Introduction to Oceanography

In this reading assignment, you will explore the benefits that we derive from studying the ocean, and learn about some of the basic concepts in oceanography. In addition, I try to mention many of the subjects that we will cover later in the semester, so it is also an introduction to what this course will cover. ***Welcome aboard!***

According to the National Oceanic and Atmospheric Administration (NOAA), in 2008 at least 28 million jobs in the United States were related directly or indirectly to the ocean, *which was about 1 in 6 jobs*!

A HISTORY OF OCEANOGRAPHY

Human Use of the Ocean

Humans began using the ocean long before there was a formal science of oceanography. In early times, the ocean was used mainly for food. We eat fish, shrimp, clams, squid, seaweed, and much more. About 1/6th of our protein comes from the ocean, closer to 1/3rd if you include all the small fish that are ground up into fish meal and fed to cattle, chicken, pigs, etc. to make them grow faster. (Isn't modern agribusiness great?) Another important use is transportation: it is much easier and cheaper to move goods and people over the ocean than over land. This was obviously true in the past when the seas were ruled by sailing ships which relied on the free power supplied by the wind. It remains true even today: huge cargo ships cross the ocean with objects made in places like China to stock the shelves of Wal-Mart and other stores. If transporting goods across the ocean was expensive, then these items would cost a lot more. Today, food and transportation are still important uses of the ocean, but they are joined by a third major use: energy; about 1/3 rd of the world's oil and natural gas is pumped out of the ocean floor.

Using the Ocean. National Oceanic and Atmospheric Administration, Department of Commerce

There are about 3,000 huge cargo ships in the world; many of them can carry 4,000 huge cargo containers. These cargo ships carry about 80% of the world's commercial goods at one point or another. As global trade continues to expand and developing countries' economies grow rapidly, many more of these ships will be needed. About 40% of all the goods imported into the United States – worth $200 billion – come through the ports of Los Angeles and Long Beach. Taken together, they are one of the largest ports in the world (in the top 10). Port activity contributes $39 billion in wages and taxes to the local economy, and is related to about 800,000 local jobs (about 1 in 8). Many more port-related jobs will be added throughout the United States as ports continue to expand and grow.

The Beginnings of the Science of Oceanography

People have studied the ocean for a long time. However, until the end of the 19th century and the beginning of the 20th century, most people were interested in studying a particular aspect of the ocean. For example, some people were interested in ocean life, often for food. Others were interested in how the ocean produces weather conditions like storms. Some wanted to know about ocean currents and winds so that they could travel more quickly and safely. A little over a century ago, ocean scientists began to recognize that all these different aspects of the ocean are tied together; to understand one aspect of the ocean, you must understand many aspects of the ocean that may seem unrelated. For example, ocean currents (physics) can control were life (biology) is abundant in the ocean, because they carry special chemicals (chemistry) necessary to sustain plant-like plankton away from places where they are washed into the ocean from rich soils on land (geology). Instead of being biologist, chemists, geologist, physicists, etc. who studied the ocean, they began to found institutions where they would learn about one another's fields and work together: they became oceanographers.

The beginning of oceanography is typically dated to the "Challenger Expedition" of 1872-1876. The Challenger went all the way around the world, surveying the life, sediments, water chemistry, winds, currents, etc. of all the of the world's oceans (except the Arctic). Its work was funded by the British Navy. At that time, the British Empire controlled much of the world (India, South Africa, Australia, Canada, etc.); it was said that "The Sun never sets on the British Empire." Great Britain, an island nation, greatly valued information about the ocean, because they needed to dominate the seas to maintain and protect their empire.


The Challenger. National Oceanic and Atmospheric Administration, Department of Commerce

Most people know "Atlantis," "Challenger," "Columbia," "Discovery," "Endeavor," etc. as the names of our space shuttles. The shuttles are named for famous oceanographic ships.

At this time, most scientific research was funded by private individuals or foundations. To be a scientist, you needed to be independently wealthy or gain employment in an institution that was interested in the same research you were. The first oceanographic institutions were founded in the early 20th century by wealthy benefactors. For example, the Scripps Institution of Oceanography in San Diego, one of the top oceanography research centers in the world (if not the best), was funded in its early days by the wealthy Scripps family.

Oceanography at War

During World War I, the federal government began funding some science, but it preferred to work through industry rather than directly employing scientists. To save money after the war, the government abandoned many of the military research projects that it had started[1]. The philosophy at the time was that since people could make money from scientific research, those people should pay for the research, not the government.

Scientific research proved to be even more valuable during World War II than World War I. Perhaps the most famous example is the Manhattan Project which developed the first atomic bombs. Developing and maintaining a lead in the application of RADAR to find enemy ships and planes was probably even more important. Knowledge about the oceans was so highly valued that a recently published introductory textbook ("The Oceans") was "classified" by the federal government. Oceanographers participated in the war effort in a variety of ways. Knowledge of ocean currents helped transport troops and supplies quickly and conserve limited fuel. Knowledge of the weather, waves, and tides was used to determine the best time for beach landings like those on "D-Day[2]" (e.g., the beginning of the movie *Saving Private Ryan*). Knowledge of ocean water's physical and chemical properties was used to develop improved SONAR and other technologies to find and destroy enemy submarines and protect our own. This was particularly important early in the war during the "Battle of Atlantic:" once the United States entered the war (and even somewhat before), we shipped supplies to England as quickly as possible. We needed England to resist the Germans until we could build enough machines and train enough troops to enter the war in Europe. German U-boats (submarines) sank large number of quickly-produced "liberty ships" (like the SS Lane Victory that you can visit down in San Pedro) trying to cross the Atlantic.

Believe it or not, our strategy at the beginning of the war was to produce more, cheap ships than the Germans could sink. At the end of the war, a larger percentage of our men died serving in the merchant marine (on cargo ships) than in any other service, including the marines – who ran up beaches towards German and Japanese machine guns!

D-Day (Public Domain)

[1] It was, after all, "the war to end all wars." The navy and other organizations who recognized the valuable contributions of scientists often tried to help keep the research moving forward in small ways where they could.

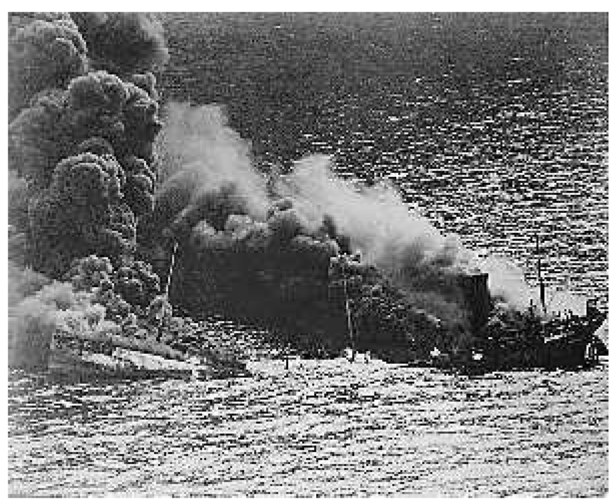
[2] During World War II, Germany conquered all of Europe. D-day was the allied invasion that began the liberation of the conquered European countries.

