

Linking Biomedical and Behavioral Research for Tobacco Use Prevention Sundance and Beyond

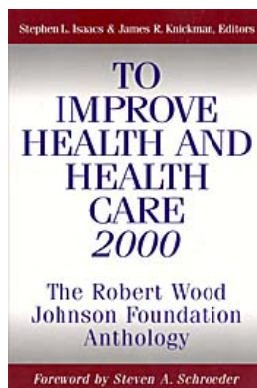
BY NANCY J. KAUFMAN AND KARYN L. FEIDEN



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Editor's Introduction

Over the past eight years, the Foundation has supported a wide array of initiatives aimed at reducing the use of tobacco, especially among young people. These include approaches as varied as creating local antismoking coalitions, restricting young people's access to cigarettes, funding antismoking advertisements and enlisting Major League Baseball in a campaign against spit tobacco (described by Leonard Koppett in last year's *Anthology*).

Despite the Foundation's wide-ranging efforts—and those of federal agencies such as the National Institutes of Health and voluntary organizations such as the American Cancer Society—teenage smoking is on the rise. Painfully little is known about why young people start smoking, how they become addicted and why some are able to stop. This reflects a lack of knowledge more generally about the complex interactions of environment, biology and behavior that drive people to do things that are known to be harmful to them.

To gain a better understanding of these interactions as they apply to teenage smoking, a group of researchers from different disciplines came together in Sundance, Utah, in May 1997. In this chapter, Nancy Kaufman, a vice president of the Robert Wood Johnson Foundation, and Karyn Feiden, a freelance journalist, describe the discussions that took place at the Sundance conference and the insights that emerged about new, transdisciplinary approaches to research. They go on to discuss related efforts funded partly or wholly by the Foundation, such as creating a research network to study the roots of tobacco dependence, setting up a university-based transdisciplinary study group and convening a meeting on transdisciplinary research at the National Institutes of Health.

The attempt to craft a new transdisciplinary approach to adolescent smoking is an example of how a philanthropy can benefit from being a "learning" organization—one that makes programmatic decisions based on research findings and other evidence. It is an approach that requires patience, a long-range perspective, and a commitment to stay the course of funding in an area until new understanding of the problem and how to address it emerge. The authors make the case that this long-range perspective is important in the area of tobacco control.

The Sundance conference and its progeny have already borne fruit. Both the federal government and the Robert Wood Johnson Foundation have recently approved substantial funding to carry out

transdisciplinary research on tobacco use, including careful attention to the public policy implications of findings that emerge.

A door clangs shut. A soft whirring pervades the dimly lit, cool room, as Mark's¹ body glides into a machine that, during the experiment, will partially entomb him. Mark's head adjusts to its new surroundings. In a small observation room a few feet away, a technician adjusts dials to sharpen the brain scan image and begins recording video images of minutely thin slices of Mark's brain. It is as if someone has removed the top of Mark's skull and brain and is peering down at cross sections of all its lobes.

Mark relaxes, and soon a nature video appears on the small screen before his eyes. The bucolic scenes soon come to an end, and a new video begins—a much different video: scenes of people using drugs, of drug paraphernalia, of drug user surroundings. Now things really begin to happen on the brain scan screen. A small, central part of the brain that controls emotion and impulse, the amygdala, lights up as the research team crowds in to get a look. Mark is a recovering cocaine addict. This is not his brain *on* drugs—this is his brain *remembering* drugs. He experiences craving as the amygdala lights up. A new age in biology and behavior has begun.

And not a moment too soon. We must enter the new millennium better equipped to study the complex causes of disease and poor health. Although most of us recognize that the causes of poor health, such as tobacco use, involve many factors, the way research is structured in this country rewards incremental and isolated efforts. The current scientific research system is strong, but we need to challenge ourselves to think about how to connect related research efforts to get maximum impact and how to promote research opportunities that lead more quickly to breakthrough applications in the real world. Doing so will require scientific talent from such diverse fields as genetics, molecular biology, epidemiology, behavioral sciences, anthropology, marketing, law, education and public policy.

Unfortunately, the current university research structure and the system of funding agencies do not reward such an approach. University departments and grant review committees discourage collaborations outside of targeted fields and expertise. Additionally, the constant need to focus on obtaining short-term research grants directs the attention of researchers away from science and into the grant application process. These barriers, however, are not immutable.

Transdisciplinary research—an approach that links the biomedical to the behavioral and beyond—has the potential to inform the work in multiple fields, linking basic science to practice. It involves examining

critical challenges and then having researchers from various disciplines collaborate in addressing the research questions. It recognizes the strengths of each field, and asks researchers to become conversant in the language and methods of related fields, and requires that they design coordinated research to answer specific questions.

