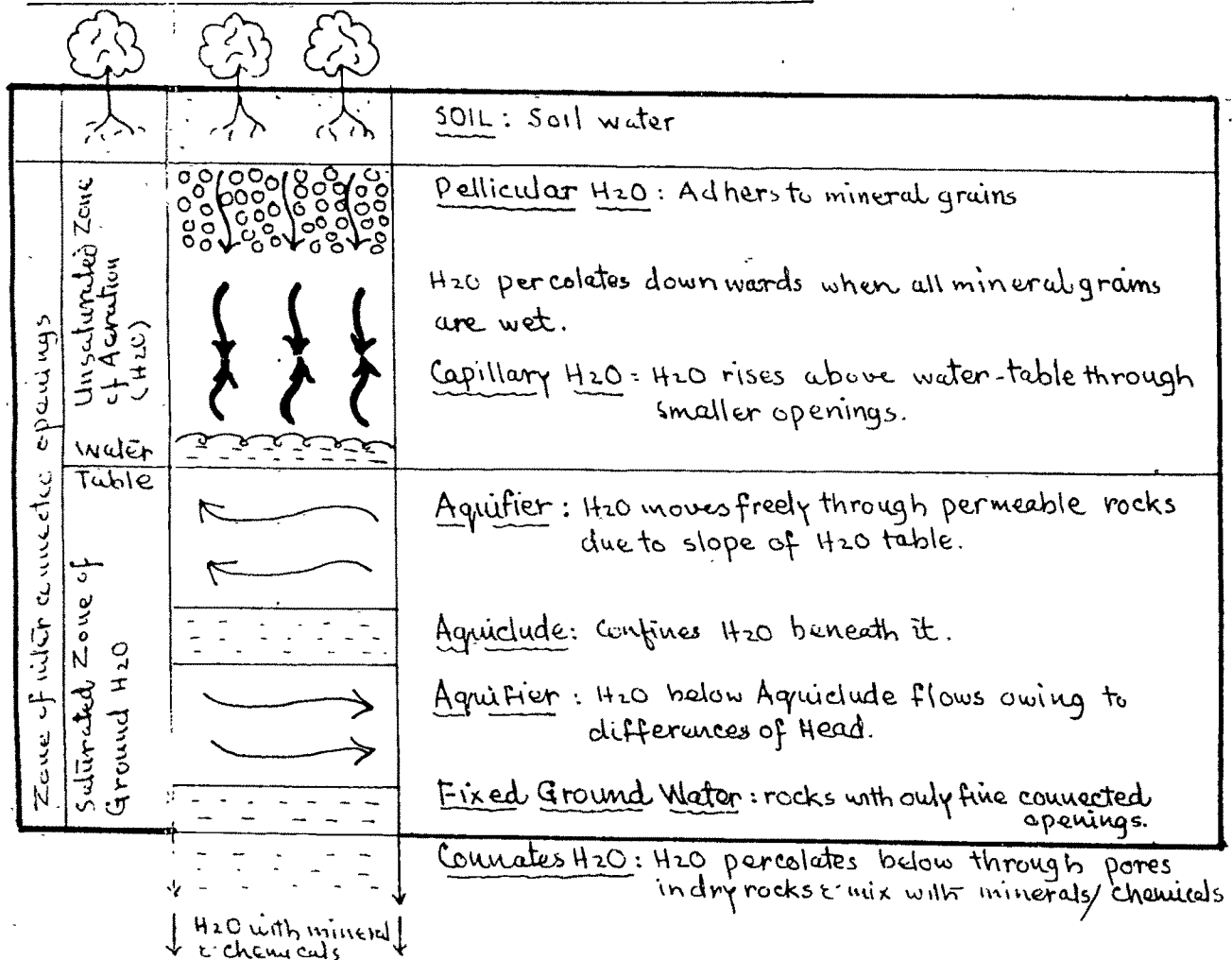
Evaporation occurs from all open bodies of water, as well as from the wetted surface of plants and soil. But the direct evaporation of ocean water is the principal source of water vapour in the atmosphere. 'TRANSPIRATION' is also a source of vapour when soil water absorbed by plants through root is ultimately evaporated out through the stomata of leaves.

Sublimation: Water molecules can not escape to air from 'Ice' surface as they escape from water surface, because in ice, water molecules are more lightly bound. Thus sublimation occurs, when more water enters the vapour phase than returns to ice and deposition of ice takes place when more water return to ice than vaporises.

Global Water Budget: When investigated globally, it was found that more water evaporates from sea to form cloud and less rains i.e. precipitates on sea. While less amount of water evaporates from land to form cloud and more quantity precipitates on land. Thus there is always gain of water on land.

GLOBAL WATER BUDGET...contd...

SOURCE	VOLUME/m ³ per year
Precipitation on sea	3.24x10
Evaporation from sea	3.60x10
Net LOSS from sea	-0.36x10
Precipitation on land	0.98x10
Evaporation from land	0.62x10
Net GAIN on land	+0.36x10

Water Beneath The Earth:

sub chapter iii

Water Reservoirs in Sky:

Allah The Almighty reveals in Qoran, the presence of water in the form of vapour, which establishes 'cloud' in the sky. The following Qoranic Verses favour the existence of water reservoirs in the sky though temporarily in the form of cloud:

- وَتَصْرِيفِ الرِّيحِ وَالسَّحَابِ الْمُسَخَّرِ بَيْنَ السَّمَاءِ وَالْأَرْضِ لَآيَاتٍ لِّقَوْمٍ يَعْقِلُونَ (بقرة-164) ٥
- وَهُوَ الَّذِي يُرْسِلُ الرِّيحَ بُشْرًا بَيْنَ يَدَيْ رَحْمَتِهِ ۖ حَتَّىٰ إِذَا أَثَلَّتْ سَحَابًا ۖ ٥ (اعراف-57)
- هُوَ الَّذِي يُرِيكُمُ الْبَرْقَ خَوْفًا وَطَمَعًا وَيُنْزِلُ السَّحَابَ الْمُنْتَثَلَّ ۖ (الرعد-12)
- وَأَرْسَلْنَا الرِّيحَ بَوَاقٍ فَأَنْزَلْنَا مِنْ سَمَاءٍ مَّاءً ۖ فَاسْقِيْنَاكُم مَّاءً ۖ (الحجر-14)
- وَمَنْ يُرْسِلِ الرِّيحَ بُشْرًا بَيْنَ يَدَيْ رَحْمَتِهِ ۖ ٥ (النمل-65)
- وَاللَّهُ الَّذِي أَرْسَلَ الرِّيحَ فَتُثِيرُ سَحَابًا فَسُقْنَاهُ إِلَىٰ بَلَدٍ مِّيتٍ فَأَحْيَيْنَاهِ الْأَرْضَ بَعْدَ مَوْتِهَا ۖ ٥ (فاطر-9)
- وَإِنْ يَرَوْا كِسْفًا مِّنَ السَّمَاءِ سَاقِطًا يَقُولُوا سَحَابٌ مَّرْكُومٌ ٥ (طه-44)
- أَوْ كَصَيِّبٍ مِّنَ السَّمَاءِ فِيهِ ظُلُمٌ وَرَعٌ وَبَرْقٌ ۖ ٥ (البقرة-19)
- هُوَ الَّذِي يُرِيكُمُ الْبَرْقَ خَوْفًا وَطَمَعًا وَيُنْزِلُ السَّحَابَ الْمُنْتَثَلَّ ۖ (الرعد-12)
- أَلَمْ تَرَ أَنَّ اللَّهَ يُزْجِي سَحَابًا ۖ ٥ (النور-45)
- اللَّهُ الَّذِي يُرْسِلُ الرِّيحَ فَتُثِيرُ سَحَابًا فَيَبْسُطُهُ فِي السَّمَاءِ كَيْفَ يَشَاءُ ۖ ٥ (الروم-48)
- أَكْظَلُمْتُ فِي بَرٍّ لَّجِيٍّ بِفَيْسِهِ مَوْجٌ مِّن مَّوْجٍ مِّن فَوْقِهِ سَحَابٌ ۖ ٥ (النور-40)

Sometimes, clouds appear in the sky, forecast the storm; destroys lives & properties:

فَلَمَّا رَأَوْهُ غَارُوا مِنْهُ فَتَشَاءُ ۚ قَالَ أَوَلَمْ يَكُنْ لَّآيَاتٍ لِّقَوْمٍ يَعْقِلُونَ (الاحقاف-26)

Let me see the scientific view regarding the existence of water reservoirs in the sky. Yes, as per Qoran, the water reservoirs in the forms of 'cloud' are hanging in the sky i.e. above the certain distance from the earth.

