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SYSTEM ALERT!

Tomorrow is almost here.

The **leap** to general **intelligence**

Sometimes people ask, "When will computers finally be smarter than humans?" In truth, there's no straightforward answer. In some ways, they already are. But in other ways, they lag far behind.

Computers have proven to be extraordinary at specific tasks they are programmed to do. Yet they have long lacked what scientists call general intelligence. This is what allows humans to learn and excel at many different things.

But this gap is closing, in part thanks to an approach called neural networks. A neural network is a computing system modeled after biological brains. Brains (of humans and other animals) contain nerve cells called neurons. Neurons are connected in complex networks. These cooperate to help us learn and think about information. There are roughly 100 billion neurons in a human brain.

Artificial neural networks mimic this structure. Such machines learn through experience. They can become experts at things they were not specifically programmed for.

Recently Google developed a neural network computer system called AlphaGo, which beat a human world-champion Go player. (Go is an ancient Chinese board game. There are believed to be more possible Go moves than atoms in the universe!) The most recent version of AlphaGo wasn't programmed with all the right moves. It learned by playing.

So, have computers finally attained general intelligence? Some think so. But there is evidence that neural networks still have a way to go before they are on par with humans.

(continued on page 4)

A step forward for lifelike **robots**

"We've been making great strides toward making robots' minds, but robot bodies are still primitive." These are the words of Hod Lipson, lead scientist of a group at Columbia Engineering. His team is attempting to revolutionize the construction of robots in favor of something more lifelike.

Lipson's team has created a soft material made of silicone rubber. It can push, pull, and bend. And it can be made to respond to an electrical signal. In theory, this material could be for a robot what muscles are for humans, giving them greater independence and range of motion. The team hopes to combine their creation with an artificially intelligent brain. ⚠

BEFORE ACTUATION **ACTUATED**

An electrical signal causes the "muscle" to perform its task – in this case, to expand. Image credit: Aslan Miriyev/Columbia Engineering

Changing life from the bottom up: **New tool edits DNA**

The DNA molecule is a set of instructions that tells an organism's body how to build itself. Change these instructions and the organism changes. For years tools have existed to modify DNA, but a new one called CRISPR has revolutionized the game. It is so powerful that it is leaving researchers astounded.

CRISPR is a set of molecules with amazing properties. It can be used to cut out sections of DNA or make changes to it, even rearranging atoms. CRISPR was developed based on molecules that were already found inside of bacteria. How might CRISPR affect our lives and our world? Here are just a couple of ways.

By cutting out or modifying mutations in DNA, doctors might cure genetic disorders. Researchers were recently able to completely remove HIV infection in mice. "Infecting" pest species (such as mosquitoes) with these molecules could allow the molecules to spread, causing the species to die out. However, could its use come with dangers we have not considered? ⚠

Online quiz and electronic version now available. Visit Pitsco.com/SySTEMalert.

TRUSS BRIDGE: Form and function

For 200 years, the truss bridge has been a classic design in the United States. Designers have admired its efficiency. Drivers and train passengers have trusted its strength. Photographers have appreciated its simple elegance. And model bridge builders have been won over by its straightforward construction.

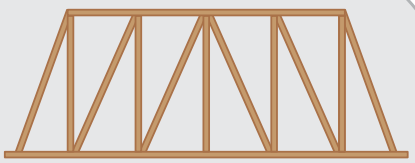
For most truss bridges, the secret of the design is the triangle. The support structure, the truss, is usually made of triangular sections.

Why is the triangle considered by many to be the strongest shape? Of course, any shape is only as strong as the material from which it is built. (Traditionally, most truss bridges have been made of wood or steel.) But some shapes can be inherently weaker than their materials. Pressures can cause some shapes to deform at the places where the lines come together. Imagine a square with an uneven force being exerted on it. The angles can pivot and the shape can collapse even if the material itself does not fail.

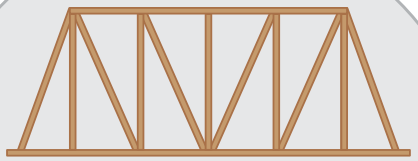
Now imagine an equilateral triangle (one in which all the sides are the same length). Because of the way a triangle is structured, this deformation can't happen. The lines brace one another and distribute force evenly throughout the shape. ⚠

Truss bridge types

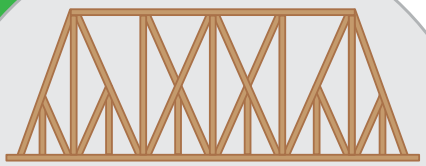
The three types of truss bridges shown here are only a few of the many effective trusses that have been discovered. And not all trusses are easily defined. How would you design your truss?