Why, for example, do 70 percent of adolescents try smoking cigarettes?² Why do some teenagers persist in smoking even when doing so nauseates them? Why do young people take different forks in the road? Thirty percent never smoke; some try one or two cigarettes and stop; others smoke for a while and then quit.³ How can some addicted smokers quit with one attempt, but others need numerous attempts to succeed? Why are some smokers apparently doomed to lifelong addiction? What roles do biology, genetics, family and peer influences play? Do advertisements for tobacco products and environmental tobacco smoke cue the amygdala in recovering smokers and produce craving? How do price and availability influence use?

In 1996, a group of staff members at the Robert Wood Johnson Foundation wrestled with such questions while examining what is known about the etiology of tobacco use among young people and the effectiveness of programs and policies to prevent smoking. With smoking rates among high school students rising sharply—a 32.4 percent increase from 1991 to 1997⁴—finding answers has assumed new urgency. Although researchers now know more about the genetic, biologic, personality, family and community influences that put young people at risk for becoming smokers or protect them from it, how these factors interact to produce behavior is not well understood. Much of the scientific inquiry devoted to unraveling these strands takes place in categorical "silos"—with, for example, geneticists searching for inherited smoking traits, biologists examining the effects of nicotine on brain neurotransmitters or looking at individual differences in the metabolism of nicotine, psychologists delving into personality traits like sensation-seeking or exploring the conditioning effects of tobacco advertising, epidemiologists associating targeted tobacco advertising and promotion campaigns with rises in prevalence, and economists calculating what effects higher or lower tobacco prices will have on smoking among the young. Virtually none of the science considers the adolescent as a whole—as a complex biobehavioral organism influenced by its interpersonal and societal environments.

Most prevention programs (for example, teaching young people to refuse cigarettes offered by peers) or policies (for example, banning sales of cigarettes from vending machines) use general approaches, called universal programs, to reach large numbers of adolescents. Few prevention programs tailor interventions

to address risk or protective factors at the individual level. There is some evidence that life skills training and programs including school, family, and community components prevent the use of tobacco or delay experimentation with it,⁵ but these universal approaches may not be effective with high-risk youth. How effective these interventions are against tobacco advertising and promotion campaigns and price discounts is also not known.⁶ Like the physician who keeps selecting antihypertensive drugs for a patient until an effective one is found, shouldn't those interested in preventing tobacco use among the young have a variety of approaches?

The American scientific community stands poised on the verge of great silo discoveries about tobacco use and its prevention. For example, we now know that roughly 50 percent of the likelihood that someone will initiate smoking or become addicted to nicotine is genetic.⁷ One gene, CYP2A6, produces an enzyme that metabolizes nicotine. If this gene is defective, it protects the smoker by making smoking a nauseating experience and by decreasing the number of cigarettes needed to keep nicotine levels high in dependent smokers.⁸ Research on child development and psychology reveals that children and adolescents with conduct disorders or depression are at a higher risk for smoking than those without them.⁹ Economic studies find that permanent, inflation-adjusted increases in cigarette prices decrease smoking among the young, with a 10 percent price increase resulting in a 7 percent decline in prevalence, as well as decreased consumption among young people who continue to smoke.¹⁰ The field of biology brings important findings about where in the brain and other tissues nicotine produces effects. The effects of nicotine on the pleasure neurotransmitter dopamine in the amygdala parallel the neurochemical pathway of other addictive drugs like cocaine and heroin. Also, it is now possible to prevent mice from taking nicotine by eliminating one of several nicotine brain receptors.¹¹ And brain imaging has revealed that cigarette smoke inhibits an important enzyme, MAO, that affects dopamine levels, perhaps explaining the roughly 80 percent prevalence of smoking among alcoholics and those with schizophrenia and major depression.¹²

In these contexts—a sharp rise in smoking among the young; exciting new science coming out of categorical silos, but minimal understanding of the interactions between biology and the environment that produces tobacco use; and the paucity of prevention approaches tailored to specific risk profiles—the Robert Wood Johnson Foundation launched a series of related activities to speed up research aimed at preventing tobacco use. These included the Sundance conference, the Research Network on the Etiology

of Tobacco Dependence, the Stone House project, and a special study group at the Stanford University Center for Advanced Study in the Behavioral Sciences.

