The

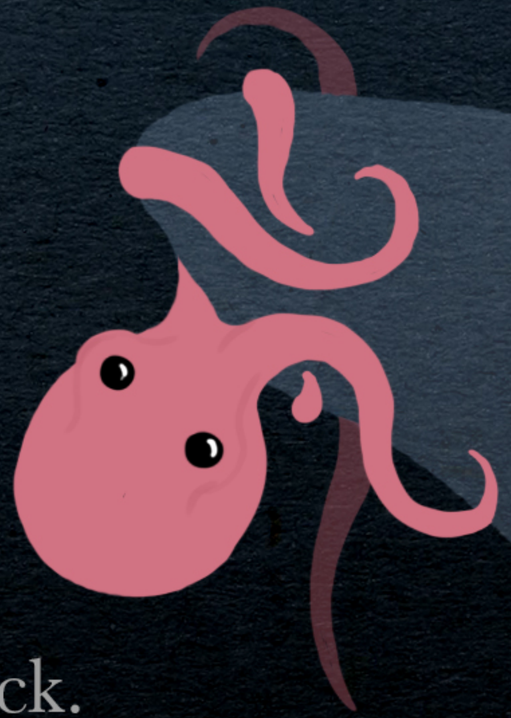
Deep Sea Guide to Parenthood

by Michael LoPalo

This is *Fiona*.

She is a deep sea octopus searching for a place to lay her eggs.

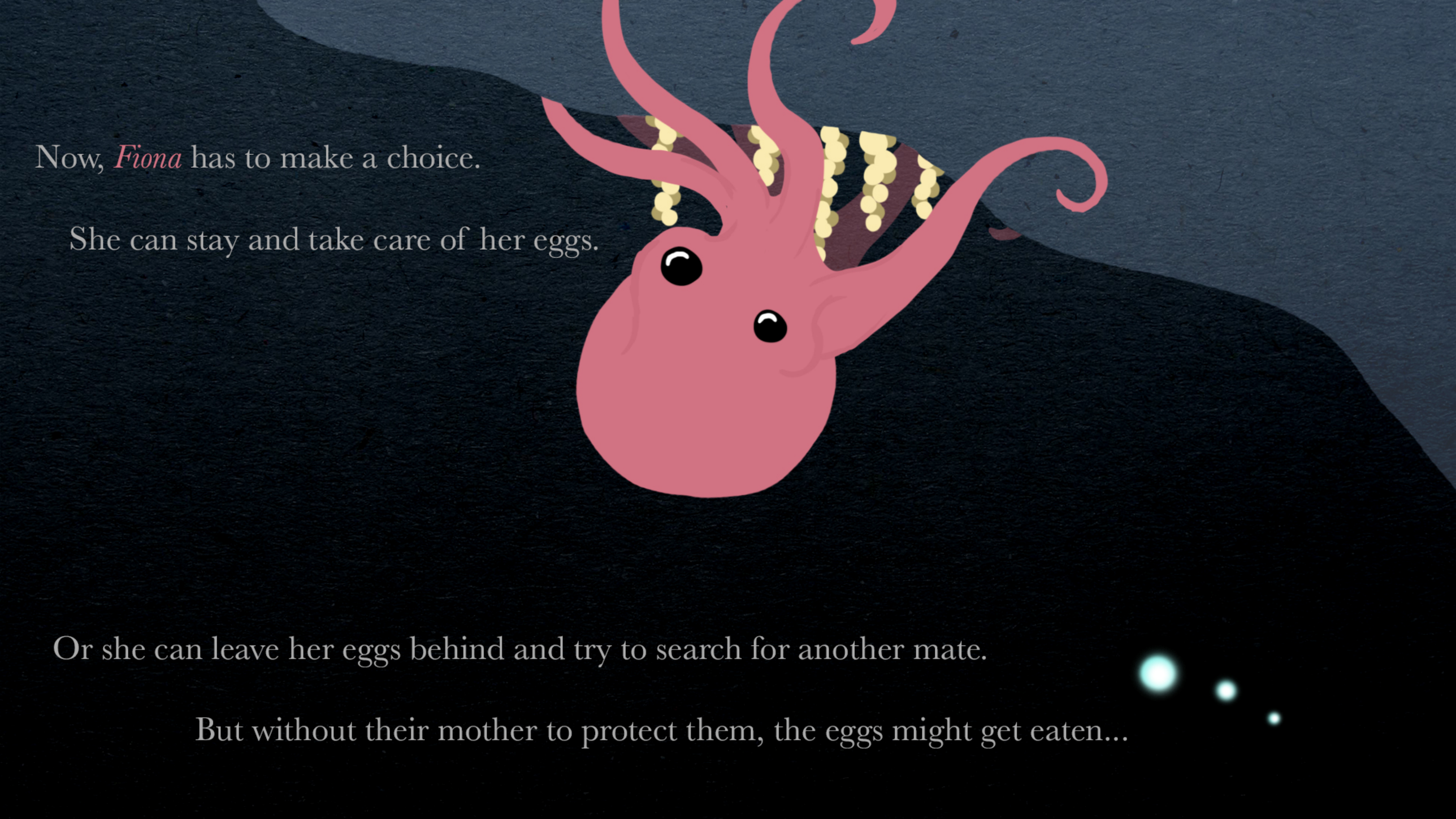
Her home is one of the toughest places for any animal to live.

