Spot On Science & Technology

CANDLES IN SPACE

by William Caper

What are we learning from burning candles in space?

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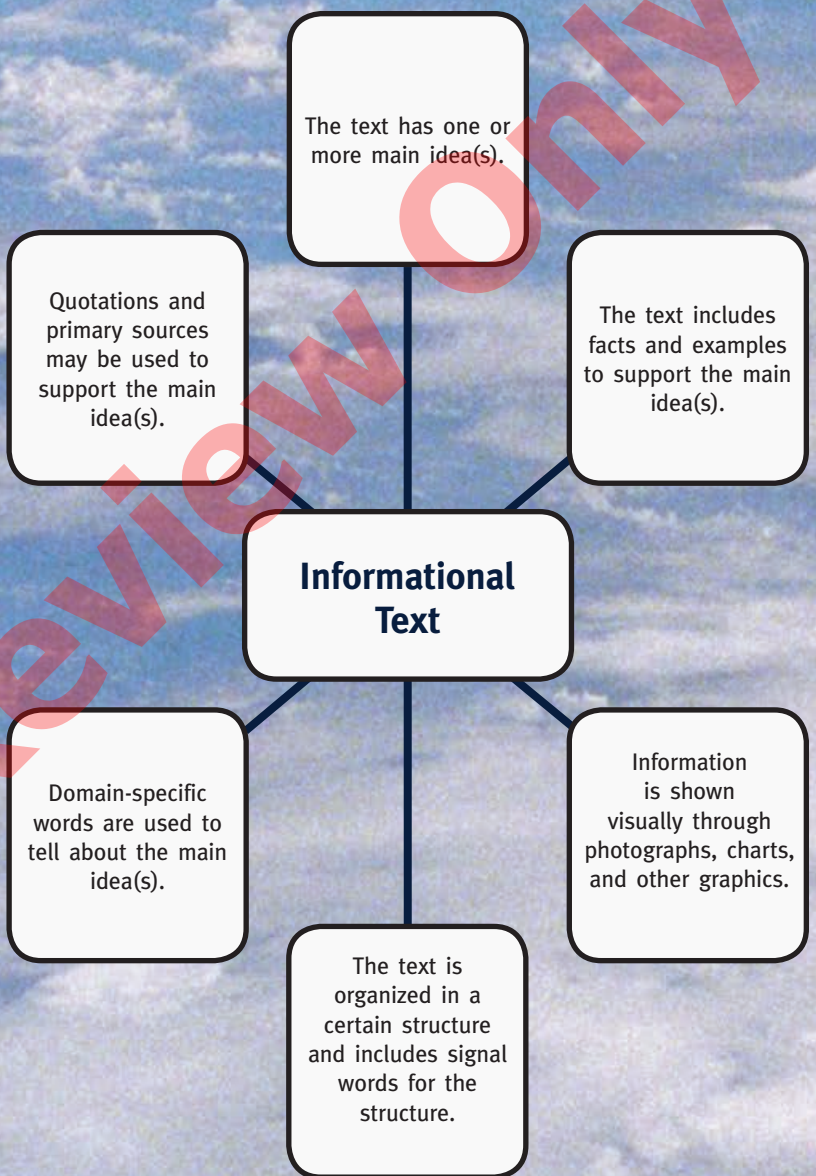

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INTRODUCTION

an astronaut in outer space

The Shape of Fire

Picture a candle flame. The image most people form in their mind is a long, pointy, yellow flame. That is what most candle flames on Earth look like.

But in outer space, a candle flame looks different. The flame is round and blue. Why does a candle flame look different in outer space? The answer is that a candle burns differently from how it burns on Earth. The reason for this is Earth's **gravity**.

Earth's gravity is a strong force that pulls matter—liquids, solids, and gases—toward Earth. But in outer space, the pull of Earth's gravity is weaker. This is called **microgravity**. Microgravity is why astronauts seem to float in outer space.

▲ a candle flame on Earth

▲ a candle flame in outer space

For decades, scientists with the National **Aeronautics** and Space Administration (NASA) have been studying flame in outer space. Understanding how flame behaves in microgravity can help scientists build systems and equipment that better prevent and **extinguish** fires on spacecraft. This will help keep astronauts safe as well as help reduce damage to a spacecraft in the event of fire.

Understanding how flame burns in space will also help scientists build spacecraft that burn less fuel. Burning fuel **efficiently** will help lower the cost of space flights.

