MEDICAL BULLETIN

UNIVERSITY OF *Minnesota*

in this issue

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VOLUME XXXVI, NUMBER 7 MARCH 1965

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Special Article

The Department of Physiology

Maurice B. Visscher, M.D., Ph.D.*

The history of any University of Minnesota department is a complex of personal and environmental influences, and the annals of the Department of Physiology are no exception to the rule. History is always a rather esoteric enterprise but it does illuminate the reasons for the present and the choices of pathways for the future.

It is always hazardous to let a participant write history, for the same reason that so many autobiographies are not worth reading—they often end up as exercises in self-justification. Even if every point mentioned is factually correct, there is always at least a feeling of uncertainty as to whether that which the author failed to mention may be more important than that which he did.

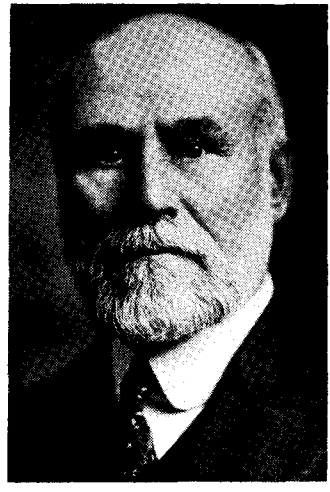
This is the fourth in a series of articles about the departments and divisions of the University of Minnesota Medical School. Next: The School of Public Health.

The University of Minnesota itself began as a kind of dream on the part of a few citizens even before Minnesota became a state. They saw that higher education would be a necessity for the welfare of the community. Authority for the Board of Regents of the University was set up in the Territorial Charter, and its partial independence from the legislative and executive branches of the government was spelled out in those early days.

In that pioneer period medical education in Minnesota, as elsewhere in the United States, was largely an unregulated proprietary business. Medical schools were profit-making enterprises producing a product which varied in quality from fairly good to very bad. The better proprietary schools tried to do a respectable job, but they soon found that it was impossible to do so at a profit. Consequently, the more idealistic medical school teachers sought ways to shift the burden of medical education either to the state or to charitable trusts.

*Distinguished Service Professor and Head, Department of Physiology

This transition occurred in Minnesota in the 1880's as the State University took over the charters, students, and faculties of several proprietary schools. Interestingly, this movement in Minnesota occurred a quarter century before Abraham Flexner aroused the nation with his celebrated report of the unsatisfactory state of medical education in the country. Incidentally, Flexner is famous for two exposés in his lifetime: The one was of the sad state of medical education at the turn of the century, and the other dealt with the evils of prostitution in the United States. There may be just a possibility that Flexner saw some similarities, and considered that the commercialization of medical education was some kind of perversion of the Hippocratic tradition. Within a few years after the Flexner report—subsidized by the Carnegie Foundation—appeared in 1910, very few schools attempted to make a profit from grinding out M.D. degrees. In fact, the University of Minnesota was undoubtedly influenced to some extent by that report in its 1913 reorganization.



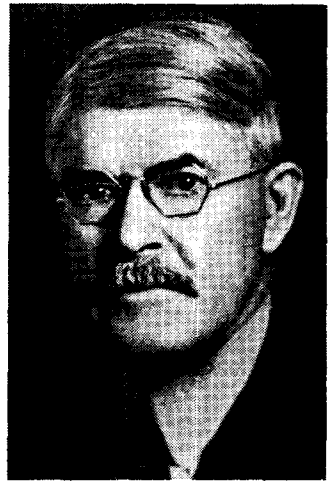
RICHARD O. BEARD

The Department of Physiology at Minnesota was established when the University took over the charters of the proprietary schools in 1888 and **Richard Olding Beard, M.D.,** became Professor and Head of the Department. He was a graduate of the Medical School of Northwestern University in Chicago and had settled in Minneapolis to engage in part time private practice, to serve as Assistant Health Officer for the City, and to become a member of the faculty of the Minneapolis Medical College. He was one of the group of physicians who constituted the first Faculty of Medicine at the University, which was "an examining rather than a teaching body," according to the University catalogue of that day. The latter group promoted the establishment of the Medical School within the University because they realized that the physician of the future could not be educated properly outside a University environment.

Beard served as Professor and Head of the Department from

1888 until 1913 when **George Edgar Vincent,** then President of the University and later to become President of the Rockefeller Foundation during its most influential years, launched a drastic reorganization of the Medical School. Vincent asked for (and received) the resignations of all members of the medical faculty. He had decided to take the bull by the horns, so to speak, and, by new appointments where necessary, to create a Medical School of true University stature. Fortunately for his objectives, this was before the days of tenure rules and he had no formal difficulties, although he created a state-wide furore by his action. Vincent visualized an institution in which graduate as well as undergraduate teaching could properly be carried out, and he realized that it would be impossible to have a first-rate University unless its academic faculty were interested in, competent in, and provided with opportunity for creative scholarly work.

At this juncture, the second Head of the Department of Physiology was appointed. **Elias Potter Lyon,** the appointee, was also given the post of Dean of the Medical School. Lyon had been a pupil of Jacques Loeb at the University of Chicago where he was known to President Vincent, who had been Dean of the College there. Lyon had demonstrated his administrative ability by a short tenure as Dean of the Medical School of St. Louis University. He was, fundamentally, a general physiologist and his great merit was that he brought scholars into each vacancy as it existed or occurred in the medical faculty. His predecessor, Dr. Beard, was not excluded from the faculty, but was made an associate professor and served as secretary of the faculty. He taught certain elementary courses until his retirement at age 68 in 1925.



ELIAS P. LYON

In 1913, **Frederick Hughes Scott,** a faculty member with M.D. and Ph.D. degrees from the University of Toronto, who had done postdoctoral work with Bayliss and Starling at University College, London, and who had come to Minnesota some years earlier as an assis-

tant professor, was promoted to associate professor and given larger responsibilities in the teaching of physiology to medical and graduate students. He was promoted again to the rank of professor in 1918 and served in that capacity till his retirement in 1941. Dr. Scott was to make a major impact on the Medical School. He was a hard-working, critical, and devoted teacher and scholar. He served in a time when the developing science of physiology was still growing at a slow enough pace so that a serious scholar could read all of the major research journals in the field and yet have time for creative work of his own. That situation has, of course, long since changed. Today, the volume of research literature in physiology is so great that simply to read a single year's output would require several years of ten hours per day reading.

