

May 7, 2007

TO: Chairman Brad Miller
Subcommittee on Investigations and Oversight

FROM: Subcommittee Staff

RE: Investigation by Purdue University of Allegations of Research Misconduct
against Dr. Rusi Taleyarkhan

In March of 2006, Sally Mason, provost of Purdue University, announced a review of the research in sonofusion, commonly called "bubble" fusion, done by Dr. Rusi Taleyarkhan, a nuclear engineering professor at the university. Dr. Taleyarkhan had published research findings in 2002 while at Oak Ridge National Laboratory claiming that he had achieved bubble fusion in an inexpensive, tabletop system. He later claimed "independent" confirmation of that research by junior researchers working in his own Purdue laboratory. Bubble fusion is supposed to generate nuclear reactions by creating tiny bubbles that are then bombarded with sound waves that collapse the bubbles. The potential for creating clean, non-fossil-fuel energy from fusion has intrigued scientists for decades, resulting in a \$10-billion international project and several smaller projects.

Except for the claimed confirmation in the Purdue laboratory, no other researchers have been able to independently replicate Dr. Taleyarkhan's experiments, including researchers from three universities working under a grant from the Defense Advanced Research Projects Agency (DARPA). After a series of articles in *Nature* magazine¹ and an informal fact-finding effort from the School of Nuclear Engineering to determine who had actually written the "confirmatory" papers, Provost Mason stated that she had asked Dr. Peter Dunn, associate vice provost for research, to conduct a "thorough review of the work and any concerns expressed about it" that would be "fair to everyone involved."²

In particular, the nuclear engineering school's fact-finding effort found that a graduate student listed as one of the co-authors of an "independent" confirmation paper stated that he had nothing to do with the research, but had his name placed on the paper at the last minute by Dr. Taleyarkhan. The second co-author refused to say who had written the final draft, stating that it would affect the claim of independence of the research.

The final report dated December 15, 2006, of the University's Inquiry Committee exonerated Dr. Taleyarkhan of research misconduct, although the report itself made several findings that appear to point to a likelihood of misconduct that should have resulted in further investigation. The Committee determined that the research would not be accepted in the scientific community as independent, that Dr. Taleyarkhan has played

¹ See, e.g., "Is Bubble Fusion Simply Hot Air?" *Nature*,
<http://news.nature.com/news/2006/060306/060306-2.html> March 8, 2006

² "Purdue Initiates Objective Review of 'Bubble' Fusion," *Purdue News*, March 8, 2006.

a significant role in writing the papers and had abused his position as a senior scientist in working with younger researchers.

After reviewing the report, it is our opinion that the review was not thorough in that it never addressed the validity of the underlying research as Provost Mason promised. The result was a missed opportunity to address a potential scientific integrity scandal which has seriously divided and damaged the nuclear engineering school. The very serious allegations of the university's own senior faculty brought forward only after over two years of concerns have been publicly disparaged. The committee appeared to ignore the criteria for research misconduct established in Purdue's own research integrity policy for publication of research. Attempts by some officials to build a public case that the entire controversy resulted because of "faculty relations" or "management" concerns in the nuclear engineering school seem to have caused more, not less, strife and don't address the underlying integrity issues. For example, according to a recent comment from Provost Mason,

What you've got are really some individuals here who, for whatever reason, are pretty unhappy with each other and are going at it tooth and nail. And they really like to use whoever they can as a scapegoat to make a point.³

This position was reinforced in an April 12, 2007, letter to you from Purdue President Martin C. Jischke, which claimed to have dealt with the "turmoil regarding sonofusion research" in 2006 by not only gathering information on the research, but also on the School of Nuclear Engineering's "faculty relations and management protocols." There is no evidence in the materials provided to us that Purdue ever gathered information about the underlying research. The most public result appears to have been the removal of the head of the school who initially brought the allegations to the University's attention.⁴ Dismissing serious allegations of research misconduct as a "faculty relations" problem or a clash of large egos only increases public scrutiny and concern.⁵

As a result of complaints made to the inspector general for the Office of Naval Research which investigates allegations concerning research funded by Defense Advanced Research Projects Agency (DARPA), Purdue is now doing a second inquiry which addresses very specific allegations concerning fabrication or falsification of data. Because of the roles played by various faculty members and administration officials in the previous inquiry and related reviews, it is important that no one involved in any earlier examination of the bubble fusion research and resulting publications play a role in the on-going inquiry. We were quite surprised to learn that three members of previous committees would be serving as the new committee, and that staff support would come from the same person who provided it previously. Purdue's response, as conveyed by its

³ "U.S. House Panel Reviews Research-Misconduct Investigation at Purdue," *The Chronicle of Higher Education*, April 6, 2007, A20.

