# Do interventions using threshold concepts assist learning in biology?

Louise Lutze-Mann, Noel Whitaker, Anne Galea, Pauline Ross, Charlotte Taylor, Chris Hughes, Vicky Tzioumis

University of New South Wales
University of Western Sydney
University of Sydney

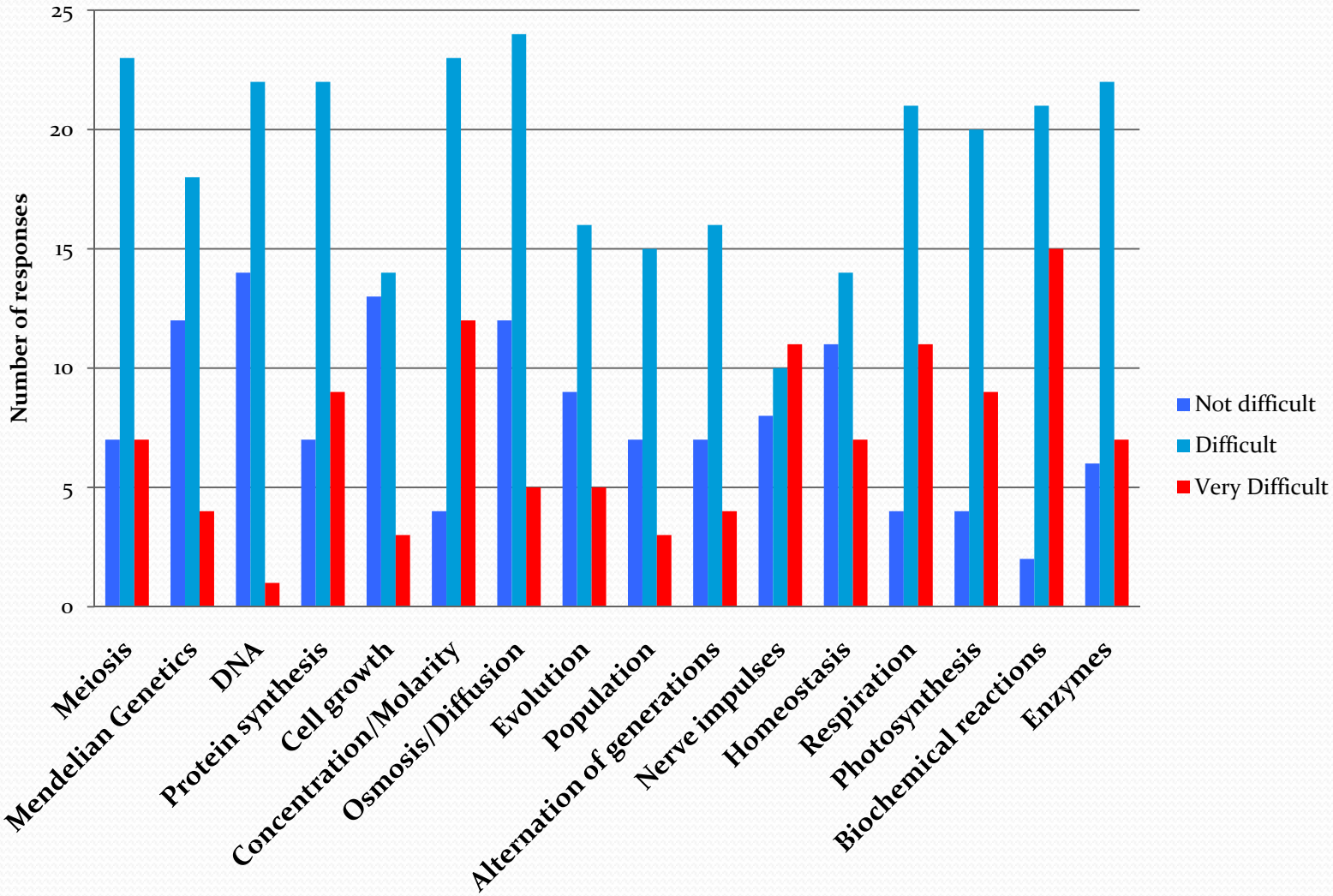
# Thresholds

- Conceptual gateway
- Three critical descriptors are used to identify threshold concepts: transformative, irreversible and integrative.
- ALTC-funded project to investigate biology thresholds
- Surveys:
  - Initially, staff surveys and interviews to identify biological threshold concepts
  - Student interviews are ongoing at 3 universities
- Workshops
- First intervention at UNSW

