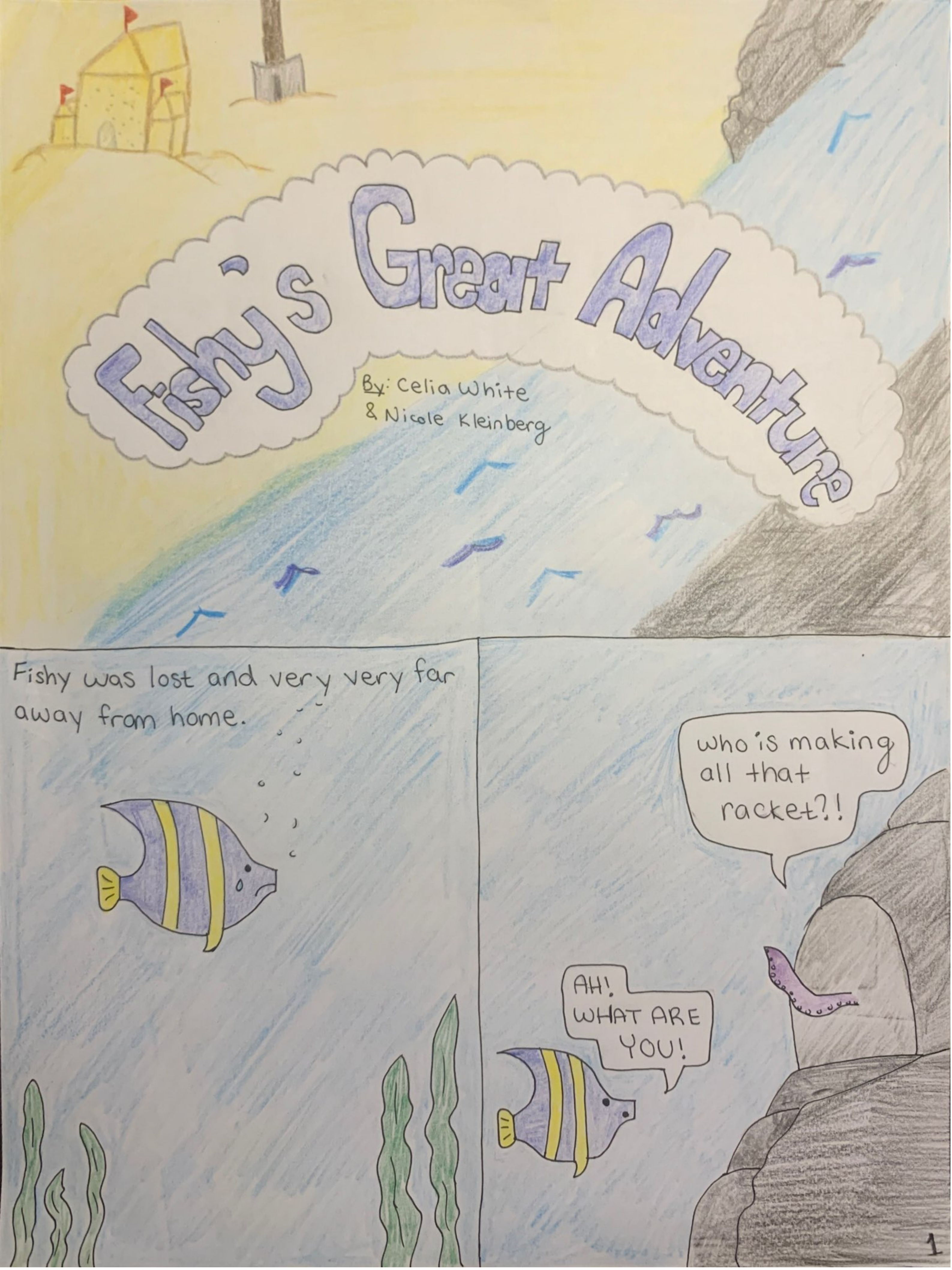
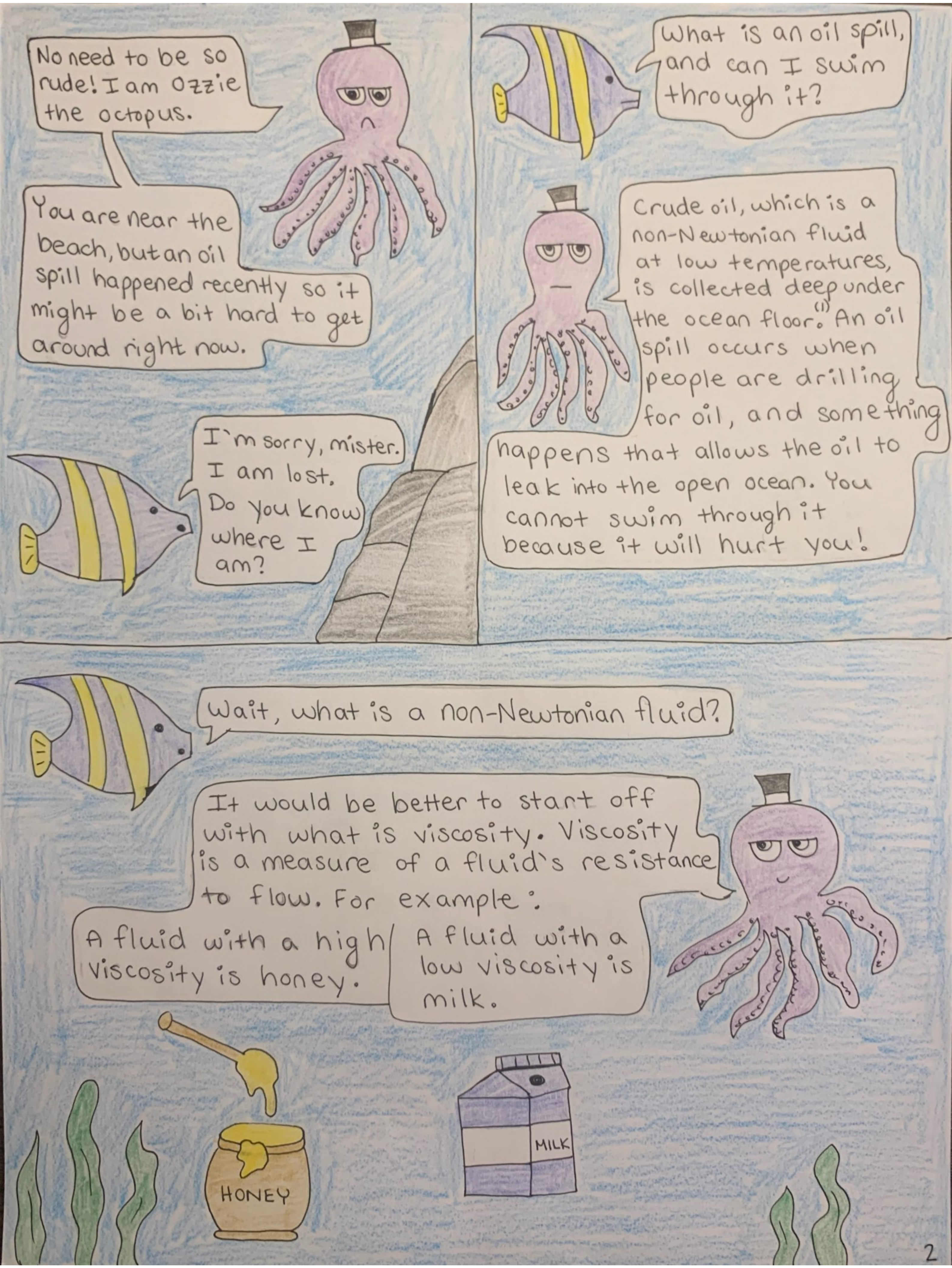
