Evidence-Based Public Policy toward Cold Fusion:

Rational Choices for a Potential Alternative Energy Source

Stanley Pons and Martin Fleischmann

Cold Fusion Pioneers

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by

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Cold fusion (CF) is a possible phenomenon in which energy-producing nuclear reactions occur at earth-surface temperatures rather than at high temperatures that are characteristic of hot fusion, such as in the interior of the sun. CF was dramatically and unexpectedly announced at a press conference in 1989. For a variety of reasons, including the method of announcement and difficulties in experimental replication, CF was rejected by mainstream science within a year. Continued experimental success under highly marginalized conditions in the years since rejection indicates, with reasonable probability, that CF may eventually be found to be a real phenomenon. The scientific results accumulated in the years since rejection include over 300 verifications of CF-related phenomena.

There appears to be a high level of public interest in the eventual success of CF, both for its promise as a source of nuclear energy and its other possibilities, such as transmutation of elements. Future public policy toward CF is most effectively determined on a rational basis – within a framework of evidence-based policymaking. Consideration of several aspects of the CF experimental results leads to the conclusion that there is at least a preponderance of evidence (probability greater than

50%) that CF is a real phenomenon. The level could be as high as clear and convincing evidence (greater than 70% probability) – and possibly even beyond a reasonable doubt (greater than 90%).

The appropriate policy response to such high levels of evidence is to reinstate and support CF as a legitimate area of scientific investigation at a minimum. An in-depth policy analysis will be highly beneficial to energy policymakers in determining if even higher levels of support should be considered. With clear and convincing evidence, the response should be to support CF on a par with hot fusion research. If the reality of CF is accepted beyond a reasonable doubt, a crash program of development similar to the Manhattan Project may arguably be justified in the public interest.

There is ample precedent of public support of newly discovered (or claimed) phenomena when the potential public welfare benefit is sufficiently high. Skepticism toward claims of new discoveries is also normally a public welfare benefit. However, skepticism may cease to be in the public interest when new information is not adequately taken into account, which may be the case for CF. Recovery and reinstatement of CF to maximize its possibilities – and realize its potential public welfare benefits – must specifically take into account the negative early outcome and resulting marginalized status of the field. The key players on both sides – the protagonists and antagonists – must adopt a commitment to work in harmony and resolve the issues around CF in order to advance the public interest.

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List of Acronyms

ARPA	Advanced Research Projects Agency
BRD	Beyond a Reasonable Doubt
BU	Business As Usual
CANR	Chemically Assisted Nuclear Reactions
CCE	Clear and Convincing Evidence
CF	Cold Fusion
CMNS	Condensed Matter Nuclear Science
CP	Crash Program
DARPA	Defense Advanced Research Projects Agency
DC	Discontinue CF Research
DOE	U.S. Department of Energy
EBM	Evidence-Based Medicine
EBP	Evidence-Based Policymaking
EDX	Energy Dispersive X-ray
ERAB	Energy Research Advisory Board
ESP	Extrasensory Perception
FPE	Fleischmann-Pons Effect
HF	Hot Fusion
ICCF	International Conference on Cold Fusion
IP	Intellectual Property
ISCMNS	International Society of Condensed Matter Nuclear Science
LBJ	Lyndon B. Johnson
LENR	Low Energy Nuclear Reactions
NAE	Nuclear Active Environment
OS	Office of Science (of the U.S. Department of Energy)
POE	Preponderance of Evidence
PRP	Policy Research Project
PTO	U.S. Patent and Trademark Office
R&D	Research and Development
RL	Reinstate CF Legitimacy

Chapter 1. Introduction

Cold fusion (CF) is a phenomenon in which energy-producing nuclear reactions occur at earth-surface temperatures rather than at high temperatures (such as the interior of the sun) that are characteristic of hot fusion. CF may, or may not, be real. If it proves to be real, CF has the potential to meet at least part of the energy requirements of humankind at low cost and with minimal adverse peripheral effects. Because of its potential as an alternative energy source, CF development is arguably in the public interest[1]. CF phenomena are further described in Chapter 2.

CF was announced by Martin Fleischmann and Stanley Pons in 1989, with indication of its potential public welfare benefit, but it was quickly judged not to be a real phenomenon by the mainstream scientific community. In the nearly 20 years since, however, continued CF research under marginalized conditions has produced evidence that the phenomenon may yet prove to be real. If it is found to be real and is accepted into mainstream science, CF may contribute to the public welfare. Current negative public policies toward CF may therefore not be in the public interest.

Both a long history and well-established precedent exist in Western nations for public support of research and development in phenomena that have not yet been fully established as "real". One example is the development of fission-based atomic energy during World War II, when the recognized potential of nuclear chain reactions was realized as the atomic bomb. Public support for unproven phenomena is deemed justifiable when there is significant potential for public benefit to be realized – when there is a sufficiently clear public interest in the successful development of the phenomenon. At the same time, a well-established tradition of skepticism exists

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[1] Most would agree that development of alternative energy sources that produce energy in large quantities at very low cost is in the public interest. By extension, support of phenomena or discoveries that have the potential to produce such energy is also in the public interest as long as there is reasonable probability the potential will be realized. This assertion is further developed in Chapter 3.

toward radically new ideas or discoveries until they have been well investigated and found to be independently verifiable. Healthy skepticism has served the public interest well in preventing waste of public resources on pseudoscientific pursuits and in reducing personal loss to individuals by unscrupulous practitioners. In cases of extraordinary claims like the announcement of CF, a balance must be struck between acceptance and support on the one hand and caution and skepticism on the other.

The overall purpose of this report is to examine the CF case on a rational basis, with a focus on the evidence for its existence, in hope of achieving a better balance between skepticism and support. Specifically, the objectives are to:

- Review the events around the announcement of CF in 1989 and its quick rejection, with emphasis on whether they led to an appropriate outcome
- Articulate the public interest in the eventual success of CF
- Establish a rational framework ("evidence-based policymaking") for examining the CF case
- Evaluate the scientific evidence and establish the level of evidence for the reality of the CF phenomenon based on universally understood terminology and criteria
- Develop rational policy response options with respect to support of CF research and development, based on the level of evidence of its being real and within a rational framework
- Identify policymaking precedents for claims of new discoveries similar to the CF case for guidance for future policy development
- Review potential "lessons learned" from the policymaking process that took place when CF was rejected in 1989
- Explore the appropriate role of skepticism in relationship to the public interest in evaluating new discoveries and claims like CF

- Develop conclusions on the level of evidence for CF and the consequent appropriate policy directions for realizing the potential of CF
- Identify specific steps for future CF policy development and implementation.

It is specifically not the objective here to demonstrate the reality of CF. Rather, the focus is on evaluating the policy options for CF based on the level of evidence that it is a real phenomenon and on reaching a conclusion about future policy directions in relation to current *de facto* negative CF policies with a focus on the public interest.

The principal signature of CF is the production of "excess heat" – energy that is detected (usually by a calorimeter) in quantities above what can be accounted for by chemical reactions and is therefore inferred to be the result of nuclear reactions. CF, if it exists, has proven to be remarkably difficult to achieve reliably and consistently – certainly much more so than was believed and represented when it was announced in 1989. CF has also proven to be very challenging for development of a satisfactory theoretical underpinning. No doubt experimental reproducibility[2] would become better established once a clear theoretical understanding has been achieved. Reciprocally, theory development would be enhanced if consistent replication were to be achieved. The current status of CF is not atypical of radical new discoveries in the early stages of their investigation and development.

CF appears to be in a classic "double bind" situation for scientific acceptance[3]. Given its potential public welfare benefit, CF must be evaluated and judged, within a rational policymaking framework, and based on the level of evidence of its reality, for appropriate public policy and support in the future.

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[2] The terms "reproducibility" and "replication" are used interchangeably in this report. "Repeatability" is a similar term that often refers to performing the same experiment in the same setting and achieving consistent results.

[3] The evidence that CF exists is not sufficient to warrant the funding that would be needed to do the research that could establish the level of evidence required in order to justify granting research funds.

Chapter 2. Cold Fusion Origins and Controversy

CF was announced rather unconventionally at a press conference in 1989. Current public policy toward CF emerged from the way in which it was announced, how the scientific community reacted to the announcement, and, possibly, by a lapse of the scientific process during the weeks and months afterward. Future CF public policy may be guided by a review of the origins of CF and the controversy that has surrounded it from the beginning. Within this context the evidence for the existence of CF – especially the evidence developed subsequent to its initial announcement – can be evaluated and future public policy established on a rational basis.

What Is Cold Fusion (Or What Might It Be)?

CF is best understood in relation to hot fusion, which occurs naturally in the interiors of the sun and other stars. In the case of hot fusion – in simplified terms – protons (the nuclei of hydrogen atoms) fuse to form the nuclei of helium atoms, which have two protons each. A small fraction of the mass of the protons is lost in the fusion process and is converted into energy in accordance with Einstein's famous equation, $E=mc^2$.

Human achievement of hot fusion took place in 1952 with the explosion of "Mike", the first hydrogen bomb, on the Pacific atoll Eniwetok. Efforts have been made in the years since to capture hot fusion energy for peaceful, beneficial purposes, such as electrical power generation[4]. Tremendous technical obstacles have been encountered in this endeavor, however, and the realization of beneficial energy from hot fusion remains elusive. The most recent and largest research facility for hot fusion

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[4] Large-scale energy release from fission nuclear reactions was first artificially achieved in the Trinity test in New Mexico in 1945, followed by the bombing of Hiroshima and Nagasaki. Commercial power generation from fission nuclear plants began in 1956 with the Calder Hall plant in Sellafield, England. It was widely anticipated that peaceful applications of fusion would follow a similar, parallel path to the success of nuclear fission, but this has not happened despite over 50 years of intensive research.

development is ITER (formerly International Thermonuclear Experimental Reactor), which is in the planning stages for construction in France.

The primary assertion of CF is that a similar release of energy from the fusion of nuclear particles (such as protons) takes place when certain chemical conditions or reactions are created artificially, but the fusion process occurs at temperatures that prevail at the surface of the earth (ambient temperature). In its most basic explanation, CF is induced when hydrogen nuclei are caused to enter the metallic crystal lattice of the element (metal) palladium[5]. By some means not yet adequately explained by nuclear theory, the natural repulsion[6] of the hydrogen nuclei (protons) in the palladium is overcome so that they fuse to form helium as in the case of hot fusion. The energy generated is transferred to the palladium atoms as "excess heat"[7].

The earliest, and perhaps still most widely used experimental apparatus for achieving cold fusion reactions, is the electrochemical cell having an electrolyte of heavy water (deuterium oxide), an anode of platinum, and a cathode of palladium (Figure 1). When a current is applied to the cell, the deuterium ions in the heavy water migrate to the cathode and enter the metal lattice of the palladium as described above, where CF reactions occur.

It now appears that the CF reactions are considerably more complex than envisioned in this early, simple model and may involve more than just hydrogen-to-helium nuclear reactions. But the basic assertion, that nuclear reactions occur at ambient temperature, and energy (in the form of heat transferred to the metal lattice)

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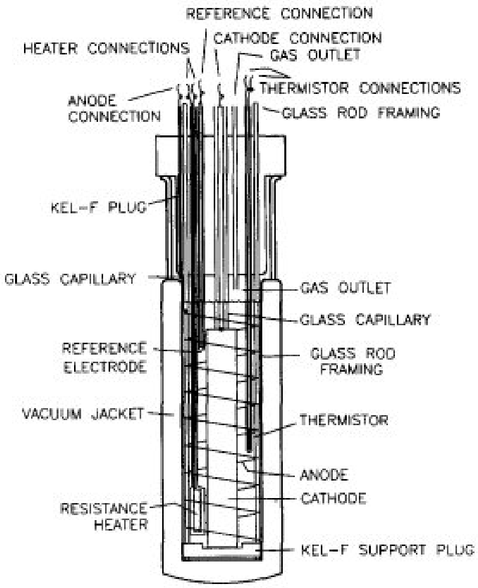
[5] Palladium has the unusual property of accommodating hydrogen or deuterium atoms into the metallic crystal lattice, up to a D:Pd ratio of 1:1 or higher.

[6] The natural repulsion of the positively charged protons is referred to as the "Coloumb barrier". Overcoming this barrier is very difficult and is achieved in hot fusion through high-speed collisions of nuclear particles that can only occur at very high temperatures; i.e., plasma conditions.

[7] Excess heat is considered to be energy produced in a cell that is above what can be accounted for by chemical reactions and is therefore attributed to nuclear reactions.

Figure 1.
Diagram of Fleischmann-Pons Electrolytic Cell for Cold Fusion Experiments



The anode is made of platinum and the cathode of palladium. This figure is from an early Fleischmann-Pons paper[8].

is released, remains the central point of CF. Two other "signatures" of CF reactions besides excess heat (evolved energy beyond what can be accounted for from chemical reactions) are radiation (e.g., alpha, beta, and gamma radiation) and transmutation of elements involved in the reactions caused by changes in the number of protons in the nucleus resulting from fusion reactions[9].

It is currently believed that CF reactions take place in isolated microscopic "pockets", where conditions develop that enable the reactions to occur. These

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[8] Fleischmann, Martin, Stanley Pons, Mark Anderson, Lian Jun Li and Marvin Hawkins. Calorimetry of the Palladium-Deuterium-Heavy Water System. *Journal of Electroanalytical Chemistry*, vol. 287 (1990), p. 293. Online. Available: http://www.newenergytimes.com/TRCF/FPColdFusionMethod.htm

[9] Transmutation of elements in CF reactions involves atoms in the metal electrodes in addition to deuterium or hydrogen atoms.

pockets, termed the "nuclear active environment" (NAE)[10], develop in many adjacent locations simultaneously, resulting in a gross energy-producing effect. The NAE pockets apparently develop in a surface layer on the bulk deuterium-filled metal substrate and individually "self destruct" by tiny explosions when the nuclear reactions occur.

The details of the conditions, and the reactions, that occur in the NAE of a successful CF experiment are in urgent need of in-depth scientific investigation. When these details have been determined, a sound basis will exist for development of explanatory theories. And when the phenomena are understood, and explained by adequate theory, the experimental variables can be controlled, which will then result in greatly improved reproducibility. Pending an adequate program of investigation (which will require substantial funding), achieving the conditions for excess heat generation remains as much an art as a science, which characterizes the prevailing CF experimental situation. This urgent need to develop and implement an adequate research program necessitates a fresh look at public policy toward support of CF phenomena.

Cold Fusion and the Sociology of Science

The work in the scientific community of defining what is accepted as science and what is not comprises a major component of the sociology of science[11]. Robert Merton, the "father" of that field of study, advanced (1942[12], 1968[13]) five

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[10] Storms, Edmund. "What Conditions Are Required to Achieve the LENR Effect?" Paper presented at the "10th International Conference on Cold Fusion (ICCF-10)", Cambridge, MA, 2003.

[11] Ben-David, Joseph, and Teresa Sullivan. "Sociology of Science". Annual Review of Sociology, vol. 1 (1975), p. 203-222.

[12] Merton, Robert. "The Normative Structure of Science." In *The Sociology of Science – Theoretical and Empirical Investigations*, ed. Robert K. Merton Chicago, IL: The University of Chicago Press, 1968. Originally published as Merton 1942.

[13] Merton, Robert K. *The Sociology of Science – Theoretical and Empirical Investigations*: Chicago, IL: The University of Chicago Press, 1968.

characteristics of science that have been summarized by the acronym CUDOS: communalism, universalism, disinterestedness, originality[14], and skepticism. Scientific skeptics are major players in performing scientific boundary work and, as such, may be considered “guardians of the gate” into the realm of true or accepted science. The work of the sociology of science in the case of CF has been well described by Simon[15]. The steps in this process were announcement, attempts at verification, repudiation, and marginalization.

1989 Announcement and Attempts at Verification

CF began when it was announced by scientists Martin Fleischmann and Stanley Pons at a press conference at the University of Utah on March 23, 1989. Nuclear reactions induced by chemical means at ambient temperatures had previously been reported in 1926[16], but the report was subsequently withdrawn when it was determined that the findings were the result of contamination[17]. The events that transpired in the year following the 1989 press conference led to the dismissal and rejection of CF as a real scientific phenomenon by mainstream science. These events will surely be the subject of study by researchers in the sociology of science for years to come[18].

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[14] “Originality” was not in Merton’s essay where the norms were introduced; it was added subsequently.

[15] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

[16] Paneth Paneth, Fritz and Kurt Peters. "Uber die Vervandlung von Wasserstoff in Helium." *Die Naturwissenschaften*, vol. 14, issue 43 (October 1926), p. 956-963.

[17] Paneth, Fritz. "Neure Versuche uber Vervandlung von Wasserstoff in Helium." *Die Naturwissenschaften*, vol. 15, issue 16 (April 1927), p. 379.

[18] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

After Fleischmann and Pons (Figure 2) made their announcement, there was a tremendous response in the research community to verify the assertions made at the press conference. Many researchers at laboratories across the U.S. and around the world sought to build CF cells of similar design, based on meager information available from the press conference and pre-prints of the supporting technical paper, which was not published for another two months[19].

Figure 2.
Stanley Pons and Martin Fleischmann

Pons (left) is holding what appears to be an electrolytic cold fusion cell[20].

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[19] Fleischmann, M. and Stanley Pons. "Electrochemically Induced Nuclear Fusion of Deuterium." *J. Electroanal. Chem.*, vol. 261, p. 301 and Errata in vol. 263 (1989).

[20] Photo source: http://www.ioriocirillo.com/ita/dettagli.documento.php?id=10

The chronology of early events has been well documented by both protagonists and antagonists[21,22]. The results of the verification attempts were decidedly mixed – some researchers reported success at achieving excess heat, while others found the expected nuclear byproducts. Many experimenters were not successful in achieving any results at all. In addition, some initially positive results were subsequently retracted because of contamination or experimental error.

Repudiation

Within the space of a year CF was found to be a non-real phenomenon and was repudiated by most scientists. Three events, described below, stand out as particularly important in the ejection of CF from mainstream science.

Press Conference Announcement and Subsequent Publication of Paper

The announcement in a public forum prior to publication in a peer-reviewed journal was viewed as improper by many scientists and set up a negative attitude at the outset[23]. When the technical paper[24] appeared several weeks later, it was found to be lacking in many of the details needed to run independent experiments to establish reproducibility. Worse, some aspects of the work related to nuclear products were found to be erroneous. However, the claim of excess heat – the main point of the paper – was never challenged successfully. But the critics largely ignored this claim

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[21] Mallove, Eugene F. *Fire from Ice: Searching for the Truth Behind the Cold Fusion Furor*. New York: John Wiley & Sons, 1991, p. 63-101, 131-187.

[22] Taubes, Gary. *Bad Science – the Short Life and Weird Times of Cold Fusion*. New York, Random House, 1993, p. 109-300.

[23] Huizenga, John R. *Cold Fusion: the Scientific Fiasco of the Century*. Rochester, New York: University of Rochester Press, 1992, Appendix III, p. 218-222.

[24] Fleischmann, M. and Stanley Pons. "Electrochemically Induced Nuclear Fusion of Deuterium." *J. Electroanal. Chem.*, vol. 261, p. 301 and Errata in vol. 263 (1989).

and focused on the peripheral problems rather than the true significance of the announcement and paper[25].

American Physical Society Meeting in Baltimore, May 1 to 4, 1989

Through the forums of technical sessions and news conferences during this meeting, which was not attended by Pons or Fleischmann, several hot-fusion scientists collaborated successfully in calling the existence of CF into question[26]. Many observers felt that questionable tactics were used to ridicule not only the phenomenon, but also the pioneering scientists who discovered and announced it[27]. This meeting proved to be the turning point in the scientific community from hopeful support to marginalization and ridicule. Subsequent mainstream publications referred to CF as "bad science,"[28] "pathological science," and "voodoo science."[29] In terms of the sociology of science, the prevailing atmosphere changed from charity to hostility[30]

U.S. Department of Energy, Energy Research Advisor Board (ERAB), Cold Fusion Panel Report

The Secretary of Energy established a CF panel with the charter to assess the status of the phenomenon and make recommendations on whether research funding should be made available for its investigation and development. The panel issued a

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[25] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002, p. 4-5.

[26] Taubes, Gary. *Bad Science – the Short Life and Weird Times of Cold Fusion*. New York, Random House, 1993, p. 264-266.

[27] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002, p. 59-62.

[28] Taubes, Gary. *Bad Science – the Short Life and Weird Times of Cold Fusion*. New York, Random House, 1993, p. 264-266.

[29] Park, Robert L. *Voodoo Science – the Road from Foolishness to Fraud*. New York: Oxford University Press, 2000.