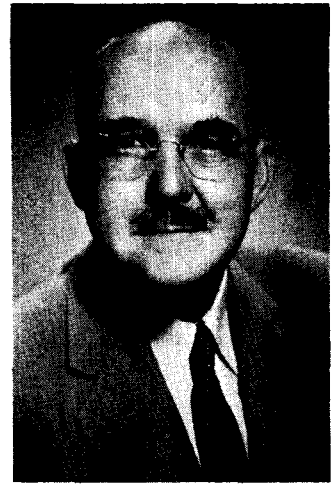
FREDERICK H. SCOTT

The writer was a graduate student under Dr. Scott and can testify to his encyclopedic knowledge as well as to his critical acumen. He was, in addition, a person who could impart to his graduate students an enthusiasm for investigation. Dr. Scott always considered that his first job was undergraduate teaching and he spared no efforts to present a comprehensive, up-to-the-minute course in physiology to his medical classes. His successors in that enterprise have more difficulty because of the very great growth of useful knowledge in the field, and they find it practically impossible to be more thorough than Scott was in his day. Today it has become impossible to attempt such exhaustive coverage of the field, simply because of the expansion of knowledge, while the time for its treatment in the medical curriculum has declined rather than increased.

E. P. Lyon and Frederick Scott were also key figures in the development of graduate education in medical fields at Minnesota. Lyon promoted the inauguration of the so-called Honors Program in medical education, in which the usual lock-step procedures could be replaced by individualized programs. This led to the development of combined M.D.-Ph.D. training programs

which are currently providing opportunity for more than 20 students to prepare themselves more adequately for careers in academic medicine. In the early years, only a few students availed themselves of these opportunities, among them the writer, who began his work at Minnesota as a part-time Teaching Fellow in 1922.

The Department of Physiology began very early to serve a kind of marsupial nurture function for other emerging medical disciplines. Beginning in 1907, biochemists were appointed in the Department to initiate systematic instruction in what was initially called physiological chemistry. In 1940 a Division of Physiological Chemistry was created and in 1946 that Division became a separate Department. (Today it is known as the Department of Biochemistry.) Physiology also provided opportunity for prospective clinical scientists to work in the Department. **Dr. Frederick W. Schlutz,** for example, who became Professor of Pediatrics at Minnesota and later head of that Department at the University of Chicago, held a staff appointment in the Department of Physiology at one time. Likewise, in the fields of Therapeutic Radiology and of Physical Medicine, their Minnesota initiators held early appointments in Physiology. **Prof. K. Wilhelm Stenstrom** was a full-time member of the Physiology Department from 1926 until 1938. During this time, he supervised the radium and x-ray therapy work in the University Hospitals and also carried out work in physical medicine. He later transferred to the Department of Radiology on a full-time basis. **Dr. Miland A. Knapp,** who was the first physician to devote his full time to physical medicine here, did his graduate work under the supervision of Dr. Scott. At a somewhat later date, **Dr. Frederic J. Kottke,** who became the first head of a Department of Physical Medicine and Rehabilitation at Minnesota, also had his graduate training in the Department of Physiology and obtained his clinical training with the aid of a Baruch Foundation grant administered by the



MAURICE B. VISSCHER

Department of Physiology. The central role of the physiological sciences in the development of scientific medicine became apparent during the Lyon-Scott era.

Dean Lyon retired from the University in 1936. His major functions as dean had been relinquished in 1931 when **Richard E. Scammon** became Dean of the College of Medical Sciences. The latter was succeeded in 1935 by **Harold S. Diehl** who served with distinction until 1958. Dean Diehl was responsible for the appointment of the writer as Lyon's successor in 1936 as Head of the Department of Physiology. In the last three decades, the Department of Physiology has continued in the paths charted by Lyon and Scott. It has served as a temporary "marsupial hostess" to several disciplines. From 1937 to 1946 it sponsored **Dr. Ancel Keys** in what is now the Laboratory of Physiological Hygiene in the School of Public Health, beginning with funds derived from intercollegiate athletic receipts, and later supported by state funds and Federal grants. In 1942 it obtained funds for the appointment of the late **Dr. John J. Bittner** as the *George Chase Christian Professor of Cancer Biology*. In 1942, a five-year grant of $350,000 from the National Foundation for Infantile Paralysis was received by and administered for interdisciplinary studies through the Department of Physiology. Program of work in neuroanatomy, neurophysiology, clinical neurology, physical medicine and rehabilitation, physiological hygiene, enzyme biochemistry, and respiration physiology were supported by these funds. Numerous fundamental and practical advances were made as a result of this support. For work done on the practical side, the American Medical Association made one of its annual awards to an interdepartmental group for advances in the methods of treatment of bulbar poliomyelitis.

A major theme of basic science interest of the Department of Physiology since 1956 has been the mechanism of transport of materials in living systems. My interest in this problem was stimulated by one of the graduate students I taught while I was a professor at the University of Southern California in 1930. This student's interest was in possibly employing the intestine as a dialyzer in renal insufficiency. Upon studying the literature, it was immediately obvious that prior to such use it would be necessary to learn more about the characteristics and functions of the intestinal epithelium. So began an interest that led to 15 years of work on transport problems by the writer. A grant of $16,500 from the Rockefeller Foundation to the Department in 1937 and a larger one a few years later to the University for

biological work with radioactive tracers facilitated this work greatly.

Events on the world scene influenced work on membrane problems at Minnesota. The German Nazi anti-Semitic mania drove the late **Prof. Herbert Freundlich** and his associate, **Dr. Karl Sollner,** from their posts at the Berlin-Dahlem Institute for Colloid Chemistry. After a stay in Britain and at Cornell University, they both came to the University of Minnesota. Freundlich was appointed in the Division of Physical Chemistry and Sollner in the Department of Physiology, where he remained for eight years. During this time, numerous problems in the behavior of membranes with specific permeability properties were investigated.

PROFESSORS EUGENE GRIM (seated), JOHN A. JOHNSON, and NATHAN LIFSON inspect radioactive tracer equipment used in the department's research program.

The entrance of the United States into World War II in 1941 interrupted many aspects of departmental work. The writer had, since 1939, urged the Division of Medical Sciences of the National Research Council to stimulate American preparedness by research on military medical and related biological problems. He served for several years on the Subcommittee on Clinical Investigation of N. R. C., which organized research on a wide variety of subjects, such as traumatic shock, decompression disease, protection against war gases, and life-raft survival. Studies in the laboratories at Minnesota led to a simple vacuum system for producing distilled water in amounts adequate to sustain life by using body heat as the source of energy. It also produced

an evaporation clothing system for body cooling, using sea water to spare the body need for potable water. Wartime studies in the Physiological Hygiene laboratories dealt with nutritional needs under scarce rations conditions. The war largely suspended normal graduate student work because of the difficulties in obtaining deferment from active military duty for such students; a national policy which was undoubtedly very shortsighted, but did the nation less harm that it would have if the war had been more prolonged.

