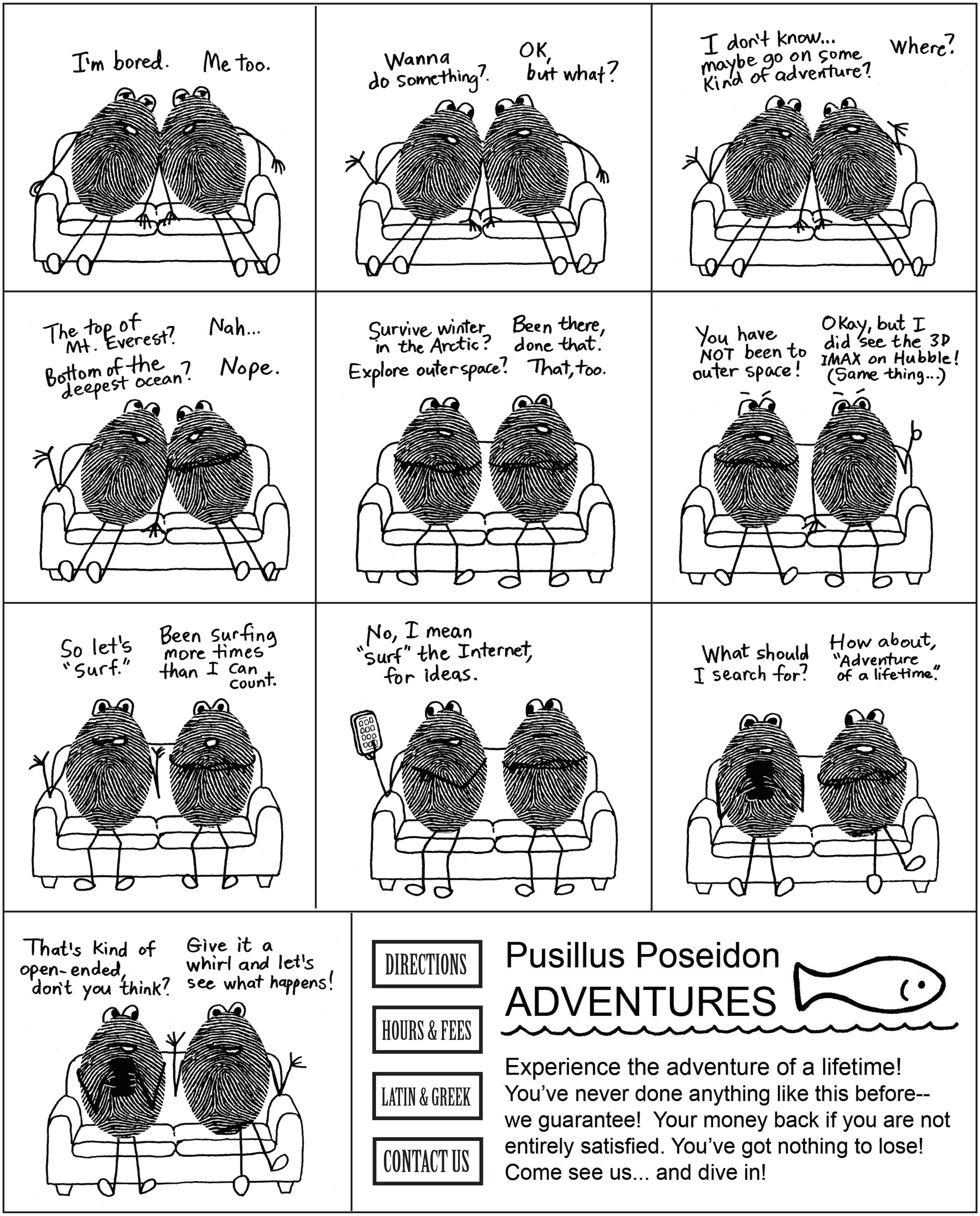
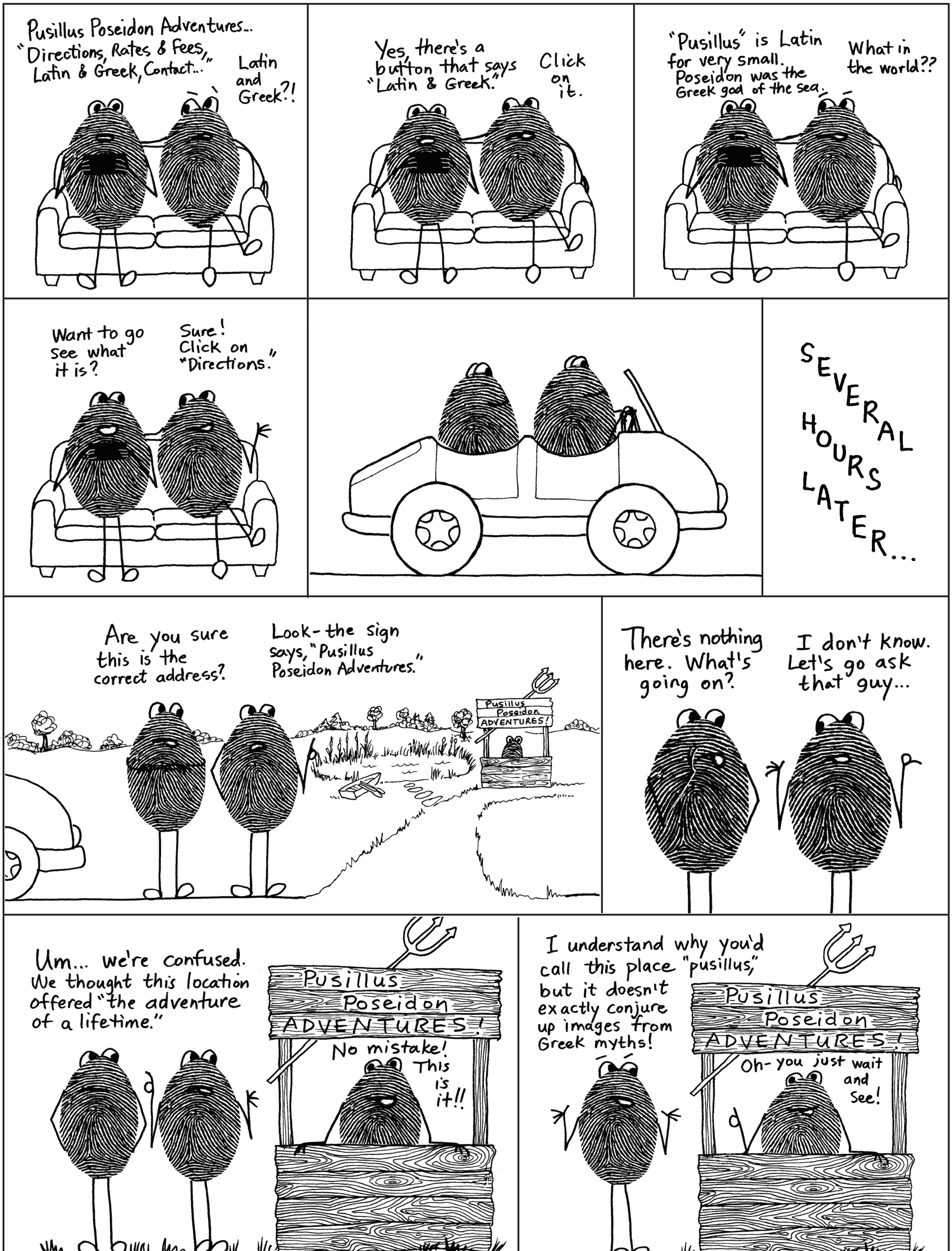
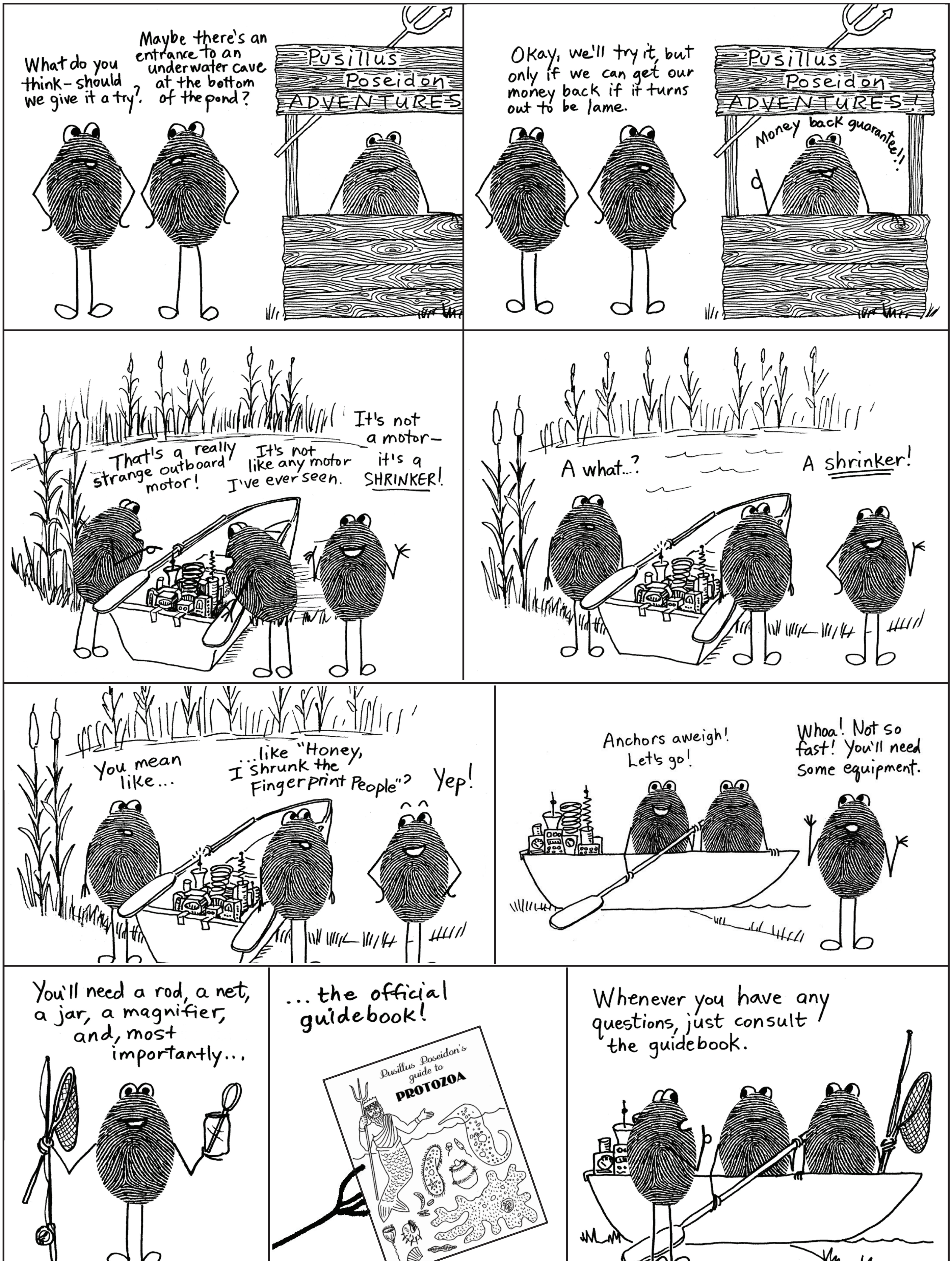
INTRODUCTION





Pusillus Poseidon Adventures.. "Directions, Rates & Fees, Latin & Greek, Contact..."
Latin and Greek?!
Yes, there's a button that says "Latin & Greek."
Click on it.
"Pusillus" is Latin for very small. Poseidon was the Greek god of the sea.
What in the world??
Want to go see what it is?
Sure! Click on "Directions."
SEVERAL HOURS LATER...
Are you sure this is the correct address?
Look- the sign says, "Pusillus Poseidon Adventures."
Pusillus Poseidon ADVENTURES!
There's nothing here. What's going on?
I don't know. Let's go ask that guy...
Um... we're confused. We thought this location offered "the adventure of a lifetime."
Pusillus Poseidon ADVENTURES!
No mistake! This is it!!
I understand why you'd call this place "pusillus," but it doesn't exactly conjure up images from Greek myths!
Pusillus Poseidon ADVENTURES!
Oh- you just wait and see!



What do you think–should we give it a try?
Maybe there's an entrance to an underwater cave at the bottom of the pond?
Pusillus Poseidon ADVENTURES
Okay, we'll try it, but only if we can get our money back if it turns out to be lame.
Pusillus Poseidon ADVENTURES!
Money back guarantee!!
That's a really strange outboard motor!
It's not like any motor I've ever seen.
It's not a motor– it's a SHRINKER!
A what...?
A shrinker!
You mean like...
...like "Honey, I shrunk the Fingerprint People"?
Yep!
Anchors aweigh! Let's go!
Whoa! Not so fast! You'll need some equipment.
You'll need a rod, a net, a jar, a magnifier, and, most importantly...
...the official guidebook!
Pusillus Poseidon's guide to PROTOZOA
Whenever you have any questions, just consult the guidebook.


Press the green button to start the shrinking rays, and push the red button to stop them and return to normal.
Got it!
Here we go!
Yikes! Green icebergs? I don't remember seeing stuff like this in the pond!!
Remember, we're miniature now. Those things are probably duck weed leaves. I do remember seeing duck weed floating by the edge of the pond.
How small are we?
Um... I think if you look up, it will put things into perspective.
boat
Is that one of those teeny tiny water bugs? Because if it is....
...yeah, that would mean we're REALLY small!
Do you think we're, like, microscopic?
I don't know. Maybe we'd better start reading?

CHAPTER ONE: MICRONS AND PARAMECIA

How do we measure really tiny things? For example, how would you measure the dot underneath the question mark at this end of this sentence? It's pretty small. If you put a ruler next to it, you'd find that centimeters or inches would be far too large. You'd have to estimate in fractions, making it very difficult to be accurate.

The smallest lines on this ruler are ***millimeters***. (A millimeter is 1/1000 of a meter. A meter is about as tall as an adult's waist.) As you can see, there are ten millimeters in a centimeter. (In other words, a millimeter is a 1/10 of a centimeter.) A millimeter would be a better measuring unit to use than a centimeter, but let's be honest—even a millimeter is still pretty big in comparison to that little dot. Is the dot half a millimeter? A fourth? A tenth? It's hard to tell. You'd need a magnifier to get a good estimate. And even then, you'd be taking a guess.

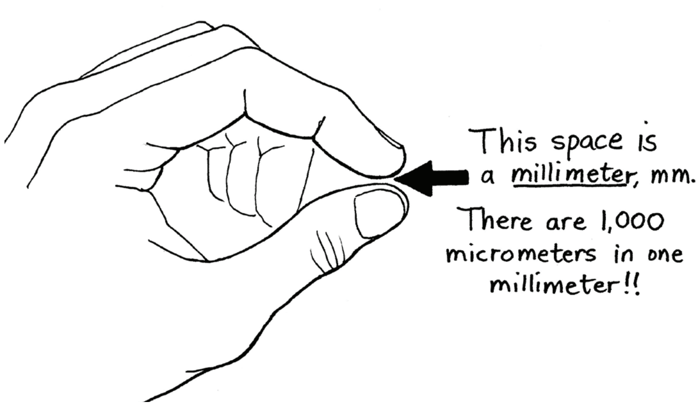
Looks like we need a unit of measurement smaller than a millimeter. How small should it be, and what should we call it? We could divide a millimeter into even smaller units, like tenths or hundredths or thousandths. Dividing it into tenths might allow us to measure that dot fairly accurately, but what about even smaller things? What if we wanted to measure a bacteria?

