Intro to Solar Electricity

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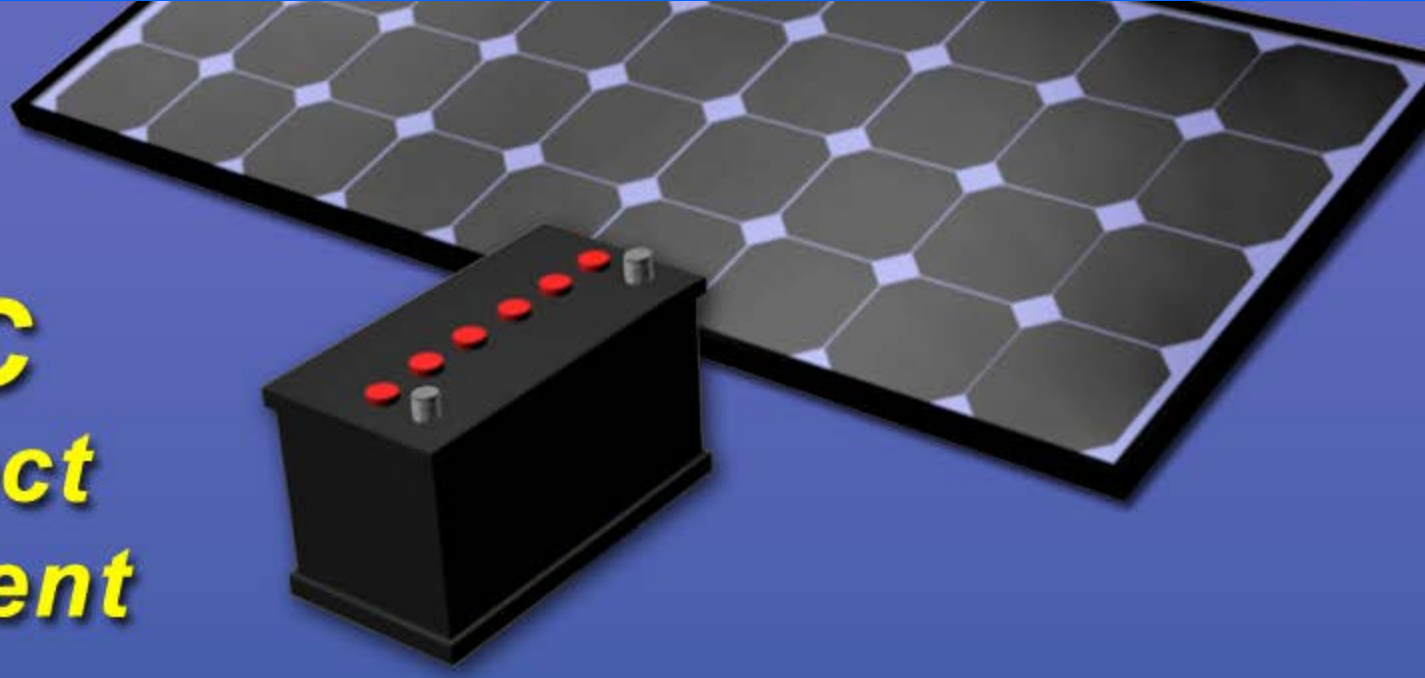
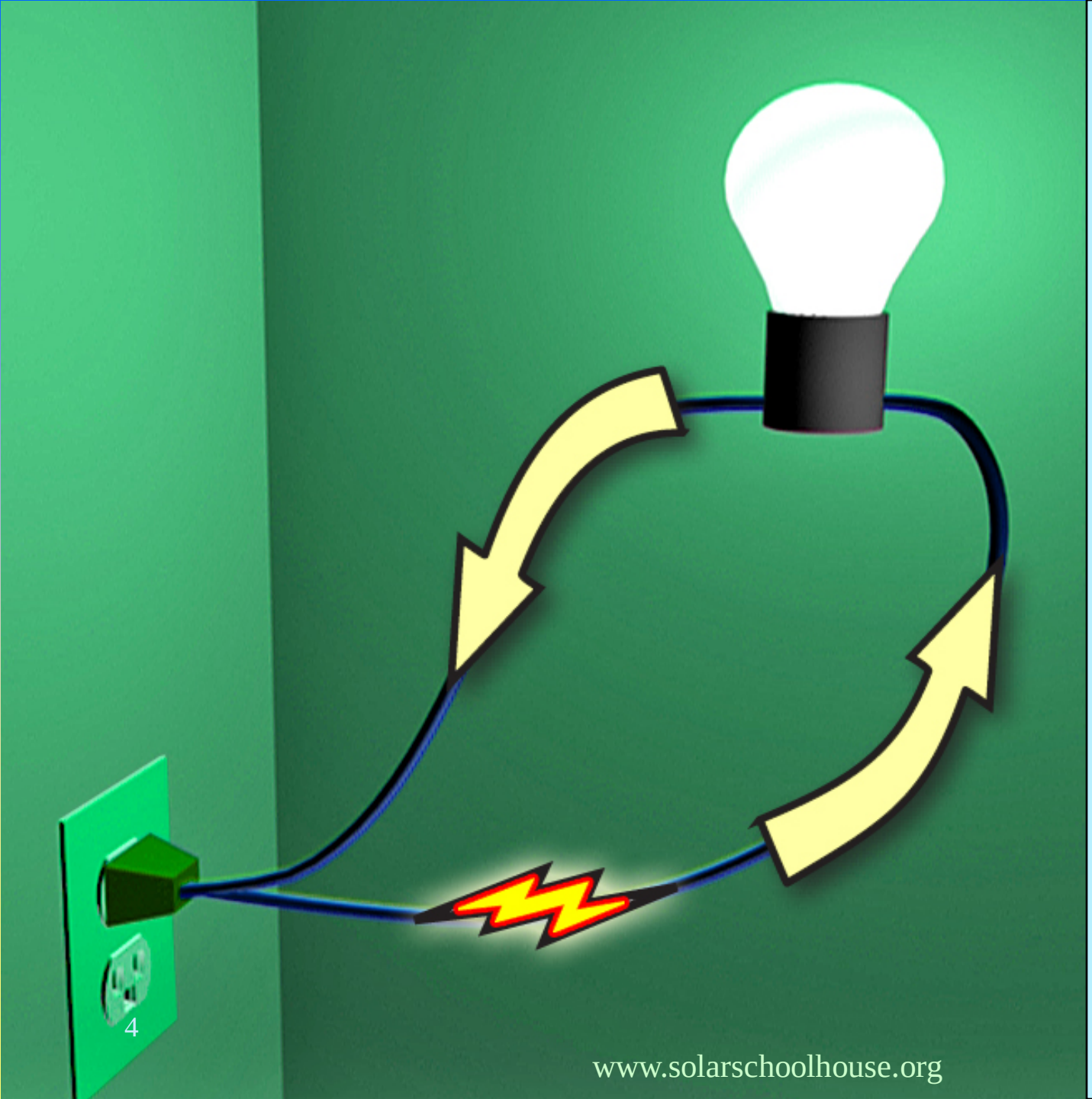
- *AC & DC Electricity*
- *Electrical Terminology*
- *PV Cell Structure*
- *Simple Solar Circuits*
- *Advanced Projects*

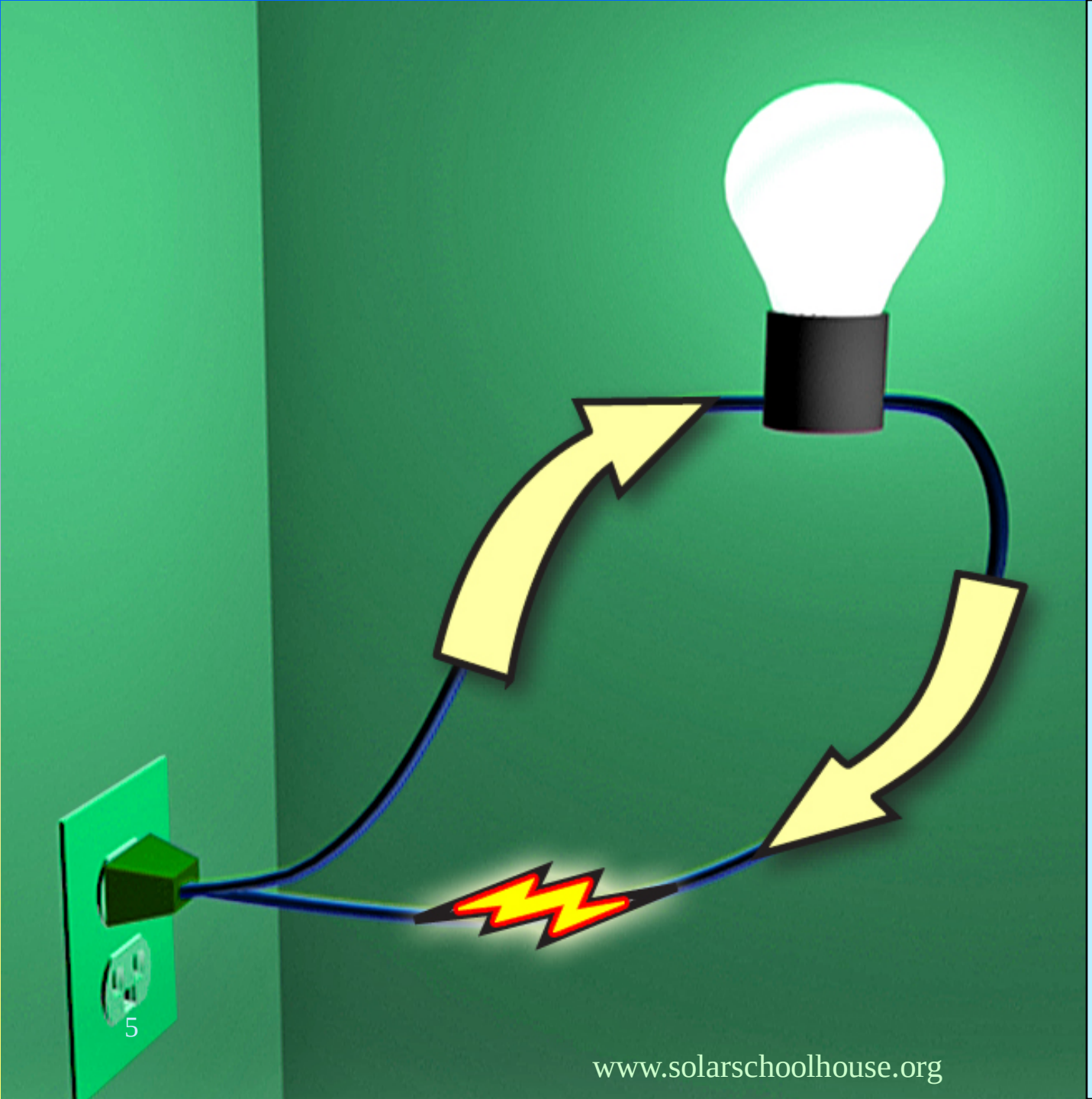


DC
Direct Current

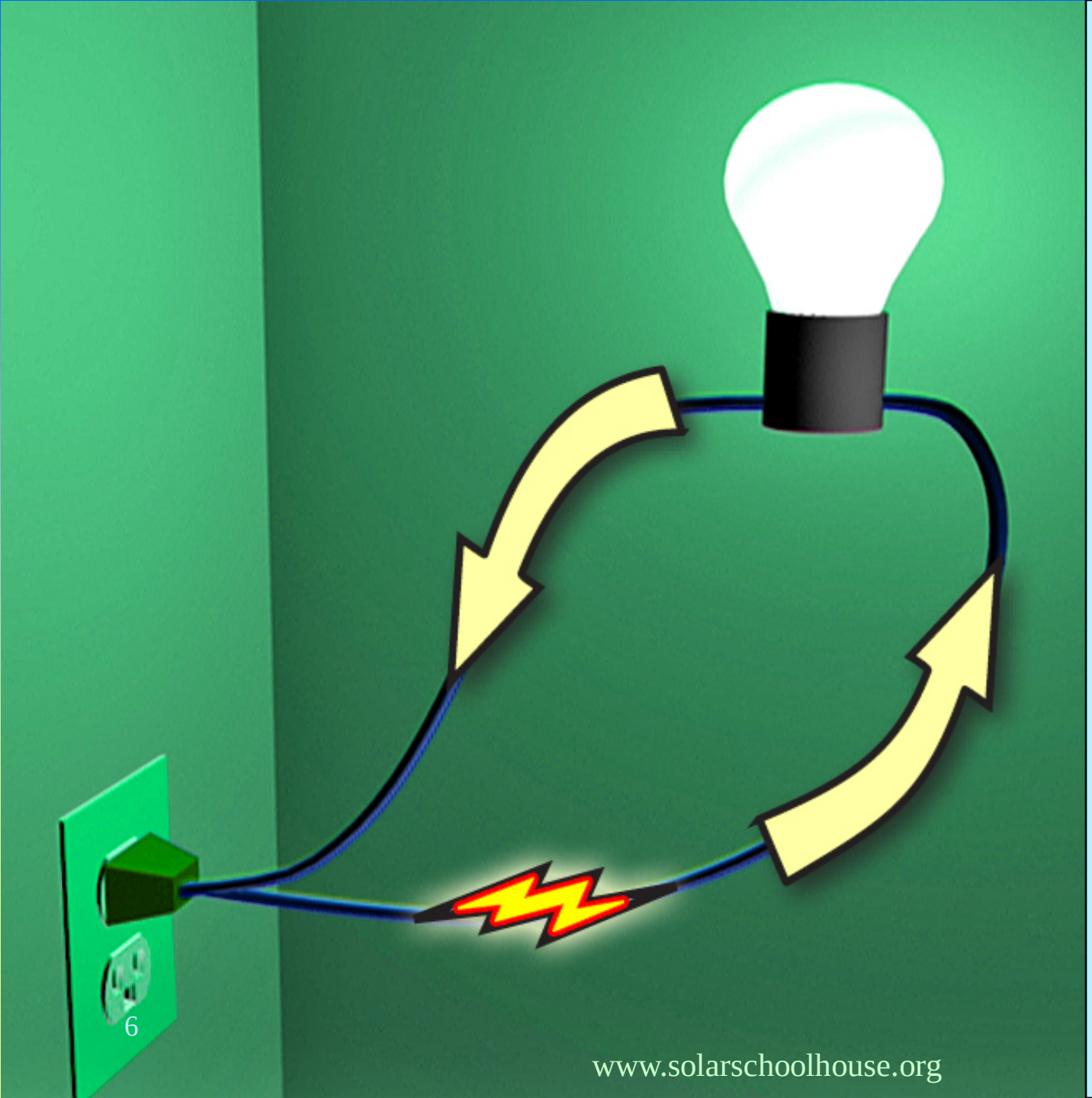
AC
Alternating Current



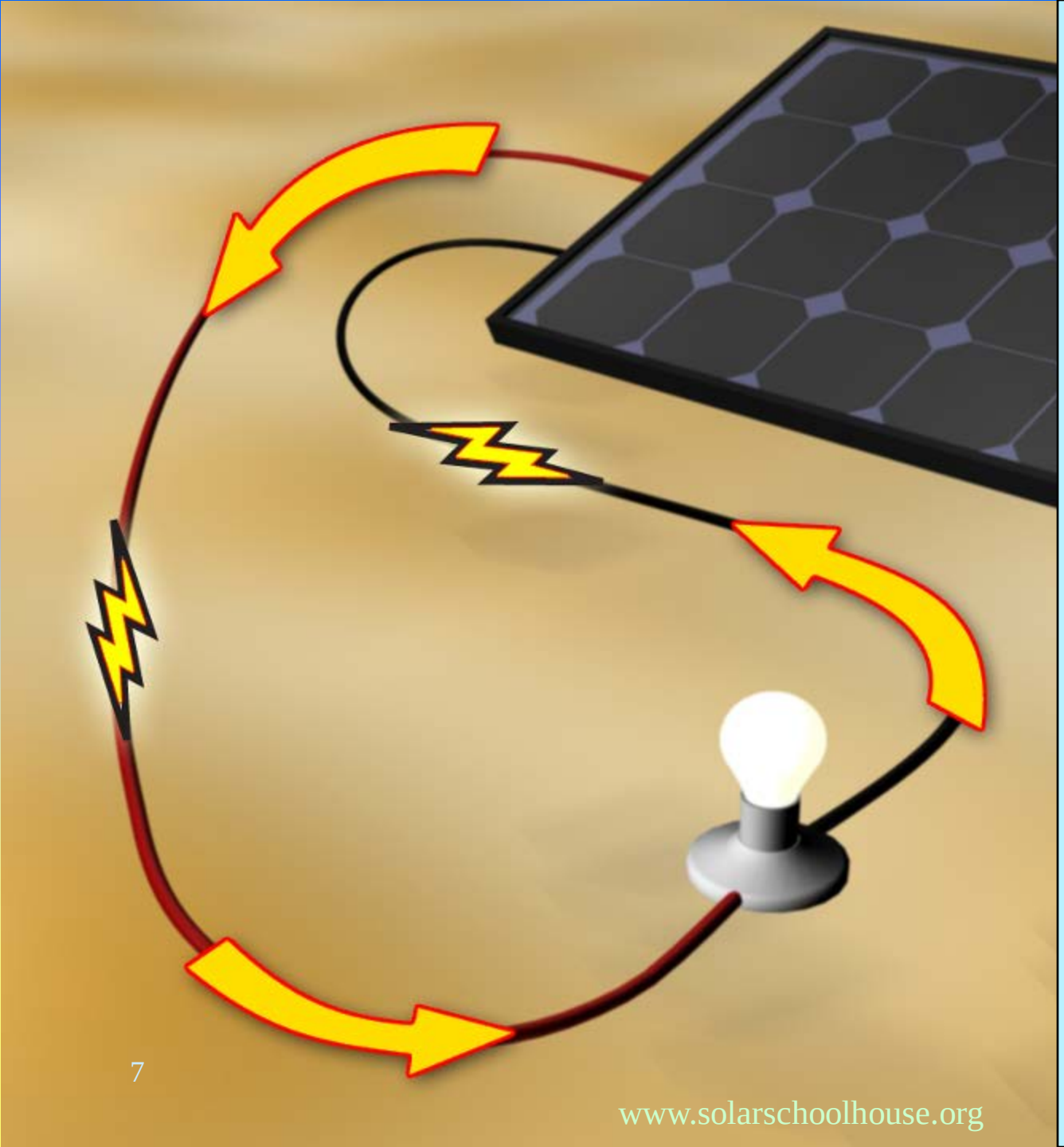
AC flows one way…



…and then the other.



