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KARL SPENCER LASHLEY

1890—1958

A Biographical Memoir by

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Eminent psychologist with no earned degree in psychology
Famous theorist who specialized in disproving theories, including his own
Inspiring teacher who described all teaching as useless

KARL SPENCER LASHLEY, one of the great psychologists of our time, was born on June 7, 1890, and died on August 7, 1958. His birth occurred in Davis, West Virginia; his death in Poitiers, France. Over a span of sixty-eight years Karl Lashley grew from a small-town boy with the heart of a naturalist to become an eminent neuropsychologist. He helped to shape the beginning of a new era in physiological psychology, and his research and theorizing concerning the brain and behavior had an important influence upon contemporaneous thought in psychology and neurology.

Ancestry. Lashley came from substantial, middle-class stock of English derivation. Henry Lashley, Karl's paternal great-grandfather, owned a tannery and a brickyard in the village of Gilpin, Maryland, which was located about twelve miles from Cumberland. He also owned, at various times, small stores in Flintstone, Cumberland, and Davis. Henry had little use for formal education, and as soon as his sons had completed their elementary schooling they became clerks in one of his merchandising establishments. Three sons eventually became managers of branch stores.

Karl's grandfather, Jacob Lashley, managed the store in Davis, and was succeeded by Charles Gilpin Lashley, Karl's father. Charles had at one time expressed an ambition to "read medicine" with a local physician, but Jacob persuaded him to follow the family tradition. In addition to managing the family store, Charles Lashley organized a small bank in Davis, and held a number of political posts. He served as mayor for several terms, and was appointed postmaster during the administrations of Harrison, Coolidge, and Hoover. Fragmentary notes left by Karl portray his father as a kindly man with a certain talent for local politics, some business acumen, and strong family ties and affections, but without any powerful ambition or drive—all in all not a likely sire to a famous scientist.

On the distaff side, Lashley's great-grandfather was Osa Spencer, also of English blood. By his second wife, Ann Mercer, Osa fathered seven children including David Hatton Spencer, grandfather to Karl. David married Maria Chalfonte who must have been a woman of great energy and strong character for she not only raised nine children, but, following her husband's death, successfully managed the family farm for thirty-six years until her death at the age of ninety. Karl's grandmother Maria was the daughter of William Chalfonte and Elizabeth Edwards. Elizabeth, in turn was descended from Jonathan Edwards, to whose judgment General George Washington often deferred with the statement, "We must consult Brother Jonathan." Although, as noted later, Karl steadfastly refused to prepare a formal autobiography, he did occasionally jot down casual notes and observations concerning his own history. At one time he wrote of his hereditary background, ". . . it is clear that the intellectual curiosity and drive descended through that maternal line."

The plausibility of this conclusion is increased by consideration of the talents and accomplishments of Karl's mother. Maggie Blanche Spencer, daughter of David and Maria, had a normal school education and began teaching country school at the age of sixteen.

She was always an avid reader, and she amassed a personal library of more than 2,000 volumes.

Throughout her life she manifested great reverence for learning, and although she resigned her school position at the time of her marriage to Charles Lashley, Maggie never ceased teaching. The Lashley home in Davis became a center for what today would be called "adult education" where women came for instruction in a variety of subjects ranging from civics to Greek poetry and drama. Not content with caring for her family and acting as instructress to her neighbors, Maggie Lashley opened and operated a commercial photographic studio. As a hobby she learned the art of painting and firing chinaware, and became expert in the production of delicate, translucent cups, saucers, and other pieces.

Considering the accomplishments of Henry, Jacob, and Charles Lashley, and comparing these with the descriptions of Osa and Maggie Spencer, one is strongly inclined to agree with Karl's belief that the hereditary elements contributing to his own intellectual reach and thirst for knowledge are traceable chiefly to "Edwards genes."

The Early Years. The remarkable woman, Maggie Lashley, exerted a very powerful influence upon the early development of Karl, her only child. They were extremely close, and from his mother the boy acquired a love of nature and of learning. In later years he was wont to say that he was reared on a combination of Nestle's Food and Nietzsche, although later we shall have something to say concerning Lashley's love of the "low bow."

In any event, Lashley's mother encouraged him in intellectual pursuits, with the result that he could read at the age of four, and throughout his childhood made avid use of the extensive family library. But Karl was not destined to be merely a bookworm for he had the instincts of a naturalist, and from early childhood displayed a deep interest in plant life and in all kinds of animals, both wild and domestic. A favorite boyhood pastime was to wander through

the woods and fields, observing and sometimes collecting various plants and animals. At different times he maintained collections of butterflies, snakes, frogs, and snails, not to mention pet mice and racoons.

Upon at least one occasion young Karl's interest in animal behavior took a practical turn. The family barn was infested by large numbers of rats, and his father offered to pay five cents for each rodent bagged. The first day of trapping yielded thirty-six rats; the second brought twenty-seven. At this point Lashley senior prudently terminated the contract.

An interest in animals persisted throughout his life, and Lashley was never without some kind of pet. At one time he owned a cat and a parrot, but the combination created certain unexpected problems when the voluble bird displayed a disconcerting tendency to adopt the cat's new-born kittens. The roster of pets included another cat (Gottlieb Teufel), a cockateel, a monkey, and several dogs, the last of which was Till Eulenspiegel, who developed, under her master's tutelage, an inordinate fondness for daiquiris and pink ladies.

It is of considerable significance that during his childhood, while he was exploring the countryside or browsing in his mother's library, Karl had very few playmates. Most of his time seems to have been spent in solitude or in the company of adults. It was a prophetic pattern, in a way, for many years later Lashley told the present writer that some of his happiest days were spent all alone on an island in the Dry Tortugas.

During his childhood Karl discharged the usual stint of chores expected of a boy living in a small town near the turn of the century. He was responsible for the care of a pair of fine carriage horses owned by his father, and at the close of each day he brought in the family cow. The latter was no mean feat since there was no fenced pasture, and the beast was free to roam the countryside at will. When he grew a bit older Karl was also expected to clerk in his father's general store.

Lashley's pronounced aptitude for mechanical achievement showed

itself when he was quite young. He was fascinated by his mother's sewing machine, and learned to use it very efficiently,—an accomplishment which proved useful later when he made sails for the boats which he owned at different times. His preoccupation with sewing was so intense that Karl's father was afraid the machine would wear out, and as a substitute the boy was presented with a jigsaw outfit. This opportunity to construct things with his hands was welcome, and from his new workshop there issued a steady flow of expertly designed and finely executed articles ranging in size from spectacle cases to living room furniture. The pleasure derived from this form of creativity persisted throughout life, and even after his retirement Lashley continued with his cabinet making, and extended his efforts to include the remodeling of his house.

Most of Karl's childhood was spent in Davis, but there was a four-year interlude during which the family moved several times. Between 1894 and 1898 they lived in Elk Garden, and Hartmansville, West Virginia, Los Angeles, and Seattle. The move to Seattle in 1897 resulted in experiences which made a strong impression on the seven-year-old boy. In an informal account set down years later Lashley recalled the fever of the gold rush, and meetings with such swashbuckling characters as Swiftwater Bill and Klondike Pete who sported nugget jewelry and recounted tall tales about fabulous "strikes" and the dangers of encountering bird-sized Alaskan mosquitoes.

