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Sleep and Behavior
Roseanne Armitage, Ph.D.

Sleep Disorders
Eric A. Nofzinger, M.D.
The SRS continues to grow and to strengthen its governance and program initiatives. Our current membership now exceeds 900. We hope to surpass our 1,000-member goal during the current year. In addition, to ensure that Sections encompass the primary areas of sleep research and to better balance the Society’s needs, SRS section titles and descriptions have been updated. Current Sections are: Basic Sleep Research, Circadian Rhythms Research, Sleep & Behavior Research, and Sleep Disorders Research. We encourage all members to review the revised section descriptions and to take advantage of the opportunity to establish an affiliation with a group of professionals who share common interests and ideas.

As we move forward and continue to build upon the efforts of the last two years, the SRS retained the services of Kathleen Henrichs, Ph.D., a nationally recognized expert in non-profit management, to facilitate our strategic planning process and to help the society focus on the best ways to utilize its resources and advance the profession. Input from Society Board members, other key stakeholders and leaders in the field was considered in the development of the three primary goals the society aspires to address in the next three to five years: professional development, sleep research and organizational and financial health.

Professional Development
Training continues to be a priority for the SRS. The result of a one-year-long prioritization and review of our training programs has been completed and is now posted on the SRS Web site at www.sleeprearchsociety.org/contentmgr/showdetails.php?id/2223. The Presidential Task Force on Trainee Related Issues recognized the outstanding contributions the SRS has made in this area, most notably with the successful annual Trainee Day and travel award programs. The task force also identified initiatives to strengthen and broaden other areas of our training program to include initiatives focused on development of faculty and research careers in the field. Our society leadership is currently evaluating Task Force recommendations and plans to implement new programs in this area.

Our strategic planning efforts reinforced this effort. New initiatives directed at early career and experienced career investigators will be developed. For young investigators, this may involve establishing a mentoring program, initiating novel teaching activities focused on career development, and potentially creating seed grants to fund institutions investing in young faculty members with sleep expertise. More senior investigators will not be forgotten. Potential activities to serve this population include the development of educational material such as slide kits for teaching and the conduct of focused topic-driven workshops to develop state-of-the-art papers on specific areas of research. If strategically conducted, this last activity has the potential to direct research, training and funding into areas identified as likely to grow in the future. It may also help researchers to be more responsive to NIH call for proposals in specific areas. Finally, we hope to develop a repository of archive materials pertaining to the founders of our field. This will include videotaping in-depth scientific interviews of our most established members for posterity.

Sleep Research
To promote and support research in the field of sleep, the SRS is recommending the appointment of representatives to authoritative government committees and councils. The Society will work cooperatively with other partners, including the AASM, NSF, and NIH, to increase funding for sleep research. We will increase collaborative work with these organizations to conduct workshops and develop position papers. In addition, the SRS strives to work even more closely with NIH institute officials to ensure that a reasonable portion of the NIH budget is used for the training of young investigators in sleep research. The SRS also hopes to strengthen its ties with the National Center on Sleep Disorders Research by more actively offering its expertise to the Advisory Board and for referring grant reviewers in the area of sleep.

Organizational Financial Health and Effectiveness
SRS can only become stronger if membership is active and the society is financially sound. We have invested significantly in restructuring the SRS into a more vibrant society and we now need increased membership to sustain progress, bring additional expertise, and develop new programs. We need to recruit members more aggressively in all the diverse scientific communities that do sleep research. All researchers funded by the NIH and the NSF to conduct sleep research should become SRS members. Additionally, the funding of the SRS is currently primarily dependent on a single source of revenue—our APSS Annual Meeting. It now needs to be diversified. Some of the educational initiatives we are planning should bring additional revenues over time. For example, the SRS is planning to develop slide kits and publications that could be marketed to the diverse elements of our field.

As we move forward, increased communication with the membership is a priority. We have already introduced the SRS update and will continue our efforts to encourage the exchange of information between the leadership and members. We also wish to enhance the SRS identity and visibility and to further solidify our organizational structure.

The continuing NIH interest in promoting sleep research and education is also picking up. A very exciting development sponsored by the SRS and other sleep societies was the NIH Translational Conference, an
innovative two-day program that assembled health care providers, public health and education experts, policy makers, patient advocacy organizations, sleep medicine specialists and other stakeholders. The conference explored how information about sleep and sleep disorders can translate into cost effective, comprehensive and broadly applied strategies that improve all aspects of sleep-related health care. To address this challenge, the Conference capitalized on the unique interdisciplinary expertise of all participants to develop an action plan with high potential for improving public health and quality of life.

Another area of research funding where opportunities for SRS members are likely to develop is the field of obesity as it pertains to the interaction with sleep. A program announcement entitled, “Diet composition and energy balance” (PA-04-033) was recently released, calling for better understanding how sleep may impact energy expenditure and feeding with possible effects on obesity in humans. As you are aware, obesity is increasingly considered a major threat to public health and was recently featured in the New York Times as a factor that will soon surpass smoking as a leading cause of death in America.

Our field is uniquely positioned to benefit from increased funding in this area. At the clinical research level, interactions between obesity and sleep disorders, such as sleep apnea, are obvious to all. Additionally, sleep deprivation has neurohormonal effects that could contribute to increasing appetite or changing energy expenditure; it may even explain associations between short sleep and obesity. Finally, as best exemplified by the work of Dr. Rechtschaffen, a former SRS President who recently received the NSF lifetime achievement award for his work, long-term sleep deprivation has metabolic effects that are eventually lethal. These interactions have led many in the field to believe that a function of sleep is related to energy metabolism regulation. We encourage all SRS members to carefully look at funding opportunities in this area, as the titles of the program announcements may not always feature sleep in an obvious way.

My continuing goal will be to work with all of you to support the field and help its development. I would like to thank all SRS members for their support.

Emmanuel Mignot, M.D., Ph.D.
President, Sleep Research Society
The Sleep Research Society recently held elections to determine leadership for 2004-2005. As scientific knowledge expands and the profession grows, the SRS requires strong leaders to continue to move the Society into the future and to implement programs that will benefit the membership. We anticipate continued growth under the new leadership, and thank the members who are rotating from their positions for their dedication to the Society and field.