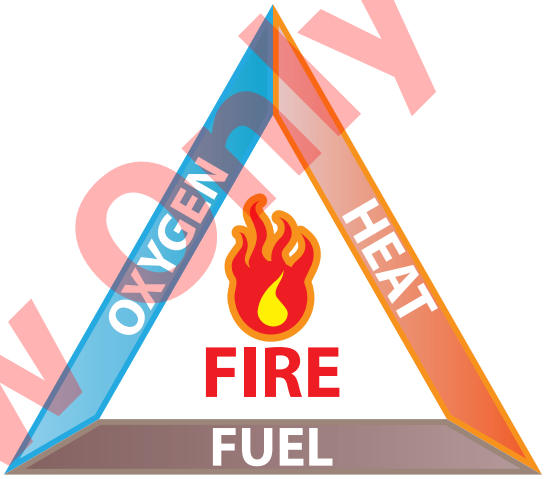
In addition, the information gained from studying flame in outer space may also help improve life on Earth. Scientists think that a better understanding of flame will lead to more fuel-efficient cars and trucks that release less pollution.

▲ **An astronaut works with equipment to study flame in outer space.**

CHAPTER 1

How a Candle Burns on Earth

What causes something to burn? The answer is contained within its very matter. All matter is composed of tiny particles called atoms. Under certain conditions, atoms within one substance will combine with the atoms in another substance to form a new substance. This process is called a **chemical reaction**. During a chemical reaction, the atoms in the two substances rearrange themselves, resulting in a chemical change in the substances. Sometimes energy is absorbed during this process. Other times, energy is released from the atoms in the form of light or heat.



▲ Fire is a chemical reaction.

▼ For wildfires, water can help cool down the fuel and slow the burning process.

Combustion

Burning, or **combustion**, is a chemical process that occurs when the atoms inside matter are heated and combined with oxygen. The chemical reaction releases heat and light, setting off a chain reaction that continues to combine atoms and release more heat and light. In order for combustion to occur, three things are needed: fuel, oxygen, and heat.

The fuel is the matter that burns. Fuel can be solid, liquid, or gas. Not every material can be the fuel for combustion. For example, water, glass, and gold do not burn. They are nonflammable materials. However, paper, wood, oil, and wax are examples of flammable materials. They can be fuel for a fire.

In order for a fuel to burn, oxygen must be present. In most fires on Earth, the oxygen that allows a fire to occur comes from the air around the object that is burning.

Heat is needed to **ignite** the fuel to its flame temperature. This is the temperature at which the atoms in the fuel will interact with oxygen. This sets off the burning chain reaction. Every flammable substance has a different flame temperature. This means that different substances will burn at different temperatures.

For a flame to continue burning, the fuel and oxygen need to continue reacting chemically in response to the heat. Remove the fuel, oxygen, or heat, and the flame will go out.

▲ **Paper is a flammable material.**

▲ **Gold is a nonflammable material. When gold is heated, it melts. It does not burn.**

Candles and Combustion

Candles have two parts: a wick and wax. The wick is often a strand of braided cotton threads. The wick runs down the center of the candle and is surrounded by the wax.

To light a candle, heat from a match flame or another source of heat must be applied to the wick. In response to the high temperature, the wick—a fuel—chemically reacts with oxygen in the air and starts to burn. The burning releases more heat, which allows more fuel to interact with oxygen in the air. The chemical chain reaction continues. The flame keeps burning.

▲ **The flame on the match gives off heat. This heat causes the wick to ignite.**

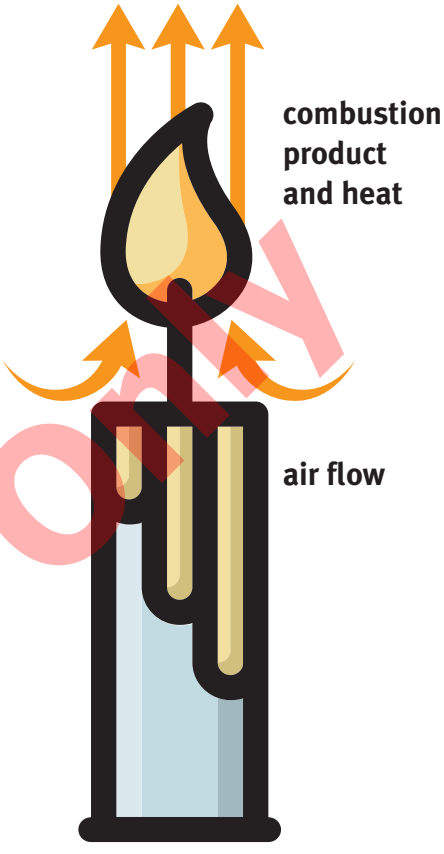
▲ **Candles come in different shapes and colors. But they all have a wick surrounded by wax.**

