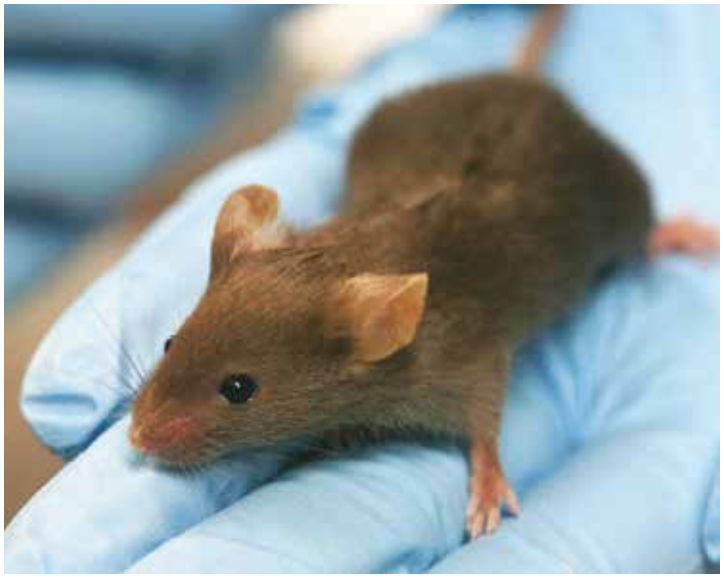
ScienceNews
IN HIGH SCHOOLS | EDUCATOR GUIDE



‘DIRTY’ MICE
make better human mimics

FROM LEFT: JAN'S CANON/FLICKR (CC BY 2.0); GLOBAL PANORAMA/FLICKR (CC BY-SA 2.0)

SOCIETY FOR
SCIENCE & THE PUBLIC

SN EDUCATOR GUIDE 'DIRTY' MICE make better human mimics

About the Guide

The *Science News* article "'Dirty' mice make better human mimics" describes the recent finding that mice exposed to pathogens are better models of the human immune system than sterile lab mice are.

"'Dirty' mice make better human mimics" can be used across a wide range of curricula, with a focus on **biology** and **health**. The activities, questions and discussions in this educator guide can be used to support the following education standards:

Next Generation Science	Common Core
Engineering Design: HS-ETS1-3	ELA Standards: Reading Informational Text (RI): 1, 2
Biological Evolution: Unity and Diversity: HS-LS4-2	ELA Standards: Writing (W): 2, 6
	ELA Standards: Speaking and Listening (SL): 1, 2, 3, 4
	ELA Standards: Language (L): 1
Connections to Middle School: From Molecules to Organisms: Structures and Processes: MS-LS1-5	ELA Standards: Reading for Literacy in Science and Technical Subjects (RST): 1, 2, 6, 9
	ELA Standards: Writing Literacy in History/Social Studies and Science and Technical Subjects (WHST): 1, 6, 7, 8, 9

Prior to reading

Guide student reading by pointing out connections between this article and what students are learning in class. Here, find ideas for standard-aligned paths to follow while reading:

- Explore your students' current understanding of scientific models by asking questions including:
  - What is a scientific model?
  - What are some different types of models? (*There are physical, conceptual and mathematical models, for example.*) You can show students Blackline Master 1, which offers different types of models that represent a cell and its activities, or you can encourage students to come up with examples based on prior experience.
  - Why do scientists use models?
  - What makes a good model?
  - What are some of the limitations of models?
- What do students know about how the body prevents and fights disease? (*Consider the role of skin, tears, the mucus membrane, lymph nodes, the liver and the spleen, for example. Also consider the cells of the immune system, including white blood cells, and the role of antibodies.*)
- What do students know about medical treatments that help prevent or fight disease?

