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HOW CAN COLD FUSION BE REAL, CONSIDERING IT WAS DISPROVED BY SEVERAL WELL-RESPECTED LABS IN 1989?

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ABSTRACT

This journalistic investigation into cold fusion follows the work of Eugene Mallove, formerly with the Massachusetts Institute of Technology press office as well as Infinite Energy magazine, and the work of author Charles Beaudette.

This paper is the result of a broad survey of original interviews with researchers who have been active in the cold fusion field for the past 15 years, their papers, and references to significant, previously undisclosed cold fusion experiments and audits.

This investigation shows that the claims of excess heat were never disproved, in contrast to the generally-held belief at the time. With the benefit of 16 years of progress and hindsight, cold fusion researchers have accumulated convincing evidence to establish the claims of a new, genuine field of science. This investigation shows that the original hope of cold fusion, a new source of energy without harmful radiation, remains. This paper also serves as a brief summary of some of the highlights of the field to date.

Until recently, the name Low Energy Nuclear Reactions also had been used for this work. However, leaders in this new field have agreed on the name Condensed Matter Nuclear Science.

Key Words: cold fusion history journalism investigation

1 HISTORICAL BACKGROUND

Martin Fleischmann, visiting professor from the University of Southhampton, and Stanley Pons, head of the chemistry department at the University of Utah, in a press conference organized by the university administration, announced the discovery of cold fusion on March 23, 1989. They disclosed the remarkable claims of 1) a sustained DD fusion reaction, 2) occurring in a low temperature experiment 3) without high levels of neutron emission and 4) without gamma radiation [1].

Numerous laboratories quickly challenged these claims. Within weeks, newspaper headlines announced that researchers at prominent laboratories, including Nathan Lewis (California Institute of Technology), David Williams (Harwell Atomic Energy Laboratory), and Ronald Parker (Massachusetts Institute of Technology), had disproved cold fusion.

Later that year, John Huizenga (University of Rochester) was appointed to chair the Department of Energy's Energy Resources Advisory Board Cold Fusion Panel and tasked with the challenge of assessing the veracity of cold fusion. The bias[1] against cold fusion, an

[1] Huizenga later wrote in *Cold Fusion: The Scientific Fiasco of the Century* (Oxford, 1993) that he thought such a panel was ill-advised because he believed "the whole cold fusion episode would be short-lived."

intruder in many ways to science and fusion energy research, adversely affected an objective, dispassionate assessment.

1.1 False Negatives

The hasty approach to cold fusion taken by many skeptical scientists was of great concern to 13 researchers in particular. These individuals were unsatisfied with the process and interpretations of the Department of Energy cold fusion panel and later conducted their own retrospective analyses of the work that supposedly disproved cold fusion. Their findings are summarized in Table 1.

Table I. False Negatives: Retrospective Analyses of Work That Supposedly Disproved Cold Fusion

Year	Analysts	Caltech	M.I.T.	Harwell
1991	1st China Lake Team [2]	Excess Power	Major Errors	Major Errors
1991	Noninski & Noninski [3]		Excess Power	
1992	Melich & Hansen [4]			Excess Power
1993	Noninski & Noninski [5]	Excess Power Major Errors	Major Errors	
1993	2nd China Lake Team [6]	Excess Power Major Errors		
1993	Swartz, Mallove [7]	Major Errors	Excess Power	
1994	Melich & Hansen [8]	Major Errors		Major Errors
1994	3rd China Lake Team [9]	Major Errors	Major Errors	Major Errors

Their analysis included interviews with some members of the original research teams as well as inspection of original raw data. Analyses indicated the findings of major errors as well as possible excess power in each of the prominent laboratories that supposedly disproved cold fusion.

None of the analysts who performed retrospective studies asserts that these laboratories showed proof of cold fusion. They did, however, state that these experiments were more likely to have replicated rather than disproved the claims of Fleischmann and Pons.