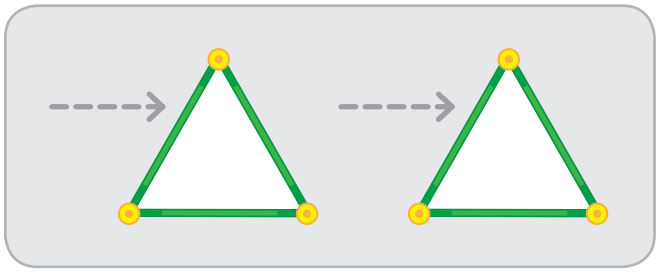
Howe truss: The diagonal supports slope toward the center of the truss. Vertical supports complete the triangular internal structure.

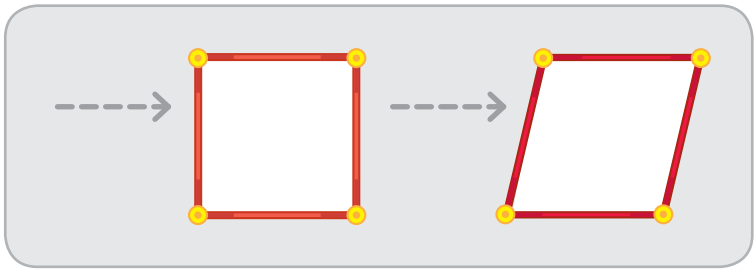


Pratt truss: The diagonal supports slope away from the center of the truss, with vertical supports creating a strong triangular structure. In some ways, it's the opposite of the Howe truss.



Baltimore truss: A twist on the Pratt truss – the diagonals are oriented similarly, but small supports create triangles within triangles for added strength. This is a very strong design.





BALSA BRIDGES

Building model bridges from balsa wood is a great way to learn the principles of science, technology, engineering, and math. Are your sights on design, strength, history, symmetry, or construction techniques? Regardless, this activity has it.

