Unit #5 ES 100 lecture outline and related internet links.

For this unit read chapters 16, 17, 14 and 15. Start with the chapter summaries. Learn the key terms and answer the review questions. The readings are required before class. The lectures and films augment and clarify the readings. The ends of chapter questions are in order of the material presented in the text. The CD Rom at the back of the book has additional material to help you.

Films:

Please view the Earth Revealed video before class.

24. Waves, Beaches and Coasts (unit #5)
This program shows the dynamic interaction of two geologic agents: rocky landmasses and the energy of the ocean. Aspects of waves — their types, parts, movement, and impact on the shore — are illustrated. The program also covers shoreline characteristics, currents, sea barriers, tides, and how the greenhouse effect could impact sea level and coastal lands.

Read the questions first. Then answer them while watching this episode of "Earth Revealed".

1. Where do waves get their energy?
2. What is moving as a wave approached the coast?
3. Describe wave motion in detail.
4. What is wave base? How it is determined?
5. What happens when wave base intersects the seafloor? Describe in detail.
6. What is a tsunami? Describe in detail.
7. What is refraction?
8. How does refraction tend to even out an irregular coastline?
9. Describe how longshore currents transport sediments along the beach face.
10. Why do beaches change from season to season?
11. How do dams affect beach processes?
12. How does the moon affect the tides?
13. How does glacial activity affect sea level?
14. What is an eustatic sea level change?
15. What is the greenhouse effect?
16. How are the use of fossil fuels causing changes in earth's greenhouse levels?
17. What is the role of the geologist in the protection of the coastlines?

Chapter Outlines:

The Atmosphere: Composition, Structure,
Objectives:

After reading, studying, and discussing Chapter 15, you should be able to:

- Describe the science of meteorology.
- Explain the difference between weather and climate.
- List the most important elements of weather and climate.
- List the major and variable components of air.
- Describe the extent and structure of the atmosphere.
- Describe how the atmosphere is heated.
- Explain the causes of the seasons.
- List the factors that cause temperature to vary from place to place.
- Describe the general distribution of global surface temperatures.

Chapter 16 Outline
The Atmosphere: Composition, Structure, and Temperature

I. Weather and climate
  A. Weather
    1. Weather is over a short period of time
    2. Constantly changing
  B. Climate
    1. Climate is over a long period of time
    2. Generalized, composite of weather
  C. Elements of weather and climate
    1. Properties that are measured regularly
    2. Most important elements
      a. Temperature
      b. Humidity
      c. Cloudiness
      d. Precipitation
      e. Air pressure
      f. Wind speed and direction

II. Composition of the atmosphere
  A. Air is a mixture of discrete gases
  B. Major components of clean, dry air
    1. Nitrogen (N) – 78%
    2. Oxygen (O_2) – 21%
    3. Argon and other gases
    4. Carbon dioxide (CO_2) – 0.036% – absorbs heat energy from Earth
  C. Variable components of air
    1. Water vapor
      a. Up to about 4% of the air's volume
      b. Forms clouds and precipitation
      c. Absorbs heat energy from Earth

2. Aerosols
    a. Tiny solid and liquid particles
    b. Water vapor can condense on solids
    c. Reflect sunlight
    d. Help color sunrise and sunset
3. Ozone
    a. Three atom oxygen (O_3)
    b. Distribution not uniform
    c. Concentrated between 10 to 50 kilometers above the surface
    d. Absorbs harmful UV radiation
    e. Human activity is depleting ozone by adding chlorofluorocarbons (CFCs)

III. Structure of the atmosphere
A. Pressure changes
1. Pressure is the weight of the air above
2. Average sea level pressure
    a. Slightly more than 1000 millibars
    b. About 14.7 pounds per square inch
3. Pressure decreases with altitude
    a. One-half of the atmosphere is below 3.5 miles (5.6 km)
    b. Ninety percent of the atmosphere is below 10 miles (16 km)

