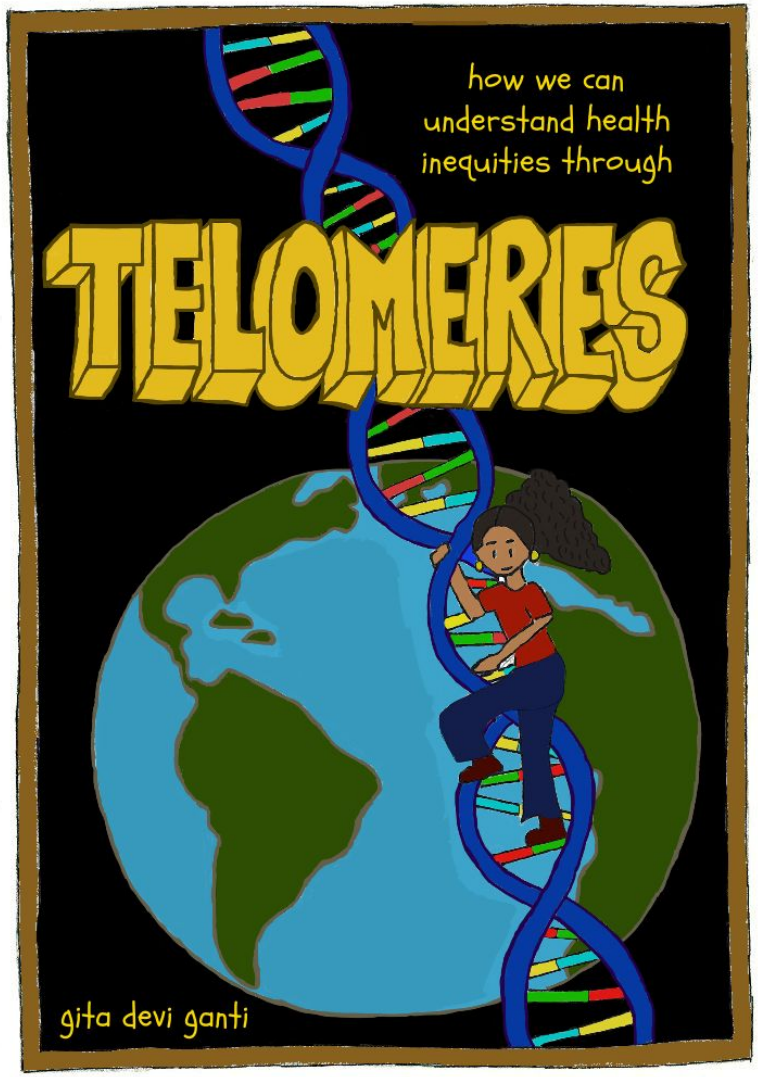

how we can
understand health
inequities through
TELOMERES
gita devi ganti

"We live in a society exquisitely dependent on science and technology and yet have cleverly arranged things so that almost no one understands science and technology."

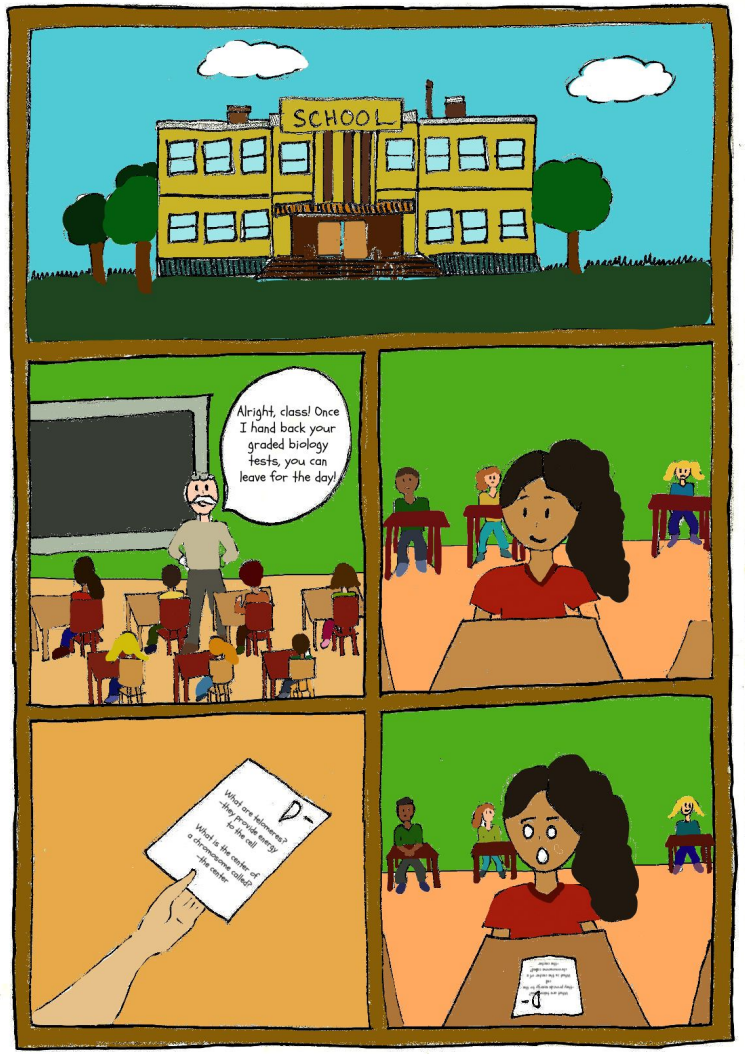
-Carl Sagan

To My Parents, Kameswari and Subrahmanyam Ganti
To My Sisters, Siri and Lalita
To Mr. Menelaos Tsapekos
To Prof. Makaela Kingsley
To My Housemates
To My Friends
To Every Teacher I Ever Had

NOTES FROM THE AUTHOR

This past summer, I interned for Life Length, a biotech company in Madrid, Spain that provides telomere measurements to its clients in order to help them identify their biological age, and understand the ways in which they can improve their health so that they can have a better quality life. I didn't get the chance to travel to this beloved city because of the pandemic, but working remotely for the company was both a fun and educational experience. As the school year came around, I knew that I wanted to take on a creative project that would require combining my amateur artistic skills with a topic in health studies.