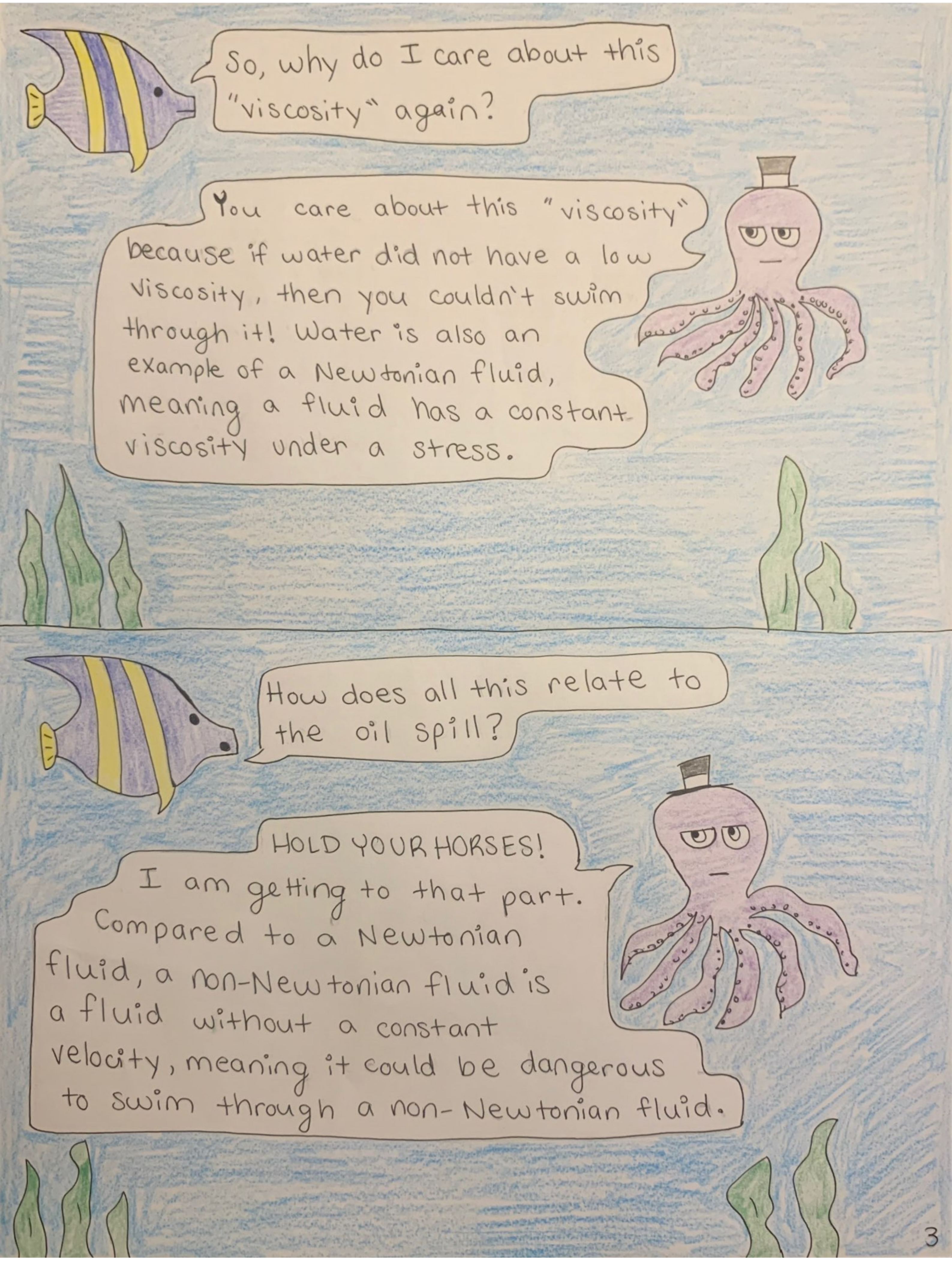