The Board of Directors is comprised of four Officers, seven Directors elected by the eligible voting membership and the Trainee Member at Large. Charles Czeisler, M.D., Ph.D. was elected to serve as President-Elect. Dr. Czeisler brings much leadership expertise and knowledge of the field to the position with his extensive background in sleep medicine and biobehavioral sciences. As Sonia Ancoli-Israel, Ph.D. rotates to the role of President, Emmanuel Mignot, M.D., Ph.D. rotates to the role of Past President. The 2003-2004 Past President, Ruth Benca, M.D., Ph.D., rotates off the Board of Directors.

Chiara Cirelli, M.D., Ph.D. and Martha Gillette, Ph.D. were elected to serve as Directors for a three-year term. Dr. Cirelli began her long-time interest in sleep research in Italy and received her degrees in Neuroscience. Today, her focus is molecular and genetic approaches of sleep regulation. Dr. Gillette’s primary study is the mechanisms of the brain’s circadian clock. She also holds membership with various academic and scientific societies. Rotating off the Board of Directors as Directors are Michael Vitiello, Ph.D. and Christine Acebo, Ph.D. We appreciate their service and dedication to the Board of Directors and the energy and ideas they brought to the position.

Anne Germain, Ph.D. was recommended by an election of the student membership for appointment as the Trainee Member at Large for a one-year term. In this capacity, Dr. Germain will represent the interests of the student members of the Society. She is a non-voting member of the Board of Directors, replacing Daniel Taylor, Ph.D. who rotates off the Board in June.

The Sleep Research Society Sections provide Society members the opportunity to establish an affiliation with colleagues who share common interests and ideas. Section-sponsored activities and programs encourage and promote research and education in each area of specialty. Section Chairs are elected annually by the members of the respective section, and may serve up to three one-year terms.

The 2004-2005 chair of the Basic Sleep Research Section is Robert Greene, M.D., Ph.D. Dr. Greene’s major research interests are molecular, cell and systems neurobiology of central nervous system state control and function.

Helen Burgess, Ph.D., was elected chair of Circadian Rhythms Research Section. Dr. Burgess has conducted research in the field of sleep and circadian rhythms for more than 10 years. Her focus is on the basic properties of human circadian rhythms with applications to jet lag and shift work.

Rachel Manber, Ph.D., was elected as the chair of Sleep and Behavior Research Section. Dr. Manber is a licensed clinical psychologist, certified by the AASM in Behavioral Sleep Medicine.

Ronald Chervin, M.D., M.S., was elected as the chair of the Sleep Disorders Research Section. Dr. Chervin’s research interests focus on sleep-disordered breathing and its neurobehavioral effects, particularly sleepiness in adults and hyperactive behavior in children.

### New SRS Coordinator

The Sleep Research Society welcomes Kimberly McNamara as SRS Coordinator effective April 2004.

Judy Milton, who ably served as the SRS Coordinator for the past two years, has moved into a new position with reporting responsibilities that are within the American Academy of Sleep Medicine structure. McNamara has assumed the primary staff responsibility for managing SRS activities.

McNamara will be a considerable asset to the SRS as she comes to the Society with previous association management experience. She formerly was the Associate Director of Marketing and Communications for the Illinois Manufacturing Association, located in Oak Brook, Ill. Her professional experience and skills will aptly support the SRS.

As she becomes familiar with the organization, McNamara welcomes member comment and feedback. To reach her, send an e-mail to kmcnamara@srsnet.org, or call (708) 492-1093.
The Associated Professional Sleep Societies Annual Meeting is the professional highlight of the year for researchers and other sleep specialists. The 18th Annual Meeting in Philadelphia is expected to present many scientific discoveries to the sleep field.

In order to experience all of the scientific knowledge the Annual Meeting has to offer, program additions are being offered to benefit attendees and members of the sleep field. Featured this year is access to a personalized itinerary so attendees can plan their attendance at oral and poster presentations, symposiums, or discussion groups by criteria online. Also, clinical workshops will provide a new forum for clinicians to review and discuss challenges in sleep medicine, and will run concurrently with the poster sessions. Another first for the 18th Annual Meeting, all audio-visual presentations will be coordinated through a central server system. This change will eliminate delays between presentations that occur when multiple laptops are used.

As these new additions increase the Annual Meeting’s prominence, we expect interest in the profession to increase. The SRS is confident that scientific submissions will prove strong in number and quality. Every year, the APSS attendance has increased, along with high-quality proposals for post-graduate courses, symposia, and discussions.

The SRS Board appreciates the committee members and all members who contribute their time and energy to various initiatives in the sleep field. These efforts make a substantial difference in every aspect of the SRS, including the APSS Annual Meeting.

Members are invited to join one of the special interest Sections, which encourage the sharing of research and education through sponsored activities and programs. By participating in a Section, members are able to share their expertise in a specific area of interest, gain knowledge from colleagues, and help shape the research direction of the respective area by contributing ideas and offering recommendations.

SRS Sections are holding concurrent breakfast meetings at the APSS 18th Annual Meeting in Philadelphia. All meeting attendees are invited to attend the section meetings listed below. Meetings will be held on Wednesday, June 9 from 7:00 a.m. to 8:00 a.m. at the Philadelphia Marriott.

Section descriptions are posted on the SRS Web site. For additional information, please contact Kimberly McNamara via e-mail, kmcnamara@srsnet.org or at (708) 492-1093.
Strategic Planning Executive Summary Available Online

In the summer of 2002, the Sleep Research Society leadership initiated a strategic planning process. The early phases of this process included a preliminary restructuring of Society committees and a bylaw revision that strengthened governance.

The goal of the strategic planning process is for the Society to become more focused and cohesive in order to best utilize its resources for the advancement of the profession.

An executive summary of the strategic planning process is available on the SRS Web site, www.sleepresearchsociety.org, for members to review.

NIH to Host Research Festival

The National Institutes of Health will host its annual NIH Research Festival on September 28 to October 1, 2004. This four-day event is a showcase for the NIH intramural research program and features several events, including a keynote address, “The NIH Intramural Research Program: Current Status and Future Prospects,” by Dr. Michael M. Gottesman, Deputy Director for Intramural Research; scientific symposia and poster sessions; a job fair for NIH postdoctoral and clinical fellows and a scientific equipment show.

The deadline for poster abstract submissions is July 2, 2004. Relevant Research Festival and abstract submission information can be found at http://festival04.nih.gov.

American Academy of Neurology Honors Ronald Chervin, M.D.

The American Academy of Neurology honored Ronald Chervin, M.D., with the 2004 Sleep Science Award. His collective data shows that the respiratory cycle-related EEG changes predict behavioral responses after children have their tonsils and adenoid removed.

