KAIS EMS

Solar Challenge Grand Prix

Harness the Power of the Sun

Build your own solar power car from recycled materials from your own house!

Start collecting and storing materials (at home) now. You will be instructed when to bring them to school. Wash everything you collect and one small bag should provide you enough materials.

Materials you will be temporarily provided:

One small dc motor with pulley
One solar panel
Two alligator clips
One large and One small rubber band

Materials You Need to provide from Home (only recycled materials like packaging):

Car body or platform	For example: cardboard or plastic
Two axels	For example: straws or skewers
Four wheels	For example: bottle tops,

In class we will discuss your designs and ideas:

Topics will include:

How will gear ratios impact your vehicles' initial and top speed?
How will the position and angle of the solar panel affect your race?
What would the advantages be of a three or four wheeled vehicle?
How does weight and friction impact speed?
What chemical reactions on the sun create light and why do they occur?
What materials make up a solar panel?
What reaction is occurring within the solar panel to produce a electrical current?

Harnessing the power of the sun for energy has evolved over the years. This timeline examines the journey of Solar Power.

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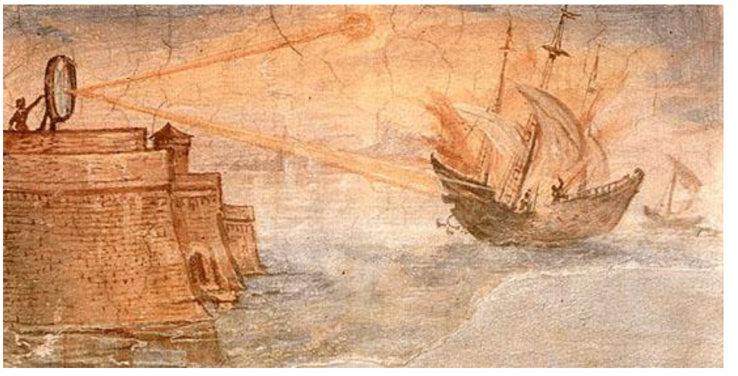
214 - 212



Archimedes' Heat Ray

214 BC - 212 BC. Historians claim that Archimedes, a Greek inventor, put solar energy to use already in the 3rd Century BC. He destroyed enemy ships with fire during the Siege of Syracuse with a "heat ray", which supposedly was a collection of mirrors that concentrated sunlight onto the ships. Whether or not Archimedes' invention has any root in reality is uncertain. Several experiments have been carried out to verify or bust the story, most of which concluded in the phenomena being possible, but highly unlikely.

700

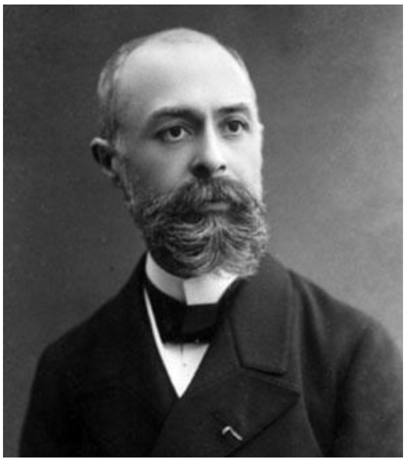
Sunlit Fires

700 BC. We know that all the way back to the 7th century B.C., humans figured out how to make fires by concentrating the sunlight with magnifying glass.

1767

The First Solar Oven

In 1767, the first solar oven was invented. The credit goes to **Horace de Saussure**, a Swiss physicist, who probably had no idea his invention would help people prepare their dinner two and a half centuries into the future.



1839

The Discovery of the Photovoltaic Effect

This marks a big year in the history because **Edmund Becquerel**, a French physicist, only 19 years old at the time, discovered that there is a creation of voltage when a material is exposed to light.
Little did he know, that his discovery would lay the foundation of solar power.

1873

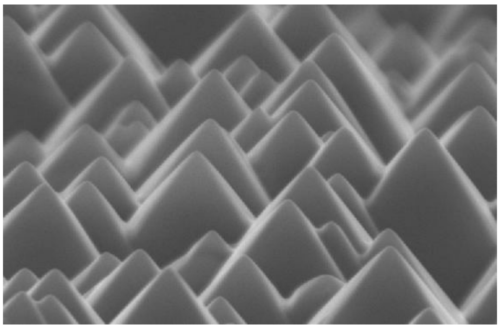
Photoconductivity in Selenium

Willoughby Smith, an English engineer, discovered photoconductivity in solid selenium.

