



MULTIMEDIA RESEARCH

33 BROWNS LANE • BELLPORT, NY 11713 • (631) 286-8925

Science Friday
Summative Evaluation Phase One:
Focus Groups about “Basic Research”

Report for
Samana Productions
National Public Radio

by
Dr. Barbara N. Flagg
Multimedia Research

Research Report No. 02-018
December 2, 2002



This material is based on work supported by the National Science Foundation under Grant No. 0206324. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

INTRODUCTION

National Public Radio and Samana Productions has received a four-year grant from the National Science Foundation (NSF) that includes an expansion of *Talk of the Nation: Science Friday* to “examine the importance of research as a theme underlying all science and technology changes.”¹ *Science Friday*’s project goals for presenting research as a topic to listeners include the following:

- *Science Friday* will find the research roots at the bottom of each story.... We explore the research underpinning the discovery and the research that needs to be accomplished.
- *Science Friday* will explore the cooperation among corporations, private institutions and research foundations, when appropriate, illuminating how each one plays a role in the research process.
- *Science Friday* will follow the research ‘bumps’ in the road.... research is a trial-and-error process and that failures are useful - and necessary - to achieve success. Much of the success will take many years of research.
- *Science Friday* will illuminate the barriers to successful research....what priorities and options are that researchers must juggle during their work.
- *Science Friday* will help listeners understand the thought process of research.
- *Science Friday* will scale the ‘ivory tower’listeners question and talk directly with researchers.... gain insight into the human side of research scientists.
- *Science Friday* will help listeners understand the role of basic research in policy-making.

This document reports on the first phase of a summative evaluation of the NSF-sponsored project. In this phase of the evaluation, in-depth qualitative discussions concerning public understanding of basic research were held with listeners of *Science Friday*. The study has two goals:

- To provide feedback to producers as to the series’ current strengths and weaknesses with respect to the above stated goals.
- To guide the development of a written questionnaire to be mailed to random public radio subscribers in the first and last years of the NSF grant.

¹ NPR proposal to NSF, November 15, 2001. Goals are quoted from page 4 of proposal.

METHOD

On the west coast, east coast and midwest, a total of 32 listeners of *Science Friday* were recruited to listen at home to a 50 minutes CD of one *Science Friday* program, complete a questionnaire, and then attend a focus group meeting to discuss issues of basic research. Scientists were explicitly not recruited, but a wide range of professions are represented from professionals (lawyer, high school teachers, editors) to skilled workers (sales, court reporter) to unskilled laborers (golf course maintenance).

The CD program, an astronomy update, was chosen by *Science Friday* staff as one that represents the direction to be taken in meeting NSF's new initiative to increase public understanding of research (see program description in Appendix). The CD listening experience was intended to provide a common background for discussion in addition to participants' previous listening experience.

Respondents were requested to listen to the CD only one time before answering the questionnaire, which they then brought to their focus group meeting. The focus groups followed traditional procedures encompassing about one hour for which the participants received a small honorarium. The questionnaire and group discussions considered the following issues:

- How do listeners define basic research?
- How do listeners see basic research as presented through *Science Friday*?
- What is the importance of basic research in their own lives?
- What would be the consequences of a reduction in basic research?
- What are barriers or obstacles to successful research?
- How are scientists perceived; what characteristics do listeners attribute to scientists?
- How should the government be involved or not in basic research?
- What is the listeners' understanding of the role of basic research in policy-making?

SAMPLE DEMOGRAPHICS AND BACKGROUND

Four men and four women participated at each of four sites: Sacramento, CA; St. Paul, MN; Philadelphia, PA; and Miami, FL. Radio stations on which participants could hear *Science Friday* included KUOP, KKTO, KQED, KNGA, WHYI, WLRN, WXEL.

Table 1 compares the demographics of our focus group sample of 32 *Science Friday* listeners to a much larger sample of public radio member listeners used in a previous mailed-survey study.² The smaller sample has demographic and background characteristics similar to the larger randomly drawn sample, thus, this focus group study should permit valid generalization of results to all listeners in the public radio subscriber population.

Table 1. Distribution of Demographic and Background Variables for SF Listeners

		N = 32 Focus groups	N = 223 Public Radio Members
Gender	Male	50%	49%
	Female	50%	51%
Age	Median	47 years	50 years
	Range	22-64	22-83
Ethnicity	White	97%	97%
	Minority	3%	3%
Education	Attended college	16%	11%
	Graduated college	28%	24%
	Post-college degree	56%	64%
Employment Status Occupational Status (Hi, Med, Lo)	Employed:	84%	83%
	High Status ³	67%	79%
	Medium Status	26%	14%
	Low Status	7%	6%
	Retired	0%	12%
	Unemployed	6%	1%
	Homemaker	6%	4%
Student	3%	1%	
Interest in science	1=not at all; 5=very	mean = 4.0	mean = 4.1
Knowledge of science	1=not at all; 5=very	mean = 3.3	mean = 3.6

² Flagg, B. Impact of *Science Friday* on public radio member listeners. *The Informal Learning Review*. September/October 2000 issue – a study based on mailed surveys to random public radio subscribers in Boston and Tallahassee.

³ "High" occupational status includes those with professional and managerial jobs (e.g., lawyer, counselor) "Medium" are skilled or technical jobs (e.g., court reporter, physical therapist); and "low" are unskilled or menial labor positions (e.g., golf course upkeep).

Listening to *Talk of the Nation*, Monday -Thursday

All respondents were asked how often they listened to the Monday through Thursday public broadcasting radio series, *Talk of the Nation*, which precedes the Friday broadcast of *Science Friday*. Table 2 indicates that 100% of the sample were listeners of *Talk of the Nation* with 38% tuning in every week.

Table 2. Frequency of Listening to *Talk of the Nation*, Monday - Thursday

Frequency of Listening to <i>Talk of the Nation</i>	N = 32
Listen less than once per month	25%
Listen 1-3 times per month	38%
Listen every week	38%

Listening to *Talk of the Nation*: *Science Friday*

Table 3 presents frequency of listening to *Science Friday* for both the focus group sample and the larger member sample.⁴ Our small focus group sample is not quite as regular in listening to *Science Friday* as the larger general public radio membership but two-thirds of both samples listen once per month or more.

Table 3. Frequency of Listening to *Science Friday*

Frequency of Listening to <i>Science Friday</i>	N = 32 Focus groups	N = 223 Public Radio Members
Listen less than once per month	31%	32%
Listen 1-3 times per month	66%	56%
Listen every week	3%	12%

Listening frequency for Mon-Thurs TOTN was significantly correlated with *Science Friday* listening frequency ($r = .55$). No other demographic and background variables related significantly to frequency of *SF* listening.

Sources of Science Information

Respondents were asked to indicate their primary source of science news given eight possible sources. The largest percentages reported that "newspapers" (31%), "magazines/journals" (28%) and "radio" (19%) were their primary sources of science news. Self-reported interest in science was a significant predictor of primary source ($R^2 = .32$): those with high self-reported interest in science chose only text-based primary sources of science news (newspapers, magazines/journals, books, web).

⁴ Flagg, B. Impact of *Science Friday* on public radio member listeners. *The Informal Learning Review*. September/October 2000 issue – a study based on mailed surveys to random public radio subscribers in Boston and Tallahassee.

Respondents also indicated their secondary source of science news from the same list. Listeners of *SF* indicated "radio" as their most frequent secondary choice (34%) with "newspapers" second (16%).

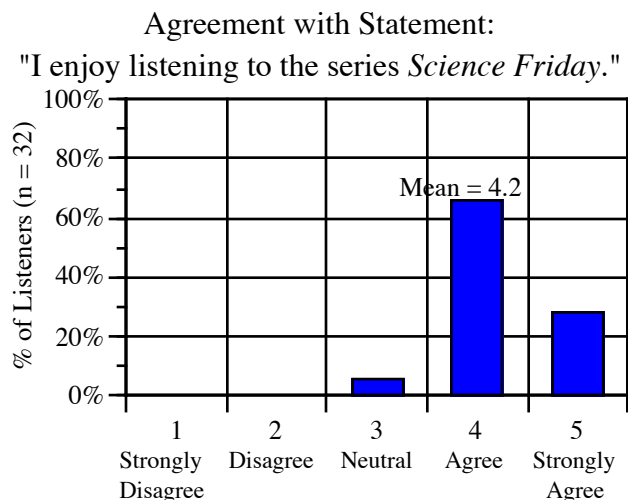
Combining the votes for primary and secondary sources gives us an overall picture of where the sample feels they obtain most of their science news. Listeners of *Science Friday* considered their major sources of information to be "radio" (53%) and equally "newspapers" (47%) with "magazines/journals" coming in a close third (34%).

ATTITUDES TOWARD SCIENCE FRIDAY

The focus group participants enjoy *Science Friday* (94%), listen attentively when it airs (62%) and feel the information is not too technical (66%). Almost all (90%) feel their knowledge of science expands by listening to *Science Friday*, that the series increases their awareness of science news topics (82%) and makes them notice science in other news media (60%). When asked how the series affects them personally, most respondents wrote about an increased awareness of or acquisition of science knowledge. These attitudes replicate the findings of our studies of larger samples of *Science Friday* listeners.

Appeal of Science Friday

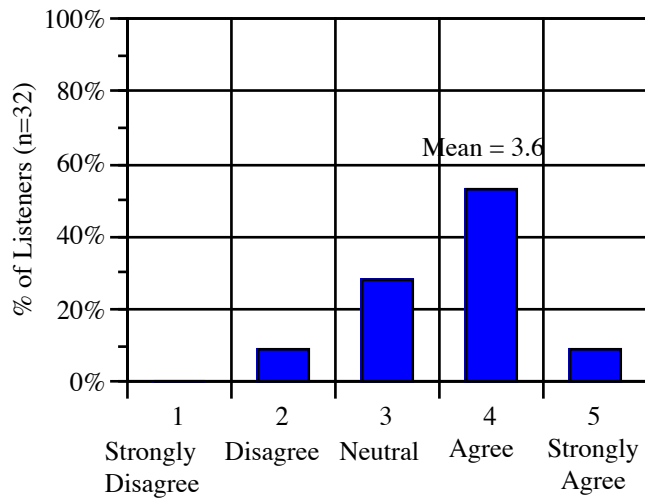
The focus group participants were asked to respond to several statements reflecting their feelings about the series using a 5-point scale, from strongly disagree (1) to strongly agree (5). In response to the statement, "I enjoy listening to the series, *Science Friday*," 94% agreed or strongly agreed (see chart).⁵ The mean rating was 4.2. Of the demographic and background variables, higher interest in science is significantly related to more enjoyment of the series ($r = .46$).



⁵ Of the general public radio member listeners in the larger study, 93% either strongly agreed or agreed that they "enjoyed listening to the series."

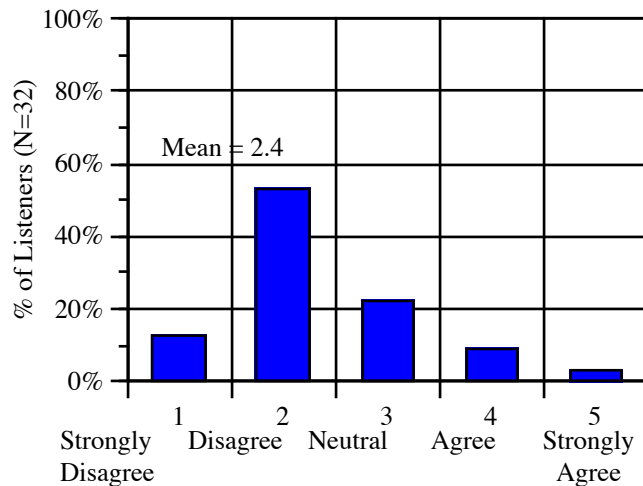
Almost two-thirds (62%) of the focus group sample agreed or strongly agreed that they "listen attentively" when the show comes on the radio (see chart).⁶ The mean rating was 3.6. Higher interest in science was significantly correlated to more attentive listening ($r = .65$).

Agreement with Statement: "I listen attentively when I hear the series come on the radio."