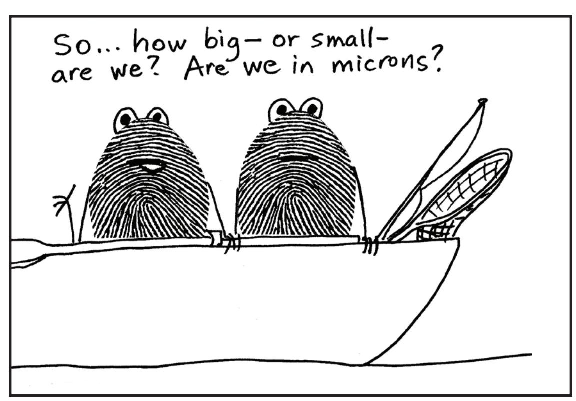
Scientists decided to divide the millimeter into 1,000 smaller units called ***micrometers***. This makes sense because you will need a <u>micro</u>scope to see things that are measured in <u>micro</u>meters. Now what about an abbreviation? "Millimeters" is abbreviated as **mm**: "m" for "milli" and "m" for "meter." If we used the same method for micrometers, we come up with... mm. Oops. We can't have two measurements with the same exact letters. We won't be able to keep them straight. What to do?

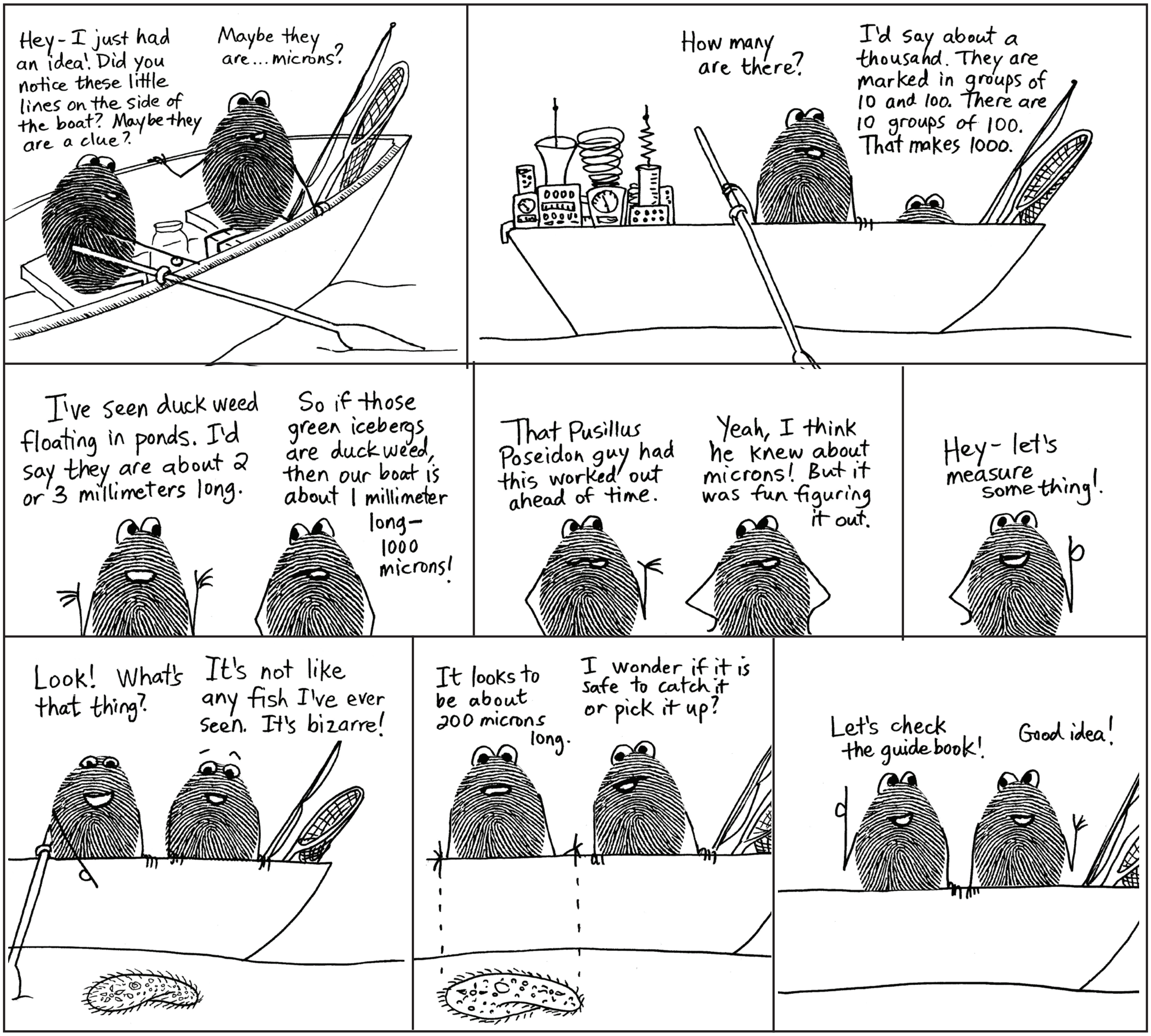
Zeus was the king of all the mythological Greek gods and goddesses. He has no connection to the words micrometer or micron. But he did know Poseidon.

Zeus to the rescue! (Well, not really. Just the ancient Greeks.) The Greeks had basically the same alphabet as we do, but some of the letters looked just a little different. For example, their letter "m" in the lower case looked like this: μ   (It might look a "u" but it is an "m" and they called it "mu.") If we use the Greek m, we can still use "mm" for micrometer, but it will look like this: μm. That way we won't get it mixed up with the mm that stands for millimeter. When we see "μm" we'll say "micrometer." Or, even better, we could use a shorter and easier word that means the same thing. How about ***micron***?

So, how big is a micrometer (a micron)? To get your mind around how small these units are, put your finger and thumb so that they are almost touching, but don't let them actually touch. That tiny space is a millimeter—one of those little increments on the ruler above. There are 1,000 microns in that little space. Many bacteria are only one micron in diameter. That means that you could fit a string of 1,000 bacteria into that space!







You, the reader, have a copy of their guide book, located after the last chapter of this book.

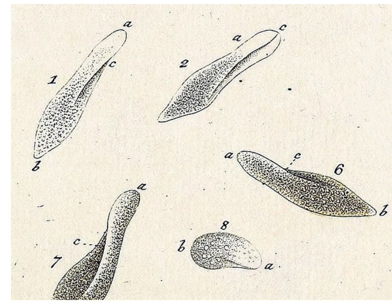
Take a quick look at the guidebook. You'll see that it has basic information arranged in a very structured format. The guidebook will come in handy when you need to find basic facts quickly. For example, if you are doing an activity and need to compare sizes or feeding behaviors, the guidebook will be much easier to use than this text. (If you would like to print additional copies of the guidebook, you can download and print by going to www.ellenjmchenry.com and clicking on FREE DOWNLOADS, then on MICROBIOLOGY, then on PROTOZOA GUIDEBOOK.)

The ***Paramecium*** was probably the very first ***protozoan*** to be discovered. The Dutch scientist Antony van Leeuwenhoek saw these in his simple microscope in the late 1600s. Then, in 1718, a French scientist named Louis Jablot *(Zhah-blo)* published a description of a little "animal" he had found in a drop of water. Jablot called this creature a "chausson" (*sho-SOHN*) meaning "slipper" because its shape does look a bit like a slipper. The name stuck, and this creature was referred to as the "slipper animacule" for the next two hundred years.

Jablot's drawing of the "little slipper"

The official name, “Paramecium,” was created in 1752 by English scientist John Hill, using the Greek word “paramekes” meaning “oblong.” Hill used this term to describe any microscopic creature that had no fins, legs, tails, or any other visible appendages. Few people actually used this term, however, and continued to use the very cute nickname “little slipper.”

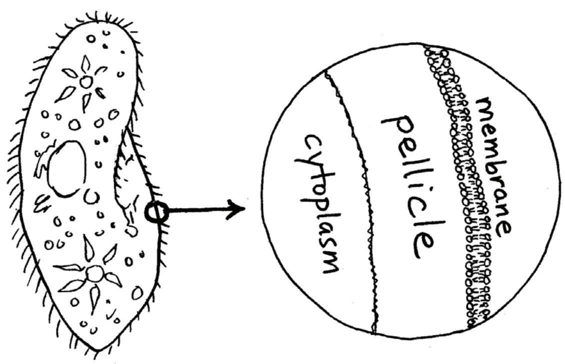
In 1773, a Danish scientist named Otto Müller changed the spelling to “Paramoecium.” Then, in 1838, a German scientist decided to change the spelling back to “Paramecium,” and that is what we still use today. In future chapters, we will see other places where scientists have disagreed about how to spell words. The fight about whether to use “oe” or just “e” will show up again soon. Strangely, in some cases, the “oe” is still with us, though in very recent times there has been an effort to standardize spelling and get rid of “oe” once and for all. But enough about that for right now... back to Paramecia. (Paramecia is the plural form of Paramecium. One Paramecium, two Paramecia.)


Muller’s drawing of Paramecia

What are these strange creatures? Even though they look and act like little animals, they are not in the animal kingdom. To be a part of the animal kingdom, you have to be ***multicellular***, meaning made of many cells. The Paramecium is made of only one cell, so it is ***unicellular***. It doesn’t have skin cells or blood cells or neurons or any of the specialized cells that animals do. It is just one cell. However, this one cell is very much alive and does many things you do every day: move, find food, eat, digest, take in oxgen, expel waste, move away from uncomfortable situations, defend itself, and even communicate with others of its species. How does it accomplish all of these things without any organs such as muscles, stomach, heart, lungs, brain or kidneys?

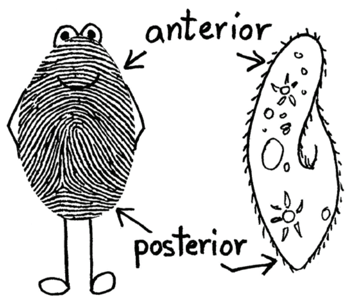
Let’s take an up-close look at the anatomy of a Paramecium. One nice thing about studying protozoa is that they are transparent. You don’t have to cut them open to see inside.

A Paramecium doesn’t have skin, but it does have an outer layer called a ***pellicle***. The word pellicle comes from the Latin word “pellicula” meaning “skin” or “husk.” If you’ve ever “husked” corn, you’ve peeled off what the Latin-speaking Romans would have called a pellicle: a protective layer designed to cover something important inside.

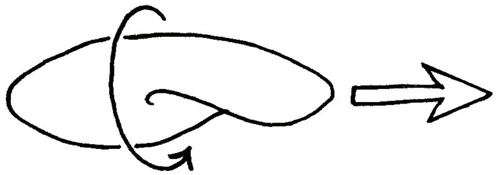


The pellicle is very thin (less than a micron) but has several layers. The inner layers are made of a substance that is tough but flexible. The body of the Paramecium needs to hold its shape, but it must also be able to bend and twist so it can get out of tight spots.

The outermost layer is an extremely thin ***membrane*** (only two molecules thick!) that acts like a fence, or screen, all around the cell. It keeps large molecules from entering the cell, but will allow tiny molecules, such as water and oxygen, to leak through. (Large molecules that are helpful can be brought in at places that act as gates.) This type of membrane (often called a ***plasma membrane***) is found not just in protozoa but in all living cells. Every cell in your body is surrounded by a plasma membrane.



The Paramecium has openings in its pellicle, just like you have openings at various places in your body where there is a hole that leads to the interior: mouth, nose, ears, and... some “exits” at your posterior end. ***Posterior*** means your bottom part. ***Anterior*** means your top part. (“Post” is Latin for “after” and “ante” is Latin for “before.”) Your head is located at the anterior region of your body. If you want a polite way to refer to your bottom, you can call it your posterior.

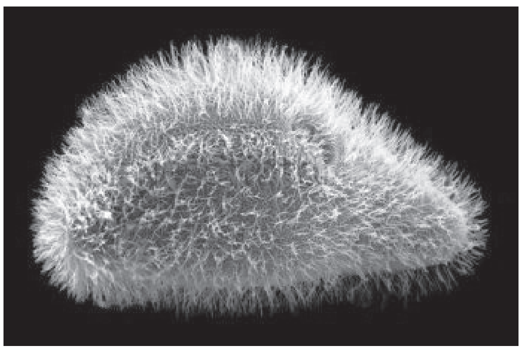


Paramecia also spiral as they swim forward.

The Paramecium's anterior isn't a head. It does not have eyes or ears or a brain or anything that you would recognize as part of a head. What makes scientists consider one of its ends as the anterior is that when it swims, a Paramecium will generally move in the direction of its anterior end, as if it were a fish or snake or something that moves headfirst.

Another similarity between your skin and a Paramecium's outer covering is that they both have hairs. The Paramecium's hairs are called ***cilia***. This word comes from Latin and means "small hairs or eyelashes." (The singular is cilium. One cilium, two cilia. Just like Paramecium and Paramecia.) The Paramecium can move its cilia like little arms or fins, propelling itself through the water. The cilia are hard to see, though, unless you have a microscope with very high magnification. If you are lucky enough to have an extremely powerful (and extremely expensive) kind of microscope called a ***scanning electron microscope (SEM)***, you can look at the surface texture and see all the cilia.

A scanning electron microscope (SEM) uses electrons to "see" instead of light. You don't look into an electron microscope; the chamber is all sealed up. The microscope bounces electrons off the sample, causing the electrons to go flying off at various angles. The electrons then hit a screen where they are recorded. The pattern of all these millions of hits on the screen eventually makes a picture that looks three-dimensional. The drawback to this method is that you can't see anything inside the Paramecium. You only see the surface texture. So it really takes both regular microscopes and electron microscopes to give us an accurate understanding of what a Paramecium is like. If you see just one or the other, you miss important visual information.

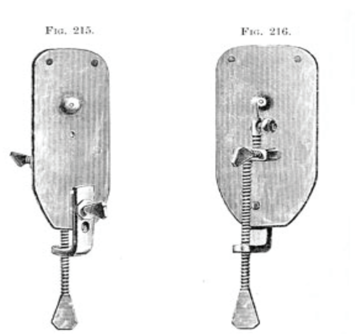


An SEM image showing the surface texture

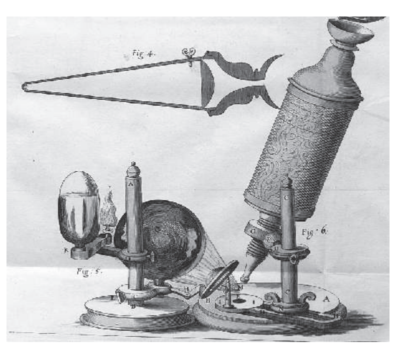
The Paramecium moves its cilia using the same basic chemical process that your muscles use. Movement is caused by chemical changes (usually a sudden increase in calcium). This chemical change causes protein chains in the cilia to contract.

The motion of the cilia is surprisingly similar to how we use our arms to swim. There is a forward "power" stroke that propels the body, then a weak "reset" stroke where the cilia (or arms) are brought back to their original position. The Paramecium can swim backwards, too, if it needs to. If it bumps into something it can back up, turn, then try going forward in a new direction.

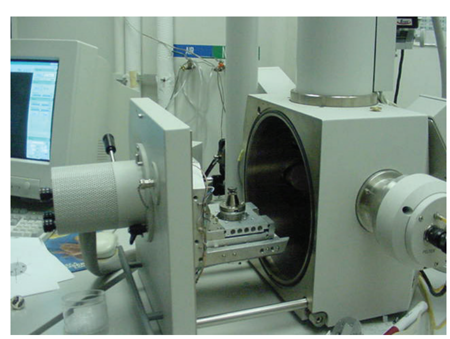
A Paramecium's swimming motion looks very smooth. The cilia don't all beat at once; they take turns in a very orderly fashion to create waves of motion. Beating cilia might look a bit like a gust of wind blowing over a field of tall grass. If you'd like to see Paramecia swimming, Activity 1.1 gives directions for accessing links to videos of Paramecia.



The world's first microscopes, made by Antony van Leeuwenhoek in the late 1600s.



