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The Use of Egeria Densa in Understanding The Cellular Movement at The Micro Level of Prospective Science Teachers

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ABSTRACT This study aims to help students learn cytoplasmic flow movement by using *Egeria densa* as a model. The study was conducted with six prospective science teachers studying at Bayburt University's Faculty of Education Science Teaching Undergraduate Program. As a data collection tool, a form containing questions to obtain prospective science teachers' knowledge of the concept of living things and the common characteristics of living things was used. The content analysis method was used to analyze the data. As a result of the findings, it was determined that although the prospective science teachers had sufficient knowledge about the vitality feature, they could not explain the movement, which has the vitality feature in detail. In addition, it was determined that the prospective science teachers could explain the cellular movement, which they had difficulty understanding at the micro level, by using *Egeria densa* as a model. Therefore, it can be said that using Egeria densa as a model for prospective science teachers to make sense of movement at a micro level is helpful.

Keywords Cellular movement, Prospective science teachers, *Egeria densa*

1. INTRODUCTION

Science is a branch that allows us to understand and explain the physical and biological elements that make up our world and the events that occur because of them (Hastürk, 2017). It is known that science, which includes many concrete and abstract concepts, is an area where students have learning difficulties. Especially in science lessons, non-observable and abstract events, situations, and concepts at the micro level make science lessons more complex for students. (Adadan, 2013; Frailich, Kesner, & Hofstein, 2009; Haigh, France, & Gounder, 2011; Mumba, Chabalengula, & Banda, 2014). In this complex situation, the students may experience difficulties perceiving and making sense of scientific events around them (Stoica, Miron, Jipa, Al & Popescu, 2016). The fact that many of these scientific facts in question are in abstract form and that learning these abstract concepts requires high-level thinking skills can be expressed as the reason for these problems. To eliminate the difficulties that students experience in learning science subjects, many countries are developing science education and creating a positive attitude toward science among their educational goals (Demirci, 2017). It is noteworthy that teaching basic concepts is essential to achieve these goals. When the contents of science courses are considering, it is seen that the concepts have a very wide place in these contents (Öztürk, 2017).

Concepts that have a great importance in science teaching *are units of abstract thought that are formed by grouping two or more entities according to their common characteristics and distinguishing them from other entities according to the experiences obtained as a result of those experiences* (Ayas, 2016; İşbirliği, 1998). Ülgen (2004) evaluates the concept *as information forms that find meaning in the human mind and represent the common characteristics of different objects and phenomena that can change and are generally expressed with a term.* As it can be understood from the definitions, the concepts that are the building blocks of knowledge are units of abstract thought, and when we classify the beings, events, situations, and phenomena in our environment according to their similarities and differences, it can be expressed as the class and first association that occurs in our minds. In this sense, considering that concepts are the building blocks of knowledge and enable individuals to organize, structure, classify, and shape what they learn (Treagust, 1998), it is

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extremely important to know the concepts related to a discipline field and the relations between these concepts. Because knowing the basic concepts well is the primary condition for structuring new concepts to be learned in many disciplines. Considering that concept teaching has an important place in the learning process and forms the basis for further learning, it is necessary to give importance to concept teaching in every discipline and to learning and teaching concepts in a meaningful and correct way.

In science education, when it comes to biology education, it is necessary to recognize the living and non-living elements and to structure the concepts of living and non-living to understand the functioning of nature. Because the concept of living things is the basis of many concepts in biology, it would be beneficial to know what a living thing is, what the basis of life is, and what kind of features express vitality. Since biological sciences focus on living things and their relationships with their environment, it has become necessary to distinguish living things from non-living things (Gallegos-Cázares, García-Rivera, Flores-Camacho & Calderón-Canales, 2016). Along with this necessity, it is known that individuals have limited knowledge about living things, have some misunderstandings, and have difficulties structuring the concept of living things correctly. Therefore, to eliminate these problems and facilitate learning more complex subjects, it is considered important to structure knowledge about the concept of living things. Since it is a basic concept and being well-known is a prerequisite for further learning, there are different studies and results on the concept of "living things" in the literature. For example, while Bahar (2003) determined that secondary school students know the common characteristics of living things, Mortimer and Scott (2003) argued that the students did not sufficiently structure these concepts. Again, Yılmaz, Timur and Timur (2017) stated that secondary school students have misunderstandings about the concept of living things and other concepts with which they associate the concept of living things, and they have a significant lack of knowledge about identifying common characteristics of living things and classifying living things.