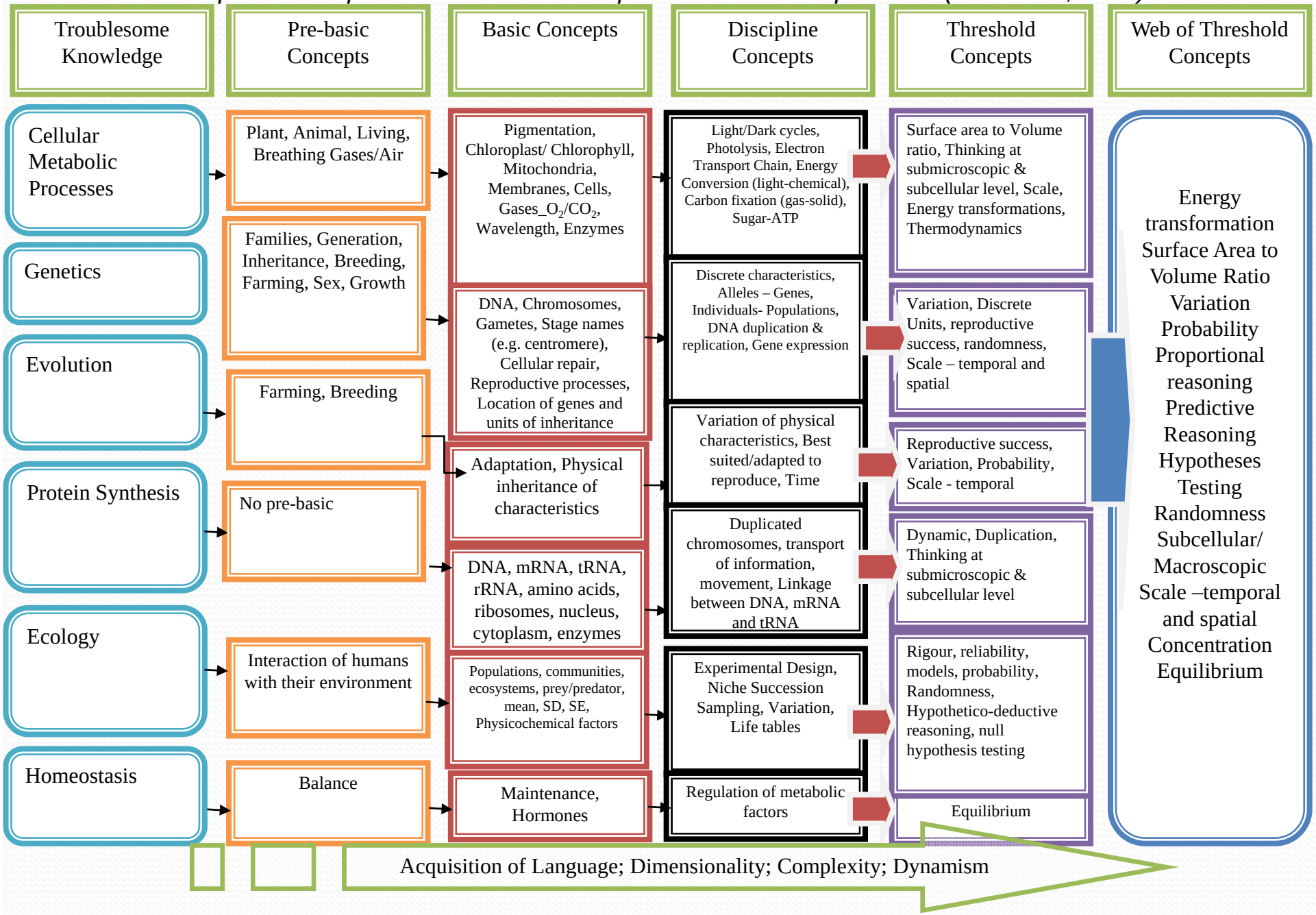
Responses of experienced academics to the question "What are threshold concepts in Biology?"

