

# Cell Cyclin

## Game Design Document



**LMM Designs**

**Linda Marie Martinez**

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# Cell Cyclin

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**Cell Cyclin is a 3D bicycling adventure game for PCs.**

## **Learning Goals (Overall Game):**

- To teach students the phases of interphase of the cell cycle and for them to understand the major characteristics of each phase of interphase.
- To teach students that interphase is where the cell doubles in volume and duplicates its DNA in preparation for cell division( Mitosis).
- To teach students that the cell cycle is used by human bodies to replace damaged cells and grow.

## **Learning Objectives (Overall Game):**

- After playing through the entire game, students will be able to state that Interphase of the cell cycle is comprised of the G<sub>0</sub>, G<sub>1</sub>, S, and G<sub>2</sub> phases.
- Students will be able to correctly explain verbally when called upon by their teacher that interphase is where the cell doubles in volume and duplicates its DNA in preparation for cell division(Mitosis) after playing the entire game.
- After passing each level in the game, students will be able to correctly describe to other struggling students the major events in each phase of interphase. They will apply this knowledge to teach their classmates how to succeed in the game.
- Students will test their knowledge of the major events in each phase of interphase by passing each level of the game.
- After playing the entire game, students will be able to correctly verbally describe how the cell cycle is involved in healing wounds in the human body.
- Playing the game will enable students to correctly answer the questions on their state biology exam about Interphase.

## **Audience:**

**High school students and science lovers**

## **Teaching Standards:**

Texas State Teaching Standards: Texas Essential Knowledge and Skills(TEKS): Biology: Skill: 5A:Describe the stages of the cell cycle, including deoxyribonucleic acid (DNA) replication and mitosis, and the importance of the cell cycle to the growth of organisms.

## **How these standards are taught in the game:**

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Texas Experiential learning theory is a widely accepted and applied theory of student learning that was developed in 1984 by education scholar David A. Kolb, professor of Organizational Behavior in the Weatherhead School of Management at Case Western Reserve University (Carleton College, 2016)(Kolb, 2014). Experiential learning theory is used in over 30 academic fields to create curriculum for elementary, middle, high school, college, and adult training (Kolb, 2014).

This game teaches the learning goals and objectives with Experiential Learning Theory. In this theory, developed by David A. Kolb, users start by having concrete experiences in the game. They reflect on these experiences as they are playing. These are the first 2 steps in experiential learning. The third step is abstract conceptualization. The player tries to make sense of what is happening and normally a teacher facilitates this step. In video games the user interface and feedback from the game acts as the teacher and gives immediate feedback when a player makes a positive move, or a negative move. In the final step, the player actively experiments with these newly learned concepts. They are now able to play the game and apply what they have learned from the user interface and game feedback.

For example, in this game players learn that eating healthy food gives them energy to make cyclins which is shown in the user interface at the top of the game screen. Cyclins and nutrients are a real requirement to move the cell cycle forward. Eating junk food does not increase cyclins and players learn not to eat these items.

# Game Influence/References

## It's Paper Boy meets Mario meets cellular biology

Figure 1



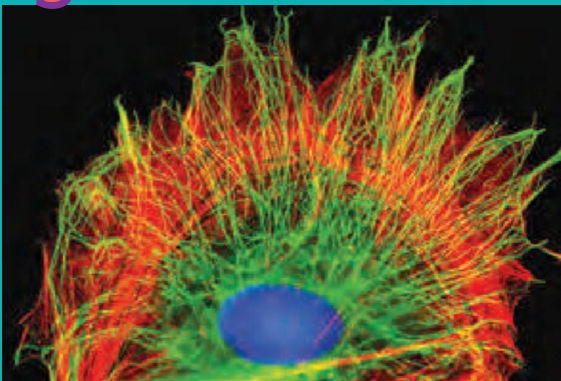
A scene from the action game Paperboy created in 1985 by Atari for arcades. The biking perspectives and scenes influenced the creation of Cell Cyclin.

Figure 2



A scene from Super Mario World created by Shigeru Miyamoto for Nintendo. This game's feeling of adventure and wonder influenced the creation of Cell Cyclin.

Figure 3



A cellular biology image of a cell migrating from Molecular Biology of the Cell by Bruce Alberts. This book's contents influenced the creation of Cell Cyclin.

# Key Characters

**Gabby:** Reluctant Hero- Gabby is a depressed and insecure 16 year old Hispanic teenage girl who loves science, medicine, and helping others.

**Xavier:** Xavier is a 16 year old Hispanic teenage boy who loves to skateboard and is best friends with Gabby.

**Mom:** Beatriz is a cellular biologist whose parents were born in Saltillo Mexico. She is Gabby's mother

**Dad:** Alberto is a math professor whose parents were born in Durango Mexico. He is Gabby's dad

**Organelles:** Organelles are tiny functional units of the cell.

**Mitochondria:** Mitochondria are an organelle responsible for generating the energy used by cells in the form of ATP.

**Deoxyribonucleic Acid (DNA):** DNA is the molecule that the cell uses as directions to create all proteins and RNA molecules in the human body. DNA is made of 2 strands that are joined and twisted in a double helix shape. Each strand has a backbone that four different types of nucleotides attach to. The nucleotides in DNA are adenine (A), cytosine (C), Guanine (G), and thymine (T).

**DNA Polymerase:** DNA Polymerase is an enzyme used by the cell to create a new copy of DNA from an existing strand of DNA in the S-Phase of Interphase.

**Nucleotides:** Nucleotides are the building blocks of DNA and RNA. They are made of a sugar, phosphate, and a nitrogen base. There are 4 types of nucleotides used in DNA: adenine (A), cytosine (C), guanine (G), and Thymine (T). These 4 nucleotides are used in long strands like a code by the cell to direct the formation of proteins.

# Key Characters Continued...

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**mRNA:** an RNA molecule that travels to and carries the instructions ribosomes read to create a protein out of amino acids. mRNA is a copy of DNA that can travel out of the cell nucleus where amino acids are located.

**ribosome:** Ribosomes are protein factories of the cell. It's a particle made of protein and RNA that reads mRNA to create an amino acid sequences that become proteins.

## Dramatic Arc:

**Exposition:** Gabby and her mom Beatrice are introduced. Beatrice, a cellular biologist dies in a car accident while driving to buy Gabby ice cream. Gabby blames herself and becomes depressed and starts having cellular hallucinations. Gabby's mother's ghost appears and tells Gabby she has special powers to feel her cells. Gabby realizes that this is why she has been cellular objects everywhere. Her mother tells her she can use these powers to help her friend who is about to ask her for help. Gabby wakes up to her friend Xavier calling her asking her to help him. He has had a bad skateboarding accident and he doesn't want to call an ambulance because he is an undocumented citizen. Gabby has taken classes to prepare her to be a nurse at school and she thinks she might be able to help. She hops on her bike and prepares to ride to the skate park where her friend is. She sees more cellular objects in her neighborhood and isn't scared of them anymore. She views them as help from her mother.

**Rising Action:** Gabby starts her journey to save her friend in the G1 level by biking to the skate park. She encounters obstacles like cars and busses that she must avoid. She must learn that she must double her organelles to pass G1.