There are various types of cloud occupying different shapes and positions in the sky.

* TYPES OF CLOUD:

- 1) High Clouds
- 2) Middle Clouds
- 3) Low Clouds
- 4) Vertical Clouds
- 5) Un-usual Clouds

1) High Clouds: Also called as 'Stratiform' or layer cloud. The base of High cloud is at 6 km above the earth. Temperature is below -25°C . High Cloud almost contains 'Icy Crystals'. Types of High Clouds:

- a) Cirrus: Nearly transparent like silky strand - 'Mares tail'
- b) Cirrostratus: Nearly transparent like thin 'veil'. Moon & sun shines through them.
- c) Cirrocumulus: Small, while and thick patches. Sun looks through like 'frosted' glass.
- d) Alto cumulus: 'Roll' like patches/puffs, that form a line or wave with sharper 'edge'. Presence of water is noticed.

* وَإِنْ يَشِرْ ذَاكُسْفَانٍ اسْتَمَاءَ سَاقَطًا يَقُولُوا سَحَابٌ مَرْكُومٌ ۝ (٢٦ - الطور - ٤٤)

2) Middle Clouds: The base of Middle Cloud is at the altitude between 2-6 km. Temperature is 0°C to -25°C. Middle Clouds contain Ice Crystals or Super Cool Water.

a) Altostratus: Uniformly grey or white & thick. Sun is thinly visible like frosted glass (alto - high).

b) Alto cumulus: Already described under high cloud's 'd'.

2) Low Clouds: The base of low cloud is from earth surface (Fog) upto 2 km. Temperature is about -5°C. It contains mostly water drop-lets.

a) Stratocumulus: Large, irregular & puffs/rolls arranged in layers.

b) Stratus: Uniform grey layer stretches from 'Horizon' to 'Horizon'. Only drizzles from stratus.

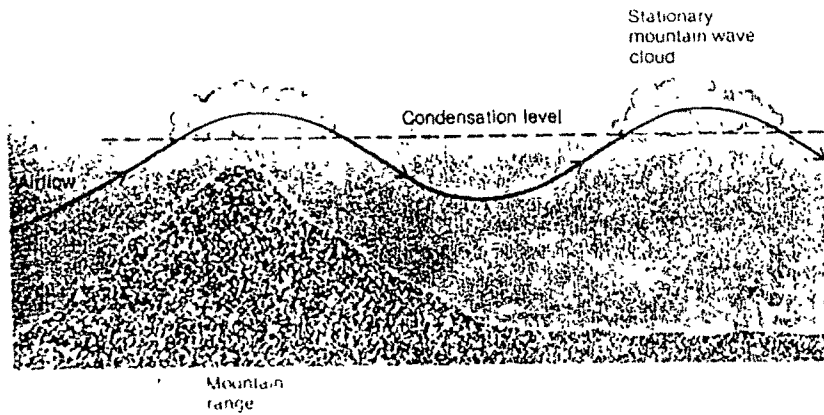
c) Nimbo-stratus: These are thicker & darker than stratus and yield more rains.

3) Vertical Clouds: As unsaturated air rise its temperature, so the 'relative humidity' increases with continued ascent and expansional 'cooling'. The 'relative humidity' reaches upto 100% and this way 'cumulus' clouds are formed. The base of these clouds are 1-2 km altitude.

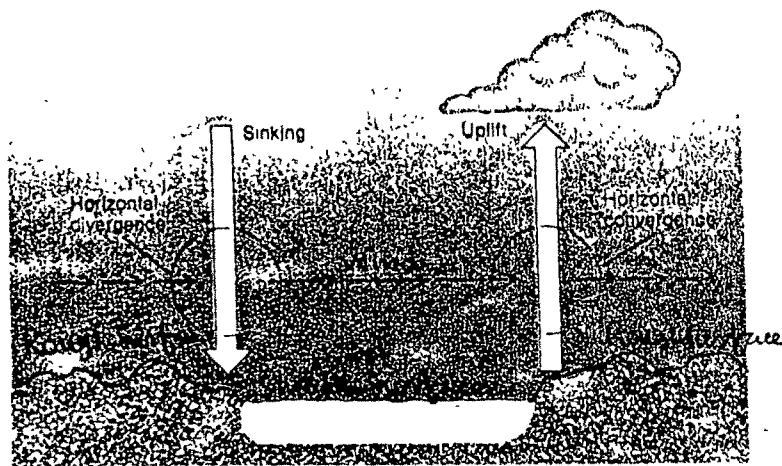
a) Cumulus Congestus: Cauliflower appearance.

b) Cumulo Nimbus: Thunder storm clouds.

5) Un-usual Clouds: Mountain wave clouds are unusual clouds, formed when a mountain range deflects the 'horizontal wind' into wave like pattern. Clouds develop on the 'wave-crest', where the air flow is upward and expansional cooling takes place. Such

Fig: Un-usual Clouds

clouds are absent in the wave troughs where airflow is downward and compressional warming occurs.



Surface winds undergo horizontal divergence when blowing from a rough to a smooth surface, and horizontal convergence when blowing from a smooth surface to a rough surface. Horizontal divergence air causes air to sink, and horizontal convergence of air causes air to rise.

sub chapter iv

Rains Making:

Allah The Almighty rains from the clouds suspended between earth and sky, whenever, wherever and as much Allah The Almighty wishes. As per Qoran, 'rain' is based on an important factor i.e. a special air, blown by The Almighty Allah, heralding the good news of life to the living creatures on the earth.

In the following Qoranic Verse Allah The Almighty announces the 'basic needs', where rain is prime importance:

يُرْسِلُ السَّمَاءَ عَلَيْكُمْ مِدْرَارًا وَيُمْدِدْكُمْ بِأَمْوَالٍ وَبَنِينَ وَيَجْعَلْ لَكُمْ جَنَّاتٍ
وَيَجْعَلْ لَكُمْ أَنْهَارًا (29- نو ح- 12)

STEPS IN RAINS MAKING:

1) ASCENDING OF WATER:

The following Qoranic Verses indicate that 'current of air' causes the evaporation of water from the reservoirs on earth. Again the 'air current' lifts the vapors towards the sky. Where vapor is scattered in the form of cloud:

وَالَّذِي يَبْدَأُ الْخَلْقَ يُعِيدُهُ وَإِلَى عِندِهِ تُرْجَعُ الْأُمُورُ (21- الزمر ح- 12)

أَمْ رَأَيْتُ لَكُمْ الْخَلْقَ إِذْ أَوَّلًا ۚ بَلْ رَأَيْتُمْ كُفْرًا (26- الذر ح- 4-1) وَأَرْسَلْنَا الرِّيحَ لَوَاحِشٍ ۝ (14- الحجر ح- 22)

وَالْمُرْسَلَاتِ عُرْفَاهُ ۚ فَإِذَا هِيَ خِطَاةٌ بِأَعْيُنِنَا ۚ وَطُوفَاتِ الْغُيُوتِ ۚ (29- المرسلات ح- 4-1)

وَهُوَ الَّذِي يُرْسِلُ الرِّيحَ بُفْرًا ۖ بَيْنَ يَدَيْ رَحْمَتِهِ ۖ خُفٍّ إِذَا تَلَّتْ سَحَابًا ثِقَالًا ۝ (8- الامرات ح- 57)

