I. Why study marine biology?

II. History of Marine Biology

   A. View the course website videos on Aquarius and answer the following:
      1. What is Aquarius and where is it located?

III. The Scientific Method

   A. Read pp. 8 – 15 “The Scientific Method” and address the following:
      1. What is the definition of “the scientific method”?

2. Know the steps (listed below) of the scientific method and how they are used to find an answer to a question.
   a. Observation
   b. Constructing the hypothesis
   c. Testing the hypothesis by running experiments & collecting data
   d. Make conclusions and determine whether or not previous testing supports hypothesis

3. What is a hypothesis and why does it need to be testable?

4. What is the difference between a “scientific theory” and the everyday use of the word “theory”?
The Sea Floor (Chapter 2)

I. The Water Planet
What % of the Earth’s surface is covered with water?

A. Four Ocean Basins (Fig. 2.1 & Table 2.1)
   1. What are our four ocean basins?

   2. Which one is the largest and which one is the smallest?

B. Earth’s Structure
   1. The crust – (Fig. 2.3)

      Two crust types: due to physical and chemical differences of rock, not because one is covered by water and the other is not (Table 2.2).

   2. Continental and Oceanic Crusts
      a. Where is each type of crust generally found on Earth?

      b. What mineral makes up each crust type?

      c. What crust type has the highest density?

C. How did oceans form?
   Continental Drift – all the continents had once been joined in a single ‘supercontinent’ called Pangaea. (Fig. 2.17)
   1. Evidence of drift (Fig. 2.4)

   2. What causes continental drift?
a. Plate tectonics

3. What causes plates to move? Sea-floor spreading
   a. What happens at mid-ocean ridges? (Fig. 2.5, 2.10)

   b. What happens at trenches? (Fig. 2.5, 2.12, 2.13)

   c. Where do many earthquakes and volcanoes tend to occur and why? (Fig. 2.8)

4. View the course website video on “The Discovery of Sea floor Spreading & Plate Tectonics” and answer the following:
   a. What did scientists discover at the bottom of the Atlantic Ocean in 1953 and what type of readings were they taking when they discovered it?

   b. What did Harry Hess discover about the age of the Atlantic sea floor while analyzing core samples and sonar readings? What did he call his discovery?

   c. What is subduction? And where does it occur, at trenches or mid ocean ridges? (Hint: We learned about this in class)

   d. At what rate (speed) do the earth’s large, interconnected plates move? (Hint: It is compared to the growth of a body part)

   e. What is currently happening to the size of the Pacific Ocean and the size of the Atlantic Ocean? Explain why this is happening by explaining which ocean is experiencing more subduction and which one is experiencing less?
D. Read pp. 36 – 37, “The Hawaiian Islands, Hot Spots, and the Great Mantle Plume Debate” and address the following:
   1. What process, believed by most scientists, is responsible for forming the Emperor Seamounts and Hawaiian Island chain?
   2. Which of the Hawaiian Islands is the oldest and which is the youngest? Explain why.

E. The sea floor is divided into two main regions (Fig. 2.20)
   1. Continental margin
   2. Deep-sea floor (abyssal plain)

F. The Continental Margin – boundary between continental crust and oceanic crust (Fig. 2.20, 2.21, 2.22)
   1. Read pp. 33 – 34 “Continental Margins” and address the following:
      a. What three areas make up the continental margin?
      b. Using Figure 2.20, draw the continental margin and label the three areas that make up the continental margin.
      c. Which area…
         … is the shallowest and most biologically rich (has the highest amount of living organisms)?
         … is the continent’s edge and consists of canyons that channel sediment to the deep-sea floor?
         … is where sediment accumulates?
G. The Deep Sea Floor – abyssal plain
1. **Read pp. 35 – 38 “Deep-Ocean Basins” and “The Mid-Ocean Ridge & Hydrothermal Vents” and address the following:**
a. Where is the abyssal plain located and what does it generally look like?

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**Chemical & Physical Features of Seawater & the World Ocean (Chapter 3)**

**Watch the Amoeba Sisters Properties of Water**

I. The Unique Nature of Pure Water
   A. Water is polar (Fig. 3.1)

   ![Water Molecule Diagram](image)

B. 3 states of water – water is only substance that naturally occurs in gas, solid, liquid (Fig. 3.2).
   1. **Read pp. 41–42 “The Three States of Water” and address the following:**
      a. Which state has the fastest moving water molecules and which has the slowest? Why is this?

