

# Teaching About Hydrogen Fuel Cells

NSTA - March 12, 2011

**Chris Keller**  
*Curriculum Developer*  
SEPUP

The Lawrence Hall of Science  
UC Berkeley



© 2011 The Regents of the University of California



# For More Information

Contact me: [chris\\_k@berkeley.edu](mailto:chris_k@berkeley.edu)

Publisher: LAB-AIDS, Inc. [lab-aids.com](http://lab-aids.com)

Curriculum Website: [sepuplhs.org/hydrogen](http://sepuplhs.org/hydrogen)

Both #1613

# HyTEC: Hydrogen Technology and Energy Curriculum

- Funded by U.S. Dept of Energy
- Module: “Investigating Alternative Energy: Hydrogen & Fuel Cells”
- High School Chemistry (or Physics & Envi. Sci.)
- Developed by a team of scientists, engineers, curriculum developers, and teachers
- Development process includes extensive classroom testing and feedback



# Partners

**The Lawrence  
Hall of Science**



**Schatz Energy  
Research Center**



**AC Transit**



**FilmSight  
Productions**



**LAB-AIDS, Inc.**



**Teachers and students from SF Bay Area, Washington,  
Ohio, California, Connecticut, Georgia, New York, and  
South Carolina**



# Issue-Oriented Science

- Engages students in learning science and applying it to make evidence-based decisions.
- Does not advocate a particular decision, but does advocate the use of scientific evidence and concepts in the decision-making process.
- Encourages students to look at various sides of an issue and evaluate the trade-offs involved in a complex decision.

# *Hydrogen & Fuel Cells* Curriculum

Six activities take approximately two weeks of instructional time.

- 1. Hydrogen for Transportation?** - Students examine trade-offs of various fuel/vehicle combinations.

# Activity #1: Hydrogen for Transportation?





# Alternative Energy Vehicles



Gasoline Internal  
Combustion (ICE)



Bio-diesel



Electric



Hydrogen  
Fuel Cell



Hybrid

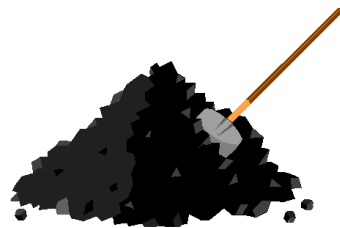
Other?



# Hydrogen

- Hydrogen is the most common element in the universe.
- The sun is composed mostly of hydrogen gas.
- Where is hydrogen found on Earth?