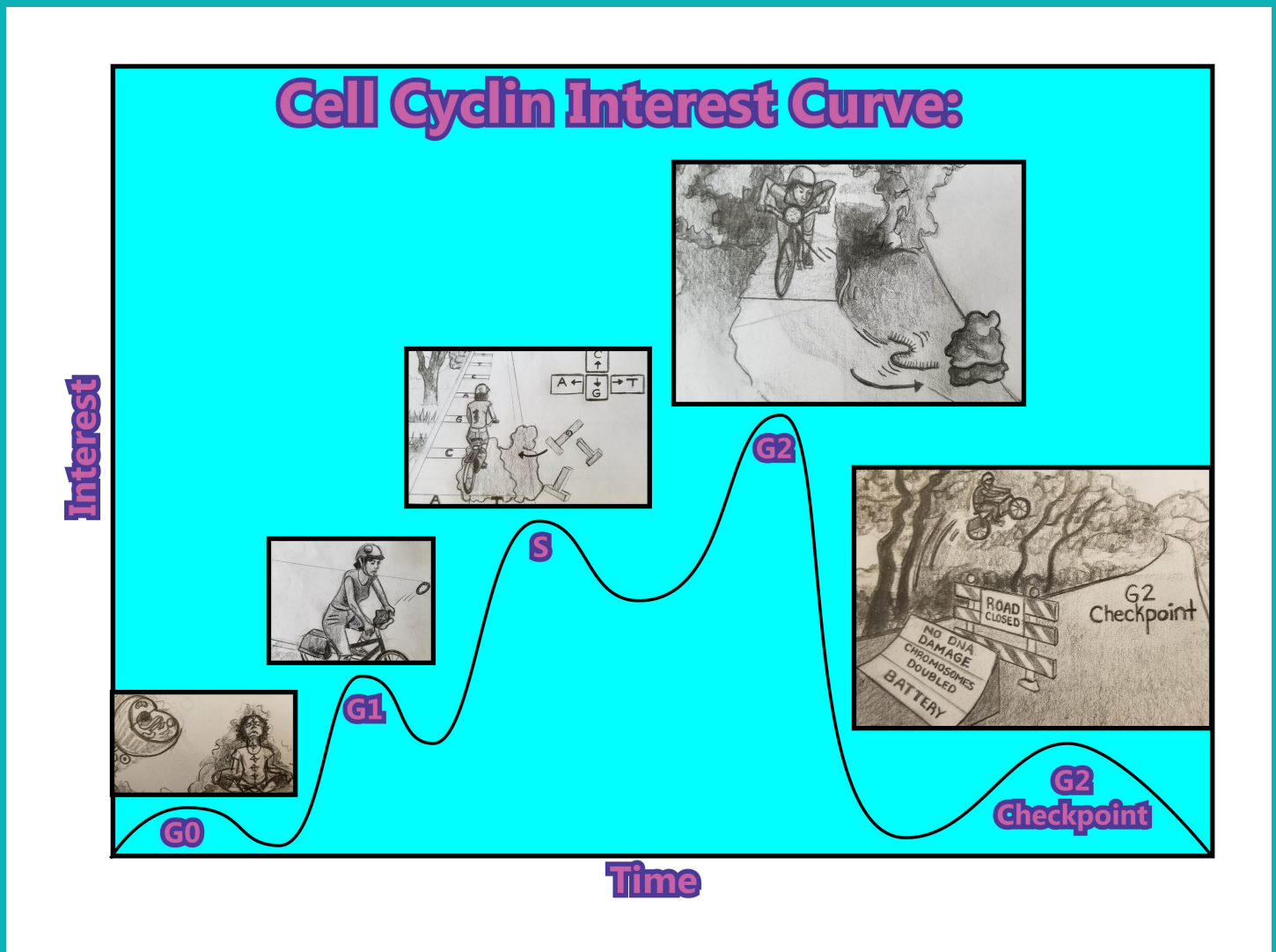
**Climax:** In the S- phase of the game Gabby must duplicate her DNA. The player acts as DNA Polymerase and rides along unwound DNA strands and correctly matches base pairs by using the arrow keys on her keyboard. In the G2 level Gabby must eat healthy food to create mRNA. She shoots the mRNA at ribosomes 2 times to create proteins needed for mitosis.

**Falling Action:** Gabby passes the G2 checkpoint and has successfully finished interphase. She will now be ready for Mitosis.

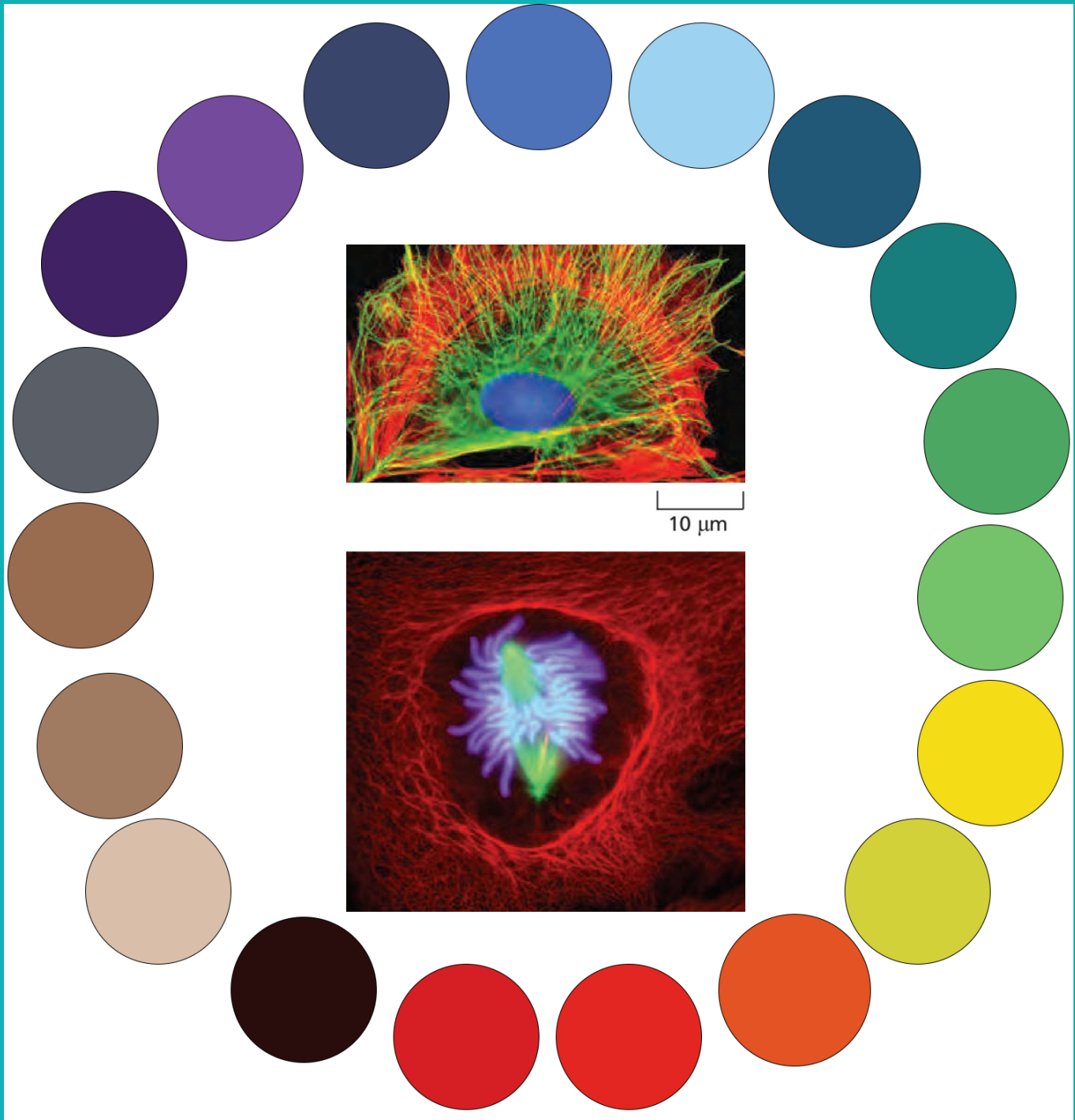
# Dramatic Arc Continued:

**Resolution:** Gabby is now closer to her friend and has the proteins she needs for Mitosis and her DNA and organelles duplicated. She needs to complete Mitosis(a future game to be developed) before she can save her friend Xavier.