[30] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

draft report in July and a final report in November 1989[31]. The panel was co-chaired by Norman Ramsey and John Huizenga, one of the most outspoken critics of CF. It was widely recognized that Huizenga was the stronger force of the two chairmen. The panel's recommendation was that the U.S. Department of Energy (U.S. DOE) not provide support specifically for CF research. The panel report was one of the most influential factors in establishing negative public policies toward CF that continues to this day[32,33]. The ERAB and its report are discussed in more detail in Chapter 9.

Reasons for Repudiation

In hindsight there were a number of reasons for the quick repudiation of CF. The question of whether the process and factors were rational will be further explored in Chapter 9. The primary reasons appear to be as follows:

> <u>CF was announced with little or no research precedent</u>. Although earlier research, reported in 1926 and subsequently retracted, indicated evidence of chemically-induced nuclear fusion, there had been no research or publications leading up to the March 23 announcement. Reaction by the public and by the scientific community to the announcement was one of surprise bordering on astonishment.
>
> <u>The method of announcement was unconventional</u>. The choice of a press conference method was made by university officials in response to a perceived threat of preemption by researchers at another university (Brigham Young University in nearby Provo, Utah). As noted, the use of this method in advance

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[31] U.S. Department of Energy, Energy Research Advisory Board. "Final Report of the Cold Fusion Panel of the Energy Research Advisory Board." Unpublished U.S. DOE Report, 61 p. November, 1989.

[32] Huizenga, John R. *Cold Fusion: the Scientific Fiasco of the Century*. Rochester, New York: University of Rochester Press, 1992, p. 218-222

[33] Mallove, Eugene F. *Fire from Ice: Searching for the Truth Behind the Cold Fusion Furor*. New York: John Wiley & Sons, 1991, p. 176-181.

of a conventional staged review, including review by competent peers, was viewed as a violation of protocol if not outright impropriety.

The CF phenomenon was not consistently achieved by all researchers. As noted, attempts to replicate the CF experimental results were decidedly mixed. The difficulty of achieving success was understated in the initial announcement, and insufficient detail was provided in the initial paper on how to run the experiment. Failure to achieve expected results was mistakenly interpreted as evidence that CF was not real.

The expected nuclear byproducts were not consistently observed. CF, in other words, did not meet the criteria or expectations based on current theories or understanding of nuclear reactions. As has often been the case for newly discovered scientific phenomena, the initial response was to question or reject the phenomenon. The question appeared not to be, "Since we don't see what's expected, let's find out why through further investigation" but rather "Since we don't see what we expect, the phenomenon must not be real." Discoveries in the past that have survived initial rejection have often resulted in the dramatic expansion of current understanding or revolutionary new theories[34]. An example from the geological sciences is continental drift, which was rejected as impossible until a mechanism for its occurrence – plate tectonics – was discovered, whereupon it became almost universally accepted.

The chemists who discovered and developed CF were insufficiently competent in the field of nuclear physics. Because the 1989 announcement came virtually without research precedent, it arrived "without warning" to the community of high-temperature fusion physicists, who were unaware of development of nuclear fusion by any other means. A degree of suspicion may have been a natural human response under the circumstances. The situation was

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[34] Additional observations on this aspect of the sociology of science are made in Chapter 4.

exacerbated by errors in the measurement of neutron emissions and other problems with the original very brief technical paper.

The news was too good to be true. The prospect of virtually free and unlimited energy, after humankind's long historical dependence on carbon-based fuels (with all of their encumbrances), was viewed with both anticipation and caution.

It couldn't be that easy or simple (particularly in relation to hot fusion). The Manhattan Project had produced the first atomic (fission) bomb ignition in New Mexico (the Trinity Test) in 1945, just four years after the project started. The first hydrogen (fusion) bomb followed just seven years later, in 1952. Peaceful uses of fission energy were achieved in 1956. But by 1989, thirty-five years of research by the world's top scientists had not yielded a reasonable prospect of beneficial energy from high-temperature fusion.

It is noteworthy that most of these factors have to do with the sociology of scientific investigation rather than the science (physics) of the CF phenomenon itself. That is to say, CF was rejected, and CF research was marginalized, not so much because of the phenomenon itself as the context, researchers' background, methods of announcement, and similar human (sociological) factors. The public interest calls for a rational policy based on the actual phenomenon and its promise rather than the sociological factors of how "science is done."

Marginalization and Continued Promise

After its rejection, CF was thoroughly marginalized but did not experience the fate of most discredited scientific claims. Instead, it has continued to be pursued by a number of investigators who have continued to find favorable experimental evidence. These findings, along with reinterpretation of some of the original research in the early months, indicate that there is a reasonable probability that nuclear energy may be produced in CF reactions.

The Cold Fusion Research Community

In spite of (or perhaps because of) CF's marginalized status, scientists who remain active in the field have formed a mutually supportive, albeit sometimes fractious, research community[35]. Research funding is difficult to obtain, laboratory and other facilities are not available[36], graduate students cannot be found to conduct experiments, and research reports are routinely rejected by mainstream scientific journals. In response, the CF community has developed a research setting that is outside, but in many ways parallel to mainstream science. For example, a CF professional organization has emerged (International Society of Condensed Matter Nuclear Science, ISCMNS), and international conferences are held about every 16 to 18 months (International Conference on Cold Fusion, ICCF). The 14th ICCF conference was held in Washington, DC in August 2008 with over 180 attendees.

Because of CF's lack of normal communication and reporting venues, the CF research community perhaps makes more extensive use of digital methods and tools than those publishing in mainstream science journals and similar channels. An open source journal for cold fusion papers (Journal of Condensed Matter Nuclear Science) has been initiated. Technical and sociological dialogue takes place on a Google Group, CMNS, which can be joined by invitation from a current participant. At least two websites have been developed that include most of the papers published in CF research since the beginning; one of the sites includes more than 500 papers and a bibliography of over 3,000 journal articles and books. Newsworthy CF events are assiduously reported on The New Energy Times website, which is maintained by a news reporter who has dedicated a great deal of effort to "tell the CF story".

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[35] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

[36] Much CF research is conducted with little or no budget "on the side" at facilities where scientists are conducting more "legitimate" research programs. CF research is also conducted in individual garage and back-yard laboratories.

Chapter 3. The Public Interest in Cold Fusion

Future public policymaking for CF must be guided by what is most rational and in the public interest. The focus on public interest is founded on the responsibility of representative, constitutional democracies, which derive their power from the consent of the governed, to serve the people represented in the best manner possible (Birkland, p. 21)[37,a]. Protection and enhancement of the public interest are the principal responsibilities of representative governments and form the basis of policies they adopt (Anderson, p. 137)[38,b]. The public has a strong interest in readily available energy supplies at reasonable cost.

The world has insatiable energy needs because of a burgeoning population and the requirements of industrial and technological society. Current methods and resources for meeting those needs have become increasingly problematic owing to a combination of depletion, environmental degradation, and geopolitical issues. The need for alternative energy resources and technologies to current fossil-fuel based energy supplies has become almost universally recognized. Identification and development of new and alternative sources of energy is therefore now broadly accepted as being strongly in the public interest. By extension, research into CF – as long as it holds promise as a source of energy –rationally must also be considered to be in the public interest. The public interest in CF thus lies not in its demonstrated basis in reality and ability to meet society's energy needs but rather in the potential that it may be real and may be able to be a source of energy. The public interest argument for supporting pursuit of CF is therefore assumed throughout this report.

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[37] Birkland, Thomas A. *An Introduction to the Policy Process – Theories, Concepts, and Models of Public Policy Making*. Armonk, NY: M.E. Sharpe, 2001. See also Endnote a.

[38] Anderson, James E. *Public Policymaking*. 6th ed. Boston: Houghton Mifflin, 2006. See also Endnote b.

The potential public welfare benefits of CF were initially asserted by Fleischmann and Pons in the 1989 press conference[39]. Although the public interest in CF is based primarily on its prospects as an energy source, there may also be other substantial public benefits, such as elemental transmutation. Some CF protagonists argue for an ethical necessity to pursue CF development as rigorously as possible.

Cold Fusion as a Potential Source of Energy

If it is shown with a reasonable probability that excess heat is generated in CF reactions, the public interest in the phenomenon follows: CF should be pursued to realize its benefit to humankind as a source of energy. The public interest in energy from CF reactions derives from several of its characteristics:

> The energy produced is free (or at least very low cost). The raw materials, probably palladium and deuterium, occur in reasonable abundance at the surface of the earth. And they are consumed at extremely low rates in relation to the quantity of energy produced.
>
> Minimal adverse side effects are generated. No radioactive waste similar to that produced in fission energy processes are generated in CF. And there are few, if any, other adverse environmental impacts. And any replacement of fossil fuels by CF as a source of energy would reduce global climate change caused by increase in carbon dioxide levels in the atmosphere.
>
> A number of geopolitical factors would be improved. The Western dependence on foreign sources of petroleum could be alleviated to the extent that CF can provide an alternate source of energy.

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[39] Pons stated in the 1989 press conference: “But it does seem that there is here a possibility of realizing sustained fusion ... with a relatively inexpensive device, which could be ... brought to some sort of successful conclusion fairly early on.” Fleischmann similarly stated “… it does seem that there is here a possibility of realizing sustained fusion... with a relatively inexpensive device, which could be ... brought to some sort of successful conclusion fairly early on.”

> Energy may be produced by both large concentrated and small dispersed generation units. Large power production facilities may be built for major energy applications, such as power generation and desalinization. And small, distributed units could be deployed for communities or individual residences for heating or cooking.

The prospect of excess heat by itself appears to be sufficient for a cogent public interest argument for careful policy analysis toward CF.

Promise for Elemental Transmutation

Excess heat appears not to be the only potentially beneficial phenomenon associated with CF reactions. CF may, in fact, be a “door opener” for an entirely new branch of physical science. For example, some experiments have found the presence of chemical elements that were not present at the start of the experiment, indicating that elemental transmutation is occurring (see Chapter 6, below). If controlled transmutation could be achieved, the potential benefit could be as great as that of excess energy.

Ethical Considerations

The argument for changes in CF policy may go beyond just the general public interest. The human condition in many regions and nations of the world could be greatly improved by the availability of dispersed CF-based energy sources for cooking and heating. For example, the ability to readily boil water to eliminate pathogens in drinking water would greatly improve general public health conditions, particularly through reductions in infant mortality. Some CF protagonists argue that this potential to help meet basic human needs in poverty-stricken areas makes CF support a matter of ethical necessity that transcends higher-level public interest considerations. The ethical dimension of developing sources of low-cost, readily available energy sources may change the question of “Should we support CF development?” to one of “Must we?”

Key Policymakers

Change in public policy toward CF, if deemed appropriate and necessary (by the evidence-based case made in this report or other driving force), will involve many participants. It is apparent that the greatest need for CF development is for increased research in the fundamentals of what is occurring at the nuclear level and in explanations (theory development) for experimental results. The “key players” are then identified as those having the capability to provide support (funding) – by both the public and private sectors – for research and development into CF phenomena. In the U.S., the Department of Energy (U.S. DOE) would be the logical source of CF support. Given the national security implications of CF realization, agencies of the U.S. Department of Defense (U.S. DOD), such as the U.S. Defense Advanced Research Projects Agency (U.S. DARPA), would also be candidates. Also, changes in current policies of the U.S. Patent and Trademark Office (U.S. PTO) will be required in order for private-sector support to be significantly enhanced.

Conclusion: the Public Interest in Cold Fusion

The public has a strong interest in CF not only because of its potential as a source of energy, but also because of other possible benefits, such as transmutation. The pursuit of CF may, in fact, be more than a public interest question – it may be ethically mandated given the promise that it holds as a diffuse energy source for populations at risk due to unsafe water supplies in poverty-stricken areas.

Chapter 4. Policy Precedents for New Discoveries

CF may, or may not, be real. The significant question for policymakers is what policies to adopt regarding CF, given the high public interest in its success and the possibility that it may eventually prove to be a real phenomenon. CF is by no means the first idea or discovery that has challenged policymakers in determining how best to serve the public interest and what course of action to pursue. Future policy toward CF may therefore be informed by policymaking approaches for similar cases in the past. Three aspects of past treatment of new discoveries and associated policies are particularly significant – public support of phenomena not yet accepted by mainstream science, "paradigm-shifting" discoveries generally, and the role of skepticism in dealing with new claims or discoveries.

Public Support of Unproven Phenomena

There is a long-standing practice in the U.S. and other Western countries of providing public support to promising new discoveries during early stages of their development when it is in the public interest to do so. It may be argued that the greater the change demanded by a new discovery, and the greater the payoff for the public interest, the higher the need for public support to bring the discovery to fruition.

The potential value of phenomena that are not yet well established or accepted by the scientific community has long been recognized in the U.S. For example, after the surprise launch of Sputnik in 1957, a new research support agency – Advanced Research Projects Agency (ARPA) – was established in the U.S. Department of Defense. The mission of the new organization (later renamed Defense Advanced Research Projects Agency, DARPA), is described as follows:

> DARPA's original mission, inspired by the Soviet Union beating the United States into space with Sputnik, was to prevent technological surprise. This mission has evolved over time. Today, DARPA's mission is to prevent technological surprise for us *and* to create technological surprise for our adversaries…[40]

DARPA has sponsored many projects resulting in technological advances that have had worldwide impact. These advances include computer networking, which led to development of the Internet, and the precursor to the graphical user interface (GUI) currently used on nearly all computers.

Expenditure of public funds in pursuit of non-established phenomena is a matter of historical record in areas such as extra-sensory perception (ESP), telekinesis and other "paranormal" phenomena. Thus when the public interest is high, and when the level of evidence is great enough, there is ample precedent of public support for phenomena not yet fully demonstrated. Regardless of whether public support is given to development of a new claim or discovery, the outcome for the discovery may be favorable or unfavorable. There are many examples of different levels of public support and final outcomes; six are shown below for illustrative purposes:

	Support	No Support
Success	Atomic Bomb[i]	Cold Fusion[ii]
No Success	ESP; Telekinesis[iii]	N-Rays; Polywater[iv]

[i] Manhattan Project at the end of World War II
[ii] Success of CF is still a matter of debate
[iii] DARPA-supported research with no positive results to date
[iv] N-rays and polywater claims have been fully discredited[41,42]

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[40] U.S. DARPA. "DARPA Strategic Plan 2007 – Bridging the Gap, Powered by Ideas". Washington, D.C., U.S. DARPA, February 2007, 48 p. Online. Available: http://www.darpa.mil/body/mission.html. Accessed October 2008.

[41] Rene-Prosper Blondlot, a distinguished French physicist at the University of Nancy claimed discovery of N-rays – which he named for the university – in 1903. A period of international interest and excitement followed as other scientist sought to replicate the N-ray experiments. U.S. physicist Robert Wood debunked the existence of N-rays during a visit to Blondlot's laboratory, when he

These examples, of course, represent “end points’ in a spectrum of level of support (full to none) and degree of success.

Paradigm-Shifting Discoveries

The case of CF is in many ways without historical precedent. However, review of the events that occurred when CF was rejected in the initial year after its announcement, and in the nearly 20 years of highly marginalized research since, reveals many similarities to other major scientific discoveries in the past.

CF was rejected in large measure because of its incompatibility with known theories of nuclear phenomena. It is now well understood from the sociology of scientific investigation that new or unexpected discoveries are often initially rejected. Incremental advances in scientific discovery are normally accepted without much perturbation of the sociological system of scientific investigation. But radical new discoveries that fundamentally challenge the existing framework of understanding are often initially rejected, and even held up for ridicule, before the evidence becomes overwhelming and their basis in reality is accepted. The example of continental drift and plate tectonics was provided above in Chapter 2.

The phenomenon of initial rejection and ridicule followed by acceptance has been well characterized for science in general by Kuhn[43] and for the CF case specifically by Simon[44]. CF policymaking on the basis of evidence may benefit from

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secretly removed or replaced key components of the apparatus as the experiment was performed. The experimenters continued to believe they were observing N-rays after Wood’s secret actions. The N-rays case is frequently referenced as an example of pathological science.

[42] The discovery of polywater was claimed by Russian Scientists Fedaykin and Derjaguin in the 1960s. The anomalous properties claimed for polywater were eventually found to be the result of laboratory contamination. Like N-rays, the case of polywater is often cited as an example of pathological science.

[43] Kuhn; Thomas. *The Structure of Scientific Revolutions*. 2nd ed. Chicago: Univ. of Chicago Press, 1970

[44] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

viewing CF as a potential “paradigm-shifting” discovery as conceived by Kuhn[45]. If CF proves to be real in spite of objections of the hot fusion nuclear physicists, radical revision of the understanding of nuclear phenomena would be required. In other words, the discovery, rejection and marginalization of CF may prove to be a textbook example of a paradigm-shifting discovery.

The history of science is replete with examples of initially rejected claims that have proven to be true. Two examples of revolutionary and initially rejected scientific discoveries are the heliocentric theory of Copernicus and the quantum theory of Max Planck and Albert Einstein. Another candidate would be the theory of continental drift of Alfred Wegener of 1912[46], which was rejected until the theory of plate tectonics was developed in the 1960s and 1970s.

Few rejected discoveries are eventually reinstated and bring about a reordering of scientific understanding of the magnitude of a paradigm shift. Whether CF should receive public support is a balanced decision based on the high level of public interest, the level of evidence that it is real, and the risks involved if it is not.

Skepticism and the Public Interest

Many untrue or impossible claims regarding natural and paranormal phenomena have been made throughout the course of human history. And many people have been “taken in” by false claims and suffered financial or other harm from such claims. Healthy skepticism provides a substantial service to society by “putting the lie” to all manner of pseudoscientific claims, whether innocent or diabolical, and

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[45] Sharrock, Wes and Rupert Read. *Kuhn: Philosopher of Scientific Revolutions*. Malden, Massachusetts: Blackwell, 2002.

[46] Wegener, Alfred. *The Origin of Continents and Oceans*. Translated from the third German edition by J. G. A. Skerl. New York: Dutton, 1924.

avoiding wasteful expenditure of public or private funds. The social value of skepticism is asserted by leading contemporary scientific skeptics[47].

As will be asserted in Chapter 6, the burden of proof in scientific research lies with the investigator, who must make the case for a new discovery in order for it to gain acceptance in the scientific community. The "boundary work" – determining what is and what is not accepted – is a primary component of the sociology of science and is essential to the scientific progress. This boundary work has been well described specifically for the CF case by Simon[48].

CF has been the subject of its share of skepticism. CF is referenced specifically, for example, in Shermer's Skeptical Manifesto and his Baloney Detection Test[49]. The drive to debunk CF as a legitimate area of scientific investigation in the early weeks and months after its announcement will no doubt be the subject of investigation in the sociology of science for some time to come. Once CF was called into serious question in 1989, a "bandwagon" effect set in that resulted in many publications referring to CF variously as bad[50] or voodoo[51] science or as a scientific fiasco[52].

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[47] Shermer, Michael. "A Skeptical Manifesto". Altadena, CA, Skeptics Society. Online. Available: http://www.skeptic.com/about_us/manifesto.html. (See section on "The Essential Tension Between Skepticism and Credulity" for specific reference to cold fusion.)

[48] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

[49] Shermer, Michael. "Baloney Detection - How to Draw Boundaries between Science and Pseudoscience, Part I". *Scientific American*, v 285, Issue 5 (November 2001). Online. Available: http://www.sciam.com/print_version.cfm?articleID=000D743A-CC5C-1C6E-84A9809EC588EF21. (See question #3 for specific reference to cold fusion.)

[50] Taubes, Gary. *Bad Science – the Short Life and Weird Times of Cold Fusion*. New York, Random House, 1993

[51] Park, Robert L. *Voodoo Science – the Road from Foolishness to Fraud*. New York: Oxford University Press, 2000.

[52] Huizenga, John R. *Cold Fusion: the Scientific Fiasco of the Century*. Rochester, New York: University of Rochester Press, 1992.

In the case of CF, as for potential paradigm-shifting discoveries, the main questions are: “When does skepticism no longer serve the public interest? When has the pendulum of skepticism swung too far?” This pendulum swing is referred to as “pathological disbelief”[53] by protagonists; it may be more damaging to the public interest than fraudulent scientific claims. Excessive skepticism may contribute to the closed-mindedness toward CF that appears now to prevail in the scientific community.

Whereas CF should certainly not be exempted from healthy, legitimate skepticism, neither should it continue to be marginalized because of an outmoded bandwagon effect or excessive skepticism. If CF has been established based on a reasonable level of evidence, continuation of the marginalization of CF may legitimately be considered as pathological disbelief and contrary to the public interest.

Conclusion: Policy Precedents for the Cold Fusion Case

Notwithstanding the friction and drama associated with the announcement and rejection of CF, the historical record shows that its case may not, in reality, be particularly unusual. Discoveries requiring a major scientific paradigm shift (as CF certainly must be if it ultimately proves to be real) more often than not are initially rejected and even vilified because of the threat posed to the existing order – and the vested interests that exist in that order[54].