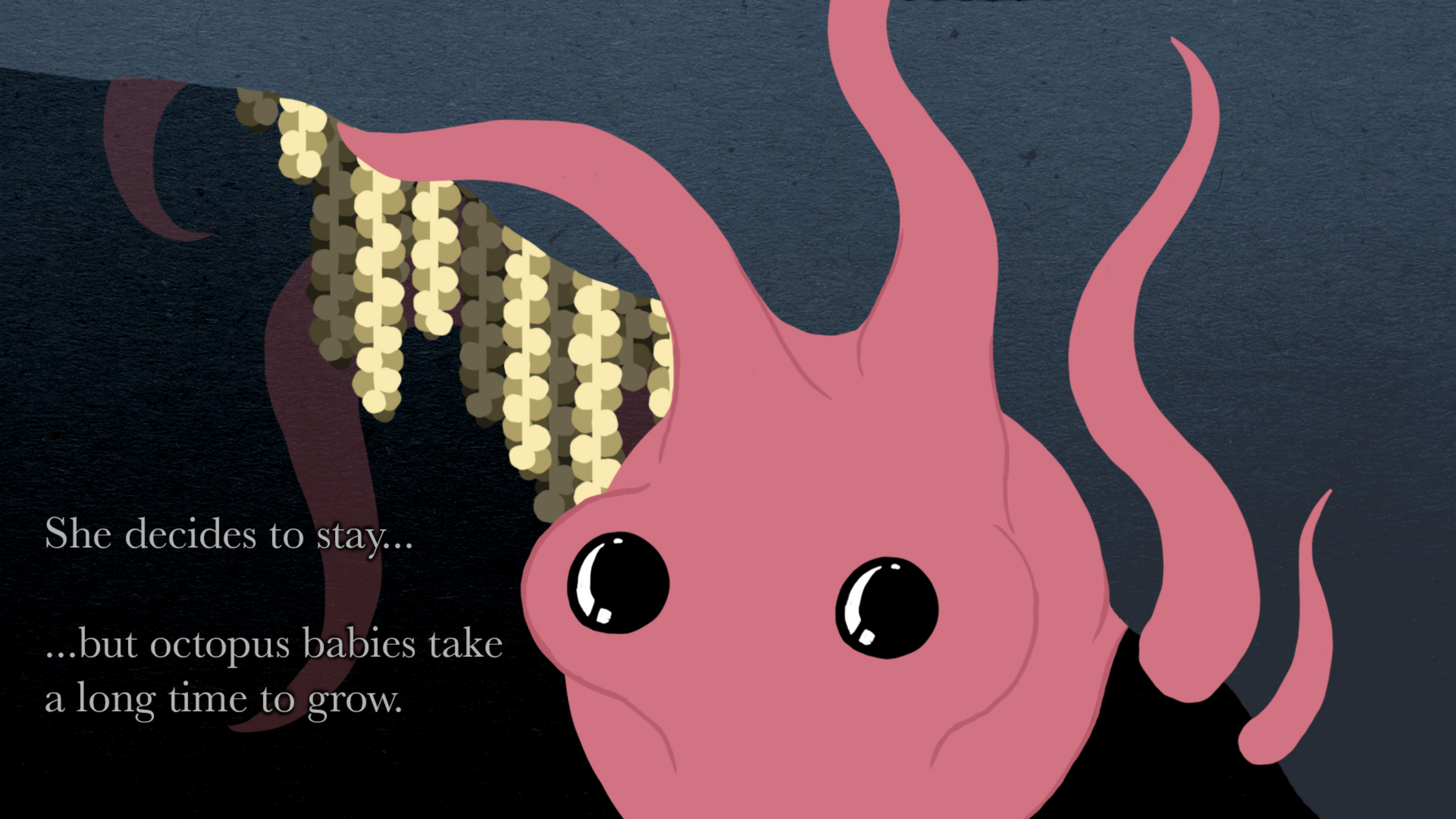