## Interest Curve: Figure 4



## Figure 5



The colors for this game were influenced by cellular biology images of cells stained.



# Style Guide

Figure 6



The colors are applied to a drawing of the main character Gabby.

# Cell Cyclin Game Levels:

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## G0 phase:

### Learning Goals (Level):

Learners will know the purpose of the G0 phase.

### Learning Objectives (Level):

Students will be able to explain to their teacher that in G0, cells are resting from growing, they do not copy their DNA, and not actively preparing to divide.

### Game Mechanics:

The mechanics consist of clicking through the backstory of the game. Simple choices are offered to the player, such as deciding to answer the phone, or not? And should the player be woken up, or not?

### Narrative Hook:

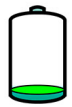
Gabby's mother dies and Gabby gets very depressed and loses confidence in herself to be a productive member of society. Her mother's ghost appears and tells Gabby she has special powers to feel her cells. She tells her using these powers will help her save her friend who is injured and reminds Gabby that she loves helping people. The level ends with her answering a phone call from her friend Xavier. He is seriously injured from a skateboard accident and needs her to come help him. She agrees to help and hops on her bike as the level ends.

### How level teaches objectives:

How level teaches objectives: The mechanics of this level were made to be very simple and restful to mimic the mechanics of G0 in the cell cycle. Finally, the main character, Gabby, is sleeping through much of this level except when she gets ready to transition to level 2 the G1-phase level. In the user interface, the cell volume does not increase in G0. This teaches students that no growth occurs in this phase of the cell cycle.

Figure 7

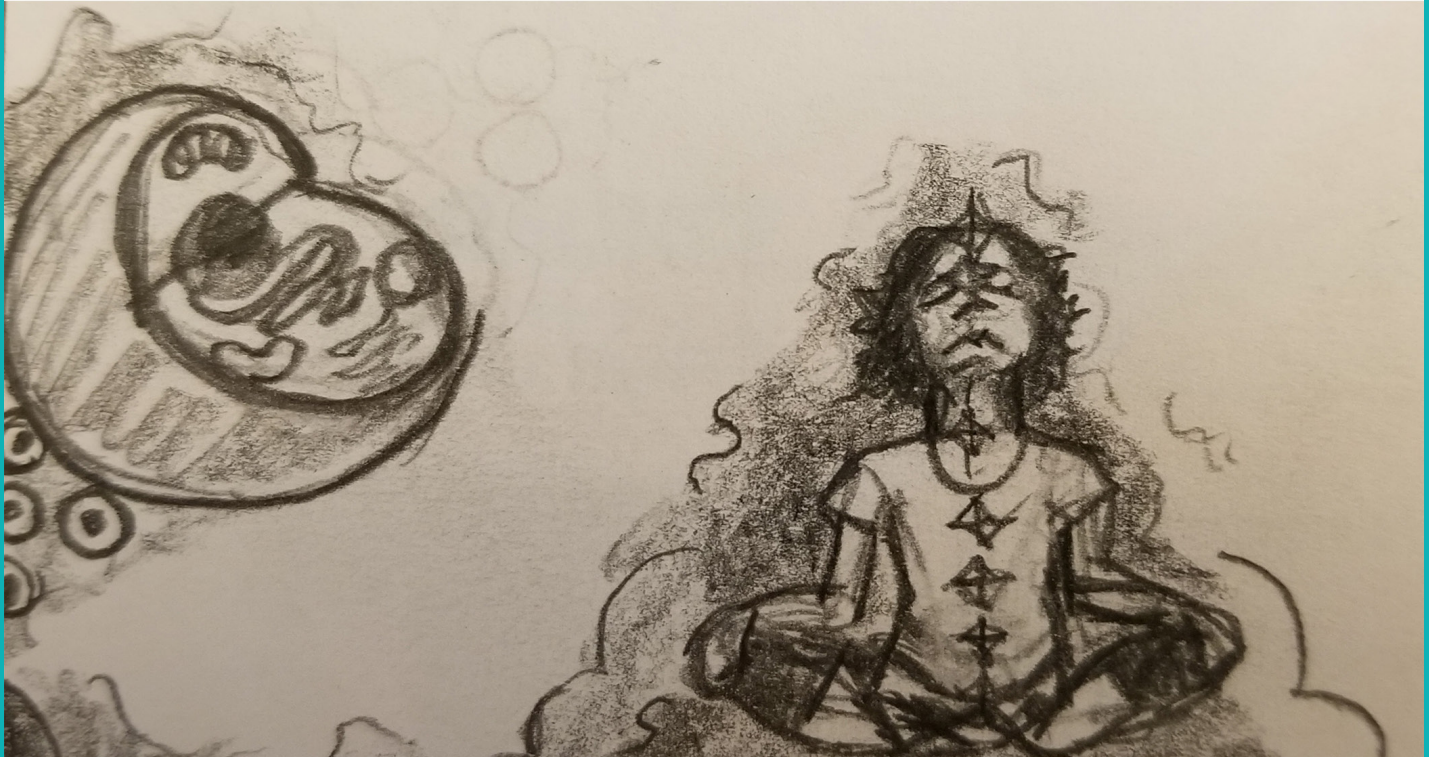
GABBY  
00350



Cyclins

Level  
G0

Volume



**G0 Level: The mechanics are easy and restful clicking through the backstory. This represents the cell resting in G0 of the cell cycle. Gabby is feeling her special powers to connect to her own cells in this scene.**

## Figure 8



**Score:** Players earn points by completing the level objectives such as resting and clicking through the backstory.

**Battery icon:** This battery represents the players energy and has the word cyclins next to it. Players get more energy by eating healthy food in the game and by completing each levels objective such as duplicating DNA. Cyclin proteins power the cell cycle forward like a battery powers a toy car.

**Level:** The level is displayed which also helps the player learn the key functions of that section of the cell cycle.

**Volume meter:** Volume doubling is a requirement of the cell cycle. Players double their volume by eating food, and by doubling organelles, DNA, and proteins. Volume does not increase in G0 because the cell is not actively growing. Volume will not increase until G1.

**Sleep meter:** The player must rest and sleep in the G0 level just like cells do in the cell cycle. Once the player has rested enough by clicking through dreams and clicking the option to sleep the meter will reach alarm section. This will allow the player to end the level and wake up to start the G1 level.

### How to complete level:

The player must click through the backstory, wake the player up, and answer the phone. This initiates the transition into the next level G1.

## Learning Goals (Level):

- To teach students the main activities cells perform in G1.
- Learners will know what conditions must be met in the G1-phase of the cell cycle to pass into the S-phase.

## Learning Objectives (Level):

- Students will be able to demonstrate by passing the G1 level that the positive external environmental conditions(plenty of nutrients, low radiation) of a cell will allow it to pass into G1 and enter the S-phase.
- Students will be able to discuss to other students and their teacher that no DNA damage must be detected and corrected in the cell by the time it reaches the G1 checkpoint.
- Students will apply this knowledge about DNA damage to pass the level.
- Students will explain to their teacher and other players that organelles must be doubled in order to pass the G1 level.
- Students will deduce that this doubling of organelles increases the cell volume.

## Game Mechanics:

In the G1 level the player eats healthy food to gain energy and ammo for a protein shooter attached to the front of their bike. This protein ammo will be used to shoot at organelles in the biking environment and floating in the sky. Shooting the organelle once causes it to double in volume. And shooting it a second time causes it to be split into 2 organelles. This doubles the original organelle.