وَتَضْرِبُ الرِّيحُ أَيْتُ الْقَوْمِ يَفْقَهُونَ ۝ (25- الجاثية ح- 5)

Then, Allah The Almighty scatters the vaporised from of water, through 'current of air' and suspended between earth and sky in the form of 'cloud':

وَمَا أَنْزَلَ اللَّهُ مِنَ السَّمَاءِ مِنْ مَّاءٍ فَأَحْيَا بِهِ الْأَرْضَ بَعَثَ مَوْثِقًا وَبَثَّ فِيهَا مِنْ كُلِّ رَآبِيَةٍ ۖ وَتَضْرِبُ الرِّيحُ السَّحَابَ الْمُسَخَّرَ بَيْنَ السَّمَاءِ وَالْأَرْضِ لَا يَبْقَىٰ لِقَوْمٍ يُفْقِلُونَ ۝ (2- البقرة - 164)

Allah The Almighty reveals in the following Qoranic Verse that, how the surface of water of reservoirs, convert into vapor, which later changes to cloud when ascend towards the sky:

أَوْ كُفِّلُمَاتٍ فِي بَحْرِ لُجِّي يَغْشَاهُ مَوْجٌ مِّنْ فَوْقِهِ مَوْجٌ مِّنْ فَوْقِهِمْ سَحَابٌ ط
فُلُكُمُ بِخَضْبِهَا فَوْقَ بَحْضٍ ط ... ۝ (18- النور - 40)

The following Qoranic Verse reveals the 'RECYCLE' of water. That Allah The Almighty takes up again, the rained water towards the sky (the take up of water is in gaseous; since not visible to human eyes):

وَأَنْزَلْنَا مِنَ السَّمَاءِ مَاءً بِقَدَرٍ فَأَسْكَنَتْهُ فِي الْأَرْضِ ط وَأَتَانَا عَلَىٰ ذَهَابٍ بِهِ لِقَابِ رُؤُونِ ۝ (18- المؤمنون - 18)

When cloud becomes mature and ready to rain, Allah The Almighty 'blows' an unique 'air current' that directs the clouds to proper territory, where Allah The Almighty wishes to rain to alive the dead earth:

اللَّهُ الَّذِي يُرْسِلُ الرِّيحَ فَتُثِيرُ سَحَابًا يَبْسُطُهُ فِي السَّمَاءِ كَيْفَ يَشَاءُ وَيَجْعَلُهُ كِسْفًا ۝ (21- الروم - 48)

وَاللَّهُ الَّذِي أَرْسَلَ الرِّيحَ فَتُثِيرُ سَحَابًا فَنُسْقِنُهُ إِلَىٰ بَلَدٍ مَّيِّتٍ فَأَحْيَيْنَا بِهِ الْأَرْضَ بَعَثَ مَوْثِقًا ط ... ۝ (22- فاطر - 9)

Allah The Almighty knows* the fact regarding: what is absorbed into the earth, when rain falls i.e. rainy water. And what is come out of earth i.e. ground water; which human obtains by digging the earth and utilises in drinking and farming etc. And what descends down from the sky i.e. the rain fall. And what ascends to the sky i.e. change of water of the earth surface to the vapor and its ascent to the sky, which later forms the cloud (vapor is not visible to human eyes):

وَهُوَ الْكَافِيُ الْخَبِيرُ يَعْلَمُ مَا يَلْجُ فِي الْأَرْضِ وَمَا يَخْرُجُ مِنْهَا وَمَا يَنْزِلُ مِنَ السَّمَاءِ وَمَا يَخْرُجُ مِنْهَا... ه (22- سبا - 2- 1) و (27- الحديد - 4)

Allah The Almighty mentions, in the following Qoranic Verse 'the mechanism' of cloud formation and its arrangements in the sky. Also the existence of different types of clouds, occupy sky at different distances from the earth:

أَلَمْ تَرَ أَنَّ اللَّهَ يُرْسِلُ سَحَابًا ثُمَّ يُؤَلِّفُ بَيْنَهُ ثُمَّ يَجْعَلُهُ رُكَامًا... ه (18- النور - 43)

اللَّهُ الَّذِي يُرْسِلُ الرِّيَّاحَ فَتُثِيرُ سَحَابًا فَيَبْسُطُهُ فِي السَّمَاءِ كَيْفَ يَشَاءُ... ه (21- الروم - 48)

وَإِنْ يَرَوْا كِسْفًا مِنَ السَّمَاءِ سَاقِطًا يَقُولُوا سَحَابٌ مَرْكُومٌ ه (27- الطور - 44)

*Allah The Almighty reveals His knowledge regarding the different stages of the water cycle, which Allah The Almighty performs as He wishes, without getting the assistance from any one, because hidden water beneath the earth and ascent of vapor is not visible.

ii) DESCENDING OF WATER:

Descending of water from the sky or actual rains making is very well described in Qoran.

Qoran says - when water vapor ascends up towards the sky and cloud is formed, Allah The Almighty blows an "air-current", which herald the good news of rain:

أَمَّنْ يَصْبِيحُ يَكْفُ فِي ظِلْمَتِ الْبَرِّ وَالْبَحْرِ وَمَنْ يُرْسِلُ الرِّيحَ بُشْرًا بَيْنَ
يَبِّ رَحْمَتِهِمْ ؕ إِلَهُ مَعَ اللَّهِ ... ه (20 - المل - 63)
أَوْ كَصَيْبٍ مِّنَ السَّمَاءِ ... ه (1 - البقرة - 19) وَأَرْسَلْنَا السَّمَاءَ عَلَيْهِمْ مِدْرَارًا (الانعام)

Qoran says - this is the sign of existence of Allah The Almighty's matchless supreme power that He blows an "air-current" heralding the good news of rain, so that 'you' i.e. we the mankind taste the outcome of one of His Mercies:

وَمِنَ آيَاتِهِ أَنْ يُرْسِلَ الرِّيحَ مُبَشِّرَاتٍ لِّرَبِّينَ يَقْلَعُونَ رَحْمَتِهِ ... ه (21 - الروم)
اللَّهُ الَّذِي خَلَقَ السَّمَوَاتِ وَالْأَرْضَ وَأَنْزَلَ مِنَ السَّمَاءِ مَاءً ... ه (13 - ابراهيم - 32)

Allah The Almighty instructs the mankind in Qoran to apologise for their sins committed and do not resist the wrong doings, only then Allah The Almighty will rain heavily, which will be helpful to increase your 'energy':

وَلْيَقُومُوا اسْتَغْفِرُوا رَبَّهُمْ ثُمَّ تُؤَدُّوْا إِلَيْهِ يُرْسِلِ السَّمَاءَ عَلَيْكُمْ مِدْرَارًا
يَزِدْكُمْ قُوَّةً إِلَى قُوَّتِكُمْ وَلَا تَتَوَلَّوْا مُجْرِمِينَ ه (12 - هود - 52)
وَالَّذِي نَزَّلَ مِنَ السَّمَاءِ مَاءً بِقَدَرٍ ... ه (25 - الزخرف - 11)
وَنَزَّلْنَا مِنَ السَّمَاءِ مَاءً مُّبَارَكًا ... ه (26 - ق - 19)

*The rain causes the vegetation, which is the medium to absorb the solar energy; utilized during the process of 'photosynthesis' The produces of photosynthesis are stored in fruits, vegetables and cereals etc., which, ultimately, human eats to gain 'energy'.

Do you not see that Allah The Almighty transports the vapor/cloud through the 'air current'. These vapor/cloud merge, concentrate and saturate as real 'cloud', which are arranged in the different layers in the sky, to form different types of clouds*. Water drops come out of the clouds, which are like the mountains of Ice**.