      ![Gas, Liquid, and Solid Water Diagram](image)

      b. Which state has the highest number of hydrogen bonds and which has the lowest? Why is this?

      c. Which state has the highest density and which has the lowest? Why is this?

      ![Density Comparison Diagram](image)

   d. Does ice float? Why is this important to marine organisms?
C. Heat & Water (Fig. 3.3)
   1. Water has a great capacity to absorb and store heat. Why?
   
   2. When heat is applied, how does it affect hydrogen bonds and molecule speed (temp.) of water?
   
   3. When water is changing states (i.e. when ice is melting into liquid water or when liquid water is turning into a gas), how is added heat affecting hydrogen bonds and molecule speed (temp.)?
   
   4. How do hydrogen bonds allow water to absorb heat without greatly affecting temp.?
   
   5. Because of the high number of hydrogen bonds, it takes a large amount of heat to melt ice (break hydrogen bonds) and a great deal of heat must be removed from it to freeze it. Therefore, water can absorb a lot of heat without greatly increasing temperature and it takes a long period of very cold weather before a body of water freezes.
   
   6. Why is this important to marine organisms?

D. Water as a Solvent (Fig. 3.5)
   1. Read p. 43 “Water as a Solvent” and address the following:
      a. Why is water called the “universal solvent”?
      
      b. Why is water so good at dissolving substances, especially salts?

II. Seawater
   A. Why is the sea salty? (Fig. 3.6)
      1. Read pp. 43-44 “Seawater” and state the ways in which dissolved solids (salts) enter the sea.
      
      2. Salt Composition (Table 3.1)
         a. Salinity
b. Salinity is expressed as the # of grams of salt left behind when 1,000 g of seawater are evaporated. If we evaporate 1,000 g of seawater and were left w/ 35 g of salt, the salinity would be 35 parts per thousand, or 35 0/00

c. Average salinity of ocean is 35 0/00, depending on evaporation and rain fall
- Range in south. Calif. = 30 – 34 0/00

- Red Sea vs. Baltic Sea

B. Salinity, Temperature & Density of Seawater
1. Density - mass of a given volume of a substance

2. Temp. & salinity of seawater determines its density. Read p. 44-45 “Salinity, Temperature, and Density” and state happens to the density of water as it gets saltier and colder?

C. Transparency (Fig. 3.11 & 3.12)
1. What color penetrates the deepest?
2. What color is filtered out first?
3. How does this affect photosynthetic organisms?
4. How does this affect the color of marine organisms?

D. Pressure (Fig. 3.14 & 3.15) - the weight exerted over a unit of surface area.
1. Read p. 48 “Pressure” and state if pressure increases or decreases with depth and describe why pressure changes with depth.

2. Read p. 48 “Pressure” and describe how this change affects marine organisms, especially those with gas-filled structures.
III. Ocean Circulation
A. Surface Circulation
1. Surface currents are driven by wind, which is in turn driven by heat from sun. Winds & currents are also influenced by the Coriolis effect. All are involved in forming gyres.
   a. Coriolis Effect – because the earth rotates, anything that moves over its surface tends to turn to one side rather than move in a straight line (Fig. 3.16)
   b. Winds – driven by heat from the sun (Fig. 3.17) How so?
   c. Surface Currents – (driven by wind) created when wind pushes the sea surface (Fig. 3.19)
      When pushed by wind, does surface water move in same direction as the wind?
   d. Gyres – (Fig. 3.20 & 3.21)
Why is surface temperature higher on the western sides of ocean basins?

Learn more about ocean currents, the Coriolis Effect, & their effects on marine organisms by visiting the related website on our course website.

IV. Waves & Tides
   A. Waves - also driven by wind (storm winds)
      1. Read pp. 56 – 57 “Waves” and address the following:
         a. Know your wave anatomy: Define the following parts of a wave. (Fig. 3.26)
            crest
            trough
            wave height
b. Understand how a wave forms by understanding what the following terms are. (Fig. 3.29)

seas

swells

surf

2. Read pp. 58 – 59, “Waves That Kill” and the online article “Rogue Giants at Sea” and address the following:
Understand the main differences between tsunamis and rogue waves.

a. How are tsunamis produced?

b. How are rogue waves produced?

c. Where do tsunamis do the most damage? Where do rogue waves do the most damage? (ex. near or far from land?)
d. What are more deadly and destructive to people and marine habitats, tsunamis or rogue waves? Explain why.

e. Where did the deadliest tsunami in history occur?

