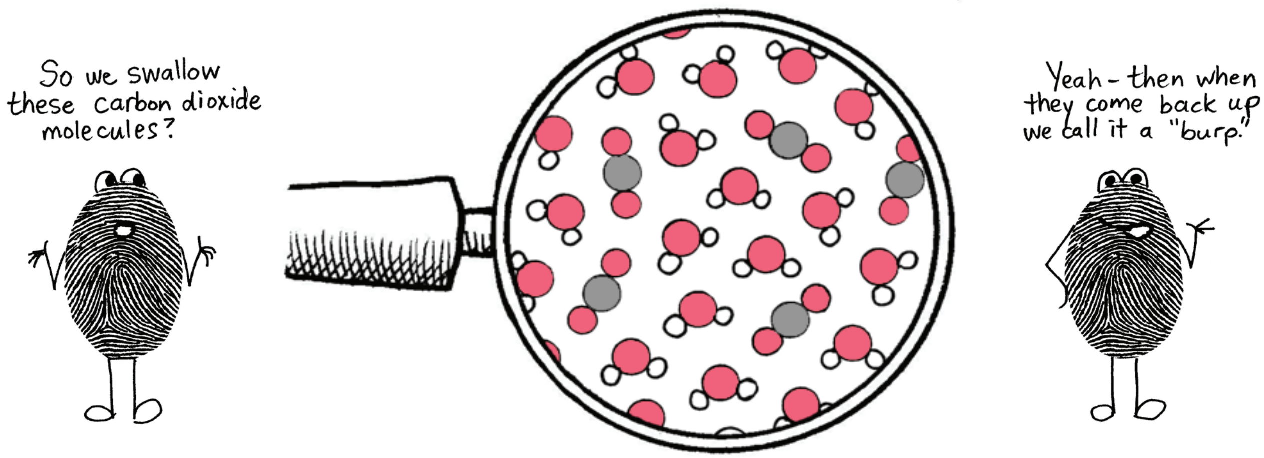
2: Your Beverages Arrive

The waiters have brought your beverages. They have provided milk and a carbonated drink. You may have a special name for carbonated beverages, such as “soda,” or “pop” or “coke.” You can imagine this to be whatever kind you like. (If you don’t drink carbonated beverages in real life, just play along and pretend you do. It’s just an excuse to study more chemistry.)

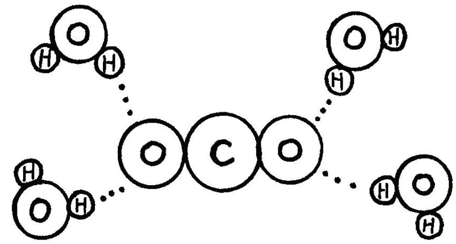
Let’s look at the carbonated beverage first. Don’t drink it yet—we need to dissect it first!

Most of a carbonated beverage is water. But there are a number of substances ***dissolved*** into the water. Do you remember how salt and sugar dissolved into water? The pull of the water molecules overcame the attraction that the molecules had for each other. The molecules of the **solute** (the salt or sugar) were equally dispersed among the water molecules. In this carbonated beverage we’ll see that gases can also be dissolved into liquids.



You can see the red and white water molecules, easily recongizable by their Mickey Mouse ears. (No sticks between the atoms here, just to save space.) But what are those other molecules—the ones that look like water molecules that have been straightened out? Those are ***carbon dioxide*** molecules, made of one carbon atom attached to two oxygen atoms. You probably know that carbon dioxide is one of the gases that you breathe out when you exhale. There is a certain amount of carbon dioxide that floats around in the air all the time. Plants take in carbon dioxide and use it for photosynthesis. You may also know that some chemical reactions, such as combustion, produce carbon dioxide. It seems strange, though, to think of carbon dioxide, a gas, being dissolved into water in the same way that salt and sugar are. Yet that is exactly what happens. (It’s even weirder to think of carbon dioxide, a gas, freezing and turning into a solid. That’s what “dry ice” is.)

The carbon dioxide molecule is somewhat ***polar*** (though you will find it in lists of nonpolar molecules because its straight line geometry makes it electrically symmetric, not lopsided). The oxygen atoms are slightly heavier than the carbon atom, and therefore they can get away with being bullies and demanding to have the electrons. The electrons end up spending more time going around the oxygens than they do the carbon. Since electrons carry a negative charge, the ends of this molecule (the oxygens) become more negative. These negative ends are attracted to the positive parts of the water molecules. The dotted lines represent this attraction, which, as you will remember, is called ***hydrogen bonding***.



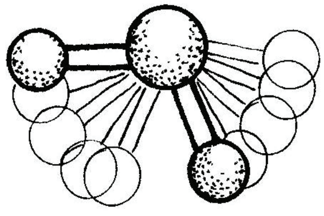
Carbon dioxide (CO_2) molecules can be dissolved into water the same way that sugar or salt can. CO_2 is the ***solute*** and water is the ***solvent***. Here's an interesting question: can you mix and match states of matter (solid, liquid, gas) to form solutions? For example, could you dissolve a liquid into a solid? Or a liquid into a liquid? Or a solid into a gas? Oddly enough, yes, you can form a solution with just about any of these. Here are some examples of solutes dissolved into solvents.

A **gas** dissolved into a **gas**: Air, but a mixture of gases isn't called a solution. It's called a ***mixture***.
A **gas** dissolved into a **liquid**: Carbonated beverages; nitrogen into blood during deep scuba dives (dangerous!)
A **gas** dissolved into a **solid**: Hydrogen can dissolve into metals, believe it or not!

A **liquid** dissolved into a **gas**: Fog
A **liquid** dissolved into a **liquid**: Vinegar (acetic acid, water); windshield washer fluid (alcohol, water)
A **liquid** dissolved into a **solid**: Gelatin; mercury dissolved into gold (the mercury seems to be solid)

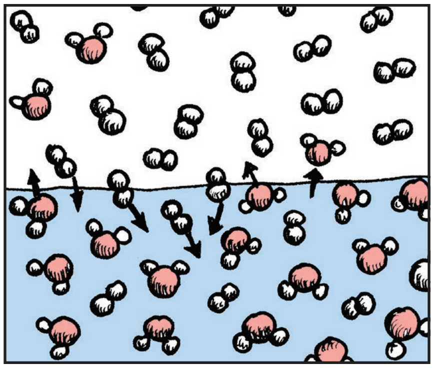
A **solid** dissolved into a **gas**: Smoke
A **solid** dissolved into a l**iquid**: Sugar water; salt water
A **solid** dissolved into a **solid**: Bronze (copper and tin); steel (carbon and iron)

Returning to our carbonated beverage, how is it possible to make a gas dissolve into a liquid? Well, to begin with, gases will do this on their own to some extent. For example, the water found in lakes, rivers and oceans has some oxygen. Fish and other aquatic animals "breathe" this dissolved oxygen. The way oxygen gets into the water is based on the fact that molecules are in constant motion. The bonds between the atoms in a molecule are constantly stretching and pulling and shaking, so you've got internal vibration going on. Also, the entire molecule is in motion, bumping and banging into other molecules. Molecular motion corresponds to how much "heat" a substance has. The molecules in hot substances are moving very fast. The molecules in cold objects are moving very slowly. If we cool something down to -273° C, motion stops completely. (This is called absolulte zero.)



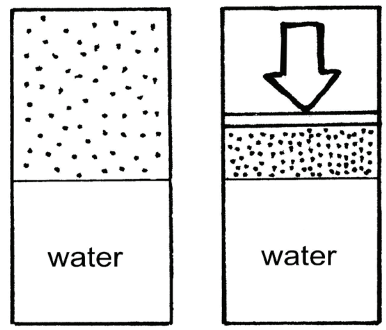
One molecule vibrating

Many molecules bumping and crashing



Oxygen molecules (O_2) are constantly going in and out of the water.

As oxygen molecules crash into the water molecules at the surface, some of them dive right in and vibrate their way down among all the vibrating water molecules. The opposite happens, too. Some water molecules move from the water to the air. Oxygen atoms in the water might go back into the air and, if conditions are right, water might move from the air back into the water. If you adjust the temperature and pressure you can control how many of each type of molecule will go in or out of the water. The faster water molecules vibrate, the more likely they are to take off and go into the air. For instance, if you turn up the heat under a pot of water on a stove, the water molecules will move faster and faster until many of them begin escaping as steam.



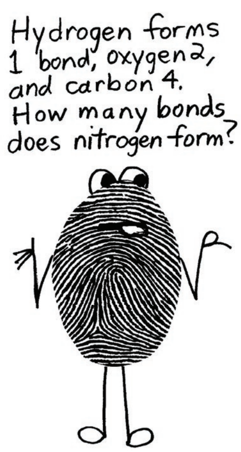
Regular water has dissolved gases in it, but it is certainly not fizzy like carbonated beverages. We need to pump lots and lots of gas molecules into water to get it to fizz. We must force those gas molecules to go in and stay there for as long as possible. One way to do this is to use pressure. If you squeeze the air above the water (using a machine a bit like a bicycle tire pump) you can force many more gas molecules down into the water. But this still might not be enough. You may also have to increase the amount of surface area (those places where the gas can touch water molecules) by creating lots of bubbles, like a water bubbler in a fish tank. But what if this still wasn't enough?

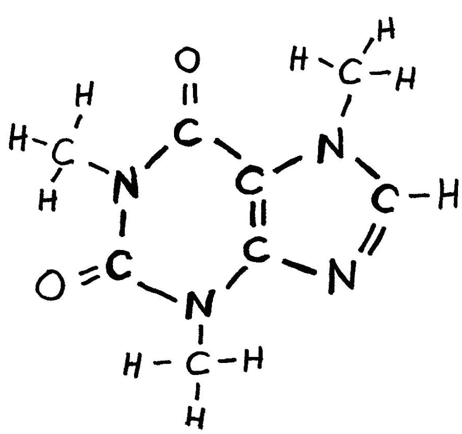
The last thing you can do to get more gas molecules into the water is to turn down the temperature. Cold water can hold more gas than hot water can. Why? Because heat is the same thing as molecular motion. The faster the molecules move, the more heat they have. The less they move, the less heat they have. So which molecules are moving faster—molecules of ice or molecules of liquid water? Liquid water, because it is warmer than the ice, and therefore its molecules are moving faster. Motion is heat. Heat is motion. More motion, more heat. Less motion, less heat.