Ice balls drop from such clouds when temprature is very low, and clouds are mature enough to rain. When Ice balls*** fall on the earth, they damage lives and properties. And some times Allah The Almighty re-evaporates i.e. sublimates the Ice balls, before they fall down on the earth. Also, some times the clouds**** cause flash of light of light. The intensity of light is so high that our eyes are unable to bear:

أَلَمْ تَرَ أَنَّ اللَّهَ يُزْجِي سَحَابًا ثُمَّ يُؤَوِّفُ بَيْنَهُ ثُمَّ يَجْعَلُهُ رُكَامًا تَتْرَى الْأَوْدُنُ
يَخْرُجُ مِنْ خِلَالِهِ وَيُنْزِلُ مِنَ السَّمَاءِ مِنْ جِبَالٍ فِيهَا مِنْ بَرَدٍ نُفِثَ بِهِ مِنْ
يَشَاءُ وَيُصْرِفُهُ عَنْ مَنْ يَشَاءُ يَكَاذِبُونَ سَتَا بَرَقِهِ يَذْهَبُ بِالْأَبْصَارِ (١٨-النور-٤٣)

Benjamin Franklin & French Physist d'Alibard in 1752, proved the presence of electricity in thunderbolt. Franklin put his knuckle to a key attached to a string of silk ribbon (insulator) and produced a considerable spark.
 ظَلَمْتُ وَرَعْتُ وَبَرَقْتُ؟ يَجْمَلُونَ أَصَابِعَهُمْ فِيَّ إِذَا نَصَمُ... ٥
 يَكَاذِبُونَ يَخْطِفُ أَبْصَارَهُمْ... ٥ (١-البقرة-١٩٣٥)

* Strateform or layer cloud

*Types of cloud

***Hail Stone

****Thunderbolt Storm Cloud

Allah The Almighty blows air current which lifts and spreads the clouds in the sky, as He wishes. Again, Allah The Almighty breaks the clouds* into pieces and water drops come out of the clouds. People of the locality where Allah The Almighty rains becomes jubilant and celebrates the rain:

اللَّهُ الَّذِي يُرْسِلُ الرِّيحَ تَثِيرٌ مِّنْ سَحَابٍ فَيُبْسِطُهُ فِي السَّمَاءِ كَيْفَ يَشَاءُ ۚ وَ
يَجْعَلُ السَّحَابَ مُنْتَزِعًا يُخْرِجُ مِنْ خَلِيمٍ ۚ نَّازِلًا أَصَابَ بِهِ مَن يَشَاءُ
مِّنْ عِبَادِهِ إِذَا هُمْ يَسْتَبِشِرُونَ ۝ (21- الروم - 48) أَلَمْ تَرَ أَنَّ اللَّهَ أَنزَلَ مِنَ السَّمَاءِ مَاءً فَسَلَخًا
Allah The Almighty alives the dead earth and creates on it all

types of moving** creatures. Actually, the rain falls down from the cloud which hangs between earth and sky. The clouds are taken up and scattered around the suitable directions in the sky by means of 'air-current' blown by the Almighty Allah. The 'phenomenon of rain is one of the signs of 'existence' of The Almighty Allah, for those who are really 'wise': (2-البقرة-164)

وَمَا أَنزَلَ مِنَ السَّمَاءِ مِنْ مَّاءٍ فَآخِيَابُهُ الْأَرْضِ بِحَدِّ مَوْتِحَا وَبَثَّ فِيهَا مِنْ
كُلِّ دَآبَّةٍ ۚ وَتَصْرِيفِ الرِّيحِ وَالسَّحَابِ الْمُسَخَّرِينَ السَّمَاءِ وَالْأَرْضِ لَا يَتَّبِعُ لِقَوْمٍ يَحْقِلُونَ

Allah The Almighty blows the 'air-current' that transports the clouds in the sky. Allah The Almighty rains the fresh and sweet water from the sky, bestows us for 'drinking'. And you i.e. we; the mankind, are not the custodian of water which is a natural gift from The Almighty:

وَأَرْسَلْنَا الرِّيحَ لَوَاقِحَ فَأَنزَلْنَا مِنَ السَّمَاءِ مَاءً فَأَسْقَيْنَاكُمُوهُ ۚ وَمَا أَنتُمْ
لَهُ بِحَازِرِينَ ۝ (14- الحجر - 22)
الَّذِي جَعَلَ لَكُمُ الْأَرْضَ فِرَاشًا وَالسَّمَاءَ بِنَاءً ۚ وَأَنزَلَ مِنَ السَّمَاءِ مَاءً ۝ (1-البقرة - 22)

*condensation of cloud

**movement is one of the characteristics of life

O, the mankind; the fresh and sweet water which you drink, is rained by you or "I am capable to rain it", Allah The Almighty says in Qoran. Certainly, Allah The Almighty rains sweet water from the cloud. If Allah The Almighty wishes, He may convert this sweet water to salty, which is not drinkable, so why are you not thankful to Allah The Almighty:

أَفَرَأَيْتُمُ الْمَاءَ الَّذِي تَشْرَبُونَ ؕ أَأَنْتُمْ أَنْزَلْتُمُوهُ مِنَ الْمُزْنِ أَمْ نَحْنُ الْمُنْزِلُونَ
لَوْ شَاءَ جَعَلْنَاهُ أُجَاجًا فَلَوْلَا تَشْكُرُونَ ؕ (27- الواقعه - 68-70)
وَاللَّهُ أَنْزَلَ مِنَ السَّمَاءِ مَاءً... ؕ (14- النحل - 65) يُزِيلُ السَّمَاءَ عَنْكُمْ وَمَنْ رَأَاهُ (29- نوح - 11)

Not only sweet water to drink is described above, Allah The Almighty bestows us food too, through reviving the dead earth i.e. by way of vegetation, when rain falls from the sky. The most important factor for the cycle of water is the 'air current'.

Wise people are invited to ponder over it:

وَمَا أَنْزَلَ اللَّهُ مِنْ سَمَاءٍ مِنْ رِزْقٍ فَأَحْيَا بِهِ الْأَرْضَ بَعْدَ مَوْتِهَا وَتَصْرِيفِ الرِّيحِ
أَيُّكُمْ لِقَوٍّ يَفْقَهُونَ ؕ (25- الاحقاف - 5)
وَأَنْزَلْنَا مِنَ الْمُعْصِرَاتِ مَاءً ثَجَّاجًا لِنُخْرِجَ بِهِ حَبًّا وَنَبَاتًا لِرِجَّتِ الْأَفَاقُ (30- الانبا - 16-14)

Regarding the exact timing for rain, no one knows other than The Almighty Allah:

إِنَّ اللَّهَ عِنْدَهُ عِلْمُ السَّاعَةِ وَيُنَزِّلُ الْغَيْثَ... ؕ (21- لقمن - 34)
وَأَنْزَلَ مِنَ السَّمَاءِ مَاءً... ؕ (21- لقمن - 10) ۞ (20- النحل - 60)

Allah The Almighty rain falls when you the mankind become hopeless and this way Allah The Almighty spreads His Mercy to all:

وَهُوَ الَّذِي يُنَزِّلُ الْغَيْثَ مِنْ بَعْدِ مَا قُطِّعُوا وَيُنْشِرُ رَحْمَتَهُ لَهُوَ الْوَلِيُّ الْحَمِيدُ
(25- الشورى - 28)

sub chapter iv

Rains Making: contd ...

This portion of my thesis covers the scientific aspects dealing the actual phenomenon of rains making, based on the process of rains making mentioned in Qoran.

As per the scientific investigations , the process of cloud formation is based on 'Earth-Atmosphere System', develops due to 'Solar Radiation'. The net incoming of 'Solar Radiation' is balanced by the Infra Red Radiation, emitted by Earth Atmosphere System to the space.

Absorption of Solar Radiation causes WARMING and emission of Infra Red Radiation to space causes COOLING. The Warming and Cooling is not same everywhere.

