SCIENCE CEILIDH
TEACHER PACK

THE CELL CYCLE: FROM BIRTH TO DEATH

THE LIFE OF A CELL

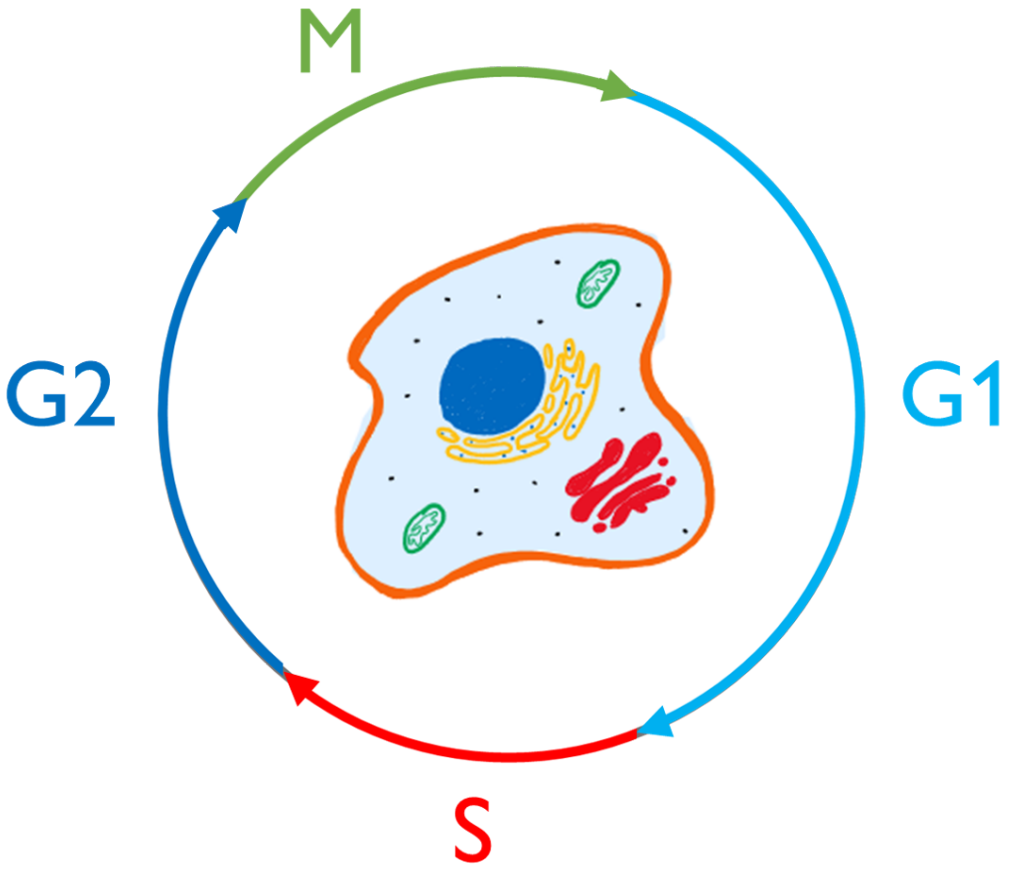
LEARNING INTENTIONS

- Demonstrate understanding of the cell cycle
- Be able to identify the 4 phases of the cell cycle
- Understand how the cell cycle is controlled and what happens when this goes wrong.

Featuring Research From:
Wellcome Centre for Cell Biology, University of Edinburgh

Biological systems - Body systems and cells.

