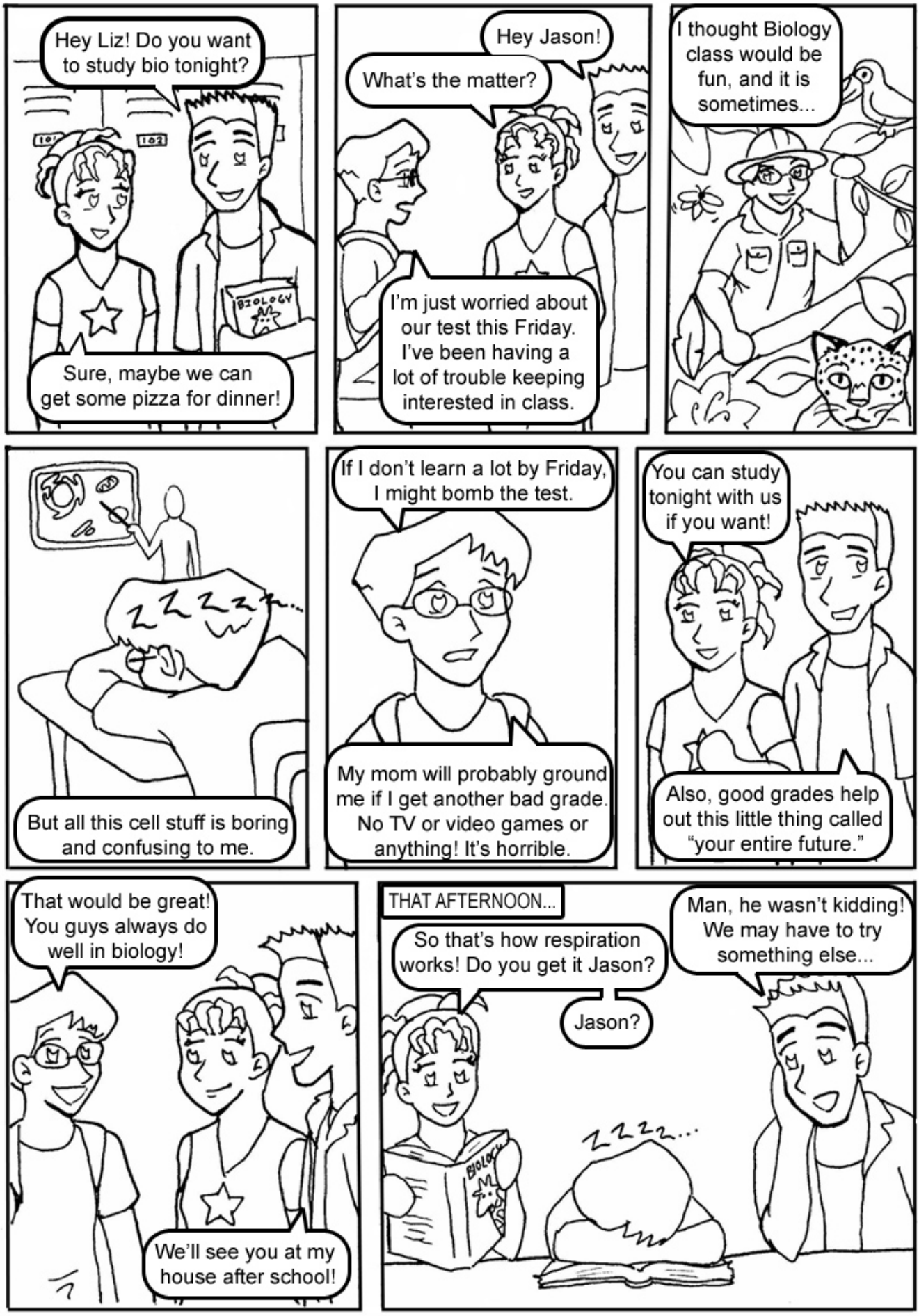

Hey Liz! Do you want to study bio tonight?
101
102
BIOLOGY
Sure, maybe we can get some pizza for dinner!
Hey Jason!
What's the matter?
I'm just worried about our test this Friday. I've been having a lot of trouble keeping interested in class.
I thought Biology class would be fun, and it is sometimes...
But all this cell stuff is boring and confusing to me.
If I don't learn a lot by Friday, I might bomb the test.
My mom will probably ground me if I get another bad grade. No TV or video games or anything! It's horrible.
You can study tonight with us if you want!
Also, good grades help out this little thing called "your entire future."
That would be great! You guys always do well in biology!
We'll see you at my house after school!
THAT AFTERNOON...
So that's how respiration works! Do you get it Jason?
Jason?
BIOLOGY
Man, he wasn't kidding! We may have to try something else...

Jason! Jason! Wake up!

Is he okay?

Yeah, just lazy.

Ugh... where am I?

Your guess is as good as mine. Sometime after you dozed off, there was a bright flash and a crazy, evil voice that said...

... "Beat the video game if you want to live!"

And now we're here - if this is a video game, it's a strange one!

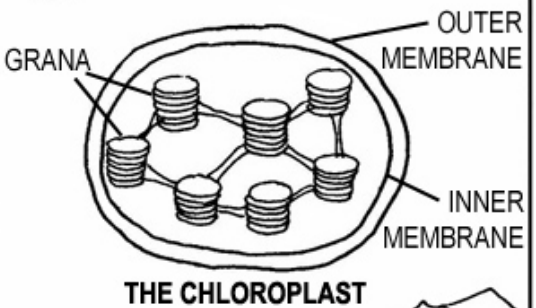
What are those things? They look like giant green pancakes...?

Oh! I know where we are!

The weirdest IHOP ever?