Similarly, there are different studies in the literature showing that students have misconceptions when classifying animate and inanimate elements (Babai, Sekal, & Stavy, 2010; Hofer & Pintrich, 1997; Mortimer & Scott, 2003; Opfer & Siegler, 2004). When the studies in the literature were examined, it was seen that the first words that came to the minds of the students about the concept of living things were human, animal, and plant; as a reason for this, students showed breathing, nutrition, reproduction-development, and movement as features of vitality (Yılmaz, Timur & Timur, 2017). Studies show that students recognize animals as living but not plants as living (Martínez-Losada, García-Barros & Garrido 2014). Wandersee and Schussler (1999) defined students' indifference to plants as "plant blindness", while Uno (2009) named students' incomplete knowledge about the importance of plants as "plant ignorance". Moreover, when the preschool teacher candidates were asked to search for living things in a natural environment with plenty of plants, it was observed that they did an animal-centered search (Torres-Porras & Alcántara-Manzanares, 2021). Kurt (2013) stated in her study that even biology teacher candidates may have superficial and limited views on the concept of living things. He emphasized that studies on living things are mostly done by taking samples of pre-university age groups. The value of the studies carried out in pre-university age groups, especially in preschool, primary, and secondary schools, is obvious. Because the concepts structured in individuals during this period are the basis for further knowledge. However, the accuracy, completeness, and meaningfulness of the knowledge of the teachers who will teach the students about the characteristics of the concept of living things and what is the basis of vitality, and the teacher candidates who are the teachers of the future about this concept, is also valuable. For this reason, it is still important to develop studies with teachers and teacher candidates, determine the infrastructure of the concept of living things, and carry out the necessary improvement studies according to this reference point.

Considering the lack of knowledge and misunderstandings of students from all levels, pre-service teachers, and even teachers about the concept of living things, it can be said that teachers have an essential role in overcoming this situation. Teachers, who take on important tasks in the planning of the teaching process of the concepts, manage the process by discussing the characteristics of the concept and providing a clear understanding of its relations with other concepts before defining a concept (Wandersee, Mintzes & Novak, 1994). For this reason, special attention should be paid to concept teaching and conceptual learning in the undergraduate education of prospective teachers, who are the cornerstones of raising the new generation (Kurt, 2013). Otherwise, concept teaching with traditional didactic teaching causes some difficulties in structuring knowledge. Still, it often leads to boring and ineffective lessons without interaction between teacher-student and student-student (Su, Cheng & Lin, 2014). In traditional didactic education, students take the information exactly as the teacher conveys it and repeat it when necessary, so the information learned in this way is not permanent. Likewise, students tend to memorize content-rich topics such as biology rather than learn by comprehending. Therefore, since students memorize the information without processing it, it is forgotten quickly (Selvi & Öztürk-Coşan, 2018). In this sense, in a discipline such as biology that is part of life, it should be ensured that students learn by doing experience and gain experience through these examples in structuring concepts by examining examples from daily life. In this direction, this study is important in that it teaches the ability to move, one of the basic characteristics of living things, to the prospective teachers in micro-scale cellular movement in plants by working on the example in the laboratory, doing experience, and presenting a model.

As it is known, living things generally have characteristics such as cellular structure, movement, respiration, excretion, growth and development, and reproduction. Being able to move within these characteristics is more complex than the others. While movement occurs at the will of a living thing, it is accepted as an indication that something is alive, but some non-living things move, and some living things do not (Dubeck, Boss & Moshier, 2004). The movement mentioned here is perceived as a displacement movement, and the occurrence of the movement at the micro level is ignored. In nature, plants move to survive. For example, plant leaves adjust their position to receive more light. Plant shoots bend to compete for light, and parasitic plants follow other plants, and the root tips of the plant search for water and minerals in the soil (Brenner, 2017). However, apart from all this macro-scale plant movement, the movement of plants can be shown to students in the micro-cellular dimension under the name of cytoplasmic streaming. It is seen that the students have difficulties perceiving the movement in the plants. For example, Kwon (2003) stated that children aged five and six consider plants non-living because they do not move. This misconception, which begins in childhood, makes it difficult for individuals to notice the vitality features of plants. Babai, Sekal & Stavy (2010) stated that children have difficulty distinguishing between living and non-living things, and they observe movement while making this distinction. Again, the same study found that movement is a prerequisite for detecting vitality even at advanced ages (as in high school students).