Sixty Times Per Second



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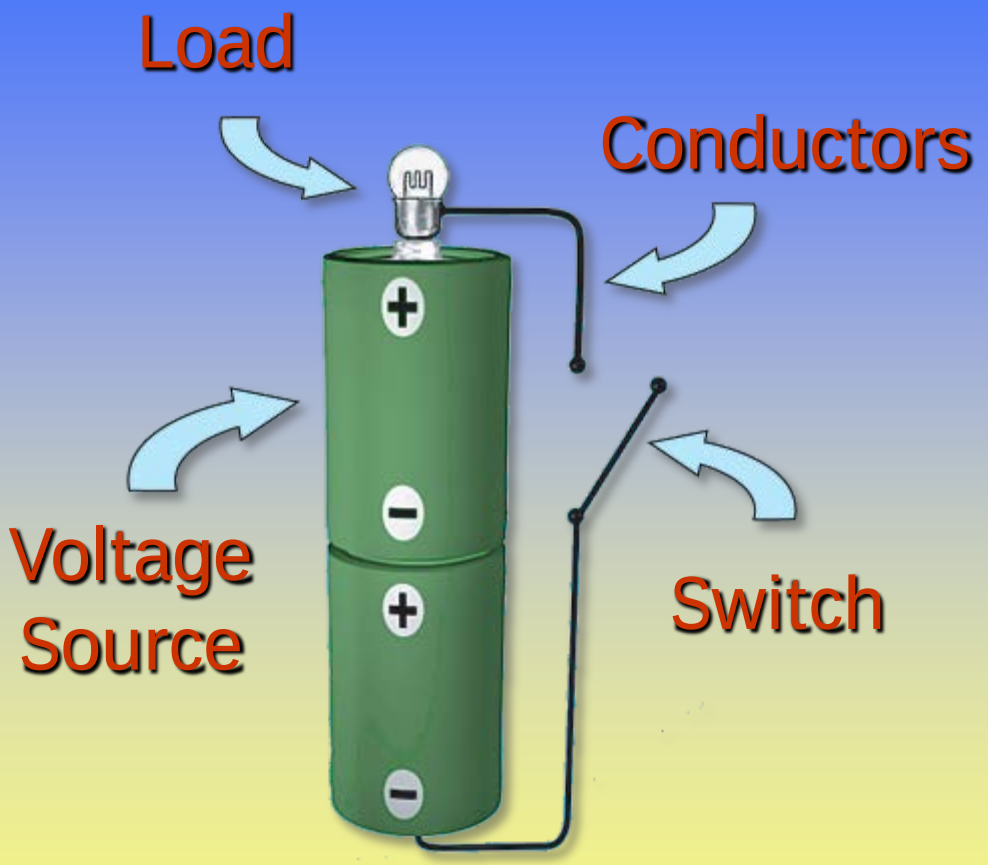
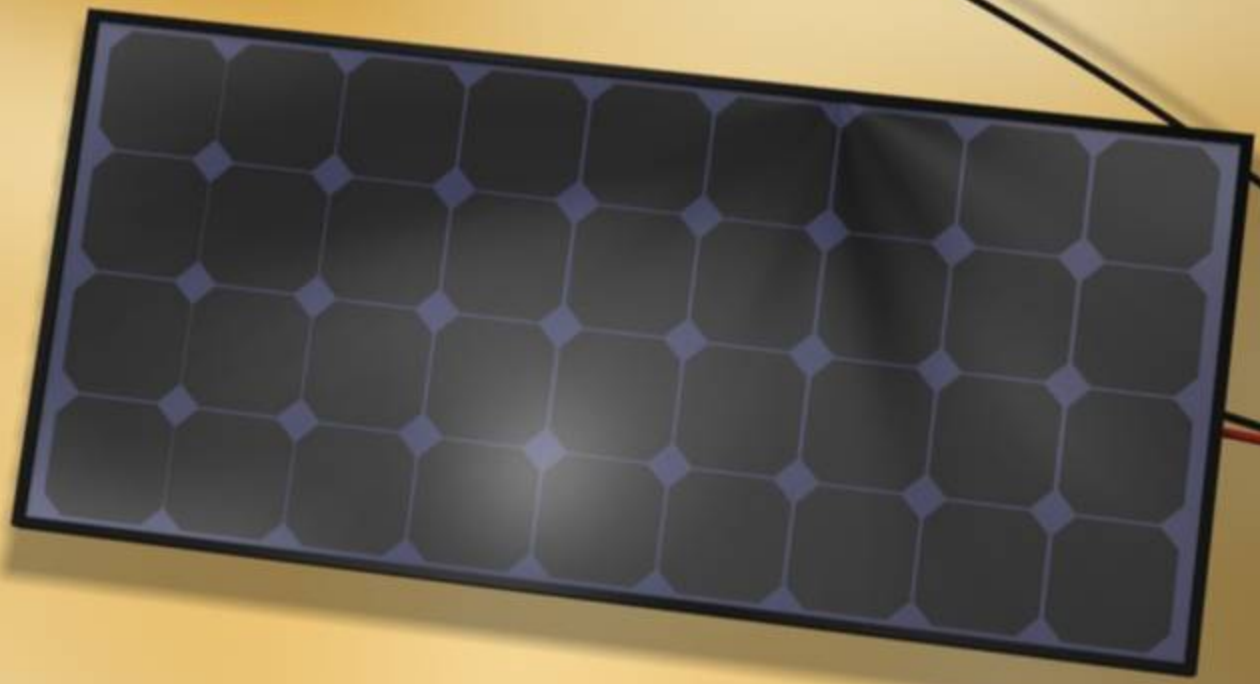
DC flows in one direction

Simple DC Circuit

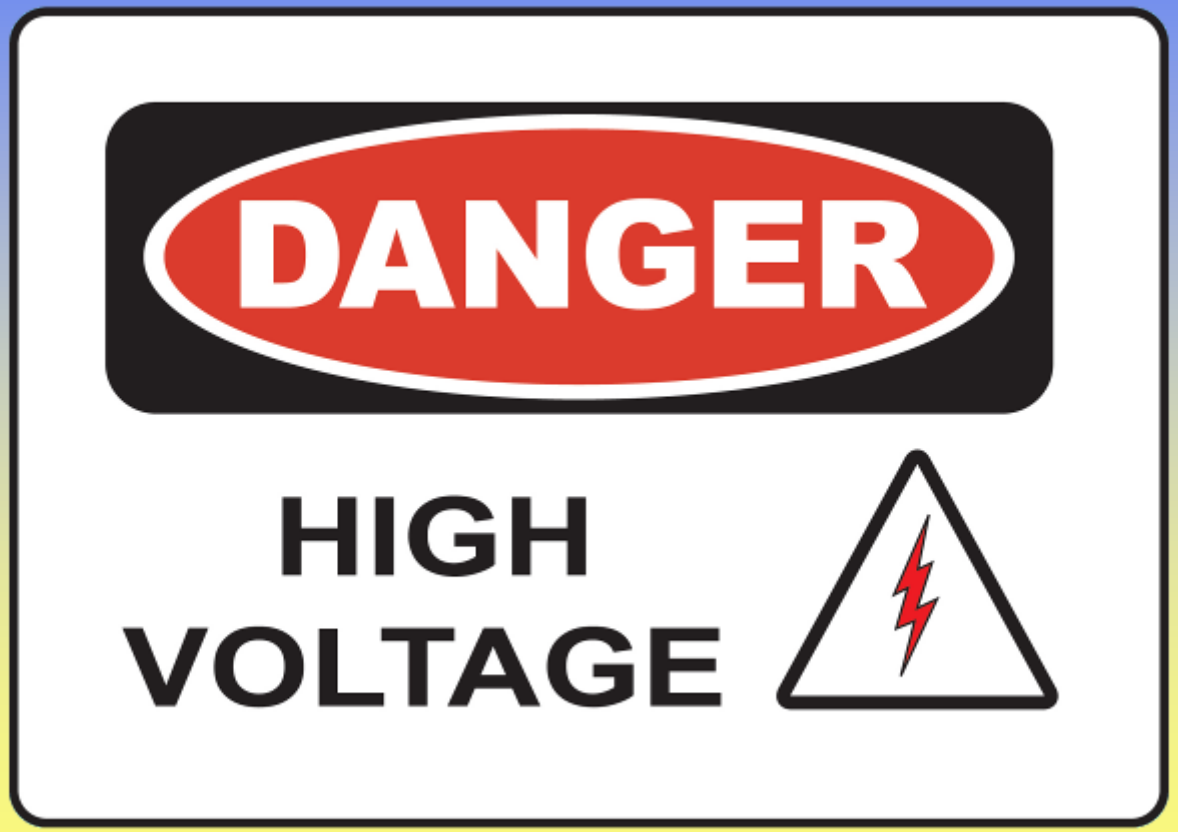
Elements of Simple DC Circuits





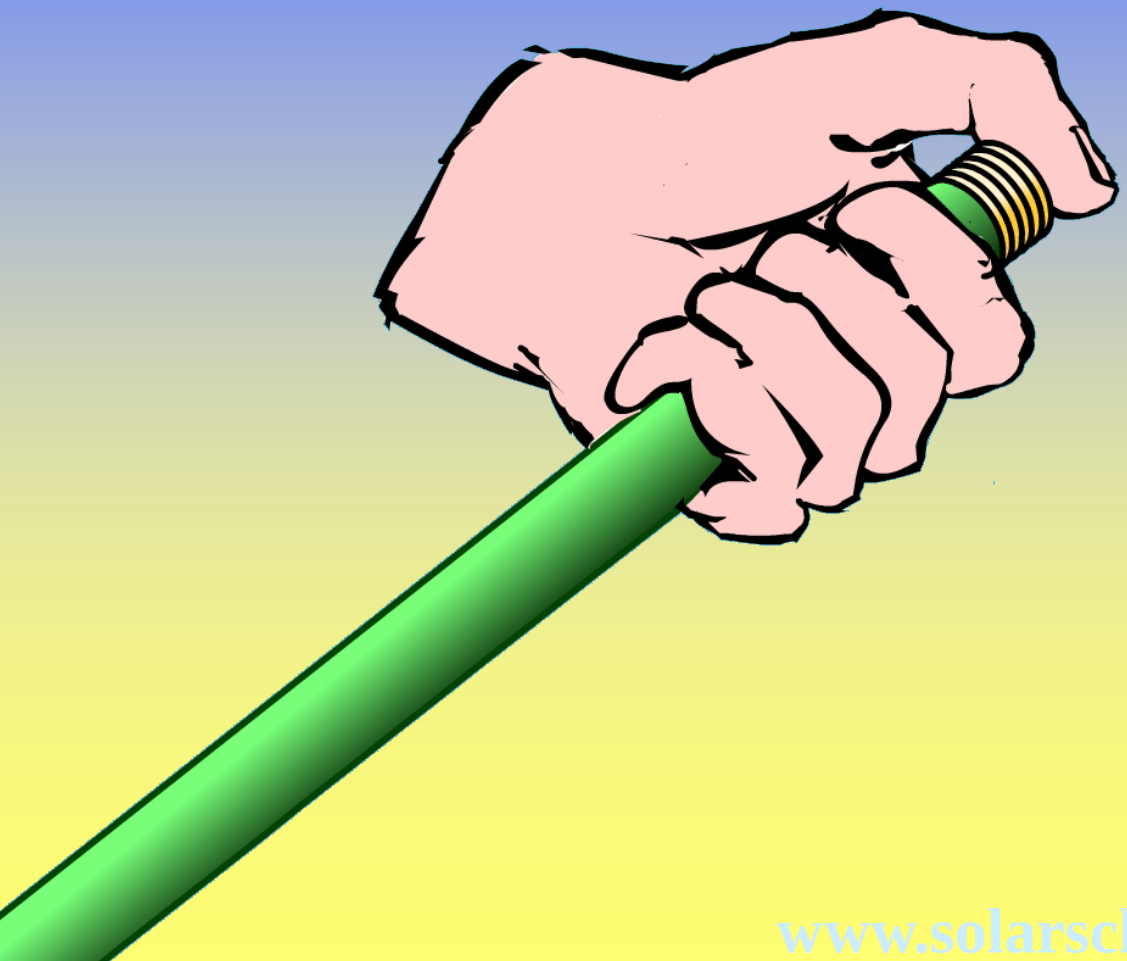
Photovoltaic Voltage Sources

What is Voltage?

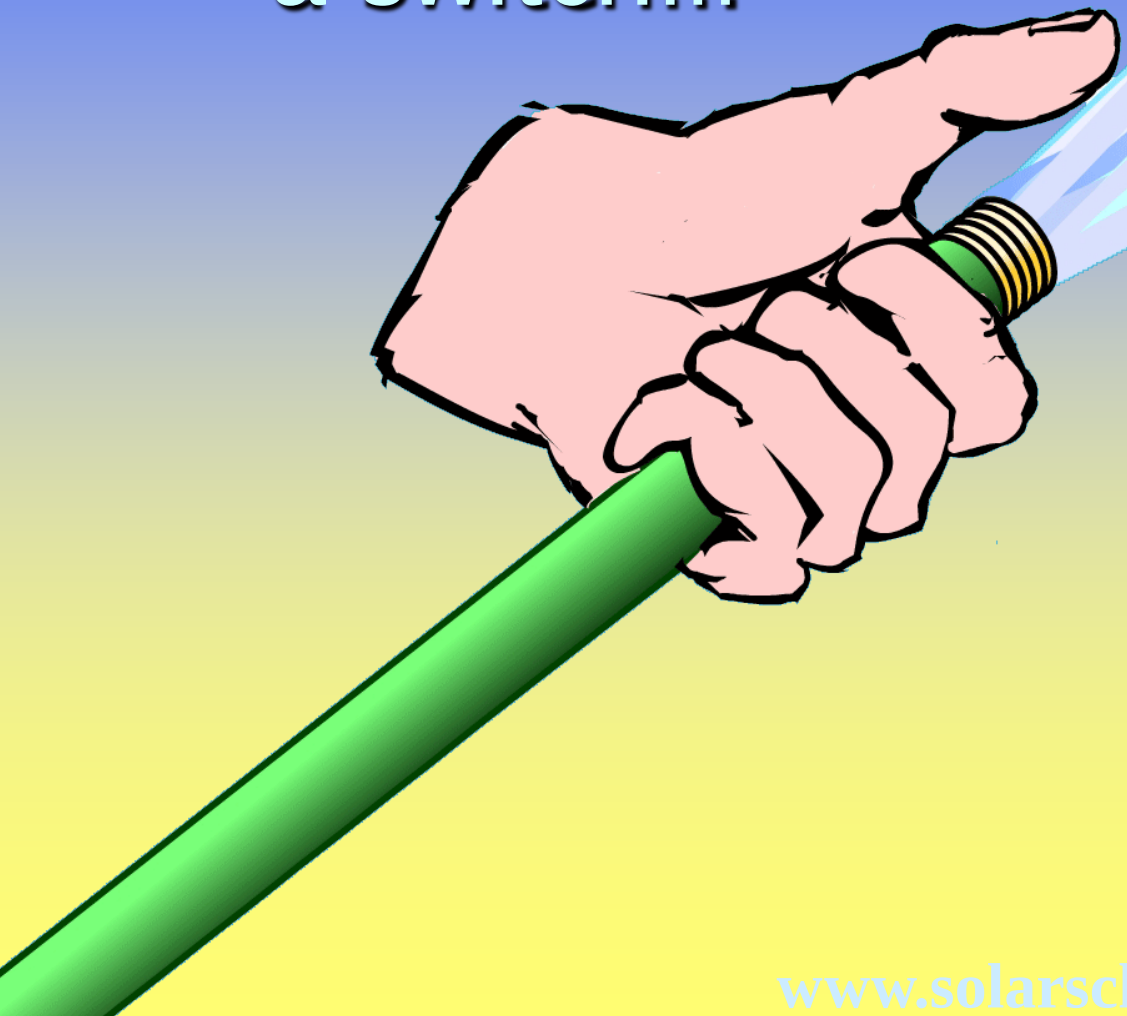


Voltage is the FORCE (or pressure) pushing an electric current through a wire.

Voltage is like water pressure.

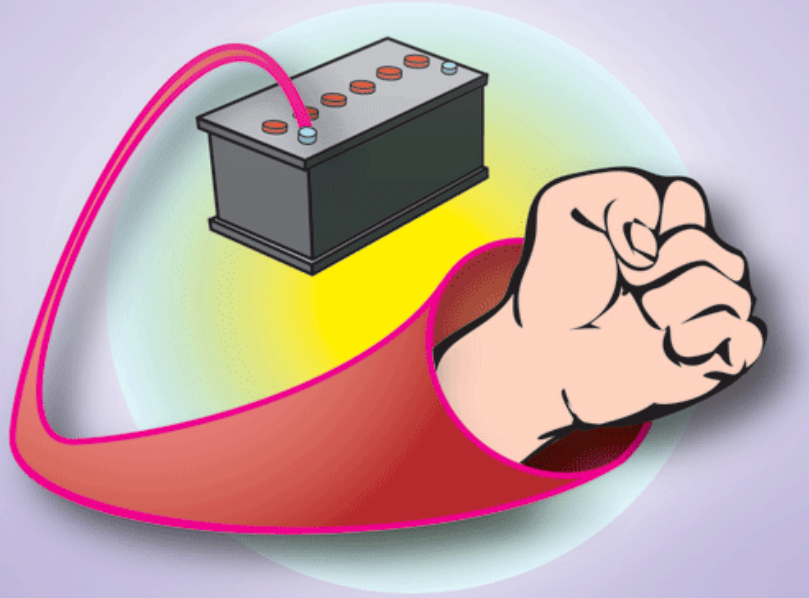


A thumb is like a switch...



...letting current flow.

VOLT
(FORCE)



MEASURES ELECTRICAL PRESSURE

The Voltage Song

sung to the tune of "Jimmy Crack Corn"

Voltage is the force that pushes the current,
voltage is the force that pushes the current,
voltage is the force that pushes the current,
And makes the current flow.

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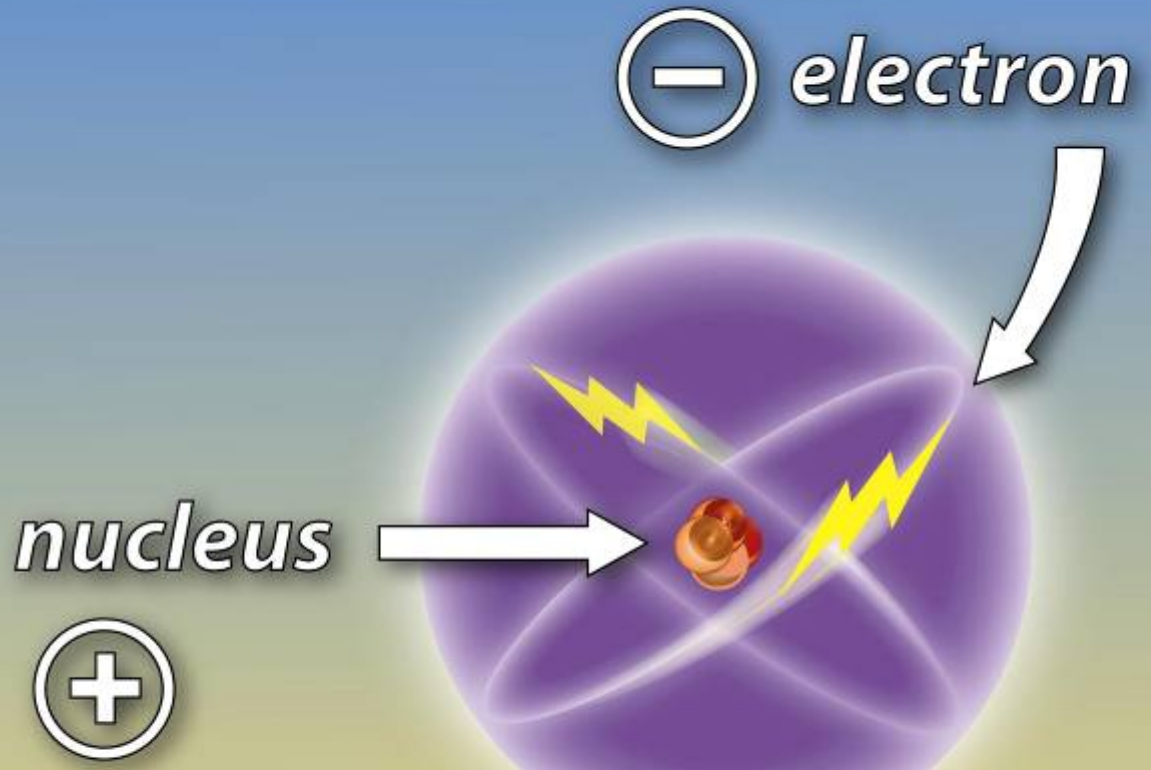
What is Current?

