

COLD FUSION

A lecture for the class:

“They Laughed at Einstein: How Science Responds to Cranks and Visionaries”

Steven B. Krivit, Editor

New Energy Times

Princeton University, Princeton, N.J.

April 3, 2006

*An invited lecture by Adjunct Prof. Michael Lemonick,
author of the 1989 TIME magazine cover story on “cold fusion”*

Part 1: The Cold Fusion Story

London Financial Times

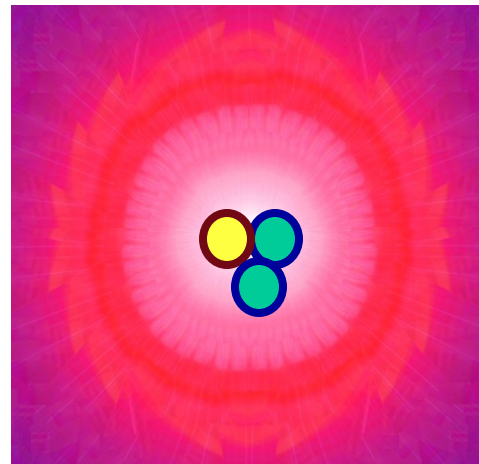
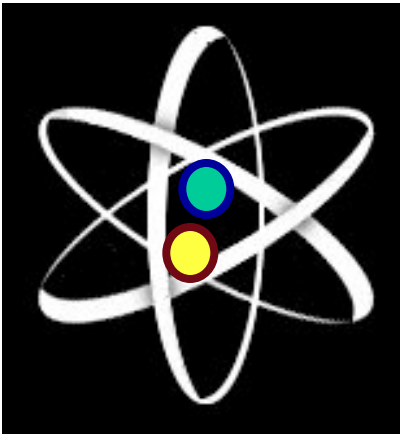
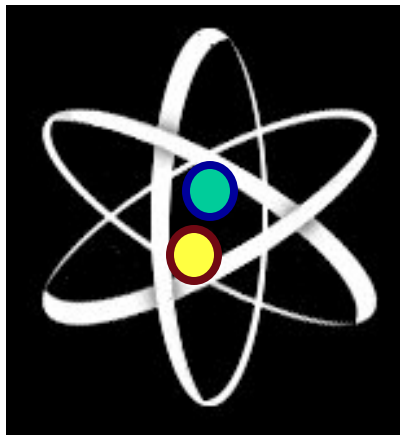
March 23, 1989 - Page 1, 26

-Martin Fleischmann and Stanley Pons-
Controlled Nuclear Fusion in a Test Tube

“... discovery will transform the outlook for the world's energy supplies ... raw materials for fusion are inexhaustible”

Nuclear Fusion

Fusion theory well-understood since 1930s



Plasma fusion

Thermonuclear fusion

The Immediate Problems

March 23, 1989 – Before the Press Conference

- Univ. of Utah didn't have a fusion energy program.
- Chemistry experiments didn't produce nuclear reactions.
- Chemists didn't perform nuclear research.
- Nuclear fusion didn't occur in test tubes.
- Nuclear fusion didn't occur at room temperature.