Learning about the cells as the basic units of life. Investigating body systems and potential problems which they may develop. **SCN 2-12a**



BY ANDRI KONSTANTINOU

FREELY ACCESSIBLE:
SCIENCECEILIDH.COM/PLACEMENTRESOURCES#LIFE-OF-A-CELL

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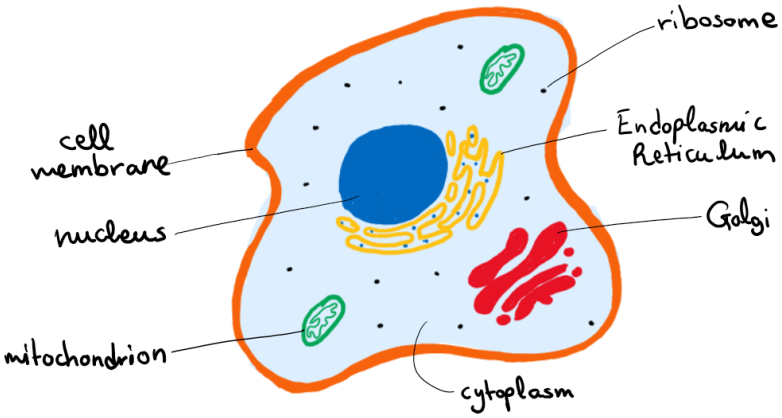
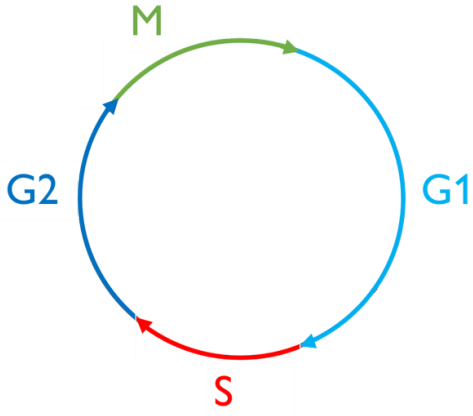
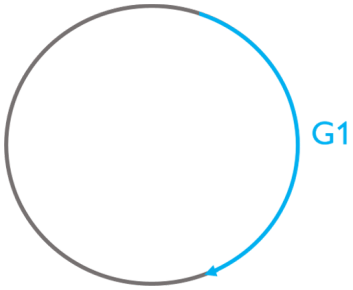
THE CELL CYCLE

The human body has 15 trillion cells, that is 15 followed by 12 zeros! Each one of our cells goes through its own life cycle. This is a 4-stage process where a cell grows in size, replicates its DNA and undergoes a process called mitosis, ultimately resulting in cell division.

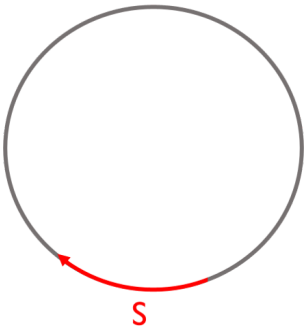


THE 4 PHASES OF THE CELL CYCLE

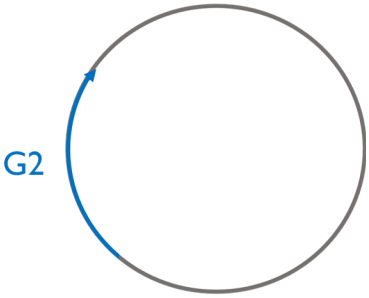




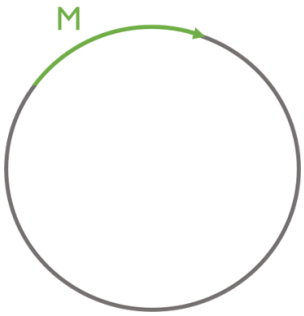
1. G1: Gap Phase 1 - cell growth
The cell begins its life cycle with the G1 phase.
In this phase the cell grows i.e. makes more of its contents.



2. S: S phase - DNA synthesis
This is followed by the S phase, where the cell replicates its DNA. The DNA is found in the nucleus and DNA replication is the process by which **one** copy of the cell's DNA becomes **two** copies.