A battery is shown in the user interface acts as an abstraction of energy and cyclins. Eating healthy food and doubling organelles increases cyclin levels in the user interface.

When the player rides their bike into the sun ray it initially increases their cyclin levels(is good), but if they stay in the sun too long (3 seconds or more) it causes DNA damage. Eating unhealthy food also causes DNA damage and the words "DNA Damage" appear on the screen in these 2 situations along with a negative sound effect. DNA damage must be repaired with a DNA repair kit. Players must find the kit while biking and ride over it to pick it up and repair their damaged DNA. In order to pass the G1 checkpoint at the end of this level the DNA damage indicator in the user interface must be shown in the off position.

## **Narrative Hook:**

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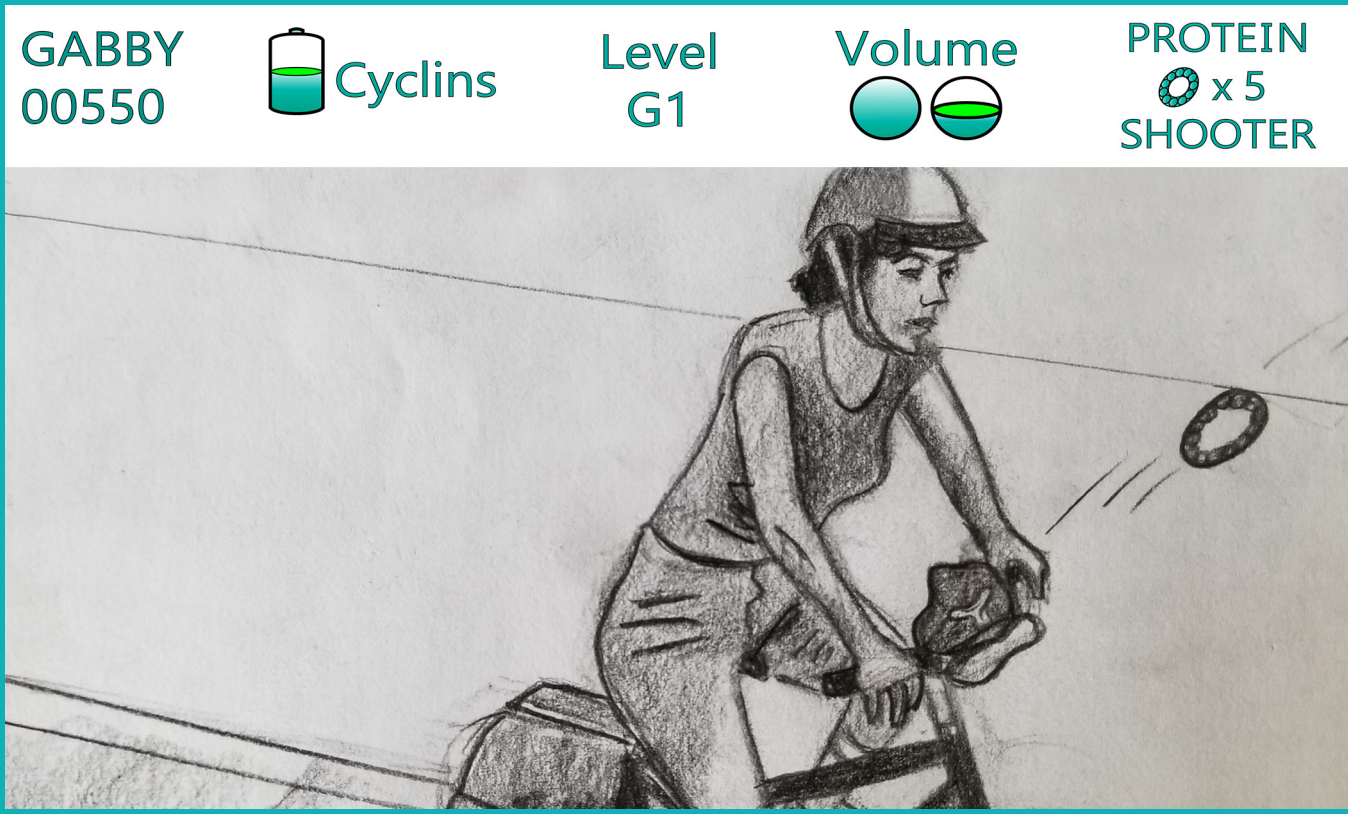
Players will be motivated to help Gabby pass G1 and help her friend Xavier at the skate park. Gabby and the Player's confidence will increase as they successfully learn the game rules and double their organelles and correct DNA damage. This confidence will peak as the player bikes over the G1 checkpoint ramp and into the air.

## **How level teaches objectives:**

In the G1 level the player eats healthy food to gain energy and protein shooter ammo. These are the favorable environmental conditions that allow the player to double their cell organelles and increase the cell volume. The player will learn all these requirements are important by getting feedback from the user interface and the game. This replaces the role of a teacher in part 3 of the experiential learning cycle called abstract conceptualization. User feedback from the game such as the displaying of the words: "Organelles Doubled!" When players double their organelles along with a special sound effect act as feedback and a reward to let the player know this is important to passing the G1 level.

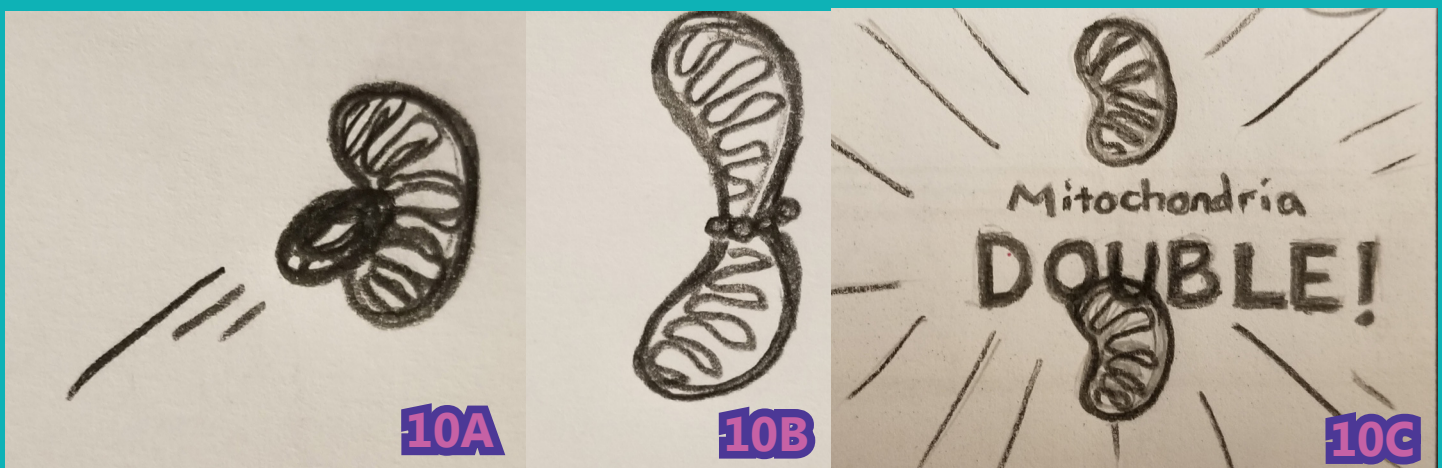
DNA damage from the sun and from eating junk food must be repaired with a DNA repair kit, in order to pass this checkpoint. In the user interface the words "DNA Damage On" will be displayed along with a different more stressful version of the background music in the game. These mechanics give the player feedback that the player must incorporate into their game play to demonstrate that the cell can't pass the G1 checkpoint with DNA damage.