No, we must be inside a cell! Specifically, we're in a chloroplast!

You're right... it does look like a chloroplast. The stacked things must be the grana!



THE CHLOROPLAST

A video game in a chloroplast. This is punishment for me being a bad student, isn't it?

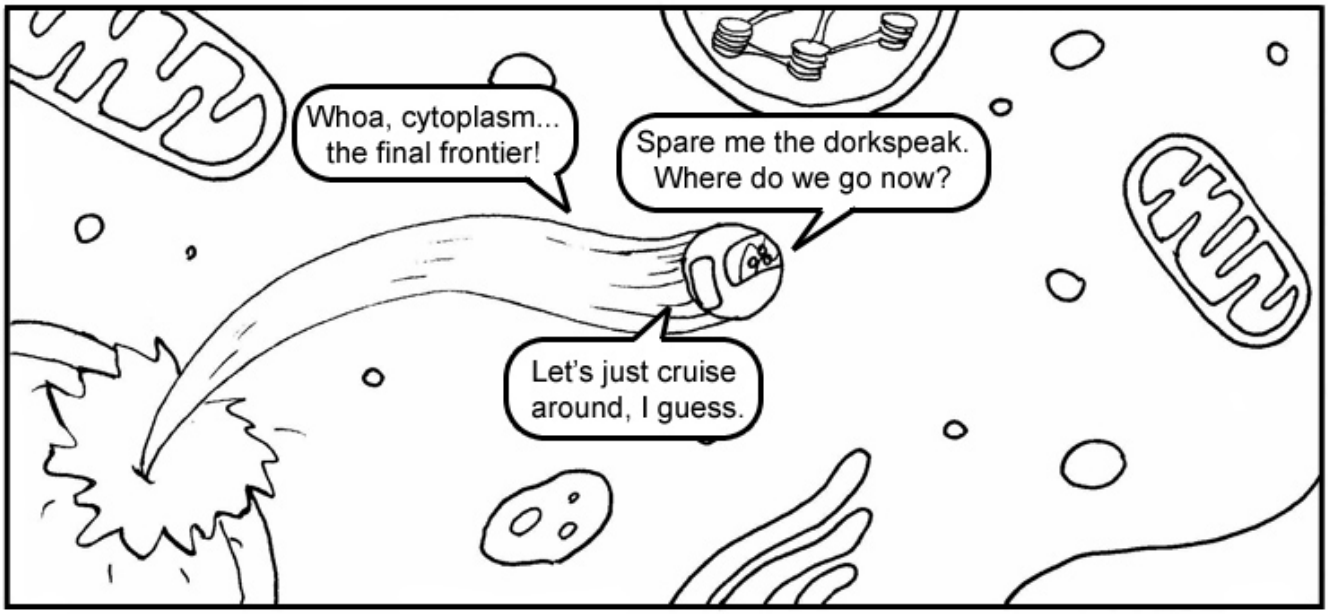
Oh come on, Jason! Learning some stuff before the test can't hurt!

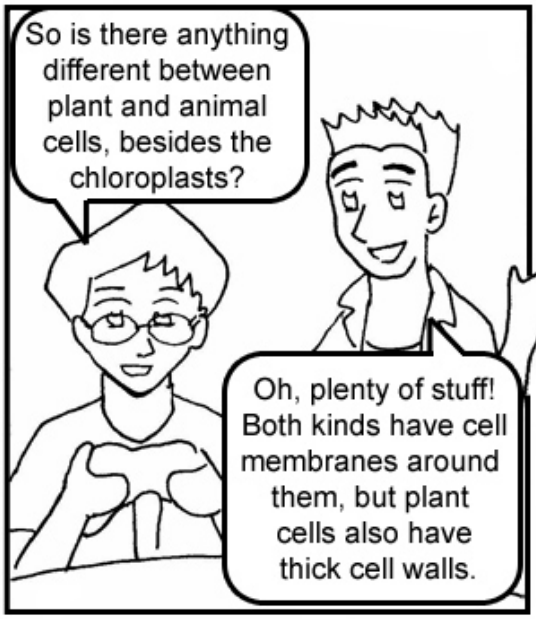
Yeah, I suppose I'll learn more than I was drooling on the table.

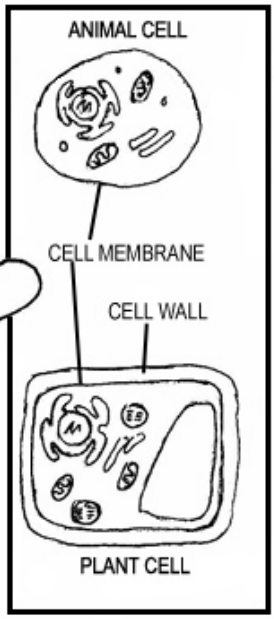
No one's taking any tests until we figure out this game! Where do we even start??