1876

Electricity from Light

Building on Smith's discovery three years before, professor **William Grylls Adams**, accompanied by his student, Richard Evans Day, were the first to observe an electrical current when a material was exposed to light. They used two electrodes onto a plate of selenium, and observed a tiny amount of electricity when the plate was exposed to light.



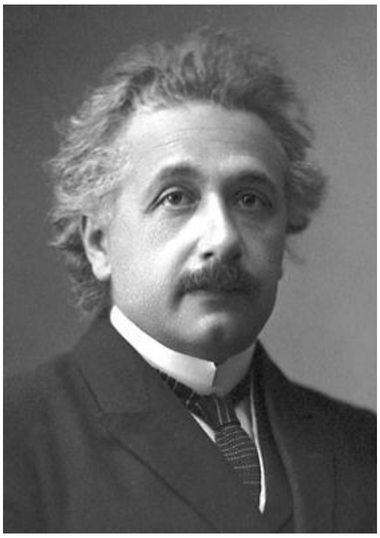
1883

The First Design of a Photovoltaic Cell

An American inventor, Charles Fritts, was the first to came up with plans for how to make solar cells. His simple designs in the late 19th century were based on selenium wafers.

1905

Albert Einstein and the Photoelectric Effect



Albert Einstein - The Nobel Prize in Physics 1921.
Albert Einstein is famous for a wide variety of scientific milestones, but most people are not aware of his paper on the photoelectric effect. He formulated the photon theory of light, which describes how light can "liberate" electrons on a metal surface. In 1921, 16 years after he submitted this paper, he was awarded the Nobel Prize for the scientific breakthroughs he had discovered.

1918

Single-Crystal Silicon

Jan Czochralski, a Polish scientist, figured out a method to grow single-crystal silicon. His discoveries laid the foundation for solar cells based on silicon.

1954

The Birth of Photovoltaics

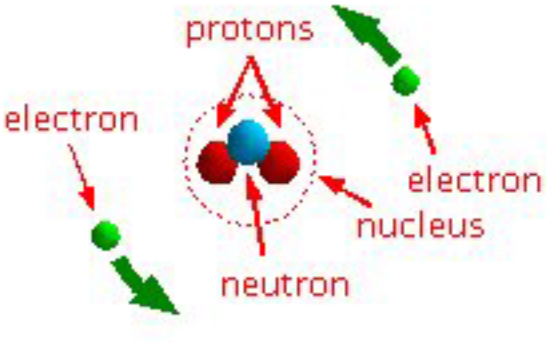
David Chapin, **Calvin Fuller** and **Gerald Pearson** of Bell Labs are credited with the world's first photovoltaic cell (solar cell). In other words, these are the men that made the first device that converted sunlight into electrical power. They later pushed the conversion efficiency from 4% to 11%.

Solar Energy

The purpose of this reading is to give some of the basic physics about where the energy comes from that is used in renewable energy systems. Rather than starting at the usual place, down here on Earth, this will take us further back to the ultimate source, the sun. Attempts will be made to keep the explanations as simple as possible while still offering a lower level of understanding.

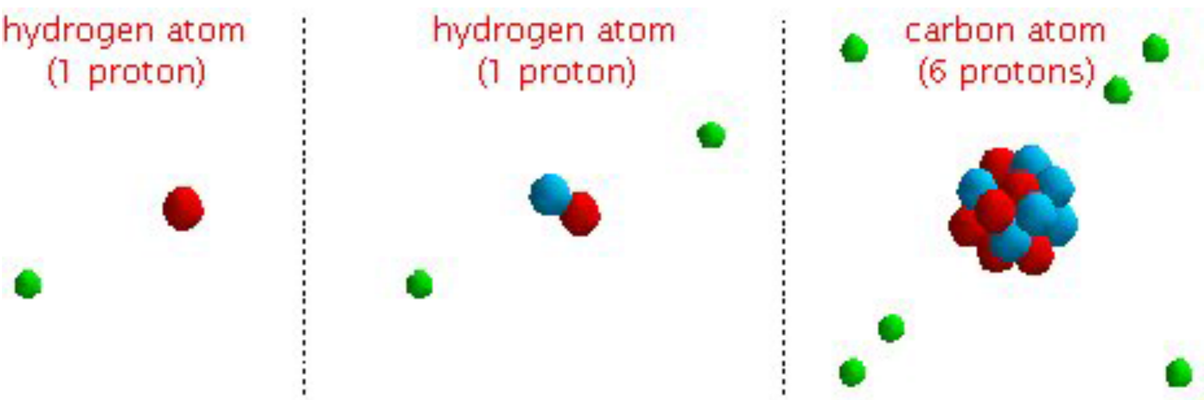
Atoms, protons, electrons

All matter is made up of **atoms.** Your body, for example, is made up of countless of these very, very small atoms. Using a simple model of the atom, an atom consists of a **nucleus** around which **electrons** rotate. The nucleus is made up of **neutrons** and **protons**.