B. Atmospheric layers based on temperature
1. Troposphere
    a. Bottom layer
    b. Temperature decreases with altitude – called the environmental lapse rate
        1. 6.5 C per kilometer (average)
        2. 3.5 F per 1000 feet (average)
    c. Thickness varies – average height is about 12 km
    d. Outer boundary is named the tropopause
2. Stratosphere
    a. About 12 km to 50 km
    b. Temperature increases at top
    c. Outer boundary is named the stratopause
3. Mesosphere
    a. About 50 km to 80 km
    b. Temperature decreases
    c. Outer boundary is named the mesopause
4. Thermosphere
    a. No well-defined upper limit
    b. Fraction of atmosphere's mass
    c. Gases moving at high speeds

IV. Earth-Sun relations
A. Earth motions
1. Rotates on its axis
2. Revolves around the Sun

B. Seasons
1. Result of
    a. Changing Sun angle
    b. Changing length of daylight
2. Caused by Earth's changing orientation to the Sun
    a. Axis is inclined 23½°
    b. Axis is always pointed in the same direction

3. Special days (Northern Hemisphere)
    a. Summer solstice
        1. June 21-22
        2. Sun's vertical rays are located at the Tropic of Cancer (23½°N latitude)
        1. December 21-22
        2. Sun's vertical rays are located at the Tropic of Capricorn (23½°S latitude)
    c. Autumnal equinox
        1. September 22-23
        2. Sun's vertical rays are located at the Equator (0° latitude)
    d. Spring equinox
        1. March 21-22
        2. Sun's vertical rays are located at the Equator (0° latitude)

V. Atmospheric heating
  A. Heat is always transferred from warmer to cooler objects
  B. Mechanisms of heat transfer
    1. Conduction through molecular activity
    2. Convection
        a. Mass movement within a substance
        b. Usually vertical motions
    3. Radiation (electromagnetic radiation)
        a. Velocity: 300,000 kilometers (186,000 miles) per second in a vacuum
        b. Consists of different wavelengths
            1. Gamma (very short waves)
            2. X-rays
            3. Ultraviolet (UV)
            4. Visible
            5. Infrared
            6. Microwaves
            7. Radio (longest waves)
        c. Governed by basic laws
            1. All objects, at whatever temperature, emit radiation
            2. Hotter objects radiate more total energy per unit area than do cooler objects
            3. The hotter the radiating body, the shorter the wavelength of maximum radiation
            4. Objects that are good absorbers of radiation are good emitters as well
  C. Incoming solar radiation
    1. Atmosphere is largely transparent to incoming solar radiation
    2. Atmospheric effects
        b. Reflection – albedo (percent reflected)
        a. Scattering
        c. Absorption
    3. Most visible radiation reaches the surface
    4. About 50% absorbed at Earth's surface
  D. Radiation from Earth's surface
    1. Earth re-radiates radiation (terrestrial radiation) at the longer wavelengths
    2. Longer wavelength terrestrial radiation is absorbed by
        a. Carbon dioxide and
        b. Water vapor in the atmosphere
    3. Lower atmosphere is heated from Earth's surface
  E. Heating of the atmosphere is termed the greenhouse effect

VI. Temperature measurement
A. Daily maximum and minimum
B. Other measurements
1. Daily mean temperature
2. Daily range
3. Monthly mean
4. Annual mean
5. Annual temperature range
C. Human perception of temperature
1.Anything that influences the rate of heat loss from the body also influences the sensation of temperature
2. Important factors are
a. Air temperature
b. Relative humidity
c. Wind speed
d. Sunshine

VII. Controls of temperature
A. Cause temperature to vary
B. Receipt of solar radiation is the most important control
C. Other important controls
1. Differential heating of land and water
a. Land heats more rapidly than water
b. Land gets hotter than water
c. Land cools faster than water
d. Land gets cooler than water
2. Altitude
3. Geographic position
4. Cloud cover
5. Albedo