A stream of...

An electric current is a stream of ELECTRICALLY CHARGED PARTICLES.

In a wire they're *ELECTRONS!*



Atoms are made of charged particles.

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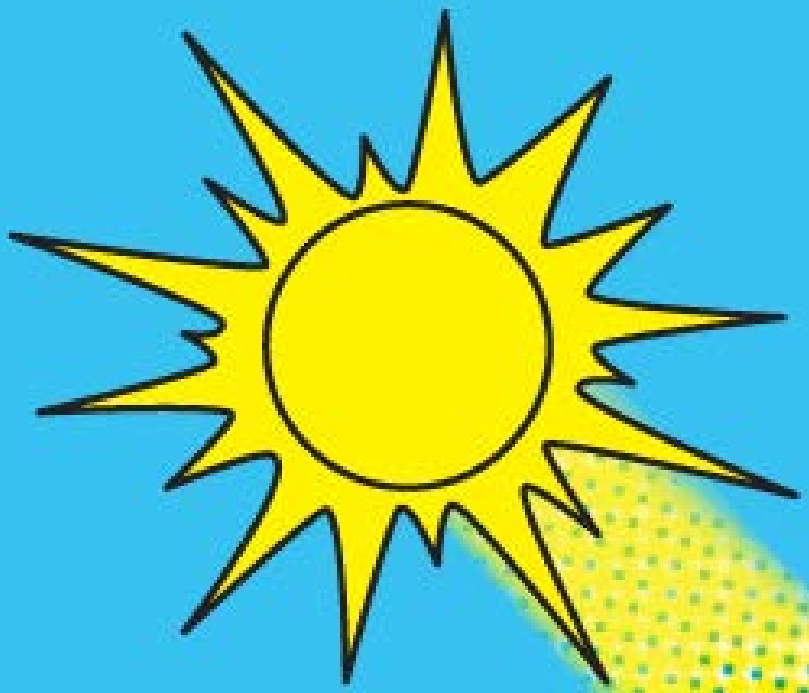
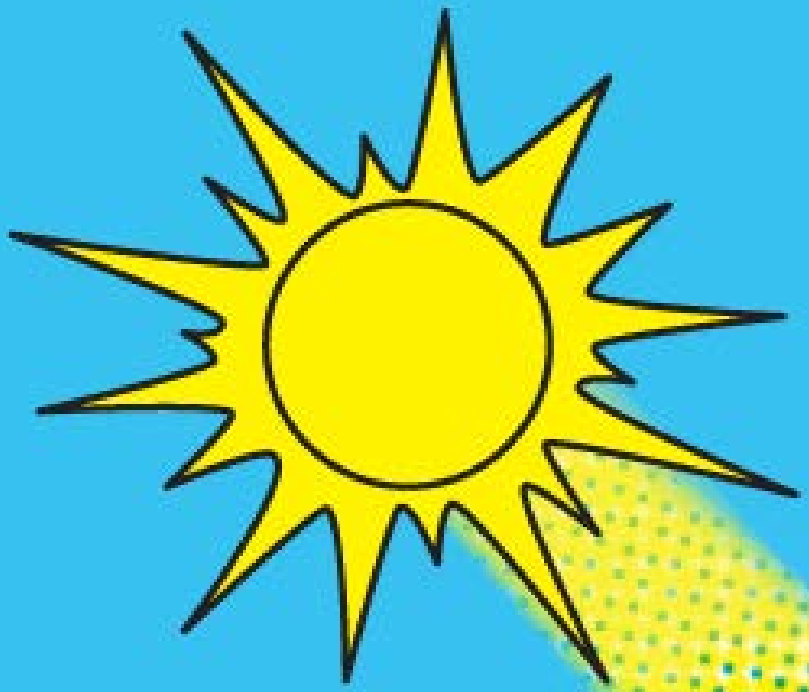
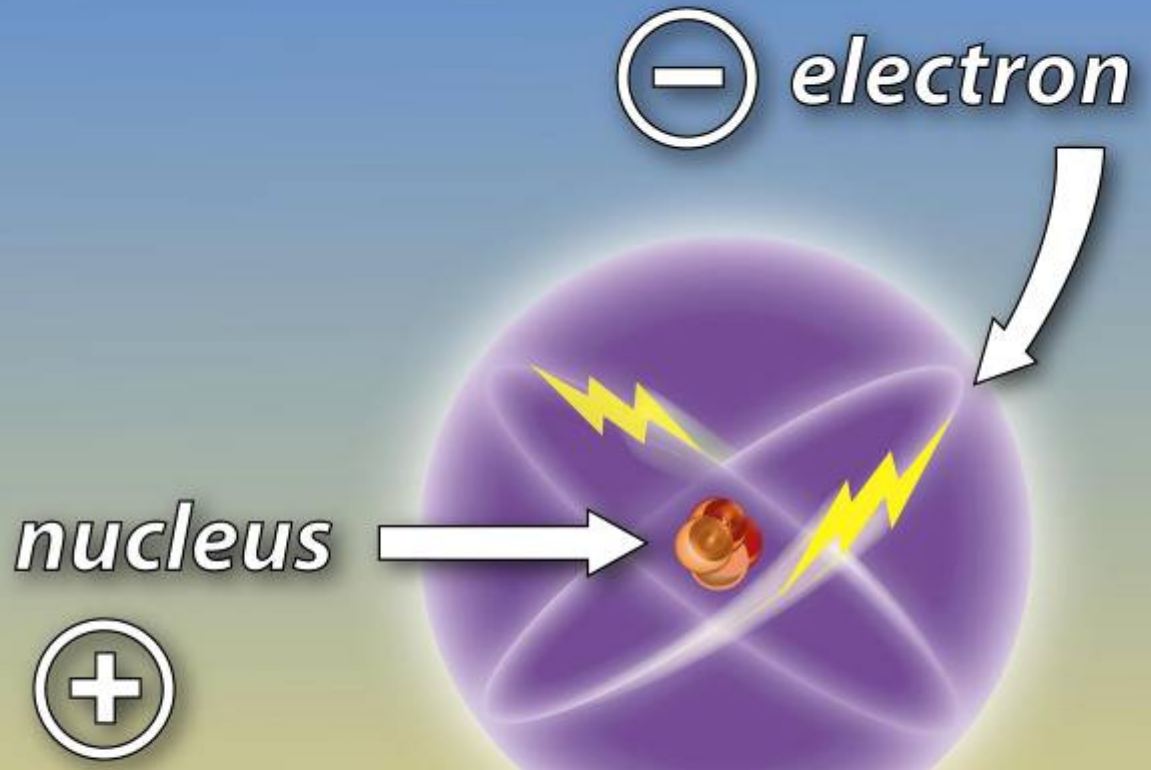


LIGHT can act like PARTICLES...



...called
PHOTONS

LIGHT can
act like
PARTICLES...



Atoms are made of charged particles.

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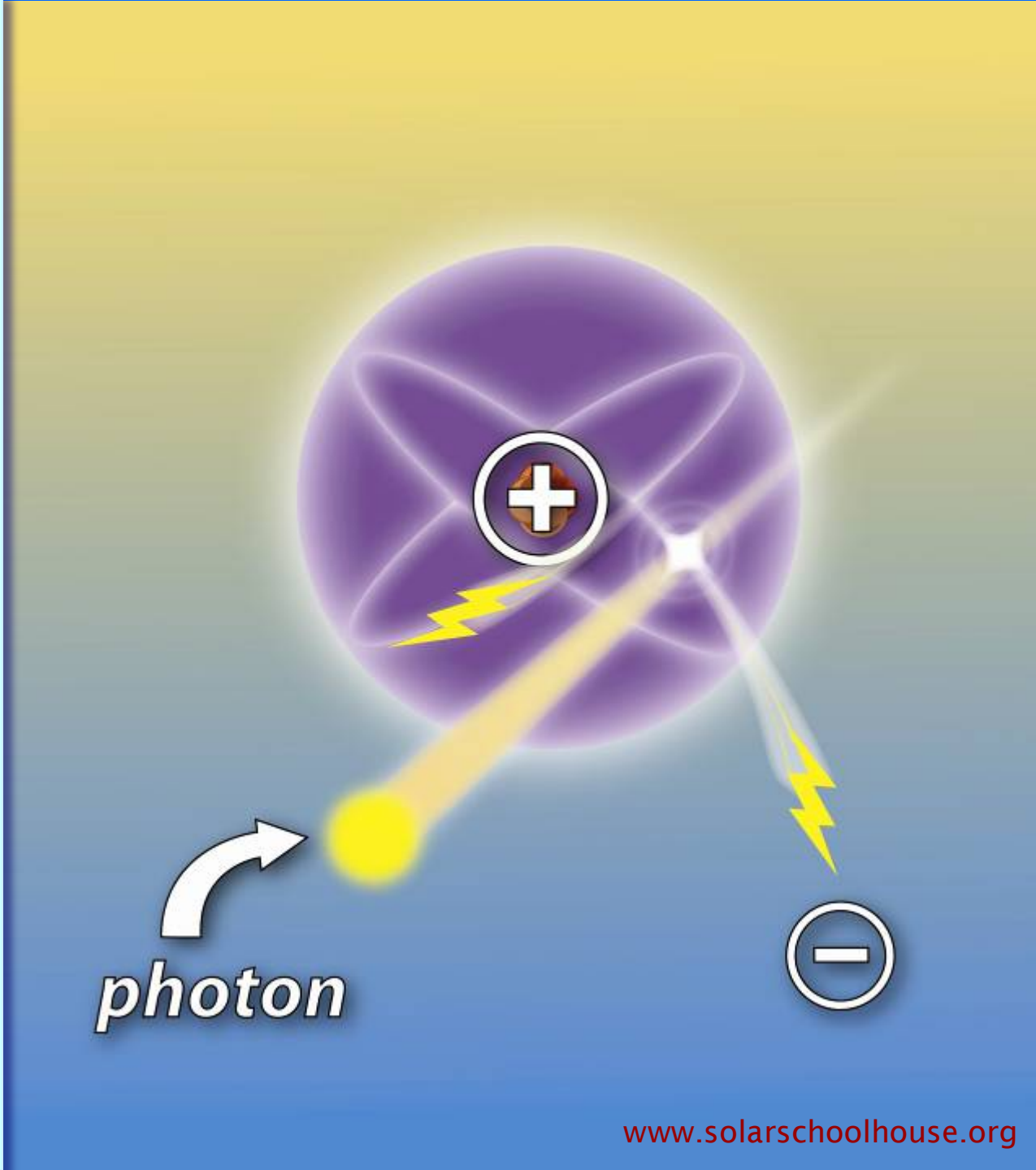
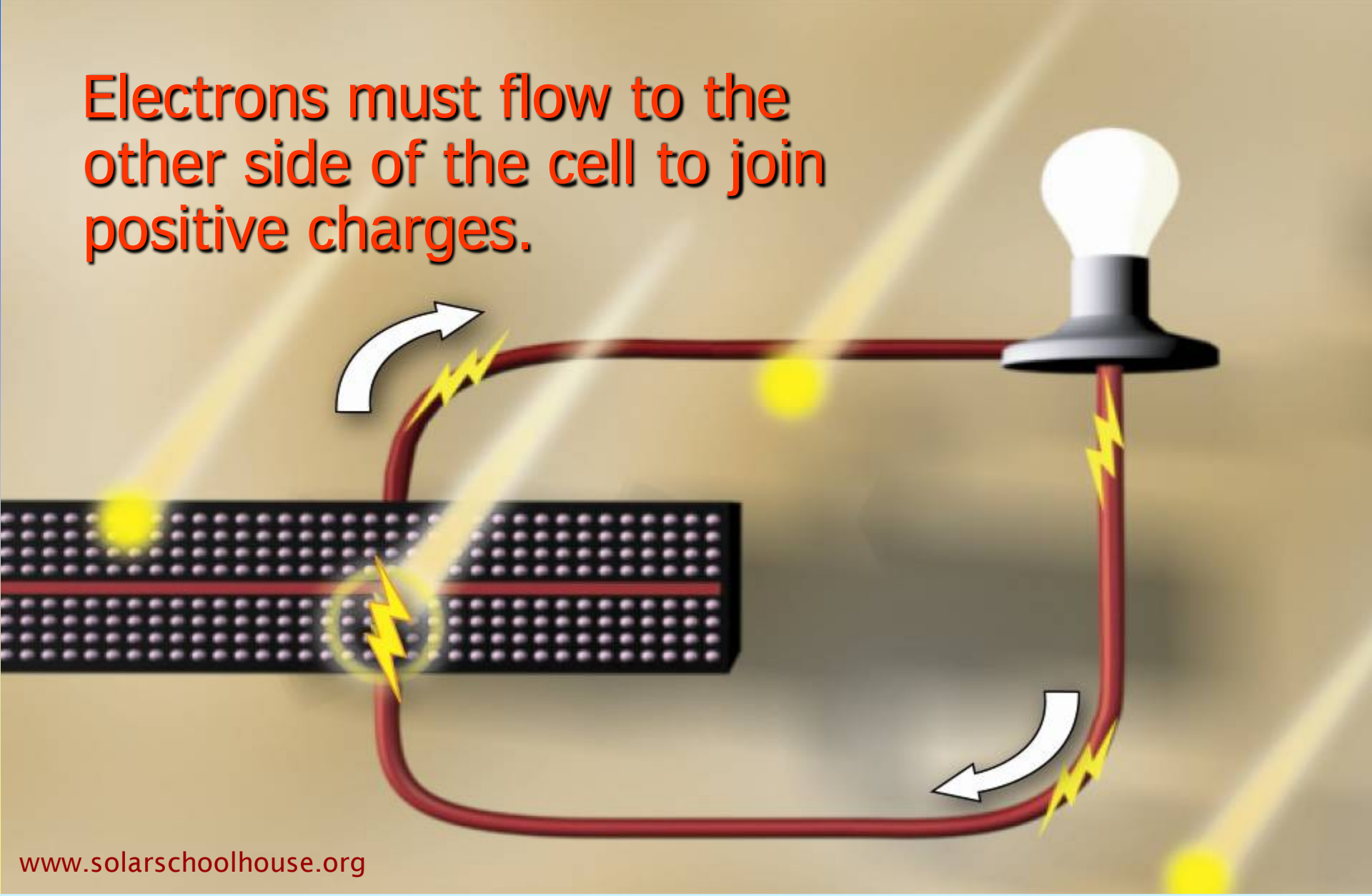
The charges balance each other, and the atom has no total charge…

HOWEVER…

Photons can knock electrons out of orbit...

... making separate charged particles.

