

Appendix B

Federal Research Activities

Research on biological rhythms in this country has been directed primarily at the basic mechanisms underlying those rhythms. It has produced a marked increase in our understanding of the biology and functions of circadian rhythms over the past two decades, as reviewed in chapter 3. However, little effort has been made to apply these research findings to workplace issues, as reviewed in chapter 5. While it is clear that many of the findings from studies on animals can lead to identification of problems of circadian function in humans, there is a need for research aimed at identifying appropriate interventions to alleviate these problems, which affect the health, safety, family welfare, and productivity of U.S. citizens.

The Federal Government is the principal supporter of research on biological rhythms in this country. Its effort is distributed among various departments, agencies, and institutes, based upon their missions and priorities.

Department of Health and Human Services

National Institutes of Health

The National Institutes of Health (NIH) is the principal Federal agency supporting biomedical research. In fiscal year 1989, NIH funded 150 research projects focused primarily on biological rhythms, according to a search of the NIH's Computer Retrieval of Information on Scientific Projects (CRISP) database. Almost all were competitive grants to investigators in public and private institutions; only five were conducted by the NIH. About 40 percent of the biological rhythm research was supported by two institutes, the National Institute of Child Health and Human Development and the National Institute of Diabetes and Digestive and Kidney Diseases. Most of this research deals with the cyclic production of hormones and their influence upon reproductive functions and energy metabolism. Eight other NIH institutes and divisions funded the remaining 60 percent. Almost all of this research supported by NIH deals with the physiological bases of biological rhythms (primarily circadian rhythms) and their manifestations in endocrine, metabolic, reproductive, or sleep-wake functions. Many of these projects are aimed at delineating the neural circuitry that links the light signal to the biological clock in the hypothalamus (the suprachiasmatic nucleus) and to the neuroendocrine mechanisms which regulate other organ systems. Approximately half of the projects involved human subjects. This research should also lead to further understanding of other problems of circadian dysfunction, such as disturbed sleep, jet lag, and shift work. Only 5 of these 150 projects are directly related to the effects of shift work, with total expenditures of about \$250,000. Individual research projects averaged about \$112,000, and NIH expenditures

on research primarily related to biological rhythms totaled approximately \$17 million. This was about 2.5 percent of NIH's total budget of \$6.8 billion for fiscal year 1989.

Alcohol, Drug Abuse, and Mental Health Administration

The Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) is also a major supporter of biomedical research in this country. It had 46 projects on biological rhythms in fiscal year 1989, according to a CRISP search, most of them supported by the National Institute of Mental Health. Much of this research deals with the desynchronization and regulation of biological rhythms in psychiatric states, primarily depression. Goals of studies are not only to delineate the causes of these disturbances, but also to develop effective treatments for them. Other research is directed toward understanding the basic neural structures, processes, and functions of the circadian clock. Such efforts to elucidate the physiological mechanisms controlling normal and disordered biological rhythms can lead to improved diagnosis and treatment of the pathophysiological conditions associated with circadian rhythms dysfunction. ADAMHA funded 39 extramural grants at a cost of about \$4.6 million, or about \$117,000 per project.

Centers for Disease Control

*National Institute for Occupational Safety and Health—*The National Institute for Occupational Safety and Health is a component of the Centers for Disease Control. Its mission is to conduct and support research related to issues of occupational health and safety. Circadian rhythm and related shift work research is presently being conducted in one intramural laboratory, with funding of about \$100,000. Studies are being conducted on 12-hour work schedules as well as means of promoting adaptation to and coping with shift work (1).

National Science Foundation

The National Science Foundation (NSF) is an independent agency of the Federal Government established to promote and advance science in the United States. Research supported by NSF in the biological and social sciences does not include clinical research, either in human beings or in animal models of disease. Thus, the research on circadian rhythms supported by the NSF is basic research. In fiscal year 1990, NSF supported 24 grants totaling about \$1.2 million of the \$9.8 million allocated to the biological, behavioral, and social sciences. These projects dealt with fundamental molecular and cellular processes underlying biological rhythms

across a number of species. While the results from these studies will add to knowledge of the control of biological and circadian rhythms, no NSF projects directly addressed biological rhythms in the workplace (13).