Like so many others, Charles and Maggie Lashley fell prey to gold fever and decided to go north to prospect. The decision brought with it one welcome release for Karl. Recalling the occasion he wrote, "The happy event for me was the cutting of my long blond curls, à la Fauntleroy, which had been my shame for two years."

Two of Charles' brothers were persuaded to leave the East and join the Lashley party. Because there was a near famine in Dawson in 1897, the Canadian Government required that prospectors bring with them provisions sufficient for two years. This amounted to one ton per person. Eventually an outfit was assembled and the four

adults and one child took passage on the steamer *Queen,* sailing from Seattle to Skagway. Lashley's vivid recollections of the passage included the memory of colorful fellow passengers such as, "miners, cheechawkers, dance hall girls, and a deckload of dogs ranging from a ten-pound terrier to a huge mastiff,—few more suited to the trail than their masters."

At Skagway the party disembarked and then proceeded by dog sled for some distance. Eventually all supplies and equipment had to be transferred to hand sleds for the arduous climb over Chilkoot Pass. Lashley's written reminiscences of this experience are full of color and vitality. The primitive Chilkoot trail must have taxed a seven-year-old boy's endurance, but the memory was so rewarding that Lashley arranged to revisit the site of these childhood adventures in 1948 and again in 1957. The fragmentary account of the original trip was found in an album of snapshots which were taken when he retraced portions of the original route in 1948.

Following the Alaskan excursion the Lashley family returned to Davis and resettled there in 1899.

School and College. Karl was entered in a private school at the age of four. In 1895 he attended the public school in Elk Garden, and the next year the one in Hartmansville. There followed two interrupted terms at the Denny School in Seattle, and the remainder of Lashley's precollege education was received in the public system in Davis where he graduated from high school when he was fourteen years old.

Because Davis High School was not accredited Karl did not qualify as a freshman when he entered the University of West Virginia, but had to spend one year in the "Preparatory Department" of that institution. During the subsequent year as a freshman he was, as he later wrote, "thoroughly lost." He was "vaguely inclined to engineering"; his father wanted him to study medicine, but his mother insisted on his earning an A.B. degree, and this he did.

His first plan was to major in Latin, but the university registrar instructed him to make English his major. To fill a vacant hour in

his schedule Karl enrolled in a course in zoology. His professor was John Black Johnston, a neurologist and the only teacher of zoology in the university. The contact with Johnston and his subject matter had a profound influence upon the sixteen-year-old boy. Of the first course he later wrote, "Within a few weeks in his class I knew that I had found my life's work."

At the beginning of the next academic quarter Lashley rebelled against his faculty advisor's order that he drop the course in zoology and replace it with one in Old English. Instead of complying, the young freshman changed his major from English to zoology. Explaining this decision in retrospect he wrote as follows:

"Zoology attracted me because of my prior interest in animals, because it required much freehand drawing, which I enjoyed, and because it seemed to support the materialism which, even at 16, I was beginning to formulate vaguely."

During his freshman year Karl studied general zoology and comparative anatomy with Johnston, but Johnston left at the close of the spring term and was replaced by Albert M. Reese. Reese appointed Lashley departmental assistant, at a salary of twenty-five cents per hour. One of the new assistant's first tasks was to sort out various materials that Johnston had left behind. The result of this assignment can best be expressed in Lashley's own words:

"Among them I found a beautiful Golgi series of the frog brain. I took these to Reese and proposed that I draw all of the connections between the cells. Then we would know how the frog worked. It was a shock to learn that the Golgi method does not stain all cells, but I think almost ever since I have been trying to trace those connections."

As a sophomore Karl took several courses in zoology including embryology, histology, animal behavior, and general technique. At the start of his junior year he wanted to register for an advanced course in zoology, but as the only zoologist on the faculty Reese was too busy to conduct a one-student seminar. Nevertheless Lashley learned a great deal in the course of his assistantship. Reese's instruc-

tions were such as to encourage, in fact to compel, the exercise of initiative, and to develop independence of thought and action, "You will find some bones in the basement. Go work up a course in comparative osteology." Another time Lashley was told, "Here is a copy of Burkholder. Get some sheep brains and work up the anatomy. I want you to take charge of the laboratory course in neurology next term." This experience had lasting effects upon Lashley's philosophy of education and influenced his treatment of his own students in later years.

Advanced Training. After earning his A.B. at West Virginia in 1910, Lashley applied for and was awarded a teaching fellowship in biology at the University of Pittsburgh. He taught several laboratory sections of the biology course, and carried out the research for his Master's thesis. Unquestionably the most important aspect of Lashley's year at Pittsburgh was his contact with another teaching fellow, Karl Dallenbach, a psychologist. Dallenbach's memory of their year together includes the following observation:

"Lashley's laboratory was on the floor above mine. Though he had never taken a course in psychology, he was permitted, because he was a fellow, to elect my laboratory course in experimental psychology. The class was small and we worked intimately together upon the various experiments. Lashley was intensely interested and was the outstanding student in the class—as one might expect being a graduate student in an undergraduate class, but he was more than a run-of-the-mine graduate student. He showed in that course the promise that he later fulfilled."

Receiving his Master's degree in June, 1911, Lashley spent the summer at the Carnegie Laboratories at Cold Spring Harbor. There he studied the variability in the number of cirri in the ciliate, *Stylonychia.* This work attracted the attention of H. S. Jennings, professor of zoology at the Johns Hopkins University, and he offered Lashley a fellowship which was accepted. At Hopkins Karl participated in Jennings' research on paramecia, and also worked with S. O. Mast on the behavior of various invertebrates. His thesis dealt with

inheritance in the asexual reproduction of *Hydra,* and he received the Ph.D. degree in 1914.

The interest in psychology, first aroused by Dallenbach, continued while Lashley was at Hopkins. He was greatly stimulated by contact with Adolf Meyer, professor of psychiatry and director of the newly established Henry Phipps Clinic. While majoring in zoology, Karl took two minors. One was with Meyer, and the other was with a psychologist destined for fame, John B. Watson. The impact of Watson's behavioristic approach was so great that forty-four years later Lashley asserted, "anyone who knows American psychology today knows that its value derives from biology and from Watson."

During the year following the granting of the Ph.D. Lashley remained at Hopkins as a Bruce Fellow in zoology. In the summer of 1914 he and Watson carried on field experiments on the behavior of sea birds. They made their observations on Bird Key in the Dry Tortugas, studying chiefly the homing, nesting, and reproductive behavior of sooty and noddy terns. That same year Lashley carried on experiments on the acquisition of motor skills in human subjects, color vision in birds, and conditioning of the salivary reflex.

During the academic year of 1915–1916 Lashley continued at Hopkins with an appointment as Johnston Scholar. He occupied a basement laboratory adjacent to one which housed a beginning graduate student, W. H. Taliaferro, who became a life-long friend, and was for a while Lashley's colleague at the University of Chicago.

