If you are a student that **HAS** access to technology, this is not the packet for you. This packet is for students who pick up and drop off their work at the front office every week. If you have access to technology, please go back to your teacher's website and complete the correct assignment.

Name: ________________________________ Period: __________ Teacher: ____________

Assignment 7.1 – Buffers

Part I. → What is a Buffer?

Buffers are substances in a solution that stabilize the pH (cause it not to jump too high or too low if an acid or base are added.

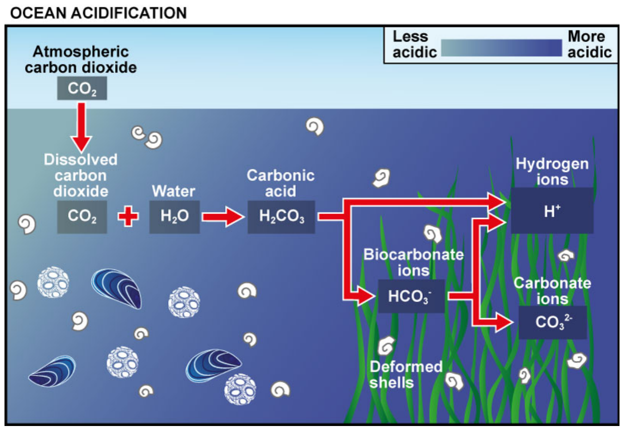
In your body, you have buffers in the plasma of your cells that keep your blood pH right around 7.35-7.45. (If your blood plasma were to change by .2 or .3 pH points it can cause seizures, a coma, or death…thank goodness for your blood buffers!! 😊)

1. Is 7.4 slightly acidic OR basic? ________
2. If you drank orange juice (acid) should the pH of your body go up or down? _____
3. If you brushed your teeth with baking soda toothpaste (base) should the pH of your body go up or down?______

Part II. → Buffers in the Ocean

The pH of the ocean is, on average 8.1. It is stabilized around the pH by buffers.
Sand, containing calcium carbonate, falls into the ocean. The carbonate ion acts a buffer to keep the pH stable.

1. Naturally, we (and animals) breathe out what gas? ______________
2. When carbon dioxide joins with water in the ocean it makes H_2CO_3, carbonic acid. Would that make the ocean pH go up OR down? ________
3. The carbonic acid ionizes to make a hydrogen ion and a bicarbonate ion. Working together, the carbonate (from sand) and the bicarbonate (from carbon dioxide) keep the ocean pH stable by acting as a ___________.
4. However, consider the industrial revolution…over the last century, the ocean has been absorbing way more carbon dioxide than normal so the number of hydrogen ions is up by 25%!!!! What do you think that is doing to the pH of our oceans? ______________ (Hint: Remember, more H^+=acid and more OH^-=base)



An ocean pH that is too high OR too low has devastating effects in our oceans!

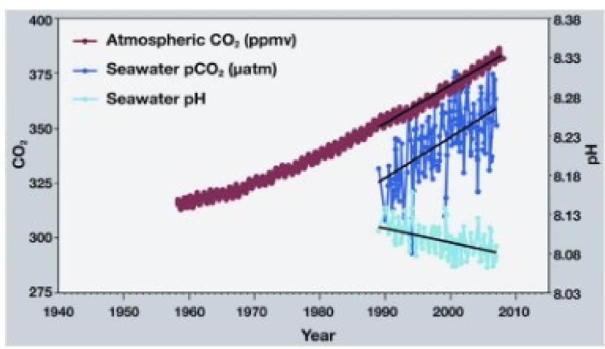
Buffers = keep ocean 😊

Too much carbon dioxide without extra sand to make buffers with carbonate = low pH = bad things start to happen in ocean ☹

Assignment 7.2 – Ocean Acidification

Part I. → Data: pH of our oceans

Scientists began recording the pH of our oceans about 60 years ago. Here is a graph of data off the coast of Hawaii:



1. Since 1960, what is happening to the carbon dioxide in the air? ________
2. What is happening to the carbon dioxide in the ocean water? _________
3. What is happening to the pH of the ocean? _______
4. How much has the pH dropped since 1990? _______
   (A pH drop of .1 may not seem like much but the pH scale is similar to a logarithmic earthquake Richter scale. If pH of 8.1 drops to 7.1…that is 10x more acidic!!!)

Part II. → Effects of extra H+ on marine life

- Some crustaceans, corals, and fish use the calcium and carbonate dissolved in the ocean to make their shells and skeletons.