| Concept | Number of Responses = Level of Difficulty |
|---|---|
| Meiosis and Genetics | 3 |
| Evolution | 3 |
| Photosynthesis | 2 |
| Respiration | 1 |
| Enzymes | 1 |
| Osmosis/concentrations | 1 |
| Protein synthesis | 1 |
| Probability | 1 |
| Homeostasis | 2 |
| Dynamics and Change | 1 |
| Surface Area to Volume | 2 |
| Scale | 3 |
| Energy | 1 |

# Ranking of concepts



*The relationship between troublesome, conceptually difficult concepts, basic and fundamental key concepts, discipline concepts and threshold concepts and threshold epistemes (Ross et al, 2009).*



# Why Scale?

- Biological world extends from the submicroscopic (molecular) to the macroscopic (ecology) with interactions at various levels of scale
- Scale is a component of many “difficult concepts” or “troublesome knowledge”:
  - Photosynthesis
  - Metabolism
  - Enzymes and substrate recognition
  - Transcription/translation
  - Cellular transport
  - Micro-environments
  - Osmosis/diffusion

# Scale intervention

- Initial intervention at UNSW with 700 first year biology students
- Placed into 2 groups – intervention and control
- Threshold investigated: scale
- Outline
    1. Pre-course survey
    2. Intervention 1
    3. Intervention 2
    4. Survey
    5. Assessment

# Pre-course survey

- Provided with image of plant cell. Asked to:
  - Identify cell type and organelles
  - Which organelles would you be able to see under a light microscope?
- Results (247 respondents):
  - 70% correctly identified cell type
  - Of 36 who identified as animal cell, 33 then correctly identified plant cell features
  - Under the microscope: nucleus (38%), cell wall (16%), chloroplast (12%), vacuole (13%)

# Intervention 1

**Intervention group**

Directed to Cells Alive website

- Images of different cell types sitting on the head of a pin
- With this as stimulus, asked to reflect on size of organisms, organelles and molecules
- Also, movement of molecules within and around cells

**Control Group**

Directed to same website but different section

- Told to use animation to visualize the differences between plant and animal cells.
- Then use it to identify key intracellular components of the different cell types.

# Intervention 2

## WEHI transcription/translation animation

(http://www.youtube.com/watch?v=4PKjF7OumYo)

- Scale issues from this resource
  - Temporal (fast!)
  - Concentration of molecules
  - Substrate recognition (flexibility/dynamics of molecules, 3D-shape)
  - Functional (protein) domains
  - Relative size of nucleic acids versus protein

# Intervention 2

**Intervention Group**

**While you are watching the video, consider the following in relation to the different processes that are occurring:**

- Where do these processes happen?
- How fast are these processes?
- Do you think transport of the components to the required locations is important?
- What is the size of the region (or organelle) where this process is happening in relation to the size of the cell? (i.e. Is it much bigger or smaller?)
- How often do these processes occur in a cell?

**Control Group**

**While you are watching the video, consider the following in relation to the different processes that are occurring:**

- What is happening?
- What are the components, substrates and enzymes?
- What is a template?
- What are the products of the process?