While he held the Johnston Scholarship, Lashley continued to work with Watson, studying, among other problems, the effects of strychnine and other drugs upon maze learning in rats. At this time Shepherd Ivory Franz was examining the behavior of brain-injured patients at Saint Elizabeth's Hospital in Washington, D. C. He was also carrying out experiments with animals to investigate the behavioral effects of surgically inflicted brain lesions. Lashley became greatly interested in Franz's program and journeyed frequently to Washington to observe the brain-operated monkeys.

Lashley was anxious to learn surgical techniques from Franz, but

first he was required to participate in a study of body types which involved the photographing of nude women. Surviving this first assignment he was permitted to graduate to the study of neurological cases on the wards. Eventually he acquired the surgical and histological skills which permitted the inception of a major program of studies on the neural basis of learning. With the inauguration of this program, which eventually brought eminence and world-wide recognition, Lashley's research career was solidly launched, and this terminated his period of training.

Professional Posts. Lashley's first, full-time professional position was that of instructor in psychology at the University of Minnesota, where he took up his duties in the fall of 1917. The appointment was arranged by Robert M. Yerkes who was slated to assume the chairmanship of the psychology department. However, Yerkes became involved in the organization of the new National Research Council and was forced to remain in Washington instead of taking up his administrative duties at Minnesota. Because of this, or for other reasons, departmental morale was not high, and Lashley left at the end of his first year, taking a leave of absence.

From Minnesota he went to Baltimore, accepting a position with the United States International Hygiene Board. His vision was too poor to meet Army standards and the wartime program to which he was assigned was aimed primarily at educating the public with respect to the dangers of venereal disease. Working once more with Watson, Lashley participated in showing and discussing motion picture films designed to further the campaign against this particular affliction. In later years he enjoyed telling of one time when he and Watson went into a small town and distributed advertisements announcing a free motion picture show. The announcements included no mention of the subject matter, and, according to Lashley, he and Watson were fortunate to escape from the Sheriff and outraged citizenry with whole skins.

In 1920, R. M. Elliott, who had become chairman of the department of psychology at the University of Minnesota, persuaded Lash-

ley to return as an assistant professor. This promotion was made at Elliott's insistence. In his contribution to *A History of Psychology in Autobiography,* Elliott recalls Lashley's career at Minnesota in vivid terms.

When he had been back for just one year, Elliott insisted "violently" that Lashley be promoted to associate professor. In another two years he was advanced to full professorship, at which time he was thirty-four years old. John Black Johnston, under whom Lashley had studied at West Virginia, was then a dean at Minnesota.

Referring to Lashley's situation at Minnesota in the early twenties, Elliott has written as follows:

"Lashley's intellectual pre-eminence and the brilliant reports of study after study of brain function in rats and monkeys presented at our all-department seminar placed him in the prestige spot among us. I constituted myself guardian and protector outside his laboratory door, fending off official expectations of a usual teaching load and other threats to his research productivity, all the while shoving into him and his students (how the good ones do flock around a good man!) whatever supplies and equipment they needed. We think those six years were the most productive period of Lashley's career."[1]

In 1926 Lashley left Minnesota for Chicago to accept an appointment as a research psychologist associated with the Behavior Research Fund at the Institute for Juvenile Research. In 1929 he became professor of psychology at the University of Chicago. In this position he remained until 1935.

When James B. Conant succeeded Lowell as president of Harvard University one of his early acts, according to E. G. Boring, was to appoint his first ad hoc committee to find the "best psychologist in the world" to elect to a Chair at Harvard.[2] Lashley was chosen by the committee. He was first elected professor of psychology, and only then was he informed of this action and asked whether he would

[1] *A History of Psychology in Autobiography,* Vol. IV, edited by E. G. Boring, H. S. Langfeld, and R. M. Yerkes (Worcester, Mass.: Clark University Press, 1952), p. 88.

[2] *Ibid.,* p. 45.

accept. He did so, and was given laboratory space in the new Biological Laboratories.

In 1937 Lashley was made research professor in neuropsychology. Retaining this title, he became, in 1942, Director of the Yerkes Laboratories of Primate Biology, and continued in this position until his retirement in 1955. During the thirteen-year period at the Yerkes Laboratories in Orange Park, Florida, Lashley journeyed to Cambridge once each year to give a two-week seminar for graduate students.

Research. Throughout his professional life Lashley persisted in his attempts to discover "how the frog works" by learning how the nervous system works. Despite the world-wide recognition accorded his research, Lashley did not feel that he or anyone else had made much progress toward a solution of the central problems involved. Toward the close of his life he expressed his views in a letter to Sir Francis Walshe:

"Brain function presents the most difficult and elusive problems in science and I have little hope of seeing any of them solved . . . But if we have contributed something of orientation and scientific approach to the problems I think we may feel that we have done about all that is possible in our generation."

Lashley's contributions to psychology are accurately represented in a recently published volume of selected papers, *The Neuropsychology of Lashley.*[3] The reprinted articles reflect the four major divisions of Lashley's total scientific production: (1) laying the foundations, (2) the grand attack upon connectionism, (3) experimental studies of sensory representation (chiefly vision), and (4) general theory.

The earliest papers dealing with protozoans and coelenterates stem directly from Lashley's training as a biologist and geneticist, but among them are clear indications of his concern with problems of behavior. Such, for example, are his field studies with Watson of the reproductive and homing behavior of terns. After a brief period of work on Pavlovian conditioning Lashley began to concentrate more

[3] McGraw-Hill Book Company, Inc., 1960.

and more upon the study of neural mechanisms and learning. He quickly convinced himself that contemporary theories were erroneous, and that learning could never be explained in terms of the formation of simple connections within the brain. During the years at Minnesota and at the Behavior Research Fund, Lashley experienced his most productive period and his studies of learning and brain function culminated in the publication of the monograph, *Brain Mechanisms and Intelligence,* published by the University of Chicago Press in 1929. This was Lashley's longest single publication. He never wrote a book, and in fact sometimes, only half facetiously, pronounced his opinion that book writing should be left to those who could not or would not carry on research. In the 1929 monograph, in addition to the results of many careful experiments, Lashley enunciated his controversial concepts of "mass action" and "equipotentiality." These were, in actuality, simply a summary of the experimental findings, and did not purport to serve as explanations.

According to the principle of mass action, learning is mediated by the cerebral cortex acting as a whole; at least this is true of certain types of learning. The experimental evidence was drawn principally from studies of maze learning in rats which had been surgically deprived of different amounts of cortical tissue. The results showed that such operations reduce the efficiency of learning, and that the degree of reduction is roughly proportionate to the amount of cortex destroyed, but unrelated to the locus of the lesion within the neopallium.

The notion of equipotentiality was generated by Lashley's experiments on the function of the association areas of the cortex and later extended to apply to neural mechanisms for vision. He found that a rat which had been trained to discriminate between triangles and circles would lose the habit after the striate cortex was removed. However, this result depended upon destruction of the entire striate area. If as little as ten per cent was spared there was no impairment of the learned discrimination. Since it made no difference which subregion within the striate cortex was left intact, Lashley concluded

that all parts of the visual area are "equipotential" as far as the mediation of discrimination learning is concerned.