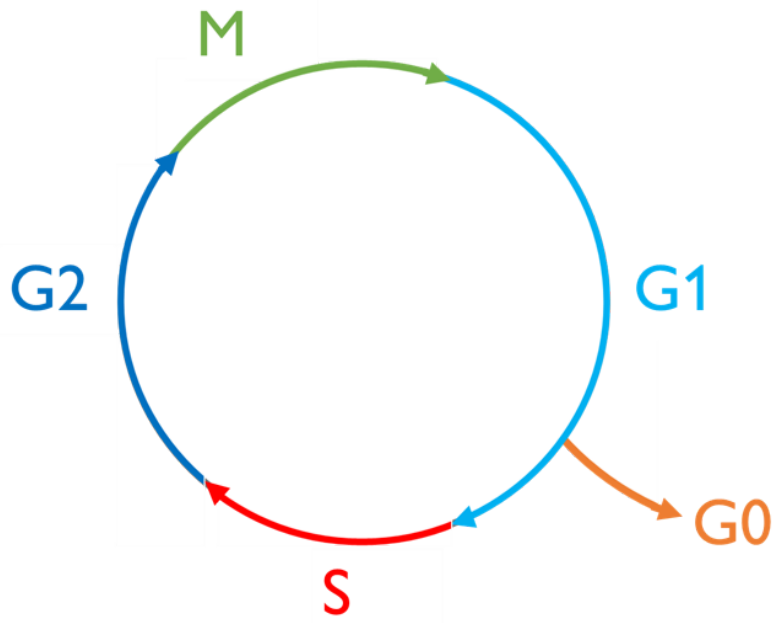
3. G2: Gap Phase 2 - growth and preparation for mitosis
When DNA replication is completed, the cell enters G2.
G2 is a second growth phase where more cell components are made.



4. M: M phase - mitosis and cytokinesis
The M phase is split into two parts: mitosis and cytokinesis.
Mitosis is the process by which one cell becomes two daughter cells. During mitosis the replicated chromosomes are separated in different nuclei. Once this is complete the cell goes through **cytokinesis**, meaning it splits into two cells.
These new cells will go through the same cell cycle, starting at G1.

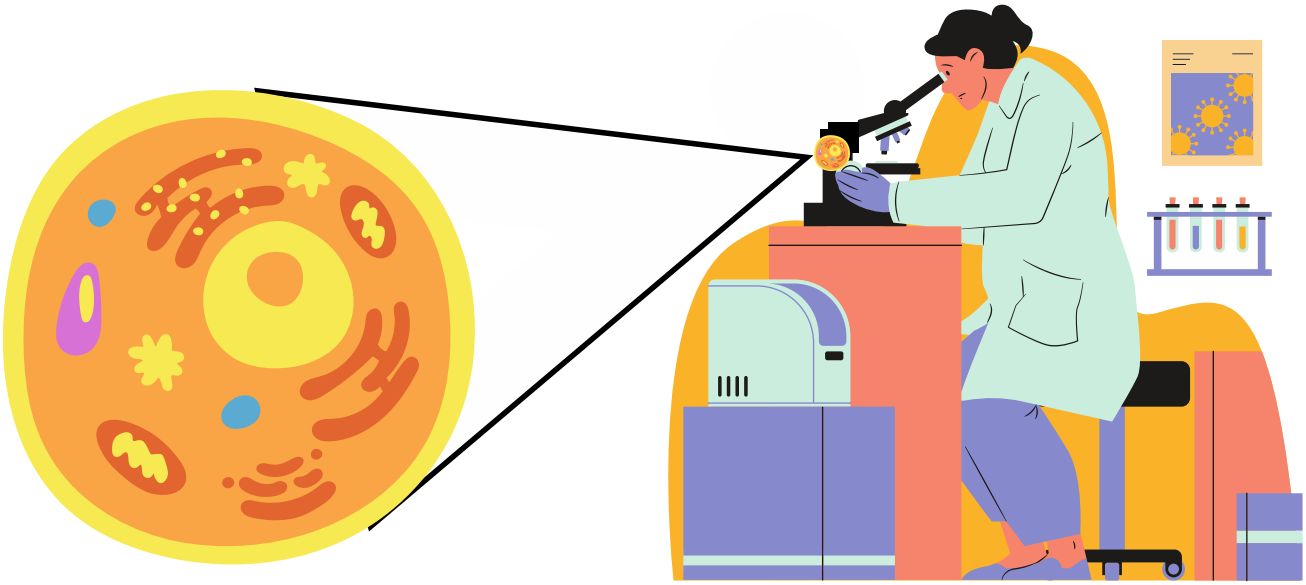
The two gap phases, G1 and G2 allow the cell time to check the environment inside and outside the cell. This is to ensure that conditions are suitable and that all preparations are complete before the cell commits itself to the major changes of the S phase and M phase respectively.