As further assessment of appeal and interest, the survey included a statement to assess whether the content is presented at a comprehensible level for the audience. In response to the statement, "The information on *Science Friday* is too technical for me," 66% of listeners either disagreed or strongly disagreed (see chart).⁷ The mean rating was 2.4.

Agreement with Statement: "The information on *Science Friday* is too technical for me."



Interest in Science and Gender account for a significant amount of variance ($R^2 = 50%$) in the responses to the statement about technical level. Lower science interest and being female were related to feeling that the series was too technical.⁸

⁶ Of the general public radio member listeners in the larger study, 74% either strongly agreed or agreed that they "listened attentively when they heard the series come on the radio."

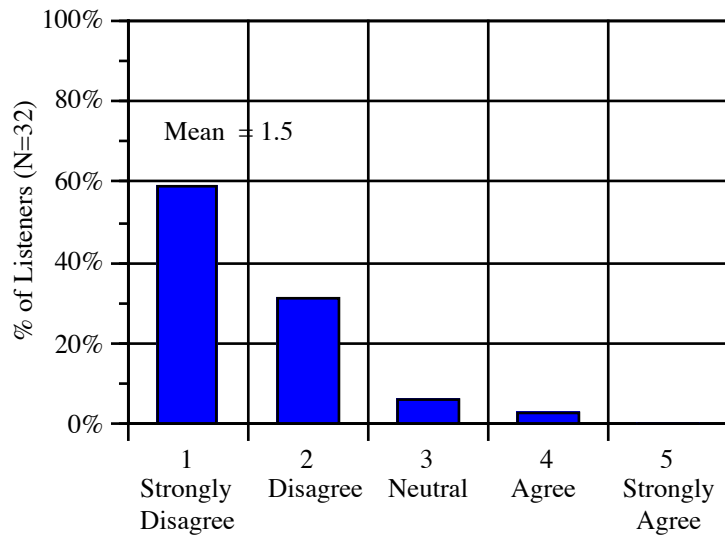
⁷ In previous studies, more public radio member listeners (85%) either strongly disagreed or disagreed with the negative statement that "the information on *Science Friday* is too technical for me." Some focus group participants commented that the content of the CD (particularly the discussion of the constant) was more difficult for them to understand than typical shows, which may have led to the rating difference.

⁸ Gender was not an issue in the responses of the larger listening sample for this statement.

Impact of Science Friday

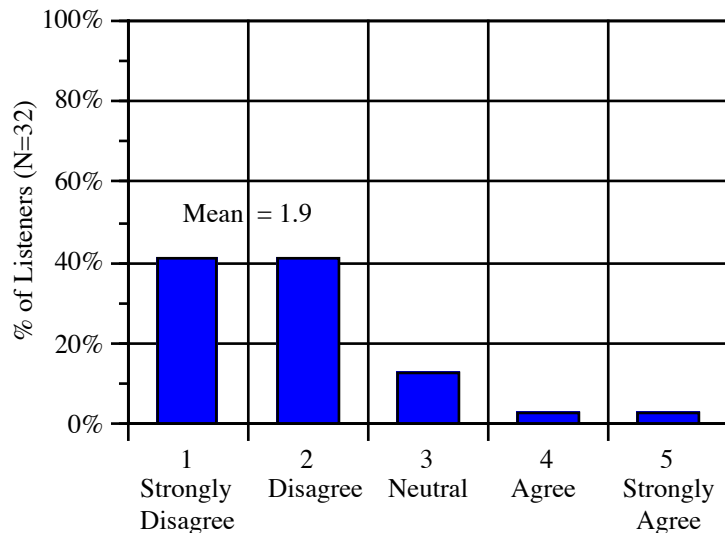
Several statements were included in the questionnaire to evaluate whether listeners felt the series affected their science awareness and science knowledge. Almost all (90%) listeners disagreed or strongly disagreed with the statement, "I have not expanded my knowledge of science by listening to the series" (see chart).⁹ The mean response was 1.5. None of the demographic or background variables were significantly related to ratings of this statement.

Agreement with Statement: "I have not expanded my knowledge of science by listening to the series."



Related to the statement above, respondents were also asked how much they agree or disagree with the statement, "the series has not increased my awareness of science news topics." Those who disagreed or strongly disagreed included 82% of listeners (see chart).¹⁰ The mean response was 1.9. None of the demographic or background variables were significantly related to ratings of this statement.

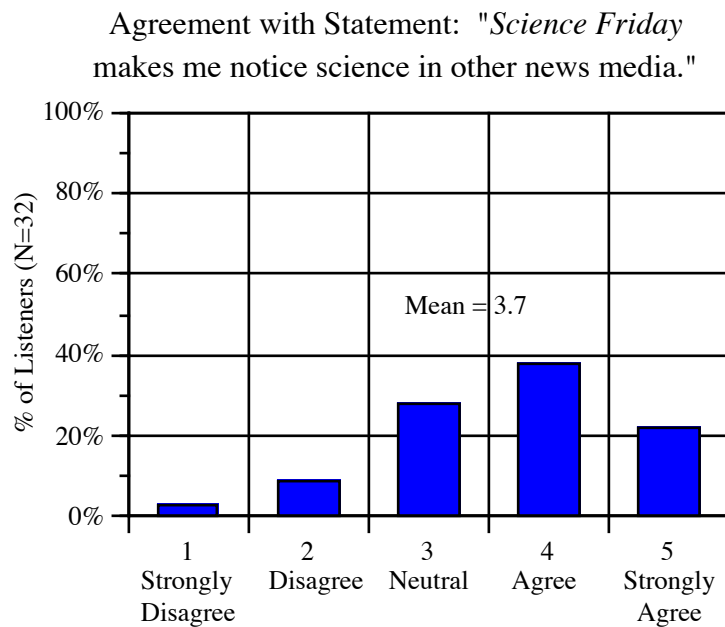
Agreement with Statement: "The series has not increased my awareness of science news topics."



⁹ Of the larger sample of public radio member listeners, 84% disagreed that the series had not expanded their knowledge of science.

¹⁰ In previous studies, 80% of the general public radio member listeners disagreed that "the series has not increased my awareness of science news topics."

Finally, 60% of respondents agreed or strongly agreed that "Science Friday makes me notice science in other news media" (see chart).¹¹ The mean agreement was 3.7. None of the demographic or background variables were significantly related to ratings of this statement.



The questionnaire also asked the open-ended question: "How do you feel *Science Friday* has affected you personally, if at all?" No answer was given by 16% of the sample, and 6% felt there was no effect. Responses to this question were categorized and sorted by keywords and content, as presented below. The strongest impact noted was in the cognitive area of increased awareness of or acquisition of science knowledge, with less impact on actions and feelings. No one mentioned changes in attitudes.

- 16% Increases/broadens knowledge in science;
- 13% Increases interest/learning/awareness in unfamiliar fields of science;
- 13% Updates on current events and advances in science;
- 13% Prompts to seek out more/related information;
- 13% Interesting program;
- 9% Informs and adds to conversations;
- 6% Makes me think more deeply;
- 6% Informative.

¹¹ In previous studies, 60% of member listeners either strongly agreed or agreed with the sentiment that *Science Friday* makes them "notice science in other news media."

LISTENERS' DEFINITIONS OF BASIC RESEARCH

When asked to describe components or features of 'basic research,' 41% of respondents wrote something to the effect that basic research focuses on fundamental laws of the universe. About a quarter of the sample mentioned that basic research refutes or confirms theories. Another quarter noted that commercial application does not motivate basic research. However, at least 20% of the respondents were unfamiliar with and confused by the term - "basic research."

In the questionnaire, *Science Friday* listeners were asked to discuss their definition of basic research. The questionnaire asked:

People make distinctions between applied science research that addresses current practical problems and basic research. What do you see as components or features of "basic research"?

The largest portion of respondents (41%) described basic research as focusing on fundamental laws or processes of the universe or life. It is possible that the content of the CD increased responses of this sort. About a quarter of the sample noted that basic research refutes or confirms theories, and another quarter defined basic research as that not motivated by commercial application. Despite the apparent clarity of these results, the use of the term "basic research" in the questionnaire was a stumbling block for many respondents; most knew that the CD they listened to did not use the term "basic research" and so it was not clear to them that the content in the CD was considered "basic research;" whereas others were unfamiliar or only vaguely familiar with the term "basic research" and responded with confusion to the questions utilizing this term.

- 41% wrote that basic research focuses on "fundamental/basic" "laws/properties/concepts/assumptions/processes/principles/building blocks" of our "life/world/universe;" for example,
"Research that investigates a basic principle which knowledge is based upon."
"Answers how things are fundamentally."
"Looks into the fundamental laws of science."
"Looks at basic building blocks of physical world and essential relationships that govern it."
- 25% felt that basic research "refutes" or "confirms" "theories;" for example,
"Confirms or refutes existing theories but is never absolute."
"Tests if our truths are in fact so."
- 22% noted that basic research was not motivated by application and had no immediate "commercial application;" for example,
"Undertaken with no particular end for commercialization."
"No profit motive. Not necessarily to produce something of commercial value."
- 16% described basic research as expanding the "knowledge base;" for example,
"Pursuit of understanding of how the world works for purpose of increasing existing knowledge."
- 13% suggested that basic research was motivated by scientists' "curiosity;"
"Driven by scientist's curiosity, in a sense, pure – study for study's sake."

- 13% defined basic research in terms of research method; for example, "The compiling of data, the comparison of data, the drawing of conclusions based directly on research data."
"Having a control and variable, accurate and detailed record keeping, a hypothesis, a conclusion.
- 16% did not answer because they were unfamiliar with the term or were unsure: "I really never thought of what basic research was, but for someone who knows so little about science, I would like more of the basics for myself, but think that it would be boring for the regular listener."

All four of the focus group discussions at some point in their hour session had someone ask what is REALLY meant by the term "basic research" or had someone present a concept that is outside an accepted definition. About one-fifth of the *Science Friday* listeners were unfamiliar with the term or uncertain about their understanding of the term, as indicated in the discussions presented below:

Respondent 1: Could you actually define basic research?

Respondent 2: It's basic core knowledge. They apply that constant [mentioned in the CD] to a million different things.

Respondent 1: I think that politicians do basic research and they find out what people are interested in and what their positions are and then they form their policies to echo back to those people to get those votes. So even if they don't feel that way they change their gears to change their votes.

Well, of course there's all different types of basic research. Even what we are doing here is basic research. ... They let us to listen to a CD and now they want to know how it has affected us or what our opinions are on it.

I guess I read so many medical journal gobblety-gook stuff about basic research, where they tell you the number of subjects and how they did an experiment and what the outcome was, and analysis. The show doesn't do that. It basically keeps me up to date on new things coming out in science. ... like they found another solar system recently or something similar. ... But I don't know that that's basic research.

Respondent 3: What IS basic research? Is this a term I'm supposed to be familiar with? Are we talking about – well, the questionnaire asked us about basic research, and I thought, "Well, is this about the way in which they did this process? Or is it a part of science I don't remember?"

Respondent 4: Basic research is defined as research that doesn't have any commercial application. As opposed to practical research. This show that we're talking about certainly falls into that [basic research] basket.

Respondent 5: But some of what they observed, they observed *through* practical research, too. The instruments they were using, where they have these telescopes that they use now. I think of those more as practical.

Respondent 6: I think that when they talked about the instruments, they were talking about the technology that got them further along in their basic research.

Respondent 5: Isn't basic research really just the scientific method?

Respondent 6: No. Here's an example: "What's the mechanism that makes cells die?" It's not about disease. It's not about drugs. It's just posing very basic questions. And then if you get hold of what triggers that, then you might say, "How can we make cancer cells die and not kill the other ones around them," so that would be applied research.

Actually, before this questionnaire I wasn't even aware that there was a term, "basic research." And I'm not even sure my definition is what it is. I mean, I think basic research is something about research that goes into our foundation of what our thought is and what our cosmology is.

"Basic research" to me is sort of an oxymoron. There's nothing that I hear on *Science Friday* that is really "basic." It's all advanced. I mean from my perspective. It sort of opens up, it challenges your philosophy of reality, but it's not basic to me, it's advanced, but I understand it's a scientific term. But to me "basic research" isn't, it's so mind boggling.