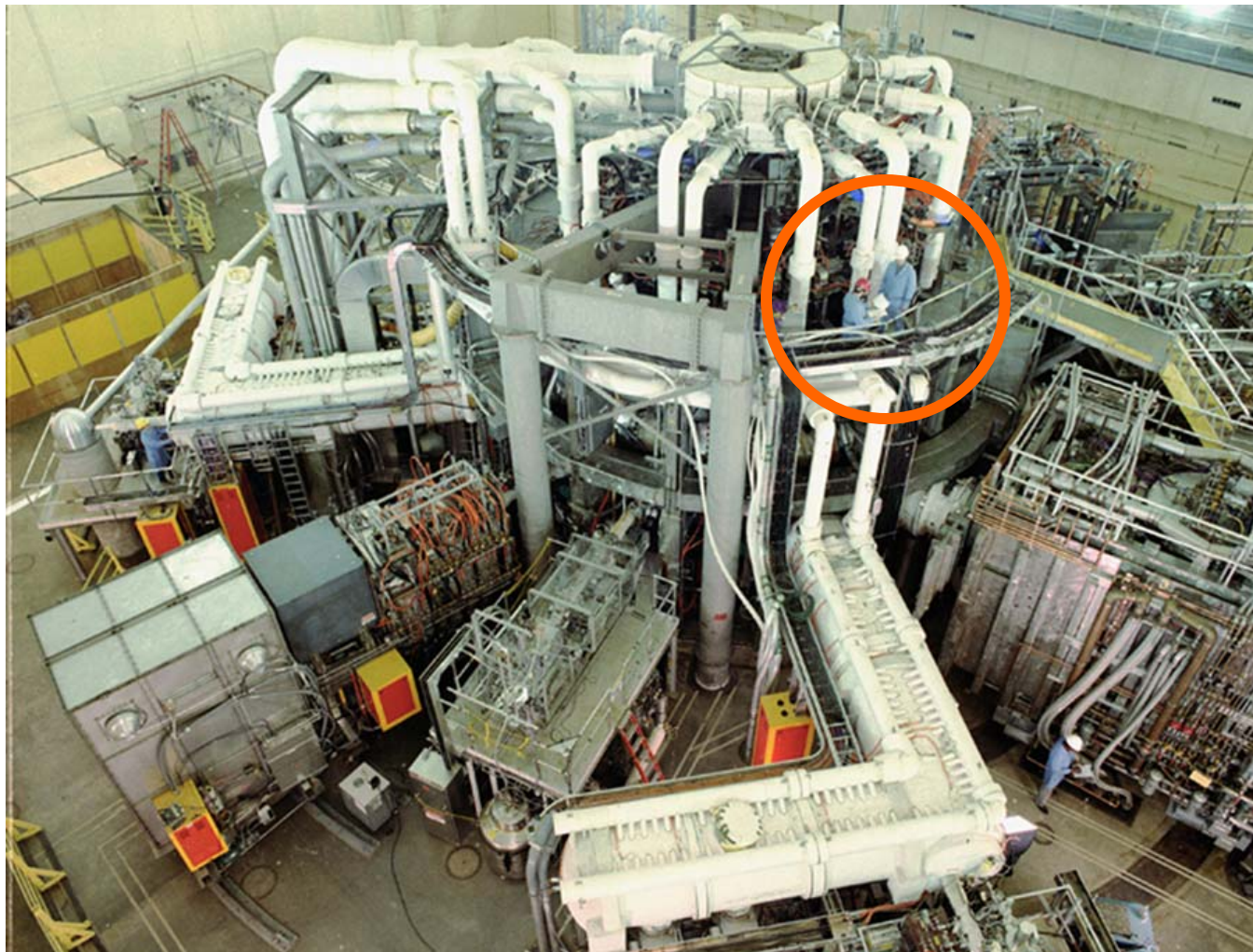
Fusion Research Prior to March 29, 1989

Well-established since 1951

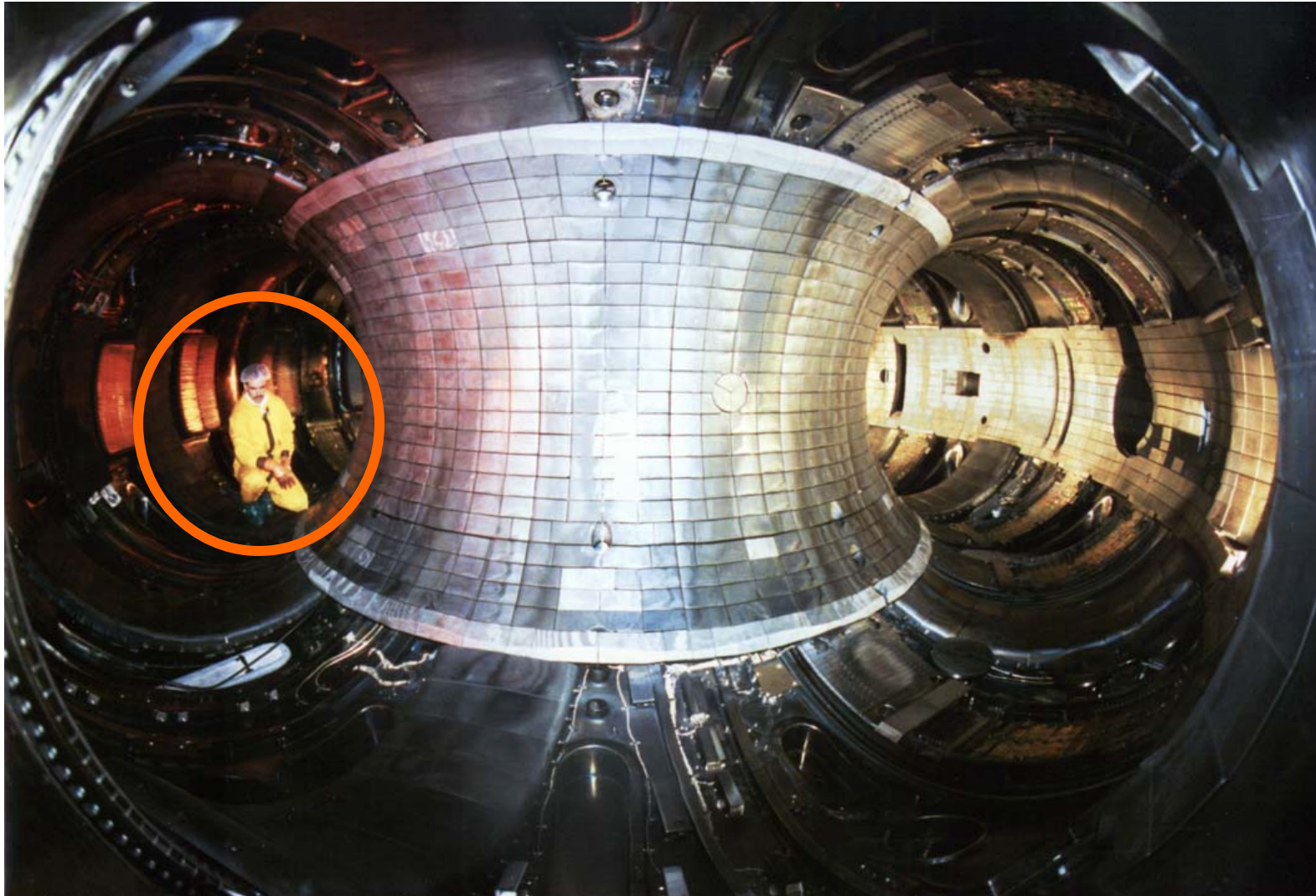
Well-funded - \$15B



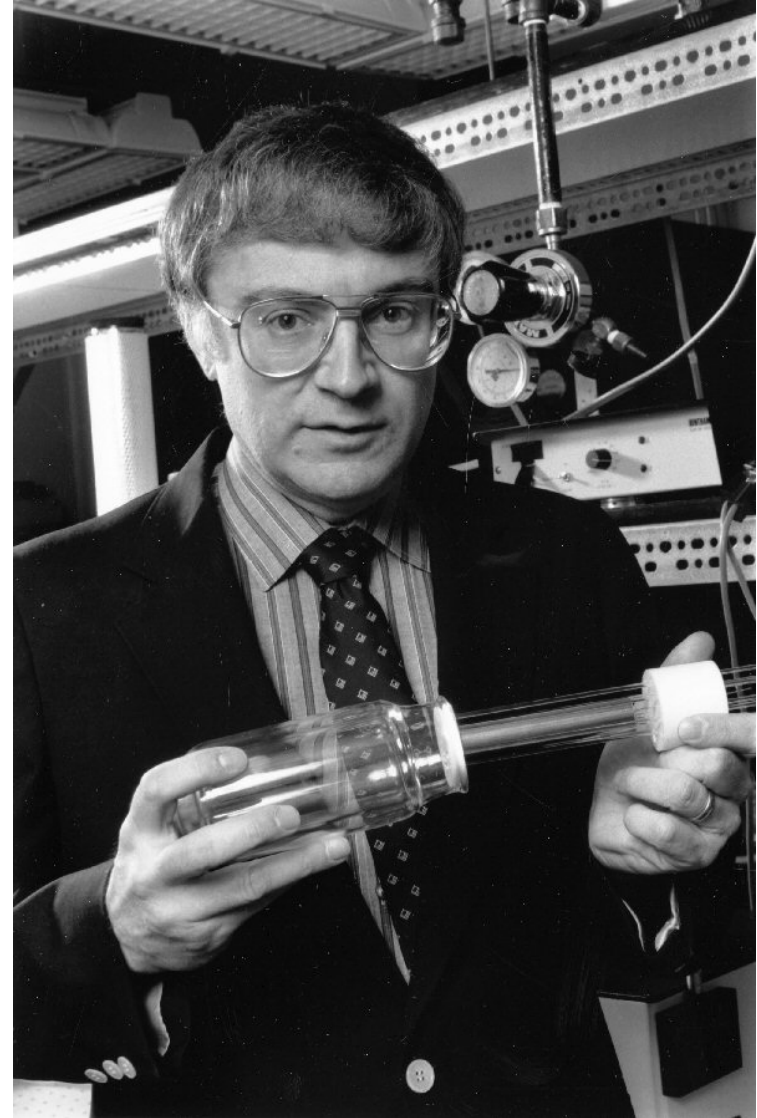
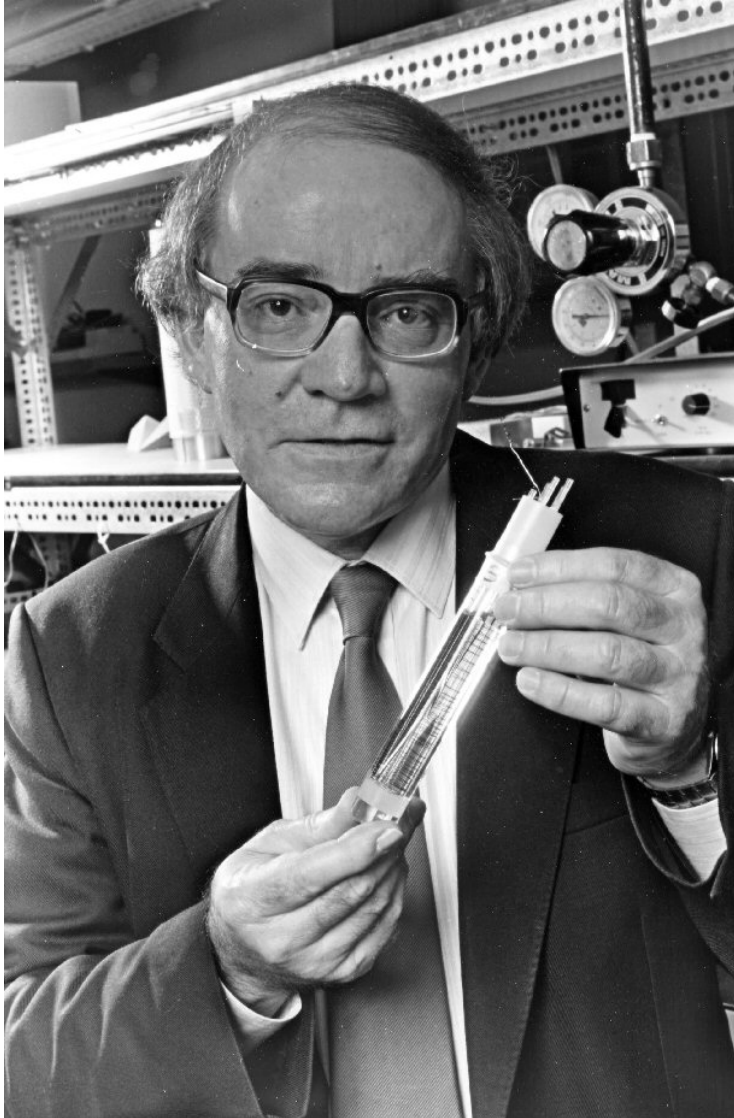
Princeton Plasma Physics Lab Tokamak Reactor Exterior