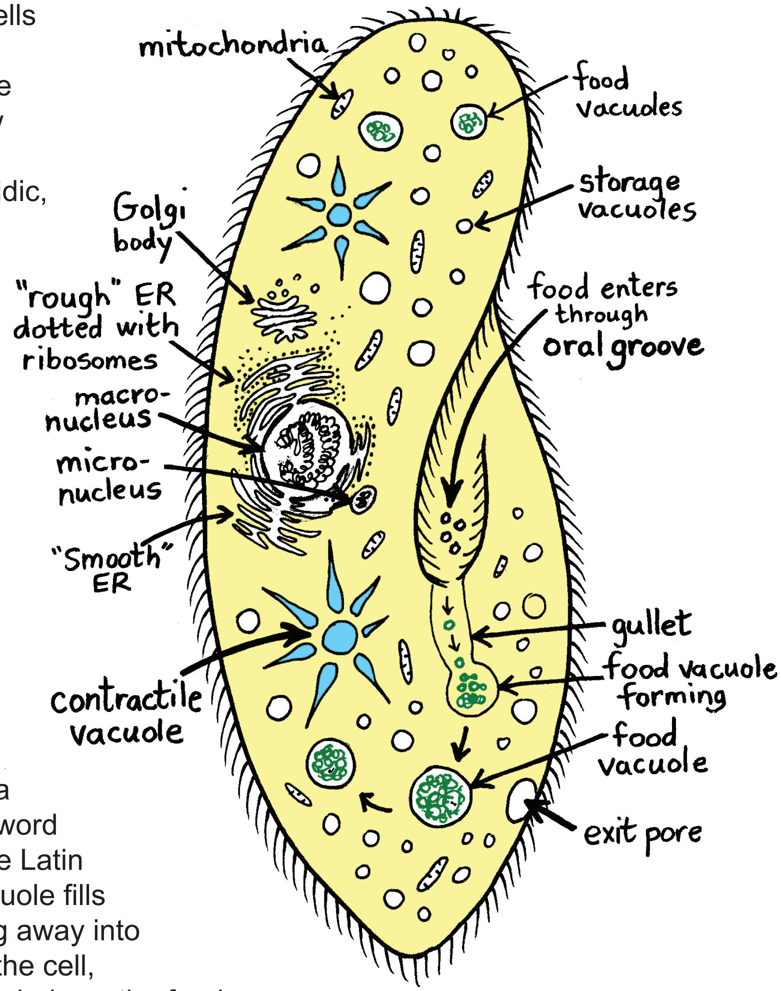
This is the first microscope to use two lenses, at the top and bottom of the tube. It is from the 1700s.



A modern SEM "electron microscope," showing the chamber open. The chamber will be sealed and the air removed.

The Paramecium's pellicle can't feel things like your skin does. Your skin is loaded with nerve cells that sense hot, cold, pain and pressure. The Paramecium is just one cell so it can't have nerve cells. But even without nerve cells it is somehow able to sense things in its environment. If the environment around it becomes too hot, cold, acidic, or toxic, it will try to move to a place that is safer.

A Paramecium also somehow knows how to search for food, even without a brain to give it hunger signals or to tell it what to eat. It "knows" what it can digest: bacteria, algae, plant cells, and even other ciliated protozoa (smaller ones). The place where it takes in food is called the ***oral groove***. ("Oral" comes from the Latin word root "or-," meaning "mouth.")



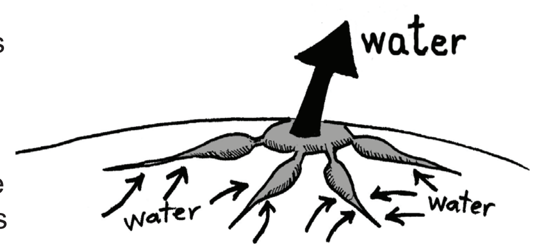
At the bottom of the oral groove is an opening which is sometimes referred to as its mouth. The food goes through this opening into a short tube called the ***gullet***. The gullet is the rough equivalent to our throat (esophagus).

At the bottom of the gullet a bubble sort of thing starts to form, collecting the food. The more technical word for a bubble inside a cell is a ***vacuole***. (You might notice the similarity of this word to the word "vacuum." Both words come from the Latin word "vacuus," meaning "empty.") Once this vacuole fills up, it pinches off from the gullet and goes floating away into the interior of the cell. While it circulates around the cell, digestive enzymes will enter the vacuole and break down the food. This is exactly what happens in your stomach. Your body makes chemicals that break down your food into tiny bits that your cells can absorb. So the food vacuoles are sort of like little stomachs.

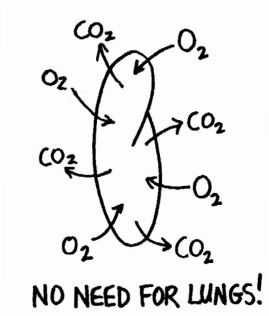
The digested nutrients leak out of the vacuoles into the cellular fluid, called the ***cytoplasm***. ("Cyto" comes from the Greek word "kytos" meaning "container," while "plasm" is from the Greek word "plasma" meaning "something molded or formed." The word plastic is also related to the word "plasma." Plastic is definitely able to be molded and formed into things.) The cytoplasm is a jelly-like substance made mostly of water. All cells, including every cell in your body, is filled with cytoplasm. Dissolved gases such as oxygen and carbon dioxide float around freely in the cytoplasm, as do small nutrients such as glucose (a sugar).

Notice that the Paramecium has an ***exit pore*** where it can get rid of waste. This is somewhat similar to the exit at the end of your digestive system, although not nearly as complicated. The Paramecium's exit is basically a vacuole that opens to the outside.

A Paramecium is constantly taking in food. As soon as one food vacuole fills up and pinches off from the gullet, a new one starts to form. A Paramecium may have many food vacuoles floating around inside. The cilia along the oral groove sweep food down toward the gullet. Along with the food, water gets swept in, too. This constant sweeping motion brings lots of extra water into the cell. The Paramecium needs a way to get rid of the extra water. It does not have kidneys or a bladder, but it does have two ***contractile vacuoles***. They are easy to spot because they are star-shaped, with arms radiating out from a central circle. The arms gather the extra water and bring it to that central circle, which then acts like a pump, pushing the water back outside of the cell.

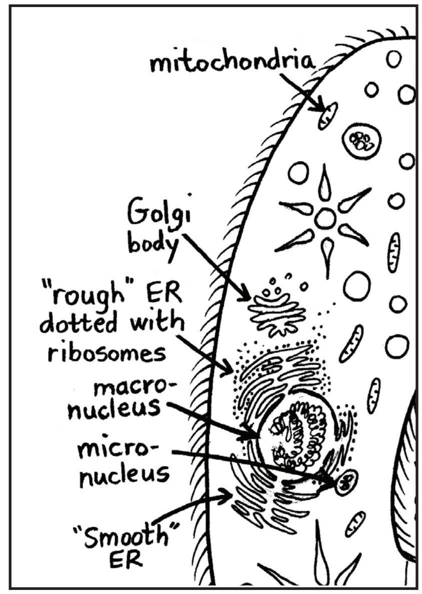


The contractile vaculole contracts (shrinks) suddenly, forcing water out the circular part in the middle.



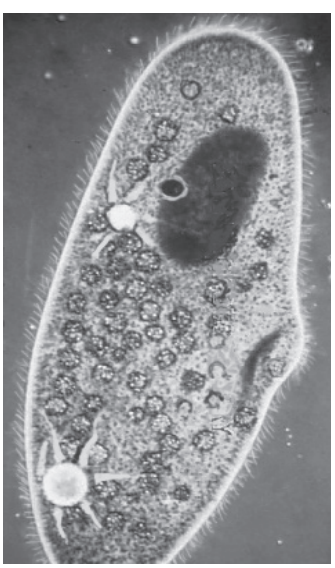
A Paramecium needs oxygen, just like you do. You require lungs to get oxygen from your environment. A Paramecium can simply take oxygen right out of the water around it. It doesn't even need gills like a fish does. Oxygen molecules are so small that they can leak through the membrane and the pellicle. (When tiny particles go across a barrier, this is called ***diffusion***.) Oxygen diffuses into the Paramecium and floats around in the cytoplasm. Like all of our cells, the Paramecium makes carbon dioxide as a waste product. We breathe out carbon dioxide when we exhale. In a Paramecium, the carbon dioxide goes right through the outer membrane, out into the surrounding water.

A Paramecium does not need lungs, nor does it need a heart or a system of veins and arteries. We need these things because we are large organisms and have many cells deep inside our bodies, far away from sources of oxygen. Oxygen must be transported to all of our cells. A Paramecium is so small that diffusion is good enough — no need for any transportation!



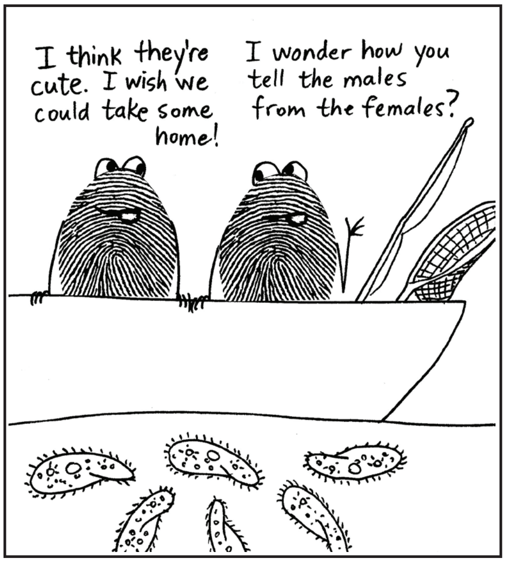
Four other structures found in all animal, plant and protozoan cells are mitochondria, ribosomes, endoplasmic reticulum (ER) and Golgi bodies. The ***mitochondria*** are the energy-makers of the cell. They take sugar and oxygen and turn them into energy in the form of ATPs. ***Ribosomes*** are like little factories. They assemble all the parts and products that the cell needs. (Cell parts are made out of proteins.) Ribosomes are often found near networks of tubes called ***endoplasmic reticulum (ER)***. These tubes can both make things and transport things. Some ER looks "rough" because of the ribosomes all around it. If the ER is not dotted with ribosomes, it looks "smooth." The ***Golgi bodies*** act like little packaging and sorting warehouses, or maybe post offices. They take the proteins made by the ribosomes and make sure they get delivered to places where they are needed.

If you want to learn a lot more about these cell parts, try the curriculum called Cells by the author of this book. You can find it on Amazon.com, or by going to www.ellenjmchenry.com. For those of you who have already read Cells, you may be wondering if the Paramecium has lysosomes and a cytoskeleton. Yes, it does, but information about these is extremely difficult to find. You have to read post-graduate-level research papers, and even these are very few and far between. There just isn't a lot of information about the normal organelles of a Paramecium.



The endoplasmic reticulum is connected to the ***nucleus***. All cells have a nucleus. This is where DNA is kept. The DNA is like a library that contains all the information a cell needs. It has instructions for how to make and repair all the cell's parts. Most cells, including yours, have only one large nucleus. A Paramecium has two nuclei: a large ***macronucleus*** and a small ***micronucleus***. You can see them in this photograph as the large and small black ovals. The macronucleus is absolutely stuffed full of DNA. For unknown reasons, it has lots and lots of copies of the same information. It's like having multiple copies of the same book in a library. In some cases a macronucleus can have as many as 800 copies of the same information. Why? There must be a reason, but researchers have not discovered it yet.

The micronucleus has all the same information as the macronucleus, but it does not have lots of extra copies, so it can be much smaller. The micronucleus doesn't seem to do anything while the cell is going about its normal daily life. Its only job seems to be allowing the cell to exchange DNA with another Paramecium before it splits in half.

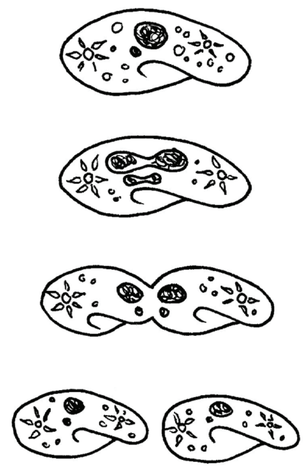


Paramecia aren't male or female. They have no gender at all. You can't say "he" or "she" for a Paramecium; you have to say "it." They have no reproductive parts, so they don't lay eggs or have babies. The methods they use for reproduction are very basic.

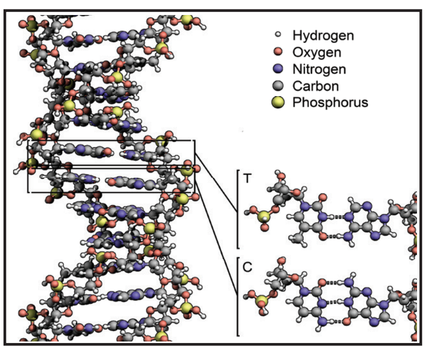
A Paramecium can reproduce in two ways:

1) It can simply split in half (making clones of itself), or

2) it can exchange DNA with another Paramecium before it divides, thus creating new Paramecia that are not identical to the original (a bit more like children instead of clones).



The first method—just splitting in half—is called ***binary fission***. (Binary comes from the Latin root word "bini" meaning "by twos." Fission is a Latin word that means "splitting." So binary fission means splitting in two.) The Paramecium makes extras of its inner parts, then splits in half. The two new cells are exact copies of the original one. Then those two new Paramecia can each split in half. Now we have four. Then those four can split in half, making eight. Eight goes to sixteen, sixteen goes to thirty-two, and so on. This process can go on for quite some time, but scientists have discovered that eventually the clones-of-clones-of-clones-of-clones-of-clones-etc. become weaker and weaker until they are unable to continue dividing. The process of binary fission "wears out" after about 200 splits.



DNA is made of a ladder-shaped string of molecules. Information is stored as a pattern in the rungs of the ladder.

Researchers guess that each time the macronucleus makes a copy of itself, tiny mistakes occur. The mistakes are small, so it does not make a difference at first. But after about 200 duplications of the DNA, so many mistakes have occurred that the information starts to be affected. The Paramecium's instructions for how to make and fix cell parts are now hard to understand or are wrong. The cells begin to be unable to do the processes that they must do to keep themselves alive, so they die. (The picture to the left shows the molecular structure of DNA. If those "beads" get mixed up, the information does, too.)

This is where the micronucleus comes in. The DNA must be fixed. The fixing process involves trading DNA with another Paramecium. The Paramecium somehow knows how to find another Paramecium who also needs to trade DNA. They line up next to each other, side by side, and at the place where they touch, their cell membranes and pellicles dissolve so that cytoplasm can stream back and forth. (The technical term for this process is ***conjugation***.) Then the micronucleus of each Paramecium divides several times (using a process called meiosis which we are not going to explain right at this moment because it is a bit complicated).

