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Geography

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Preface

If you ever happen to be walking down the streets of places where preparation for Civil Services is done, it will not be uncommon for you to come across or make the acquaintance of 'several' starry eyed yet completely committed IAS aspirants. Yet, 'several' would be an understatement given the number that runs into lakhs! But when we say committed, we mean it; these young men and women are ready to sacrifice almost all their youthful follows including sleep, comfort and even a semblance of a normal life to achieve one goal—IAS!

Sadly, this dream remains a distant one for a large majority of these aspirants in spite of the endless hours of study and sleep forsaken nights. When we tried to unravel WHY, the responses were almost synchronous:

"The subject was so vast that there was too much to cover and I could never complete it."

"I read so much but could not retain it."

"I studied something but was quizzed on something else in the exam."

"I kept reading but did not attempt to solve the past year papers or give a mock exam."

"Subscribing to several sources of information/preparation such as a coaching class, the internet and books was futile; after all there are only 24 hours in a day."

"My almirah was full of too many books, but I could barely complete a few."

And while the candid answers stated above clearly gave us a challenging problem—we did not attempt to solve it. We instead focused on a holistic solution—the synchronizing of effort i.e. Learning and Positive Results!

It is with this aim that we—PrepMate collaborated with Cengage India—are continuously striving to develop a comprehensive learning model that is a combination of print and digital product so as to effectively address the issues that most aspirants grapple with.

About the Print–Digital Learning Model

The learning model initiates the process with a series of books targeted at cracking the UPSC exam. The books stand apart from others available because of the following unique features:

- We use a conceptual approach, simple language, explain concepts with diagrams, cite sufficient examples, pose pertinent questions in a reader friendly format—to ensure that the contents of these books can be read and assimilated in a time-bound manner.
- The content is specially designed taking into account the trend in UPSC exams in recent years. We have also included the previous years' questions (with solutions) after every chapter.

- The Practice Questions at the end of each chapter are exhaustive to provide sufficient preparation to crack the exams.
- The book series also contains additional information on 'how to write answers' along with what your approach should be for the mains—here too we have explained by solving questions and showing you the 'preferred answering style'.
- We have tried to encapsulate all that is required to be learnt for a particular subject into a single book.

Usually, an aspirant purchases a book, but never gets a chance to contact the authors. We believe that the contact among aspirants and authors is important for learning and motivation of the aspirants. That is precisely why we have developed an application and a web portal to answer your queries and provide you with continuous support during your preparation.

It is through this digital component that we provide the following services:

1. Videos covering important and difficult topics
2. Answer writing practice sessions
3. Daily prelims quiz
4. Assistance in interview preparation
5. Regular updates
6. Daily currentaffairs
7. Monthly current affairs magazine
8. Radio news analysis
9. Educational videos
10. Previous years' papers and solutions
11. Free study materials

Looking forward to being your partner in the journey towards achieving your dream!

In case you have any specific queries or constructive feedback you can always share the same with us via e-mail at info@prepmate.in.

PrepMate

Acknowledgements

"We cannot accomplish all that we want to do without working together"

The complete UPSC learning module by Prepmate has been the culmination of more than a year of ideation and brain storming by a lot of people. It is only natural that we should gratefully acknowledge their valuable contribution sincerely. I, Shubham Singla, founder of PrepMate Edutech, thank you all for being with me in this whole project. Rajinder Paul Singla, Nirmal Singla, Ramnik Jindal, Sharat Gupta, Subhash Singla and Vijay Singla—thank you for your continuous support and motivation.

We would also like to thank Maninder Mann and Sundeep Singh Garha who helped us in first conceiving and later developing the synergistic print–digital model of the project— without you we would be missing our competitive edge.

Implementation of strategy can more often than not prove challenging and the development of the online module did prove to be tougher than we had envisaged. But our technical team was focused on enabling our dream and delivering the best, and they surely did. With a specific mention to the testing of both the website and the application, we would like to thank Surabhi Misra, Parth and Tanvir who did their job patiently and effectively in spite of the road blocks.

Our videos and books could not have been possible without the help of our graphics design team—Sandeep, Sukhjinder and Roshni toiled endlessly to ensure the best designed audio-visuals.

It is an understatement to state that the sourcing and reviewing of existing content and the generation of content was the most crucial part of this project and the backbone of our Learning Module. This would just not have been possible without our team of content contributors: Isha Gupta, Shelly Jindal, Gurdeep Kaur, Surabhi Misra, Shaffy Garg, Dipika Arora, Sunil, Bhupinderjit Singh, Shantnu, Tanvir, Anmol, Kriti, Tanya, Sahil, Suraj and Dilshad, who left no stone unturned in their pursuit of excellence—your pivotal contributions are gratefully acknowledged.

We would like to extend a special thanks to our staff members Geeta, Jitender, Manoj and Pinki, who helped us in the most laborious job i.e. typing through the several manuscripts of our books—your contribution is sincerely appreciated.

It is imperative that we thank Isha Gupta, Shelly Jindal, Anjum Diwan, Rajesh Goel, Shikha Sharma and Ravinder Indoura, for their critical yet constructive feedback that identified and subsequently rectified the errors that crept in during the development process. We will never be able to thank them enough for this—you fortified the very foundation of our model.

We sincerely acknowledge the initiatives and support from the entire editorial team of Cengage India in the process of publishing this book.