VIII. World distribution of temperature
A. Temperature maps
1. Isotherm – a line connecting places of equal temperature
2. Temperatures are adjusted to sea level
3. January and July are used for analysis because they represent the temperature extremes
B. Global temperature patterns
1. Temperature decreases poleward from the tropics
2. Isotherms exhibit a latitudinal shift with the seasons
3. Warmest and coldest temperatures occur over land
4. In the Southern Hemisphere
a. Isotherms are straighter
b. Isotherms are more stable
5. Isotherms show ocean currents
6. Annual temperature range
a. Small near equator
b. Increases with an increase in latitude
c. Greatest over continental locations

Chapter #17
Objectives:
After reading, studying, and discussing Chapter 16, you should be able to:

- List the processes that cause water to change from one state of matter to another.
- Explain saturation, vapor pressure, mixing ratio, relative humidity, and dew point.
- Describe how relative humidity is determined.
- Explain the basic cloud-forming process.
- List the processes that initiate the vertical movement of air.
- Describe stable and unstable air.
- Discuss the conditions necessary for condensation and cloud formation.
- List the criteria used to classify clouds.
- Describe the formation of fog.
- Discuss the formation and forms of precipitation.

Outline: Chapter # 17 **Moisture, Clouds, and Precipitation**

I. Changes of state of water
  A. Heat energy
    1. Measured in calories – one calorie is the heat necessary to raise the temperature of one gram of water one degree Celsius
    2. Latent heat
      a. Stored or hidden heat
      b. Not derived from temperature change
      c. Important in atmospheric processes
  B. Three states of matter
    1. Solid
    2. Liquid
    3. Gas
  C. To change state, heat must be
    1. Absorbed, or
    2. Released
  D. Processes
    1. Evaporation
      a. Liquid is changed to gas
      b. 600 calories per gram of water are added – called latent heat of vaporization
    2. Condensation
      a. Water vapor (gas) is changed to a liquid
      b. Heat energy is released – called latent heat of condensation
    3. Melting
      a. Solid is changed to a liquid
      b. 80 calories per gram of water are added – called latent heat of melting
    4. Freezing
      a. Liquid is changed to a solid
      b. Heat is released – called latent heat of fusion
    5. Sublimation
      a. Solid is changed directly to a gas (e.g., ice cubes shrinking in a freezer)
      b. 680 calories per gram of water are added
    6. Deposition
      a. Water vapor (gas) changed to a solid (e.g., frost in a freezer compartment)
      b. Heat is released

II. Humidity
  A. Amount of water vapor in the air
    1. Saturated air is air that is filled with water vapor to capacity
    2. Capacity is temperature dependent – warm air has a much greater capacity
    3. Water vapor adds pressure (called vapor pressure) to the air
  B. Measuring humidity
    1. Mixing ratio
      a. Mass of water vapor in a unit of air compared to the remaining mass of dry air
      b. Often measured in grams per kilogram
      2. Relative humidity
        a. Ratio of the air's actual water vapor content compared with the amount of water vapor required for saturation at that temperature (and pressure).
      b. Expressed as a percent
      c. Saturated air
        1. Content equals capacity
        2. Has a 100% relative humidity
      d. Relative humidity can be changed in two ways
        1. Add or subtract moisture to the air
          a. Adding moisture raises the relative humidity
          b. Removing moisture lowers the relative humidity
        2. Changing the air temperature
          a. Lowering the temperature raises the relative humidity
          b. Raising the temperature lowers the relative humidity
      e. Dew point temperature
        1. Temperature to which a parcel of air would need to be cooled to reach saturation
        2. Cooling the air below the dew point causes condensation
          a. e.g., dew, fog, or cloud formation
          b. Water vapor requires a surface to condense on
      f. Two types of hygrometers are used to measure humidity
        1. Psychrometer
          a. Compares temperatures of
            1. Wet-bulb thermometer, and
            2. Dry-bulb thermometer
          b. If the air is saturated (100% relative humidity) then both thermometers read the same temperature
          c. The greater the difference between the thermometer readings, the lower the relative humidity
        2. Hair hygrometer – reads the humidity directly

III. Adiabatic heating/cooling
  A. Adiabatic temperature changes occur when
    1. Air is compressed
      a. Motion of air molecules increases
      b. Air will warm
      c. Descending air is compressed due to increasing air pressure
    2. Air expands
      a. Air parcel does work on the surrounding air
      b. Air will cool
      c. Rising air will expand due to decreasing air pressure