Figure 9



The G1 Level: In G1 Gabby shoots protein rings at organelles to double them and then cut them in half.

Figure 10 (A, B, C)



The details of the G1 Level game mechanics: In G1 Gabby shoots protein rings at organelles to double them in volume(8A) and then cut/pinch(8B) them in half. Once the organelle is duplicated, the words “Mitochondria Double!” appear.

## User Interface (UI) for G1: Figure 11



**Protein Shooter:** The UI for G1 is the same as G0 except for the Protein Shooter. The Protein Shooter is a tool the player uses to shoot protein rings at organelles to double their volume with one shot and split them in 2 with 2 shots. This doubles the organelle and increases the volume, cyclins, and score. Players get more ammo for the protein shooter by eating healthy food and increasing their cyclins.

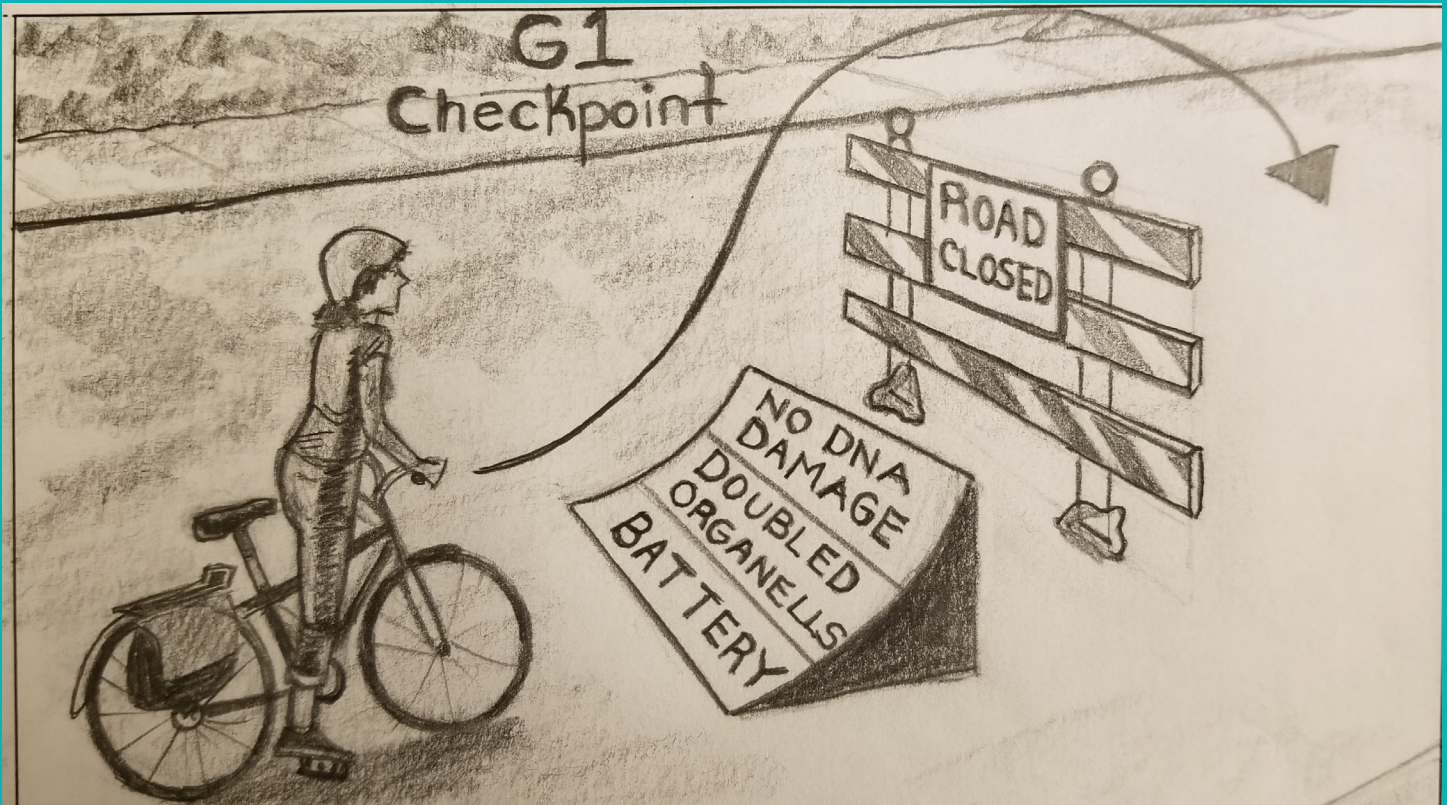
### How to complete level:

To pass the G1 level, players must eat healthy food. This gives them energy displayed as a battery filling with power with the word cyclins written below it. Having cyclins allows them to unlock a protein shooter tool on their bike and get ammo for it. Players shoot this ammo twice at an organelle to double it. One shot doubles the volume and one shot splits the organelle in 2. Doubling organelles is one requirement to pass the G1 level. One other requirement is that all DNA damage is repaired with an DNA repair kit. The final requirement is that the player has full cyclin levels by the time they reach the G1 checkpoint. The player must also bike to the G1 checkpoint.

### Mini-activity/Checkpoint/Transition to Next Level:

To pass the G1 level the player must pass through the G1 checkpoint. The G1 checkpoint requires players to have corrected all DNA damage (shown as DNA damage OFF in the UI), consumed ample nutrients (healthy food that is shown as cyclins in the UI), and doubled their organelles (increases cyclins in the UI). These requirements are written onto the ramp that players must successfully use to jump over the barricades on the road that takes them into the S-phase. When the player bikes over this ramp, the conditions they successfully have met will light up and give the player more power to jump the barricades. If the player does not meet a requirement, they will not make the jump and will fall over onto the street. They will then have to repeat the level. This feedback from the ramp teaches the player these conditions are essential to moving through the G1 checkpoint.





A scene from the G1 Level Checkpoint. The three G1 level checkpoints are written on the ramp shown above. If Gabby meets the requirements they light up as she bikes up the ramp and she is given extra energy that launches her into the air over the road block. This advances her to the next level and it reinforces the learning objectives. If she does not meet the 3 requirements she must repeat the level.

## S-phase:

### Learning Goals (Level):

- To teach students the main activities cells perform in the S-Phase.
- Learners will know the DNA nucleotide base pair rules.
- Learners will understand that DNA damage must be repaired.

### Learning Objectives (Level):

- Students will be able to explain to their teacher that in the S-phase, cells must accurately duplicate their DNA.
- Students will correctly apply base pairing rules(A to T)(C to G) of nucleotides to copy DNA in the game.

## **Game Mechanics:**

In this level players will embody DNA polymerase and ride along an unwound DNA strand. A translucent DNA polymerase will envelop then player and attract loose nucleotides like a magnet from the environment. The player will choose the correct nucleotide to match to the nucleotide they see first following the base pairing rules: A to T and C to G. The player will choose the correct nucleotide with the arrow keys on their keyboard. This can be done as fast as the player is capable of. This is similar to the mechanics of the game Dance Dance Revolution (DDR). When a player makes a mistake in base pairing, the words “DNA Damage” will be displayed on the screen. The player will have a chance to repair this damage by riding over a DNA repair kit to repair their damage.