Moderator: You're thinking the term "basic" refers to "simple." I'm not sure I really thought about [the term] until this assignment.

UNDERSTANDING BASIC RESEARCH AS PRESENTED THROUGH SCIENCE FRIDAY

After listening to the CD, respondents wrote about what they learned or were reminded of regarding how basic research is carried out. Four of eight issues presented in the CD were described:

- basic research must have independent replication and confirmation (22%);
- scientists question assumptions and accepted theories (19%);
- the research process is time-consuming (16%);
- observation is an important methodology (13%).

Small portions of the sample (9%) noted the university setting, described the serendipitous nature of research, mentioned the passionate nature of scientists or felt they had not learned anything about basic research.

Almost one-third of the participants, mostly men, feel that the series is successful in indirectly explaining background research process, and they enjoy having Ira play the surrogate naive listener for them. One-third feel that the success depends upon the listener's knowledge, the scientists' explanatory abilities and the call-in questions' technical level. Over one-third of the sample, mostly women, think the show varies in success or is not successful due to the show's format; but this is not a failure because they have no expectation that the series would focus on research process nor do they want it to have that focus.

When asked whether the series changes or adds to their understanding of basic research, about one-third of respondents, mostly men, feel that the series clarifies and reinforces their understanding of basic research rather than changing or adding to it. One-fifth of the sample feel the series does not impact their idea of basic research. One-quarter were surprised by references to basic research in the discussion because these respondents listen for current research findings and have no expectation that basic research (as they understand the topic) is presented through the series, either indirectly or directly. Finally, four respondents were unsure of what was being asked with respect to the term "basic research" and found it difficult to apply to an analysis of the series.

In the questionnaire and focus group, *Science Friday* listeners were asked about their understanding of the process of basic research as presented by *Science Friday*.

The questionnaire asked:

*After listening to the 50 minutes of Science Friday on the CD, describe anything you learned or were reminded of regarding how basic research is carried out?*¹²

The discussion group addressed the issue more generally with two questions:

How successful do you think Science Friday is in explaining the research processes underpinning a story or a discovery?

Has listening to Science Friday changed your idea of what basic research is or added to your understanding of what basic research is?

¹² Verbatim responses to this question are included in the Appendix.

The CD, which was intended to provide a similar background in listening, made no direct mention of the term “basic research;” however, general features of basic research process and the researchers themselves were discussed during the show, including the following issues:

- Scientists are open to new evidence even when it conflicts with paradigms that have stood through many tests.
- Confirmation of new research findings is important to scientific progress. Independent researchers and equipment replicating the same experiment and different types of experiments confirming the same results are necessary for credibility of new discoveries.
- New technologies permit scientists to observe the world and reality differently and more precisely.
- Observations are time-consuming so research process can take years, decades.
- Alternative theories can be tested and assessed with observations. There is a natural selection of theories and ideas over time as experimental results become available.
- Scientists are motivated by their curiosity, their wondering why. For every question scientists answer, there are ten more questions.
- Research involves teams of scientists.
- Different fields of science draw upon and build upon the work of other fields of science. There is a symbiosis, a mutual dependence among scientists.

Questionnaire

When asked what the CD program reminded or taught listeners about how research is carried out, the first four ideas above were described. In addition, three respondents picked up on the implication that basic research is done in university settings because the guest speakers were associated with universities. Three respondents concluded from listening that research is serendipitous, and three noted that researchers are passionate about their work. Categories and examples of responses appear below:

- 22% of the respondent sample described an understanding that basic research must have independent replication and confirmation; for example,
“Basic research needs to be duplicated and the same results obtained for the study to be even minimally accepted. The show mentioned that until other scientists replicate the studies then you’re not going to hear a lot about the findings.”
“A single source of information is inadequate. Confirmation is required before findings are accepted/validated.”
- 19% were reminded of scientists’ constant questioning of assumptions and accepted theories; for example,
“I was reminded of how much of science is open to question. That questioning assumptions is so important.”
“Reminded that very little is constant. Important to question ‘accepted’ theories.”

- 16% described the basic research process as being time-consuming; for example, "It takes a long time (i.e., Observing the orbital life of planets in other solar systems)."
"Can be long and difficult."
- 13% noted observation as an important research method; for example, "Many times discoveries must be inferred from the observations. Application of knowledge and previous theory to observation."
"Much involves observation-our ability to observe and measure has been enhanced given current technology."
- 9% mentioned the university setting for basic research; for example, "Carried out at universities, little emphasis on teaching, is always re-evaluated and changing."
"A lot of basic research happens at academic institutions and is supported by graduate students and faculty."
- 9% described the sometimes serendipitous process of basic research; for example, "That it can be fairly haphazard, one thing leads to another and you end up somewhere that you had no idea you were going."
"Serendipitous nature of discovery (the scientist that accidentally discovered 2 planets with solar systems 50 light years away)..."
- 9% noted a passionate nature of basic researchers; for example, "...passion of scientists about (to me anyway) obscure and complex sciences like astronomy, quantum mechanics and bizarre behavior of particles is so foreign to me."
"...how enthralled scientists are about their work."
- 9% felt that they did not learn anything about basic research process; for example, "I felt that it was not explained clearly how basic research was carried out."

And despite the discussion of team work, one respondent "was reminded of the intensely solitary nature of the men and women who make their area of curiosity their life's work."

Focus Groups

The first focus group question related to understanding basic research was *How successful do you think "Science Friday" is in explaining the research processes underpinning a story or a discovery?*

Almost one-third of the participants, mostly men, feel that the series is successful in indirectly explaining background research process and they enjoy having Ira play the surrogate naive listener for them. One-third of respondents feel that the success depends upon the listener's knowledge, the scientists' explanatory ability and the callers' technical level. Over one-third of the sample, mostly women, think the show varies in success or is not successful due to the show's format; but this is not interpreted as a failure because they have no expectation that the series would focus on research process nor want it to have that focus. These listeners are less interested in research process and more interested in what the research means to them. Excerpts from the group discussions are provided below to illustrate the response categories. Paragraph discussions separated by a blank line are independent of each other.

- 28% of the respondents feel that *Science Friday* successful explains the research process underpinning a story or discovery. They identify with the host, Ira Flatow, and believe that he acts like the naive listener, providing necessary background and asking questions of clarification on behalf of the less knowledgeable listener. However, this group

notes that the research process is not so much addressed directly but through inference by the listener, which means that the audience must bring some knowledge of research process and the subject matter to bear on their listening experience. All but one of this category are male.

Man: Ira's job in this show to bring it back, for him to be me essentially, and bring it back and fill in those areas of knowledge that I don't necessarily have.

Moderator: In terms of "research process," do you feel like it's done?

Man: On a whole that has been my experience with the show -- generally speaking, of course you can't do it every time. But a lot of times he does bring it back to what I don't know or what I probably wouldn't know and just slip in a little bit there in way of explanation or get the speaker to open it up a little bit.

Man: In general, I think they do a pretty good job in explaining the research process, sort of in shorthand. I think they assume that the audience has some basic idea of the scientific method, some set of precepts, so that they don't have to start too far at the beginning.

Man: I think they do a good job because when Ira Flatow does his lead in, he gives good information about who the players are, what the research is, and what they're doing, how they started, what their milestones were, and what they're heading toward. So I think in what I can remember of the shows I've listened to it's always well done. You always go into the meat of the show with a good understanding of how you got there. . . . I think the programming reflects the difficulty of approaching basic research in a systematic way. And its always reflected in the guests' comments about how the research was conceptualized and how it was engaged. And never have I listened to a show that I haven't come away with a good idea of the difficulties engaged when they started the research, how they even defined it, then how they actually did it.

Man: I think they do a very good job. . . . And the procedures used in the research. . . . And especially in things like cloning, the number of trials and things like that - where in general, the population might think, "Well, cloning is a certain type process that yields results pretty quickly." I know when they covered it on *Science Friday* It's based on a small number of a large number of trials. So they bring in the tediousness of the process. . . . I think a lot of times on this, it isn't really relevant how the research was done. I know on this CD, they mentioned the supercomputer, pushing the data into the supercomputer. So, therefore right away I have this image of the billions of calculations that is the basis for the research. What we want is the results from the research, to see it all would be dull and boring. But just, like I say, that one reference to a supercomputer makes you realize that this is a serious number crunching endeavor.

Woman: [The research process] kind of comes out organically I guess, in the discussion.

Man: Especially if they have more than one speaker or if they have conflicting views of scientists, and then they have to bring their research into it to bolster their claims. Particularly the diet thing last week was - you know those guys were going at it, with the studies they did and the number of people involved, and "oh, no, that was only 25 people, or 300 people as opposed to, whatever.

Woman: I think they start into the discussion about things, and then they kind of backtrack their way into a part within the story, as they get their experts to talk more and more about it. But, I think in a way, it's kind of easier for me that way, because hearing some of the more technical jargon in the very beginning, might turn me off.

Man: They're pretty successful. I don't know that it's overt, that that's what they are trying to do. It's coming through in that some of the information that's coming out; for instance there was a comment about them having to observe the planetary circulation of this planet that they think they found for 7 years, before they could really make a definitive decision about something they did, so a lot of the discussion about how long it takes to do some of these things, kind of gives you the idea that basic research is important.

Man: What I liked about the CD program in particular was that it seemed to be throwing up everything in science as a question, because if there isn't any constant, then everything is pretty open-ended, in terms of discovery. And I found that really interesting. So because I found it interesting, I listened more intently to those people. . . . I didn't think that much about the process or conclusions. Although I gather that it was mathematical, because they talked about Einstein, and his theory of relativity.

- 34% of respondents felt that success of explaining the research process behind a discovery varied dependent mainly upon (1) listeners' previous knowledge of the topic; (2) explanatory abilities of guest scientists; and (3) the technical level of callers' questions. Many felt that the CD on astronomy that they were given to listen to did not address research process as effectively as other *Science Friday* shows.

Woman: I think it depends on the subject matter that they're talking about and what your basis of knowledge is. And sometimes you can even tell by the callers who're really heavy into that particular subject matter, so I think that changes the direction or level of discussion by the speakers that they may assume that their audience has a certain base of knowledge. There have been some programs I have listened to that I say "cool I get that, I understand that" and they are explaining the more basic process or the way they got to where they are. But then there have been others where I'm just lost and I have no idea what they're talking about, and it seems like the callers are calling in and they are up on that level with them or maybe they have that base of knowledge there.

Woman: I think it varies all over the place by who the guests are that they get on the show... Some of them can explain themselves a lot better than others. And on the CD, the woman who was talking about planets, I thought she was fabulous. She was really clear and articulate and easy to listen to, but the man talking about the constant was a little bit harder because of his accent, but also I just had a really hard time paying attention to him. He was confusing and I couldn't figure out what the point was and why we should care about this constant, it wasn't apparently constant.

Woman: The CD had two guests that I really understood well, and that third guest I didn't really understand that well. And it was just more for the vocabulary that they used. It sounded more like they were talking to a colleague than the public. So it depends on the guests but also on the questions that are asked by the public. If those questions are questions that are asked in a way that are things I might know too, or things that I had no idea about--they sound like another colleague of theirs, or I think it also depends too on the host. Because there was a couple moments there when I was very distracted by the host. Ira interrupts a lot, and says things when he's not really an expert but behaves as if he was one. And he rephrases the people who call in to ask; he rephrases their questions and sometimes makes them questions that weren't what they asked, so he's asking his own question, so it kind of takes away from the public's ability to ask its own question.

Man: I think it depends as much on the particular speakers as to making a general statement about the program. I find that some of the scientists express themselves very well to a member of the general public, like myself. And some of them would really struggle to be able to talk at my level. . . . I'm not sure if the whole premise of the program is to explain the research process, but I think that's something that comes along with the territory. You're talking about science and new discoveries. . . . In the CD, it seemed like they focused on one subject a lot more than they focused on the other. The person who is looking for new planets, it was like she was tossed in there at the last minute.