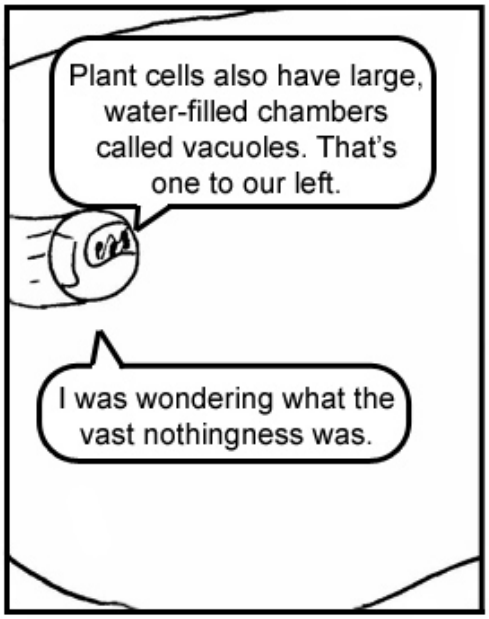

In the role-playing games I have, you don't always know what to do at first.
So how do we find out?
Well generally you ask the people you meet annoying questions and collect stuff.
Whoa, like that! What is that?!
ATP
Got it!
An ATP!
Yes, I can read... but what does that mean??
ATP is the energy unit of the cell.
Oh yeah... it powers a lot of reactions, right?
Yes, reactions that are necessary for the cell to grow and survive!
The chloroplast makes some ATP during photosynthesis. Since plants can't eat, they use photosynthesis to make their own food energy.
Photosynthesis involves light, right?
Right. Those zig-zag things must be photons, packets of light energy. Plants convert energy from the sun into sugars, which it can store for later use.
The photons are absorbed by chlorophyll - a pigment that gives plants their green color.
chlorophyll
The chlorophyll uses the energy from the photon to help produce the six-sided rings of the sugar molecules. Carbon dioxide is used in the reaction, and oxygen is released afterwards.
And when we eat plants, we get energy from the sugars too!
While you guys were discussing the wonders of biology, I caught more ATP!
We're very proud of you.

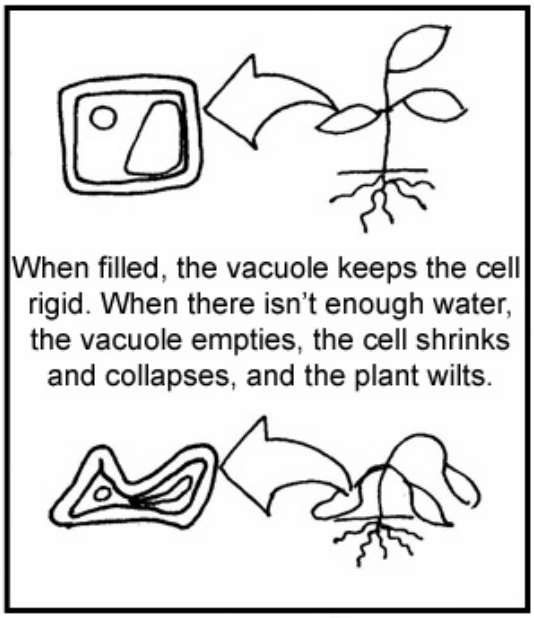

So Jason, you're the game expert. What do we do with these?
Oh, we might not know that until a lot later. We might not need them at all, actually.
Might not need...? You mean I just ran around...
Role-playing games are lame.
Hey guys, there's a store over there... for some reason.
A store in a cell? Well in a game I suppose anything goes.
Do they take ATP?
MARTY'S
Welcome to Marty's Cell Emporium! Can I interest you in some chlorophyll, or maybe in a used vesicle? Like New! Only 8 ATP!
Jackpot!
We'll take it! Luis, pay the man.
What do we need that for?
Vesicles transport various particles around the cell. Hopefully this one will transport us!
Oh yeah, I remember now. They're like bubbles made out of cell membrane?
Yeah, they usually break off from larger organelles.
They don't usually have windows or doors, I imagine...?
Oh sweet! PS2 steering!
Yeah, this was definitely meant for Jason to drive.
This thing is awesome!
Slow down!
RAR!
Well we have to speed up if we're going to make it through the walls!
Now I know how buyer's remorse feels!

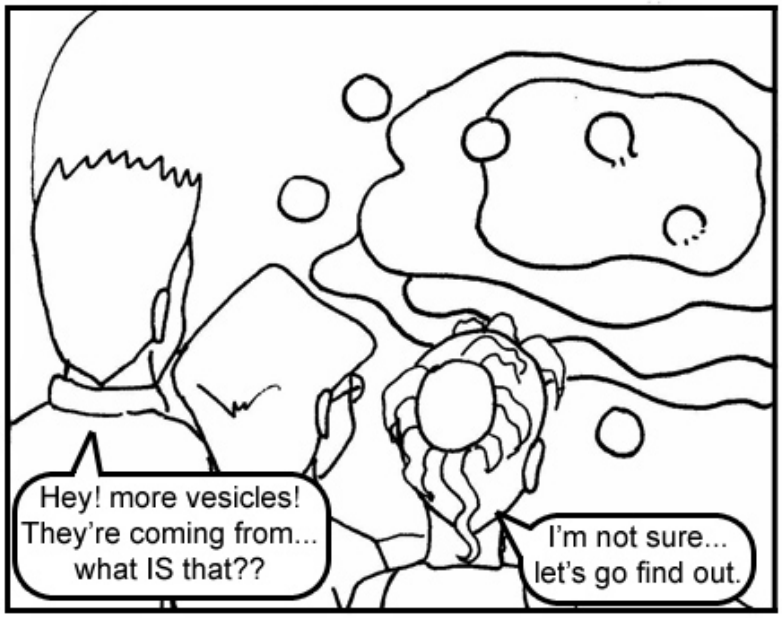

Whoa, cytoplasm... the final frontier!
Spare me the dorkspeak. Where do we go now?
Let's just cruise around, I guess.