After reading: Comprehend

You can adapt and print these questions (Blackline Master 2) to check for comprehension and analysis before or after discussion:

1. **What is the main topic of the article?** *(Scientists have debated the use of mice as stand-ins for medical research, and a new study explores the limits of these mice for modeling the human immune system.)*
2. **Why are lab mice compared to human babies in the article?** *(Lab mice have inexperienced immune systems. Their existence is too hygienic. They have fewer of the memory T cells that cull body cells that are infected with viruses or bacteria or are cancerous.)*
3. **What might be a better model, according to the article?** *(Wild mice or mice from pet stores. Or, researchers could find ways to raise mice that more closely emulate human physiology.)*

After reading: Analyze

1. **Why is a lab mouse used for medical testing considered an animal "model"?** *(In medical testing, scientists use lab mice as stand-ins to represent human patients and to try to understand what is going on in the human body. Lab mice are a physical model, and they are intended to provide a close approximation.)*
2. **What assumptions do scientists make in using lab mice and other mammals for medical testing?** *(Answers will vary, but some examples include: Scientists assume that mammals share a similar biology. They assume that what holds true in one species might hold true in another. They often assume that further testing will be conducted that will corroborate or challenge their findings.)*

3. **Can you think of any drawbacks to using pet mice or wild mice for medical testing?** *(Answers will vary, but some examples include: Wild or pet mice might be better for studying the immune systems, but they might not be as good for studying other diseases, such as cardiovascular disease or cancer. Even if wild or pet mice are better models, they might be hard to acquire and keep in the lab. Also, lab mice are bred to be genetically identical so they have the same reactions. By comparing identical mice with just one gene difference, for example, scientists can look at the effects of that one gene. Wild and pet store mice have many different genes, so such experiments would be harder.)*

4. **Some scientists argue that the environment of young children in developed countries is too clean, and thus their immune systems overreact to things that aren't dangerous, leading to asthma and allergies. How does this idea, called the hygiene hypothesis, relate to this article?** *(Young people who live in environments that are too clean, like the lab mice, might develop an immune system that attacks the wrong things, such as pollen, pet hair or peanuts. These children are also, in an essence, "raised in a bubble." Their immune systems may be immature or react in unexpected ways compared with people whose immune systems have been trained by encounters with many different pathogens.)*

Discuss and Assess

After students read the article independently, return as a group to the concepts outlined prior to reading. Invite students to share their answers and observations from the article and lead a class discussion that further underscores your current curriculum. The discussion can serve as an informal assessment. Ideas for further reading discussion or writing prompts include:

- Use this article as a starting point to explore with your students the incomplete nature of models. Ask them to brainstorm ways for researchers to make their models more reliable, either by choosing a different organism to act as a model, making genetic or upbringing-related changes to the mouse model itself, or altering the types and extent of testing conducted. Encourage students to think about other model organisms. What are the advantages and disadvantages of using those organisms? What logistical, economic and ethical issues influence model selection?
- Ask students if they can think of a time when some subset of their friends, family members or classmates were exposed to a disease *(the flu or chicken pox, for example)*. It's unlikely that everyone got the disease. Ask students what might account for differences in people's ability to fight off disease. *(Whether or not a person was exposed is a key point, but encourage students to go beyond that insight to discuss past exposures, genetic differences, variation in where people live and grow up, their ages, diet and general health.)* Ask students if they can think of a disease that used to be more common than it is today (*polio, for example*). What about a disease that is more common in some parts of the world than others *(tuberculosis, for example)*? What factors explain who is infected and who isn't?
- Ask students what they know about how drugs and other medical treatments are tested in the United States. The U.S. Food and Drug Administration's Development & Approval Process page can be a helpful resource to facilitate the conversation: http://www.fda.gov/Drugs/DevelopmentApprovalProcess/default.htm. Be sure to follow the link to "How Drugs Are Developed & Approved." What role do lab mice and other animal models play in this process? Why are these model organisms considered essential to the process? How does the nature of this process affect what treatments are available in the United States? How might the process be different in other countries? Encourage students to make connections between the process of drug development and the availability and price of drugs in the United States. Encourage students to research and discuss the risks and benefits of exceptions to the process, as well as potential changes that might improve the process.