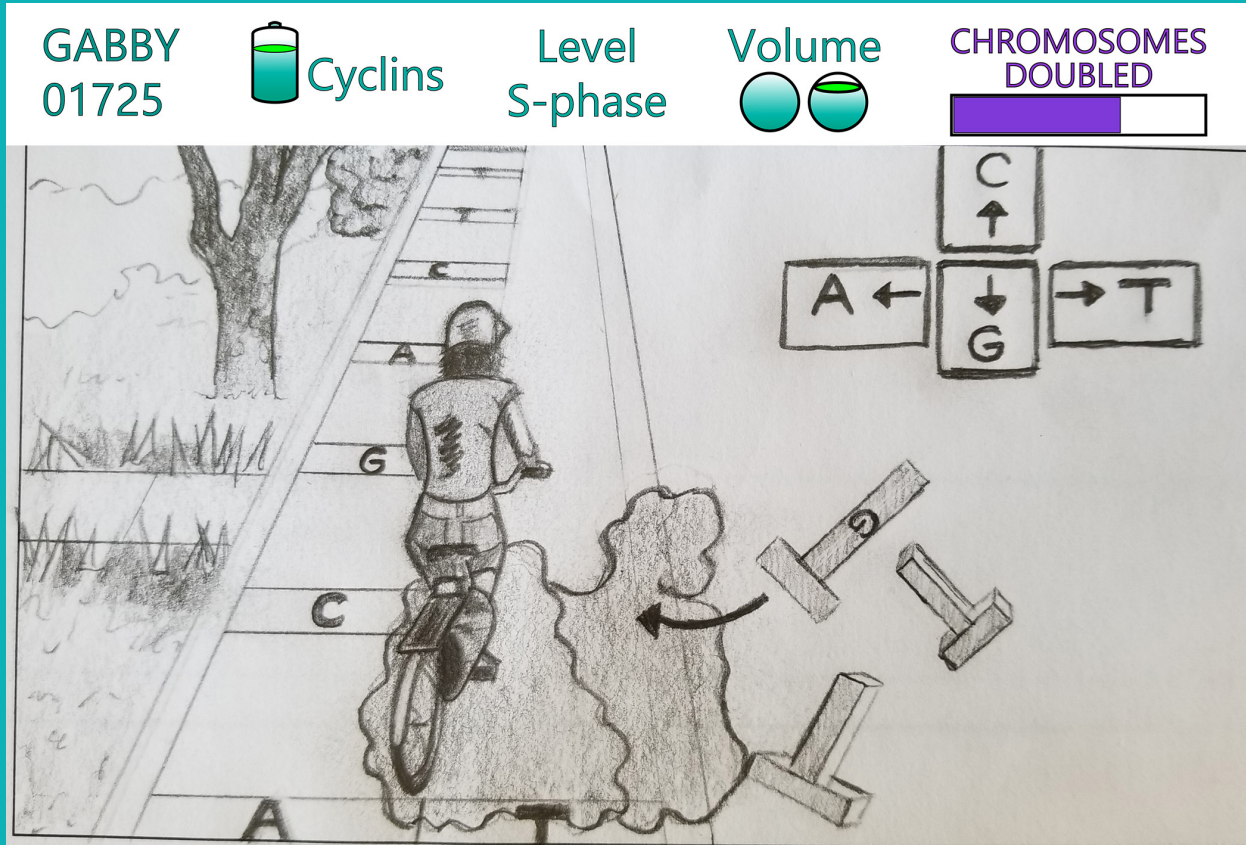
## **Narrative Hook:**

Gabby’s confidence is higher after G1, and in the S-phase she faces new challenges. She feels pressure and anxiety to quickly and correctly match DNA base pairs on unwound DNA. This increased stress adds emotional intensity to this level.

## **How level teaches objectives:**

Players will be embodying the enzyme DNA polymerase. This enzyme is responsible for matching base pairs in cells. Players will be actively duplicating DNA in this level by correctly matching base pairs. They will use the keyboard arrows to match A to T and C to G. If they make a mistake a status will appear in the user interface that will say DNA Damage On. And the words mutation will appear on the screen, but the player will be allowed to move forward. They can change their status to DNA Damage Off by riding over a DNA repair kit. This feedback from the game will teach students that DNA must be repaired. They will also learn the correct base pairing rules from the game feedback.

Figure 13

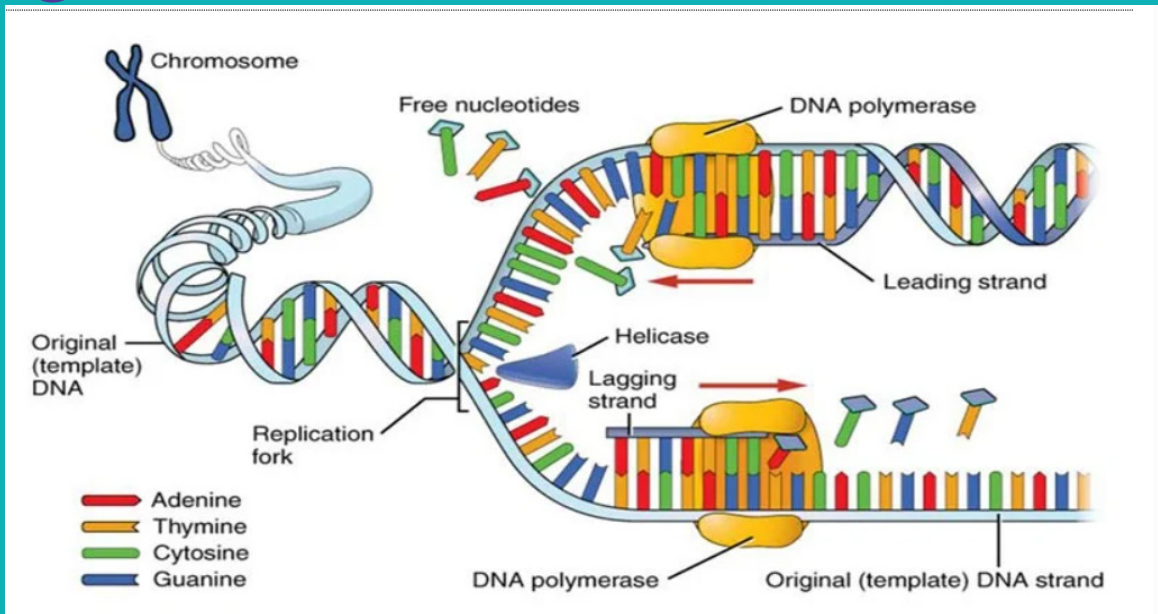


The S-Phase Level: In the S-phase level Gabby uses the keyboard letters A, T, C, and G to match DNA base pairs that are lining the sidewalk.

Figure 14



The mechanics of the S-phase game were influenced by the popular game Dance Dance Revolution made in 1999 by Konami. In the game arrows are used to represent dance steps.



The mechanics of the S-phase game were created to mimic the real steps involved in DNA replication. In the image above DNA polymerase is adding nucleotides to an unwound DNA strand to duplicate it. Players in Cell Cyclin will embody DNA polymerase and add nucleotides to an unwound strand (shown in figure 10).