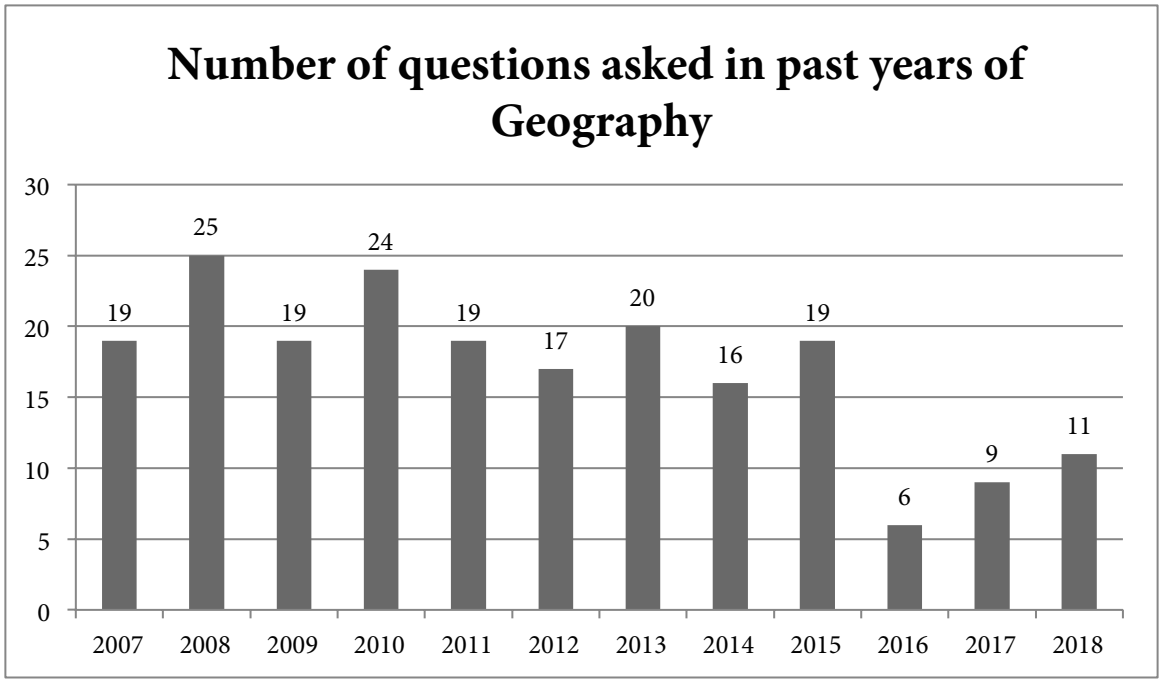
PrepMate

List of Videos

Chapter-wise Break Up of Previous Year's Questions (Prelims)

Chapter names	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	Total
1. Universe							2	1					6
2. The Solar System							2	1					6
3. Our Earth						1						1	2
4. Moon													0
5. Structure of Earth	1									1			2
6. Lithosphere					1								1
7. Landforms	1				1		1					1	4
8. Atmosphere													0
9. Insolation and Temperature							1		1		1		3
10. Air Circulation and Winds		1		1		1		2	1	1		1	8
11. Cyclones and Anti-Cyclones				1									1
12. Water in the atmosphere						1		1					2
13. Oceanography				2		3	1		1			1	8
14. Drainage System													0
15. World Climate Types				1	1	2	1	1	2				8
16. Continents	1	1		2	2	1		1	1	4	4	3	20
17. India Political	2	1		2	1		1		1		2	1	11
18. Structure and Relief	1	2	1	1	1		1				1	2	10
19. Rivers of India		1	2	1	1	1		1	3	5	5	2	22
20. Soils	1		1	1	1	2		2	2				10
21. India's Climate							1		1	1			3
22. Natural Disasters													0
23. Biodiversity							1	2					3
24. Natural Vegetation	1		1	3	1	2		2	2		1		13
25. Protected Area Network	1	1		2	2	2	3	3	3		2		19

Chapter names	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	Total
26. Economic Activities and location Factors							1		1			1	3
27. Agriculture	1	1	1		2	1	2	2	2		1	1	14
28. Mineral and Energy Resources	1			1		1			2	1	2	3	11
29. Transportation		1								1			2
30. Population					2	2	1	1	1	3	4	1	15
31. World Economic and Social Geography										1	1		2
Total	11	9	6	19	16	20	17	19	24	19	25	19	207


Number of questions asked in past years of Geography
30
25
20
15
10
5
0
19
25
19
24
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19
6
9
11
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

Unit - I

UNIVERSE

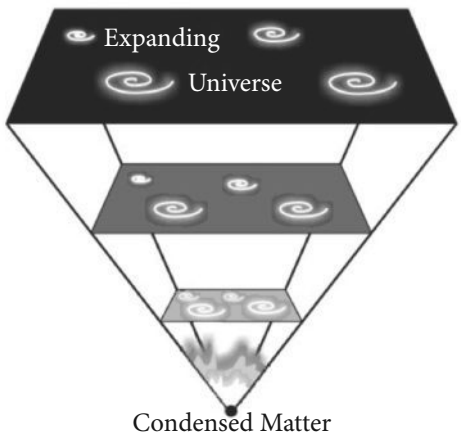
Chapter 1 UNIVERSE

1 ORIGIN OF UNIVERSE

The universe was formed about 13.77 billion years ago. Our planet Earth is much younger and was formed around 4.5 billion years ago.

Big Bang Theory

The most acceptable theory regarding the origin of the universe is the Big Bang Theory. It is also called the **expanding universe hypothesis**. Edwin Hubble, in 1920, provided evidence that the universe is expanding.



The Big Bang

The Big Bang Theory considers the following stages in the development of the universe:

1. In the beginning, all the matter forming the universe existed in one place in the form of a "compact ball" of condensed matter with an unimaginably small volume.
2. The compact ball exploded violently due to continuous contraction. This huge explosion is popularly known as the Big Bang.
3. As a result of explosion, universe is continuously expanding ever since.

The argument for expansion of the universe is supported by the phenomenon of red shift.

Red shift

The frequency of a wave appears to be higher when a source approaches the observer and it is lower when a source moves away from the observer. In the spectrum of visible light, red has the lowest frequency and the longest wavelength, while violet has the highest frequency and the shortest wavelength.

It is observed that light coming from distant galaxies shift towards the red-end of the light spectrum and this shift of light is called red shift.

Thus, red shift of the light emerging from other galaxies proves that galaxies are moving away from each other. In other words, the universe is expanding.

Oscillating Universe Theory

The oscillating universe theory is built upon the Big Bang Theory. It affirms that at present, the universe is in the state of expansion because of the force generated due to the big bang explosion.

However, the theory predicts that when the magnitude of repulsive force, on account of big bang, will be lesser than the gravitational pull of the matter (after 29 billion years), the matter would again start moving towards the centre of the universe and there would be another big bang. This process of contraction and expansion would continue forever.

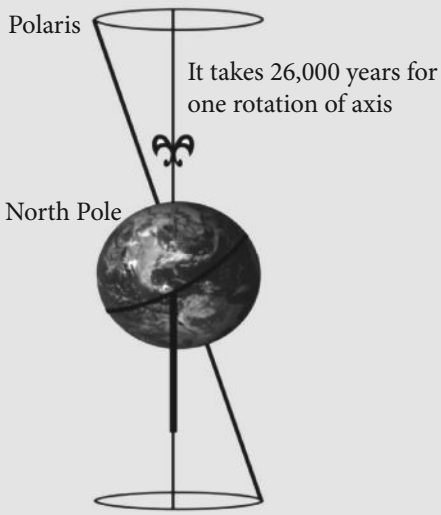
2 COMPONENTS OF UNIVERSE: CELESTIAL BODIES

1. **Galaxies:** A galaxy is the congregation of millions of stars held together by their own gravitational force. Our galaxy is called the Milky Way.
2. **Star:** It generates energy in the form of light through the process of nuclear fusion in which lighter elements, particularly hydrogen, fuse to form heavier elements such as helium. Sun and Polaris are popular stars.
3. **Constellation:** Cluster of stars organized into different shapes is called constellation. Saptarishi or the Big Dipper is one of the most popular pattern of stars visible in the sky, consisting of the seven brightest stars of the large constellation Ursa Major. The constellation's most recognizable stars (group of seven stars) are commonly known as "the Big Dipper". The Big Dipper and the constellation as a whole have mythological significance in numerous world cultures, including India.