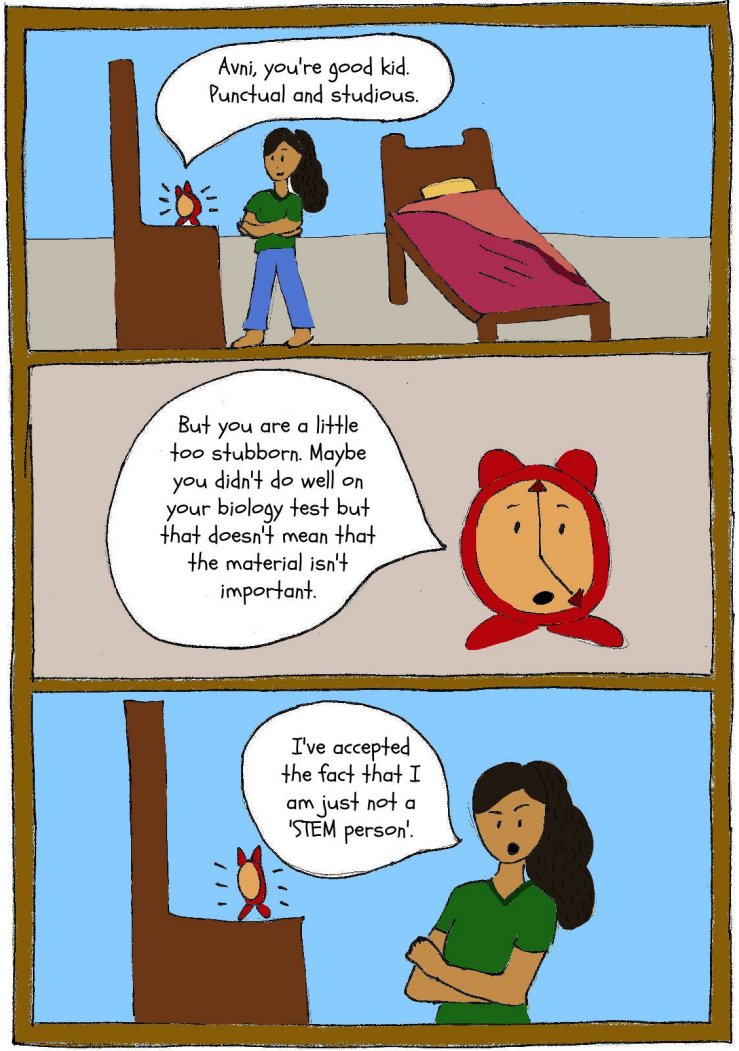
As I sifted through possible topics, I struggled for some time in deciding what I should focus on. I knew one thing for sure though: I wasn't quite done with telomeres. I think that completing this internship remotely, and not in-person, had made me feel like I couldn't immerse myself into this organization's mission as much as I had wanted to. I also felt that not enough people knew what telomeres were, and how they are relevant to health disparities. At the end of my internship, I told my boss, Menelaos, about my plan, and he agreed to be my mentor for this project. While this is only a draft of the graphic novel, I am excited for the journey of this book - how it will morph into a new work over the course of these next fews months. I hope that it will be a reflection both of myself, and a means for communication concepts in biology to an audience that is not familiar with the field too well.

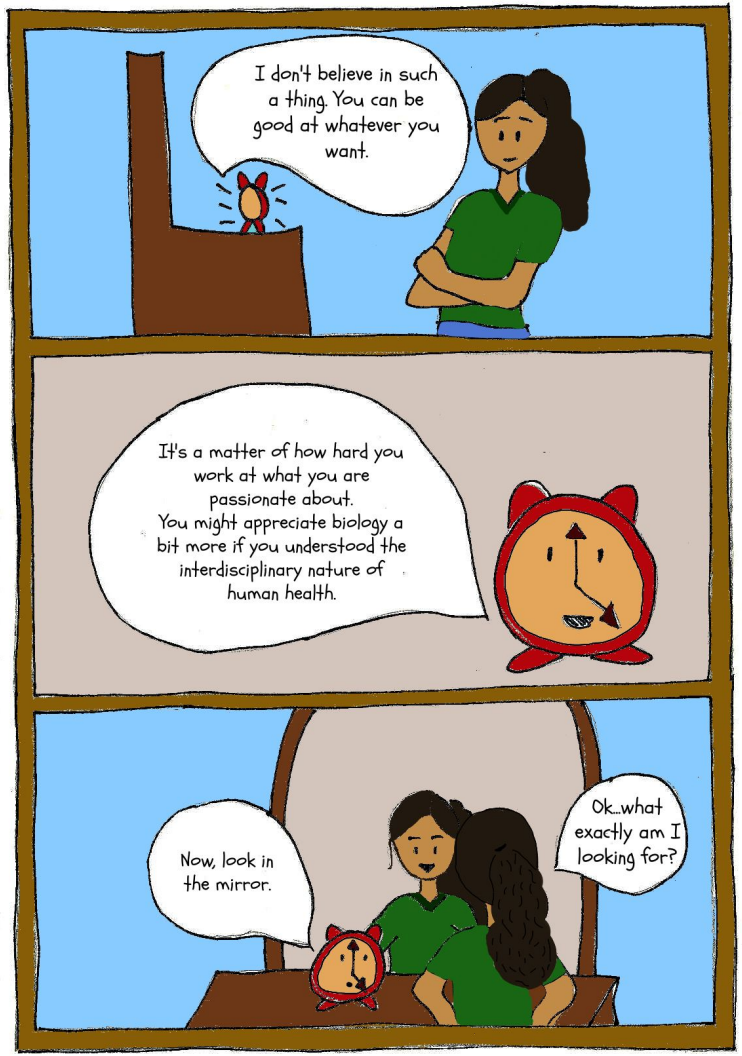

SCHOOL
Alright, class! Once I hand back your graded biology tests, you can leave for the day!
D-
What are telomeres? -they provide energy for the cell
What is the center of a chromosome called? -the center


FLIP
D-
WHAT.
How could I do so poorly?
I am enraged!
Why should I stress about understanding chromosomes anyways? Let alone telomeres!
Oh my..
CRUSH


Zzz
WAKE UP, AVNI!
...telomeres... failure...GPA...
Zzz
WHO IS THERE?!