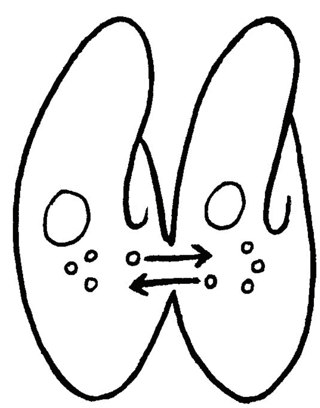
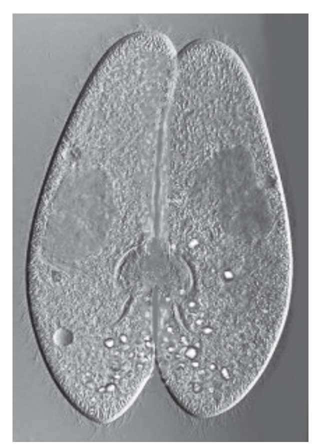


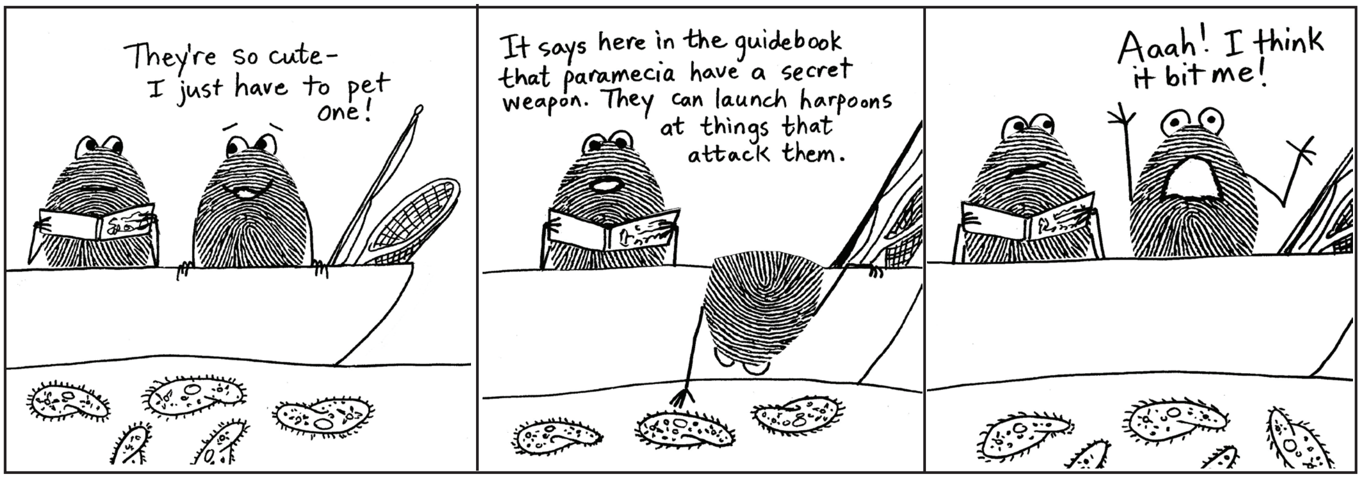
Diagram of what happens

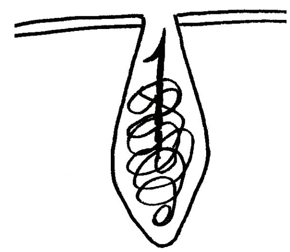


Actual photo

These divisions create little “half nuclei.” Each Paramecium gives a “half nucleus” to the other. Then the two “half nuclei” join together to form a new whole. Now each Paramecium has a new micronucleus, half of which came from the other Paramecium.

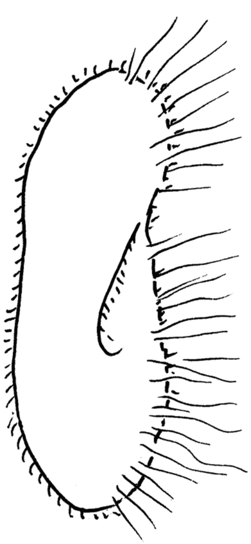
Right after this happens, the Paramecium’s old macronucleus dissolves and disappears forever. The new micronucleus divides and makes a new macronucleus. Thus, the old, defective DNA is gone and the new combination takes over. The new, revitalized Paramecium can then start using binary fission again until it wears out after several hundred divisions.





Paramecia can’t bite, but they do have a secret weapon. Attached to the inside of the pellicle are tiny structures called ***trichocysts***. (“Tricho” is Greek for “hair” and “cyst” comes from the Greek word “kystis” meaning “bag or pouch.” So it’s a hair in a bag.) A trichocyst is a bit like a harpoon tied to a string, all curled up inside a hidden pouch, waiting to spring out and pierce whatever happens to be in its line of fire. Scientists are still not totally sure they have figured out all the functions of the trichocysts, but the Paramecium does seem to use them as weapons. They might also be used to anchor the Paramecium to something while it feeds. But using them as weapons is a lot more interesting, so let’s investigate that use.

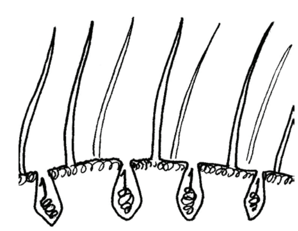
If the Paramecium gets into a situation where it is threatened by a predator, a chemical signal (using calcium) can be released thoughout the cell, causing a very rapid chemical change inside the trichocysts, resulting in the harpoons being launched out at a very high speed. How effective are these little weapons? Well, to be honest, if the predator is at least as large as the Paramecium, the harpoons are far from deadly. The predator will likely be back soon for a second try. In the meantime, though, the Paramecium will have turned and started swimming as fast as it can in the opposite direction. Retreat is one of the Paramecium’s primary survial strategies.



Trichocysts can fire on just one side.

Unlike sailors on old-fashioned whaling boats, the Paramecium can’t reel in its harpoons and reuse them. Once they are fired, that’s it. It would take muscles to pull the harpoons back, and the Paramecium does not have msucles. Instead, the cell machinery (the ribosomes, the endoplasmic reticulum, the Golgi bodies, and other parts) gets busy making a new batch of trichocysts. The old ones are dissolved and the new ones take their place. This process must go on continually for the Paramecium to stayed armed.

Trichocysts are very small. A Paramecium has hundreds, or perhaps thousands, of them, hiding among the cilia. Because they are so small, and so numerous, they were not shown on the big diagram on page 9.



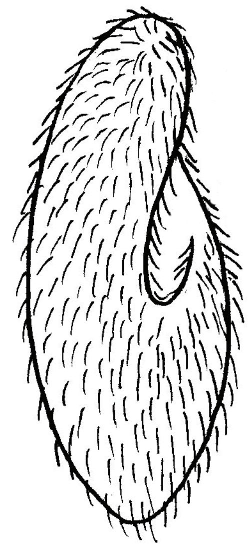
ACTIVITY 1.1 Watch some videos of real Paramecia

Go to the special channel that was set up for this curriculum at: YouTube.com/TheBasementWorkshop. Click on "Playlists," then on "Protozoa." The videos that go with this chapter will be labeled as Chapter 1. You'll see Paramecia swimming, eating, and even firing off their trichocysts.

ACTIVITY 1.2 Comparative anatomy

Can you match the Paramecium part with its equivalent human part? Draw a line between the matches.

Paramecium parts:	Human parts:
pellicle	mouth
cilia	head
oral groove	throat
gullet	kidneys
anterior	stomach
contractile vacuole	lungs
food vacuole	no equivalent
trichocysts	arms and legs
no equivalent	skin



ACTIVITY 1.3 Can you answer these questions?

1) This word means "made of more than one cell." ___________________

2) The Greek word "paramekes" means ____________________.

3) For two hundred years, Paramecia were usually called little ________________.

4) A Paramecium's thick-yet-flexible outer layer is called the ______________.

5) On top of the layer in the previous question, there is a very thin layer called the __________ ____________.

6) Where are your eyes and nose located—on your anterior or your posterior? ________________

7) A Paramecium does not need lungs because oxygen can simply ____________ through its outer layers.

8) Which body part does the Paramecium use to swim? _______________

9) Which body part does the Paramecium use to pump out excess water? ______________ _______________

10) Which body part only becomes active during conjugation? _______________________

11) Parameciua use this method of reproduction most of the time: _____________ _____________

12) Approximately how many times can a Paramecium split in half before it must go through conjugation? ___

13) What does a Paramecium eat? ____

14) The Latin word root "or-" means ___________.

15) The Greek word "tricho" means __________.

BONUS QUESTION: Which body part is responsible for generating energy? __________________

SECOND BONUS QUESTION: Which body part sorts things like a post office does? __________________

ACTIVITY 1.4 ZEUS versus JUPITER, round 1

The Titans have fought over many things, but... vocabulary words? Doubtful. Well, then, this will be a first for them! The god with the most words wins. (Actually, Zeus and Jupiter were the same deity because the Romans borrowed Zeus from the Greeks and changed his name to Jupiter, so it's a "win-win" situation. The king of the pantheon wins, either way!)

We have listed Greek and Latin word roots found in words in this chapter that are printed in bold italic type (the words that are darker than the others). The Greek word roots are under Zeus, the king of the Greek gods, and the Latin word roots are under Jupiter, the king of the Roman gods.

In this first chapter, it looks like Jupiter wins by three words.

Your job in this activity is to figure out which vocabulary words contain these word roots. Look back through the chapter and find those words in bold type. Write the appropriate vocabulary word (or words) on each line. (For example, the word "microscope" contains two Greek words: "mikros" and "skopos." So write the word "microscope" on the line after "mikros," and also on the line after "skopos.")

GREEK

mikros (small) ____________________

makros (large) ____________________

metron (measure) __________________

protos (first) _________________

zoion (animal) ________________

skopos (to watch) _______________

paramekes (oblong) _______________

kystis (bag) ____________

kytos (container) __________________

tricho (hair) _________________

plasma (plastic) ___________________

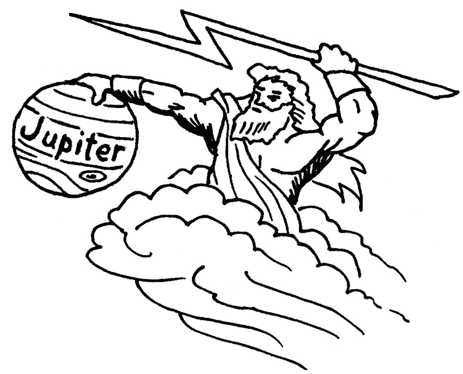
soma (body) _____________________

poros (passageway) _______________

endon (inside) ________________

mitos (thread) _____________________

chondrion (small grain) ____________________



LATIN

multus (many) ________________

uni (one) _________________

bi (two) ______________

ante (before) ________________

post (after) ___________________

pellicula (husk) __________________

cilia (hair) _______________

or (mouth) _______________

vacuus (empty) __________________

ex (out) ___________

porus (passageway) ___________________

fissus (split) _____________

con (with) __________________

jugum (yoke) ________________

mille (1,000) __________________

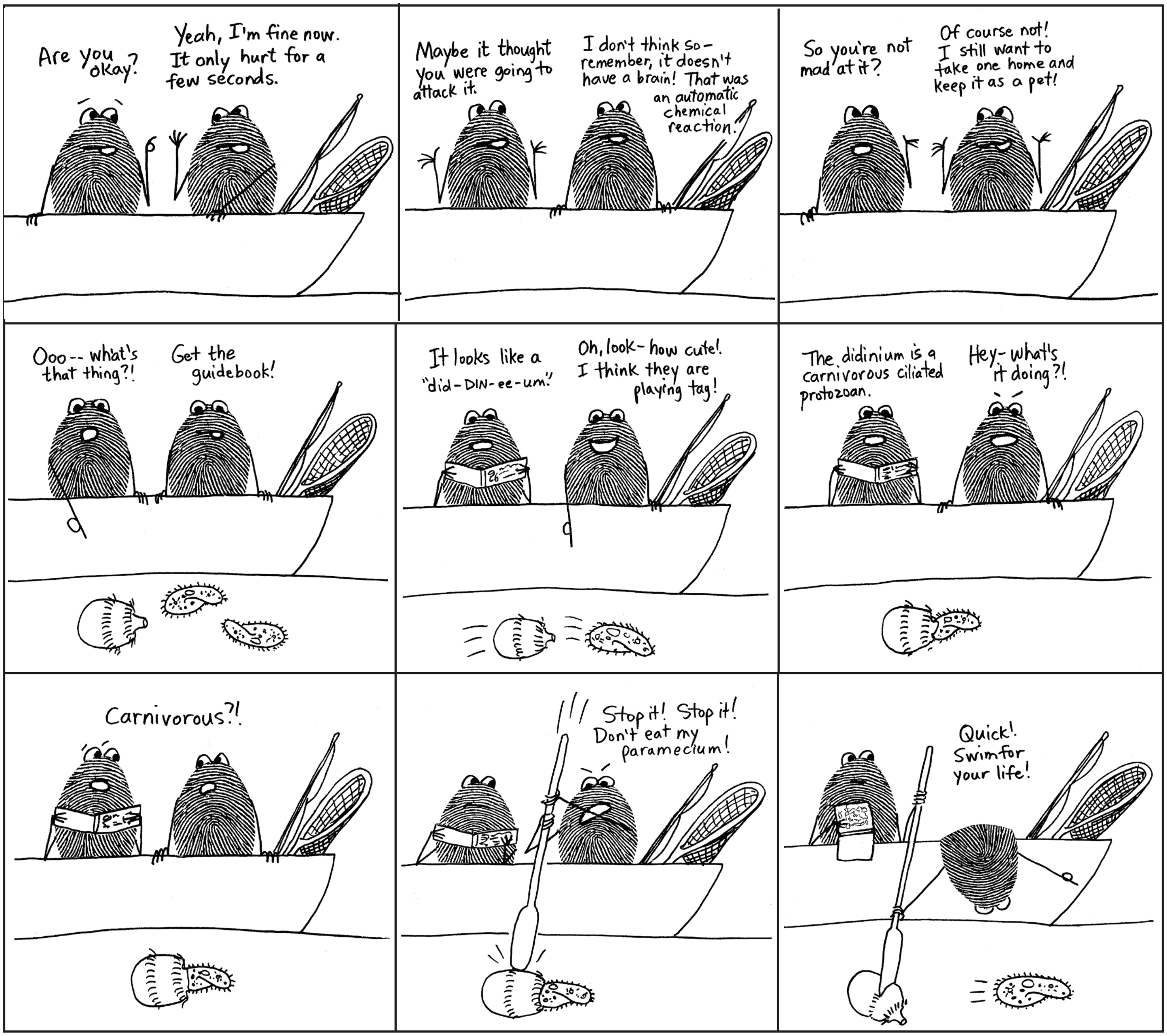
nucula (little nut) _________________

diffusio (to spread out) ______________

gula (throat) ______________

membrana (thin parchment) _______________

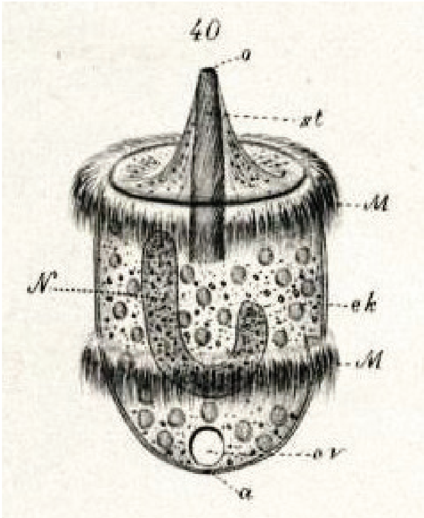
CHAPTER TWO: MORE CILIATES



Meet ***Didinium***, the tiger of the protozoan world. It's a ***carnivore***. ("Carn" comes from Latin and means "flesh or meat." "Vore" is from the Latin word "vorare," meaning " to eat.") Didinium kills and eats other ciliates, even some twice its size, and its favorite meal is a Paramecium. Why it prefers Paramecium to other ciliates is unknown. It can be forced to eat other things, but if Paramecia are around, it will go after them first.

Didinia (the plural of Didinium) might look very different from Paramecia, but they actually are quite similar. Almost everything we learned about Paramecia is true for Didinia. They have the same cells parts, they swim through the water using cilia, they reproduce using binary fission and conjugation, they have food vacuoles and exit pores, and they can fire little harpoon darts.