Polaris: It is commonly known as the North Star or the Pole Star. Its position appears fixed in the sky, while all other stars appear to be moving. This is because it lies directly over the Earth's North Pole, making it the current northern Pole Star.

This position, however, is not permanent. The orientation of the Earth's axis too undergoes a change with time. The Earth's axis takes 26,000 years to complete one cycle.

So after some hundreds of years from now, Polaris may no longer be the "static" Pole Star as the Earth's axis may point towards a new star.



Formation of Galaxies and Stars

A galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called nebula. Eventually, growing **nebula** develops localized clumps of gas. These clumps continue to grow into even denser gaseous bodies, giving rise to stars.

The formation of stars is believed to have taken place some 5–6 billion years ago.

4. **Asteroids:** These are the remains of matter or space debris that could not become part of any planet. In our solar system, asteroids are mainly found, in the form of **asteroid belt**, between Mars and Jupiter.
5. **Comets:** These are loose collections of ice, dust, and small rocky particles, found in the outer fringes of the solar system. As a comet approaches the inner solar system, solar radiation causes the volatile materials within the comet to vaporize. These vaporized materials carry away dust with them leading to formation of a tail. Under the influence of solar winds, the tail always points away from the Sun. Comets follow an eccentric path but have a definite periodicity. Haley's Comet is a popular comet, which is seen from the Earth after a period of 76 years.
6. **Meteors or shooting stars:** A meteor or a shooting star is the flash of light that appears when a small chunk of interplanetary debris burns up as it passes through our atmosphere. It is to be noted that "meteor" refers to the flash of light caused by the debris, not the debris itself.

   The debris is called a meteoroid. Most **meteoroids** are only a few millimetres in size. Most meteoroids that enter the Earth's atmosphere are so small that they vaporize completely and never reach the planet's surface.

   If any part of a meteoroid survives the fall through the atmosphere and lands on Earth, it is called a meteorite. Although the vast majority of **meteorites** are very small, their size can range from about a fraction of a gram (the size of a pebble) to 100 kg or even more.

3 THE LIFE CYCLE OF A STAR

A star evolves through many stages from a cloud of gas and dust to a dark, dense matter. Various stages in the life cycle of a star are as follows:

NEBULA

A nebula is a huge cloud of gas (particularly hydrogen) and dust in space. Nebulae are the nurseries where stars are born.

STAR

A star is a luminous body of gas. It produces light (along with heat) upon fusion of hydrogen into helium. The fusion of lighter elements into heavier elements is called nuclear fusion.

The surface temperatures of a star can range from 2000°C to above 30,000°C. The light emitted by a star depends on its temperature. A star with a surface temperature near 30,000°C appears blue and that near 2000°C appears red. The Sun's surface temperature is about 6000°C. Although the Sun appears yellow to us, actually the light emitted by it is white.

If the Sun's surface temperature was low, it would give more light on the red end of the spectrum, and if the temperature was higher, it would give light more on the blue end of the spectrum.

Red Dwarfs

Red dwarfs have the lowest temperature. These stars are a fraction of the mass of our Sun (minimum 8% mass of the Sun). They appear red because their surface temperature is about 3500°C. The surface temperature does not exceed because these stars have less fuel on account of their small size. Consequently, the light emitted by these stars is towards the red end of the spectrum.

They burn very slowly and have estimated lifetimes of 100 billion years. Proxima Centauri and Barnard's Star are red dwarfs.

Brown Dwarfs

Brown dwarfs are even smaller than red dwarfs. Their mass is less than the critical mass, and thus they do not shine like a normal star.

Their surface temperature is low and are faint in appearance. Their size is approximately one-tenth the mass and diameter of Sun.

RED GIANT

Towards the end of its life, a star turns into a red giant. Red giants have diameters between 10 and 100 times that of Sun. They also appear bright. They have a lower surface temperature because they have

already exhausted their fuel in the core. When the fuel in the core exhausts, the fusion of hydrogen begins in a shell surrounding the core.

Red giants become larger in size because when their outer layer burns, the heat energy released from the outer core pushes against the core of the star and thus, the volume of the star expands.

When all the hydrogen of the star converts into helium, the star begins to contract under its gravitational pull, resulting further in the fusion of helium into heavier elements.

They appear very bright because of their massive size, although their surface temperature is lower than that of Sun, about 2000–3000°C.

Very large red giants are called "super giants". Super giants can have a diameter 1000 times that of Sun, and their luminosity can be 1,000,000 times greater than that of Sun.

WHITE DWARF

Eventually, a star loses some of its outer layers on account of gravitational pull exhibited by nearby bodies. Moreover, the remaining star contracts further under its own gravitational pull, resulting into a white dwarf.

A white dwarf is a very small and hot star. White dwarfs have a mass similar to that of Sun, with only 1% of its diameter. The surface temperature of a white dwarf is 8000°C or more. On account of reduction in nuclear fusion, it emits around 1% light as that of Sun. White dwarfs cool down and fade over several billion years.

SUPERNOVA

In this stage, a star meets with an explosive death. The star becomes 100 million times as bright as the Sun but for a short time. Supernova occurs mainly due to two reasons:

1. These occur when gas from one star falls on a white dwarf, causing it to explode.
2. These occur in stars that are 10 times or more in size than the Sun. These stars experience quick internal nuclear reactions at the end of their lives, leading to an explosion.

   They leave behind neutron stars and black holes. Supernovae are thought to be main source of elements heavier than hydrogen and helium.

NEUTRON STARS

Neutron stars are called so because they are composed mainly of neutrons. These stars emerge upon supernova explosion, forcing the protons and electrons to combine to produce neutrons.

Neutron stars are very dense. A typical neutron star has three times the mass as that of the Sun but a diameter of only 20 km. If the mass is even greater, its gravity is so strong that it shrinks further to become a black hole.

BLACK HOLES

Massive stars at the end of their life cycle result into black holes. The gravitational pull of a black hole is so high that nothing can escape from it, not even light. The density of matter in a black hole cannot be measured. Black holes distort the space around them, and often suck mass in their neighbourhood.

Practice Questions

1. A meteorite is:
   (a) A comet with a bright gaseous tail.
   (b) A piece of matter that burns and gets converted into ash as it enters the Earth's atmosphere from outer space.
   (c) A piece of matter that does not burn completely and reaches the surface of the Earth.
   (d) None of the above.

2. What is the difference between asteroids and comets?
   1. Asteroids are found between Mars and Jupiter, whereas comets are in the outer fringes of the solar system.
   2. Asteroids are gaseous in nature, whereas comets are not.
   3. Comets have a tail, while asteroids do not.

   Which of the statements given above is/are correct?
   (a) 1 and 2 only
   (b) 1 and 3 only
   (c) 3 only
   (d) 1, 2, and 3

3. Which of the following statements about our universe is/are correct?
   1. Our universe is in the state of expansion.
   2. Light waves are used to study the distant galaxies present in the universe.
   3. Sound waves are used to measure the distance among various celestial bodies.