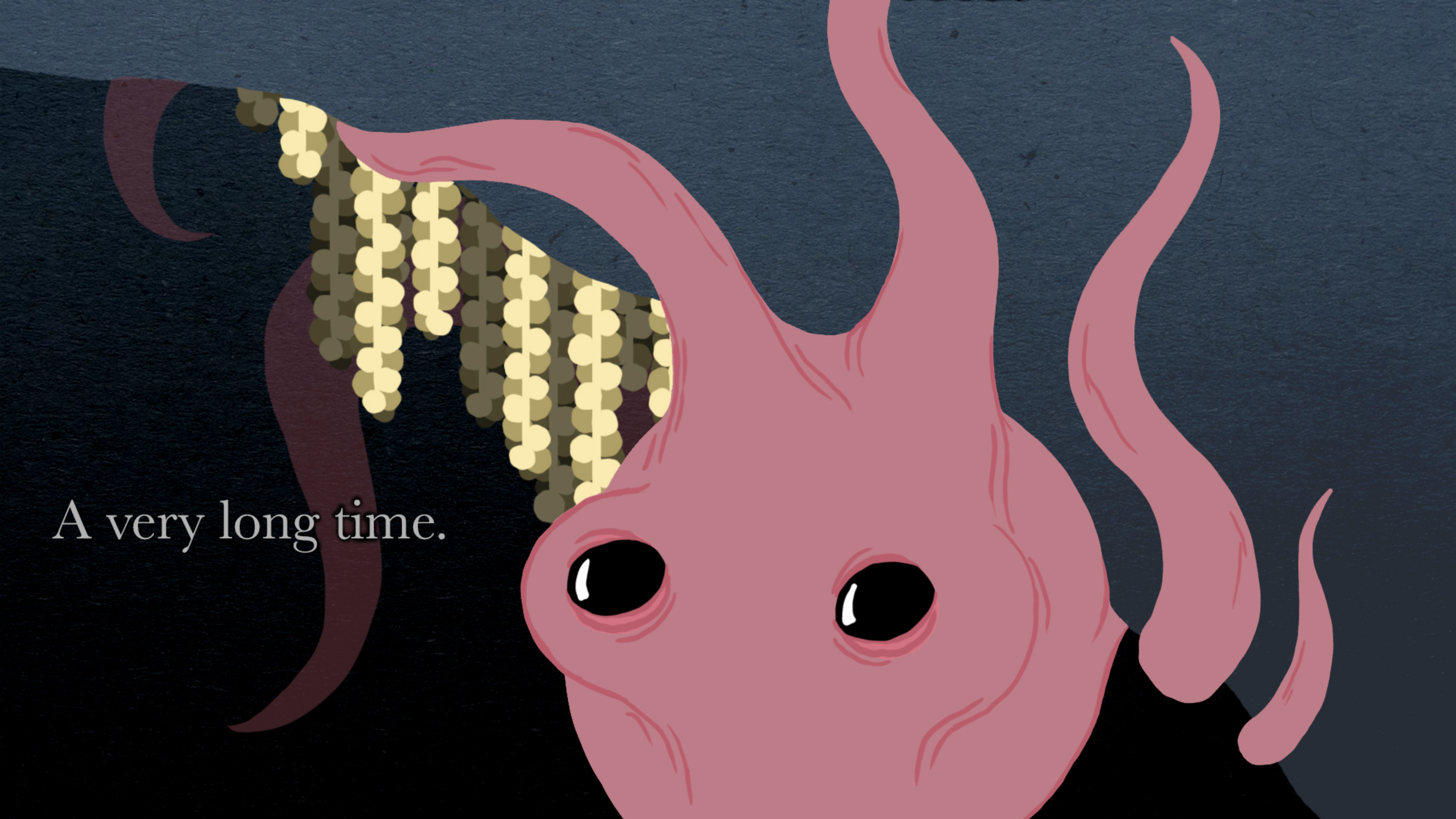
Fiona finds the perfect rock.