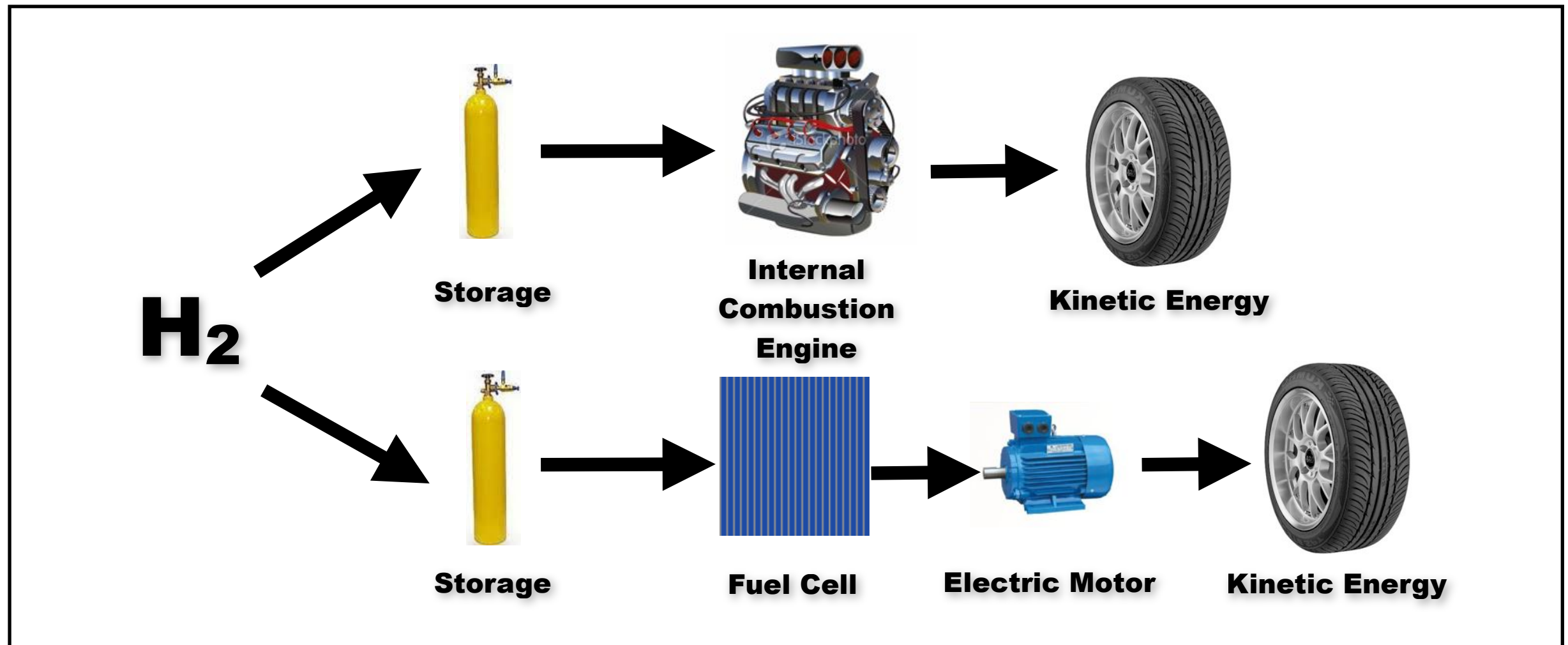
Hydrogen occurs naturally as a component of water, air, and hydrocarbon fuels like coal and natural gas.



# How do we get Hydrogen?



# What do we do with Hydrogen?



- A way to store energy (like a battery)
- A way to move energy (like electricity)
- NOT an energy source and NOT free



# *Hydrogen & Fuel Cells* Curriculum

- 1. Hydrogen for Transportation?** - Students examine trade-offs of various fuel/vehicle combinations.
- 2. Obtaining Hydrogen through Electrolysis** - In this hands-on lab, students generate hydrogen and examine the required energy input, stoichiometry, and electrochemistry involved in the process.