Extend

Offer students other ways to explore the content of the article as it relates to your curriculum, such as:

DEBATE THE ISSUE

Purpose: In-class debates are an effective technique for fostering communication skills and building the attitudes that promote active citizenship. Debates can follow formal protocols, such as Lincoln-Douglas or Parliamentary debates, but they can also be less formal, such as the approach suggested here. This debate protocol can be used in part or in whole to engage students in a topic.

Directions:

PART 1 — This exercise accesses prior knowledge and helps students evaluate and solidify what they think.

1. Post four pieces of chart paper in separate corners of the room. Give each a label: Strongly agree, Agree, Disagree, Strongly disagree.
2. Present students with a statement based on a topic related to the article. Examples include:
   a. Laboratory mice are vital to the development of new medicines.
   b. Laboratory testing on animals can predict a treatment's success in humans.
   c. Animal testing is justified only when it is used to reduce human suffering.
   d. Animal testing should be banned.
3. Tell students they have 10 seconds to go stand by the chart paper that most represents their opinions.
4. Once they have organized themselves, give students 2 minutes to brainstorm why they have this opinion. Students might want to write down some of the strongest arguments.

5. Give students 1 minute to combine their thoughts and select a spokesperson to represent the group.
6. Give each group 1 minute to state their reasoning and try to convince members of the other groups to join them.
7. Give students the opportunity to change opinions (and thus relocate to another group) if they'd like.
8. Ask students why they stayed in their group or what convinced them to move.

PART 2 — This exercise deepens students' knowledge on a topic.

1. Present a question that relates to the article, such as: Do the benefits of using laboratory mice to test medical treatments outweigh the costs?
2. Give students 15 to 20 minutes to research the topic on their own and form an opinion. Encourage them to find facts that support the opinion they are forming, as well as facts that could refute claims made by anyone who disagrees.
3. Have students form teams with different opinions on the topic and give them 5 minutes to discuss how they will most strongly convey their perspective. Each team must select three spokespeople (one for each round). Other members of the team will be the fact-finders, feeding well-researched information to the members of their group.
4. Appoint someone as chief arbiter. This student's role is to keep track of the points of information shared by a team and whether the other team addresses those points. Debaters call this form of note-taking the "flow," and it is usually an informal list of words and phrases that helps keep track of ideas raised and addressed.
5. When ready, each team is given 1 minute for their first spokesperson to make an opening argument. This round is followed by a new spokesperson from each team responding to what has been previously said in 30 seconds. New information can be raised in this second round to strengthen the initial argument. The final speaker for each team is then given 1 minute to summarize the team's argument without adding new information. The purpose of this round is to make sure each team's perspective is clearly articulated.
6. Once the debate is complete, discuss how persuasive the arguments and responses were. Ask the arbiter whether all the points were refuted or whether there were some that weren't addressed. Any argument that goes unaddressed earns the team that presented the argument a point. The team with the most points wins.
7. You can repeat this process over multiple rounds, with points carrying over to the next round. Questions for subsequent rounds might include:
   a. Is it OK to use test mice for research into terminal illnesses, such as cancer?
   b. Is it OK to test cosmetic and skincare products on mice?
   c. Should monkeys, rather than mice, be used for more animal testing?
   d. Should dogs, rather than mice, be used for animal testing?
   e. Does the age of the mice matter for medical testing?
8. Debrief the entire debate experience. What information and strategies were most effective?
9. Discuss the role that personal experience plays in forming a person's opinion on these issues. Would students with pets be more or less inclined to allow animal testing? What about students who have a family member with cancer?

TANGRAMS AND T CELLS

Purpose: To model the importance of memory in immune response.

Notes to the teacher: Students might have some experience with tangram puzzles — the goal is to create an image using all of the shape pieces provided without any pieces overlapping. By solving these puzzles over multiple rounds, students will see how experience helps students solve the puzzle faster. In a similar way, experience with pathogens helps the body fight future pathogens.