The length of G1 can vary greatly depending on the outside conditions and signals from other cells. If such conditions are unfavourable, cells delay progressing through G1 and may even go into a specialised **resting state** known as **G0**. Cells can remain in G0 for days, weeks or years before continuing their life cycle. Some cells can remain in G0 until they die.



FACT

G1, **S** and **G2** are called the interphase. Interphase lasts about 23 hours. **M** phase lasts about 1 hour.



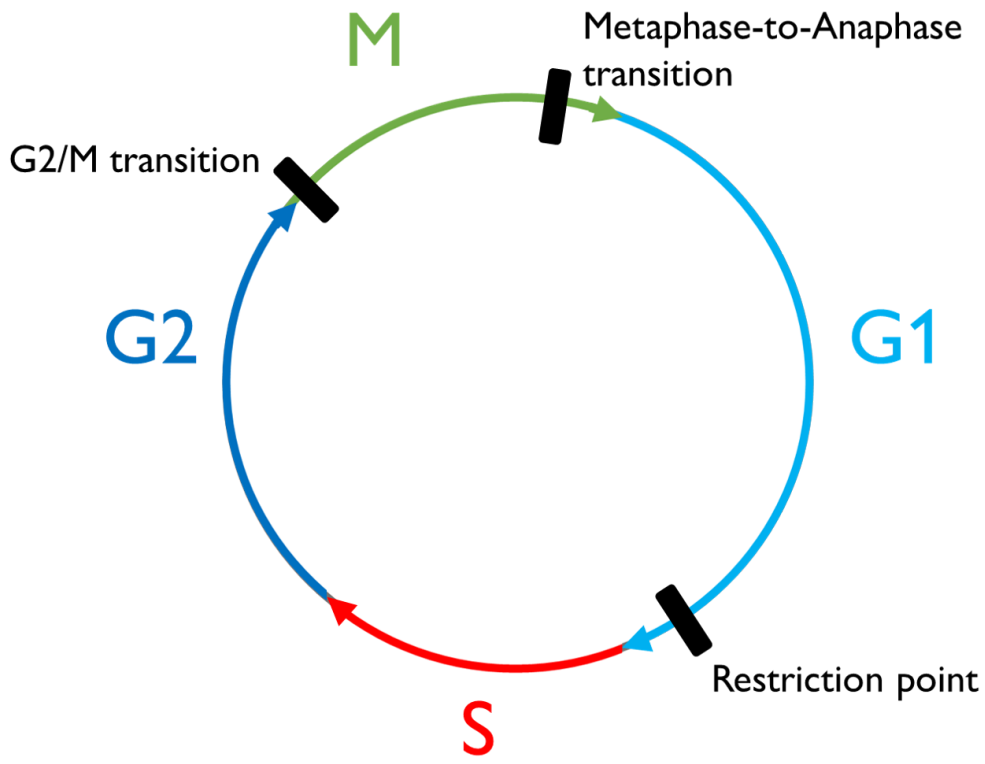
THE CELL CYCLE CONTROL SYSTEM

The cell cycle control system is made up of several different proteins which work like clockwork in a highly coordinated way to start specific cell cycle events. The system is incredibly robust, reliable and highly adaptable, ensuring appropriate progression of the cell cycle. The system can be modified to suit specific cell types and to respond to specific external and internal signals.