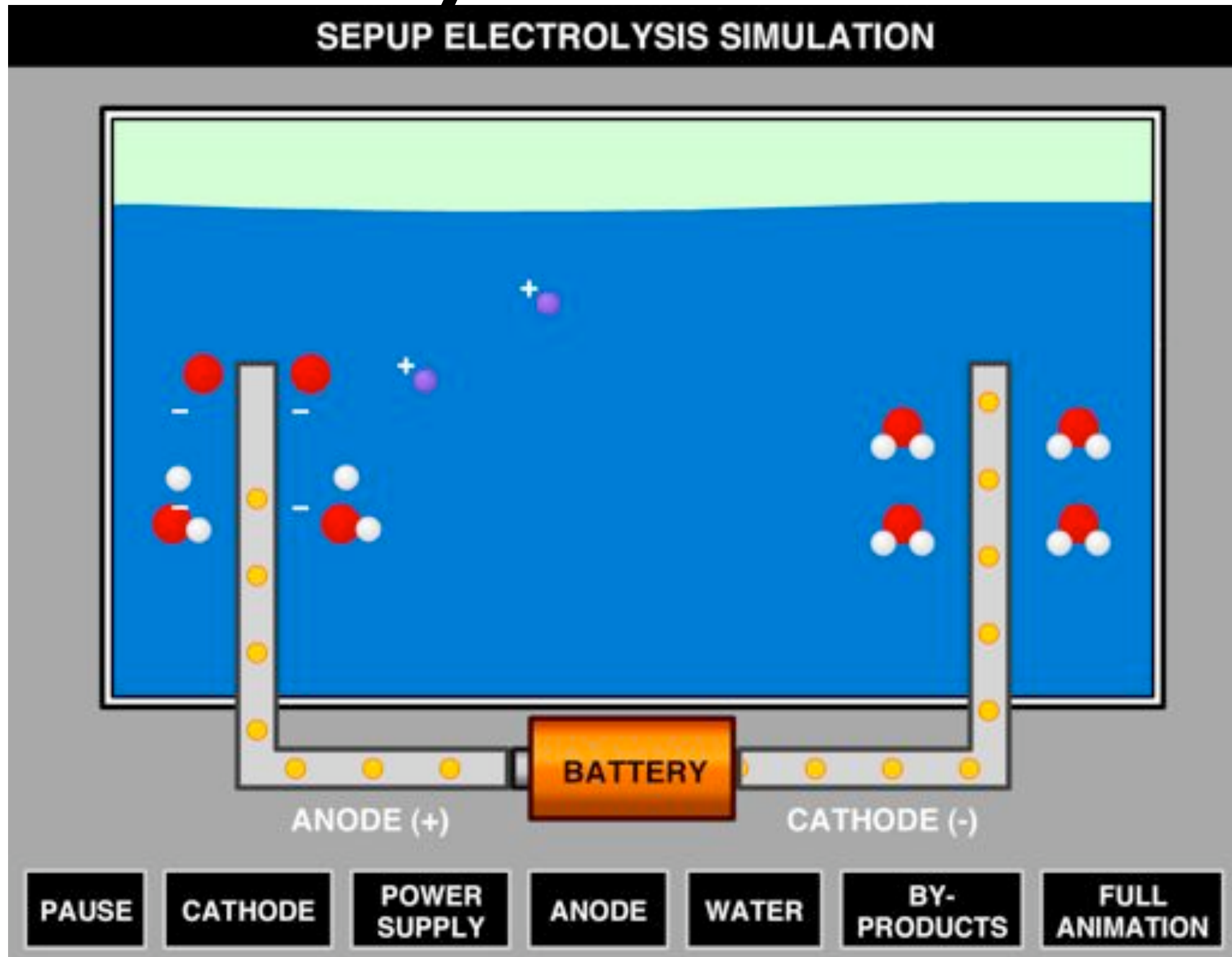


# Kit Materials



- Electrolyzer
- Power Supply
- Fuel Cell
- Motor
- etc.