THE SUNDANCE CONFERENCE

Sixty scholars and practitioners met in the mountain retreat of Sundance, Utah, in early May 1997 to create an opportunity for researchers to escape old paradigms, to think creatively, and to stretch across disciplines and develop new ideas to help prevent tobacco use. The Foundation chose participants with strong research and practice credentials whom colleagues also thought of as boundary-spanners. Four objectives framed the three-day conference on New Partnerships and Paradigms for Tobacco Prevention Research:

- Clarify shortcomings in current models and methods of tobacco prevention research.
- Identify gaps in knowledge about the most significant factors associated with tobacco use among young people and with its successful prevention.
- Identify limitations in existing methods of intervention.
- Facilitate collaborations among the various disciplines by identifying areas that represent opportunities for significant progress in tobacco prevention research; primary questions that can serve as the focus of research collaborations; and obstacles to such collaborations and strategies for overcoming them.

The conference emphasized the value of transdisciplinary research—a term that is used to imply a higher level of cross-fertilization than is traditionally suggested by an interdisciplinary approach and that includes the use of the methodology and language of other fields. "Lose the walls of your discipline," David Abrams, of the Brown University School of Medicine, urged the assembled experts in neuroscience, genetics, marketing, epidemiology, anthropology, economics, psychology, adolescent development, addiction research and other biological and social sciences.

The participants were challenged to explore possible links between subcellular biology and policy initiatives, and to identify ways in which biomedical research could be used in new behavioral interventions. Advertising experts were asked to become more familiar with the biomedical basis of addiction. Neuroscientists and developmental psychologists involved in adolescent studies sought common ground. It was a unique opportunity, as Richard R. Clayton, of the University of Kentucky, said, "to climb in different trees and to begin to appreciate better the variety of trees and the similarities that hold us together in the broader scientific forest."

The discussions about the relationships among biology, social science, public policy and prevention strategies occasionally became heated. As the participants stretched the limits of their intellectual comfort, they tended to reveal their own biases. "There is political power in biological information," one speaker asserted. Yes, said a social scientist, but "we are being asked to make a difference now, without all the scientific information available to us." Threading through the conference was the theme that no single factor fully explains why young people start smoking and continue to use tobacco. Genetics, brain biology, social policy, family culture, gender, societal images of tobacco use, advertising messages, the price of tobacco products and peer dynamics are just some of the influences, and the interactions among them are complex. What's more, there is no magic bullet—no single approach to limiting access to tobacco, no one advertising message—likely to end smoking across all populations. Various interventions may have differing effects on specific population groups, and multiple strategies are likely to have a cumulative impact in ways that need to be explored more fully. To understand how risk and protective factors play out, the construction of multivariate models was identified as a priority for research.

A significant part of the Sundance conference involved presentations of state-of-the-art findings in biomedicine, psychosocial research, societal influences and intervention strategies, giving experts in each field a rare opportunity to learn about emerging research in other fields relevant to the prevention of tobacco use. Conference organizers structured the presentations to be brief—10 minutes, four slides—and stimulating. Before the conference, the Foundation commissioned a paper from each presenter highlighting the newest findings and posing questions for future research. Topics included the epidemiology of tobacco use, neuropsychopharmacology, genetics, psychosocial risk factors, protective factors, adolescent development, advertising and counteradvertising, culture and gender differences, economic forces and behavioral economics, school-based interventions, community-wide interventions and politics, mass media campaigns, and risk perception and communication. Each participant received these papers before the conference. Several unique features of the conference, including a panel discussion with teenagers and a videotape of antismoking commercials, added perspective. Equally important were the extensive opportunities for discussion and debate—after each presentation, in the many hours devoted to informal small groups, during mealtimes, and even on the walks that punctuated each afternoon.

SUNDANCE HIGHLIGHTS

The range and the depth of the presentations and subsequent discussions underscored the complexity of preventing or reducing the use of tobacco, especially among young people. Knowledge gaps exist in every

field, and bridges need to be built across disciplines in order to create effective interventions and see that they are properly aimed. A number of themes emerged as the conference participants talked about what is known, what remains to be learned, and how knowledge can most effectively be shared and used.

Differing idioms make interdisciplinary research a challenge; nonetheless, a courtship among disciplines is vital if new paradigms are to be constructed. Reaching across disciplines to learn from one another is not simply a matter of open-mindedness and good will. Organizational and structural differences, the absence of a common language, the failure to share data or even to read one another's journals—all are barriers that are not easily overcome. Yet the combination of environmental and biological characteristics that fosters smoking among the young, and the potential for synergistic effects from coordinated efforts at prevention, are too significant to be ignored. One participant suggested that researchers look for ways to mirror others' experiments in their own discipline, and asked, "Can everyone work on the same question and triangulate from there? Could an animal person and a prevention person work together to consider the implications of animal research and what it means to prevention?"