Princeton Plasma Physics Lab Tokamak Reactor Interior



Utah Test Tube Fusion



Wall Street Journal

March 23, 1989 - Page 1

“... a sustained thermonuclear reaction”

London Financial Times

March 23, 1989 - Page 1

“... generated more energy than it consumed”

What about Thermonuclear Fusion?

Sustained reaction highly impractical.

No thermonuclear fusion experiment
generated more energy than it consumed.

Fleischmann and Pons's Problems at the Press Conference

March 23, 1989 - Afternoon

- No published paper at the time
- No pre-print of the paper available
- Used unconventional instrumentation for nuclear science: calorimetry
- *Appeared* to be working outside of their field of expertise

The Neutron “Problem”

F&P claimed four watts of power

For every 10 fusion reactions, 5 reactions will yield a neutron

Neutrons from 1 watt of fusion will kill you without shielding

Where's the neutrons?

How come these guys aren't
dead yet?

Fleischmann and Pons's Problems After the Press Conference

- Not enough neutrons to explain energy
- Withheld information from their peers.
- Measurements of helium-4 and tritium not sufficiently rigorous for publication
- Their experiment was not highly repeatable
- Their theory was wrong

Bad News!

- Looked like a hoax
- Appeared like an embarrassment to science
- Caused shame and disgrace to “real fusion” researchers

“It was obvious that they were incompetent boobs”

-William Happer, Princeton Plasma Physics Lab

American Physical Society Meeting Baltimore, MD, May 2, 1989



"We are suffering from the incompetence and perhaps delusions of Drs. Pons and Fleischmann."
– S. Koonin (Caltech / British Petroleum)

Suspicion of Fleischmann and Pons

- Neutron measurements and gamma ray spectra data looked suspicious
- Clear errors
- Not sufficiently forthcoming when their gamma spectra errors were revealed

Director of MIT Hot Fusion: “It’s Fraud”



Ronald R. Parker

Interview with Nick Tate, Boston Herald, April 29, 1989

Feature Article in
New York Times Magazine
“Cold Fusion Confusion,”
Sep 24, 1989

By Robert P. Crease

*Assistant professor of philosophy at the State University of New York
at Stony Brook, historian at Brookhaven National Laboratory.*

N. P. Samios

Director of the Brookhaven National Laboratory

“Victims of self-deception”

“End of Story”