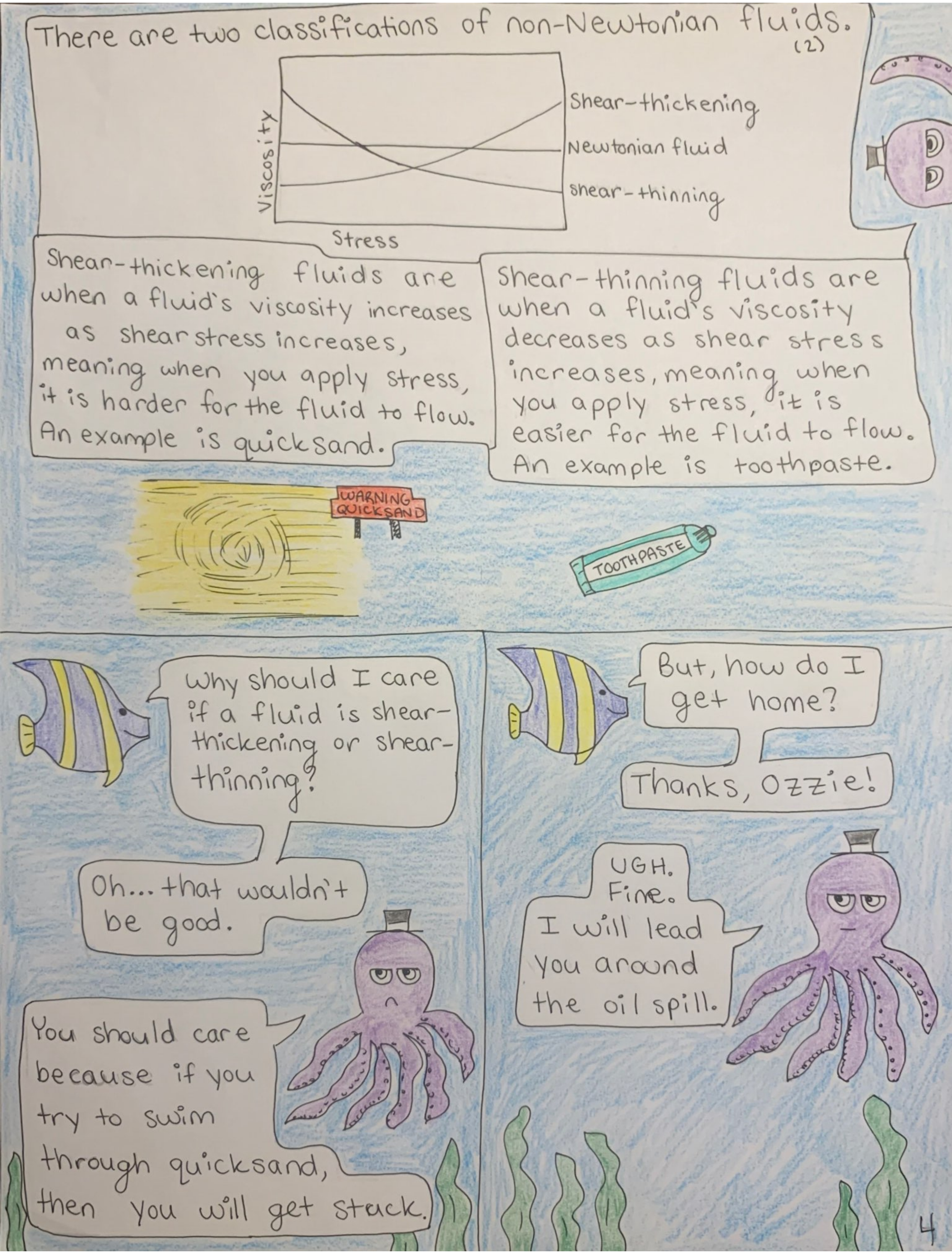
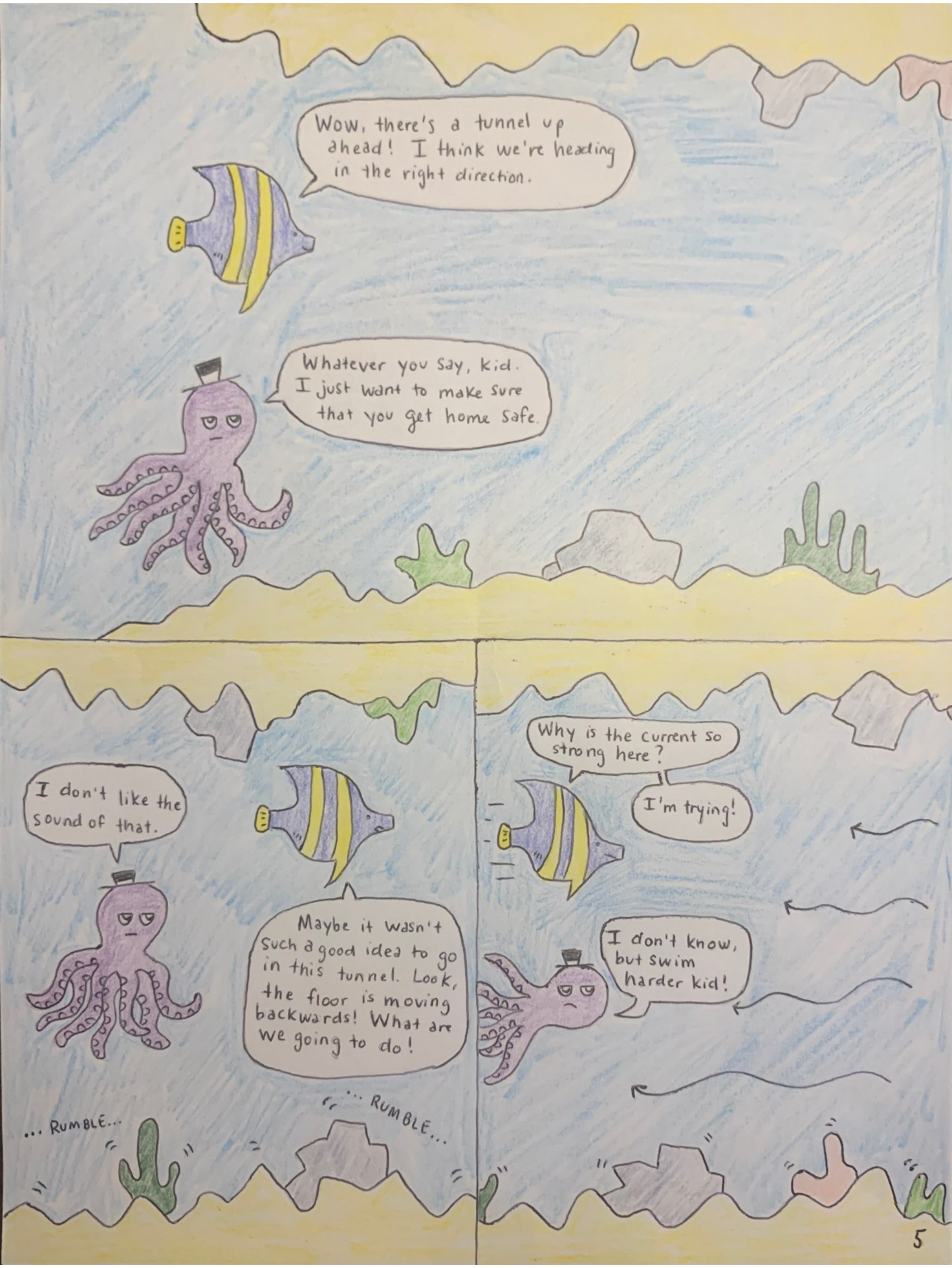