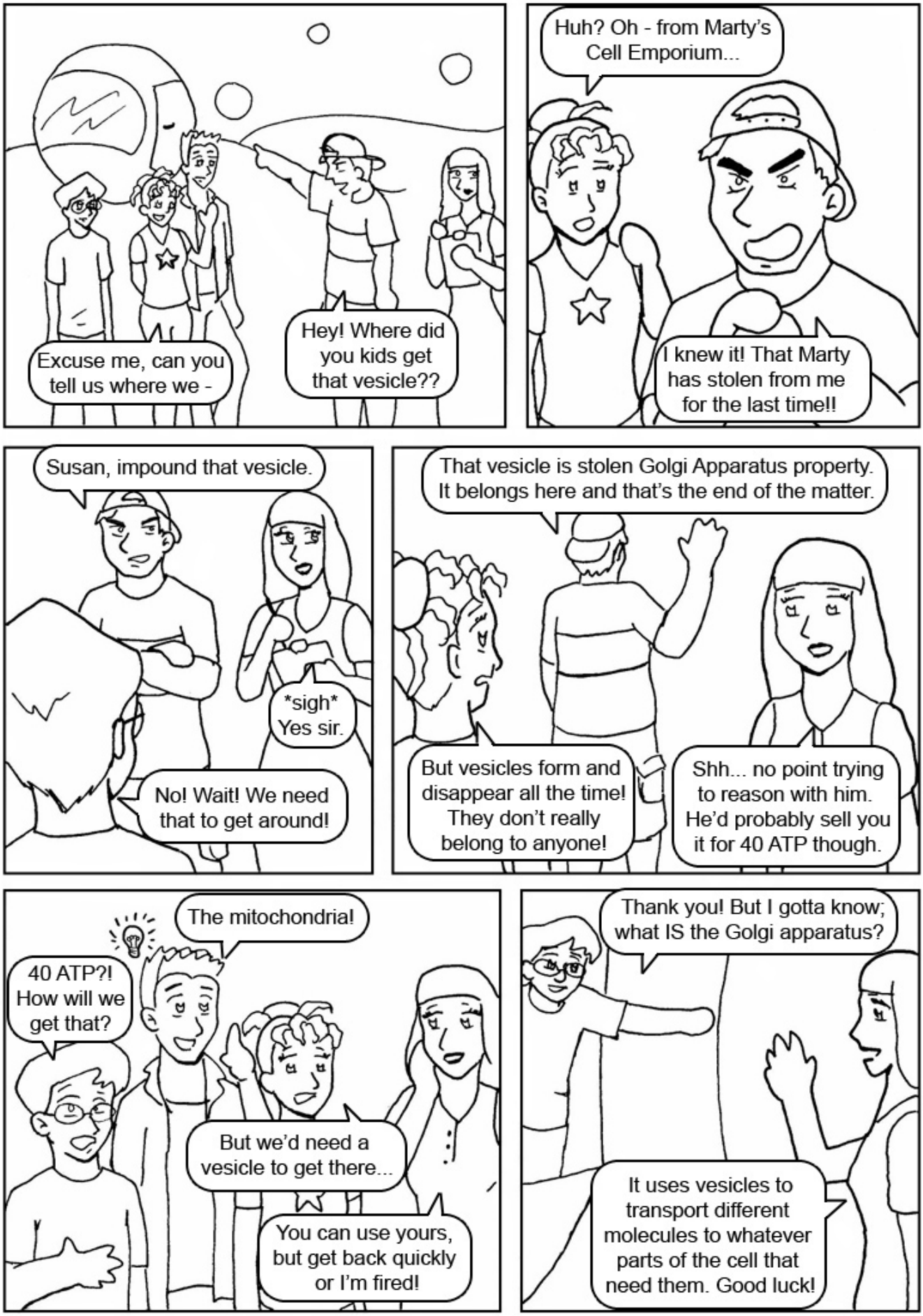

So is there anything different between plant and animal cells, besides the chloroplasts?
Oh, plenty of stuff! Both kinds have cell membranes around them, but plant cells also have thick cell walls.

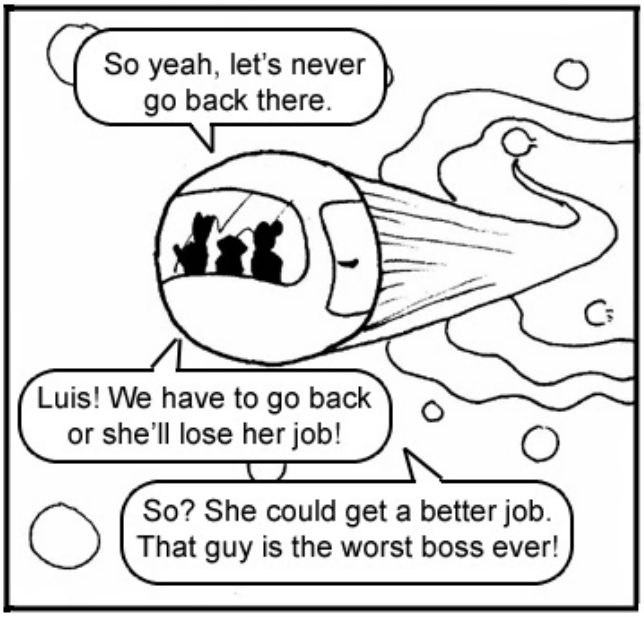

ANIMAL CELL
CELL MEMBRANE
CELL WALL
PLANT CELL

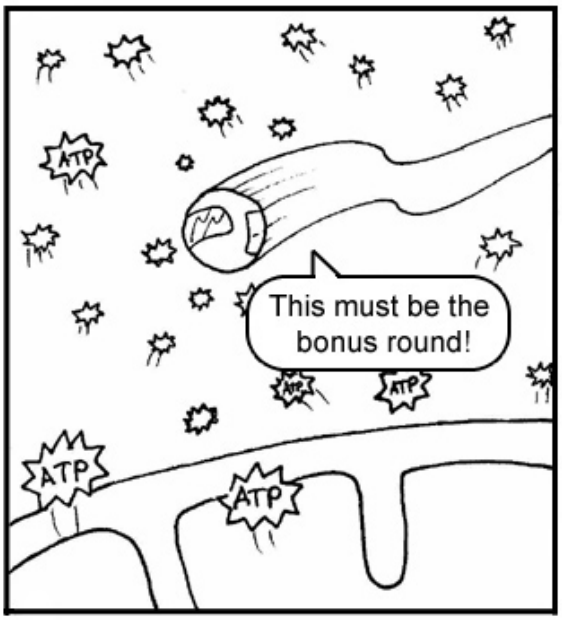

Plant cells also have large, water-filled chambers called vacuoles. That's one to our left.
I was wondering what the vast nothingness was.