As is true of all first-rank scientists, Lashley's interests and insights ranged far beyond the boundaries encompassing his personal research. In 1920, as an assistant professor at Minnesota, he wrote to a prospective graduate student, outlining several potential thesis projects:

March 21, 1920

Dear Mr. Stone:

The discussion of plans and problems at long range will probably not be very satisfactory to either of us, but we shall have to make the best of a bad situation. I shall attempt now only a most general outline of possibilities. Then, when I know your interests somewhat better, we can take up specific problems.

Do you expect to come up for your doctorate next year? The selection of your problem will depend largely upon this. If you do, your choice is limited to problems in which the technique is pretty well worked out and a good many interesting possibilities are ruled out. If you have more time to spend you can produce a much more attractive and original thesis.

At present I am interested chiefly in the following fields:

1. Comparative anatomical and physiological studies of the sense-organs, especially in audition and color-vision. Work here will give immediate definite results but does not seem to attract much attention. An advantage for you would be the fact that you have the technique.
2. Effect of drugs, diet, starvation, hormones, etc. upon the learning process. Here the technique is simple and results are fairly certain.
3. The experimental control of instincts; the effects of internal secretions upon specific reactions—for example, attempts to induce maternal behavior in virgin females by injection or transplanting pregnant uterus. A great deal of preliminary work will be necessary here and I doubt that much could be done in a single year, but positive results would be pretty sure to make a man in psychology.
4. Physiology of the nervous system in relation to learning. You can get some idea of this field from my recent paper in Psychobiology. A few specific problems are—

   The formation of conditioned reflexes without the cerebrum. The best chance here is in work with decerebrate frogs or salamanders.

   The determination of the exact cortical path of visual or auditory

habits; a more detailed application of the method which I used for the visual area in the rat.

The function of the motor cortex in habits; training an animal in a habit of manipulation, recovery from paralysis without practice in the habit, tests for retention of the habit—to determine whether the motor area functions in habit or only in tonic control.

Effects of maldevelopment of the brain upon intelligence and learning ability. Partial occlusion of carotids in infancy (rat). Production of abnormal development of brain in fish or amphibia.

5. General functional anatomy of the brain.

Correlation of excitable areas with cytoarchitecture. Combined stimulation and anatomical studies of the development of the motor cortex in young animals.

The determination of sensory projection areas in the rat by strychnine and extirpation methods.

Location of reflex paths of instincts by destruction of basilar regions. I think I have a technique for destroying minute areas of the thalamus, which may or may not give results.

Binocular and monocular vision of birds in relation to cerebral function.

These are the types of problems. Most of them demand some histological technique and if you have had experience in this it will help greatly. If by chance you have the string galvanometer technique there is a wealth of problems to be attacked at once. If you have a good foundation in chemistry, there are some important problems in the relation of efficiency to the chemistry of the blood which might be practicable. If we can get clinical material, which I doubt, you might work on a problem in re-education, or such a thing as the factors which modify tonic innervation in hemiplegia.

Let me know if any of the above problems seem attractive to you and I will give you a more detailed program with suggestions as to working up the technique. If you want to work in functional neurology you will have to have some surgical technique, and if you can pick it up this summer, so much the better. You can probably get a third year medic to help you out. Decide what animals you want to work with and get as familiar with their normal behavior as you can. If you have not done so, work out the gross anatomy of several brains, cat, sheep, and rabbit.

As for literature, there are very few suggestive books. Parker's Elementary Nervous System (forget exact title), Verworn-Irritability, Lucas-Conduction of Nerve Impulse, Gaskell-Auto-Funktionen der Nerven

Centra Bd. 3, Von Monakow-Lokalisation im Gros hirn. Look up Von Monakow's articles and T. Graham Brown's in Ergebnisse der Physiologie. Run through recent volumes of Brain, Amer. J. of Physiol., Journal of Physiol. (British), and read whatever interests you. What can you find out about intra-uterine development of reflexes?

It is going to be rather difficult for you to work into a new field and to turn out a well rounded piece of work in one year, but we can try, at any rate. Let me have your reaction to these suggestions soon and do not hesitate to ask for more detailed programs or any help that I can give you.

Sincerely yours,

(signed) K. S. Lashley

The recipient of this letter was Calvin Stone who was, years later, elected to the National Academy of Sciences. Those who are familiar with developments in physiological psychology since the letter was written will find many of Lashley's suggestions impressively prophetic. He was then thinking more than a decade ahead of his time, and several of the lines of investigation which he mentioned have since been opened with fruitful and significant results.

Lashley's enduring interest in visual mechanisms resulted in a long series of publications representing basic contributions, not only to visual learning and its physiological basis, but also to the science of neuroanatomy. By studying degenerative changes in the lateral geniculate nucleus consequent to restricted destruction in the visual cortex, for example, he was able to demonstrate that different parts of the thalamic nucleus are connected to different areas in the striate region. There is, in fact, something approximating a point-for-point projection of the lateral geniculate upon the visual cortex. Lashley later went on to show that there is a similar projection of other thalamic nuclei to the cortex.

Another major contribution to neuroanatomy was made by Lashley and George Clark in 1946, when they reported their study of the cytoarchitecture of the primate cerebral cortex. Prior to this work various scholars had subdivided the cortex in different ways, basing their decisions upon apparent, local differences in the types, numbers, and sizes of cells present. Some specialists listed more than one

hundred separate cortical areas. Brodmann, one of the most widely followed authorities, described forty-seven distinct areas in the human cortex.

Lashley and Clark's critical examination of the cortex of the spider monkey, *Ateles,* revealed that at most there are six, architectonically discriminable areas in the neopallium. As Hebb has said, the study was crucial and at one blow demolished the current reliance upon local differences in cellular composition as indices to major structural compartmentalism.[4] The results were so convincing that no refutation was even attempted, and Lashley received congratulations from several leading neuroanatomists including Lorente de Nó.

His fertile mind was ever on the alert for any facts that might throw light on how the nervous system works. A long-time sufferer from migraine, Lashley made careful records of the visual patterns and scotomata which accompanied his attacks, and from these data formulated a provocative hypothesis concerning concurrent activity within the striate cortex. He once calculated the speed of finger movements involved in playing a rapid cadenza on the piano, and compared this with the known speed of neural transmission. The comparison revealed that the intervals between successive finger movements were too short to support the theory that each movement is aroused by motor impulses which in turn are set off by sensory impulses derived from the preceding finger movement. There is not enough time for a sensory message from the finger to go to the brain and pass to the motor area and then for a motor impulse to return to the finger muscles. Lashley often cited this example in support of the notion of central patterning of complex motor sequences.