1.2 Unknown Positives

Table II displays results of several audits and analyses of studies that confirmed cold fusion. Results of several rigorously performed experiments which corroborated cold fusion are also displayed. Numerous instances of excess power and nuclear products including ^{4}He and tritium are reported. Three authors, including Richard Garwin, explicitly state that the anomalous energy is far too great to be the result of chemistry.

Table II. Unknown Positives: Early Successful Excess Power Experiments & Analyses

Analyst/ Experimenter	Fleischmann & Pons	U.S. Navy China Lake Team	Amoco Oil	Shell Oil	SRI International
W. Hansen [10] (1991 Analysis)	Excess Power Not Chemistry				
Bard, Barnes, Birnbaum [11] (1991 Analysis)					Excess Power No Major Errors
U.S. Navy - China Lake Team [6] (1993 Experiment)		Excess Power Correlated Heat and Helium-4			
R. Garwin & N. Lewis [12] (1993 Analysis)					Excess Power No Major Errors Not Chemistry
Melich & Hansen [8] (1994 Analysis)	Excess Power		Excess Power Tritium		
Shell Oil (DuFour, Foos, Millot) [13] (1995 Experiment)				Excess Power Helium-4	
Amoco Oil (Lautzenhiser, et al.) [14] (1995 Experiment)			Excess Power Tritium Not Chemistry		

1.3 Overview of Reaction Products

Figure 1 displays the known reaction products from cold fusion/condensed matter nuclear science experiments. They are grouped according to input materials, showing deuterium on the top left and protium on the top right. The reaction products measured in greatest quantities are listed in the top center; least occurring products are shown toward the bottom.

With deuterium, ^{4}He is reported at rates which imply 10^{12} nuclear events per second for a one-watt reaction and heat at 10^{11} events per second for a one-watt reaction. Tritium is reported at 10^4 events per second [15], and neutrons at 57 per hour [16].

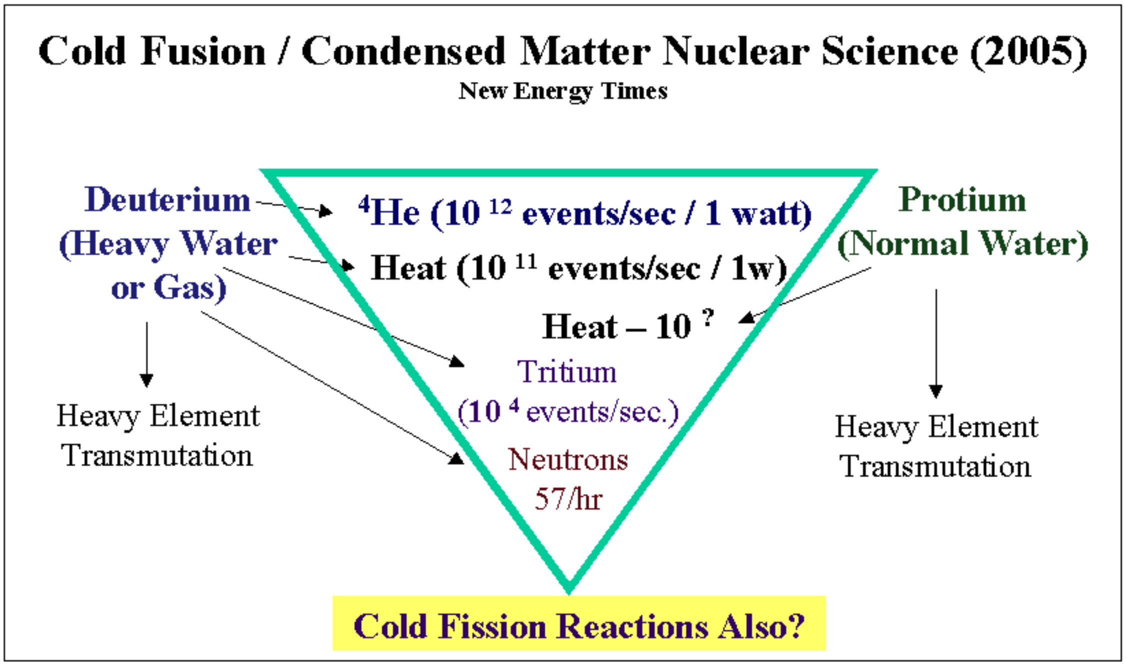

Figure 1. Overview of Reaction Products

Using protium, heat is reported at a lesser degree than with deuterium. Specific reaction rates are unavailable at this time. Both input products have been widely reported to exhibit heavy element transmutation, and some "cold fission" reactions are also reported [17].