B. Adiabatic rates
    1. Dry adiabatic rate
        a. Unsaturated air
        b. Rising air expands and cools at 1°C per 100 meters (5.5 °F per 1000 feet)
        c. Descending air is compressed and warms at 1°C per 100 meters
    2. Wet adiabatic rate
        a. Commences at condensation level
        b. Air has reached the dew point
        c. Condensation is occurring and latent heat is being liberated
        d. Heat released by the condensing water reduces the rate of cooling
        e. Rate varies from 0.5°C to 0.9°C per 100 meters

IV. Processes that lift air
  A. Orographic lifting
    1. Elevated terrains act as barriers
    2. Result can be a rain shadow desert
  B. Frontal wedging
    1. Cool air acts as a barrier to warm air
    2. Fronts are part of the storm systems called middle-latitude cyclones
  C. Convergence where the air is flowing together and rising
  D. Localized convective lifting where unequal surface heating causes localized pockets of air to rise because of their buoyancy

V. Stability of air
  A. Types of stability
    1. Stable air
      a. Resists vertical displacement
        1. Cooler than surrounding air
        2. Denser than surrounding air
        3. Wants to sink
      b. No adiabatic cooling
      c. Absolute stability occurs when the environmental lapse rate is less than the wet adiabatic rate
      d. Often results in widespread clouds with little vertical thickness
      e. Precipitation, if any, is light to moderate
    2. Absolute instability
      a. Acts like a hot air balloon
      b. Rising air
        1. Warmer than surrounding air
        2. Less dense than surrounding air
        3. Continues to rise until it reaches an altitude with the same temperature
      c. Adiabatic cooling
      d. Environmental lapse rate is greater than the dry adiabatic rate
      e. Clouds are often towering
      f. Conditional instability occurs when the atmosphere is stable for an unsaturated parcel of air but unstable for a saturated parcel
  B. Determines to a large degree
    1. Type of clouds that develop
    2. Intensity of the precipitation

VI. Condensation and cloud formation

A. Condensation
1. Water vapor in the air changes to a liquid and forms dew, fog, or clouds
2. Water vapor requires a surface to condense on
    a. Possible condensation surfaces on the ground can be the grass, a car window, etc.
    b. Possible condensation surfaces in the atmosphere are tiny bits of particulate matter
        1. Called condensation nuclei
        2. Dust, smoke, etc.
        3. Ocean salt crystals which serve as hygroscopic ("water seeking") nuclei

B. Clouds
1. Made of millions and millions of
    a. Minute water droplets, or
    b. Tiny crystals of ice
2. Classification based on
    a. Form (three basic forms)
        1. Cirrus – high, white, thin
        2. Cumulus
            a. Globular cloud masses
            b. Often associated with fair weather
        3. Stratus
            a. Sheets or layers
            b. Cover much or all of the sky
    b. Height
        1. High clouds
            a. Above 6000 meters
            b. Types
                1. Cirrus
                2. Cirrostratus
                3. Cirrocumulus
        2. Middle clouds
            a. 2000 to 6000 meters
            b. Types (alto as part of the name)
                1. Altocumulus
                2. Altostratus
        3. Low clouds
            a. Below 2000 meters
            b. Types
                1. Stratus
                2. Stratocumulus
                3. Nimbostratus (nimbus means "rainy")
        4. Clouds of vertical development
            a. From low to high altitudes
            b. Called cumulonimbus
            c. Often produce
                1. Rain showers
                2. Thunderstorms

VII. Fog
- A. Considered an atmospheric hazard
- B. Cloud with its base at or near the ground
- C. Most fogs form because of
  1. Radiation cooling, or
  2. Movement of air over a cold surface
- D. Types of fog
  1. Fogs caused by cooling
     - a. Advection fog – warm, moist air moves over a cool surface
     - b. Radiation fog
       1. Earth's surface cools rapidly
       2. Forms during cool, clear, calm nights
     - c. Upslope fog
       1. Humid air moves up a slope
       2. Adiabatic cooling occurs
  2. Evaporation fogs
     - a. Steam fog
       1. Cool air moves over warm water and moisture is added to the air
       2. Water has a steaming appearance
     - b. Frontal fog, or precipitation fog
       1. Forms during frontal wedging when warm air lifted over colder air
       2. Rain evaporates to form fog