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[53] Josephson, Brian D. “Pathological Disbelief”. Presentation to Nobel Laureates’ meeting, Lindau, Germany, June 30, 2004.

[54] Max Planck is credited with this quote: “Scientific progress takes place one funeral at a time.”

Chapter 5. Framework: Evidence-Based Policymaking

Given the demonstrated public interest in the success of CF, the policy precedents for claims of new discoveries in the past, and the current diminished status of the phenomenon in scientific circles, how should future policy be determined? Public policy is normally made in response to many driving forces and constraining factors. As is the case for other topics in the public arena, future CF policy may proceed within different frameworks, such as the ideological, political, and rational approaches.

When the founding fathers established the American government, they created a system of checks and balances that was based on faith in reason – it was believed that policies would emerge through the political process that were, at a minimum, rational. Such faith in reason extends back to the beginnings of the Enlightenment and the development of Western civilization. Although it was recognized that many forces besides reason would certainly influence policy, seldom would transparently irrational decisions or directions be acceptable to the public or judged to be in the public interest.

Postmodern trends and influences, which are rooted in part in unanticipated collateral effects of Modernist solutions to human problems, have resulted in a decrease in the role of rationality in recent years as the primary criterion for policymaking. A number of prominent policymakers have decried the decline of reason as a primary guiding force in policymaking[55]. However, the failures of non-rational decision making and policy setting have resulted in a resurgence of rationality as a superior basis or framework for decision making and policy setting. The return to rational policymaking, based on actual evidence, began in the medical

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[55] See, for example, Gore, Al, *The Assault on Reason*. New York: The Penguin Press, 2007.

field as “evidence-based medicine” (EBM) and has extended to other areas. A strong overtone of pragmatism – “what works” – pervades the movement to rational, evidence-based decision making in medical treatment, business management, policy development, and other arenas.

Origins in Evidence-Based Medicine

EBM seeks to apply the scientific method to medical practice in order to achieve consistency and improvements in the medical care of patients. One prominent source in the field defines EMB as “the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients.”[56]

EBM traces its roots to Avicenna’s “The Canon of Medicine”, which appeared in the 11th century. But EBM started to become a major force in medical practice in 1972 with the publication[57] of “Effectiveness and Efficiency: Random Reflections on Health Sciences.” The author of this book, Archie Cochrane, has had evidence-based medical research organizations, the “Cochrane Centers”, named for him as well as the international Cochrane Collaboration[c] organization. EBM applies the scientific method to medical practice by making explicit use of research results when developing guidelines for diagnosing and treating medical conditions and individual patients. The success of rational, evidence-based methodologies in medicine has resulted in its extension to other fields, including business management[58] and public policymaking.

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[56] Sackett D.L., W.M. Rosenberg, J.A. Gray, R.B. Haynes, and W.S. Richardson. “Evidence Based Medicine: What It Is and What It Isn’t”. *British Medical Journal (BMJ)*, vol. 312, no. 7023 (1996), p. 71-72.

[57] Cochrane, Archie, *Effectiveness and Efficiency: Random Reflections on Health Sciences*. London: Nuffield Provincial Hospitals Trust, 1972.

[58] See, for example, Cascio, Wayne. “Evidence-Based Management and the Markletplace for Ideas”. *Academy of Management Journal*, vol. 50, no. 8 (2007), p. 1009-1012.

Characteristics of Evidence-Based Policymaking

Evidence-based policymaking (EBP) is fundamentally the formulation of policy on a rational basis, relying on objective evidence as established by research and past experience. Its rise in recent years may be attributed to the success of EBM and to a reaction to the failures of non-rational policies. EBP has been particularly prominent in the United Kingdom, perhaps reaching a peak in application with the election of the Labour Government in 1997[59]. This government's guidance document[60], *Modernising Government*, states the following (underline added):

> This government expects more of policy makers. More new ideas, more willingness to question inherited ways of doing things, better use of evidence and research in policy making and better focus on policies that will deliver long term goals.

One of the early proponents of extension of EBM to EBP was Adrian Smith, a British academician. And EBP has since been particularly well articulated by British authors[61,62,63]. However, EBP's origins as "experimental social reform" can actually be traced to the U.S., when Campbell[64] wrote the following in 1969 (p. 409):

> The Untied States and other modern nations should be ready for an experimental approach to social reform, an approach in which we try out new programs designed to cure specific problems, in which we learn whether or not these programs are effective, and in which we retain, imitate, modify or discard them on the basis of their apparent effectiveness on the multiple

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[59] Davies, Huw, Sandra Nutley and Peter Smith. "Introducing Evidence-Based Policy and Practice in Public Services"." In *What Works? Evidence-based Policy and Practice in Public Services*, ed. Huw T.O. Davies, Sandra M. Nutley and Peter C. Smith. Bristol, England: The Policy Press, 2000.

[60] Cabinet Office. *Modernising Government*, Cm4310. London: Stationery Office, 1999

[61] Davies, Huw, Sandra Nutley and Peter Smith. *What Works? Evidence-based Policy and Practice in Public Services*. Bristol, England: The Policy Press, 2000.

[62] Sanderson, Ian. "Evaluation, Policy Learning and Evidence-Based Policy Making". *Public Administration*, vol. 89, no. 1 (2002), p. 1-22.

[63] Pawson, Ray. *Evidence-based Policy – a Realist Perspective*. London: Sage Publications, 2006.

[64] Campbell, Donald T. "Reforms as Experiments". *American Psychologist*, vol. 24, no. 9 (1969), p. 409-429.

> imperfect criteria available. Our readiness for this stage is indicated by the inclusion of specific provisions for program evaluation in the first wave of the 'Great Society' legislation and by the current congressional proposals for establishing 'social indicators' and 'data banks'[65]

A rational and scientific basis for policy study has been embraced by many authors of policy texts. For example, Birkland[66] (p. 3) states the following:

> Some readers may have trouble believing that the study of something that is as chaotic as public policy making can be treated as a "science" and can employ the scientific method. For those readers, I hope this discussion of policy "science" will serve as a confidence builder in the face of the almost inevitable claim that the research policy scholars do "isn't really science." While the study of public policy is different from the "natural" or "hard" sciences, I hope to explain how those of us who study policy believe it can be a scientific and rigorous endeavor that yields important hypotheses and allows these ideas to be tested and refined.

Anderson[67] (p. 4) recognized five stages of the policy process: 1) problem identification and agenda setting; 2) formulation; 3) adoption; 4) implementation; and 5) evaluation. These stages are depicted diagrammatically as shown in Figure 3; note the use of the term "common sense" – signifying reliance on rationality – in the lower portion of the figure. The rational basis for the policy cycle is described by Sanderson[68] (p. 5-6):

> Thus it appears to be rational common sense to see policy as a purposive course of action in pursuit of objectives based upon careful assessment of alternative ways of achieving such objectives and effective implementation of the selected course of action. Moreover, rationality is enhanced by being clear about the objectives we wish to achieve and by evaluating the extent to which

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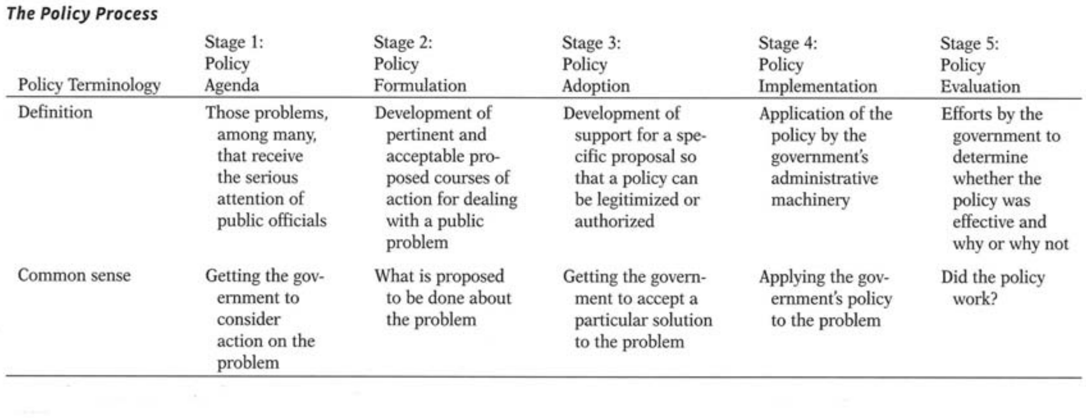
[65] As cited on page 2 of Pawson, Ray. *Evidence-based Policy – a Realist Perspective*. London: Sage Publications, 2006.

[66] Birkland, Thomas A. *An Introduction to the Policy Process – Theories, Concepts, and Models of Public Policy Making*. Armonk, NY: M.E. Sharpe, 2001.

[67] Anderson, James E. *Public Policymaking*. 6th ed. Boston: Houghton Mifflin, 2006.

[68] Sanderson, Ian. "Evaluation, Policy Learning and Evidence-Based Policy Making". *Public Administration*, vol. 89, no. 1 (2002), p. 1-22.

Figure 3.
The Policy Process



The Policy Process

Policy Terminology	Stage 1: Policy Agenda	Stage 2: Policy Formulation	Stage 3: Policy Adoption	Stage 4: Policy Implementation	Stage 5: Policy Evaluation
Definition	Those problems, among many, that receive the serious attention of public officials	Development of pertinent and acceptable proposed courses of action for dealing with a public problem	Development of support for a specific proposal so that a policy can be legitimized or authorized	Application of the policy by the government's administrative machinery	Efforts by the government to determine whether the policy was effective and why or why not
Common sense	Getting the government to consider action on the problem	What is proposed to be done about the problem	Getting the government to accept a particular solution to the problem	Applying the government's policy to the problem	Did the policy work?

Source: Anderson[69], p. 4

the policy as implemented actually achieves these objectives. If policy is goal-driven, evaluation should be goal-oriented. Such evaluation completes the cycle and provides feedback to improve the policy.

The principal causes of the rise of (or return to) a rational, evidence-based framework for policymaking are cited by Davies, Nutley, and Smith[70] (p. 1-2) as follows:

- Increasing public and political skepticism toward professionals and experts based solely on their experience and judgment
- An increasingly well-educated and well-informed public
- The explosion in the availability of all types of data
- Technological developments in information technology
- Growth in the size and capabilities of the research community

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[69] Anderson, James E. *Public Policymaking*. 6th ed. Boston: Houghton Mifflin, 2006.

[70] Davies, Huw, Sandra Nutley and Peter Smith. "Introducing Evidence-Based Policy and Practice in Public Services"." In *What Works? Evidence-based Policy and Practice in Public Services*, ed. Huw T.O. Davies, Sandra M. Nutley and Peter C. Smith. Bristol, England: The Policy Press, 2000.

- Increasing emphasis on productivity and international competitiveness
- Increasing scrutiny and accountability in government in general

Two of the central features of EBP are its reference to realism for its philosophical underpinnings and its focus on pragmatism ("what works"). The case for realism is well summarized by Pawson[71] (p. 17):

> …as the foundation stone of social science, 'realism' provides the most comprehensive account of principles and practice, theory and method, promise and limitations. Given this pedigree, realism is solidly placed to supply a durable understanding of the process of cumulation of social scientific knowledge. Evidence-based policy seeks to stockpile the collective wisdom of thousands of pieces of applied research and can do no better than to look to realism for a methodology of synthesizing the available evidence.

And the reliance on pragmatism is stated in Davies, Nutley and Smith[72] (p. 3):

> While all sorts of systematic enquiry may have much to offer the rational development of public services, our primary interest is in evidence of what works, hence the title of this volume. We will to some extent assume that policy goals have been articulated and that client needs have been identified. The crucial question that remains is what interventions or strategies should be used to meet the goals and satisfy the client needs?

The case for using pragmatism and realism in EBP is set forth by Sanderson[73] (p. 8) as follows:

> … the task is to understand what works, for whom, in what circumstances, and why as a basis for piecemeal social reform; indeed, the phrase 'what matters is what works' has become something of a mantra in evidence-based policy circles. Realists argue that they provide the basis for a 'middle ground' between the over-optimistic claims of objectivists on the one hand and over-pessimistic nihilism of relativists on the other…. Realism therefore offers the

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[71] Pawson, Ray. *Evidence-based Policy – a Realist Perspective*. London: Sage Publications, 2006.

[72] Davies, Huw, Sandra Nutley and Peter Smith. "Introducing Evidence-Based Policy and Practice in Public Services"." In *What Works? Evidence-based Policy and Practice in Public Services*, ed. Huw T.O. Davies, Sandra M. Nutley and Peter C. Smith. Bristol, England: The Policy Press, 2000.

[73] Sanderson, Ian. "Evaluation, Policy Learning and Evidence-Based Policy Making". *Public Administration*, vol. 89, no. 1 (2002), p. 1-22.

> prospect of ‘steering the juggernaut’ on the basis of a better understanding of what is likely to work in terms of public policies and programmes. This provides a potentially important basis for effective governance but a broader institutional framework is required to deal with social complexity that goes beyond traditional command and control models…

Application to the Cold Fusion Case

In summary, EBP is the rational application of evidence, generally in the form of research results, in a scientific way for the formulation and implementation of public policy in many different arenas. EBP has been found to be superior to other policymaking frameworks by ensuring that the public interest is best served.

EBP has been applied in many areas of social interventions, such as crime control, education, housing, and transportation. With its emphasis on realism and pragmatism, EBP also provides the optimum framework for determining public policy toward CF. Given the high level of public interest in the success of CF development, public support should be measured by the level of evidence that it is a real phenomenon. Evidence for the existence of CF is best determined first by reviewing the scientific “case” for its basis in reality and then by interpreting the scientific case in terms of levels of evidence that are widely understood and readily applied to formulating policy.

Chapter 6. Scientific Evidence of Cold Fusion

The central question for the future of CF and its realization for the public interest remains whether it is, or is not, a real phenomenon. There is at present not a definitive answer to this question. What constitutes "sufficient evidence" for the existence of CF? Who has the responsibility for making the case? What is the strength of evidence for the reality of CF at the present time? Answers to these questions are critical to determining appropriate public policy toward CF.

An assessment of the scientific evidence for CF provides the basis for evaluating the level of evidence of its existence, expressed in universally understood and accepted terms, and the appropriate (rational) public policy response. The scientific evidence can be assessed by first establishing who has the burden of proof for CF existence and then considering examples of early experimental verifications, the growing body of evidence since initial rejection, particularly convincing experiments and demonstrations, and a statistical analysis of the initial attempts at confirmation (both successful and unsuccessful).

Burden of Proof

In scientific investigation, proof of the reality of a new discovery lies with the researcher. The necessity of making a sound scientific argument for CF has been accepted by investigators from the outset and continues to the present. This "burden of proof" concept is defined from a legal perspective (Garner[74], p. 209) as follows:

> <u>Burden of Proof</u>. 1. A party's duty to prove a disputed assertion or charge. The burden of proof includes both the burden of persuasion and the burden of production. – Also termed *onus probandi*. 2. Loosely, burden of persuasion.

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[74] Garner, Garner, Bryan A. *Black's Law Dictionary*. . 8th ed. St Paul, Minnesota: West Publishing Co. 1990.

When an investigator claims a discovery, it is incumbent upon him or her to make the case for its reality, including the experimental evidence, the methods and materials used, the analysis and interpretation of the data, and the conclusions drawn, so that the experiment can be independently verified.

Most scientists would agree that the more momentous the discovery, the stronger the case needs to be in order to gain acceptance. However, the standard of independent verification through a simple experiment may suffice even when the results have momentous implications. Even the 1989 U.S. DOE ERAB report[75], which was pivotal in the rejection of CF, recognized in its preamble the validity of a limited experimental verification (quoted in Beaudette[76], 2002; underline added):

> Ordinarily, new scientific discoveries are claimed to be consistent and reproducible; as a result, if the experiments are not complicated, the discovery can usually be confirmed or disproved in a few months. The claims of cold fusion, however, are unusual in that even the strongest proponents of cold fusion assert that the experiments, for unknown reasons, are not consistent and reproducible at the present time. However, even a single short but valid cold fusion period would be revolutionary.

The strength of proof of excess heat in CF reactions is the subject of varied opinion – it is the crux of the CF controversy.

Early Experimental Verifications

In the normal course of events in scientific investigation, confirmation of a new discovery (or, at most, just a few confirmations) leads quickly to widespread acceptance of the discovery throughout the scientific community. For a variety of

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[75] U.S. Department of Energy, Energy Research Advisory Board. “Final Report of the Cold Fusion Panel of the Energy Research Advisory Board.” Unpublished U.S. DOE Report, November, 1989, 61 p.

[76] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002. p. 129

reasons, this was not the case for CF. Four experiments described by Beaudette[77] (pp. 185-203) are summarized below as examples of early experiments that confirmed the findings of excess heat from CF reactions.

Example 1. Richard Oriani

Richard Oriani, professor emeritus at the University of Minnesota performed confirmatory experiments using a Fleischmann and Pons cell design in the summer of 1989. This was within a few months of the March 23 announcement, although the results were not published until December 1990[78]. The experimental results are summarized in a graph (Figure 4) showing power output (in terms of calorimeter voltage) as a function of input power. The condition of power output equaling input is indicated by the diagonal line in the diagram. One of the cells indicated excess heat for six of the recorded power values (dots within open circles), and another cell (solid dots) indicated lesser amounts of excess power for at least two of the recorded values. According the Beaudette[79] (p. 196):

> The highest point reached during the run was held for 150 minutes and signifies the generation of 3.6 watts ±0.2 watts of anomalous power in the cell. The calculated energy generated during that time was 32.4 kiloJoules. The energy density was 106 watts/per cubic centimeter of palladium. Total energy generated during the run was 200 kJ.

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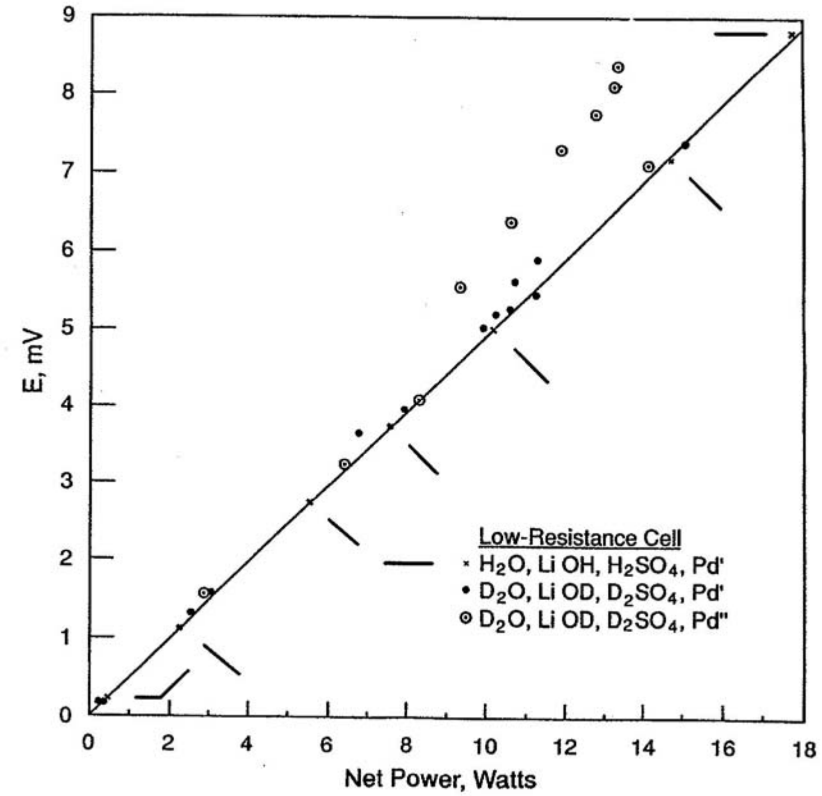
[77] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002.

[78] Oriani, R.A., J.C. Nelson, S-K Lee, and J.H. Broadhurst, Calorimetric Measurements of Excess Power Output during the Cathodic Charging of Deuterium into Palladium. *Fusion Technology*, vol. 18 (December 1990), p. 652.

[79] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002.

Figure 4.
Plot of Oriani's Experimental Results



Excess heat is indicated in a heavy water and palladium CF cell. The two solid dots and six open circles above the diagonal line appear to indicate more energy being emitted from the cell than is being put into it. From Oriani[80] as presented in Beaudette[81] (p. 195).

Also according to Beaudette (p. 196): "Six of the excess heat's open circle dots are well separated from it [the diagonal line]. This separation demonstrates a good signal to noise ratio in the data."

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[80] Oriani, R.A., John C. Nelson, et al., Calorimetric Measurements of Excess Power Output During the Cathodic Charging of Deuterium into Palladium. *Fusion Technology*, vol. 18 (Dec 1990), p. 652.