So if we chill the water we are trying to carbonate, we will slow down the vibration of its molecules. And the slower the water molecules are going, the less they will bump into the carbon dioxide gas molecules. And the less the CO_2 bubbles are bumped, the more likely they are to stay in the water. (This is the reason that carbonated beverages go "flat" faster if they sit at room temperature than if they are kept in the refrigerator.)

What else is in a carbonated beverage, besides carbon dioxide bubbles? If you read the label, you will see that sugar, or some kind of sweetener, is a major ingredient. We'll assume that the beverage on your table has sucrose in it, which you have already dissected.

Some carbonated beverages have caffeine in them, especially colas. This is what a molecule of caffeine looks like. Caffeine is known for its ability to keep you from feeling sleepy. Food companies must think that their customers will enjoy that "wide awake" feeling and therefore want to purchase those beverages again.

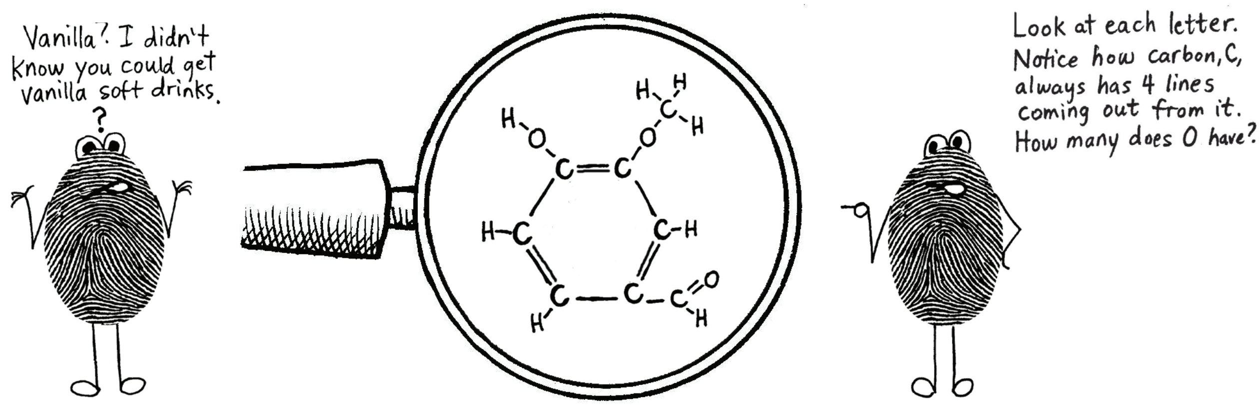




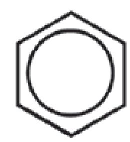
Caffeine has two rings: one pentagon and one hexagon. They might remind you of fructose and glucose. A big difference is that those rings include ***nitrogen*** atoms (N). Nitrogen molecules (as N_2) make up about 80% of the air we breathe. So what are they doing in a caffeine molecule? Just like carbon and oxygen, nitrogen is a common atom that you find in all kinds of things. Sometimes it's in a gas, and other times it's in a liquid or solid.

Caffeine is a natural substance produced by certain types of plants, especially tea and coffee plants. Plants don't need to stay awake, so why do plants make caffeine, then? For a plant, caffeine is a pesticide (a poison that paralyzes or kills certain types of insects). Fortunately, caffeine doesn't have the same effect on humans that it does on very small bugs!

What else is in carbonated beverages, besides water, fizz, sweetener and sometimes caffeine? We wouldn't want to drink them if they didn't have an enjoyable taste. Can we find any flavor molecules?



What have we got here? Looks like we've found some ***vanillin***, a common artificial vanilla flavoring used in many snacks and desserts. It must be a glass of "cream soda." (That's the name for a vanilla-flavored soft drink.) Vanillin has a hexagonal ring made of 6 of carbons, with some additional carbons, hydrogens and oxygens attached to it. This hexagonal carbon ring shows up all the time in chemistry. Six carbons joined together in a hexagon shape (with a hydrogen attached to each carbon) is called a ***benzene ring***. Many molecules have one or more (modified) benzene rings as part of their structure. Not all flavors have this ring; many have short strings of carbon, instead.

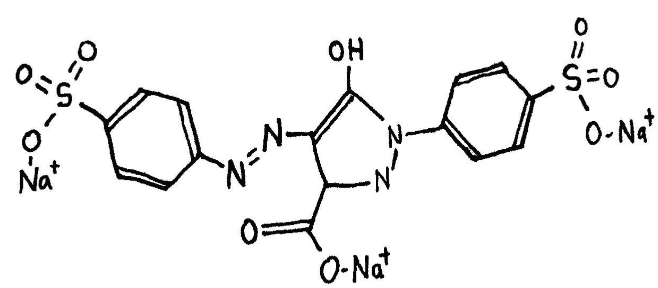


Benzene rings are sometimes drawn like this. Chemists know there are carbons at the corners and 6 invisible hydrogens.

Why does this molecule taste like vanilla? Technically, it doesn't. Most of what we think of as taste is actually smell. There are only five "tastes" that the tongue can sense: sweet, sour, bitter, salty and savory. If you've tasted vanilla flavor right out of the bottle, you know that it can't be described by one of these words. Sensing flavor is a job for the nose, not the tongue. Tiny molecules of the vanillin get up into your nose and tingle receptor sites on cells inside your nose. That's why you can't taste very well when you hold your nose; taste is mostly smell. The shape of a molecule determines which receptors it can tingle. Those tingled cells send electrical impulses to the part of your brain that interprets smells. So once again, we find that **the shape of a molecule is critical to its function**.

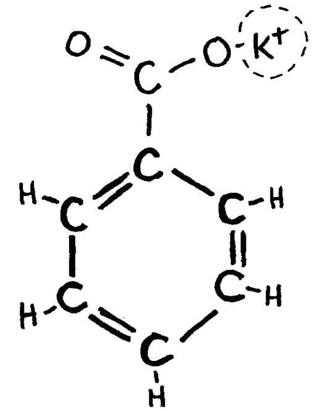
Your carbonated beverage might also have food coloring in it. Most consumers think clear liquids are boring. They are more likely to drink something bright orange or red or yellow. Most food coloring found in carbonated beverages is artificial, meaning scientists made the molecules in a lab. This doesn't mean they are poisonous, though. All colorings used in food products have been tested thoroughly to make sure they are safe. Like any food or drink, there will always be people who have allergic reactions, or sensitivities, to them.

If you want to go natural and use color that comes from plants such as beets or carrots, the color molecules will look just as complicated.

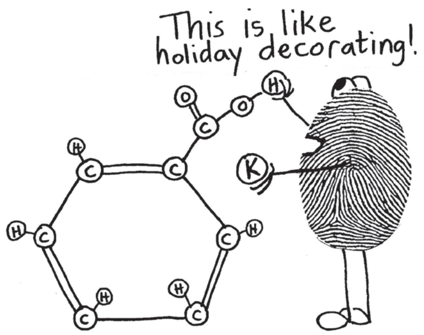


This is "Yellow #5." Other options you can legally use are Yellow #6, Reds #3 and #40, Blues #1 and #2, and Green #3. That's it. Want orange? Mix yellow with one of the reds. Purple? Mix a blue and a red. Black? Use a lot of blue with some added red, yellow and green.

Some beverages also have ***preservatives*** that discourage bacteria, molds and yeasts from living in the drink. A common preservative is ***potassium benzoate***. ***Potassium*** (symbol "K") is another type of element, and can be found on the Periodic Table at number 19. The most significant fact to know about potassium is that it has only one place it can bond, just like hydrogen. In this molecule, the potassium is hanging out with one of the oxygens.



The "benzo" part of the name comes from the hexagonal ring, which can be turned into a benzene ring if the chemistry of the solution is just right. A benzene ring by itself, with no extra atoms stuck to it is a fairly dangerous molecule named ***benzene***. Benzene is suspected to be a ***carcinogen***—a substance that causes cancer. As long as the ring in this molecule keeps those extra atoms attached to it (a carbon, two oxygens and a potassium) it's considered to be harmless to humans. If you're a microorganism, however, you are in big trouble. When put into a liquid such as fruit juice or soda, potassium benzoate drops its potassium ion and picks up a hydrogen instead, turning itself into ***benzoic acid.*** The benzoic acid goes into the cells of the microorganisms and prevents them from being able to digest sugar. Basically, the little critters starve to death while being surrounded by sugar!



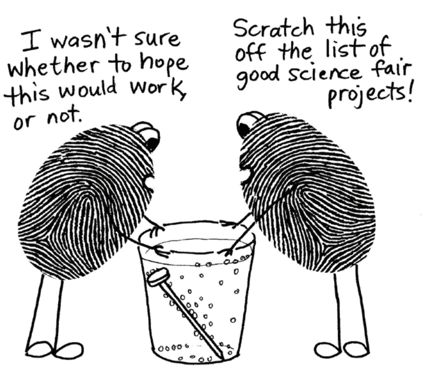
Benzoic acid doesn't affect humans the way it affects microorganisms, but there is a small potential danger to humans. If benzoic acid comes into contact with vitamin C, the vitamin C molecule strips off those extra atoms at the top (C, O and O), and thus turns benzoic acid into a benzene ring. However, the total amount of benzene formed inside a beverage can is very, very small. You get a much bigger dose of benzene by breathing the air in a big city, or by smelling gasoline fumes as you are pumping gas into your car. You'd have to drink five gallons of a carbonated beverage every day to get even close to the amount of benzene you get from other sources.

The US Food and Drug Administration runs tests on beverage products to determine if they contain unacceptable levels of benzene. Companies that produce these products are warned that they must find a way to reduce the levels down to what the FDA considers safe. In 2008, the Coca-cola® company announced that they were going to stop using benzoates in all their soft drinks except Fanta®, Dr. Pepper® and Coca-cola Zero®.