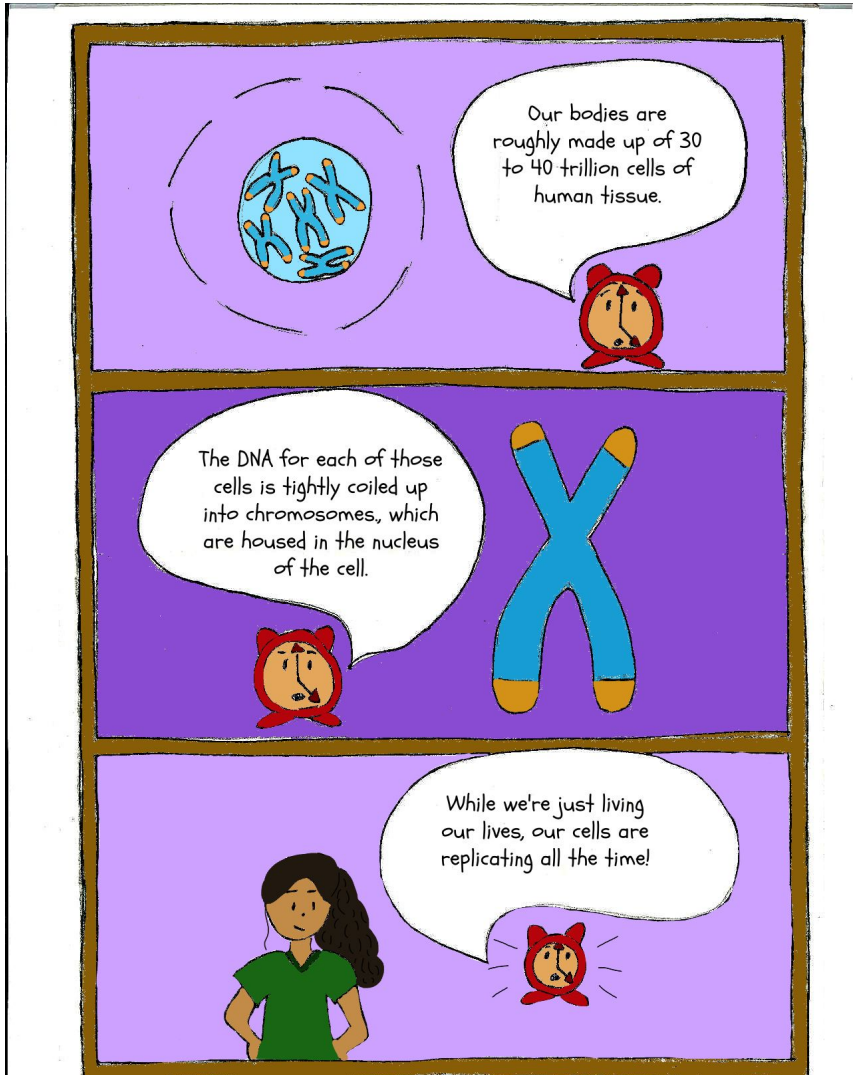

Huh?
It's me. Your clock.
Um. Clock, you really shouldn't be able to talk.
Ah yes, normally I cannot but this is a dream!