# Post Intervention 2 Survey

**In a practical focusing on the variables that affect enzyme function and kinetics, students (intervention and control groups) were asked to fill out a survey:**

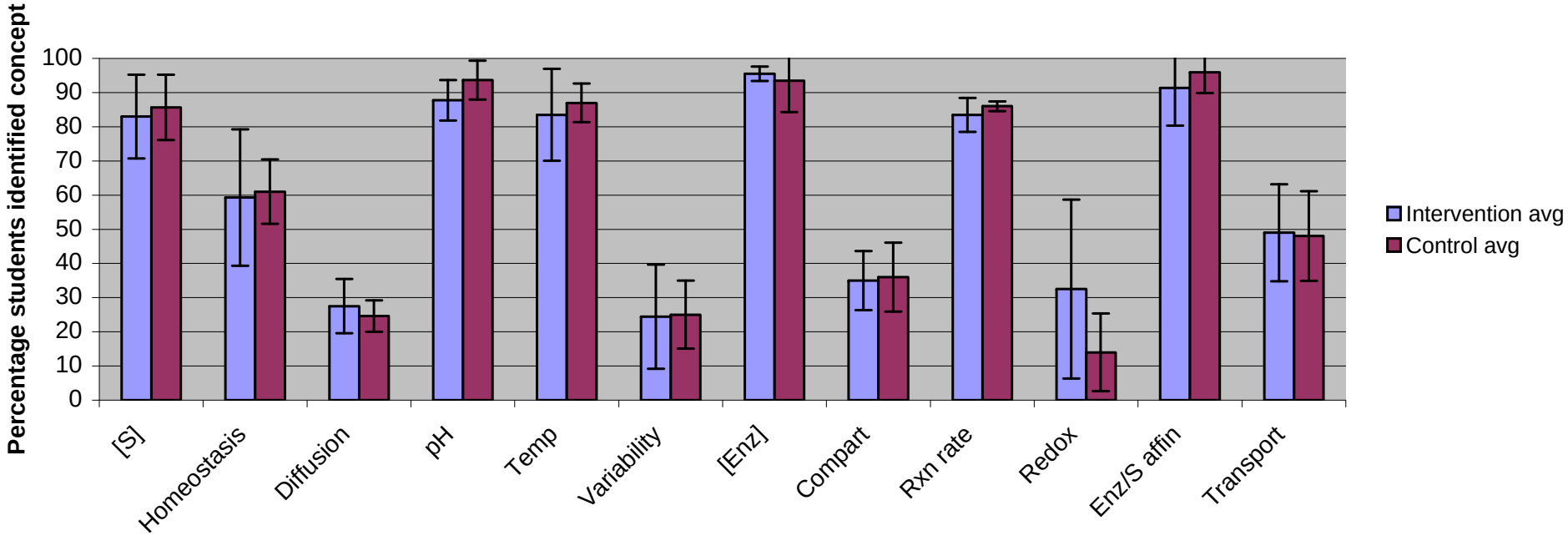
In considering the functioning of DNA polymerase:

1. Which of the following concepts would you include?
2. Which of these concepts do you consider to be difficult to understand?

- compartmentalisation
- ES complex formation
- reaction rate
- enzyme/substrate affinity
- structure/function
- substrate concentration
- enzyme concentration
- effect of temperature
- effect of pH