B. Tides – the rhythmic pattern of rising and falling of the sea surface
   1. Tides are caused by gravitational pull of moon & sun & by rotations of earth (centrifugal force), moon & sun

   2. How are high and low tides produced? (Fig. 3.31 & 3.32)
      a. On side of the earth nearest the moon, the moon’s gravity pulls water toward or away from the moon?

      On the opposite side, centrifugal force pushes water toward or away from moon?

      How do these forces affect amount of water in these areas and what kind of tide is produced here?

      How much water is left in adjacent areas and what kind of tide is produced here?

      b. As the earth spins on its axis, any given point on the surface will be under a bulge and then away from it. The part of the earth that is under a bulge is experiencing a high tide. The part that is not is experiencing a low tide.

      c. Earth takes 24 hours to rotate. During this time, how many high tides and how many low tides do we experience each day?
How long is a full tidal cycle? Why?

Will the time of the tides occur at the same time every day?

Watch how extreme tides can be in the Bay of Fundy

3. Tides can differ according to their tidal ranges (Fig. 3.33)

a. Spring tides:
   - Where are the moon and sun?
   - Will gravitational pulls be acting together or partially canceling each other out?
   - Are tidal bulges large or small? Is tidal range at its greatest or smallest?
   - When does this occur in a month?

b. Neap tides:
   - Where are the moon and sun?
   - Will gravitational pulls be acting together or partially canceling each other out?
Are tidal bulges large or small? Is tidal range at its greatest or smallest?

When does this occur in a month?

4. Tides in the Real World: Tides vary from place to place because the continents and the shape of sea floor affect how the water rises and falls. (Fig. 3.34 & 3.35)

Read pp. 61 – 62 “Tides in the Real World” and describe the differences among the following types of tides and label the tide type on the figure below. Also, know the type of tides that we mainly experience here in Southern California.

a. Semidiurnal tides

b. Mixed semidiurnal tides

c. Diurnal tides

C. Predicting & Graphing Tides

1. Go to the McGraw-Hill online student resource website: www.mhhe.com/castrohuber9e

2. Click on the “Student Edition” of the Online Learning Center. Click on “Site Map” in the upper right corner of the page. Scroll down to Chapter 3 and click on “Marine Biology on the Net”. Scroll down to “Waves, Tides and Currents”. Click on “Tide Location Selection for California”

3. Using this website, determine the tides for Newport Bay Entrance, Corona del Mar. Display tides for Sep. 2017, with the first day for tides being the 16th , and 14 days of tides. Using that data, focus on the tides for Sep. 18 – Sep. 21, 2017.

4. In order to graph out the data that you just found, open the “Microsoft Excel Graph Template” located on our course website on the “Handouts & Articles” page. Save the file and work off of your saved file. Fill in the “Day”, “Time”, and “Tide Height” columns on the spreadsheet with the data that you just found for. See this example graph below for assistance:
5. Label and title the graph and x and y axes by clicking on each label.

E. Answer the following questions using the tide data and the graph that you just made:
1. What type of tide cycle (diurnal, semidiurnal, or mixed semidiurnal) does the graph that you made show? (Hint: Look at the previous section on our outline called “Tides in the Real World” for help.)

2. Notice the first low tide of each day. Does the time of the first low, become earlier, later, or stay the same over the days?

3. Does your tide sequence represent a spring or neap tide? Also, does your tide sequence occur during a new or full moon? (Hint: look at the “% Moon Visible” on your data table for help)

4. Let’s say that you want to go out into the intertidal (tide pool) habitat to look at the various tide pool organisms between for Sep. 18 – Sep. 21, 2017. What day and what time of day would be the best time to go in order to see extensive tide pools (i.e. the greatest exposure of the sea floor)?

F. How do tides affect marine organisms?
Many marine organisms use the tides to ensure their survival. Many organisms can internally 'predict' the tides and use the tides to their advantage.

1. One such organism is the grunion. Research the grunion using these websites (https://www.wildlife.ca.gov/Fishing/Ocean/Grunion, http://grunion.pepperdine.edu/) and answer the following:

   a. Give a brief description of the grunion and where on our planet it is generally found.
b. Describe how and why grunion use the tides.

c. Lastly, why do you think grunion go to such great lengths to lay their eggs up on the beach rather than right in the water like most other fish?