- **Incompetence**
- **Delusions**
- **Fraud**
- **Self-deception**

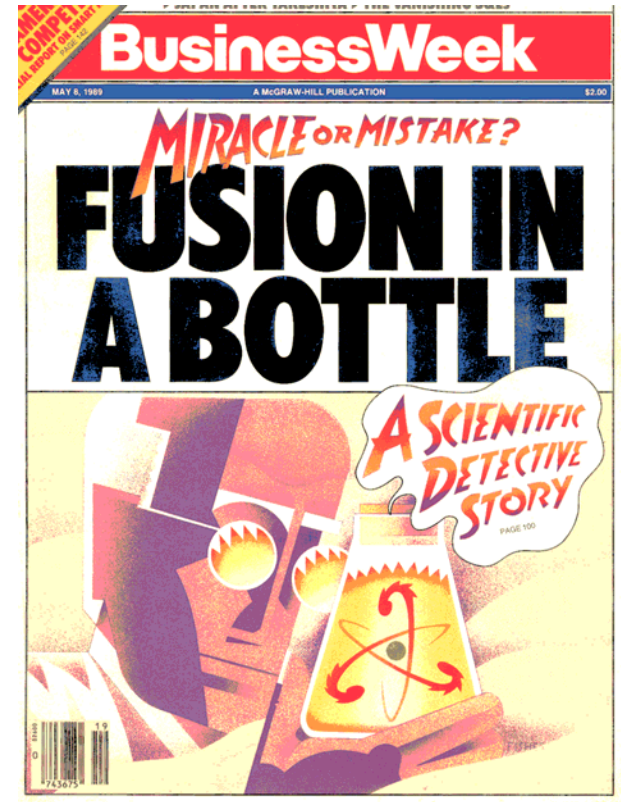
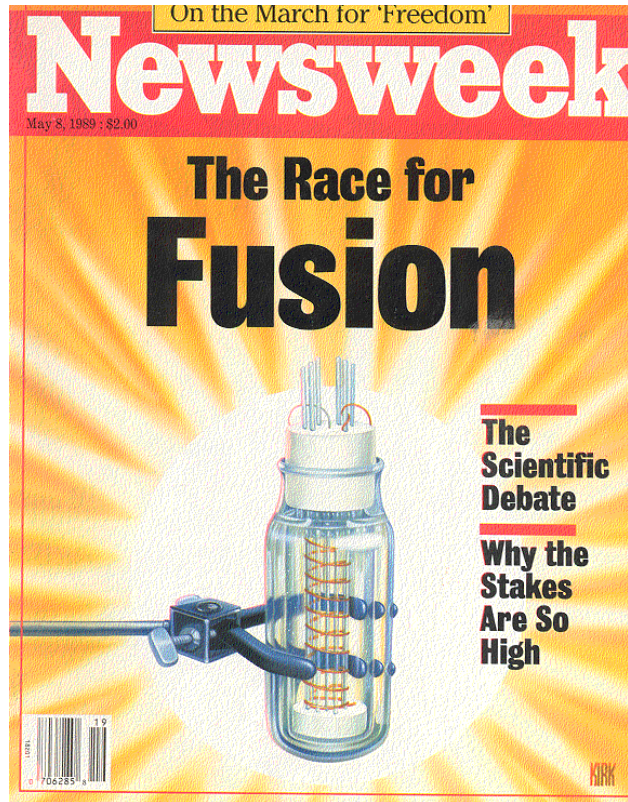
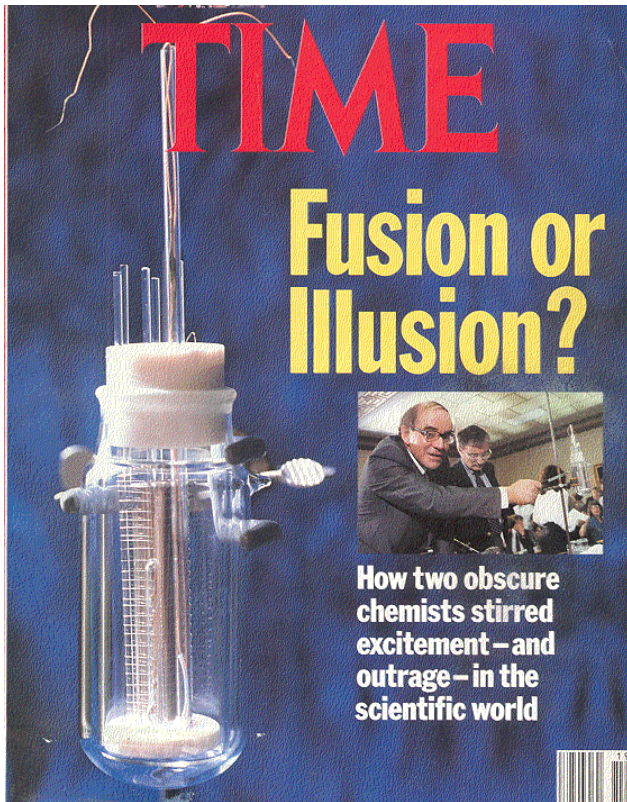
Part 2: Cold Fusion: The Untold Story

Science Lesson: Key Elements

- **Palladium – Precious metal**
- **Deuterium – Isotope of hydrogen**
 - **As a gas (D₂) or in heavy water (D₂O)**

Nationwide Cover Stories

May 8, 1989

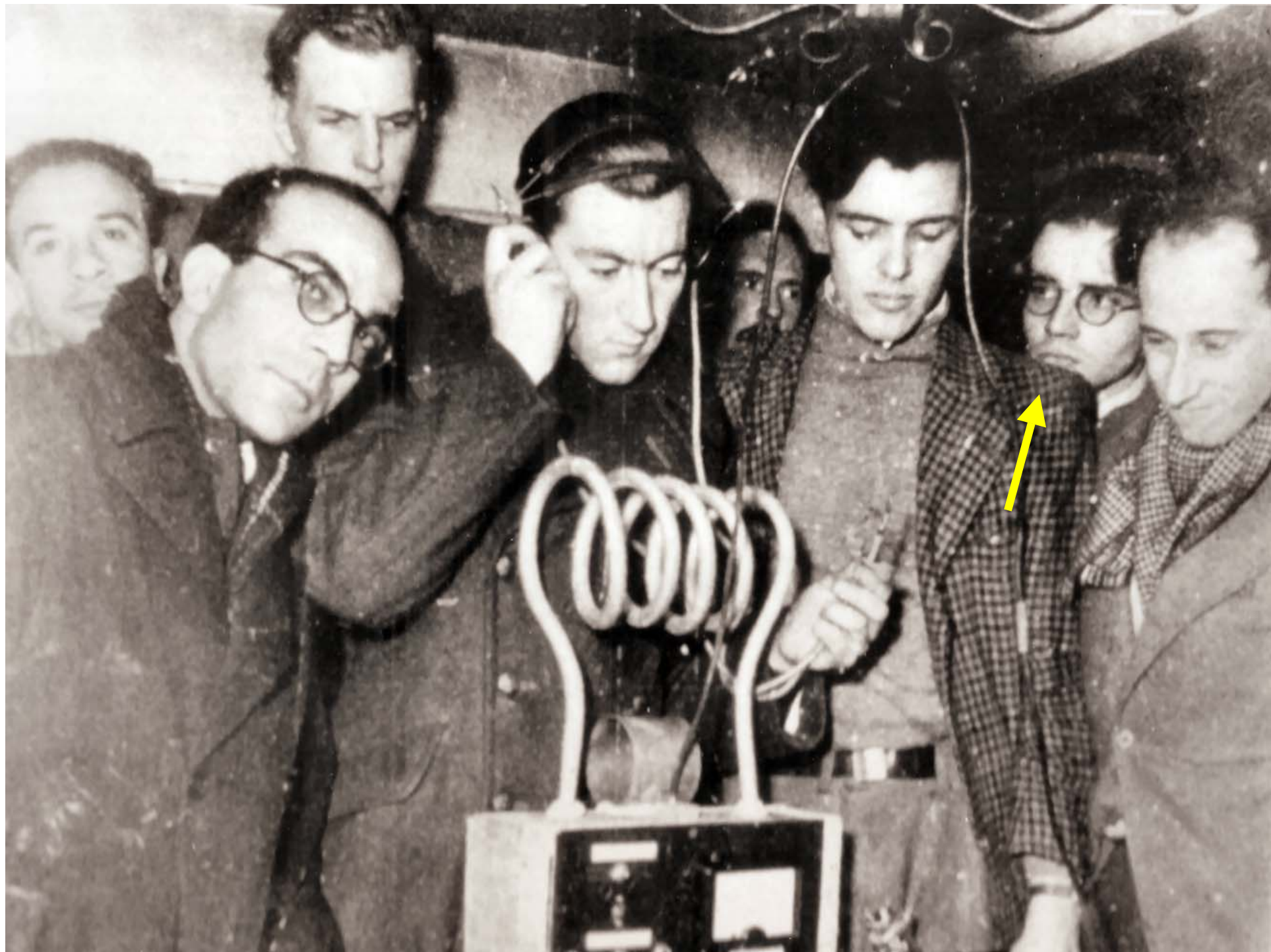


“Two obscure chemists”

Martin Fleischmann

and Related History of Pd/D

- **1926 – Fritz Paneth, Kurt Peters, Pd/D experiment**
- **1927 – Fleischmann born in Czechoslovakia**
- **1929 – Alfred Cohn publishes Pd/D paper**
- **1929 – Percy Bridgman - Prof. Physics Harvard, Nobel Prize winner, paper on cold nuclear effects**
- **1947 – Fleischmann (Age 20) reads Cohn paper**
- **1948 – Imperial College, University of London (#3 in EU)**
- **1950 – Receives Ph.D. Chemistry, Thesis: Pt/H (Age 23)**



Fleischmann's History

- **1967 – Becomes Chair of Electrochemistry Department University of Southampton (Age 40)**
- **1970 – Elected President, International Society of Electrochemists**
- **1970 – Started preparing for the experiment** (Excess Heat pg. 34)
- **1983 – Retires, moved to Utah**
- **1985 – Named Fellow of the Royal Society**

One of the World's Best ...