   Select the correct answer using the codes given below:
   (a) 2 and 3 only
   (b) 1 and 2 only
   (c) 1 only
   (d) 1, 2, and 3

4. Consider the following statements:
   1. Comets have highly elliptical orbits that bring them close to the Sun, often beyond the orbit of Pluto.
   2. Solar wind is responsible for the formation of tails in comets.

   Which of the statements given above is/are correct?
   (a) 1 only
   (b) 2 only
   (c) Both 1 and 2
   (d) Neither 1 nor 2

5. Consider the following statements about our universe:
   1. Our universe was formed 9 billion years ago.
   2. Light waves help in determining the distance among celestial bodies.
   3. Our solar system is in a continuous state of expansion.

   Which of the statements given above is/are correct?
   (a) 2 and 3 only
   (b) 1 and 2 only
   (c) 2 only
   (d) 1, 2, and 3

PERFECTING PAST PRELIMS

1. What is the difference between asteroids and comets? **(2011)**
   1. Asteroids are small rocky planetoids, while comets are formed of frozen gases held together by rocky and metallic material.
   2. Asteroids are found mostly between the orbits of Jupiter and Mars, while comets are found mostly between Venus and Mercury.
   3. Comets show a perceptible glowing tail, while asteroids do not.

   Which of the statements given above is/are correct?
   (a) 1 and 2 only
   (b) 1 and 3 only
   (c) 3 only
   (d) 1, 2, and 3

2. A person stood alone in a desert on a dark night and wanted to reach his village, which was situated 5 km east of the point where he was standing. He had no instruments to find the direction, but he located the Pole Star. The most convenient way now to reach his village is to walk in the direction **(2012)**
   (a) Facing the Pole Star.
   (b) Opposite to the Pole Star.
   (c) Keeping the Pole Star to his left.
   (d) Keeping the Pole Star to his right.

3. Which of the following is/are cited by scientists as evidence for the continued expansion of the universe? **(2012)**
   1. Detection of microwaves in space
   2. Observation of red shift phenomenon in space
   3. Movement of asteroids in space
   4. Occurrence of supernova explosions in space.

   Select the correct answer using the codes given below:
   (a) 1 and 2 only
   (b) 2 only
   (c) 1, 3, and 4
   (d) None

ANSWER KEYS

Practice Questions

1. (c)	**2.** (b)	**3.** (b)	**4.** (c)	**5.** (c)

Perfecting Past Prelims

1. (b)	**2.** (c)	**3.** (a)		

Chapter 10

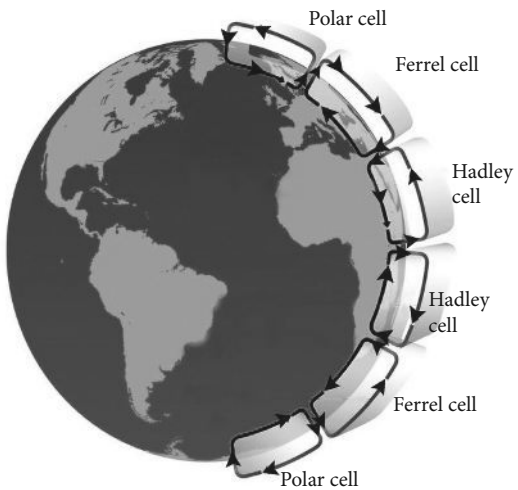
Air Circulation and Winds

1 LATITUDINAL AIR CIRCULATION

Atmospheric circulation is the large-scale movement of air by which heat is distributed on the surface of the Earth. This large-scale movement occurs both across latitudes and longitudes.

Latitudinal air circulation refers to the circulation of air between two latitudes over the surface of the Earth. Latitudinal air circulation comprises three cells: Hadley Cell, Ferrel Cell, and Polar Cell. These three cells exist in both northern and southern hemispheres.

Here, "cell" is defined as a closed loop of circulating winds. In a cell, the circulation of winds at the surface of the Earth is in the direction which is opposite to the direction in which the upper atmospheric winds move.



Hadley Cell

Hadley Cell is the atmospheric circulation pattern described by George Hadley.

The **equatorial low-pressure belt** exists between 0° and 5° latitudes in both northern and southern hemispheres. This low-pressure belt is on account of intense heating of the equator region. On account of low pressure in the equatorial belt, wind converges from the nearby regions. Thus, the equatorial low-pressure belt is the zone of wind convergence. In ancient times, the equatorial low-pressure belt was known as **Doldrums** as sailors used to get stuck at the equatorial low-pressure belt after sailing from the **subtropical high-pressure belt**.

On account of intense heating in this belt, the air gets warm and consequently light in weight. The warm air rises upwards and expands. This warm air, after reaching the upper atmosphere, starts moving towards the subtropical high-pressure belt. By the time air reaches above the subtropical high-pressure belt, it is cold enough to descend downwards. On account of this cold descending air, the subtropical (30° latitude in both northern and southern hemispheres) belt has high pressure. On account of high pressure, winds blow towards the equatorial low-pressure belt from these regions.

Thus, the movement of winds from the subtropical high-pressure belt to the equatorial low-pressure belt, rise of winds to the upper atmosphere, subsequent movement towards the subtropical belt in the upper atmosphere, and descend of winds on the surface of the Earth at the subtropical belt complete the Hadley Cell.

The subtropical high-pressure belt was known as the **horse latitude** because at this belt, sailors used to throw horses in the water to reduce the weight of the ship so that the ship could sail a little and come under the influence of winds.

Polar Cell

The **polar high-pressure belt** exists at the 90° latitude in both northern and southern hemispheres. The temperature is very low in this belt. Thus, the air becomes cold and heavy, constituting a high-pressure belt. The cold polar winds move towards the temperate regions. By the time these cold winds reach the 60° latitude, they get warm enough to rise upwards. At the 60° latitude, in both northern and southern hemispheres, there is a **temperate low-pressure belt**.

After rising, these winds start moving towards the poles in the upper atmosphere. By the time these winds reach the poles, they get cold enough to descend downwards.

Thus, the movement of winds from the polar high-pressure belt to the temperate low-pressure belt, rise of winds to the upper atmosphere, subsequent movement towards the polar belt in the upper atmosphere, and descend of winds on the surface of the Earth at the polar belt complete the Polar Cell.

Ferrel Cell

The existence of the Ferrel Cell depends on the Hadley and Polar Cells. Thus, the Hadley and Polar Cells are considered primary cells, and the Ferrel Cell is considered secondary cell.

In this cell, winds from the subtropical high-pressure belt move towards the temperate low-pressure belt. By the time these winds reach the temperate low-pressure belt, they become warm enough to rise upwards. These warm winds after rising upwards start moving towards the subtropical high-pressure belt. By the time these winds reach the subtropical high-pressure belt, they get cold enough to descend downwards.