Watch a grunion run!: http://www.youtube.com/watch?v=f2JhafqT_I&feature=fvw

2. Another type of organism that depends on the tides for reproduction are corals. Watch these videos and answer the following questions: https://www.youtube.com/watch?v=tntOA4qXiIo, https://www.youtube.com/watch?v=wsaZ8-I7akg

a. Do corals spawn (release their eggs and sperm) during spring or neap tides? Explain why they spawn during that particular type of tide.
I. What is life? What makes an organism alive? What characteristics do all living organisms have?

A. All Living Things are Composed of One or More Cells

Watch the Amoeba Sisters Introduction to Cells: The Grand Cell Tour

1. Basic Cell Anatomy (Fig. 4.7 & 4.8)
   - Cell membrane (plasma membrane) – cell wrapper
   - Cytoplasm – gelatinous contents of cell
   - Organelles – membrane bound structures in cell

2. Cell Types
   a. Prokaryotic cells (Fig. 4.7)
      - ex. Bacteria (best known group of prokaryotes)
   b. Eukaryotic cells (Fig. 4.8)
1. Two Types of Eukaryotic Cells: Animal & Plant Cells (fig. 4.8)
a. Read p. 69 “Structurally Complex Cells: Eukaryotes” and state the main differences between animal and plant/algal cells

B. The Fuel of Life: All Living Things Obtain & Use Energy
1. Making Fuel from Solar Energy: Photosynthesis (Fig. 4.4)
a. Most organisms ultimately get their energy from the sun
b. Photosynthesis
c. What organisms use this process?

2. Burning the Fuel: Cellular Respiration – reverse of photosynthesis (Fig. 4.5)
a. Glucose is broken down using oxygen while CO₂, water, and energy (ATP) are given off
b. Energy can now be used by organism to make organic matter (living material).
c. What organisms use cellular respiration?

3. Autotrophs vs. Heterotrophs
   a. Autotrophs (Primary Producers)
b. Heterotrophs

4. Primary Production

C. All Living Things Maintain Relatively Constant Internal Environment = Homeostasis

1. Regulation of Salt and Water Balance
   a. Diffusion (Fig. 4.12)
   b. Osmosis
   c. Whenever internal composition of cell differs from that on the outside, water will tend to move in or out of the cell (Fig. 4.13)
   d. Read pp. 74-75 “Regulation of Salt & Water Balance” and describe how each of the following deals with salinity changes.
Osmoconformers

Osmoregulators

Read pp. 74-75 “Regulation of Salt & Water Balance” and p. 166 “Regulation of the Internal Environment” describe how each of the following animals osmoregulate and label adaptations used by each on diagrams:

Marine fish:

Freshwater fish:

Sharks:
2. Regulation of Body Temperature
   a. Ectothermic animals (ecto = outside; therm = heat) - internal body temperature is controlled by temperature of environment
      
      Examples?
      
      Are they able to internally regulate their body temperature?
      
      Do they exist at same temperature as their surroundings?
      
      How do they obtain their body heat?
      
      How is metabolic rate (activity level) affected when environmental temperature changes?
      
      How will the rate of cellular respiration be affected when it is in a warm environment? When in a cold environment?

   b. Endothermic animals (endo = inside; therm = heat) - internal temperature is controlled by internal metabolism
      
      Examples?
      
      Are they able to internally regulate their body temperature?
      
      Do they exist at same temperature as their surroundings?
      
      How do they obtain their body heat?
      
      How is metabolic rate (activity level) affected when environmental temperature changes?
How will the rate of cellular respiration be affected when it is in a warm environment? When in a cold environment?

How will the rate of cellular respiration be affected when it is in a warm environment? When in a cold environment?

D. All Living Things Reproduce

Watch Amoeba Sisters Asexual and Sexual Reproduction

1. Asexual Reproduction

Advantages and Disadvantages of Asexual Reproduction:

2. Sexual Reproduction (Fig. 4.20)

Advantages and Disadvantages of Sexual Reproduction:

3. Reproductive Strategies
   a. External fertilization (broadcast spawning)
Advantages and Disadvantages of External Reproduction:

b. Internal fertilization

Advantages and Disadvantages of Internal Reproduction: