Revealing Student Knowledge of the Cell Through Student-Generated Drawings

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Why Drawings?

Student-generated drawings:

- Can reveal what students are thinking[1].
- Allows students to demonstrate their knowledge in a spatial form[2] versus linear form, as in text or a verbal explanation.
- Reveal student difficulties[3] which is helpful for both the student and the instructor in assessing student difficulties with basic cell structure in Human Anatomy and Physiology.

Student drawings were coded to answer the following questions:

1. **Do students who draw more correctly labeled cell structures represent those structure in a more in-depth and anatomically correct manner?**

2. **How likely are students to draw non-animal cell characteristics?**

Methods

- Human Anatomy and Physiology with drawing as a weekly assignment
- 429 student drawings collected prior to instruction on cells
- Students given 5-10 minutes to complete drawings
- Voluntary participation

Drawing Question

Start by drawing a cell
- Include & label significant parts

Which parts are involved in the following typical cell activities?
- Protein synthesis
- Energy transformation
- Acquisition of materials & removal of wastes
- Distribution of materials
- Communication with other cells
- Structural support

Rubric

- Rubric quantified the number of correct and incorrect cell structures
- Cell structures refers to all organelles, supporting fluids, protein structures, membranes, and membrane projections depicted.
- Rubric was applicable to all cell types
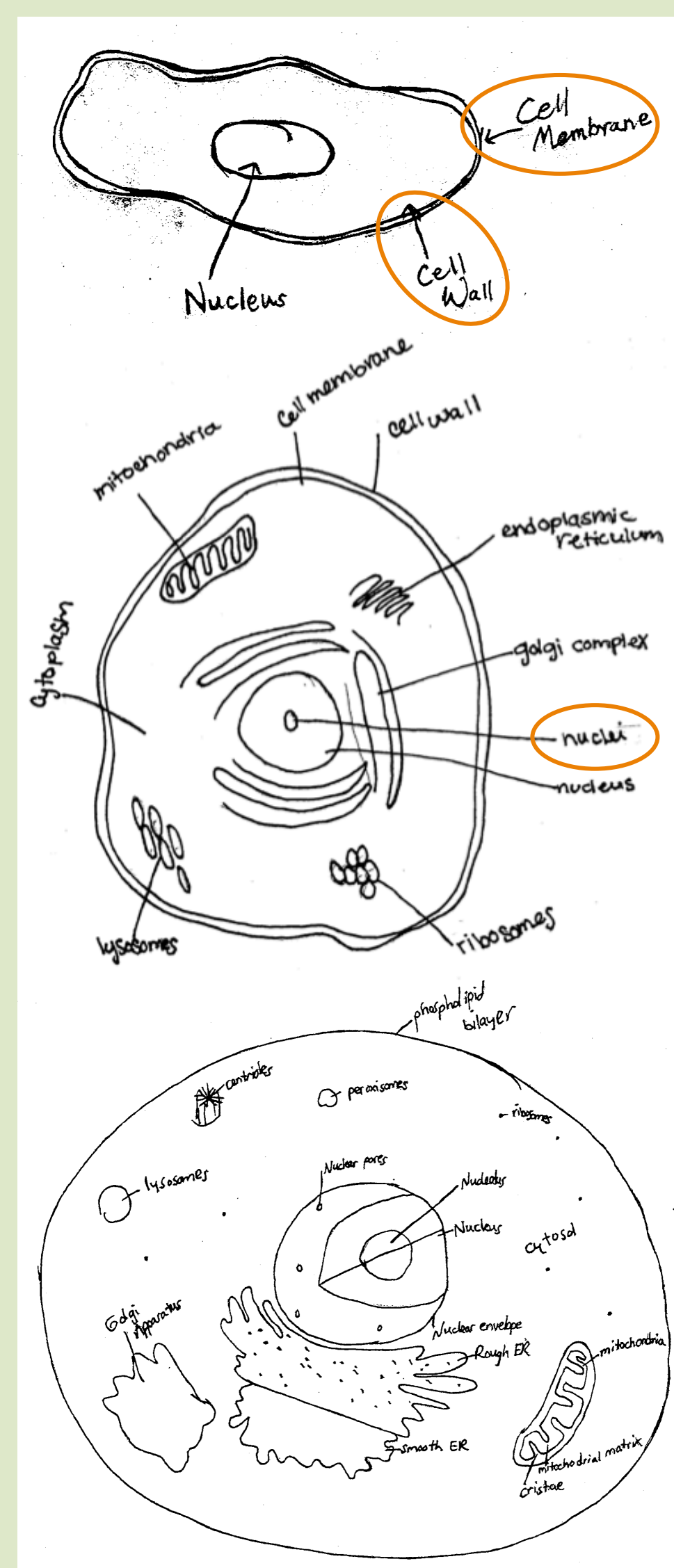
Student Example 1
- 1 Correct Structure
- 2 Incorrect Structures
- Depicts basic cell structure
- Utilizes use of simple circles and lines

Student Example 2
- 9 Correct Structures
- 1 Incorrect Structure
- Most structures correctly identified but not depicted in a correct relationship with other structures

Student Example 3
- 16 Correct Structures
- Does not contain any incorrectly labeled structures
- Cell structures are labeled in-depth (structures within structures) and with detail
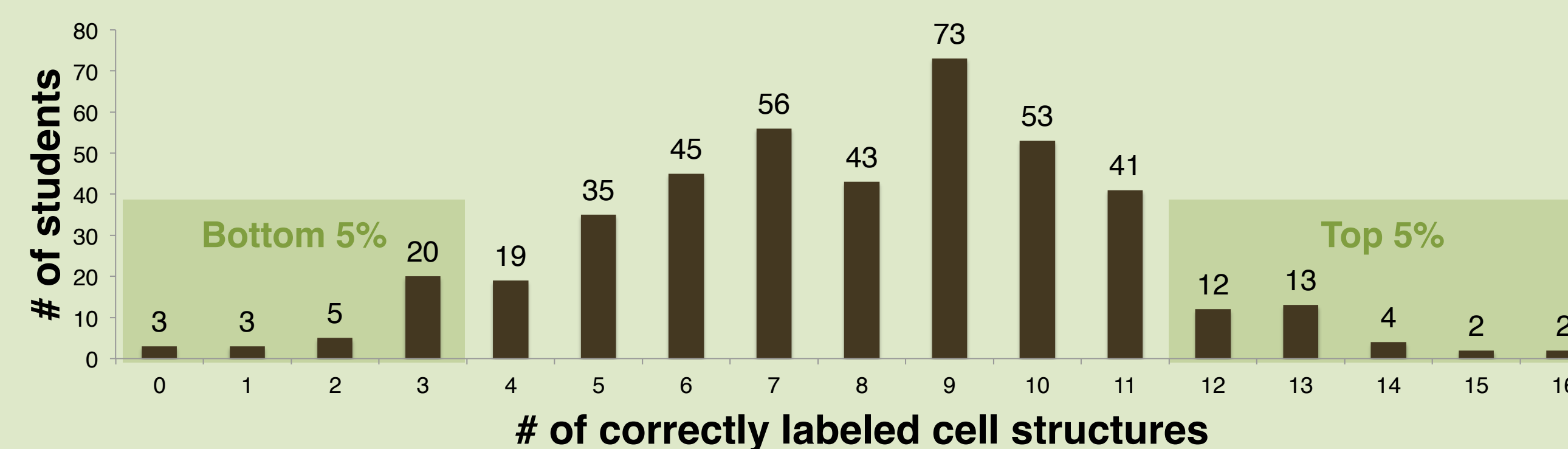
Basic Cell Structures