Man: Sometimes yes and sometimes no, but if there were consistent failure to explain the process and other things in discovery I wouldn't listen. And I think it happens certainly often enough that it keeps me listening when I have the opportunity. They go into certain programs with a base of knowledge or other programs where my base of knowledge is much weaker and I have a much harder time, and frankly with this CD, I have a hard time with this program. This is not my favorite.

Woman: I didn't think that this CD show was very representative of the series in general. I really thought it was one of the most boring ones I've ever heard. . . . The interview they had with Jane Goodall the other week was wonderful. That was: "How did you get there? How did you meet Leakey? What was the thought process that got you to where you were?" It was very much: "Explain how did it all begin." That was fascinating.

Moderator: In terms of the CD you listened to, was there anything that they said about the process of science?

Woman: That's not what came through to me. In terms of what I *did* get out of it - enthusiasm of the scientists, the discovery of the planet, that came through very clearly. But not process.

Man: It varies, sometimes yes, sometimes no. The field of science is so broad. And every week the show is on an entirely new and different subject. . . . So, it really depends a lot on the individual show. Sometimes they talk about the basic underpinnings, sometimes they get right into the specific details of a very scientific and specific discussion or debate that's relevant to scientists within the scientific community, but those of us without a background may not even know what they are talking about necessarily or specifically. But we always get an idea of the kind of passion they have for what they do.

Man: I don't think that this CD is very typical of *Talk of the Nation: Science Fridays*. It was kind of oddly constructed. I mean, you have these two guys talking about the fine structure constant, and then there was this poor woman who'd discovered a number of new planets. And there is a point there when the interviewer *himself* says, "Well, you must feel like you're kind of out there in left field."

- 13% also note that successful presentation of research underpinnings varied by show but they added the caveat that they did not really want a focus on research process in the series and were more interested in the "meaning" of the findings.

Man: I'm not sure that they always do go into the process of how things are. . . . I'd say I listen to it twice a month. Ira Flatow will basically give a brief introduction --"Now, you found out this" and then he usually goes right into "Can you explain how that's done," then he'll say basically, "What does that mean." That's where they'll spend most of their time in how that discovery, or whatever they were working on, what it means to the general person, what it means to our planet. And I think for me, that's really what is important, you know--"What does it mean," and I might not be really that interested in the research process. I just assume that they're doing their job.

Woman: I think sometimes they do a really good job explaining it, and other times they don't really tell you a lot what's behind it. They maybe assume that you know or maybe feel that you can draw adequate conclusions without knowing that. . . . I probably don't need to know the details behind how they got where they are. On occasion there's a few stories that I might have a little knowledge on and then I might be more curious what's behind it, but other than that, it's usually, "So what does that mean?" I was more interested in the CD topic --"so what, Planck's constant, or whatever, is changing, so what does that mean to me? and life here?"

Woman: . . . I think you would lose some of the audience if you started going down some of the methodology of ". . . And then we have a test group, and a focus group, and a this, and a that." You might lose something because that's not all that exciting. . . . I don't care about the details of the process. It's like making sausage. I don't care what goes into it but I'm just amazed when they're discovering solar systems 50 light years away. I can't find the next town! It's mind boggling to me. . . . So they kind of hook me on that as opposed to how many years of research they've done.

Woman: For me, for what I'm trying to get out of the program, I'm not that interested in a lot of the methods, the technical methods that they used. And if I hear the type of, that they just refer to the length of time they've been studying it or the credentials of the people, then I just assume a certain level and I don't worry about it. I'm not really listening to it for a very technical definition. For me it's successful. I don't wonder how they arrived at their conclusions. They give me enough information.

- 25% did not feel that the series was successful in explaining basic research process but argued that this was a function of the medium of radio and the format of the show, which did not permit an in-depth presentation. These respondents had no expectation that the series would deal with research process and did not see this as a failure to meet their needs as listeners. All but one of the respondents in this category were women.

Woman: [successful?] Not really. I guess there was some explanation there, but I think the format of the show is kind of jumpy. Ira would ask a question, and they would stay on that topic for 30 seconds, however long they had to answer that question, and then he would jump in a different direction or a caller would jump in a different direction, so you're getting sound bites versus somebody who's explaining something from point A to point G, or whatever. So, and I think just the format, because it's media, I don't think they go as in depth as a scientific journal or something like that, so I think there's just a limit

to how much, you know, I mean, the researcher spends their whole career, years and years trying to understand the process, so to explain that to the public is a difficult thing period, I think.

Woman: My recollection in listening to the show is that they don't spend a lot of time talking about how they got to the topic that they're discussing. Usually, it's "OK, something new has come up in this field or this is now controversial so we're going to talk about it," but as far as the basic research that was done to bring that about, I don't remember hearing about it on any of the shows.

Moderator: Do you think that's a strength or a weakness that they don't explain that research process very well?

Woman: I think it's a fact-of-life for radio. I think it's that you don't lead with a lot of background. And then if the background is relevant to the story, you might bring it in. Or if, in this case, it's a call-in, if people want to know more about it, they ask. Or maybe it comes up in the course of discussing it. But I don't think this is the main purpose of the show.

Moderator: So it's not, for you, a weakness that they don't really tell you how they got there?

Woman: Uh....no....Well, I never even thought about it because it's not my expectation.

Woman: I don't remember Ira, in general, talking very much about the background research. But I think the credibility of his guests always comes through and they tend to refer to the research they're doing as it's relevant to the discussion that unfolds. But I don't really recall Ira talking about studies that are ongoing or research in his introduction. . . . I think that it is difficult to explain the research process in this format. I don't think the average nonscientific listener has an understanding of what goes into rigorous research. And, I just think that the format is difficult to get that across. . . . I consider myself to be a non-scientific listener. And I don't get the sense of the depth of research that's behind most of the topics.

Moderator: Do you come away thinking that or do you come away just being confused?

Woman: I just don't think it is really strongly and clearly supported. I think what is the strength in terms of research is the credibility of the speakers and kind of the references they make throughout that gives you the idea that research has happened. And that they wouldn't be arriving at these conclusions without it. But I don't think there's an explanation of how the research was conducted and how long it took and how it was repeatable and repeated. And I just don't think that is there.

Woman: I don't think I thought about it as a show on research process.

Woman: I don't think [basic research process] is a major part of the shows. But I do remember having a better sense of the background, and how people have gotten to where they were, why people were on NPR, on *Science Friday*, and why they were discussing the topic they were talking. To me, as a non-scientist, that went a long way in setting the stage and helping get me interested.

[In terms of the CD we listened to] I think that if we knew something about the history and how this person got to where they were, that would help at least *me* understand why we care. They kept on talking about this 1/137th, and I still don't know why we care. And I'm thinking that if everybody had known some of the background and been able to build a foundation for this discussion, at least for those of us that have *no* clue going into this kind of topic, that would have helped me care a whole lot more.

Man: I did not think they did the research part very well in the CD show. While the people spoke, I could understand what they were saying. But they didn't go back far enough to say what is underpinning what they were doing, how they got where they were, and what the importance of it is, and what the effect will be.

The second focus group question related to modifying audience understanding of basic research:

Has listening to Science Friday changed your idea of what basic research is or added to your understanding of what basic research is?

About one-third of respondents, mostly men, feel that the series clarifies and reinforces their understanding of basic research rather than changing or adding to it. One-fifth of the sample feel the series does not impact their idea of basic research. One-quarter of the sample were surprised by references to basic research in the discussion because these respondents listen for current research findings and have no expectation that basic research (as they understand the topic) is presented through the series, either indirectly or directly. Finally, four respondents (13%) were unsure of what was being asked with respect to the term “basic research” and found it difficult to apply to an analysis of the series.

- 34% feel that the series reinforces their understanding of basic research rather than changing or adding to it. Below are some excerpts from the discussion illustrating the reactions of this category of responses, which included mostly men:

Man: It reinforces it [my understanding]. It reinforces who is out there doing it, what they're getting from it, and where they're going with it. It's not [my only source].

Man: The CD that we listened to for this focus group reinforced what I know about basic research. Very simply, very straightforwardly. It showed how very basically, quantum mechanics and cosmology are very closely tied. And this show showed it, this show described it, and it again, just reinforced what I know to be basic research.

Moderator: And the series in general does that?

Man: Absolutely. They never fail to do that. Because they do treat every subject - you can't approach any system in the universe without approaching it from the basics of physics.

Man: The other thing is in the CD, the man from Baltimore referred to it really in passing, but the fact of the matter is that if we don't have evolving basic research, you get “high-centered.”

Moderator: What do you mean by that?

Man: Well, Newtonian physics took us only so far in understanding the world. Now it appears that Einsteinian physics will only take us so far in explaining the world. And you have to have a constant evaluation of what's going on at the most fundamental level of the world to keep making that kind of progress.

Moderator: So it sounds like this particular show did help you get a sense that -

Man: It helped clarify my thoughts.

Man: I think in learning about what different scientists do, though, we can get an idea of something that -- we can form a more solid impression of how some of what the research process is. For example, for a theory to be actually accepted as fact, it needs to have been researched in more than one place, using more than one set of machinery. Just because there might be some inherent flaw in that machinery, and that's something that they mentioned in the CD that I thought was a really good point, and it was -- they didn't really focus on that, but they mentioned it.

Woman: It reinforces my understanding of basic research . . . it reinforces or enriches, or fills out, I guess, what my assumptions are. . . This particular episode on the CD would be an example because they talked about the fact that if they're going to observe the solar system they have to do so for 12 years because the orbital cycle, or span of life of this cycle is, so it just sort of reinforces.

Woman: It's stretching my ideas about what can be researched and thinking about what is happening in research, and about what is this new field or problem, and wow, someone has had a bright new idea and is pursuing it. But I don't think I've seen it alter what I think about what basic research is.

Woman: I think it intrigues me that there are people who do this whatever it is they're talking about - wow, they're in some little laboratory somewhere or they're out in some field somewhere or they're digging or whatever. I'm thinking about what they're doing and how they're explaining it. So sure it's broadened my horizons or my perspective of what they do, how they research, what they research and certainly how they go about doing it. However, I've never thought about it in those terms as I'm listening to it.

Man: Sometimes I think the best way to condition people to be more accepting about basic research isn't to discuss "basic research", but to have some sort of example of it, which this [show] undoubtedly fits the definition that I have of "basic research."

Moderator: So this show does provide an example of basic research.

Man: It certainly fits within my definition of basic research. There's millions of other examples of basic research that are so much more contextual. I mean, IBM might be doing basic research on something that perhaps is about 50 years away. *This* show was about as basic as it gets.

- 22% feel that the series does not influence their understanding of basic research. Example responses follow:

Woman: It's not changing my idea of what basic research is. It can be amazing to me that they thought about research on this topic, that would not have occurred to me; but that still doesn't change my idea of what basic research is, which is certain people sitting around thinking about things that they want to explore and then doing them. So, it didn't seem to me like this program changes that. It changes maybe my concept of what topics people are doing research on that would have never occurred to me but not what basic research is.

Man: I've been more affected by thinking things like - gee, isn't it neat how they got to this particular result. I don't think it changed my concept of basic research or how they do it.

Woman: I'm not really listening to that program to find out the details of basic research. I rely more on the credentials of the people who are being interviewed. If they are in a position where they should be knowledgeable, I more or less accept what they're saying. If they didn't have any credentials or position, I would probably wonder what their background was, but, I think when you hear about the studies that they do and their positions and they'll talk about the programs they're involved with, that gives me enough information. I'm listening to it more like a topical thing. I don't need every little scientific method that they used.

Woman: So I'm just saying that I don't think that listening to *Science Friday* has changed my idea of what basic research is. It tells me what different people do, how their research works, but not what BASIC research is, per se. I think you're expected to already know that. I mean, if you're interested in science you probably already have some fundamental idea of what basic research is.

- 28% were surprised by references to basic research in the questionnaire and focus group because they never thought that impact on understanding basic research and research process is a goal of the series. These respondents listen for current research findings and have no expectation that basic research (as they understand the topic) is presented through the show, either indirectly or directly. Our questioning forced this audience to think about the show in a way that they had not before:

Woman: I never thought about it affecting my sense of research or what it is. I have thought about it changing what I know about a given topic or area of study. That is about it.