Lashley's attitude toward research was that it demands the complete, personal involvement of the investigator. In his beginning years as an experimenter he was interested in the acquisition of motor skills. One of the tasks investigated was that of throwing darts at a target. A single session lasted twenty-two hours and each subject, Lashley among them, was required to make a cast every few min-

[4] *American Journal of Psychology,* Vol. 72, No. 1 (1959), p. 148.

utes. A table loaded with sandwiches stood in one corner of the laboratory, and the subjects marched from the throwing stand, around the table, grabbing a sandwich when necessary, thence back to the throwing line once more.

In later years Lashley continued to conduct his own experiments, and the system of employing assistants to make the actual tests found little favor in his scheme of things. It was his conviction that good research workers are rare and that money cannot buy inspiration and brains. In a letter written to John B. Watson in 1953, Lashley expressed himself as follows:

"The money available for research now is rather shocking. The man who doesn't have $20,000 per year for his research is probably intellectually honest. There are not enough competent men to spend the money. I recently attended a symposium on the training of graduate students at the Southern Society of Philosophy and Psychology. The discussion was entirely on training men for clinical practice. I finally blew up and delivered a speech to the effect that some research is needed as a basis for clinical practice and that I had heard rumors that graduate instruction might occasionally be concerned with training men for research, though one would never suspect it from the symposium. The head of the Civil Service was there and said that he cannot find competent research men, and thanked me for bringing up the subject. Membership in the A.P.A. is approaching 20,000, but I don't believe there are as many good research men in the field as there were in 1918."

Theory Building and Razing. A major source of motivation which influenced Lashley throughout most of his professional life was the desire to formulate a comprehensive theory of learning. He was, of course, certain that any tenable theory would have to be of a neurophysiological nature, and he made several attempts in this direction. Being convinced that simple connectionism would never explain learning, Lashley was inclined toward some form of field theory, but despite the brilliance of his speculations he was never satisfied with any of them for very long. As a matter of fact he was especially

adept at marshalling convincing evidence which demolished every existing theory of learning, including his own.

In the 1920's he was persuaded by R. M. Elliott, who was editing the Century Psychology Series, to write a book on learning. The task was never completed. In 1928 Lashley wrote to Professor Elliott referring to the project and making the following comment:

"I am working on it intermittently. The difficulty is the final collapse of my whole neurological and psychological system. I am sure that none of the existing theories of learning is even relevant to the problem. I am coming to doubt that even the reflex is a valid statement of spinal mechanisms. I have no alternative hypothesis."

Ten years later, while at Harvard, Lashley wrote, "I am afraid the prospects for a book are not good. My bricks won't hang together without speculative straw that I know is hooey."

Speaking before the Society for Experimental Biology at Cambridge University in 1950, Lashley summarized a large number of investigations on the neurophysiology of learning, and then added the following observation:

"This series of experiments has yielded a good bit of information about what and where the memory trace is not. It has discovered nothing directly of the real nature of the engram. I sometimes feel, in reviewing the evidence on the localization of the memory trace, that the necessary conclusion is that learning just is not possible."[5]

In his Vanuxem Lectures, delivered at Princeton in 1952, Lashley enunciated a theory of shifting fields of excitation within the cerebral cortex as a basis for learning. In 1955 he wrote to John B. Watson as follows:

"I shall try to finish up a couple of books in the next year or two. The Vanuxem Lectures are giving me trouble; since I gave them my students and I have disproved most of what I said in the lectures—my theory of spreading neural patterns—and I have no alternative to offer."

[5] Pp. 477–78, In Search of the Engram. In: *Physiological Mechanisms in Animal Behaviour.* Symp. of the Soc. for Exp. Biol. No. IV, 1950, pp. 454–482.

Although he was unconvinced by his own theories, many of Lashley's formulations had significant impact upon contemporary thought and stimulated much original research. For example, demolition of connectionistic explanations opened the way for alternative hypotheses. Demonstration that certain visual habits lost after cortical injury could be relearned postoperatively pointed up the problem of vicarious function. An ingenious analysis of "pseudoaffective states" in brain-injured patients exploded current theories implicating the thalamus as the center for emotional experience.

Teacher, Friend, Associate. It was Lashley's professed philosophy that trying to teach people is useless, "Those who need to be taught can't learn, and those who can learn don't need to be taught." Nevertheless he could upon occasion be a stimulating lecturer, and he was particularly effective in informal seminars. A former student recalls Lashley's effect upon students at Minnesota very vividly:

"I saw Karl for the first time when I was taking a General Psychology course. An assembly lecture was given to all psychology classes once every two weeks, with different professors giving one lecture to about 200 students. Karl tall, lean, sardonic, held up a frog, made the muscles jump, grinned at us and talked informally in his rather precise voice. We learned more in 40 minutes from him than we had from the other eight professors and we all filed out of the hall wanting to know when we could take a course from this thin, splendid lecturer with the pince-nez on a black string. We quickly learned that we couldn't. He hated teaching formally and was available for only a few graduate students."

One of Lashley's colleagues during the Minnesota period remembers him as being always deep in research for what seemed to be eighteen hours of every day. Though thin as a rail and sometimes white as a sheet he was imbued with great zest and never seemed tired. At the bi-weekly departmental seminars Lashley's presentation of his own research always generated great excitement. When others made their own reports he spoke rarely, but when he did, "it would

be hard to exaggerate the impact of his thinking and of his personality on his students and colleagues."

R. M. Elliott recalls that at Minnesota there was "always a small coterie of devoted students who practically lived with him in the laboratory." This was true also at the University of Chicago and later at Harvard. Lashley did a great deal of teaching, but this took place in small groups, the traditional coffee hour in his laboratory, or in individual conversations in his own office or the student's lab. He very rarely visited the research room of a subordinate, being a great believer in letting a student "go it alone"; but he was available for advice and consultation if the student sought him out. It is plausible that this attitude stemmed from Lashley's experiences at the University of West Virginia, when Reese simply told him to "work up" the anatomy of the sheep brain and then left him to his own devices.

The system worked with superior students, but others fell by the wayside, overwhelmed by a situation in which they were, for the first time in their college careers, offered unlimited freedom in research and expected to perform like mature scientists. The present writer used to argue with Lashley that a little more direction and guidance might help some students achieve independence and develop the ability to plan and execute their own research, but Lashley believed that anyone who needed this kind of support would never become a successful investigator and might as well be eliminated early in the game.

Within the limits just described Lashley gave willingly of himself in his relations with students and colleagues, but his intimates were few. He surrounded himself with a distinct reserve, which held no note of unfriendliness, but tended to discourage personal intimacy. He was, in a sense, aloof without being cold.

Some feeling for Lashley's effect upon those who associated with him can be gained from letters written after his death:

"I can help you very little in your search for light on Lashley's early career. I ask myself why this is so, why I did not take advantage

of my six years of association with Lashley to find out more about his background and earlier professional life. The only answer I can give myself is that Lashley did not encourage personal enquiry."

Sir Frederic Bartlett has said of Lashley:

"In his experimental and theoretical work, and in his life outside the lab as well, he would go where he wanted, he would say what he believed, not because he was insensitive, but because his only ultimate compulsion came from inside himself."[6]

Another psychologist whose research paralleled that of Lashley in certain respects has written as follows:

"Your asking me these questions about Lashley made me aware for the first time that although I liked him and had the highest regard for his mind and work, I never had the least curiosity about his personal life—his mind somehow seemed disembodied."