⁴ Letter from Dr. Martin Jischke to Chairman Miller, April 12, 2007.

⁵ See e.g., Vance, "The Bursting of Bubble Fusion," *The Chronicle of Higher Education*, April 6, 2007.

attorney, was that inquiry committees require a great deal of work, and that these persons were already familiar with the issues at hand.

It is certainly true that these committees require a large time commitment from their members. When the University of California at San Diego investigated allegations that a professor had placed students' names on fraudulent papers, it took a year to fully investigate.⁶ We are recommending that, in order to retain credibility, Purdue appoint at least two members to the second inquiry committee who either have no connection with Purdue or did not participate in any of the previous committees. These persons could come from national laboratories or other scientific facilities familiar with fusion research. Support staff should also not have been associated with the prior inquiry.

Purdue's Research Integrity Policy

Purdue's "Policy on Integrity in Research," more commonly known as "C-22", defines research misconduct as "fabrication, falsification, plagiarism, or other practices that seriously deviate from those that are commonly accepted with the scientific and academic community for proposing, conducting, or reporting research."⁷ All members of the academic community have the obligation to report research misconduct and are to be protected against reprisals. As stated in the policy,

The integrity of the research process must depend largely on self-regulation; it is the responsibility of all who engage in the search for knowledge. Advances are gleaned from rigorous application of scientific and scholarly methods in compliance with critical codes rooted in intellectual honesty.⁸

Purdue's Graduate Council also has "Guiding Standards for Advising and Mentoring Graduate Students" that emphasizes faculty members' responsibility to adhere to integrity in research, to avoid exploiting students, to advise on ethical and responsible conduct in research and to serve as an "exemplar in recognizing and acknowledging the scholarly contributions of others; in providing complete and accurate records and reports of the results and conclusions of their research, scholarly, or artistic endeavors; and in preserving the integrity of the research record."⁹

According to the Research Integrity Policy, allegations of research misconduct at Purdue are supposed to be reviewed in a two-step process: an Inquiry Committee conducts an information and fact-finding effort to determine whether the allegations warrant the convening of an Investigative Committee. The Inquiry Committee is appointed by the dean of the school – the College of Engineering in this case. If a

⁶ Eliot Marshall, "San Diego's Tough Stand of Research Fraud," *Science*, Oct. 31, 1986, pp. 534-35. The papers were retracted, and Dr. Robert Slusky was forced to resign.

⁷ Executive Memorandum No. C-22, Sept. 6, 1991.

⁸ *Id.*

⁹ Graduate Council Taskforce on Ethics in Graduate Education, November 2003; see Graduate School Policies and Procedures Manual, Purdue University, Appendix G (Oct. 2, 2006).

graduate student is involved, as was the case here, the dean of the Graduate School is also to be notified.¹⁰ If the Inquiry Committee determines a full investigation is warranted, an Investigative Committee is appointed by the school dean, the executive vice president for academic affairs and the chairperson of the faculty affairs committee of the University Senate. The Investigative Committee can take testimony, allow cross-examination and accept records, exhibits and written statements as evidence.