# Comparison of control and intervention groups by concept

## Concepts identified as important to DNA Polymerase function

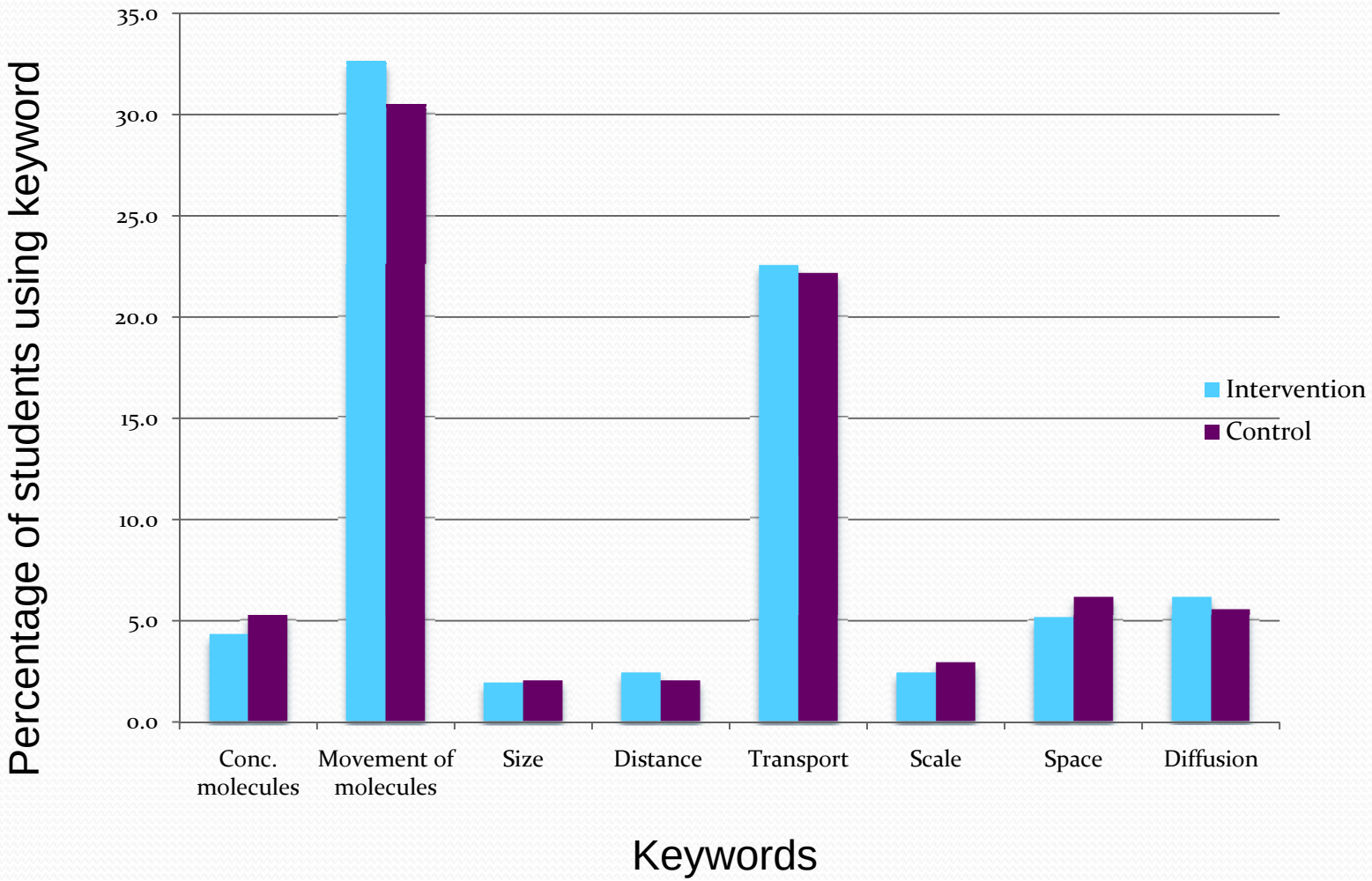


# Assessment

In the final exam, students were asked to answer an essay question on respiration and photosynthesis including the following:

… the movement of molecules through the cell and across the membranes that are involved.

# Comparison of control and intervention groups by keyword



# Conclusions

- No clear difference between the intervention and the control groups
  - Intervention too subtle?
  - Logistics of running an intervention on only some students in a course
  - Threshold may have been too peripheral to the course for us to be able to demonstrate a quantitative difference
  - Short-term assessment on what might be a long-term effect
- How do you measure or assess thresholds?

# Future directions

- Use entire class and compare with previous year's cohort (have a base-line)
- Incorporate a longitudinal review of this and future cohorts
- Additional and more focused questions
- Other thresholds being examined include:
  - Hypothesis formulation and testing
  - Language
  - Energy transfer
- Need to consider how we communicate ideas and concepts in biology (scale is integral to learning and how we teach biology)