Fishy's Great Adventure
By: Celia White
& Nicole Kleinberg
Fishy was lost and very very far away from home.
who is making all that racket?!
AH! WHAT ARE YOU!


No need to be so rude! I am Ozzie the octopus.
You are near the beach, but an oil spill happened recently so it might be a bit hard to get around right now.
I'm sorry, mister. I am lost. Do you know where I am?
What is an oil spill, and can I swim through it?
Crude oil, which is a non-Newtonian fluid at low temperatures, is collected deep under the ocean floor.[1] An oil spill occurs when people are drilling for oil, and something happens that allows the oil to leak into the open ocean. You cannot swim through it because it will hurt you!
Wait, what is a non-Newtonian fluid?
It would be better to start off with what is viscosity. Viscosity is a measure of a fluid's resistance to flow. For example:
A fluid with a high viscosity is honey.
A fluid with a low viscosity is milk.
HONEY
MILK

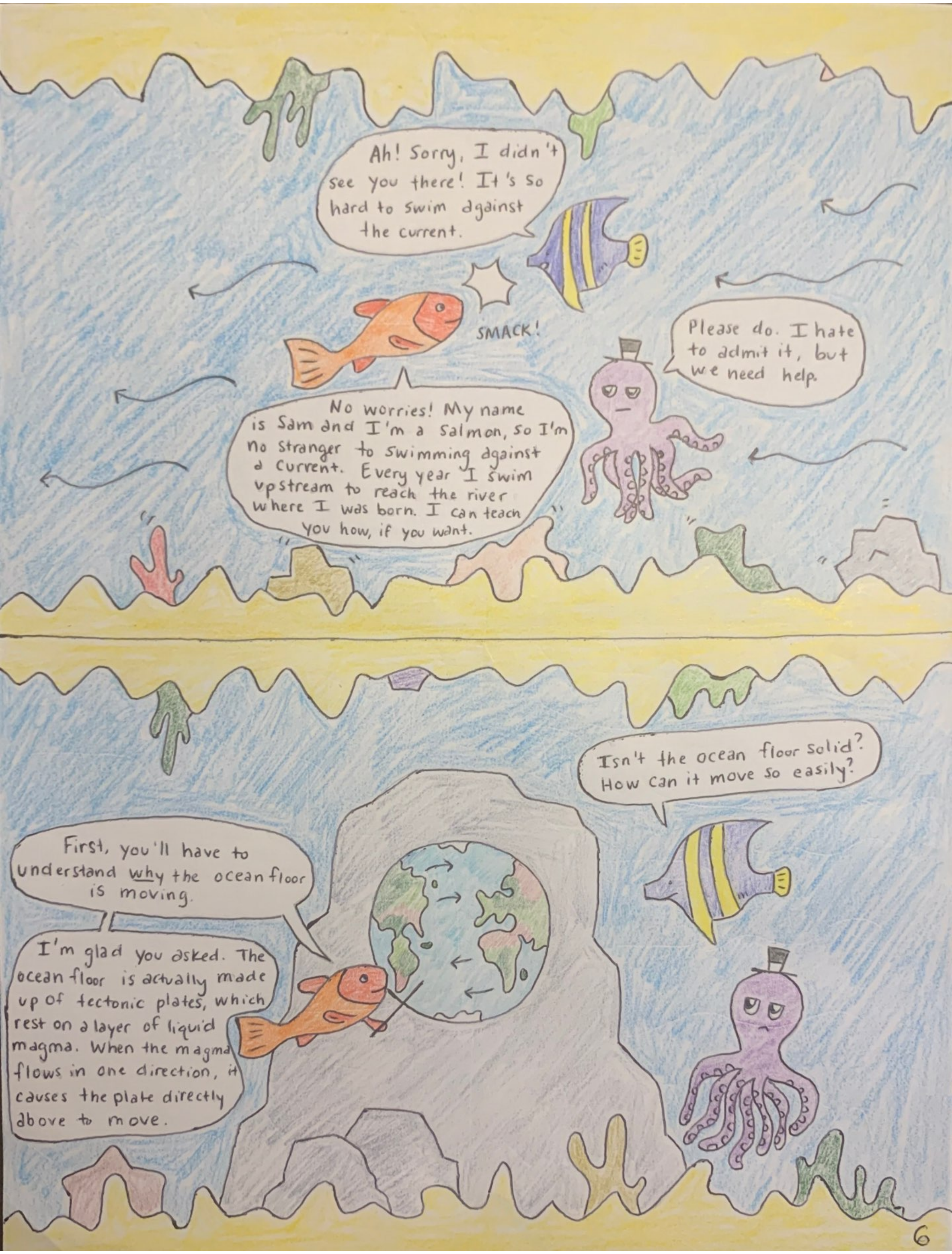

So, why do I care about this "viscosity" again?
You care about this "viscosity" because if water did not have a low viscosity, then you couldn't swim through it! Water is also an example of a Newtonian fluid, meaning a fluid has a constant viscosity under a stress.
How does all this relate to the oil spill?
HOLD YOUR HORSES! I am getting to that part. Compared to a Newtonian fluid, a non-Newtonian fluid is a fluid without a constant velocity, meaning it could be dangerous to swim through a non-Newtonian fluid.
3