The use of preservatives is controversial, but seems to be a "necessary evil." We prefer not to have harmful substances in our drinks, but we don't want to find bacteria or mold growing in them, either. Modern food delivery systems usually require that food be able to sit in storage for a certain amount of time. Food companies get into much bigger trouble if microorganisms are found in their products than they do if they use preservatives. Of course, some products can be preserved just by keeping them cold, but this requires a lot of energy. For some products, the added energy costs would make them too expensive for the consumer.

When we talked about potassium benzoate turning into benzoic acid, we used the word "acid" without explaining it. We could do this because you are probably already familiar with the word ***acid***. You know that lemon juice and unripe apples are acidic. The acid in these fruits is what gives them their sour taste. But did you know that many carbonated beverages are just as acidic as lemons, even if they taste sweet? We already mentioned benzoic acid, but you meet other acids in carbonated beverages, too. The most common one is ***phosphoric acid***. Its name comes from the element ***phosphorus*** (P), number 15 on the Periodic Table.

Before we launch into a chemistry lesson about acids, let's ponder this question: Why do food companies put acids into carbonated beverages, anyway? They are supposed to taste sweet, not sour. Actually, there is a bit of sour "tang" to them, even if you don't notice it. Consumers prefer drinks that are sweet yet still acidic enough to make their salivary glands tingle. The acid in these beverages isn't enough to bother people who don't particularly like sour tastes, because there is so much added sugar that it covers the tartness. There is also a chemical reason to add acid to carbonated beverages: preservatives like potassium benzoate work more efficiently in an acidic environment. If you're adding potassium benzoate to natural fruit juice, the fruit provides the acid. But artificially flavored beverages need to have acid added to them in order for the preservatives to work.



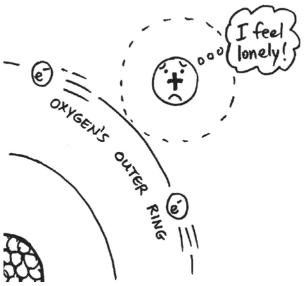
Phosphoric acid in carbonated beverages is just as controversial as potassium benzoate (or its "sister" molecule, sodium benzoate). Some people love to quote the fact that phosphoric acid can be used to remove rust from metal. One Internet rumor says that cola drinks will dissolve a nail in 4 days. That'll scare you from ever drinking a cola again, eh? (It turns out to be a false claim, of course. If you want to see the results of an experiment where someone actually tried this, you can go to: **http://joshmadison.com/2003/12/14/will-coke-dissolve-a-nail-experiment/**) Pure phosphoric acid in large amounts might be able to dissolve rust or soften a nail, but the amount that is in carbonated beverages is so low that these Internet claims are ridiculous.

Phosphoric acid has also been accused of causing children to have weak bones and cavities in their teeth. They say that the phosphorus atoms are able to grab calcium atoms out of the digestive system and blood, so that they don't get delivered to the bones and teeth that need them. It is true that phosphorus atoms can grab calcium atoms, but to what degree? Enough to harm you? Studies have been done to test whether consumption of carbonated beverages (especially colas) affects bone health. Some studies claim to have found a definite link between cola consumption and reduced bone density. Other studies claim there is no link at all. How are we to know which study is right?

All researchers agree, however, that people should not drink carbonated beverages all the time. The high sugar content provides plenty of food for the bacteria that live in our mouths, and the acids in the drinks make the environment of the mouth just right for them to multiply. Even natural fruit juices can be a problem if you sip on them all day. To get rid of this extra sugar and acid, brush your teeth as often as you can.

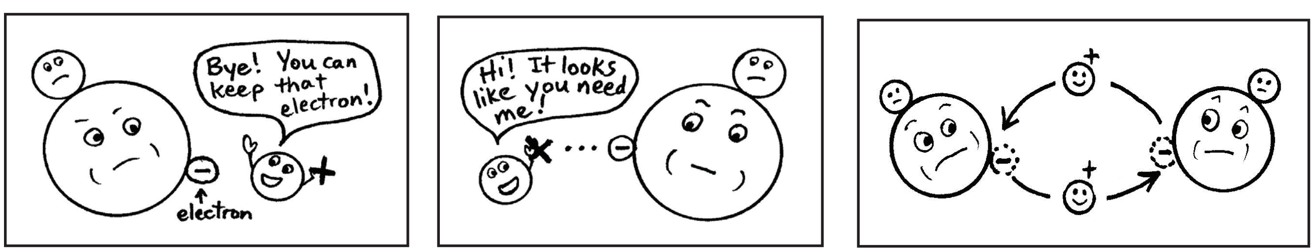
Now it's time to find out exactly what an acid is. To do this, we'll start by looking at water again.

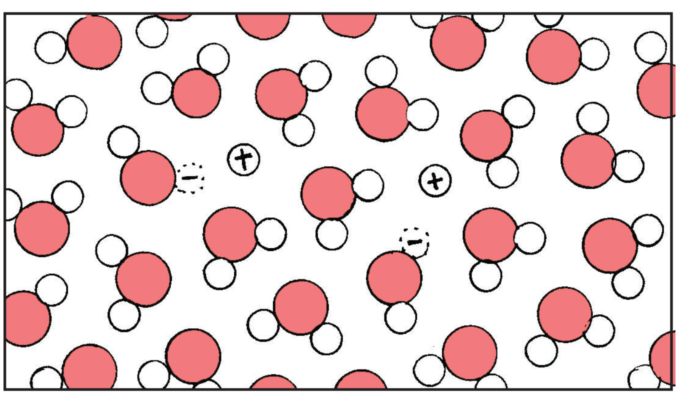
You'll remember that water molecules are made of two hydrogen atoms attached to an oxygen atom. Well, it turns out that those hydrogen atoms are not very faithful to their water molecules. They sometimes go wandering off, leaving H_2O as OH^-.



It is important to notice that once a hydrogen atom's single electron goes off to join the electrons in the oxygen atom, the hydrogen atom is reduced to being nothing but a proton. Just one proton! Can that proton still be called a hydrogen atom? Not really. We'll need to start calling it a ***hydrogen ion***. An ion is atom that has become electrically unbalanced. In this case, the imbalance is plain to see, as there is just one proton with a positive charge, and no electron to balance it. Since a hydrogen ion is nothing but a proton, we can use either word and they mean the same thing. "HYDROGEN ION" = "PROTON" (This is a very useful thing to know when studying chemistry. Many students do not realize that these words are interchangeable.)

And so it happens that once in a while the lonely hydrogen ion will leave its water molecule and go off to seek its fortune elsewhere. Before long, it runs into a sad water molecule that is limping along with only one "ear." Off to the rescue it goes, and sticks itself to this disadvantaged water molecule, restoring it to H_2O. Hmm... wonder why that water molecule was missing a hydrogen? Could it be because one of *its* hydrogens got unhappy and left? Yes, hydrogens are that stupid. They keep leaving their old water molecules to join new ones even though their new molecules are identical to their old ones. The hydrogens apparently don't understand the concept that the grass really isn't greener on the other side of the fence.

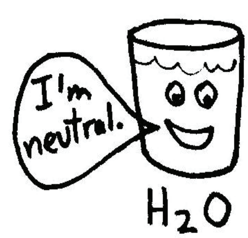




Imagine those hydrogen ions zooming around, pointlessly trading places with each other, when—SNAP! We take a picture. We have a split second of time frozen in a "photograph." Most of the water molecules are intact. But we've caught a few hydrogens mid-switch.

As you can see in this diagram, the hydrogen atom's electron stays with the oxygen atom. That little circle with the minus sign in it represents the electron that was left behind. These "broken" water molecules are no longer H_2O. They are now called ***hydroxide ions***, and are written like this: OH^-. So in this picture we have lots of regular water molecules, H_2O, two hydrogen ions, H^+, and two hydroxide ions, OH^-.

In normal water, the number of hydrogen ions, H^+, always equals the number of hydroxide ions, OH^-. The ions are leaving molecules and joining molecules at about the same rate. So overall, water is electrically balanced. The positive and negative charges sort of cancel out.



What would happen if we added extra protons to regular water? It would certainly upset the balance of positive and negative ions. Is it possible to add extra protons? What about adding extra hydroxide ions?

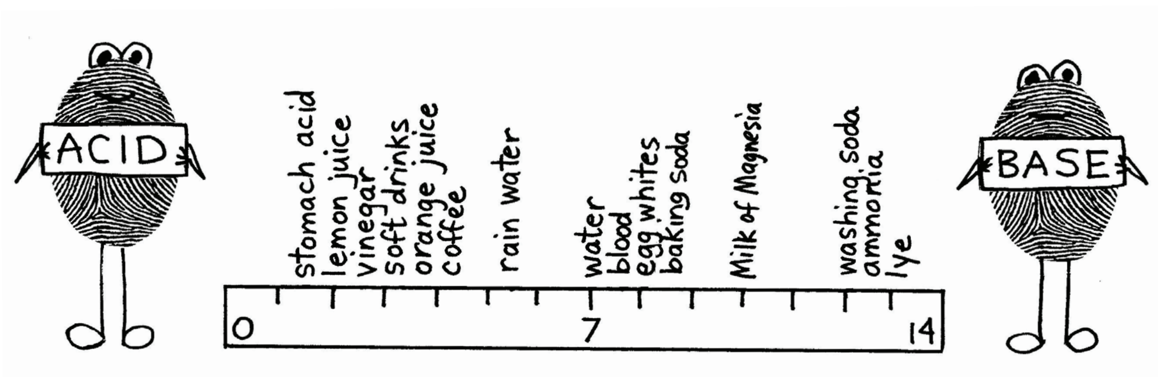
There are certain substances that release H^+ ions (protons) when they are dissolved in water. For example, if you put hydrochloric acid, HCl, into water, the ions H^+ and Cl^- would separate. The Cl^-s would quickly be surrounded by water molecules, as we saw in the salt water. The H^+s would be your source of extra protons.