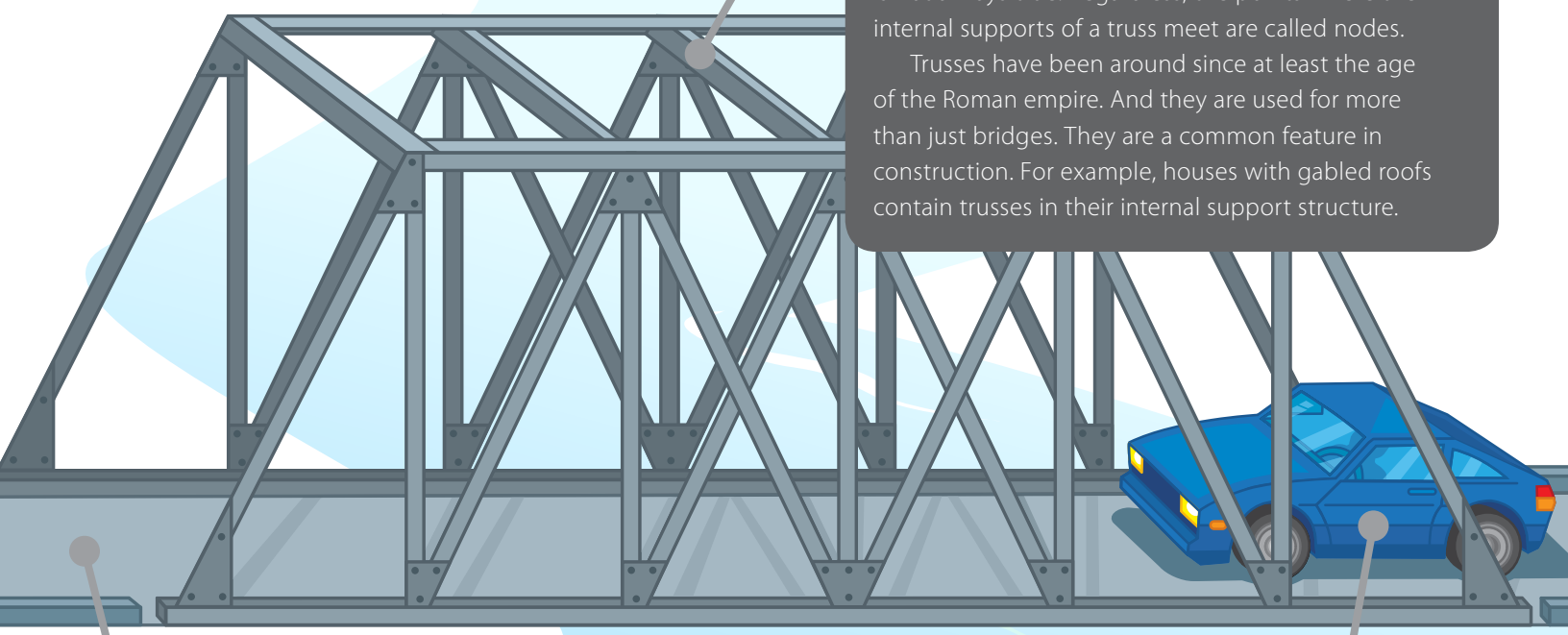
Pitsco.com/balsabridges

TRUSS STRUCTURE

In a truss bridge, the truss is the large stabilizing structure supporting the roadbed. A defining feature of a truss is that it is made of several sections but functions as a whole when bearing weight. You could say that a truss is more than the sum of its parts.

Most trusses are constructed of triangles, but this is not always true. Regardless, the points where the internal supports of a truss meet are called nodes.

Trusses have been around since at least the age of the Roman empire. And they are used for more than just bridges. They are a common feature in construction. For example, houses with gabled roofs contain trusses in their internal support structure.



ROADBED

The roadbed is the part of a bridge that carries traffic. In a truss bridge, the roadbed can be below, above, or between trusses.

