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## Looking for the Forest and the Trees : Exercises to Provoke Abstract Thinking

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### INTRODUCTION

I doubt that there is an educator who would hesitate to agree that abstract thinking and comfort in asking questions are pivotal to scientific inquiry and advancement of knowledge. Yet, most of the time the mechanics of fostering these skills is as challenging as photographing dense fog. As biologists we constantly reevaluate what we know, how we think about what we know, and how we communicate our knowledge about the living world.

Teaching biology on the cellular and molecular level is especially challenging. Despite the enormous advancements in the area of imaging techniques (2, 3) we cannot directly observe most cellular processes. Understanding them requires reasonable proficiency in working with abstract concepts at a skill level few students have reached at the beginning of their undergraduate education. While this is not surprising, having in mind that abstract thinking starts developing only in early adolescence, the pace of 21<sup>st</sup> century science calls for conscientious efforts to foster this valuable skill.

I have designed short engaging exercises that challenge students to appreciate the central role of abstract thinking and question-asking in scientific inquiry. Currently, I use the exercises in an Introductory Cell Biology course (BIOL200) as a part of the first class period following a segment introducing course expectations.

### PROCEDURE

#### From hidden faces to abstract thinking

This exercise takes advantage of an optical illusion image that incorporates hidden faces in a bouquet of various flowers (Fig. 1). The image (without the asterisks) is projected on the classroom screen together with a writing prompt “Describe what you see!” Students are given an

index card and two minutes to write their answers. When presented with the task most students are visibly confused: the bouquet image definitely does not fit in with the scope of cell biology which has just been introduced to the class. When the time for writing is over, I pose the question “How many hidden faces can you find in the picture?” and ask the students to record the number on their index card. I can



FIGURE 1. A sample slide used to introduce the “From Hidden Faces to Abstract Thinking” exercise. The displayed slide is projected on the classroom screen and students are asked to describe what they are seeing and then to identify the hidden faces. Hidden faces are marked with asterisks for the reader’s convenience. The original optical illusion picture can be downloaded from: <http://www.moillusions.com/2009/02/mystery-of-bouquet-illusion.html>.

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see that most faces relax a bit, while curiously scanning the picture again. In a minute I ask a new question: “Can you find all five hidden faces in the picture?” and invite a volunteer to come to the front of the classroom and trace the hidden faces on the white board. After the excitement from the exercise settles down, I summarize the experience pointing out the importance of being open-minded and persistent when “solving biological puzzles” and emphasize that scientists use both concrete and abstract thinking to analyze biological phenomena. I tell my students to expect similar experiences with every new topic. It is very likely that initially new concepts will not make perfect sense, i.e. one would be seeing only the bouquet and not the hidden faces. However, after a few rounds of inquiry evaluating what we know, what we assume, and what does not seem to fit in the picture, one would be able to put all the pieces together. To do so one has to be comfortable asking questions and critically evaluating the answers that come along. To emphasize this point I follow up with an exercise using a small article from the popular press capitalizing on students’ interest in a local sports team.

### Ask until one of us gets it

The storyline of the article, a reader’s contribution to the “Tales from the City” section of *Boston Globe Magazine* published in the summer of 2009 (1), describes a vacation experience of a New England traveler in Italy, where he encountered a person wearing a New York Yankees baseball hat. Being an avid Boston Red Sox fan the author started discussing the popular sport rivalry only to realize that the assumed NY Yankees fan barely speaks English or has any awareness of baseball. Shortly, it becomes apparent that NY are the initials of the hat’s owner and the puzzle is resolved.

Building on the story, I emphasize how important it is to keep asking questions until everything makes sense, as well as to be open-minded and critically examine alternative possibilities. I reassure students that all questions are important and welcomed, and that if they are confused about something themselves, chances are that someone else in the classroom might be confused too. Thus, by asking questions one not only clarifies the matter to one’s self but also contributes to the knowledge of one’s colleagues. Furthermore, I state that making mistakes is a natural component of learning and asking questions is just the way human beings pursue their inquiry. Even when there is confusion due to wrong assumptions, as demonstrated in the presented story, if all parties involved keep asking questions and working together, the puzzle under discussion will be solved.

### CONCLUSION

The described exercises provoke students to think about the process of acquiring knowledge and building an

inventory of tools needed for productive scientific inquiry. In my experience, most of the students find the exercises somewhat shocking and respond positively to the triggered discussion. Occasionally, single students will spot the hidden faces immediately. When that happens I would stop the clock of the writing prompt and ask the classroom to continue with the next task of the exercise. Throughout the course I often refer to concrete and abstract content components as the “bouquet flowers” and the “hidden faces” of the topic. For example, when teaching about the Golgi apparatus I point out to my students that we often think about the organelle as a static pile of membranes that is reminiscent of stack of pancakes, simply because that is what we see on electron micrographs or textbook illustrations. In fact, the Golgi apparatus is a very dynamic organelle that is constantly being “built” from vesicles merging to its receiving end and constantly being “destroyed” by vesicles budding off from its shipping end. In other words, in order to understand how the Golgi apparatus is functioning one has to combine the concrete image with the abstract idea of the transient nature of the organelle.

The take-home messages of both exercises can be sent across the classroom with different versions of optical illusion images or stories. I chose the ones described here to capitalize on (i) connection to organismal biology that offers a different balance of concrete vs. abstract content (hidden faces exercise) and (ii) connection to popular culture that appeals to students (the question-asking exercise). A good source of optical illusion images is <http://brainden.com>, a website that offers them cataloged by topic along with short explanations referencing brain function. Some of their video illusions could be a good extension of the hidden faces exercise or they could be an alternative that engages students as spectators and not as participants. The exercises can be easily used in any introductory level biology course and with proper content adaptation in other disciplines.

### ACKNOWLEDGMENTS

The author declares that there are no conflicts of interest.

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