One of his students writes:

"Lashley was always impersonal in his dealings with his students and associates. I do not believe that he had the capacity for a real close friendship with anybody."

It is revealing in this connection that although he impressed most of them as being quite impersonal, Lashley carefully kept a list of all of his former students, and noted down any honors that came their way.

Of course, such a complex personality was, inevitably, perceived differently by different people, and one acquaintance who knew Lashley at Minnesota during the early twenties remembers him as being,

". . . very perceptive about people . . . sensitive to their states of mind and feeling . . . kind and generous to his friends, students and colleagues, but without harboring any sentimental illusions about them . . . his opinion of human nature was not at all flattering, yet he didn't want people to be hurt. He did not suffer fools gladly, but he did suffer them courteously and gently—except of

[6] *Biographical Memoirs of Fellows of the Royal Society*, Vol. 5 (1959), pp. 107–119.

course when they got in the way of something really important and then he disposed of them efficiently."

Remembering that as a child, Karl Lashley had very few playmates, associated predominantly with adults, and apparently spent more than the usual amount of time in solitude, wandering the woods and fields, working in his shop, reading—remembering these things one is inclined to wonder whether Lashley the man may not have found it difficult, embarrassing, or simply not worthwhile to make or accept those overtures which are essential to the eventual establishment of numerous friendships. A letter from one of the few men with whom he developed true intimacy describes Lashley as,

". . . a man who desired friendship and love, but was cautious when approached, similar to approaching a thing of wildness and timidity. As teacher and pupil, but more as friends and companions, we worked together for many years. At times I look back upon those years with longing."

The genuine friendships Lashley did form were deep and abiding. A former colleague, writing after Lashley's death, refers to the "sheer friendship and affection" he felt, and adds, "with him I felt at ease as with few other people." One psychologist, when asked to contribute information regarding Karl's life, declined because it would be too painful to delve into the past, and in any event, Lashley would not have wanted it done. This conclusion may be correct, for Lashley steadfastly refused to prepare an account of his life for publication in the semiofficial series entitled *A History of Psychology in Autobiography*. He also declined a request to contribute an autobiographical account to the volume *Perspectives in Biology and Medicine.*

His deep sense of personal privacy would have made it exceedingly difficult for Lashley to write about himself for public consumption. This sort of difficulty is revealed in the following note sent to the present writer after more than twenty years of association:

May 20, 1957

Dear Beach:

As usual we are having library trouble here. I would appreciate it, if

you would get one of your students to look up the page citations in the enclosed list. I enclose a check to pay for his time. The references are from the translation of the papers of Lorenz and Tinbergen. The translation has served my purpose, at any rate, in that by it I have caught a wife.

Claire Schiller and I are to be married on June 9. We plan to drive to California this summer, then to live here for a couple of years, until Christina is ready for college. It was a surprise to me—that is, being accepted.

I hope you can find someone to do this job quickly, so the printers can get out the page proof before we leave.

Sincerely,

Lashley

It would be incorrect to portray Lashley as a withdrawn, unapproachable, overintellectualized sort of person. He was, on the contrary, possessed of a keen sense of humor, and was almost unable to refrain from embroidering a good story when confronted with an appreciative audience. One of his students recalls being, "duly warned not to depend too much on the absolute veracity of K. S.'s stories, since he loved to embellish any story that he might tell if he thought the listener was impressed."

Although he loved and appreciated good plays and music, with the exception of opera, Lashley was not averse to attending burlesque shows. He read widely and his taste was catholic including Icelandic sagas, Virgil, Bertrand Russell, Balzac, Ambrose Bierce, and nonsense poetry which he greatly enjoyed composing as well as reading. His wry humor is reflected in his account of having sent money to an ailing aunt whom he had never seen. He found later that instead of being indigent, the lady was well off, and when she died she left her estate to the Philadelphia Antivivisectionist Society; Lashley concluded his story by saying, "I had never expected to contribute to that organization."

In both his professional and his private life Lashley displayed a great zest and love of exploration and excitement. To ride with him in his car, which was usually a flashy convertible, was truly a hair-raising experience. He operated an automobile with supreme disdain,

both for traffic regulations and for the mechanical limitations of the vehicle.

For years Lashley sailed in dangerous waters without bothering to learn to swim. He did finally master that skill at the age of sixty-seven. He disliked inactivity and particularly begrudged the time lost in sleep, saying that it was a waste of life.

Marriages. Lashley was married twice. In 1918 he married Edith Anne Baker, an accomplished musician who could have had a professional career had she not been chronically afflicted with a severe asthmatic condition. Her illness required expensive medication and frequent hospitalization during the early years of the marriage; and the medical bills for the first year exceeded Lashley's salary as an instructor.

A son born to the couple in 1919 died shortly after birth and the Lashleys remained childless thereafter.

They were very close, sharing, among other things, a deep love of music. In many ways Edith's personality complemented Karl's. He was completely impractical with respect to financial matters, and as likely as not to spend an entire quarterly stipend on the purchase of a new car without worrying about money for living expenses until the next payment arrived. Edith therefore handled all of the family finances, and Lashley used to say that he never knew whether they had ten dollars or ten thousand in the bank, and never cared.

One family friend has written that, "Edith not only did not understand science, but at times disliked it. She was, however, much interested in people of all types—including scientists." This interest plus great natural charm made her a gracious hostess, and an evening in the Lashley home was always a relaxed and pleasant occasion.

Edith died in 1948 and Lashley remained a widower for nine years. In 1957 he married Claire Imredy Schiller, widow of the brilliant Hungarian psychologist, Paul Schiller. This second marriage, while tragically short, was a very happy one, and had an obviously revitalizing effect upon Lashley. He and his bride traveled across the United States, and on their honeymoon revisited the scene of his

boyhood year in Alaska. At the time of his death they were planning joint research in the area of linguistics, for Lashley had a theory that certain problems of brain function might be illuminated through the study of language.

Extraprofessional Interests. Lashley's chief recreational interests were sailing and music. In addition he enjoyed shopwork and chess, and could, when he wished, perform very creditably in the role of chef.

When he was eleven years old he had a few piano lessons, but found scale practice impossibly dull. According to his own account he "picked up the violin without instruction" when he was eighteen. Lashley first heard classical music at the age of twenty and was immediately fascinated by it. During his first year in Minneapolis he was introduced by his wife, Edith, to the literature of chamber music.

The Lashleys' circle of acquaintances included many professional musicians, and beginning in 1920, the couple and their friends devoted at least one evening each week to the playing of chamber music. Lashley had bought an inexpensive 'cello and learned to play it while he was at Hopkins. Later he acquired two excellent ones. He collected an extensive library of instrumental music and continued to play as long as he lived. After moving from Harvard he played with the Jacksonville Philharmonic Orchestra and organized a small group of musicians which met regularly at his home. He was a trustee and generous benefactor of the Jacksonville College of Music.