Candles, Wicking, and Shape

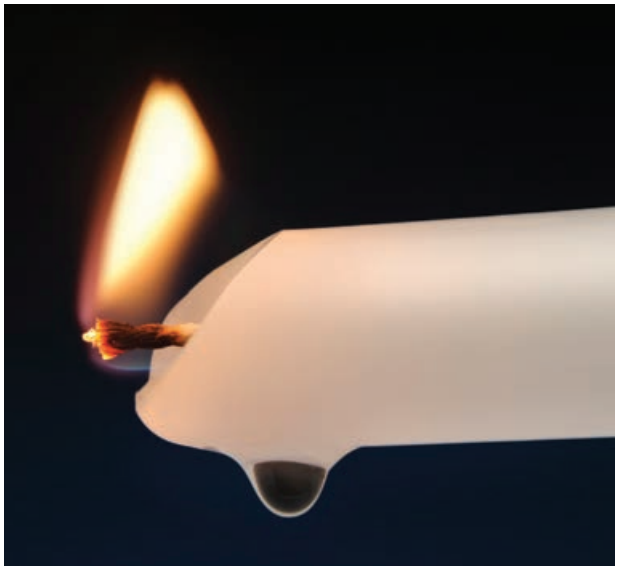
At the same time that the wick is burning, the heat from the flame melts the wax around the wick, turning the wax into a liquid. Some of the liquid wax drips down the sides of the candle. But some of the liquid wax is drawn up through the wick to the top of the wick. This process is called wicking.

At the top of the wick, the heat from the flame causes the liquid wax to become a gas. The gas is a fuel. It burns, along with the wick, creating a flame.

The flame heats up the surrounding air. Warm air is lighter than cool air. So the warmed-up air rises. Cool air fills in the space around the bottom of the flame. This air is then heated up by the flame and rises, too. This continual upward motion of air is called **convection**. It causes the flame to have a long, narrow shape that is tapered, or pointy, at the top.



▲ Some candles drip. But other candles are made with a wax that does not drip. All of the wax in dripless candles turns into a gas.



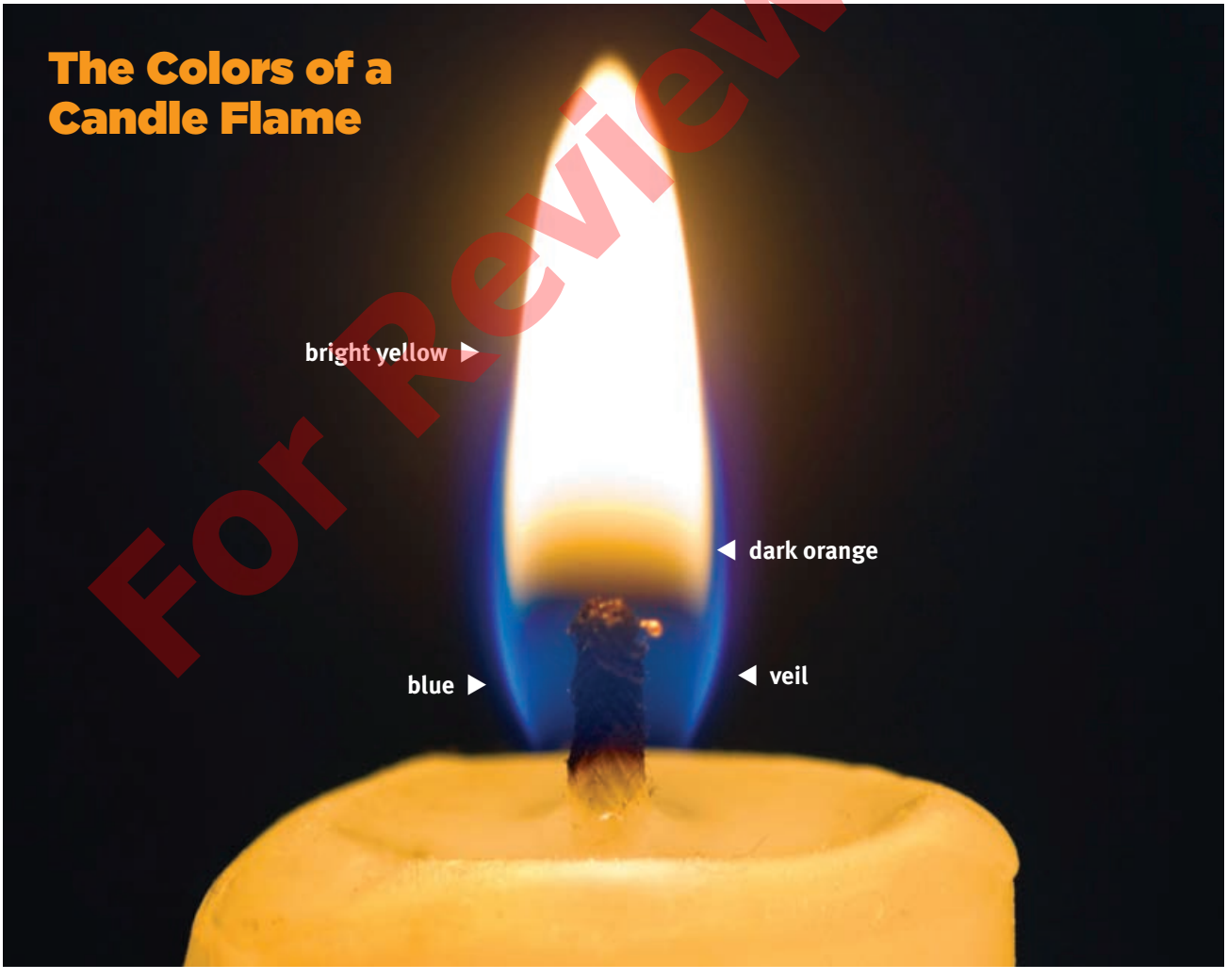
▲ On Earth, air flows up as it gets hotter. This gives a candle flame its shape.