Shifting of Cells and Pressure Belts

The entire system of cells and, consequently, pressure belts shifts latitudes on the basis of the strength of sunrays. In June, when the sunrays are maximum over the Tropic of Cancer, the cells and pressure belts shift northwards. In December, when the sunrays are maximum over the Tropic of Capricorn, the cells and pressure belts shift southwards.

Convergence Zone and Divergence Zone

Convergence and divergence, in meteorology, refer to the accumulation and drawing apart of air, respectively. The terms are used to refer to the horizontal inflow (convergence) or outflow (divergence) of air. The convergence of horizontal winds causes air to rise, whereas the divergence of horizontal winds causes downward motion of the air (subsidence). Ground-level atmospheric pressure is not affected by convergence if divergence of an equal magnitude occurs simultaneously at higher levels.

Implications of Convergence and Divergence

Convergence and divergence determine where air will be sinking or rising. Rising air is associated with clouds and precipitation; sinking air is associated with clear, calm conditions and good weather.

Where are Convergence and Divergence Zones Formed?

Winds converge at low-pressure regions and diverge at high-pressure regions. Thus, the equatorial low-pressure belt and the temperate low-pressure belt are convergence zones. On the other hand, the subtropical high-pressure belt and the polar high-pressure belt are divergence zones.

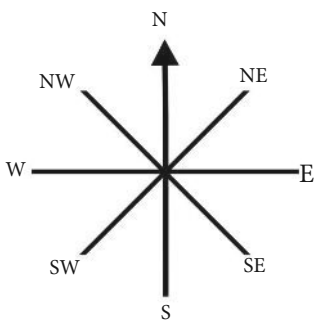
The zone of convergence at the surface of the Earth is balanced by the zone of divergence in the upper atmosphere and vice versa.

What is the Inter-tropical Convergence Zone?

The inter-tropical convergence zone (ITCZ) is formed where winds coming from the subtropical regions (both northern and southern hemispheres) meet. Usually, the ITCZ is at the equator. However, the ITCZ shifts depending on the maximum intensity of sunrays. During summers in the northern hemisphere, the ITCZ shifts northwards. During summers in the southern hemisphere, the ITCZ shifts southwards.

2 PATTERN OF WINDS

Wind blows from high-pressure to low-pressure regions. Also, on account of rotation of the Earth, winds tend to deflect towards their right in the northern hemisphere and towards their left in the southern hemisphere. This is known as "Ferrel's law". The deflection of wind arises on account of **Coriolis force**, which is generated due to the rotation of the Earth.



Winds are known by the direction from which they originate. For instance, winds originating from the north-east direction are called north-east winds. Winds originating from the sea towards land are called sea breeze.

What is Coriolis Force?

Coriolis force refers to the tendency of objects to maintain their motion when they move from one place to another. Let us see how it works in the case of Earth!

The Earth rotates faster at the equator than it does at the poles. This is because the Earth is wider at the equator. A point on the equator travels faster than a point on the pole.

Coriolis Effect in the Northern Hemisphere

Let us assume you are standing at the equator and you want to throw a ball towards your friend in North America. If you throw the ball in a straight line, it would appear to land to the right of your friend because your friend is rotating (along with the Earth) at a slow speed, but the ball will maintain its speed of rotation as it shifts from the equator towards your friend. Therefore, the ball will appear to have moved to the right side.

Now let us assume you are standing at the North Pole. When you throw the ball to your friend, it will again appear to land to the right of him. But this time, it is because he is moving faster than you are and has moved ahead of the ball. This apparent deflection is the Coriolis effect.

Thus, we can safely conclude that on account of Coriolis effect, all fluids such as winds and ocean currents move towards their right in the northern hemisphere.

Coriolis Effect in the Southern Hemisphere

In the southern hemisphere, winds appear to bend to the left. When winds shift from the equator towards the poles, they will maintain their motion and, thus, will move ahead of points on higher latitudes.

When winds move from the poles towards the equator, the winds from the poles will rotate slowly and remain behind the points on lower latitudes. Consequently, winds deflect towards their left.

Thus, we can safely conclude that on account of Coriolis effect, all fluids such as winds and ocean currents move towards their left in the southern hemisphere.

Does Coriolis Effect Vary at Various Points on the Earth?

Coriolis effect is minimal at the equator. Thus, there is minimum apparent deflection of fluids such as water and winds. On the other hand, it is maximum at the poles where there is maximum deflection of fluids.

3 PLANETARY WINDS

Trade Winds

Trade Winds blow from the subtropical high-pressure belt to the equatorial low-pressure belt. Due to Coriolis force, these winds deflect towards their right in the northern hemisphere and left side in the

Chapter 15

World Climate Types

World Climatic Zones

Polar Zone	POLAR TYPE			90°
				65°
Cold Temperate	British Type	Siberian Type	Laurentian Type	
Warm Temperate	Mediterranean Type	Steppe Type	China Type	45°
Tropical	Desert Type	Sudan Type / Savanna Type	Monsoon Type Marine Type	30°
				10°
	Hot Wet Equatorial Climate			0°

1 HOT WET EQUATORIAL CLIMATE

Distribution

The hot wet equatorial climate is found from 0° to 10° north and south of the equator.

Climate

Rainfall: As this region receives maximum sunrays throughout the year, the evaporation rate is very high and there is continuous rainfall throughout the year. The annual rainfall is nearly 150–250 cm.

Though the rainfall is well distributed throughout the year, the rainfall is slightly higher in the months of April and October (months following March and September equinox when the sunrays are maximum at the equator).

Temperature: As the sunrays are high throughout the year, there is no winter and the annual range of temperature is also very low, i.e. up to 2°C. (Range of temperature increases with latitude). The annual average temperature at the equator is 27°C.

Relative humidity: The relative humidity in equatorial regions is very high, more than 80%.

Type of Vegetation

Equatorial regions are characterized by evergreen forests. These forests are called evergreen because these forests always remain green on account of abundant availability of moisture throughout the year. These forests are also called rainforests because these forests receive high rainfall throughout the year.

The single longest stretch of these forests is in Brazil and Indonesia. In Brazil, these forests are locally called Selvas.

Characteristics of evergreen forests

- In equatorial evergreen forests, there is a peculiar arrangement of plants. The tallest trees attain a height of nearly 150 feet. Their trunks are narrow with widespread branches at the top to gather sunlight. The smaller trees lie beneath the taller trees. The smaller trees receive less sunlight. At the lowest level are shrubs, herbs, etc., which can survive in minimal sunlight.
- The plant cover is very dense. As a result, sunlight fails to reach the ground. Thus, there is no grass in these forests.
- Though the equatorial regions are rich in forests, commercial exploitation of forests is difficult because tree varieties in these forests are heterogeneous in nature. Moreover, the wood is heavy and thus cannot be transported through water. Usually, forest wood is transported through rivers, because it is almost impossible for the trucks to enter into the dense forests.
- If equatorial forests are cut down, heavy rainfall leads to sudden soil erosion. Thus, regeneration of these forests is difficult.