D-Day (Public Domain)

Oceanography after World War II

U.S. Convoy during the "Battle of the Atlantic" (Public Domain)

German U-Boat (Submarine) (Public Domain)



Tanker Hit by a German Torpedo (Public Domain)

After the war, the United States government decided that science was too valuable to leave to the private sector to develop alone. It had to fund research for its own needs and to keep United States at the forefront technology. Given the traditional reluctance to fund science, this was a hard battle to win in the United States Congress. Vannevar Bush was one of the key people who got President Roosevelt to put money into scientific research during the war, and he oversaw U.S. research and development during the war. He led the charge to convince Congress that scientific research was essential to the future of the United States. His case, presented in the now famous "Science: The Endless Frontier," eventually won the day in Congress, and led to the government-supported science programs that we have today.

Early government funding of research in all areas was modeled after the successful institutions developed between the Navy (through the Office of Naval Research, ONR) and oceanographers. You might expect that scientists would be happy to accept government money, but the reality is more complex. In science, you get ahead in your career by discovering new things and publishing your work. By displaying your talents, you are able to get good positions in universities or institutes, and attract funding and better equipment. In addition, sharing scientific research helps other people develop new ideas, moving the field forward faster. The government, though, often wants to tell scientists what to research (not always what scientists think they should be doing) and to keep the research secret (in some cases). Scientists were also worried that the government might suddenly stop funding research as it did after World War I, and that it would be too late to go back to their private funding sources. The oceanographic community and ONR were particularly successful in balancing the concerns of the scientists with those of the navy, leading to a successful and much imitated partnership.

Most of the research and development done in the United States is still funded by private industry. The federal government only funds about 1/3 of the nation's research. It mainly focuses on "basic" research (on "how things work"), often leaving "applied" research to the private sector. However, about 2/3 of the citations in patents are for "basic" research funded by the government, showing how the open sharing of information can spur innovation.

Following World War II, submarine detection and camouflage continued to be an important area of research. During the "Cold War" with the Soviet Union, each side could wipe out the other side using nuclear weapons, but neither side would attack the other, because they would be wiped out as well. This was called the "MAD" policy ("mutually assured destruction," not "mother's against drunk driving"). The only way to win a nuclear war is with a sneak attack that takes out the other side's nuclear weapons before they can launch. Nuclear submarines armed with nuclear missiles can prowl underneath the ocean, undetectable for long periods of time, without needing to refuel. Keeping our submarines hidden was a top priority, because the Soviet Union knew that it could not attack us without being annihilated out by our submarines.

A fishery is any animal population which we "harvest." So, you can talk about a shrimp fishery or clam fishery even though shrimp and clams are not fish.

As time passed and the Cold War waned, though, civilian government agencies like the National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF) funded a larger and larger proportion of oceanographic research. These agencies fund research on finding and exploiting mineral resources like oil and natural gas or monitoring and preserving living resources like fisheries. They also fund studies of ocean pollution, looking for ways to prevent beach closures and seafood-poisoning that hurt coastal communities. Most people in the United States live near the ocean[3] (more than 50% live in counties next to the ocean), so the agencies conduct research on how to mitigate natural disasters that strike the coast like hurricanes and tsunami, and promote sustainable coastal development. They also fund work on how the ocean affects weather and climate (e.g., El Niño), particularly important for the nation's farmers and for those threatened by natural disasters like droughts, floods, snow storms, and wildfires.

Oceanographic research is only a very small part of the government's research budget. The vast majority of government-funded research involves defense and human health.

***Stop Reading.* This would be a good time try to answer some of the study guide questions (hint: 2, 3, & 4).**

[3] This is pretty normal: over half the world's population lives in a narrow strip of land (say, within 60 miles) of a large body of water, and most of the rest lives only a little farther inland.

Modern Topics of Oceanographic Research

Hurricane (NASA)

Oil Rig (NASA)

Beach Closure Sign

Seafood Counter at a Grocery Store

Sign by a Storm Drain

Fishermen & a Shark (NOAA)

ABOUT THE OCEAN AND OCEANOGRAPHY

Oceanography: A "Young" Science

Oceanography is still a relatively "young" science. Discoveries over the last half century (e.g., the development of plate tectonics, food chains based on chemicals seeping out of the sea floor) have led to major revisions and additions to our knowledge. We still know next to nothing about bacteria, fungi, and viruses in ocean water and most deep-sea life. I expect that there will be big discoveries in our lifetime, and that some parts of future editions of our textbook will be very different than those found in our textbook today.

Oceanography: An Interdisciplinary Science

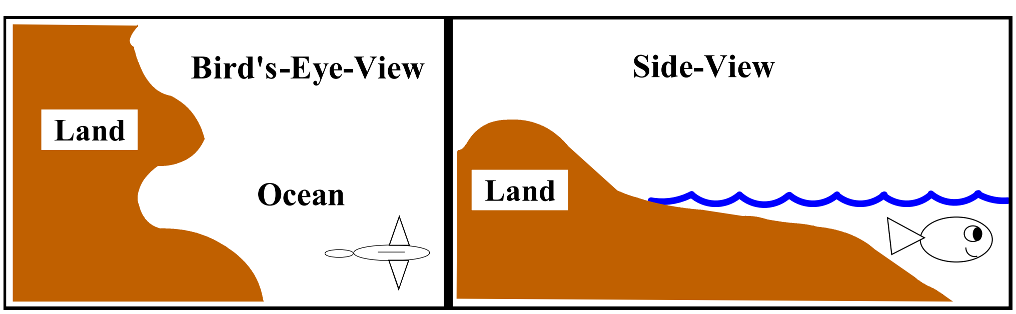
To truly understand the ocean, you must understand processes and concepts from many scientific fields: biology, chemistry, geology, physics, astronomy, and more. For this reason, we call oceanography an "interdisciplinary" science, one in which scientists with many different specialties must work together. For example, the life at the bottom of the ocean food chain (biology) depends upon nutrients (chemicals) which are often brought up to the surface of the ocean by waves and ocean currents (physics). We can study how the amount of life (biology) changed in the past by studying their remains ("fossils") on the ocean floor (geology). Thus, in this class, you can expect to learn ***a little bit*** about <u>many</u> different areas of science.