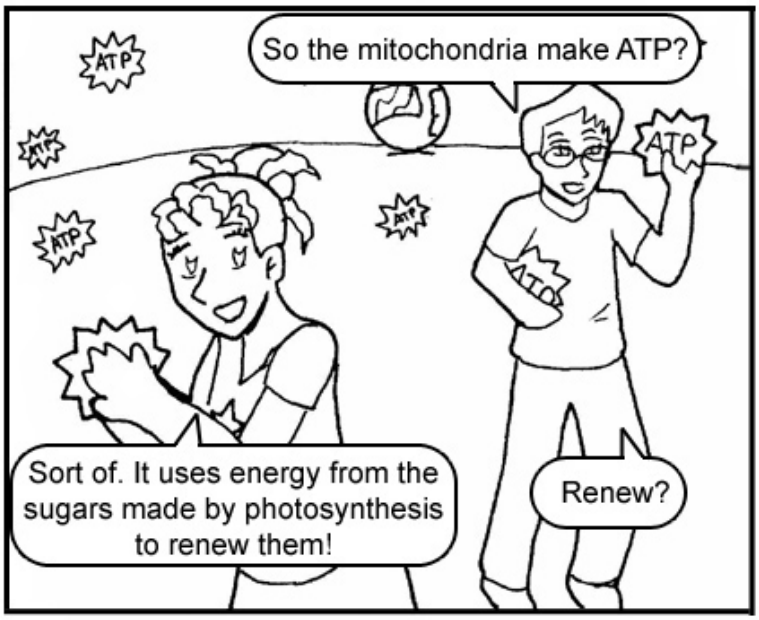

When filled, the vacuole keeps the cell rigid. When there isn't enough water, the vacuole empties, the cell shrinks and collapses, and the plant wilts.


Hey! more vesicles! They're coming from... what IS that??
I'm not sure... let's go find out.

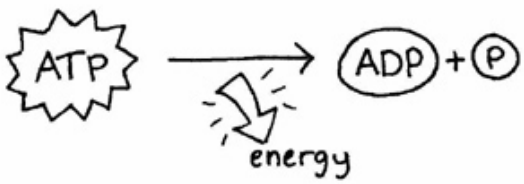

Excuse me, can you tell us where we -
Hey! Where did you kids get that vesicle??
Huh? Oh - from Marty's Cell Emporium...
I knew it! That Marty has stolen from me for the last time!!
Susan, impound that vesicle.
sigh Yes sir.
No! Wait! We need that to get around!
That vesicle is stolen Golgi Apparatus property. It belongs here and that's the end of the matter.
But vesicles form and disappear all the time! They don't really belong to anyone!
Shh... no point trying to reason with him. He'd probably sell you it for 40 ATP though.
The mitochondria!
40 ATP?! How will we get that?
But we'd need a vesicle to get there...
You can use yours, but get back quickly or I'm fired!
Thank you! But I gotta know; what IS the Golgi apparatus?
It uses vesicles to transport different molecules to whatever parts of the cell that need them. Good luck!





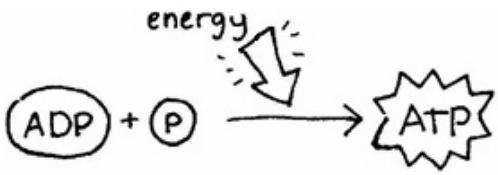


Well, ATP stands for Adenosine Triphosphate, meaning it had three phosphorus atoms.