Background: T cells help fight infection. Memory T cells are a type of T cell that has been in contact with a foreign antigen before. As a result, memory T cells "remember" which antigens are bad and can thus help the body mount a faster and stronger response.

Materials:

- Blackline Master 3 puzzle pieces (duplicated for each student)
- Blackline Master 4 puzzle images (printed on projector sheets and projected)
- Blackline Master 5 answer keys (one of each answer cut out and then folded or placed in an envelope with the name of the object on the outside)
- Scissors
- Timer (projected or use a stopwatch)

Directions:

1. Give each student Blackline Master 3 and time to cut out their shapes.
2. Explain that the class is going to use these tools to think about the benefits of memory T cells.
3. Divide your class as follows:
   a. Ask four people to be in charge of the answer keys. You can call them the "answer keepers."
   b. Split the remaining students into two equal-sized groups. One group (A) will have access to the "answer keepers," but the other (B) will not have access.

4. Give each “answer keeper” one of the four answer keys and a few minutes to review the solutions.
5. Project one of the puzzles.
6. When the timer starts, students in Group A and Group B should work individually to try to solve the puzzle. Without showing the answer key, the “answer keeper” for that puzzle can use his or her pieces to help students in Group A. Students in Group B have no access to anyone who knows the answer.
7. Each student should record how long it takes to solve the puzzle. You can set a maximum time (5 minutes, for example). The three “answer keepers” who don’t have the solution can help record finish times.
8. Repeat steps 5 through 7 with the remaining puzzles.
9. When you have finished all four puzzles (or as many as time allows), ask students how this scenario might model the immune system. What do the puzzles represent? What do the “answer keepers” represent? What do Group A and Group Be represent? If this model is appropriate, which students should have solved the puzzles fastest?
10. Have your students graph the finish times of students in Group A and Group B on each puzzle. What trends do they see? Is this what they expected? In what ways is the tangram exercise a good model for the immune system? In what ways is it insufficient? What additional information would you need to make conclusions about the accuracy and success of this model?

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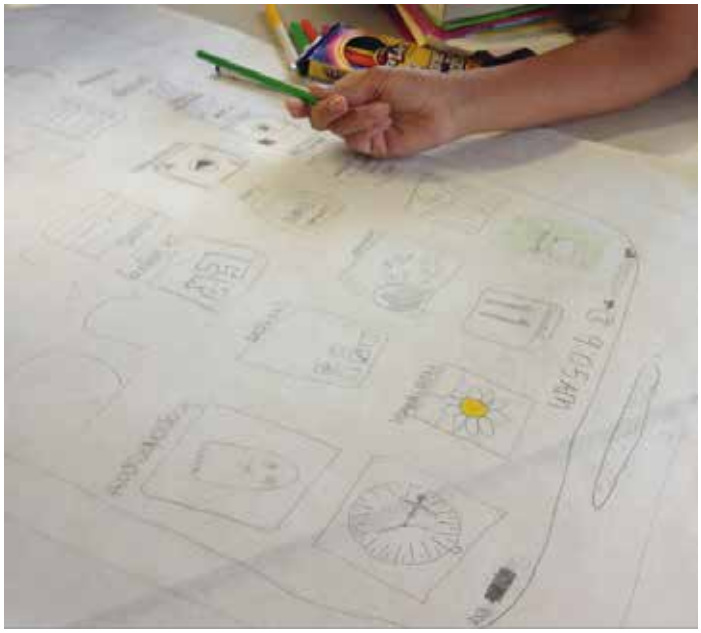
Types of models for a cell

Physical:
Students place an egg (its shell has been dissolved) into different substances, such as vinegar or syrup, to see how the cell membrane allows fluids to flow or not flow through.

Conceptual:
Cell phone apps can be thought of as a metaphor for the organelles of cells. Each app has its own structure and function that contributes to the whole.