### User Interface (UI) for S-Phase: Figure 16

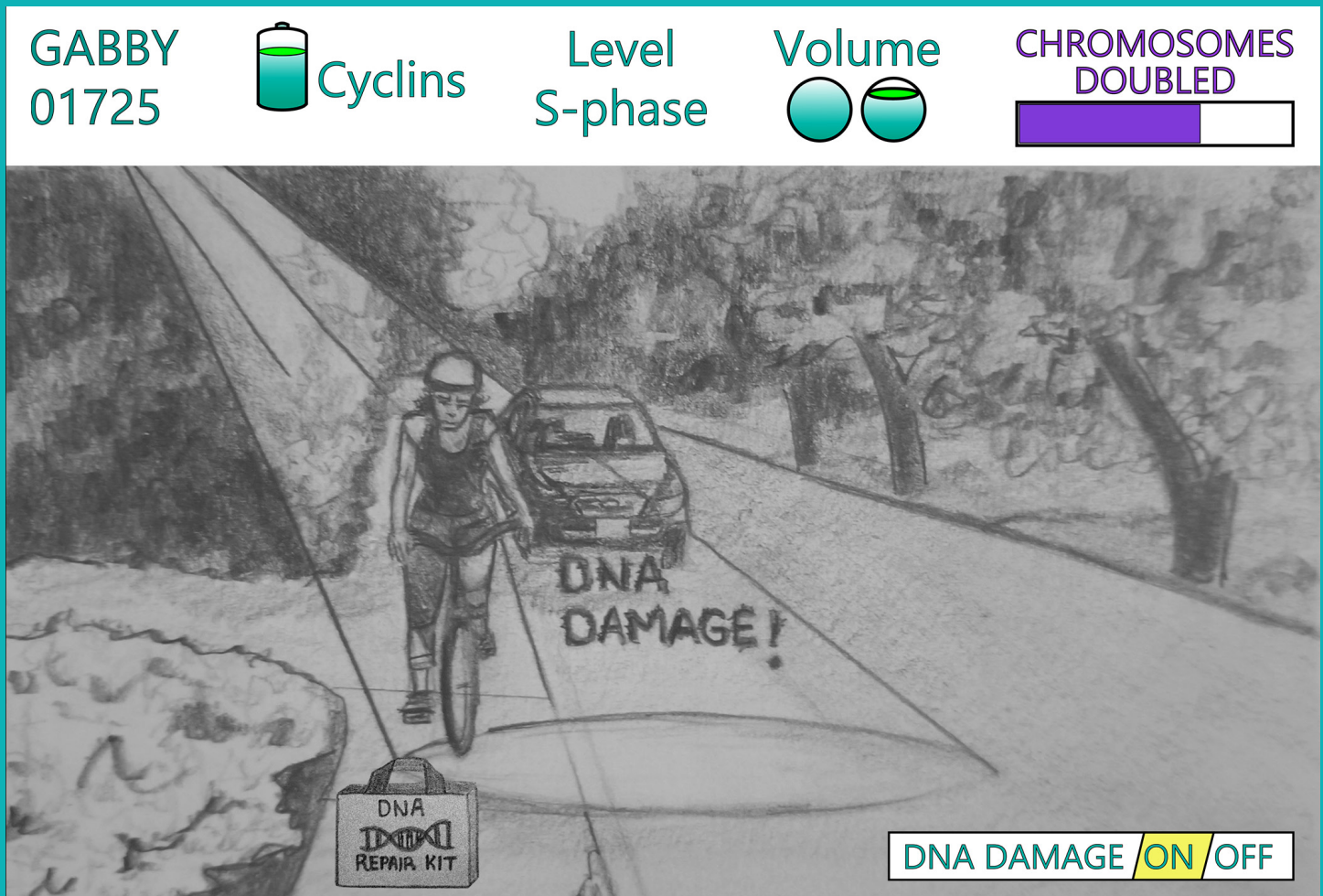
GABBY 01725	 Cyclins	Level S-phase	Volume 	CHROMOSOMES DOUBLED 
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Chromosomes Doubled: Everything in the UI is the same as the previous levels except for the Chromosomes Doubled meter. This bar moves the right as the player doubles DNA strands that are randomly scattered in the environment by using their arrow keys to match base pairs with the unwound strands. This doubling of DNA that folds into chromosomes will increase the volume of the cell and the cyclins, and score.

In the S-Phase and the entire game the will be an extra UI that detects DNA damage.

# DNA Damage User Interface (UI): Figure 17

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Players can ride over DNA Repair Kits located in the environment to repair damaged DNA from the sun rays, or from incorrectly matching DNA base pairs.

## How to complete level:

Players must correctly duplicate 5 different DNA strands located in the level while continuing to bike forward. In between DNA strands players must correct any mistakes with DNA repair kits. Players must still also avoid the obstacles of cars, too much sun, and junk food all of which cause DNA damage as well. This damage is also repaired with DNA repair kits.

## G2 phase:

### Learning Goals (Level):

- To teach students the main activities cells perform in the G2-Phase.
- Players will learn the function of ribosomes

### Learning Objectives (Level):

- Players will deduce that proteins must be doubled in the G2 phase.
- Learners will conclude from playing the level that ribosomes make proteins.

### Game Mechanics:

Players will be actively doubling proteins in this level. They will shoot an mRNA strand from a nucleus shooter mounted to their bike at ribosomes that are floating in the environment. A scope will appear on the screen to help the player shoot and the mRNA will zig zag toward this moving ribosome target making it challenging to hit. Successfully hitting the ribosome will cause it to start translating the mRNA into an amino acid sequence. The player will shoot the same ribosome a 2nd time to cause the ribosome to release the mRNA strand and newly created amino acid chain. The amino acid chain will then spin and fold into a protein. The words “Protein Created” will then appear on the screen as a game reward with lights and a rewarding SciFi music sound effect.

### Narrative Hook:

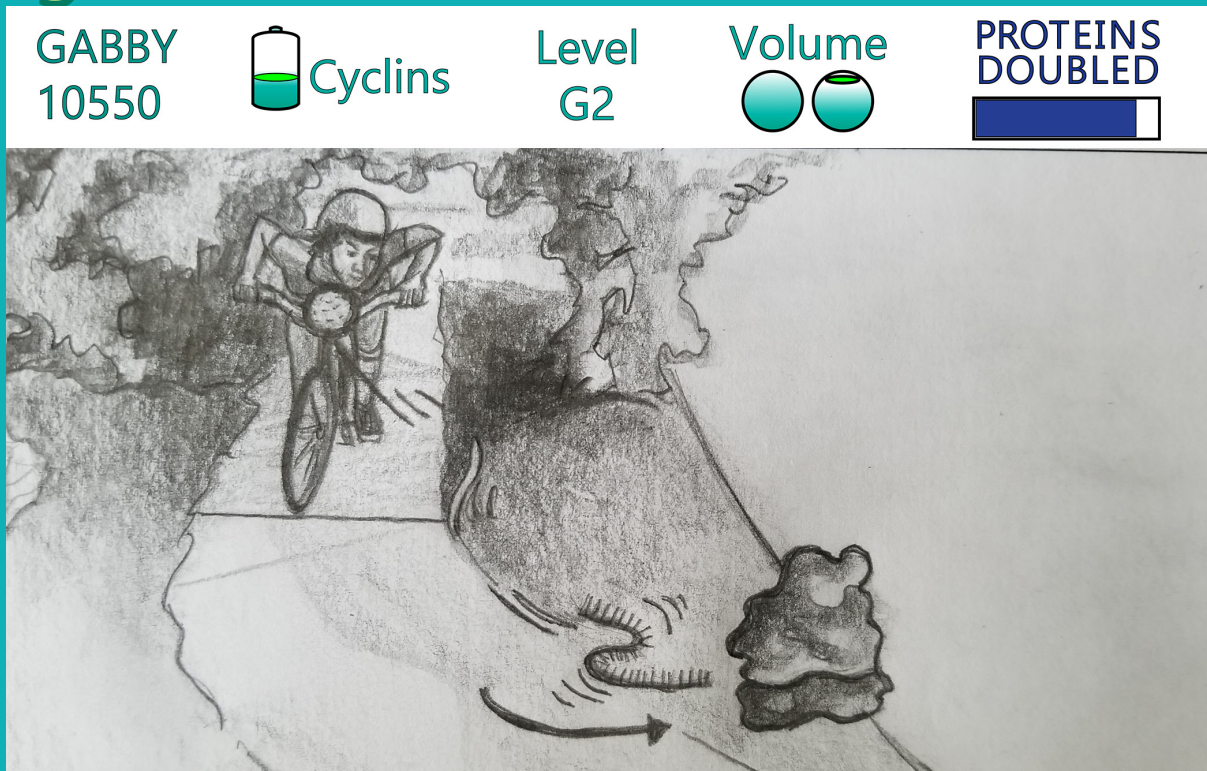
Gabby is challenged by a new level, the hardest one yet. She has confidence from passing the previous levels and has a new tool in this level. This makes her feel well prepared to pass this level with lots of hard work. When she arrives at the G2 checkpoint at the end of the level she will feel a huge sense of achievement as she uses the ramp to jump the road blocks and flies high into the air. She will have finished the game and be happy and confident. The player will feel the same emotions as Gabby by developing empathy through controlling Gabby through the game. This type of empathy is unique to the medium of video games.