In the 20 years since World War II ended, the Department of Physiology has shared in the growth of medical science activities common to most American medical schools. In 1941 there were five physiology staff persons who were also members of the faculty of the Graduate School. In 1965 there are 14. In 1941 there were a half-dozen full-time graduate students working in the Department. In 1965 there are about 50. In 1941, slightly more than 100 medical students per year were provided undergraduate instruction; today, 150 per year are taught.

VICTOR LORBER

CARLOS MARTINEZ

CARLO A. TERZUOLO

New courses of instruction are now being offered to both undergraduate and graduate students. An introduction to the Principles of Physiology is offered to students in the upper divisions of the College of Liberal Arts and of the Institute of Technology who have had two years or more of physical science and mathematics, but without a collegiate biology prerequisite. Courses are offered in physical methodology for physiological experimentation. Major remodelling, renovation, and enlargement in space, particularly in Millard Hall, for undergraduate and graduate teaching and for research has occurred. Fifty percent more space has been provided for undergaduate instruc-

tion, and thoroughly modern instrumentation has been provided. The modern Lyon Laboratories house many departmental activities. Closed circuit television has been installed as an aid to laboratory teaching.

The additions to teaching facilities have come from State Legislative appropriations, but the research facilities have been provided in larger part from private gifts and from Federal matching funds.

Two former professors in the Department of Physiology have retired from the University. **Dr. Ernst Gellhorn** was appointed Professor in 1943 and headed work in neurophysiology in the Department until his retirement in 1960. He is known for his excellence as a teacher and his investigations of autonomic nervous system physiology and its application to psychiatry. **Dr. Joseph T. King** devoted his entire academic life to the University of Minnesota, becoming a graduate student in physiology in 1923 and retiring as a professor in 1964. Besides giving a lifetime to devoted service as a teacher, he carried out and is continuing an important research program in mineral, vitamin, and fat nutrition.

The present full-time academic staff members of the Department of Physiology and their major research fields are as follows:

Professors	
Eugene Grim	Transport Mechanisms, Physico-Chemical Aspects of Membrane Function
John A. Johnson	Transport Mechanisms; General Physiology
Nathan Lifson	Transport Mechanisms (especially intestinal)
Victor Lorber	Ion Movements in Heart Muscle
Carlos Martinez	Endocrinology, Transplantation Tolerance and Immunity
Carlo A. Terzuolo	Neurophysiology Biophysics
Maurice B. Visscher	Cardiovascular Physiology
Associate Professors	
Marvin Bacaner	Myocardial Metabolism; Peripheral Blood Flow
H. Mead Cavert	Myocardial Metabolism
Charles Edwards	Muscle and Nerve Physiology; Biophysics
Irwin J. Fox	Methodology of Flow Measurement; Circulatory Physiology
Rodney B. Harvey	Renal Physiology

Assistant Professors	
James S. Beck	Mathematical Biophysics
J. S. Lee	Intestinal Absorption; Lymphatic Function
Asher Ilani	Membrane Phenomena
John Walker	Ion Transport
Research Associates	
Ali A. Hakim	Transport Across Epithelial Membranes
Y. Chiung Puh Lee	Cardiac Physiology
Laurence O. Pilgeram	Arteriosclerosis
Luigi Rossini	Neurophysiology
Instructors	
Richard Purple	Sensory Nerve Function
Daniel Weiner	Transport Mechanisms
Lecturer	
Maurice W. Meyer	Circulation with Particular Reference to Teeth and Bone
Research Fellows	
Giovanni Ayala	Neurophysiology
Takehiko Azuma	Catecholamine Metabolism
Alberto Binia	Catecholamine Metabolism
H. R. Lorkovic	Neurophysiology
Richard Stish	Biophysical Methodology

The historical role of physiologists has been to study the physics and chemistry of life in health and in disease. They have always used any tools which offered promise in elucidating such mechanisms. The microscope, the scalpel, the mercury manometer, levers, and the kymograph, the test tube, the analytical balance, the burette, and the colorimeter have been supplemented but not replaced by electron microscopes, Geiger counters, autoanalyzers, chromatographs, computers, electromagnetic flowmeters, electronic transducers, spectographs, fluorescence meters, micropipettes, Cartesian divers and a thousand and one other tools for special purposes. The aim remains the same: to unravel the mysteries of living systems from the simplest to the most complex.

The "compleat scholar" would be one who combines talents for creative discovery with the systematic mind and contagious enthusiasm for his subject which makes him a good teacher. There are probably no perfectly "compleat scholars", but it is the objective of the Department of Physiology at Minnesota to provide at this University some reasonable approach to the ideal. Some undergraduate students may have had the impression that the discrepancy between the real and the ideal has sometimes been too great in the direction of interest in creative original work. Balance is not easy to achieve, but I wish to make one final confession: I have always thought that if one has to err on one side or the other, it is better for all concerned that a University err in appointing academic staff members who are too much, rather than too little, motivated to do scholarly work. To do the opposite is to kill the University.

The present Department Head has always followed his preceptor and predecessor, Elias P. Lyon, in accepting a very broad definition of the scope of Physiology. Lyon believed that anything that happened in living systems was a proper subject for a physiologist to deal with. This liberality of viewpoint caused him to encourage prospective pediatricians to study the physiology of growth, prospective therapeutic radiologists to study the physiology of radiation effects, and the physiatrist to study muscle, joint, and circulation physiology. The same logic accounts for presence of experts in the Department today who study the basis of neoplasia, transplantation tolerance and immunity, bacterial endotoxin shock, the electrochemistry of nonaqueous phase barriers and mathematical models of transport systems. If physiology departments ever become inhospitable to scholars who work in unconventional areas, they will largely lose their major *raison d'etre,* which is to look at life processes in their entirety and to utilize any promising tools from anatomy to mathematics, to attempt to understand them in physical terms.

SPECIAL ANNOUNCEMENT

With the aid of the Hill Family Foundation, the University of Minnesota will present, as part of the commemoration of the 75th Anniversary of the Medical School, a three-day Symposium, April 15-17, 1965 noting the Centennial Year of the publication of his *Introduction to the Study of Experimental Medicine* by Claude Bernard.

Beginning on the evening of April 15 and extending until noon, April 17, Scientific sessions will be held in the Mayo Auditorium. Papers and discussions will deal with Bernard's contributions to physiology and medical science generally as well as with his role in the history of ideas. Alumni are especially invited to attend.