Drawing by Otto Müller, 1786



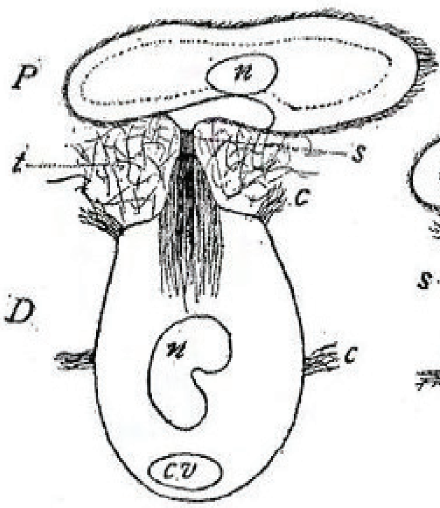
A Didinium drawing from 1896

The two biggest differences between Paramecia and Didinia are the arrangement of the cilia and the shape of the "mouth." The Didinium's cilia are arranged in two neat rows, one along its "belt line" and one around the top rim. When it beats these cilia, it spins through the water. The thing sticking out of the top of Didinium is called the ***cytostome*** and is equivalent to the Paramecium's oral groove. It is the opening where the food goes in. (Cytostome is Greek for "cell mouth.") Yes, that cytostome really stretches! Can you imagine it taking in an animal as large as the Didinium itself?

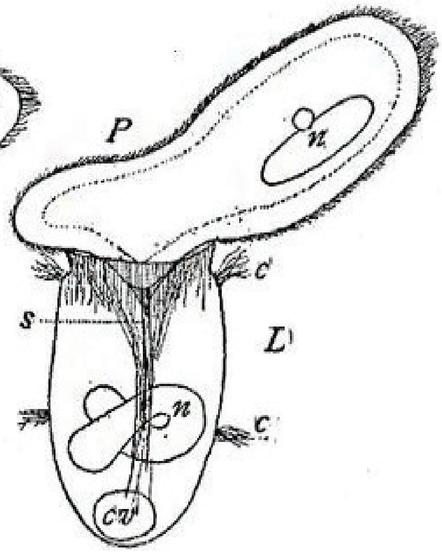
That dark "J" in the middle is the macronucleus. All those other little dots are probably food vacuoles. You can see the exit pore at the bottom. When this picture was drawn, over 100 years ago, scientists had no idea what the organelles did. They did not yet know about DNA, so they really had no clue what the role of the nucleus was.

The Didinium makes specialized trichocysts called ***toxicysts***, which contain a toxic (poisonous) substance. The toxic chemicals are capable of paralyzing the Didinium's prey. This is part of the reason Didinium is able to capture prey that is as large, or larger, than itself.

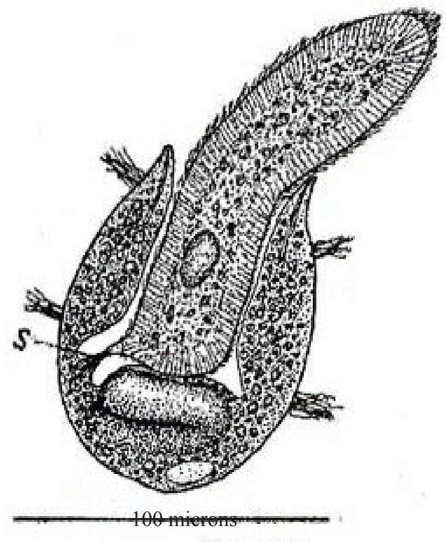
These drawings are from 1909.



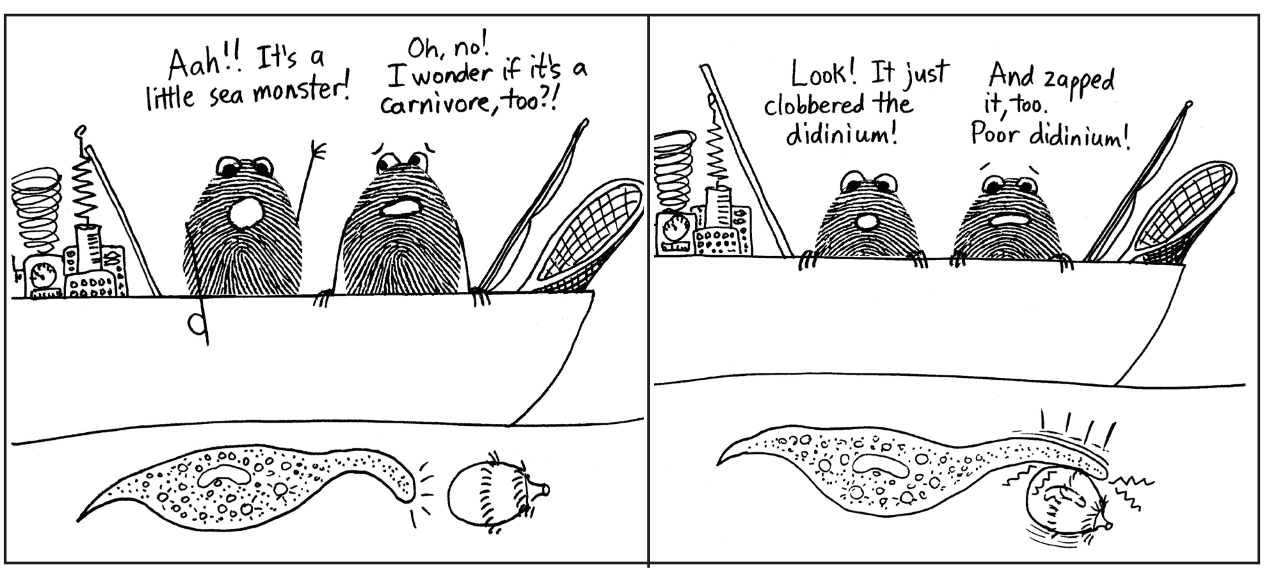
Didinium "stings" the Paramecium with its toxicyst darts.

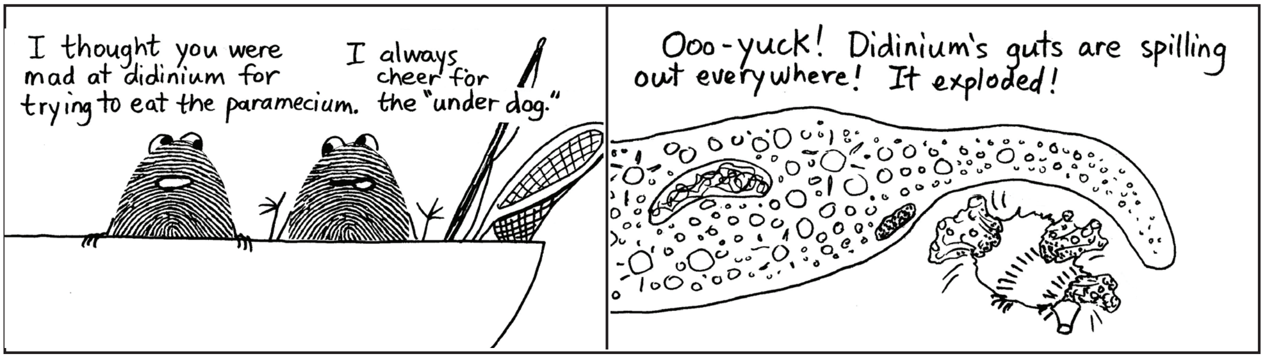


After the Paramecium is still, Didinium is able to start ingesting it.

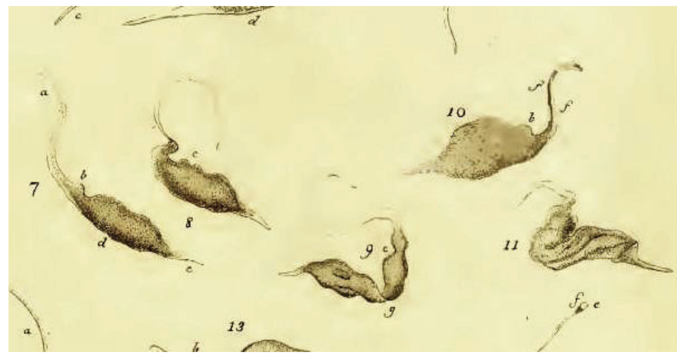


A cross section of a Didinium with a half-eaten Paramecium. (Notice the line that is 100 microns long.)

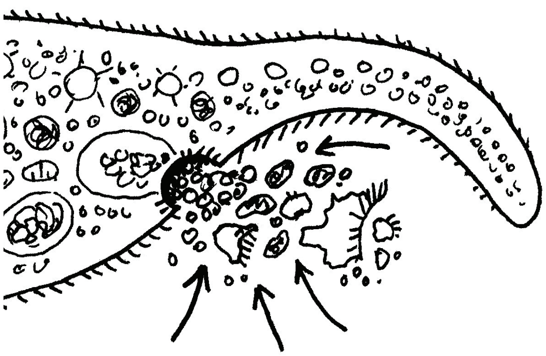




Meet ***Dileptus***, the elephant of the protozoan world. (Killer elephant, that is.) Dileptus reminds many people of an elephant because it is large and has a long ***proboscis*** at its anterior end. (The word proboscis comes from the Greek words "pro" meaning "for," and "boskein" meaning "to feed." The Greeks called an elephant's trunk a "pro-boskis" meaning "for feeding.") But you may think Dileptus looks like something else—a plesiosaurus with no fins, a leg-less swan, a snake that ate a watermelon?



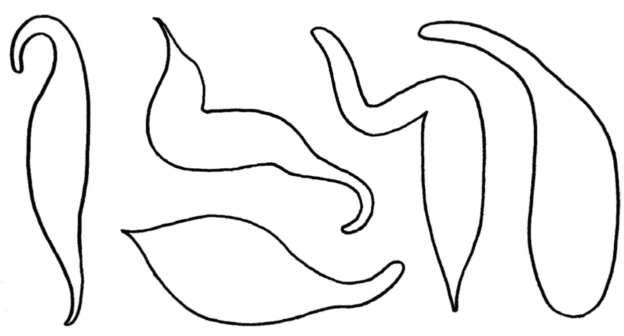
Drawing by Otto Muller, 1786. He called them "vibrios."



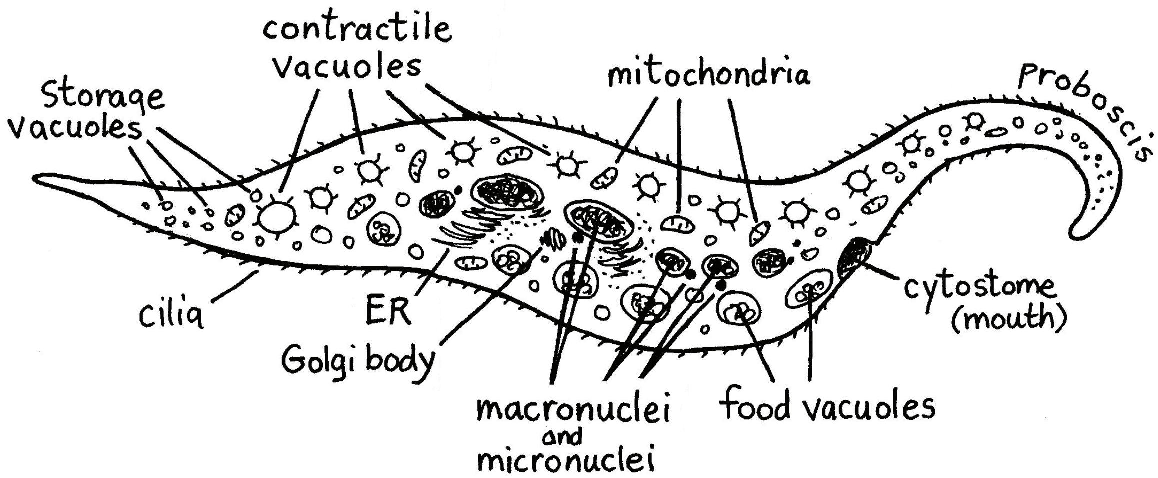
Dileptus can't use its proboscis for feeding in the same way an elephant does. An elephant uses its trunk almost like we use our arms, hands and fingers. Dileptus is not nearly as smart as an elephant, but it does pretty well for a single cell. It uses its proboscis to injure its prey. Just like Didinium, Dileptus has toxicysts (tiny harpoons with poison tips). These toxicysts are located primarily at the base of the proboscis. A toxic smack from a Dileptus proboscis can completely rupture the pellicle of most ciliates. As the prey's cytoplasm and organelles ooze out into the water, Dileptus starts sucking them up with its "mouth" (cytostome) which is located at the base of the proboscis. Cilia help to sweep the particles toward the cytosome.

The Dileptus forms food vacuoles, just like Paramecia do. The food vacuoles float around the cell as digestive chemicals go to work breaking down the food particles into smaller and smaller pieces. Eventually, the protein, fat, and carbohydrate molecules inside the food vacuoles are released into the cytoplasm where they can be used as raw ingredients for manufacturing new cell parts for the Dileptus. (If the Dileptus then gets eaten by a larger predator, the Dileptus' cell parts will be recycled and used by the animal that ate it. And if that animal then gets eaten, its parts are recycled. And so it goes, up the food chain, until it reaches the very largest predator who does not get eaten. But that predator dies eventually, and then bacteria do the recycling.)

There are about a dozen different types of Dilepti (one Dileptus, two Dilepti). They are all similar in shape, but not identical. This picture shows shapes from actual photographs. What animals to they remind you of? We think the first one looks like a seahorse. The second one (on top) looks like a seal, or maybe a baby bird with a long tail. Seriously, though, can you tell which of these Dilepti just ate a big meal?

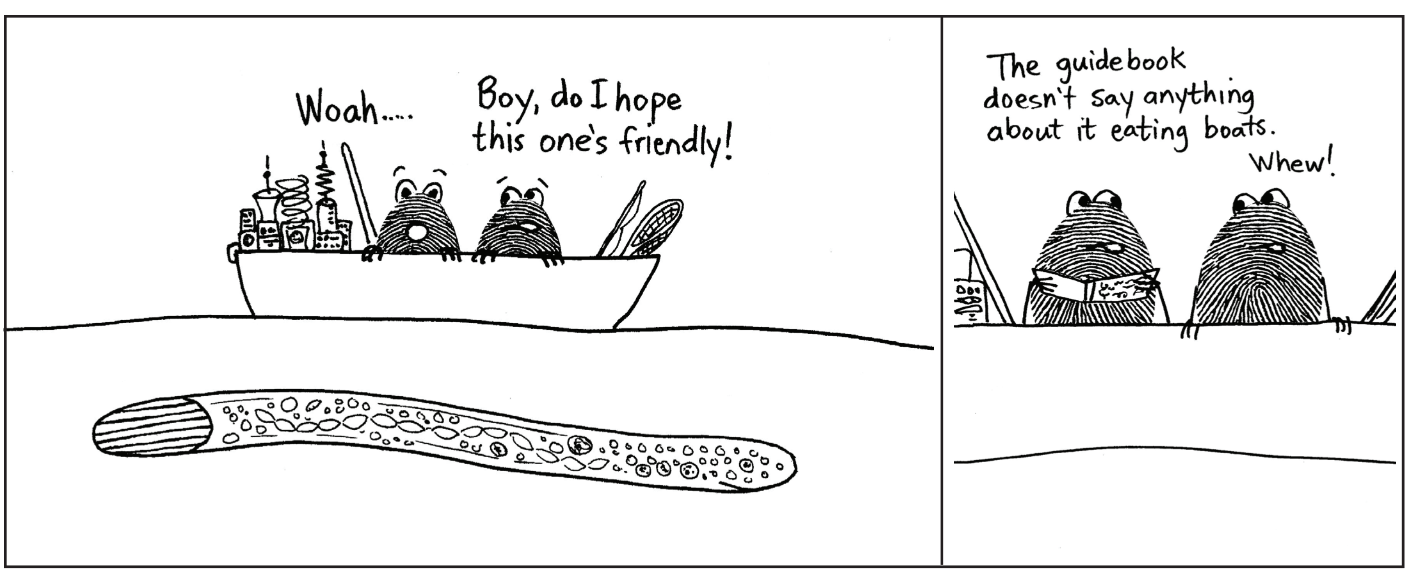


Dileptus looks as if it is filled with tiny circles, like marbles of various sizes. Many of these circles are vacuoles of various types: food vacuoles, storage vacuoles, and contractile vacuoles. Paramecium and Didinium had just a few contractile vacuoles. Dileptus has many more. Most of the contractile vacuoles are lined up in row, along what would be its back if it were a larger animal. Since Dileptus is only a single cell and doesn't really have a proper back, that side is simply called the ***dorsal*** side, meaning the side opposite the mouth opening. (The word "dorsal" shows up a lot when you study animals and it always means something having to do with the back. Dorsal comes from the Latin word "dorsum" meaning "back.")