1.4 Energy Production: Selected Reports of Excess Heat

Table III displays excess energy data from a few selected reports. Work by El-Boher of Energetics Technologies offers the most comprehensive data sets.

Table III. Energy Production: Selected Reports of Excess Heat

Researcher / Experiment No.	Year	Maximum Excess Heat	Percent Excess Heat	Time	Excess Energy
Arata [18]	1999	10w	No data	2000h	No data
Takahashi [19]	1992	130w	70%	1440h	No Data
El-Boher #56 [20]	2004	3.5w	80%	300h	3.1Mj
El-Boher #64a [20]	2004	34w	2,500%	17h	1.1Mj
El-Boher #64b [20]	2004	32w	1,500%	80h	4.6Mj
Stringham [21]	2004	40w	No Data	No Data	No Data

Arata's work is noted because of the rigorous nature of the experiment and its subsequent replication by McKubre et al. at SRI International. Takahashi performed an early electrolysis experiment which was reportedly replicated by E. Storms as well as F. Celani. The Stringham work, while sparse in its data, is included because of its reported 100% reproducibility and early potential for commercialization.

1.5 Cold Fusion / Condensed Matter Nuclear Science Volumetric Power Densities

Several researchers in the cold fusion/condensed matter nuclear science field have calculated the volumetric power density of palladium when used in these experiments. M. Fleischmann & S. Pons reported in Physics Letters A [22] and J. Preparata et al. reported in J. Electroanalytical Chemistry [23] that their experiments showed significant power densities greater than that of uranium fuel rods (10^3 watts/cm^3) used in nuclear fission reactors. Fleischmann and Pons reported 10^4 watts/cm^3 and Preparata reported 10^5 watts/cm^3.

In recent years, some researchers speculate that the surface area of the host metal, (Pd), is exclusively responsible for the effect. This is in contrast to the consideration that the entire bulk of the palladium is responsible for the effect. Still others consider that in some circumstances, a host metal may not be required at all.

1.6 Heavy Element Transmutation in Cold Fusion / Condensed Matter Nuclear Science

G. Miley performed a survey of experiments demonstrating heavy element transmutation in condensed matter nuclear science. This survey says that 14 laboratories worldwide report claims of nuclear transmutations at low energies [17]. Work pioneered by Y. Iwamura of Mitsubishi Heavy Industries [24], reported first in 2002, is considered among the best in the field. T. Higashiyama of Osaka University [25] reported a replication of the Iwamura work in 2003. Both groups claim 100% reproducibility.

1.7 Myths and Facts of Cold Fusion / Condensed Matter Nuclear Science

Myth 1: Cold fusion is "not reproducible." An effect is reproducible if it happens "more often than not." (Richard Garwin, IBM)
Fact 1: In the early 1990s, the rate of reproducibility was very low. As of 2003, cold fusion shows 83% average reproducibility, with some reports of 100% reproducibility [26].
Myth 2: "Nobody in mainstream science" is researching cold fusion. Mainstream scientists are those "who work in universities." (Frank Close, Rutherford Appleton Laboratory)
Fact 2: Several dozen university scientists have been, or are researching cold fusion [27].
Myth 3: Cold fusion is "impossible according to current nuclear theory." (John Huizenga, Chair, 1989 Department of Energy Cold Fusion Panel)
Fact 3: That was true in 1989, but it no longer is [28].
Myth 4: "The claim that cold fusion is a nuclear process producing excess power without commensurate nuclear reaction products, is pathological science." (John Huizenga)
Fact 4: The pathology ended when proportional amounts of reaction products were discovered in the early 1990s, which demonstrated conformance with the first law of thermodynamics [29].
Myth 5: Cold fusion is false because there are no significant neutrons. "There is no reason to think that the branching ratios would be different for cold fusion" than with hot fusion. (John Huizenga)
Fact 5: Cold fusion is not a colder form of hot fusion. The assumption that cold fusion should follow hot fusion branching ratios is erroneous [30].