Oceanography: A Science of Maps

Diagrams and pictures are commonly used to present and summarize information in science. Oceanography is a science that uses a lot of pictures, particularly maps. When you first look at a diagram or picture, the first thing that you should do is to determine its "point-of-view." The two most common are:

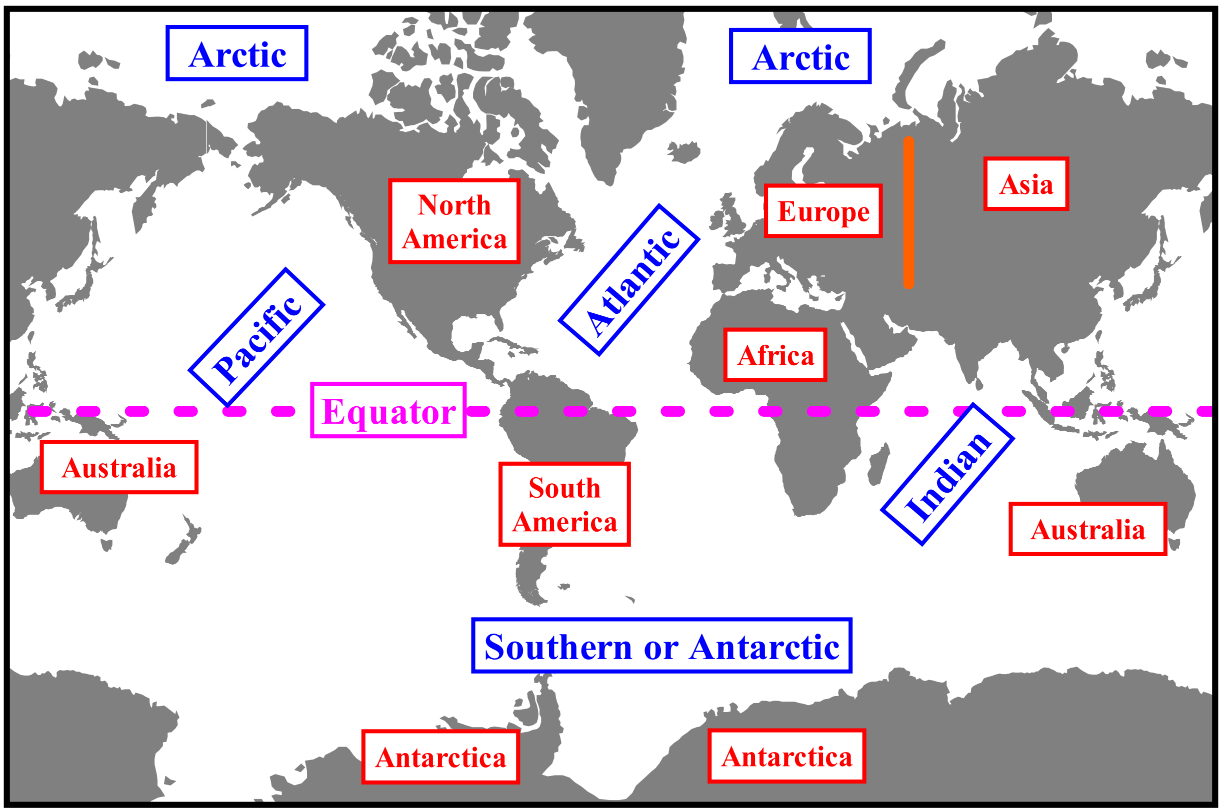
- "bird's-eye view:" also known as "view from above," "map view," or "planview"
- "side view:" also known as a "cross section" or "profile"

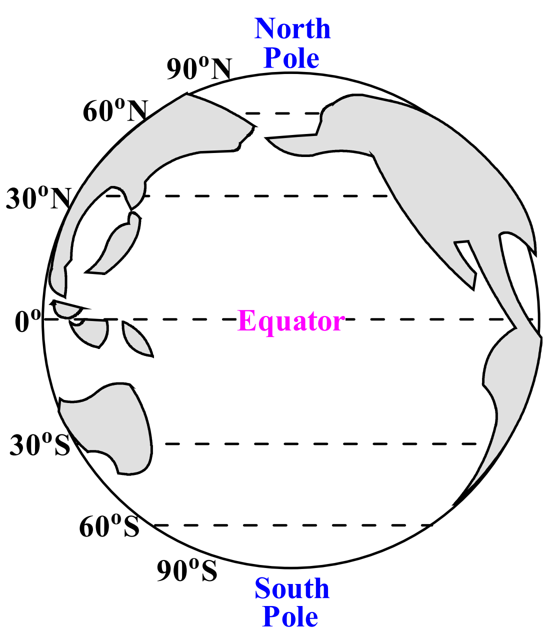
In this class, I will try to make the point-of-view of my diagrams clearer by adding a "fish" to each picture as shown below. In the picture on the left, you see the "top" of the fish (a "bird's-eye view"), and in the picture on the right, you see the "side" of the fish (a "side view). This may not seem important for many of the pictures in your lecture notes, but when we sketch pictures in class, you may find that your pictures look like a bunch of squiggly lines unless you understand the point of view. Also, I encourage you to include a "fish" in your drawings in labs and on exams to help me understand what you are trying to express.

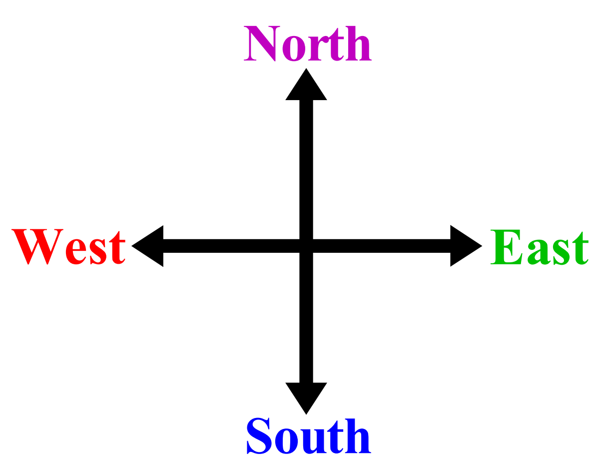


It is very important that you are familiar with the continents, the oceans, the locations of the Equator and the Poles, and the 4 directions on a map. Please memorize these features, otherwise you will have difficulty understanding the lectures and reading assignments.

Note that there are 5 oceans labeled on the map below. The southern parts of the Atlantic, Pacific, and Indian Oceans have a lot in common, so oceanographers often talk about this region as the "Southern Ocean" or the "Antarctic Ocean." It is often difficult to determine exactly where one ocean ends and another begins; the lines we draw are somewhat arbitrary.







Plankton

Plankton are the most common kind of life in the ocean. Most plankton are tiny (microscopic) animals and algae (plant-like organisms), but plankton can be quite large. For example, jellyfish are plankton, and can have tentacles over 100-feet long. The key characteristics that make organisms "plankton" are:

- Plankton are ***floaters***: they try to float, or at least sink very slow through ocean water
- Plankton are ***drifters***: they cannot swim or swim poorly, so ocean currents and waves push them around, and they cannot do anything about it.

"Plankton" means "wanderers."

Note that many plankton can swim;
however, plankton are not very strong swimmers.

Plankton are important in the ocean, because they are at the bottom of most ocean food chains. (In other words, they are food for many ocean animals.) There are two major categories of plankton, phytoplankton and zooplankton. Phytoplankton are algae; like plants, they make their own food using the energy of the sun. Zooplankton are animals.