Staff Meeting Report

Leukemic Cell Growth, Host Death, and the Response to X-irradiation *

Yosh Maruyama, M.D.†

Leukemia represents a disease which is widely disseminated at an early stage in its evolution. From experiments done in many strains of mice, it is known that the murine thymus represents the initial site of leukemic transformation of normal lymphocytes. The process eventually expresses itself in the hematologic picture of lymphatic leukemia. The factors that enter into this primary event still remain obscure, but it is clear that the process is initiated by a virus, which infects a cell, transforming it to malignancy. The eventual invariable consequence of this process is the death of the host animal itself. This latter aspect, i.e., the death of the host animal, has been the problem towards which our interest has been directed. The studies reported here represent efforts to understand (1) the survival time and (2) modification of survival time by a therapeutic agent, namely x-radiation.

Recently, we proposed (Maruyama and Brown, 1964) that the growth, i.e., the rate of replication and formation of new cells, proceeds exponentially over wide ranges of leukemic cell growth. By extension, it might be postulated that host death takes place when the leukemic tumor cell population attains a critical value which we have called N*, or lethal number. Thus, when a therapeutic maneuver is executed in the course of the tumor growth process, prolongation of the survival time of the host is predictable depending on the fraction of cells which survive the killing event. Postulates such as these can be verified by direct measurement under certain conditions of leukemic cell growth, e.g., in the peritoneal cavity.

In these experiments, an isogenic transplantable lymphoma of a highly inbred species of C57B1 mice was used. When the

*From a report to the Staff Meeting of University Hospitals on March 5, 1965. This work was partially supported by grants CRT5008, and CA08163-01 from the National Institutes of Health, and the J. Picker Foundation.

†Assistant Professor, Division of Radiation Therapy, Department of Radiology

cells are injected intravenously into normal isogenic recipients, we find that all the animals will die at a fairly sharp end point following certain intervals of time which we call the survival time. The time of death will vary as a function of cell dose. As one would expect, the more the number of cells given, the shorter will be the survival time. Such data fits a straight line relating survival time to log of cell number over wide ranges of cells inoculated. The survival time assay thus offers a means of estimating the proportion of cells in an irradiated population that retains its reproductive integrity, manifested by their ability to multiply to a lethal number.

In a series of experiments, we were able to show that the survival time of recipient mice did vary as a function of X-ray dose. With small doses of radiation, survival time was increased by a short interval of time, and with graded higher doses, progressive lengthening of average life span was observed. In such experiments, irradiation can be delivered before transplantation or at intervals following transplantation into normal recipients.

To compare our results with those of earlier experiments in which Silini and the author had studied the surviving fraction by another method, (the TD50 assay,) the present experiments were performed in the following manner: Accurate cell dilutions were prepared containing known numbers of tumor cells. The low dilutions were inoculated intravenously into recipient mice, for the survival time assay and were carried to high idlution to determine the TD50 end point. The lymphomatous cells were exposed to X-rays under three different conditions; (1) *in situ* in ascitic mice, (2) *in vitro* under condition of full oxygenation, and (3) in N_2 asphyxiated mice shortly after sacrifice. These conditions are known to markedly alter the response of these cells to ionizing radiation: Cells are most radiosensitive under oxygenated conditions, intermediate in response in the ascitic fluid of living mice, (where oxygen tension is reduced), and least sensitive under anoxic conditions (e.g., in the dead mice).

The results indicate that under *in vitro* conditions of full oxygenation, the survival times are prolonged to the greatest extent and the least under anoxic conditions. The *in situ* data are intermediate in response. Additional conclusions can be drawn:

(1) The D_0 (dose necessary to reduce survival by 0.37 on the exponential curve) for X-ray dose response as determined by the survival time assay for apparent cell number is similar *in vitro* to that derived by the TD50 assay. All are dependent on the state of cell oxygenation at the time of irradiation.

(2) The D_0 for the *in situ* and anoxic conditions of irradia-

tion are significantly less than that derived by the TD50 assay.

(3) The ratio for the oxygen enhancement ration in these experiments was 1.6, and less than that for the TD50 assay where it is about 2.6.

Thus, while anoxia protects the reproductive integrity of the cell, the results indicate that a lesion is inflicted on the cell which expresses itself either by a greater lag period before growth commences, a radiation induced alteration in growth rate, or perhaps both of these. Under *in vitro* conditions of full oxygenation, the assay is not sufficiently sensitive to detect any difference in the response curve. Under anerobic conditions, however, differences are detectable which suggest that division delay must either be much greater, or that there may be more complex effects on the rate of growth of the cells, under conditions wherein the oxygen tension is reduced at the time of irradiation.

Staff Meeting Report

Studies in Behavior Modification*

Edward S. Sulzer, Ph.D.†

Applications of the principles of human learning are proving effective in altering the behavior of psychiatric and non-psychiatric patients. Several straight-forward procedures are reported that change deviant patterns of behavior in children and adults.

It appears that most, if not all, complex human behavior is acquired and maintained by the consequences of the behavior. That is, behavior followed by certain changes in the environment tends to make the behavior re-occur in similar situations. Normal and deviant complex human behavior appears to be primarily acquired in this fashion. In the laboratory such pat-

*From a report to the Staff Meeting of University Hospitals on March 12, 1965

†Assistant Professor, Division of Clinical Psychology, Department of Psychiatry and Neurology

terns of behavior acquisition and maintenance are labeled "operant," i.e., controlled by the events subsequent to the behavior being performed. In contradistinction to operant behavior, classical respondent conditioning usually is a smooth muscle behavior controlled by immediately preceding or concurrent events in the environment, e.g., Pavlovian studies of salivation.

A stimulus that tends to raise the probability of a behavior being exhibited is called reinforcing or a reinforcer. A stimulus tending to decrease a particular behavior is called aversive. Combining both reinforcement and aversive conditioning, one may bring various types of behavior under control in the medical setting. The following examples are taken from recent experiences involving the staff of the University of Minnesota.

A five year old child, diagnosed as autistic, had a vocal repertoire of essentially one frequently used phrase, "Push it." The child rarely smiled, showed little evidence of discriminating among children and adults, exhibited little play behavior usually seen in five year olds, was not communicating in a recognizable way with others, did not dress himself, and was not toilet trained. All of these aforementioned behaviors were considered appropriate areas for change in order to bring him to the point of acceptance in a special form of school setting.

The child was seen in sessions in which he was taught certain responses. For example, the child would not initially look at the faces of adults or children. By reinforcing (smiling, verbal approval, hugging, food giving) successive approximations to the end goal behavior, the child rapidly acquired the behavior of looking, then smiling at others. Gradually, other actions such as using words, manipulating toys, discriminating among colors, sizes, shapes, and people were taught. Substantially all of the initial goals have been achieved.