Myth 6: No “hard evidence” supports the claims of cold fusion. (Frank Close)

Fact 6: Evidence exists for 4He, 3He, tritium, transmutation and charged particles [31].

Myth 7: Only a “dwindling band of true believers” studies cold fusion. (Robert Park, American Physics Society)

Fact 7: ~200 researchers in 13 countries are actively researching cold fusion [32].

Myth 8: Calorimetry is unreliable.

Fact 8: Many calorimeters applied to cold fusion are accurate to ±50 mW. Energy in excess of 1000 mW is frequently measured [33]. Calorimetry has been a common and trusted tool for electrochemists for over 200 years.

Myth 9: “The fact of the matter is Pons & Fleischmann's experiment never did demonstrate any excess heat. ... It was nothing more than experimental error.” (Lee Hansen, Brigham Young University) Another related myth is that all of the claims of excess heat from the last 16 years of research are all the result of operator error.

Fact 9: Wilford Hansen, of Utah State University, in a report to the state of Utah, verified the excess heat claims of Fleischmann and Pons [10]. Hundreds of observations, using a variety of calorimeters, have been made. It is unlikely that they are all erroneous [34].

Myth 10: Cold fusion “is a simple chemical reaction that has nothing to do with fusion." (Nathan Lewis, Caltech)

Fact 10: Energy generation starts too quickly to result from storage. No specific chemical explanation has been offered for the anomalous heat. The excess heat effect is too large to be of chemical origin. Infrared microscope/ thermographs measure nanoscale hot spots that are hotter than any known chemical heat source. [35].

Myth 11: Cold fusion papers have not been published in peer-reviewed journals.

Fact 11: More than 55 peer-reviewed journals have published cold fusion papers [36].

Myth 12: If cold fusion were “a real phenomenon it would have emerged and be on the way to exploitation.” (Richard Garwin)

Fact 12: Many scientific endeavors are valid but not yet commercially viable including thermonuclear fusion energy [37].

Myth 13: Fleischmann and Pons were incompetent. "Just by looking at these guys on television, it was obvious that they were incompetent fools,” (William Happer, Princeton Plasma Physics Laboratory, former head of the U.S. Dept. of Energy Office of Energy Research)

Fact 13: A refined image does not necessarily correlate with scientific competency [38]. Fleischmann and Pons were poorly prepared by the University of Utah administration for the press conference [39]. Being scientists, not performers, they were ill-prepared for the McNeil/Lehrer TV news show later that day, and their discomfort and unease was evident. They were asked silly questions such as "You did this in the kitchen, right?" by correspondent Charlene Hunter-Gault. Fleischmann was also very worried about other scientists' safety and was concerned that they might inadvertently replicate the "meltdown" experiment and cause fatalities as a result of the news interview.

Myth 14: Fleischmann and Pons were working "outside of their field of expertise." (John Huizenga)

Fact 14: Fleischmann and Pons were among the world's top electrochemists and were experts in their craft and pioneers in a significant new field of science [40].

Myth 15: Fleischmann and Pons "circumvented the normal peer review process." (John Huizenga)

Fact 15: Fleischmann and Pons did not announce their findings before the acceptance of their paper in a peer-reviewed journal [41].

Myth 16: No qualified scientists are convinced of the general phenomena of cold fusion.

Fact 16: Dozens of qualified scientists in universities and government laboratories are convinced that the claims of excess heat and transmutation in "cold fusion" research are valid [42].