A HELIUM ATOM

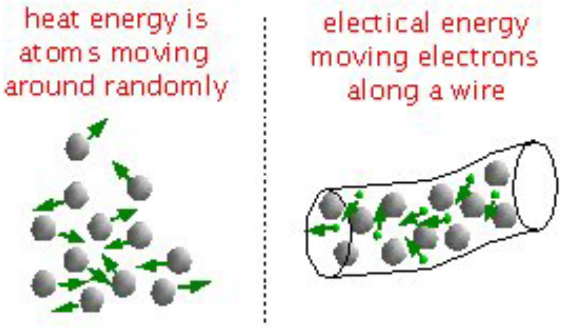
Different types of **atoms** have different numbers of **protons** in the nucleus. That's how we distinguish between the different types.



EXAMPLES OF ATOMS

What is energy?

Put simply, **energy** is defined as the potential for moving things around. In physics this is considered **doing work**. There are many forms of **energy**. For example, **heat energy** is atoms moving around randomly. The more movement there is the hotter we say it is. **Electrical energy** moves electrons along a wire (electrons don't always stay with their atoms).



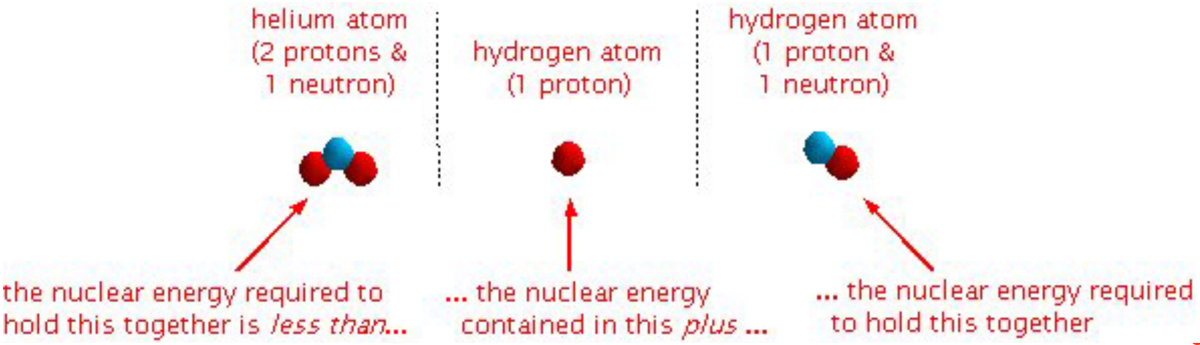
EXAMPLES OF ENERGY

Nuclear fusion - how the sun provides energy

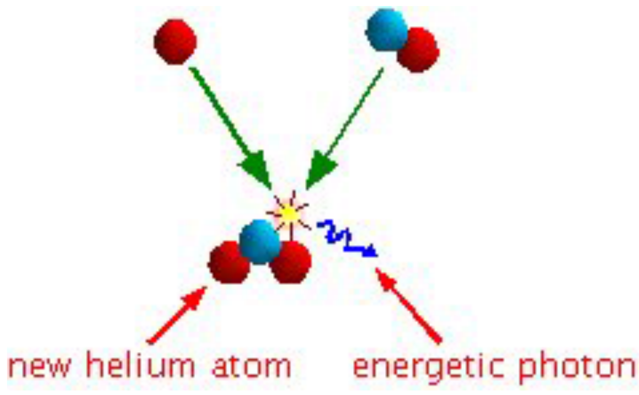
The **energy** we use from the sun arrives in the form of **sunlight**, a form of **electromagnetic energy**. We convert this to **heat energy** in a solar hot water heater to heat water and we convert it to **electrical energy** in a solar power, or **photovoltaic**, panel to produce electricity. But how does the sun produce that sunlight?