It juts out from the side of a cliff, an ideal place to hide her eggs from *predators*.


She hangs her eggs from the rock...
...all two hundred of them.


Now, *Fiona* has to make a choice.
She can stay and take care of her eggs.
Or she can leave her eggs behind and try to search for another mate.
But without their mother to protect them, the eggs might get eaten...


She decides to stay...
...but octopus babies take
a long time to grow.


A very long time.


The longer the eggs take to hatch, the easier it will be for her babies to start their new lives in these harsh surroundings.
For four years, *Fiona* waits, keeping her eggs safe and warm.
She doesn't ever leave to eat.


The babies finally hatch. Four years of growing made them strong and ready to take on the challenges of the deep sea.
But where did their mommy go?
They are getting hungry.

After so long without food of her own, *Fiona* died just as her eggs hatched.

She gave up her life to make sure her babies got the best head start.

They are still hungry...

Food is so hard to find in the deep sea that the babies must eat anything they can find.

So, they eat their own mommy.

Even when she is dead, *Fiona* still helps make her babies' survival as easy as possible.

Because of their mommy's sacrifice, the baby octopi will have a better chance of survival in the deep sea.

Despite her best efforts, she cannot save all of them. Many will die-- being eaten or starving to death.

But one might survive.

And that one baby will grow up to find a mate of her own.

She'll lay her own eggs, she'll take care of them, and then she'll die.

Because that's what her mommy did for her, and she is a part of her mommy.

Michael LoPalo

Evolution Term Project Summary - Draft

My project will be focusing on phenoptosis and what effects it has on the species that experience it. Phenoptosis is the genetically programmed death of an organism, which usually occurs immediately after reproduction (1,2). It is still not known exactly how this phenomenon evolved, but it will be my goal to tell a story about how it works, why it works, and what environmental extremes cause such adaptations. In regards to our class, I will mainly be alluding to group selection and how some adaptations can be harmful to the survivability of an individual, but beneficial to the survivability of a group or species. I believe that phenoptosis is the most extreme case of this type of adaptation.

The main document that I will be referencing in my work is Bruce Robinson's *Deep-Sea Octopus* study. This animal, which broods its young for longer than any other known animal, dies only moments before its eggs finally hatch. The newly-born young then go on to eat their mother's body, giving them a nutritious head start to life in the open, desert deep sea (3). This adaptation can be explained in many different ways. First off, It is obviously beneficial for young octopi to stay in a secure environment for as long as possible, in this case, in their eggs and under the protection of their mother. This gives the young more time to develop than any other animal species on earth (3), which is extremely useful when food is so difficult to catch. In regards to difficult-to-catch food, it is also beneficial to the young that they are supplied with a highly-nutritious meal immediately upon hatching. The environment in which Graneledone *boreopacifica* lives is the marine equivalent of desert (3). Supplying highly developed young with an excellent meal boosts their initial survival rate incredibly.