[81] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002.

Example 2. Robert Huggins

Robert Huggins, materials science professor at Stanford University, also began his work in CF in 1989. His results[82] (summarized in Figure 5) are shown as excess power (in terms of percent of input power, which was 10 watts) as a function of time for 120 minutes. The temperature rose from 11ºC to 18ºC starting at 40 minutes and tapering off after about 70 minutes. Anomalous power also increased – to a maximum of 56% (5.6 watts) – starting at about 40 minutes and continuing to about 100 minutes.

Example 3. Melvin Miles

Melvin Miles, research scientist at the U.S. Navy Naval Weapons Center at China Lake, California, was successful in measuring excess power by the end of 1989. The results of his investigation[83,84], shown in Figure 6, are reported as a ratio of output power to input power. The experiment shown in the figure lasted 26 days. Anomalous power was noted starting at about day 7 and reached a maximum of 30% of input power from day 10 to day 15. According to Beaudette[85] (p. 200):

> The estimated accuracy of this power reading is ±20 mw or ±1% of the input power, whichever is larger. Its average over 11 days was 14.5% excess power.

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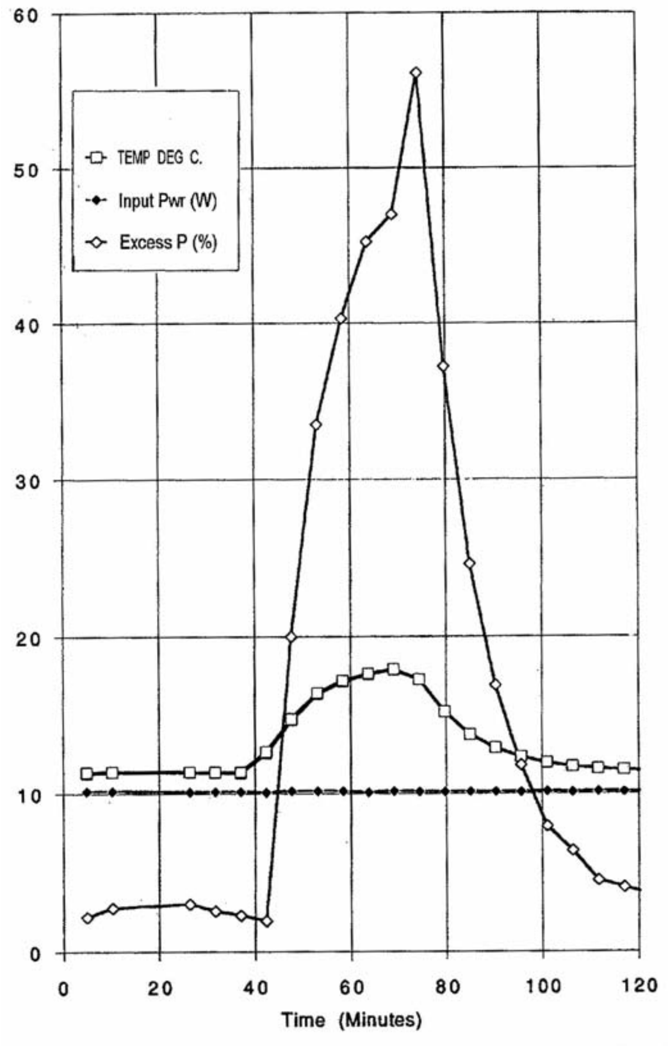
[82] Schreiber, M.T., T.M. Gur, G. Lucier, J.A. Ferrante, J. Chao, and R.A. Huggins, “Recent measurements of excess energy production in electrochemical cells containing heavy water and palladium.” In *The First Annual Conference on Cold Fusion*, Will, F. Salt Lake City, Utah: National Cold Fusion Institute, 1990, p. 44.

[83] Miles, M.H., Park, K.H., and Stilwell, D.E. “Electrochemical Calorimetric Studies of the Cold Fusion Effect.” In *The First Annual Conference on Cold Fusion*, Will, F. Salt Lake City, Utah: National Cold Fusion Institute, 1990, p. 328.

[84] Miles, M.H., Park, K.H., and Stilwell, D.E., Electrochemical Calorimetric Evidence for Cold Fusion in the Palladium-Deuterium System. *Journal Electroanal Chem*., vol. 296 (1990), p. 241.

[85] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed*. 2nd ed. South Bristol, Maine: Oak Grove Press, 2002. p. 200.

Figure 5.
Huggins' Experimental Results for a CF Cell Operated for 120 Minutes



The vertical scale indicates power (watts), temperature (ºC), and anomalous power (percent of input power, all at the same scale). Figure as presented in Beaudette[86]*, p. 199.*

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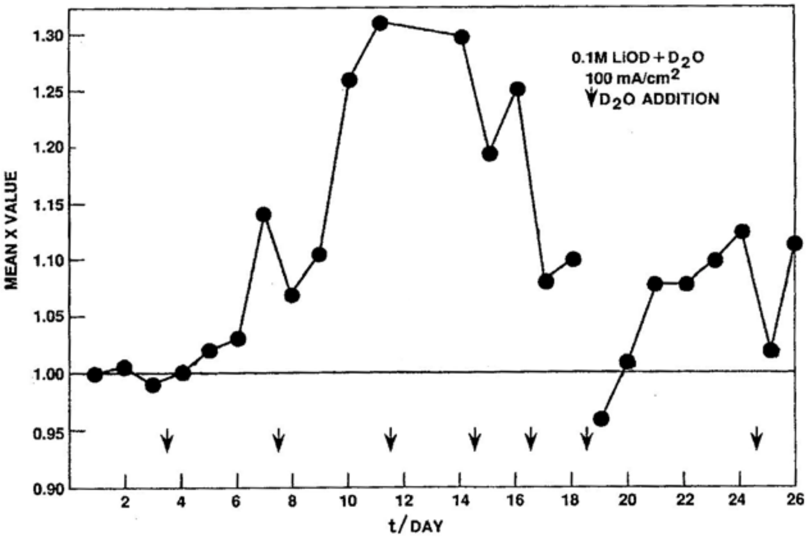
[86] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002.

Figure 6.
Excess Power Results from Research by Miles.



The "Mean X Value" is excess power expressed as a ratio of output power to input power. Figure as presented in Beaudette[87], p. 200.

The average excess power was 140 milliwatts, and the total excess energy was 110 kiloJoules. Miles stated that his excess power results for at least one of his runs was significant at the 99.5% confidence level.

Example 4. Michael McKubre

Michael McKubre, an experimentalist at SRI International, used conventional Fleischmann-Pons electrochemical CF cells but a different type of calorimeter[88]. He was able to confirm excess heat initially during the period from August 1990 to February 1991. One of his cells began producing excess heat after 53 days of operation and continued to do so for 11 days (Figure 7). The work of McKubre and

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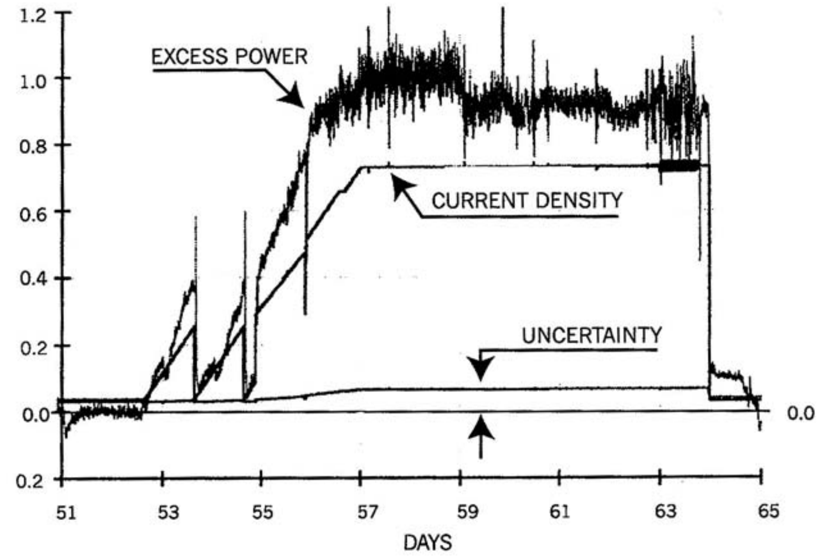
[87] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002.

[88] McKubre, Michael, et al. "Isothermal Flow Calorimetric Investigations of the D/Pd System". *Journal of Electroanalytical Chemistry*, vol. 368 (1994), p. 61.

his team verified Fleischmann and Pons observations of the need for cells to be "pre-operated" at lower currents until the palladium is saturated with deuterium at a D/Pd ratio approaching 1.0.

Figure 7.
Plot of Excess Power in One of McKubre's Electrochemical Cells



Excess power of about 9 watts was observed in this cell from day 53 to day 64. Figure as presented in Beaudette[89]*, p. 193.*

The four examples summarized above are representative of results of successful experiments conducted in the initial months after the March 1989 announcement by Fleischmann and Pons. As shown below, many other experiments resulting in excess heat generation were conducted in the same timeframe and in the years since.

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[89] Beaudette, Charles G. *Excess Heat: Why Cold Fusion Research Prevailed.* 2nd ed. South Bristol, Maine: Oak Grove Press, 2002.

Cumulative Experimental Evidence

Under normal circumstances, as noted above, just a few confirmatory experiments would have been sufficient to ensure at least a continued charitable attitude toward CF in the scientific community. And the confirmations did not end with these initial successes, but they have continued steadily in the nearly 20 years since. Storms[90] has conducted a thorough review of reports (for the period 1989 to 2004) of positive findings for three signatures of CF reactions – excess heat, elemental transmutation, and anomalous radiation. Storms' review is summarized in Appendices A, B and C, respectively, for these three parameters; the number of positive reports for the three parameters is as follows:

	Reports
Excess Heat	184
Elemental Transmutation	80
Anomalous Radiation	55

This large number of positive reports appears to strongly confirm that CF has a basis in reality. The probability of all these reports being untrue, and the investigators being in error, would seem to be nil. Such overwhelming experimental findings of the signatures of CF reactions mean that the level of evidence must be estimated at a correspondingly high level[91].

Particularly Convincing Experiments and Demonstrations

The scientific case for CF reality may be further assessed by considering experiments that appear to demonstrate the phenomenon particularly well. Many

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[90] Storms, Edmund. *The Science of Low Energy Nuclear Reaction – a Comprehensive Compilation of Evidence and Explanations about Cold Fusion*. Singapore: World Scientific Publishing Co., 2007, Tables 2, 8, and 11, p. 53 to 104.

[91] Because of the rejected and marginalized status of CF, this evidence continues to be ignored by the mainstream scientific community.

candidates could be chosen, but two well-documented examples are selected here for illustrative purposes – one a public demonstration of excess heat attributed to CF and the other a dramatic explosion attributed to CF nuclear reactions and transmutation.

Public Demonstration of Excess Heat from Deuterium Gas and Palladium Powder

On May 22, 2008, Yoshiaki Arata of Osaka University in Japan, and his collaborator, Yue Chang Zhang, held a public demonstration of deuterium- and palladium-based cold fusion that produced both excess heat and helium. The parameters of the experiment were published by Arata in two issues of the Journal of High Temperature Society[92,93] and are well described by Chubb[94], Carbonelle[95], and Krivit[96]. The principal accomplishments of the demonstration were the reliable (reproducible) production of heat immediately and on demand, the generation of detectable quantities of helium, and the simplicity of the setup, in both the procedure and the materials used. Arata, a distinguished Japanese scientist (recipient, for example, of the Cultural Order of Merit), has worked in the CF field since its 1989 beginnings. A 1990 paper by Arata and Zhang[97] was among the first to verify the cold fusion announcement of Fleischmann and Pons.

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[92] Arata, Yoshiaki. "Research Project of New Energy Generation." *J. High Temperature Society*, vol. 34, no. 1 (January 2008), special report at the end of the issue (no pages given).

[93] Arata, Yoshiaki and Yue Chang Zhang. "Establishment of the 'Solid Fusion' Reactor." *J. High Temperature Society*, vol. 34, no. 2 (March 2008), special report at the end of the issue (no pages given).

[94] Chubb, Talbot. "The Arata Demonstration: a Review Summary." Infinite Energy, Issue 60 (2008). Online. Available: http://www.infinite-energy.com/images/pdfs/ChubbonArata.pdf.

[95] Carbonelle, Pierre. "Arata Experiment". Google Groups, CMNS, June 2, 2008. Online. Available: http://groups.google.com/group/cmns/web/arata-experiment?hl=en. Accessed September 2008.

[96] Krivit, Steven. "Under the Hood: the Arata-Zhang Osaka University LENR Demonstratin." New Energy Times, Issue 29 (July 10, 2008), News Item #10. Online. Available: http://www.newenergytimes.com/news/2008/NET29-8dd54geg.htm#hood

[97] Arata, Yoshiaki, and Zhang, Yue Chang. "Achievement of Intense 'Cold' Fusion Reaction." *Proc. Japan Acad.*, 66 Series B (1990).

Although their initial work involved similar methods of other earlier workers – electrolytic cells with palladium and heavy water – they moved on to other techniques that used deuterium gas and finely-divided palladium (nanopowders). The May 2008 demonstration made use of small (five nanometer) palladium particles mixed with zirconium dioxide power in a stainless steel chamber about 20 cm tall and three cm in diameter. High-purity deuterium gas was injected into the chamber at pressures building up to 65 atmospheres as temperatures were measured within and outside the chamber for comparison in order to detect heat being generated inside.

The experiment started at room temperature (about 24 ° C) after a stage of baking and cooling the chamber that lasted 50 minutes. At that point, deuterium gas was injected into the chamber, resulting in an internal temperature spike to just over 78 ° C. Simultaneously the temperature outside the cell rose to about 34 ° C. Then the inside and outside temperatures fell to about 32 ° C after about 80 minutes. Both temperatures then very gradually decreased to 26 ° to 27 ° C over the duration of the experiment – about 3000 minutes (a little over two days).

The most significant observation was an approximately 2 ° C higher temperature measured inside the cell than outside throughout the duration of the demonstration, with no indication of "narrowing" of the difference over time. Such a continued temperature difference between the inside and outside sensors in the cell – as the cell and its contents cooled toward room temperature – can only be explained by a source of heat inside the chamber[98]. In the absence of energy input or possible chemical reactions (no reactants were present), the excess heat must have been generated by CF-type nuclear reactions. A total of about 250 kilojoules of heat was

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[98] This observation brings to mind the discovery of radium, when a sample was observed to remain above room temperature. Pierre Curie found the rate of heat generation to be 590 joules per hour per gram of radium and continued indefinitely.

apparently reported by Arata[99]. Helium was measured in the cell using a mass spectrometer after the demonstration was completed.

Three aspects of the Arata and Zhang demonstration are particularly meaningful for the CF case: 1) the ability to deliver excess heat immediately and on demand, thus demonstrating experimental replication; 2) the continued generation of excess heat for many hours after the experiment was initiated; and 3) the demonstrated existence of helium in the cell chamber after the experiment was concluded, where helium was not present prior to the start of the demonstration.

Explosive Cold Fusion Experiment with Elemental Transmutation

Another dramatic experiment allegedly involving CF reactions occurred on January 24, 2005 at another Japanese institution – Hokkaido University. This experiment, reported by Mizuno and Toriyabee[100], ended in a laboratory explosion that was deafeningly loud and resulted in minor injuries to Mizuno and a guest caused by flying shards of glass. It was determined in this experiment that excess heat and elemental transmutation (rather than helium production) were involved. The experimental approach – a variant of the electrolytic cell called plasma glow discharge – involved the use of a platinum anode, tungsten cathode, and potassium carbonate electrolyte. Thus the cell differs from a normal Fleischmann-Pons setup – both in the cathode (tungsten rather than palladium) and electrolyte (potassium carbonate solution rather than heavy water) used.

The cell was assembled in a one-liter glass container with a Teflon rubber cap with holes for electrodes and temperature sensors. The behavior of the cell, particularly a dramatic temperature change during the early stages, was atypical for

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[99] Carbonelle, Pierre. “Arata Experiment”. Google Groups, CMNS, June 2, 2008. Online. Available: http://groups.google.com/group/cmns/web/arata-experiment?hl=en. Accessed September 2008.

[100] Mizuno, Tadahiko, and Akimoto Toriyabe. “Anomalous Energy Generation during Conventional Electrolysis”. Paper presented to The 12th International Confernece on Condensed Matter Nuclear Science (ICCF-12)” at Yokohama, Japan, 2005.

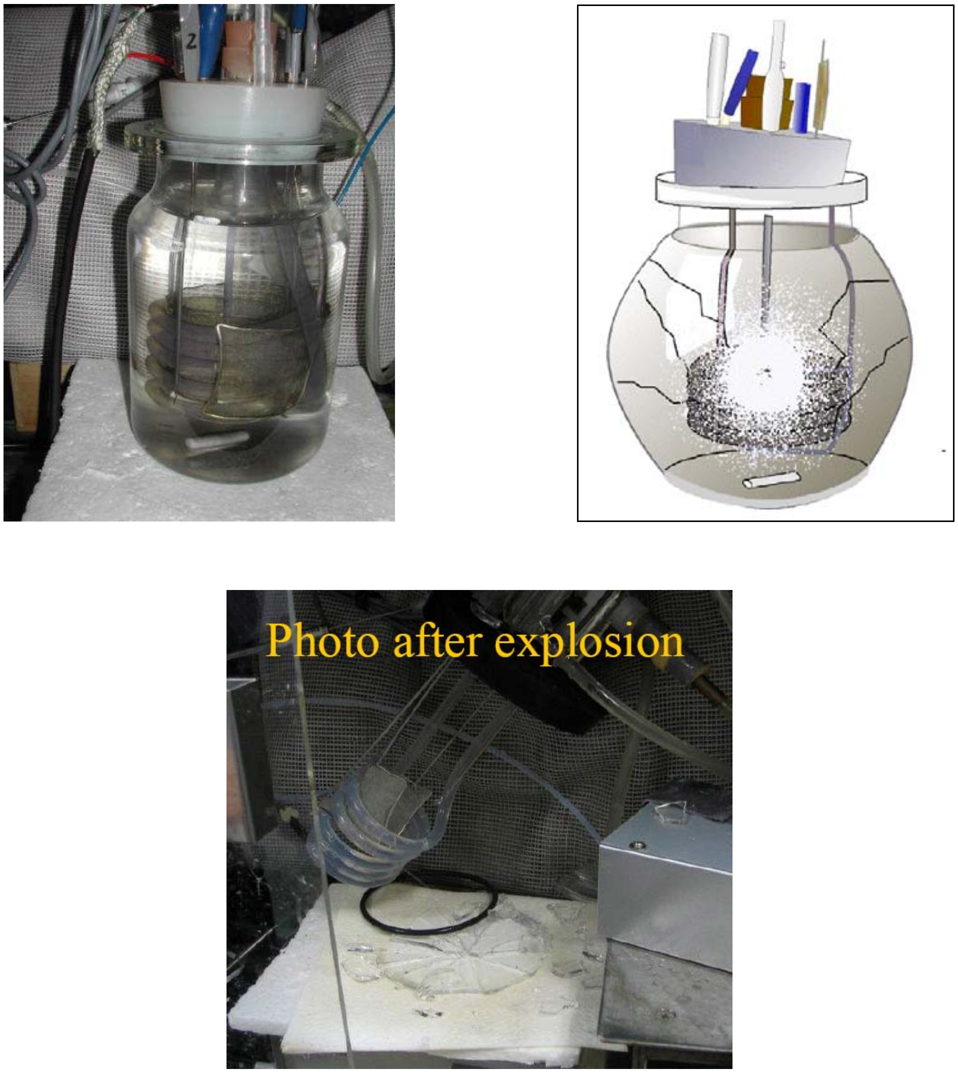
the experiment, which had been performed many times previously at the lab without similar incident. Images of the explosion are shown in Figure 8.

Calculations performed after the explosion found that the energy output of the event was about 800 times more than the energy input into the cell before the explosion. Examination of the electrodes after the explosion by energy dispersive X-ray (EDX) analysis found a number of elements not present prior to the experiment, including primarily calcium and sulfur, but also potassium, silicon, barium, titanium, cesium, niobium, samarium, iron, cobalt and copper.

The experimenters concluded that the energy of the explosion was derived from energy release associated with nuclear reactions involving hydrogen nuclei (protons) and tungsten nuclei in the electrode. These reactions also resulted in elemental transmutation of tungsten to the elements found after the explosion. Tungsten has three naturally-occurring isotopes, with atomic weights of 182, 184 and 186. Reaction of four hydrogen nuclei with the 182 isotope, it is hypothesized, resulted in formation of iron, titanium, calcium, sulfur and silicon, with particular energy releases for each transmuted element. Similar reactions of four hydrogen nuclei occurred with the 184 isotope (production of iron, titanium, calcium, sulfur and silicon) and the 186 isotope (calcium, sulfur and silicon) and with corresponding energy release rates for each reaction.