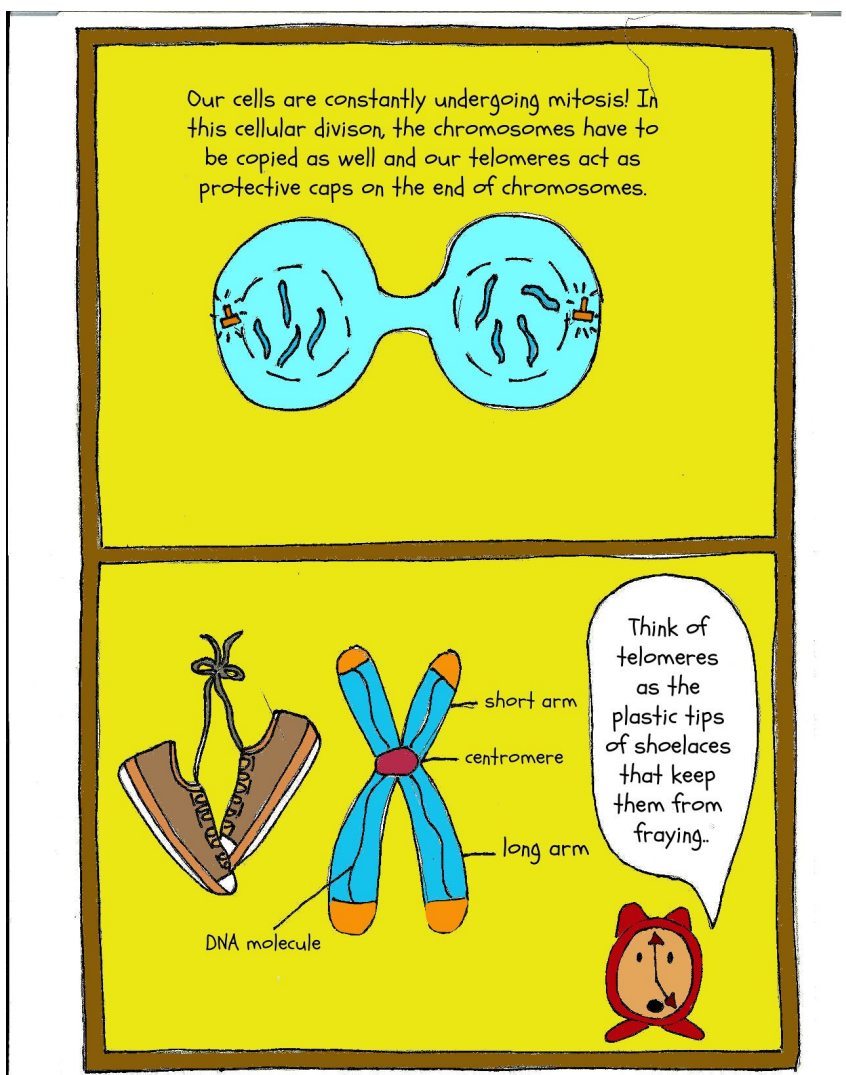

Avni, you're good kid. Punctual and studious.
But you are a little too stubborn. Maybe you didn't do well on your biology test but that doesn't mean that the material isn't important.
I've accepted the fact that I am just not a 'STEM person'.


I don't believe in such a thing. You can be good at whatever you want.
It's a matter of how hard you work at what you are passionate about. You might appreciate biology a bit more if you understood the interdisciplinary nature of human health.
Now, look in the mirror.
Ok...what exactly am I looking for?

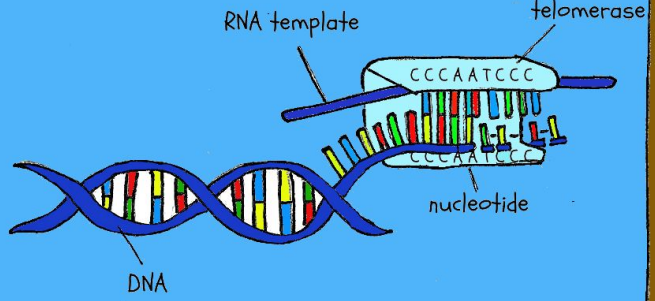

Look again. Do you notice anything different?
I'm old... these wrinkles and gray hair...
Change me back now!
I will. But I hope that looking at your older self reminds you of the brevity of life.


This is a heavy lesson to be learning at SAM.
Yes, indeed. But there is so much you must learn!
What I will teach you now may help you appreciate your biology class more. But first, I will change you back.
Thank goodness.
So Avni, you had asked your teacher yesterday what is the point in learning about telomeres? Think of telomeres as a biological clock in each cell. They can tell us a lot about our aging process, and our most prevalent health inequities in society.

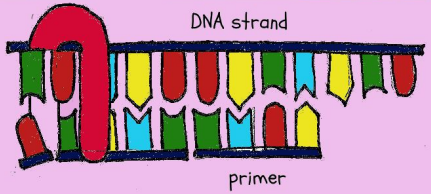

Our bodies are roughly made up of 30 to 40 trillion cells of human tissue.
The DNA for each of those cells is tightly coiled up into chromosomes., which are housed in the nucleus of the cell.
While we're just living our lives, our cells are replicating all the time!


Our cells are constantly undergoing mitosis! In this cellular divison, the chromosomes have to be copied as well and our telomeres act as protective caps on the end of chromosomes.
short arm
centromere
long arm
DNA molecule
Think of telomeres as the plastic tips of shoelaces that keep them from fraying..

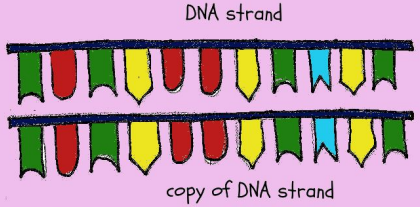
Telomeres are made up of a sequence of six nucleotides that are repeated over and over again. With telomeres, DNA can get shorter over time without the risk of losing important genetic information.



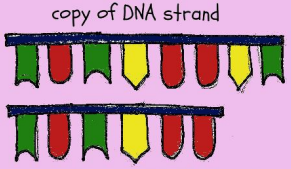
In egg and sperm cells, the enzyme telomerase repeatedly adds this nucleotide sequence onto the end of DNA strands so that the telomeres don't shorten. But in other cells, telomerase is not as active, and thus telomeres shorten over time.



So here we are looking at DNA replication. The primer serves as the starting point for the DNA synthesis.