Human Life

High humidity results in early tiredness. Mental alertness is also low. Harsh climatic conditions are cited as reason for low economic development in these regions. Consequently, many primitive societies are living

in these regions. The high temperature and humid conditions are ideal for growth of microorganisms. Thus, these regions are vulnerable to communicable diseases.

Agriculture and Biodiversity

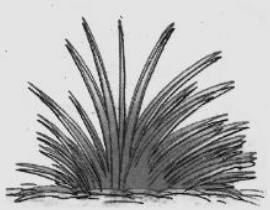
- These regions have maximum biodiversity (biodiversity reduces with increase in altitude and latitude).
- This region is also home to large plantations. Malaysia and Indonesia account for more than two-thirds of natural rubber production. Malaysia is also a leading producer of oil palm. Other important crops cultivated in this region are tea, coffee, tobacco, cocoa, etc.

What Are Herbs and Shrubs?

Herbs are plants with little or no wood tissue. They are often aromatic, and the leaves can be used to flavour food. **Shrubs** are plants with multiple wood stems growing from a common centre, while trees usually have a single woody stem. Herbs and shrubs are small plants, and trees are big plants.

Herbs are not more than 1 m tall. On the other hand, shrubs can be up to 6 m tall.

Herbs



Grass

Mint

Wheat

Shrubs

Rose

Tulsi

2 TROPICAL MONSOON CLIMATE

Distribution

- This type of climate is found in the Indian subcontinent, Myanmar, Thailand, Vietnam, Cambodia, and Laos.
- In the southern hemisphere, this climate is prevalent in north-eastern Australia.

Climate

- Monsoon type of climate refers to seasonal reversal of winds.
- Up to 95% of rainfall is confined to 4 months (during summers) in a year. The average annual rainfall experienced in this climate is nearly 125 cm.

Type of Vegetation

The forests in these regions are mainly of deciduous type. After rainy season, trees shed their leaves because they are required to adjust to the dry period. Shedding of leaves prevents moisture loss. Such

forests are called deciduous forests because they shed their leaves to avoid moisture loss. The main characteristics of these forests are as follows:

- As the rainfall is concentrated during 4 months, the forests are green only during the rainy season.
- These forests are less dense and homogenous in nature. The wood of these forests is light in weight. Thus, these forests are most favourable for commercial exploitation. Lumbering is an important activity in these regions.
- Myanmar alone accounts for three-fourths of the world's teak production.

  Rice, jute, cotton, tea, and coffee are important crops in this region.

3 TROPICAL MARINE CLIMATE

Distribution

This type of climate is confined to the eastern part of the continents in tropical regions.

Climate

- These regions come under the influence of Trade Winds, thus receive steady rainfall throughout the year.
- However, 70% of rainfall is concentrated during the months of summer because the rate of evaporation is high in summers. The average annual rainfall experienced in this climate is nearly 150 cm.
- The range of temperature varies from 21°C (monthly average temperature of coldest month) to 27°C (monthly average temperature of the hottest month).

Human Life: Comparison with Tropical Monsoon

Due to steady rainfall on account of Trade Winds, the climate is more favourable for habitation. However, this climate is experienced in regions that are prone to severe tropical cyclones, earthquakes, and volcanoes.

Type of Vegetation

The majority of vegetation in the tropical marine climate is mainly of deciduous type with some evergreen forests. However, if we compare the vegetation of tropical marine and tropical monsoon type of climate, then evergreen forests are more prevalent in the marine type of climate.

1 NORTH AMERICA

Lakes

Name	Information
Lake Superior	World's second largest lake, after Caspian Sea, shared between USA and Canada
Lake Michigan	Only lake of the five great lakes that is entirely within USA
Lake Huron	
Lake Erie	Niagara Falls drains Lake Erie into Lake Ontario
Lake Ontario	

Rivers

Name	Source	Outflow	Information
Mackenzie river		Beaufort Sea	Longest river of Canada
Mississippi-Missouri river	Rocky mountains	Gulf of Mexico	One of the world's largest basin
St. Lawrence river	Lake Ontario	Gulf of St. Lawrence	Forms the boundary of USA and Canada
Columbia river	Rocky mountains	Pacific Ocean	■ Snake River is the biggest tributary. ■ Grand Coulee is the largest hydroelectric power project of North America, located on Snake river.
Rio Grande river	—	Gulf of Mexico	Forms natural boundary between USA and Mexico

Mountain Ranges

Name	Information
Rocky Mountains	■ Runs from Alaska to Mexico with average height over 4000 m ■ Denali (6194 m, formerly Mt. McKinley), the highest peak of North America, is located here ■ Mt. Whitney (4418 m) is the highest peak of USA.

Depression

Name	Information
Death Valley	■ Located to the west of Rocky Mountains in California region ■ Deepest point (85 m below sea level) of North America ■ Highest diurnal range of temperature in the world is recorded here.

Peninsulas

Name	Information
Ungava Peninsula	■ Located in North Canada ■ Surrounded by Hudson Bay and Labrador Sea
Yucatan Peninsula	■ Deepest place of Mexico
Kenai Peninsula	■ Located in Alaska, USA ■ Known for its petroleum reserves

Other Physical Features

Name	Information
Canadian Shield	■ Includes Laurentian Plateau ■ Rich in mineral resources
Caribbean Islands	■ Composed of a large number of big and small islands in the Caribbean Sea ■ Many have become independent countries
Bermuda Triangle	■ Triangular-shaped area in the North Atlantic Ocean ■ Formed by Bermuda, Puerto Rico, and Florida ■ Since the 1940s, many ships and aircraft have disappeared mysteriously in the sea without giving any warning or explanation. ■ The cause of disappearance is believed to be the presence of rogue waves in this region. These rogue waves are 'extreme storm waves'. These waves can reach a height of up to 100 feet and are very spontaneous. Rogue waves were first observed in 1997 by a satellite. The rouge waves are more than twice the size of surrounding waves, are very unpredictable, and often come unexpectedly from various directions.

2 SOUTH AMERICA

Straits and Passages

Name	Information
Magellan Strait	Separates the southern end of South America from Tierra Del Fuego, the southern most extreme of South America
Drake Passage	Passage between South America and Antarctica

Solutions for

Practice Questions and Perfecting Past Prelims

CHAPTER 1 UNIVERSE

Practice Questions

1. (c) A meteorite is space debris that strikes the Earth's surface.

Meteoroid is space debris before striking the surface of the Earth. Meteor is the light emitted by space debris when it enters the Earth's atmosphere.

2. (b) Statement 2 is incorrect because comets are gaseous in nature, whereas asteroids are solid space debris.

3. (b) Statement 3 is incorrect. Sound waves cannot travel through vacuum. Therefore, they cannot be used to measure distance among celestial bodies.

5. (c) Statement 1 is incorrect. Our universe is 13.77 billion years old.