Sponsored by the AAN Sleep Section, the Sleep Science Award recognizes scientific breakthroughs in the pursuit of basic or clinical research in sleep. Dr. Chervin’s study suggested a way to improve the clinical utility of sleep studies and may possibly provide new insight into mechanisms by which sleep-disordered breathing affects the brain and behavior.

The American Academy of Neurology is dedicated to improving patient care through education and research. Dr. Chervin was honored during the American Academy of Neurology 56th Annual Meeting held April 24 – May 1 in San Francisco.

Decade of Behavior Research Award Presented to David Dinges, Ph.D.

David Dinges, Ph.D. has been identified as a recipient of a 2004 Decade of Behavior Research Award.

This annual award, developed through the Decade of Behavior initiative, recognizes high caliber research that has had a demonstrated impact on policy or society at large, has contributed to the use of social and behavioral science knowledge in policy settings, or has enhanced public understanding of behavioral or social science principles.

Understanding his significant contribution to the behavioral sciences, especially the fields of health and safety, the Federation of Behavioral, Psychological, and Cognitive Sciences (FBPCS) nominated Dr. Dinges to receive the annual award. More information about the Decade of Behavior is available at www.decadeofbehavior.org/.

Harvard Announces the Establishment of Three Endowed Sleep Medicine Chairs

Harvard Medical School (HMS) announced on May 11, 2004, the simultaneous establishment of three endowed chairs all devoted to the emerging critical field of Sleep Medicine. The endowed chairs are a critical step forward in the on-going effort to establish sleep disorders medicine as a formally recognized medical discipline, and to forge a path of discovery while providing training for the next generation of researchers and clinicians.

The three chairs are named after the founders and Chairmen of three publicly listed companies that have been innovators in sleep therapy: Dr. Frank Baldino, CEO of Cephalon, Inc.; Mr. Gerald E. McGinnis, Board of Chairmen, of Respironics; and Dr. Peter C. Farrell, CEO of ResMed.

Charles A. Czeisler, Ph.D., M.D. is The Frank Baldino Jr., Ph.D. Professor of Sleep Medicine, which was the first of the fully-endowed chairs. David P. White, M.D. will fill The Gerald E. McGinnis Professorship of Sleep Medicine. The third chair, The Peter C. Farrell Professorship of Sleep Medicine will be filled at a later time and an international recruitment is underway to bring a researcher to HMS.

According to a statement released by HMS, these three new chairs will aid the Division of Sleep Medicine as it provides greater focus on critical sleep disorder issues and helps to inform public policies aimed at decreasing sleep/alertness-related injuries and the costs associated with them. The endowment for each chair when fully funded, $2.75 million each, will greatly expand the capacity of the division to embark on creative avenues of research that might not garner traditional federal support.

To read more about this advancement for the field, visit http://134.174.17.106/news/releases/0504sleep.html.
As always, this has been a very busy year with regards to trainee activities. The Trainee Day sub-committee has finalized the Associate Professional Sleep Societies Trainee Day program and career fair. Substantial progress has been made in developing a new Web-based trainee directory. The nomination process for the trainee member-at-large elect has progressed. Steps have been initiated to reactivate a trainee listserv.

In addition to having the responsibility of representing student interests on the Sleep Research Society’s (SRS) Board of Directors, the single most important job of the Trainee Member at Large, with the help of the Trainee Day sub-committee and oversight of the Trainee Education Advisory Committee, is the organization of the SRS Trainee Day Symposium held in conjunction with the APSS Annual Meeting. The purpose of Trainee Day is to educate, inspire, and motivate trainees, as well as provide a rare opportunity for them to interact with the leaders from their respective sleep research fields. The members of the Trainee Day sub-committee this year are: Daniel Taylor, Ph.D. – Chair, Anne Germain, Ph.D. – Trainee Member at Large-Elect, Sabra Abbott, Stuart Fogel, Carie Holladay, Lisa Meltzer, Ph.D., Jonathan Peever, Ph.D., Tracy Rupp, M.S., and Catherine Vena, R.N., M.S.N. This year, over 20 trainees volunteered to serve on the sub-committee. In recommending appointments, there was an effort to ensure that the Trainee Day sub-committee reflected the diversity of this multi-discipline field. Areas of focus include: behavioral sleep medicine, cancer, circadian rhythms, behavioral neuroscience, pediatrics, biology, adolescent psychology, neurobiology, and nursing. It was hoped that this diversity in interests would produce a Trainee Day with enough variety to be of interest to the majority of trainees. Although I think this is the best Trainee Day to date, there is always room for improvement and new ideas. Please consider volunteering when Anne Germain, Ph.D. solicits for sub-committee members for the 2005 program.

In addition, the sub-committee has organized the career fair to be held in conjunction with the Trainee Day reception at the end of the day’s activities. The impetus behind the career fair is to give trainees the opportunity to meet with representatives of academic institutions and industry regarding educational and professional opportunities in the field. We expect a large turn out and a successful event.

The trainee directory is a resource for institutions to publicize educational programs and for trainees to explore advance training opportunities. Based on trainee recommendations, the SRS has allocated funds and space on their Web site to update the directory. This is an immense-ly important undertaking. Without this resource, many of our current trainees might not have been able to locate their current mentors and training programs. In addition, the single most important way to ensure the growth of the field is by bringing together interested trainees and suitable mentors. That being said, the trainee manual is only as successful as the information in it. The Trainee Member at Large-Elect, Anne Germain, Ph.D., has been working diligently with SRS staff to create and finalize the online directory, in an effort to make it more user-friendly. The Trainee Directory will be publicized through the SRS electronic updates, as well as the SRS Web site. It is imperative that those individuals with training opportunities go to the Web site and enter your information. Look for the announcement regarding the directory update soon.

Each year, nominations are accepted for the position of SRS Trainee Member at Large (Trainee Representative). The duties of the representative include participating in SRS Board Meetings, coordinating APSS trainee-related activities and contributing a trainee-related article for publication in the SRS Bulletin. The Trainee Member at Large gains invaluable experience working closely with the members of the SRS Board of Directors and providing input regarding Society initiatives and programs. The position of SRS Trainee Member-at-Large requires a two-year commitment. This year, Sabra Abbott and Fiona Baker were nominated for the position, and ballots were mailed to all trainees.