Candles, Combustion, and Color

What color is a candle flame? "Yellow" is probably the most common response. But a candle flame is actually several different colors. The bottom of a flame is blue. Above the blue is a thin dark-orange layer. Above this layer is the bright yellow part. Surrounding the flame is a "veil"—a very thin outside layer. At the bottom of the flame, the veil is blue. The veil becomes a lighter blue and then almost clear around the sides and tip of the flame.

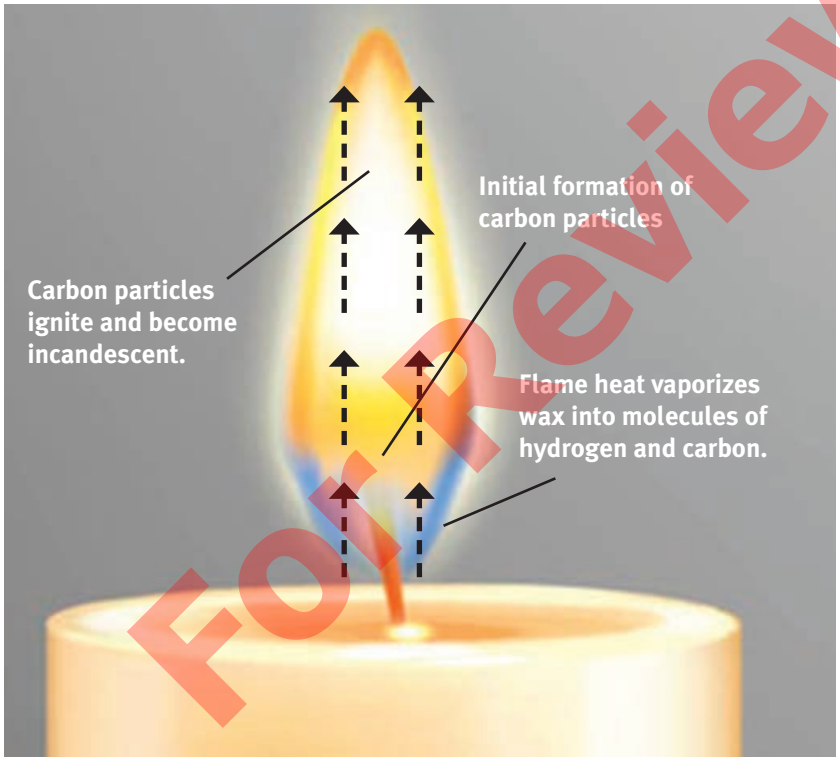
Different chemical reactions happen in each layer, resulting in the different colors.

The wax of a candle is mostly made up of hydrogen and carbon atoms. When a candle is lit, the hydrogen atoms are the first to react. They mix with oxygen in the air to form water vapor (a gas). The oxygen gives this layer its blue color.



In the blue layer, some carbon atoms attach to oxygen atoms to form carbon dioxide. These atoms and other carbon particles rise above the blue layer, forming the dark-orange layer. The carbon gives this layer its coloring. This layer also has less oxygen than the blue layer.

The carbon particles continue to rise, and as they rise, they get hotter. Some ignite, giving off a glowing, bright yellow light that forms most of the flame.



▲ Carbon particles become incandescent when heated to their burning point. *Incandescent* means "to give off light when heated." Burning carbon particles give a candle flame its yellow glow.

What Is That Black Mark?

Sometimes, if a candle is placed near a wall, a black mark will form on the wall. Or, if placed high up near a ceiling, the black mark will appear on the ceiling. This black mark is called soot. Soot is carbon particles that did not burn completely. The soot rises from the flame as smoke, and collects on a nearby wall or on the ceiling. Many candles today are made to be smokeless. So they do not leave soot marks.