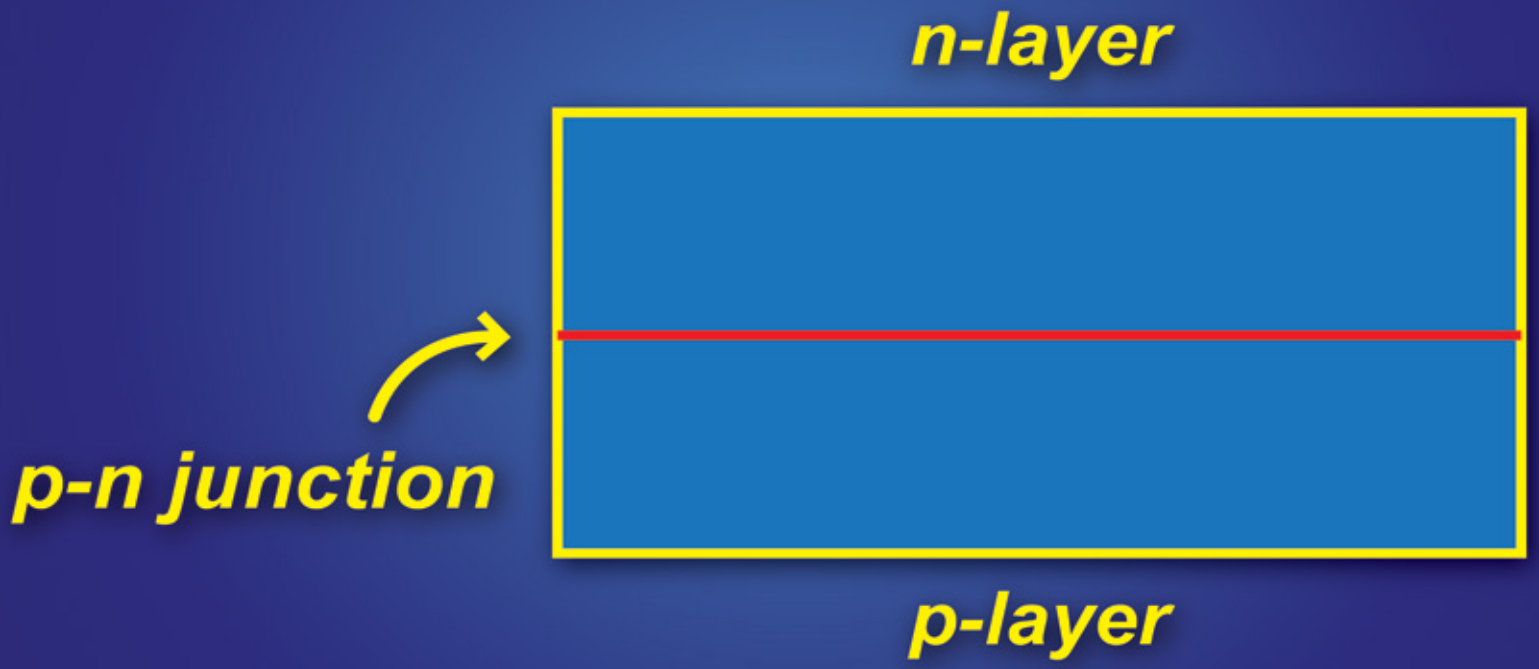




Imaginary Solar Cell Cross Section

PV CELL: CROSS-SECTION

Two layers of silicon "doped"
with small amounts of other elements



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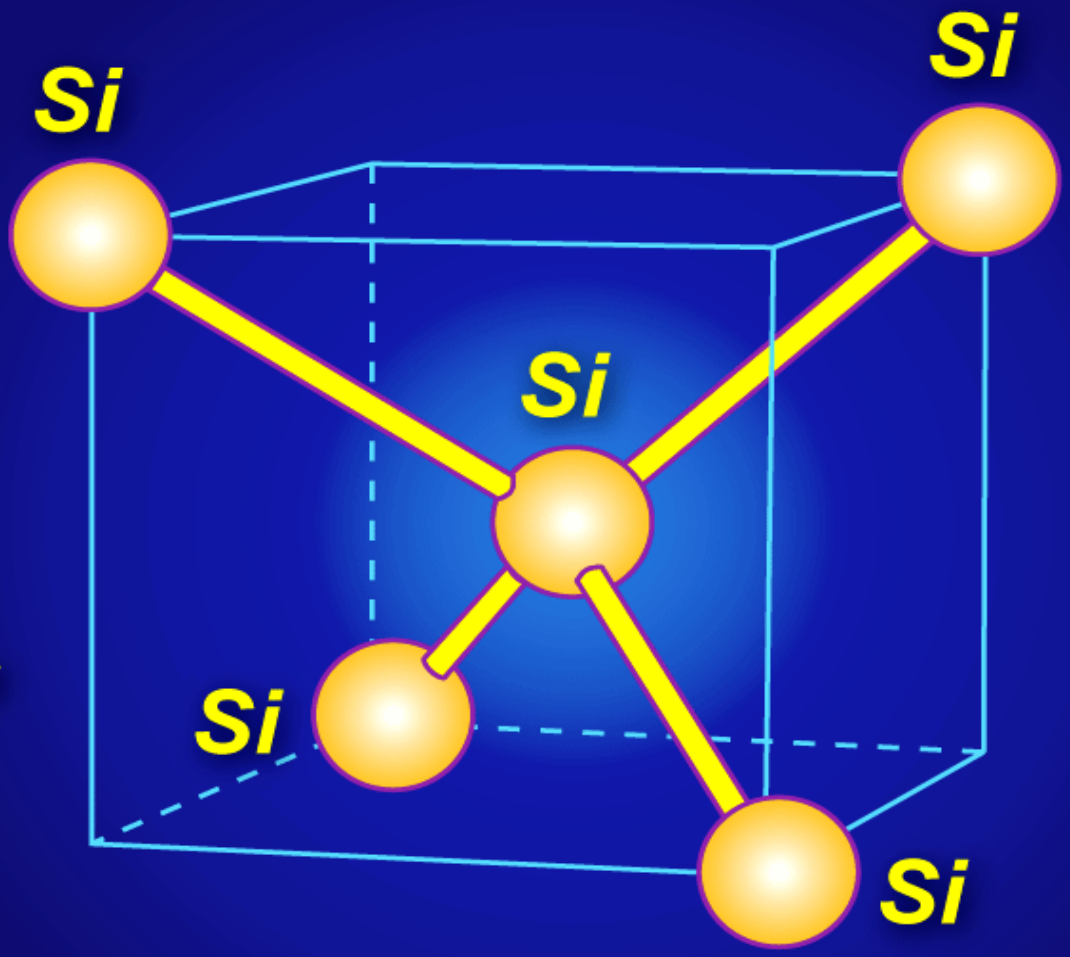
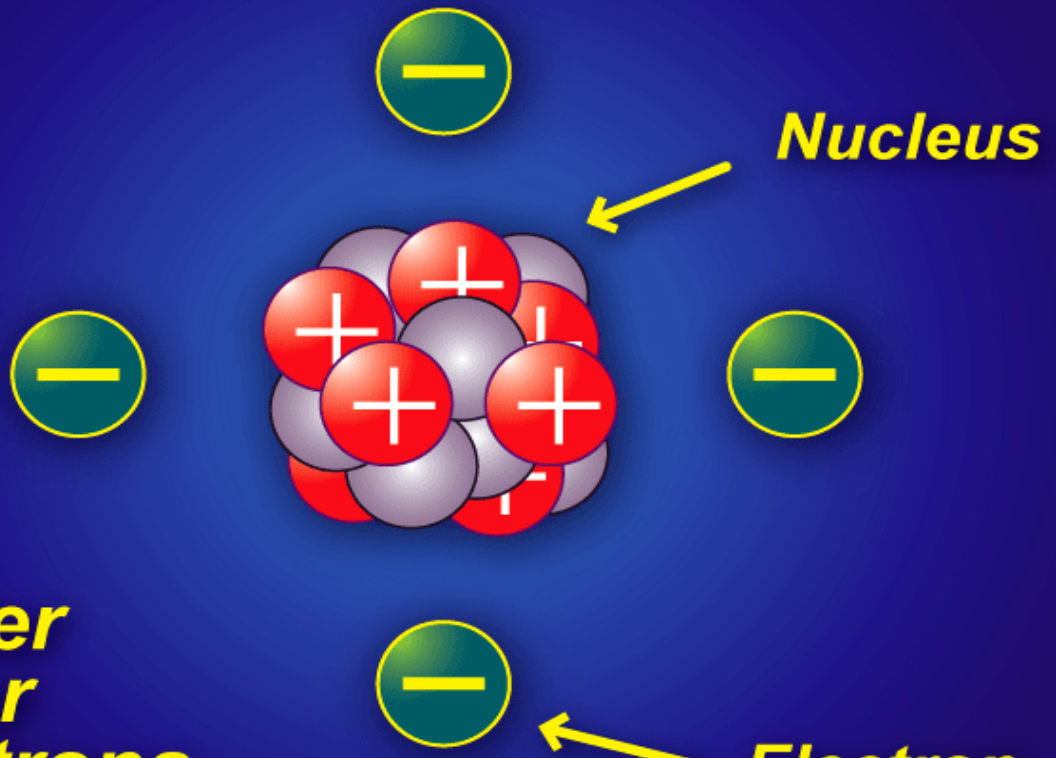
SILICON CRYSTAL



Pure crystal free from doping by other elements

SILICON ATOM



Silicon's outer shell has four valence electrons

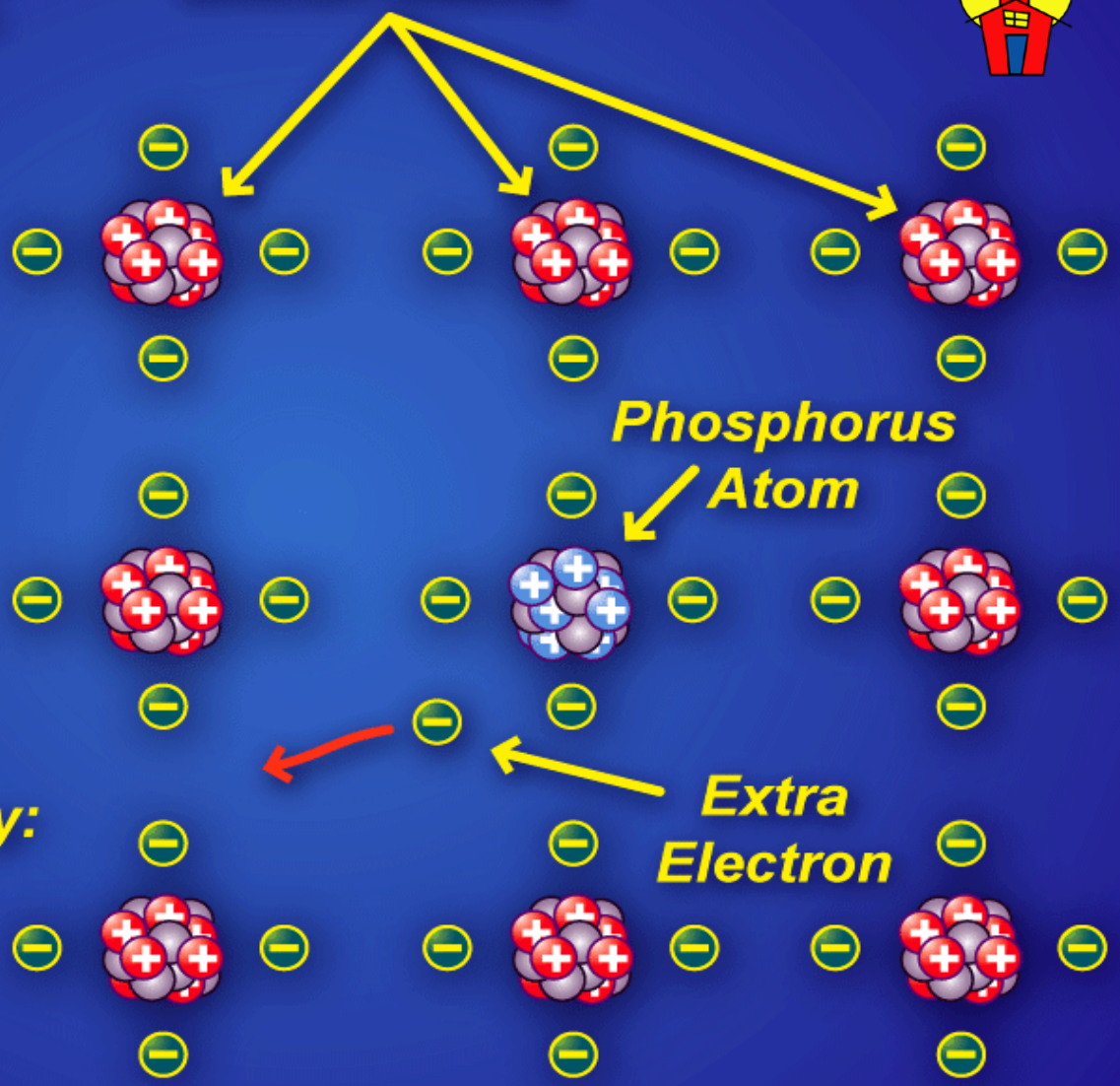
N-TYPE SILICON

Doped with Phosphorus

Phosphorus' outer shell has five electrons

Extra electron is free to move

Negative Tendency: Wants to give up electrons



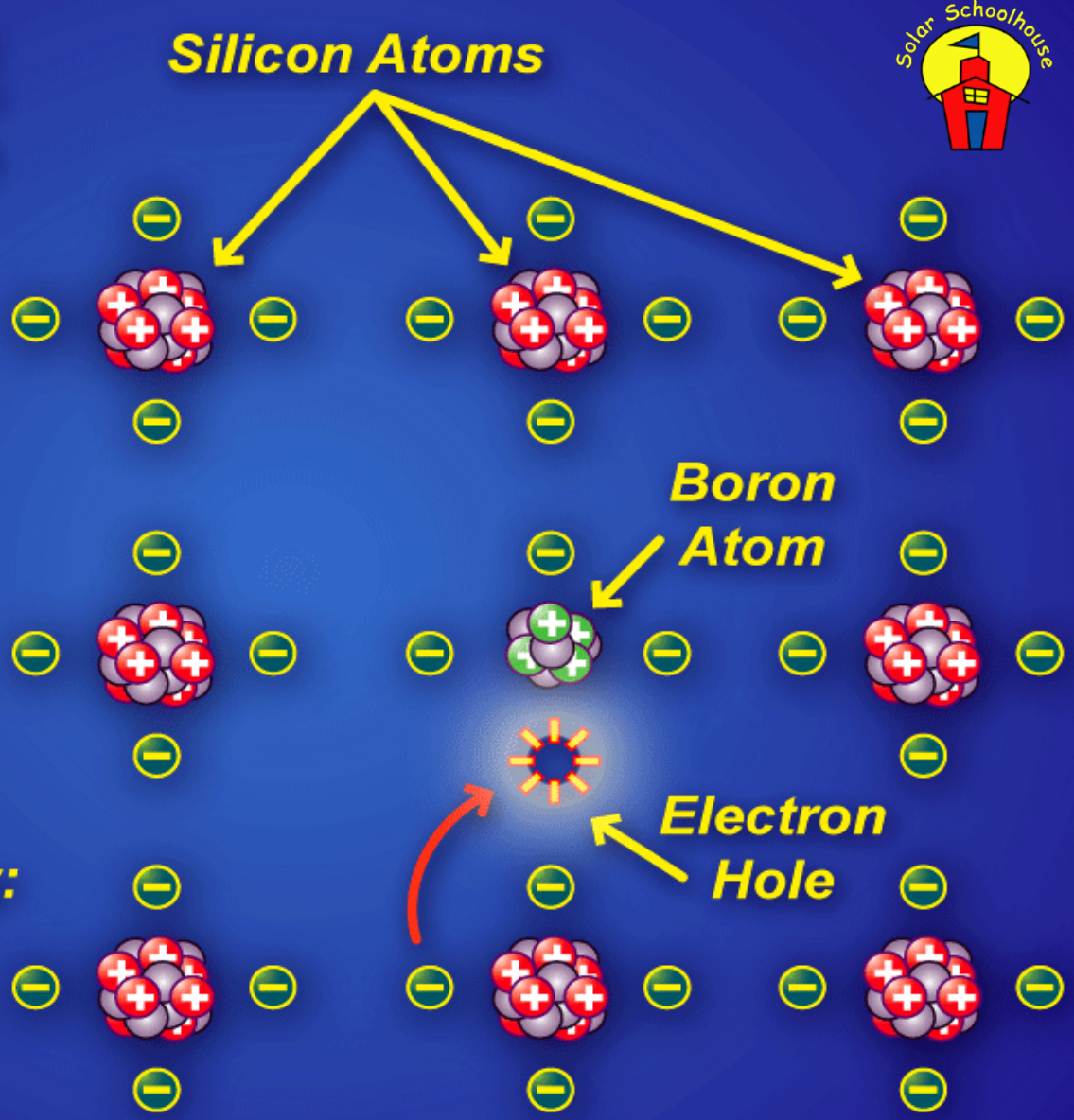
P-TYPE SILICON

Doped with Boron

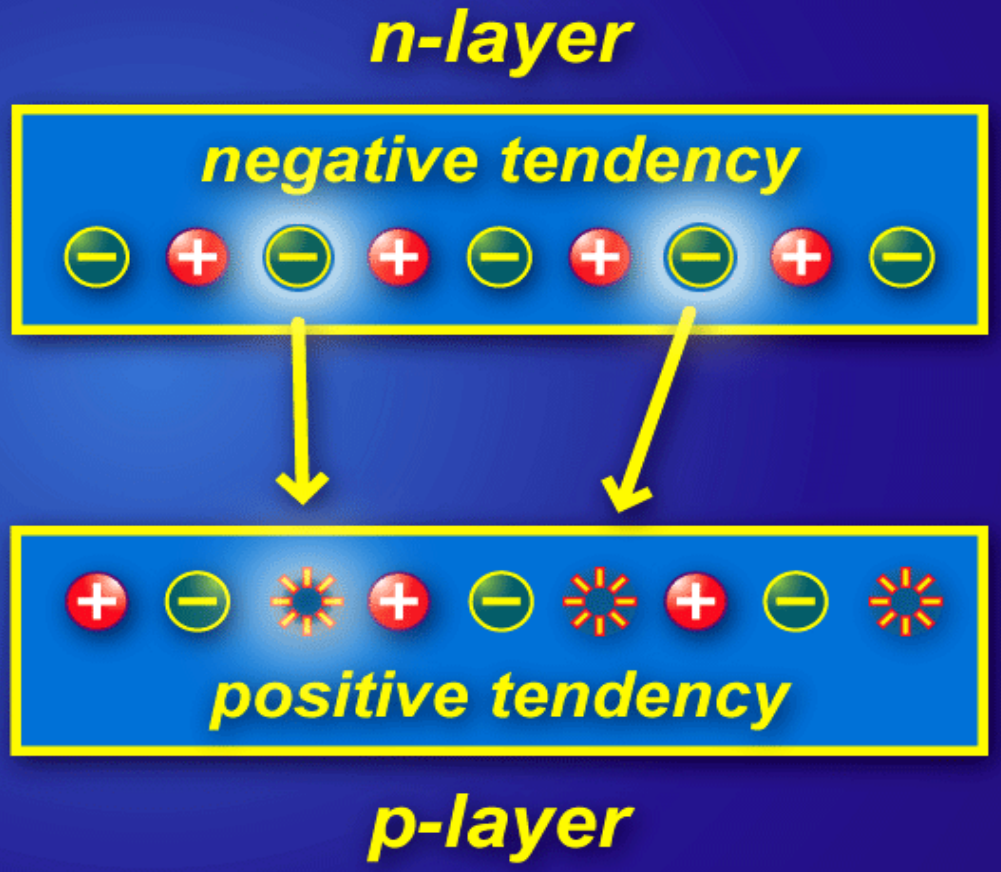
Boron's outer shell has three electrons

Silicon electrons move into the hole

Positive Tendency: wants to attract electrons



PV CELL: CROSS-SECTION

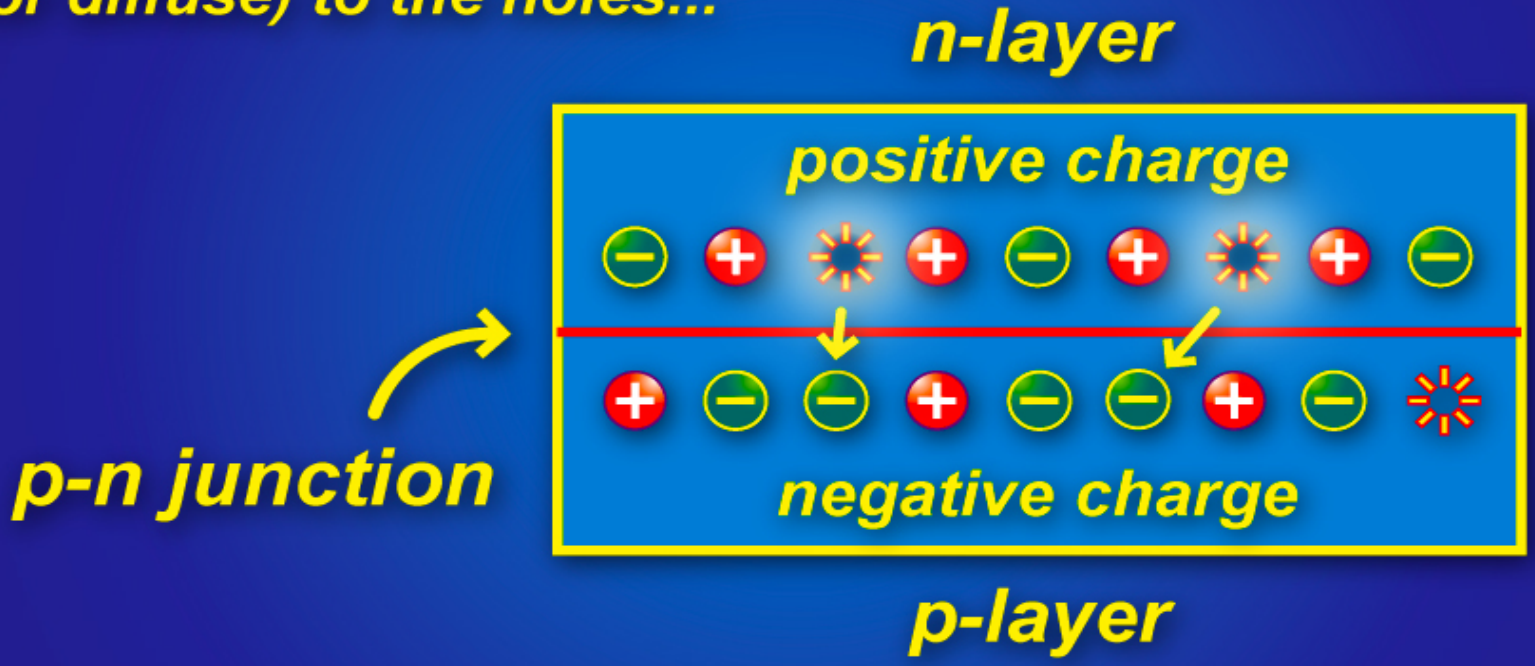


No charge, but wants to give up electrons

No charge, but attracts electrons

PV CELL: CROSS-SECTION

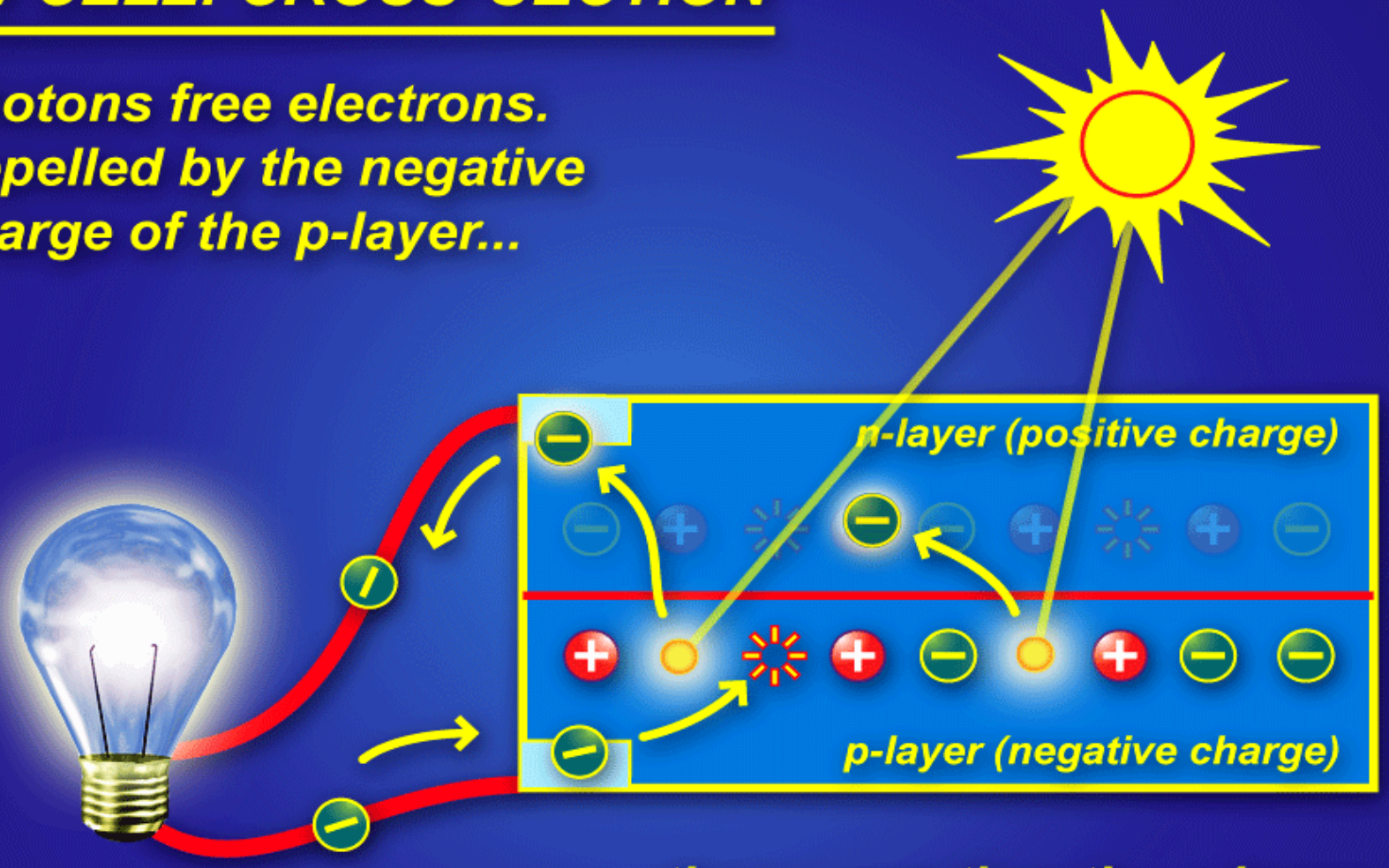
If the layers are in close contact, the free electrons move (or diffuse) to the holes...