Man: I don't think that's the responsibility of the show. I think the best thing the show can do for us, isn't so much to explain science to us as lay people, but to give us an insight into the world of science and scientists, so that we can really hear what they're talking about, you know what's poignant to them and it makes it so exciting. I think it makes it much more interesting. There may be a need for a show that explains science to me, but I don't think *Science Friday* is that show and I don't think it needs to be that show. I really want to hear what these scientists say to one another.... I get to really hear what they're talking about in the world of science and it's fascinating, even if I don't always understand it.

Woman: I know a little bit about basic research versus applied research or clinical research. I don't know that *Science Friday* really helped me understand it. I don't know that I necessarily think of those things -- think of the stories in terms of basic or applied research. I think it would be interesting for them to combine those two things and take someone who is doing basic research in a subject in the same episode maybe then take that information and then how it might be used in applied research, or how someone's using, applying it to see how the two work together. So I don't know that that really gave me more information. Maybe it does and I'm not aware of it. I just don't think of things in those terms.

Man: If there is a particular goal to educate the American public on the need for more basic research funding etc., then they ought to be more overt in kind of tying in each subject that they have with the fact that this is a result of basic research in such and such. You know, we are doing this basic research because we want to find out this 27 years down the line... They need to be more forthcoming about their goal or at least work it in there somehow... A specific show on what is basic research and how it is important certainly might help.

Man: Actually, before this questionnaire I wasn't even aware that there was a term "basic research." Looking back at the shows -- were they focusing on research that was focused on basic stuff or were they doing cutting edge stuff? I mean I don't know if *Science Friday* is even -- if their goal is to bring up stories in basic research. . . . *Science Friday* is looking on a meta level of what science is doing, and getting experts in different fields to bring that meta level across to its listeners. And in that sense I appreciate it. And now that I'm thinking about it in basic research terms -- yes, I can say that's what they're doing, they're bringing that meta level of understanding of what's going on in the foundation of science and trying to bring that across to its listeners.

Moderator: But not in an overt way?

Man: No. I mean no one ever said, "This is a show about basic research." And so, and I had no idea there was a definition of basic research versus applied or versus whatever.

Woman: I don't know that it ever explained to me what basic research is. . . . What it does do is let me know that there's a lot of people doing a lot of really amazing things that I will never know about. And it fascinates me from that point of view that people are doing all these amazing things. . . . But if you had said to me, "What is that?" I wouldn't have been able to tell you it was basic research.

Moderator: You wouldn't have been able to give it that name.

Woman: Right.

Moderator: So this show did not increase your knowledge about basic research.

Woman: Well, to the extent that I could say, "Well, here's somebody else doing another type of basic research that I didn't know anybody was doing." To that extent it might have expanded my horizons a bit. But that was it.

Woman: The term "basic research" never came into my mind when I was listening. Ever. If the National Science Foundation wants to promote basic research through this program, they need to use the term. Regularly. As opposed to "applied science." If one of their objectives is to teach the non-scientific public what basic research is, as opposed to applied science, then they need to use those terms more regularly, so that people can become more attuned to them.

- 13% were stymied by the fact that the series (and the CD) does not use the term "basic research" and appeared to them to not address "basic research" in the way they understood the term. These four respondents were unsure of what was being asked with respect to the term "basic" and found it difficult to apply to an analysis of the series:

Man: I don't know where they go from this CD to basic research, perhaps I don't have a good understanding of basic research. The survey asked, "What do you say are components of basic research?" I gave an answer, but I'm thinking, "What does that have to do with the show I just heard?"

Moderator: So, *this show* didn't help one way or the other in helping change or add to your understanding of what basic research is?

Man: Right. It didn't.

Another man in focus group: ...*This show* was about as basic as it gets.

Man: I didn't get that impression. That this was basic research. You talk about context. Where did this come from? Why we're even asking this question to begin with.

Woman: Why was the survey we took so skewed towards basic research, because that hasn't been described. I would have said that the take away [from the CD] is: "Somebody somewhere is studying something, and that our assumption about light is changing. Thank God somebody is paying attention to that." . . . The deconstructionist aspect of the show I liked. I'm always arguing with scientists about how they got to where they got to. I thought it was great that they said that this new discovery basically shakes up everything we've believed up to this point.

Woman: "Basic research" to me is sort of an oxymoron. There's nothing that I hear on *Science Friday* or any other kind of research that is really "basic." It's all advanced.

Woman: I really never thought of what basic research was, but for someone who knows so little about science, I would like more of the basics for myself, but think that it would be boring for the regular listener.

PERCEIVED VALUE OR IMPORTANCE OF BASIC RESEARCH

Over one-third of the respondents value basic research because it expands our fundamental knowledge base; another third value it because such knowledge feeds into applied research; and another third noted the unknown value of basic research.

In the questionnaire, *Science Friday* listeners were asked about the value or importance of basic research. The questionnaire asked:

What, if anything, do you see as the value or importance of basic research?

- 38% thought basic research is valuable because it develops or expands our fundamental knowledge base; for example,
"Helps us understand the underlying fundamental dynamics of the universe."
"Expands human knowledge in important ways."
- 34% felt basic research is important because it informs and supports applied research; for example,
"Applied science depends on the discoveries of basic research."
"Forms a vital path way for transfer of intellectual capital from academia to industry."
- 31% noted that basic research may have an unknown value – solving problems not yet thought of or advancing other fields of science or questioning assumptions previously taken for granted; for example,
"May lead to solving a problem that wasn't even contemplated."
"It's foundational to other sciences."
"Questions issues we assume to be correct."
- 9% did not answer or were unsure.

PERCEIVED CONSEQUENCES OF A REDUCTION IN BASIC RESEARCH

Everyone feels that a reduction in basic research is not a good idea. Over one-third conclude that a reduction in basic research would hamper our understanding of the world; one-quarter foresee a decline in applied research as a result; and one-fifth outline resulting educational and economic disadvantages. A smaller portion feel that the validity of scientific thought would be threatened if basic research were reduced.

In the questionnaire, *Science Friday* listeners were asked about the consequences of a reduction in basic research. The questionnaire asked:

What, if anything, do you see as the consequences of a reduction in basic research?

- 38% felt a reduction in basic research would hamper understanding of the world, the universe or human condition; for example,
“Less comprehension of our universe.”
“Reducing will slow the advancement of knowledge.”
“Further development of our human condition and understanding of our world would be hampered.”
- 25% foresaw a decline in achievements in applied research if basic research were reduced; for example,
“A muting of applied science.”
“Would reduce the flow of ideas and techniques to applied research.”
- 22% suggested that reductions in basic research would lead to educational and economic disadvantages; for example,
“Grants subsidize research universities, research declines then higher education declines.”
“Reflects poorly on society. Long-term economic disadvantage based on less-rich academics and secondary type benefits of basic research.”
- 16% thought a reduction in basic research would threaten or influence the validity of scientific thought; for example,
“Science will become less valid.”
“Then it becomes opinion.”
“Danger of politics affecting the status quo of current scientific philosophies.”
“To become complacent and believe more things without testing them.”

UNDERSTANDING OF BARRIERS TO SUCCESSFUL BASIC RESEARCH

In writing about barriers or obstacles to successful basic research, respondents listed lack of money or resources; limitations of previous knowledge and resistance to change; time; restrictions of research methodologies; scientific uncertainty and need for replication; lack of practical application; and finally limits of the human mind itself. The focus group discussions moved farther from the influence of the CD. Money was agreed upon as the number one barrier to success, followed by pressure for practical benefits and applications; negative public perceptions through media coverage; lack of institutional and societal sponsorship; politics at all levels; and scientists' own hesitation to question accepted theories.

In the questionnaire and the focus group discussion, *Science Friday* listeners were asked about barriers or obstacles to successful basic research.

The questionnaire asked:

Listening to the CD, did you learn or were reminded of any barriers or obstacles to the success of basic research?

The focus group asked:

What do you think prevents scientists from doing basic research?

Barriers or obstacles to successful basic research were not discussed directly in the CD. However, barriers implied in the CD were 1) resistance to changes in accepted paradigms and 2) time required for observation and 3) independent confirmation of findings. These three barriers were among those described by questionnaire participants as well as lack of money, which was not mentioned at all in the CD.

- 16% of respondents felt that barriers or obstacles were not an issue discussed in the CD.
- 38% mentioned lack of money or resources as an obstacle; for example,
"Funding. Folks who look at stars or rocks aren't typically funded well."
"Lack of funding for those items or ideas where benefits may not be immediately apparent."
- 28% felt that success could be limited by previous knowledge and resistance to change; for example,
"Changing old beliefs, supported by a long history of research is difficult. We entrench ourselves in what we 'know'."
"Preconceived notions and established beliefs can stymie the acceptance of new information."
- 22% noted the time-consuming process of basic research; for example,
"Long process of proving / disproving / validating scientific findings."
"Time. Years and years of study and observation that often must accompany discovery (loved interview with Jane Goodall)."
- 13% recognized limits of research methodologies; for example,
"Bounded by limits of technology for gathering and measuring various phenomena."
"Limits of our high tech equipment."

- 13% wrote of scientific uncertainty and need for replication; for example, "You can never really reach an absolute truth because everything always has a certain percentage of questionability."
"Without others getting similar results very little enthusiasm will be generated."
- 6% pointed out limits of scientists as humans; for example, "Human mind could never truly comprehend absolutely the rules of time and space."
"Talent pool, social stigma (scientists = eggheads not popular)."
- 6% declared that the lack of application is a barrier to basic research; for example, "That society and funders may not value the research if they don't see any practical application for it."

The focus group asked:

What do you think prevents scientists from doing basic research?

The groups all agreed that money was the main factor in limiting basic research, followed by pressure for practical benefits and applications; negative public perceptions through media coverage; lack of institutional and societal sponsorship; politics at all levels; and scientists own hesitation to question accepted theories.

- **Money**

Woman: I don't know who funds these things, but I'm guessing the only way research can happen is if there's monies, and whoever is giving the money is the one that's ordering what gets done.

Woman: Well, my guess is that basic research is done through universities and colleges and institutions of learning. So, my guess is that if there is no funding, basic research doesn't get done. So we need to make sure there's funding. Now that's just an assumption on my part. Now I know that colleges and universities take about 25% of that grant, so they want their scientists to be doing those kinds of research, or that kind of research.

Moderator: Where do the grants come from?

Woman: Um, the government. Because then the trickle-down effect, in my perspective, is that basic research is done, and then it funnels to the applied research and corporations take over the funding of specific ideas.

- **Pressure for practical benefits and applications**

Woman: And if it's in an area that's not tied to money, but tied to a general interest or something you can see that is big or going to benefit some group somewhere, that benefit is also a factor that affects what gets done and what doesn't get done.

Woman: If you are looking to get funding, you know you can say I am looking to cure cancer or I'm going to invent something plastic or something really useful, you know you will have all kinds of foundations or institutions wanting to fund you. But if you just want to explore great ideas, I don't know. Maybe if you are in an academic institution setting and you are lucky they will cover your salary to do, but the big bucks I'm sure are for things that have a specific result in mind.

Woman: The public cares most about what affects it, so science areas like health and medicine, and maybe even warfare and other such things, will get higher priority.

Man: I think it does come down to what the goal is and unfortunately I think basic science really is more the exploration and journey, not the end destination while applied science is much more the destination and I think you know if you look at the field of archeology you know there isn't that much that benefits folks directly, its not funded that well in any of our institutions or foundations. But then look at the field of volcanology is somewhere in between there where we need to be a little more informed of when a volcano is going to blow up. But in something like HIV research, there is funding, probably not enough, but it is a more marketable product when you are going after grant monies. To think that you are going to help cure an incredibly devastating illness.

- **Negative public perception through media coverage**

Man: Building on the idea of someone doing some kind of obscure research and the media gets ahold of it and asks what are we wasting our money on this time? And that plays into public perception of what is of value and what isn't, and that is a very difficult yardstick to measure the value of basic research when you are not talking about specific applications or you can't imagine what application might apply. Sitting from where I am, doing what I am doing day to day, I probably can't figure it out, but there probably is something. But I really do think that plays into public perception and in turn drives funding politics.

