**Name:** **Date:** **Section:**

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# Cell Diffusion Explorer Activity: Transport Across Membranes

## Investigating Cell Size Limitations Through Diffusion

### Phase 1: ENGAGE (5 minutes)

- *Getting Started:**

Open peebedu.com and navigate to Cell Diffusion Explorer

Read the introduction popup to understand SA/V ratio and its importance.

- *Essential Question:**

Why are cells microscopic? What prevents them from growing indefinitely larger?

- *Initial Hypothesis:**

Based on your knowledge of diffusion, predict which cell shape will complete diffusion fastest if all have the same volume:

- Circle (sphere-like): _______
- Tall rectangle: _______

Explain your reasoning: ____________________________________________

### Phase 2: EXPLORE (20 minutes)

- *Systematic Investigation of Cell Shape and Diffusion**

- *Part A: Shape Comparison**

1. Drag the following shapes into the beaker (all have V=100):

- Circle
- Star
- Tall Rectangle
- Wide Rectangle

1. **Before starting diffusion**, calculate SA/V for each:

| Shape | Volume (V) | Surface Area (SA) | SA/V Ratio | Predicted Rank (1=fastest) |
|---|---|---|---|---|
| Circle | 100 | | | |
| Star | 100 | | | |
| Tall Rectangle | 100 | | | |
| Wide Rectangle | 100 | | | |

1. Click "Start/Resume All" and observe diffusion

- *Data Collection:**

| Shape | Time to 50% Diffused | Time to 100% Diffused | Actual Rank |
|---|---|---|---|
| Circle | | | |
| Star | | | |
| Tall Rectangle | | | |
| Wide Rectangle | | | |

  - *Part B: Extreme Shapes**
  1. Reset and test these shapes:
  - T-Shape

- Crescent
- Squiggle
- Amoeba
- *Pattern Recognition:**

What do they have in common? _________________

- *Part C: Mathematical Analysis**

1. Plot your data:

- X-axis: SA/V ratio
- Y-axis: Time to complete diffusion

Describe the relationship: ________________

### Phase 3: EXPLAIN (10 minutes)

- *Connecting Structure to Function**

1. **Identify Key Patterns (List 3):**

- Pattern 2: Shapes with projections have _______ SA/V ratios

1. **Cause-Effect Analysis:**

Complete the relationships:

- Larger SA → More membrane area → _______ exchange points
- Higher SA/V → _______ diffusion efficiency → _______ survival

1. **Cell Size Limitations:**

If a spherical cell doubles its radius:

- Surface area increases by factor of: _______
- SA/V ratio changes by factor of: _______

1. **Real Cell Adaptations:**

Match the cell type to its shape adaptation:

- Red blood cell • Branching projections
- Neuron • Flattened disc
- Root hair cell • Elongated extension
- Alveolar cell • Thin and flat

## Phase 4: ELABORATE (10 minutes)

- *Applying Concepts to Biological Systems**
- *Scenario Analysis:**

1. **Muscle Cell Problem:**

Active muscle cells need rapid oxygen delivery.

- Why can't muscle cells just grow larger? _______

1. **Intestinal Adaptation:**

Small intestine cells have microvilli (tiny projections).

- Calculate: If a cubic cell (side=10μm) adds 1000 microvilli, each adding 5μm² surface area:
- New SA: _______ μm²

1. **Evolutionary Trade-offs:**

Some organisms have giant cells (bird eggs, algae).

- What strategies might they use? _______

## Phase 5: EVALUATE (5 minutes)

- *Assessment Questions**

1. **Pattern Application:** A cell biologist observes that cancer cells are typically smaller than normal cells of the same type. Using SA/V principles, explain why this might provide a growth advantage. (3 pts)
1. **Data Analysis:** Two cells have equal volumes. Cell A takes 30 seconds to fully diffuse nutrients, Cell B takes 90 seconds. What can you conclude about their shapes? Calculate their approximate SA/V ratio difference. (3 pts)
1. **Systems Integration:** Explain how the SA/V ratio constraint connects to:

- Membrane transport (Unit 2.4)
- Cellular respiration needs (Unit 3)
- Cell communication (Unit 4)

(4 pts)

- *Model Evaluation:**

What simplifications does this 2D model make compared to real 3D cells? How might results differ?

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## **Extension Investigation:**

- *Research Question:** How do different organisms overcome SA/V limitations?

Investigate one example:

- Xenophyos (giant single-celled organism)
- Caulerpa (giant algae cell)
- Plasmodial slime molds

Explain their structural adaptations: _______________________