A substance that can release OH^- ions is sodium hydroxide, NaOH. ("Na" is the symbol for sodium. It used to be called "natrium.") When NaOH is put into water, you get Na^+s surrounded by water cages and loose OH^- ions all over the place.

An increase in either the number of hydrogen (H^+) ions or hydroxide (OH^-) ions in a solution affects the chemistry of the solution, so this imbalance is important for chemists to measure. They use a scale called the ***pH scale***. The letters ***pH*** are most often interpreted as being an abbreviation for "**p**otential **H**ydrogen" because if a hydrogen ion (a proton) gets just one electron, it becomes an actual hydrogen atom again. That's why the H is capitalized; "H" is the symbol for the element hydrogen.

The pH scale runs from 0 to 14. The middle of the scale, 7, is defined as ***neutral.*** Numbers below 7 are ***acids***. The lower the number, the more acidic the solution is. Substances that have a pH value greater than 7 are called ***bases***. And, just to confuse you, bases have an alternate name, too: ***alkaline*** substances. You'll find these words used interchangeably in chemistry texts. One minute they'll be talking about bases and the next minute they'll be talking about how alkaline something is. These terms mean the same thing. Alkaline substances release hydroxide ions (OH^-), the counterparts (or "opposites") to the hydrogen ions (H^+).

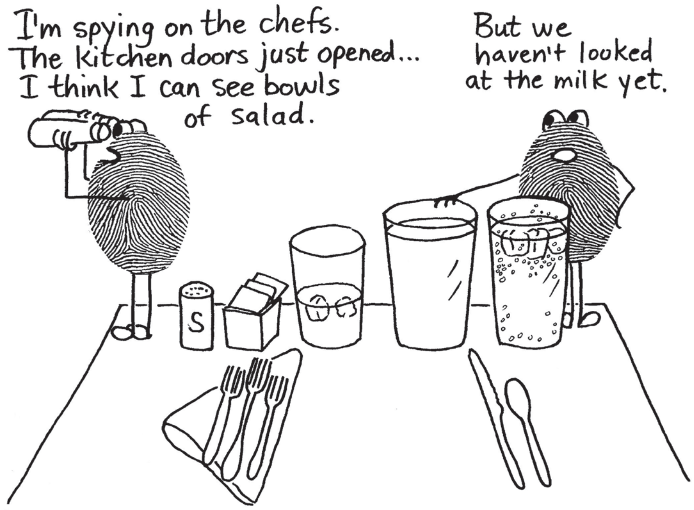
Here are the pH values of some common household substances.



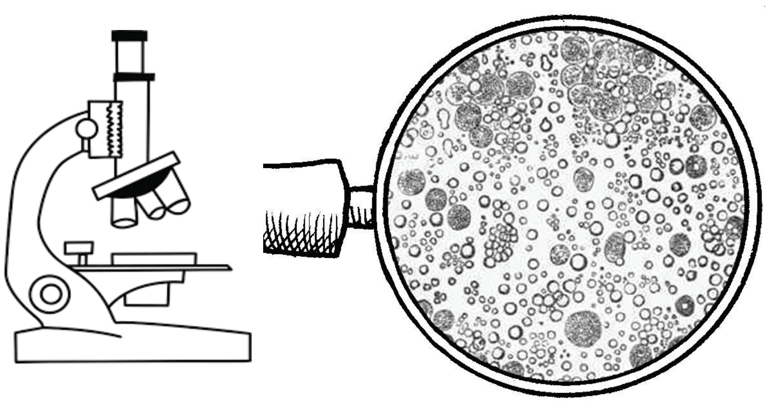
Here's a thought: If acidic substances have lots of hydrogen ions (H^+) and alkaline substances (bases) have lots of hydroxide ions (OH^-), what would happen if you mixed them together? Would all the hydrogen ions decide to attach to hydroxide ions? Yes, that's exactly what happens! And what do a hydrogen ion and a hydroxide ion make when they join together? A normal water molecule. If you put an acid and a base together, the hydrogen ions and hydroxide ions will ***neutralize*** each other, producing water molecules. Also, in the midst of this reaction, the other pieces of the molecules join together to form a salt compound. Table salt is only one kind of salt, just like table sugar is only one kind of sugar. There's a big family of related compounds that are all called salts. ***When you mix and acid and a base, you get water and a "salt***."

Many of us have mixed vinegar (an acid) with baking soda (a base) and witnessed the intense bubbling effect (carbon dioxide being given off). But most of us have never thought about the other product that is produced, a "salt" called ***sodium acetate***. You don't normally see this salt because it stays dissolved in the solution. However, if you boil the solution (after all the excitement of the bubbles is over!) to get rid of excess water, you will be left with a solution so rich in sodium acetate that it will begin to form crystals. If you pour out the solution quickly, it will appear to be "freezing" into crystals within seconds. Because the sodium acetate crystals look similar to ice, and because this reaction releases a lot of heat energy, this experiment is often called the "hot ice" experiment.

If acids and bases make salts, is there an acid/base combo that can make table salt, NaCl? Yes, but making NaCl requires chemicals that are not edible, HCl and NaOH, so it's beyond the scope of kitchen chemistry.



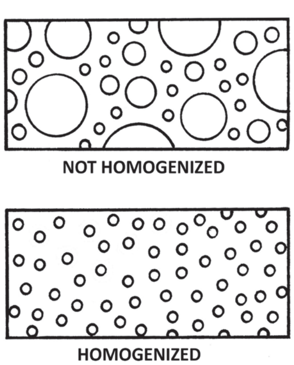
Let's take a look at your glass of milk before your salad arrives. We'll set our viewer's magnification on "regular microscope." If you could look at milk through a microscope in a biology lab, this is what you would see.



Those little round balls are blobs of fat. They're really small, about the size of a bacteria. And speaking of bacteria, if your milk had not been ***pasteurized*** (heated) at the dairy it came from, you would have seen bacteria floating amidst the fat blobs. Dairies that sell milk to the general public are required to heat the milk to a certain temperature for a certain amount of time, so that all bacteria will be killed. Pasteurization does a very good job of killing bad bacteria and keeping milk safe to drink. However, it also kills good bacteria, too. Most bacteria are harmless to people, and there even are species of bacteria that you can't live without. Your intestines are filled with "good" bacteria.

It's bacterial warfare all the time in your digestive system as the "good" bacteria try to keep the "bad" ones out. For customers who want these good bacteria in their milk, dairies often sell a type of milk that has had some of the good bacteria put back into it. The most well-known of these good bacteria is ***Lactobacillus***. *(lack-to-ba-SILL-us)* The "lacto" on the front of the word means "milk." If you see a dairy product with a label that says, "Contains live cultures," that usually means it has *Lactobacillus* in it. (The most common kind of *Lactobacillus* found in milk is called *Lactobacillus acidophilus*.)

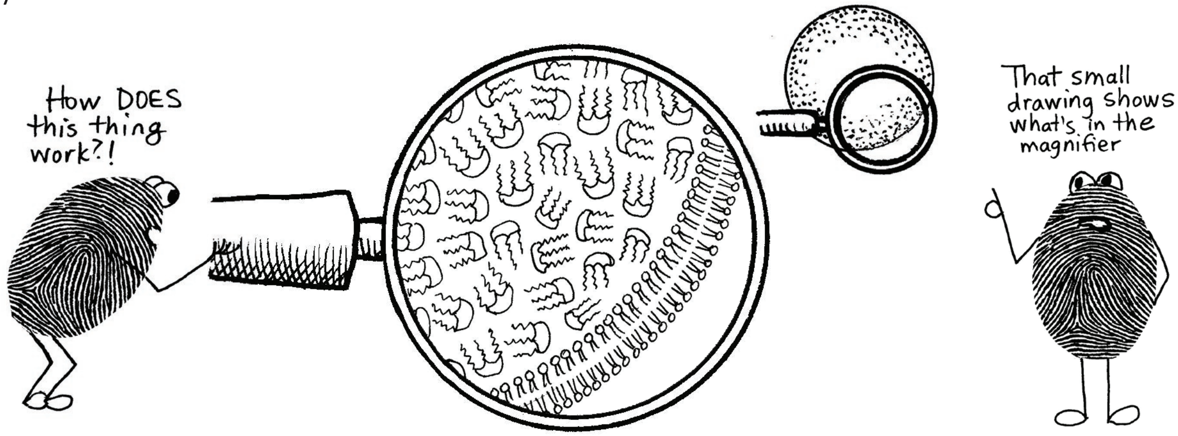
Lactobacillus acidophilus



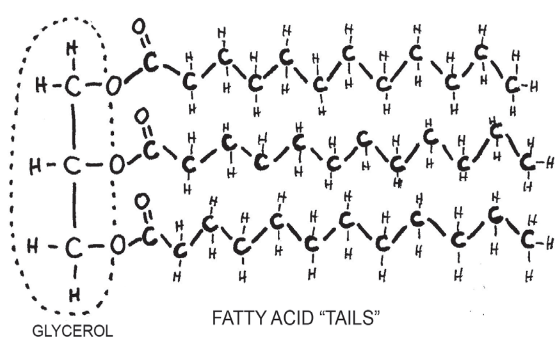
In addition to pasteurization, milk is usually ***homogenized*** *(hom-odge-en-ized)*. "Homo" means "same" and "gen" means "to make" so in homogenization you are making something the same. If you look at milk that just came out of a cow ("raw" milk) you'll find that the fat blobs are not all the same size. If the milk sits for a while, the larger fat blobs rise to the surface because fat is less dense than water. The fat blobs that collect at the top are known as cream. Farmers who drink raw milk just give their milk jug a good shake to mix the cream back into the milk before they pour it into their glass. However, most consumers don't want to do this. So the dairy presses the milk through a screen with very small holes in order to break the fat blobs into very tiny blobs that are too small to float to the surface. So in homogenization, fat blobs are made to be the same size.