I am in the process of trying to work out an arrangement for a renewal of the trainee listserv. In the past the “T-net” has been run by the Trainee Member at Large. However, it was been difficult to maintain due to the increased mobility involved with training (e.g., I have lived in three different states since being awarded this position) and the necessity of a server to operate a listserv. This is an ongoing process that will require a creative solution. Possible options include, but are not limited to: the SRS providing a moderated listserv, with all communications being processed through the national office; a member of the SRS volunteering to operate the listserv on their institution’s server indefinitely (similar to the way SLEEP-L is currently operated); or disbanding the trainee listserv. If you have any input in this regard, please do not hesitate to contact me at dtay15@mednet.swmed.edu.

Student BITS is a section of the SRS Bulletin reserved for issues pertaining to trainees involved in sleep research. Undergraduate, graduate, or postdoctoral trainees are welcome to submit articles for this section of the Bulletin. Please contact the national office for upcoming deadlines and information.
II. Attempts To Demonstrate Functional Changes In The Nervous System During Experimental Insomnia

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Deprivation of sleep, however produced, results in a group of varying subjective symptoms and a feeling of decreased efficiency in the performance of daily tasks. In a previous paper (1) by one of us it was reported that no variation from the normal could be detected in a large number of functions of the human organism during sleeplessness, and that certain changes could be explained by greater muscular relaxation of the sleepy subject. The purpose of this study was to determine if any changes occur in the activity of the higher and lower centers of the nervous system as a result of prolonged deprivation of sleep. The work of Patrick and Gilbert (2), of Aschaffenburg (3) and Roemer (4) all points to the deterioration of some functions, but insufficient data of normal daily variations in these functions before and after the tests are given to render their conclusions above question. Smith (5), on the contrary, reports the effect of several short sleepless periods on one subject to be increased efficiency immediately following the period of insomnia, succeeded by a few days of gradually decreasing efficiency. Recently Robinson and Herrmann (6) concluded from well-controlled experiments that the results of the tests performed “were not affected by insomnia in any marked or consistent manner.” The data obtained by them during the sleepless period fall within the daily variations during the control periods and, in the main, their results were negative.

In our work we followed the method employed by Robinson and Herrmann. Our study has extended over nearly one year with very, long control periods between insomnia tests. The daily test occupied about two hours, and, for this reason only one subject was employed. He underwent six sleepless periods, three of 60 hours, two of 90 hours, and two of 114 hours. Two of these insomnia tests were made in the fall, two in the winter, one in the spring, and one in the summer. The various determinations were made by the same experimenter and under the same conditions throughout the entire series of experiments. The tests were made once daily at the same hour, both during the control period and during insomnia, and with each new experiment a new hour was set. On some occasions the tests were made twice each day, in the morning and in the evening. The subject was a male student, 28 years of age of medium height and weight, and in good health. He is a good sleeper normally, and during the control periods adhered to a strict schedule of hours of sleep, meals and work. During the periods of insomnia he ate and worked as usual, but could keep himself awake only by continued activity. An assistant was constantly with him to prevent his falling asleep.

METHODS. In the selection of the tests we wished to include only those which in the hands of other workers had been found capable of demonstrating the effect of fatigue and of drugs, and which were found suitable for long-repeated use and quantitative treatment. The tests chosen fall into two classes: those in which effort can in no direct way be a factor, and those in which it may be one of the factors. The first group consists of the knee jerk, pupillary reflex, determination of the sensory threshold for faradic stimuli, and a test for steadiness. The vascular skin reflex described by Marey, Mueller and others, and used as a quantitative test by Ryan, proved unsatisfactory in our hands. In the second group we include reaction time, naming of opposites, color naming, cancellation and mental arithmetic. We took some records of the frequency of the inversion of the image of a cube or other solid object, when a simple drawing of it was fixated, but did not succeed in standardizing the condition of the test and therefore abandoned it. Determination of the threshold for auditory stimuli was likewise found impracticable in our laboratory. In all of the tests finally used, except mental arithmetic in which improvement continued throughout the year we were able to reach satisfactory practice levels during the control periods.

Knee-jerk. The subject was seated in a comfortable semi-reclining chair, his leg hanging free from the knee, at eight angles to the thigh. A fine nonelastic wire attached to the heel by means of a stirrup was passed over a pulley to a writing point registering on a slowly moving kymograph. This simple time-honored method in which the extent of the kick was measured by the movements of the heel is proportional to the height of the excursion of the writing point proved reliable and accurate enough for comparing the performance of the same individual on different days or under different conditions. The stimulating device consisted of a spring hammer in which the strength of the blow depended upon the degree of compression of the driving spring and could be changed at will, while the extent of excursion of the hammer and the consequent depression of the tendon remained the same, thus rendering the mechanical component of the knee jerk a constant. The various screws and hinges made possible very accurate adjustments, so that the hammer could be made to strike the tendon perpendicularly and always at the same point. The hammer was released electrically by means of a suitable key, which could be operated at a distance. A sketch and description of this device are given in figure 1.

The first stimulus was given after the subject had been reclining in the chair for 10 minutes, relaxed, silent, and with eyes closed. We obtained consistent results when we averaged ten successive knee jerks elicited at irregular intervals of 15 to 30 seconds each. Our preliminary work showed that if less than 15 seconds elapsed between blows, the second response was markedly affected by the first; in some subjects it was increased, in others decreased. It was also observed incidentally that the extent of the knee jerk was, up to a certain point, directly proportional to the strength of the stimulus and then decreased as the strength of the stimulus increased—because of the stimulation perhaps of the antagonistic flexors as well as the extensors. The optimum stimulus was determined for our subject and thereafter was used throughout the experiment.

Pupillary reflex. The reflex of the pupil to light and accommodation was determined by placing in front of the subject an opaque box containing...
a powerful electric light and equipped with suitable chin and forehead rests. In the front wall of the box was inserted a large disc of frosted glass which could be covered by a sliding paper screen. When this only slightly translucent screen was in place, enough light would diffuse through to illuminate faintly the face of the subject. When the screen was removed the bright light fell on the pupils of the subject. The observed eye was a constant distance, about 4 inches from the source of light. The observer looked at the pupil through a telescope from a distance of approximately 8 feet. This telescope contained a fine cross section scale which projected on the image of the pupil gave a very accurate indication of its size. After one minute in which the eye became adapted to the feeble light and the pupil no longer changed in size, a reading was taken, and the screen removed. Ten seconds were given for adaptation to light, and a second reading taken. Up to this point the subject was maintaining a relaxed accommodation. Then at a given signal the subject would accommodate for the bright disc of glass and a reading was taken 2 seconds later. This procedure was repeated three times and the average for the day obtained.