Woman: Secondary might be lack of visibility. All this great basic research is going on, and if it doesn't get the visibility, either from TV, from radio, from print, from the Internet, people don't understand how important it is. So, without that visibility, they might not write their congressmen, senators, and so forth and say, "Hey, we need this funding for basic research."

Man: I think one of the main things is a loss of credibility, because of the way the press reports on basic research. . . .

Moderator: What do you mean by credibility?

Man: Confidence. For instance, back when Reagan was president—star wars. They spent billions and billions of dollars, and we still don't have anything approaching an active star wars system. So basic fundamental research was tagged with unrealistic expectations. So, fundamental research, basic research, almost needs to be funded and left alone. And not be ragged on by the press because the press doesn't understand it and the press doesn't appreciate it.

Woman1: I don't know why I should care about this planet stuff, and I don't know why I care about the constant changing. So when the National Science Foundation comes to the government or comes to me and says, "I want more money for this research," I'm going to go, "Um, I think there's things I'd rather do with my money."

Woman2: I think it comes back to pitching the product. You always have to pitch the product. So scientists should do their thing, and then they should contract their best-speaking person, get them all together so that they all agree on the same points, and then present it to the marketing and the sales side to say, "this is what we are trying to say." Now, maybe that marketing person has a science background, so that he or she can then parrot it out, but you always have to sell your product..

Woman1: I worked with scientists to try to make stuff English and the number of times I've had to say, "OK, this is really neat, but why do I care?" in order to get them to – and there's usually a reason; I just haven't heard it.

Moderator: And do you think feel that the show that we heard got to the "Why do we care?"

Woman1, Woman2, Man1: No [Note that these three people had difficulty understanding the term "basic research."]

Woman3: But Ira Flatow often does.

Moderator: So you think that Ira Flatow usually does get to the "Why do we care?"

Woman3: But he just didn't get to it this time.

Woman4: I almost had the impression that he didn't understand this stuff enough to get to it . He seemed often as confused as I was. And he's a smart guy.

Woman2: Didn't he ask one of the callers what the weather was?

Woman1: I agree. This was an unusual program in that respect.

Moderator: But you think usually he gets to the problem.

Woman3: He often asks those very basic questions. He often says, "Why should we care?" He's an extremely articulate man. And I think he asks those questions very simply so that his audience can get it.

Man: Public opinion and the fear that people have of science and of scientific research puts a lot of prohibition on scientific research in this country and throughout the world. The public's somewhat ungrounded fears of what new discoveries might mean. . . . [basic research with stem cells] means change, and so people say I don't like change and so they want to put the brakes on and so it holds up the research if it, especially moratoriums on research and things like that, make it illegal to do the work, but it's inevitable that it will happen.

- **Lack of institutional and societal sponsorship or patronage**

Man: I think that we've put up an obstacle to basic research: it's sponsorship. . . You're going to need to have someone help champion the cause. You need to have a society get interested in it; someone to help encourage you because you're not necessarily going to come up with these breakthroughs on your own. And I get the feeling that maybe this guy [on the CD] is starting to get known within a segment of the scientific community, and that's probably a big deal for that reason, but he's probably not going to get a lot of public plaudits based on whatever he's doing with this constant.

Woman: What you were saying about the idea of sponsorship...I'm just reading this book about 16th century female patron....You know, artists have always needed patrons. So, in that way that you were talking about sponsors, it's like those patrons. Artists always needed people to champion them. It's more than salaries, more than money. It's people who will support them. And support their efforts.

Man: There should not be any focus on end result in basic research, however when you look at the institution of academia, there are these sexy things and career options in medicine and science and then there is the career killer – basic research. Yet there is always this guy who fell in love with the notion of research as a child and grew up and got distracted from it and then came back and solved it alone simply because he wouldn't have to put up with the constant pressure of academia trying to push him away from this thing that had no real sex appeal. It wasn't a career enhancing move for him and it had absolutely nothing to do with money. . . . there is that institutional pressure that keeps some people away from some topics and moving into directions that have more practical value. I think it creates lost opportunities for advancing science in many ways.

Man: You are assuming the scientists are already there. Are we training scientists to do basic research? Are we supporting the whole idea that science is important and that scientists are good in our society? Not as a general popular society situation, but in the academic society there is still a strong enough push and there's still a sizable group of Americans that are interested in that. . . . We may not be doing such a good job with the children growing up here in America, pushing them.

Man: I have to say that I felt, as an artist, that the scientists who pursue basic research have something in common with what artists go through. I think that the fact that they are somewhat marginalized from the society at large, that what they do doesn't often result in monetary reward, that they do it for some similar reasons that scientists do their work, too. They take pleasure in the experimentation and in observation, too. They just keep on trying new things in that sense of discovery. I think they have that in common.

Moderator: And, so do you feel that, with scientists and artists being somewhat marginalized, that that is something that might make it difficult for some scientists to pursue basic research?

Man: I think that they're doing something that a lot of the population doesn't really care about that much.

- **Politics**

Woman: I think politics. I mean there are personal politics in any kind of work you are in, wherever you work. Any workplace.

Man: Yes, and university politics for one!

Woman2: And corporate politics!

Man: Of course there's lots of self interests, like in Congress. I think Congress has lots of committees. The guys in Congress are really pretty smart, actually, but they have such self interests in their narrow constituencies. "We don't want to spend a lot of money making a massive accelerator in Texas, because what's that going to do for Minnesota?" So we have that give and take and yet you have a project like building a massive particle accelerator and its going to take up whatever part of Texas it's going to take up, and it's going to be billions of dollars over so many periods of..... It's hard to make that commitment.

Man: I think that the politics that go on in an academic institutions and elsewhere in government do also tie into funding. I don't think it is right to act like these are separate things, they are incredibly interwoven. And it can be the politics of whoever is throwing the money at the work, whether in government or whatever. It can be at the level of an agency and within that agency who has control of the money and how the department is situated in the agency and how it is viewed within the agency and what kind of support it gets from the institution.

- **Tendency not to question accepted theory**

Woman5: I'm thinking, if you think outside the box, you know historically, they've done research on some things, like on the subject matter we listened to - cosmology. They only said it was one way and that it is the speed of light times this times this, and you know it has always been the same constant, right? And so all of a sudden you have to rewrite all these texts because now it is different. And I think maybe thinking outside of the box or going beyond what has already been researched and researching it again, looking at it again - maybe that prevents scientists from researching more into the same thing - That the results could come out differently.

Woman6: Right, accepting the assumptions that underlie it rather than challenging them. I agree with that observation, it is an interesting one.

Man: . . . Every once in a while there is a discovery which sort of pulls the rug out from underneath our feet, because no one had seemed to look there before. I think a lot of times we just assume because "someone else" discovered "something" that we don't have to look any deeper than that, and I think, scientists more likely NOT to overlook those things, but they still do overlook some basic assumptions, you know. And we build a lot on those assumptions. . . . So the internal factor that is holding scientists back is just basically assumptions that --what their science professor told them was true. And so why would you question what your teacher told you, and that is how knowledge is passed down.

Woman: Some of the barriers are just someone being open to see things differently. If something doesn't work out the way that you thought to be to wonder why that is rather than just thinking still that something should be the way you thought it should be. So, having an open mind to outcomes and new ideas.

PERCEPTION OF BASIC RESEARCH SCIENTISTS

Respondents feel that basic researchers do the kind of work that they do because of their innate curiosity; a love of discovery and knowledge; a drive to understand how our world works; and an enjoyment of solving problems or answering questions. When asked about characteristics or personalities of basic research scientists, most descriptors were quite positive: passionate and enthusiastic about their work; inquisitive and curious; patient and persistent; intelligent and articulate; open-minded and skeptical; methodical and thorough; but also insular in the academic world.

In the questionnaire, *Science Friday* listeners were asked to discuss basic researchers as people.

The questionnaire asked:

Why do you think basic researchers do the kind of work that they do?

and

Listening to the CD, what did you learn or were reminded about regarding the characteristics or personalities of basic research scientists?

The CD very briefly touched on why one of the guests did her work, revealing that she was "motivated by wondering" why.

Respondents felt that basic researchers do the kind of work that they do because of their innate curiosity; a love of discovery and knowledge; a drive to understand how our world works; and an enjoyment of solving problems or answering questions:

- 28% felt basic researchers have an innate curiosity; for example,
"All consuming curiosity."
"More curiosity than the rest of us."
- 25% suggested that basic researchers love knowledge for its own sake; for example,
"Enjoyment of knowledge and quest for knowledge on a personal level."
"Love of knowledge for its own sake."
- 25% mentioned that basic researchers were driven to understand how the universe works; for example,
"They're driven to define, understand such foundational concepts upon which other sciences are built."
"I think most researchers are motivated by their keen interest in our world and what makes it tick."
- 19% pointed out that basic researchers enjoy solving problems and answering questions; for example,
"Fundamental interest and enjoyment in seeking answers to unsolved questions."
"To move closer to a solution to a problem or to explain a situation."
- 9% said that researchers simply do what interests them.

When asked about characteristics or personalities of basic research scientists, most descriptors were quite positive: passionate and enthusiastic about their work; inquisitive and curious; patient and persistent; intelligent and articulate; open-minded and skeptical; methodical and thorough; but also insular in the academic world:

- 44% noted that the researchers on the show expressed clearly their passion and enthusiasm for their science; for example,
"Their enthusiasm for the work that they are doing comes across."
"...what impresses is that they are also very passionate about what they do."
- 34% described the researchers as curious and inquisitive; for example,
"Curious..."
"Inquisitive abstract thinkers."
- 28% felt that the on-air scientists were intelligent and articulate but respondents did not necessarily feel that was a characteristic of all or even most scientists; for example,
"I don't feel the three scientists are truly representative of all basic research scientists. They did express themselves very well, and I was able to follow the discussion."
"Those with a sense of humor and eloquence of language are better fitted to be ambassadors of their view for lay folk."
- 25% pointed out that the researchers were patient and persistent; for example,
"Patient, persistent..."
"Patient, recognize that research requires time..."
- 16% focused on the characteristics of open-mindedness and skepticism; for example,
"Open-minded, questioning, skeptical all at the same time."
- 9% said basic researchers were methodical and thorough; for example,
"Careful, thorough, passionate about their research."

- 6% interpreted the profession as one of a solitary nature; for example, "Intensely solitary nature...."
"They are working in an academic environment which is very insular."

GOVERNMENT INVOLVEMENT IN BASIC RESEARCH

All respondents feel that the government should fund basic research because it is the only institution with enough resources to do so. Also, basic research advances our civilization and our economy, may lead to applications, and other institutions are less likely to fund research. Three of the four focus groups felt that politics should stay out of basic research decisions as much as possible. One group pointed out that the government itself is directly involved in carrying out basic research, while another group recommended that the government support an educational infrastructure to develop future basic researchers.

The focus group discussion covered the question:
How should the government be involved or not in basic research?

All respondents felt that the government's role should be in funding basic research because

- the government is the only institution with enough resources to do so;
- basic research advances our civilization and our economy;
- basic research may lead to applications; and
- no one else is going to do it.

Three of the four focus groups felt that politics should stay out of basic research as much as possible. One group pointed out that the government itself is directly involved in carrying out basic research. Another group posited that the government should support an educational infrastructure to develop and support future basic researchers.

- **Government should fund basic research,**

because it's the only institution with enough resources to do so:

Man: In the pure sense, as a vehicle for taking resources from everybody and distributing it broadly, the government is the only organization my brain can think of that does that. ...that's the only way to distribute those resources in a focused enough manner to make things work.

Man: Many of the projects we are working on in basic research, the Feds are the only ones with the deep enough pockets to do it.

Woman1: We were just talking about artists and their patrons. The government really is the only possible patron *for* a lot of this stuff, because it's the only one with that much money. Not for any individual project but for basic science to be done on any kind of scale that allows a bunch of different people doing it. ... They should fund lots of basic science and let us get out of the way.