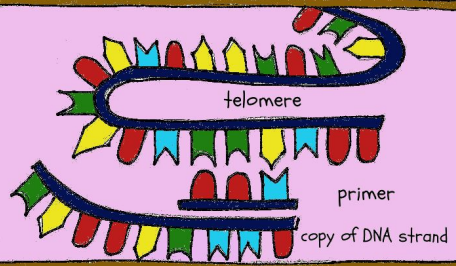


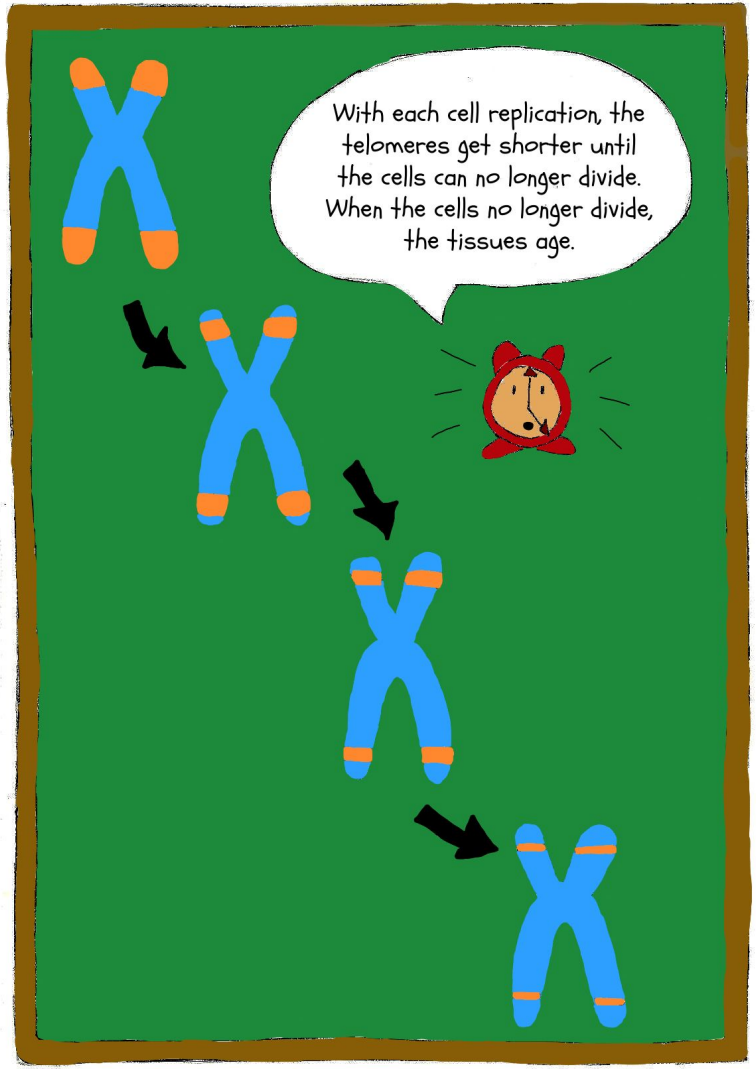
But the copy of the DNA strand is missing a bit of DNA because the primer doesn't attach itself to the very end of the strand.



Thus, the DNA gets shorter and shorter with each copy.

But telomeres come to the rescue! They counter the shortening of the DNA, and make sure the strand gets copied properly.




With each cell replication, the telomeres get shorter until the cells can no longer divide. When the cells no longer divide, the tissues age.


So our telomeres naturally shorten with each cell division. This trend is called attrition.
But it's only natural that your telomeres are shorter now than they were when you were younger.
Hmm...I don't remember.
As we age, our chromosomes are less protected from damage which scientists suggest as the reason behind the decreased function and wellness of the human body which can onset degenerate diseases such as Alzherimer's.

So there is nothing I can do to keep my telomeres from shortening as I age?

Well, there may not be much you can do. There are many factors that influence your telomere health that are simply outside of your control.

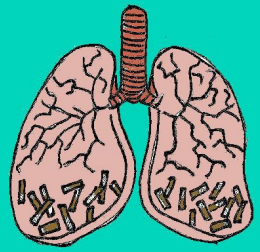
Genetics is one example. So your telomere length, Avni, can be influenced by your parent's age when they conceived you, and their own health habits.

But there are some things under our control!

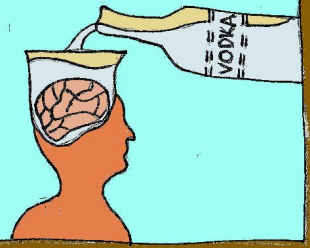
Through our lifestyle choices we can impact our telomere length.

For example, cigarette smoking can accelerate telomere attrition.

By staying away from cigarettes, we can add years to our lives through telomere length preservation.

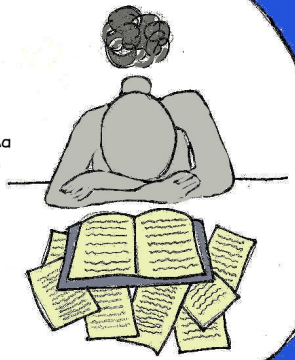


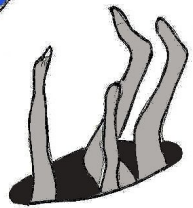
Even moderate consumption of alcohol is not risk-free! Excessive drinking can increase the risk of serious health problems.



An unhealthy diet has also been associated with shorter telomere length. You are what you eat!

Stress and severe trauma are associated with accelerated telomere shortening.





Poor mental health, including depression and anxiety, can also impact our telomere health.

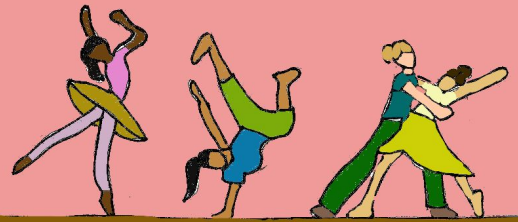
So you must always set aside time in your day to de-stress!

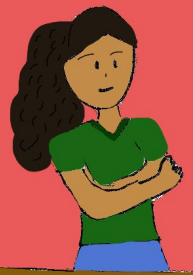
Practice yoga and meditate! Realize that mastering your inner self will allow you to face any external challenge calmly and bravely!

Social interaction has its health benefits as well! People who spend time with friends and family oftentimes find it easier to cope with stress.

Exercise, Avni! Exercise will help you maintain good body composition, which in turn leads to maintenance of a good metabolic balance, and healthier states of oxidative stress and inflammatory status.

By increasing physical activity and decreasing sedentary behavior you can reduce telomere attrition. In fact, some professional athletes are found to have longer telomeres than non-athletes who are of the same age.