If a problem occurs, from either outside or inside the cell, signals are sent to the control system which acts to stop the cell cycle. This allows the cell to repair the problem before the cycle continues. The cell cycle can stop at any one of the 3 major checkpoints.

- **Start or Restriction Point**
- **G2/M transition**
- **Metaphase-to-Anaphase transition**

THE 3 MAJOR CHECKPOINTS OF THE CELL CYCLE

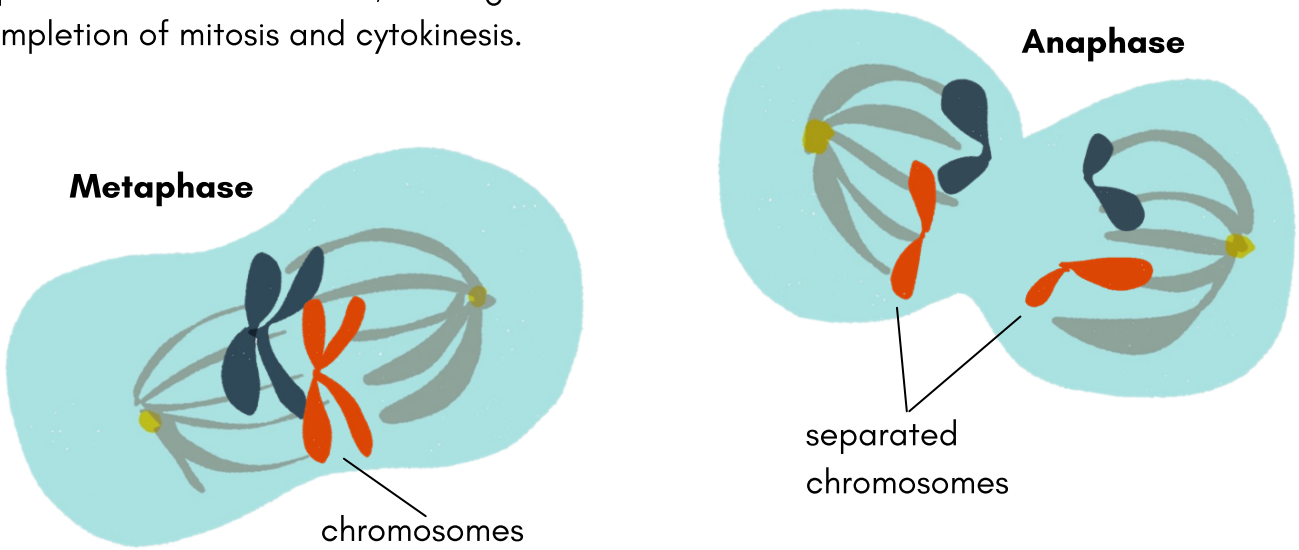


START OR RESTRICTION POINT - the cell commits to entering the S phase
If the conditions in the environment outside the cell are favourable, and signals to grow and divide are present, the cell can go from early G1, through the first checkpoint, to the end of G1. This commits the cell to fully replicating its DNA even if the growth signals from the environment are removed.