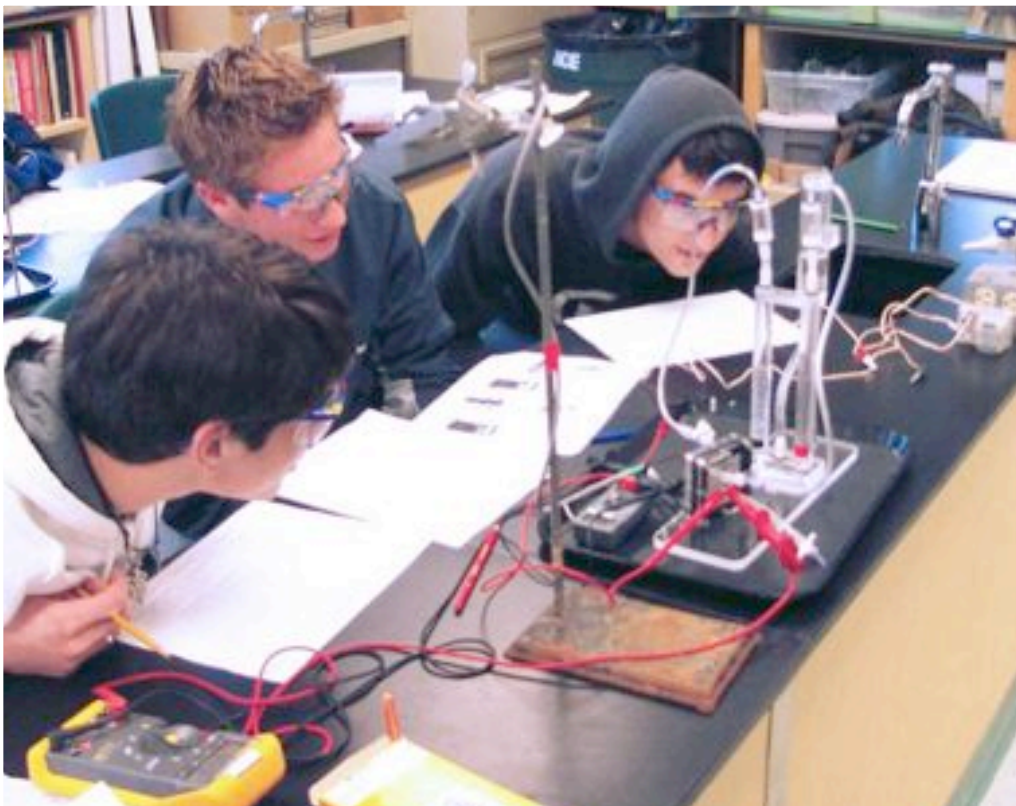
# Electrolysis Simulation





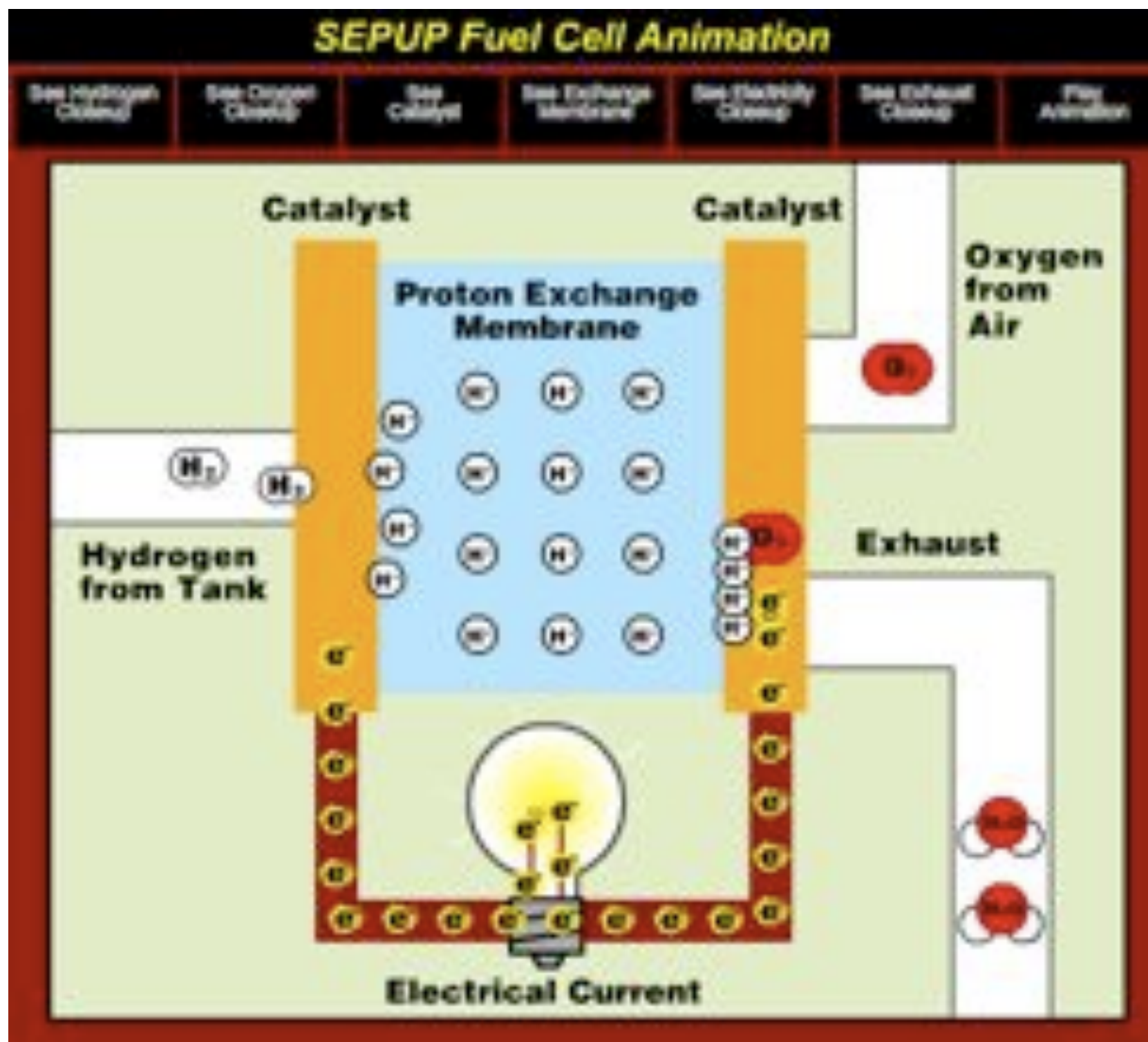
# Hydrogen & Fuel Cells Curriculum

3. **Observing a Fuel Cell** - Students generate  $H_2$  and  $O_2$ , and use a single cell fuel cell to perform work.