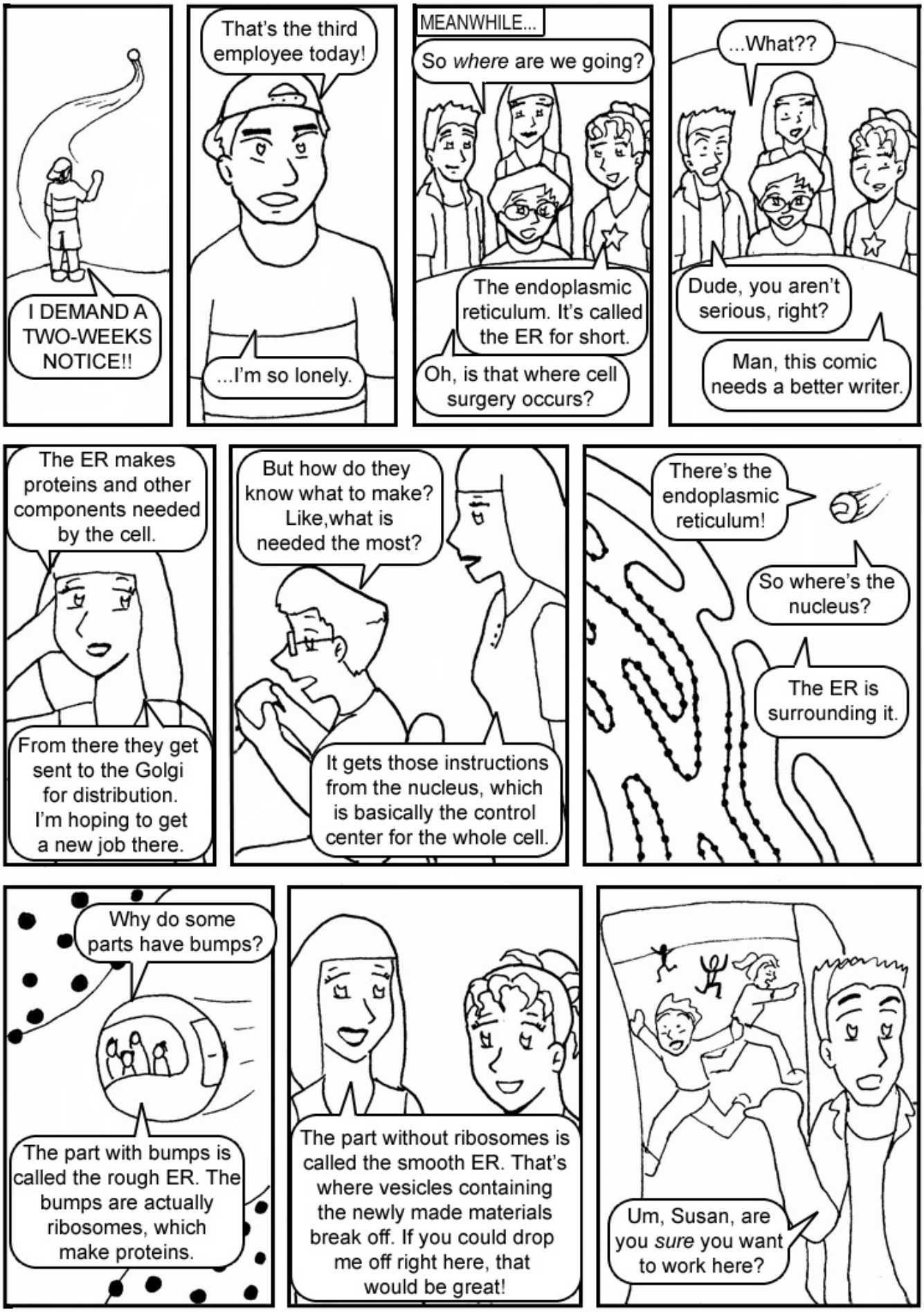
By breaking the bond of one phosphorus, it releases the energy that was in the bond. Then it becomes ADP - Adenosine Diphosphate. It's that released energy that makes reactions all over the cell possible.

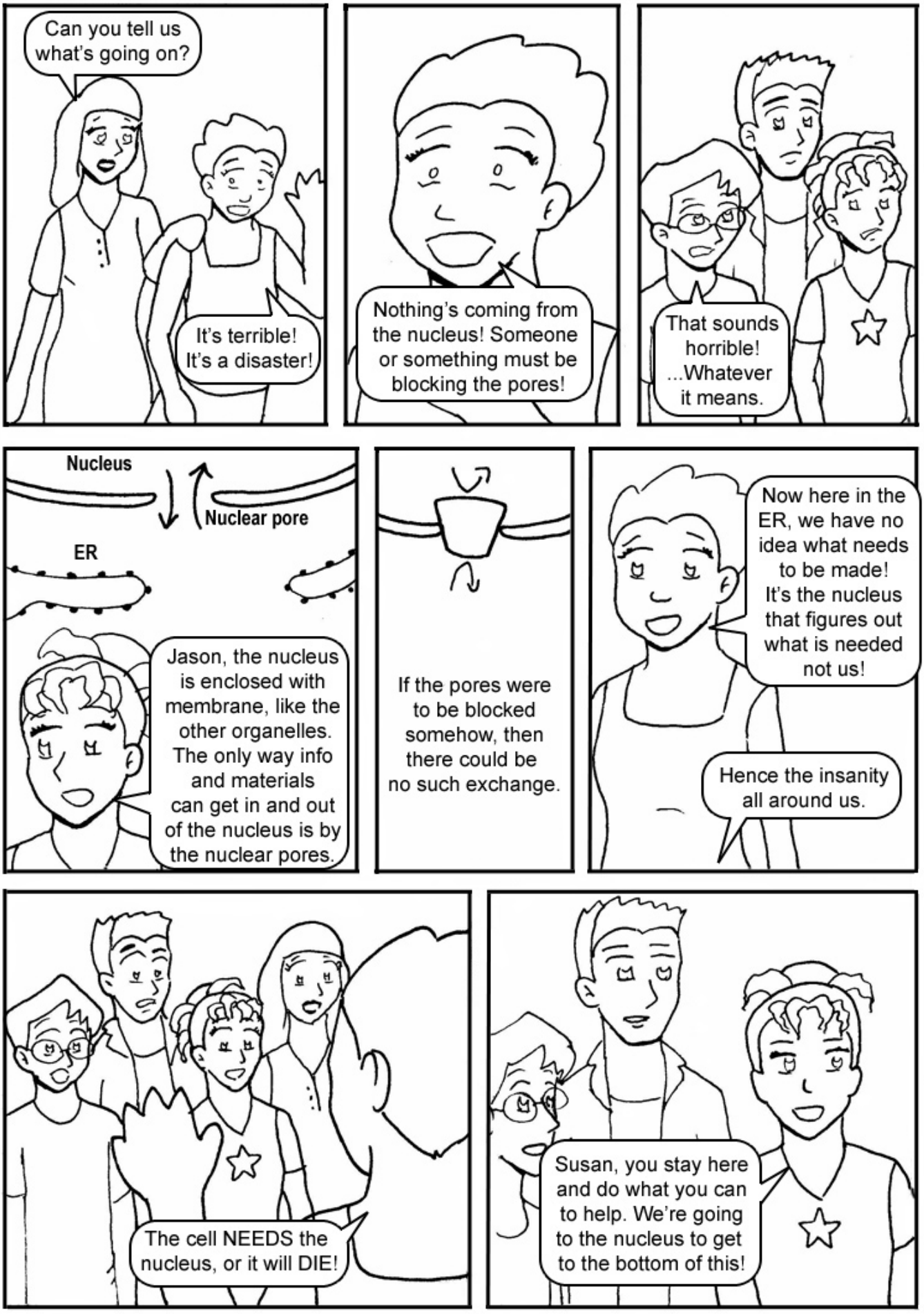
But to make more ATP, energy needs to be put back into the bond between ADP and the third phosphorus atom.