In their study on cytoplasmic streaming, Tominaga and Ito (2015) emphasized that plants usually stay where they germinate, referring to the obvious movement of animals, but they have cellular movements. Cytoplasmic streaming, which is accepted as a primitive and basic principle in plants (Shimmen, 2007; Verchot-Lubicz & Goldstein, 2010), was first reported in cells of Nitella and Chara algae species in 1774 by a physicist, Bonaventura Corti (Tominaga & Ito, 2015). Even though two and a half centuries have passed since cytoplasmic streaming was published in the literature, it is thought-provoking that the cytoplasmic movement is still ignored while explaining the movement feature in living things.

Plants are frequently used in science laboratory lessons. *Egeria densa*, a plant species, has an important place in laboratory activities and experiments, and it is possible to keep and grow these plant species in an aquarium (Lankford & Friedrichsen, 2012). *Egeria densa* can be shown to students who take laboratory courses for different purposes. *Egeria densa* is widely preferred to emphasize the importance of photosynthesis (Mu̇nkel-Jiménez, Bonilla-Araya, Grey-Pérez & Herrera-Sancho, 2019) and to show the cytoplasmic streaming movement to undergraduate students (Shmaefsky, 2004). However, when studies on the common characteristics of living things are examined, it has been determined that plant cells are not preferred for the concept of movement, and displacement movements are the subject.

Researchers have been asking prospective science teachers questions about the concept of vitality in the first weeks of the lesson in the science laboratory lessons they have been conducting in recent years. In the answers from the prospective science teachers, the researchers' attention was drawn to the fact that the prospective science teachers gave limited examples of movement, which is one of the common characteristics of living things, and that they only expressed their orientation to gravity and light in exemplifying the movement in plants. For this reason, when it was realized that the prospective science teachers did not think about the movement of plants in the cytoplasmic dimension, the researchers found it beneficial to conduct such a study. In this direction, the research was designed to determine how first-year prospective science teachers who have just started their undergraduate education perceive movement in living things. This study presents that *Egeria densa* is preferred as a model to show the movement of the common characteristics of living things.

2. METHOD

This study was carried out with six first-year prospective science teachers studying at Bayburt University's Faculty of Education Science Teaching Undergraduate Program. The study group for the research consists of six prospective science teachers who got close scores on the exam they entered at the beginning of their undergraduate education. Also, the type of high school students who graduate is the same. In this respect, it can be said that the content of the education received by the prospective science teachers in the research group before starting their undergraduate education is similar. The convenience sampling method, one of the non-random sampling methods, was used to determine the research group. The convenience sampling method is preferred since the study was carried out with prospective science teachers studying at the institution where the researchers work. Because, in this method, the main purpose of determining the research group is to minimize the loss of money, time, and labor (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2014), easily accessible individuals (Johnson & Christensen, 2014) can also be included in the study.