Woman2: I also think it's more important as we go forward that the government stay involved because corporations are less and less able – and I don't mean that with any kind of judgement – in the best case, they are more and more responsive to their stockholders who are demanding more and more, and there's less flexibility in putting more money into "Let's just see what happens." And good or bad, they're less and less able to do that. The same thing is true with universities. So I think the government is the only place where that money can come from.

because basic research advances our civilization and our economy:

Man: It helps to advance this whole idea that we are an advanced civilization, much like art does on a common denominator to the advancing civilization. I think basic science is also that kind of denominator. It should advance us.

Man: They should give money because it's so important to everyone. It's important to know the truth. I mean, our society's supposed to be based on truth, and if we find something that we're standing on that was not true, then it's for our strength to correct it.

Woman: Because basic science generates lots of basic ideas and techniques that are happy accidents and that come to add up to commercial application and feed our economy. Like the Internet used to be ARPA, and it was something that they put together so that people doing missile research could talk to one another. Transistor radios came out of the space program. All kinds of stuff. Gene therapies came out of people doing this basic research. And I don't think there's any way to predict that stuff, so I'd like it.

Man: Perhaps our economy would be better off if there was more research. More research and development could lead to a more vital society that would be more stimulating in the economy.

because basic research leads to applications, even if we cannot predict how:

Man: There are many things out there that end up very helpful for society that the end was not foreseeable. But so much of science is like that. It's hard to say.

Woman: It's also really hard...it's kind of like hitting a moving target.... You're not going to be able to predict [what will have an application]. It's a leap of faith with these things.

Man: The government should be trying to fund things that might not get funded otherwise, that's for sure, but that doesn't mean that the government shouldn't also fund some things with a shorter time frame. And also, just because you can see a payback, but perhaps somebody doesn't want to fund, let's say, a particular kind of AIDS research, there's nothing inappropriate for the government to want to do that. Including the knowledge for knowledge's sake kind of research that might not have payback.

because no other institution is going to do it:

Man: Basic research isn't immediately financially rewarding. You can't put basic research to work to make a widget immediately that you can sell. So the government has a greater responsibility, not that corporate America doesn't, but money is put to use in basic research because nobody else is going to do it.

Man: Things that are profitable are going to get funded in the private sector. But there's a lot of important research that needs to be done, that doesn't get funded. A lot of it is probably in the arena of basic research and it's important for the future in a broader sense. So I think the government has a responsibility to fund the projects that the private sector is unwilling to fund because they are less profitable.

- **Politics should stay out of basic research decisions**

Woman: I'd like to see the government involved in funding, but I would like to see the government involved more indirectly. Because if the government is specifically choosing what they want to fund, then it becomes a political thing. ... I'd rather see the money go more towards universities, research facilities. And even then, a research facility could be doing something that is not agreeable to most people. But I don't like the idea of the government being the one to select the specific funding, because the cloning, the stem-cell, it may be a religious reason that they don't want something done, that isn't politically correct and that's not the way I'd like to see money being used. I'd rather have more of an independent consensus.

Woman: I'm afraid the government's role is determined by congressional leaders and Senators who know people at places as opposed to the merits of the research itself. It's more who you know, what you know, and what your constituency is, as opposed to what the projects are and what institutions they're at. ... I think it should be a fair funding decision based on who has projects that qualify for things that would be benefiting human nature or human beings going forward.

Woman: ... The government should fund this stuff but I think they shouldn't be allowed to decide what gets studied and what doesn't, because I think that if that was the case then we'd be studying a lot more things that were not as necessary. ... Because I think, really, the people who do the research are the people who are going to have the most expertise in deciding what needs to be studied.

Man: I think the government should just supply the money and stand back and just let the scientists do the rest. ... If it's very politically motivated then you're going to add to those biases and take attention away from what needs to be looked at, or what might happen naturally in a lab or in someone's thought process.

Man: Two points of view prevailed that were absolutely hooted down in the government and in the funding process: the fellow who established that it was bacteria that caused gastric ulcers and the guy who discovered prions as a source of infection. Theirs were considered so far out of the mainstream view as to not have deserved evaluation. And that's the risk you run - it's all a political choice.

- **Government does its own basic research**

Man: ... the other role is where there are government entities in which the research is carried out, so with all due respect to the USGS where my brother used to work, in terms of a government funded agency that carries out the research as opposed to just the dollars going out.

Man: I think the Feds have a set-up for institutions that do some basic research. I think the US Fish and Wildlife service does a lot of research into species development and recovery. The USGS does a lot of basic research into earth science and NOAA does a lot of research into atmospheric science. There are a lot of institutions already in place in the federal bureaucracy that do a lot of work and are great conduits.

- **Government should support educational infrastructure for researchers**

Man1: I guess I think they should make [basic research] a higher priority from what it is now. And making it a priority down to the classroom level because that is where it starts. To understand the scientific process and how to go about the conduct of inquiry and do it in a reasonable and straightforward way so that you actually end up with something rather than just watching Jerry Springer and having your hormones tell you what to do.

Woman1: In order for our nation to compete globally - one looks at the young people of other emerging nations, young bright hungry minds - I don't see the same thing going on in this culture. And

I don't know exactly where to point the finger, but I think the point about more emphasis and hence more funding being put into shows like this and direct outreach to kids. I think it is very important.

Woman2: I think the government, if it doesn't educate its people, is not going to have a well developed society I think it should not only fund the research but fund the education of the people doing the research. Ten years ago, I worked on my doctorate, I would've gotten funding, now it's not there. The government has cut a lot of the money for educational resources, cut a lot of the programs it was assisting. I think funding research is one thing, but you need scientists in your country to do it. If our kids aren't educated into getting interested in these things, it's not going to happen.

Man2: It's not just funding various research projects, but to build an infrastructure. We need scientists as well. I think she nailed it. Education is the key. Educated from the beginning. Let's get our kids interested in science, let's stimulate them.... You learn to enjoy these things. If you are never exposed to them, you're not going to catch the fire. You are not going to go in that direction. You won't have the opportunity to have good researchers and scientists in this country.

ROLE OF BASIC RESEARCH IN POLICY-MAKING

Respondents in all four focus groups concluded that government policy-making is driven by economics and election cycles more than being influenced by basic research. Two focus groups gave examples of the influence of basic research on government policies, with one of these groups suggesting that the impact was through the efforts of political-action and environmental organizations. Finally, one of the four groups did not believe that research has any role in policy making.

The final question for the focus group discussion was - *What do you think is the role of basic research in policy-making?* As moderators had been instructed to permit the respondents to define "policy-making" as they wish, this question elicited considerable confusion and hesitation in answers as illustrated by these initial group responses:

What is policy-making?

I'm drawing a blank. Can I think about that some more?

Policy-making by whom?

Are they asking - is basic science supposed to be affecting policy or is policy supposed to be affecting basic science or ...?

I'm confused.

Respondents in all four groups appeared to conclude that government policy-making is driven by economics and election cycles as opposed to being influenced by basic research. Two focus groups discussed the influence of research on government policies, with one group addressing impact through political-action committees and environmental organizations. One group was not aware that research has any role in policy making.

- **Government policy making is market-driven, election-driven not research-driven**

Man: Basic research says we can't go on the way we're going right now being fossil fuel dependent, but our administration is still totally backing that. Everyone I talk to realizes that and knows that -- people are there. But we haven't gotten to the point of voting that in with our consciousness, with our mind, with the collective consciousness.

Woman: I think policy making is market-driven, and that's how decisions are made. We can have all these wonderful discoveries, but we're still not willing to take the step to [change]. ... I think the oil is a good example that was given, as are many other health and environmental ones - that we know what's out there, we know these things are happening but we still aren't willing to take the step to be better from it.

Moderator: What do you mean by market-driven?

Woman: We don't want to be dependent on oil, but a lot of people are invested in it and make a lot of money promoting oil and the usage.

Man: One of the most classic examples though was the shooting down of the super-conducting super collider. That was the US's most vigorous attempt to push knowledge forward by a bunch, but it wasn't politically expedient. And Bush was facing a bad economy, and folks said, no, I'm not going to go out of my way for this thing. And because there was no tangible outcome - you get new ideas out of it. Stuff, new thinking, smart ideas.

Man: Government has policy, with their fingers crossed, to figure out certain outcomes. But basic research by its very definition has no outcome. At least no tangible outcome. To me it's the same as saying, "What role should poetry play?" Not that there isn't a social role for poetry, but I don't think it's government's. ... A lot of mathematical research has no immediate outcome and policy is supposed to have a short time horizon. Because a President runs for election every 4 years.

Moderator: So what you're saying is that government is oriented towards outcomes and basic research is not particularly outcome-directed, but now I'm hearing you also say that it's not only about *outcome*, it's about *time*. A short time span.

Woman: It's like a quarterly stockholder's meeting, only it's an election. So it's about "what have you done for me in the last 4 years," like in the quarterly report, you have to at least have milestones at least to say, "This is what I have done for you."

Man: I can assure you that neither candidate in the next election will advocate or not the funding of research into the Fine Structure Constant.

Woman: As a politician, I'm going to focus MY efforts on telling you about the roads I'm going to build for you or the jobs I'm going to create. ... And I'm going to focus on the things that a) I can address reasonably intelligently or at least make the effort and b) that my constituents are going to care about. And I'm going to avoid that group of scientists because someone might push me up against the wall and I have no clue. I just don't think it's going to be part of the agenda.

Woman: I would think that the role of research would be to come to a consensus and inform what would be a good choice to make and what is a bad choice that is being made, but I don't think that the research really affects the policy making for a long time. I think the thing that ends up driving the policy-making is the economics. In our health, the smoking, even the McDonalds - the trans-fatty acids that they are using, researchers have known about that for years. The only thing that's driving it is that people are not eating as much of their French-fried foods and the restaurant feels that they have to capture more of their audience. So again, economics. Anybody setting policy is not doing it because researchers told them one thing is better and one thing isn't. You know, they've known about all these things. They do nothing about it.

- **Basic research can affect some policy-making**

Man1: The way that I interpret that question is that basic researchers have a responsibility to bring certain things to light. That's why they are in the field they are in, they're trying to find out things. I think that as they find out things, especially things that may be important on a social scale, that those things need to be brought to light through the policy makers, so that policy can then be written to include the new information. So I think that is the way that basic research can impact policy making, by communicating so that appropriate policies can be built around research.

Man2: It definitely affects it. As information comes out, it's acted upon and policies change. Something that might be pointed to is nuclear weapons. At one point, what a great thing, we can end the war with this one bomb, and then whoa, it doesn't just blow people up, it causes them to have some disease that carries on and kills some people, and low and behold, even if you don't die, 30 years down the line either your children or yourself are going to be affected by that, and how's this going to affect policy throughout the world. Okay, ultimately you know Russian and the U.S. didn't throw nuclear weapons at each other, because ultimately we realized that there was no winning a nuclear war. Someone throws one, they throw one back, even if we don't destroy every living thing, we're going to kill the earth. So as the research progressed on that particular subject, we discovered something that changed our policy and may have changed history.

Woman1: Well, I totally agreed with what Man2 said. But, I'll elaborate a little, because of what you said at the end. It's how people interpret it. And how I would interpret it would probably be very different than how the policy makers would interpret it. So, even though we learn things and policy is created, you have to have a consensus in some way for the policy to be created so it's a very complicated thing. I think the role of basic research is to point out truths as they are learned, to be guidelines for policymaking in that human beings interpret those truths in whatever way they see fit.

- **but organizations exist to bring basic research to influence policy-making**

Man3: Policy making is a function of the government. And it has been my experience that most politicians aren't really smart enough to understand basic research. Their focus in life has nothing to do with understanding things to that degree. It's just like apples and oranges.

Man4: Yeah, but look at what that California legislature did this year. They passed a bill for global warming, and they got the governor to sign.

Man3: Well, yeah, but that is political action committees.

Man4: I think they did that because there were certain people in the legislature who listened to smart people in groups like the Sierra Club and other organizations who said this is a problem and they persuaded them. ... they were able to take basic research, as I don't think it is applied research yet in terms of global warming, and persuade the majority of 120 people under the dome over there that it's a problem and that we need to lead the world and challenge the auto companies and so forth and address it. So, here's an example of how basic research led to a fundamental change, and at least this state is doing something about the air quality.

