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FIRE FORENSICS: CLAIMS & EVIDENCE

STUDENT

INVESTIGATORS ACADEMY NOTEBOOK

A STUDY OF FIRE BEHAVIOR & FIRE SCIENCE

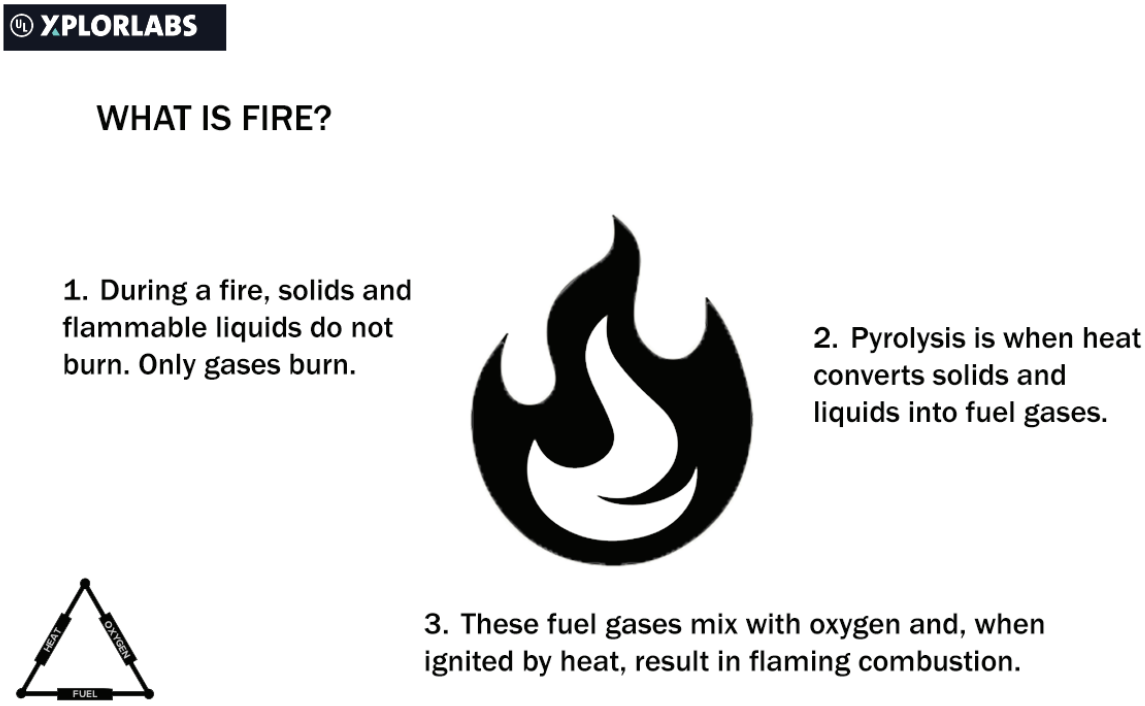
GATHER, EXAMINE, ANALYZE CLUES USING THE SCIENTIFIC METHOD

YOUR NAME

INVESTIGATORS ACADEMY

Fire Investigator in training! With the understanding of fire science, you can identify and analyze fire scene evidence to solve a case!

01 WHAT IS FIRE?



What is Fire?

Fire is a gas-phase chemical reaction that emits heat and light.

During a fire, solids and flammable liquids do not burn. Only gases burn.

In a fire, solids don't burn. And liquids don't burn. So what is burning? Fire is the result of fuel gases mixing with oxygen and heat is the correct proportion.

Pyrolysis is when heat converts solids and liquids into fuel gases.

Pyrolysis is a process when heat breaks down solids and liquids into fuel gases. Click on this extra link to watch this lampshade pyrolyze and the gases ignite. These fuel gases mix with oxygen, and when ignited by heat, result in flaming combustion.

Another word for fire is combustion, when the fuel gases mix with oxygen and are ignited by heat which results in flames. We'll learn more about fuel in the next section.