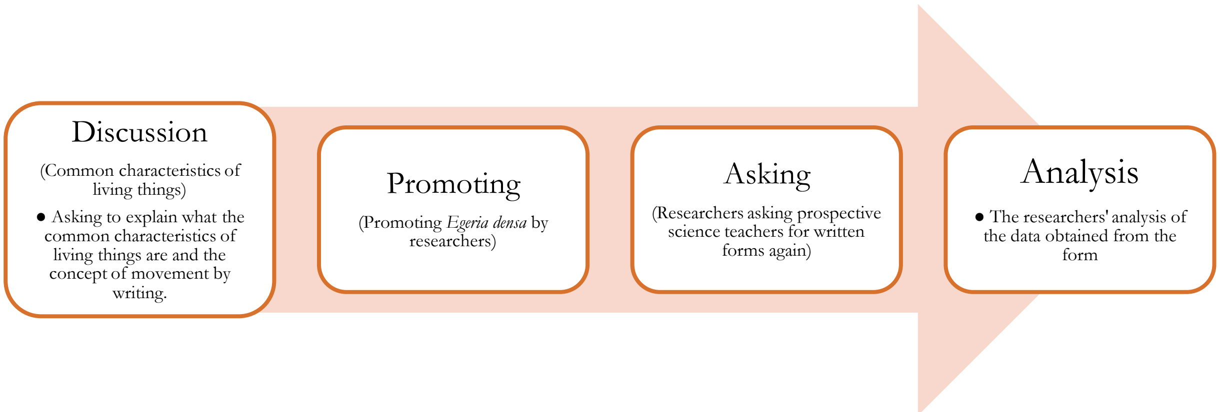

Figure 1 Mechanism of the use of *Egeria densa* in understanding the cellular movement.

In the study, a form created by the researchers as a data collection tool was used, and it contains questions aimed at getting prospective science teachers' information about the concept and the common characteristics of living things. The form was first administered to the prospective science teachers as a pre-test without discussing vitality and the characteristics of living things and without showing the cytoplasmic streaming movement, then as a post-test after the concepts were discussed and the cytoplasmic streaming movement was demonstrated. The content analysis method was used to analyze the data obtained from the form. In content analysis, which starts with data collection, categories and codes are created, and the researchers carry out the meaning and synthesis of the data (McMillan & Schumacher, 2010). Content analysis was adopted because there were no previously determined categories and codes in the study, and the researchers interpreted the data. In the content analysis process, the codes were first created. The researchers repeated the code generation process at different times to obtain accurate and reliable findings. The consistency among researchers was determined to be 96.3%, calculated according to Miles and Huberman's consistency formula (1994). According to Miles and Huberman (1994), since the consistency between researchers is over 70%, indicating that the coding is consistent, it has been demonstrated that there is consistency among researchers with the percentage found in this study.

The flow of the work is as follows (Figure 1):

A. Researchers' discussions with students on vitality and the common characteristics of living things and researchers' requests from students for written forms

1. Ask prospective science teachers to explain the common characteristics of living things and the concept of movement by writing.
2. Asking prospective science teachers to write examples of living things related to the concept of movement
3. Discussions of the researchers with prospective science teachers on the concept of living things and the common characteristics of living things.

B. Promoting *Egeria densa* by researchers (Figure 2)

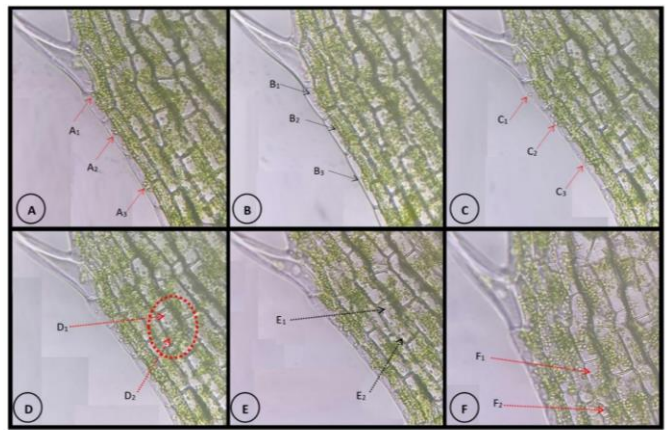

Figure 2 observation of cytoplasmic streaming in *Egeria densa*. A.B. and C. show streaming of marginal cells (moving the chloroplast). D.E. and F. show streaming of the inner cells.

Figure 3 A. the examinations made in microscopes and B. watching the movement collectively by reflecting on the TV screen

4. Examination of *Egeria densa* under a microscope: Young and fresh leaves are placed on a slide (Lankford & Friedrichsen, 2012), a drop of water is added, and the coverslip is closed at a 45-degree angle.
5. Monitoring the cytoplasmic movement in *Egeria densa*, watching the movement collectively by mirroring it on the TV screen after the examinations made in Leica binocular microscopes (Figure 3)

C. Researchers asking prospective science teachers for written forms again

6. Researchers are asking prospective science teachers for written forms again
7. Asking the prospective science teachers to explain what the common characteristics of living things are and the concept of movement by writing again

8. Asking prospective science teachers to write examples of living things related to the concept of movement again

9. The researchers and prospective science teachers exchange ideas on the concept of living things, especially movement in living things.