...& make a barrier that blocks electrons from moving between layers

PV CELL: CROSS-SECTION

Photons free electrons. Repelled by the negative charge of the p-layer...



...they move thru the n-layer, then the load, & finally return to holes in the p-layer.

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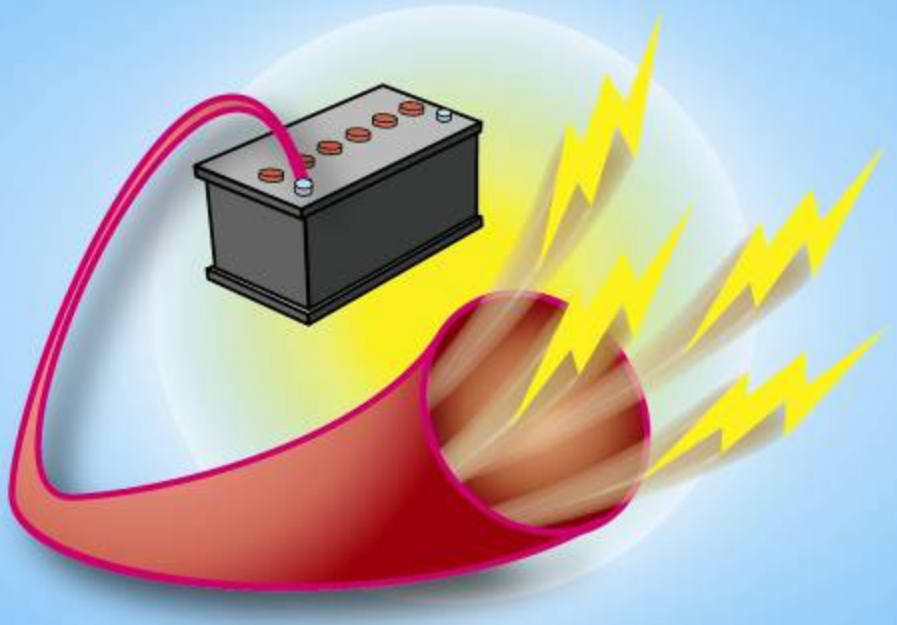
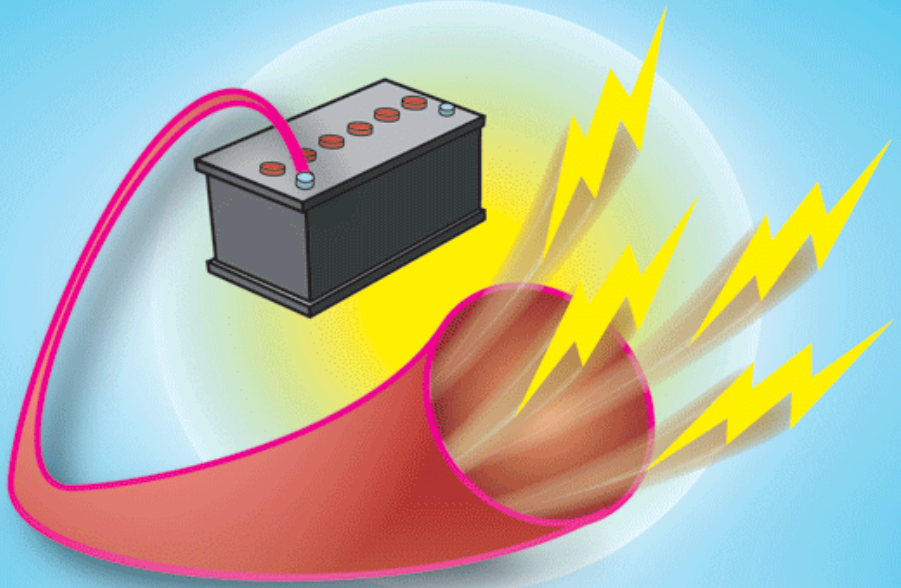
How do we measure...



... how many electrons are flowing through a wire?

AMPERE
(CURRENT)



MEASURES THE NUMBER
OF MOVING ELECTRONS
(OR ELECTRIC CHARGES)

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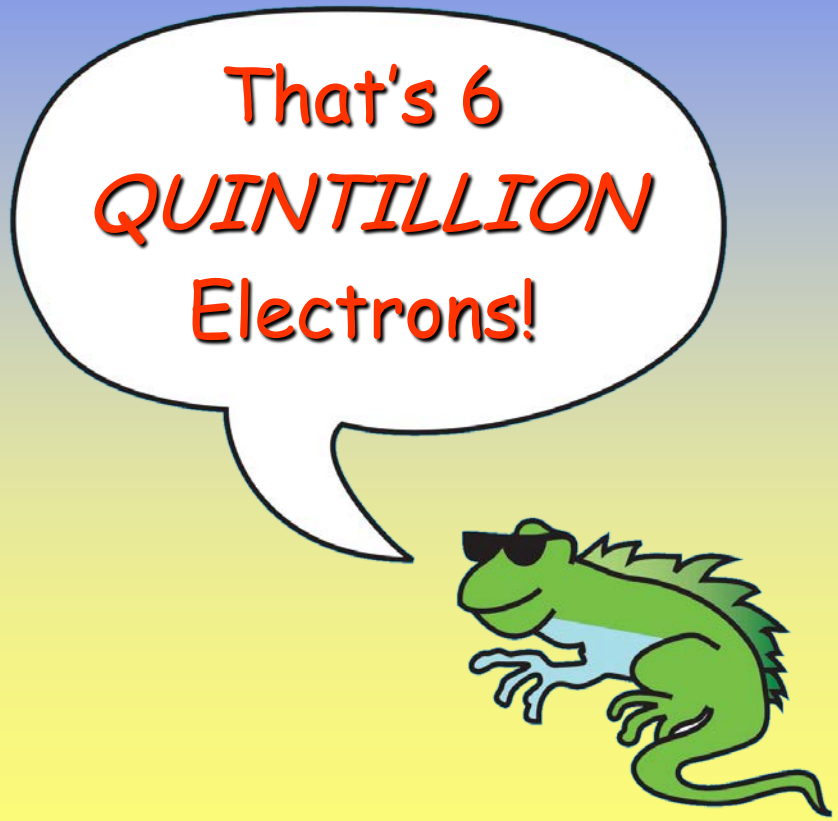
One AMP is about
6,000,000,000,000,000,000
electrons flowing
by a point
in just
1 second!



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Amp Town Races

sung to the tune of "Camptown Races"

Electrons moving in a wire,
amperes, amperes.
6 quintillion passing by,
in a second's time.

This is what we mean,
when we say ampere,
6 quintillion passing by,
in one second's time!


When we have a FORCE,
pushing a CURRENT…
…we get ENERGY!
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Energy can be harnessed to do work....
....like spinning a turbine.
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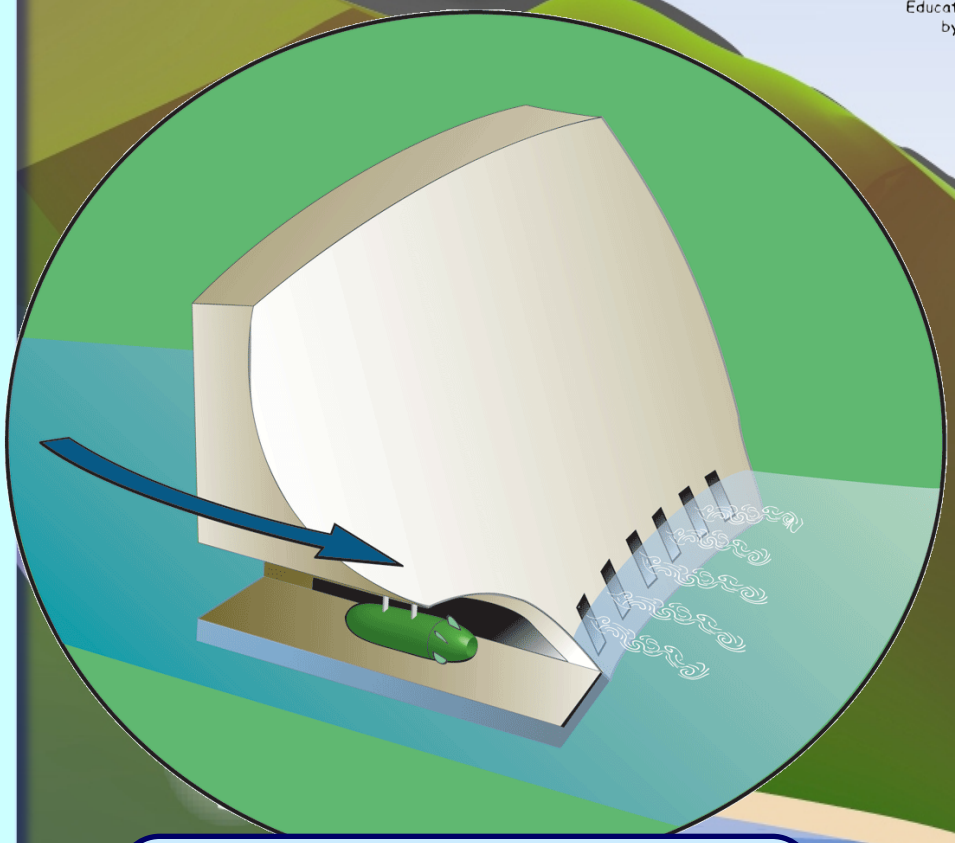
Work is an ACTIVITY, like:

- Moving something
- Heating something
- POWERING something

Work changes one form of energy into another form.



Movement into Electricity

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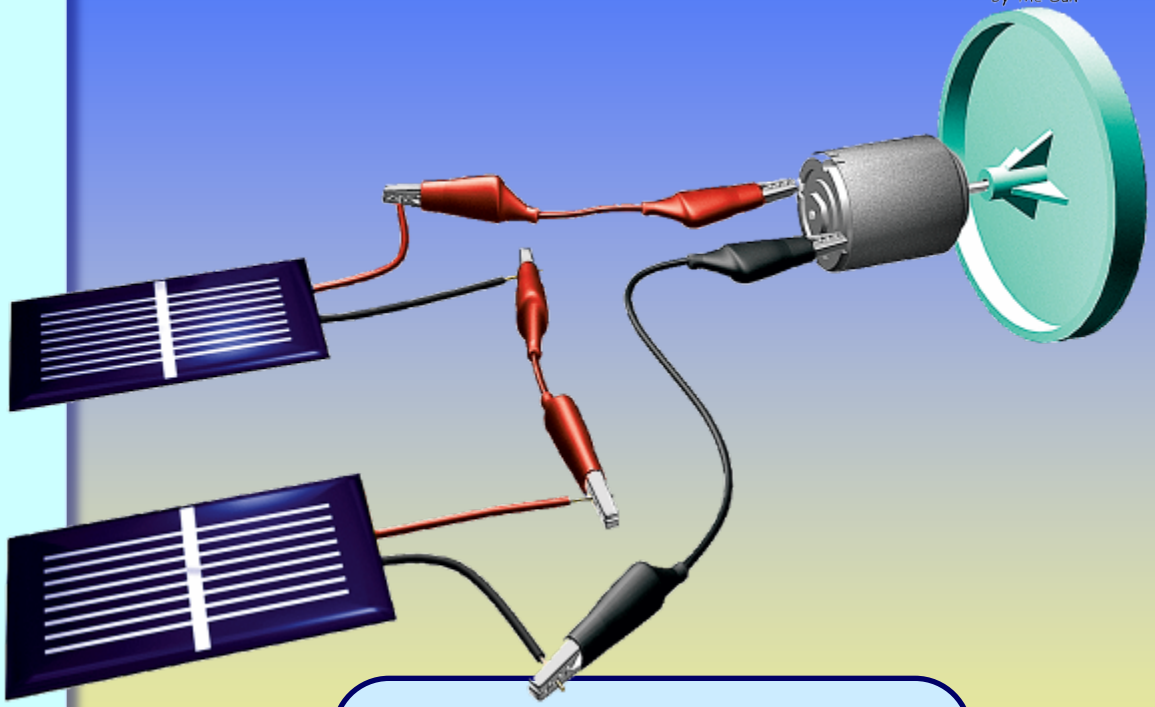
Work changes one form of energy into another form.

Electricity into Light & Heat

Work changes one form of energy into another form.



Light into Electricity into Motion

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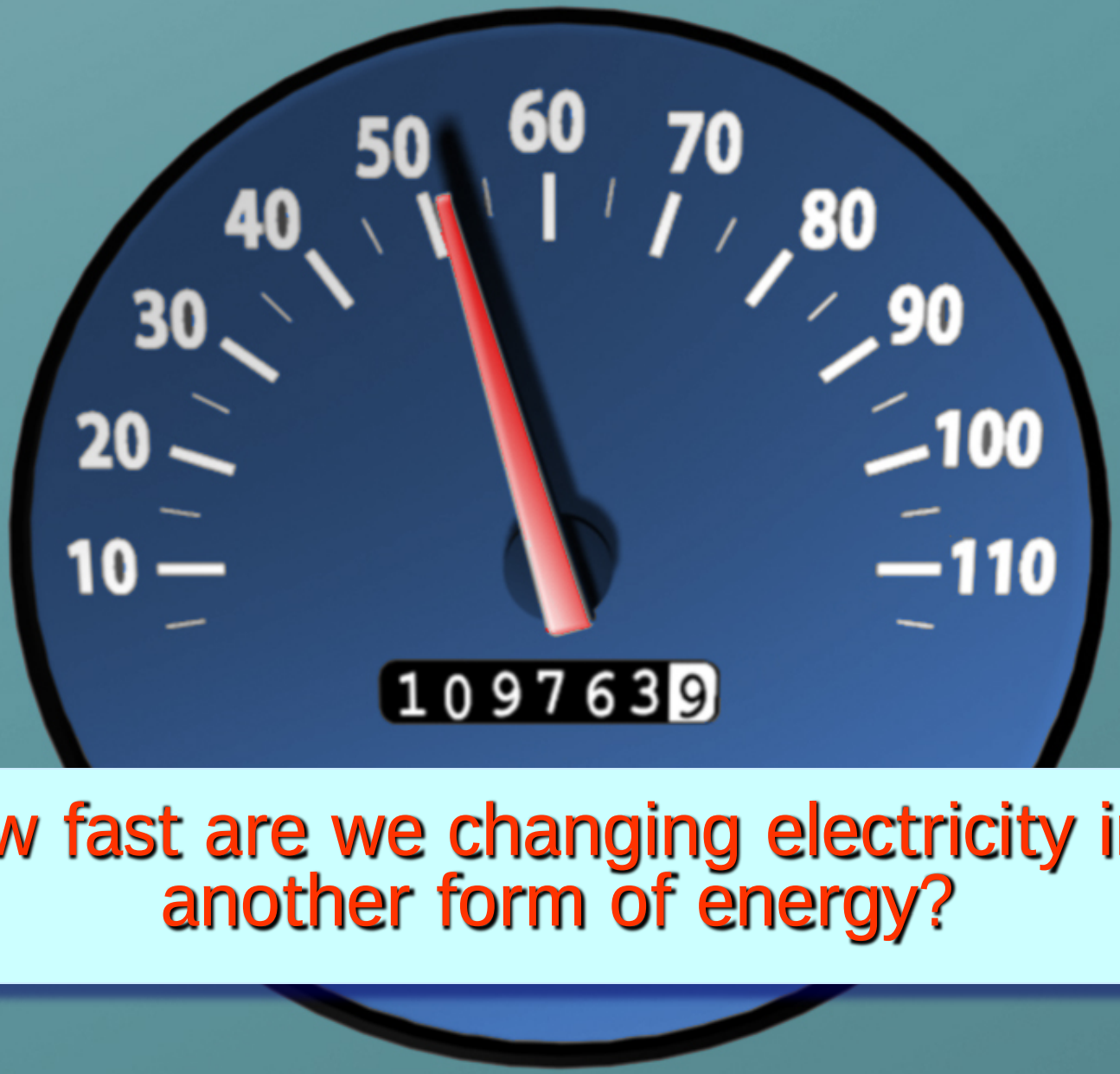
How fast are we using electricity?



How fast are we changing electricity into another form of energy?

WATT
(POWER)

MEASURES HOW FAST
ELECTRICITY IS USED
(OR GENERATED)

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This lightbulb uses energy half as fast...

50 watts

100 watts

...as this lightbulb

Watts is like miles per hour...

..but it has the "per hour" built in.

A Watt = an amount of energy converted per second

The Watts Song

sung to the tune of "On Top of Old Smokey"

Watts measure how quickly
We convert energy,
How fast we produce or
Use electricity!