Sensory threshold for faradic stimuli. The method and technique of Martin were followed, and for a detailed description the reader is referred to his original work (7). We assumed that the tissue resistance was the same throughout the experiment.

Steadiness. As there has been no test for steadiness described in which the technique and scoring are wholly satisfactory, we used a method suggested by some unpublished work of Dr. A. I. Gates of Columbia University. A special instrument was devised consisting of a cylinder fastened upright to a head band. The upper end of the cylinder was stoppered with a cork, and through a channel in the cork was passed a wire fastened to a spring located within the cylinder (fig. 2). When this instrument had been firmly adjusted to the forehead of the subject, a horizontal metal plate covered with smoked paper was lowered on a standard until the paper just touched the end of the vertical wire. The easy compressibility of the spring within the cylinder insured continuous contact of the writing point and the smoked surface and free play over the latter. Still more delicate adjustment was obtained later by attaching the

![Fig. 1. A sketch of the apparatus used to stimulate the tendon in eliciting a knee jerk. MB is the main bar which connects the device with an adjustment-stand or with an adjusting arrangement on the chair on which the subject is seated. By means of adjustment screws not shown on the figure the entire apparatus may be moved up and down, forward and backward, and from side to side. The brass plate BP to which the various parts of the apparatus are attached is joined to the main bar by the hinge Hi and is generally kept in a vertical position, but can be fixed at any desired angle with the aid of the screw Si. This makes it possible to use the apparatus with the log in any position in reference to the thigh. To the plate BP is attached a hollow brass cylinder C carrying a strong steel spring (not shown) fastened to the stimulating hammer Ha. The degree of compression of the spring, and therefore the force with which the hammer is driven, is determined by fastening the end of the spring to the hammer at any point along the cylinder by means of the screw Si. In setting the apparatus the hook, Ho is placed in a groove near Si, and the movable bar pulled toward the stationary bar SB until the end of the brass trigger T can be fitted into a notch at the end of the hammer. EM is an electromagnet connected to a cell and a key at some distance from the subject, and when the circuit is closed the electromagnet attracts the iron plate IP at the end of the trigger, turning the latter and so releasing the spring hammer. The side piece SP limits the excursion of the tendon constant irrespective of the force of the blow. By means of the rubber pad RP operated by the screw S2 the distance from the cross-bar at the end of the hammer to the tendon may W kept constant or varied at will. The apparatus designed by one of use for use in her studies of individual reflex variability now in progress was made by Mr. August Johnson of our laboratory and was found to give very good results.

![Fig. 2. A sketch of the device used in the steadiness test. The apparatus was strapped to the head of the subject and the wire allowed to record the swinging of the body by lowering a horizontal metal plate covered with smoked paper until the paper touched the tip of the wire. The fine spring which carried the wire insured continuous contact between the wire and the smoked surface, with the minimum of friction. The recording was entirely inaudible.
paper loosely to the plate. The subject was told to “stand still” with the eyes closed, as in the Romberg test, and a tracing of the writing point was taken for 2 minutes. As the instrument was perfectly noiseless, he was unable to tell the extent of the excursion of the writing point, and therefore made no especial effort to decrease the magnitude of the oscillations of his body on the days that these were greatest. The records obtained by this method lend themselves only roughly to numerical treatment, but their interpretation is not difficult.

Reaction time. For the determination of the reaction time the Johns Hopkins chronoscope described by Dunlap (8), (9) was employed. The instrument we used was made by the Stoelting Company for the University of Chicago, and was provided with a pneumatic key.1 The reaction time was read off in sigmas. We took auditory and visual reactions. The auditory stimulus was of the “suspected” type, i.e., a telegraph apparatus was clicked at intervals of from 1 to 10 seconds after the signal “ready” was given. Visual reaction was of the choice discrimination type, the subject being instructed to react to yellow or green light only, and the color of the light changed at will by the experimenter. The interval of time between the signal “ready” and the stimulus in this case was the usual one of one second. Forty auditory time tests were made at each sitting, and thirty- two visual (twenty correct stimuli and twelve incorrect ones, arranged in chance order).

Naming of opposites. We prepared a list of fifty words, such as was used by Bonser, Hollingworth and others. The same words were printed on six cards, in different order on each card. The subject had to look at the card and read off the opposite of each word as rapidly as possible, the total length of time it took him to name the fifty opposites being determined by means of a stop watch. Thus on looking at the words “drunk, sacred, stale, hostile, noisy,” he would read off loudly “sober, profane, fresh, friendly, quiet.” Each day a different card was used, and it was therefore impossible for him to memorize the order of the opposites.

Color naming. On a square piece of cardboard were pasted, in chance order, 100 little squares of colored paper, I cm. square and I cm. apart, red, yellow, brown, black, gray, violet, green, blue, pink and orange—ten of each color. A different arrangement of colors was obtained by rotating the card successively through an angle of 90 degrees. In our first series we followed exactly the method described by Hollingworth (10). The card was placed face down before the subject and turned over at a given signal. At a second signal the colors were named as rapidly as possible in reading sequence. The experimenter called the subject’s attention to every mistake made, and had him correct it before proceeding. The score was the total time necessary to name the 100 colors correctly. In a second series of experiments, after the 100 colors of one card had been named, another card with the colors in a different order, was immediately placed before the subject, and in this manner the number of colors correctly named in 15 minutes determined. A third series of experiments consisted of a daily record of the time necessary to name 1200 colors (12 cards) without correction of errors. The latter were observed by the experimenter on a duplicate card, and recorded both as to the errors that the subject himself corrected and as to those he left uncorrected. Both this test and the one of the naming of opposites have been found by Hollingworth to show diurnal variation, influencing fatigue and the effect of caffeine.

Cancellation. Printed lists were prepared on which the digits 2 to 9 inclusive appeared each 50 times, making 400 figures in all. They were arranged in rows of 12 and 13 alternately in a chance order. We followed the pattern used by Franz, but extended it in length (11). The subject was told to go through the entire list as rapidly as possible, crossing out a certain one of the digits, say, all the 4’s. On a second card he was instructed to cross out two digits, on a third three digits. Different digits or combinations of digits were designated by the experimenter each day, and the time it took the subject to go through each of the three cards as well as the number of errors recorded.