4. **Modeling the Fuel Cell Reaction** - Students use model pieces and a fuel cell simulation to explore the fuel cell reaction.

# Activity #4: Modeling the Fuel Cell Reaction

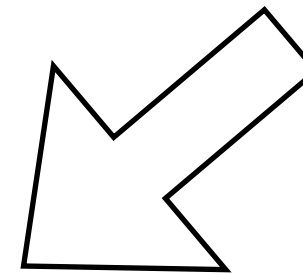
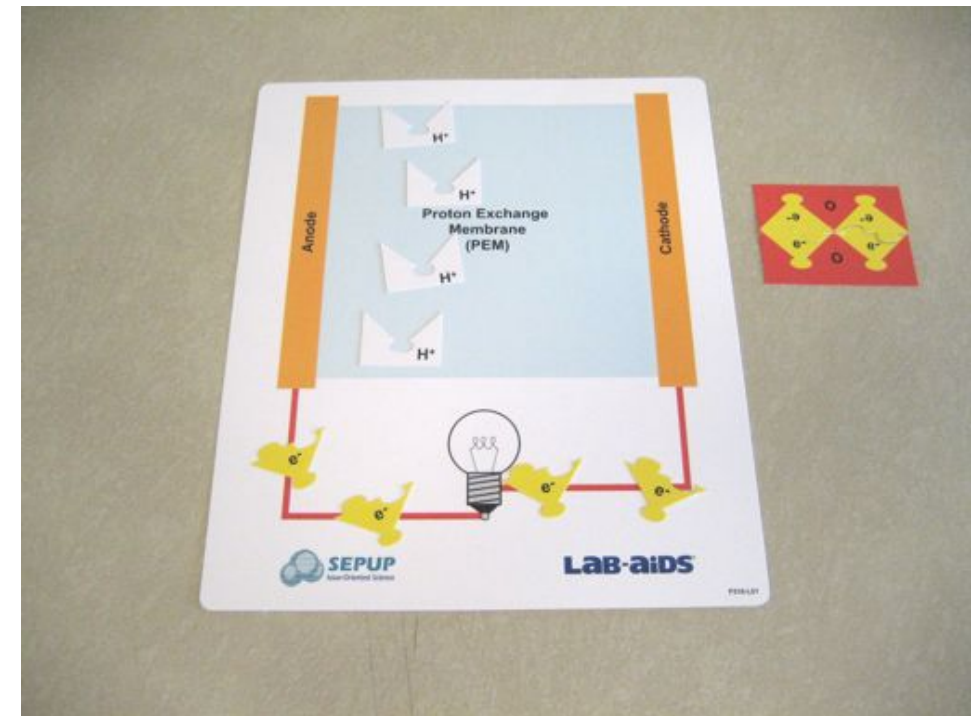
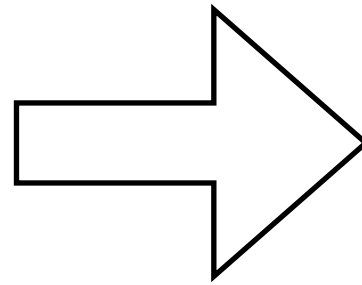
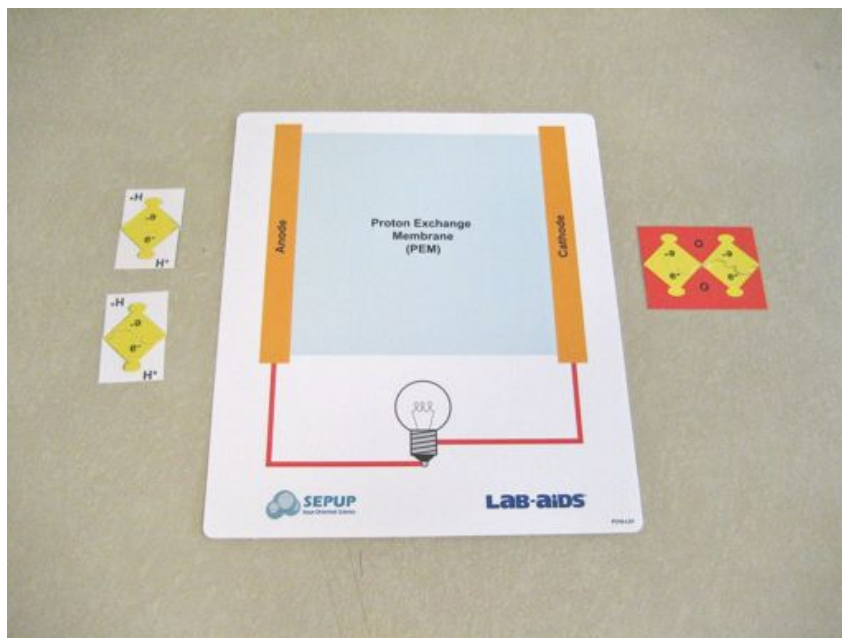