Lashley's interest in sailing stemmed from childhood when he often fashioned a simple raft by tying two logs together and paddled about on the river. He recalled this pastime as being one of his greatest joys. During his family's sojourn in Seattle they lived next door to a boat designer whose yard was littered with scale models. These fascinated young Karl and awakened an enduring passion for sailing.

During his years at Hopkins he acquired a canoe, equipped it with leeboards, and learned, by trial and error, to sail. When he and

Edith moved to Chicago he bought the Banshee, a thirty-foot yawl. Though he owned six other boats at later times, including a thirty-six foot yawl, the Banshee held his greatest affection. A letter written in 1955 acknowledges that the motor sailer he then owned was much more comfortable, but did not "provide much excitement."

Lashley's skill and interest in woodworking and other types of shopwork traced back to his boyhood when his father gave him a jigsaw outfit to reduce the wear and tear on the family sewing machine. This talent was often put to practical use. His last boat, the Skidbladnir, carried many fittings and castings of Lashley's own design. At the time of his second marriage Lashley did a major job of remodeling his house, which stands on the bank of the St. John's River, with a boat dock in the back yard. In enlarging the house, he laid a parquet floor, put up the ceiling, paneled the walls with knotty pine, and installed closets and a window seat, and then built the furniture including a bed, dressing table, desk, and bookcases.

Extramural Service. Despite the fact that he hated to divert his energies from his research, Lashley did serve his profession in a number of extramural capacities. He was a member of the editorial boards of several scientific journals including the following: *Journal of Genetic Psychology, Journal of Comparative Psychology, Journal of Animal Behavior, Acta Biologica, Acta Psychologica, Quarterly Review of Biology,* and *Journal of the Philosophy of Science.*

At various times Lashley served on different private or governmental committees and boards. His longest term was spent as a member of the National Academy of Science—National Research Council's Committee for Research on Problems of Sex. The annual meetings of this body afforded opportunity for the renewal of old acquaintanceships, particularly with Adolf Meyer whose seminars at Johns Hopkins had stimulated Lashley during his graduate and postgraduate years. Eventually, however, Lashley resigned from this committee because, as he put it, "I found myself saying 'no' to everything."

He was Civilian Advisor to the Office of Scientific Research and

Development, and earlier in his career was actively associated with the Research and Development Division of the Prosthetic and Sensory Aids Service.

Elections and Honors. Although he had little enthusiasm for attending large meetings or conventions, and rarely did so, Lashley was elected to many scientific and philosophical societies. The following is a list of his affiliations: American Psychological Association (Council member 1926–1928; President, 1929), Eastern Psychological Association (President, 1937), Society of Experimental Psychologists, British Psychological Association (Honorary Fellow), American Society of Zoologists, American Society of Naturalists (President, 1947), British Institute for the Study of Animal Behavior (Honorary Member), American Society of Human Genetics, American Physiological Society, Harvey Society (Honorary Member), National Academy of Sciences (elected in 1930), Royal Society, London (Foreign Member), American Philosophical Society, American Academy of Arts and Sciences, New York Academy of Sciences (Honorary Member), Florida Psychological Association.

Among many invited addresses, Lashley delivered the Hughlings Jackson Lectures at Montreal in 1937, and the Vanuxem Lectures at Princeton in 1952.

That his eminence as an investigator was officially recognized by psychologists, zoologists, and physiologists is attested by several major awards. In 1937 the Society of Experimental Psychologists honored Lashley with the Howard Crosby Warren Medal which signifies outstanding scientific contributions to psychology. The National Academy of Sciences, in 1943, awarded Lashley the Daniel Girard Elliot Medal in Zoology. From the Royal College of Physicians he received the William Baly Medal in Physiology. This occurred in 1953.

Lashley was awarded Doctor of Science degrees from the University of Pittsburgh (1936), the University of Chicago (1941), Western Reserve University (1951), the University of Pennsylvania (1955),

and in 1953 the Johns Hopkins University honored Lashley with the degree LL.D.

Importance of Lashley's Scientific Contributions. This memoir was prepared nearly two years after Lashley's death, and a number of necrologies and notes of appreciation had appeared in print during the interim. There is, perhaps, no better way to reflect his scientific stature than to reproduce extracts from several published accounts.

Sir Francis Walshe, in his tribute which appeared in *Neurology,* describes Lashley as:

". . . one of the most brilliant exponents of those problems that include psychology and the physiology of the brain. He moved in this difficult territory with an experimental flair, an intellectual poise, and a competence he shared with few. His contributions to science were of a major order, and lesser men than he have been Nobel Prize men."[7]

Professor H. Thorpe, FRS, has written that for many years Lashley was in a class by himself as an experimenter, and was, "perhaps the leading investigator of the physiological basis of animal behavior of recent times."[8]

A former colleague, Professor E. G. Boring, has described Lashley as, "perhaps the world's leading neuropsychologist," and adds that because of his research on cerebral mechanisms, "his name will long continue to be recalled with honor."[9]

Writing for the *Biographical Memoirs* of Fellows of the Royal Society, Sir Frederic Bartlett credits Lashley with, "extreme scientific honesty and carefulness, combined both with outstanding technological and manipulative skill, and with a capacity for brilliant intuition."[10]

Professor D. O. Hebb, one of Lashley's most influential, stimulating, and independent students, refers to Lashley's death as:

[7] *Neurology,* Vol. 8, No. 11 (1958), p. 870.
[8] *London Times* (Sept. 1, 1958), p. 12, No. 54, 244.
[9] *Harvard University Gazette,* Vol. LIV, No. 23 (Feb. 21, 1959), pp. 115–116.
[10] *Biographical Memoirs of Fellows of the Royal Society,* Vol. 5 (1959), pp. 107–119.

". . . bringing to an end a brilliant career, perhaps the most brilliant in the psychology of this century. He clarified many problems, often by setting them in a new context that his own research or scholarship made possible, with corresponding implications for new research."[11]

In a letter describing Lashley as he was during the year at the University of Pittsburgh, Professor Karl Dallenbach has written, "He was a neurophysiologist, not a psychologist in the traditional sense, . . . but certainly in the sense that psychology is treated today." It should be added that the present emphasis upon physiological psychology is to an appreciable degree traceable to Lashley's pioneering investigations in the nineteen twenties and thirties. It was at that time that his influence upon psychology was most evident.

During the intervening years several changes have taken place in American psychology, one of which has involved rapid growth in the areas of clinical, industrial, and social psychology. This has resulted in a proportionate decrease in the attention paid to the physiological variables affecting behavior. Even within the realm of traditional experimental psychology physiological theories of learning were, for a time, deemphasized. As Hebb points out in his memoir, Lashley had so successfully criticized and disproven the naïve neurophysiological theories of the nineteen twenties that learning theorists turned away from explanations involving any detailed reference to the nervous system, and couched their theories in nonphysiological terms.

In a sense this was all they could do. Lashley's role had been essentially that of an iconoclast. After destroying the image of simple connectionism he had been unable to replace it with a more acceptable theoretical position. The fact is that existing techniques and knowledge of neural function were too limited to support the formulation, and particularly the testing of radically new theories of learning.