WHAT DID YOU LEARN?

1) What is the fuel for a fire?

2) What is pyrolysis?

Make some observations! Record your thinking! What do you wonder about now?

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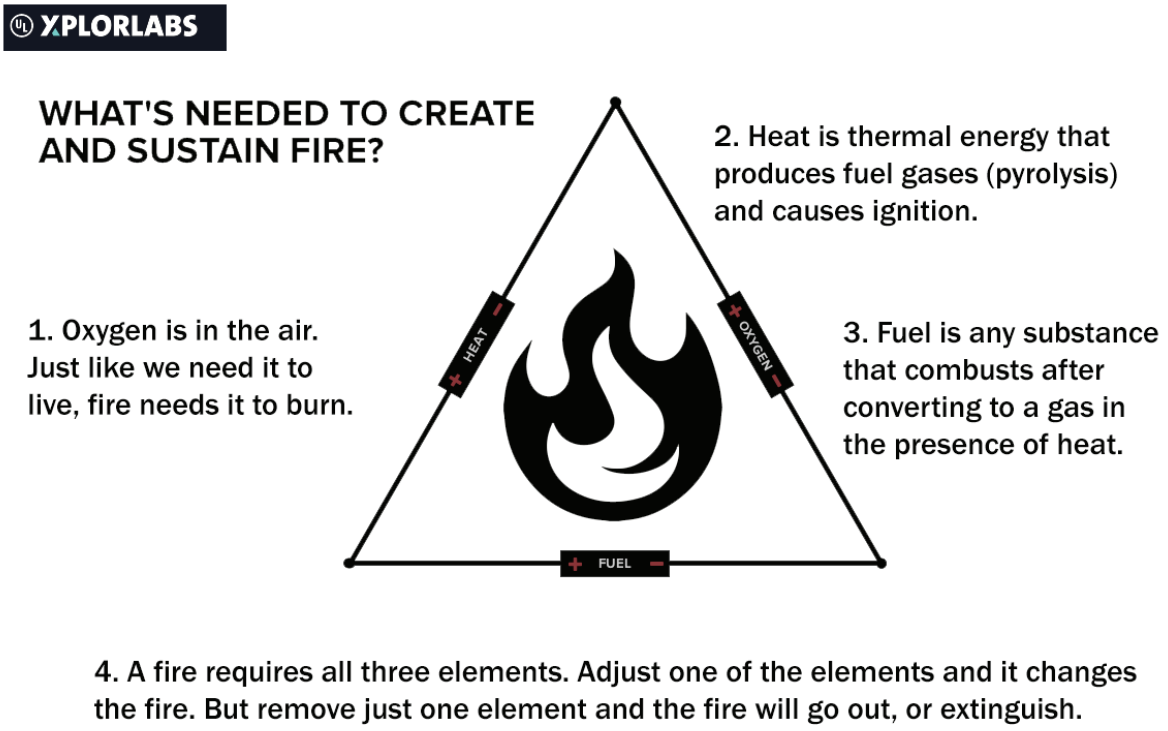
02 ELEMENTS OF FIRE



What's Needed to Create and Sustain Fire?

Three elements must be present for a fire to start and continue burning.
Oxygen is in the air. Just like we need it to live, fire needs it to burn.
Oxygen is the most common element on Earth.
Heat is thermal energy that produces fuel gases (pyrolysis) and causes ignition.
Heat is the thermal energy needed to produce the fuel that combines with oxygen. Heat promotes the fire growth and the spread of flames by maintain a continuous cycle of fuel production and ignition.
Fuel is any substance that combusts after converting to a gas in the presence of heat.

Wood, furniture, carpeting...just about any material that surrounds us is potential fuel. When heated, these materials create gases and combine with oxygen. With the heat, the gases ignite and release light, heat and smoke. This is fire.