VIII. Precipitation
- A. Cloud droplets
  1. Less than 20 micrometers (0.02 millimeter) in diameter
  2. Fall incredibly slow
- B. Formation of precipitation
  1. Bergeron process
     - a. Temperature in the cloud is below freezing
     - b. Ice crystals collect water vapor
     - c. Large snowflakes form and
       1. Fall to the ground as snow, or
       2. Melt on their descent and form rain
     - d. Dominant in the middle latitudes
  2. Collision-coalescence process
     - a. Warm clouds
     - b. Large hygroscopic condensation nuclei
     - c. Large droplets form
     - d. Droplets collide with other droplets during their descent
     - e. Common in the tropics
- C. Forms of precipitation
  1. Rain and drizzle
     - a. Rain – droplets have at least a 0.5 mm diameter
     - b. Drizzle – droplets have less than a 0.5 mm diameter
  2. Snow – ice crystals, or aggregates of ice crystals
  3. Sleet and glaze
     - a. Sleet
       1. Wintertime phenomenon
       2. Small particles of ice

3. Occurs when
a. Warmer air overlies colder air
b. Rain freezes as it falls
b. Glaze, or freezing rain – impact with a solid causes freezing
c. Hail
1. Hard rounded pellets
a. Concentric shells
b. Most diameters range from 1 to 5 cm
2. Formation
a. Occurs in large cumulonimbus clouds with violent up- and down drafts
b. Layers of freezing rain are caught in up- and down drafts in the cloud
c. Pellets fall to the ground when they become too heavy
d. Rime
1. Forms on cold surfaces
2. Freezing of
a. Supercooled fog, or
b. Cloud droplets

D. Measuring precipitation
1. Rain
a. Easiest form to measure
b. Measuring instruments
1. Standard rain gauge
a. Uses a funnel to collect and conduct rain
b. Cylindrical measuring tube measures rainfall in centimeters or inches
2. Recording gauge
2. Snow has two measurements
a. Depth
b. Water equivalent
1. General ratio is 10 snow units to 1 water unit
2. Varies widely
3. Radar is also used to measure the rate of rainfall

Chapter #14
Objectives:
Ocean Water and Ocean Life

After reading, studying, and discussing Chapter 14, you should be able to:

- Discuss the chemical composition of seawater and the sources of sea salts.
- Explain the ocean's layered temperature and density structures.
- Describe the classification of marine organisms and marine life zones.
- Discuss the productivity of polar, tropical, and temperate oceans.
- Summarize oceanic feeding relationships, food chains, and food webs.

Outline:
Chapter 14: **Ocean Water and Ocean Life**

I. Composition of seawater
  A. Seawater consists of about 3.5% (by weight) dissolved minerals
  B. Salinity
    1. Total amount of solid material dissolved in water
    2. Typically expressed in parts-per-thousand (‰)
    3. Average salinity is 35‰
    4. Major constituent is sodium chloride
  C. Sources of sea salts
    1. Chemical weathering of rocks
    2. Outgassing – gases from volcanic eruptions
  D. Processes affecting seawater salinity
    1. Variations in salinity are a consequence of changes in the water content of the solution
    2. Processes that decrease salinity (add water)
      a. Precipitation
      b. Runoff from land
      c. Icebergs melting
      d. Sea ice melting
    3. Processes that increase salinity (remove water)
      a. Evaporation
      b. Formation of sea ice
    4. Surface salinity in the open ocean ranges from 33‰ to 38‰
II. Ocean temperature
  A. Surface water temperature varies with the amount of solar radiation received
    1. Lower surface temperatures are found in high-latitude regions
    2. Higher temperatures found in low-latitude regions
  B. Temperature variation with depth
    1. Low-latitudes
      a. High temperature at the surface
      b. Rapid decrease in temperature with depth (thermocline)
    2. High-latitudes
      a. Cooler surface temperatures
      b. No rapid change in temperature with depth
  C. Ocean temperature over time
    1. The unique thermal properties of seawater make it resistant to temperature changes
    2. Global warming could eventually influence ocean temperatures