Woman2: It's not just the government that's policy making because it's the Sierra Club and other foundations that do basic research, because they have a certain political leaning and they believe in clean air and rivers and saving our earth. So they are going to focus their basic research or funding or whatever they do, while a more right leaning organization is going to look more at oil exploration... But I think if you look at these foundations, they are affecting policy because they affect government. They convince some smart legislatures about stem cell research as well. The money isn't just in government that directs where basic research is headed, it is also in foundations and organizations that try to convince the government. Here, the governor passes the brain stem research while the federal government has a completely different viewpoint on it. I think policy making through basic research is possible. I think it does direct where we are going as a community, state, nation, and a world. And it can start really little, like with our local problem with smog and how that has led to a larger state effort with global warming.

Woman3: I guess I'm back to where Man3 started. I think it is an issue of apples and oranges. My own philosophy is that basic research should inform policy making, but "should" and "what is" the political reality are two different things.... Like it is great that California has passed the bill on global warming, but who else has? So, I think sometimes politicians don't even inform themselves about what is going on. So I do think it is the role of the research community to do some political action.

Man5: I think there are a couple issues we talked about already—stem cell research and research on the environment. These are two issues where the definition of basic research are very important to those policy issues. They both inform and underlie those issues.

Woman4: I'm wondering if maybe in asking this question they were trying to get at the research into the ozone layer. The research is showing that the hole over Antarctica is changing. I was reading something about that recently, and they were saying that it's a different shape now, and that maybe we should have signed that treaty in Kyoto. Is it supposed to be driving those sorts of policy decisions?

- **Not aware that research has any role in policy making**

Woman5My guess is that policy makers don't have an Ira Flatow helping them understand and step back and ask the questions, like we get on *Science Friday*.

Woman6: Well, I don't really understand what it [the role] is right now. ... I'm imagining that there could be lobbyists who are doing that communicating piece and that if there aren't, there should be. Maybe there are.

Woman7: I mean [research] has gotta be considered in some way, but I have no idea in what way. You know cause it's the most basic, the most basic fundamental things that are believed to be fact. So I'm sure it's incorporated in some way.

Man6: I think they could make policies without taking these basic principles into account. I think they can, that policy making can pretty much ignore the basic principles of research that's going into it.

Woman7: I think they can ignore a lot of research, I mean especially the research that doesn't fit what they want to do. You know, ignore the research that says that the Mississippi river is polluted, if they want to dump.

DISCUSSION

A four-year grant from the National Science Foundation (NSF) to *Talk of the Nation: Science Friday* is to support examination of “the importance of research as a theme underlying all science and technology changes.” One of the goals of this evaluation is to provide feedback as to the series’ current strengths and weaknesses with respect to the NSF grant goals. Listed below are each of the proposed goals and what we have learned from *Science Friday* listeners.

- *Science Friday* will find the research roots at the bottom of each story.... We explore the research underpinning the discovery and the research that needs to be accomplished.
- *Science Friday* will help listeners understand the thought process of research.

The questionnaire and focus group discussions focused on “basic research” as compared with just “research.” The main components or features of “basic research” as described by listeners include the idea that basic research focuses on fundamental laws of the universe, it refutes or confirms theories and is not motivated by commercial applications. However, at least 20% of the respondents were unfamiliar with and confused by the term – “basic research.” This is not a term commonly used in the series nor one that a good portion of our participants were comfortable discussing. Thus, we can conclude that at least 20% of *Science Friday*’s listening audience is not familiar with the concepts of basic research and will need more support than is currently given in the series to meet the above goal.

Almost one-third of the participants, mostly men, feel that the series is successful in indirectly explaining background research process. They feel that Ira asks the questions that they as a listener would ask. One-third of the listeners feel that the series’ success in explaining the research process underpinning a discovery depends upon the listener’s knowledge, the scientists’ explanatory abilities and the call-in questions’ technical level. Over one-third of the sample, mostly women, think the show varies in success or is not successful due to the show’s format, but they do not interpret this as a weakness because they have no expectation that the series would focus on research process nor do they want it to have that focus. These results indicate that listeners on average feel that the series currently addresses the underlying research process at least implicitly if not explicitly, yet one-third of the audience is not interested in having the series expand that effort.

None of the listeners feel that the series changes or adds to their understanding of basic research, however, one-third of respondents, mostly men, feel that the series clarifies and reinforces their understanding. One-quarter of listeners noted that they listen for current research findings and have no expectation that research process is presented through the series, either indirectly or directly. Thus, the series as it stands reinforces the knowledge of basic research that the audience brings to the listening experience rather than adding to it. It is likely that the issues of basic research process are not independently highlighted enough in the series to be memorable separate from research findings. In planning changes to the show with respect to this goal, note that 25% of current listeners may be resistant to increased discussion of research process.

- *Science Friday* will explore the cooperation among corporations, private institutions and research foundations, when appropriate, illuminating how each one plays a role in the research process.

This goal was addressed indirectly by asking if the government should be involved or not involved in basic research. Listeners believe that the government should fund basic research because it is the only institution with enough resources to do so; furthermore, they feel basic research advances our civilization and our economy and may lead to applications. Participants noted that other institutions are less likely to fund basic research. Three of the four focus groups felt that politics should stay out of basic research decisions as much as possible. One group pointed out that the government itself is directly involved in carrying out basic research, while another group recommended that the government support an educational infrastructure to develop future basic researchers. When private institutions and foundations were mentioned in discussions, respondents noted that they tend to fund applied research rather than basic research.

- *Science Friday* will follow the research ‘bumps’ in the road.... research is a trial-and-error process and that failures are useful –and necessary- to achieve success. Much of the success will take many years of research.
- *Science Friday* will illuminate the barriers to successful research....what priorities and options are that researchers must juggle during their work.

In writing about barriers or obstacles to successful basic research, respondents listed lack of money or resources; limitations of previous knowledge and resistance to change; time; restrictions of research methodologies; scientific uncertainty and need for replication; lack of practical application; and finally limits of the human mind itself. In the focus group discussions, money was agreed upon as the number one barrier to success, followed by pressure for practical benefits and applications; negative public perceptions through media coverage; lack of institutional and societal sponsorship; politics at all levels; and scientists’ own hesitation to question accepted theories. Thus, the current series appears to be quite successful in communicating a wide range of research bumps and barriers.

- *Science Friday* will scale the ‘ivory tower’listeners question and talk directly with researchers.... gain insight into the human side of research scientists.

Our listeners’ written and verbal responses about basic research scientists illustrate that they do not carry a stereotype of researchers. Listeners feel that basic researchers do the kind of work that they do because of their innate curiosity; a love of discovery and knowledge; a drive to understand how our world works; and an enjoyment of solving problems or answering questions. When asked about characteristics or personalities of basic research scientists, most descriptors were quite positive: passionate and enthusiastic about their work; inquisitive and curious; patient and persistent; intelligent and articulate; open-minded and skeptical; methodical and thorough; but also insular in the academic world.

- *Science Friday* will help listeners understand the role of basic research in policy-making.

Listeners value basic research and feel that reductions in research would have serious consequences, but they did not believe that basic research currently has a significant role in policy-making.

One-third of listeners value basic research because it expands our fundamental knowledge base; another third value it because such knowledge feeds into applied research; and another third noted the unknown value of basic research.

Over one-third of respondents conclude that a reduction in basic research would hamper our understanding of the world; one-quarter foresee a decline in applied research as a result; and one-fifth outline resulting educational and economic disadvantages. A smaller portion feel that the validity of scientific thought would be threatened if basic research were reduced.

Respondents in all four focus groups concluded that government policy-making is driven by economics and election cycles more than being influenced by basic research, although two focus groups gave examples of the influence of basic research on state government policies due to the efforts of political-action and environmental organizations. Thus, if the goal stated above is to be met by *Science Friday*, much more coverage and clarity of purpose will be needed in the series defining what basic research is, what policy-making is and how one influences the other at what levels of government, either through specific examples or more general discussion.

APPENDIX

August 24, 2001: Hour one

Astronomy and Astrophysics Update

There's a basic number in nature approximately equal to 1 divided by 137. The number is so basic that physicists just call it 'alpha.' It's obtained by dividing the square of the charge of the electron by the product of Planck's constant and the speed of light. It's not supposed to change.

But now some scientists are saying that numbers, also known as the fine structure constant, might not be constant after all. It may have changed slightly as the universe has evolved - shifting by about one part in 100,000 over some 12 billion years. In this hour of Science Friday, we'll talk about what that finding, if true, might mean for other laws of the universe.

We'll also find out about the discovery of a solar system 51 light years from Earth that reminds some astronomers a little bit of our own home. The system has at least two planets, orbiting the system's star in nearly circular orbits. We'll talk about how those planets were spotted, and what their presence might mean.

Guests:

Debra Fischer, Dept. of Astronomy, Berkeley, CA

Mario Livio, Space Telescope Science Institute, Baltimore, MD

Christopher Churchill, Dept. of Astronomy, Penn State, PA

After listening to the 50 minutes of "Science Friday" on the CD, describe anything you learned or were reminded of regarding how basic research is carried out?

Verbatim responses:

Basic research needs to be duplicated and the same results obtained for the study to be even minimally accepted. The show mentioned that until other scientists replicate the studies then you're not going to hear a lot about the findings.

A single source of information is inadequate. Confirmation is required before findings are accepted/validated.

Need replication of results using both same techniques and a different set of experiments to yield same results.

All new information must be proven beyond doubt before it can be claimed as fact. The same experiments (or investigations of the same subject) must be carried out in different locations with different equipment to be taken seriously.

Testing a theory and then having another group use the same model and test the theory also.

They talked about the possibility that the constants may in fact not be constant after all. They reached this possibility through the running of all the numbers, basic research. It was then pointed out that we can draw no definite conclusions because the findings have not been independently confirmed.

The emphasis on confirming new theories was hard to miss. Theory evolves via peer review and the ability of others to reproduce results.

Reminded of constant revision of our assumptions about nature, importance of the scientific method.

I was reminded of how much of science is open to question. That questioning assumptions is so important.

Reminded that very little is constant. Important to question 'accepted' theories.

Observation and number crunching and constant re-evaluation of foundational laws.

Theories of the universe are constantly changing, and there's a new one to fit any new data which is discovered.

Mentioned that 7 years was necessary to view the rotation of a suspected new planet in order to confirm findings; mentioned that they could assume the presence of planets because other visible bodies changed in speed- based on previous research.

It takes a long time (i.e., Observing the orbital life of planets in other solar systems).

Can be long and difficult.

I was reminded that the process may be long and is constantly exposed to questioning and new information.

Reminded me of the arduous, long-term, painstaking process of using science to prove/disprove theories. Reminded me that much basic research is carried out in university settings.

Carried out at universities, little emphasis on teaching, is always re-evaluated and changing.

A lot of basic research happens at academic institutions and is supported by graduate students and faculty.

Many times discoveries must be inferred from the observations. Application of knowledge and previous theory to observation.

Answering questions through indirect means. May not be possible to answer a question directly. Trying to isolate a particular thing to measure/observe.

Much involves observation-our ability to observe and measure has been enhanced given current technology.

Observation is a keystone to scientific understanding. How enthralled scientists are about their work. The importance of using plain English in describing complex ideas.

Incremental, changes in understanding, lead to changes in methods which impacts results.

Open process - lots of discussion. Generally respectful.

That it can be fairly haphazard, one thing leads to another and you end up somewhere that you had no idea you were going.

Serendipitous nature of discovery (the scientist that accidentally discovered 2 planets with solar systems 50 light years away) and passion of scientists about (to me anyway) obscure and complex sciences like astronomy, quantum mechanics and bizarre behavior of particles is so foreign to me.

I was reminded of the intensely solitary nature of the men and women who make their area of curiosity their life's work.

I learned that there are studies that are ongoing regarding our solar system.

Interesting explained how. [no further description]

I felt that it was not explained clearly how basic research was carried out.

I learned nothing about what is basic research.

No answer.