Department of Veterans Affairs

The Department of Veterans Affairs (VA) supports an intramural research program related to its mission both with its own funds and with funding from other granting agencies. In fiscal year 1989, sleep disorders research received about \$800,000 in VA funds and \$1.4 million from other granting agencies. Within this program, four projects related to circadian rhythms received about \$350,000. Only one of these projects focused directly on the performance deficit associated with continuous operation and strategies for ameliorating it; the other projects dealt primarily with the neural mechanisms of sleep and sleep-related disorders. Total VA support of research in fiscal year 1989 was \$220 million (11).

National Transportation Safety Board

The National Transportation Safety Board (NTSB) is an independent Federal accident investigation agency. Its mission is to determine probable causes of transportation accidents and to formulate recommendations to improve transportation safety. It has investigated a number of major transportation accidents in which fatigue, sleepiness, sleep disorders, and circadian factors were involved. The NTSB does not have a research capability, aside from its very important function of gathering accident data and conducting special studies based on its investigative experience, but it does develop agreements with other Federal agencies when research is necessary (4).

Department of Transportation

Federal Highway Administration

The Federal Highway Administration (FHWA) supports research on highway safety in three general areas: safety design, traffic safety research, and traffic systems. The Traffic Systems Division is responsible for human factors research. In fiscal year 1989 FHWA awarded a \$1.4-million contract entitled, "Fatigue and Driver Alertness Study." The objectives of this study are to: 1) establish measurable relationships between commercial motor vehicle driver activities and physiological and psychological indicators of fatigue and reduced driver alertness, and 2) identify and evaluate the effectiveness of any alertness-enhancing measures that may legally be used by commercial motor vehicle drivers. In fiscal year 1990, a companion \$1.35-million contract, Physiological Measurement of Commercial Motor Vehicle Drivers, was awarded to the Trucking Research Institute (TRI) to complement the project through development and implementation of additional methods for collection and analysis of physiological data from the same group of

driver subjects. This contract is being funded jointly by the FHWA and TRI (6).

Federal Aviation Administration

The Federal Aviation Administration's (FAA) Civil Aeromedical Institute conducts two kinds of research to assess the performance of personnel in technical occupations. The first addresses individual performance, identifying factors such as workload and work schedules, equipment design characteristics, and operational stressors that positively and negatively affect it. The second type of research addresses system performance, evaluating the effectiveness and efficiency of agency recruitment, selection, and training programs for employees. Specific research projects currently under way include: 1) identification of the interactive effects of stressors such as age, sleep loss, altitude, alcohol, and fatigue on performance, and 2) analysis of the effects of a 10-hour workday and rotating shift schedules on measures of air traffic controllers' performance and attitudes (14).

The FAA is also engaged in cooperative research efforts with the National Aeronautics and Space Administration. The FAA is providing \$450,000 for three studies in fiscal year 1991 examining alertness and controlled napping, long-haul operations, and bunk rest for flight crews (9).

Federal Railroad Administration

The Federal Railroad Administration (FRA) is currently sponsoring research into the effects of work-schedule-related disruptions of sleep and rest patterns on fatigue and job performance. Most locomotive crews work highly irregular and unpredictable schedules, resulting in sleep loss and circadian desynchronization. The Volpe National Transportation Systems Center (VNTSC), a part of the Department of Transportation's Research and Special Project Administration, has been given tasks in two areas related to this problem. The first task is to work with the railroad industry to develop quantitative measures of work schedule irregularity in various groups of workers and to explore new approaches to scheduling in order to reduce problems. The second task is to design and conduct experiments to quantify degradation in train-handling performance and compliance with safety rules caused by sleep loss and circadian desynchronization. In addition, the FRA and VNTSC have an agreement with Transport Canada to study effects of fatigue. Funding for FRA-sponsored projects for fiscal 1991 is approximately \$400,000 (16).