III. Ocean density
A. Density is mass per unit volume - how heavy something is for its size
B. Determines the water's vertical position in the ocean
C. Factors affecting seawater density
1. Salinity
2. Temperature - the greatest influence
D. Variations with depth
1. Low-latitudes
a. Low density at the surface
b. Density increases rapidly with depth (pycnocline) because of colder water
2. High-latitudes
a. High-density (cold) water at the surface
b. Little change in density with depth
E. Ocean layering
1. Layered according to density
2. Three-layered structure
a. Surface mixed zone
1. Sun-warmed zone
2. Zone of mixing
2. Shallow (300 meters)
b. Transition zone
1. Between surface layer and deep zone
2. Thermocline and pycnocline
c. Deep zone
1. Sunlight never reaches this zone
2. Temperatures are just a few degrees above freezing
3. Constant high density water
3. Three-layer structure does not exist in high-latitudes

IV. Ocean life
A. Marine environment is inhabited by a wide variety of organisms

B. Most organisms live within the sunlight surface waters (photosynthesis)

C. Classification of marine organisms
1. Plankton
a. Floaters
b. Algae (phytoplankton)
c. Animals (zooplankton)
d. Bacteria
e. Most of Earth's biomass
2. Nekton
a. All animals capable of moving independently of the ocean currents
b. They are unable to move throughout the breath of the ocean
3. Benthos
a. Bottom dwellers
b. A great number of species exist on the shallow coastal floor
c. Most live in perpetual darkness in deep water

D. Marine life zones
1. Several factors are used to divide the ocean into distinct marine life zones
a. Availability of light
1. Photic (light) zone
a. Upper part of ocean
b. Sunlit
c. Euphotic zone is near the surface where the light is strong
1. Phytoplankton use sunlight to produce food
2. Different wavelengths of light are absorbed at different depths
2. Aphotic (without light) zone
a. Deep ocean
b. No sunlight
b. Distance from shore
1. Intertidal zone – area where land and ocean meet and overlap
2. Neritic zone – seaward from the low tide line, the continental shelf out to the shelf break
3. Oceanic zone – beyond the continental shelf
c. Water depth
1. Pelagic zone – open ocean of any depth
2. Benthic zone – includes any sea-bottom surface
3. Abyssal zone – a subdivision of the benthic zone
a. Deep
b. Extremely high water pressure
c. Low temperatures
d. No sunlight
e. Sparse life
f. Food sources
1. Decaying particles from above
2. Large fragments falling
3. Hydrothermal vents

V. Oceanic Productivity

A. Related to primary productivity
1. The amount of carbon fixed by organisms through the synthesis of organic matter
2. Sources of energy
a. Photosynthesis (solar radiation)
b. Chemosynthesis (chemical reactions)
3. Influenced by
a. Availability of nutrients
b. Amount of solar radiation
4. Most abundant marine life exists where there is ample
a. Nutrients, and
b. Good sunlight

B. Productivity in polar oceans
1. Because of nutrients rising from deeper water, high-latitude surface waters have high nutrient concentrations
2. Low solar energy limits photosynthetic productivity

C. Productivity in tropical oceans
1. Low in the open ocean
2. Thermocline eliminates the supply of nutrients from deeper waters below
D. Productivity in temperate oceans
1. Winter
a. Low productivity
b. Days are short and sun angle is low
2. Spring
a. Spring bloom of phytoplankton is quickly depleted
b. Productivity is limited
3. Summer
a. Strong thermocline develops so surface nutrients are not replaced from below
b. Phytoplankton population remains relatively low
4. Fall
a. Thermocline breaks down and nutrients return to the surface
b. Short-lived fall bloom of phytoplankton
E. Highest overall productivity occurs in temperate regions

