Cell Engineering Design Challenge

What cell shape will have the fastest diffusion rate (grams/minute)?

Learning Targets:

- *I can analyze why cell size and shape (surface area to volume ratio) matters for cell survival*
- *I can follow the problem solving process to design a solution to a problem.*

Objective:

In this engineering design challenge your team will design different cell shapes that are carved from agar gel and test how rapidly diffusion takes place. You will apply what you have learned about surface area, volume, and the ratio between these two variables to design a cell that has the fastest diffusion time for its size. Wait, what? That's right...for its size (in this case MASS). We want you to be creative and think outside the box / cube...all of which presents challenges when trying to accurately and precisely measure surface area and volume. However, what you can measure accurately is mass (using an electronic balance). You will need to apply the surface area and volume ideas to maximize diffusion in your designs. Your team will compete in a class diffusion race in which the cell with the largest ratio of mass (grams) to diffusion time (minutes) wins. Good luck! May the force be with you!

Criteria and Constraints (ie. the rules):

- You have a materials budget: Your team will be given ONE block and ONE BLOCK ONLY of agar to use. If you mess it up, you are out of luck! Test as many cells as you can make with your agar.
- No cell can be less than **4 grams** in mass.
- You may create any shape that you want, however, **NO** poking holes, cutting through or scratching the surfaces of any of the pieces (real cells don't exist with holes through them)!
- You **MUST** record mass (g) of cell AND time (min:sec) for diffusion through entire cell (100% yellow!)
- Not adhering to any of the rules and procedures above will disqualify your cell from the competition!

STEP 1: RESEARCH THE PROBLEM

All engineering design challenge begins with a bit of research about the problem. Focus on the following:

- *What are different human cell types and what are their shapes?*
- *How do human cells maximize their surface area to volume ratios?*

Take notes here (including diagrams / drawings). **Attach additional paper if needed.**

STEP 2: CREATE THE DESIGNS

In the space below add a picture of your DRAWINGS of the shapes of cells that you intend to carve out of agar and test with a short justification / reasoning for why you are choosing this cell shape.

Cell Shapes (number each cell design)	Justification / Reasoning

STEP 3: TEST, EVALUATE, TWEAK THE DESIGN, REPEAT

- Perform your initial test/s. Calculate your times in min and your diffusion rates.
    - To convert your min: sec into minutes only format, divide seconds of time by 60 sec/min.
    - Ex: 6:38 is your time
    - 38 sec ÷ 60 sec/min = .63 min
    - 6:38 = 6.63 min (this is what you would write in the **Time (min)** column)
- Evaluate your results.
- Discuss how the team is going to tweak or change your cell designs to improve diffusion rates.
- Go back and add cell shapes with justification to Step 2.
- Repeat as many times as needed or as you have opportunity to in the given time frame.

Data / Results:

Cell #	**Shape** (take a picture and add it)	**Mass** (g)	**Time** (min:sec)	**Time** (min)	**Diffusion Rate** **Mass ÷ Time** (g/min)

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STEP 4: EVALUATE AND REFLECT

1. What were the characteristics of the top model cells with the fastest diffusion rates (highest mass/time ratio) in the class? How did each use surface area : volume ratio to their advantage? What were the strengths of each cell design? What were the weaknesses?

2. Why do our cells have to stay so small? Justify your answer using:
   - actual data from the design challenge
   - by relating it back to the job of the cell membrane, the role of the cytoplasm and needs of the cell.