The physiological effects of nicotine on adolescents differ from the effects on adults and need to be understood more fully. Research into the effects of nicotine on young people has lagged behind research on adults, yet the hormonal and physiological plasticity that characterizes adolescence may make young people uniquely vulnerable to this drug. A number of biological markers have already been identified that provide a lens into the changes that nicotine produces in the body. The possibility of mapping nicotine levels in blood plasma against their sedating and arousal effects was also discussed. Other markers may help to determine whether adolescent cravings for nicotine differ from adult cravings, to identify changes that correlate with nicotine's impact on mood and attention span, and to refine current understandings of dependence and withdrawal in young people. Biological differences between males and females represent another source of variation that needs to be addressed.

Nicotine addiction in adolescents is not universally acknowledged. The reality that adolescents become addicted to nicotine has been recognized only relatively recently, and is not fully understood. "We still have the notion that teens who continue to smoke haven't really decided they are ready to stop," one scientist commented. "Prevention is not fully honest unless it teaches that half the teenagers who try smoking will become addicted, and that only 30 to 50 percent of those will be able to become unaddicted. Kids haven't been told they can't stop once they start."

Two developmental characteristics of adolescents—the desire for independence and a sense of invulnerability—complicate the response to addiction. To capitalize on their fierce determination to be autonomous, it may be useful to convey the message that nicotine creates a potentially insurmountable dependence. But Valerie Graves of Motown Records cautioned against sending a message of hopelessness to young people, and others argued that youthful expectations ("I can quit whenever I want") inevitably clash with the realities of addictive behavior.

The biological and behavioral consequences of exposure to nicotine before the adolescent years need to be more fully explored. The influence of prior exposure to nicotine—both in utero and during childhood—on adolescent smoking is not fully understood, but the possibilities are alarming. In utero exposure appears to increase the likelihood of attention deficit disorder. Scientists are also studying how nicotinic receptors form in the brain, beginning in fetal development and continuing with childhood exposure to environmental tobacco smoke; although the results so far are inconclusive, this investigation may ultimately support the hypothesis that early exposure affects the transition from the experimental use of tobacco to dependence.

Such data could become a powerful tool for discouraging pregnant women from smoking, possibly prompting a campaign analogous to the one launched to prevent fetal alcohol syndrome. It may also lead to prevention campaigns targeted at preadolescents, who have largely been overlooked in current research.

Smoking behavior is rooted in both nature and nurture. Prevention strategies designed to change behavior need to take a holistic perspective, in which the individual is recognized as the point at which multiple external and internal factors intersect. "Social factors and biology converge in discussions of why kids smoke," one conference participant said. "Adolescent response to nicotine is a psychologically based biological reaction."

Teasing out the characteristics that enhance vulnerability to smoking may allow researchers to identify the groups of young people at greatest risk. Multivariate analyses are required to understand how the complex physiological actions of nicotine interact with the unique developmental patterns of adolescence, with multiple environmental factors, and with a palette of individual traits to steer a young person toward smoking or away from it. How might the biological changes that occur with smoking interact with parenting practices to foster addiction? Are public policies restricting access to tobacco

potent enough to counter a family pattern of smoking? How does a cultural bias against smoking compete with peer group influences? Characterizing the moderating and mediating influences among the relevant variables is one of the big challenges of the next generation of tobacco prevention research.

Nicotine has a functional value for young people that needs to be acknowledged. The benefits that adolescents derive from smoking are ignored at our peril, emphasized Neil Grundberg, of the Uniformed Services University of the Health Sciences. "To develop alternatives to tobacco we need to understand not only the damaging effects but the beneficial ones more thoroughly," he said. "This tells us to consider the functionality of tobacco use, to recognize the purposes it fulfills." To intervene effectively, the push toward adulthood, one of the defining characteristics of adolescence, must be recognized. To the extent that smoking is viewed as normal for adults, it becomes a behavior that teenagers are tempted to emulate; consequently, prevention messages aimed exclusively at young people may backfire.

Understanding why some people are able to avoid risky behaviors may help researchers capture elements of resilience that can be taught. Teasing out the factors that have allowed some young people to avoid risky behavior may be useful. One prevention researcher asked, "What are the natural forces of prevention? Can we engage with kids who have avoided tobacco, marijuana, drinking and driving? What do they have to teach us about resilience? Another group that has attracted the attention of researchers from many disciplines are the young people who experimented with tobacco before giving it up. We need a better understanding of the exit process."