### How level teaches objectives:

Players will be experientially creating proteins with mRNA and ribosomes. This will teach them that ribosomes create proteins from an mRNA template that is sent from the nucleus. This template is then read and used to make amino acid chains that fold into proteins. This will all be visible in the game and the words: “Protein Created” will be displayed on the screen.

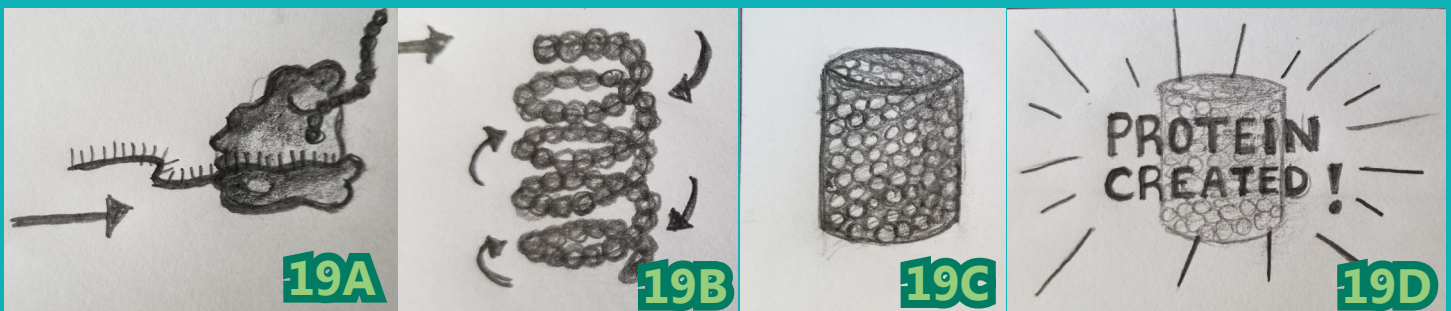
## Image/Storyboard/Action Shot: :

### Figure 18



A scene from the G2 level. In the G2 level players must successfully double 20 proteins while biking. This will give them enough battery/cyclins to win the game. They must shoot an mRNA strand from their nucleus shooter at a floating ribosome. The ribosome target will be moving and challenging to hit. The mRNA will zigzag as it moves to its target.

### Figure 19(A, B, C, D)



The details of the G2 game mechanics. Once an mRNA strand has been shot at a ribosome it is read and translated into an amino acid strand that forms at the top of the ribosome shown above in figure 14A. Once the amino acid strand is fully formed it folds(14B) into a protein(14C). Then the words, "Protein Created!" are shown on the screen(14D).

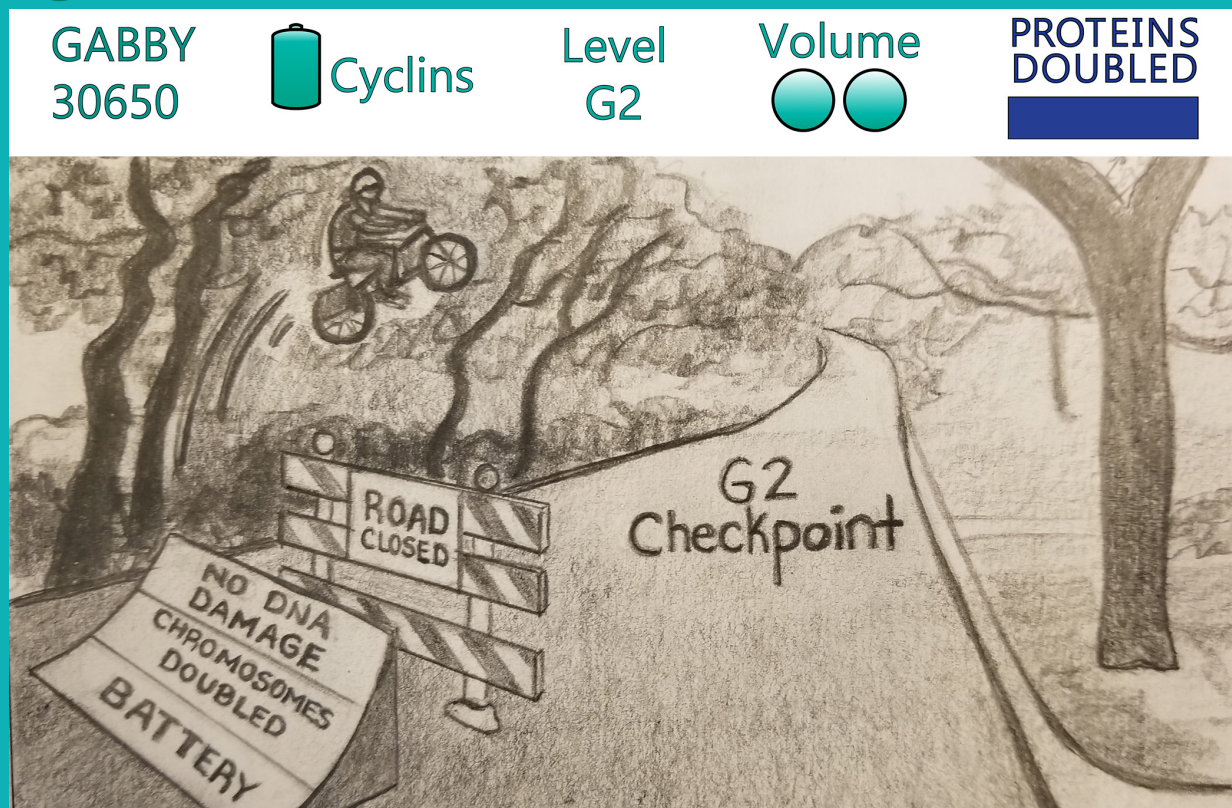
## How to complete level:

Players must successfully double 20 proteins while biking. This will give them enough battery/cyclins to win the game. They must simultaneously avoid getting DNA damage from the sun, junk food, and getting hit by a car. If they do get DNA damage it must be repaired with a DNA repair kit.

## Mini-activity/Checkpoint/Transition to Next Level

### G2 Checkpoint

#### Figure 20



This is a scene from the G2 Checkpoint. To pass the G2 checkpoint the player must have no DNA damage, their chromosomes must have been doubled successfully in the S-phase, and they must have enough battery power (cyclins). When the player successfully jumps the ramp the following messages will be temporarily displayed and fade out on the screen: Congratulations! Cell rested: G0! Organelles doubled: G1! Chromosomes duplicated: S-Phase! Proteins doubled: G2! You successfully passed Interphase!

The following sentences will be displayed until the player quits the game: Gabby, you are halfway to your goal of saving Xavier! Can you pass the future Mitosis games to save your friend? Time will tell...



# Next Steps:

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## Playtesting

- Is it fun?- Build a digital prototype and test it with teenagers
- Series of with mechanical tweaks in between to make more fun based on feedback

## Mitosis- Game expansion/sequel

- How to teach players game mechanics?- Use narrative- Gabby's mom's ghost helps you in tutorial level.
- Build the game including the mitosis expansion