[11] *American Journal of Psychology*, Vol. 72, No. 1 (March 1959), p. 142.

At present new technical developments and new forms of emphasis are moving psychology toward a position from which the signal importance of Lashley's pioneering contributions will become increasingly apparent. Recently developed methods permit study of activity taking place in different regions of the brain while the human or animal subject is in the process of learning a new habit or solving a problem. It has been found possible to produce learning by direct stimulation of the brain. Such technical advances have occasioned a profound resurgence of interest in the neural basis for behavior in general, and for learning in particular. Commenting on the changes which have occurred in the past thirty years, and their relation to Lashley's place in psychology, Hebb has written as follows:

"Today the pendulum is swinging again . . . , and it seems likely that history will see him in something like the same light as he was seen in 1930, when he stood head and shoulders above his field."[12]

A second significant movement in contemporary psychology represents a recovery from the narrow, self-conscious pseudo objectivism which resulted from the behaviorists' revolt against introspectionism. Psychologists are gradually coming to accept the fact that problems represented by such concepts as "thinking" and "consciousness" are central to the discipline and must be brought under experimental attack.

Lashley never lost sight of these problems; in fact he insisted that they could and should be formulated in terms of brain function. His article "The Problem of Serial Order in Behavior" (1951) deals, as he put it, with, "the logical and orderly arrangement of thought and action." It is a brilliant tour de force, assembling evidence from such varied sources as studies of language, the behavior of paraplegics, experiments on imageless thought, and mechanisms of locomotion in insects. The argument is too complex to be easily summarized, but represents an attempt to describe the neural mechanisms which

[12] *Ibid.*, p. 150.

could mediate serial order in action as represented by the use of syntax in sentence formulation or the playing of a rapid cadenza by a violinist.

Lashley's last published article was entitled "Cerebral Organization and Behavior" (1958). In the words of its author, this article deals with, "the problem of how the brain knows that it knows; what characteristics of neural activity constitute mind." Steadfastly opposing any retreat into metaphysics, Lashley liberally documents his claim that study of "the organization of mental states does not reveal any operations which cannot be accounted for in principle by the mechanisms of the brain." His final conclusion deserves full quotation:

"Mind is a complex organization, held together by interaction of processes and by time scales of memory, centered about the body image. It has no distinguishing features other than its organization. The mental phenomena must be subjected to an analysis as complete and detailed as that which is being made of neural activities. Only as progress is made in such an analysis, and as the picture of the brain's activities is completed, will it be possible to make significant correlations between the two organized systems. Meanwhile, there is no logical or empirical reason for denying the possibility that the correlation may eventually show a complete identity of the two organizations (p. 542)."

This was Lashley in 1958, insisting that psychologists face up to the responsibility of attacking the problems central to their discipline, and expressing the conviction that the solution lies in a fuller understanding of the intricacies of brain function. There are signs that eventually psychology will catch up with Karl Lashley.

Illness and Death. In February of 1954, while doing his annual two-weekly stint of teaching at Harvard, Lashley collapsed, and, to his disgust, was hospitalized. The eventual diagnosis was acquired hemolytic anemia which might yield to splenectomy or to treatment with cortisone. Lashley's opinion of the medical profession was not high, and he resisted the notion of surgery. As soon as cortisone

treatment made it possible he returned to Jacksonville where, as he put it, he could "control the doctors."

Months of cortisone administration resulted in softening of the vertebrae with attendant spinal dislocations and, in November of 1955, a splenectomy was performed. Lashley's subsequent recovery seemed complete, and he remained in comparatively good health until his trip to Europe with his wife, Claire, in 1958. His sudden passing was in accord with a wish he once expressed to a friend, namely the hope that at the end he would simply collapse at one of the street corners of the world. The rest of the wish was not fulfilled, and will not be. It was that he would then be forgotten.

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To Mrs. Claire Imredy Lashley I am immensely grateful for numerous items of otherwise unobtainable information concerning Lashley's life, particularly the early phases.

Finally, it is fitting that thanks be extended to the many individuals who took the time and trouble to write about their contacts with and impressions of Lashley. A number of these men and women were also kind enough to read and comment on the first draft of this memoir, and I have profited greatly from their suggestions. The list is as follows: Sir Frederic Bartlett, Dr. Leonard Carmichael, Dr. George W. Corner, Dr. Karl M. Dallenbach, Dr. Richard M. Elliott, Dr. John F. Fulton, Dr. Edwin E. Ghiselli, Dr. Edna Heidbreder, Dr. Ernest R. Hilgard, Dr. Carlyle F. Jacobsen, Dr. Heinrich Klüver, Dr. David Krech, Dr. Carney Landis, Dr. Clifford T. Morgan, Dr. Curt Richter, Dr. William H. Taliaferro, Dr. William H. Thorpe, and Sir Francis Walshe.

KEY TO ABBREVIATIONS

Amer. J. Physiol.=American Journal of Physiology
Arch. Neurol. Psychiat.=Archives of Neurology and Psychiatry
Behav. Sci.=Behavioral Science
Biol. Symp.=Biological Symposium
Carnegie Instn. Publ.=Carnegie Institution Publications
Comp. Psychol. Monogr.=Comparative Psychology Monographs
Encycl. Brit.=Encyclopedia Britannica
Genet. Psychol. Monogr.=Genetic Psychology Monographs
J. Anim. Behav.=Journal of Animal Behavior
J. Comp. Neurol.=Journal of Comparative Neurology
J. Comp. Psychol.=Journal of Comparative Psychology
J. Exp. Psychol.=Journal of Experimental Psychology
J. Exp. Zool.=Journal of Experimental Zoology
J. Gen. Psychol.=Journal of General Psychology
J. Genet. Psychol.=Journal of Genetic Psychology
J. Nerv. Ment. Dis.=Journal of Nervous and Mental Diseases
J. Psychol.=Journal of Psychology
Ment. Hyg.=Mental Hygiene
Natl. Res. Council=National Research Council
Physiol. Rev.=Physiological Reviews
Proc. Amer. Phil. Soc.=Proceedings of the American Philosophical Society
Proc. Ass. Res. Nerv. Ment. Dis.=Proceedings of Association for Research in Nervous and Mental Disease
Proc. Nat. Acad. Sci.=Proceedings of the National Academy of Sciences
Psychol. Bull.=Psychological Bulletin
Psychol. Rev.=Psychological Review
Publ. U.S. Interdepartmental Social Hygiene Board=Publication of the U.S. Interdepartmental Social Hygiene Board
Quart. Rev. Biol.=Quarterly Review of Biology
Riv. Psicol. Gen. Apl.=Rivista Psicologia Generale Applicata
Symp. Soc. Exp. Biol.=Symposia of the Society for Experimental Biology
Trans. Amer. Neurol. Ass.=Transactions of the American Neurological Association
Ukr. Psikhonevrol. Akad.=Ukrainskaia Psikhonevrologicheskaia Akademiia

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