D. The researchers' analysis of the data obtained from the form.

3. RESULT AND DISCUSSION

3.1. Findings

In the data collection tool, the prospective science teachers were first asked the question, "What are the characteristics that an entity must have to be qualified as a living thing?" and the answers given by the prospective science teachers to this question in the pre-test and post-test are given in Table 1.

When Table 1 is examined, it is seen that there is no significant difference before and after the practice in the prospective science teachers' views about the characteristics that an entity must have to be qualified as a living thing. While expressing the vitality features, it was determined that the prospective science teachers stated the concepts of respiration, nutrition, reproduction, excretion, and homeostasis as common characteristics, with movement being the first. In addition to these concepts, the concepts of metabolism, cellular structure, adaptation, digestion, circulation, stimulus-response, and growth were also used by the prospective science teachers.

In the data collection tool, the prospective science teachers were asked the question, "How is cellular movement at the micro level? Please explain." the answers given by the prospective science teachers to this question in the pre-test and post-test are given in Table 2.

When Table 2 is examined, it is noteworthy that the prospective science teachers's views on how cellular movement occurs at the micro level differ before and after the practice. Before the practice, prospective science teachers explained cellular movement at the micro level as *active or passive displacement of the cell* and *endocytosis and phagocytosis depending on cell nutrition*. After the prospective science teachers examined *Egeria densa* in detail, it was determined that while explaining the cellular movement at the micro level, they explained *the movement of the organelles as*

Table 1 Prospective science teachers' views on the characteristics that an entity must have to be qualified as a living thing

Pre-test			**Post-test**		
Characteristics	**Prospective science teachers**	**Frequency**	**Characteristics**	**Prospective science teachers**	**Frequency**
Movement	$S_1, S_2, S_3, S_4, S_5, S_6$	6	Movement	$S_1, S_2, S_3, S_4, S_5, S_6$	6
Respiratory	S_1, S_3, S_4, S_5, S_6	5	Respiratory	$S_1, S_2, S_3, S_4, S_5, S_6$	6
Nutrition	S_1, S_2, S_3, S_4, S_6	5	Nutrition	S_1, S_2, S_3, S_4	4
Reproduction	S_2, S_4, S_5, S_6	4	Reproduction	S_2, S_4, S_5, S_6	4
Excretion	S_1, S_4, S_5, S_6	4	Excretion	S_1, S_2, S_4, S_5, S_6	5
Homeostasis	S_2, S_4, S_5	3	Homeostasis	S_2, S_4, S_5, S_6	4
Metabolism	S_2, S_4, S_6	3	Metabolism	S_2, S_4, S_6	3
Cellular structure	S_1, S_5	2	Cellular structure	S_2, S_3, S_6	3
Adaption	S_3, S_4	2	Adaption	S_3, S_4, S_5	3
Digestion	S_5	1	Digestion	S_2, S_5	2
Circulation	S_5	1	Circulation	S_5, S_6	2
Stimulus-response	S_4	1	Stimulus-response	S_4	1

Table 2 Students' views on how cellular movement occurs at the micro level

	Description of the movement	**Prospective science teachers**	**Frequency**
Pre-test	Cell movement (active-passive)	S_3, S_5, S_6	3
	Cells perform endocytosis and phagocytosis	S_1, S_4	2
	Empty	S_2	1
Post-test	**Description of the movement**	**Prospective science teachers**	**Frequency**
	Movement of organelles in the form of small dots by merging	S_1, S_4, S_6	3
	Sliding movement of organelles	S_1, S_2, S_3	3
	The flowing movement of organelles	S_1, S_5	2
	Displacement movement	S_6	1

Table 3. Statements made by prospective science teachers in terms of the cytoplasmic streaming movement

Cytoplasmic streaming movement	**Prospective science teachers**	**Frequency**
Intracellular organelle movement	S_1, S_2, S_3, S_5, S_6	5
Intracellular flow movement	S_1, S_2, S_3, S_6	4
Intracellular particle movement	S_1, S_4, S_6	3
Intracellular sliding movement	S_1, S_5, S_6	3
Intracellular oscillatory movement	S_4, S_6	2

small dots, the sliding and flowing movement of the organelles, and the displacement movement.