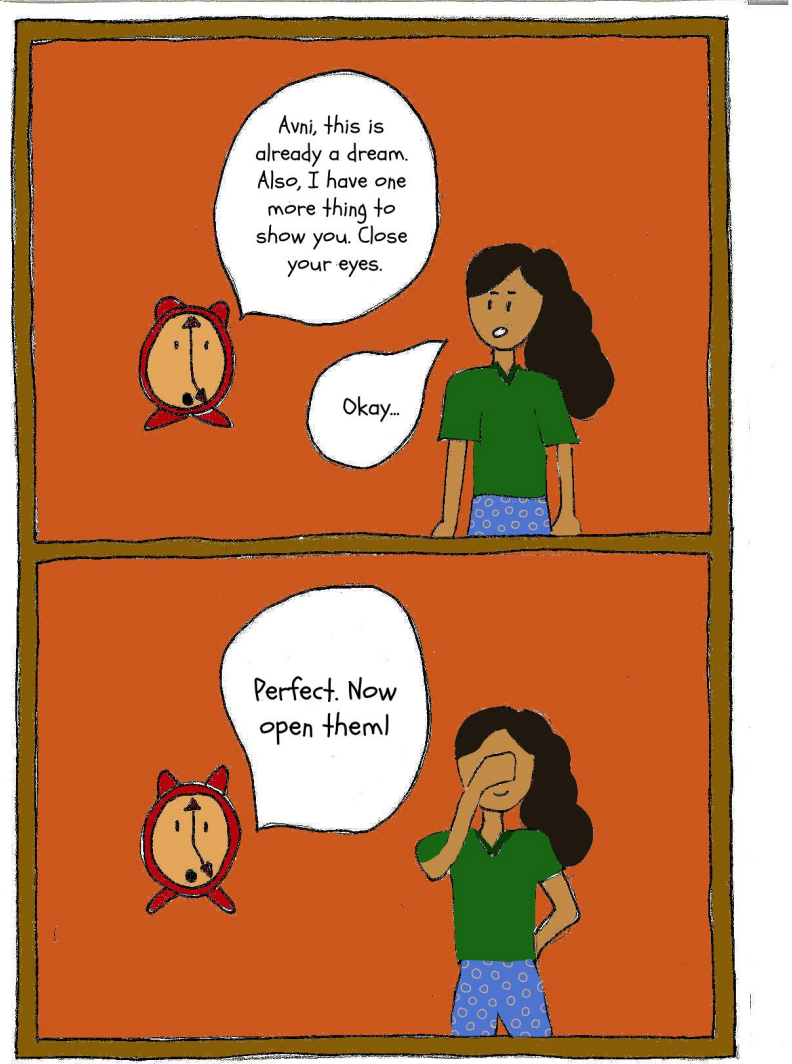


As exercise can lead to less telomere attrition, exercise can also diminish the risk of cancer and other chronic diseases.

So does money matter for health? Yes! The most fundamental causes of health disparities are socioeconomic disparities. Socioeconomic status is linked to a wide range of health problems, with lower socioeconomic status associated with higher mortality and morbitiy rates.

Income, education, and occupation, which define an individual's socioeconomic status, can influence other determinants of health such as healthcare accessibility and housing.

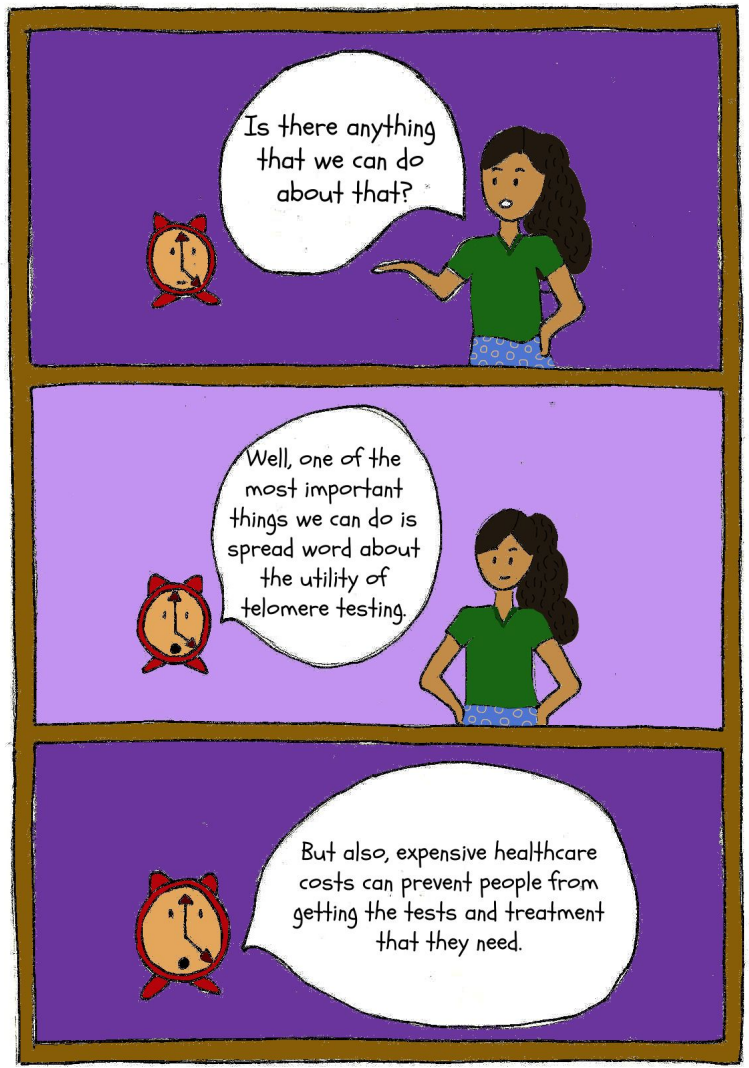

So now you know why our telomeres are important!
And also how to properly care for your telomeres so you can live a wonderful life!
Great! I am tired. Thanks for everything, Clock.


Avni, this is already a dream. Also, I have one more thing to show you. Close your eyes.
Okay...
Perfect. Now open them!