Another notable difference between a Dileptus and a Paramecium is the number of nuclei. A Paramecium has just one big macronucleus and one small micronucleus. A Dileptus can have up to 60 or 70 macronuclei and hundreds of micronuclei. Why it has so many is still a mystery. Do all of the micronuclei play a role in conjugation (trading DNA), as we saw in the Paramecium? We know that in some ciliates with multiple nuclei, more than one micronucleus is traded back and forth during conjugation. But no one has ever been able to observe Dilepti for long enough to determine what happens to all of their micronuclei. (It's important to remember that scientists don't know everything!)

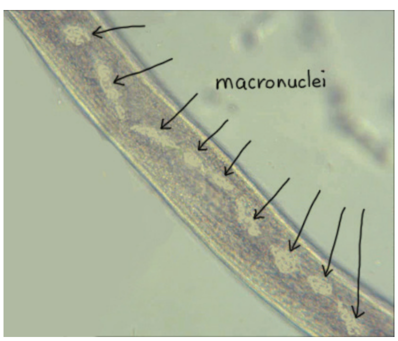
The Dileptus is not the largest ciliate in the pond. There are several well-known ciliates that can grow to be much larger than a Dileptus. In fact, they are so large that you can see them without a microscope if you have really good vision. You won't see any detail, of course. They'll just look like a little dot smaller than the head of a pin.



Meet ***Spirostomum***, the mammoth water snake of the protozoan world. (Its name comes from the Greek words "spiros" meaning "spiral," and "stomum" meaning "mouth.") Actually, the Spirostomum doesn't have much in common with snakes of any kind — it doesn't bite, poison, or squeeze its prey. It's much less aggressive than Didinium or Dileptus and does not have trichocysts. It's more like a hungry swimming tree trunk. Its lifestyle is fairly similar to that of the Paramecium; it wanders about taking in whatever bits of food it can find: bacteria, algae, tiny pieces of rotting plants, and small protozoa.

The most notable feature of the spirostomum is the stripy pattern on one end. This is the posterior end (the "tail"). The stripes are sort of like muscle fibers and they run the whole length of the animal even though you can only see them in this posterior region. (They are called *myonemes*, for those of you who like to know the proper names for things.) The reason you can see them here is that at the posterior end is a giant vacuole (a contractile vacuole that expels water). This vacuole is fairly transparent ("see-through") so you can see the myonemes.

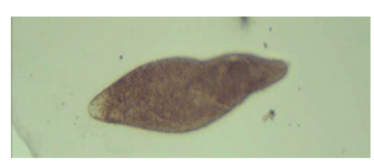
The cytostome ("mouth") is very hard to see because it is simply a small slit in the anterior end. It is similar to the oral groove and gullet of the Paramecium. The cytostome does not stretch like the Didinium's, so the Spirostomum can't possibly eat anything super large.



A very noticeable feature inside the Spirostomum is the string of macronuclei, all joined together like a string of beads. Some scientists say it is just one really long nucleus pinched off into smaller pieces. It makes sense for the Spirostomum to have a very long nucleus because, as you will remember, it is the DNA in the nucleus that provides information to the cell's organelles. If the nucleus was only at one end, the poor organelles at the other end would be far away from the source of information, making it very hard for them to do their jobs.

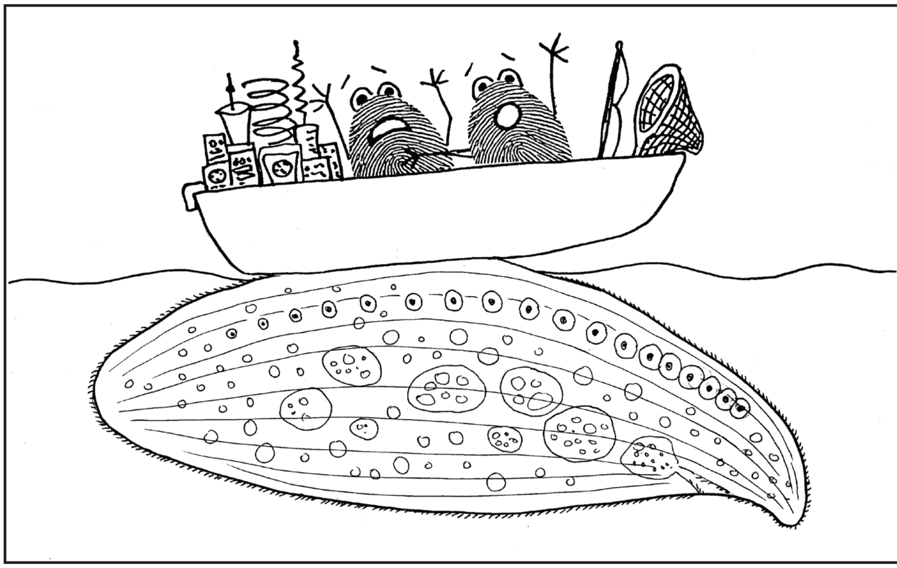
The Spirostomum uses binary fission as its primary method of reproduction. Like all ciliates, it also uses conjugation once in a while, whenever it feels its DNA is getting "worn out" and needs to be traded. Trading DNA revitalizes and renews them.

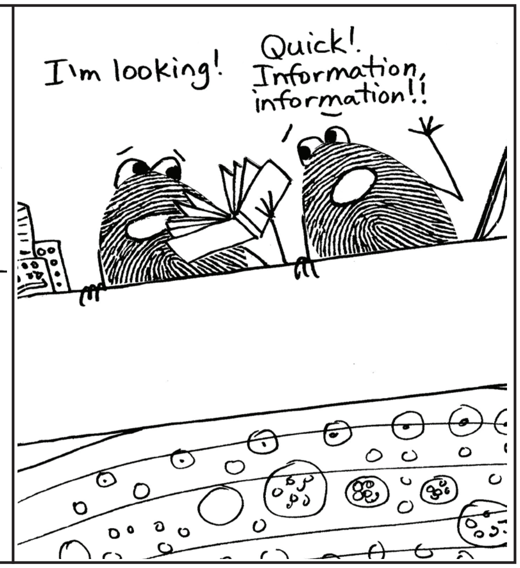
The Spirostomum does not usually wriggle back and forth like a snake. It glides smoothly through the water using rows of cilia so small that you can't see them without very high magnification. It can change direction easily and quickly without turning around. Spirostomum starts its cilia going in the opposite direction and it moves backwards. Even though it usually stays straight, it can bend if it needs to and is capable of making a U shape.



Spirostomum's claim to fame is that it can contract its body down to about one fourth of its original size in a fraction of a second (1/200 of a second). No other living cell can contract faster than a Spirostomum. The contraction happens whenever the Spirostomum is startled. In the lab, you can make them contract by gently tapping the microscope slide.

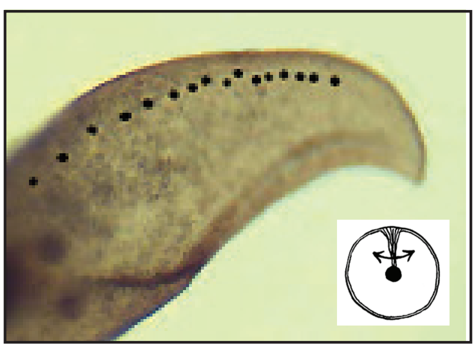
Is the Spirostomum the biggest protozoa in the pond? Turn the page and find out.





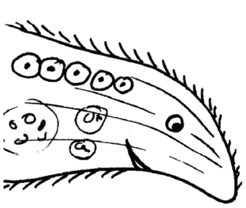
Meet ***Loxodes*** (*locks-OH-dees*), the whale of the protozoan world. It's most similar to a baleen whale because although it is very large it eats small things. Baleen whales eat a diet of microscopic plankton. Loxodes eats bacteria, algae, and tiny protozoa. Those large circles you see in the drawing of Loxodes are food vacuoles filled with tiny food particles. Those guys in the boat aren't in much danger of being eaten. They're probably too large.

Loxodes is a ciliate, just like the others we've met, so you already know all the basics about it—how it swims (cilia), how it digests (food vacuoles), and how it reproduces (binary fission and conjugation). Loxodes is different from other ciliates in two respects, however. The first is that it does not have any contractile vacuoles. The second is that it has a special type of organelle that helps it know which way is "up." You can see a string of these organelles in the picture above. They look like perfectly round fried eggs lined up in a row. They are called ***Müller bodies***, named after Otto Müller, the guy from the 1800s that we met back on page 6 when he wanted to spell Paramecium with an "o" (paramoecium). He also did the drawing of the Didinium on page 15 and the drawing of the Dilepti on page 17.



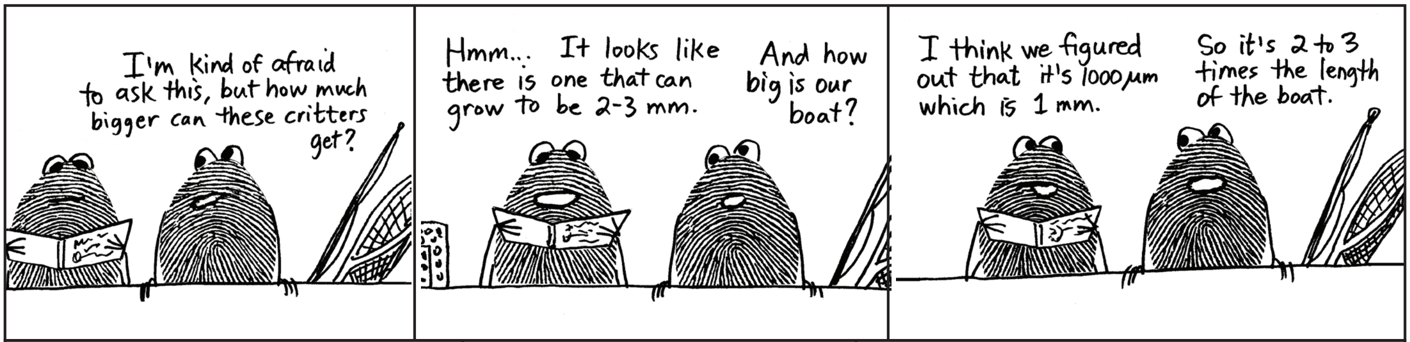
The Müller bodies allow the Loxodes to sense gravity. They work a little bit like the cells in your inner ear, which let you sense the tilt of your head. Even with your eyes closed, you know if your head is level or is tipped forward or backward. The little inset picture shows how the dark blob in the middle of the organelle is suspended by a thin protein thread. It's like a ball on a string. Imagine rotating that circle clockwise. What would happen to the position of the ball? It would go toward one side, wouldn't it? When the inner part of the Müller body migrates toward one side of the circle, chemical and electrical changes take place around it.

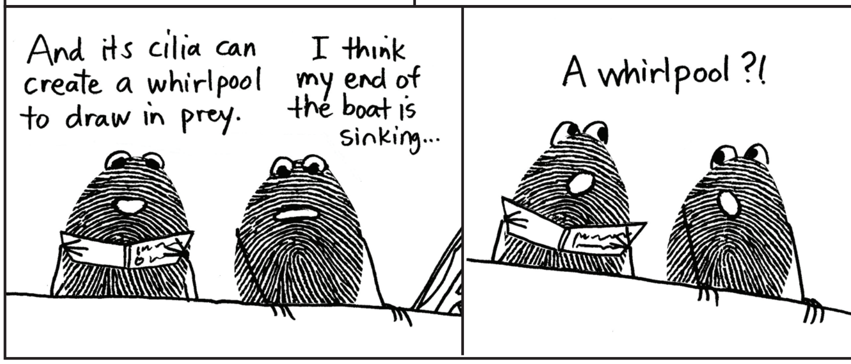
Why would Loxodes need to sense gravity? The best guess so far is that it needs to migrate to areas of less oxygen. Loxodes doesn't like too much oxygen. When there is too much oxygen near the surface, Loxodes takes a dive.

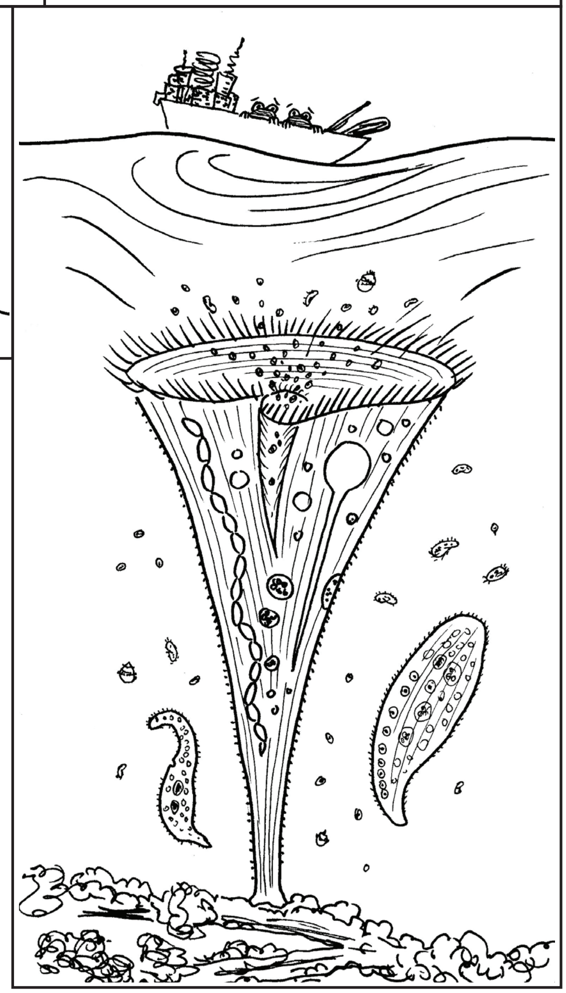


It's easy to tell which end of Loxodes is the anterior end, since it is pointy-looking, sort of like a beak. It is called the ***rostrum***, which is Latin for "beak." It's not really a beak, of course. It just reminds us of one because of its general shape. The mouth opening is very small and is located right under the rostrum, just where you would put the mouth if you were making a cartoon Loxodes. (We added a cartoon eye, too!)

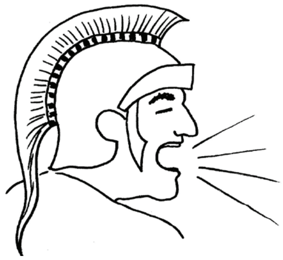
So... is Loxodes the largest ciliate? (Okay, okay, you've already looked at the next page.)







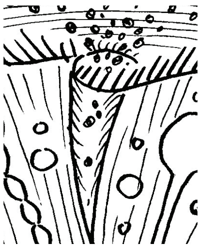
Meet ***Stentor,*** the living trumpet. It is named after an ancient Greek who was known for his loud voice. He was a herald (announcer) in the Greek army. Supposedly, the voice of Stentor was louder than the combined voices of 50 men. Things were fine as long as he remained humble about his ability. However, as so often happened in these legends, the mortal got overly confident about his abilities and challenged one of the Olympian gods. Stentor foolishly agreed to a shouting contest with Hermes, the herald of the gods. Stentor lost not only his voice, but his life.