Children and adults with a variety of behavior disorders have been treated similarly. The problems have included infantile anorexia, aggression, temper tantrums, phobias, compulsive behavior, alcoholism, marital discord, and others. In each instance, the specific act or acts are specified that one wishes to cease or become less frequent and other behaviors that are desired are carefully described. The conditions that tend to give rise to the behavior are examined and the environment is investigated to determine appropriate, and if possible, naturally occurring reinforcers.

The technique is outlined here in only the briefest manner. However, it appears to hold promise for a large variety of be-

havioral disturbances in both children and adults. Further, the procedures have the advantage of being inherently open to careful measurement and the results being fairly rapidly determined. Success or failure determines adequacy of treatment even in the absence of well-developed theory.

Staff Meeting Report

Clinical Applications of Electromyography*

William R. Kennedy, M.D.†

Electromyography (EMG) is the electrical testing of the peripheral nerves and muscles. It is indicated in those patients suspected of having disease affecting the motor unit, i.e., the anterior horn cell, peripheral nerve, neuromuscular junction or muscle. This paper will describe the method of testing and the type of clinical information that the physician can expect from EMG in this group of patients.

Method

The test can be divided into two stages. The first concerns the determination of conduction velocity of nerves, i.e., how fast a nerve can transmit an electrical impulse that is applied to it. The second stage is the needle electrode examination.

Conduction velocity is usually determined for three separate nerves of each patient. Because the median, ulnar, peroneal and tibial nerves are the most accessible they are used frequently but not exclusively. An electric stimulator is used to apply an impulse to the nerve which then transmits it to muscle where its arrival is recorded. These events are seen on the oscilloscope as a straight line representing time of transit followed by a negative deflection signifying arrival. The average conduction velocity for normal nerves is 55 meters per second.

*From a report to the Staff Meeting of University Hospitals on March 19, 1965

†Assistant Professor, Division of Neurology, Department of Psychiatry and Neurology

Sensory conduction is measured in a somewhat similar manner. Stimulating electrodes are placed over the digital nerves of a finger and the action potential is recorded as it passes under recording electrodes at the wrist.

For the needle electrode examination a recording needle, which is about the size of a 22 gauge hypodermic needle, is placed into the muscle. First, a search is made for abnormal electrical activity with the muscle relaxed, and normally silent. The two most frequently encountered forms are (1) the low amplitude, short duration potentials associated with activity of single muscle fibers, called fibrillations; and (2) the larger action potentials called fasciculations which are associated with contraction of entire motor units. Next, the patient is asked to contract the muscle and the generated motor unit action potentials (MUAPs) are evaluated by their appearance on the oscilloscope and their sound over an auditory system.

Results

The value of EMG in the most commonly encountered diseases of the motor unit will now be described, beginning with disorders of the anterior horn cell and proceeding peripherally toward muscle.

The clinical diagnosis of diseases affecting the anterior horn cell, such as amyotrophic lateral sclerosis, can usually be confirmed by EMG. In spite of severe wasting, the conduction velocity of the motor nerves is in the low normal range. Sensory conduction is normal. The needle electrode often detects fibrillation potentials from the denervated muscle. The MUAPs seen during contraction may have a high amplitude and increased duration. Fasciculations are common.

Radiculitis, usually secondary to compression of the nerve root from a protruded intervertebral disc, is a common clinical problem. The EMG is valuable in separating root involvement from a peripheral nerve lesion or generalized neuropathy. Conduction velocity of the nerves, including those supplied by the involved root, is normal. Needle electrode examination reveals abnormalities, usually in the form of fibrillation potentials, only in the muscles supplied by the root in question. The EMG findings are dependent upon the occurrence of partial denervation of muscle and take 10 to 21 days to develop. Since the patient may experience pain in the absence of denervation, a normal EMG does not negate this clinical diagnosis but can be a favorable prognostic sign.

In traumatic lesions of peripheral nerves, the EMG can be useful in finding the site and extent of the lesion. The discovery

of focal slowing or a block in conduction of the nerve can be localizing. Needle electrode examination may distinguish between a complete and incomplete lesion or determine whether more than one nerve is involved. Appropriate use of the delay between time of injury and appearance of electrical signs of denervation can help to rule out previous abnormalities, an important aspect in legal cases. The onset of re-innervation is detectable by EMG before it is obvious clinically.

In patients with peripheral neuritis, regardless of etiology, the conduction velocities are decreased. These values provide the clinician with an objective measurement of the extent of involvement and serial studies can aid in his evaluation of therapy. The needle examination may reveal evidence of denervation and the MUAPs often are decreased in number and increased in amplitude or may have a polyphasic contour.

Myasthenia gravis is believed to result from defective transmission across the neuromuscular junction. When the motor nerve of an involved muscle is stimulated repetitively at a rate of two per second there is a progressive decline in the amplitude of each succeeding muscle action potential. Needle electrode recordings of the MUAPs from a single repetitively firing motor unit show a variation in amplitude due to the transmission defect. The nerve conduction velocity and the remainder of the needle testing are normal. In most patients these electrical findings are demonstrable in several muscles, but in a few patients with a more localized form of the disease repeated testing may be necessary.

The clinical diagnosis of a primary disease of muscle is at times difficult. However, EMG findings can be conclusive. Nerve conduction velocities are normal. The MUAPs recorded by the needle electrode are recognized as being myopathic by their low voltage, short duration, frequent polyphasic appearance. Occasional fibrillation potentials are also seen. These latter are more numerous in the acute forms of polymyositis than in the dystrophies, but often these two conditions cannot be distinguished electrically. Occasional patients with a myopathy have a normal EMG because the appropriate muscles are not tested or because the disease has not progressed to a detectable level.

Myotonia, whether of congenital or dystrophic variety, is often easier to diagnose than the other myopathies. The needle electrode detects spontaneous high frequency discharges which have been referred to as having a dive-bomber quality when heard via the auditory system. In myotonic dystrophy the other myopathic electrical signs also exist.

Conclusion

EMG is presented as an electrical extension of the neurological examination of patients with neuromuscular disorders. It can give high yields of specific diagnostic information in diseases affecting the motor unit. The amount of information to be gained by this test is highly dependent upon a concise statement of the clinical problem and the pertinent physical findings from the referring physician.