After the application, it was determined that the prospective science teachers formed sentences expressing the cytoplasmic streaming movement while describing the cellular movement at the micro level. The findings regarding the codes used by the prospective science teachers to indicate the cytoplasmic streaming movement are given in Table 3.

When Table 3 is examined, it is seen that the students explained the cytoplasmic streaming movement as intracellular, *organelle movement* first, and respectively, *flowing movement, particle movement, sliding movement, and oscillating movement.*

3.2. Discussion

It is known that the movement that comes to mind first when it comes to movement in plants that are of little interest to students is in the form of orientation to light, water, and gravity (Brenner, 2017; Dalkılıç, 2020). However, in plants, cytoplasmic streaming and cellular movement are at the micro level. This cytoplasmic streaming movement is often ignored or unknown by students. Similarly, some researchers have shown that students know the common characteristics of living things, but these characteristics, especially movement, are not sufficiently structured (Bahar, 2003; Mortimer & Scott, 2003). In this study it is aimed to use *Egeria densa*, which is used for many experiments in science laboratories, as a model for the prospective science teachers to structure the movement, which has a vitality feature that cannot be explained at the micro level (Mŭnkel-Jiménez, Bonilla-Araya, Grey-Pérez & Herrera-Sancho, 2019; Vondrasek, 2013), and to enable the prospective science teachers to learn the cytoplasmic streaming movement through this model.

In the study, it was seen that the prospective science teachers could easily indicate the general characteristics of living things before and after the practice, and they expressed similar characteristics in both stages. While defining vitality, prospective science teachers stated, including movement first, the concepts of respiration, nutrition, reproductive and excretion, homeostasis, metabolism, cellular structure, adaptation, digestion, circulation, stimulus-response, and growth as typical characteristics. The prospective science teacher's statements about these characteristics are compatible with the literature (Bahar, 2003; Yılmaz, Timur & Timur, 2017). One of the remarkable results is that all of the prospective science teachers included in the research stated movement as a characteristic that an entity must have to be described as a living thing. In previous studies, it has been revealed that the first sign of vitality that comes to the minds of individuals when describing an entity as a living thing is movement (Bahar, Cihangir & Gözün, 2002; Kılıç, Atasoy, Tertemiz, Şeren & Ercan, 2001; Tamir, Gal-Choppin & Nussinovitz, 1981). Therefore, it can be said that this result is parallel to the literature. However, what is important here is not whether the prospective science teachers express the vitality features but whether they know them in depth. When the movement feature discussed by the prospective science teachers was examined in depth, it was seen that the prospective science teachers could not exemplify the movement feature in detail and made superficial explanations such as the active or passive displacement of the cell and endocytosis and phagocytosis depending on the cell nutrition.

Similarly, Mortimer and Scott (2003) found that students could not structure the movement features of living things in detail. However, it was determined that the prospective science teachers explained the movement in more detail after observing *Egeria densa* under the microscope. After the practice, students explained the movement of organelles in small dots by merging, sliding, and flowing movements and displacement movements of organelles. This may mean that when the prospective science teachers could observe *Egeria densa* under a microscope, they structured the cellular movement in detail at the micro level. In this direction, it can be said that it is helpful to use *Egeria densa* as a model for undergraduate students to make sense of movement at a micro level.

4. CONCLUSION

Generally, for students, movement is perceived as an apparent displacement for moving creatures and tropism movement for living things such as plants. For stationary organisms or cells, intracellular streaming is an example of movement that has been neglected because it is difficult for students to observe. After the practice, it was determined that the prospective science teachers explained cellular movement at the micro level as organelle movement and, respectively, flowing movement, particle movement, sliding movement, and oscillating movement. These explanations point to the movement of cytoplasmic streaming. In this direction, it can be said that the prospective science teachers made detailed explanations about cellular movement directly by examining *Egeria densa* under the microscope. Therefore, the *Egeria densa* plant can be observed at a microscopic level, explaining the micro-level movement in plants in a short time. In addition to the many uses of *Egeria densa* in science laboratories (Mŭnkel-Jiménez, Bonilla-Araya, Grey-Pérez & Herrera-Sancho, 2019; Vondrasek, 2013), in monitoring movement at the microscopic level (cytoplasmic streaming), *Egeria densa* can be used as a model in the microscope to provide students with more detailed configurations of movement.

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