# Modeling the Fuel Cell Reaction





# Modeling the Fuel Cell Reaction



# Student Activity

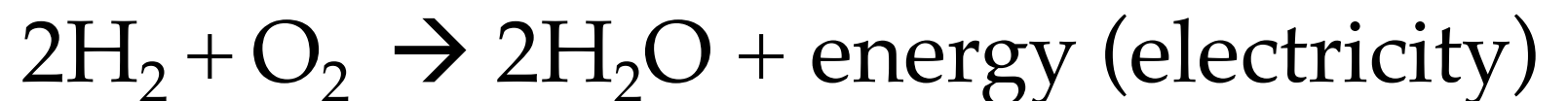
## The Fuel Cell Half Reactions

The half-reactions:

- Oxidation:  $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
- Reduction:  $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$

Adding the half-reactions:

- Oxidation:  $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$
- Reduction:  $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$



# Hydrogen & Fuel Cells Curriculum

- 5. Fuel Cell Efficiency** - In a hands-on lab, students measure fuel cell efficiency.
- 6. Hydrogen for Buses?** Students conduct research and engage in a simulated City Council Meeting to present the advantages and challenges of using hydrogen and fuel cells for a city bus program.





# Website and Videos

*Hydrogen & Fuel Cells*  
website:

[sepuplhs.org/hydrogen](http://sepuplhs.org/hydrogen)

Simulations

Clips from video field trip

Web Resources

Info on fuel cells





# SEPUP

## Science Education for Public Understanding Program

[HOME](#)[CURRICULA](#)[RESOURCES](#)[ABOUT](#)[NEWS](#)[OUR PUBLISHER](#)[CONTACT](#)[ONLINE STUDENT BOOK](#)

### HYTEC: VIDEOS



Video 1: Intro



Video 2: On the Bus



Video 3: Portable Fuel Cells



Video 4: Solar Power

# Applications of Fuel Cells

## Video highlights:

- Fuel cell bus in Oakland, CA
- Portable applications: video camera, computer
- Production from hydrogen using renewable sources
- Production of hydrogen from landfill gas





# NSES Addressed

## **Structure of Atoms:**

- Matter is made of minute particles called atoms.

## **Structure and Properties of Matter:**

- Atoms interact with one another by sharing or transferring electrons

## **Chemical Reactions:**

- Chemical reactions occur all around us
- Chemical reactions may release or consume energy
- A large number of reactions involve transfer of electrons
- Catalysts lower activation energy necessary for reactions