Mental arithmetic. Two numbers of two digits each were written on a card which was given face down to the subject. At a given signal, he turned it over and multiplied one number by the other, mentally, the score being the time it took him to obtain the correct answer. As the subject kept on improving with practice, the test was made harder by using one number of two and another of three digits, and finally two numbers of three digits each. As stated above, we never reached a practice level, the time curve going down continuously, but we hoped to detect a break in the curve in case a lowered ability to multiply mentally should develop during insomnia.

RESULTS. In a general way the various functions were little affected by the loss of sleep. The amount of numerical data we collected during the past year is enormous, and we spent a good deal of time in tabulating and plotting our results. Were not the control periods before and after the insomnia tests of such long duration, the interpretation of our results would have been different. As it is, the values obtained are well within the limits of the diurnal curves, and those who have read the paper by Robinson and Herrmann (6), who obtained similar results, will understand why we refrain from giving tables and curves in this paper. Some functions studied showed, however, very definite changes during sleeplessness, and those we shall report more in detail.

The extent of the knee jerk varied from day to day in out control periods, but only within very definite limits. No change whatsoever could be observed in the knee jerk as a result of sleeplessness. Toward spring the knee jerk disappeared altogether, and could be elicited only by Jendrassik’s method of augmentation. At this time it was absent also in insomnia, and when brought out by reinforcement, it did not differ in extent from the knee jerk obtained normally by this method. Incidentally we found that squeezing the hands together tightly or any such powerful outpouring of motor impulses to the skeletal musculature was not usually necessary to augment the knee jerk or to elicit it when absent. Ordinary speaking, as in answering a question, proved an efficient milder method of augmentation. It occurred to us that this method could be of us clinically when an ordinary stimulus fails to elicit a knee jerk. Another, interesting observation was the complete disappearance of the knee jerk, if the subject happened to fall asleep during the test. As stated above, he was required to lean back in the chair, silent, with eyes closed, for 10 minutes before the knee jerk was taken. During the periods of enforced insomnia he would often fall asleep under these conditions, and if this occurred no knee jerk was obtained. If, however, the experimenter woke him before releasing the hammer of the stimulating device, a normal knee jerk was obtained (fig. 3). If left undisturbed, the subject, under these conditions of complete muscular relaxation, would immediately fall asleep again, and this test could be repeated any number of times. It confirms the observation made long ago by Lombard (12) under somewhat different Conditions and seems to establish the fact that the knee jerk is lost during sleep.

In measuring the size of the pupil we found that it becomes smaller as a result of sleeplessness. In one experiment the average size of the pupil during the control periods preceding and following the insomnia period was as measured by the divisions on the telescope scale) 12.16 under faint illumination and 4.50 in bright light; during the period of sleeplessness (average of four daily observations), the corresponding figures for the size of the pupil were 10.55 and 4.68. The change in size or narrowing of the pupil due to bright light was 7.66 normally and 5.87 during insomnia. The narrowing of the pupil as a result of accommodation was negligible under any circumstances, but it is the very bright light caused a maximal contraction of the pupil. Indeed, sometimes a slight dilatation of the pupil could be noticed as a result of accommodation. In another experiment, with the light somewhat

1 We are greatly indebted to Professor Robinson of the Department of Psychology for the opportunity to use this delicate and accurate chronoscope.
stronger, the pupil changed in response to light from 8.18 to 5.63 during the normal control period, and, from 7.00 to 4.66 during insomnia.

In the sensory threshold for faradic stimulation, in the reaction time to auditory and visual stimuli, in the naming of opposites, in the cancellation, in the mental arithmetic tests, in none of these could changes be detected during sleeplessness that did not fall within the limits of daily variations during the control periods. During some insomnia periods we found, indeed, changes in these, but could not confirm them in subsequent tests. Insofar as color naming is concerned, we found no changes as a result of sleeplessness during the first series of experiments, when we used only one card, but in later experiments, when several hundred colors had to be named, and the attention had to be fixed on the color naming for as long as 15 minutes, we did detect an effect of insomnia. This was especially noticeable during the third series of tests, in which the subject, if he made an error, was not stopped for its correction. Thus during the control period of one experiment it took him 749.4 seconds on the average to name 1200 colors, with a daily average of 9 errors corrected and 4.2 unnoticed and therefore uncorrected. During insomnia he spent on the average 773.3 seconds in naming 1200 colors, and the average number of corrected mistakes rose to 12.7, and of uncorrected to 5.7. In another insomnia period of longer duration the change was more marked, as the subject spent on the average 792.5 seconds in naming 1200 colors as compared with 742.2 during the control period.

In the steadiness test the changes as a result of sleeplessness were very marked. In figures 4 are shown some of the records made by the instrument attached to the subject’s forehead. As the subject had his eyes closed and the writing device was noiseless, he had no idea how well or how poorly he was doing, and was very often surprised upon seeing the record he made. Occasionally the oscillations of the subject’s body were rather wide under the normal control conditions but they were invariably so during insomnia.

DISCUSSION. The only purely skeletal reflex function we studied, the knee jerk, showed no change as a result of sleeplessness. Although the method of recording in which the leg itself is used as a lever is admittedly crude, we are satisfied that had there been a change in the extent of the knee jerk we would have detected it. Thus in other experiments (to be reported soon) on the effects of certain drugs and of prolonged fasting on the knee jerk we used the same stimulating and recording devices, and had no difficulty in detecting marked changes in the reflex. Yet the onset of sleep abolishes the knee jerk altogether, and awakening restores it immediately. This is especially significant, because the position of the knee with reference to the spring hammer and the strength of the stimulus is the same in all of these cases. It would seem that as long as the individual is awake, the reflex centers, as judged by the center for the knee jerk, function with undiminished intensity, even though the period of wakefulness is prolonged to several times its normal length, which is 16 hours. It is not necessary to enter here into a discussion whether the knee jerk, is a true reflex, but it is generally accepted that its magnitude and even its presence depends upon the tonicity of the muscles involved. Its disappearance with the onset of sleep would indicate a coincident lowering of the tonus in the skeletal muscles.