The results of the Mizuno and Toriyabee experiment were particularly significant to the CF case not only because of the non-chemical (therefore nuclear) energy released, but also because of the strong indications of elemental transmutation associated with the CF-type nuclear reactions.

Figure 8.
Explosive Cold Fusion Event of Mizuno and Toriyabee



Note: Photos depict the experiment before, during and after the explosive event. Images are from Mizuno and Toriyabee[101]*.*

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[101] Mizuno, Tadahiko, and Akimoto Toriyabe. “Anomalous Energy Generation during Conventional Electrolysis”. Paper presented to The 12th International Confernece on Condensed Matter Nuclear Science (ICCF-12)” at Yokohama, Japan, 2005.

Statistical (Bayesian Network) Analysis of Early Verification Attempts

Bayesian network analysis is an appropriate and powerful tool for analyzing situations like the CF case, where there was an initial experiment (by Fleischmann and Pons) followed by a series of attempted verifications, both successes and failures. Bayesian networks are an extension or application of Bayes' theorem, shown below, to solve complex problems through probabilistic inference.

$$P(A|B) = [P(B|A) * P(A)] / P(B)$$

where:
$P(A)$ = marginal probability of A
$P(B)$ = marginal probability of B
$P(A|B)$ = conditional probability of A, given B
$P(B|A)$ = conditional probability of B, given A

Johnson and Melich[102,103,104] have demonstrated the applicability of Bayesian network analysis to the CF case using software available from the Laboratory for Computational Intelligence[105] at the University of British Columbia. This method enables the probability for the reality of CF reactions (based on the presence of excess heat) to be quantitatively estimated based on the outcomes of the first few attempts at verification as well as the estimated pre-experimental probability that CF is real.

Pre-Experimental Probability

In order to assess the probability that CF is real using the original (Fleischmann and Pons) and subsequent experiments, it is first necessary to estimate

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[102] Johnson, Rodney, and Michael Melich. "Can Probability Theory Help Us Assess 17 Years of Results in CMNS?". Unpublished Powerpoint Presentation, U.S. Naval Postgraduate School, May 2, 2007

[103] Melich, Michael, and Rodney Johnson. "Multiple Experiments". Unpublished Powerpoint Presentation, U.S. Naval Postgraduate School, May 1, 2008

[104] Johnson, Rodney, and Michael Melich. "Weight of Evidence for the Fleischmann-Pons Effect". Unpublished Powerpoint Presentation, U.S. Naval Postgraduate School. Poster session presented at the "14th International Conference on Cold Fusion (ICCF-14)", Washington, D.C., August 2008

[105] See: http://www.cs.ubc.ca/nest/lci/

the initial probability (before any experiments were performed) that the phenomenon could be real. One way of looking at this pre-experimental ("starting") probability is to consider an uninformed and unbiased party (such as a member of a legal jury), who may view the probability equal that CF is or is not real ($p = 0.50$). However, in the context in which CF was introduced (i.e., by two chemists to a host of nuclear physicists), the pre-experimental probability may have been judged to be much lower, say at 5% ($p = 0.05$). Therefore, the probability of CF reality is assessed using the Bayesian network method for six starting probability scenarios: p-values of 0.05, 0.10, 0.20, 0.30, 0.40, and 0.50.

Early Attempts at Experimental Verification

Cravens and Letts[106] performed an extensive analysis of the reports of CF experiments – those that used electrolytic cells – going back to the original paper by Fleischman and Pons[107]. This analysis focused on experimental success or failure (based on whether excess heat was produced in the cells) – and the associated causes of failures or successes[108] – as reported in the 167 reports reviewed[109]. In conducting their review, the authors established the general sequence of the performance of the attempted experimental verifications.

The analysis of the reports consisted of two steps – a screening step followed by an evaluation of the qualified reports as a success or failure. For the screening

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[106] Cravens, Dennis, and Dennis Letts. "The Enabling Criteria of Electrochemical Heat: Beyond Reasonable Doubt." Paper presented at the "14th International Conference on Cold Fusion" (ICCF-14), Washington, D.C., August 2008

[107] Fleischmann, M. and Stanley Pons. "Electrochemically Induced Nuclear Fusion of Deuterium." *J. Electroanal. Chem.*, vol. 261, p. 301 and Errata in vol. 263 (1989).

[108] Four criteria for success in achieving excess heat were identified – deuterium loading of the palladium cathode, chemical procedures affecting the cathode and electrolyte, the current applied during loading and during operation, and application of non-equilibrium conditions (stimuli) to the cathode during operation.

[109] Electronically-available reports were used. Papers were selected from two databases – LENR-CANR (http://lenr-canr.org/) and the Dieter Britz database (http://www.chem.au.dk/~db/fusion/)

step, several observations were used to eliminate reports of experiments that could not be considered as candidates:

- Another method besides a Fleischmann-Pons electrolytic cell was used
- Cell materials or construction were not in a comparable range
- Method of cell operation was not in a comparable range
- Parameters other than excess heat were measured
- Topics addressed were other than specific experiments (e.g. comparative discussions)
- Insufficient data were reported to make an evaluation

Table 1 shows the results for the first 30 experiments in 1989 and 1990[110]. Ten of the 30 were deemed to be qualified, and six of these ten were considered successes – excess heat was observed.

Probability Changes with Verification Experiments

When the Bayesian network method is applied to the results of the ten qualified verification attempts, and using the six starting probability scenarios, the results are as shown in Table 2.

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[110] The authors acknowledge that some of the earliest reports may not have been included because they did not appear in the LENR-CANR or Britz databases. Reasons for non-selection from personal communication with Dennis Letts, October 2008.

Table 1.
The First 30 Qualified Cold Fusion Experiments and Associated Outcomes for Bayesian Analysis

Author(s)	Year*	Selected?	Reason for Non-Selection	Success?
1. Fleischmann & Pons	1989	Yes	---	Yes
2. Armstrong	1989	Yes	---	No
3. Armstrong	1989	No	Cell power was cycled – invalid comparison	---
4. Balej	1989	No	No criteria met for comparison	---
5. Blaser	1989	No	Looking for radiation, not heat	---
6. Chu	1989	No	Chlorides present; large cathodes	---
7. Ikeya	1989	No	Not electrochemical	---
8. Kainthla	1989	Yes	---	Yes
9. Kainthla	1989	No	Discussion; not experimental report	---
10. Lewis	1989	Yes	---	No
11. Ohashi	1989	No	Not an experimental report	---
12. Santhanam	1989	No	Chloride electrolyte; not comparable	---
13. Santhanam	1989	No	Titanium electrode, not palladium	---
14. Shapavolov	1989	No	Insufficient data provided	---
15. Williams	1989	Yes	---	No
16. An	1990	No	Calorimetry study rather than CF report	---
17. Appleby	1990	Yes	---	Yes
18. Arata	1990	Yes	---	Yes
19. Arata	1990	No	Nuclear study, not an excess heat paper	---
20. Arata	1990	No	Nuclear study, not an excess heat paper	---
21. Birgul	1990	No	Not a Fleischmann-Pons-type experiment	---
22. Bosch	1990	No	Outgassing test, not a CF experiment	---
23. Brudanin	1990	No	Nuclear study	---
24. Fleming	1990	No	Not a Fleischmann-Pons-type experiment	---
25. Gozzi	1990	No	Nuclear study; not electrochemical	---
26. Guruswamy	1990	Yes	---	Yes
27. Jow	1990	No	Cells moved during loading	---
28. Lautzen	1990	Yes	---	Yes
29. Lewis	1990	No	Huge cathode; marginal load; marginal heat	---
30. Longhurst	1990	Yes	---	No

** Year conducted, not year performed*

Note: Success is defined as producing excess heat. See Bibliography for citations for experimental reports.

Table 2.
Probabilities of the Existence of CF for Six Starting Probabilities and Ten Qualified Experiments

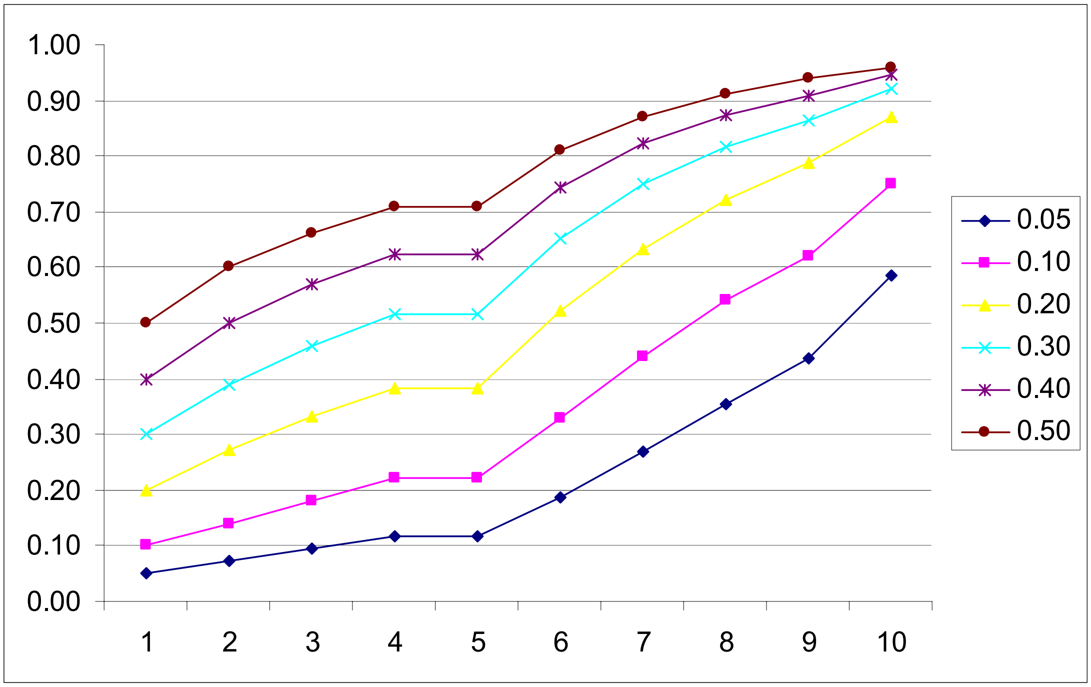
No.	Experiment	Success?	Starting Probability					
			0.05	0.10	0.20	0.30	0.40	0.50
1	1	Yes	0.05	0.10	0.20	0.30	0.40	0.50
2	2	No	0.07	0.14	0.27	0.39	0.50	0.60
3	8	Yes	0.09	0.18	0.33	0.46	0.57	0.66
4	10	No	0.12	0.22	0.38	0.52	0.62	0.71
5	15	No	0.12	0.22	0.38	0.52	0.62	0.71
6	17	Yes	0.19	0.33	0.52	0.65	0.74	0.81
7	18	Yes	0.27	0.44	0.63	0.75	0.82	0.87
8	26	Yes	0.35	0.54	0.72	0.82	0.87	0.91
9	28	Yes	0.44	0.62	0.79	0.86	0.91	0.94
10	30	No	0.59	0.75	0.87	0.92	0.95	0.96

These tabulated results are shown in graphical form in Figure 9. The lower curve shows how the probability of CF reality (as indicated by excess heat) changes with the first ten qualified experiments at a low starting probability ($p = 0.05$) that CF is real. The upper curve shows similar results for a starting probability of 50%, and the intervening curves represent starting values between 0.05 and 0.50. Note that the probability of CF reality is greater than 50% within the ten experiments for all six starting probability scenarios – even though four of the ten were considered to be failures. The tabulated and graphical results are highly significant in establishing the level of evidence for CF reality as shown in Chapter 7.

Conclusion: Scientific Evidence for Cold Fusion

The case for the reality of CF is very strong based on the scientific evidence as viewed from the four perspectives described in this chapter. In similar situations of announcement of major new discoveries in the past, early experimental verification (four examples of which have been described in this chapter) would have been sufficient to establish at least tentative acceptance by mainstream science.

Figure 9.
Plots of Probabilities of CF Existence for Six Starting Probabilities and First Ten Qualified Experiments



Note: Probabilities are from 0.05 to 0.50. Probabilities and trends are as determined by Bayesian network analysis

Certainly the many subsequent verifications of excess heat, elemental transmutation, and anomalous radiation from 1989 to 2004 provide ample basis for acceptance of CF reality at a high level of probability. The two example demonstrative experiments (among the many verifications) described above further build the case for a high probability of the reality of CF phenomena. And the case seems to be "clinched" at a high level of evidence by statistical (Bayesian network) analysis of the first 10 qualified electrochemical cell experiments.

Chapter 7. Level of Evidence for Cold Fusion Reality and Policy Response Options

The scientific evidence that CF may be a real phenomenon as shown in the previous chapter may seem compelling, but an issue remains for effectively communicating the case for CF in terms that are readily understood by policymakers. When differences of opinion prevail among scientists regarding the validity of a new discovery, as is the case for CF, policymakers may have difficulty in deciding on appropriate policy directions. One way to deal with this issue in a rational policymaking framework is to develop categories of levels of evidence, and associated spectrum of probabilities, that the discovery is true. Candidate policy options can then be defined, and appropriate (most in the public interest) choices can reasonably be made.

Levels of Evidence for Rational Policymaking

One way of interpreting the scientific evidence in a way that is readily comprehended and applied to policy development is to adopt terminology from the legal field – preponderance of evidence, clear and convincing evidence, and beyond a reasonable doubt. If these terms are clearly defined and applied to the scientific evidence of CF reality, then a rational policy response can be more readily implemented. The terms are defined as follows in Black's Law Dictionary[111]:

> <u>Preponderance of Evidence (POE)</u>. The greater weight of the evidence, not necessarily established by the greater number of witnesses testifying to a fact but by evidence that has the most convincing force; superior evidentiary weight that, though not sufficient to free the mind wholly from all reasonable doubt, is still sufficient to incline a fair and impartial mind to one side of the issue rather than the other. This is the burden of proof in most civil trials, in which the jury is instructed to find for the party that, on the whole, has the

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[111] Add any necessary qualifiers about this parallel.

stronger evidence, however slight the edge may be. – Also termed preponderance of proof, balance of probability[112].

Clear and Convincing Evidence (CCE). Evidence indicating that the thing to be proved is highly probable or reasonably certain. This is a greater burden than preponderance of the evidence, the standard applied in most civil trials but less than evidence beyond a reasonable doubt, the norm for criminal trials. Also termed clear and convincing proof[113].

Beyond a Reasonable Doubt (BRD). Where "reasonable doubt" is the doubt that prevents one from being firmly convinced of a defendant's guilt, or the belief that there is a real possibility that a defendant is not guilty. "Beyond a reasonable doubt" is the standard used by a jury to determine whether a criminal defendant is guilty… In deciding whether guilt has been proved beyond a reasonable doubt, the jury must begin with the presumption that the defendant is innocent. – Also termed rational doubt[114].

These levels of evidence may reasonably be interpreted in terms of probability (see, for example, Loevinger[115], p. 335-336). The POE level is generally applied in civil cases and has an associated probability of greater than 50%. The BRD level is normally applied in criminal cases and, because of the higher consequences of error, has an associated probability approaching 90%. The CCE level, between POE and PRD, then (by inference) reasonably has an associated probability of 70%.

As a means of applying EBP to the CF case, the following levels of evidence and associated probabilities are therefore proposed.

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[112] Garner, Bryan A. *Black's Law Dictionary*. St Paul, MN, West Publishing Co. 8th ed. 1990, page 1220.

[113] Garner, Bryan A. *Black's Law Dictionary*. St Paul, MN, West Publishing Co. 8th ed. 1990, page 596.

[114] Garner, Bryan A. *Black's Law Dictionary*. St Paul, MN, West Publishing Co. 8th ed. 1990, page 1293.

[115] Loevinger, Lee. "Standards of Proof in Science and Law." *Jurimetrics Journal of Law, Science and Technology*. vol. 32, Spring (1992). p. 323-344.

Low Probability	<10%
Moderate Probability	10-50%
Preponderance of Evidence, POE	50-70%
Clear and Convincing Evidence, CCE	70-90%
Beyond a Reasonable Doubt, BRD	>90%

Probability Interpretations of Early Verification Experiments

Bayesian network analysis of the ten earliest relevant experiments to verify CF reality, as shown in the preceding chapter, found that the probability of reality exceeded 50% even when the assumed pre-experimental probability was as low as 0.05. If the Bayesian analysis data in Chapter 6 are interpreted in terms of level of evidence, the results are as shown in Table 3. Remarkably, the BRD level was reached within the first ten experiments when the pre-experimental probability that CF could be real was estimated as low as 30%. The CCE level was reached within ten experiments for all starting probabilities except the lowest (p = 0.05). And the POE level was reached for all pre-experimental probabilities including p as low as 5%.

Table 3.
Number of Experiments Required to Reach Commonly Understood Levels of Evidence

Starting Probability	POE: p = 0.50	CCE: p = 0.70	BRD: p = 0.90
0.50	1	4	8
0.40	2	6	9
0.30	4	7	10
0.20	6	8	N[a]
0.10	8	10	N
0.05	9	N	N

N – Not reached.

[a] p = 0.87 at 10 experiments – very close to 0.90.

Cold Fusion Level of Evidence: Additional Interpretation of the Scientific Evidence

As shown in Chapter 6, the scientific evidence for the reality of CF is compelling. Based on the four perspectives presented, it is clear that there is a probability exceeding 50% that CF reactions occur when experimental conditions are right. Lower levels of probability therefore need not be given further consideration.

Preponderance of Evidence

CF reactions are not nearly as easy to achieve in lab experiments as was at first believed going back to the Fleischmann and Pons 1989 announcement. Because the required experimental conditions fall in a narrow zone[116], they were not achieved in many cases during the early attempts at verification. Nevertheless, there were a number of successes in verifying the results announced by Fleischmann and Pons. Bayesian network analysis found a probability of CF existence over 50% even when the assumed pre-experimental probability was as low as 5%. Based on these initial confirmations alone, it is asserted that a Preponderance of Evidence has been established for the existence of CF as a phenomenon.

Clear and Convincing Evidence

The scientific results accumulated in the years since CF was rejected further increases the level of evidence of its basis in reality. The remarkable number of verifications of CF signatures – 184 for excess power, 80 for elemental transmutation, and 55 for anomalous radiation (total of more than 300) – elevates the level of evidence to Clear and Convincing Evidence. Assignment of the CCF level is further reinforced by experiments, such as those of Mizuno and Toriyabee and of Arata and Zhang, that most clearly demonstrate the effects of CF reactions. Furthermore,

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[116] Cravens, Dennis, and Dennis Letts. "The Enabling Criteria of Electrochemical Heat: Beyond Reasonable Doubt." Paper presented at the "14th International Conference on Cold Fusion (ICCF-14)", Washington, D.C., August 2008

Bayesian network analysis shows that CCE level was reached for all starting probabilities above 5%.

Beyond a Reasonable Doubt

Rigorous statistical analysis of the CF experiment history, based just on the first ten attempts at verification (three of which were failures), further increases the level of evidence for CF. Bayesian network analysis demonstrates that the BRD level was reached within the first ten experiments when the pre-experimental probability that CF could be real was estimated to be as low as 30%. Thus an excellent case is made for assigning even a BRD level of evidence that CF is a real phenomenon.

Policy Response Options

With the level of evidence for the existence of CF thus reasonably established, the next step is to determine the appropriate rational policy response for public support of the phenomenon. For the CF case, there appear to be five possible responses based on public support for research in general:

1. Discontinue CF Research Entirely (DC): Treat CF like other discredited new discoveries, such as N-rays and polywater. This scenario appears unlikely because of the continued research interest in CF even under marginalized conditions as described in Chapter 2.
2. Business as Usual (BU). Conduct CF research under marginalized conditions with little or no public support. This course would represent continuation of the present situation, again as described in Chapter 2.
3. Reinstate CF Legitimacy (RL). Recognize that the problems observed with CF (erratic reproducibility, lack of solid theory, etc.) are consistent with new scientific discoveries. Provide public support at a modest but substantial level consistent with other possible but still unproven claims or discoveries.

4. <u>Support on a Par with Hot Fusion (HF)</u>. Recognize that the evidence is compelling that CF is a real phenomenon and; given the high public interest in its success, provide funding on a par with hot fusion research in support in past years.
5. <u>Initiate Crash Development Program (CP)</u>. Fully embrace the promise of CF and its possibilities for human welfare benefit. Implement a major national program to fully research CF and develop its potential as was done, for example, with the development of the atomic bomb in the Manhattan Project.