WATSON AWARD WINNER

Dr. Byron U. Musa, post-doctoral fellow in the Department of Internal Medicine, was winner of the 1964 Watson Award of the Minneapolis Society of Internal Medicine. Dr. Musa is shown above with Dr. C. J. Watson (left) and Dr. Leslie Zieve (right), president of the Society, who conferred the award and $500 prize in ceremonies at the Medical School, Feb. 19.

Established in 1961, the award honors Dr. Watson, professor and head of internal medicine at Minnesota, and is given for the year's outstanding research achievement by a physician in graduate clinical training. Dr. Musa's prize winning work was titled "The Purification and Properties of Human Liver Beta-Glucuronidase." He is a graduate of the University of Oregon Medical School, and is now taking postgraduate training at the Minneapolis V.A. Hospital.

Medical School News

MEDICAL EDUCATION AND PHYSICIANS FOR THE STATE OF MINNESOTA

Questions concerning the supply of physicians for the State of Minnesota are frequent. The following information was compiled by Dr. N. L. Gault, Jr., associate dean of the University of Minnesota College of Medical Sciences, and reflects several parameters which have a bearing on the question. It is published here as a service to readers of the University of Minnesota MEDICAL BULLETIN.

An analysis of the statistics relating to the admission of students to the University of Minnesota Medical School in 1964 gives a picture of the demand for medical education at this university. Applications from 689 students were filed for admission to the class beginning medical school in the Fall of 1964. To admit a class of 150 students the Admissions Committee, composed of faculty members, selected 181 students. Twenty nine (29) of these students withdrew their applications or declined to accept a place in the Freshman Class at Minnesota. Of the remaining 152 accepted students, 87% were residents of the State of Minnesota and 13% were non-residents. Ninety one percent of the class were men and 9% women. Fifty percent of the class had attended the University of Minnesota and 32% were from other Minnesota colleges. Five percent were from colleges and universities in neighboring states. Sixty nine percent completed four years of college work before entering the Medical School.

The common practice of grading used in colleges and universities is to assign 4 grade points for each credit of "A," 3 for "B," etc. The total grade points divided by the total credits provides the Grade Point Average (GPA) which indicates a student's academic performance. The total grade point average of students accepted at Minnesota for 1964 ranged as follows:

GPA	Percentage of the Class
Under 2.6	7%
2.6 to 3.0	32%
3.1 to 3.5	43%
3.6 and above	18%

There are students who do poorly in the beginning of their college careers. Subsequently, they mature, have supporting qualifications, and demonstrate consistently quarter after quarter that they can perform at an academic level which warrants their admission to the Medical School class even though their overall GPA is low due to their poor initial records. The Admissions Committee is alert not to by-pass these so-called "late bloomers" and this explains the acceptance of a small percentage of students with lower than 2.6 GPA.

Of the Minnesota residents accepted for the 1964 class, 16 declined the position to attend other medical schools of their choice or to enter another field of study. Only 11 Minnesota residents not chosen for admission to the University of Minnesota Medical School gained acceptance to another medical school. Another 121 Minnesota residents, who did not qualify for admission to this class, also failed to be accepted by other medical schools or apparently did not apply to other schools.

Regarding non-resident applicants, the Admissions Committee rejected 113 who were subsequently accepted by other medical schools. Sixteen non-residents were offered places in the Minnesota class but declined. Minnesota also rejected 102 non-resident students who apparently were not offered a position in any other medical school in the United States.

The University of Minnesota has long ranked among the top 20 colleges and universities in the United States which are producing most of the nation's pool of first-year medical students: 90 in 1954; 87 in 1956; 76 in 1958; 84 in 1960; and 95 in 1962. These figures represent the numbers of students, both residents and non-residents, who completed their undergraduate premedical education at the University of Minnesota and were admitted to one of the nation's 87 medical schools.

Internships

What happens to the graduates of the University of Minnesota Medical School when they finish their course work? After graduation, all graduates must serve an internship in an approved hospital program for one year. There are three types of programs offered: a *rotating internship* which includes experience in most of the specialty areas of medicine; a *mixed internship* which provides experience primarily in internal medicine, surgery, pediatrics, or obstetrics-gynecology with minor experience in other areas; and a *straight internship* which is a full year assignment to internal medicine, surgery, pediatrics, obstetrics-gynecology, or pathology. The students in their senior year select

the type of internship they desire. Most graduating students with an ultimate interest in general practice choose a rotating internship. Others may select this type of internship as a broad experience in preparation for specialty training. The distribution of choices made by our students in the past two years is as follows:

Type	1963	1964
Rotating	93%	83%
Mixed	2%	5%
Straight	5%	12%

The question that follows is "Where do University of Minnesota graduates intern?" Records for the past two years denoting the state in which our graduates intern show the following distribution:

State	1963	1964
Minnesota	40%	42%
California	26%	17%
Illinois	13%	6%
West Virginia	1%	5%
New York	1%	4%
Michigan	1%	3%
Other states selected by 3 or fewer graduates	18%	23%

The statement is often made that a physician is apt to remain and enter practice in the community where he interns. This conclusion was probably more justified in times past before our society became more mobile.

Career Choices

In March 1962 the Association of American Medical Colleges reported that on a national basis 63% of the medical graduates of 1950 had chosen a specialty and 33% had chosen general practice. Of the 1959 medical graduates, on the other hand, 65% chose specialty careers while only 27% selected general practice. As is evident, the University of Minnesota Medical School graduates have followed the national trend in selecting careers. In addition to providing this distribution of graduates

among the various types of practice, the University of Minnesota ranks 8th in the nation in providing graduates who have entered full-time teaching positions in the medical schools in this country. Although this is not a great number (158 as of July 1960), it is an important achievement and an essential one if new medical schools are to be established in the United States.

In 1964, 4494 graduates of the University of Minnesota Medical School filed registration forms with the American Medical Association. The largest percentage of graduates (32.3%) indicated they were in general practice. The distribution of University of Minnesota medical graduates among the ten most common specialties according to 5 year groupings is shown in the following table:

YEAR OF GRADUATION

	1930-1934	1935-1939	1940-1944	1945-1949	1950-1954	1955-1959	Percent of all graduates
General Practice	32	34	26	24	35	29	32.3
Internal Medicine	9	13	18	18	12	12	12.6
General Surgery	7	9	8	8	8	7	7.9
Psychiatry	6	3	6	7	5	8	5.4
Pediatrics	4	3	6	7	6	5	4.8
Radiology	5	4	4	6	6	5	4.7
Obstetrics & Gynecology	4	4	4	5	3	5	4.1
Ophthalmology	4	5	4	2	3	6	3.9
Pathology	2	3	3	4	5	4	2.9
Orthopedic Surgery	2	3	4	2	2	4	2.4
Number of graduates registered	501	535	605	558	565	566	

(Raw data furnished by Dr. A. E. Severinghaus)

Physicians in Minnesota

The Minnesota State Board of Medical Examiners reported that a total of 4484 physicians were licensed and registered for practice in Minnesota as of May, 1964. This figure includes graduates of both the University of Minnesota Medical School and graduates of a host of other accredited medical schools. Although physicians in training are not required to be registered, some do indeed register. This figure (4484) then does include an undetermined number who were in specialty training and thus not in private practice. Further, the figure also includes physicians who were staffing institutions such as the Veterans Administration Hospitals, the University Hospitals, the State mental institutions, the State Board of Health, and other administrative positions in industry and insurance companies. In addition 3787 physicians who in 1964 were practicing outside the State of Minnesota were also registered with the Board; this practice is

commonly followed and indicates that these physicians want to retain the right to return to Minnesota to practice medicine.