WATT-HOUR

If this heater uses 1,000 watts…

…and it runs for 1 hour

It will use 1,000 watt-hours

If this heater uses 1,000 watts…

…and it runs for 1 hour

It will use 1,000 watt-hours

..or 1 kilowatt-hour

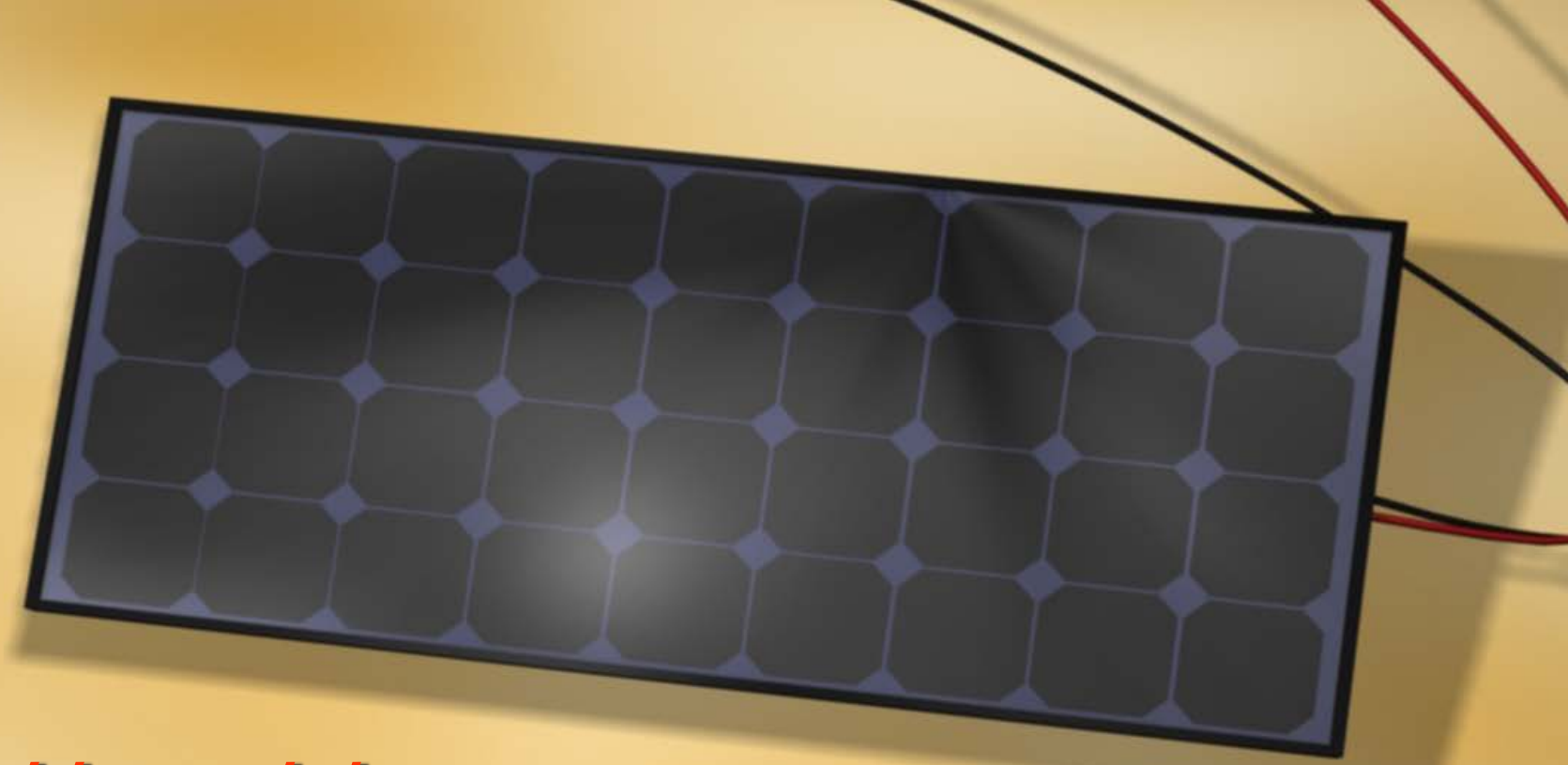
1,000 WATT-HOURS =

Watts is a rate of energy use

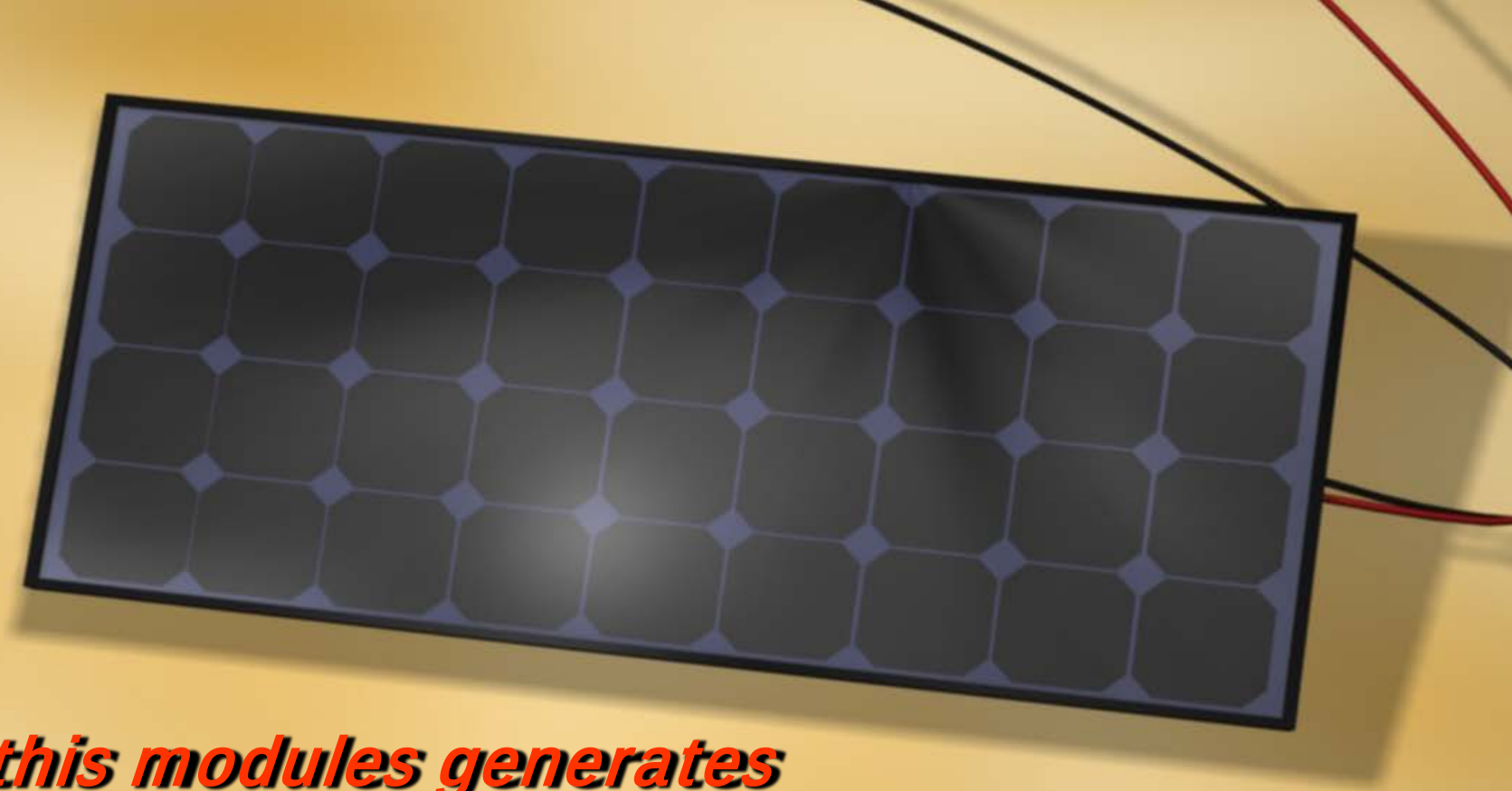
Watt-Hours is an AMOUNT of energy used

Watts is a rate of energy CONVERSION

Watt-Hours is an AMOUNT of energy used (or generated)

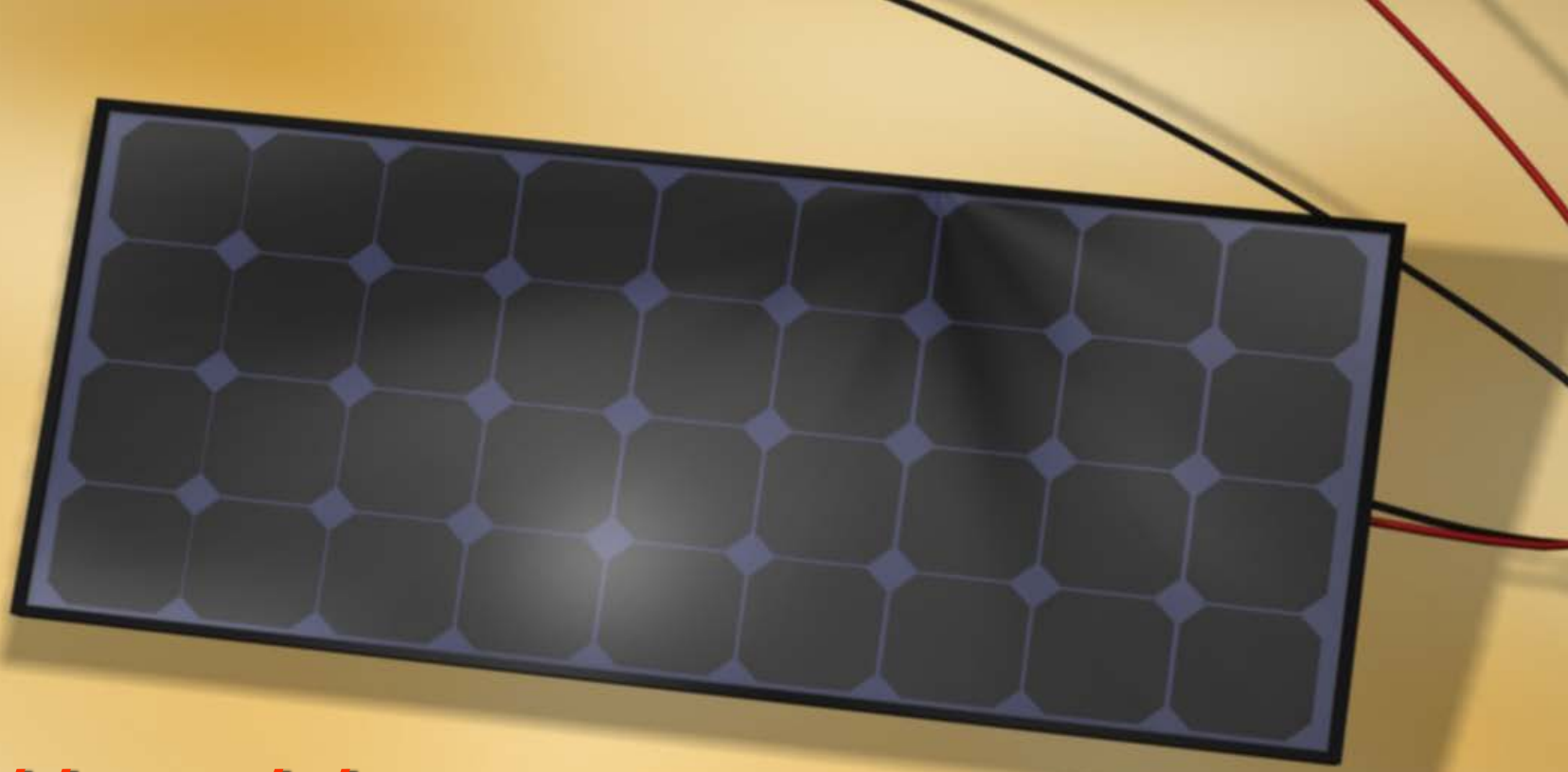


If this modules generates electricity at a rate of 100 watts…



If this modules generates electricity at a rate of 100 watts…

…for 1 hour…



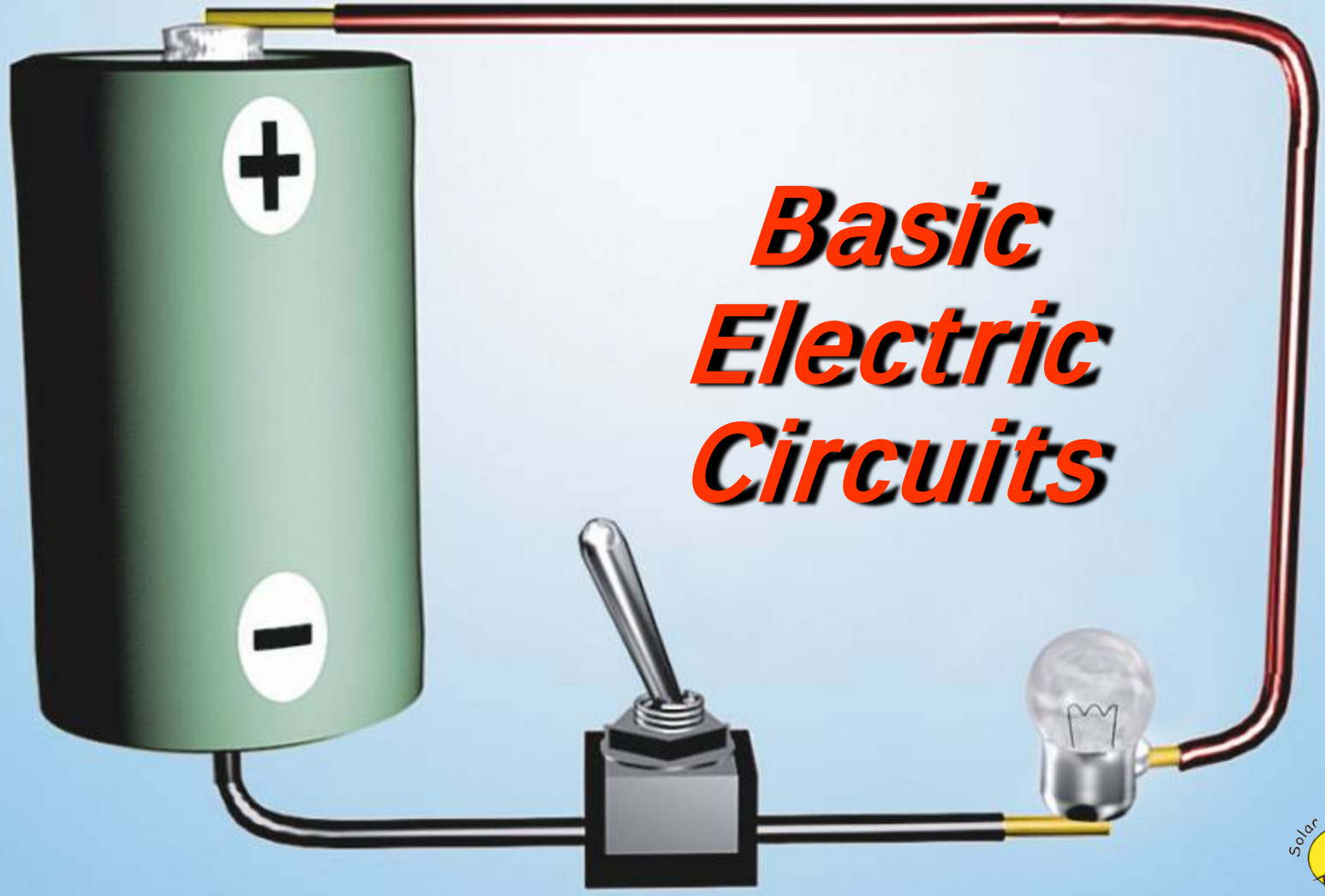
If this modules generates electricity at a rate of 100 watts...

...for 10 hours...

...it will supply 100 watt-hours

A *WATT* is an RATE of energy conversion

A *WATT-HOUR* is an AMOUNT of energy converted



Basic Electric Circuits

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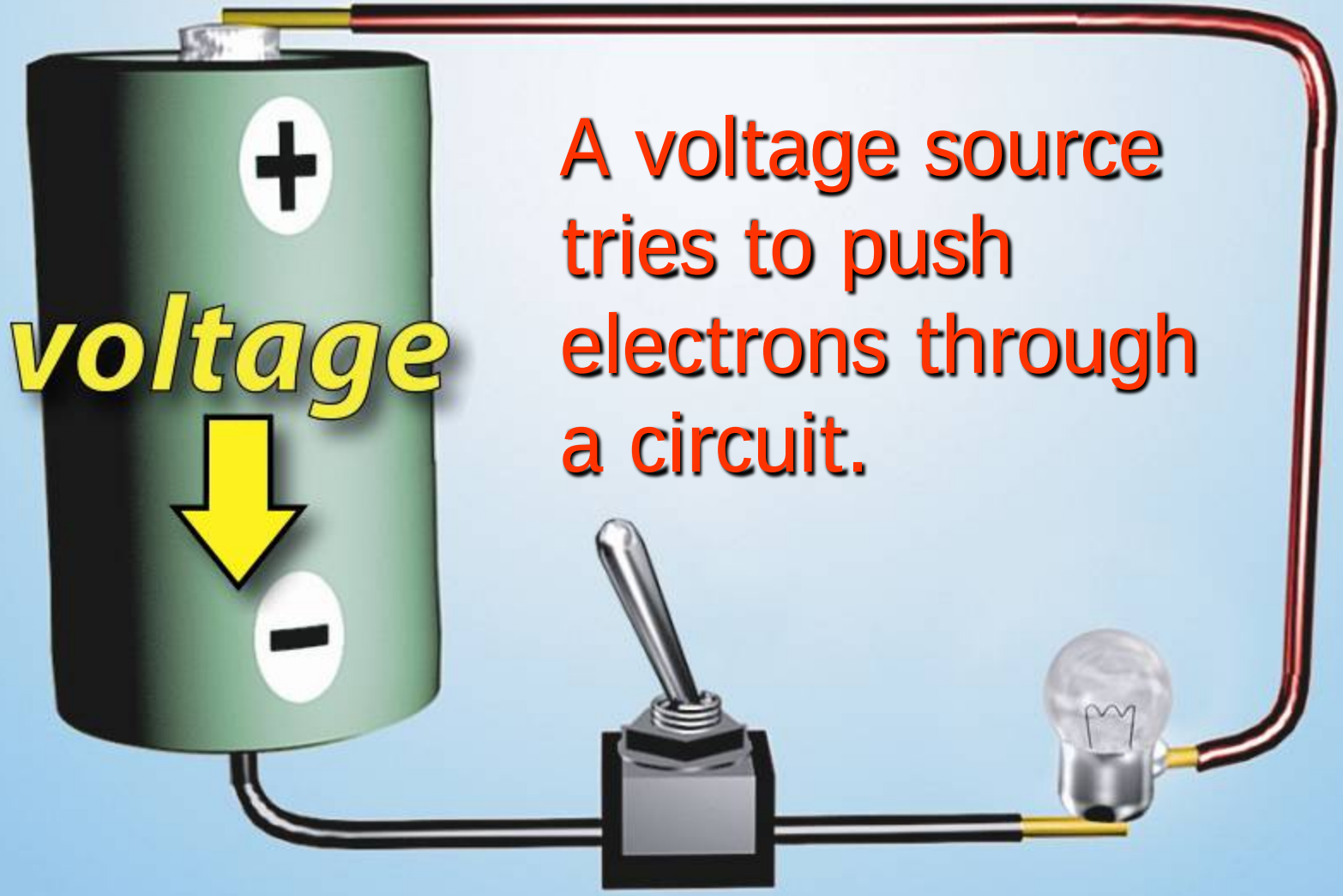
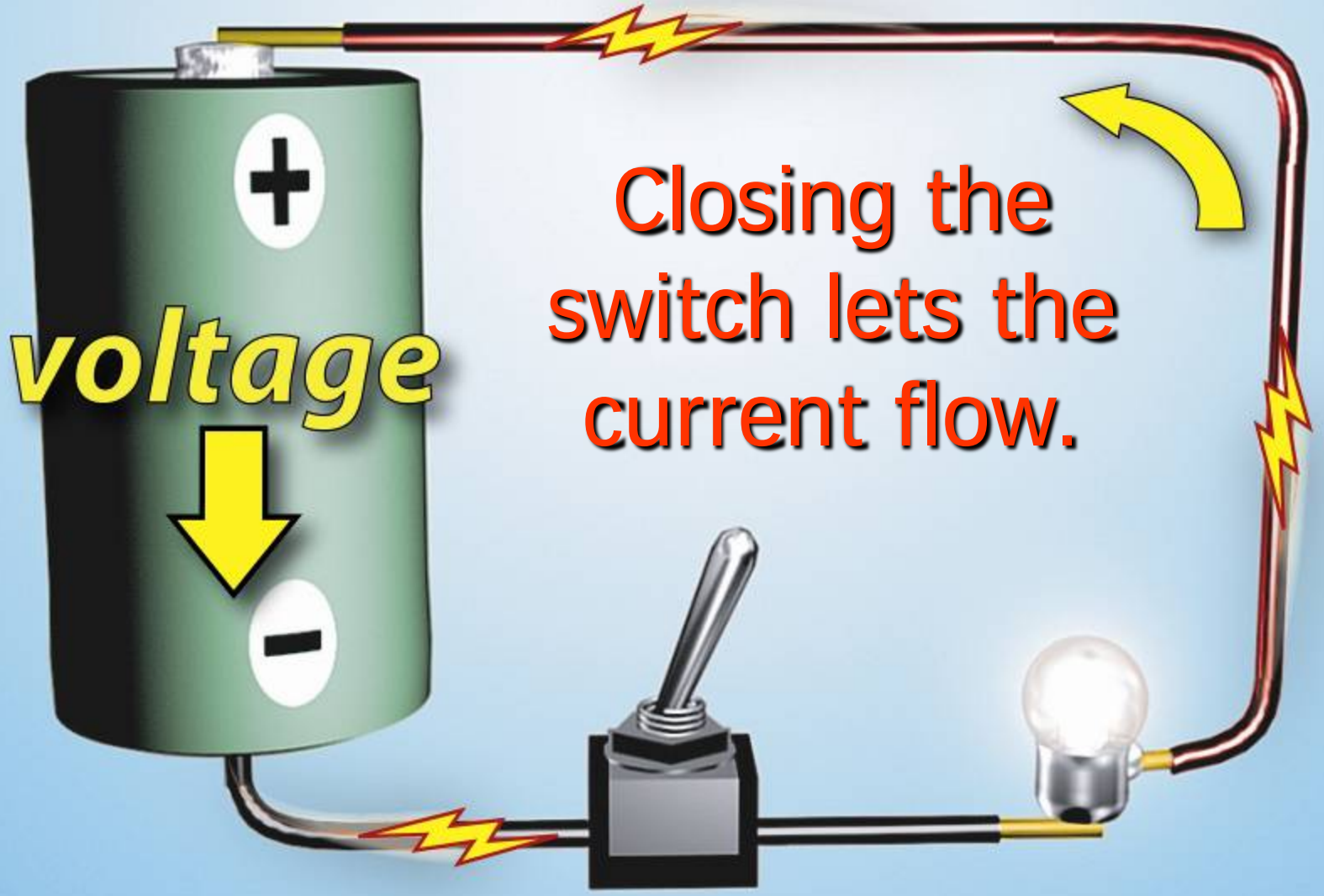