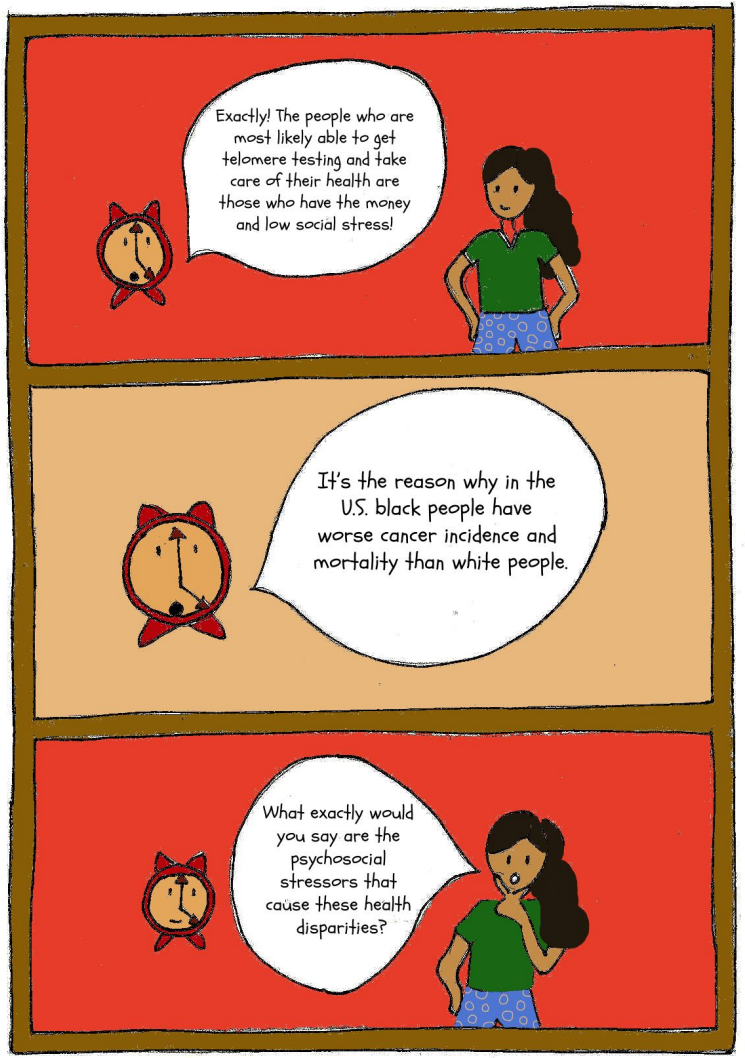

Welcome to Life Length!
Now, here is a biotech company working to improve peoples' health worldwide through telomere measurement and diagnostics!
Wait, where exactly are we? Clearly I must be dreaming because there's no way that we are in...
Madrid, Spain!

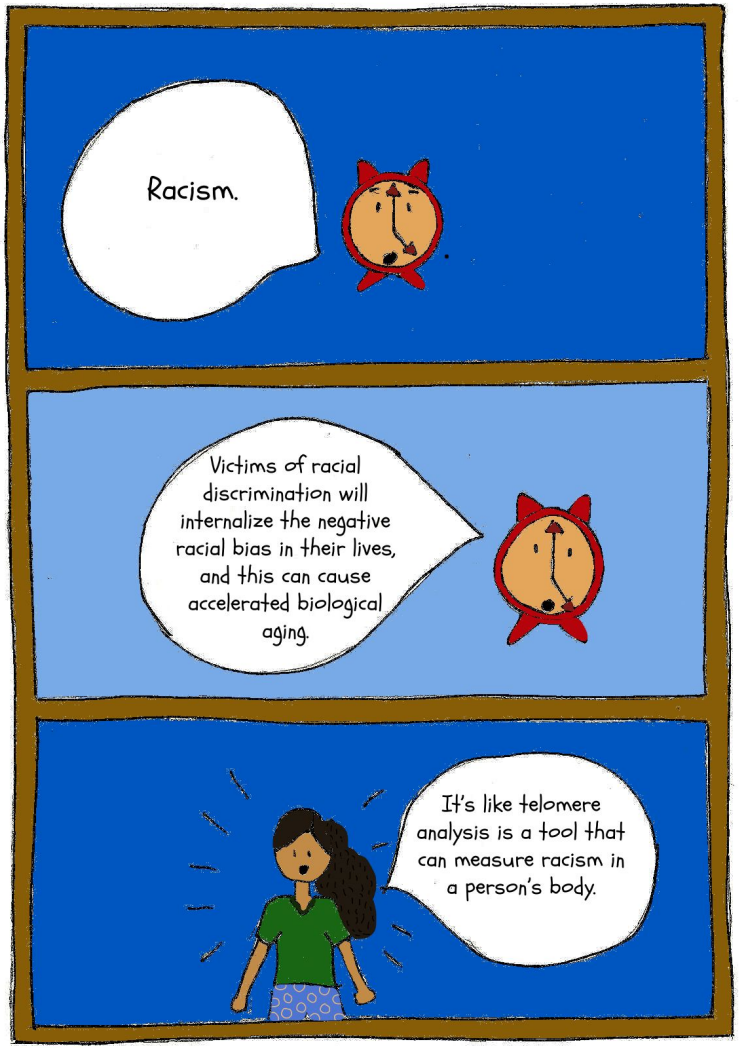

What in the world...
Now, this is a dream but Life Length is very much real.
Life Length uses telomere analysis technology to measure the percentage of short telomeres in cells to determine a person's biological age.