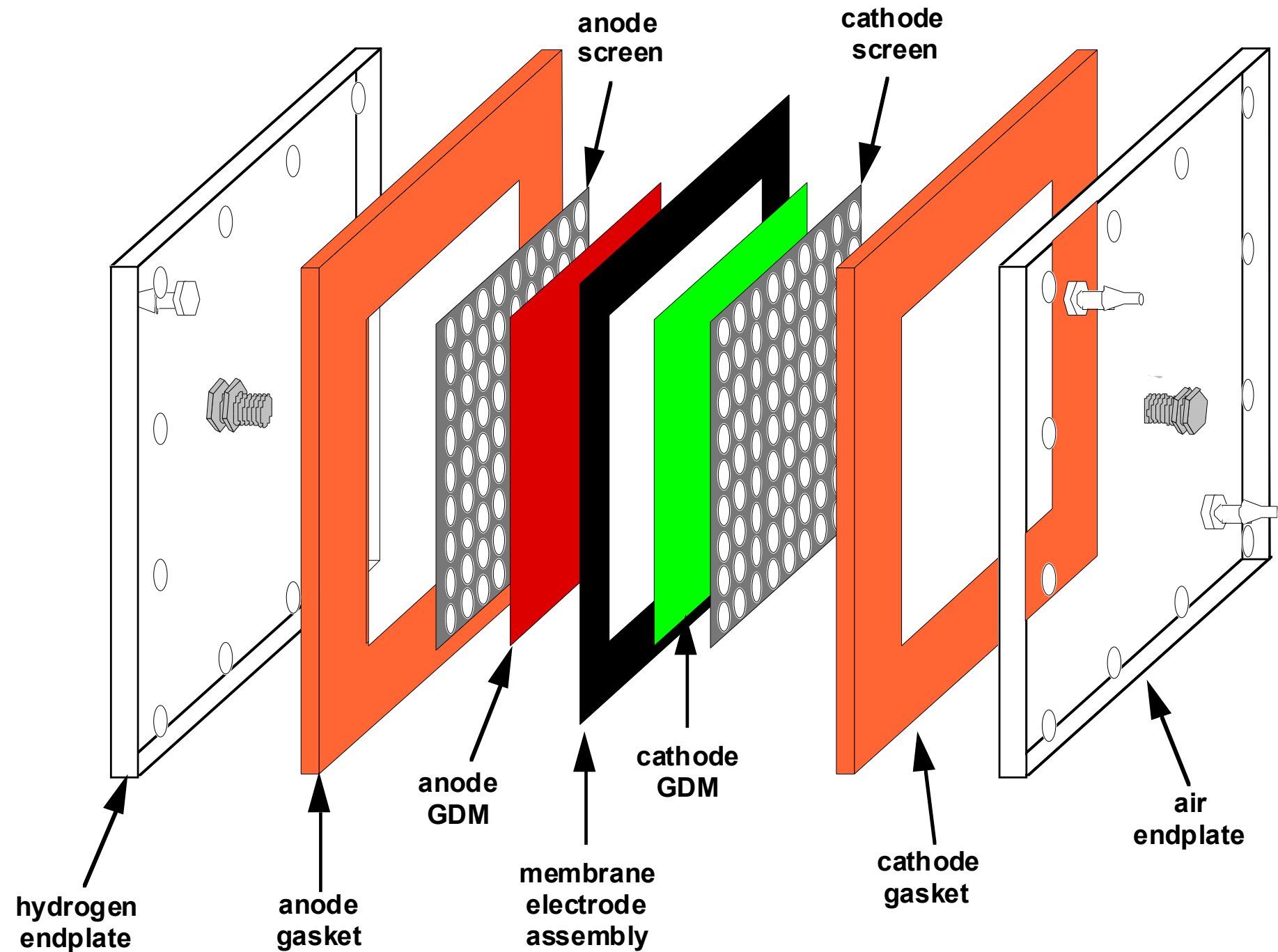


# Challenges to Hydrogen Economy



- Developing infrastructure and improving technology
- Reducing cost
- Addressing public concerns about safety
- Production of hydrogen from water using renewable energy sources

# Fuel Cell Parts - Form and Function



# Contact Info:

|                     |  |
|---------------------|--|
| Contact me:         | <a href="mailto:chris_k@berkeley.edu">chris_k@berkeley.edu</a>     |
| PPT and handouts:   | <a href="http://sepuplhs.org/news/">sepuplhs.org/news/</a>         |
| Curriculum website: | <a href="http://sepuplhs.org/hydrogen/">sepuplhs.org/hydrogen/</a> |
| Publisher website:  | <a href="http://lab-aids.com">lab-aids.com</a>                     |