The visceral reflex we studied, the contraction of the pupil in response to bright light, also shows persistence with practically undiminished intensity during sleeplessness. Unlike the knee jerk it can be elicited during sleep, even in deep sleep that follows a period of prolonged insomnia, although the response is more sluggish than during wakefulness (I). The size of the pupil, however, with dim light is considerably smaller than normal. There are so many elements involved in the control of the size of the pupil that it is difficult to interpret this finding. It may be due only indirectly to sleeplessness. As the eyes are kept open throughout the entire sleepless period, it may be that the continuous action of light on the retina is responsible for this narrowing of the pupil. We are not warranted in assuming that sleeplessness as such is the direct cause of this narrowing of the pupil.

The various tests involving mental as well as muscular activity of comparatively short duration gave negative results, and in this respect we can fully confirm the findings of Robinson and Herrmann. These investigators caution us against the assumption that the effort in the performance of daily tests, although theoretically always maximal, is practically so. In the long lasting control periods after the novelty of the experience

Fig. 3. The knee jerk record obtained during a sleepless period. The subject fell asleep before any knee jerk was obtained. The three arrows indicate that the subject was awakened before the stimulus was applied. After he was awakened for the for the third time, he was told to keep his eyes open for the rest of the test. Intervals between successive stimulations, about 30 seconds.

Fig. 4. The record obtained with the device shown in figure 2. A is a typical record obtained on March 23, 1923, just before the beginning of a sleepless period. B is record obtained with the same apparatus on March 25, 1923, after two sleepless nights. Both records were taken at 10 a.m. Some records obtained during sleepless periods were twice as large as that shown in B.
has worn off and the practice level established, the subject takes the daily
tests like any other routine task, and is not liable to put the maximal
effort into its performance. During the sleepless period, however, the
subject is spurred to do his utmost by the desire to show an undiminished
capacity for mental and muscular activity. The results obtained with the
color naming tests illustrate this possibility. In the first series of experi-
ments where the subject had to name only 100 colors, which he learned
to do in about one minute, no deviation from the normal could be
observed during sleeplessness. When, however, he had to name 1200 or
more colors in succession and had to keep his attention unflagging for
700 or 800 seconds, we found a marked qualitative and quantitative
change as a result of sleeplessness. In other words, the effect of
increased effort disappeared when the test became one of endurance.

In the steadiness test we obtained unmistakable evidence of the deterio-
rating effect of the lack of sleep upon the ability to maintain one’s equi-
librium. It was our impression that effort played no part in this test, and
perhaps that accounts for the positive results we obtained. How far the
unsteadiness manifested may be explained by simple muscular fatigue
we are unprepared to state at the present time. More work of a compar-
ative nature will be necessary to elucidate this point. As indicated in a
previous paper (1), the tests we performed were not strictly insomnia
tests. In order to keep awake the subject had to move about practically
all of the time and some of the results might be due to fatigue of the neu-
romuscular mechanism that was made to function uninterruptedly. As
the period of insomnia progressed, a tendency toward muscular relax-
ation became evident and it was increasingly more difficult to keep the
musculature in tonus. This alone might account for the progressive
inability to preserve equilibrium. It should be remembered, however,
that from the practical standpoint sleeplessness always involves a certain
amount of muscular activity which invariably accompanies the state of
wakefulness, is indeed one of its most characteristic features.

SUMMARY

1. Experiments were performed to detect any functional changes in the
nervous system as a result of experimental insomnia in man, the
periods of sleeplessness varying from 60 to 114 hours, and separat-
ed by long control periods.
2. The knee jerk is not affected by insomnia, but promptly disappears
with the onset of sleep.
3. The pupillary reflex persists practically unchanged during insomnia,
but in dim lights of standard intensity, the diameter of the pupa is
much smaller than normal.
4. The sensory threshold for faradic stimuli, the ability to react to audi-
tory and visual stimuli, to name opposites, to multiply mentally, -all
these show no change in insomnia, confirming the observations of Robin-
son and Herrmann, who used similar tests.
5. The ability to name colors was not impaired during insomnia, if the
number of colors was small (100), but when the subject had to name
1200 colors in succession, he spent more time and made more errors
than during the control periods, thus showing inability to sustain
attention under these conditions.
6. The power to maintain one’s equilibrium, applying the graphic
method to Romberg’s test, showed marked deterioration during
insomnia, but this was possibly due to concomitant muscular
fatigue.

We wish to thank Dr. A. J. Carlson for his aid in the selection of the tests
and the interpretation of the results.
The Sleep Research Society welcomes members who recently joined the organization. Our membership continues to grow — help us strengthen the impact of the profession by encouraging your colleagues to join.

Information regarding membership can be found on the Society Web site (www.sleepresearchsociety.org), or from Kimberly McNamara at kmcnama@srsnet.org.

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The Department of Health and Human Services (HHS) launched a new Web site that contains information about finding and applying for all federal grant programs. The Web site, www.grants.gov, will make it easier for organizations to learn about and apply for federal grants, the agency said in a release.

“For the first time, there will be a single government-wide source for information about grants programs across the federal government,” Secretary Thompson said. “By putting relevant information in one place, we’re helping to level the playing field for organizations less familiar with federal grant programs so that they too can identify and apply for appropriate grants.”

The site provides information in a standardized format across agencies, and includes a “Find Grant Opportunities” feature to help applicants find potential funding opportunities. It also contains an “Apply for Grants” feature that is intended to simplify the application process by allowing applicants to download, complete, and submit applications for specific grant opportunities from any federal grant-making agency.

Five agencies – the U.S. Departments of Commerce, Education, Energy, Justice, and HHS – have posted application packages on the Web site, and the site will be expanded as federal agencies continue to post information about additional grant opportunities.

For more information, visit www.grants.gov.
The sleep group at the Department of Biomedicine, Section on Physiology, University of Bergen, Norway was formed around 1980. Today the members of the group are: Associate Professor Chiara Maria Portas (head) and Professor Emeritus Reidun Ursin, Post-doctoral Fellow Eli Sørensen (who in August 2003 to August 2004 worked with the group of Mary Carskadon, Ph.D. at the Department of Psychiatry and Human Behavior, Brown Medical School, Brown University in Providence, Rhode Island), graduate students Jamne Gronli and Eldbjørg Fiske, master degree students Ingvild Saxvig, Eyvind Kvitvold and Anne Marie Kinn, and engineers Freydis Hamre (presently on leave of absence) and Jan Idar Hjelle (temporary). Professor Bjørn Bjorvatn, Section for General Practice, University of Bergen is also a group member. Bjorvatn and Ursin are members of Locus on Neuroscience of the Medical Faculty. The group is affiliated to the Center for Stress, Sleep and Health at the University of Bergen.