When we described what makes up an atom, we said the **nucleus** is made up of **neutrons** and **protons**. It takes energy to hold these neutrons and protons together into a nucleus (there are even smaller particles inside the neutrons and protons that do this work.) This energy comes in the form of a force is called the **nuclear force**, which makes sense as it is the force holding the nucleus together.

The interesting thing (see the diagram below) is that it takes **less energy** to hold a neutron and two protons together (an **helium atom)** than the total energy holding together a hydrogen atom consisting of just a proton and another hydrogen atom consisting of a proton and a neutron.



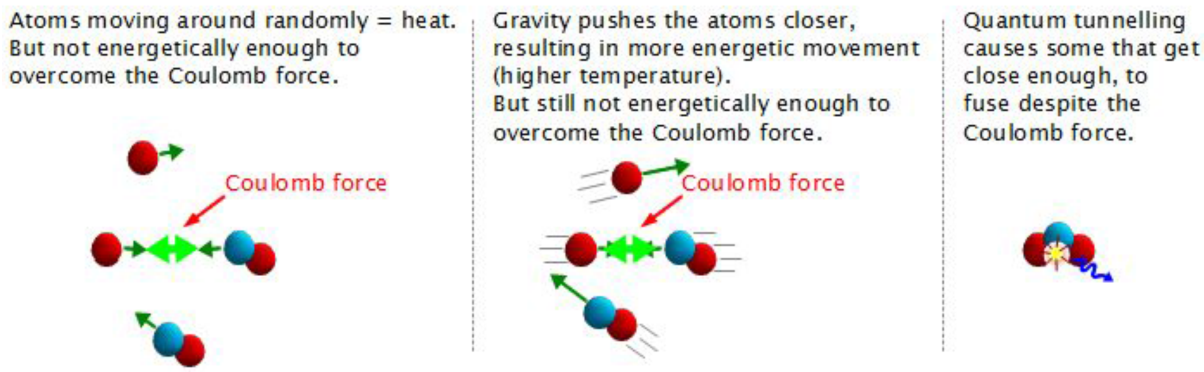
So if you combine the two hydrogen atoms you get a helium atom plus some leftover energy. In this particular example, the leftover energy will be in the form of a very high **energy photon**.



COMBINING TWO HYDROGEN ATOMS TO PRODUCE ONE HELIUM ATOM AND SOME EXCESS ENERGY IN THE FORM OF A PHOTON

Another word we could have used instead of "**combine**" is "**fuse**". We have fused the two hydrogen together, resulting in helium. We have done **nuclear fusion**. This is an example of the type of fusion going on inside our sun. There is also nuclear fusion going on involving other, larger atoms resulting in even more energy being released.

But didn't it take energy to pull the two hydrogen atoms together? The answer is yes, and in the case of the sun, this energy is provided by **gravity**. Wherever you have **matter,** then you have gravity. The more matter you have, the stronger the gravity. The sun has an enormous amount of matter and so the resulting gravity is also enormous. It is this **gravitational energy** that pulls the atoms together. But that alone doesn't fuse them.
There's a force called the **Coulomb force** that prevents them from fusing, or coming together.

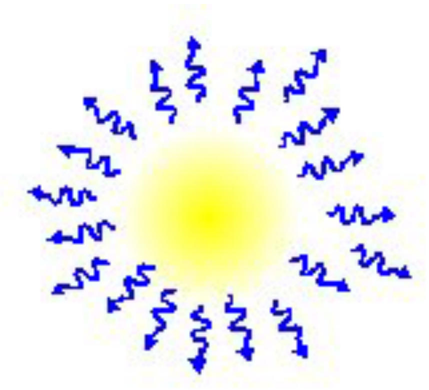


THE COMPLETE NUCLEAR FUSION PICTURE

As we said above, **heat energy** is atoms moving around randomly. The more energetically they move around, the hotter it is. The enormous gravity in the sun compresses the atoms into a smaller volume and they therefore move around very energetically; the temperature is very high. The result is that these energetically moving atoms end up getting very close together at times. But in our sun they aren't moving energetically enough to overcome the Coulomb force and fuse; i.e. the temperature isn't hot enough.