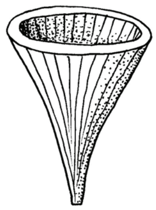
A simple device that can be used to magnify the sound of your voice (to make you as loud as Stentor was) is a cone-shaped device called a megaphone. The protozoan Stentor is the same shape as a megaphone.

The Stentor is a ciliate, just like all the protozoa we've met so far. In the next chapter, we will meet some protozoa who are not ciliates, but so far everyone we've met has cilia. The Stentor has cilia on its body and also along the top rim of its "trumpet." The cilia along its body are shorter and are used for swimming. The cilia on the rim are longer and are used for creating a vortex (whirlpool) in the water, which draws food down. Most often you will find Stentor standing still. (The fancy word for this is ***sessile*** (*seh-sill),* which means "attached to something and not swimming around"). The Stentor can attach to any large piece of floating debris, like a twig or leaf, or a floating clump of algae. It stays there while the supply of food lasts. When it senses that the food supply is dwindling, it detaches itself and goes off to find a new place to attach.

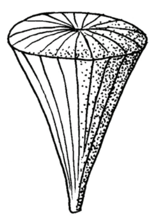
You can see that Stentor has the same kind of nucleus as Spirostomum. Its looks like a long string of oval beads. Long protozoa need long nuclei! The blank circle (with a long, thin tube running down from it) is a contractile vacuole. The Stentor is continually taking in water and needs a way to pump it back out again. Every few minutes the contractile vacuole reaches capacity and gives a sudden and strong "squeeze" to expel the water. (The long tube part helps to collect water from the lower part of the cell.) You can also see lots of food vacuoles.



The V-shaped thing in the middle of the top is the "mouth." The proper name for it is the ***buccal cavity.*** (You say the word "buccal" exactly like the word "buckle." So next time you are required to think of homonyms for an English assignment, you can use this one and amaze everyone with your knowledge of biology!) The word "buccal" comes from the Latin word "bucca" meaning "mouth" or "cheek." The muscle in your cheek (which lets you draw in your cheeks to make the silly "kissing fish" face) is called the buccinator muscle *(buck-sin-a-tor)*.

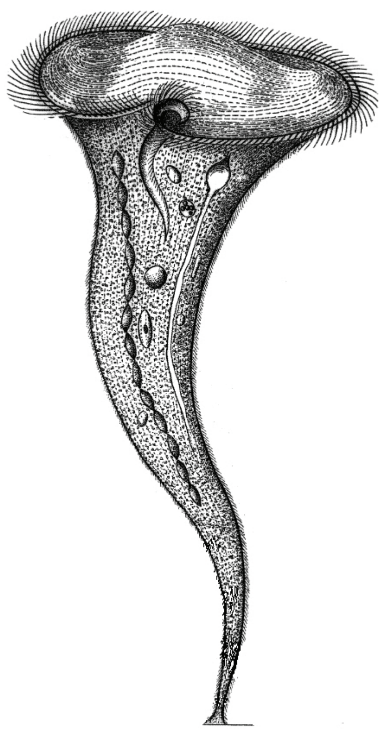


WRONG



RIGHT

As we look at the buccal cavity on the top of Stentor, we need to understand something very important about the overall shape of the Stentor. It is very easy to misinterpret drawings and photographs. Most students get the impression that Stentor is shaped like a hollow cone, like the drawing on the left. We must assume that the organelles are somehow embedded in the walls. In reality, the Stentor is not hollow, but has a top. It is like a full ice cream cone, not an empty one.



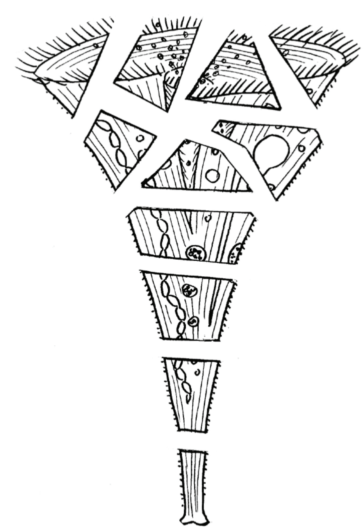
This antique drawing (from over 100 years ago) is perhaps the best drawing you can find on the Internet. It is the drawing that most clearly shows that the top is solid, not open. Notice the buccal cavity going into the cell like a funnel. The contractile vacuole and the macronucleus look very much like the ones in our cartoon picture on the previous page.

Again, don't forget that protozoa are transparent (see-through). The nucleus (even in this very good picture) looks like it is pasted on the side. It is actually *inside* the cell, not on the surface.

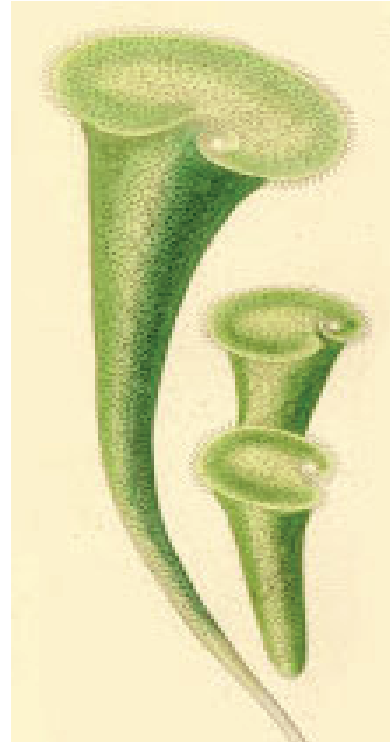
The skinny part at the bottom is called the ***peduncle*** (*PED-uncle*, or *peh-DUNK-el*, take your pick). This word comes from the Latin root "ped" meaning "foot," and the Latin ending "unculus" meaning "little." (As a brief side note for those of you interested in Latin, this word ending doesn't mean "small" in the same way that "brevis" and "parvus" do. Rather, "unculus" is similar to what we do with "y" in English. A grown man is "Bob," and his little boy is "Bobby.")

A Stentor attaches to things using the peduncle. It can secrete a sticky substance that will hold it in place.

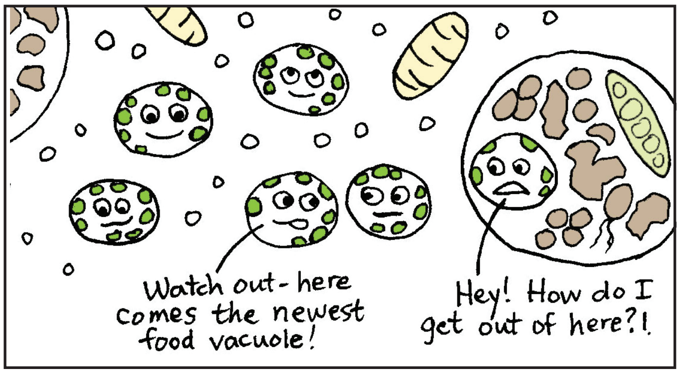
Besides being the largest of the ciliates, the Stentor has two other characteristics that set it apart from most other protozoa. First, it can regenerate if it is chopped into pieces. Each piece will grow into a new Stentor. Some researches claim they have grown Stentors from pieces as small as 1/100 of an original cell. This is not only amazing, but technically impossible. Why? Remember that the cell only "knows" what to do because of the information stored in its DNA in the nucleus. If it needs new cell parts, the information for how to make them comes from the DNA. A piece of Stentor that had a piece of nucleus would have the necessary information to be able to grow new organelles. But even if you separate that string of macronuclei into individual beads and give one to each piece, you still would not have enough for 100 pieces. How do the pieces without any DNA know what to do? Are there bits and pieces of DNA floating around in the cell? (If you become a cell researcher someday, here is a puzzle for you to solve!)



The second somewhat unusual thing Stentor can do is to allow algae to live and grow inside its body without digesting them. This is what gives green Stentors their color. It's the algae that are green, not the Stentor.



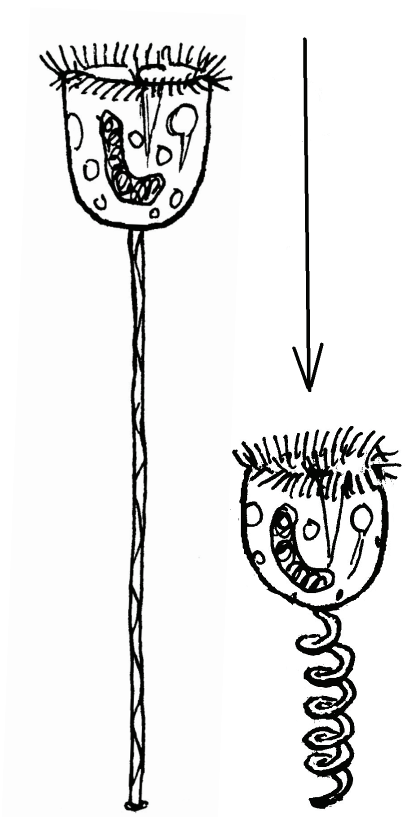
The Stentor takes in algae through the buccal cavity and puts them into food vacuoles. But somehow or other the algae resist digestion and eventually escape from the vacuoles. They float around in the Stentor's cytoplasm, like fish in an aquarium. The Stentor doesn't mind a bit; they don't cause any harm. In fact, they are somewhat helpful. The algae can take carbon dioxide, one of the waste products that all living cells make, and use it for photosynthesis, making sugars that both the algae and the Stentor can eat. So the algae sort of function as both housekeepers and cooks!



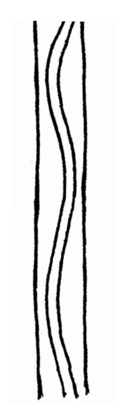
A protozoan that is very similar to Stentor is Vorticella *(vort-i-SELL-ah)*. If you stretched a Stentor's peduncle so that it got very skinny, and you rounded the trumpet into more of a bell shape, you'd have a Vorticella. They are considered to be closely related.

As with Stentor, when you look at drawings of Vorticella you often get the wrong impression of its shape. Though it is shaped like an upside down bell, it is not hollow. The SEM photograph on the right shows the true shape of the top of the bell. You can't see this when you look at pictures taken with a regular light microscope

The top of Vorticella's bell is covered; the bell is not hollow.



Vorticella's claim to fame is its springy peduncle. It is quite entertaining to watch a Vorticella under a microscope. The slightest disturbance startles it, and it suddenly coils up. A few seconds later, when the coast is clear, it begins to stretch out again. It's fun to tap the microscope slide again and again and watch Vorticella bounce up and down! The Stentor, also, can contract its peduncle quite quickly, but it is not as entertaining to watch as the Vorticella's "spring."

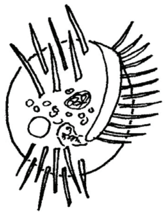


The mechanism that contracts both Stentor and Vorticella is very similar to the one found in Spirostomum. It is called a ***spasmoneme*** because it causes a very fast contraction, or "spasm." The Vorticella's spasmoneme is visible inside the stalk of the peduncle.

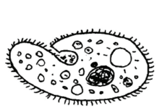
The Vorticella's peduncle is a bit fragile; it doesn't take much to rip it off. The Vorticella can function well enough without it, though. It can start swimming around, like Stentor can. Then it can grow a new peduncle in less than an hour.

Several times we've mentioned "smaller protozoa" that get eaten (along with bacteria and algae) by the larger ciliates such as Spirostomum, Loxodes, and Stentor. Let's wrap up this chapter with a look at the smallest members of the ciliate family.

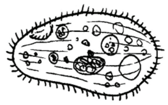
In descending size, our "Top Four" list is:



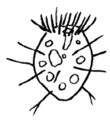
Euplotes *(yu-PLOH-tees)*: A unique ciliate that not only swims, but "walks." ("Eu" is Greek for "good" and "plos" is Greek for "swimmer.") It is also a picky eater and spends quite a bit of time sorting out the particles that come into its buccal cavity. It spits out things it does not like.
About 150 μm



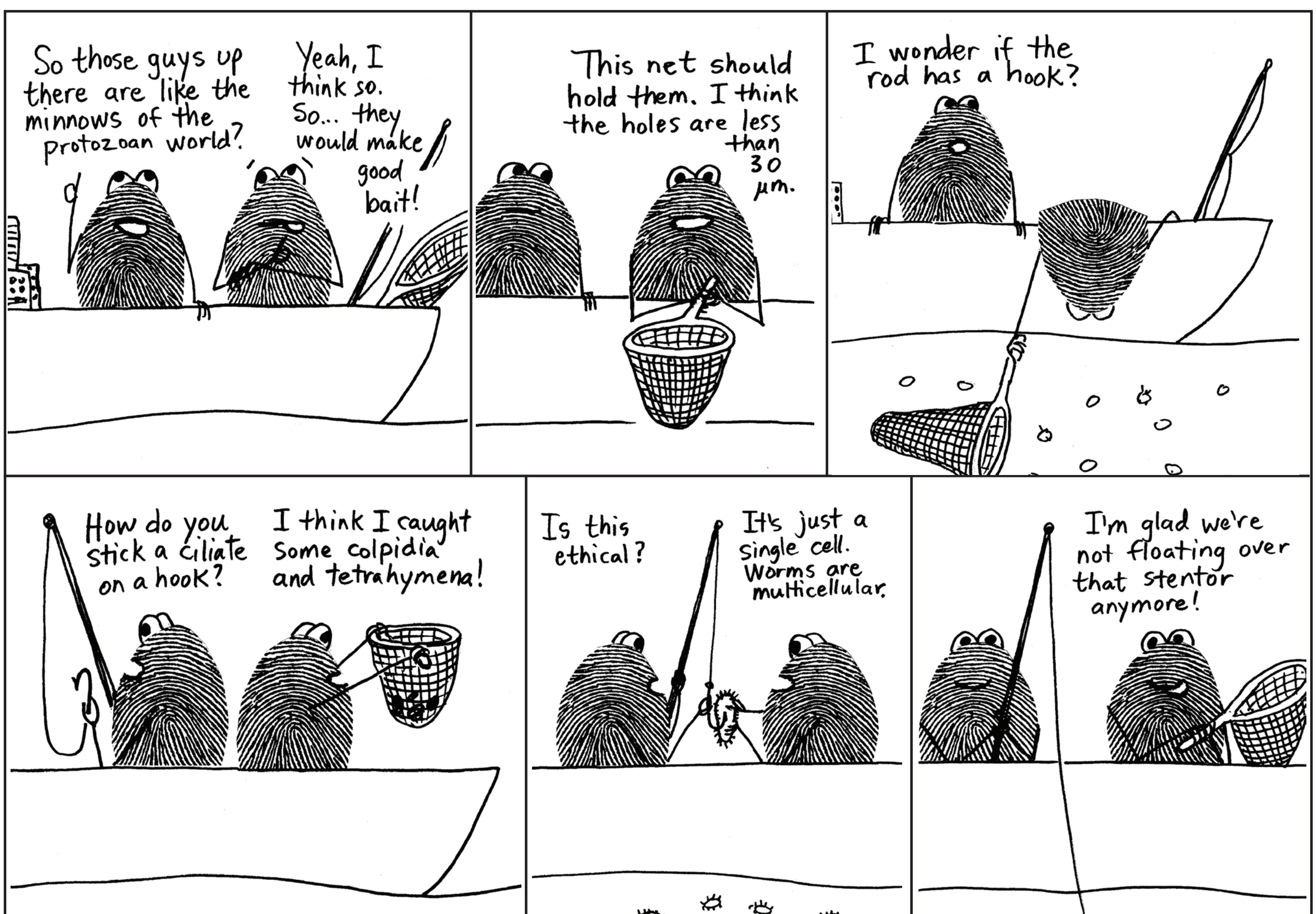
Colpidium *(cole-PID-ee-um)*: A very common ciliate found in most ponds. It looks like a junior version of Paramecium. The name comes from the Greek "kolpos" meaning "gulf." Perhaps Copidium's oral groove area reminded early scientists of a gulf or bay.
About 60 μm

