INTRODUCTION

Flashcards are a preferred study strategy of students in medically-oriented curricula (1, 4). Unfortunately, students often use them very limitedly, when preparing for exams—for instance, students will write the name of an infectious microbe on one side of the card and its corresponding disease on the other, and simply troll through the stack until they have all microbe–disease associations memorized. While this technique helps students establish a word bank for learning and improves random recall, it does little toward applying that information to the actual context of microbiology (2) and students may over-estimate its study value (3).

Here are some strategies I have developed to stimulate in-depth studying using flashcards. These strategies allow students to stay within the comfort of using flashcards, do not require generating new study aids, and add novelty.

PROCEDURE

Four flashcard techniques are expounded below. For each, a medical microbiology course-based example is given. Each activity assumes that students have already familiarized themselves with the names and/or definitions on the flashcards. Smaller sets of terms should be used when first introducing the strategies; once students gain proficiency, larger numbers of flashcards may be included. Technique variations and other applications are discussed.

Technique #1: In-and-Out. In-and-out is good for seeing commonalities or differences in a set of items by sorting them into groups. The strategy gets its name because I model it using a plastic or Styrofoam bowl for the “in” group and the surrounding tabletop for the “out” group. For an example, assume a learning unit where students are given a group of microbes and asked to learn their general characteristics (taxonomy, transmission, symptoms, treatment, prevention & control, and historical context). In Figure I, Box 1a gives a list of 10 RNA viruses commonly studied; each of the 10 names would be represented by a separate flashcard. Appendix I contains a PDF version of the complete card set from Box 1. If students were trying to memorize the Baltimore classes for each virus, an appropriate exercise might be to place all of the class V viruses “in” and all others “out” (Box 1b; the “out” viruses are all class IV except for HIV, which is class VI). Alternatively, you could put “in” all those viruses that are primarily transmitted via the respiratory route and “out” all others. A more complex, application/concept-based exercise would be to present students with a clinical scenario (“Your 14-year-old patient presents with a fever and rashes”) and ask them to make an “in” pile of likely culprits and an “out” pile of unlikely suspects. A second example of In-and-Out using basic components of the human immune system important in host-microbe interactions, with complete card set, is available in the online supplemental materials for this article.

Technique #2: Perfect Pairs. Perfect Pairs relies on the same cognitive skills as and has similar learning outcomes to In-and-Out but is more difficult because it challenges students to consider a wider scope of information. The premise and cards from Box 1a (Appendix 1) will be used again in this example. Students place all 10 cards into five “perfect pairs” and justify their pairings (Box 1c, with pairs presented first and rationale for pairings in parentheses). Notice that the pairs in Box 1c encompass a breadth of knowledge (transmission, symptoms, etc.) because the activity requires considering the microbes from multiple vantages. After completing one set of pairings, students challenge themselves by breaking all pairs and coming up with a different set. Using mumps from Box 1c, students would either have to generate a different reason for keeping mumps and RSV together (respiratory transmission) or would need to repair both mumps and RSV with other cards. Appendix 2

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† Supplemental material available at http://jmbe.asm.org
supplies a second example of how to execute Perfect Pairs using the immune system cards.

Technique #3: Venn Diagrams. Concept maps are another method for comparing and contrasting items, and appeal especially to visual learners. For an example, assume a lecture on the properties of viruses, prokaryotes, and eukaryotes. In Figure 2, Box 2a presents a list of molecular or cellular structures that may be compared/contrasted between these three groups; each of the 10 structures would be represented by a separate flashcard. Appendix 3 in the Supplement online contains a PDF version of the complete card set from Box 2. Using a Venn diagram, students are prompted to place the flashcards on the diagram corresponding to which of the three groups that structure may be found (Box 2b). I suggest this specific example early in my courses to help students grasp the differences between microbes, because oftentimes latter-semester problems (such as understanding mechanisms of drug actions, or drug selection rationale) stem from early conceptual misunderstandings. For instance, utilizing the outcome from Box 2b helps students see why anti-HIV drugs that target DNA/RNA processes have side effects in human cells. A second example of a Venn diagram activity using the immune system cards is provided online in Appendix 2.

Technique #4: Relationship/Hierarchy Mapping. A different way to visually organize material is to place the flashcards spatially to show relationships between items. The premise and cards from Box 2a (Appendix 3) will be used again in this example. For relationship (procedural or sequential) mapping, students place the cards in sequence to show the structures involved in synthesizing a new molecule (Box 2c; note that other structures, such as mRNA, nuclear pores, and vacuoles are not included in the card set, but could be added). Using the same card set for hierarchical mapping, students could arrange the cards in size from largest to smallest. Appendix 2 provides another example of relationship/hierarchical mapping using the immune system component cards.

CONCLUSION

Four strategies to stimulate higher-order thinking using flashcards have been proffered within the context of undergraduate medical microbiology. These strategies are applicable to any scientific discipline and other plausible applications or combinations of strategies are numerous. If you want students to perform specific exercises when studying, one possibility is to produce electronic card sets (such as in Excel), to post them online with instructions, and to allow students to print them off and practice outside of class. Alternatively, when students come to office hours and report problems understanding course material or with performance, I might employ one of these activities to help diagnose why the student is struggling. Finally, these strategies can quickly be adapted to use as in-class activities if you prepare and print card sets for students in advance; if used in-class, they can then serve the supplemental purpose of also being a formative assessment tool.

SUPPLEMENTAL MATERIALS

Appendix 1: RNA Viruses
Appendix 2: Human Immune System Cards
Appendix 3: Cell Components

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REFERENCES


FIGURE 2. Cell components word list (a) with applications to Venn diagram mapping (b) and procedural mapping (c)