Pop quiz: French scientists study the physics of popcorn, savor the results

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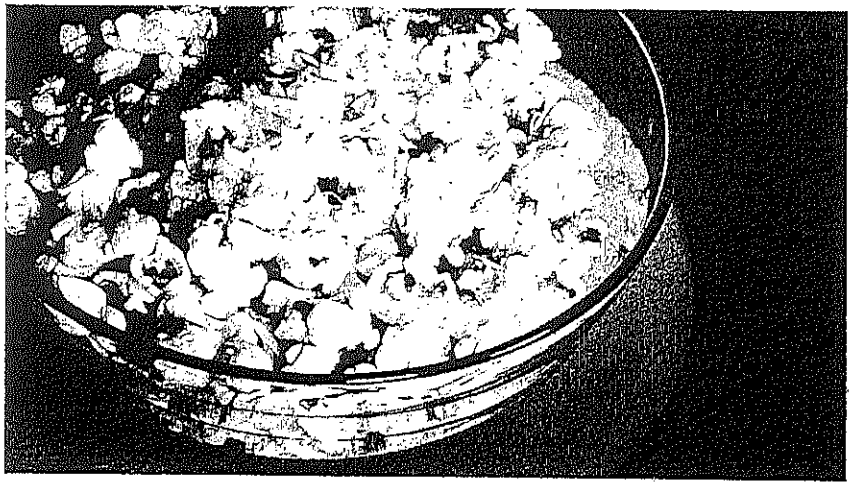

In this image taken on Jan. 28, 2013, Stovetop Popcorn Many Ways is shown served in a bowl in Concord, New Hampshire. AP Photo/Matthew Mead

Each time you make popcorn in the microwave, look closely: you're witnessing one of the most dramatic scientific transformations.

Most people do not understand how complex popping kernels can be. A pair of French science researchers were fascinated by how the kernel transforms into a fluffy treat. The popping of corn presents a powerful display of how the laws of physics apply to everything — even snack food.

"Thermodynamics, Biomechanics And Acoustics"

"This phenomenon contains interesting physics from different fields: thermodynamics, biomechanics and acoustics," said engineer Emmanuel Virot and physicist Alexandre Ponomarenko. They are the authors of a recent study about popcorn published in the Journal of the Royal Society Interface.

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Until now, most research on popcorn has been focused on practical questions. Chemists who study food determined the optimal amount of moisture that should be in each kernel for it to pop right. Other scientists studied the shape of kernels. They found that the ideal shape for an unpopped kernel is a sphere. Other plant researchers have figured out how to reduce the number of unpopped kernels in a batch of popcorn.

Virot and Ponomarenko aren't interested in improving the taste or experience of popcorn. Instead, they wanted to understand the physical origins of some of the most famous traits about the food, like what makes it jump and where that pop-pop-pop sound comes from.

2,900 Pictures Per Second

Their popcorn investigations were inspired by other scientists who work in a laboratory in France. The scientists who inspired the popcorn researchers were using a high-speed camera to take 2,900 pictures per second of small, everyday events, like a drop landing on the surface of water.

For a while, Virot and Ponomarenko were using the cameras on plants to take pictures. Before long, they turned their attention to popcorn.

The scientific name for popcorn is Zea mays everta and it is the only type of corn that pops. Popcorn kernels are shaped more like a sphere compared to other corn kernels. The thin layer, or hull, that surrounds the seed, called a pericarp, is also thicker. Inside the seed is the kernel's endosperm. The endosperm is a starchy carbohydrate that provides food (energy) for the living part of the kernel, known as the germ or embryo.

A Kernel Of Knowledge

When the kernel gets very hot and the water inside hits its boiling point — above 100 degrees Celsius (212 degrees Fahrenheit) — it turns to steam. The steam creates a vapor that forces its way into the hard endosperm. The endosperm melts into a molten mass, like a bread dough or thick batter. The water vapor puts pressure on the hull. Eventually, the hull cannot take the heat anymore and the kernel explodes.

The starch, which used to be hot, cools very quickly as soon as the kernel bursts. It turns into a spongy white flake of popcorn. After this popping is over, the fluffy corn is twice as large and eight times less dense than the original kernel.

There are other types of grains that pop, including millet, quinoa and amaranth, but none of them do so as dramatically as popcorn.

To observe this process very closely, Virot and Ponomarenko used their high-speed cameras to capture kernels popping on a hot plate. They turned the heat up to 350 degrees Celsius (662 degrees Fahrenheit) and placed a few kernels on the scorching surface.

A Great Leap Upward

After hundreds of tries, they discovered that the popcorn gets kicked into the air by a "leg" that emerges from the broken hull. The steam does not make the kernel jump, like they had believed at first.

The kernel doesn't move very far, only a few millimeters to a few centimeters. When the leg is released, the popcorn moves like a gymnast doing a somersault. All of this happens in just one-fifteenth of a second.

After studying these small movements, the French team determined the critical temperature that popcorn needs to pop. They put kernels of microwaveable popcorn in an oven and cranked up the temperature 50 degrees at a time. Ninety-six percent of the kernels popped when it reached 180 degrees Celsius (356 degrees Fahrenheit) — regardless of the size of the kernel.

Finally, they investigated why popcorn makes its famous popping noise.

Sound Analysis, Then A Snack

They identified three possible reasons: the cracking of the hull, the bounce of the corn on the ground, or the release of pressurized water vapor. To figure out which was responsible, they placed very sensitive microphones less than a foot away from the hot plate. The microphones were connected to the high-speed cameras.