Phytoplankton and Photosynthesis

Phytoplankton are tiny (one-celled) algae: plant-like organisms that use sunlight as an energy source to make their own food in a process called photosynthesis ("making with light"). When they carry out photosynthesis, they use large amounts of water and the gas carbon dioxide – both abundant in ocean water – to make carbohydrates ("food" molecules):

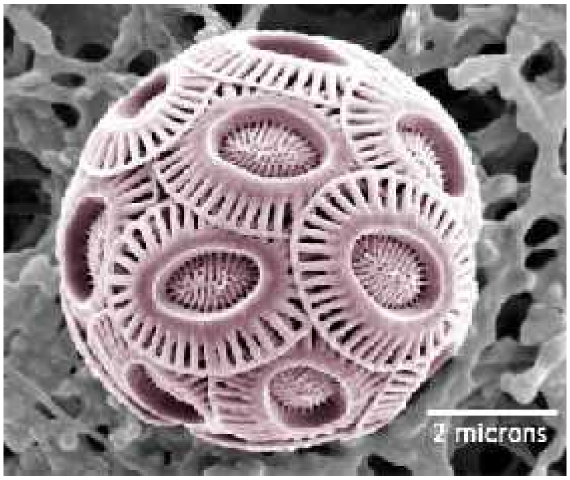
Sunlight + Water + Carbon Dioxide ⟶ Carbohydrates ("Sugars") + Oxygen

They also need small amounts of nutrients[4], molecules that they use to build their bodies (e.g., shells) or molecular "tools" that are needed to carry out photosynthesis. Nutrients are ***not*** used up in the process. (A spatula is a tool that can be used to make a hamburger, but a spatula is not part of the hamburger, the food. It can be re-used again and again to make more hamburgers.) Examples of nutrients include nitrates, phosphates, and silica.

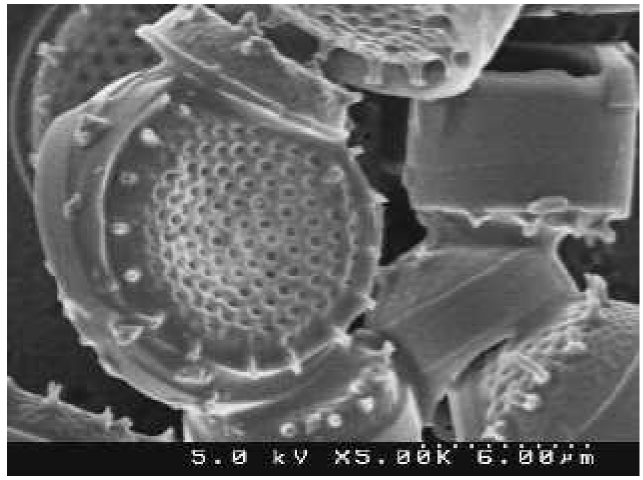
In photosynthesis, the carbon in the carbon dioxide is combined with water to create a carbohydrate ("hydro" means water). The oxygen in the carbon dioxide is simply released.

There are many different kinds of phytoplankton. Some have calcium carbonate shells (e.g., coccolithophores), some have silica shells (e.g., diatoms), and some do not have hard shells. Some phytoplankton can even swim (e.g., dinoflagellates). Silica dissolves more rapidly in warm water than cold water, so silica-shelled phytoplankton tend to prefer living in colder surface water. Calcium-carbonate dissolves more rapidly in cold, carbon-dioxide-rich water (more acidic), so calcium-carbonate-shelled phytoplankton tend to prefer living in warmer surface water[5].

[4] Another word for nutrients is "minerals;" however, they are *not* "vitamins."
[5] There are many examples of calcium-carbonate-shelled phytoplankton and zooplankton who live in cold water, and silica-shelled phytoplankton and zooplankton who live in warm water, so this is not an absolute rule.



Coccolithophore (Calcium Carbonate Shell)
Courtesy of Dr. Markus Geisen, Public Domain



Diatoms (Silica Shells) (Public Domain)

Sunlight and nutrients are the hardest things for phytoplankton to obtain in most of the ocean, so wherever there are both sunlight and nutrients, phytoplankton will be abundant. Most nutrients enter the ocean when nutrients in soil are washed off of the land and into the ocean by rain, so most phytoplankton live near the coasts. Animals will be attracted there too, because phytoplankton are at the bottom of the ocean food chain. In other words, animals in the ocean eat phytoplankton (e.g., zooplankton) or they eat other animals which eat phytoplankton. The phytoplankton make their own food, so we call them "primary producers:" they make ("produce") organic material from inorganic material (carbon dioxide, water). This is the first or "primary" step in the food chain. Animals are secondary, tertiary, etc. producers depending upon their level in the food chain. They make the organic material of their bodies from organic material that they eat.

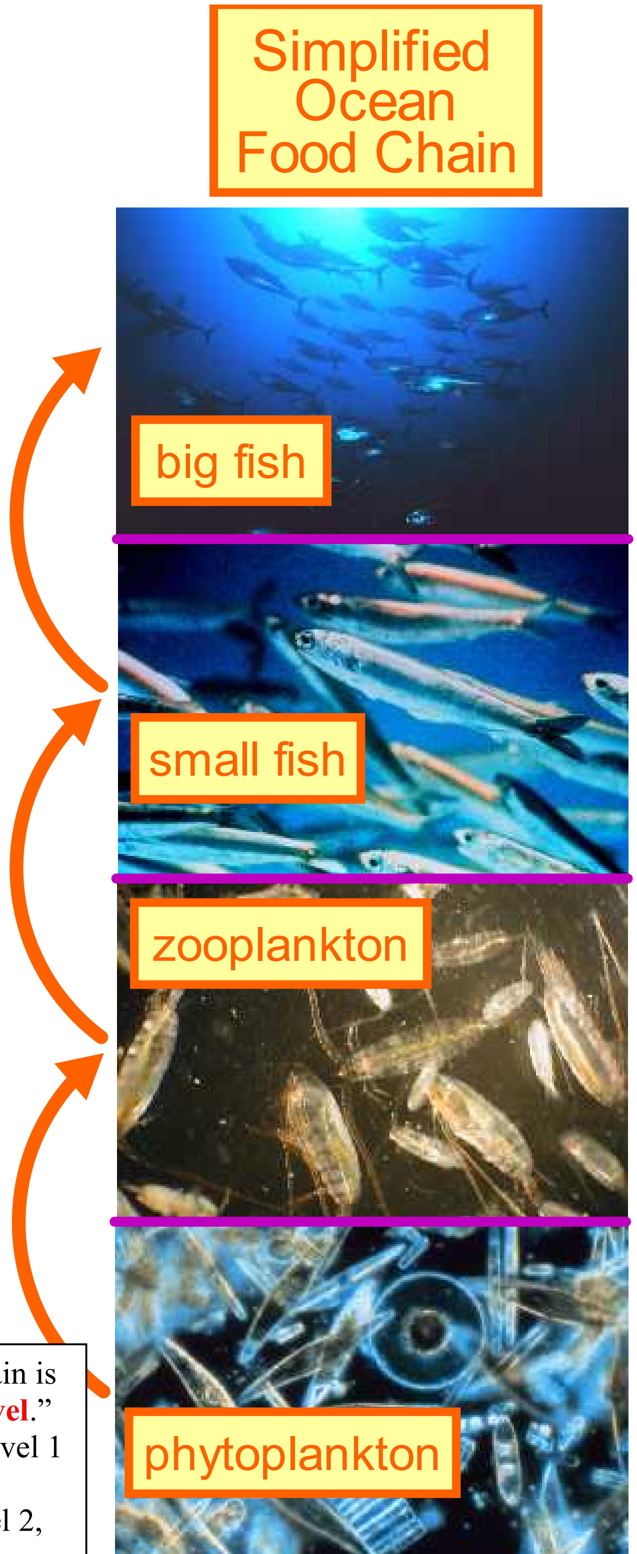
> Think of nutrients as "fertilizing" the phytoplankton. Nutrients are not "food" or "eaten" by phytoplankton. (Phytoplankton make their own food.) As you will observe under the microscope, phytoplankton have no tentacles, arms, or other structures with which to grab the extremely tiny nutrients. Instead they rely upon chance: the nutrients drift into their bodies through the holes in their shells or cell walls.