Statement 3 is incorrect. The distances within our solar system are fixed. Our solar system is not in a state of expansion.

Perfecting Past Prelims

1. (b) Statement 2 is incorrect. Comets are found in the outer fringes of the solar system.

2. (c) The person would walk keeping the Pole Star to his left direction. Pole Star is situated in the north direction. If a person walks by keeping polestar in the left direction, then the person is moving in the east direction.

3. (a) Statement 1 is correct. Microwaves have wavelengths that can be measured in centimetres! The longer microwaves, those closer to a foot in length, are the waves that heat our food in a microwave oven. Microwaves are good for transmitting information from one place to another because microwave energy can penetrate haze, light, rain, snow, clouds, and smoke. There are microwaves-based telescopes to study the universe.

Statement 3 is incorrect. Asteroids are space debris. They have very small size and are attracted by mass of the universe. Their movement does not provide evidence of universe expansion.

Statement 4 is incorrect. Supernova explosions help us in determining the distance of a particular star. However, they do not provide evidence about the continued expansion of the universe.

CHAPTER 2 THE SOLAR SYSTEM

Practice Questions

2. (c) Mars has two moons: Phobos and Deimos. Ganymede is Jupiter's moon. It is the largest satellite of our solar system.

Titan is Saturn's moon. It is the only moon that has its own atmosphere.

Miranda is Uranus's moon.

3. (d) Statement 1 is incorrect. Terrestrial planets are smaller than Jovian planets.

Statement 2 is incorrect. Terrestrial planets are denser than Jovian planets.

Statement 3 is incorrect. Jovian planets have larger mass and thus greater gravitational pull.

5. **(d)** Goldilocks zone is that zone that can support life. It has the possibility of presence of liquid water. It is at such a distance from the Sun that it is neither too cold nor too hot. Venus, Earth, and Mars are part of Goldilocks zone of our solar system.

6. **(c)** Statement 3 is incorrect because Mars lies within the Goldilocks zone.

   Statement 4 is incorrect. Mars has oxygen and water in very minute quantities. Almost all water on Mars today exists as ice, though it also exists in small quantities as vapour in the atmosphere. The only place where water ice is visible at the surface is at the north polar ice cap.

   Thus, Statements 3 and 4 are incorrect.

CHAPTER 3 OUR EARTH

Practice Questions

1. **(a)** Statement 2 is incorrect. IDL (International dateline) deviates from the 180° meridian so that it does not pass through any country.

2. **(d)** Statement 1 is incorrect. Time depends on the longitude of a place and not its latitude.

   Statement 2 is incorrect. Countries with smaller east–west extent are bound to have a single time zone.

3. **(c)** Statement 2 is incorrect. Earth's rotation causes day and night. Seasons of the Earth are caused due to the inclination of its axis and its revolution.

4. **(c)** Statement 1 is incorrect. A person crossing the IDL from east (e.g. USA) to west (e.g. Japan) will lose a day. It is to be noted that east and west change when viewed from the International Dateline. When east and west are considered from the Prime Meridian, then Japan is on the east and USA is on the west.

5. **(d)** Difference of longitude between London and Delhi is 82.5°, so $82.55 \times 4 = 330$ min, i.e. 5 h 30 min (multiplication is done with 4 because difference of one-degree longitude creates time difference of 4 min).

   Since Delhi is to the east of London, if it is 10.30 pm in London, it will be 4.00 am in Delhi (10.30 + 5 h 30 min).

Perfecting Past Prelims

1. **(d)** Addis Ababa (Ethiopia) does not share the same longitude as that of the other three cities mentioned in the question.

CHAPTER 4 MOON

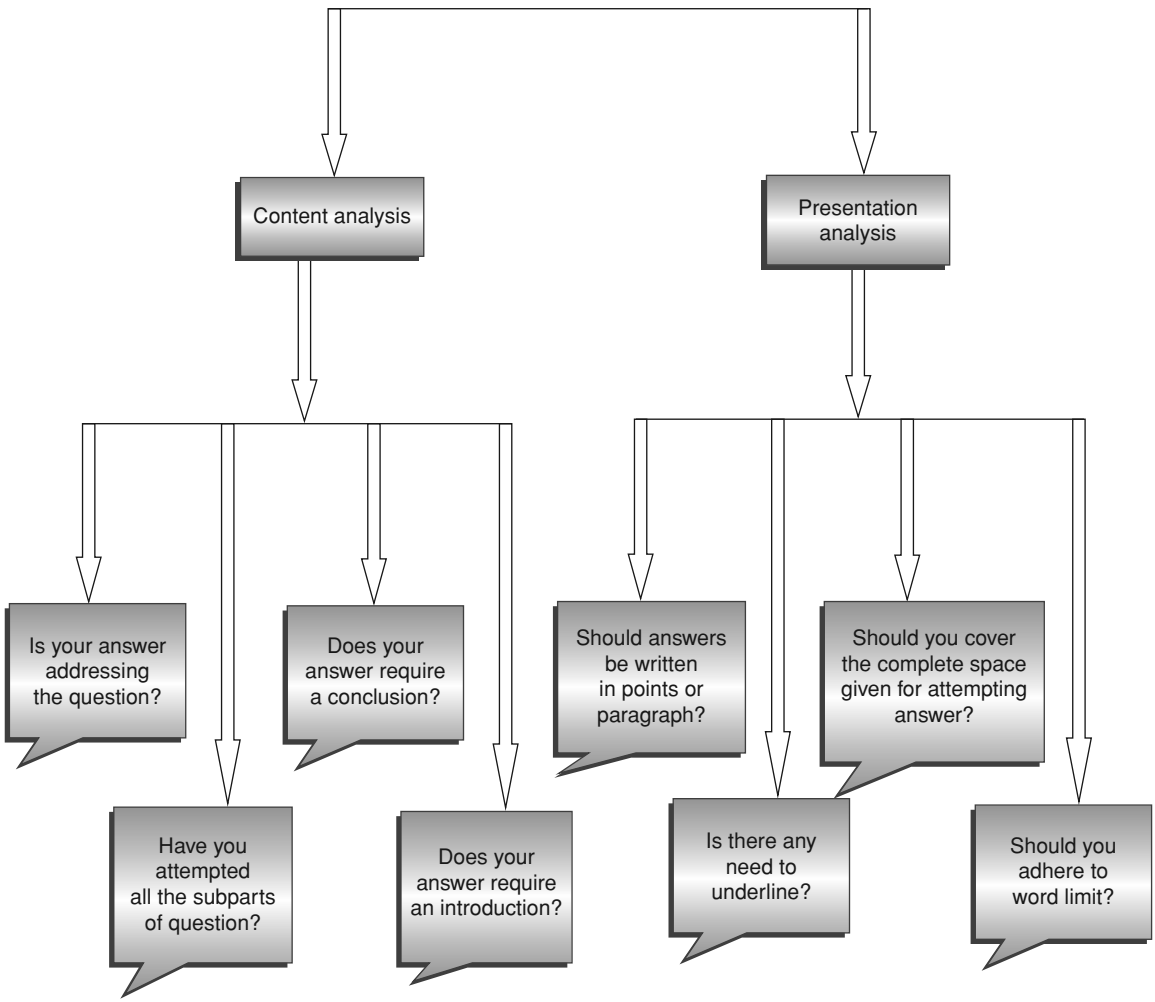
Practice Questions

3. **(b)** A lunar eclipse takes place during the full moon phase. The moon may appear copper red at the time of lunar eclipse because even though the moon is in the shadow of the Earth, some light does reach it. Out of the light reflected by the moon, fine particles in the atmosphere scatter the blue component, and longer wavelength red light reaches us.