Another process can take some of the fat out of the milk, creating low-fat varieties of milk, such as 2%, 1%, or skim (no fat) milk. Some dairy scientists claim that "raw" (unprocessed) milk is better for your health, but others say store milk is just fine. If milk is not pasteurized, the dairy has to be very careful to monitor the number of microorganisms in it. Rarely, people do get sick from drinking raw milk.

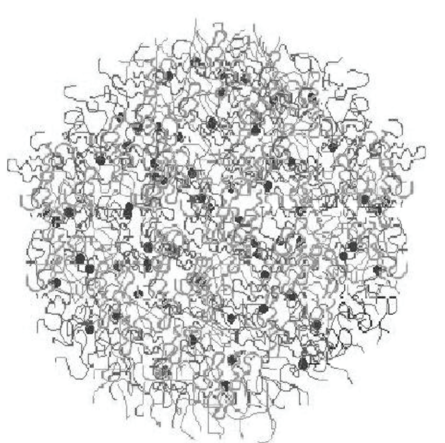
Let's take a closer look at one of those balls of fat. We'll have to switch to our super close-up view where you can see atoms and molecules.



We are looking at just one part of a fat blob so that we can zoom in enough to be able to see its molecular structure. The outer layer, or "shell," of the ball is a very thin membrane, the same kind of membrane that surrounds each cell in your body. The membrane was made by the cells inside the cow's mammary glands. It's only two molecules thick. Those things that look like balls with two tails are the membrane molecules. Inside the membrane are thousands of fat molecules that look like jellyfish with three tentacles.



Let's zoom in on one fat molecule. This type of fat molecule is called a ***triglyceride*** *(tri-GLISS-er-ide)*. The prefix "tri" means "three." The ending "glyceride" refers to that 3-carbon structure inside the dotted line, ***glycerol*** *(GLISS-er-ol)*. Glycerol is like a handle that holds on to three very long molecules called ***fatty acids***. The "fatty" part of the name comes from the long chains of carbon atoms. All forms or fat and grease are made of long chains of carbon atoms that have hydrogens attached to them. Since the word "acid" is also part of the name, this must mean that they are capable of donating hydrogen ions. It's not obvious from this picture where the hydrogens would come from. Before these tails were attached to the glycerol, there was a hydrogen stuck to the oxygen that is now sitting on the dotted line. That hydrogen comes off as the tail attaches to the glycerol.



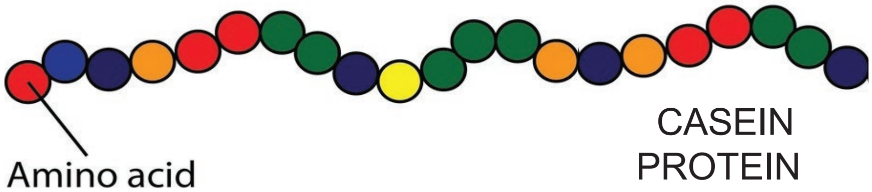
*Little clumps are called **micelles**. This word is used for other types of clumps, too.*

Let's keep going and see what else is in this milk. There are smaller blobs floating around. Let's zoom in on one of them.

There's no membrane around this ball. It looks like a clump of spaghetti and meatballs. The "meatballs" are made of a mineral called ***calcium phosphate***. You've probably been told that milk has lots of calcium in it. This is where the calcium is located—it's found in these "mineral meatballs." Milk is a good source of phosphorus, not just calcium. During our discussion of the phosphoric acid in colas, you may have gotten the impression that phosphorus is bad for you. Phosphorus is actually an essential mineral that your body can't live without. Not only is it a main ingredient in bones and teeth, it is also an important part of the ATP molecule that provides energy to all your cells. Here, we see phosphorus working with calcium to keep these protein strands together.

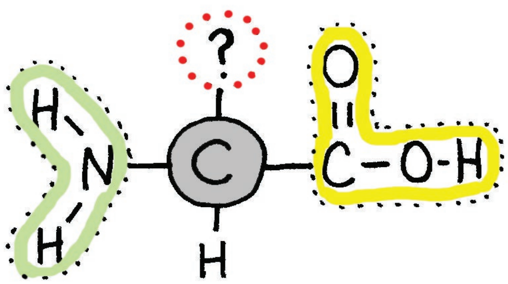
Let's zoom in closer on the "spaghetti noodles."

The "noodles" of the micelle aren't noodles, of course! They are long strings of protein called ***casein*** *(kay-seen)*. People have been extracting casein protein from milk since ancient times. They didn't know the molecular structure of the proteins, but they knew how to get them out of the milk and use them for paint and glue. Casein paint was commonly used until the 1960s when acrylic paint was invented. Milk glue was in general use until World War II. Also, casein proteins are the basis for many cheeses. (The word "casein" comes from the Greek word for cheese.) Casein has even been used to make a hard "plastic."



Casein paint was used for centuries.

If we zoom in to look at the casein, it might at first look like long strings of beads. Each bead is called an ***amino acid.*** Amino acids are the individual pieces that make ***proteins*** like casein. You are already familiar with the word protein. You probably have been told you should eat meat or eggs or beans because they contain protein. Your digestive system tears apart the protein chains until they are single units called amino acids. The digested amino acids will be used by your cells to build and maintain body parts.

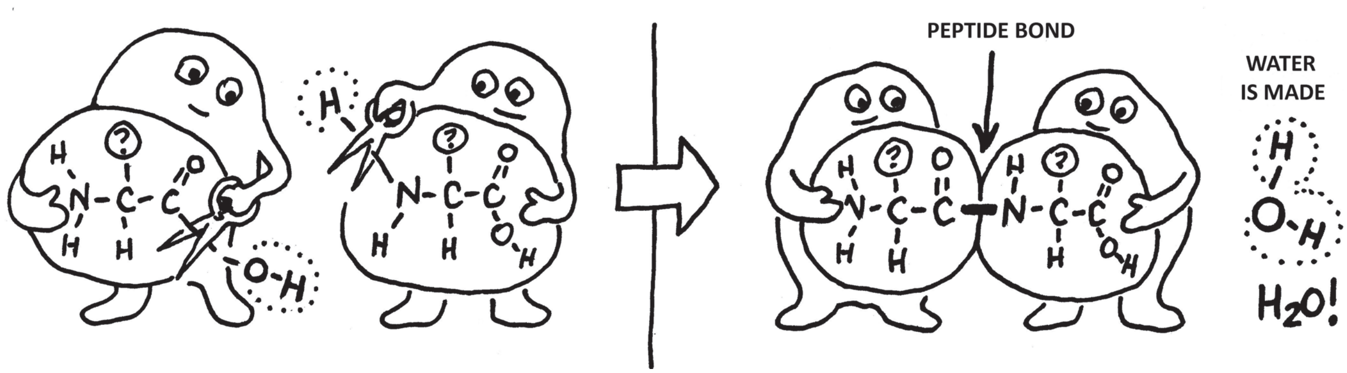


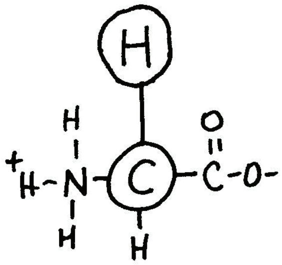
Let's use the highest power on our zoom lens and take a look at one amino acid. Since the word "acid" is in its name, we should expect to find at least one hydrogen, H, that will be able to leave the molecule in the form of a proton.

Amino acids have a carbon atom at their center. This is called the ***alpha carbon***. ("Alpha" is Greek for "A.") Imagine that the alpha carbon has four arms. The lines that represent arms are the bonds that it is making. The alpha carbon's bottom "arm" is attached to one hydrogen atom. The top arm is attached to a "wild card" that could be any one of 20 different molecules. Chemists use the letter "R" instead of our nice question mark. The R stands for "residue," but it is easier to think of it as the Rest of the molecule. More about the R in a minute. Let's look at the alpha carbon's left and right arms.

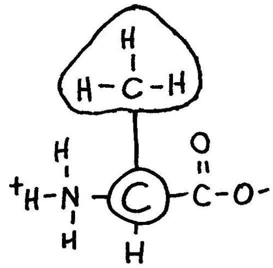
The alpha carbon's left arm is attached to a COOH. Notice the H on the end. It is sitting next to an electron-hogging oxygen atom. The oxygen atom has a strong pull on the hydrogen's only electron. From the hydrogen's point of view, its electron spends far too much time going around the oxygen atom, so the hydrogen is liable to take off and leave its electron behind. When you have hydrogen ions (protons) taking off and roaming around, then by definition, you've got an acid. The NH_2 side of the molecule (the part circled in green) is called the "amine" group. So now we know why they are called "amino acids." The "amino" is NH_2 and the "acid" is the COOH.

Amino acids are not that acidic, though. They can't be put onto the pH scale like vinegar or lemon juice. The H on the end disappears when amino acids hook together to make a chain. The bond between amino acids is called a ***peptide bond***. To make this bond, you chop an OH off on side and an H off another, producing an H_2O.

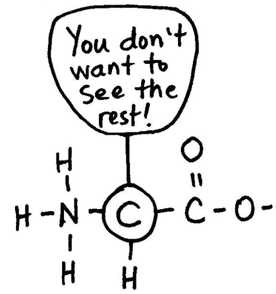




glycine



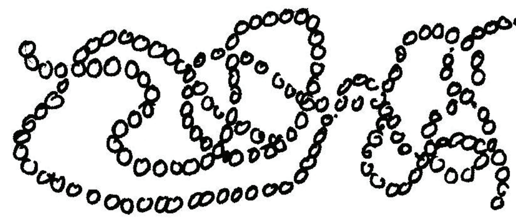
alanine



Now just a little bit of info about that "wild card" (?) at the top...