This radiational heating & cooling cause the 'Atmospheric Circulation'. The imbalance of heat energy i.e. Atmospheric Circulation is based on i) Heat, ii) Temperature & iii) Heat Transfer Process.

- i) **Heat**: Heat is the total Kinetic Molecular Energy, contained in a substance. Units of Heat are Calories, Joules
 - ii) **Temperature**: Temperature is a 'measure' of average Kinetic Energy of an individual atom/molecule, within a substance. We use Celcius, Fahrenheit & Kelvin as temperature scale.
-

iii) **Heat Transfer Process:** A change in temperature with distance is known as 'Temperature Gradient'. A familiar Temperature Gradient is between the HOT "Equator" and the COLD "Poles" i.e. a Horizontal Temperature Gradient. Another is the Temperature Gradient between the relatively mild 'Earth's Surface' and relatively cold "Tropopause" i.e. a Vertical Temperature Gradient.

Within Earth Atmosphere System, Heat is transported from area of higher temperature to the area of lower temperature; through Conduction, Convection & Radiation.

1) **Conduction of Heat:** When heat transfers within a substance or between substances that are in physical contact, is called CONDUCTION of Heat. The Kinetic Energy of atoms/molecules is transferred by 'collision' between neighbouring atoms/molecules of the substance.

Heat is transferred from warm ground to cooler overlying air, Since air has low heat conductivity, conduction is significant only in a very thin layer in immediate contact with the Earth's surface.

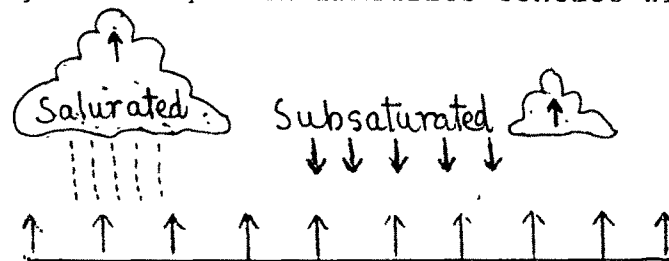


Fig: A saturated vapour overlying a plane surface of pure water/ice.

Convection is more important in transporting Heat vertically within TROPOSPHERE.

Heat Conductivity* in some familiar substances:

<u>SUBSTANCE</u>	<u>HEAT CONDUCTIVITY (cal/cm/sec/cm)</u>
Copper	.92
Concrete	.0022
Iron	.16
Ice at 0 °C	.0054
Water at 10°C	.0014
Air at 0 °C	.000058
Air at 20°C	.000061
Dry Sand	.0013

2) **Convection of Heat:** Conduction takes place in substances i.e. solids, liquids and gases, while Convection occurs only in liquid or gases. Convection is the transport of heat within a fluid via motion of fluid itself. Convection occurs within atmosphere as a sequence of differences in 'Air Density'.

As heat is conducted from relatively warm ground to cooler overlying air, the air becomes warmer than the surrounding air.

'Warm Air' is less dense than cold air. So the cooler/denser air sinks downward and forces the warmer/lighter air to rise. Again, the cooler air is then heated by the ground and the process is repeated. In this way, a convective circulation of air transports heat 'vertically' from earth's surface into the TROPOSPHERE.

* On any day of the year, the solar altitude varies with latitude because the earth's surface is curved. Hence, the solar radiation is most intense at equator and least intense at poles.

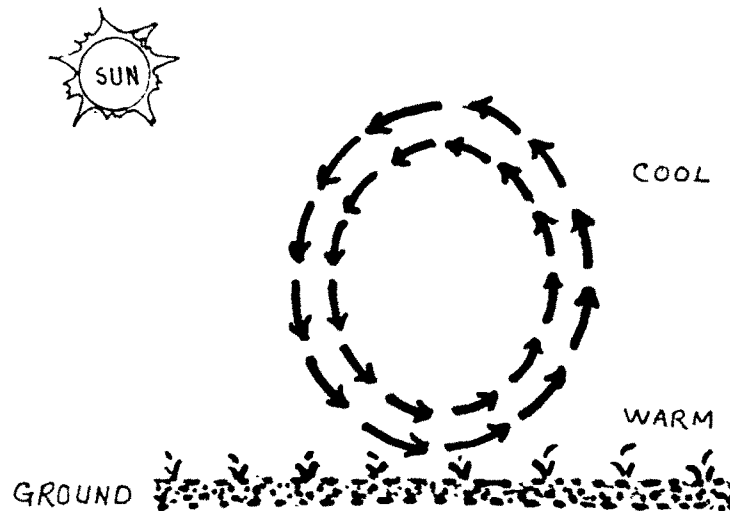


Fig: Vertical Convection of Heat

3) Radiation of Heat: Radiation consists of 'Electro Magnetic Waves' travelling at the speed of the light. Unlike, Conduction and Convection, Radiation does not require intervening physical medium. It can take place in a vacuum. Sun heat reaches to Earth Atmosphere System. Also, through Radiation Earth Atmosphere System loses heat to space.

Advection: When heat is transported horizontally with the atmosphere is known as Advection.

AIR MASS ADVECTION: Movement of 'Air Mass' from one locality to another locality.

COLD AIR ADVECTION: When wind blows from colder area to warmer area, across the 'Regional Isotherms'.

WARM AIR ADVECTION: When wind blows from warmer area to colder area across the 'Regional Isotherms'.

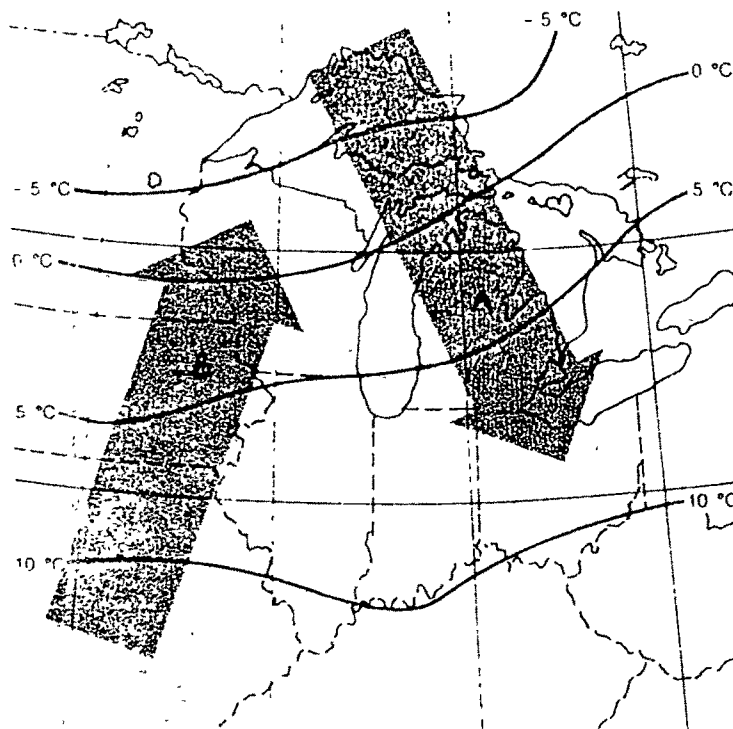


FIGURE
Cold air advection occurs when (A) the horizontal wind blows across isotherms from cold areas toward warmer areas, and warm air advection occurs when (B) the horizontal wind blows across isotherms from warm areas toward colder areas. Solid lines are isotherms.

Fig: Diagram showing warm/cold waves.

TEMPERATURE PROFILE OF THE ATMOSPHERE:

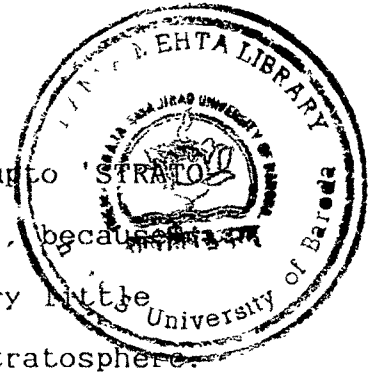
The atmosphere is usually sub-divided into concentric layers, according to the vertical profile of the average air temperature.