In regards to the mother octopus, this adaptation seems to be extremely problematic. How does this adaptation get passed on from one generation to the next, if it would seemingly be more productive to leave your eggs behind and search for a new mate. As I mentioned before, this deep sea environment is basically a vast, lifeless desert. In addition to having difficulties finding food, it is most likely the case that the mother octopus will never find another mate for as long as she lives (3). So, leaving her brood behind to search for something that might not exist is extremely high risk. It makes more sense to stay behind with your eggs.

The phenoptotic part of this concept is that the death of the mother octopus is *secondary* to her extreme brooding behavior. It is not caused by a programmed overflow of chemicals that breaks down her body such as in mice and salmon (1), it is caused by the fact that she spends over four years of energy watching over her eggs-- and it is speculated that she does not eat the entire time (3). This phenoptosis is not physiological as in most other species (1,2,4), but is behavioral. It is the instinct of the mother octopus to guard her young until she dies. The fact that her newborn young benefit from her perfectly-timed death certainly helps reinforce the evolution

of this behavior, since her young will be more likely to behave the same way. Since these young have gotten a head start in their long and difficult life, this behavior is more likely to be passed on than by octopi who do not guard their eggs until death, and whose young are unable to attain that most important first meal.

I will put all of these concepts, ideas, and information into a children's book, with cartoonish characters and simple, easy-to-read text that sacrifices its scientific roots as little as possible. It will be hand-drawn, and I will use Photoshop for the coloring, texturing, and text placement. This obviously morbid children's book will follow a family of octopi, from their mother laying her eggs to her young leaving their home, bellies full with their first meal (which is their deceased mother).

As this is a book, the majority of the themes and ideas will be conveyed directly through text. The text will include explanations and motives behind the behavior of the mother octopus, as well as anthropomorphized emotions conveying how all of the characters feel about their situation (i.e. dying to protect your young, eating your dead mother, etc.). As previously stated, the text will simplify the scientific ideas behind these concepts into layman's terms so that the completed work feels like a children's book. The illustrations will simply reinforce what the text has stated. This is a story of an octopus family, and so the illustrations will show what the family is doing at each stage in the process of this story.

This book will be targeted at teenagers and young adults, who will be able to understand the topics and themes, but will also appreciate the morbid humor in the idea that this is designed as a children's book. It is my goal that those who read this book come to understand strange adaptations such as phenoptosis, as well as the idea that death may not always be such a horrible thing if it indirectly helps your offspring survive.

In order to more effectively complete this assignment, I have narrowed down my initial source list to the following four documents:

[1] Skulachev, Vladimir. *Aging as a particular case of phenoptosis, the programmed death of an organism (a response to Kirkwood and Melov "On the programmed/non-programmed nature of ageing within the life history")*

> This article explores the idea of aging in both humans and other organisms as a form of "slow phenoptosis." It is a response to a similar paper about phenoptosis that suggests that death is not caused by programmed ageing genes.

[2] Skulachev, Vladimir. *Phenoptosis: programmed death of an organism*

> This paper explains a large variety of ideas relating to phenoptosis such as mitochondrial suicide (mitoptosis), phenoptosis in unicellular organisms like bacteria, and how this precedent might have evolved in multicellular organisms.

[3] Robison, Bruce. *Deep-Sea Octopus (*Graneledone boreopacifica*) Conducts the Longest-Known Egg-Brooding Period of Any Animal*

After taking care of her eggs for almost 53 months, this mother simply dies. Her corpse serves as her children's' first meal. This is an example of programmed organism death that directly affects the survivability of the following generation.

[4] Skulachev, Vladimir. *Programmed death phenomena: from organelle to organism*

This article talks about programmed death in everything from single cells to organelles to entire individuals. It relates programmed cell death (apoptosis) to programmed organism death (phenoptosis) and explains the usefulness of such a trait in terms of evolution.