A fire requires all three elements. Adjust one of the elements and it changes the fire. But remove just one element and the fire will go out, or extinguish.

Fire exists only when all three elements of the Fire Triangle work together.

Fuels are different. The amount of energy stored in a fuel varies based on the fuel itself. Synthetic, or man-made fuels may have 2-3 times more stored energy per pound than a natural fuel such as wood. Higher energy fuels tend to generate more smoke. As we can observe the campfire has significantly less smoke than the burning piece of furniture made from foam plastics.

EXTRA!

Conduction – heat transfer within a solid or between two solids
Convection – heat transfer between gases and solids
Radiation – heat transfer due to light energy or electromagnetic waves

WHAT DID YOU LEARN?

1. What type of fuel releases the most smoke and can generate the most soot?

2. What is heat?

Make some observations! Record your thinking! What do you wonder about now?

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03 FIRE DEVELOPMENT

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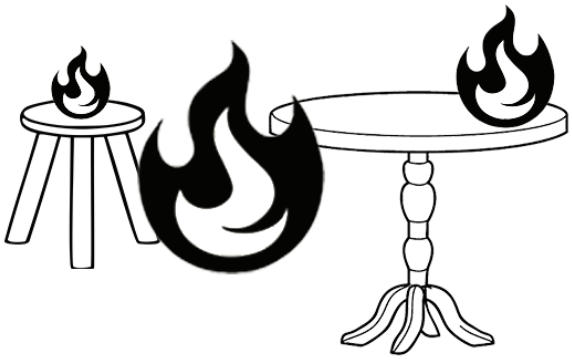
FOUR STAGES OF FIRE DEVELOPMENT



1. IGNITION
Heat, oxygen and a fuel source combine. The result of this chemical reaction is fire.

2. GROWTH
The fuel load will continue to burn because oxygen is available.

3. FULL DEVELOPMENT
All combustible materials are ignited with enough oxygen.

4. DECAY
Usually the longest stage of a fire, with oxygen, heat and fuel decrease until the fire goes out.

FIRE DEVELOPMENT

The behavior of a fire in an open space (fuel limited)

INGITION – Heat, oxygen and a fuel source combine. The result of this chemical reaction is fire.
Here the gas-phase chemical reaction causes the fire to start.
GROWTH – The fuel load will continue to burn because oxygen is available.
As long as there's enough oxygen in the room, the fire continues to burn.
FULL DEVELOPMENT – All combustible materials are ignited with enough oxygen.
If a steady supply of oxygen exists, all the combustible fuels will be consumed in the fire.
DECAY – Usually the longest stage of a fire, with oxygen, heat and fuel decreases until the fire goes out.

The decay stage is usually the longest as heat and fuel slowly dissipate. With ample oxygen, the fire only stops burning after the fuel has been completely consumed. Some fuels leave behind evidence such as char, ash or other chemicals.

What did you learn?

During the GROWTH stage what does the fire need to keep burning? Make some observations! Record your thinking! What do you wonder about now?