“Won virtually every prize an electrochemist could win.” (Bad Science pg. 8)

“Helped generate a renaissance in the field of electrochemistry.” (Bad Science pg. 9)

“More innovative than any other electrochemist in the world.” (Too Hot pg. 71)

B. Stanley Pons

- **1965 – Wake Forest University (#17 in U.S.)**
- **1965-1967 – Post-grad studies, University of Michigan**
- **1967-1975 – Manages Pons Enterprises**
- **1978 – Receives Ph.D. in Electrochemistry, University of Southampton**
- **1983 – University of Utah chemistry department**
- **1988 – Named head of chemistry department**

Author or co-author of more than 200 scientific papers.

(Excess Heat pg. 34)

The Collaboration

- **1983-1984 – Started planning and implementing the experiment**
- **1985 – A laboratory accident**

Spring 1985 - The Accident

- Cell and part of the fume hood destroyed
- Part of the palladium cathode melted, part vaporized
- Thick lab bench with a 12 inch hole through it
- Crater in concrete floor (4 inches deep)
- Particulate dust in air
- Radioactivity levels three times higher than background

(Sources: F&P Preliminary Report, Excess Heat, Rebirth of Cold Fusion, Bad Science, Wall Street Journal)

Fleischmann:

“This was a potentially lethal experiment. Somebody could have gotten hurt.”

(Private Communications, 9/24/2003)

3 Years and \$100,000 Later ...

- Aug. 1988 – F&P Submit research proposal for Dept. of Energy funding.
- Sept. 1988 – Dept. of Energy selects Steven Earl Jones at Brigham Young University as 1 of 5 reviewers
- Fall 1988 to Spring 1989

**Collaboration attempt and failure - Conflict and blame
Fight for intellectual primacy and intellectual property**

- March 11, 1989 – F&P submit paper JEAC
- March 22, 1989 – F&P notified that paper is accepted
- March 23, 1989 – The infamous press conference

**The purpose of press conference was *not* for science,
it was in response to the conflict with Jones**

London Financial Times

March 23, 1989 - Page 1

Fleischmann: “The nature of the experiment is so ridiculously simple yet in a way so far-fetched.”

Major miscommunication
Fleischmann was downplaying

London Financial Times

March 23, 1989 - Page 1

“The experiments carried out by Fleischmann and Pons are no more complex than work done by chemistry undergraduates.”

Wrong! Big misunderstanding

London Financial Times

March 23, 1989 - Page 1

F&P: “It will be easy to make into usable technology for generating heat and power ...”

“but a lot more work is needed to prove its validity further and then to develop practical generating devices.”

Easy? No way. More work? You bet.

London Financial Times

March 23, 1989 - Page 26

“They are convinced ... because very large amounts of heat are released.”

Heat: primary signature of “cold fusion”

**Neutrons: primary signature of
thermonuclear fusion**

Search for Nuclear Products

Nuclear Signature	Quantity/ Rate	Challenge to Measure	Domain
1. Neutrons	Low	Easy	Nuclear Physics
2. Gamma	Low	Easy	Nuclear Physics
3. Heat	High	Difficult	Chemistry
4. Helium-4	High	Difficult	Chemistry

Heat: primary signature of “cold fusion”

Helium-4: Unexpected fusion signature

What Excess Heat?

May 2, 1989, APS Press Conference:

“Should reporters ignore claims of excess heat?”

Nathan Lewis (Caltech): "Absolutely."

(Excess Heat pg. 352)

Guess what reporters did...oops

London Financial Times

March 23, 1989 - Page 26

“Couldn’t be more of a contrast to the
large nuclear research projects trying to
achieve fusion by heating gases ...”

Couldn’t be more of a conflict too!

London Financial Times

March 23, 1989 - Page 26

“... governments becoming impatient with the apparently slow progress ...”

“world-wide expenditure ... exceeds \$1B per year.”

Not very good publicity for them...

London Financial Times

March 23, 1989 - Page 26

“Unclear if the most advanced fusion project will achieve the "break even" state ...”

Serious doubts about a \$1B/Year research program

Wall Street Journal

March 23, 1989 - Page 1

“So far, these methods still require more energy than the reaction releases.”

**Scientifically valid, but not a working
source of energy**

London Financial Times

March 23, 1989 - Page 26

“Fleischmann and Pons say that their experiment is comfortably in credit.”

What does this mean?

London Financial Times

March 23, 1989 - Page 26

“Fleischmann and Pons say that their experiment is comfortably in credit.”

It's a delicate way to say “making more energy than it consumes”

If You Were a Fusion Researcher

...and you spent your entire life studying thermonuclear fusion, teaching fusion, being employed in fusion ...

1. Would you be enthusiastic about “fusion” in a test tube?
2. Would you be eager to learn electrochemistry?
3. Would you be eager to learn calorimetry?
4. Would it bother you to see a couple of chemists achieve break even before you did?
5. Would you be worried about your job security if chemists could do fusion – in tiny, cheap laboratories?

Was this a problem?

Writer Upton Sinclair Would Have Understood

“It is difficult to get a man to understand something when his salary depends upon his not understanding it.”

Shortly Before the Press Conference,
Fleischmann Predicted It:

“We shall be dismissed.”

(Excess Heat, pg 149)

Part 3: Line by Line
Deconstruction of the
Cold Fusion News Story

As reported by The New York
Times on May 3, 1989

“Physicists Debunk Claim Of a New Kind of Fusion”

May 3, 1989

By MALCOLM W. BROWNE

SPECIAL TO *THE NEW YORK TIMES*

BALTIMORE –

1. “Hopes that a new kind of nuclear fusion might give the world an unlimited source of cheap energy appear to have been dealt a **devastating blow** by scientific evidence presented here.”

2. “In two days of meetings lasting until midnight, members of the American Physical Society heard fresh experimental evidence from many researchers that nuclear fusion in a jar of water **does not exist.**”

Perhaps it wasn't fusion...

3. “Physicists seemed generally persuaded as the sessions ended that assertions of "cold fusion" were based on **nothing more than experimental errors** by scientists in Utah.”

**But it was certainly
not mere experimental error**

Footnote

Most people (including Broad) paid attention to the loud voices from the skeptics... few people noticed the available details ...