The alpha carbon (the one in the circle) will have one of 20 possible groups of atoms stuck onto that top arm. The simplest possibility is to stick a hydrogen on the end. When it does this, it forms an amino acid called ***glycine*** *(glie-seen).* Glycine is the smallest amino acid and is very useful for building things in tight spaces. It is a primary ingredient in collagen, which is found in connective tissue like ligaments and tendons, but it is also abundant in skin and bone. Collagen is like a protein "rope" that is wrapped very tightly, and glycine, because it is small, helps to get the wrap tight. If a carbon and three hydrogens are attached to the top arm, the amino acid ***alanine*** is formed. If a sulfur is added to that group, ***cysteine*** *(sis-teen)* is formed. The remaining 17 possibilities are much more complicated, but they are all based on a unique (one of a kind) arrangement of carbon and hydrogen atoms with an occasional sulfur or nitrogen added in. We'll see amino acids again in a future chapter and learn more about them.

So, back to milk... Casein protein is made of long strings of amino acids. You'll find 18 of the 20 kinds of amino acids in casein. As our enzyme guys demonstrated on the previous page, the amino acids in casein are linked together using ***peptide bonds***. Protein chains can have hundreds or thousands of amino acids in them. These long chains are called ***polypeptides***. ("Poly" means "many," and "pep" means "protein.")

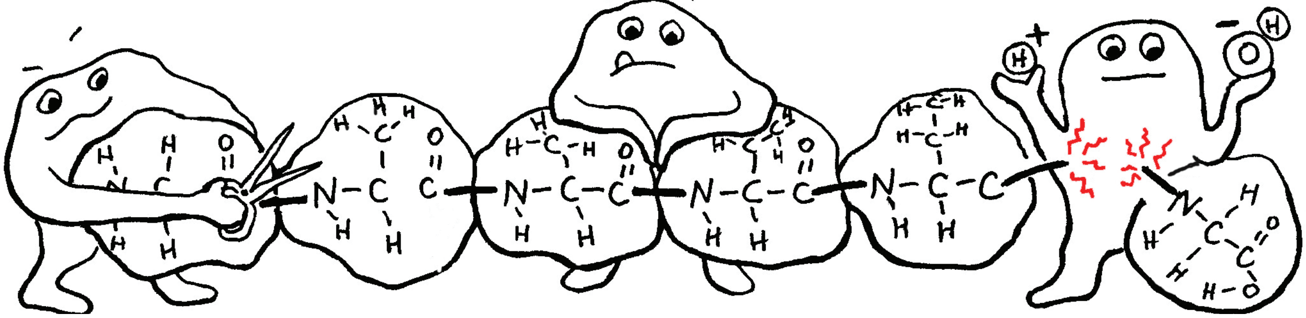


If we made a model of casein protein using colored beads, we'd have to use 18 different colors!

Enzymes that can break apart peptide bonds are called ***peptidases*** *(pep-tid-ace-ez).* The ending "***ase***" is almost always used for an enzyme that breaks things apart. Interestingly, there are several kinds of peptidase enzymes. Some peptidases can only break off the amino acids that are on the very ends of the chain. Other peptidases can get in between the amino acids in the middle of the chain and break them apart. Some can only separater certain kinds of amino acids. Enzymes are highly specialized. As a general rule, enzymes are designed to do only one job.

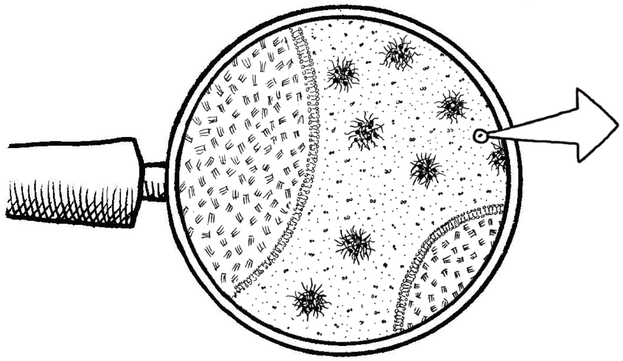
When peptidases break apart amino acids, they use water molecules to patch the unhappy broken bonds they leave behind, just like we saw in the case of sucrose being broken apart. A water molecule can be split into H^+ and OH^-, and each of these parts can be used as a "band aid" on one side of the broken bond.

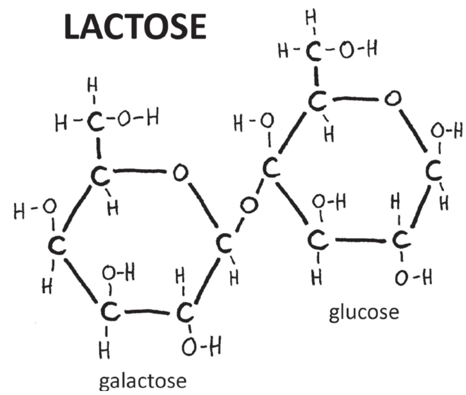
This guy is going to use a broken water molecule to patch the ragged ends.



Peptidase enzyme guys tearing apart the amino acids in a protein molecule

Let’s take one more look at the milk under our Sooper Dooper magnifier and see if we can find anything else. You can see the edges of the large fat globules with their triglycerides inside, and there's those casein "spaghetti" clumps with their calcium phosphate mineral "meatballs." The tiniest dots are water molecules. But there are some larger dots that look like they might be double rings of some kind. Let's zoom in closer.





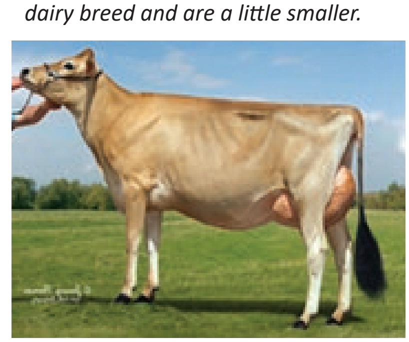
Yes, we've found some double-ring molecules. Could they be sucrose? Is there sucrose in milk? Very careful examination of the rings reveals that one of them is glucose but the other is not fructose. The other ring is a type of simple sugar that we have not seen yet. It’s almost identical to glucose except that the H and OH on one side are reversed. Seems like a small difference that shouldn’t matter at all, but in fact it changes glucose into ***galactose***. The existence of galactose was first discovered by the famous scientist Louis Pasteur in 1856. He named his newly discovered chemical "lactose" because it was in milk, but he did not know its molecular structure. Later, chemists figured out the structure and decided to use the word ***lactose*** to describe the larger two-ring structure, and created a new name, "ga-lactose," for the single ring.

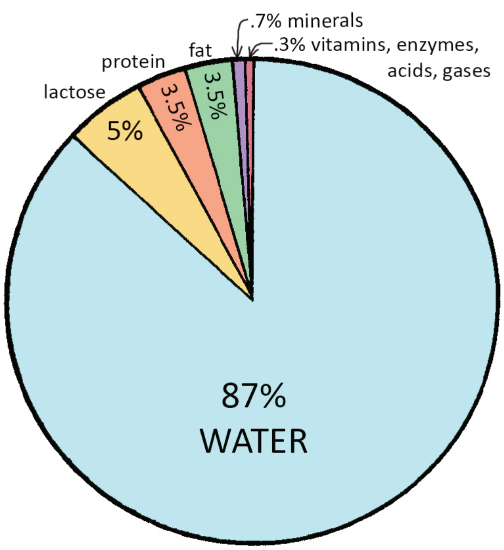
To tear apart the double-ring lactose molecule you need (no surprise) a special enzyme that can snip the bond between glucose and galactose. That enzyme is called ***lactase***. Babies of all mammals produce lactase in their digestive systems to that they can digest their mother's milk. In the vast majority of cases, mammals lose the ability to produce lactase as they get older. Not being babies anymore, they don't need to drink their mother's milk. It makes sense. This happens in most humans, too. However, in western Europe many centuries ago, a genetic mutation occurred. The genetic "switch" in the DNA that is supposed to turn off lactase production became broken. Without any instructions to stop, these people's guts go right on producing lactase as if they are still babies. This genetic mistake became very widespread and millions of people today who have European ancestors can drink milk into adulthood. (There are a few places in Africa, also, where some of the population can drink milk.) The ability to drink milk came to be seen as "normal" and therefore people who could not drink milk were considered the defective ones. In modern times, we call this inability to digest milk "lactose intolerance." (Perhaps we should switch the labeling, though, and call the milk drinkers "lactose tolerant," since they are the ones with the broken DNA!) People with lactose intolerance can often take lactase pills that will allow them to digest milk. Cheese and butter are usually less of a problem because much of the lactose has been removed.

Not surprisingly, the milk-drinking Europeans began raising herds of dairy cows to supply them with plenty of milk. They discovered that by controlling the breeding of the cows, they could create cows that could give even more milk per day. A modern dairy cow can give up to 8 gallons of milk every day. That's a lot of milk!

Holsteins are the most popular dairy cow in the world right now.

Jerseys are the second most popular dairy breed and are a little smaller.





This chart shows you an overview of what cows' milk is made of. (The numbers are averages, so different breeds of cows might have slightly different numbers.) Most of milk is water. For cows, lactose sugar is the most abundant solid substance, followed by fat and protein. Casein is by far the most abundant type of protein, but there are some other minor proteins, too. ***Whey*** *(whay)* ***protein*** is the general term for all these other smaller proteins. They include some proteins that are made by the immune system to fight germs. Others act like "taxi cabs" for transporting things like minerals. There are also are a number of different enzymes and hormones, plus some cow body proteins that leak in accidentally.

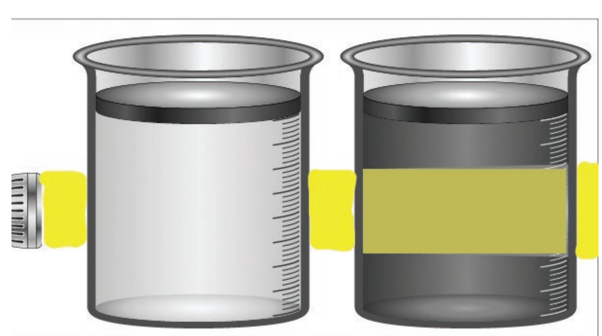
We saw the most abundant minerals in milk when we looked at those mineral "meatballs" in the casein protein. Milk also has a small amount of a few other minerals such as iron and zinc. The only category we haven't mentioned at all is vitamins. Milk has most of the major vitamins: A, B, C, D and E. We'll discuss vitamins more in aa future chapter.