VI. Oceanic feeding relationships
A. Main oceanic producers
1. Marine algae
2. Plants
3. Bacteria
4. Bacteria-like archaea
B. Only a small percentage of the energy taken in at any level is passed on to the next
C. Trophic levels
1. Chemical energy stored in the mass of the ocean's algae is transferred to the animal community mostly through feeding
2. Each feeding stage is called a trophic level
D. Transfer of energy between trophic levels is very inefficient (about 2%)
E. Food chains and food webs
1. Food chain - a sequence of organisms through which energy is transferred
2. Food web
a. Involves feeding on a number of different animals
b. Animals that feed through a food web rather than a food chain are more likely to survive

Chapter 15 Objectives: The Dynamic Ocean

After reading, studying, and discussing Chapter 14, you should be able to:

- List the factors that influence surface ocean currents.
- Discuss the importance of surface ocean currents.
- Describe deep-ocean circulation.
- Describe wave characteristics and types.
- Describe wave erosion and the features produced by wave erosion.
- Discuss shoreline erosional problems and solutions.
- Explain the differences between an emergent and submergent coast.
- Discuss the factors that influence tides.
- Describe the monthly tidal cycle, three main tidal patterns, and tidal currents.

Outline:

Chapter 15: **The Dynamic Ocean**

I. Ocean water movements
  A. Surface circulation
    1.Ocean currents are masses of water that flow from one place to another
    2. Surface currents develop from friction between the ocean and the wind that blows across the surface
    3. Huge, slowly moving gyres
    3. Five main gyres
      a. North Pacific Gyre
      b. South Pacific Gyre
      c. North Atlantic Gyre
      d. South Atlantic Gyre
      e. Indian Ocean Gyre
    4. Related to atmospheric circulation
    5. Deflected by the Coriolis effect
      a. To the right in the Northern Hemisphere
      b. To the left in the Southern Hemisphere
    6. Four main currents generally exist within each gyre
    7. Importance of surface currents
      a. Climate
        1. Currents from low latitudes into higher latitudes (warm currents) transfer heat from warmer to cooler areas
        2. Influence of cold currents is most pronounced in the tropics or during the summer months in the middle latitudes
      b. Upwelling
        1. The rising of cold water from deeper layers
        2. Most characteristic along west coasts of continents
        3. Brings greater concentrations of dissolved nutrients to the ocean surface
  B. Deep-ocean circulation
    1. A response to density differences
    2. Factors creating a dense mass of water
      a. Temperature – cold water is dense
      b. Salinity – density increases with increasing salinity
    3. Called thermohaline circulation
    4. Most water involved in deep-ocean currents begins in high latitudes at the surface
    5. A simplified model of ocean circulation is similar to a conveyor belt that travels from the Atlantic Ocean, through the Indian and Pacific Oceans and back again
  C. Waves
    1. Energy traveling along the interface between ocean and atmosphere
    2. Derive their energy and motion from wind
    3. Parts
      a. Crest
      b. Trough
    4. Measurements of a wave
      a. Wave height – the distance between a trough and a crest
      b. Wavelength – the horizontal distance between successive crests (or troughs)
      c. Wave period – the time interval for one full wave to pass a fixed position

5. Wave height, length, and period depend on
    a. Wind speed
    b. Length of time the wind blows
    c. Fetch – the distance that the wind travels
6. As the wave travels, the water passes energy along by moving in a circle
    a. Waveform moves forward
    b. At a depth of about one-half the wavelength, the movement of water particles becomes negligible (the wave base)

II. Beaches and shoreline processes
A. Beaches are composed of whatever material is available
1. Some beaches have a significant biological component
2. Material does not stay in one place
B. Wave erosion
1. Caused by
    a. Wave impact and pressure
    b. Abrasion by rock fragments
2. Breaks down rock material and supplies sand to beaches
C. Wave refraction
    a. Bending of a waves
    b. Wave arrives parallel to shore
    c. Results
        1. Wave energy is concentrated against the sides and ends of headland
        2. Wave erosion straightens an irregular shoreline
D. Longshore transport
    a. Beach drift – sediment moves in a zigzag pattern along the beach face
    b. Longshore current
        1. Current in surf zone
        2. Flows parallel to the shore
        3. Moves substantially more sediment than beach drift