Rational Cold Fusion Policy Responses Based on Level of Evidence

Given the high levels of evidence for the reality of CF and the possible response scenarios, what options are the most rational and best serve the public interest? This question may be reasonably answered for two scenarios – a conservative policymaking stance and a more moderate approach. The conservative view takes into account the troubled history and ongoing marginalization of CF and would represent a "go-slow" approach. A more moderate stance would be to "leave the past behind" and move forward primarily on the basis of what the evidence indicates and what best serves the public interest. The following answers are asserted as the most reasonable for the question – for both scenarios – of the most rational and public-interest-serving policy response options.

It seems clear that if it is accepted that there is a Preponderance of Evidence for CF reality, then rationally it should at least be reinstated with full legitimacy (RL) under a conservative policy scenario. Under a moderate policy scenario and at the POE level, CF should be supported on a par with hot fusion support (HF) in past years. At the Clear and Convincing level and under a conservative scenario, CF would also be supported on a par with hot fusion. With a moderate policy stance at the CCE level, CF would rationally be the subject of a crash program (CP) of development in the public interest. And a similar crash program would similarly be called for under either policy scenario if CF reality is accepted Beyond a Reasonable Doubt. These proposed policy responses are summarized in Table 4.

Table 4.
Proposed Policy Response Scenarios

		Policy Response	
Level of Evidence	Probability	Conservative	Moderate
Preponderance of Evidence	50-70%	RL	HF
Clear and Convincing Evidence	70-90%	HF	CP
Beyond a Reasonable Doubt	>90%	CP	CP

Where:

RL = Reinstate to full legitimacy
HF = Support on a par with hot fusion
CP = Crash program

Conclusion: Levels of Evidence and Policy Responses

What level of evidence for the reality of CF should be embraced? Should a conservative or moderate policymaking approach be adopted? What course of action – simple reinstatement, support on a par with hot fusion, or crash development program – should then be taken? Answers to these questions are fundamental to future policymaking – the task of elected officials and government staff responsible for energy policy in their respective nations. They are addressed in the next chapter.

Chapter 8. Assessment of Future Cold Fusion Public Policy Options

Given the high level of evidence that it does exist, which of the available policy response options outlined in the previous chapter should be adopted? Just as an evidence-based approach has been shown to be superior for establishing the basis in reality of CF phenomena, a similar rational stance best serves the public interest in selecting which of the three options – reinstatement, support on a par with hot fusion, or crash program – to adopt.

It is clear from the analysis in Chapter 7, and the scientific evidence described in Chapter 6, that CF should, in the public interest and based on the evidence, be reinstated with full legitimacy and support (at a minimum). However, energy policymakers still have the task of deciding if the evidence is sufficient to support CF in a comparable manner to hot fusion support in the past or even on a crash program basis. An in-depth policy analysis study – building on the findings of this report – would be helpful to policymakers in determining if higher levels of support would also serve the public interest. Concurrently, a number of specific actions can also be implemented for each of the three policy response options set forth in Chapter 7.

In-Depth Policy Analysis

A comprehensive and well-supported analysis of the policy options and future directions will be highly beneficial for guiding energy policymakers. Such a policy analysis project would seek an answer to the question of how CF best "fits in" with other alternative (non-fossil-fuel) technologies in the overall energy policy – and associated research program – of the U.S. and other countries. It could begin by confirming and building on the findings of this report in order to develop more concrete and all-encompassing policy directions.

The study could be organized to include a broad base of participants with varying viewpoints, constituencies and agendas. It could be conducted on "neutral ground" (such as an academic setting) where CF protagonists and antagonists can bridge communication gaps, work collectively, and make progress. The scope of the study would include not only the role of direct public support for CF R&D, but also the policies and regulations regarding private sector contributions, particularly the method and level of intellectual property protection.

Participants would be selected not only on the basis of varied backgrounds and perspectives, but also on a demonstrated interest in overcoming polarization and gridlock that has characterized the relationships between CF protagonists and mainstream scientists. In addition, a senior level advisory panel with a similar cross section of representation could be set up to provide direction and feedback to those conducting the study. The overall guiding principle and reference point for setting up and conducting the study would be to focus on what's most in the public interest.

Reinstatement

Four categories of action appear to be appropriate if it is accepted that there is a preponderance of evidence of CF existence and it is reinstated as a legitimate area of scientific investigation.

Capture Previous Research. Assemble and evaluate the results of research and reports prepared to date in order to increase efficiency by avoiding performance of work already done. Engage the existing CF research community to assist in the location, inventory and availability of previously performed experiments and associated reports. Implement a dedicated CF database that captures previous work by utilizing and building on existing information repositories, such as the LENR-CANR website[117]. Develop a methodology for assessing the quality and applicability of

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[117] http://www.lenr-canr.org/

existing experimental data and attempts at theory development for application to future work.

Develop a Comprehensive Research Plan. Work within and beyond the current CF research community to define the major issues in experimentation and theory. Break down and organize the topics for concrete, funded projects with specific scopes and budgets. Identify which areas should be supported with public funding and which would best be pursued by the private sector. Include both "hard science" and social impact and accommodation in the slate of research. Establish a forum and method for communication and coordination among all the parties that will ensure input in the planning process. Identify the most appropriate channels and agencies (e.g., U.S. DOE, U.S. DARPA) for implementing the plan and disbursing funds for CF R&D. Determine the near-term and longer-term priorities to achieve the quickest results for the public benefit. Be sure that the study and its recommendations are "informed" by historical precedent with respect to initially rejected, paradigm-shifting discoveries and public support of phenomena not fully accepted by the scientific community. Determine how support should be structured in a general sense – e.g., to what extent should research be distributed among independent researchers versus centralized in one or just a few organizations or laboratories?

Initiate Substantial Research Funding. In accordance with the Research Plan, gradually and on a selective and phased basis raise the level of public support. Balance funding for research into "hard science" and sociological issues. Proceed with care to fund research areas with highest priority first and on a phased basis depending on evolving understanding of the level of evidence for CF reality.

Rationalize Intellectual Property Protection. Build on the findings and recommendations of the policy analysis study, develop a comprehensive, rational set of IP policies. Through effective communication channels (to be identified), communicate to the U.S. Patent and Trademark Office (PTO) the need for update of the current negative stance toward CF and affirmatively propose a concrete alternative set of policies. Follow through as necessary to ensure that long-standing and potentially habitual IP positions on CF are revised according to new evidence and policies. Determine methods of effectively communicating the changed stance of the U.S. Patent and Trademark Office to the R&D and research investment communities to stimulate interest in and support for CF development by the private sector.

Hot Fusion Level of Support

If it is accepted that there is clear and convincing evidence of CF existence, several categories of action would be undertaken to support CF on a par with hot fusion.

Establish a High Level Advisory Body. Fully utilize the guidance entity and recommendations of the policy analysis study. Ensure the presence of balanced representation of CF parties-at-interest so that guidance will be widely accepted and implemented. Consider protagonists, skeptics, policy makers, funding agency staff, broad-based energy experts, and (possibly) interested and informed lay persons for membership. Make full use of the experience gained (and perhaps individual members) with the advisory panel of the policy analysis study described above in this chapter. Prepare and publish guidelines for the committee, including scope, responsibilities, and functions. Include development and approval of the Research Plan in the scope of responsibilities.

Address Management of Secondary Impacts. Recognize the potential disruptive effects on institutions and constituencies that depend on current energy sources. Identify CF rollout scenarios for identification of secondary impacts[118]. Establish how far secondary impact evaluation should be carried – preliminary identification only or planning for mitigation of adverse impacts. Review the historical precedents for impact mitigation for broad-based energy development.

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[118] Rothwell, Jed. *Cold Fusion and the Future*. Published by LENR-CANR, December 2004. Online. Available http://www.lenr-canr.org. Accessed August 2005.

Develop the approach and methods of technology assessment for CF impact identification and mitigation[119]. Identify examples of accelerated deployment of new technologies that will best "inform" the identification and mitigation of CF deployment impacts. Prepare transition plans needed to ease the dislocations engendered by rapid replacement of existing energy sources with CF sources.

Focus on Reconciliation and Recovery[120]. Articulate what makes the CF case unique or particularly challenging for moving forward as compared to other scientific discoveries. Assess how the experience of past similarly initially rejected discoveries that were ultimately accepted into mainstream science can guide the recovery and reconciliation of CF. Identify common ground that exists (or can be developed) between protagonists and antagonists. Determine how to restore legitimacy for CF research with minimum adverse consequences to the antagonists so that resistance to restoration is minimized. Determine processes and infrastructure that can be set up to achieve constructive communication among the parties at interest. Identify incentives that can be established to reduce resistance and encourage cooperation and CF normalization. Identify mistakes that were made by protagonists and antagonists during the introduction of CF, and what are the lessons learned that can be used for recovery. Determine the kind of education program needed for both technical specialists and the general public to counter the negative press of the past and overcome momentum of negative attitude toward CF.

Ramp Up Research Funding. Prepare or revise the Research Plan for a more aggressive R&D program with corresponding level of support. Pursue a more aggressive posture in funding projects with less dependence on monitoring of CF successes and levels of evidence of its existence. Ramp up funding levels quickly to

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[119] O'Brien, David, and Donald Marchand. *The Politics of Technology Assessment – Institutions, Processes, and Policy Disputes*. Lexington Massachusetts: Lexington Books, 1982.

[120] Additional observations and analyses of the recovery process are provided in Chapter 9.

annual expenditures close to average annual levels for hot fusion research for the past 30 to 40 years.

Crash Program

If the existence of CF is accepted beyond a reasonable doubt and a major initiative (crash program) is undertaken to maximize the public interest, a number of additional actions would be appropriate.

Increase Funding Level Dramatically. Remove many of the funding constraints of lower levels of support. Make sure that most or all of the Research Plan is fully funded. As appropriate, fully fund government and private sector laboratories that are demonstrating success in securing CF experimental data. Selectively but liberally support nuclear theorists who are successful in explaining the experimental results. Select and support experts in planning for and dealing with expected profound secondary impacts through mitigative programs.

Set Up a Dedicated National Cold Fusion Laboratory[121]. Take into account the history of CF evolution in deciding whether existing government labs may be targeted or if a new entity will be required in order to be effective. Organize the laboratory in accordance with the comprehensive CF Research Plan with appropriate research priorities for experimental work and theory development. Engage the current CF research community in determining the best way to allocate research efforts between in-house programs and independent researchers. Direct the increased level of funding, to extent possible, through the dedicated CF research organization, in a manner similar to the Manhattan Project at the end of World War II.

Develop a Complementary Office for Private Sector Support. Review the IP policies developed for lower development scenarios and amplify as required to enhance private sector participation in CF development. Ensure that public funding is

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[121] A dedicated function could also be set up in an existing national laboratory if sufficiently receptive conditions can be fouind.

appropriately allocated (as described above) between public and private research entities to optimize efforts and contributions from both categories.

Potential Risks of Cold Fusion Public Support

In response to skeptics, and to protect the public interest, the potential risk of public support for CF must be well understood. Although the public welfare benefits of CF are apparent, they must be balanced against the potential risks of CF support. The CF-related risks appear to be the following: 1) expenditures for CF research support are wasteful of scarce public funds, which might better be spent in other research areas; 2) conducting CF research is in violation of more universally held philosophical, moral or ethical standard; and 3) the reputations of prominent scientists who have been antagonistic toward CF may be questioned.

Regarding the first factor, given both the high level of public interest in CF and the high level of evidence that it is a real phenomenon that may contribute greatly to the public welfare, research support that is commensurate with other primary energy technologies is well justified. With respect to the second factor, CF is little different from other promising technologies for public support except for the issues – protagonistic and antagonistic – that surfaced when it was first announced and then rejected. As noted in Chapter 9, attention must be given specifically to these issues as part of the recovery process.

Regarding the third factor, it may be challenging for many highly reputable and well-regarded scientists to reconsider their CF positions. But this would be a small price to pay for the potential gain in the public welfare benefit of CF success. As noted in the next chapter, the public interest will be well served not only by a willingness of antagonists to reconsider their positions, but also by a charitable and supportive stance by all parties-at-interest, especially the current marginalized CF research community. Additional perspective on the recovery process is provided in the next chapter.

Chapter 9. Recovering from Cold Fusion Rejection for the Public Interest

Although it cannot be stated with certainty that CF is real, it appears that there is at least a preponderance of evidence that it is. And it should, at a minimum, be fully reinstated in the public interest. At the same time, it must be clearly recognized that changes in policy toward CF will continue to be problematic, given its history of rejection and ridicule[122], regardless of the policy response option that is chosen. Specific attention must therefore be given to the recovery process. The path to recovery of CF begins with recognition of the events and causes of rejection and proceeds with constructive responses based on the lessons learned in order to minimize continued resistance.

Difficulties in Experimental Reproducibility

A principal reason for CF rejection was the difficulty experienced by many researchers in reproducing the effect. CF reactions are, in fact, remarkably difficult to achieve in the laboratory, and reproducibility is still unacceptably low. Fleischmann and Pons, in the 1989 press conference where they announced the discovery of CF, predicted that it would be quickly developed as a source of energy. A review of the transcript of the news conference[123] shows that Pons said (underline added for emphasis):

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[122] Many scientists of considerable stature and influence, especially nuclear physicists, "came out against" CF in the early months and have a great deal at stake in the ultimate outcome of the reality of CF. As noted above, Max Plank asserted that "scientific progress occurs one funeral at a time." The public interest in the possible success of CF necessitates that policymaking move faster than will occur with a succession of funerals.

[123] Palmer, Nick, and Steven Krivit. Transcript of University of Utah N-Fusion Press Conference, March 23, 1989, Salt Lake City, Utah. *New Energy Times*. Online. Available: http://newenergytimes.com/Reports/UUtahPressConferenceTranscript.htm

> Well we've been concerned primarily with the effect …the observation of the ... fusion event. I would think that it would be reasonable within a short number of years to build a fully operational device that could drive … produce electric power or to drive a steam generator or a steam turbine, for instance.

And Fleischmann stated:

> So, if I could go to that question about the implications – we don't know what the implications are. The subject has to be fully researched, the science base has to be established. I would emphasize that it is absolutely essential to establish a science base, as widely as possible, as correctly as possible, to challenge our findings, to extend our findings. Having established that, you have to, of course, consider all the engineering implications. But it does seem that there is here a possibility of realizing sustained fusion in a relatively inexpensive ... with a relatively inexpensive device, which could be ... brought to some sort of successful conclusion fairly early on.

Storms[124] (p. 49) has noted: "Fleischmann and Pons were wrong in a few minor ways and were certainly wrong about how easy the claims would be to replicate." Storms also makes the point (p. 52) that there are also many reports of negative findings, and the number of unreported negative results far outstrips the number that have been reported.

As noted in Chapter 2, the principal reasons for the erratic reproducibility are a lack of detailed understanding of what is occurring at the nuclear level and a corresponding lack of an adequate theory to explain the phenomenon. Both the understanding and the theoretical underpinnings for CF are still being developed. The reproducibility situation has improved since 1989 with successes like the Arata and Zhang demonstration described in Chapter 6.

The Absence of Evidence Is Not Evidence of Absence

The difficulties of reproducibility were used by antagonists as one of the main reasons for rejecting CF. Yet one of the central tenets of scientific investigation is that the failure to achieve experimental results does not mean that the phenomenon does not exist[125] – the failure to find that something is so is far different from demonstrating that it is not so.

Regarding the reality of excess heat from CF reactions, the failed experiments most likely did not achieve the necessary conditions for the reactions to occur. As shown in the Bayesian network analysis in Chapter 6, where three of the 10 initial experiments were considered failures, the occurrence of failed experiments does not negate the probability that CF exists.

Breakdown of the Scientific Process?

The developmental possibilities of CF may have been curtailed by a breakdown in the sociology of science – in the process by which promising new phenomena are evaluated and accepted (or rejected) for public support[126,127]. Indications of this possible breakdown may be seen in the CF policymaking processes employed by the U.S. government, particularly the U.S. Department of Energy.

U.S. Department of Energy Report in 1989

As noted in Chapter 2, the Energy Research Advisory Board (ERAB) of the U.S. Department of Energy was commissioned to evaluate CF and its prospects as an energy source. The findings and recommendations of this panel were a principal reason for the negative policies toward CF that ensued. Because of the importance of this panel to CF policymaking, excerpts from the most relevant parts of the executive

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[124] Storms, Edmund. *The Science of Low Energy Nuclear Reaction – a Comprehensive Compilation of Evidence and Explanations about Cold Fusion*. Singapore: World Scientific Publishing Co., 2007.

[125] Altman, Douglas and J Martin Bland. “Absence of Evidence is Not Evidence of Absence.” *British Medical Journal* (*BMJ)*, vol. 311 (1995), p. 485.

[126] Chubb, Scott. “Introduction to the Special Series of Papers in Accountability in Research Dealing with ‘Cold Fusion’”. *Accountability in Research*, vol 8 (2000), p. 1-17.

[127] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

summary and the conclusions and recommendations of the ERAB report are provided below[128]:

Excerpts from Executive Summary

> As a result of the startling announcements in March 1989 by Utah scientists claiming the attainment of cold fusion, the Secretary of Energy requested … that the Energy Research Advisory Board (ERAB) convene a panel to assess the possibility of cold fusion. Since early May 1989, the Panel or subgroups thereof have participated in the Workshop on Cold Fusion in Santa Fe, have visited several laboratories, have studied the open literature and numerous privately distributed reports, and have participated in many discussions…
>
> The Panel concludes that the experimental results on excess heat from calorimetric cells reported to date do not present convincing evidence that useful sources of energy will result from the phenomena attributed to cold fusion. In addition, the Panel concludes that experiments reported to date do not present convincing evidence to associate the reported anomalous heat with a nuclear process…
>
> The Panel also concludes that some observations attributed to cold fusion are not yet invalidated.
>
> The Panel recommends against the establishment of special programs or research centers to develop cold fusion. However, there remain unresolved issues which may have interesting implications. The Panel is, therefore, sympathetic toward modest support for carefully focused and cooperative experiments within the present funding system…

Excerpts from Conclusions and Recommendations

> A. PREAMBLE
>
> Ordinarily, new scientific discoveries are claimed to be consistent and reproducible; as a result, if the experiments are not complicated, the discovery can usually be confirmed or disproved in a few months. The claims of cold fusion, however, are unusual in that even the strongest

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[128] U.S. Department of Energy, Energy Research Advisory Board. "Final Report of the Cold Fusion Panel of the Energy Research Advisory Board." Unpublished U.S. DOE Report, 61 p. November, 1989.

proponents of cold fusion assert that the experiments, for unknown reasons, are not consistent and reproducible at the present time.

However, even a single short but valid cold fusion period would be revolutionary. As a result, it is difficult convincingly to resolve all cold fusion claims since, for example, any good experiment that fails to find cold fusion can be discounted as merely not working for unknown reasons. Likewise the failure of a theory to account for cold fusion can be discounted on the grounds that the correct explanation and theory has not been provided. Consequently, with the many contradictory existing claims it is not possible at this time to state categorically that all the claims for cold fusion have been convincingly either proved or disproved. Nonetheless, on balance, the Panel has reached the following conclusions and recommendations.

B. CONCLUSIONS

Based on the examination of published reports, reprints, numerous communications to the Panel and several site visits, the Panel concludes that the experimental results of excess heat from calorimetric cells reported to date do not present convincing evidence that useful sources of energy will result from the phenomena attributed to cold fusion…

C. RECOMMENDATIONS

The Panel recommends against any special funding for the investigation of phenomena attributed to cold fusion. Hence, we recommend against the establishment of special programs or research centers to develop cold fusion.

The Panel is sympathetic toward modest support for carefully focused and cooperative experiments within the present funding system.

The Panel recommends that the cold fusion research efforts in the area of heat production focus primarily on confirming or disproving reports of excess heat. Emphasis should be placed on calorimetry with closed systems and total gas recombination, use of alternative calorimetric methods, use of reasonably well characterized materials, exchange of materials between groups, and careful estimation of systematic and random errors. Cooperative experiments are encouraged to resolve some of the claims and counterclaims in calorimetry.

Although appearing to leave the door open in a few areas, the ERAB report arrives at an overall negative conclusion on CF:

- Experimental results “do not present convincing evidence” that “useful sources of energy will result from the phenomena attributed to cold fusion” or that “associate the reported anomalous heat with a nuclear process”.
- “The Panel recommends against the establishment of special programs or research centers to develop cold fusion”
- CF experiments are “not consistent and reproducible at the present time”

Areas where the door appears to be left open are as follows:

- “Some observations attributed to cold fusion are not yet invalidated”
- “Modest support for carefully focused and cooperative experiments” may be provided within the existing funding system
- “Even a simple short but valid cold fusion period would be revolutionary”
- “It is not possible at this time to state categorically that all claims for cold fusion have been convincingly either proved or disproved”
- CF research should focus on “confirming or disproving reports of excess heat”

However, despite the apparent open-door aspects of the report, no meaningful U.S. DOE funding was forthcoming in the ensuing months and years.