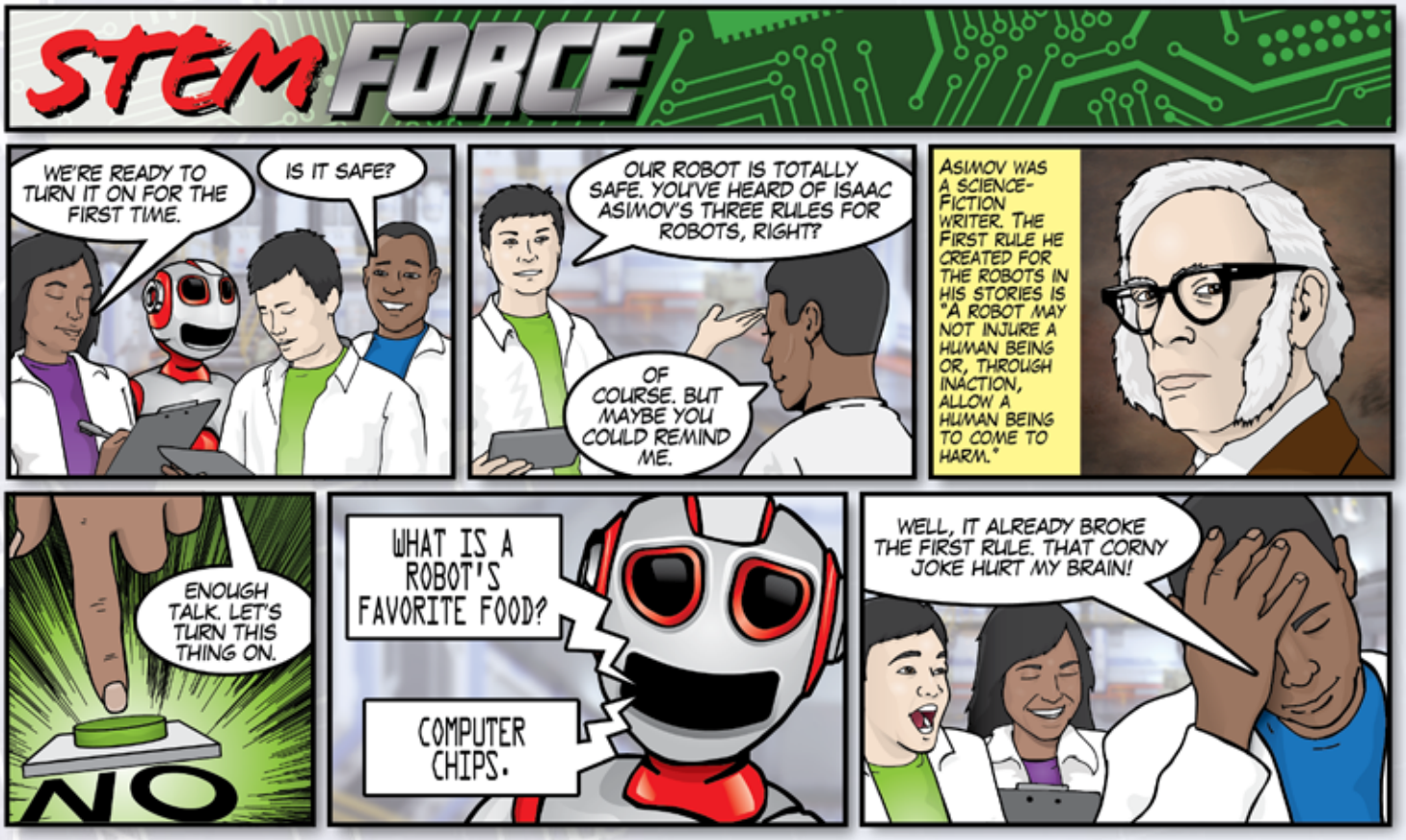
TENSION & COMPRESSION

When a truss bridge supports a load (such as a vehicle passing over it), it must resist two forces: tension and compression. Tension stretches the material of the bridge, pulling it apart. Compression, oppositely, pushes the material together. These forces act most strongly at the nodes.

TOOTHPICK BRIDGES

Building bridges comes down to size. Using toothpicks and glue, build and then test a bridge model using Pitsco's Toothpick Bridge Tester. Along the way, learn about strength, shapes, and forces. Is a triangle really the strongest shape? Find out!

Pitsco.com/toothpickbridges



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LEARN MORE ABOUT THE ELITE TEAM OF HEROES IN STEM FORCE BY VISITING PITSCO.COM/SYSTEMALERT/STEMFORCE.

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BEYOND CALCULATION

Researchers at the University of California at Santa Barbara have discovered something interesting about neural networks.

How many toothbrushes do you count in this picture?

Now, which one did you see first? Most humans in the researchers' study spotted the small one on the counter first and then noticed the larger one on the wall. Why? Because humans know from experience that a toothbrush is normally small and found on a bathroom counter.

A neural network lacks the experience telling it to look for something small. For this reason, when a neural network was told to identify toothbrushes, it spotted the larger one first.

Image credit: University of California – Santa Barbara

In another human-vs-neural network match, both were asked to locate objects in an image. For example, a cell phone. The neural network mistook objects that were a similar shape such as computer keyboards. The humans, who have held a cell phone and touched a keyboard, had no trouble telling the two apart.

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Student name: _____ **Class/Hour**: _____

SySTEM Alert! Quiz (Volume 6, Number 3)

1. _____ is a force that pulls material apart, and _____ is a force that pushes material together.
   A. Friction; gravity
   B. Tension; compression
   C. Gravity; friction
   D. Compression; tension

2. CRISPR is a set of molecules that scientists are using to _____.
   A. modify DNA
   B. form artificial muscles for robots
   C. increase the thinking speed of artificially intelligent brains
   D. improve the texture of cooked foods

3. Roughly how many neurons are in the human brain?
   A. 100 million
   B. 900 million
   C. 100 billion
   D. 500 billion

4. The support structure of a truss bridge is usually composed of which shape?
   A. square
   B. triangle
   C. rectangle
   D. circle

5. In a truss bridge, the _____ is the large stabilizing structure supporting the roadbed.
   A. beam
   B. arch
   C. tower
   D. truss

6. The part of a bridge that carries traffic is called the _____.
   A. girder
   B. tower
   C. roadbed
   D. truss

7. Which science-fiction writer famously created three rules for robots?
   A. Isaac Asimov
   B. Ray Bradbury
   C. Ursula K. Le Guin
   D. Damon Knight

8. Which ancient Chinese board game was recently mastered by an artificially intelligent computer?
   A. checkers
   B. chess
   C. Go
   D. xiangqi

9. Scientists recently made a soft material that might function as muscles for robots. What is this material made of?
   A. biodegradable plastic
   B. nylon 66
   C. steel fiber
   D. silicone rubber

10. A _____ is a computing system modeled after a human brain.
   A. CRISPR
   B. truss
   C. hard drive
   D. neural network

Bonus:
You are an engineer who has been hired to create a new truss bridge design. It must be strong enough to handle heavy traffic. Draw a sketch of your design proposal and write a couple of sentences explaining its features and why you believe it will be strong. Your design should differ from those shown in the *SySTEM Alert!* newsletter.