Why Phytoplankton Are Important

As discussed previously, phytoplankton are at the bottom of the ocean food chain. So, without them, ocean animals would have little food, and there would be fewer fish and other animals for us to catch and eat. Oceanographers can observe where phytoplankton are common in the ocean using satellites (they typically make the water "greener"), and predict where lots of fish and other animals will be found.

As part of photosynthesis, phytoplankton add oxygen to ocean water. A lot of this oxygen leaks from the ocean into the atmosphere. ***At least half of the oxygen that you and I breathe was produced by phytoplankton.*** In addition, phytoplankton remove carbon dioxide from ocean water to carry out photosynthesis and make their shells (e.g., calcium carbonate). Humans have added large amounts of carbon dioxide to the atmosphere by burning fossil fuels like oil and natural gas, increasing it by over 33%. Carbon dioxide is a "greenhouse gas:" it absorbs infrared "light" ("heat") radiated to outer space by the Earth, "trapping it" and thus warming the world. This "greenhouse effect" actually is a good thing, because it keeps our planet from becoming a giant ball of ice. However, by adding so much extra "greenhouse gas" to the atmosphere, humans are likely to have caused the (usually fast) warming over the past century. A large amount of the carbon dioxide that we add to the atmosphere leaks into the ocean where it no longer adds to the greenhouse effect. By removing it from ocean water, phytoplankton create more "space" in the ocean water, allowing the ocean to absorb more carbon dioxide. Most phytoplankton bodies end up being eaten or decomposed and their carbon is released back into the ocean water, but a few become part of the sediments on the bottom of the ocean; this permanently removes the carbon from the ocean-atmosphere system and thus "cleans up" some of our carbon dioxide pollution.

Finally, over vast amounts of time, the phytoplankton bodies in the sediments can become fossil fuels like oil and natural gas. Diatoms in particular are thought to contribute, because they contain a drop of oil in their bodies, a way for them to store food and lower their density so that they can float in the sunlit waters at the surface of the ocean. So, you may be "burning" some phytoplankton when you drive your car. Don't forget to say "thank you."

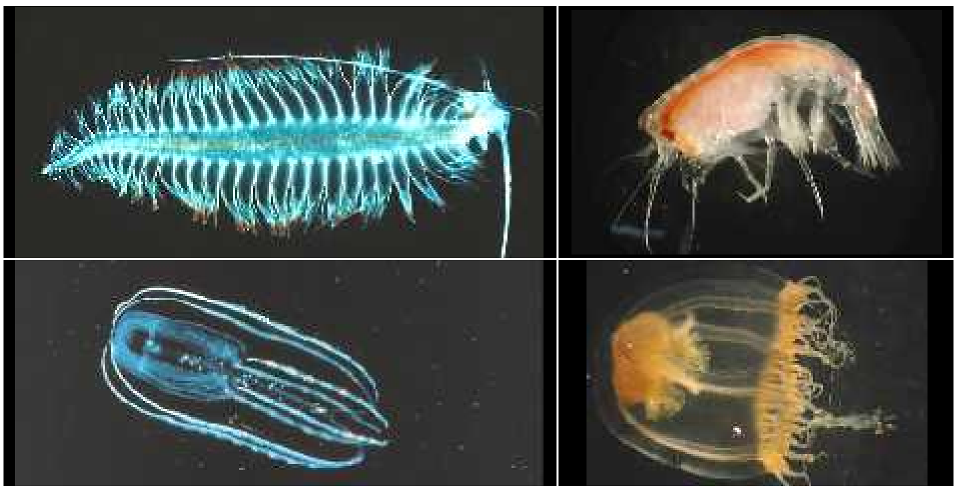


Each step in a food chain is a different "**trophic level**." Phytoplankton are at level 1 (the first step), zooplankton are at level 2, small fish are at level 3, and larger fish are at level 4.

Photographs Courtesy of the National Oceanic and Atmospheric Administration, Department of Commerce

Zooplankton

Zooplankton are animal plankton. (Think about it: if you are going to the "zoo," what are you going to see?) Examples that you might have heard of include jellyfish and krill. A vast number of worms, snails, slugs, crustaceans (like crabs), and many more kinds of animals are zooplankton. Animals carry out the opposite of photosynthesis, a process that we call "respiration." When animals respire ("breathe"), they combine oxygen with food (carbohydrates), which liberates energy from the carbohydrates that they use to fuel their bodies. Respiration also produces the byproducts water and carbon dioxide (which they release back into the environment). Plants and algae also undergo respiration to utilize the food that they make, but they tend to do more photosynthesis than respiration.



Zooplankton. Upper Left: Courtesy of Uwe Kils (CC BY-SA 3.0).
Others: National Atmospheric and Oceanic Administration, Department of Commerce

Copepods are an ***extremely common*** kind of zooplankton in the ocean. They are small, crustaceans (like crabs) who eat the even smaller algae (phytoplankton). For this reason, I like to call them the "cows of the sea" (they eat algae in the ocean like cows eat grass on land). Their "antennules" can detect both water motion and odors (they use them to smell!). "Copepod" literally means "oar feet" in Greek. Presumably they were named this because they have lots of little feet (like shrimp) up and down the sides of the their bodies, like many oars sticking out of an ancient Greek or Roman galley. They are primarily used for eating (grabbing food), not for swimming. Copepods have one "eye," an organ capable detecting light but not much else. It helps them stay near the surface of the ocean where most of their food lives. As you may have already guessed, the character *Sheldon J. Plankton* in the series SpongeBob Squarepants is a copepod.