4. **(a)** Statement 3 is incorrect. During a total solar eclipse, the Sun is not visible from the area behind full shadow of

Introduction to Writing Answers for Mains

A good answer is based on the following aspects



Let us discuss each aspect mentioned in the above diagram on one-by-one basis.

1. **Is Your Answer Addressing the Question?**

   The most common reason behind scoring low marks is lack of candidate's ability to address the question.

   Have you ever heard a candidate saying that I attempted almost all (or all the questions), yet I could not clear mains examination? You have probably met the candidate who wrote answers which did not address the questions.

   To understand how to address question appropriately, we can classify each question into two parts: 'Statement' and 'Directive'.

   For example,

   > It is said that India has substantial reserves of shale oil and gas, which can feed the needs of country for quarter century. However, tapping of the resources doesn't appear to be high on the agenda. Discuss critically the availability and issues involved. **(UPSC Mains, 2013)**

   In this question, the statement is 'availability of shale oil and gas and the issues involved in tapping it' and the directive is 'discuss critically'.

   Various candidates will interpret 'discuss critically' in different manner. Some will attempt to provide positives and negatives and some will attempt to identify various aspects of the topic asked. So, which one is correct? Let us learn by going through the document.

   It is to be noted that a particular directive may be attached to a sub-part of a question. In a single question, there can be as many directives as there are number of sub-parts.

So What All Directives UPSC Can Use? What Do These Directives Mean?

Here is a simple list for you. We will further learn about their application by attempting past year questions.

1. **Enumerate:** Mention a number of things one by one or give the list of things.

   > Enumerate the problems and prospects of inland water transport in India. **(UPSC Mains, 2016)**

2. **Highlight:** Draw special attention to something.
3. **Outline:** Give a summary of something.
4. **Discuss:** Write about a topic in detail, taking into account different issues or ideas.

   > Discuss the concept of air mass and explain its role in macro-climatic changes. **(UPSC Mains, 2016)**

5. **Explain:** What is meant by a word, text, concept, or action.

   > The effective management of land and water resources will drastically reduce the human miseries. Explain. **(UPSC Mains, 2016)**

6. **Justify:** Show or prove something.
7. **Comment:** Express an opinion or reaction.

   > South China Sea has assumed great geopolitical significance in the present context. Comment. **(UPSC Mains, 2016)**

Previous Years' Questions (Mains) with Solutions

1. What do you understand by the theory of continental drift? Discuss the prominent evidences in its support. **(2013)**

Sol.

Analysis of Question	
Discuss	Write about the topic in detail, taking into account different ideas.
Number of parts	Two sub-parts Part I—Explanation of theory of continental drift Part II—Evidences that support the theory
Mode of presentation	Mix of paragraph and point form
Importance of conclusion	Not necessary

Continental drift theory

According to this theory, there existed one single landmass called Pangaea which was surrounded by one big ocean called Panthalassa. A sea called Tethys divided Pangaea into two huge landmasses, namely, Laurasia in the north and Gondwanaland in the south. Laurasia consisted of present continents of Asia, Europe, and North America.

Gondwanaland consisted of continents of Africa, South America, Antarctica, Australia, and Indian sub-continent.

The single landmass began to break and the various parts formed, began drifting away from each other 200 million years ago.

Evidence in support of continental drift theory

1. **Similarity of physical features:** The bulging part of Brazil seems to fit into Gulf of Guinea (part of Africa), suggesting that South America and Africa were part of single landmass.
2. Far landmasses such as Australia, India, South Africa, etc., share similar rocks and plant species.
3. The drift of continents is also proved by the fact that old magnetic rocks show different directions of magnetism as compared to newly formed magnetic rocks.

Conclusion

The continental drift theory is accepted without any doubt. The theory formed the basis of later theories such as sea floor spreading and plate tectonics theory.

2. There is no formation of deltas by rivers of the Western Ghats. Why? **(2013)**

Sol.

Analysis of Question	
Discuss	Write about the topic in detail, taking into account different ideas.
Number of parts	One part
Mode of presentation	Point form
Importance of conclusion	Not necessary

Western Ghats act as a watershed in the south India. The rivers that originate in the western part of the Western Ghats flow towards west coast, and the rivers that originate in the eastern part of the Western Ghats flow towards east coast.

The west-flowing rivers do not make delta due to following factors:

1. The west flowing rivers are short in length. These rivers pass through high gradient of land and thus maintain great speed. The width of the west coast is only 10–15 km. Thus, rivers do not slow down and drain away at fast speed into the sea.
2. Moreover, shorter path results in narrow width that hampers the ability to carry large amount of sediments.
3. The west coast is a submerged land mass. Consequently, western coast merges with the Arabian sea, giving rivers little opportunity to deposit any sediment before merging into the sea.

On the other hand, Eastern Ghats are not a continuous chain of mountains. They have gaps in between. Most rivers flowing towards east coast are adequately wide with low velocity and carry huge amounts of sediments.

Conclusion

Thus, rivers emerging from Western Ghats flowing towards west coast do not make delta. On the other hand, rivers flowing towards east coast do make delta.

3. Major hot deserts in northern hemisphere are located between 20 and 30 degrees north and on the western side of the continents. Why? **(UPSC Mains, 2013)**

Sol.

Analysis of Question	
Number of parts	One Reason for location of deserts between 20 and 30 degrees north and on the western side of continents.
Mode of presentation	Mix of point form and paragraph.
Importance of conclusion	Not required

The major deserts of the world, namely, Sahara, Atacama, Namib, and Arabian are located between 20 and 30 degrees north and on the western side of the continents on account of following factors:

1. **Offshore trade winds in the region and location in rain shadow zone:** Trade winds that blow in the region shed their moisture on the eastern part and by the time they reach the western margin, they become dry.
2. **Anticyclonic conditions:** Areas between 20 and 30 degree latitudes on western margins of continents are the regions of descending air. The descending winds are cold and dry.
3. **Presence of cold ocean currents along the western coast of continents:** The zone of cold ocean currents receives descending winds. Cold descending winds are characterized by dry conditions. On the contrary, the warm ocean currents cause winds to rise upwards. The warm winds form clouds, leading to rainfall.