This chart is only for cows. The composition of milk depends on what type of mammal is making it. Each animal has milk suited to what the baby needs in that environment. For example, animals that live in cold climates will have a lot more fat in their milk. Animals who nurse their babies for a long time will have milk lower in fat.

One final bit of chemistry before we go on to our appetizers. We need to learn the correct name for the type of liquid that milk is, because milk isn't a solution. Solutions occur when the dissolved particles are extremely small. In salt water, for example, the solute (salt) is made of individual atoms (ions). In sugar water, the sugar molecules are also very tiny. In milk, we have many different types of particles. Some, like lactose, are small. Others, like the fat globules, are large, and can even be seen under a regular microscope. Liquids that have large particles floating in them are called ***colloids***. This word comes from the Greek word "colla" meaning "glue." As we learned a few pages ago, casein protein in milk can become sticky and usable as glue. People have been making glue from milk for hundreds of years.

An easy way to determine if a liquid is a solution or a colloid is to shine a flashlight or laser pointer through it. In a solution, the particles are very small and the light will pass right through. In colloids, the particles are large enough that they reflect rays of light that hit them, so the beam of light will be visible. This is called the ***Tyndall effect***.

But why is milk white? The answer is as much about light as about milk. Natural light contains all the colors of the rainbow. If an object reflects back all the colors, it looks white. Each tiny particle of fat or protein in the milk is reflecting all of the light that hits it, so the milk looks white. Skim milk, which has had the fat removed, will reflect blue light a little more than the other colors, so it can look slightly blue.



solution ***colloid***

Comprehension self-check

See if you can answer these questions. If not, go back into the chapter and find the information.

1) How does water dissolve something? (What do the water molecules do?)

2) Fat is not a polar molecule. Would it dissolve in water?

3) To encourage carbon dioxide to dissolve into water, should the water be hot or cold?

4) In carbon dioxide, which element gets the electrons more of the time—oxygen or carbon?

5) When molecules begin to move faster, does their temperature go up or down?

6) Which senses flavor, the tongue or the nose?

7) Is benzoic acid harmful to humans? To microorganisms? Why is the FDA concerned about benzoic acid?

8) Which do consumers get more upset about—preservatives in their food, or microorganisms in their food?

9) Why do food companies put phosphoric acid into cola drink?

10) Another name for a hydrogen ion is a __________.

11) When a water molecule breaks apart, what is the OH part called?

12) If a substance has too many protons, is it an acid or a base?

13) Is baking soda acidic or basic?

14) What is the other word that means "basic"?

15) What number is neutral on the pH scale?

16) When an acid and a base combine, they produce _________ and a ________. (page 22)

17) What happens when milk is pasteurized?

18) What happens when milk is homogenized?

19) The most abundant protein in milk is called ___________. The strands form a clump called a m___________.

20) What kind of enzymes take apart proteins?

21) How many amino acids are there?

22) Which part is the "amine" end of an amino acid– the NH_2 end or the COOH end?

23) Lactose is made of what two simple sugars?

24) Two-ring sugars are called disaccharides. Can you name another one, besides lactose?

25) The Tyndall effect used to tell the difference between a ____________ and a ___________. (Milk is which?)

DONT' FORGET about the supplemental videos for this chapter on the "Dissect Your Dinner" playlist at YouTube.com/TheBasementWorkshop

ACTIVITY 2.1 Root beer float word puzzle

"Floats" are a combination of the two things we learned about in this chapter: carbonation and milk (in the form of ice cream). Fill in the correct answers below, then transfer the letters to their places on the float puzzle.

1) The things that are dissolved in solvents. ___(14) ___(65) ___(25) ___(16) ___(11) ___ ___

2) Attraction between water molecules is called ___(77) ___ ___ ___(84) ___ ___ ___(5) ___   ___(31) ___(8) ___ ___ ___(75) ___ ___

3) Plants make caffeine as a ___ ___(68) ___(28) ___(55) ___ ___(81) ___ ___ ___ (a chemical to kill insect pests).

4) The number of carbon atoms in a glucose molecule: ___(21)   5) The number of tastes your tongue can sense: ___(34)

6) This ring molecule has this formula: C_6H_6. ___(67) ___(57) ___ ___ ___(52) ___ ___(95)   7) Unprocessed milk is "___(135) ___(46) ___(112)."

8) Substances that might cause cancer are called ___ ___(10) ___(96) ___ ___(129) ___ ___(12) ___ ___(24) ___(130) ___(133)

9) This element has the symbol K: ___ ___(50) ___(78) ___(36) ___(115) ___(86) ___(71) ___(18) ___(124)

10) Benzoic acid will turn into benzene if it comes into contact with ___(26) ___ ___(9) ___(2) ___(94) ___ ___(85)   ___

11) This acid, found in cola drinks, doesn't dissolve nails! ___(138) ___ ___(49) ___(56) ___ ___(82) ___ ___(30) ___(97) ___ acid

12) The correct name for OH^- is the ___(79) ___ ___ ___(69) ___(60) ___ ___(61) ___ ___   ___(91) ___(29) ___

13) When you combine an acid and a base you get ___(23) ___(15) ___ ___ ___(140) and a ___(41) ___(54) ___ ___(20).

14) Things that are 7 to 14 on the pH scale are described as ___(58) ___(142) ___(43) ___(93) ___(37) ___ ___(109) ___(27)

15) When milk has been heated to kill germs we say that it's been ___(7) ___(100) ___(51) ___(22) ___ ___(83) ___(70) ___ ___ ___ ___(126)

16) When milk has been pressed through a screen it's been ___(4) ___(89) ___(48) ___ ___(17) ___(125) ___(64) ___ ___ ___(72) ___

17) The smallest amino acid is called ___(35) ___(38) ___ ___(98) ___ ___(40) ___(13)

18) In a triglyceride fat molecule, the fatty acid "tails" are attached to ___ ___(59) ___(114) ___ ___(80) ___(121) ___(39) ___(62)

19) Strings of casein protein are clumped together in little balls called ___(1) ___(127) ___ ___(32) ___ ___(88) ___ ___(3) (page 24)

20) Enzymes that can tear apart proteins are called ___ ___(131) ___ ___(33) ___ ___(6) ___(99) ___(19) ___ ___(117)

21) The shape of a molecule determines its ___(53) ___(90) ___ ___(128) ___(87) ___ ___(110) ___ (page 18)

22) This agency regulates food and drugs in America. ___(120) ___ ___

23) Glucose, fructose and galactose are ___(16) ___ ___ ___ ___(143) ___   ___(92) ___(44) ___ ___(113) ___(111) ___(102).

24) Triglycerides are made of three ___(74) ___(116) ___(45) ___(103) ___   ___(108) ___ ___ ___ ___(63).

25) This molecule can be used to patch the unhappy ends of broken bonds. ___(66) ___(42) ___ ___ ___(104)

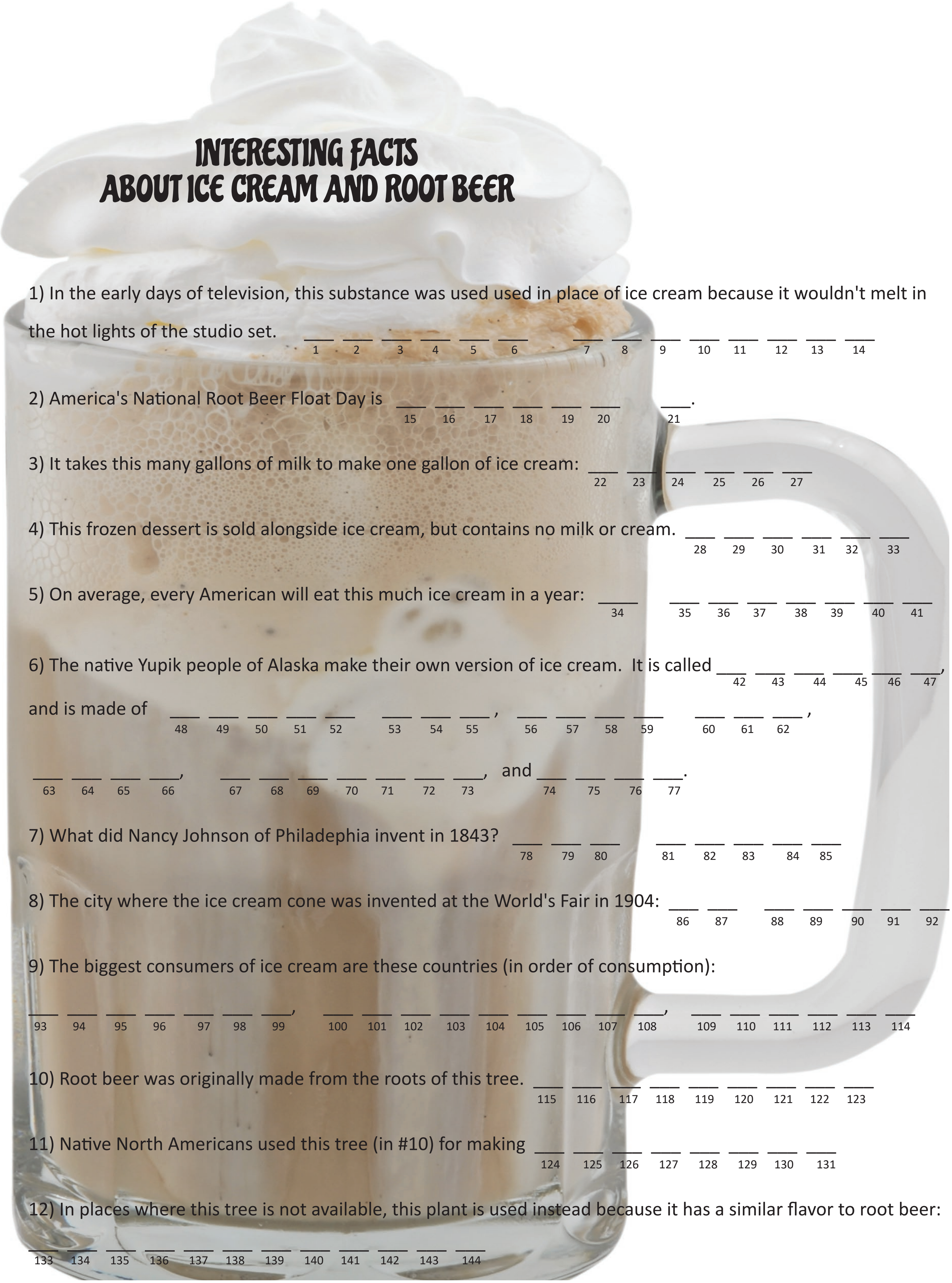
26) Carbonation is an example of a ___ ___(105) ___(73) (CO_2), dissolved into a ___(106) ___(141) ___(47) ___ ___(107) ___ (water).