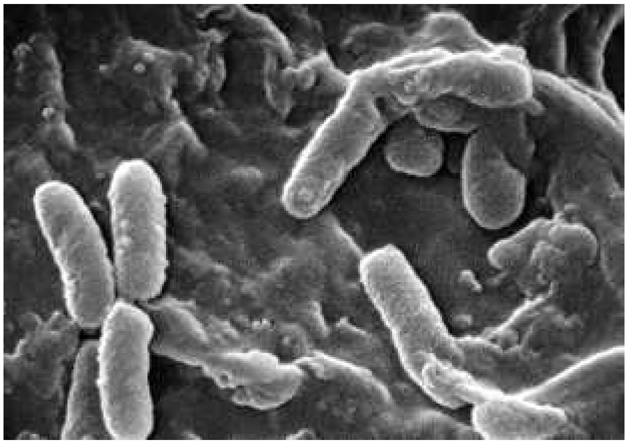
Copepods. National Atmospheric and Oceanic Administration, Department of Commerce

Shells

Both phytoplankton and zooplankton often have shells. Their shells are typically made of ***calcium carbonate*** and ***silica***. Pure calcium carbonate is white (like our bones which are also made of calcium), but silica (which has the same chemical composition as glass) is light-colored as well, so it can be hard to tell them apart just by looking at them. Most large animals (animals that you can see with your eyes, like clams) make their shells out of calcium carbonate. Colors can be added on the surface of the shell to alter its appearance.

Bacteria

Bacteria are small, single-celled organisms[6] (even smaller than phytoplankton). Bacteria use a huge number of chemical processes[7] to extract the energy necessary to sustain their lives from inorganic and organic matter, including dead, decaying material and fecal matter that animals cannot use as food. The bacteria decompose ("break down") dead, decaying material into carbon dioxide and nutrients like phosphates and nitrates, releasing them into ocean water and making them available for phytoplankton to use again. This is important because without bacteria "recycling" nutrients, there would be fewer phytoplankton in the ocean, and therefore fewer animals as well.



Bacteria. Courtesy of Janice Haney Carr, Centers for Disease Control and Prevention

Stop Reading. **This would be a good time try to answer some of the study guide questions (hint: 1, 6-17).**

[6] Bacteria are single-celled organisms that do not have a "nucleus," a structure in the cell which protects its DNA. Instead, bacteria DNA drift within the cell, making it easier for the DNA to become damaged (mutate). This can, of course, be very harmful, but upon occasion the mutation is useful. In essence, bacteria evolve faster than other organisms. For this reason, you should always take ALL of the antibiotics prescribed by your doctor, even if you start feeling better. You need to make sure that you kill ALL of the bacteria. If you only kill most of them, then the survivors – the more resistant ones – will start breeding, helping the species evolve resistance to the antibiotics and making antibiotics less useful in the future.

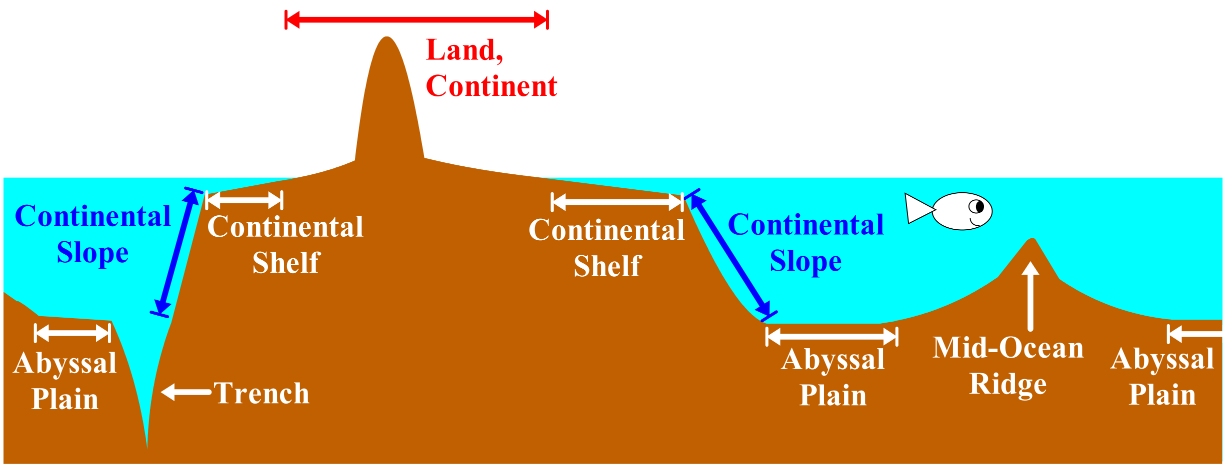
[7] Each species of bacterium specializes in using one chemical process or a few. They have evolved these differences over time.

Size and Shape of the Earth

It somewhat ironic that we call our planet the "Earth," given that about 70%[8] of the surface of the Earth is covered by the ocean. The oceans are also quite deep, about 2.5 miles (4 kilometers), on average.

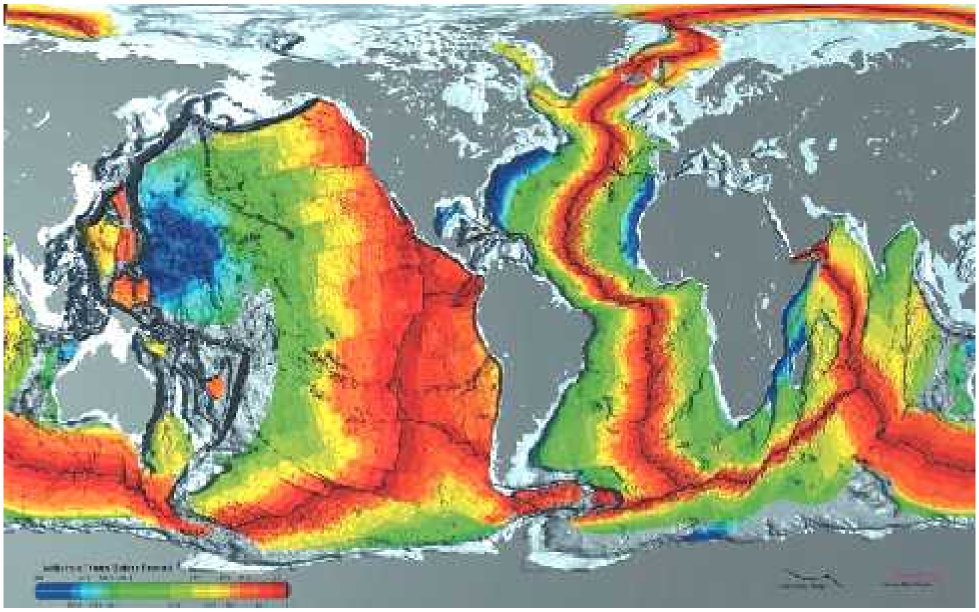
NASA

Most of the ocean bottom is pretty flat. We call the flat parts of the continents that have been covered by water "continental shelves[9]." At the edge of a shelf, the bottom of the ocean plunges downward. We call this region the "continental slope." At the bottom of slope, the ocean meets the abyssal plain[10], the flat bottom of the ocean that covers about 25% of the globe.