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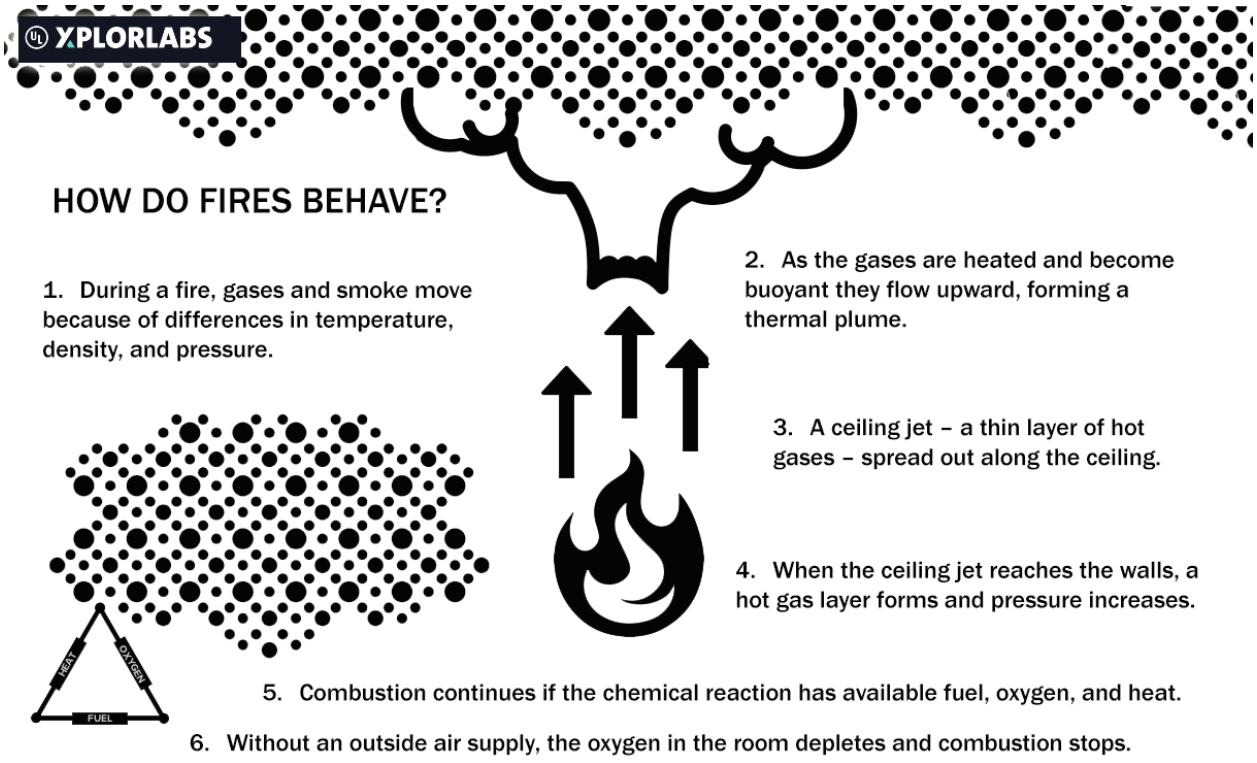

HOW DO FIRES BEHAVE?

The behavior of fire in a closed room. (ventilation limited)

During a fire, gases and smoke move because of differences in temperature, density, and pressure.

To be a fire investigator, you must understand how fires behave inside a building. During a fire, heat is transferred to gases in the room. This results in the gases expanding. When heated gases expand, they become less dense and buoyant.

As the gases are heated and become buoyant, they flow upward, forming a thermal plume.

Heated gas is less dense than the air surrounding it. Because the surrounding air hasn't been heated at this stage, a thermal plume – a column of smoke and hot gases – moves upward.

A ceiling jet – a thin layer of hot gases – spreads out along the ceiling.

When the thermal plume reaches the ceiling, it turns and continues to move away from the heat source forming a ceiling jet – a relatively thin layer of hot gases that spreads out along the ceiling.

When the ceiling jet reaches the walls, a hot gas layer forms and pressure increases.

The hot gas layer forms and pressure increases because the ceiling and walls of the room are limiting further expansion of the hot gas.

Combustion continues if the chemical reaction has available fuel, oxygen, and heat.

The smoke, which is full of heated gases, increases in temperature and pressure. As long as fuel, oxygen and heat are present in the right amounts, combustion continues.

Without an outside air supply, the oxygen in the room depletes and combustion stops.

In the previous example of the sofa burning out in the open, the fire went into decay because the fire was limited by the available fuel. In the instance of a closed-room fire, the fire goes into decay because it consumed all of the oxygen needed for combustion. This is called ventilated-limited fire in a closed compartment.

Damage to the wall and ceiling show the evidence of where the fire plume and ceiling jet were or existed. A fire investigator will use fire patterns such as these to determine the area of origin.