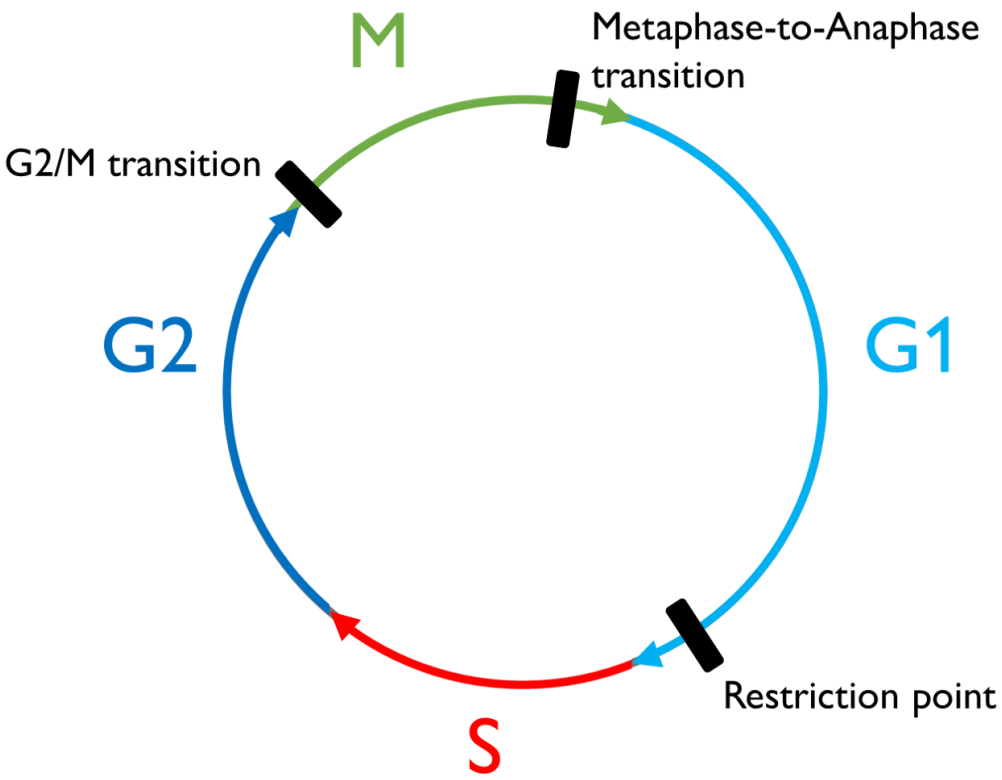
If something happens that prevents the successful completion of DNA synthesis signals are sent to the control system to delay progression to the M phase. Delays such as this give time to the cell to repair the problem and prevent a cell with defects from multiplying.

G2/M TRANSITION - the control system initiates the first step of mitosis
To pass this checkpoint there must be a favourable environment , i.e. there need to be enough nutrients for the cell to grow in G2 and it must have replicated its DNA appropriately. If both of these conditions are true then the control system will initiate the first step of mitosis.

METAPHASE-TO-ANAPHASE TRANSITION - the control system stimulates the separation of chromosomes leading to the completion of mitosis and cytokinesis
For the cell to go through this stage, all of its chromosomes must be in a position to be separated correctly.
If this is true then the control system starts the separation of chromosomes, leading to the completion of mitosis and cytokinesis.



SUMMARY OF CELL CYCLE PHASES AND CHECKPOINTS



From beginning to end:

1. **G1**. Beginning of the cell cycle, the first growth phase.
2. **Restriction point**. The cell checks if there are enough signals from the environment and enough nutrients before committing to the S phase.
3. **S**. DNA is replicated.
4. **G2**. The second growth phase where the cell doubles its contents and prepares for the M phase.
5. **G2/M transition**. The cell checks if there are appropriate signals from the environment, enough nutrients and if the DNA has been correctly replicated before it is allowed to move on to the next phase.
6. **M**. Separation of nuclei (mitosis) and completion of cell division (cytokinesis).
   For the M phase to be completed the cell has to pass the **Metaphase-to-Anaphase transition** checkpoint. At this checkpoint the cell checks whether the chromosomes are in a position that allows their separation.