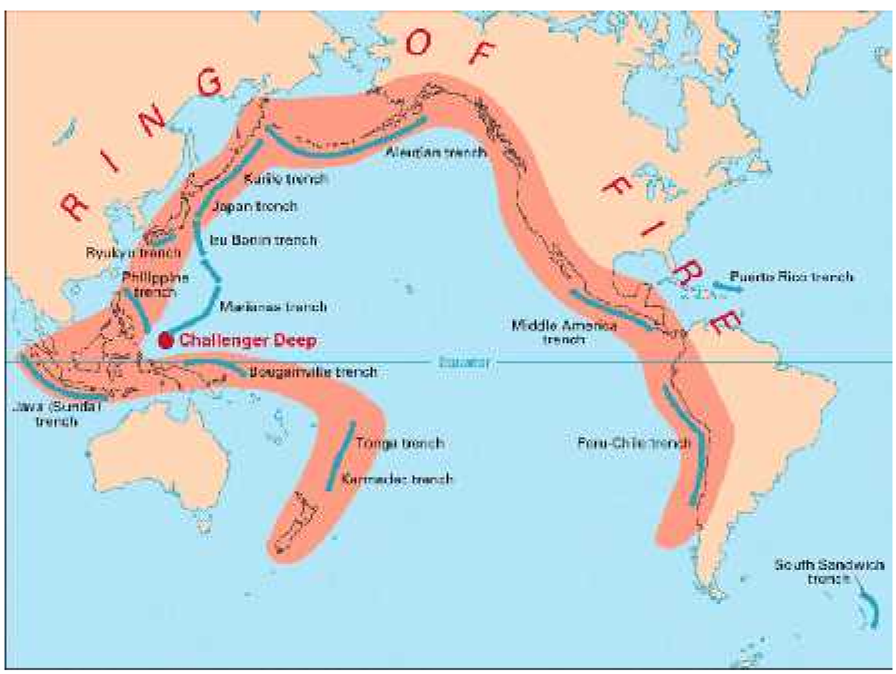
The mid-ocean ridge (MOR) is a chain of underwater volcanoes that runs all the way around the Earth. It rises 1.5 miles above the ocean floor (on average). Since the abyssal plains are about 2.5-miles-deep, the top of the mid-ocean ridge is typically about 1 mile beneath the surface of the ocean. The ridge has a very broad slope, so it also covers a large part of the Earth's surface (about 23%). The ridge is not always in the middle of the ocean, and runs into land in few places. Earthquakes and volcanoes are common along the mid-ocean ridge. I often abbreviate its name, calling it the "MOR." Feel free to use the abbreviation MOR instead of writing "mid-ocean ridge" again and again. In the picture on the next page, the MOR is the thin, dark-red line.

[8] 70.8% to be a bit more precise
[9] A "shelf" is a flat, elevated area (it is elevated high above the bottom of the ocean), like a "book shelf."
[10] "Abyss" means deep and "plains" are, of course, very flat places. "Abyss" is the Greek word from the depths of the Earth where bad people go and which spawns bad things.



The **Mid-Ocean Ridge** is the thin, dark red line in the picture above. National Geophysical Data Center, National Oceanic and Atmospheric Administration, Department of Commerce

The deepest parts of the ocean are the ocean trenches. The deepest trench in the world is the Mariana Trench which is over 6 miles deep. Many people expect the deepest part of the ocean to be in the middle of the ocean, but most ocean trenches are found near land, either near the continents[11] or next to ocean islands. For example, the Mariana Trench is found next to the Mariana Islands. Like the mid-ocean ridge, earthquakes and volcanoes are common near the trenches. The Mariana Islands are volcanoes that grew tall enough to poke above the surface of the ocean. Most of the world's trenches are near the edge of the Pacific Ocean, so volcanoes are common along the edge of the Pacific; this chain of volcanoes is called the "Ring of Fire."



USGS

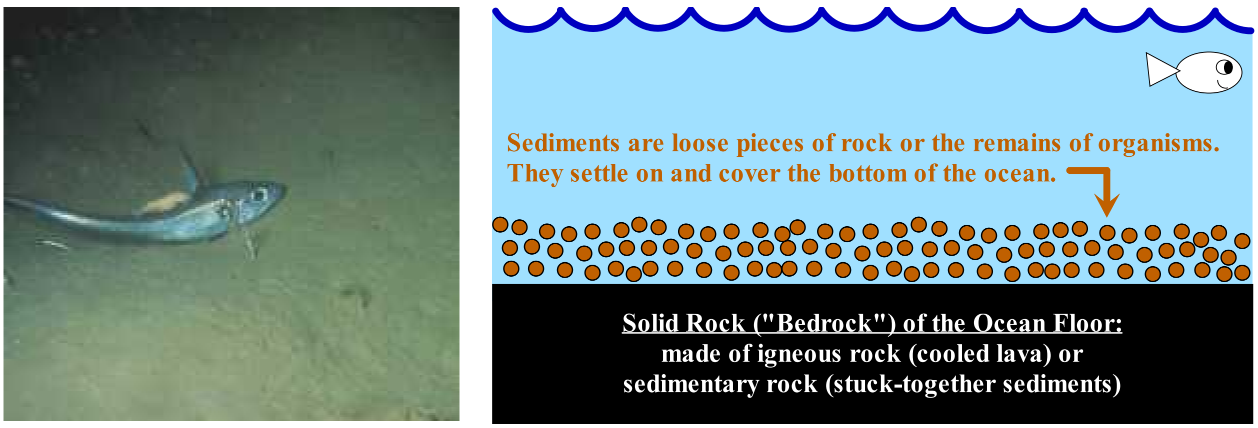
[11] In this case, the continental slope plunges down into the trench, and the abyssal plains are on the other side of the trench.

Sediments

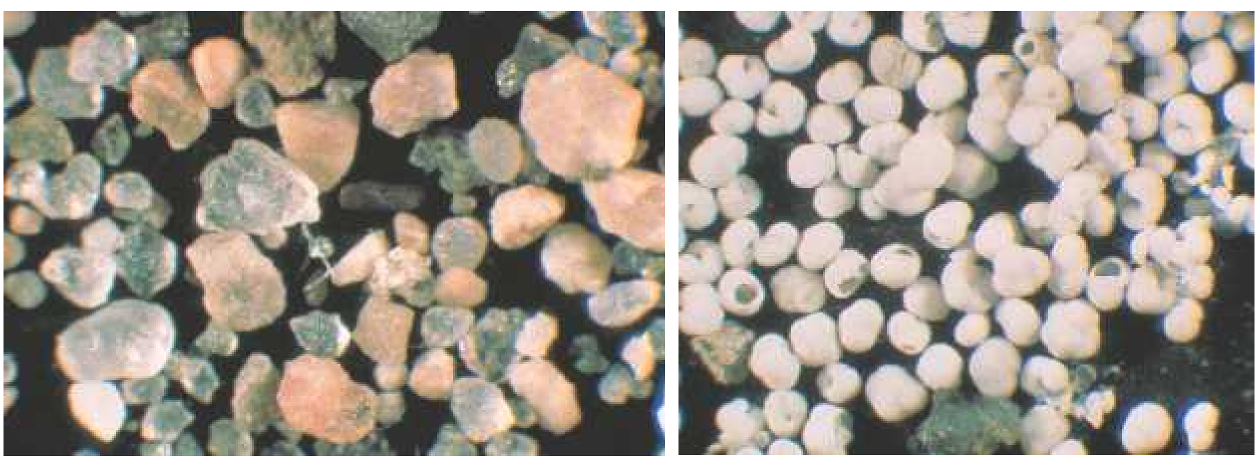
Sediment are pieces or broken parts of various materials that cover the bottom of the ocean. Sand, mud, soil, and dirt are good examples of sediments. The are 2 major kinds of sediments on the ocean floor: broken pieces of rock and the remains of ocean life, especially their shells.