Glenn Seaborg Cold Fusion Advisory to President George Bush

Just prior to the work of the ERAB panel, President George H.W. Bush requested an opinion from Glenn Seaborg – a prominent nuclear physicist who frequently advised U.S. presidents on science policy – concerning CF public policy and support. A meeting between Bush and Seaborg took place on April 14, 1989, just three scant weeks after the March 23 CF announcement. The recommendation of Seaborg played a pre-eminent role in establishing a negative U.S. policy toward CF.

The events of the meeting were subsequently described in 1995 in a presentation by Seaborg[129]; the following is a close approximation of a portion of that presentation regarding his advice to President Bush on CF.

> The idea swept the country. I was called to Washington to brief President Bush on it. It was a real dilemma. What should I do? I decided to take my background as a nuclear scientist and come to the sensible conclusion that this work was not right. It was really, well, you might say, really cold. You couldn't do it. That's what I told him at that time. I said you can't just go out and say this is not valid. You are going to have to create a high level panel that will study it for six months and then they will come out and tell you it's not valid. And that's what he did.

Two points from Seaborg’s remarks appear to be highly significant to evidence-based policymaking for CF:

1) Seaborg appears to have made his policy-setting recommendations not on the basis of evidence, but on his own opinion (or prejudice): “I decided to take my background as a nuclear scientist and come to the sensible conclusion that this work was not right. It was really, well, you might say, really cold. You couldn't do it.” At the time of the April 1989 meeting, there was insufficient evidence, either for or against CF, on which to make an informed, evidence-based conclusion or recommendation. The scientific process called for maintaining an open mind about CF prospects until meaningful experimental results were available.
2) Seaborg seems to profess that the findings of the ERAB panel were not objective but were foreordained from the outset: “I said you can't just go out and say this is not valid. You are going to have to create a high level panel that will study it for six months and then they will come out and tell you it's not valid. And that's what he did.”

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[129] Seaborg, Glenn. “FDR to Bush – Fifty Years of Advising the Presidents”. Presentation made at Lawrence Berkeley National Laboratory, October 28, 1995. Online. Available:

It is noteworthy that the more influential of the two cochairmen of the panel was invited to the post by Seaborg (Simon[130], p. 100). If the findings of the Panel were indeed foreordained, then its conclusions and recommendations are questionable. It seems apparent that there was a strong possibility of a compromise in the objectivity of the panel and the integrity of the scientific process. The CF policies that resulted were therefore not consistent with evidence-based policymaking.

The U.S. 2004 Cold Fusion Review

At the request of several CF protagonists in 2003, the U.S. DOE conducted a second review of CF phenomena, which was reported in December 2004[131]. Like the 1989 ERAB report, this review had major influence on setting U.S. policy toward CF.

The DOE first requested the group of protagonists to prepare a CF summary that "identified the most significant experimental observations and publications, and those areas where additional work would appear warranted." The requested summary report[132], which was submitted in July 2004, focused on excess heat production and nuclear emissions from deuterated metals; it consisted of the following four sections (as well as an introduction and conclusion):

- Excess Heat Effects in Fleischmann-Pons Experiments
- Helium and Excess Heat
- Excess Heat beyond the Fleischmann-Pons Experiment
- Nuclear Emissions

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http://video.google.com/videoplay?docid=-6144236233611516224&hl=en. Accessed October 2008

[130] Simon, Bart. *Undead Science: Science Studies and the Afterlife of Cold Fusion*. New Brunswick, New Jersey: Rutgers University Press, 2002.

[131] U.S. Department of Energy. "Report of the Review of Low Energy Nuclear Reactions". Unpublished U.S. DOE Report, 5 p. December 1, 2004.

[132] Hagelstein, Peter, Michael McKubre, David Nagel, Talbot A. Chubb, and Randall J. Hekman. "New Physical Effects in Metal Deuterides." Unpublished report prepared for U.S. Department of Energy Review Panel on Cold Fusion. 2004.

The report (referred to here as the “Hagelstein report”) concluded with the following assertions:

- The existence of a physical effect that produces heat in metal deuterides. The heat is measured in quantities greatly exceeding all known chemical processes and the results are many times in excess of determined errors using several kinds of apparatus. In addition, the observations have been reproduced, can be reproduced at will when the proper conditions are reproduced, and show the same patterns of behavior. Further, many of the reasons for failure to reproduce the heat effect have been discovered

- The production of ^{4}He as an ash associated with this excess heat, in amounts commensurate with a reaction mechanism consistent with D+D ^{4}He + 23.8 MeV (heat)

- A physical effect that results in the emission of: (a) energetic particles consistent with d(d,n)^{3}He and d(d,p)t fusions reactions, and (b) energetic alphas and protons with energies in excess of 10 MeV, and other emissions not consistent with deuteron-deuteron reactions

DOE then selected nine peer review scientists and prepared a “Charge Letter” with the following three charge elements:

- Examine and evaluate the experimental and theoretical evidence for the occurrences of nuclear reactions in condensed matter at low energies (less than a few electron volts).

- Determine whether the evidence is sufficiently conclusive to demonstrate that such nuclear reactions occur.

- Determine whether there is a scientific case for continued efforts in these studies and, if so, to identify the most promising areas to be pursued.

The Charge Letter and Hagelstein report were sent to the nine reviewers, and all nine responded with review comments. Nine additional peer reviewers were then selected by DOE and asked to participate in a one-day meeting for further review, which was conducted in August 2004. During this one-day review, six presentations were given by CF research scientists chosen by the authors of the Hagelstein report.

Additional written reviews were prepared by the nine participants in the one-day review and submitted to DOE.

The December 2004 report included a description of the peer review process and a summary and interpretation of the 18 reviews received, organized around the three charge elements. The primary conclusion of the 2004 report was:

> *While significant progress has been made in the sophistication of calorimeters since the review of this subject in 1989, the conclusions reached by the reviewers today are similar to those found in the 1989 review.*

This conclusion had the policymaking result, as might be expected, of continuation of negative public policy toward CF. Other principal significant observations for CF policymaking were as follows for each of the charge elements:

Charge Element 1

- Evaluations by the reviewers ranged from: 1) evidence for excess power is compelling, to 2) there is no convincing evidence that excess power is produced when integrated over the life of an experiment. The reviewers were split approximately evenly on this topic.
- Most reviewers, including those who accepted the evidence and those who did not, stated that the effects are not repeatable, the magnitude of the effect has not increased in over a decade of work, and that many of the reported experiments were not well documented.
- Two-thirds of the reviewers commenting on Charge Element 1 did not feel the evidence was conclusive for low energy nuclear reactions, one found the evidence convincing, and the remainder indicated they were somewhat convinced.

Charge Element 2

- Reviewers expert in nuclear physics noted that the cold fusion mechanism put forward by proponents is not in accord with presently accepted knowledge of D + D fusion.
- The preponderance of the reviewers' evaluations indicated that Charge Element 2, the occurrence of low energy nuclear reactions, is not conclusively demonstrated by the evidence presented.

Charge Element 3

- The nearly unanimous opinion of the reviewers was that funding agencies should entertain individual, well-designed proposals for experiments that address specific scientific issues relevant to the question of whether or not there is anomalous energy production in Pd/D systems, or whether or not D-D fusion reactions occur at energies on the order of a few eV.
- No reviewer recommended a focused federally funded program for low energy nuclear reactions.
- Reviewers identified two areas where additional research could address specific issues. One is the investigation of the properties of deuterated metals including possible effects of alloying and dislocations … A second area of investigation is the use of state-of-the-art apparatus and techniques to search for fusion events in thin deuterated foils.
- Several reviewers specifically stated that more experiments similar in nature to those that have been carried out for the past fifteen years are unlikely to advance knowledge in this area.

Conclusions

- While significant progress has been made in the sophistication of calorimeters since the review of this subject in 1989, the conclusions reached by the reviewers today are similar to those found in the 1989 review.
- The current reviewers identified a number of basic science research areas that could be helpful in resolving some of the controversies in the field, two of which were: 1) material science aspects of deuterated metals using modern characterization techniques, and 2) the study of particles reportedly emitted from deuterated foils using state-of-the-art apparatus and methods.
- The reviewers believed that this field would benefit from the peer-review processes associated with proposal submission to agencies and paper submission to archival journals.

Potential Issues of the 2004 Review

Although the 2004 DOE review does not seem to have had a foreordained conclusion as was apparently the case for the 1989 ERAB review, it may have had issues – and outcome – that did not result in the public interest being served. One potential issue was the qualifications of the peer reviewers selected. As noted by one of the CF protagonists[133] in assessment of the 2004 report:

> The DOE/OS accomplished the best peer-review evaluation that was possible under the difficult circumstances of [CF's] place in the professional community. Nevertheless, it is instructive to ask, What if the editor of an archival journal were to use a similar peer-review procedure by choosing reviewers who where not active in the field, did not know of its key experiments, and were ignorant of its literature … The Office of Science did not have a choice in this matter given the pariah status of the field. The peer-review work necessarily had to be done by scientists outside the field of CF who, unavoidably, were unfamiliar with its technical development, leading scientists, significant experiments, and principal papers.

Another potential issue was similar to the case for the 1989 review. Although the door was clearly left open for future support ("The nearly unanimous opinion of the reviewers was that funding agencies should entertain individual, well-designed proposals for experiments that address specific scientific issues relevant to the question of whether or not there is anomalous energy production in Pd/D systems…"), no meaningful DOE support was forthcoming in the ensuing months and years.

The primary issue with the 2004 review, however, is whether its outcome, and the resulting continued marginalized status of CF, was in the public interest. Whereas it may be true that "the conclusions reached by the reviewers today are similar to those found in the 1989 review," this may have been the result of the peer review process used, the basis for the review, and the peer reviewers selected. The Hagelstein report provided a summary of essential points, but the rather narrow DOE mandate limited the scope of coverage. As a result, other highly relevant facts of the CF case were not taken into consideration.

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[133] Beaudette, Charles. Response to the DOE/2004 Review of Cold Fusion Research. Unpublished Paper, 16 p. March 1, 2005. Online. Available www.lenr-canr.org. Accessed October 2005.

A key question regarding the 2004 review is why there was not a more affirmative outcome for CF when the “reviewers were split approximately evenly” on the topic of whether the “evidence for excess power is compelling.” One rational interpretation of this finding is that there is an equal chance – nearly a preponderance of evidence – that excess heat from CF reactions is or is not a real phenomenon based on the even split among the reviewers. The case is made in Chapter 7 that a preponderance of evidence for the reality of CF leads to a policy response of reinstatement at a minimum (under a conservative policymaking scenario) or support at a level commensurate with hot fusion under a moderate scenario.

In any case, there appears to be a major incongruity in the report in that “the conclusions reached today are similar to those found in the 1989 review” when the “reviewers were split approximately evenly” on whether the “evidence for excess power is compelling”.

U.S. Patent Office Responses to Cold Fusion Patent Applications

A principal means of CF policymaking is the intellectual property protection that it is provided under patent law and procedure. Many countries have granted CF-related patents, but with few exceptions, the U.S. Patent and Trademark Office (PTO) has adopted a negative stance toward CF patent applications. Apparently most CF applications have been directed to the office of a particular patent examiner who has consistently denied the applications. And apparently the reasons cited for the denials are often based on outdated information from the early days of CF rejection and marginalization. There may be excellent opportunity in the future for updating the PTO stance and procedures to be a more rational, evidence-based policymaking approach.

Lessons Learned from Past Cold Fusion Policymaking

There is much to be learned for future CF policy development from the primary policymaking events of the past, particularly within an evidence-based framework. These “lessons learned” may not only help to achieve recovery and reinstatement of CF, but also help secure the future integrity of the scientific process.

- Care must be taken when revolutionary new discoveries are claimed to ensure that full and objective evaluation of the evidence is given before conclusions are reached and judgment is passed.
- Prejudice may exist in the professional understanding and opinion of even the most prominent contributors to the advance of science; such strongly held opinion may inhibit dedication to the scientific principle of relying on evidence.
- Particular care must be taken to protect the integrity of the scientific process when assessments of new claims or phenomena are undertaken; foreordained conclusions are not consistent with such integrity.
- When an initial evaluation of a new discovery is negative, care must be taken to prevent a “momentum of opinion” from blocking open and objective consideration of new data or findings after the initial judgment.
- Although there is much value in the weight of opinion of experienced scientists, the weight of evidence must always prevail over professional opinion in making scientific judgments and setting public policy.
- The public interest must be the guiding force in setting policy based on the scientific process – the greater the potential public benefit, the greater must be the latitude or openness to claims of new discoveries.
- At the same time, the more radical a claim, the greater the evidence required to establish its basis in reality – a balance must be sought among the factors of how radical the claim is, the level of evidence for the claim, and the degree of public welfare benefit realized if it proves ultimately to be true.

- Intellectual property protection must be recognized as a major instrument of policymaking – similar safeguards for objectivity and the public interest must be applied when making decisions on support of new discoveries through instruments designed to protect private interests.

The Path to Recovery

The path to reinstatement of CF – or more aggressive policy measures as advocated in earlier chapters – cannot yet be mapped out in detail. The high level of evidence for the reality of CF phenomena provides the basis for a recovery process, and the strong public interest in its success provides the impetus. Because of its difficult beginnings and tainted reputation, CF will nevertheless require strong positions in affirmative policymaking to overcome the negative inertia surrounding it. There is no question that a degree of understanding and charity among the protagonists and antagonists must somehow be achieved in order for recovery and progress to occur in a timely manner[134]. Two initial affirmative steps set forth in Chapter 8 to further the recovery process would be to prepare a Research Plan based on reinstatement (at a minimum) and to conduct an in-depth policy analysis founded on evidence-based policymaking.

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[134] It is Max Planck who is credited with asserting that "scientific progress occurs one funeral at a time." The public interest is not served by this kind of delay in the case of CF.

Chapter 10. Conclusions and Recommendations

Because of the high level of public interest in its eventual success and contribution to the public welfare, CF must be given the best chance possible – the highest level of support commensurate with the evidence of its reality – to be developed. The public interest in CF is best served by developing policy toward its support within a rational framework – based on the evidence that it is real.

CF has experienced a difficult birthing process. Many mistakes were made at the time of its discovery and announcement, and many more mistakes were made as it was being evaluated in the initial months after announcement. The result was a premature and possibly inappropriate ejection of the phenomenon from mainstream science. Were it not for the dedicated efforts of a few competent researchers, who have continued to achieve positive experimental results, CF would have been relegated to the dustbin of discredited phenomena nearly 20 years ago.

The scientific evidence for the existence of CF, when examined from four perspectives, indicates that there is at least a preponderance of evidence (probability greater than 50%) for its existence. And an excellent case can be made for clear and convincing evidence (greater than 70% probability). Statistical (Bayesian network) analysis indicates that the level of evidence is beyond a reasonable doubt (probability over 90%).

The rational policy response – that best serves the public interest – is to reinstate CF as a legitimate area of scientific investigation if there is a preponderance of evidence for its existence – even under a conservative policymaking scenario. Such a conservative scenario would call for support of CF commensurately with hot-fusion research if the evidence is clear and convincing. And a crash development effort, on the order of the Manhattan Project, would be the rational response if the evidence for CF existence is beyond a reasonable doubt.

Future policy – including support with public funds – should be informed both by the apparent lessons learned on CF policymaking in the past and by the best available precedents for policy setting for similar previous cases. A fuller consideration of the policy aspects of CF as outlined in this report may be expected to lead to the conclusion that higher levels of support are warranted to best serve the public interest. Concurrently, several concrete actions can be undertaken to achieve recovery and reinstatement of CF as a legitimate area of scientific investigation.

A long-established and well-disciplined community of CF researchers has developed in the years since the field was rejected and marginalized nearly 20 years ago. This research community will provide the best resource and framework for development of a comprehensive, long-term research program plan – the next step needed (in addition to a policy analysis study) to prepare for legitimization and support of CF development for the public interest. The recommended future public policy toward support of CF development is not “whether”, but at what level.

Endnotes

[a] Birkland, 2001, p. 21: “The dominant ideological foundation of our constitutional system (and that of other countries, such as Canada, Australia, and Great Britain, for example) is known as classical liberalism…. Among the many beliefs of liberalism is the belief that power derives from the consent of the governed, and that “we the people” are governed who provide our consent to the government. Thus, when policy advocates seek to induce the government to make policy (by taking an action or refusing to do so), proponents of the new policy will claim that the government does so in the “public interest.”

[b] Anderson, 2006, p. 137: “The task of government, it is often proclaimed, is to serve or promote the public interest. Statutes sometimes include the public interest as a guide for agency action… Most people, if asked whether public policy should be in accord with the public interest or with private interests, would opt for the former… Difficulty arises, however, when one is asked to define the public interest… Many people, including most political scientists, would say that it is not possible to provide a universally accepted or objective definition of the concept, especially in substantive terms. Some would contend that whatever results from the political struggle over policy issues is the public interest. If all groups and persons had an equal chance to engage in that struggle, which in fact they do not, this notion of public interest might be more appealing…”

[c] “The Cochrane Collaboration is an international not-for-profit and independent organization, dedicated to making up-to-date, accurate information about the effects of healthcare readily available worldwide. It produces and disseminates systematic reviews of healthcare interventions and promotes the search for evidence in the form of clinical trials and other studies of interventions. The Cochrane Collaboration was founded in 1993 and named after the British epidemiologist, Archie Cochrane.” Online. Available: http://www.cochrane.org/docs/descrip.htm.

Appendix A. Reports of Excess Power from Cold Fusion – 1989-2004

Many experiments have been performed that appear to verify the findings of excess heat reported by Fleischmann and Pons in 1989. The table below, which was abstracted from Storms[135] (Table 2), shows reports of excess power[136] for each year from 1989 to 2004. The table includes the senior author of each report, the medium and substrate used, and the maximum power (MP, in watts) generated. besides the 1989 Fleischmann and Pons paper, some 184 reports of excess power were issued through 2004. References for the reports may be found in the Storms reference.

No	Sr Author	Method	Substrate	MP
	1989			
1	Fleischmann	electrolyte	Pd	26.8
2	Santhanam	electrolyte	Pd, Ti	1.54(Pd)
3	Kainthla	electrolyte	Pd	1.08
	1990			
4	Liaw	fused salt	Pd	25.4
5	Zhang	electrolyte	Pd	0.017
6	Scott	electrolyte	Pd	3
7	Schreiber	electrolyte	Pd	?
8	Pons	electrolyte	Pd	2.8
9	Yang	electrolyte	Pd	9
10	Guruswamy	electrolyte	Pd	7.6
11	Lewis	electrolyte	Pd	1
12	Oriani	electrolyte	Pd	3.6
13	Miles	electrolyte	Pd	0.14
14	Hutchinson	electrolyte	Pd	3
15	McKubre	electrolyte	Pd	1.25
16	Appleby	electrolyte	Pd	0.046
17	Kainthla	electrolyte	Pd	1.08
18	Beizner	electrolyte	Pd	1
	1991			
19	Yun	electrolyte	Pd	0.26
20	Will	electrolyte	Pd	0.01
21	Bush	electrolyte	Pd	0.52
22	Szpak	electrolyte	Pd	?
23	Norinski	electrolyte	Pd	2.6
24	Eagleton	electrolyte	Pd	6.8
25	Mills	electrolyte	Ni	?
26	McKubre	electrolyte	Pd	0.5
	1992			
27	Yuan	electrolyte	Pd	1080
28	Wan	electrolyte	Pd	?
38	McKubre	electrolyte	Pd	1.2
39	Kunimatsu	electrolyte	Pd	?

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[135] Storms, Edmund. *The Science of Low Energy Nuclear Reaction – a Comprehensive Compilation of Evidence and Explanations about Cold Fusion*. Singapore: World Scientific Publishing Co., 2007, p. 53 to 61.

[136] Storms presented the data in units of power, which is the rate (amount per unit of time) at which energy or heat is produced. The main point, the production of excess heat, is demonstrated whether expressed as energy or energy per unit of time.

