**Do Atoms Really Exist?**

**Dalton and Gases**

Visit the following two links to watch what happens:

**1:** https://www.youtube.com/watch?v=OUoV--CuLDA

**Optional 2:** https://www.youtube.com/watch?v=d2WWgTGJsIw (you can choose to stop at 4:12)

John Dalton found that, in his work with gases, that hydrogen gas and oxygen gas can fuse to make liquid water and that the ratio of hydrogen to oxygen will always be 2 to 1. John Dalton found this with many other reactions which suggested that basic chemical ingredients always combine in simple multiples of one another.

(Adapted from "Atoms Under the Floorboards: The Surprising Science Hidden in Your Home" by Chris Woodford)

What does this exhibit show?

How is this indirect evidence of the existence of atoms (tiny particles which we cannot directly see)?

How compelling is this evidence to you? In other words, how well does this evidence prove the existence of atoms?

**Bag Diffusion**

Visit the following two links to watch what happens:

**1:** https://www.youtube.com/watch?v=wO1yq6YTJDI (0:30)

**2:** https://www.youtube.com/watch?v=2Th0PuORsWY (0:40)

Starch is a white substance which you can see in the beaker in video 1 and in the bag in video 2. Iodine is the brown substance which you see in the bag in video 1 and in the beaker in video 2. When starch and iodine come in contact, they react and form a dark purple mixture.

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**Brownian Motion**

Visit the following two links:

**1:** https://www.youtube.com/watch?v=2Vdjin734gE (0:40)

**2:** https://www.youtube.com/watch?v=R5t-oA796to (0:30)

Botanist Robert Brown noticed that tiny objects like pollen grains shook and moved erratically when viewed under a light microscope. Nearly seventy years later, Albert Einstein explained this "Brownian motion" as the result of being hit by many tiny objects that are smaller than what can be seen by a light microscope. His explanation was quantitative; he was able to mathematically predict the average distance that the particles should be moved over time as a result of being hit by these tiny and “invisible” objects. A few years later Jean Perrin painstakingly measured the movements of particles of a resin suspended in water; his experimental average movement was in excellent agreement with Einstein's prediction.

(Adapted from http://antoine.frostburg.edu/chem/senese/101/atoms/faq/are-atoms-real.shtml)

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**Scanning Tunnel Microscopy**

Visit the following two links:

**1:** (start at 0:45) https://www.youtube.com/watch?v=Ha53tFTsmW8&list=PLv1hJnaxTVPA9o24c9VEgEMLdhHSc2sKB

Scanning Tunnel Microscopy was developed in the mid-1900's and more recently has been used to visualize atoms. It works somewhat like sonar technology to map the ocean floor. In sonar technology, various depths are scanned over multiple times to be visualized as peaks and valleys to provide a complete 3-D picture. In the same way, in Scanning Tunneling Microscopy, a tiny tip is moved across a surface and the tip interacts with the sample in such a way that it adjusts to varying heights on that surface to ultimately produce an “image” of the sample.  The resulting image from a Scanning Tunnel Microscope on the next page is a visual representation of mathematical data.

**2:** If this technology is unclear, this microscope makes indirect observations in a way slightly similar to sonar technology: https://www.youtube.com/watch?v=5crADuCo2L4 (you can optionally stop at 0:40)

Visualization of silicon atoms:



(from http://www.nature.com/am/journal/2011/201107/images/am2011123i1.jpg)

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How compelling is this evidence to you? In other words, how well does this evidence prove the existence of atoms?

In most arguments, a single piece of evidence itself is not always sufficient to prove an idea. Instead, several pieces of evidence are often necessary to make a strong case for or against an idea. Do you think these exhibits combined are enough to convince you that atoms exist? Why or why not?

Even if you don't believe it, there's more evidence to come!