Bits of rock are typically washed off the land and into the ocean by rain, though sediments can also be carried from the land into the ocean by winds. Larger rocks like boulders, cobbles, and even gravel are too large and heavy to be carried out into the ocean, so smaller sediments like sand, clay, and silt tend to cover the bottom of the ocean.

Shells make up most of the remains of ocean life on the sea floor, but fecal matter, mucous, and other body parts are also found in ocean sediments. These kinds of ocean sediments can typically be broken into 2 categories, calcareous sediments (made of calcium carbonate shells) and siliceous sediments (made of silica shells).



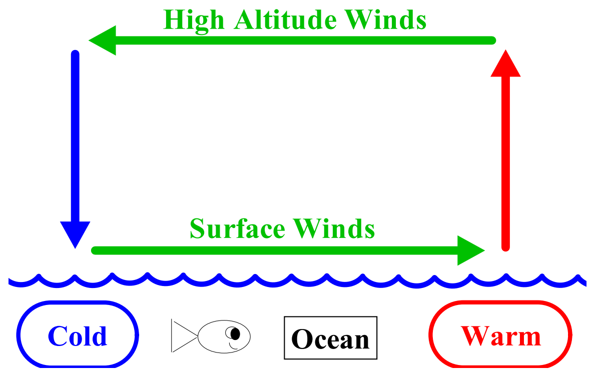
Seafloor Sediments. Above Left: National Oceanic and Atmospheric Administration, Department of Commerce



Sediments Up Close: Bits of Rock (left) and Shells of Forams (right, microscopic animals or "zooplankton").
Anne Jennings, NOAA Paleoclimatology Program, US Department of Commerce

Stop Reading. **This would be a good time try to answer some of the study guide questions (hint: 18-26).**

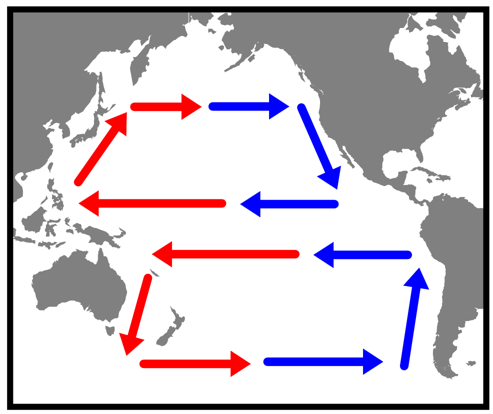
Winds and Ocean Currents



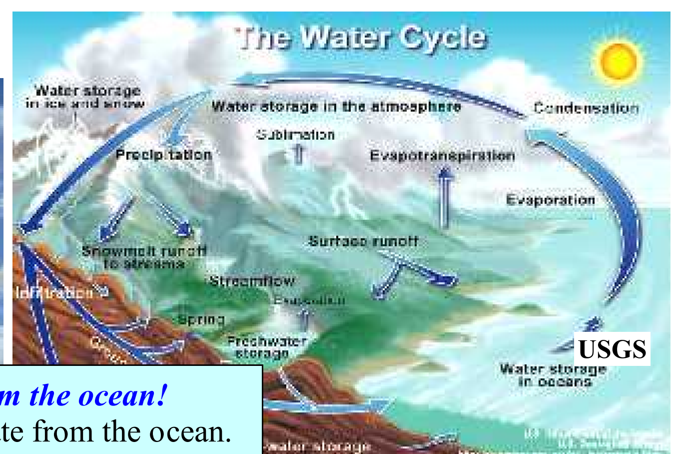
The ocean is constantly in motion because of winds blowing across its surface. The resulting waves stir up the surface of the ocean, helping to bring up nutrients and to keep phytoplankton (algae) from sinking too deep. Winds are powered by the heat of the sun. If one place becomes warmer than another, warmer, lower-density air rises above the warm spot. Cooler, higher-density air sinks over the cold spot, pushing air towards the warm spot to replace the air the rose upwards[12].

"Evaporate" means to "transform from liquid to gas," ***not*** "rise." Please be careful how you use this word!

Winds also create ocean currents. Ocean currents are like rivers in the ocean; they carry water and everything in it (e.g., plankton) from place to place. The largest, most important ocean currents flow in huge loops[13] around the ocean basins. These currents can have a big impact on climate by moving warm water towards the Poles and cold water towards the Equator. For example, warm water evaporates more easily than cold water, so air above warm water is more humid (contains more water vapor). Eventually, the air cannot hold anymore water, and the water falls out of the atmosphere as rain. Thus, places next to warm currents, like the southeast coast of the United States, are more humid and get more rain than places next to cold currents, like southern California (a desert). Ocean currents are also important because they can bring up nutrients to the surface of the ocean, fertilizing the phytoplankton and thus getting the entire ocean food chain started.



Clouds produced by water that evaporated from the warm ocean by Florida.



Most of our drinking water comes from the ocean!
The heat of the Sun causes water to evaporate from the ocean.
If the moist air cools, it will fall as rain.

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[12] This is how the large-scale wind pattern is created. Notice that the air goes all the way around in a continuous loop called a "convection cell," a key concept in the class that will be used to explain much more than winds.

[13] We call these circular currents "gyres." Note that even though gyres and convection cells are both loops, they are completely different concepts. Gyres are pushed by the wind and go in a horizontal loop. The air in the convection cells moves because of its density and goes in a vertical loop.

Humans and the Ocean

<u>Groundwater:</u> There is 40 times more water in the ground than on the surface in lakes and rivers. Nearly 98% of the world's water is in the oceans, though.

In this class, we will look at the impacts that humans have on the oceans. For example, we have wiped out 90% of large fish, and coastal development continues to destroy shallow water environments like wetlands that are breeding grounds for many ocean fish. We also poison the coastal environment with chemicals found in our wastes, which can work their way back up the food chain and harm us when we eat seafood. The nutrients in our wastes[14] (like untreated sewage and material washed down storm drains) can over-fertilize the ocean, causing the growth of disease-causing bacteria and toxic algae which lead to beach closures and shut down fisheries. While this can be a depressing subject, we will also look at possible solutions to these problems and the trade-offs that they involve.

This would be a good time try to answer some of the study guide questions (hint: 3, 5, & 28).

National Oceanic and Atmospheric Administration, Department of Commerce

My opinion is that we can either use the ocean as a <u>waste dump</u> ***or*** for <u>recreation and food</u>. Either one is fine by me, but using it for both is ***gross***.

[14] Most nutrients enter the ocean naturally (are washed off the land), <u>not</u> added by humans.