Mathematical:
The equation to the right represents cellular respiration by showing the inputs and products.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 25ATP$$

or

glucose + oxygen $\rightarrow$ *carbon dioxide + water + ATP*

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Comprehend

After reading the article “‘Dirty’ mice make better human mimics,” answer these questions:

1. **What is the main topic of the article?**

2. **Why are lab mice compared to human babies in the article?**

3. **What might be a better model, according to the article?**

Analyze

1. **Why is a lab mouse used for medical testing considered an animal "model"?**

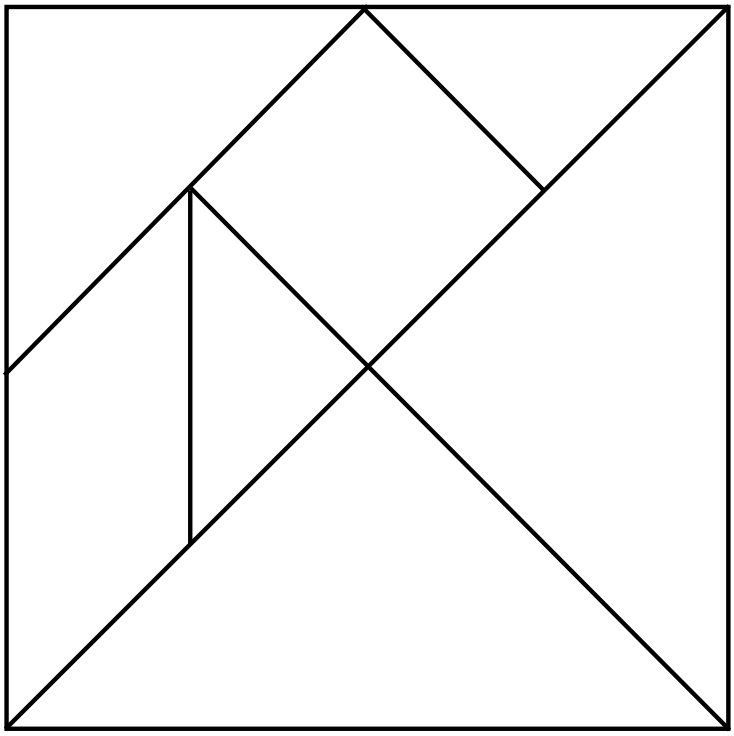
2. **What assumptions do scientists make in using lab mice and other mammals for medical testing?**

3. **Can you think of any drawbacks to using pet mice or wild mice for medical testing?**

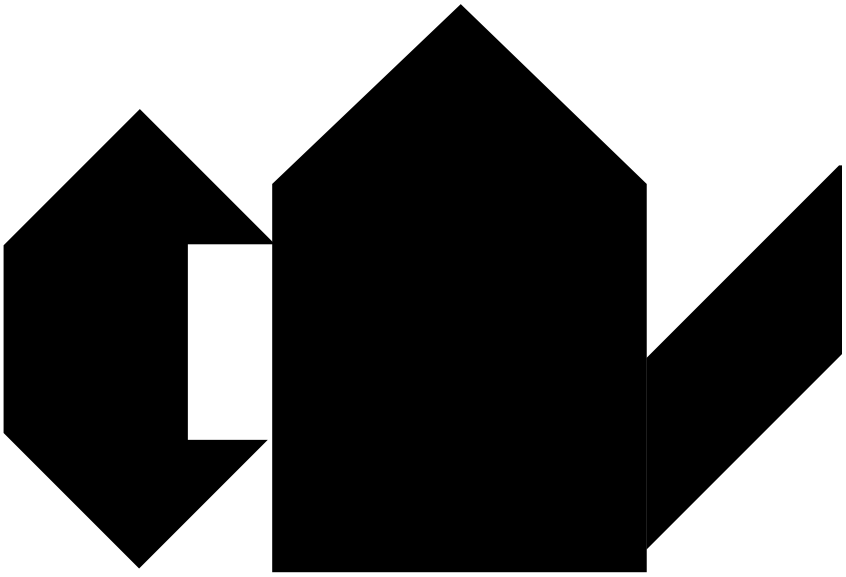
4. **Some scientists argue that the environment of young children in developed countries is too clean, and thus their immune systems overreact to things that aren't dangerous, leading to asthma and allergies. How does this idea, called the hygiene hypothesis, relate to this article?**