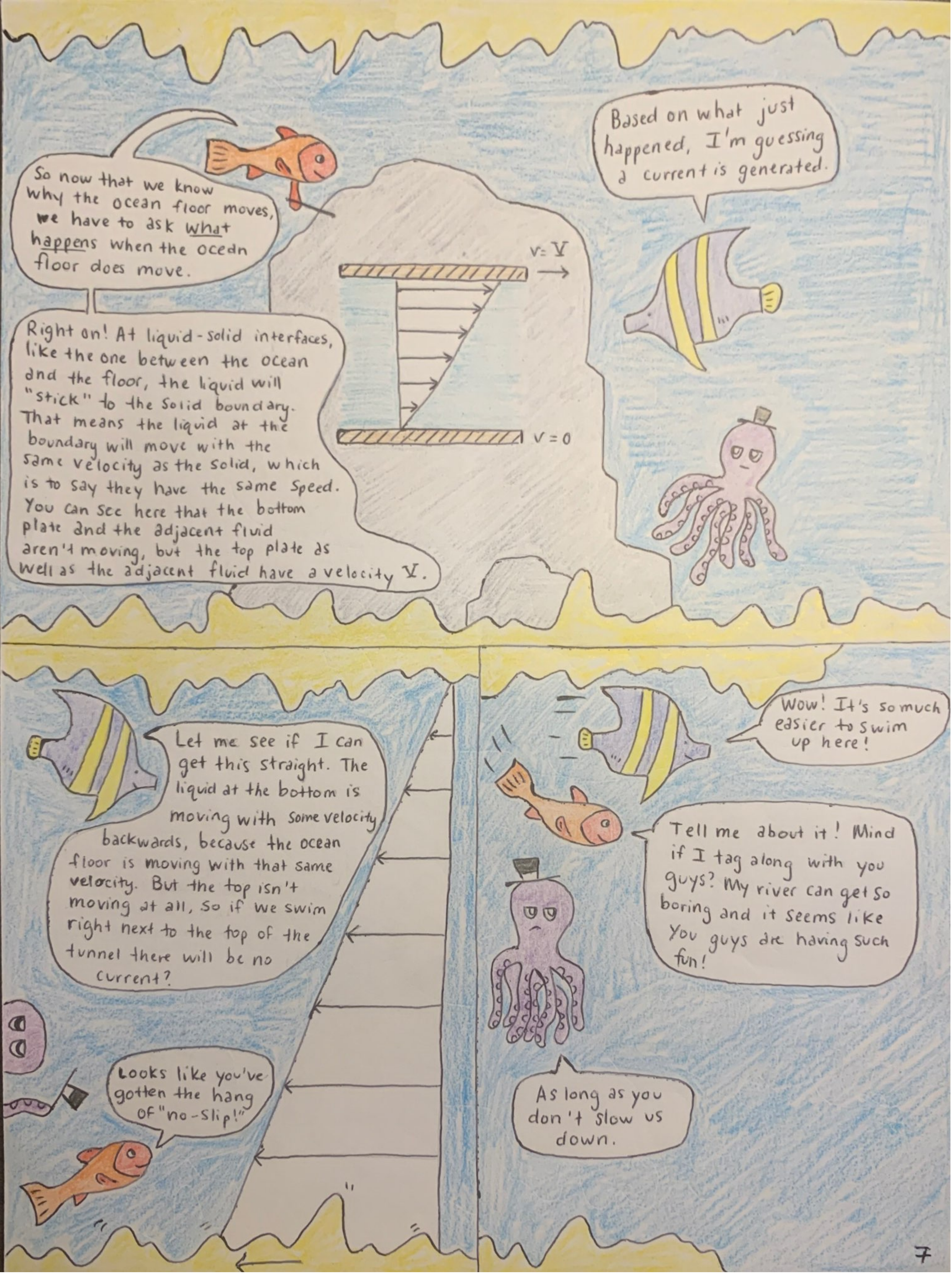
There are two classifications of non-Newtonian fluids. (2)
Viscosity
Stress
Shear-thickening
Newtonian fluid
shear-thinning
Shear-thickening fluids are when a fluid's viscosity increases as shear stress increases, meaning when you apply stress, it is harder for the fluid to flow. An example is quicksand.
Shear-thinning fluids are when a fluid's viscosity decreases as shear stress increases, meaning when you apply stress, it is easier for the fluid to flow. An example is toothpaste.
WARNING QUICKSAND
TOOTHPASTE
Why should I care if a fluid is shear-thickening or shear-thinning?
You should care because if you try to swim through quicksand, then you will get stuck.
Oh... that wouldn't be good.
But, how do I get home?
UGH. Fine. I will lead you around the oil spill.
Thanks, Ozzie!