- However, with extra hydrogen ions in the water when the ocean gets acidic, the hydrogen ions bond to the carbonate ions to make bicarbonate and then the **marine animals can't use it.** ☹

→ Use the following excerpts from ***'IMPACTS ON OCEAN LIFE'*** in the NOAA Ocean Acidification Website to **Answer these questions:**

1. Coral Reefs:

Branching corals, because of their more fragile structure, struggle to live in acidified waters around natural carbon dioxide seeps, a model for a more acidic future ocean. *(Laetitia Plaisance)*

Reef-building corals craft their own homes from calcium carbonate, **forming complex reefs** that house the coral animals themselves and provide habitat for many other organisms. Acidification may **limit coral growth** by corroding pre-existing coral skeletons while simultaneously slowing the growth of new ones, and the weaker reefs that result will be more vulnerable to erosion. This erosion will come not only from storm waves, but also from **animals that drill into** or eat coral. **A recent study** predicts that by roughly 2080 ocean conditions will be so acidic that even otherwise healthy coral reefs will be eroding more quickly than they can rebuild.

Acidification may also impact corals before they even begin constructing their homes. The eggs and larvae of only a few coral species have been studied, and more acidic water **didn't hurt their development** while they were still in the plankton. However, larvae in acidic water had more **trouble finding a good place to settle**, preventing them from reaching adulthood.

How much trouble corals run into will vary by species. Some types of coral can **use bicarbonate** instead of carbonate ions to build their skeletons, which gives them more options in an acidifying ocean. Some can survive without a skeleton and **return to normal skeleton-building activities** once the water returns to a more comfortable pH. Others can handle a wider pH range.

Nonetheless, in the next century we will see the common types of coral found in reefs shifting—though we can't be entirely certain what that change will look like. **On reefs in Papua New Guinea** that are affected by natural carbon dioxide seeps, big boulder colonies have taken over and the delicately branching forms have disappeared, probably because their thin branches are more susceptible to dissolving. This change is also likely to affect the many thousands of organisms that live among the coral, including those that people fish and eat, in unpredictable ways. In addition, acidification gets piled on top of all the other stresses that reefs have been suffering from, such as warming water (which causes another threat to reefs known as **coral bleaching**), pollution, and overfishing.

   a. What does ocean acidity do to coral skeletons?

   b. How does ocean acidity affect coral larvae eggs?

   c. If corals begin to die, what affect will that have on people?

2. Oysters, Muscles, Urchins, and Starfish:

Generally, shelled animals—including mussels, clams, urchins and starfish—are going to **have trouble building their shells** in more acidic water, just like the corals. Mussels and oysters are expected to grow less shell by 25 percent and 10 percent respectively by the end of the century. Urchins and starfish aren't as well studied, but they **build their shell-like parts from high-magnesium calcite**, a type of calcium carbonate that dissolves even more quickly than the aragonite form of calcium carbonate that corals use. This means a weaker shell for these organisms, increasing the chance of being crushed or eaten.

Some of the major impacts on these organisms go beyond adult shell-building, however. Mussels' byssal threads, with which they famously cling to rocks in the pounding surf, **can't hold on as well** in acidic water. Meanwhile, oyster larvae fail to even begin growing their shells. In their first 48 hours of life, oyster larvae **undergo a massive growth spurt**, building their shells quickly so they can start feeding. But the more acidic seawater eats away at their shells before they can form; this has **already caused massive oyster die-offs** in the U.S. Pacific Northwest.

This massive failure isn't universal, however: studies have found that crustaceans (such as lobsters, crabs, and shrimp) **grow even stronger shells** under higher acidity. This may be because their shells are constructed differently. Additionally, some species may have already adapted to higher acidity or have the ability to do so, **such as purple sea urchins**. (Although a new study found that **larval urchins have trouble digesting** their food under raised acidity.)

Of course, the loss of these organisms would have much larger effects in the food chain, as they are food and habitat for many other animals.

a. In acidic water, shelled organisms will have trouble building their _______________.

b. How does this affect muscle ability to hang on to rocks?

c. How does this affect oyster larvae shell development?

d. Name 2 shelled organisms that are doing well despite more acidic waters:
1. 2.

3. Zooplankton:

There are two major types of zooplankton (tiny drifting animals) that build shells made of calcium carbonate: **foraminifera** and **pteropods**. They may be small, but they are big players in the food webs of the ocean, as almost all larger life eats zooplankton or other animals that eat zooplankton. They are also critical to the **carbon cycle**—how carbon (as carbon dioxide and calcium carbonate) moves between air, land and sea. Oceans contain the greatest amount of actively cycled carbon in the world and are also very important in storing carbon. When shelled zooplankton (as well as shelled phytoplankton) die and sink to the seafloor, they carry their calcium carbonate shells with them, which are deposited as rock or sediment and stored for the foreseeable future. This is an important way that carbon dioxide is removed from the atmosphere, slowing the rise in temperature caused by the **greenhouse effect**.

These tiny organisms reproduce so quickly that they may be able to adapt to acidity better than large, slow-reproducing animals. However, experiments in the lab and at carbon dioxide seeps (where pH is naturally low) have found that foraminifera do not handle higher acidity very well, as their shells dissolve rapidly. One study even predicts that foraminifera from tropical areas **will be extinct by the end of the century**.