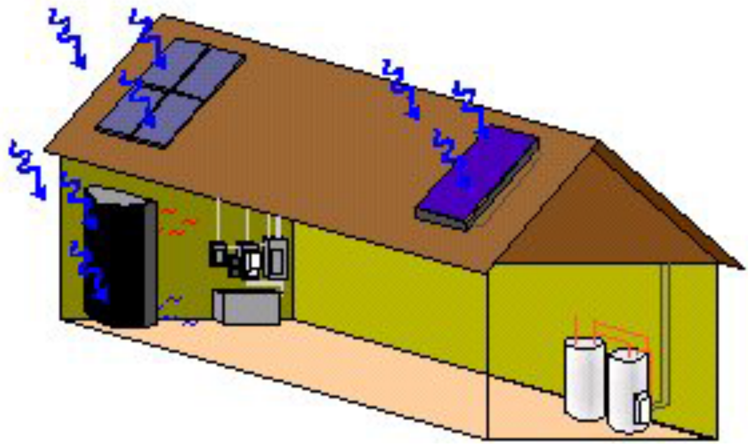
The final ingredient is quantum tunneling. **Quantum tunneling** is a process whereby if the atoms get close enough together, even if they don't come close enough to fuse on their own, some of them will fuse anyway. They sort of tunnel through the barrier made by the Coulomb force. And as we said above, one of the results of the fusion is the release of a **high energy photon.**

This **photon** doesn't actually leave the sun. Instead it participates in other fusion events, or it **transfers its energy** to other atoms making them move more energetically, i.e. transforms into **heat energy**. Eventually some of this energy makes its way up through the layers of the sun until it finally escapes from the sun in the form of very fast moving **photons**.
Photons can be thought of as either **particles or waves.** As you can see from the diagrams, we're using a combination of these to represent a **photon**, a wavey particle.



Photons coming from the sun

It's these **energetic photons** that arrive at the Earth and are converted by solar panels to electrical energy, by solar water and solar air heaters to heat energy, by heating large volumes of air to wind energy, and so on. All forms of energy on Earth came from the stars, of which our sun is one, although you may have to trace through a few steps of energy conversion to realize it.



PHOTONS ARRIVING AT EARTH

The total amount of energy in the **universe** never changes. Energy can **neither be created nor destroyed** (this is the conservation of energy law which you may have heard of.) But if that's the case, why can't we just place our solar power panels in the sun, let the panels convert the energy from the photons into electrical energy to move electrons along wires, and then put the solar panels away? After all, energy is never destroyed. That's true but energy can change from one form to another. As the electrons move down a wire they cause some of the atoms to start moving around, as if the electrons were "**bumping**" into them. Two things happen because of this bumping. The moving atoms cause heat since, remember, that's what heat means, randomly moving atoms. And the electrons move a little less, having lost a little energy through bumping. So the amount of **heat energy** has increased while the amount of **electrical energy** has decreased by the exact same amount. The total amount of energy hasn't changed. So to make up for the energy that was converted to heat energy, we need to keep converting more energy from photons to more electrical energy.

Key Concepts

- Atoms are made of extremely tiny particles called protons, neutrons, and electrons.
- Protons and neutrons are in the center of the atom, making up the nucleus.
- Electrons surround the nucleus.
- Protons have a positive charge.
- Electrons have a negative charge.
- The charge on the proton and electron are exactly the same size but opposite.
- Neutrons have no charge.
- Since opposite charges attract, protons and electrons attract each other.

Name ________________________________Date___________

Solar Cell Inquiry

Complete a Record of Inquiry each time a new arrangement succeeds—that is, each time a lamp goes on or a motor works.

Record of Inquiry

1) Using a battery and a motor. Draw a diagram that shows how the items you used are connected. On your diagram, label each item and the color of the wires (Red for Positive and Black for Negative)

2) On your diagram, identify where each of the following forms of energy is present.

Light **Mechanical** **Electrical** **Chemical** **Heat**

3) Where does the energy that powers the motor come from?

4) How fast is the motor spinning, or how bright is the lamp operating? On a scale of one to five, circle the appropriate number.

LAMP					MOTOR				
1	2	3	4	5	1	2	3	4	5
DIM				BRIGHT	SLOW				FAST

5) How long do you predict the motor or lamp will remain on, if left as you have it connected? Back up your claim by explaining your prediction.

Record of Inquiry

1) Using a solar panel and a motor. Draw a diagram that shows how the items you used are connected. On your diagram, label each item and the color of the wires (Red for Positive and Black for Negative)

2) On your diagram, identify where each of the following forms of energy is present.

Light **Mechanical** **Electrical** **Chemical** **Heat**

3) Where does the energy that powers the motor come from?

4) How fast is the motor spinning, or how bright is the lamp operating? On a scale of one to five, circle the appropriate number.

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