Prevention strategies need to be designed with the trajectory of tobacco use in mind. The transition from early experimentation with nicotine to regular use, and ultimately to nicotine dependence, needs to be characterized explicitly. In addition, the public health community should determine the relative value of prevention strategies designed to discourage any experimentation, compared with a focus primarily on the later stages of use. "Early stages of addiction may be more rooted in societal influences, while later stage, hard-core dependence may have a biological basis," one speaker commented, suggesting that effective interventions need to be developed with this distinction in mind.

To understand the journey toward dependence, one researcher proposed collecting a series of biological markers as the level of tobacco use progresses. If smoking thresholds, marked by measurable physical changes, can be identified—say, after the first few cigarettes, after 100 cigarettes, and after 500 cigarettes—the development of dependence and the triggers of progression to the next stage may be clarified. Studies

of so-called chippers—occasional users—may also offer helpful insights. More research into the theory that tobacco is a gateway drug, possibly leading to the use of other substances, is also warranted.

Multiple targeted interventions are needed to have an impact on young people's behavior. The array of data accumulating from the natural and social sciences does not suggest a single strategy for intervention. "While a variety of programs has demonstrated a reduction in youth smoking, there is no single model that can be implemented everywhere or that works consistently," said Thomas Glynn, of the National Cancer Institute. "There are strong hints that it is the simultaneous application of an amalgam of interventions and influences that lead to reduced smoking uptake and prevalence."

Population-based interventions should be a priority. Many discussants felt that the modest impact of most prevention strategies stemmed from their narrow and specific intervention site. The consensus seemed to be that a single school program, a modest tax increase, or a local counter-advertising campaign would have a limited effect, and there was a strong interest in more aggressive efforts to shift social norms and to influence mass behavior by using a multifaceted approach.

Picking up on that theme, other participants at the conference urged a stronger commitment by the public health community to engage politicians, policy-makers, school board officials, and others in a position to influence whole populations and affect policy changes on a large scale. Legislative initiatives that limit the supply of tobacco available to young people, tax policies, regulations that foster the development of safer products, and interventions that draw on the talents of health educators and the advertising community to alter perceptions of social norms and reduce demand were of particular interest. Other models that have succeeded in advancing widespread social change—such as the use of seat belts, the stigma now attached to drinking and driving, and recycling—were discussed.

Biology has the power to inform prevention in ways that may strike a responsive chord in parents, teenagers and policy-makers. Despite the gaps in basic biological knowledge, many opportunities exist to translate scientific findings into messages that enhance tobacco control. Concrete information about how nicotine alters biology may help shift cigarettes from the category of a consumer product to a lethal substance in the public mind. This evidence could also undercut the idea, popular among young people, that the real consequences of smoking do not become apparent for many decades, and that it is easy to quit long before their health is endangered.

Given the risk-taking behavior so characteristic of adolescence, however, the impact of biological information is by no means certain. "We seem to think that if adolescents just knew the real deal about nicotine, they would stop smoking," one participant observed. The opposite may, in fact, be true: "For some of them, knowing the real deal might be a motivator to continue the behavior." Strategies for countering that attitude and helping young people factor health into their decision-making need to be refined as part of any prevention effort.

Policies designed to prevent or reduce tobacco use need to be adopted cautiously, with the recognition that every action may have an opposite and unanticipated reaction. Many of the proposals advanced at the conference carried the risk of unintended consequences. When one participant proposed a campaign highlighting the manipulative tendencies of the tobacco industry, observing that young people do not want to feel that they are being controlled, another countered, "Today's youth are likely to be pro-business. Advertisements showing an 'evil industry' may go against their grain. It is adults who are more likely to have anti-business attitudes."

Similarly, the quest for safer cigarettes or alternative nicotine delivery devices encounters a minefield of obstacles. "If we bring down nicotine levels in cigarettes, we may create an enormous black market in contraband products," one participant said. The development of new products marketed as quit-smoking aids are another mixed blessing, conceivably tempting young people to begin smoking, convinced that they can easily buy a product to break their addiction if it does occur.

The impact of criminalizing tobacco possession by minors was also debated. Several people at the conference pointed out disturbing implications, especially in communities that have troubled relationships with the criminal justice system. There was also concern about diverting attention from merchants who sell tobacco illegally. Yet if criminalization proved to be effective, policy-makers would have to consider whether the benefits outweighed the risks.

Tobacco intervention programs should be rigorously evaluated so that they can be refined and replicated where appropriate. In the face of so many unanswered questions about what messages will help reduce the use of tobacco, the need for empirical validation of any intervention comes into sharp focus. "It takes time and money to evaluate prevention programs, and there is a tendency to spend limited funds on the intervention itself rather than on the evaluation," one prevention expert noted. Despite the expense, only

rigorous, formal evaluations can provide the data necessary for program replication; continuous quality improvement can help programs make midcourse corrections.