The mitochondria get that energy from the molecules in a process called respiration. The respiration reactions take place within the wrinkles inside the mitochondria, which has two membranes, like chloroplasts do.

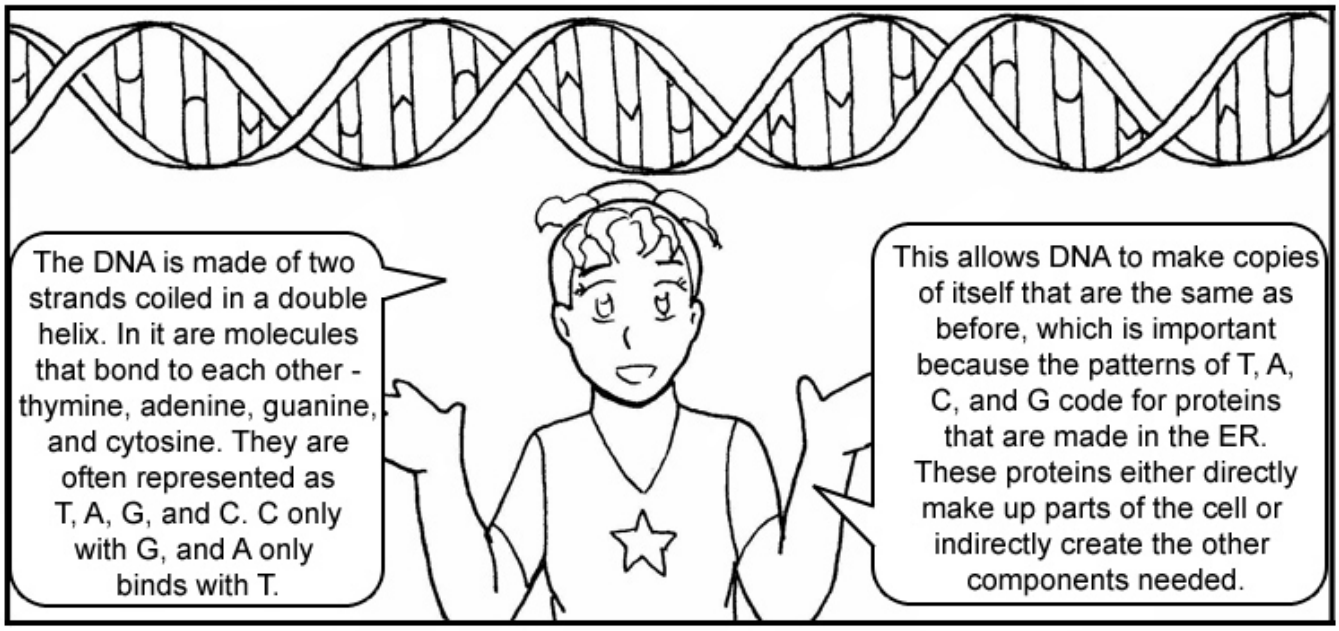

Good! Almost enough.
Hey Luis, is cellular respiration related to the breathing kind of respiration?
Absolutely!
The oxygen we breathe in is used in the mitochondria in ATP making reactions.
And the carbon dioxide we exhale is a product of those reactions.
So carbon dioxide is used in photosynthesis, which releases oxygen...
...and oxygen is used in respiration, which makes carbon dioxide...
...I think I understand how the world works.
What's up with Jason?
Either he's having an epiphany or he's realizing he forgot to flush.
Just drag him in here. We're ready to go!
A TRIP AND A BUSINESS TRANSACTION LATER...
Err, okay, I guess you can have it.
Thank you.
Now get lot, ya lousy kids.
Thanks again, Susan!
Is there anything we can do for you?
Well, can you give me a ride to the endoplasmic reticulum?
Sure!
Cool.
Find somebody else to treat like dirt because I QUIT!
Yay! I told you!
Oh shut up Luis.