The Allegations of Research Misconduct and the Process

In this case, the allegations of misconduct came after years of controversy surrounding the claims of achieving sonofusion beginning with the first publication in *Science* by Dr. Taleyarkhan *et al.* in 2002.¹¹ That publication noted in an accompanying editorial the concerns of other researchers at Oak Ridge National Laboratory – where the original research had taken place – because they had not been able to replicate the experiment.¹² Several other scientists openly pointed to problems with the underlying data. The controversy only increased when the three peer reviewers of the article for *Science* broke their silence and said they had advised that the article not be published because potential sources of error had not been ruled out.¹³ Since that time, no independent confirmation of sonofusion has occurred. In 2005, a private consortium funded by Impulse Devices, Inc., was formed to confirm Dr. Taleyarkhan's work. After spending \$4 million, it abandoned the approach.¹⁴

Almost immediately after Dr. Taleyarkhan joined the Purdue faculty in August of 2003, questions about his research practices were raised by both faculty and students, but they did not reach higher levels at that time. In 2005 and 2006, the head of the School of Nuclear Engineering alerted school officials to troubling concerns about the research, the resulting publications claiming independent confirmation, and his own team's inability to replicate the original research results. In early 2006, skepticism increased as *Nature* magazine published articles questioning the research claims, researchers from other universities added their voices, and a fact-finding committee established by the nuclear engineering school determined that the student listed as co-author of two papers claiming "independent" confirmation of Dr. Taleyarkhan's work had not participated in either the research or data analysis. In March 2006, Provost Mason announced an investigation.

The two publications at the center of this dispute were the May 2005 "Confirmatory Experiments for Nuclear Emissions During Acoustic Cavitation," published in the journal *Nuclear Engineering and Design (NED)* and the paper entitled "Bubble Dynamics and Tritium Emission during Bubble Fusion Experiments" presented at the 11th International Topical Meeting on Nuclear Reactor Thermal-Hydraulics (NURETH-11) in October 2005. Both were presented as "independent" confirmation of

¹⁰ Executive Memorandum, *supra*.

¹¹ Taleyarkhan, West, Cho, Lahey Jr. Nigmatulin and Block, "Evidence for Nuclear Emissions during Acoustic Cavitation," *Science*, March 8, 2002, p. 1868 *et seq.*

¹² Donald Kennedy, "To Publish or not to Publish," *Science*, March 8, 2002, p. 1793.

¹³ Seife, "Chemistry Casts Doubt on Bubble Reactions," *ScienceNow*, July 24, 2002.

¹⁴ Chang, "Practical Fusion, or Just a Bubble?" *New York Times*, Feb. 27, 2007, D1; "Consortium Formed to Study Acoustic Fusion," Impulse Devices, Inc. press release, Jan. 12, 2005.

work done previously at Oak Ridge National Laboratory by Dr. Taleyarkhan. The research was partially funded by the Defense Advanced Research Projects Agency (DARPA). In August of 2005, one of the students listed as a co-author on both of those papers came to the head of the School of Nuclear Engineering and said he had nothing to do with the papers and wasn't even assigned to the laboratory at the time it was done. He also alleged that Dr. Taleyarkhan had added his name to the *NED* paper a week before it was submitted for publication and was not aware that his name was on the second paper until a week before the conference.

As a result of this allegation and prodding from other faculty members, in February of 2006 the head of the nuclear engineering school -- who had already raised concerns with Purdue officials about the research and these publications -- established an informal "Fact-Finding Committee" within the school to determine the process by which these particular papers came to be published. When that committee reported back, included in its report was a statement by the graduate student that made clear he had made no intellectual contribution to the paper, and his name had been added to the paper by Dr. Taleyarkhan, his laboratory supervisor, just before it was submitted to the journal.

The student's first-hand statement to the Fact-Finding Committee was presented in its report as was the information that the other co-author, a post-doctoral researcher assigned to Dr. Taleyarkhan, refused to state who had written the final draft of the article, saying it would compromise the claim of independence. The report was then delivered to Dr. Peter Dunn, the associate vice president for research and the University's research integrity officer.

Purdue's Response

As stated above, Purdue's research integrity policy establishes only two committees to deal with allegations of research misconduct: an inquiry and an investigative committee. Purdue did not follow these procedures.¹⁵ Despite already having the Fact-Finding Committee's report as a specific allegation of misconduct, in April of 2006, Purdue's administration established a preliminary "examination committee" to

(i) discover and examine facts and circumstances surrounding concerns described in recent articles on sonofusion research at Purdue that have appeared in *Nature* (March 8, 2006) and elsewhere, by reference to published articles, conducting interviews with relevant individuals, and review of materials that may become available; (ii) from your understanding of these facts, to define questions (issues) that must be addressed to resolve these questions (issues); and (iii) to recommend approaches to resolve these questions. Through this process, it will be