SUNDANCE PROPOSALS

After two intensive days of presentations and discussions, the conference participants broke up into two groups to identify the transdisciplinary research most needed in the next few years. Brainstorming sessions produced hundreds of ideas, and by the close of the conference those had been distilled into a handful of well-developed proposals, which are summarized in Exhibit 8.1. All six research areas require researchers from biologic, behavioral, epidemiologic and intervention disciplines, and four of them require human and laboratory animal studies, which would be linked to answer complex questions about the causes and progression of tobacco use.

The Sundance conference brought together scientists to stimulate thinking about new research questions and methods, but continued work is needed to bring their recommendations to life. Three other Foundation-funded projects carry forth the Sundance call for transdisciplinary science: the Research Network on the Etiology of Tobacco Dependence, the Stone House Project and a special study group at the Stanford Center for Advanced Study in the Behavioral Sciences.

THE RESEARCH NETWORK ON THE ETIOLOGY OF TOBACCO DEPENDENCE

The gaps in understanding of the basic causes, processes, and mechanisms of tobacco and dependence and the complexity of the research questions led the Foundation to establish a collaborative research network of scholars from diverse disciplines. Based on a research network model pioneered by the MacArthur Foundation, the Research Network on the Etiology of Tobacco Dependence was funded for eight years at \$8 million. It began its work in October 1997. The Research Network consists of a scientific core group of 14 distinguished scientists who have made a commitment to work collaboratively for eight years. Located at different institutions, these scientists represent diverse disciplinary perspectives, including anthropology, behavioral pharmacology, economics, epidemiology, genetics, neurobiology, psychology, quantitative methods in behavioral research and sociology. They have knowledge of tobacco or expertise on addictive substances other than tobacco, and interests ranging from basic laboratory research, to applied clinical research, to the development and evaluation of intervention strategies in the community. Rather than constituting an exclusive working group, the core group will serve as a catalyst and stimulus to the field, attracting senior scholars to include tobacco dependence in their research

agendas and building capacity in the field by attracting junior scholars into research on tobacco use and dependence.

The goals of the Research Network are the following:

- To make major scientific advances in understanding the transitions from initial use of tobacco to regular use to dependence.
- To develop and introduce new models and methods for understanding these transitions.
- To demonstrate the critical importance and the practical utility of transdisciplinary research in understanding complex and recalcitrant problem behavior.
- To expand significantly the scientific research capacity for the study of nicotine and tobacco in all the relevant disciplines.
- To create a comprehensive base of scientific knowledge out of which can emerge a variety of truly effective prevention strategies, as well as interventions for reducing tobacco use and dependence among young people.

During the first two years of the Research Network's operation, the scientific core group and consultants will identify the gaps in knowledge from the perspective of various disciplines and develop a research agenda to fill in those gaps. This will be accomplished primarily through meetings of the scientific core group, informal visits among its members to discuss specific research studies, and the creation of task forces of two or three core group members and outside consultants.

During the second phase, from the third year through the seventh, the Research Network will conduct studies to expand the theoretical, conceptual, measurement, and analytical paradigms guiding work on tobacco dependence. In addition, the Research Network will expand the scientific capacity for conducting research on tobacco through workshops, summer institutes, and special topical sessions at professional meetings. The final phase of the Research Network, which will last approximately a year, will integrate the scientific findings emerging from its work into presentations for a variety of audiences.

The success of this network will be measured by the following:

- The degree to which new paradigms and findings frame the research questions being asked in the field about tobacco use and dependence.
- The number of senior and junior scientists who make nicotine and tobacco the focus of their research careers.
- The amount of interest in and efforts made to use transdisciplinary networks as a means of understanding complex phenomena that cannot adequately be understood by traditional funding and research mechanisms.

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- Most importantly, the incorporation of significant new findings about the causes of transitions in the use of and dependence on tobacco into new and more potent prevention and treatment strategies.

There are multiple pathways to tobacco dependence that involve genetic, biological, psychological, social, environmental, societal and cultural elements. The Research Network will map these pathways for successive generations of scientists and practitioners to use in reducing the toll of tobacco dependence on our society and its citizens.