What did you learn?

What happens when heated gases become bouyant?

In a closed room, without an air supply what will happen to the fire? Make some observations! Record your thinking! What do you wonder about now?

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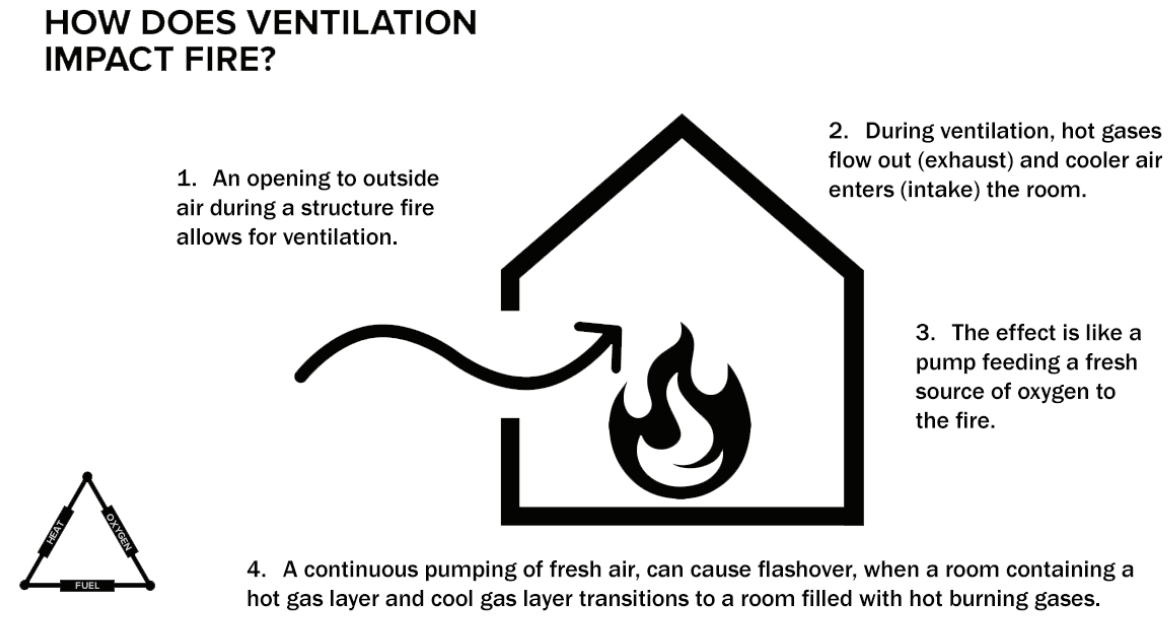
05 VENTILATION



HOW DOES VENTILATION IMPACT FIRE?

The impact of outside air on fire growth.

An opening to outside air during a structure fire allows for ventilation.

Ventilation is the exchange of hot fuel gases and air. Any opening in a structure can allow ventilation to occur.

During ventilation, hot gases flow out (exhaust) and cooler air enters (intake) the room.

In this example, buoyant hot gases, or exhaust, flow out of the open window while the intake, denser and cooler air that's loaded with more oxygen, enters the room low to the ground.

The effect is like a pump feeding a fresh source of oxygen to the fire.

High pressure flow to low pressure with the pumping of fresh, oxygen-rich air. The fuel load will continue to burn as long as oxygen is available.

A continuous pumping of fresh air, can cause flashover, when a room containing a hot gas layer and cool gas layer transitions to a room filled with hot burning gases.

With good ventilation, or a steady source of oxygen, a fire can grow until flashover occurs. Flashover causes everything in the room to pyrolyze and ignite all at the same time. Ventilation often makes a fire bigger, especially in structures with large amounts of synthetic material as potential fuel.

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STUDENT REFLECTION:

Why is it important to understand the impact of ventilation on a fire as a firefighter? As a fire investigator? For fire safety?

What happens if someone flees a fire and leaves the front door open?