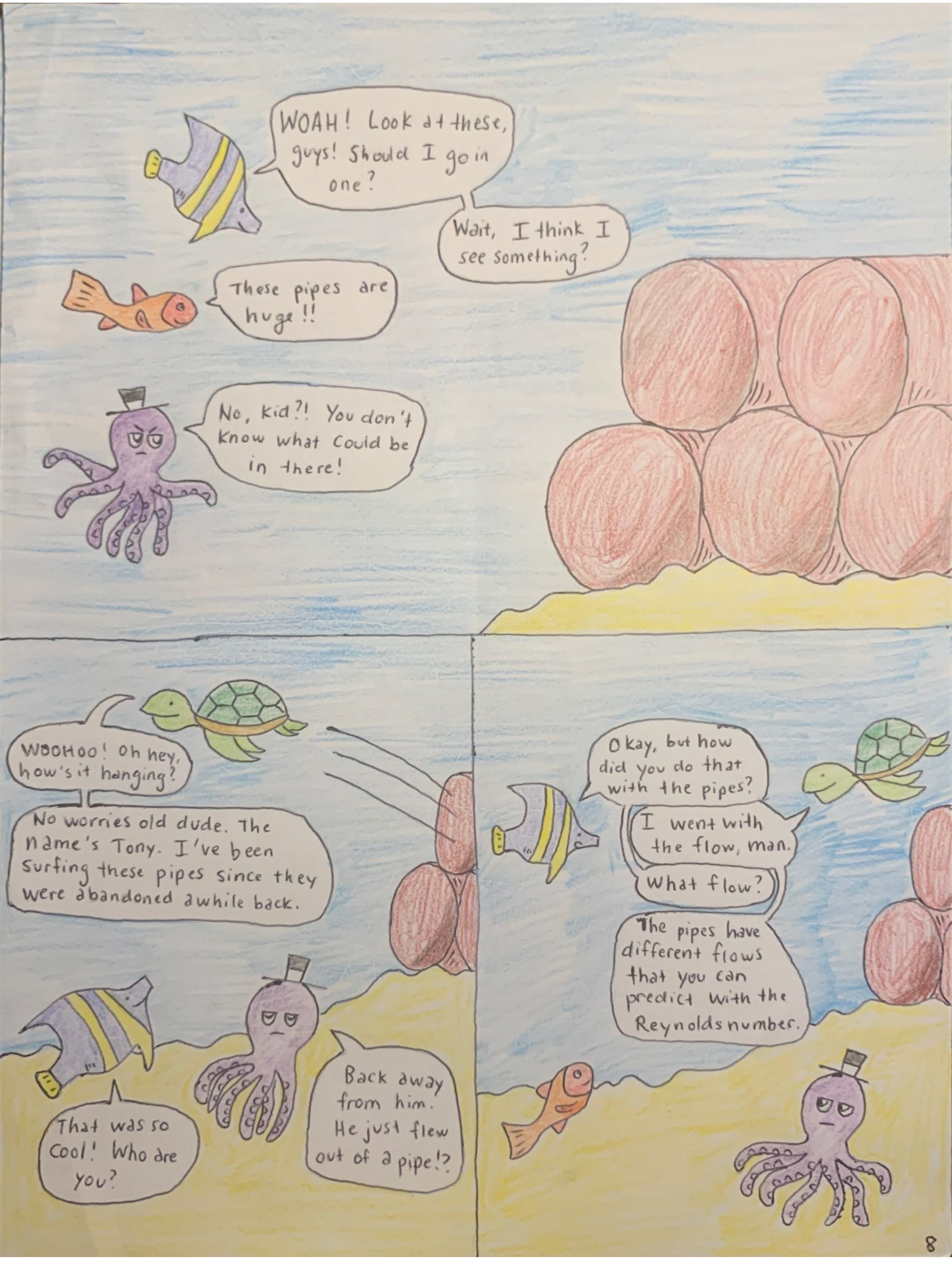


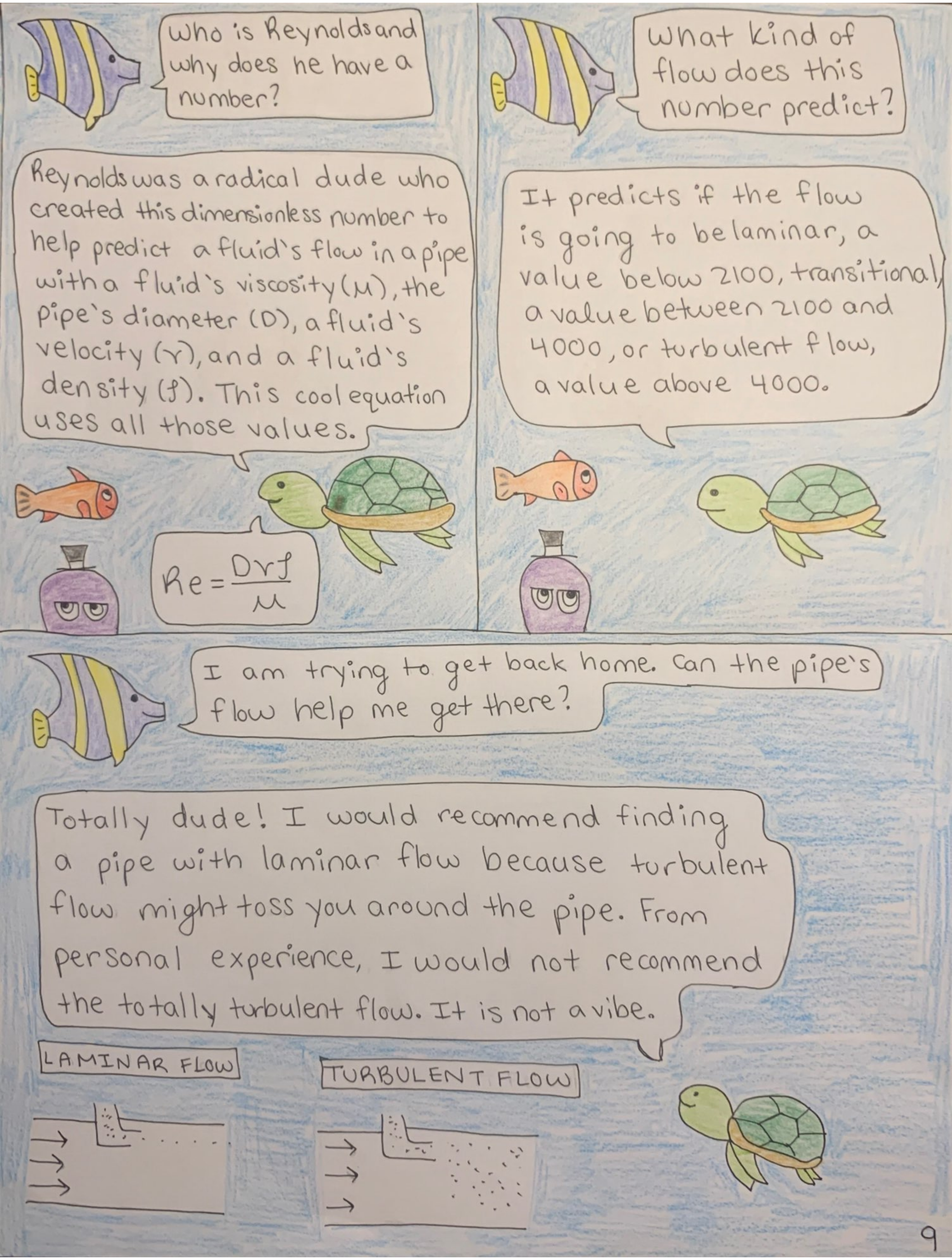
Scanned with CamScanner

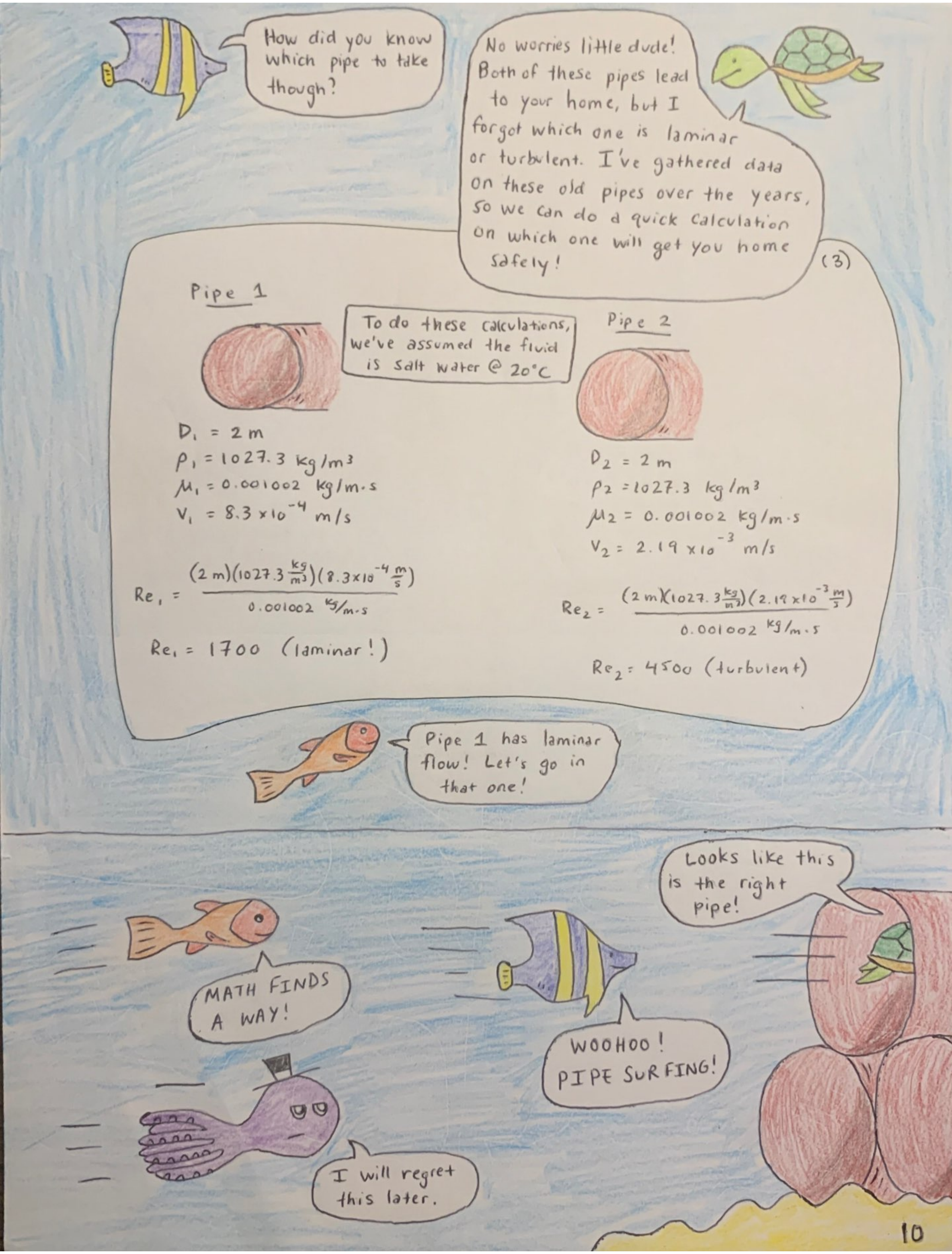


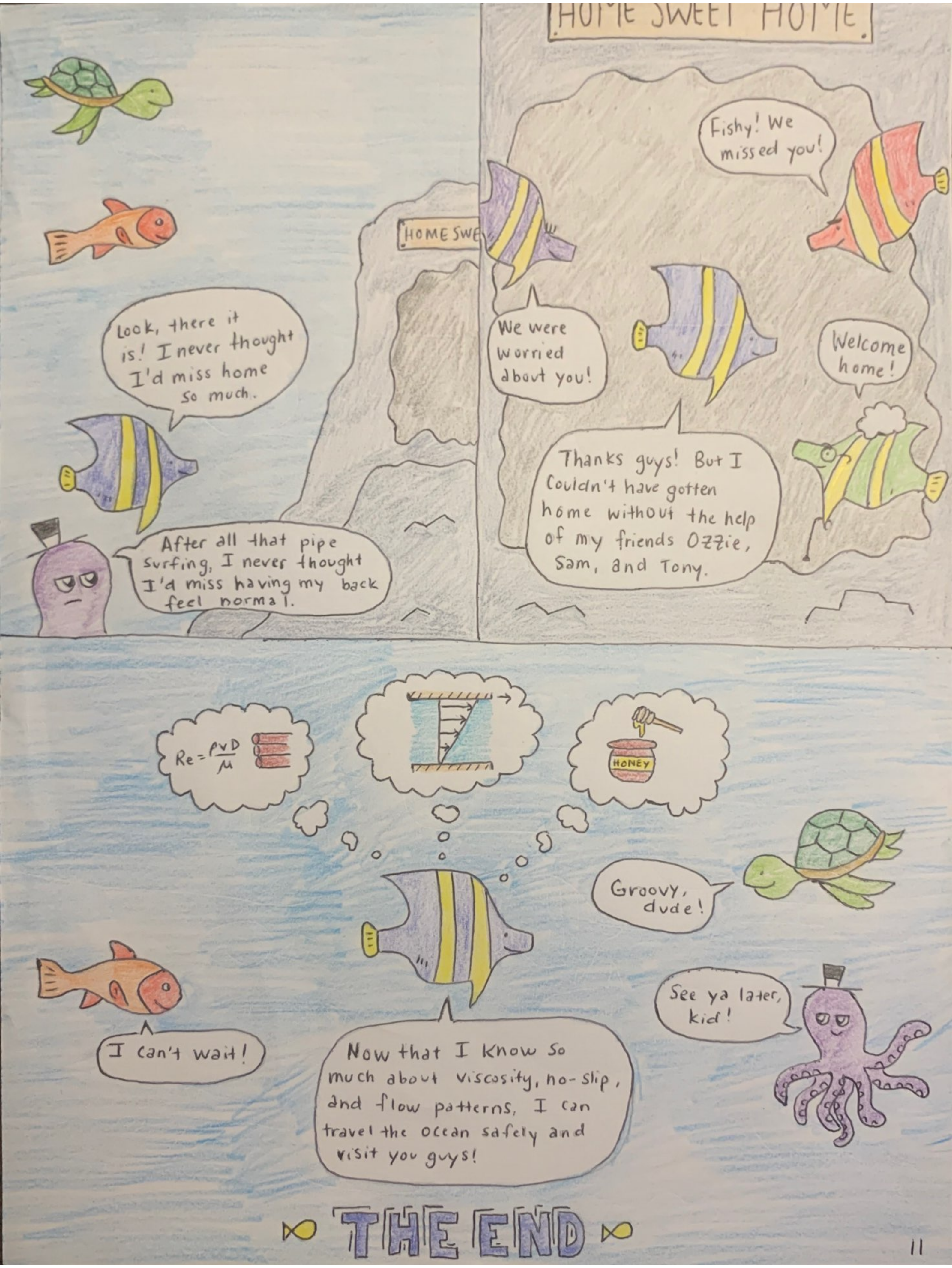
Ah! Sorry, I didn't see you there! It's so hard to swim against the current.
SMACK!
No worries! My name is Sam and I'm a Salmon, so I'm no stranger to swimming against a current. Every year I swim upstream to reach the river where I was born. I can teach you how, if you want.
Please do. I hate to admit it, but we need help.
Isn't the ocean floor solid? How can it move so easily?
First, you'll have to understand why the ocean floor is moving.
I'm glad you asked. The ocean floor is actually made up of tectonic plates, which rest on a layer of liquid magma. When the magma flows in one direction, it causes the plate directly above to move.