III. Shoreline features
A. Erosional features
1. Wave-cut cliff
2. Wave-cut platform
3. Marine terraces
4. Associated with headlands
    a. Sea arch
    b. Sea stack
B. Depositional features
1. Spit – a ridge of sand extending from the land into the mouth of an adjacent bay with an end that often hooks landward
2. Baymouth bar – a sand bar that completely crosses a bay
3. Tombolo – a ridge of sand that connects an island to the mainland
4. Barrier islands
    a. Mainly along the Atlantic and Gulf Coastal Plains
    b. Parallel the coast
    c. Originate in several ways

IV. Stabilizing the shore
A. Shoreline erosion is influenced by the local factors
1. Proximity to sediment-laden rivers
2. Degree of tectonic activity
3. Topography and composition of the land

4. Prevailing wind and weather patterns
5. Configuration of the coastline

B. Responses to erosion problems
1. Hard stabilization - building structures
a. Types of structures
1. Groins
a. Barriers built at a right angle to the beach
b. Trap sand
2. Breakwaters
a. Barriers built offshore and parallel to the coast
b. Protects boats from the force of large breaking waves
3. Seawalls
a. Armors the coast against the force of breaking waves
b. Stops waves from reaching the beach areas behind the wall
b. Often these structures are not effective
2. Alternatives to hard stabilization
a. Beach nourishment by adding sand to the beach system
b. Relocating buildings away from beach

C. Erosion problems along U.S. Coasts
1. Shoreline erosion problems are different along the opposite coasts
2. Atlantic and Gulf Coasts
a. Development occurs mainly on barrier islands
1. Face open ocean
2. Receive full force of storms
b. Development has taken place more rapidly than our understanding of barrier island dynamics
3. Pacific Coast
a. Characterized by relatively narrow beaches backed by steep cliffs and mountain ranges
b. Major problem is the narrowing of the beaches
1. Sediment for beaches is interrupted by dams and reservoirs
2. Rapid erosion occurs along the beaches

V. Coastal classification
A. Shoreline classification is difficult
B. Classification based on changes with respect to sea level
1. Emergent coast
a. Caused by
1. Uplift of the land, or
2. A drop in sea level
b. Features of an emergent coast
1. Wave-cut cliffs
2. Marine terraces
1. Submergent coast
a. Caused by
1. Land adjacent to sea subsides, or
2. Sea level rises
b. Features of a submergent coast
1. Highly irregular shoreline
2. Estuaries – drowned river mouths

VI. Tides
- A. Changes in elevation of the ocean surface
- B. Caused by the gravitational forces exerted upon the Earth by the
  1. Moon, and to a lesser extent by the
  2. Sun
- C. Monthly tidal cycle
  1. Spring tide
     a. During new and full moons
     b. Gravitational forces added together
     c. Especially high and low tides
     d. Large daily tidal range
  2. Neap tide
     a. First and third quarters of the Moon
     b. Gravitational forces are offset
     c. Daily tidal range is least
- D. Tidal patterns
  1. Many factors influence the tides
     a. Shape of the coastline
     b. Configuration of the ocean basin
     c. Water depth
  2. Main tidal patterns
     a. Diurnal tidal pattern
        1. A single high and low tide each tidal day
        2. Occurs along the northern shore of the Gulf of Mexico
     b. Semidiurnal tidal pattern
        1. Two high and two low tides each tidal day
        2. Little difference in the high and low water heights
        3. Common along the Atlantic Coast of the U.S.
     c. Mixed tidal pattern
        1. Two high and two low waters each day
        2. Large inequality in high water heights, low water heights, or both
        3. Prevalent along the Pacific Coast of the U.S.
  3. Tidal currents
     a. Horizontal flow accompanying the rise and fall of tides
     b. Types of tidal currents
        1. Flood current – advances into the coastal zone
        2. Ebb current – seaward moving water
     c. Sometimes tidal deltas are created by tidal currents