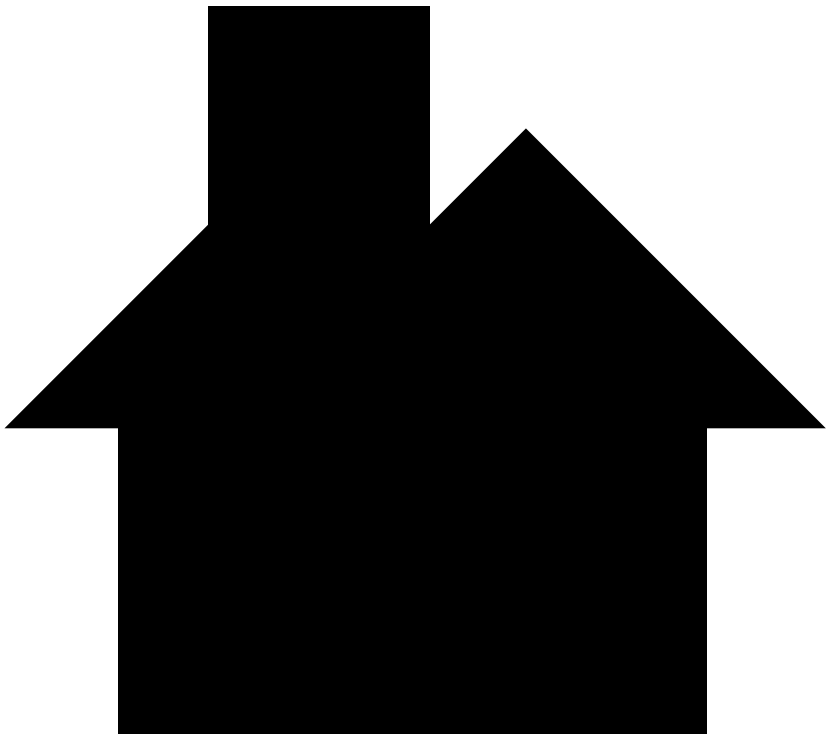
Tangrams and T cells: Puzzle pieces

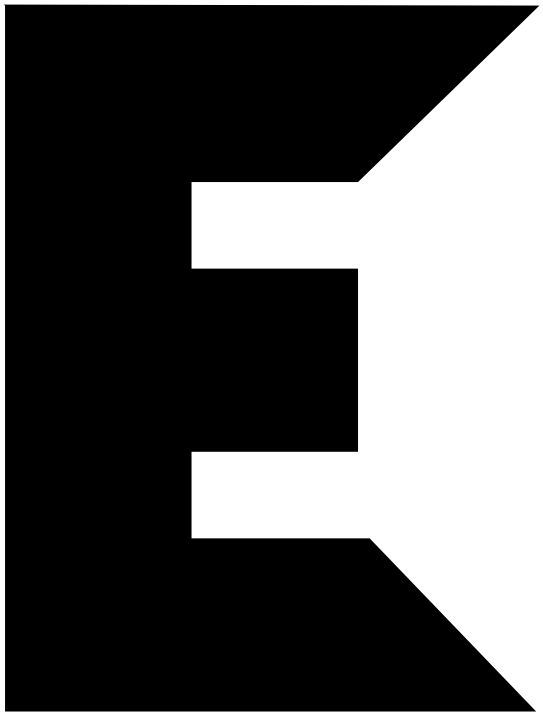
Directions: Cut out the puzzle pieces and arrange them on your desk so you can use them to make figures.