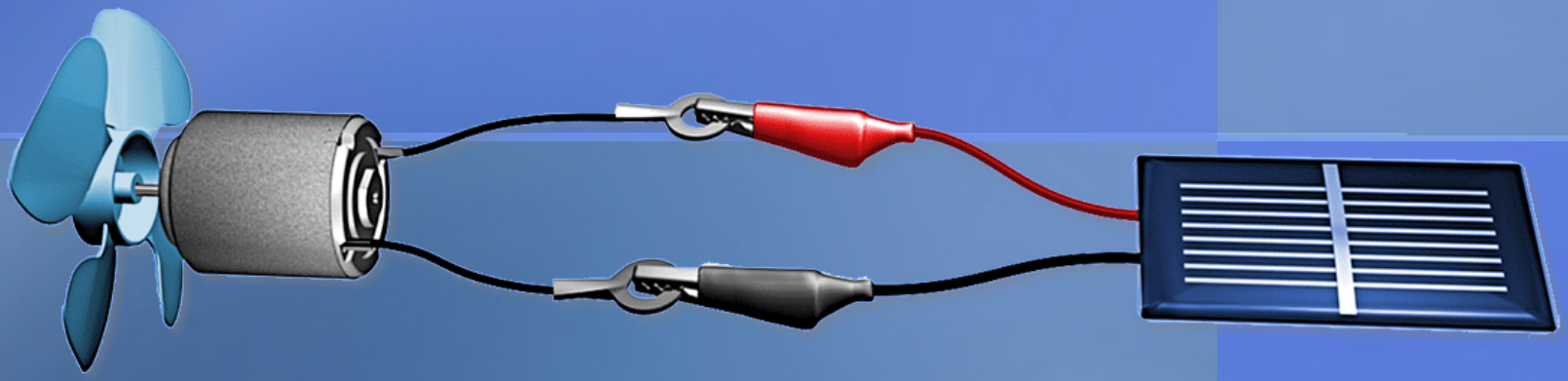
A voltage source tries to push electrons through a circuit.


voltage
Closing the switch lets the current flow.

Voltage is like water pressure…

…it forces current through conductors to power a load.

Simple Circuit



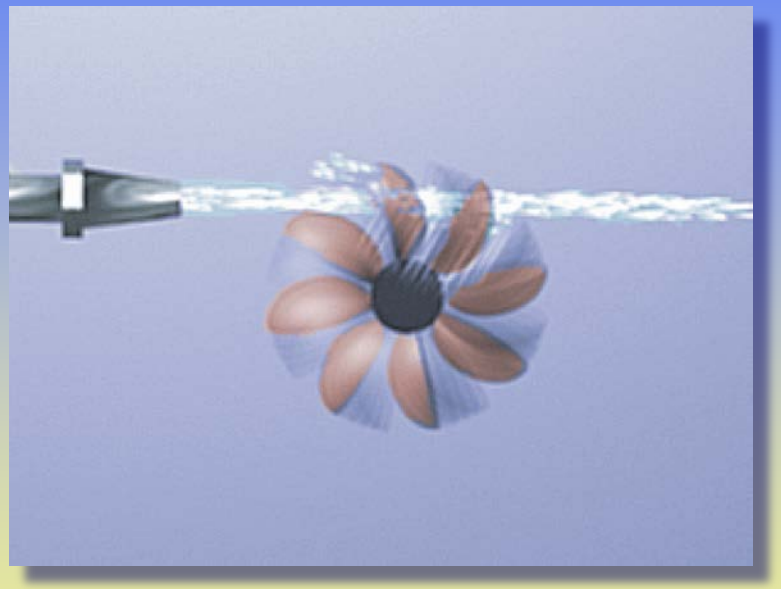
- Solar Cell
- Conductors
- Load

Red wires are positive, black are negative

Solar Cell Classroom Set

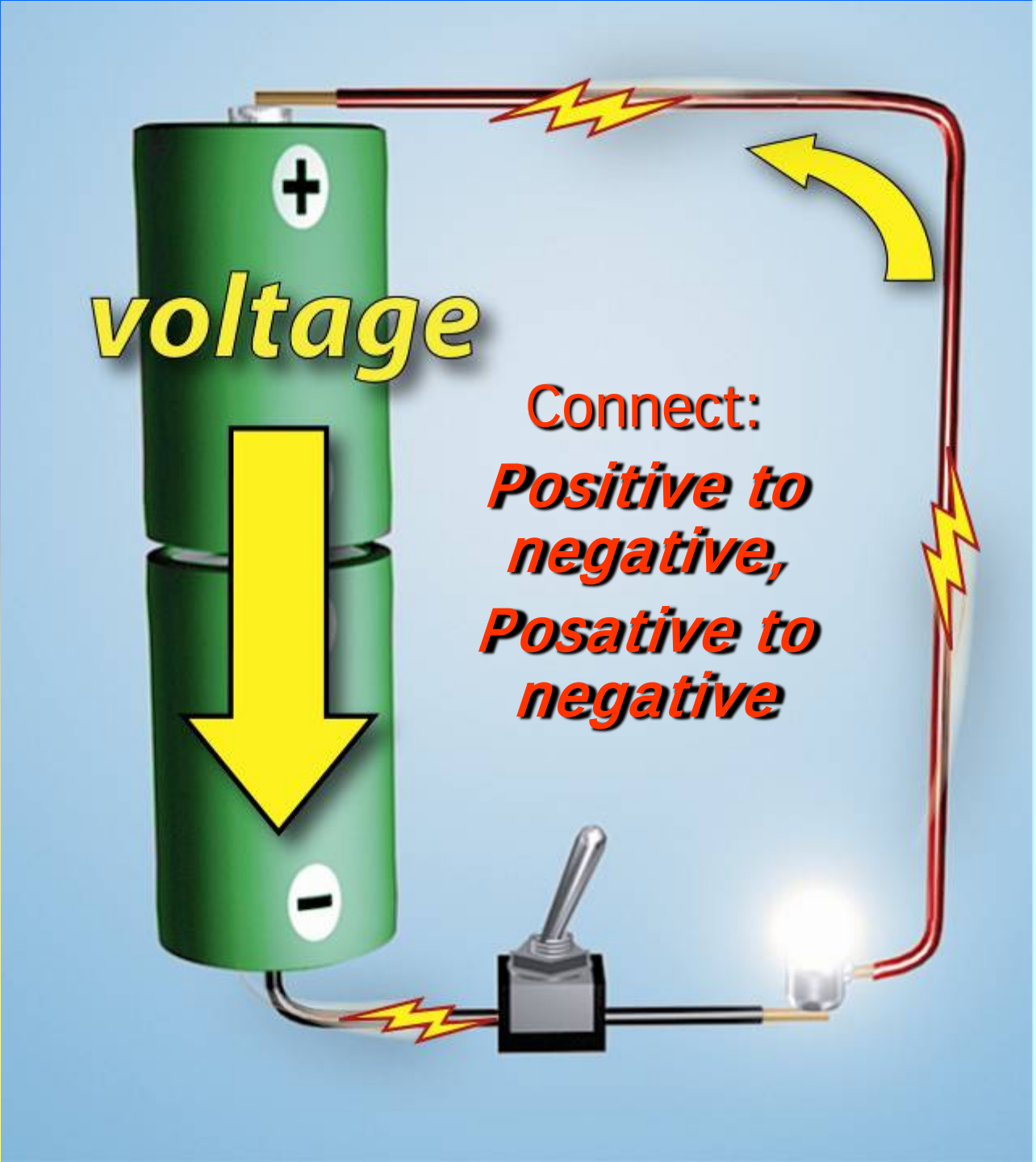
See Teaching Solar, pg. 140

What if we need more energy?



To make the wheel spin faster?

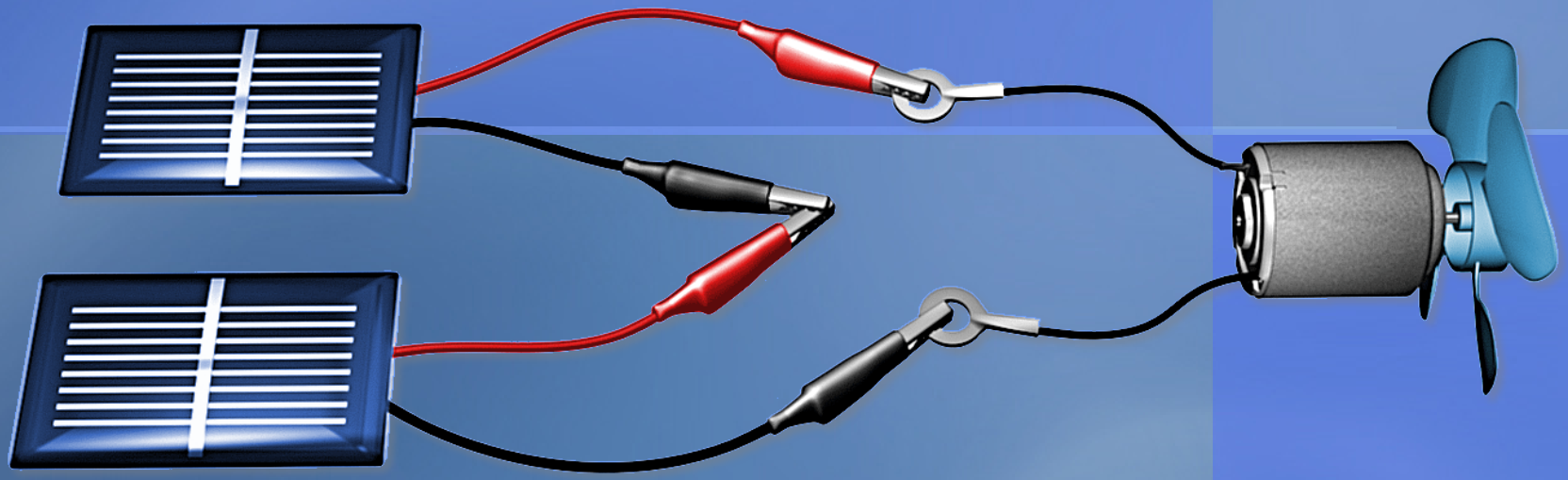
We can double the height of the tank & double the weight of the water.



Series Wiring

adds the voltage of each voltage source together.

Series Circuit

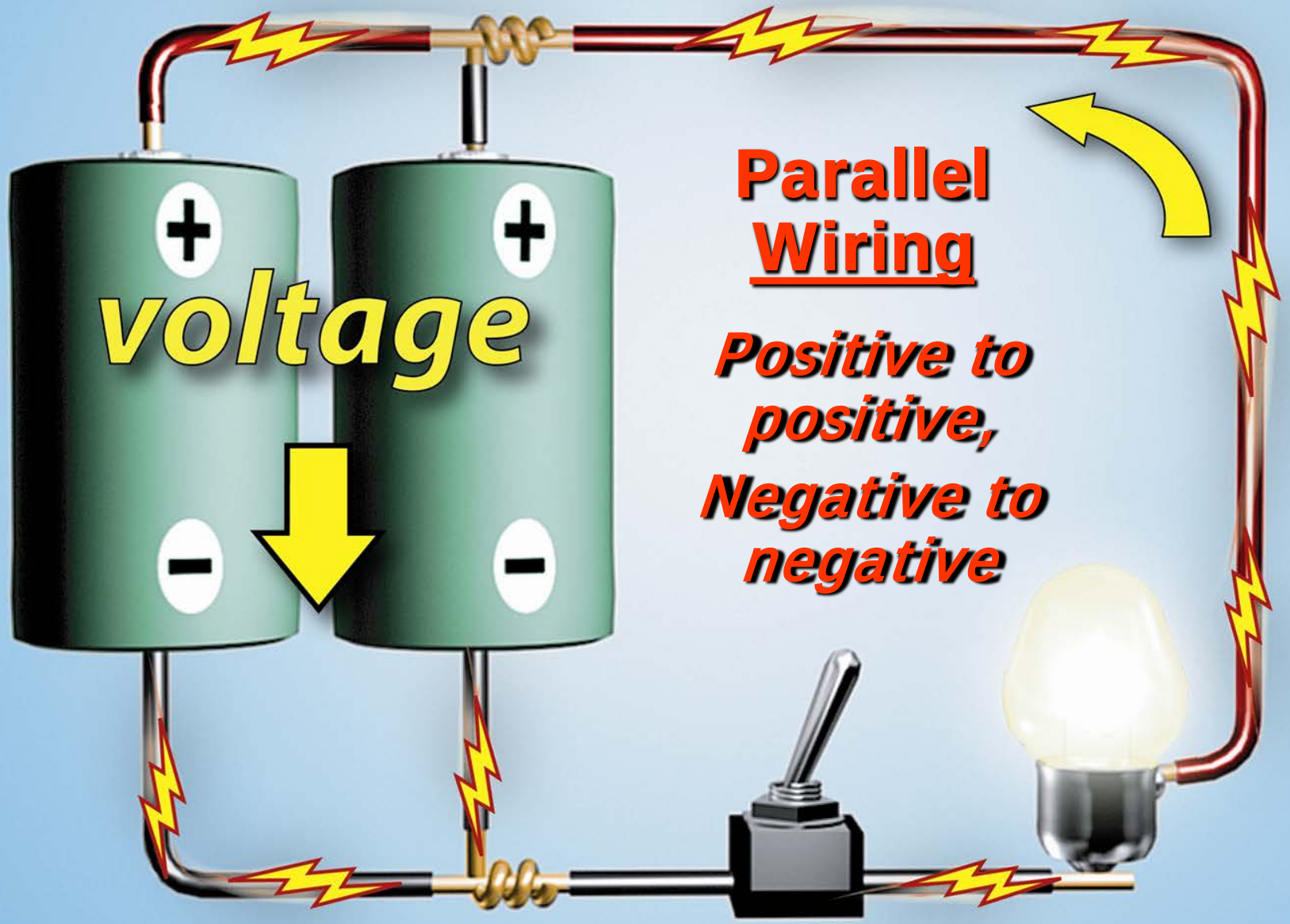


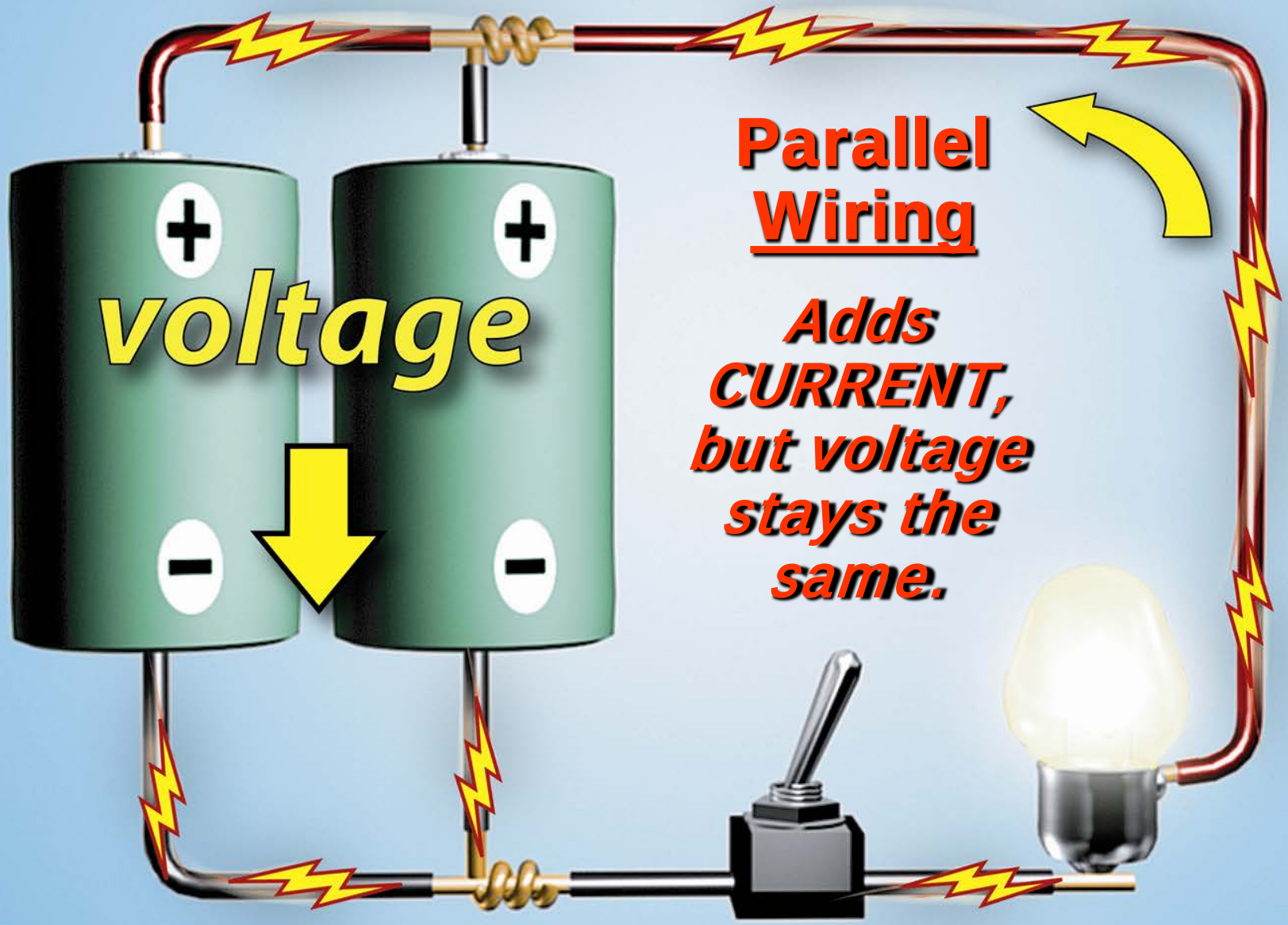
- Cells connected in a string: + to -, + to –
- Voltage is added; current stays the same

Sometimes we need to increase ***CURRENT***...