Myth 17: Fleischmann and Pons observed large quantities of excess heat quickly after turning on their cold fusion cell.

Fact 17: In the early years of cold fusion research, initiation time often took hundreds of hours.

Myth 18: The original cold fusion experiment was "ridiculously simple." (Fleischmann and Pons)

Fact 18: Not true. It was, and still is, highly complex.

Myth 19: Cold fusion cannot be used for destructive purposes.

Fact: 19: Mankind always seems to find ways to use portable, high-density energy sources for destructive as well as constructive purposes.

Myth 20: Fleischmann and Pons were "incompetent and delusional." (Steven Koonin, Caltech)

Fact 20: The final chapter on cold fusion has not been written. It is yet to be known who was thinking clearly and who was not.

Myth 21: Cold fusion is a "fraud." (Ronald Parker, MIT)

Fact 21: Parker retracted his comment in a press release several days later.

Myth 22: Working cold fusion devices will be available soon. "Prototype cold fusion home heating units are widely expected to emerge this year or next." (Eugene Mallove, 1993)

Fact 22: 12 years later, the only unit to emerge is Dennis Cravens' (Eastern New Mexico University) experimental calorimeter and cold fusion cell which heats up his laboratory.

Myth 23: Cold fusion will provide an inexpensive, inexhaustible source of energy for the entire world.

Fact 23: This is only the hope. The future is unknown.

Figure 2. Myths and Facts of Cold Fusion / Condensed Matter Nuclear Science

1.8 2004 U.S. Department of Energy Cold Fusion Review

Little insight evolved from the 2004 Department of Energy cold fusion review [43]. Storms [44] and Beaudette [45] wrote detailed critiques of the review, which, in their opinions, was poorly orchestrated and poorly executed. The most insightful reference is the reviewers' original comments [46].

1.9 Comparison of Hot and Cold Fusion

Figure 3 displays a comparison of key characteristics, and foreseeable qualities of each field are shown. Best values for hot fusion are displayed. Conservative values for cold fusion are displayed.

Government-Sponsored Research	**Hot Fusion**	**Cold Fusion**
Years Studied	54	16
Estimated U.S. funding to date	$16 Billion [47]	$25 Million [48]
Committed worldwide government funding	> $12 Billion	None
Experimental Qualities		
Shows potential for large-scale power generation	Yes	No
Potential for power production at point of consumption	No (too big)	Yes
Demonstrates self-sustaining nuclear reaction	Never	Yes [22,49-51]

Peak Experimental Power Levels		
Peak output power levels / Duration	16 Megawatt / 1 Sec.	10 watts / 2000 hrs [18,19,52]
Ratio of power out/power in (break-even =1.0)	0.67	> 1.1 [18,19,52]
Typical Experimental Power Levels		
Typical excess power levels	0	1 watt
Duration	n/a	5-600 hours [53]
Fuel		
Fuel required	D + T + Lithium	Deuterium
Dangerous and/or radioactive fuel	Yes	No
Commercialization Expectations		
Earliest estimated commercialization	2050	2010
Requires power distribution grid	Yes	No
Potential use: fixed, mobile, terrestrial, air, and space	No	Yes
Single point of failure for large service area	Yes	No
Security risk	Yes	Yes

Figure 3. Comparison of Hot and Cold Fusion

The future of both fields of study is highly speculative. However, hot fusion likely will be appropriate for large-scale, centralized power generation, and cold fusion likely will be appropriate for smaller installations, at the point of consumption, eliminating the need for a power distribution and transmission network.

2 CONCLUSIONS

Cold fusion is a difficult science problem. This does not mean, however, that the field of cold fusion is unworthy of serious consideration. In fact, as the world's petroleum and natural gas reserves reach their peak production in the next few years and as global energy demands continue to rise, every possible new source of energy becomes increasingly crucial to society and the future of civilization.

History shows us the many misunderstandings and diversions that have impeded the progress of this field of science. This author hopes that the global science community can demonstrate effective and respectable leadership to investigate the possibilities of cold fusion thoroughly.

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