TROPOSPHERE: Most weather occurs within TROPOSPHERE - the lowest layer which extends from earth's surface to 20 km altitude at the 'EQUATOR' down 8 km at the 'POLE'. The upper boundary of troposphere is called 'TROPOPAUSE'. The temperature decreases with altitude that is why, mountain's top is 'cold'.

STRATOSPHERE: Stratosphere extends from Tropopause upto 50 km. In lower portion of Stratosphere temperature does not change with altitude. When temperature is constant, the condition is known as 'ISOTHERMAL'.

STRATOSPHERE ... contd ...

Above 20 km, the temprature increases with altitude, upto 'STRATOPAUSE'. Stratosphere is ideal for jet/air-craft travel, because it has excellent visibility & there is no weather. Very little exchange of gases takes place between Troposphere & Stratosphere.



MESOSPHERE: Stratosphere is the transition zone between Stratosphere and Mesosphere. In Mesosphere temprature increases with the increase of altitude. Mesopause is 80 km above the earth's surface and features lowest temprature i.e. -90 Celcius.

THERMOSPHERE: Thermosphere is next to Mesosphere, about 80 km to 90 km above the earth's surface. Temprature is constant, i.e. Isothermal and rapidly increases with altitude.

IONOSPHERE: Zone within Thermosphere where electrically charged particles are found. Highly energised 'Solar Radiation' entering the upper 'atmosphere', strips the 'electrons' from atoms/molecules, are found in atmosphere.

Solar Wind: A stream of electrically charged sub-atomic particles i.e. protons & electrons, that continually emanates from the sun and travels into space at the speed of several hundred km per second. The Solar Wind deflects the Earth's Magnetic Field into 'Tear-Drop Shaped Cavity'. This Cavity sorrounds the earth and called as 'MAGNETOSPHERE'.

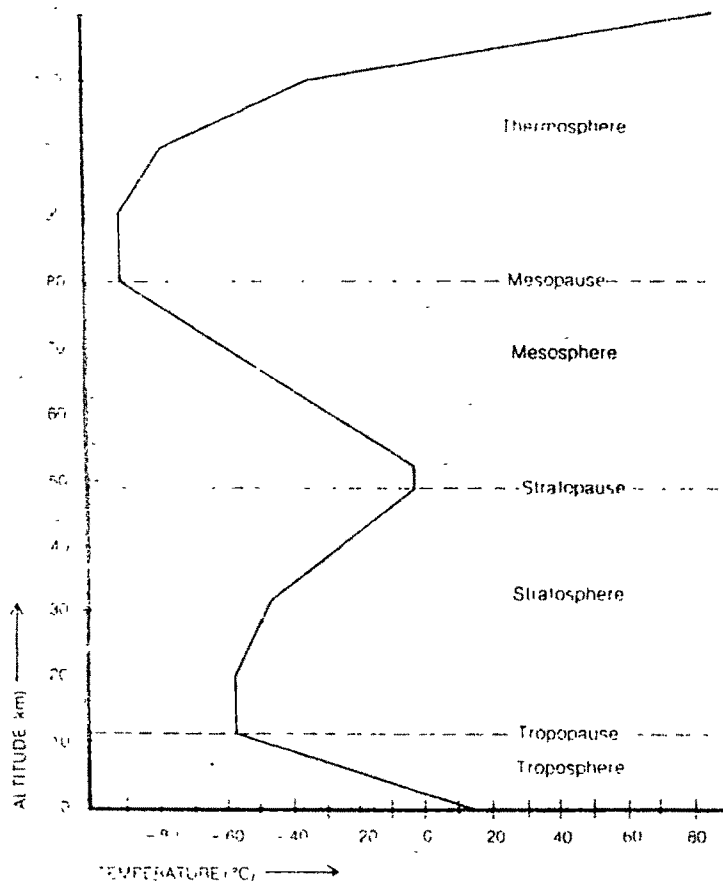


FIGURE
The average variation of temperature with altitude within the atmosphere. Based on this temperature profile, the atmosphere is subdivided vertically into four zones

Fig: Showing Temperature Profile of the Atmosphere.

Heat Imbalance: ATMOSPHERE V/S EARTH SURFACE:

There is net 100% incoming of 'Solar Radiation', out of that 70% heat is absorbed by surface i.e. 51% by water vapor, dust & ozone, 16% by cloud, 3% by others, and rest 30% of total heat is reflected i.e. 6% by air, 20% by cloud and 4% by surface.

The distribution of 100 units of incoming Solar Radiation and out-going 'Infra Red' Radiation, indicates excess heating at the Earth's Surface. The excess heat is transferred to the atmosphere via Latent Heat*.

*Pl see page # for the definition of 'Latent Heat'.

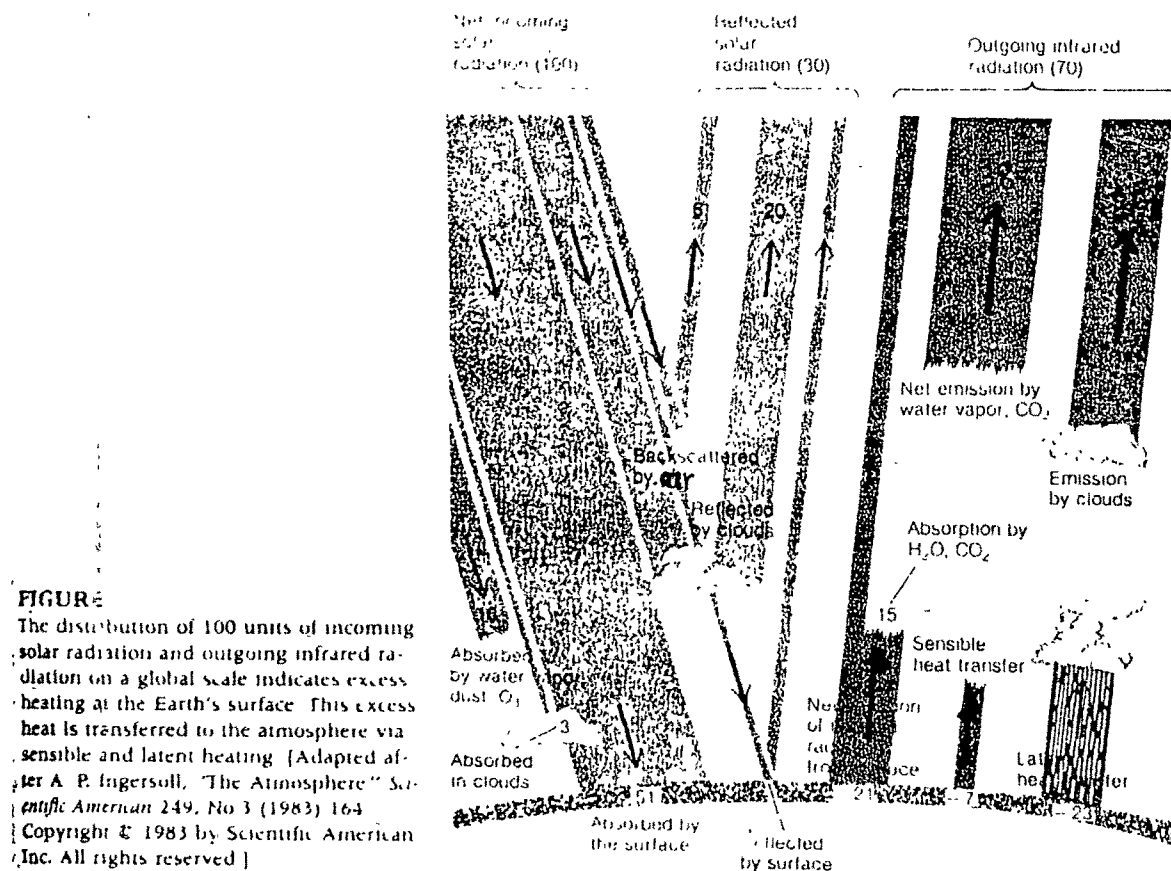


Fig. Heat Imbalance between Atmosphere & Earth Surface.