New York Times – “Georgia Tech Team Reports Flaw In Critical Experiment on Fusion,” William J. Broad, April 14, 1989

“when the experiment was done with heavy water they appeared to detect tritium, a common radioactive byproduct of atomic fusion.”

“Each time regular water was substituted, Mr. Eden said, the signal for the presence of tritium went away.”

5. “... **nine of the leading speakers were asked if they would now rule the Utah claim as dead. Eight said yes..**”

**What do you think of this?
Does science work democratically?**

“Attempts to Repeat Experiments”

13. “... **some completed their investigations just hours before the meeting was convened here Monday.**”

**They tried for less than 40 days...
and then gave up.**

14. “**The most thoroughgoing of the attempts to validate** the Pons-Fleischmann experiment was conducted at the California Institute of Technology. According to Dr. Nathan Lewis, leader of the Caltech team, every possible **variant of the Pons-Fleischmann experiment was tried without success.**”

**What do you think?
How possible is it that Lewis tried
“every possible” variant of an experiment
which F&P worked on for 5 years?**

Footnote

Retrospective 3rd Party Audits of Caltech Cold Fusion Work

Michael Melich: “It was clear that Nate Lewis didn't do the calorimetry and when asked he had little useful to say about the obvious problems with their published work.”

(Private Communications, 10/13/2003)

Every day they came into the lab and saw possible indications of energy, in the form of heat, but they apparently didn't believe it. They thought the device taking the temperature readings was out of adjustment, so they re-adjusted the measuring device every day to zero out the readings.

(Indirect quote from McKubre, *Rebirth of Cold Fusion*)

15. “**Using equipment far more sensitive than any available to the Utah group,**” Caltech “found no emitted neutrons, gamma rays, tritium or helium ...”

**Caltech scientists omitted to describe or
misinformed reporters
about the most important instrument**

Caltech calorimetry sensitivity: Unknown

MIT calorimetry sensitivity : **+/- 40 milliwatts**

Univ. of Utah calorimetry sensitivity: **+/- 1 milliwatt**

(Rebirth of Cold Fusion)

16. “The Caltech team **intentionally reproduced experimental errors**”

“By **failing to install a stirring device** in the test cell, temperature differences in the cell led to **false estimates** of its overall heat”

No, it was Caltech that screwed up...

16. “The Caltech team **intentionally reproduced experimental errors**”

“By **failing to install a stirring device** in the test cell, temperature differences in the cell led to **false estimates** of its overall heat”

The University of Utah cell was a more sophisticated design. It didn't require stirring. It used passive stirring from the action of the bubbles and the cell geometry.

Lewis (Caltech) appeared to be ignorant of this fact until May 8, 1989 when F&P explained it to him, with a videotaped demonstration, at a meeting of the Electrochemical Society of America in Los Angeles.

18. “Pons would never answer any of our questions,’Lewis said.”

Pons: “We don’t think there’s many neutrons. This is a nonclassical nuclear reaction...You’ll figure it out. Look for the heat. The heat’s the ticket. And I’ll send you a preprint when we can...Be careful, we’ve had explosions. I don’t want you to hurt yourself. I want you to be careful.” Phone call between Pons and Lewis, March 25, 1989, reported by Taubes, page 123

Fleischmann: “Stan [Pons] phoned me in the U.K. to say that he had incessant calls from the Caltech group who would not take any notice of what he said.” (Private Communications, 10/23/2003)

How factual was Lewis’ communication to the Times?

Footnote

Fleischmann's recollections from the May 8, 1989, Electrochemical Society meeting in Los Angeles:

“The horror of the Caltech cell was revealed. I recall saying to Nate Lewis. ‘You can’t do the experiment in this way.’”

(Private Communications, 10/23/2003)

19. Other scientists [who also failed to replicate the effect] said they had tried **every possible variation** of the Utah experiments.

Every possible? What do you think?

Footnote

Those who claimed success in 1989...

Tadahiko Mizuno
Applied Physicist,
Hokkaido University

“I had performed similar experiments with Pd-D for 20 years prior, but for a different purpose. I had seen some anomalous effects during that time, but I threw away the data, thinking it was noise.

After the cold fusion announcement, I spent eight months preparing for my first cold fusion experiment.

(Nuclear Transmutation, pg 59)



Footnote

Edmund Storms, Radiochemist
Lattice Energy LLC,
Los Alamos National Laboratory (ret.)

“I had worked with Pd previously,
including the hydride.

However, I had to learn
electrochemistry. I also had a great
deal of luck, no one understood exactly
what was required at the time.”

(Private Communications, 3/25/2006)



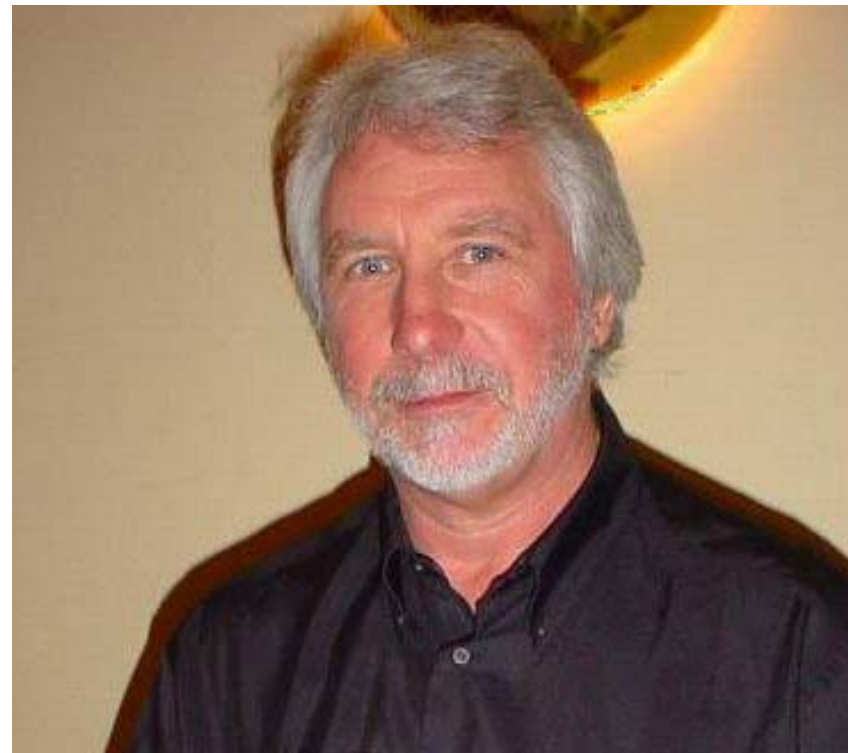
Footnote

Michael McKubre,
Electrochemist
SRI International

“I had a group of four experts already working with the Pd/D system before the announcement.

We then spent three months planning and constructing ... and spent two further months performing it.”

(Private Communications, 3/25/2006)



Footnote

John Dash, Metallurgist
Portland State University

“I had a master’s student who studied electrolysis of water in a magnetic field in the early 1980s with Pt. That experience, and the preliminary report was all we needed.”