The tables that follow are reproduced from a paper entitled, *Distribution of Physicians in Minnesota, 1962*, prepared by Ivan J. Fahs and John D. Photiadis, faculty members of the Department of Sociology of the University of Minnesota. The increase in physicians practicing in the State from 1912 to 1960 is 2237 physicians or a 98% increase. The increase in numbers of physicians for the periods of years used in this study are:

1912-1921	1921-1931	1931-1950	1950-1960
360	445	910	522

NUMBER OF TOWNS WITH ONE, TWO, AND NO PHYSICIANS
1912-1962

	1912	1921	1931	1950	1962[1]
One doctor towns	243	235	185	129	115
Two doctor towns	104	102	85	85	62
Incorporated towns with no doctor	177	241	306	378	490[2]
Total Incorporated Places in Census	633	682	728	782	841
Percent with no doctor	28	35	42	48	60

[1]30 incorporated places with population ranging from 2789 to 50,498 not included as they are newly incorporated suburbs of the Twin Cities. Twenty-three of these places show no doctors, 5 show only 1 doctor, and 2 show 2 doctors (according to listed residences).

[2]Of the 490 incorporated places with no doctor, 37 percent have a population of less than 200, 19 percent of 200-299, 25 percent of 300-499, 14 percent of 500-999 and 5 percent a population of 1000 or more.

From: Distribution of Physicians in Minnesota, 1962.
Ivan J. Fahs and John D. Photiadis

The authors conclude that only 8 of Minnesota's 87 counties have what the authors consider to be relatively low scores for availability of medical services. In evaluating the availability of medical services, Fahs and Photiadis took the 181 "no doctor" towns with a population of less than 200 and drew a circle with a 12 mile radius around each town. The results showed that 132 of these towns fell within the orbit of another town which had a doctor. If the radius was extended to 24 miles, 175 of these towns appeared within the circles.

PHYSICIANS BY SIZE OF PLACE, 1912-1960

Size of Place	1912		1921		1931		1934		1936		1950		1960	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Under 500	301	13.3	230	8.7	186	6.0	220	6.9	210	6.4	89	2.2	28	0.6
500 - 999	232	10.2	220	8.4	230	7.5	250	7.9	255	7.8	159	4.0	127	2.8
1,000 - 2,499	331	14.6	305	11.6	304	9.9	360	9.7	313	9.6	302	7.6	299	6.6
2,500 - 4,999	122	5.4	182	6.9	189	6.2	200	6.3	204	6.2	154	3.9	196	4.4
5,000 - 9,999	234	10.3	203	7.7	173	5.6	191	6.0	198	6.0	259	6.5	282	6.3
10,000 - 24,999	91	4.0	330	12.6	569	18.5	488	15.4	566	17.3	260	6.5	412	9.1
25,000 - 51,000													975	21.6
Twin Cities and Duluth	959	42.2	1160	44.1	1424	46.3	1518	47.8	1533	46.7	2762*	69.3*	2188	48.6
Total	2270	100.0	2630	100.0	3075	100.0	3227	100.0	3279	100.0	3985	100.0	4507	100.0

*Includes Rochester and St. Cloud

From: Distribution of Physicians in Minnesota, 1962, Ivan J. Fahs and John D. Photiadis

Alumni Notes

◆ **1927**

Arthur C. Kerkhof and Mrs. W. A. Carley, St. Paul, Minn., were united in marriage February 27, 1965. They will be at home after March 22, 1965 at 4224 Glencrest Road, Minneapolis, Minn.

◆ **1929**

J. Vincent Sherwood is "retired and living in sunny, lovely Florida." His address is 5245 78th Ave. N., Pinellas Park, Fla. 33565. Dr. Sherwood was formerly of Fort Wayne, Ind., where he was a chest surgeon at Irene Byron Hospital.

◆ **1930**

Everett C. Perlman is the author of his first full length book, *Travel Health Guide for Infants and Children,* published by Motor Travel Services, Inc., Minneapolis, Minn. Dr. Perlman has practiced pediatrics in Minneapolis since 1935 and is on the clinical faculty of the Medical School. He lives at 2615 W. 52nd St., Minneapolis.

O. J. FARNESS

Theodore Q. Benson, who has spent his entire medical career practicing in the Grand Forks, N.D. area, recently resigned after serving 28 years as Grand Forks County health officer.

◆ **1931**

O. J. Farness, an internist in Tucson, Ariz., has been elected to the Board of Regents of the American College of Chest Physicians.

Corrin H. Hodgson, Mayo Clinic internist, was a Visiting Professor of Medicine for two weeks in March at the University of San Marcos Lima, Peru.

◆ **1932**

Clayton T. Beecham took a new post January 1, 1965 as director of Gynecology-Obstetrics at the Geisinger Medical Center, Danville, Pa., resigning as a professor at Temple University Medical School. Associated with him in his new position is William Hunt (Med. '46), formerly of Fergus Falls, Minn.

◆ **1935**

Harold G. Scheie, professor and chairman of ophthalmology at the University of Pennsylvania School of Medicine, has been awarded the University of Buffalo's *Howe Gold Medal* for "excellence in the fields of ophthalmology and the prevention of blindness." Dr. Scheie was honored for "developing new techniques in glaucoma surgery, both in infants and adults, and for treatment of congenital cataracts, particularly in children.

C. WALTON LILLEHEI

◆ **1941**

C. Walton Lillehei, professor of surgery at the University of Minnesota, has been named president-elect of the 2,600-member American College of Cardiology.

◆ **1945**

James C. Breneman, a member of the teaching staff at Borgess Hospital, Kalamazoo, Mich., was presented the *Honors Achievement Award* of the Angiology Research Foundation for his research and an article titled "*A Formula for Predicting and a Device for Preventing Postoperative Thromboembolic Disease,*" which appeared in *Angiology* in September, 1963. He lives in Galesburg, Mich.