The shells of pteropods are **already dissolving in the Southern Ocean**, where more acidic water from the deep sea rises to the surface, hastening the effects of acidification caused by human-derived carbon dioxide. Like corals, these sea snails are particularly susceptible because their shells are made of aragonite, a delicate form of calcium carbonate that is 50 percent more soluble in seawater.

One big unknown is whether acidification will affect **jellyfish** populations. In this case, the fear is that they will survive unharmed. Jellyfish compete with fish and other predators for food—mainly smaller zooplankton—and they also eat young fish themselves. If jellyfish thrive under warm and more acidic conditions while most other organisms suffer, it's possible that **jellies will dominate some ecosystems** (a problem already seen in parts of the ocean).

a. What are the 2 types of zooplankton that make their shells out of calcium carbonate? 1. 2.

b. What happens when zooplankton die?

c. How do zooplankton dying impact the greenhouse effect?

d. What happens to the shells of zooplankton in more acidic waters?

e. What possible affect will zooplankton dying have on jellyfish populations?

4. Plants and Algae:

Plants and many algae may thrive under acidic conditions. These organisms make their energy from combining sunlight and carbon dioxide—so more carbon dioxide in the water doesn't hurt them, but helps.

Seagrasses form shallow-water ecosystems along coasts that serve as nurseries for many larger fish, and can be home to thousands of different organisms. Under more acidic lab conditions, they were able to reproduce better, grow taller, and grow deeper roots—all good things. However, they are in decline for a number of other reasons—especially pollution flowing into coastal seawater—and it's unlikely that this boost from acidification will compensate entirely for losses caused by these other stresses.

Some species of algae grow better under more acidic conditions with the boost in carbon dioxide. But **coralline algae**, which build calcium carbonate skeletons and help cement coral reefs, do not fare so well. Most coralline algae species build shells from the high-magnesium calcite form of calcium carbonate, which is more soluble than the aragonite or regular calcite forms. **One study** found that, in acidifying conditions, coralline algae covered 92 percent less area, making space for other types of non-calcifying algae, **which can smother and damage coral reefs**. This is doubly bad because many coral larvae prefer to settle onto coralline algae when they are ready to leave the plankton stage and start life on a coral reef.

One major group of phytoplankton (single celled algae that float and grow in surface waters), the **coccolithophores**, grows shells. Early studies found that, like other shelled animals, their shells weakened, making them susceptible to damage. But **a longer-term study** let a common coccolithophore (*Emiliania huxleyi*) reproduce for 700 generations, taking about 12 full months, in the warmer and more acidic conditions expected to become reality in 100 years. The population was able to adapt, growing strong shells. It could be that they just needed more time to adapt, or that adaptation varies species by species or even population by population.

a. Sea grasses are growing better because of ________________________ but are being harmed by _____________________.
b. Corraline algae do not do well in more acidic ocean water. If they die off and are replaced by non-calcifying algae, why is that bad for corals?

c. In order for species to adapt to changes in the ocean…what is the most important factor that's needed? ________

5. Fish:

While fish don't have shells, they will still feel the effects of acidification. Because the surrounding water has a lower pH, a fish's cells often come into balance with the seawater by taking in carbonic acid. This changes the pH of the fish's blood, a condition called acidosis.

Although the fish is then in harmony with its environment, many of the chemical reactions that take place in its body can be altered. Just a small change in pH can make a huge difference in survival. In humans, for instance, a drop in blood pH of 0.2-0.3 can cause seizures, comas, and even death. Likewise, a fish is also sensitive to pH and has to put its body into overdrive to bring its chemistry back to normal. To do so, it will burn extra energy to excrete the excess acid out of its blood through its gills, kidneys and intestines. It might not seem like this would use a lot of energy, but even a slight increase reduces the energy a fish has to take care of other tasks, such as digesting food, swimming rapidly to escape predators or catch food, and reproducing. It can also slow fishes growth.

Even slightly more acidic water may also affects fishes' minds. While clownfish can normally hear and avoid noisy predators, in more acidic water, they **do not flee threatening noise**. Clownfish also stray farther from home and **have trouble "smelling" their way back**. This may happen because acidification, which changes the pH of a fish's body and brain, could alter how the brain processes information. Additionally, cobia (a kind of popular game fish) **grow larger otoliths**—small ear bones that affect hearing and balance—in more acidic water, which could affect their ability to navigate and avoid prey. While there is still a lot to learn, these findings suggest that we may see unpredictable changes in animal behavior under acidification.

The ability to adapt to higher acidity will vary from fish species to fish species, and what qualities will help or hurt a given fish species is unknown. A shift in dominant fish species could have major impacts on the food web and on human fisheries.

a. What are 4 affects lower pH (which creates acidosis) can have on fish:
   1.
   2.
   3.
   4.

b. How do acidic ocean waters affect clownfish ability to hear noise?

   What about clownfish ability to “smell” their way home?