Figure 1. Correctly Labeled Structures per Student Drawing

- Mean = 7.92 Basic Cell Structures
- Standard Deviation = 2.82
- Middle 90% of students within 1.7 standard deviations of the mean
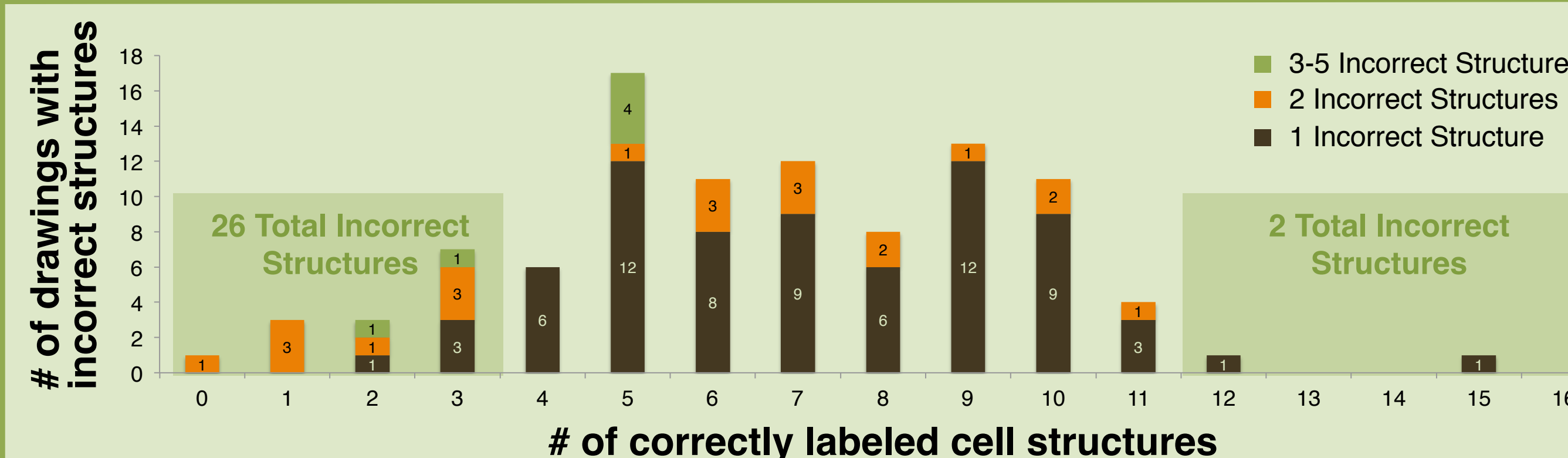- Outer 10% of student drawings further analyzed in Figure 3 and Figure 4

Figure 2. Incorrect Structures per Correctly Labeled Cell Structure Group

- n = 98; 70 drawings in the group contained only 1 incorrect cell structure
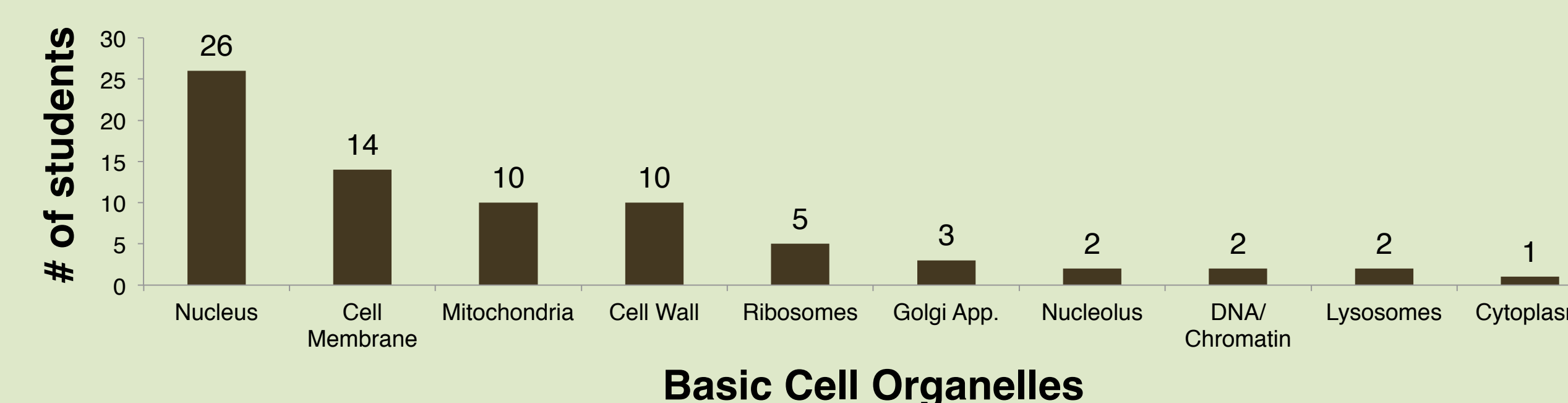
Tail End Groups