27) Industrial carbonating machines use high ___ ___ ___ ___(118) ___ ___(101) ___ ___ to push the CO_2 into the cold water.

28) (We need more A's!) Woodstock, Ontario, is the dairy farming capital of the country of ___ ___(122) ___ ___(134) ___ ___(144)

29) (We still need more A's, and another S!) These yellow fruits grow in bunches. ___ ___(137) ___ ___(139) ___ ___(119) ___(136)

30) (More A's and another S!) Beverages are served in ___ ___ ___(105) ___(123) ___(73) ___ ___(76).



INTERESTING FACTS ABOUT ICE CREAM AND ROOT BEER

1) In the early days of television, this substance was used used in place of ice cream because it wouldn't melt in the hot lights of the studio set. ___ ___ ___ ___ ___ ___   ___ ___ ___ ___ ___ ___ ___ ___
1 2 3 4 5 6   7 8 9 10 11 12 13 14

2) America's National Root Beer Float Day is ___ ___ ___ ___ ___ ___   ___.
15 16 17 18 19 20   21

3) It takes this many gallons of milk to make one gallon of ice cream: ___ ___ ___ ___ ___ ___
22 23 24 25 26 27

4) This frozen dessert is sold alongside ice cream, but contains no milk or cream. ___ ___ ___ ___ ___ ___
28 29 30 31 32 33

5) On average, every American will eat this much ice cream in a year: ___   ___ ___ ___ ___ ___ ___ ___
34   35 36 37 38 39 40 41

6) The native Yupik people of Alaska make their own version of ice cream. It is called ___ ___ ___ ___ ___ ___,
42 43 44 45 46 47

and is made of ___ ___ ___ ___ ___   ___ ___ ___,   ___ ___ ___ ___   ___ ___ ___,
48 49 50 51 52   53 54 55   56 57 58 59   60 61 62

___ ___ ___ ___,   ___ ___ ___ ___ ___ ___ ___, and ___ ___ ___ ___.
63 64 65 66   67 68 69 70 71 72 73   74 75 76 77

7) What did Nancy Johnson of Philadepphia invent in 1843? ___ ___ ___   ___ ___ ___ ___ ___
78 79 80   81 82 83 84 85

8) The city where the ice cream cone was invented at the World's Fair in 1904: ___ ___   ___ ___ ___ ___ ___
86 87   88 89 90 91 92

9) The biggest consumers of ice cream are these countries (in order of consumption):

___ ___ ___ ___ ___ ___ ___,   ___ ___ ___ ___ ___ ___ ___ ___ ___,   ___ ___ ___ ___ ___ ___
93 94 95 96 97 98 99   100 101 102 103 104 105 106 107 108   109 110 111 112 113 114

10) Root beer was originally made from the roots of this tree. ___ ___ ___ ___ ___ ___ ___ ___ ___
115 116 117 118 119 120 121 122 123

11) Native North Americans used this tree (in #10) for making ___ ___ ___ ___ ___ ___ ___ ___
124 125 126 127 128 129 130 131

12) In places where this tree is not available, this plant is used instead because it has a similar flavor to root beer:

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
133 134 135 136 137 138 139 140 141 142 143 144

ACTIVITY 2.2 Mammal milk trivia

All female mammals make milk. The chemistry of each animal's milk is just what its babies need. See if you can match these descriptions with the correct mammals. They aren't easy! Use any clues you can in the descriptions, including geography and animal behavior.

Possible answers: sheep, goat, donkey, whale, seal, horse, black rhino, wallaby, hippo, rabbit

1) The milk of this mammal holds the record for being highest in fat content. The mother only feeds her baby for about a week, but during that time the baby will double its weight, as well as putting on a thick layer of fat under the skin. The baby will need a lot of fat to protect it from the cold. _________________

2) The milk of this endangered mammal holds the record for being lowest in fat content. The mother's body can't put a lot of energy into the fat content of the milk because her pregnancy lasted for over a year, and then she will nurse her baby for over two years. _____________________

3) The milk of this mammal is excellent for making cheese because it is high in both fat and protein. (It has twice the fat content of cow's milk.) Cheeses often made with this milk include feta (Greece), Roquefort (France), and ricotta (Italy). This mammal only produces milk naturally at certain times of the year because of seasonal breeding. To get year-round milk production, farmers must give hormone shots to these animals. ________

4) This mammal produces milk that has one of the highest protein levels in the animal kingdom. The milk also has twice as much fat as cow's milk. The mother only nurses her babies in the morning and evening and spends all day foraging for food (in gardens if she gets the chance). Mammals that only nurse their babies once or twice a day often have milk that is high in protein and fat. Those few meals have to be good ones! ____________

5) This mammal's milk is the subject of an untrue "fact" that circulates on the Internet. The Internet rumor says that this mammal's milk is pink. Supposedly the milk mixes with a red body chemical, and the red and white combine to make pink. The part about the red chemical is mostly true, although it is clear when it is secreted by the skin. This chemical acts as a natural sun screen, turning red and then brown as it absorbs UV rays. The milk produced by this mammal is white, as is the milk of every mammal on the planet, although direct studies of the milk have rarely been done because of the ferocity of the animal. It would be very hard to get close enough to a nursing mother without being injured or killed. _________________

6) The milk of this mammal does not separate into milk and cream. The fat globules are bound to the other solids in the milk so they are not able to float to the top. Milk experts say that this is one of the most digestible milks and one of the most similar milks to human milk. It is often used to make cheeses. The milk has a strong flavor to it (tasting a bit like the animal smells), which makes it less popular than cow's milk. ______________

7) It is critical that this mammal's milk be high in fat so that the milk won't mix with the water around it. If the milk was low in fat it could more easily mix with water, making it difficult for the baby to get enough of it into its mouth. The mother's teats are not visible most of the time and only come out when the baby nudges them. ____________

8) This mammal's milk was first recommended by Hippocrates in 400 BC. In the ancient world it was used both as a health remedy for sick infants and as a skin cosmetic product for women. Right up until modern times this milk has been used to feed orphaned human babies if no source of human milk was available. The nutritional content of this milk is very similar to human milk except that it is slightly lower in fat. The babies would be given liquid fats such as olive oil to make up for this difference. _______________

9) In central Asia and Mongolia, the milk of this animal is used to make a fermented drink called kumis. ________

10) This mammal can produce different types of milk in different teats because she can have babies of different ages both suckling at the same time. The teats that are suckled by the tiny infant in her pouch will produce milk high in sugar. The teats for the older babies will produce milk low in sugar but high in fat and protein. ____________

ACTIVITY 2.3 Second installment of "Chew It Over," a group game to be played during a meal

Here is another round of questions for you to use at a mealtime that you share with family or friends. These questions relate to the topics we learned about in this chapter. Again, you can use these questions in a varity of ways. You can be the quiz master and determine who gets which questions, or you can cut the questions out of the book and put them into a bag or bowl and let people choose a question randomly. The answers on are the back of this page.

CHAPTER 2: CARBONATED BEVERAGES and MILK 1) The average cow can produce about how many glasses of milk each day?	CHAPTER 2: CARBONATED BEVERAGES and MILK 2) In the U.S., which month is National Dairy month?
CHAPTER 2: CARBONATED BEVERAGES and MILK 3) There are some pretty strange soft drink flavors around the world. All of these are real flavors except one. Which one is not a real flavor? a) Black Garlic b) Onion c) White Fungus d) Mustard	CHAPTER 2: CARBONATED BEVERAGES and MILK 4) Until 1950, this carbonated drink contained lithium citrate, which is today used as a brain medicine: a) Coke b) Pepsi c) 7-Up d) Dr Pepper
CHAPTER 2: CARBONATED BEVERAGES and MILK 5) About how many teaspoons of sugar are in a can of soda (pop/coke)?	CHAPTER 2: CARBONATED BEVERAGES and MILK 6) Which of these frozen desserts does not contain milk? a) sherbet (sherbert) b) sorbet c) spumoni d) gelato
CHAPTER 2: CARBONATED BEVERAGES and MILK 7) The name of the orange-flavored soft drink "Fanta" is a German word for what? a) imagination b) happiness c) intelligence d) courage	CHAPTER 2: CARBONATED BEVERAGES and MILK 8) Years ago, there was a rumor that ship-wrecked sailors from France used the milk of one of the native animals on the island to make some cheese. Can you guess the animal? a) mice b) rats c) pigs d) rabbits
CHAPTER 2: CARBONATED BEVERAGES and MILK 9) Have you ever tasted goat milk or goat cheese? Would you recommend it?	CHAPTER 2: CARBONATED BEVERAGES and MILK FUNNY FACT: When Pepsi's slogan "Come alive with Pepsi" was translated into Chinese, it said, "Pepsi brings your ancestors back from the grave."
CHAPTER 2: CARBONATED BEVERAGES and MILK 11) What is your favorite carbonated beverage?	CHAPTER 2: CARBONATED BEVERAGES and MILK 12) Which is your least favorite carbonated beverage?

1) About 100	2) June
3) Mustard	4) 7-Up
5) 10 teaspoon	6) sorbet
7) imagination	8) rats