U.S. Coast Guard and Maritime Administration

The Maritime Administration (MARAD) and the U.S. Coast Guard are collaborating in sponsoring research into a variety of issues, including scheduling of work and sleep, related to fatigue in the merchant marine and their

implications for safety. The VNTSC has recently completed a study of the potential impact on fatigue of reductions in maritime crew size. Results indicate that a major factor in fatigue is the concentration of work hours required during port calls. Ships that make frequent port calls, particularly those with irregular schedules, are likely to cause sleep loss because of disruptions in scheduling. The Coast Guard and MARAD are in the process of planning further research into this problem. Funding for the ship-manning programs, which sponsor the maritime fatigue research, is on the order of \$150,000 for fiscal year 1991 (16).

Department of the Interior

Bureau of Mines

For the past 6 years the Human Factors Group within the Safety Research Division of the Bureau of Mines has been committed to research activities on various work schedules in the mining industry. This research has principally been involved with factors that affect adjustment to work schedules and the effects of work schedules on variables such as sleep quality and quantity, eating, and physical and mental exhaustion. This project has received approximately \$150,000 per year and is funded through fiscal year 1991 (5).

National Aeronautics and Space Administration

Both the Life Sciences Division, Office of Space Sciences Application, and the Information Sciences and Human Factors Division, Office of Aeronautics, Exploration, and Technology, of the National Aeronautics and Space Administration (NASA) support research. The Life Sciences Division focuses on basic studies of biological mechanisms in animal systems and on the effects that extended time in space vehicles can have on biological rhythms and human physiology. The Information Sciences and Human Factors Division supports research and technology development for aeronautical problems in cockpit crew fatigue, sleep, and circadian rhythms.

As shuttle crews engage in missions longer than a week and planners look forward to missions lasting months, issues of circadian rhythms have emerged as critical to human performance. The Life Sciences Division sponsored a workshop in the summer of 1990 to develop a plan for circadian rhythms research. Concurrently, the application of available knowledge about circadian cycles during transmeridian flights in commercial aircraft has been the subject of applied research and technology at NASA's Ames Research Center.

NASA spent some \$2 million on circadian rhythm research in fiscal year 1991. About half was for intramural research and half for support of extramural research. Extramural research proposals are received both as

unsolicited applications and as responses to announcements. A recent announcement called for studies on human sleep, fatigue, and performance for missions over 13 days long. Questions of interest include how factors in space flight affect circadian rhythms and how to ameliorate any adverse effects. An example of this research is the feasibility of using bright light exposure to facilitate adaptation of astronauts to their work-rest schedules during extended missions (15).

Over the last 8 years, the Flight Human Factors Branch at Ames Research Center has conducted extensive field studies to examine the issues of fatigue, sleep, and circadian rhythms in flight crews. In some cases this research has been part of a cooperative effort with the FAA. The settings studied have included short and long commercial and military operations, overnight cargo operations, and helicopter operations. This work involved the collection of continuous physiological data; self-assessments of fatigue and mood; and information on sleep timing and quality, food and fluid intake, and the use of medications, alcohol, and tobacco. Funding for aeronautical research in this domain amounted to about \$750,000 in fiscal year 1991 (8).

Department of Defense

Department of the Army

U.S. Army Research Institute for the Social and Behavioral Sciences--The Army Research Institute (USARI) supports behavioral research in order to solve personnel-related problems of substantial concern to the Army. As part of a broad agency announcement issued in 1989 and again in 1990, USARI solicited proposals for fundamental research in behavioral science. One area for study was human chronopsychology--specifically, how interactions of chronopsychological variables and characteristics of a task determine performance accuracy and effectiveness. This program continues to be central to USARI's fiscal year 1991 research plans. One extramural project has been started under this program to study cognitive performance in relation to states of arousal and time-of-day variables.

USARI also supports research on the effects of continuous operations upon soldiers' performance. (In continuous operations, the military engagement is continuous but the demands upon the individual are not. This is in contrast to sustained operations, in which the individual has to perform throughout the operation.) Current research focuses upon the ability of soldiers to maintain optimal effectiveness and endurance in chemical defense situations for extended periods. How long can soldiers perform effectively while wearing chemical defense suits or being contained within tanks for up to 72 hours? What work-rest schedules for tank crews would maintain their ability to perform physical and cognitive tasks? Most of

this research is conducted as part of field exercises, although there is some contract work, which is expected to amount to about \$175,000 in fiscal year 1991 (7).