What happens if a fire crew opens the door on a fire without understanding ventilation?

Fire scientists at the Fire Lab spend a lot time studying the impact of ventilation.

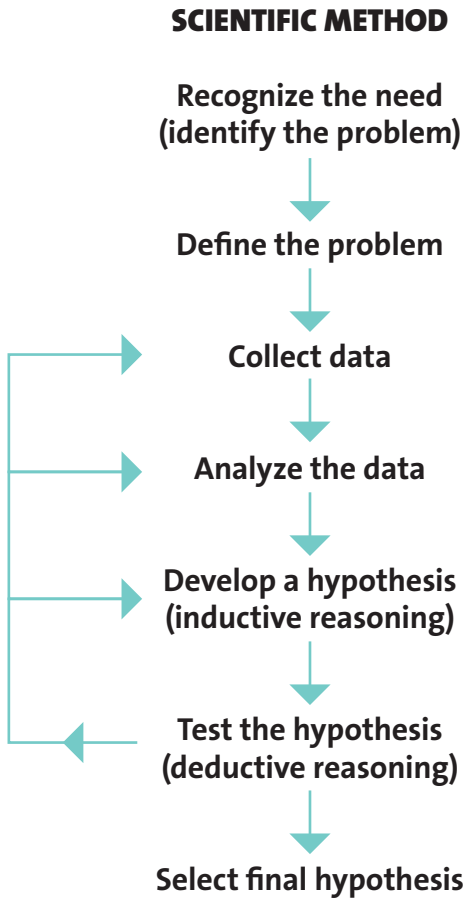
Why is that so important for safety?

SCIENTIFIC METHOD IN FIRE INVESTIGATION

How do fire investigators study a fire scene to find evidence that helps them formulate a claim about the way the fire started or where it started? Use the scientific method, of course.

When there is a fire and no one is sure about how it started or where it started, they call a fire investigator.

The scientific method adapted to fire investigation creates a step-by-step procedure that helps investigators build a claim supported by evidence. Evidence is data combined with reasoning supported by knowledge and understanding of fire science.



1. First, collect data:

a. Record all observations about the site (where the fire happened) before and after the fire, on the outside and the inside of the building.

b. Look for clues about where the fire started. This is called the area of origin.

c. Locate the cause of the fire. Examine the fire site and look for any clues about what was in the area of the fire before the fire happened (a trash can or a lamp or a cigarette).

d. Like an archeologist, excavate the burn area layer by layer of debris/rubble/remains.

e. Talk to witnesses – anyone who saw the fire or anyone who knows about the situation leading up to the fire. (or even anyone who knows the people or person living or working in the building)

f. Gather information from the fire department and fire alarms, if that information is available.

2. Analyze the data – so what does all of that evidence say?
a. What do the patterns in the burn area tell you?

b. What story does the evidence tell you – what is the story (your claim) from start to finish (the reasoning) as told by the evidence?

c. Does it match up with what you know about fire science and fire behavior?

d. Is there any part of the story that can be answered by who lives there, their habits, or asking them about their day?

e. Does it matter if the building is made of wood or brick? What about the age of the electrical system?

f. Rarely, if ever, is one piece of evidence enough.

What evidence do you have to support the fire? (Best to always have more than one hypothesis!)
What evidence do you have to support it? (reasoning)

3. Develop several possible hypotheses:
a. Begin to form a claim.

b. How do you explain the fire?

4. Test your hypotheses:
a. What is the story(Claim) of the fire from start to finish (Reasoning) as told by the evidence?

b. What is your reasoning? How do you explain the evidence that supports your claim? Connect your evidence to your claim.

c. Write it out in order of events –

d. What is the ignition source? What was the fuel? Was there ventilation in the room

5. Final hypothesis
a. Is there a competent ignition source at origin?

b. Does the origin explain the data? Does it fit in the timeline built by the evidence?

c. Are contradictions resolved?