RESEARCH

There are four main lines of research in the group.

Neurotransmitters and sleep.

Studies of serotonin and sleep in particular have been the main area of research in the group for many years. Emphasis has been put on definition of sleep stages, clear scoring criteria for waking, two stages of slow wave sleep and REM sleep and validation of these stages (Nacklemann and Ursin 1993), and on development of an automatic scoring system and validation of this (Nacklemann et al 1994). In a series of studies, Bjorvatn investigated the modulation of sleep and waking by the serotonin receptors 5-HT1A, 5-HT1B and 5-HT2 (Bjorvatn et al 1992, 1995, 1997). Nacklemann studied the effects of a 5HT reuptake inhibitor on sleep and EEG (Nacklemann et al 1996a,b). Bjørkum studied the role of the descending serotonergic system in sleep and waking (Bjørkum et al 1995a,b, Bjørkum and Ursin 1996) and Sørensen concentrated on the role of the 5-HT1A receptor in sleep (Sørensen 2000, 2001a,b). Overviews of the results and the field of serotonin and sleep in general has been given by Bjorvatn and Ursin (1998), Portas et al. (2000) and Ursin (2002).

Portas brought microdialysis expertise to the group (Marrosu et al 1995, Portas et al. 1996, 1997, and did the first study on extracellular serotonin levels during the different sleep stages in rats (Portas et al 1998). We are quite proud of our combination of sleep recording and microdialysis, with the possibility of drug administration and evaluation of neurotransmitters in the extracellular fluid in unanesthetized animals. Recently, sleep and extracellular content of serotonin in the dorsal raphe nucleus (DRN) and frontal cortex following administration of the GABA_A antagonist bicuculline into the dorsal raphe nucleus have been studied, using simultaneous sleep recording and drug administration and extracellular fluid sampling via microdialysis. Preliminary results indicate that DRN GABA_A blockade increases extracellular serotonin dose-dependently in DRN (Fiske et al 2003). SWS-2 and REM sleep is reduced, SWS-1 also following the highest dose.

Sleep and depression

The possible link between serotonin, sleep and depression is a new research area for the group. A study of extracellular serotonin in sleep deprived rats concluded that extracellular serotonin was reduced during sleep deprivation, suggesting that serotonin does not play a major role in the mood-elevating effect of sleep deprivation (Bjorvatn et al 2002).

The chronic mild stress (CMS) model of depression described by Willner (1992) has been reproduced in our laboratory, and a study on sleep in this model is in press (Gronli et al. 2003). In further studies, we also found small behavioral changes in the model animals, both in sexual activity and open field activity. Presently, neurotransmitters in extracellular fluid from the hippocampus in model and control animals are studied. We will attempt to produce a more robust version of the CMS model on a selected strain of rats known to be very sensitive to stress.

Sleep and memory

The aim of our studies is to further explore the sleep – memory consolidation hypothesis. Subjects are tested with a battery of neuropsychological tests prior to a night of sleep deprivation (Saxvig and Portas 2002). Different sleep deprivation protocols are used, including partial sleep deprivation and selective sleep deprivation (SWS and REM sleep). After the sleep deprivation procedure, subjects are retested. The tests used assess different types of memory: declarative, procedural, spatial and emotional. We also have methodological goals; we want to develop batteries of tests optimally suited for testing the specific types of memory, and also to develop the sleep deprivation protocols best suited. Studies are also planned including sleep deprivation and neuroimaging (fMRI, Portas et al. 1998a,b, 2000a,b). The studies are parts of a larger project, combining experiments on humans and animals. In animals, we will study neurotransmitters and subcellular events following sleep deprivation.

Epidemiology

The group participated in Hordaland Health Study 1997-1999 (HUSK), a collaboration between the National Health Screening Service, the University of Bergen and local health services, which included sleep questionnaires from 8000 participants aged 40-45 years (Ursin et al 2002). Eli Sørensen is studying sleep in adolescents (Sørensen and Ursin 2000) and is now working on a project on sleep habits and circadian rhythms in this age group.

DOING SLEEP RESEARCH IN BERGEN, NORWAY:

The department has recently moved into a new high-tech building situated up in the hills by the funicular to the Ulriken Mountains, with a fan-
A spectacular view over the fjord and city of Bergen. The research areas are divided according to strict rules meant to limit the spread of animal antigens in the building. Thus, there is a so-called white zone (where animals are off limits) dedicated to cellular and molecular biology, a grey zone for acute animal experiments, and a black zone for chronic animal experiments and animal housing. In the grey and black zones there is compulsory use of special clothes and shoes. This is expected to reduce the development of allergies, which was an increasing problem in the old building. The facilities are excellent—we have sound proof and climate-controlled rooms for our sleep experiments. There is also a lab for experiments with humans, where the sleep-deprivation and memory experiments are being run.

Research money is a problem here—as it is in most places—despite the money generated from oil (most of the oil money goes directly into a pension fund). However, Chiara Portas’s position and the engineer are full time secure positions at the University of Bergen. Also, both the University and the Norwegian Research Council give grants for doctorate and post-doctorate studies.

Working with sleep and with intact organisms makes us special in a structure that is defined by classical medical school fields and is being more and more focused on cellular and molecular biology. And with the increasing specialization, we are something of an anomaly among physiology, psychology and pharmacology. We are, however, venturing a little bit into molecular areas too, both in sleep-depression and sleep-memory research, in cooperation with other neuroscientists in the department. However, after the New Year, the physiology department merged with the department of biochemistry and molecular biology and the department of anatomy and cell biology into a Department of Biomedicine.

REFERENCES


Fiske E, Gronli J, Hamre F, Bjorkum AA, Portas CM, Ursin R. Effect of bicuculline perfused in DRN on 5-HT levels in the DRN and FC. Sleep 2003, 26 (suppl): A17.


TECHNIQUES

- Polysomnographic sleep recording and analysis (custom made, Neckelmann et al 1996)
- EMBLA sleep recording system (Flaga, Iceland)
- Intracerebral microdialysis (CMA/Microdialysis AB)

DATA ANALYSIS TOOLS

- HPLC (High Performance Liquid Chromatography) for assessment of neurotransmitters:
- BAS (Bioanalytical systems) LC-4C amperometric detector and BAS Chromograph software. ESA (Environmental Science Associates) with CoulArray “Multichannel” electrochemical detector & CoulArray software.
- Sleep analysis: Somnologica (Flaga, Iceland)