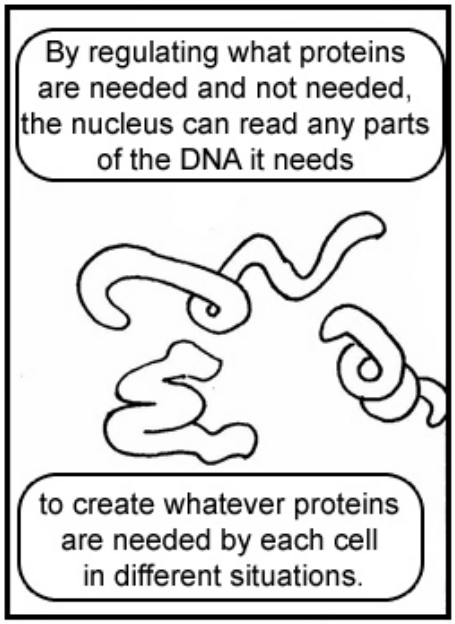

I DEMAND A TWO-WEEKS NOTICE!!
That's the third employee today!
...I'm so lonely.
MEANWHILE...
So *where* are we going?
The endoplasmic reticulum. It's called the ER for short.
Oh, is that where cell surgery occurs?
...What??
Dude, you aren't serious, right?
Man, this comic needs a better writer.
The ER makes proteins and other components needed by the cell.
From there they get sent to the Golgi for distribution. I'm hoping to get a new job there.
But how do they know what to make? Like,what is needed the most?
It gets those instructions from the nucleus, which is basically the control center for the whole cell.
There's the endoplasmic reticulum!
So where's the nucleus?
The ER is surrounding it.
Why do some parts have bumps?
The part with bumps is called the rough ER. The bumps are actually ribosomes, which make proteins.
The part without ribosomes is called the smooth ER. That's where vesicles containing the newly made materials break off. If you could drop me off right here, that would be great!
Um, Susan, are you *sure* you want to work here?

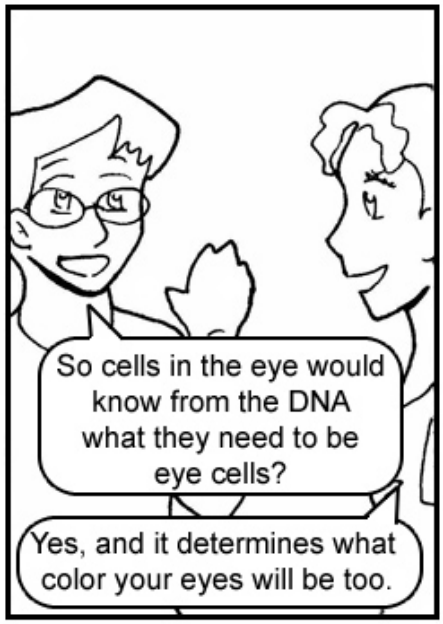

Can you tell us what's going on?
It's terrible! It's a disaster!
Nothing's coming from the nucleus! Someone or something must be blocking the pores!
That sounds horrible! ...Whatever it means.
Nucleus
Nuclear pore
ER
Jason, the nucleus is enclosed with membrane, like the other organelles. The only way info and materials can get in and out of the nucleus is by the nuclear pores.
If the pores were to be blocked somehow, then there could be no such exchange.
Now here in the ER, we have no idea what needs to be made! It's the nucleus that figures out what is needed not us!
Hence the insanity all around us.
The cell NEEDS the nucleus, or it will DIE!
Susan, you stay here and do what you can to help. We're going to the nucleus to get to the bottom of this!


INSIDE THE ER...
I don't understand how the nuclear pores could be clogged, though.
Don't worry Liz, video games always have "exciting" twists!
Hey! I *know* you just used sarcasm quotations!!
Here's a pore, but it's not clogged!
Well I suppose we should go through it then!
Oh my.
See? An evil wizard! How original!


Hey! What are you doing to that DNA!
Ah! I'm glad you finally made it!
That voice...!
You're the one who put us in this game!
Yes I am! And you've made it just in time...
... because I am about to extract from this DNA the very secrets of life that I need to become IMMORTAL!
What you're doing is killing the cell!
So what do I care? I'm evil!
Really? I couldn't tell.
Ah, the eyebrows gave it away didn't they? They kicked me out of my own video game for being too obvious. So I decided to make my own game in this cell, and I must say, you've all done a great job playing it!
So what was the POINT of the game? To make us as crazy as you?
Maybe. Or maybe it was a test to see if you were worthy of gaining immortality!
Yes, I'm still not understanding how you plan to do that.
The DNA is the cell's blueprint - if I can break the code, I will know EVERYTHING about life!
But that's not how DNA works! It has a code, but it doesn't hold a secret message!


The DNA is made of two strands coiled in a double helix. In it are molecules that bond to each other - thymine, adenine, guanine, and cytosine. They are often represented as T, A, G, and C. C only with G, and A only binds with T.
This allows DNA to make copies of itself that are the same as before, which is important because the patterns of T, A, C, and G code for proteins that are made in the ER. These proteins either directly make up parts of the cell or indirectly create the other components needed.


By regulating what proteins are needed and not needed, the nucleus can read any parts of the DNA it needs
to create whatever proteins are needed by each cell in different situations.


So cells in the eye would know from the DNA what they need to be eye cells?
Yes, and it determines what color your eyes will be too.


So the secret to life isn't IN the DNA , it IS the DNA!
And by messing with it, you're doing nothing but disrupting the cell's functions!


Hmm, you kids may have a point...
However, I do have being corrected.


So prepare to DIE!


AAAAAAHH!!!
Luis, do you have any ATP left??
Yeah, why?!
Throw it at his staff! Maybe its energy will break it!
I'VE GOT YOU NOW!!!
I don't think it works that way-
Just do it!!
ATP
ATP
KA-SMASH!
Noo! How did you ever think to do that???
Why did you stupidly program that weakness into your own game?
P
ADP
Yeah, that was kinda dumb.


A SHORT WHILE LATER...
You've saved us all! How can we ever repay you?
Oh, it was nothing, really!
We won!
Yay Jason!
We won!
Jason...
Jason?
...we won...
Uh, that's good I guess!
Man, you were really out!
I had the weirdest dream. You were both there - in the plant cell - but it was really a video game in a cell full of people -
....and we fought an evil wizard in the nucleus!!
Maybe you should go home and get MORE rest.
We could study more tomorrow if you want.
No way! I'm ready to learn more about the cell and I better do it while I'm motivated!
Well, okay then. But let's eat first; I'm starving!
Strange though... it seemed so real!
Think he's onto us?
Nah.