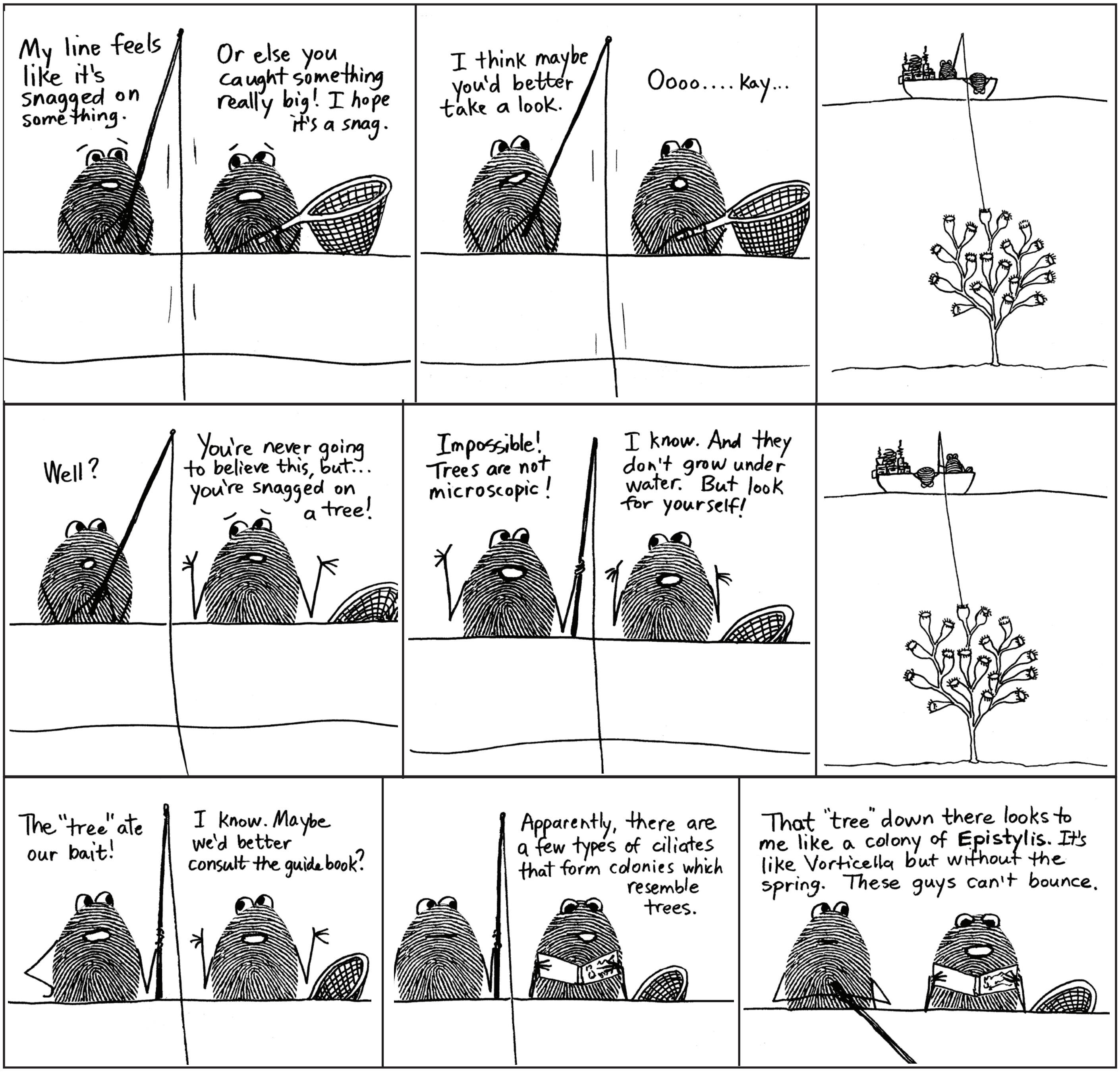


Tetrahymena *(tet-rah-HIE-men-ah)*: Another extremely common ciliate found in many ponds. This ciliate is a favorite of professional cell researchers. Some major discoveries about how cells work were made by studying this ciliate. ("Tetra" is Greek for "four," and "hymen" is Greek for "membrane.")
About 50 μm



Halteria *(hal-TARE-ee-ah)*: Perhaps the smallest ciliate of all. It is known for its swimming speed and its jumping motion. It was named after the weights used by the Greeks in their version of the long jump event. The weights were called "halteres" and were used to counterbalance body weight during the jump.
About 30 μm

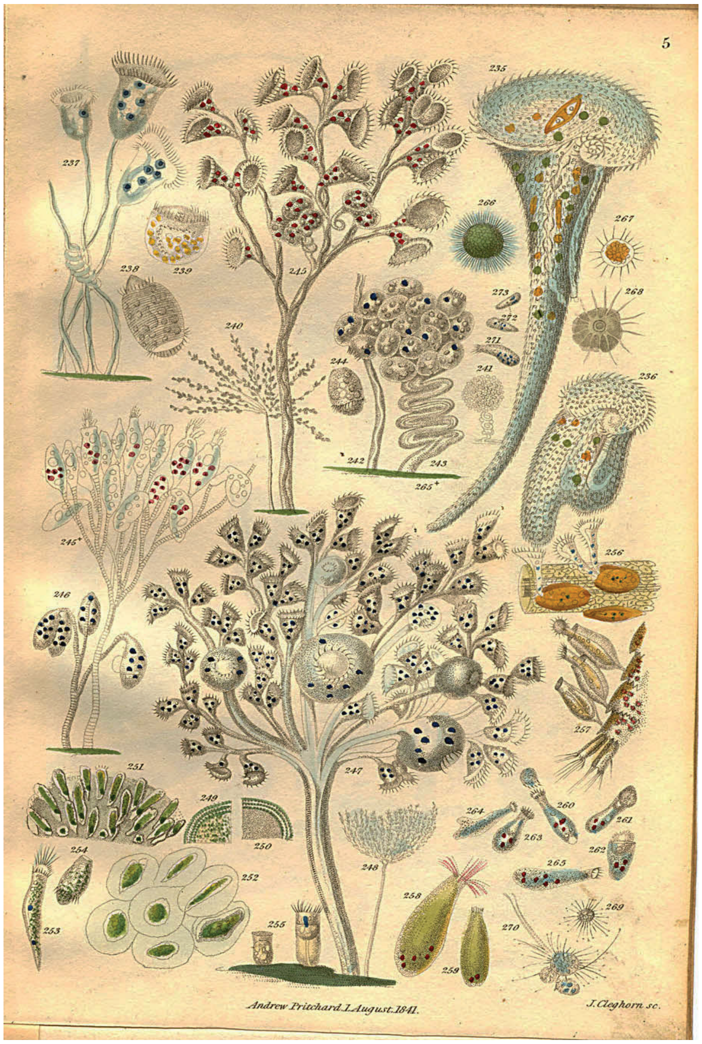


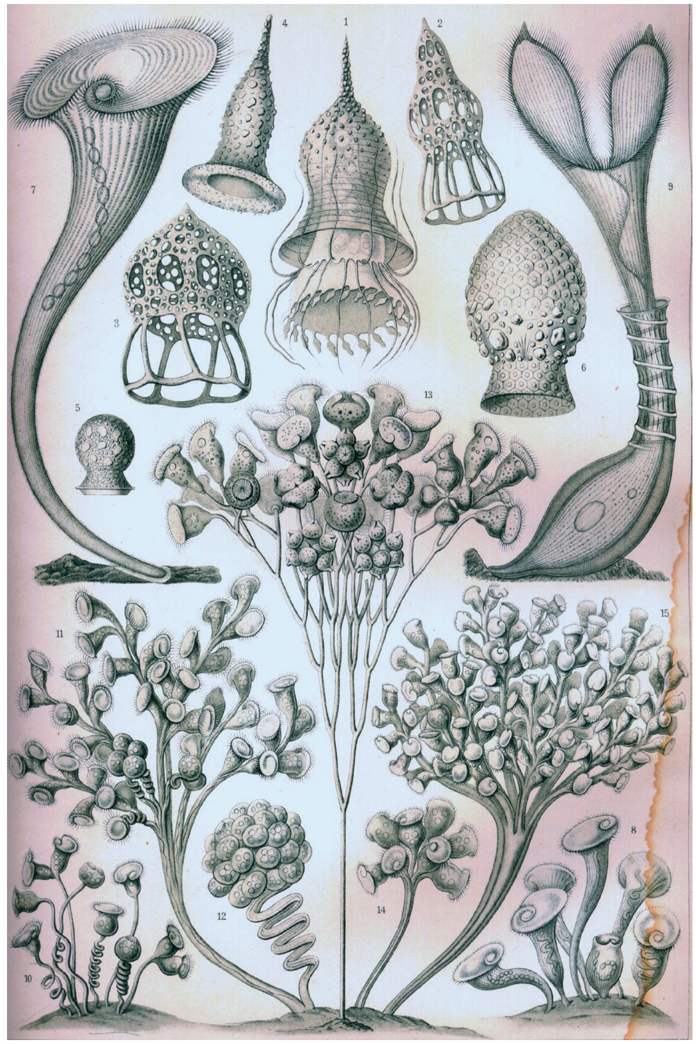


There's one last type of ciliate we really must mention because they are so different from the others. These ciliates form a group called the "Sessilida" because they are ***sessile***. (Remember meeting this word back on the page with the shouting Stentor? It is pronounced *(seh-sill)* and it means "can't move around.")

The particular member of this group that our heroes have discovered here is called ***Epistylis***. You can pronounce it *(ee-PIST-ill-is)* or *(EP-ee-STY-liss)*. It is almost impossible to find a book or website that tells you how to pronounce this word, so choose one of these and go with it. Its name comes from two Greek words: "epi" meaning "upon," and "stulos" meaning "pillar." The cups are attached to "pillars" and can't move.

These ciliates are very much like Vorticella, except that they do not have myoneme fibers. The myonemes are the muscle-like fibers that allow Vorticella, Stentor and Spirostomum to contract quickly. The Epistylis lacks these fibers, so it has to find another reason to be special.





These illustrations were drawn in the mid-1800s. They show ciliates in the group to which Stentor, Vorticella and Epistylis belong.

Epistylis is a single-celled organism so it is capable of living on its own. Each cell is a complete unit, with its own gullet, nucleus (or nuclei), contractile vacuoles, food vacuoles, and other organelles. Technically, it does not NEED other cells. However, it displays ***colonial*** behavior. This means forming protozoan "neighborhoods." The Epistylis cells permanently bond to each other, forming an overall tree-like shape. Why they do this is unknown. There must be an advantage to living this way or they would not do it.

These beautiful illustrations were drawn in the mid-1800s. Scientists had named and classified thousands of protozoans before the year 1900. Regular "light" microscopes were pretty good back in the 1800s! At 100x or 400x, they were just as good as the microscopes we use today. The scientists of the 1800s could see all the organelles and observe the contractile vacuoles squeezing and refilling. They saw the cilia and the trichocysts. They watched the protozoa go through binary fission and conjugation. They knew what each species ate, and what ate them. What they could not possibly know was the structure and function of DNA, and the molecular processes that go on inside the organelles. This knowledge would only come in the later part of the 1900s when electron microscopes were becoming widely available, allowing magnification as high as10,000x. (The discovery of DNA took more than just higher magnification. A type of imaging called x-ray diffraction was necessary, as well as some mathematical analysis.) If you'd like to see more illustrations of protozoans from the 1800s, do a Google search using keywords: "protozoa, Haeckel."

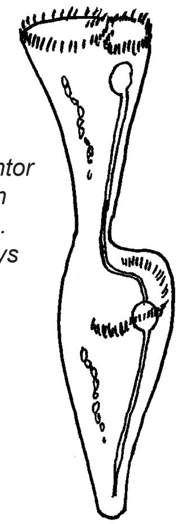
ACTIVITY 2.1 Watch some videos of cilates in action!

Go to the Protozoa playlist on YouTube.com/TheBasementWorkshop and watch all the videos that are listed for Chapter 2. You will get to see most of the ciliates mentioned in this chapter. There is even a video of a Didinium devouring a Paramecium!

ACTIVITY 2.2 Comparative anatomy

Can you match the ciliate part with its equivalent human part? Draw a line between the matches. If you don't find what you think is an exact match, just choose the best answer available.

Ciliate parts:	Human parts:
peduncle	mouth
cilia	inner ear
dorsal side	muscle
buccal cavity	kidneys
myoneme	fingers
contractile vacuole	nose
food vacuole	foot
Müller bodies	stomach
rostrum	back



This is a Stentor going through binary fission. Ciliates always divide end to end, like this.

ACTIVITY 2.3 "Who am I?"

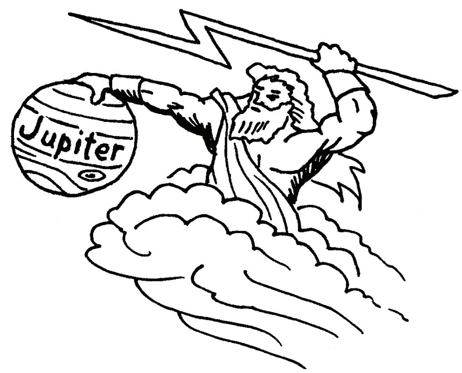
Guess which protozoan is giving you each clue. You can use the same answer more than once.

1) If I am cut up into dozens of pieces, I can grow each piece into a whole new body. ____________
2) I can contract my body to 1/4 its normal size in only 1/200 of a second. __________________
3) Paramecia are my favorite snack. ________________
4) I am a good swimmer, but I can also "walk" along surfaces. ________________
5) I am very tiny and jump about like crazy. _____________
6) I bounce up and down on my very thin peduncle, which can look like a spring. ________________
7) I am cup-shaped and colonial. _________________
8) I know which way is "up." _________________
9) I have a proboscis. ___________________
10) I have a rostrum. _____________________
11) I have two star-shaped contractile vacuoles, and one large macronucleus. __________________
12) I often take in green algae cells which then live happily inside my body for a long time. _____________
13) All my contractile vacuoles are lined up along my dorsal side. ________________
14) I am a favorite of researchers. Many discoveries about cells were made with me. _______________
15) I am long and skinny and do not have any trichocysts. ___________________

Possible answers: Paramecium, Dileptus, Didinium, Loxodes, Spirostomum, Stentor, Vorticella, Epistylis, Euplotes, Tetrahymena, Halteria

ACTIVITY 2.4 ZEUS versus JUPITER, round 2

Here they are, back at it again. Looks like Zeus has the longer list this time. Fill in the blanks below with the English words that contain these Greek or Latin words. In this round, you will also fill in a few of the meanings of the Greek and Latin words. (Also, we tossed in a few extra words.)



GREEK

boskein (to ______) ________________

di (two or twice) ___________, _____________

dinos (whirling) _________________

epi (upon) ____________________

eu (______) ______________

halteres (jumping weights) _____________

hymen (membrane) ________________

kolpos (gulf) _________________

leptus (thin) __________________

plos (swim/swimmer) _______________

pro (____) __________, ______________

*speira (coil) _________________

stoma (_______) ___________, _______________

stulos (pillar) __________________

tetra (______) ___________________

toxon (bow that shoots arrows) _________ (pg 16)

LATIN

bucca (mouth or cheek) ______________

carn (________) ________________

dorsum (_________) _____________

pedis (_______) _________________

rostrum (_______) _______________

sessilis (sitting, to be sat on) ___________

*spira (coil) ______________

vorare (to _____) _______________

vortex (vortex) ______________

Greek “halteres” jumping weight (carved from stone)

* Notice that you can trace the word “spiral” back to both Latin and Greek.

* *

Review: Can you remember the meanings of these Greek words?

1) zoion _______	4) kystis ________	7) mitos __________
2) skopos __________	5) tricho ________	8) kytos __________
3) soma _________	6) con ________	9) protos _________

Possible answers: first, with, hair, animal, to watch, body, bag, thread, container