

## CHAPTER 3 – Lectures-03 & 04

### The Earth as a Rotating Planet

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**I. The Shape of the Earth:** The outward force of the Earth's rotation causes the Earth to bulge slightly at the equator and flattened the poles - the Earth assumes the shape of an *oblate ellipsoid*.

**II. Earth Rotation:** The Earth spins slowly, making a full turn with respect to the Sun every day. One complete rotation defines a *solar day*, and by convention is divided into 24 hours.

*A. Direction of Rotation* - The Earth rotates counterclockwise when viewed looking down on the north pole. When viewed from space, the Earth is rotating from left to right or in an eastward direction. The rotation is important because:

1. The axis of rotation serves as a reference in setting up the geographic grid of latitude and longitude.
2. It provides the day as a convenient measure of the passage of time.
3. It has an important effect on physical and life processes on Earth.

*B. Environmental Effects of Earth Rotation* - These effects are of great importance to all life forms on Earth.

1. Rotation imposes a diurnal rhythm in daylight, air temperature, air humidity, and air motion. All surface life responds to this diurnal rhythm.
2. The Earth's rotation causes the Coriolis effect. The Coriolis effect is the consistent turning of the flow paths of both air and water. Flows in the northern hemisphere are turned toward the right and in the southern hemisphere toward the left.
3. The Moon exerts a gravitation attraction on the Earth, while at the same time the Earth turns with respect to the Moon. These forces induce a rhythmic rise and fall of the ocean surface known as the tide. The tide in turn causes the water currents to ebb and flow.

**III. The Geographic Grid:** Provides a system for locating places on the Earth's surface. Because of the curved surface, it is divided into an imaginary circles set on the surface that are perpendicular to the axis of rotation in one direction and parallel to the axis of rotation in the other direction.

*A. Parallels and Meridians*

1. Parallels - These are circles which are parallel to each other while being perpendicular to the axis of rotation. The equator (0° degrees) is the largest of these. These are east-west lines.
2. Meridians - Half of the circular outline, connecting one pole to the other, is known as a meridian of longitude. These are north-south lines.

3. Geographic Grid - The total system of parallels and meridians forms a network of intersecting circles.
4. Great Circles and Small Circles - A great circle is created when a plane passing through the center of the Earth intersects the Earth's surface. Small circles are created when a plane passing through the Earth's, but not the Earth's center, intersects the Earth's surface. Meridians are actually halves of great circles, while all parallels, except the equator, are small circles.

#### *B. Latitude and Longitude*

1. Latitude - Parallels are identified by latitude. It is an indicator of how far north or south of the equator a parallel is situated. Note that the equator divides the globe into two equal hemispheres. All parallels in the northern hemisphere are designated as having north latitude, and all points in the southern hemisphere are designated as having south latitude.
2. Longitude - Meridians are identified by longitude. It is a measure of the position of a meridian eastward or westward from a reference meridian, called the prime meridian. The Prime Meridian is zero degrees, and the International Date Line is 180° degrees (more or less).
3. A Global Positioning System (GPS) – Can be used to accurately determine the latitude and longitude of any point on the Earth through a system of satellites that constantly sends radio signals.

**IV. Map Projections:** Cartography is the art and science of mapmaking. Cartographers have always had to face the challenge of creating flat maps out of a spherical world. This can be done but only with distortion. Various types of map projections have been developed in order to deal with distortion in different ways.

*A. Polar projection* - This projection can be centered on either the north or south pole. Meridians are straight lines radiating outward from the pole, while parallels are nested circles centered on the pole. The spacing of the parallels increases outward from the center. Area distortion increases as the distance from the center increases.

*B. Mercator projection* - A rectangular grid of meridians as straight vertical lines and parallels as straight horizontal lines. Lines of longitude must be cut off at some arbitrary parallel, such as 80° due to distortion. These maps have special properties:

1. A straight line drawn anywhere on the map is a line of constant compass direction.
2. A great circle line curves (except on the equator) and can falsely seem to represent a much longer distance than a compass line.
3. Used to show straight-line features, such as wind and ocean currents, directions of crustal features, and lines of equal value.

*C. The Goode projection* This uses two sets of mathematical curves to form its meridians. Between the 40<sup>th</sup> parallels, sine curves are used, and beyond the 40<sup>th</sup>

parallel, toward the poles, ellipses are used. One important property is that this projection indicates the true sizes of areas of the Earth's surface. However, this projection distorts the shapes of areas, particularly in high latitudes and at the far right and left edges. To minimize this, the map is split into two smaller sectors with each centered on a different vertical meridian, then assembled at the equator. Although interrupted projection greatly reduces distortion, it separates areas that actually lie close together, particularly in high latitudes.