There was no sound when the popcorn first opened, which told the researchers that it was not the breaking hull that caused the noise. But after the first fracture, a second crack was observed in the hull. And 6 milliseconds after that, the pop sound began.

They used the process of elimination to conclude that the trigger for the popping sound was the release of water vapor.

After a long time spent testing popcorn, the researchers frequently concluded the day by enjoying their popcorn snack.

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Quiz

1 Select the paragraph from the section "A Kernel Of Knowledge" that explains how the scientists conducted their study.

2 Read the sentence from the section "Sound Analysis, Then A Snack."

> They identified three possible reasons: the cracking of the hull, the bounce of the corn on the ground, or the release of pressurized water vapor.

Which of the three reasons turned out to be correct?

(A) the release of pressurized water vapor

(B) the bounce of the corn on the ground

(C) the cracking of the hull

(D) none of the above

3 Which selection would make the BEST summary of the article as a whole?

(A) Each time you make popcorn in the microwave, look closely: you're witnessing one of the most dramatic scientific transformations.

(B) They found that the ideal shape for an unpopped kernel is a sphere. Other plant researchers have figured out how to reduce the number of unpopped kernels in a batch of popcorn.

(C) A pair of French science researchers were fascinated by how the kernel transforms into a fluffy treat. The popping of corn presents a powerful display of how the laws of physics apply to everything — even snack food.

(D) After studying these small movements, the French team determined the critical temperature that popcorn needs to pop. They put kernels of microwaveable popcorn in an oven and cranked up the temperature 50 degrees at a time.

4 Which sentence from the section "2,900 Pictures Per Second" would fit BEST in a summary of the article?

(A) Their popcorn investigations were inspired by other scientists who work in a laboratory in France.

(B) The scientists who inspired the popcorn researchers were using a high-speed camera to take 2,900 pictures per second of small, everyday events, like a drop landing on the surface of water.

(C) The scientific name for popcorn is Zea mays everta and it is the only type of corn that pops.

(D) For a while, Virot and Ponomarenko were using the cameras on plants to take pictures.

Name _____ Date _____ Class _____

Content Practice A

LESSON 2

Thermal Energy Transfers

Directions: *On each line, write the term from the word bank that correctly completes each sentence. Each term is used only once.*

conduction	**convection**	**convection current**
radiation	**specific heat**	**thermal conduction**
thermal contraction	**thermal expansion**	**thermal insulator**

1. The movement of fluids up and down in a cycle because of convection is a _____.

2. _____ is the transfer of thermal energy by the movement of particles from one part of a material to another.

3. A _____ is a material through which thermal energy flows easily.

4. _____ is the amount of thermal energy it takes to increase the temperature of 1kg of a material by 1°C.

5. _____ is the transfer of thermal energy from one material to another by electromagnetic waves.

6. A _____ is a decrease in a material's volume when the temperature is decreased.

7. The transfer of thermal energy between materials because of collisions between the particles is called _____.

8. A material through which thermal energy does not flow easily is a _____.

9. _____ is an increase in a material's volume when the temperature is increased.

Name _____ Date _____ Class _____

Key Concept Builder LESSON 2

Thermal Energy Transfers

Key Concept What happens to a material when it is heated?

Directions: *Put a check mark on the line beside the true statement.*

1. _____ **A.** Metals are better thermal conductors than nonmetals.
   _____ **B.** Nonmetals are better thermal conductors than metals.

2. _____ **A.** The specific heat of water is particularly high.
   _____ **B.** The specific heat of water is particularly low.

3. _____ **A.** Thermal expansion and contraction are most noticeable in solids, less noticeable in liquids, and least noticeable in gases.
   _____ **B.** Thermal expansion and contraction are most noticeable in gases, less noticeable in liquids, and least noticeable in solids.

4. _____ **A.** The gaps between sections of a sidewalk leave room for the sidewalk to decrease in volume.
   _____ **B.** The gaps between sections of a sidewalk leave room for the sidewalk to increase in volume.

5. _____ **A.** A burner heats the air in a hot-air balloon, causing thermal expansion.
   _____ **B.** A burner heats the air in a hot-air balloon, causing thermal contraction.

6. _____ **A.** Ovenproof glass is designed to expand more than ordinary glass when it is heated, which means it usually does not crack when it is heated.
   _____ **B.** Ovenproof glass is designed to expand less than ordinary glass when it is heated, which means it usually does not crack when it is heated.

7. _____ **A.** When water is heated, its temperature increases, its density decreases, and the heated water rises.
   _____ **B.** When water is heated, its temperature increases, its density decreases, and the heated water sinks.

Name _____ Date _____ Class _____

Key Concept Builder LESSON 2

Thermal Energy Transfers

Key Concept In what ways can thermal energy be transferred?

Directions: *On the line before each statement, write* radiation, conduction, *or* convection *to identify the type of thermal energy described.*

_____ **1.** the transfer of thermal energy from one material to another by electromagnetic waves

_____ **2.** the cycle causing cooler water to sink and forcing warmer water upward

_____ **3.** Warmer objects radiate more thermal energy than colder objects.

_____ **4.** the transfer of thermal energy between materials because of collisions between the particles

_____ **5.** When particles that have different kinetic energies collide, particles that have higher kinetic energy transfer energy to particles that have lower kinetic energy.

_____ **6.** the transfer of thermal energy by the movement of particles from one part of a material to another

_____ **7.** Because space is a vacuum, this is the only way thermal energy can travel from the Sun to Earth.

_____ **8.** only occurs in fluids

_____ **9.** When a hair dryer heats a balloon and the air inside it, the balloon expands.