THE STONE HOUSE PROJECT

Scientists at the Sundance retreat and Research Network meetings identified the barriers to understanding why young people start using tobacco and why they move from experimentation to dependence. They challenged the Robert Wood Johnson Foundation, partner agencies, and themselves to lower these barriers. As a result, in October 1997 the Foundation, in collaboration with the Office of Behavioral and Social Science Research of the National Institutes of Health (NIH), convened a meeting of North American research-funding agencies and researcher representatives at the historic Stone House building on the NIH campus. Also present were representatives of six NIH institutes as well as the Centers for Disease Control and Prevention, the National Academy of Science, the Food and Drug Administration, the Medical Research Foundation of Canada, the National Cancer Institute of Canada, the Howard Hughes Medical Institute, the American Cancer Society, the California Tobacco-Related Disease Research Program, the Addiction Research Foundation of Ontario, the Research Network, and the Uniformed Services University of Health Sciences.

The participants called for more strategic use of existing research, and noted that transdisciplinary research on preventing the use of tobacco could strengthen the relationship between basic science and policy. Ideas such as holding transdisciplinary summer institutes for young researchers were debated. In the end, the participants agreed to form working groups to explore what could be done about barriers in seven areas: delineating the critical research questions; assembling a compendium of research already completed; evaluating models to improve training for scientists; identifying professional and funding barriers and ways to overcome them; linking data systems in order to monitor outcomes and share research findings; translating science into practice; and improving communications and collaboration among funders. The Foundation funded the Center for the Advancement of Health to convene the working groups and expand them to include additional scientists and funders. The working groups met

throughout 1998, and their recommendations were discussed and modified at a conference held at the Center in late 1998.

STANFORD CENTER FOR ADVANCED STUDY IN THE BEHAVIORAL SCIENCES

The Robert Wood Johnson Foundation—in collaboration with NIH's National Institute on Drug Abuse, Office of Behavioral and Social Science Research, National Cancer Institute, and Office of AIDS Research—is funding a special study group of six fellows to work on a three-year project with the Stanford Center for Advanced Study in the Behavioral Sciences. The center has been hosting groups of scientists for 45 years in its efforts to strengthen the behavioral sciences. The study group's charge is to recommend science-based prevention strategies for related health-defiant behaviors such as licit and illicit drug abuse and risky sex.

The study group members will combine approaches from various disciplines to develop technologies of behavioral change, recommend new research strategies, and identify solutions for ending the lack of connection between research and its application to prevent smoking. Some of the questions they will explore are the following:

- Can a new paradigm be developed from a synthesis of existing data and theory?
- Are there new research and modeling tools that can be applied to these questions?
- Do behaviors that threaten health have links and common elements that can help to build theories that apply to all of them?
- Are there methods to prevent and change behaviors harmful to health that could prove to be cheaper and faster than current methods?
- What are the barriers to adopting effective ways to change behavior and prevent tobacco use, and how can they be overcome?

CONCLUSION

It is still too early to gauge the success of these projects, but there are signs that the Sundance conference and the Stone House project stimulated researchers and funders to explore transdisciplinary work. One Sundance biomedical researcher, for example, returned to Canada and convinced the human subject review committee at his institution to create protocols that will allow for biologic testing of novice teenage smokers. He is now engaged in research to measure puff patterns and nicotine exposure in adolescent smokers early in their smoking—a key factor in understanding how new smokers become addicted and one of the major barriers to improving prevention and cessation mentioned by Sundance and Research Network practitioners. Other researchers, who met for the first time at Sundance, are

pursuing funding for joint research projects. Two recent NIH tobacco and drug abuse grant announcements called for multidisciplinary approaches to understanding dependence. The National Cancer Institute of Canada incorporated this approach into its new tobacco research initiative. In July 1998, the National Institute on Drug Abuse and the Robert Wood Johnson Foundation cohosted a National Institutes of Health conference, *Addicted to Nicotine*, that highlighted the newest science and unanswered research questions, from cellular to societal levels. This was the broadest science meeting of its kind ever held at NIH.

The Sundance conference and the projects that followed stimulated discussions among scientists and funders, resulting in a groundbreaking federal announcement of funding for transdisciplinary tobacco research centers. The National Cancer Institute and the National Institute on Drug Abuse allocated \$65 million over five years to fund six research centers that will use transdisciplinary collaborations to conduct research on difficult questions related to preventing and stopping tobacco use. The new centers, which began work in the fall of 1999, will provide an opportunity for scientists to act on the research ideas emanating from the Sundance conference and the other transdisciplinary science projects. They also will train young scientists in collaborative research approaches. The Robert Wood Johnson Foundation subsequently agreed to contribute an additional \$14 million to the centers to fund policy research and dissemination of innovations emanating from the centers.