29	Takahashi	electrolyte	Pd	15	40	Kobayashi	electrolyte	Pd	?
30	Srinivasan	electrolyte	Ni	1	41	Karabut	plasma	Pd	30
31	Ray	electrolyte	Pd	?	42	Isagawa	electrolyte	Pd	30
32	Oyama	electrolyte	Pd	0.008	43	Gozzi	electrolyte	Pd	9
33	Ota	electrolyte	Pd-Ag	1.3	44	Celani	electrolyte	Pd	4
34	Notoya	electrolyte	Ni	8	45	Ohmori	electrolyte	Sn	0.907
35	Noninski	electrolyte	Ni	?	46	Bush	electrolyte	Ni	4
36	Mizuno	electrolyte	Pd	?	47	Bush	electrolyte	Pd-Ag	3
37	Miyamaru	electrolyte	Pd	2					
	1993								
48	Zhang	electrolyte	Ti	?	58	Hasegawa	electrolyte	Pd	0.5
49	Storms	electrolyte	Pd	7.5	59	Gozzi	electrolyte	Pd	19
50	Ramamurthy	electrolyte	Ni	0.8	60	Fleischmann	electrolyte	Pd	144
51	Pons	electrolyte	Pd	0.8	61	Dufour	plasma(AC)	Pd	2.07
52	Ota	electrolyte	g	1.3	62	Criddle	electrolyte	Ni	?
53	Okamoto	electrolyte	Pd	6	63	Celani	electrolyte	Pd	?
54	Ohmori	electrolyte	Sn, Sr	0.9	64	Bush	electrolyte	Ni	1.1, 0.7
55	Mizuno	solid	O3	50	65	Bertalot	electrolyte	Pd	3
56	Miles	electrolyte	Pd	0.06	66	Bazhutov	electrolyte	Ni	?
57	Hugo	electrolyte	Pd-Ag	2.6	67	Aoki	electrolyte	Pd	27
	1994								
68	Storms	electrolyte	Pd	2	72	Focardi	electrolyte	Ni	50
69	Notoya	electrolyte	Ni	0.9	73	Bush	electrolyte	Ni	?
70	Miles	electrolyte	Pd	0.06	74	Bockris	electrolyte	Pd	18
71	McKubre	electrolyte	Pd	1	75	Arata	electrolyte	Pd	28
	1995								
76	Zhang	electrolyte	Pd	?	85	Isagawa	electrolyte	Pd	6.8
77	Takahashi	electrolyte	Charcoal	?	86	Hasegawa	electrolyte	Pd	?
78	Takahashi	electrolyte	Pd	3.5	87	Gozzi	electrolyte	Pd	19
79	Samgin	solid	Sr-Ce-O	2.5	88	Dufour	plasma(AC)	Pd, etc	5.5
80	Ota	electrolyte	Pd, Pd-B	0.35	89	Cravens	electrolyte	bead	1.7
81	Ogawa	electrolyte	Pd	?	90	Celani	electrolyte	Pd	5
82	Noble	electrolyte	Pd	?	91	Biberian	solid	AlLaO3	0.5
83	Miles	electrolyte	Pd	0.4	92	Bertalot	electrolyte	Pd	11
84	Karabut	plasma	Pd	2.8					
	1996								
93	Kopecek	electrolytic	Ti	1.2	103	Mizuno	solid	O3	1.5
94	Li	ambient	Pd	0.639	104	Miles	electrolyte	Pd	0.05
95	Yasuda	electrolyte	Pd	5	105	Lonchampt	electrolyte	Pd	0.3
96	Celani	electrolyte	Pd	100	106	Kamimura	electrolyte	Pd	0.6
97	Roulette	electrolyte	Pd	101	107	Iwamura	electrolyte	Pd	1
98	Preparata	electrolyte	Pd	30	108	Isagawa	electrolyte	Pd	6.3
99	Oyama	electrolyte	Pd, Pd-Ag	0.6	109	Dufour	plasma(AC)	Pd	10
100	Oya	electrolyte	Pd, SrCeYNb	2.5	110	DeMarco	electrolyte	Pd	11
101	Oriani	solid	O3	0.7	111	Cellucci	electrolyte	Pd	10
102	Niedra	electrolyte	Ni, SrCeYNb	11	112	Arata	ambient	Pd	20
	1997								
113	Swartz	electrolytic	Ni	2	117	Mengoli	electrolytic	Ni	1
114	Ohmori	electrolytic	Au	0.937	118	Focardi	ambient	Ni	20
115	Dufour	plasma(AC)	Pd	9.5,13.5	119	Cammarota	ambient	Ni	1.2

116	Numata	ambient	PdD	6					
	1998								
120	Takahashi	electrolytic	Pd;Ti,Ag,Cu	5	129	Li	ambient	Pd	25.9
121	Stringham	sonic	Pd, etc	17	130	Iwamura	electrolytic	Pd+CaO	3.2
122	Savvatimova	plasma	W	?	131	Gozzi	electrolytic	Pd	10
123	Oya	electrolytic	Pd,Pd-B	4	132	Focardi	ambient	Ni	38.9
124	Ohmori	plasma	W	183	133	Cain	electrolytic	Pd	?
125	Mengoli	electrolytic	Ni	0.8	134	Bush	electrolytic	Pd	0.06
126	Mengoli	electrolytic	Pd	0.8	135	Biberian	solid	LaAlO3	0.05
127	Lonchampt	electrolytic	Pd,Pt(?)	?	136	Arata	ambient	Pd	24
128	Lonchampt	electrolytic	Ni beads	0.25					
	1999								
137	Szpak	electrolytic	Pd	0.4					
	2000								
138	Zhang	electrolytic	Pd	0.025	144	McKubre	ambient	Pd,U	10,4.0
139	Warner	electrolytic	Ti	0.4	145	Dufour	plasma(AC)	Pd	8.6
140	Storms	electrolytic	Pt,Pd	0.8	146	Campari	ambient	Ni	70
141	Mizuno	plasma	W	40	147	Isobe	electrolytic	Pd	2
142	Miles	electrolytic	Pd-B,Pd-Ce	0.2	148	Bernardini	electrolytic	Ti	1
143	Miles	electrolytic	Pd	0.09	149	Arata	ambient	Pd	12
	2001								
150	Dufour	(two)	U, Pd	1.3, 8.6					
	2002								
151	Warner	electrolytic	Ti	0.51	159	Kirkinskii	diffusion	Pd-black	0.3
152	Tian	ambient	Pd	49	160	Karabut	plasma	Pd	15
153	Tian	diffusion	Pd-Ag	8	161	Fujii	electrolytic	Pd-coated	7.8
154	Swartz	electrolytic	Ni	0.36	162	Del Giudici	electrolytic	Pd wire	0.02
155	Sun	electrolytic	Ti	76.5	163	Chicea	electrolytic	Ni	0.3
156	Storms	electrolytic	various	0.45	164	Castano	electrolytic	Ni.Pd film	0.3
157	Miles	electrolytic	Pd	0.27	165	Isobe	electrolytic	Pd	2.6
158	Li	diffusion	Pd	0.44	166	Arata	sonic	Pd,Ti,Au	?
	2003								
167	Wei	electrolytic	case type	0.45	173	Letts	electrolytic	Pd,Au(laser)	0.7
168	Tsvetkov	fused salt	Ti	0.35	174	Karabut	plasma	Pd spattered	12
169	Swartz	electrolytic	Pd	1.5	175	De Ninno	electrolytic	Pd	0.02
170	Storms	electrolytic	Pd,Au(laser)	0.3	176	Dardik	plasma	Pd	2.9
171	Miles	electrolytic	Pd particles	0.25	177	Celani	electrolytic	Pd	1.4
172	Li	diffusion	Pd	?					
	2004								
178	Strinham	sonic	Pd	40	182	Szpak	electrolytic	Pd (codep)	0.24
179	Savvatimova	plasma	Ti	?	183	Campari	ambient	Ni	25
180	Mizuno	plasma	W	?	184	Dash	electrolytic	Pd	0.93
181	Tian	electrolytic	Ni	?	185	Dardik	electrolytic	Pd	33

Appendix B. Reports of Transmutation from Cold Fusion – 1989-2004

One of the primary “signatures” of CF reactions is the transmutation of one or more elements to other elements – the result of a change in the number of protons in the nuclei of atoms involved in the reactions. Storms[137] (Table 8) has tabulated reports of elemental transmutation in CF experiments from 1989 to 2004. This tabulation is abstracted below with the senior authors, substrate and medium, and transmuted elements detected. During the 1989 to 2004 period, some 80 reports of transmutation were tabulated. The references for the reports are in Storms’ Table 8.

No	Sr Author	Substrate	Method[*]	Detected
1	Wang	Pd	electrolyte	Ag,Ni,Fe,Ti,S,Pt
2	Wang	Ti	electrolyte	Ag,Ni,Fe,Ti,S,Pt
3	Szpak	Pd	electrolyte	Si,Mg,Zn,Ca,Al
4	Savvatimova	Ti	plasma	Al,Mg,Br,Sr,Rb,S,F,O,Ni,Cr,Fe,Sn[1]
5	Mizuno	W	plasma	Ca,Fe,Zn
6	Lochak	Ti	fuse	Na,Mg,Al,Si,K,Ca,V,Cr,Fe,Ni,Cu,Zn
7	Karabut	Pd	plasma	Li,C,N,Ne,Si,Ca,Fe,Co,Zn,As,Ag,Cd,In[1]
8	Focardi	Ni	ambient	Cr,Mn
9	Cirillo	W	plasma	Re,Os,Au,Hf,Tm,Er,Y
10	Celani	Pd	electrolyte	Cu,Zn,Rb,Cs,Pb,Bi
11	Campari	Ni	ambient	Na,A,Si,S,Cl,K,Ca,Fe,Zn
12	Yamada	Pd	diffusion	Ti,Cr,Mn,Fe,Ni,Cu,Ag
13	Violante	Ni	electrolyte	Cu[1]
14	Passell	Pd	plasma	Pd isotope change, Co,Zn,Au,Ir
15	Ohmori	Re	plasma	K[1]
16	Celani	Pd	electrolyte	Sr --> Mo[1]
17	Violante	Ti	electrolyte	Zn,Cu,Ag[1]
18	Yamada	Pd	electrolyte	Li,B,Mg,A.,K,Ca,Ti,Cr,Mn,Fe,Co,Ni,Cu,Zn,Ba,Pb[1]
19	Warner	Ti	electrolyte	Au
20	Vysotskii	Pd	biological	Ba
21	Matsunaka	Pd	electrolyte	Fe,Zn
22	Karabut	Pd	plasma	C,Ca,Ti,Fe,Co,Zn,As,Ag,Cd[1]
23	Iwamura	Pd	diffusion	Cs --> Pr, Sr --> Mo

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[137] Storms, Edmund. *The Science of Low Energy Nuclear Reaction – a Comprehensive Compilation of Evidence and Explanations about Cold Fusion*. Singapore: World Scientific Publishing Co., 2007, p. 93 to 95.

24	Goryachev	Ni	bombard	Ni --> Rh
25	Di Guilio	Pd	laser	Ca,Fe,S,Zn,Ti,Cu,Cr
26	Arapi	Pd	plasma	Li,Be,Fe,Ni,Cu,Ba
27	Yamada	Pd	plasma	Fe,Cu
28	Warner	Ti	electrolyte	Cr,
29	Wang	TiH	bombard	He^4
30	Vysotskii	?	biological	Na + P --> Fe
31	Passell	Pd	electrolyte	Zn
32	Nassisi	Pd	laser	Zn
33	Mizuno	W	plasma	Al,Si,Ca,Ti,Cr,Fe,Ni,Zn,Ge,Pd,Ag,In
34	Li	Pd	?	Ni
35	Iwamura	Pd	diffusion	Mg,Si,S
36	Iwamura	Ni	electrolyte	F,Al,Si
37	Hanawa	C	plasma	Si,S,Cl,K,Ca,Ti,Cr,Mn,Fe,Co,Ni,Cu,Zn
38	Dufour	Pd	plasma	Mg,Zn,Fe
39	Castellano	Pd	laser	Na,Mg,Al,P,S,Cl,Ca,Ga,Fe,Ni,Zn,Cu,Sn
40	Campari	Ni	ambient	F,Na,Mg,Al,Si,P,S,Cl,K,Ca,Cr,Mn,Fe,Cu,Zn
41	Bernardini	Ti	electrolyte	Sc (radioactive)
42	Ransford	C	plasma	Fe,Cr
43	Ohmori	W	plasma	Cr,Fe,Ni,Re,Pb
44	Focardi	Ni	ambient	C,O,Mgh,Si,K,S,Cl,Al,Na,Fe,Cu
45	Klopfenstein	Ti	electrolyte	Al,S,Ca,Fe (Ti isotope change)
46	Qiao	Pd	ambient	Zn
47	Ohmori	Au	electrolyte	Hg,Kr,Ni,Fe,Si,Mg[1]
48	Ohmori	W	plasma	Ni,C,Fe,Cr,Pb (isotope change)
49	Notoya	Ni	electrolyte	Os,Ir,Pt,Au,K
50	Nassisi	Pd	XeCl laser	Al,Au,C,Ca,Cl,Cr,Fe,K,Mg,Na,Nd,Ni,V,Zn,O,S,Si, delayed n
51	Jiang	Pd	electrolyte	Mg,Al,Si,Fe,Cu,Zn,Pt
52	Jiang	C	plasma	Fe
53	Iwamura	Pd	electrolyte	Ti,Cu,Fe[1]
54	Nakamura	Ni	plasma	radioactivity
55	Ohmori	Au	electrolyte	Fe[1]
56	Qiao	Pd	ambient	Zn,Tb
57	Kopecek	Ti	electrolyte	S,K,Ca,V,Cr,Fe,Ni,Zn
58	Ohmori	Au, Pd	plasma	Fe[1]
59	Yamada	Pd	plasma	C
60	Karabut	Pd	plasma	Na,Mg,Br,Zn,S,Mo,Si
61	Miley	Ni	electrolyte	Major elements: Cr,Fe,Mn,Cu,Zn,Se,As,Cd,Ag[1]
62	Savvatimova	Pd	plasma	As,Br,Rb,Sr,Y,Cd[1]
63	Notoya	Ni	electrolyte	Ba
64	Mizuno	Pt	electrolyte	Pt (radioactive), Al,Ca,Mg,Bi,Sm,Gd,Dy
65	Sundaresan	C	plasma	Fe
66	Singh	C	plasma	Fe
67	Mizuno	Pd	electrolyte	Pt,Pb
68	Dash	Pd	electrolyte	Ag,
69	Matsunoto	Pd	plasma	Ni,Ca,Ti,Na,Al,Cl,Cd,I
70	Bush	Ni	electrolyte	Sr (radioactive)
71	Savvatimova	Pd	plasma	K --> Ca
72	Notoya	Ni	electrolyte	Na --> K, Na --> Mg, K --> Ca, Mg --> Ca
73	Komaki	Pd	biological	Mg --> Ca
74	dillon	Ni	electrolyte	Zn,Cu,Cr,Fe
75	Bush	Ni	electrolyte	Rd --> Sr

76	Ohmori	Pd	electrolyte	K --> Ca
77	Rolison	Pd	electrolyte	Rh,Ag
78	Williams	Pd	electrolyte	Li,Cu,Zn,Fe,Pb,Si,Pt
79	Divisek	Pd	electrolyte	Pb,Cu
80	Greber	Pd	electrolyte	Pb,Hg,Bi,Zn
				[1]Isotope change

*Methods:

Electrolytic = solution through which current is passed to initiate a Faraday-type reaction
Plasma = Suffficeient voltage is applied to either a gas or liquid to form gaseios ions as an arc or spark
Laser = Laser light is applied in order to stimulate nuclear reactions
Diffusion = Deuterium or hydrogen is diffused through palladium from the gas pahse
Fuse = Metal is rapidly melted by high current while under water
Ambient = Metal substrate is placed in the indicated gas
Bombard = Substrate is bombarded with the indicated charged particle
Biological = Transmutation products are made in the presence of living organisms

Appendix C. Reports of Radiation from Cold Fusion – 1989-2004

Anomalous radiation is one of the signatures of CF reactions. Storms[138] has tabulated reports of such radiation for the period 1989 to 2004 (Table 11). The table below was abstracted from Storms' data and includes the senior author, method by which reactions were achieved, type of radiation observed, and associated energies. There were some 55 reports of anomalous radiation for the 1989 to 2004 period. Bibliographic information for the reports may be found in the Storms reference.

No	Sr Author	Method	Type*	Energy	Other Behavior
1	Lochak	Ti melted	S	?	transmutation
2	Karabut	plasma	X-ray	1.5-2.5 keV	heat, transmutation
3	Lipson	electrolyte	α	9-16 MeV	bursts
4	Lipson	ambient	p (or) d	1.7 MeV	
5	Lipson	ambient	p (or) d	2.8 MeV	
6	Kowalski	ambient	?	?	
7	Focardi	ambient	γ	744 keV	heat, transmutation
8	Oriani	electrolyte	?	?	
9	Miles	electrolyte	?	?	heat, helium
10	Keeney	ambient	p	2.6 MeV	
11a	Lipson	electrolyte	α, p, X-ray	α: 11-16 MeV	heat
11b	Lipson	plasma	α,p,d,X-ray	α: 13.0 MeV	
11c	Lipson	laser	α	α: 13.0 MeV	
12	Cecil	plasma	α	6,8 MeV	
13	Afonichev	ambient	RF	?	tritium
14	Lipson	electrolyte	α,p,X-ray	α: 11-16 MeV	heat
15	Violante	electrolyte	X-ray	p: 1.7 MeV	transmutation, heat
16	Tian	ambient	X-ray	?	heat
17	Yamada	plasma	γ	106 keV	autoradiograph
18	Lipson	ambient	p	2-3 MeV	
19	Roussetski	ambient	p,t,3He	P; 3 MeV	
20	Bernardini	electrolyte	γ	1123 KeV	radioactive, heat
21	Campari	ambient	γ	412 KeV	heat, transmutation
22	Savvatimova	ambient	β,S	?	radioactive, heat
23	Iwamura	electrolyte	X-ray	10-100 KeV	heat, neutron, transmutation
24	Qiao	ambient	?	?	heat, transmutation
25	Szpak	electrolyte	X-ray	12 keV	heat, codeposition
26	Lin	gunpowder	β	?	17.7 h half-life transmutation

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[138] Storms, Edmund. *The Science of Low Energy Nuclear Reaction – a Comprehensive Compilation of Evidence and Explanations about Cold Fusion*. Singapore: World Scientific Publishing Co., 2007, p. 101 to 104.

27	Notoya	electrolyte	γ	Many values	
28	Rout	ambient	S	?	autorad.
29	Roussetski	ambient	p?	1.7,2.7,4 MeV	
30	Cellucci	electrolyte solid	X-ray	89 keV	heat, helium
31	Mizuno	electrolyte	γ	76.8 keV	radioactive tritium, radioactive decay
32	Itoh	ambient	X-ray	21 KeV	decay
33	Matsunoto	plasma	S	?	transmutation
34	Karabut	plasma	γ,β	γ: 01.-3 MeV	raticactive, heat, transmutation
35	Karabut	plasma	γ,particles	γ: 100-300 keV	radioactive decay
36	Manduchi	ambient	?	?	neutrons
37	Kovalchuk	electrolyte	EMR	380-420nm	
38	Taniguchi	electrolyte	?	4-10 MeV	
39	Matsunoto	electrolyte	S	?	
40	Matsunoto	electrolyte	S	?	
41	Mo	ambient	α	5 MeV	
42	Long	plasma	γ	?	neutrons
43	Uchida	electrolyte	?	?	bursts
44	Bush	electrolyte	X-ray	characteristic	decay, heat
45	Karabut	plasma	FIX	15-20 keV	heat, decay
46	Bush	electrolyte	?	?	decay, heat, helium
47	Wang	ambient	α	?	
48	Jin	ambient	?	?	
49	Dong	ambient	?	?	
50	Taniguchi	electrolyte	p	2-3 MeV	
51	Matsunoto	electrolyte	S	?	
52	Jones	ambient	p?	2.3-3.0 MeV	burst
53	Cecil	ambient	α or t	>4.5 MeV	burst
54	Celani	electrolyte	γ	?	burst
55	Fleischmann	electrolyte	γ	2.8 MeV	heat

*Type of Radiation:
p = proton (hydrogen)
α = alpha (helium)
t = triton (tritium)
d = Deuteron (deuterium)
γ = gamma (photon)
β = beta (electron)
S = strange
Burst = Occasional large signal over a relatively brief time.

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Vita

Thomas W. Grimshaw was born and raised in South Dakota. After receiving his B.S. degree in Geological Engineering at the S.D. School of Mines and Technology, he attended graduate school at The University of Texas at Austin, where he received the M.A. and Ph.D. degrees in geology in the 1970s. Dr. Grimshaw had the privilege of living in Austin during almost all of his professional career in environmental and infrastructure-related consulting services. After a number of years of excellent opportunities in these areas, he decided to make a change in career direction to policy analysis and public service by enrolling in the LBJ School's mid-career program. As he was completing his coursework, Dr. Grimshaw realized that the unique and fascinating case of cold fusion could be investigated, and possibly advanced, from a public interest and policy analysis perspective.

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