(Private Communications, 3/24/2006)

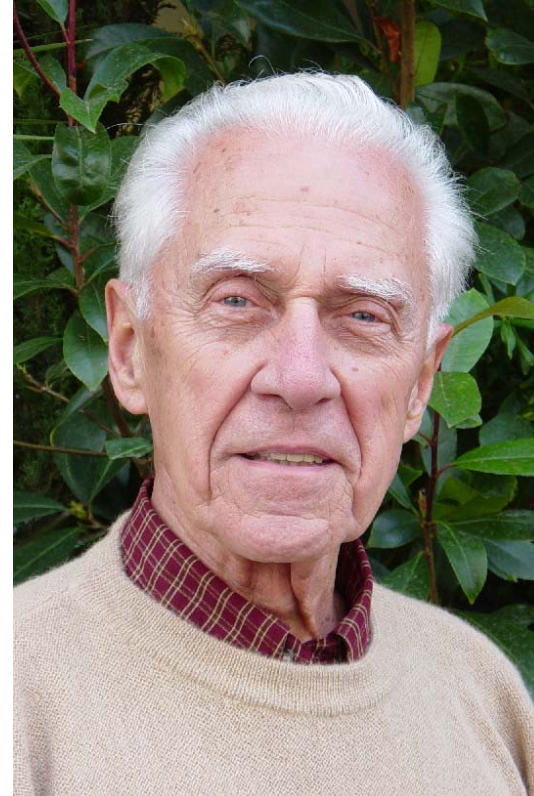


Footnote

Richard Oriani, Chemist
University of Minnesota

“I worked for three and a half months before getting definite positive results. I also had been researching the problem of hydrogen embrittlement of steels for quite some time.”

(Private Communications, 3/25/2006)

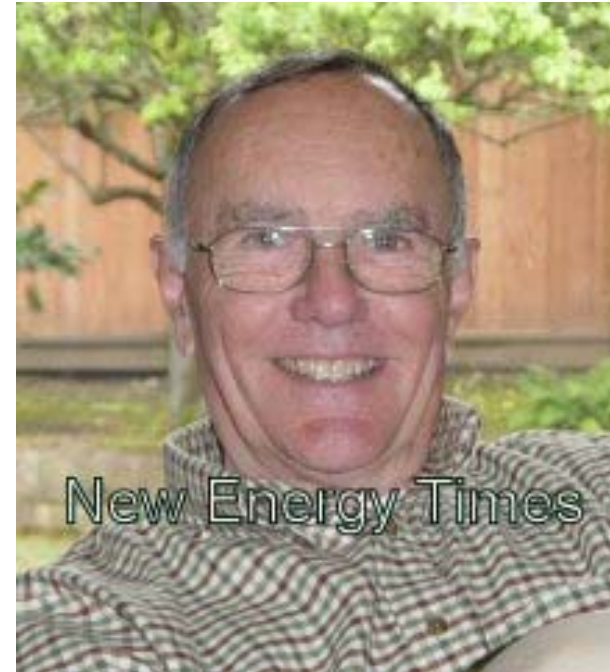


Footnote

Robert Huggins,
Materials Scientist
Stanford

“We had all kinds of background relevant to this stuff. We had our own palladium which had a lot of lithium in it.”

(Private Communications, 4/6/2006)



Footnote

Melvin Miles,
Electrochemist
U.S. Navy, China Lake

“In September of 1989, I received my order of palladium rod from Johnson-Matthey and prepared two cathodes using this material. Using this material, nearly every experiment produced the excess enthalpy effect. That, experience in electrochemistry and the original F-P paper were responsible for my success.

I could have studied my initial palladium (Wesco) for 20 years without even seeing any excess

heat ” (Private Communications, 4/16/2006 and Dec. 4, 2003)



Footnote

What was different for these researchers?

- 1. Gave experiments longer time.**
- 2. Had some related background.**
- 3. But not in nuclear physics.**
- 4. Some said they had luck.**
- 5. Materials science issues**

22. **“Dr. Pons was preparing to meet with members of Bush's staff Wednesday.”**

The White House meeting was apparently cancelled a few hours after this New York Times story published.

“My background with the Seaborg/Huizenga affair goes back to when I talked to John Sununu (Chief of Staff) about CF. He was the one who canceled Martin and Stan's appointment to see the President, and basically replaced it with Seaborg.”

(Anon w/ U.S. Military 3/27/2006)

Footnote

What Was the President Told?

Glenn T. Seaborg

(Former Chairman of the Atomic Energy Commission)

April 14, 1989 meeting with President George H.W. Bush

I came “to the sensible conclusion that **this work was not right**, that it was really cold. **You couldn't do it.**

So that's what I told [the President.]”

“I said, ‘You can't just go out and say this is not valid. You're going to have to create a high-level **panel that will study it for six months**, and then **they'll come out and tell you it's not valid,**’ and that's what he did.”

The 1989 DoE ERAB Panel was set up with the intention – from science authorities - of discrediting cold fusion research

“Failure to Elicit Information”

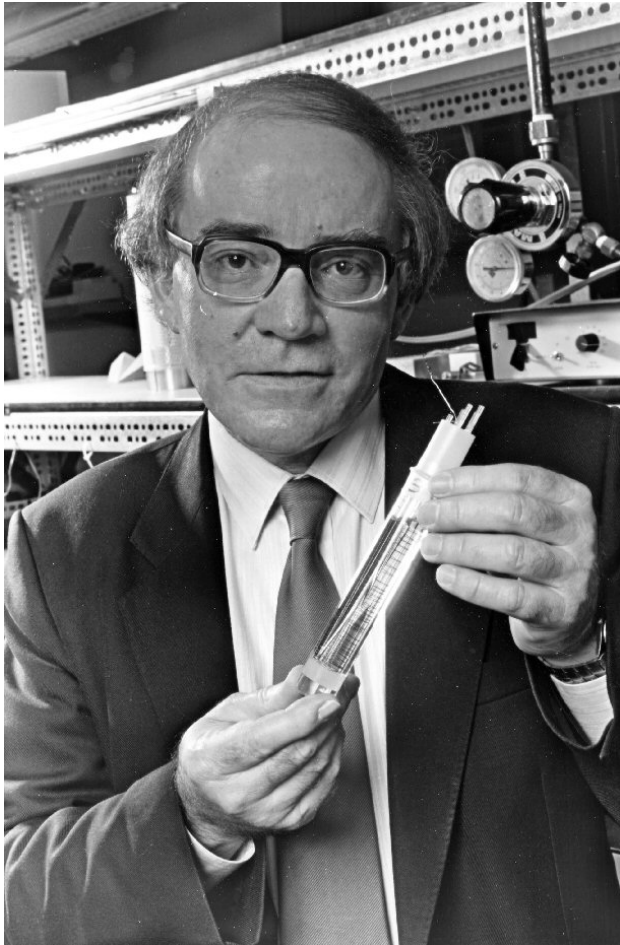
23. “Many speakers at the meeting reported **failure in their efforts to elicit information** or comments from Dr. Pons.”