Will transdisciplinary research emerge as a new form of scientific inquiry early in the new millennium? Will such science lead to discoveries that enlighten interventions into complex behavior that affects health? Will universities change the structures and the reward systems that cause "categorical silo" science to proliferate? Although years may pass before the ultimate outcome of these efforts becomes evident, dialogue within the scientific community does portend change. E. O. Wilson, in his book *Consilience*, hails the achievements of the medical and social sciences and notes their shortcomings:

Each of these enterprises has contributed something to understanding the human condition. The best of insights, if pieced together, explain the broad sweep of social behavior, at least in the same elementary sense that preliterate creation myths explain the universe, that is, with conviction and a certain internal consistency. But never—I do not think that too strong a word—have social scientists been able to embed their narratives in the physical realities of human biology and psychology, even though it is surely there and not some astral plane from which culture has risen.... The explanatory

network [of the natural sciences] now touches the edge of culture itself. It has reached the boundary that separates the natural sciences on one side from the humanities and humanistic social sciences on the other ... the line between the two domains can be easily crossed back and forth, but no one knows how to translate the tongue of one into that of the other. Should we even try? I believe so, and for the best of reasons: The goal is both important and attainable. The time has come to reassess the boundary.¹³

And in the February 1999 issue of *Science*, Norman Metzger, the executive director of the National Research Council's Commission on Physical Sciences, Mathematics, and Applications, and Richard Zare, the past chairman of the National Science Board, call for funders to back more collaborative scientific methods, support structures, and training. They note, "A substantial part of the history of U.S. research has been written by people who, against substantial cultural if not economic odds, have reached out to other fields, merging different perspectives and creating new ideas, even new fields."¹⁴

The National Cancer Institute, the National Institute on Drug Abuse, and the Robert Wood Johnson Foundation contribute in a small way, with their transdisciplinary tobacco research work, to improvements in scientific discovery. Fortunately, they are not alone. In an article entitled "Conversations with the Community: AAAS at the Millennium," the board of the American Association for the Advancement of Science called for more "creative forms of collaboration between scientists and society and for a broader range of disciplines and competencies to take part in the process."¹⁵

Notes

¹ For the sake of anonymity, a pseudonym was used.

² Centers for Disease Control. "Tobacco Use Among High School Students—United States, 1997." *Morbidity and Mortality Weekly Report*, 1998, 47, 229–233.

³ Ibid.

⁴ Ibid.

⁵ U. S. Department of Health and Human Services. *Preventing Drug Abuse Among Children and Adolescents*. NIH No. 97-4212. Bethesda, Md.: U.S. Department of Health and Human Services, National Institute on Drug Abuse, National Institutes of Health, 1997.

⁶ J. P. Pierce, E. A. Gilpin, A. J. Farkas and C. C. Berry. "Tobacco Industry Promotion of Cigarettes and Adolescent Smoking." *Journal of the American Medical Association*, 1998, 79, 511–515.

⁷ K. S. Kendler. "The Genetic Epidemiology of Smoking." *Proceedings of the Addicted to Nicotine National Research Forum*. Bethesda, Md.: National Institutes of Health, 1998.

⁸ R. F. Tyndale and E. M. Sellers. "A Common Genetic Defect in Nicotine Metabolism Decreases Smoking." *Proceedings of the Addicted to Nicotine National Research Forum*. Bethesda, Md.: National Institutes of Health, 1998.

⁹ R. J. McMahon. "Child and Adolescent Psychopathology as Risk Factors for Tobacco Use." *Proceedings of the Addicted to Nicotine National Research Forum*. Bethesda, Md.: National Institutes of Health, 1998.

¹⁰ F. J. Chaloupka. "Nicotine—Environmental Risk Factors for Initiation: Economics." *Proceedings of the Addicted to Nicotine National Research Forum*. Bethesda, Md.: National Institutes of Health, 1998.

¹¹ M. R. Picciotto, M. Zoli, R. Rimondini and others. "Acetylcholine Receptors Containing the Beta2 Subunit are Involved in the Reinforcing Properties of Nicotine." *Nature*, 1998, 391, 173–177.

¹² M. D. Volkow. "Brain Chemistry and Imaging." *Proceedings of the Addicted to Nicotine National Research Forum*. Bethesda, Md.: National Institutes of Health, 1998.

¹³ E. O. Wilson. *Consilience: The Unity of Knowledge*. Westminster: Knopf, 1998, p. 126.

¹⁴ N. Metzger and R. Zare. "Interdisciplinary Research: From Belief to Reality." *Science*, 1999, 283, 642–643.

¹⁵ American Association for the Advancement of Science. "Conversations with the Community: AAAS at the Millennium." *Science*, 1997, 278, 2,066–2,067.

TABLE

8.1 Small Working Group Recommendations on Priority Research Projects