SATURATED AIR:

70% of earth surface is absolute water in the forms of Oceans, seas Lakes, Rivers, Streams and Saline Lakes etc. and rest water is in the form of 'moist ground', like; ground water, soil water and also in the form of Ice, like; Ice Sheets and Glaciers.

This Solar Heat absorbed by surface causes evaporation i.e. rise of temprature enabales liquid water molecules to escape from water surface in the form of water vapor. Thus making the overlying layer 'SATURATED'. The air which is not fully saturated is 'sub-saturated' or 'partially saturated'.

Thus overlying layer containing vapor is 'warmer/lighter' and less 'densed', so it rises upward and upward. Non-vaporous or dry air is cooler and denser/heavier, therefore, comes down close to the

Saturated Air ... contd....

surface which is warm due to the Solar Radiation, and warms the newly arrived cooler, denser & heavier air. And at the same time, water molecules escape from the water surface in the form of 'vapor'. This newly escaped water vapor rises upwards as warmer, lighter and less dense air, displacing, upper, cooler & denser/heavier dry air, which comes down close to the earth surface. This cycle continues till the upper layer of air becomes 'SATURATED'.

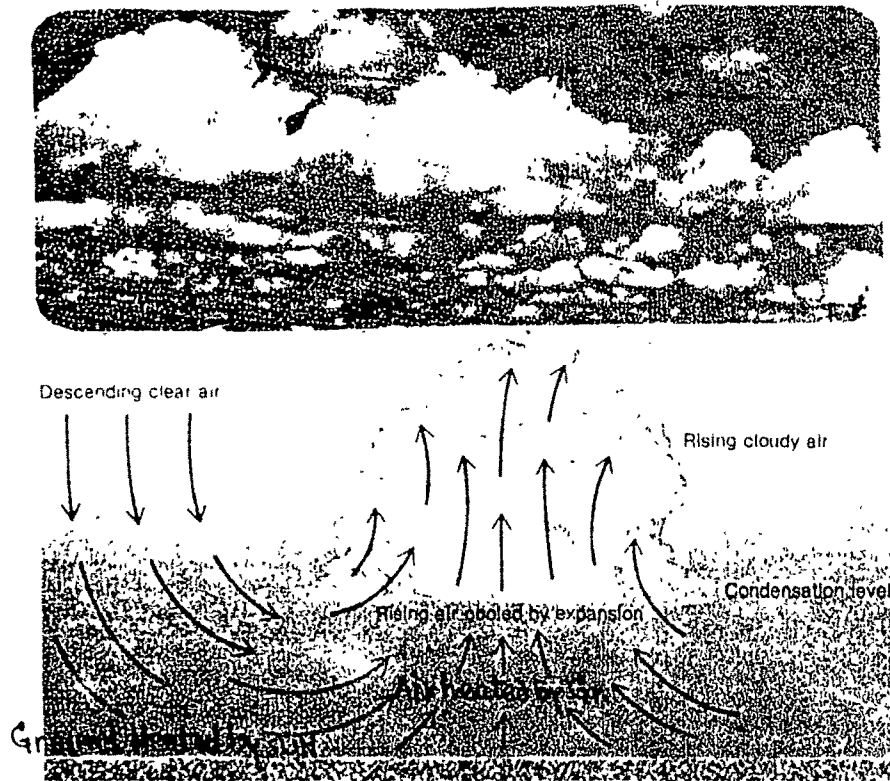


Fig: Cloud development i.e. Transport of excess heat from the earth surface into Tropo-sphere via conduction, convection & latent heat transfer.

Thus 'clouds' are formed, when 'air' containing vapor rises and expands under low air pressure, which exists at higher level in the atmosphere. And thereby, vapors are cooled down and some of the

Saturated Air... contd...

water vapors condenses into 'cloud' composed of numerous tiny water drop-lets.

CONDENSATION:

Clouds are formed by rise of damp air, which then cools down at higher level by expansion. The expansion develops when these damp air encounter the 'falling pressure' at higher level. The Relative Humidity* thereby increases. And if, air is entirely free of foreign particles and ions, the Relative Humidity will continue to increase, until 'Water Vapor Pressure' becomes eight times, that is required to 'saturate' the air.

Water vapors may condense on "AEROSOLS" i.e. air particles, when the air is slightly 'super saturated' or slightly 'under-saturated'. Air contains a number of Aerosols, which act as a centre of condensation called 'Condensation Nuclei'.

There are two types of condensation nuclei:

- 1) HYGROSCOPIC: When condensation occurs on such particle, when air is sub-saturated.
- 2) NON-HYGROSCOPIC: When condensation occurs on such particle i.e. Nuclei, only when air is 'super-saturated'.

*RH is amount of water present in a given volume of air expressed as a percentage of the amount the air can hold at the same temprature.

**The first experiment to demonstrate condensation of water vapor on air-borne particles, was carried out by Coulier of France in 1875.

CLOUD FORMATION:

Water vapor is an invisible gas, but the condensation and deposition products of water vapor are visible. 'Clouds' are the visible manifestations of the condensation & deposition of water vapor within the atmosphere. They are composed of tiny water droplets, ice crystals or mixture of both.

Laboratory studies have demonstrated that in a clean air, free of dust & aerosols, the condensation or the deposition of water vapor is extremely unlikely, except under super-saturated condition i.e. when Relative Humidity is 100%.

In clean air, the degree of 'supersaturation' needed for CLOUD development increases rapidly, as the radius of water droplets decreases. For example, relatively small droplets ($r = .10$ Micron), requires 340% supersaturation. In contrast, relatively large water droplets ($r = 1.0$ Micron), requires slight supersaturation to form the cloud.

As water surface exhibits increasing 'curvature', it becomes easier for water molecules to escape the liquid and become 'vapor'. Water molecules that form a curved surface have fewer neighbouring molecules, and hence, are more weakly held by H-bonding, than water molecules that form a 'flat' surface.

In case of spherical water droplets, the curvature increases with the decrease of radius. Hence, at the same temperature, water molecules more readily escape from small droplets than the large droplets. This implies that the 'degree of saturation' must increase i.e. supersaturation, as the water droplet size decreases.

Cloud Formation...contd...

In the atmosphere, atmost, only slightly supersaturated conditions are necessary for cloud development. This is because the atmosphere contains abundance of 'Nuclei': tiny solid & liquid particles that provide relatively large surface areas on which condensation or deposition can take place.

Nuclei are the products of both, natural and human activities, like forest fires, volcanic eruptions, wind erosion of soil, salty water spray and the discharges from domestic and industrial chimneys are the sources of 'Nuclei'.

Hygroscopic Nuclei have a special chemical efficiency/attraction for water molecules. Condensation begins on these nuclei at Relative Humidity under 100%. Infact, $MgCl_2$, a salt in sea spray is Hygroscopic substance that can initiate condensation at Relative Humidity as low as 70%. We can expect cloud formation when the Relative Humidity nears 100%.

Ice in Clouds: Presence of Ice in the clouds, depends on the type of 'Nuclei':

CLOUD CONDENSATION NUCLEI: These Nuclei are i.e. promote condensation at temperatures, both above and below 'Freezing', because water droplets condense and remain liquid even when the cloud temprature is well below 0 Celcius/32F. These are super-cooled water droplets.

ICE FORMING NUCLEI: These are comparetively less abundant and become active only at the temprature well below 'Freezing', and are of two types: i) Freezing Nuclei & ii) Deposition Nuclei.

TYPES OF ICE FORMING NUCLEI ... contd...

- 1) FREEZING NUCLEI: Freezing Nuclei cause liquid droplets to freeze.
- 2) DEPOSITION NUCLEI: Nuclei on which water vapor deposits as 'ice'.
Deposition Nuclei are also called as 'Sublimation Nuclei'.