¹⁵ In a recent communication, Provost Mason said "Purdue carefully followed the C-22 provisions in this matter." Letter from Sally Mason to "Colleagues," dated Feb. 21, 2007. The facts do not bear out this statement.

the goal of the Committee to discover and clarify facts, and identify critical issues.¹⁶

However, it does not appear that the Examination Committee carried out a full fact-finding effort. It only met with two professors and reviewed a limited number of documents before coming up with a report that raised the following questions:

1. Are the data presented in the papers referenced supported by laboratory records and appropriate experimental methods?
2. Were attempts made to restrict the publication of information critical of the successful realization of sonofusion?
3. Did certain members of the nuclear engineering faculty engage in non-professional actions, including providing misleading information?

The Examination Committee's report of June 5, 2006, recommended that further interviews be done and a detailed examination of data notebooks be made. It also concluded that:

Professor Taleyarkhan's claim of the discovery of sonofusion requires further proof when viewed under the premise that "extraordinary claims require extraordinary proof." The details of the experiments must be sufficient to eliminate doubt in interpretation of the findings by independent scholars. However, the present situation is far from the realization of this goal.¹⁷

A few days before that report was submitted, Dr. Dunn received allegations from Dr. Kenneth Suslick, one of the reviewers of the original *Science* article, of fabrication of results by Dr. Taleyarkhan.¹⁸ According to a recent communication from Dr. Suslick, his communication was "completely ignored" by Purdue.¹⁹

The role of the Examination Committee seems to have been very unclear to the affected faculty. Most of them thought that it was functionally the "Inquiry Committee" under the C-22 process. Under C-22, the Inquiry Committee is charged with "information gathering and initial fact-finding to determine whether an allegation or apparent instance of research misconduct warrants an investigation,"²⁰ which is very similar to the charge given to the Examination Committee. Upon completion, the Examination Committee stated to the dean that it "recognized an allegation of potential research misconduct."²¹ But the University only established the required Inquiry

¹⁶ Memorandum entitled "Examination Committee" from Peter E. Dunn to (redacted), April 17, 2006.

¹⁷ Examination Committee Report from Examination Committee to Charles O. Rutledge, June 5, 2006.

¹⁸ E-mail dated June 1, 2006, from Dr. Kenneth Suslick to Dr. Peter Dunn.

¹⁹ Letter dated April 22, 2007, from Dr. Kenneth Suslick to Dr. Peter Dunn.

²⁰ Executive Memorandum, *supra*.

²¹ Memorandum dated July 31, 2006, from Dean Leah Jamieson to Inquiry Committee Members.

Committee after it received the report of the Examination Committee. The Inquiry Committee then was charged with determining “if it is more likely than not that a named individual committed research misconduct.” If it made that finding, an Investigation Committee would be established.²²

However, five weeks after the Inquiry Committee began its work, it wrote to the vice president for research that it did not have proper written allegations under C-22, despite all of the materials that it had been given from the two earlier committees. The University then went back to the two professors who had made the earlier allegations that certain publications represented by Dr. Taleyarkhan as independent confirmation of his work were the result of work done in his own lab with his assistance and listed at least one author who was not involved in the research or writing of the publications. The Inquiry Committee apparently ignored the other questions about the legitimacy of the underlying research raised by others, including the Examination Committee, perhaps considering them not sufficient as formal allegations.

The allegations that were considered concerned the authorship of the disputed papers. As interpreted by the Inquiry Committee, these referred to “serious deviations” in the conducting and reporting of research. Three months later, the Inquiry Committee determined that there was “insufficient evidence” of research misconduct by a named individual necessitating a full investigation, but then went on to provide a long list of “judgment” failures that appear to fully support a finding of a “likelihood” of research misconduct under Purdue’s policy. It stated, for example, that “it is clear to the members of the committee that the great majority of the scientific community would disagree” with Dr. Taleyarkhan’s claim that his sonofusion research had been independently confirmed. It continued with a devastating critique of Dr. Taleyarkhan’s activities at Purdue as follows:

1. Dr. Taleyarkhan displayed “what might be characterized most favorably as severe lack of judgment” regarding his involvement with the “independent confirmation” experiment performed by a post-doctoral researcher and a master’s student working with him. Although the committee inexplicably failed to address the specific allegation that Dr. Taleyarkhan actually wrote the draft submitted for publication, it did find that he suggested “the inclusion of various specific technical details, text used to communicate with journal editors, and rebuttal of points made by referees.” The “sum total of this involvement,” the committee determined, “undermines the claim of independent confirmation.”
2. The committee could not understand why a graduate student, who said he had nothing to do with either of the papers or the underlying research, was listed as a co-author on both.

²² Memorandum entitled “Inquiry Committee Charge – Sonofusion Research – C-22 Proceeding” from Dean Leah Jamieson to Inquiry Committee Members, July 11, 2006.

3. Dr. Taleyarkhan's claim that the measurements by the post-doctoral researcher constituted an independent confirmation of his earlier results did not include these critical elements: a) a different critical gamma-ray detector with a different calibration curve than was used in the earlier experiment; b) researchers not affiliated with Purdue and "certainly not by individuals having close relationships to Dr. Taleyarkhan;" and c) minimal involvement by Dr. Taleyarkhan.

4. Dr. Taleyarkhan placed junior scientists in "precarious positions" in order to promote his research program and "abused his privilege as senior scientist."

5. It is "highly doubtful" that other claims by Dr. Taleyarkhan of independent confirmation of his results will be accepted by the scientific community and were "representative of poor judgment" by Dr. Taleyarkhan.²³

Based on these conclusions, it is difficult to understand how the Inquiry Committee could have then decided that Dr. Taleyarkhan's actions did not constitute research misconduct defined by Purdue as "serious deviations" from practices "commonly accepted within the scientific and academic community for proposing, conducting, or reporting research."

Our review also indicated that there were numerous failures by the University, its faculty and other responsible officials in addressing in a timely manner the concerns which began to surface in 2003 about the sonofusion research. Dr. Taleyarkhan was unusually aggressive and careless in his attempts to get confirmation of "bubble" fusion. Already in August of 2003, he allegedly asked a Purdue graduate student -- and a young Purdue researcher who was not even in the Oak Ridge laboratory at the time of Dr. Taleyarkhan's reported demonstration of sonofusion -- if they wanted to write a paper on the results of that demonstration. A draft of such a paper was actually produced with the two researchers' names on it.²⁴ The students reported back to the head of the school that they were disillusioned by the interaction.²⁵ There were other unusual activities by Dr. Taleyarkhan in the laboratory outside of normal research behavior including changing protocols established by other Purdue faculty, removing equipment necessary to replicate work done by Purdue professors, and failing to allow anyone to view the counting of samples or see the raw data. As one researcher who tried to replicate the research told us, "My question is, where is the data? I could never get the data."

²³ "Inquiry Committee Proceedings under Executive Memorandum No. C-22," Dec. 15, 2006.

²⁴ "DRAFT CONFIDENTIAL - d-Acetone and N-Acetone Pu-Be Nucleation Bubble Fusion Data Summary," August 2003.

²⁵ Confidential letter to Dr. Leah Jamieson, Sept. 12, 2007, referencing draft report with Dr. Taleyarkhan and the student and researcher named as co-authors.

But only after being prodded by other faculty members did the head of the School of Nuclear Engineering start his own informal investigation of the publications at issue.²⁶

There also was pressure on faculty in early 2005 by one of Purdue's deans to withdraw a paper authored by a number of the nuclear engineering faculty and shared with Dr. Taleyarkhan that concluded they could not achieve fusion, and an apparent directive by that dean to those faculty members to avoid working on fusion in the future. Comments that Dr. Taleyarkhan needed time to adjust to an academic environment seem unnecessary in the context of conducting scientific research since Dr. Taleyarkhan came from a highly regarded research laboratory.