Figure 3. Student Drawings in the Bottom 5%

- n = 31; 10 basic cell structures present within the population
- 83.9% of population depicted the nucleus in their drawing
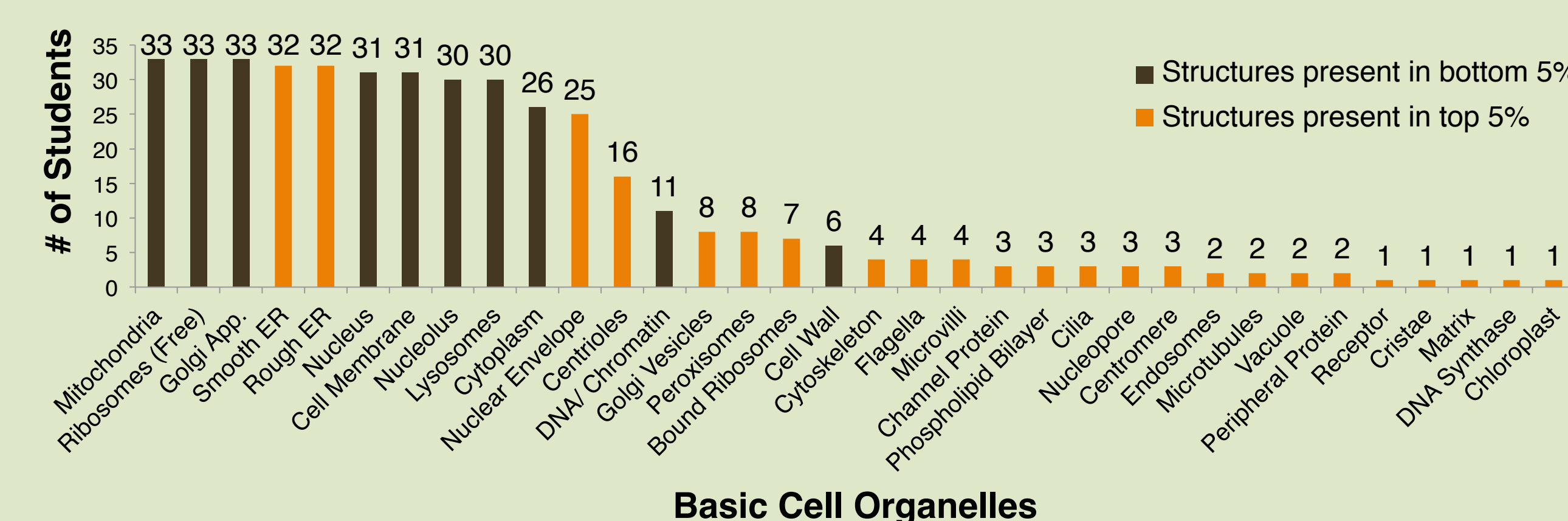- No other structures indicated a clear majority within the population

Figure 4. Student Drawings in the Top 5%

- n = 33; 34 basic cell structures present within the population
- 100% of population depicted mitochondria, ribosomes, and the golgi apparatus in their drawing