So now that we know why the ocean floor moves, we have to ask what happens when the ocean floor does move.
Right on! At liquid-solid interfaces, like the one between the ocean and the floor, the liquid will "stick" to the solid boundary. That means the liquid at the boundary will move with the same velocity as the solid, which is to say they have the same speed. You can see here that the bottom plate and the adjacent fluid aren't moving, but the top plate as well as the adjacent fluid have a velocity V.
v= V
v = 0
Based on what just happened, I'm guessing a current is generated.
Let me see if I can get this straight. The liquid at the bottom is moving with some velocity backwards, because the ocean floor is moving with that same velocity. But the top isn't moving at all, so if we swim right next to the top of the tunnel there will be no current?
Looks like you've gotten the hang of "no-slip!"
Wow! It's so much easier to swim up here!
Tell me about it! Mind if I tag along with you guys? My river can get so boring and it seems like you guys are having such fun!
As long as you don't slow us down.
7


WOAH! Look at these, guys! Should I go in one?
Wait, I think I see something?
These pipes are huge!!
No, kid?! You don't know what could be in there!
WOOHOO! Oh hey, how's it hanging?
No worries old dude. The name's Tony. I've been surfing these pipes since they were abandoned awhile back.
That was so cool! Who are you?
Back away from him. He just flew out of a pipe!?
Okay, but how did you do that with the pipes?
I went with the flow, man.
What flow?
The pipes have different flows that you can predict with the Reynolds number.


Who is Reynolds and why does he have a number?
Reynolds was a radical dude who created this dimensionless number to help predict a fluid's flow in a pipe with a fluid's viscosity (μ), the pipe's diameter (D), a fluid's velocity (v), and a fluid's density (ρ). This cool equation uses all those values.
Re = Dvρ / μ
What kind of flow does this number predict?
It predicts if the flow is going to be laminar, a value below 2100, transitional, a value between 2100 and 4000, or turbulent flow, a value above 4000.
I am trying to get back home. Can the pipe's flow help me get there?
Totally dude! I would recommend finding a pipe with laminar flow because turbulent flow might toss you around the pipe. From personal experience, I would not recommend the totally turbulent flow. It is not a vibe.
LAMINAR FLOW
TURBULENT FLOW


How did you know which pipe to take though?
No worries little dude! Both of these pipes lead to your home, but I forgot which one is laminar or turbulent. I've gathered data on these old pipes over the years, so we can do a quick calculation on which one will get you home safely!
(3)
Pipe 1
To do these calculations, we've assumed the fluid is salt water @ 20°C
Pipe 2
$D_1 = 2$ m
$\rho_1 = 1027.3$ kg/m³
$\mu_1 = 0.001002$ kg/m·s
$V_1 = 8.3 \times 10^{-4}$ m/s
$Re_1 = \frac{(2\ m)(1027.3\ \frac{kg}{m^3})(8.3 \times 10^{-4}\ \frac{m}{s})}{0.001002\ kg/m \cdot s}$
$Re_1 = 1700$ (laminar!)
$D_2 = 2$ m
$\rho_2 = 1027.3$ kg/m³
$\mu_2 = 0.001002$ kg/m·s
$V_2 = 2.19 \times 10^{-3}$ m/s
$Re_2 = \frac{(2\ m)(1027.3\ \frac{kg}{m^3})(2.19 \times 10^{-3}\ \frac{m}{s})}{0.001002\ kg/m \cdot s}$
$Re_2 = 4500$ (turbulent)
Pipe 1 has laminar flow! Let's go in that one!
Looks like this is the right pipe!
MATH FINDS A WAY!
WOOHOO! PIPE SURFING!
I will regret this later.
10



HOME SWE
Look, there it is! I never thought I'd miss home so much.
After all that pipe surfing, I never thought I'd miss having my back feel normal.
HOME SWEET HOME
Fishy! We missed you!
We were worried about you!
Welcome home!
Thanks guys! But I couldn't have gotten home without the help of my friends Ozzie, Sam, and Tony.
Re = ρvD/μ
HONEY
Groovy, dude!
See ya later, kid!
I can't wait!
Now that I know so much about viscosity, no-slip, and flow patterns, I can travel the ocean safely and visit you guys!
THE END

SOURCES

(1) B. Chen, X. L, et al. "Non-Newtonian Flow Characterization of Heavy Crude Oil in Porous Media." Journal of Petroleum Exploration and Production Technology, Springer Berlin Heidelberg, 1 Jan. 1990, link.springer.com/article/10.1007/s13202-012-0043-9.

(2) "Non-Newtonian Fluids." Science Learning Hub, www.sciencelearn.org.nz/resources/1502-non-newtonian-fluids.

(3) "Properties of Seawater." Engineering ToolBox, 2005, www.engineeringtoolbox.com/sea-water-properties-d_840.html.