**V. Global Time** Our planet requires 24 hours for a full rotation with respect to the Sun, and our global time is oriented to the Sun.  $15^\circ$  of longitude equates to an hour of time. Since the Earth turns  $360^\circ$  in a 24-hour day, the rotation rate is  $360^\circ \div 24 = 15^\circ$  per hour.

*A. Standard Time* In the standard time system, the globe is divided into 24 time zones. All inhabitants within a zone keep time according to a standard meridian that passes through their zone. Since the standard meridians are usually 15 degrees apart, the difference in time between adjacent zones is normally one hour. In some geographic regions, however, the difference is only half an hour.

*B. World Time Zones* There are 24 principal standard time zones in the world. The country spanning the greatest number of time zones from east to west is Russia, with 11 zones, but these are grouped into eight standard time zones. World time zones are numbered to indicate the number of hours' difference between time in a zone and time in Greenwich.

*C. International Date Line* This is where the day begins. It is exactly twelve hours ahead of Greenwich time and twelve hours behind. At the exact moment of midnight on the International Date Line it is the same calendar day all over the world. When crossing from California to Australia, a person would lose a day. In reverse, a day would be gained.

*D. Daylight Saving Time* We adjust our clocks during part of the year that has a longer daylight period to correspond more closely with the modern pace of society. This system is obtained by setting all clocks ahead by one hour. In the United States and Canada, this comes into effect on the first Sunday in April and is discontinued on the last Sunday of October.

*E. Precise Timekeeping* has been made necessary by modern scientific and technological applications. Coordinated Universal Time is the legal standard recognized by all nations.

**VI. The Earth's Revolution around the Sun** The Earth completes a revolution around the Sun in 365.242 days. Every four years, the extra one-fourth day adds up to approximately one whole day. By inserting a 29<sup>th</sup> day in February in leap years, we

largely correct the calendar for this effect. Other important features of the Earth's orbit are:

- The Earth's orbit is shaped like an ellipse, or oval.
- Perihelion occurs on or about January 3, when the Earth is closest to the sun.
- Aphelion occurs on or about July 4, when the Earth is the farthest from the sun.
- The Earth (as do most of the solar system's bodies) travels counterclockwise around the Sun. This is the same direction as the Earth's rotation.

*A. Tilt of the Earth's Axis* - The Earth's axis is tilted with respect to the plane of the ecliptic, the plane containing the Earth's orbit around the Sun. The axis is tilted at an angle of  $23\frac{1}{2}^\circ$  away from a right angle to the plane of the ecliptic. The angle between the axis and the plane of the ecliptic is  $66\frac{1}{2}^\circ$  not  $90^\circ$ . The direction the axis points is fixed in space, it aims at Polaris, the north star.

*B. Solstice and Equinox* - Because the direction of the Earth's axis is fixed, the north pole is tilted away from the Sun during one part of the year and is tilted toward the Sun during the other part.

1. Winter solstice (December 22) The Earth is positioned so that the north polar end of its axis leans at the maximum angle away from the Sun,  $23\frac{1}{2}^\circ$ . While it is winter in the northern hemisphere, it is summer in the southern hemisphere.
2. Summer solstice (June 21) The Earth is in the opposite side of its orbit in an equivalent position. The north polar end of the axis is tilted at  $23\frac{1}{2}^\circ$  toward the Sun. Thus the north pole and north hemisphere are tilted toward the Sun, while the south pole and southern hemisphere are tilted away.
3. Vernal equinox (March 21) The Earth's axis makes a right angle with a line drawn to the sun. Neither pole is tilted toward the Sun. Conditions are identical on the two equinoxes as far as the Earth-Sun relationship are concerned.
4. Autumnal equinox (September 23) Exactly the same orientation of the Earth and the sun as the Vernal equinox.

*C. Equinox Conditions* - The circle of illumination passes through the north and south poles. The Sun's rays graze the surface at either pole, and the surface there receives little or no solar energy. The subsolar point falls on the equator. The angle between the Sun's rays and the Earth's surface is  $90^\circ$ , and the solar illumination is received in full force. One important feature of the equinox is that day and night are of equal length everywhere on the globe.

*D. Solstice Conditions* - During the summer solstice, the farther north you travel, the more the effect increases. Even though the Earth rotates through a full cycle during a 24-hour period, the area north of the arctic circle remains in continuous daylight. The Sun's energy is the most intense over the tropic of cancer. At the winter solstice, conditions are exactly reversed from those of the summer solstice. All the area south of latitude  $66\frac{1}{2}^\circ$ S lies under the Sun's rays, inundated with 24 hours of daylight, and the most intense energy is over the tropic of Capricorn.