University officials approved a press release in the summer of 2005 heralding the publication of research claiming independent confirmation of Dr. Taleyarkhan's earlier research when it should have been clear that a post-doctoral researcher assigned to Dr. Taleyarkhan was the key author of the article, and Dr. Taleyarkhan's assistance was acknowledged in the paper.^{27 28}

The lack of clarity about the process by Purdue's administration, particularly the addition of a preliminary "Examination Committee" and the use of the word "investigation" when only an "inquiry" was underway confused some of those who had provided the initial allegations. For example, in July of 2006, as the Inquiry Committee was being formed, Provost Mason stated that, "We're entering the stage of formal investigation into this work as outlined under executive memorandum C-22."²⁹ There is no question that Purdue deviated from its own procedures in investigation this case and did not conduct a thorough investigation into the allegations against Dr. Taleyarkhan.

More recent claims by administration officials of personality conflicts, management failings and ego clashes among the various scientists involved don't address

²⁶ Confidential communication dated Jan. 13, 2006.

²⁷ The publication of the "independent" research itself was in a special issue of *Nuclear Engineering and Design (NED)* in honor of Dr. Richard Lahey, one of Dr. Taleyarkhan's co-authors of his 2002 paper, for which Dr. Taleyarkhan was one of three guest editors. Dr. Lahey had assisted Dr. Taleyarkhan in responding to the earlier comments on this paper made by the *Physical Review Letters* reviewers who eventually declined to publish it. Dr. Taleyarkhan has denied that he selected or reviewed the Purdue article for *NED*, but there is no information provided that allows us to determine whether the paper was peer-reviewed by *NED* beyond Dr. Lahey's earlier review.

It also is important to note that all of the articles in that special edition, except for two, had been previously presented at the 3rd International Symposium on Two Phase Flow Modelling held in September 2004. Of those two, one was written specifically for Dr. Lahey by Dr. Donald A. Drew, a long-time colleague at Rensselaer Polytechnical Institute; the Purdue bubble fusion paper was the other.

²⁸ This press release also resulted in an article in *Telepolis*, a German publication, which allegedly quoted one of the co-authors describing in detail the lab work that he allegedly did with the other named co-author who has stated several times that he did not work on the experiment. According to the lead author, "We found out that when comet-like streams of bubbles formed the reactions would stop. Their irregular shape diminishes the bubbles' ability to compress the enclosed gas . . ." He also claimed that "We measured a neutron increase of the right energy and a triton increase only for experiments . . ." The article was accompanied by a picture of the two alleged authors. "Bubble Fusion Takes Next Hurdle," *Telepolis*, July 18, 2005, <http://www.heise.de/tp/r4/artikel/20/20542/1.html> (emphasis added); accessed April 20, 2007.

²⁹ E-mail dated July 9, 2006, from Dr Mason to Dr. Lefteri Tsoukalas.

the allegations and only further inflame the divisions in the Nuclear Engineering School.³⁰

The New Inquiry

A new inquiry committee is being formed to look at the actual claims made against the underlying research by Dr. Taleyarkhan and others and related issues. It will be a challenge for Purdue to regain the confidence and cooperation of its nuclear engineering faculty and adequately investigate these allegations. Six of the school's senior faculty members objected in writing to the manner in which the previous inquiry was conducted and its conclusions.³¹ Some have indicated that they do not want to participate in another proceeding.

Unfortunately, all three of the members of the new committee that Purdue named to the new committee were members of previous committees, and the staff member also is the same as before. We were told that these people were appointed because they were already familiar with the issues and the research which would save committee time. We acknowledge that inquiries of this type take a great deal of time and commitment from the research university and its staff. But appointing new, independent and disinterested committee members would add credibility to the process. The dean of the Graduate School also must be involved to comply with Purdue's own policies and protect the interests of the graduate student caught in the controversy.

We are therefore recommending that one or two independent persons be appointed to the committee, and that the person providing the staff support also be someone who did not participate in the earlier inquiry.

Conclusion

Purdue is a premier research and educational institution. One of its goals is to teach the importance of scientific integrity to its students. It still has an opportunity to meet the high standards the University has set for itself for both research and academic misconduct by establishing an independent committee to review the latest allegations with a fresh eye.

³⁰ *The Chronicle of Higher Education, supra.*

³¹ Letter dated Feb. 15, 2007, from Professors Choi, Ishii, Clikeman, Ott, Hibiki and Tsoukalas to Provost Mason.