◆ **1947**

Jerome F. Smersh, Jr., has been appointed a Fellow of the American College of Obstetricians and Gynecologists.

◆ **1956**

John W. Josse, St. Louis, Mo., was appointed professor and head of the Department of Physiology at Washington University School of Medicine, effective July 1, 1965. John is presently on the staff there and has done extensive research on the enzyme pyrophosphatase, and its role in controlling the rate of nucleic acid synthesis.

Melvin E. Sigel is now in the private practice of otolaryngology in Minneapolis and teaches at the Medical School. He completed a residency here in 1963, and recently spent a year on an N.I.H. fellowship in Zurich, Switzerland.

John B. Sombeck writes from Pekin, Ill., where he has a solo practice of orthopedic surgery. John served in the Army after internship, and then took a 4-year residency at Cleveland Clinic, Ohio. His wife, Sharon, is from Pekin, a city of 30,000. The Sombecks have four boys and one girl, and live at 703 Washington St.

◆ 1958

GENE G. HUNDER

Gene G. Hunder won the 1964 Philip S. Hench Scholarship Award at the Mayo Graduate School of Medicine for "excellence in the study of rheumatic diseases." He is a consultant in internal medicine in the Mayo Clinic.

Leslie W. Jacobson lives with his wife and two youngsters at 10124 Chicago Ave., Minneapolis 20. He is finishing a residency in ophthalmology at the Medical School, and will begin private practice in Minneapolis on July 1, 1965 in association with Drs. Hoffman, Wendland, Shaw, and Rucker. After his internship, Les served two years in the Army Medical Corps.

◆ 1960

Phillip L. Edwardson was commissioned an officer in the U.S. Public Health Service in July, 1964, and is now assigned to the Choctaw Indian Hospital in Philadelphia, Miss.

C. John Hodgson has elected to make his medical career with the U.S. Air Force. He is now studying at the School of Public Health, University of California, Berkeley, Calif., under the Air Force's program in space medicine.

George E. Reisdorf is a resident in orthopedic surgery at the University of Indiana Medical Center, Indianapolis. His address is 1922 N. Capitol Ave.

◆ 1961

Barry Grundland, 2045 Dwight Way, Berkeley, Calif., writes that he expects to enter the Air Force next summer. Before that, he will present a paper on "Creation of a Therapeutic & Educational Milieu for the Deaf Mentally Retarded Child" at the 1965 meeting of the American Association on Mental Deficiency.

◆ 1962

Daniel E. Weiner has been appointed assistant professor of physiology at the University of Virginia Medical School, Charlottesville, Va., and will take his new post April 1, 1965. He is presently an instructor in physiology at the University of Minnesota, and lives at 907 27th Ave. SE., Minneapolis.

Dr. and Mrs. Robert D. Flaig announce the recent birth of their third child, a baby girl, at Eagle Butte, S.D., where Bob is

serving with the U.S.P.H.S. He will begin a residency in orthopedic surgery at the U.S.P.H.S. Hospital in San Francisco on July 1, 1965.

◆ **1963**

Richard I. Adams was married January 2, 1965 to Miss Phyllis Mattson of St. Paul, Minn., a nurse at Ancker Hospital where Dick interned. They have returned from their honeymoon in the Bahamas and Dick is now associated in general practice with the Belzer Clinic in Minneapolis.

Capt. Allen K. Larson is a flight surgeon with the Air Force at Dow AFB, Maine. He "enjoys flying about the country," and writes of meeting classmate Peter Strand at Plattsburgh AFB, New York, where Pete is a general medical officer. Al hopes to take a residency in ophthalmology after military service.

Thomas C. Leach is now in general practice at Babbitt, Minn.

Lt. Lloyd L. Leider, Jr., U.S.N., writes from Camp Pendleton, Calif., where he is serving with the Marine Corps. He and his wife are expecting their third child in April, and "looking for our first boy." Larry is contemplating a career in orthopedic surgery after military service.

◆ **1964**

Clyde W. Smith, interning at Cook County Hospital, Chicago, has become engaged to Miss Mary L. Heskje of Cedar Rapids, Iowa. They will be married July 10, 1965.

Alumni Deaths

◆ 1927

Dr. Irvin L. Norman, New York, N.Y. Died March 4, 1965 at the age of 60. A retired rear admiral in the U.S. Navy, Dr. Norman was medical director of the Chase Manhattan Bank. He retired from the Navy as assistant chief of the Bureau of Medicine and Surgery. Burial was in Arlington National Cemetery.

◆ 1933

Dr. J. Lawrence Noble, St. Paul, Minn. Died March 8, 1965, at the age of 56 years. A lifelong resident of St. Paul, he had practiced general medicine and served with the military forces in the Pacific during World War II.

◆ 1939

Dr. John E. Low, Billings, Mont. Died November 13, 1964, aged 53, of bronchogenic carcinoma. He was a member of the staffs of Deaconess and St. Vincent's hospitals.

Memorial Gifts

The Minnesota Medical Foundation acknowledges with gratitude recent contributions made in memory of:

Dr. Edward P. Burch
St. Paul, Minn.

Mary Jane Welscher
West St. Paul, Minn.

James W. Deming
Edina, Minn.

Dr. Herbert Hirsch
Minneapolis, Minn.

Memorial gifts are a thoughtful means of honoring the memory of a relative, friend, or colleague. They serve the living by strengthening medical education and research at the University of Minnesota Medical School. Gifts may be designated for specific purposes. The Minnesota Medican Foundation acknowledges all gifts to both donor and next of kin.

COMING EVENTS

University of Minnesota Medical School

CONTINUATION COURSES FOR PHYSICIANS

University of Minnesota
Center for Continuation Study

1965

April 2 - 3 . . . . . Trauma

April 22 - 24 . . . . . Obstetrics

May 3 - 5 . . . . . Ophthalmology

May 20 - 22 . . . . . Surgery

The University of Minnesota reserves the right to change this schedule without notification.

Courses are held at the Center for Continuation Study or the Mayo Memorial Auditorium on the campus of the University of Minnesota. Usual tuition fees are $50 for a two-day course, $60 for a 2½-day course, $70 for a three-day course, and $100 for a one-week course.

Specific announcements are sent out about two months prior to each course to all members of the Minnesota State Medical Association and to any physicians who request information for a specific course. For further information write to:

DIRECTOR
DEPARTMENT OF CONTINUATION MEDICAL EDUCATION
THE MEDICAL CENTER (BOX 193)
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA 55455

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