24. “‘**published photograph of the Utah cell showed Pons's hand, and that gave us the scale,**’ Lewis said.”

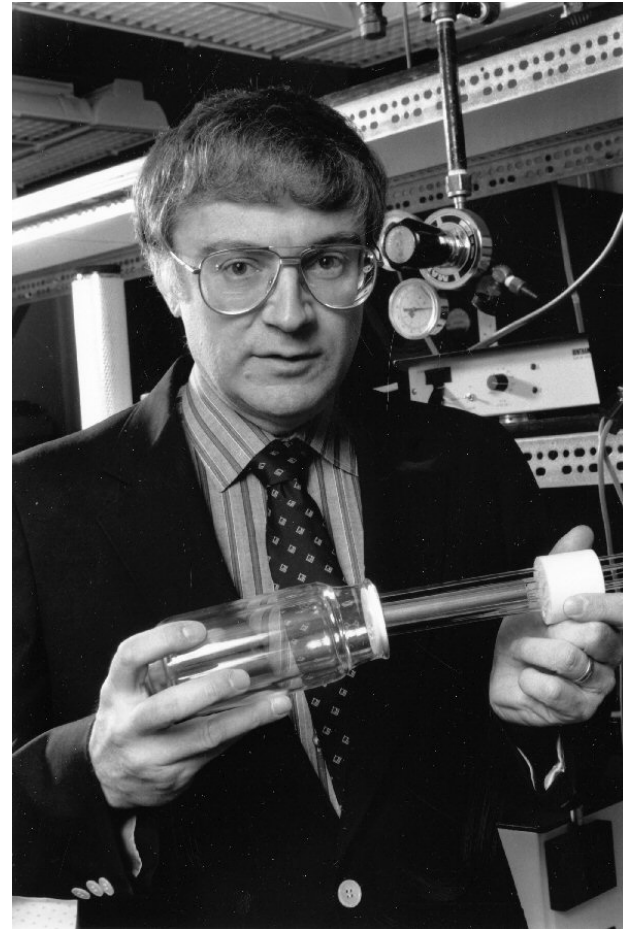
Fleischmann: “Fortune magazine said that the [cells] we had used were **not photogenic and, they wanted to photograph a really big cell.** Thus is born a really big confusion. The group at Caltech used this photograph to scale their apparatus and the use of small electrodes in such cells would have led to miserable and inexplicable results.”

Private Communications, 10/23/2003)

Footnote



3 cm Dia.



7 cm Dia.

[Ed: regarding the explosion]

26. “‘**My understanding,**’ Lewis said, ‘is that Pons's **son was there at the time ...someone turned the current off ... simple chemical reaction** that has nothing to do with fusion.’”

Lewis’s Misunderstandings Corrected:

- 1. Joey Pons was not there; it occurred in the middle of the night.** (Taubes, Beaudette, Krivit/Winocur)
- 2. It was Joey Pons who changed the current.** (Taubes: off, Beaudette: up, from 0.75 amperes to 1.5 amperes. Change in current is consistent with other similar reports)
- 3. The reported energetic effects are inconsistent with a chemical reaction.** (Taubes, Beaudette, Krivit/Winocur)

How factual was Lewis’ communication to the Times?

27. “... other major research groups failing to validate the Pons-Fleischmann results were representatives of Massachusetts Institute of Technology ...”

Not exactly...

In 1989, MIT stated “Failure to reproduce.”

In 1992, MIT, after challenged by Mallove, changed their story: “Too insensitive to confirm.”

(Rebirth of Cold Fusion)

27. “... other major research groups **failing to validate the Pons-Fleischmann results were representatives of Massachusetts Institute of Technology ...**”

It's a major distinction...

MIT, 1989: “Failure to reproduce.”

Translation: “The cold fusion effect does not exist.”

MIT, 1992: “Too insensitive to confirm.”

Translation: “We're not so sure now. Our instruments were not sensitive enough to prove or disprove.”

(Rebirth of Cold Fusion)

28. **“Dr. Douglas R. O. Morrison, a physicist representing CERN ... the entire episode was an example of ‘pathological science ...’”**

Morrison continued his interest in cold fusion and traveled around the world, attending every international cold fusion conference until his death in 2001.

Why did he bother if he was so convinced, on May 2, 1989, that it junk science?

30. “Robert A. Huggins [obtained positive] results that seemed to suggest fusion.

“But Walter Meyerhof, professor of physics ... carefully studied his colleague's apparatus and found that the experiment was flawed because of the system used to measure heat.

“Nevertheless, Dr. Huggins, a materials scientist ... he is ‘more confident than ever’ in his results.”

Myerhof made the same mistake as Lewis; a wrong assumption about the stirring. As a result, Myerhof, provided the *Times* with misinformation and contributed to the public misconception.

Part 4: Other “Problems” with Cold Fusion Research That Have Been Alleged Since 1989

Other “Problems” With “Cold Fusion” Research

- “There are no neutrons”
- “There are not enough neutrons”
 - “Contradicts theory”
- “The reaction cannot be nuclear since all nuclear reactions of significant magnitude result in dangerous levels of radiation”
 - “Calorimetry is unreliable”
 - “Prominent laboratories have disproved it”
 - “The Dept. of Energy disproved it in 1989”
 - “No nuclear products”
 - “Open-cell calorimetry is unreliable”
 - “All calorimetry is error-prone”

Other “Problems” With “Cold Fusion” Research

- “Helium quantity not commensurate with amount of claimed heat”
 - “Helium-4 leaked into the cells”
- “Reports of helium-4 are in error because there are no gamma rays”
 - “Magnitude of the effect is too small”
 - “No published papers”
 - “No published papers in peer-review journals”
 - “No published papers in *respectable* peer-review journals”
 - “No published papers in respectable *U.S.* peer-review journals”
 - “Editors of cold fusion-friendly journals are biased”
 - “No theory to explain it”
 - “No *complete* theory to explain it”

Other “Problems” With “Cold Fusion” Research

- “No independent replications”
- “Variety of methods required”
- “Replications require no variation”
- “Replicators not truly independent”
 - “Not enough replications”
 - “Replication not published”
- “Replication not published in peer-review journal”
 - “No practical device available to purchase”
 - “I can’t find the source of the error yet”
 - “Magnitude of the effect must be $Q \Rightarrow 10$ ”
 - “No mainstream scientists are studying it”
 - “The Dept. of Energy disproved it in 2004”

(References: “Excess Heat,” “Rebirth of Cold Fusion,” www.newenergytimes.com)

“Problems” With Calorimetry

- **“Release of hydrogen gas”**
- **Production of hydrogen gas”**
- **“Recombination skewing calorimetry”**
 - **“Release of stored stress”**
 - **“Current fluctuations”**
 - **“Peltier effect”**
 - **“Chemical reactions”**
 - **“Temperature gradients”**
- **“Variable thermal conductivity of the wall”**
 - **“Jahn-Teller effect”**
- **“Errors in calibration constants”**

Reference: Edmund Storms “Objective Assessment”