DANCE STEPS - THE CELL CYCLE

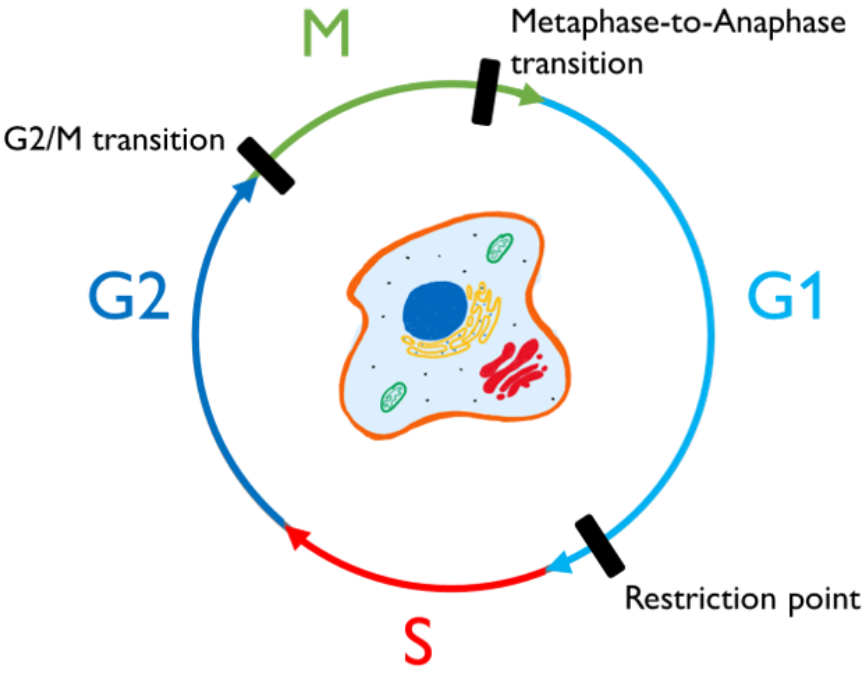
Here is an example of science steps and accompanying dance moves you can do. Can you think of any other ways to represent *The life of a cell* through movement?

Step 3 The students forming the circle stop going around and stand in place. Everyone stops holding hands and takes a few steps inward, then back in the original position.

The stopping and standing in place represents the **start of G2**. By taking a few steps inward everyone checks that the 'chromosomes' have duplicated appropriately. This represents the **G2/M transition**.

Step 4 The students break into two circles. The pairs at the centre separate, with one person from each pair going into one of the newly formed circles.

The separation of the two pairs represents separation of chromosomes and signifies the '**metaphase-to-anaphase**' transition. The big circle which represents the cell now becomes two circles, the two daughter cells. This represents cytokinesis, the **end of M phase** and the end of the cell cycle.



Step 2 Two more students enter the centre of the circle and form pairs with one of the two original students.

The two new students represent the replication of the DNA that occurs in **S phase**.

Step 1 4-5 students hold hands forming a small circle in the centre of the room. 2 students stand in the centre of the circle. The students in the circle start going round as the rest of the class joins them.

The students in the circle represent the cell, which grows during the **G1 phase**. The two students standing in the centre represent the chromosomes.

REAL WORLD APPLICATIONS

Researchers try understand how different signals affect the cell cycle by answering questions such as: Which signals drive cell division? Which signals prevent cell division? Why? What causes faults in the control system? How are such faults corrected?

Cancer is characterised by uncontrolled cell growth. One reason is that the control system no longer responds to signals that say there is a problem. Finding the answers to these questions can help scientists find better treatments for cancer.

Stem cells in our bodies multiply quickly to repair any damages, yet they do not cause cancer. What signals make them stop? What changes do these signals cause in stem cells that stop cell division?Finding the answers to these questions can help scientists deliver safer stem cell therapies to patients who need them.

FURTHER LINKS:

RESEARCHERS

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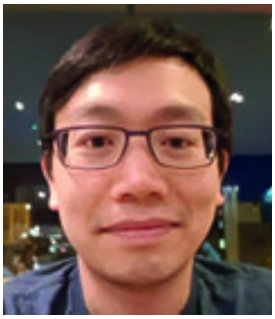

TONY LY

http://bit.ly/lifeofacell5
http://bit.ly/lifeofacell6

USEFUL RESOURCES

The Cell Cycle (and cancer) [Updated] by Amoeba Sisters: http://bit.ly/lifeofacell7

LINKS TO RELATED SCIENCE CEILIDH RESOURCES

Stem Cell Festival Dance https://www.scienceceilidh.com/stemcellfestivaldance
Mitosis Waltz https://www.scienceceilidh.com/mitosiswaltz