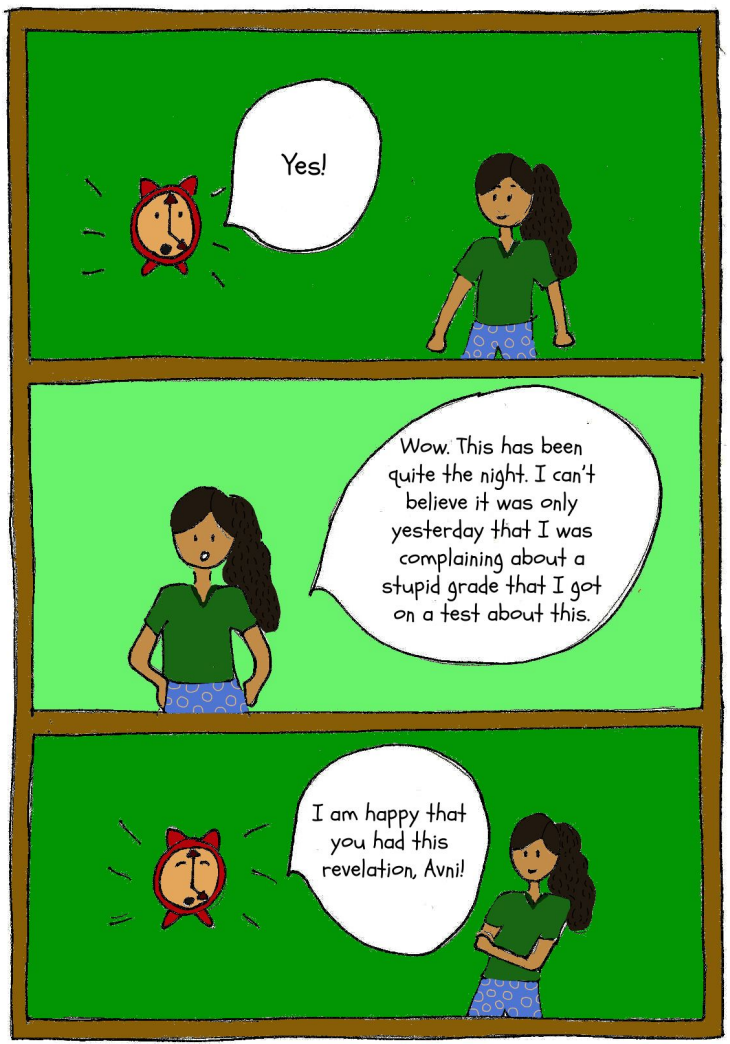

Now I understand why I am learning this lesson through my clock.
So are there other companies like Life Length around the world?
That's the problem. Life Length is one of the few companies that provide telomere testing.

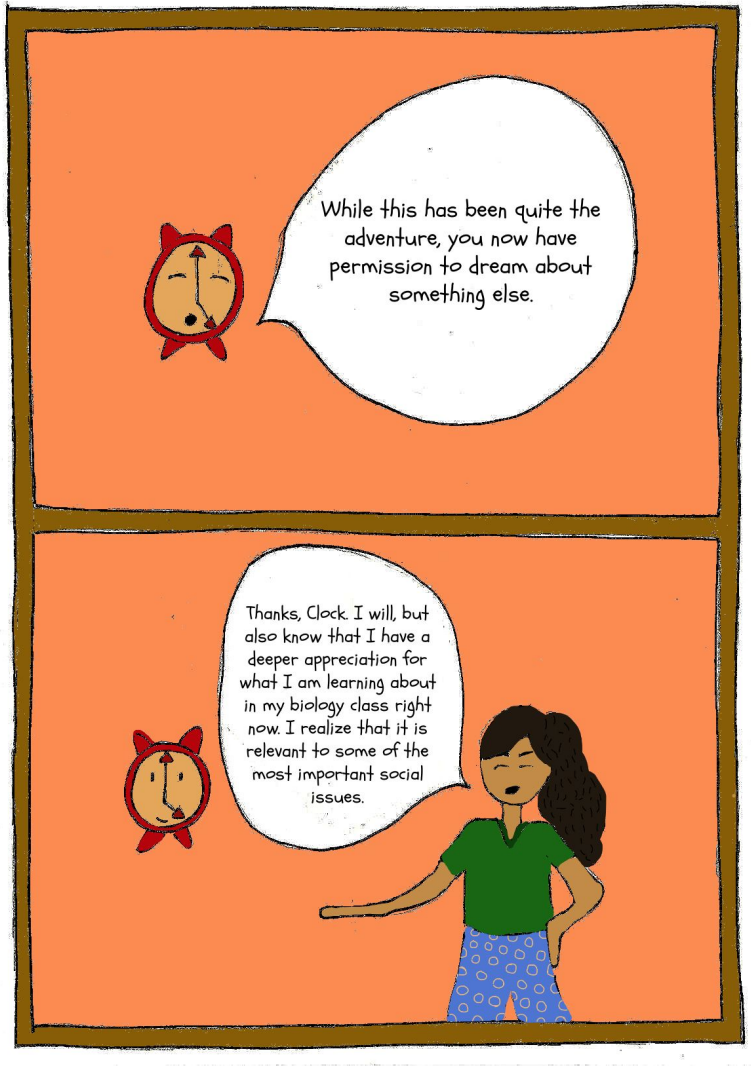

Is there anything that we can do about that?
Well, one of the most important things we can do is spread word about the utility of telomere testing.
But also, expensive healthcare costs can prevent people from getting the tests and treatment that they need.


That's true. Certain populations are more advantageous for higher paying jobs and simply better lives. Institutional racism prevents black people from accessing the opportunities that white people have in the U.S.
Yes! Do share what you know!
So basically, if a health outcome is seen between populations to a greater or lesser extent, there is a disparity. Race, ethnicity, gender and sexual identity, age, disability can impact a person's ability to achieve good health.


Exactly! The people who are most likely able to get telomere testing and take care of their health are those who have the money and low social stress!
It's the reason why in the U.S. black people have worse cancer incidence and mortality than white people.
What exactly would you say are the psychosocial stressors that cause these health disparities?


Racism.
Victims of racial discrimination will internalize the negative racial bias in their lives, and this can cause accelerated biological aging.
It's like telomere analysis is a tool that can measure racism in a person's body.


Yes!
Wow. This has been quite the night. I can't believe it was only yesterday that I was complaining about a stupid grade that I got on a test about this.
I am happy that you had this revelation, Avni!


While this has been quite the adventure, you now have permission to dream about something else.
Thanks, Clock. I will, but also know that I have a deeper appreciation for what I am learning about in my biology class right now. I realize that it is relevant to some of the most important social issues.


See ya later!