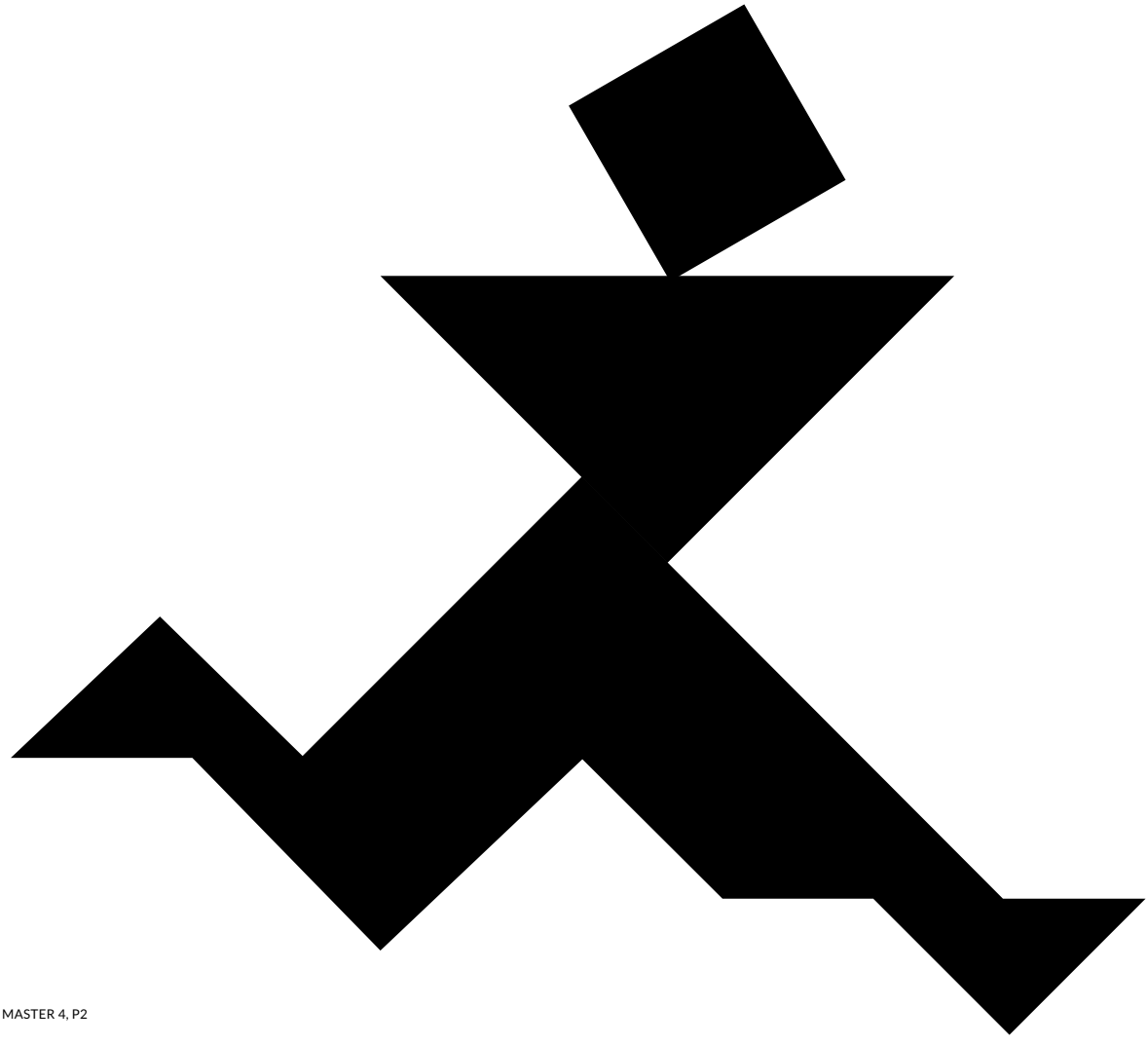


Tangrams and T cells: Puzzle images









Tangrams and T cells: Answer key