Medical Research and Development Command—Sleep research in the Medical Research and Development Command is conducted through the Walter Reed Army Institute of Research (WRAIR). Most of this research program is intramural, with only one extramural project now being supported, at a cost of about \$1 million in fiscal year 1989. The purpose of the program is to understand the effects of sleep deprivation on performance in situations of brief, fragmented sleep and extended duty hours. Field studies as well as laboratory studies are being conducted and have shown decrements in cognitive functioning (i.e., ability to think, plan, and act) in persons awake for up to 72 hours. Positron emission tomography (PET) techniques are being used to answer questions about brain activity during sleep. Intervention strategies, primarily pharmacological ones, are being investigated. For example, the use of caffeine to counter the effects of 60 hours without sleep and the use of hypnotic drugs to enable a subject to sleep under conditions not conducive to sleep (2,12,17).

The U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Aeromedical Research Laboratory (USAARL) also examine issues related to duty hours. The USARIEM evaluates the effects of various environmental factors on performance and develops appropriate strategies to reduce the adverse effects of such conditions. In addition, USARIEM conducts research and provides information upon which to base Army policy and guidance on biomedical and psychological factors limiting physical and mental performance. Since the work-rest cycle and timing of sleep are critical factors in performance, they are often key variables in research conducted at USARIEM. Laboratory and field studies have examined circadian variations in body temperature, cortisol, and spontaneous motor activity under various conditions related to military operations. Operational models to predict and prevent occupational stress by controlling the work-rest cycle have also been developed and tested. Research and development on appropriate nutritional, pharmacological, and behavioral countermeasures are currently under way. Research in this area was supported at a level of approximately \$400,000 for fiscal year 1990, and support for fiscal year 1991 will continue at that level (10). The USAARL studies pilot fatigue and safety issues, including the effects of long flights on helicopter pilots and field assessments of work-rest cycles, activity levels, and amounts of sleep obtained or lost by helicopter crews in various special operations units. Sleep deprivation and sleep stabilization and control experiments are conducted on aircrews who fly at night, to assess pilot flight control performance, cognitive performance, and decisionmak-

ing, as well as the efficacy of drugs in controlling sleep schedules during the day and slightly altering circadian rhythms (10).

Department of the Air Force

Air Force Office of Scientific Research—The Air Force Office of Scientific Research (AFOSR) supports research on the basic neural mechanisms of circadian rhythms. This research is conducted in a variety of experimental systems, from cell cultures to invertebrates to humans. The suprachiasmatic nucleus is of particular interest in much of this research, with questions ranging from the expression of gene-regulating factors and the modulating effects of neuropeptides on these cells in culture, to neurophysiological studies of photic (light) entrainment of this region of the brain in rats, to the effects of light and melatonin on the circadian rhythms of humans. This research is supported by extramural grants and intramural research at the U.S. Air Force's Armstrong Laboratory at Brooks Air Force Base; support totaled about \$1.5 million in fiscal year 1990 (3).

Department of the Navy

Office of Naval Research—The Office of Naval Research (ONR) supports programs emphasizing the creation and exploitation of a cumulative base of scientific knowledge from which new technologies can be developed to improve the effectiveness of Navy and Marine Corps personnel. There currently are no projects relevant to sleep or circadian rhythms or their effects on performance (18,20).

Navy Health Research Center—The Navy Health Research Center, in San Diego, is conducting research on sleep and circadian rhythms as they apply to activities and performance of personnel on ships and field maneuvers. These studies are documenting sleep profiles and circadian temperature rhythms during extended work and rest cycles in both laboratory and field situations. They are also investigating the use of pharmacological interventions and naps to improve performance under continuous operations and extended duty. In fiscal year 1989, support of these studies was about \$510,000 (19).

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