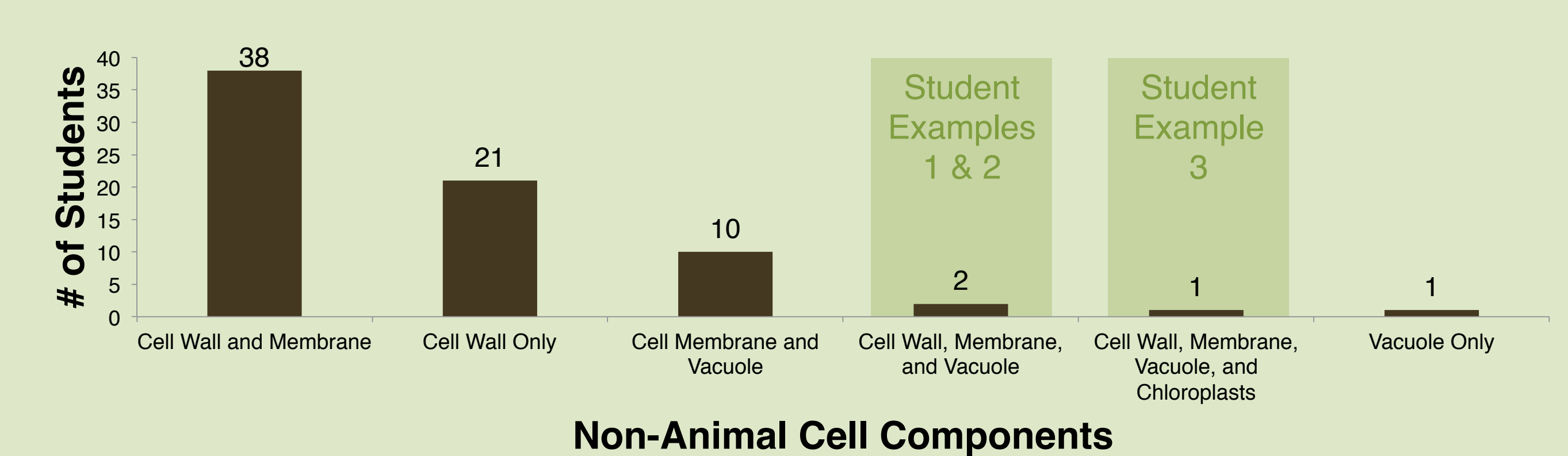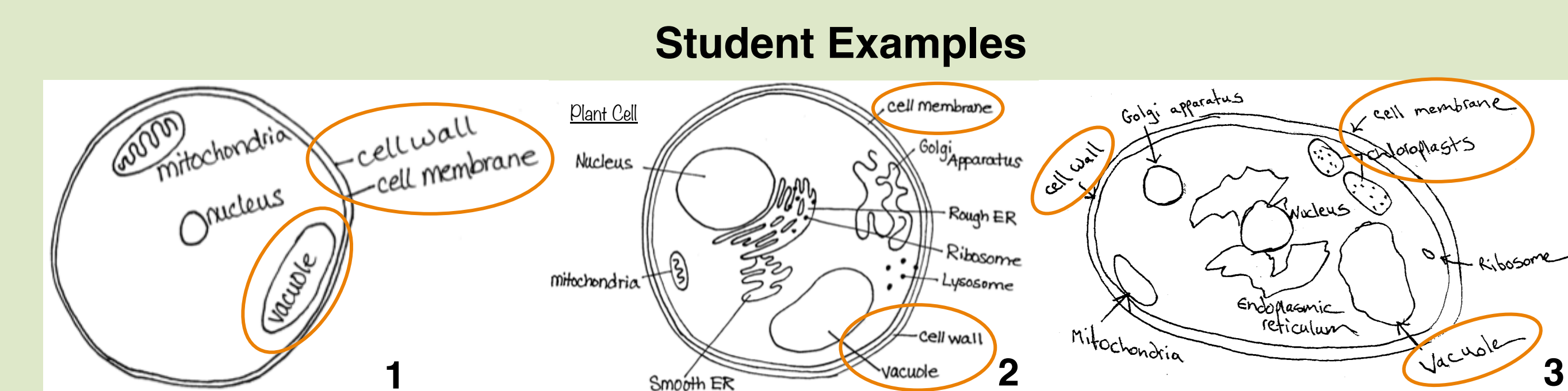## Non-Animal Cell Structures

Figure 5. Grouped Non-Animal Cell Structures per Student Drawing

- n = 73
- Cell membrane and vacuole included to clearly distinguish between animal and non-animal cells
- 62 students clearly depicted a non-animal cell (with a cell wall)
- Student examples (below) include 2 or more non-animal cell components

Student Examples

Conclusions

- Students clearly struggle with physiology. Of the 429 drawings collected, no students answered the physiology portion of the question.
- Drawings in the top 5% show more in-depth and detailed cell representations.
- 4 or more cell components with minimal incorrect structures were represented by 95% of students.
- Student drawings in the bottom 5% do not represent accurate knowledge of the cell
- Some students may be having difficulties differentiating between the cell wall and cell membrane (see Figure 5)
- 3 student drawings clearly depicted non-animal cells

Cited Literature

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2. Gobert, Janice D., and John J. Clement. "Effects of Student-Generated Diagrams versus Student-Generated Summaries on Conceptual Understanding of Casual and Dynamic Knowledge in Plate Tectonics." Journal of Research in Science Teaching 36.1 (1999): 39-53.

3. Flores, Fernando, Ma Eugenia Tovar, and Leticia Gallegos. "Representation of the cell and its processes in high school students: an integrated view." International Journal of Science Education 25.2 (2003): 269-286.

Acknowledgements

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