Freezing Nuclei are active only below -9 Celcius/16F, while Deposition Nuclei become fully active only at -20 Celcius/-4F.

PRECIPITATION PROCESS:

The development of cloud is not guarantee for rain/snow. Nimbostratus & Cumulo-nimbus clouds produce bulk of 'precipitation', (most clouds do not) and therefore, rains or snows.

Terminal Velocity:

Water droplets or ice crystals of clouds are so tiny that they remain suspended till they vaporise or grow considerably. Updraft within the cloud prevent the fall of these tiny water/snow droplets from cloud base to the earth surface. Even if water droplets/ice-crystals descend from cloud, their downward draft is slow that they re-vaporise* in mid-air before reaching to the earth.

The speed of a water droplet/ice crystal/any other particle, falling in 'calm' air, is regulated by two forces: i) Force of Gravity & ii) An Opposing Force caused by resistance of air through which particles descend. As the particles reach near the earth, 'air-resistance' increases, while 'force of gravity' remains constant. Eventually, 'resistance force' equals the 'force of gravity', and this way 'particles' drift down at a constant speed known as 'TERMINAL VELOCITY'. Terminal Velocity increases with the particle size.

* ... وَيُصْرَفُهُ عَنْ مَقَامِهِ الْوَسِيلَةِ (18- التور- 43)

Precipitation Process . . . contd...

Cloud particles of 10-20 Micron vaporises in un-saturated air below the cloud base, when they grow enough to counter the 'up-draft' and manage to descend. How does a million cloud drop-lets of 10-20 Micron, grow to form a single 'Rain Drop' of about 2mm diameter? Condensation alone cannot cause cloud droplets to grow into Rain-Drops, but there are two important Processes by which cloud particles grow large enough to precipitate:

1) Collision Coalescence Process:

This Process occurs in warm cloud i.e. clouds above the freezing temperature and entirely made of liquid water drop-lets. A large drop let of about 40 Micron produced by giant sea salt 'Nuclei', precipitate to form larger droplet in cloud. When larger droplet falls it collides/combines with smaller droplets, many times, until it becomes so large that falls out of cloud as 'Rain Drop'.

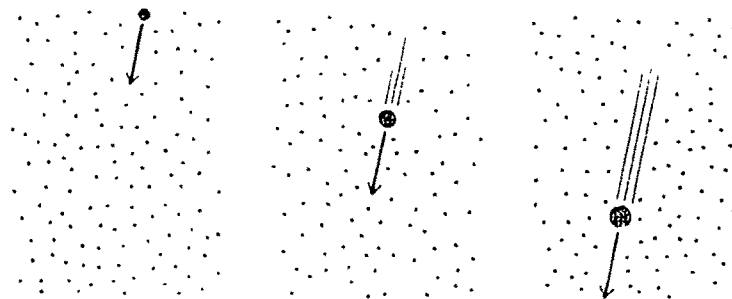


Fig: The Collision Coalescence Process

2) Bergeron Process:

Although cloud droplets grow through 'Collision Coalescence Process, but most precipitation that falls on earth originates through the

Bergeron Process ... contd...

'Bergeron Process'. This Process is applied to the 'Cold' clouds, i.e. temperature below zero Celcius. The Bergeron Process requires the co-existence of water vapor, Ice Crystals and super-cooled water droplets.

Cold Clouds: Most ice-forming nuclei are not active at the temperature higher than -9 Celcius. Consequently, clouds at the temperatures between 0 °C to -9 °C are typically composed of super-cooled water droplets exclusively. While clouds at the temperatures between -10 °C to -20 °C, are mixtures of supercooled water droplets and Ice Crystals. Again, clouds below -20 °C, contain ice crystals only.

The Bergeron Process depends on the difference in Saturation Vapor Pressure between Water Vapor over 'Ice' and water vapor over 'water'. This difference triggers Ice Crystals growth at the expense of the supercooled water droplets. Water molecules vaporise more quickly from liquid water than of solid ice at temperature below freezing point. This is because water molecules are bonded more strongly in 'solid' phase than in the solid phase. As a consequence, the Saturated Vapor Pressure of Water Vapor over ice is less than Saturated Vapor Pressure of water vapor over water.

In cold clouds that are composed of ice crystals and supercooled water droplets; vapor pressure is saturated for water droplets, therefore, is supersaturated for ice crystals.

Precipitation Process ... contd...

Suppose that the vapor pressure is 2.86 mb in a cloud at a temperature of -10 C. It means air surrounding water droplets is 'saturated' with 100% 'Relative Humidity', whereas 'air' surrounding the Ice Crystals is supersaturated with 110% Relative Humidity. In response to supersaturated conditions, water vapor deposits on the Ice Crystals, and the Ice Crystals grow larger. Deposition removes water vapor from the cloud and thereby lowers the Relative Humidity.

The Relative Humidity of the 'air' surrounding the water droplets dips below 100% and the droplet vaporises. Under these conditions, the ice crystals grow at the expense of Supercooled Water Droplets.

As the Ice Crystals grow larger and heavier, their 'Terminal Velocity' increase and they collide and 'coalesce' with smaller supercooled water droplets & Ice Crystals in their path, thereby growing still larger. Eventually, the Ice Crystals become so heavy that they fall* out of the cloud base.

If air temperature is below Freezing Point throughout upto the ground the ice crystals reach the earth as 'Snowflakes'. If the air temperature below the cloud is above the Freezing Point, Snowflakes melts and falls as 'Rain Drop'.

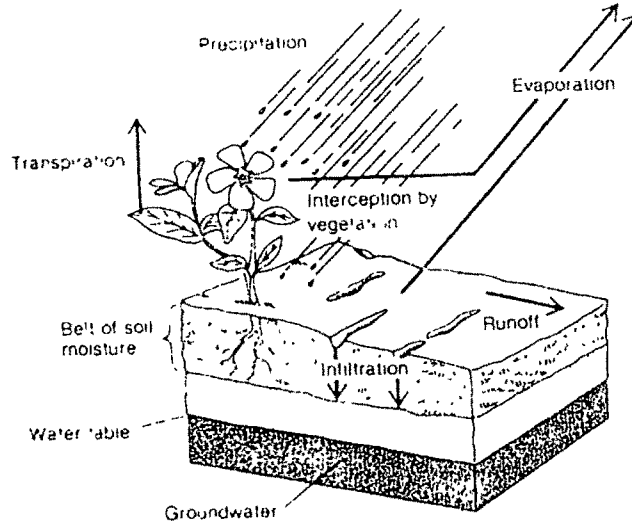
FORMS OF PRECIPITATION:

- i) DRIZZLE from stratus ii) RAIN from Nimbostratus iii) HEAVIEST-RAIN from Cumulus/Vertical Cloud iv) SHOWERS from Cumulus/Vertical Cloud v) SNOW from Stratiform vi) HAIL from Cumulus/Vertical Cloud vii) HAIL STONE from Vigorous.

* وَيُنَزِّلُ مِنَ السَّمَاءِ مِنْ جِبَالٍ فِيهَا مِنْ بَرَدٍ فَيُخِطِّبُ بِهِ مَنْ يَشَاءُ... ٥ (١٨- السور- 43)

PRECIPITATION

وَأَمْطَرْنَا عَلَيْكُمْ مَطَرًا ... ع (8-11 عراف - 84)



وَأَنْزَلَ مِنَ السَّمَاءِ مَاءً ... ع (13-14 إبراهيم - 32)

The above figure illustrates the various pathways taken by precipitation that falls on the land shown by J. M. Moran, Introduction to Environmental Science, New York, USA.

Thus, water obtained from rain fall, revive the metabolic processes in dormant seeds, through rehydration. The first stage of revival of life in seeds is called germination and the last stage of the life cycle is dehydration or death. Therefore, the next chapter II, covers The Life Cycle of Plants.