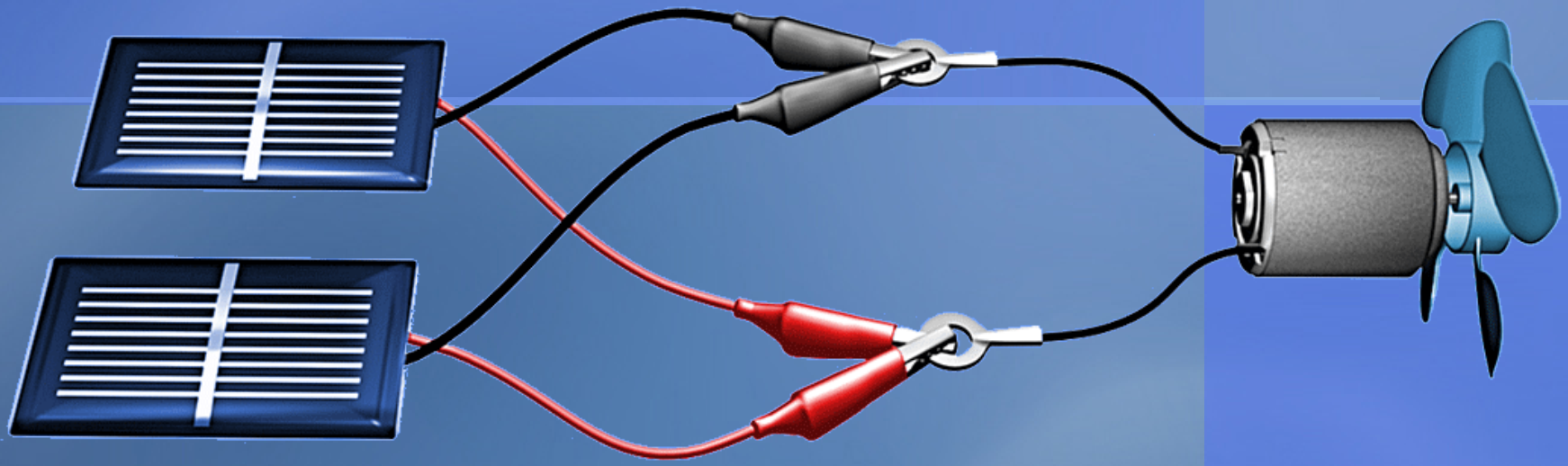
Sometimes we need to increase ***CURRENT***...

...and keep the voltage the same.


voltage
Parallel
Wiring
Positive to
positive,
Negative to
negative


Parallel
Wiring
Adds CURRENT, but voltage stays the same.
voltage
+
+
−
−

Parallel Circuit

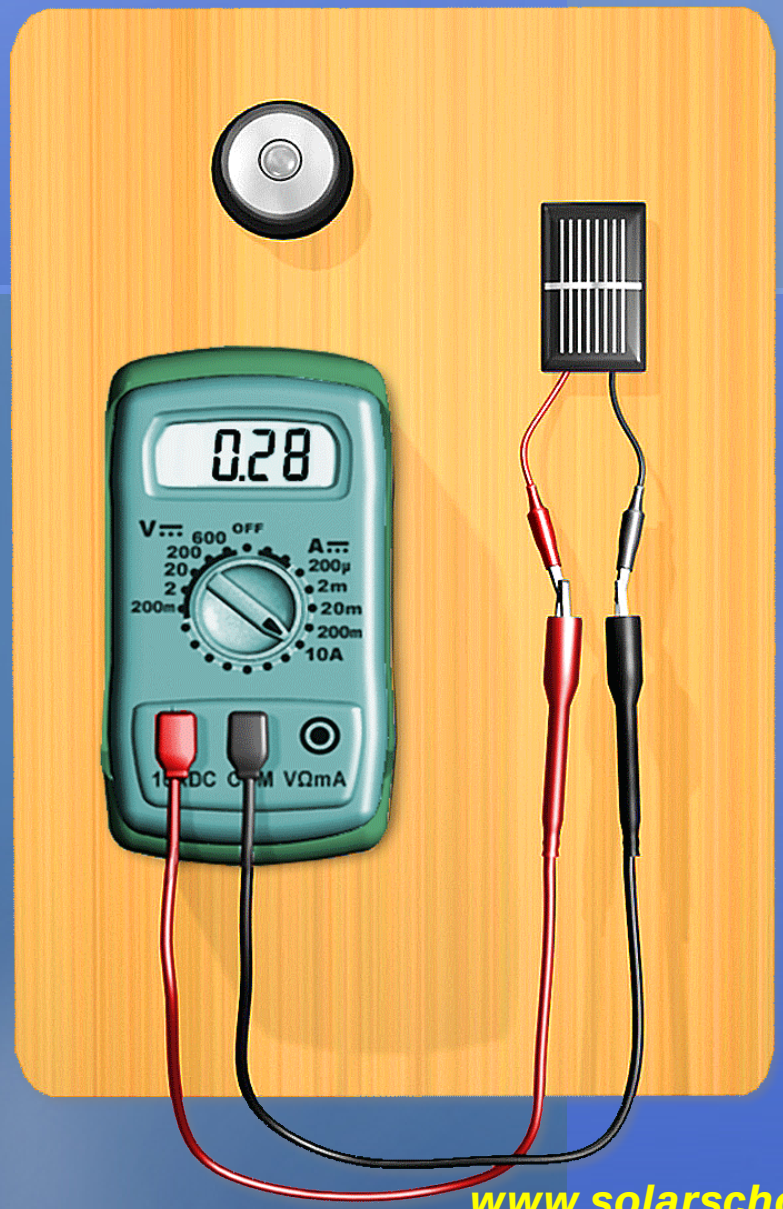


- Positives connected & negatives connected
- Amperage is added; voltage stays the same

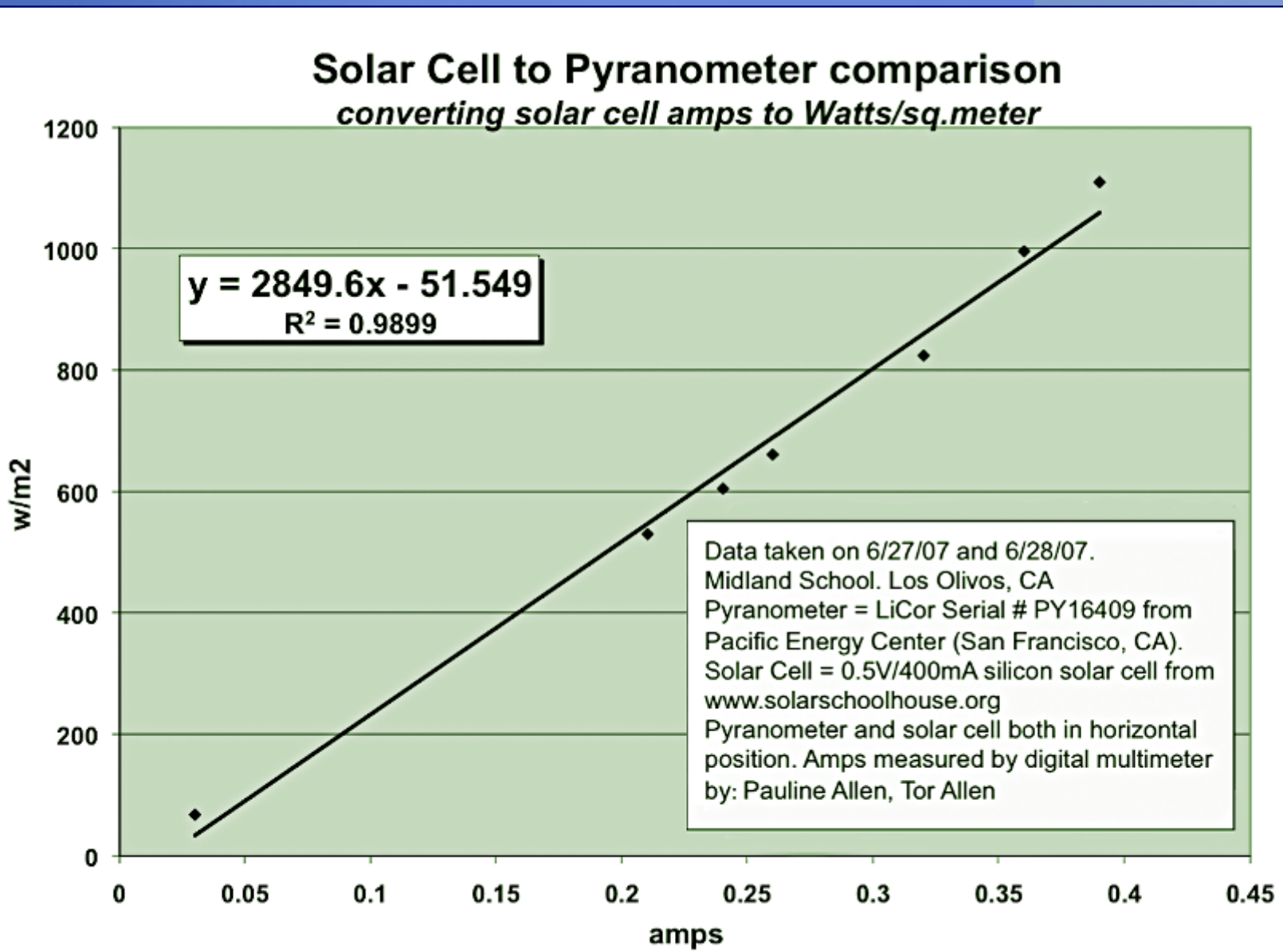
SOLRAD Meter

ADVANCED PROJECTS

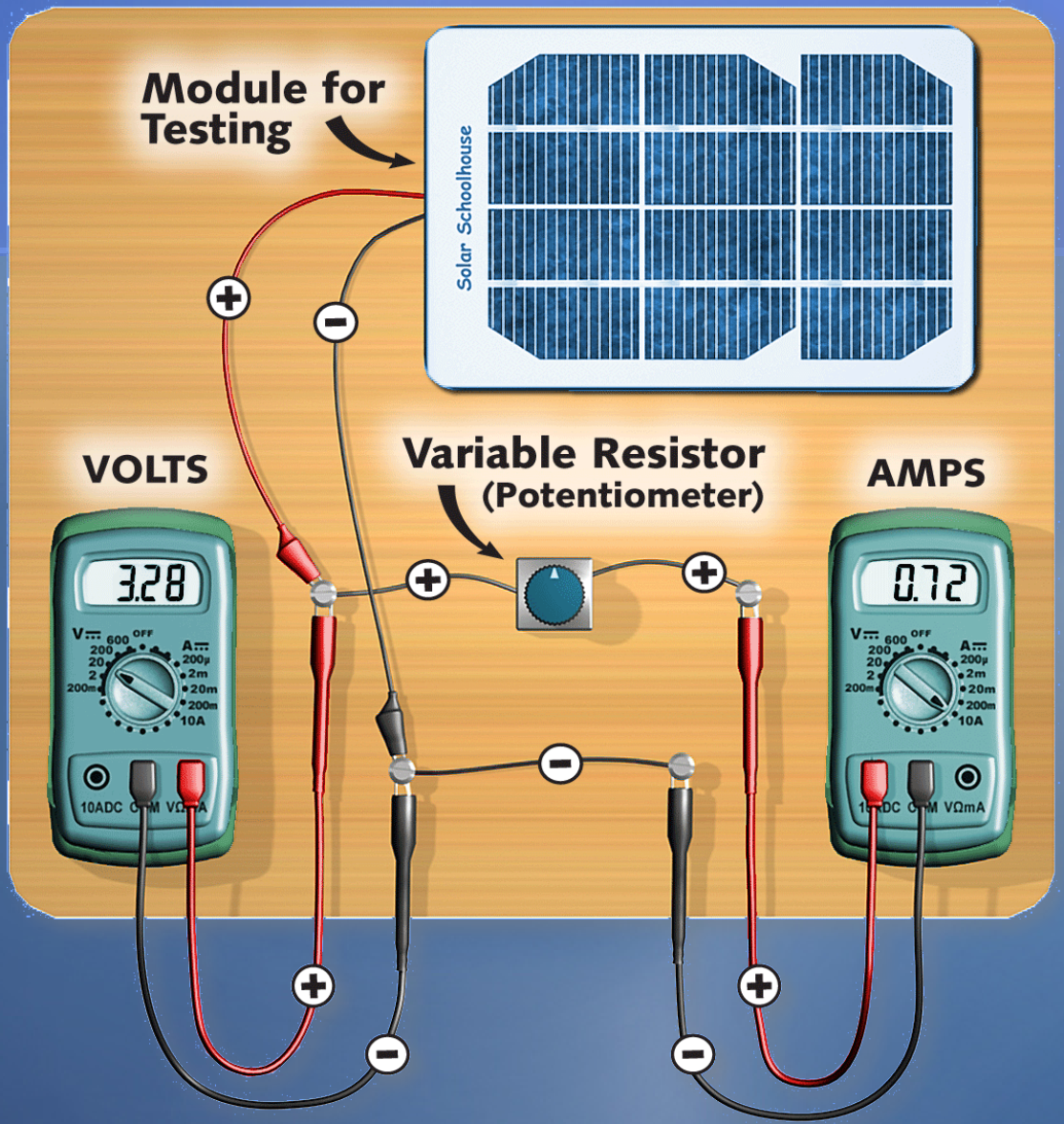
Measures Solar Radiation in Watts per Square Meter



See Teaching Solar, pg. 144


Solar Cell to Pyranometer comparison
converting solar cell amps to Watts/sq.meter
y = 2849.6x - 51.549
R² = 0.9899
w/m2
amps
0
200
400
600
800
1000
1200
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Data taken on 6/27/07 and 6/28/07.
Midland School. Los Olivos, CA
Pyranometer = LiCor Serial # PY16409 from Pacific Energy Center (San Francisco, CA).
Solar Cell = 0.5V/400mA silicon solar cell from www.solarschoolhouse.org
Pyranometer and solar cell both in horizontal position. Amps measured by digital multimeter
by: Pauline Allen, Tor Allen

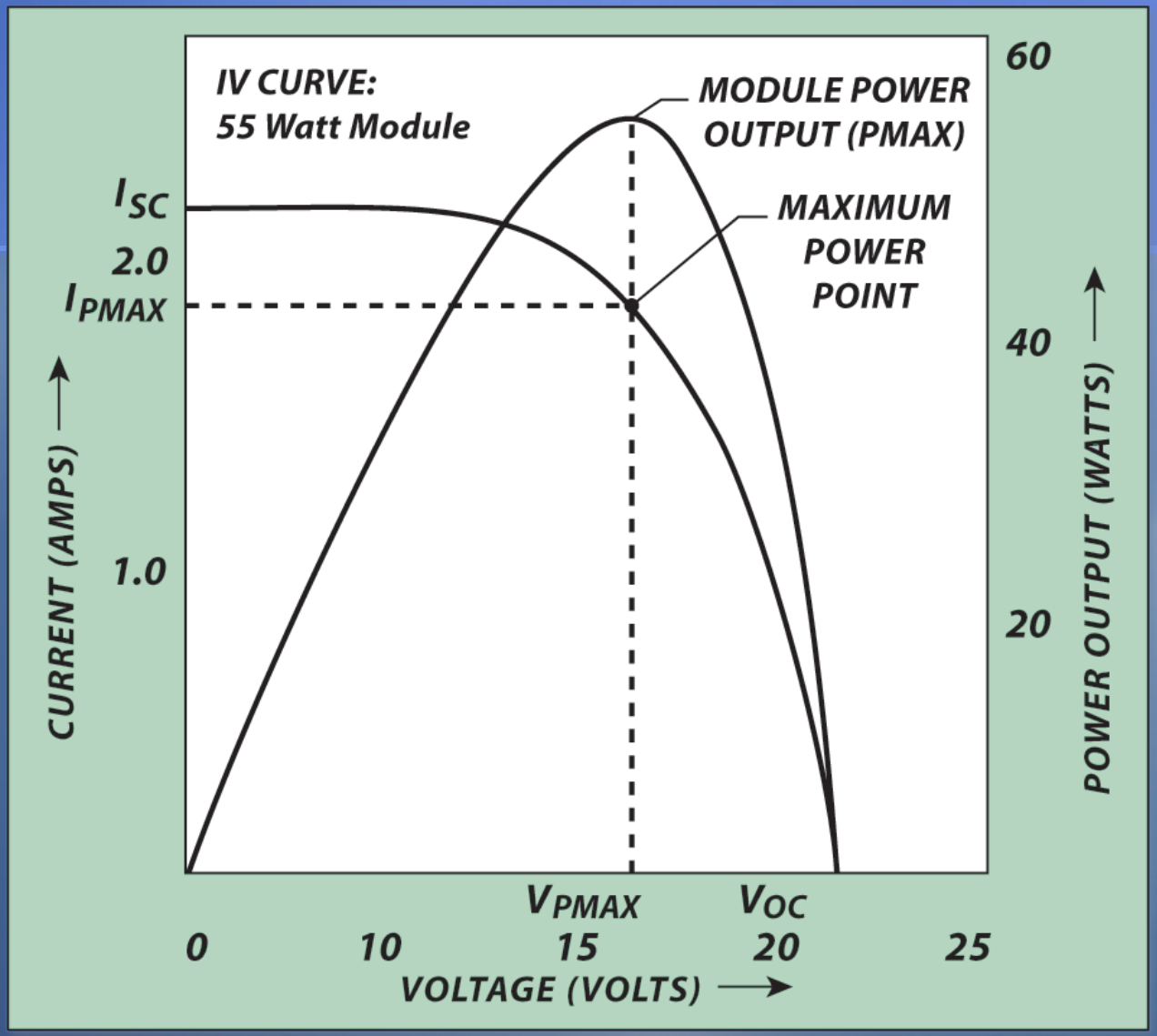
IV Curvetester



See Teaching Solar, pg. 145

Measures a module's voltage & current characteristics

IV Curvetester



Students can plot output curves to find maximum power points

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Thank You!

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