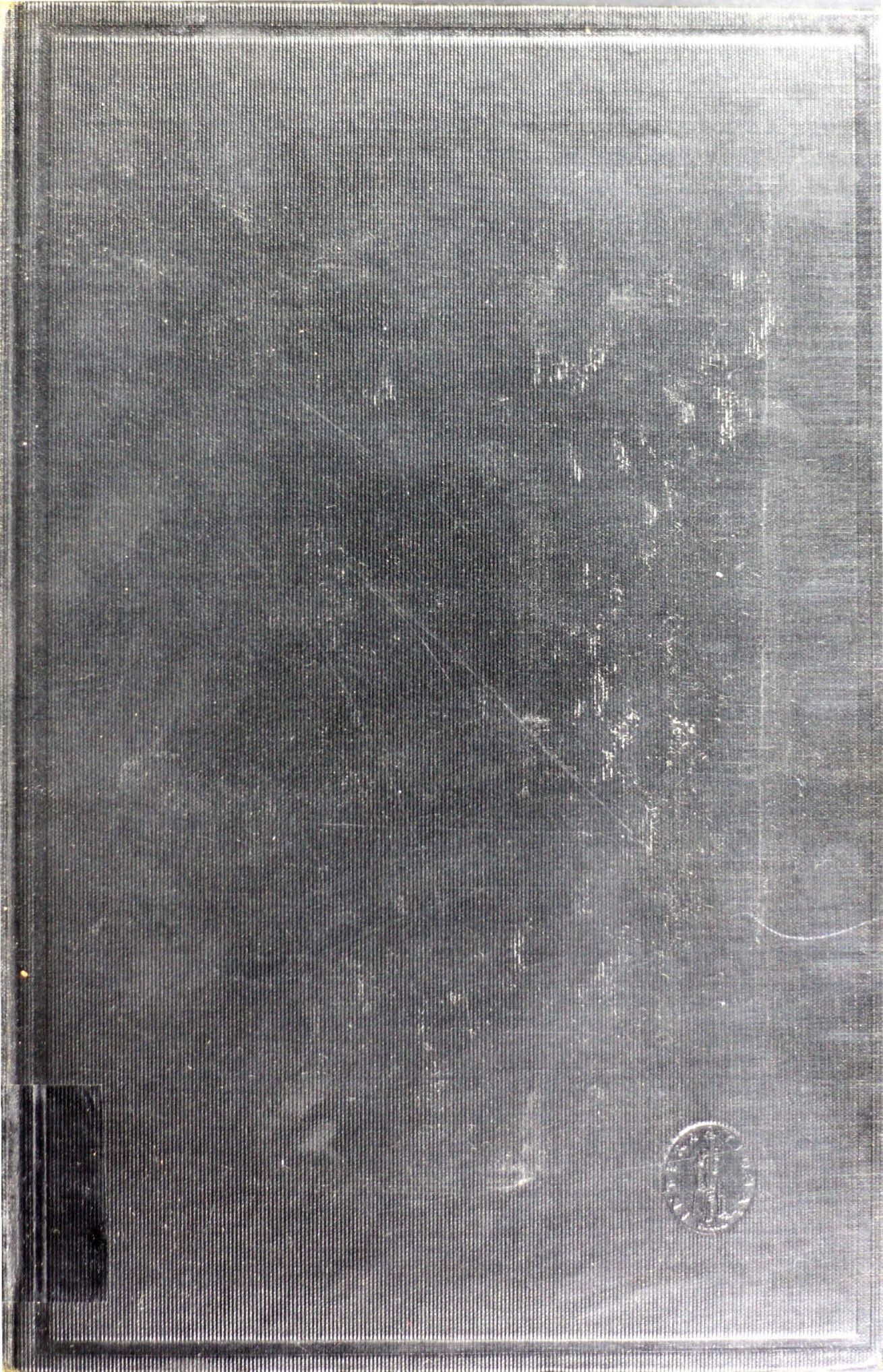
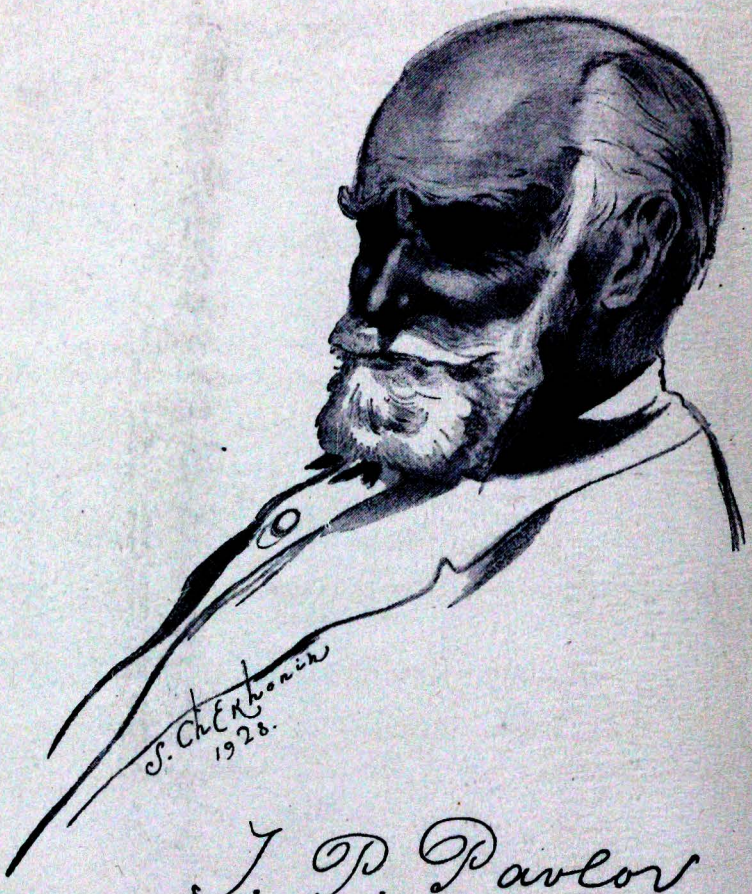


Dr. James G Matthews

LECTURES ON CONDITIONED REFLEXES

LECTURES ON CONDITIONED REFLEXES



I. P. Pavlov

LECTURES ON CONDITIONED REFLEXES

Twenty-five Years of Objective Study of the Higher Nervous Activity (Behaviour) of Animals

VOLUME ONE

IVAN PETROVITCH PAVLOV

LATE DIRECTOR PHYSIOLOGICAL LABORATORIES, INSTITUTE OF EXPERIMENTAL MEDICINE AND ACADEMY OF SCIENCES, LENINGRAD; LATE PROFESSOR OF PHYSIOLOGY, MILITARY MEDICAL ACADEMY, LENINGRAD; MEMBER ACADEMY OF SCIENCES OF THE USSR; FOREIGN MEMBER OF SEVERAL ACADEMIES AND SCIENTIFIC BODIES; NOBEL LAUREATE; *etc.*

Translated and Edited by

W. HORSLEY GANTT, M.D., B.Sc.

MEDICAL DIRECTOR LENINGRAD UNIT AMERICAN RELIEF ADMINISTRATION, 1922-23; CO-WORKER IN PAVLOV'S LABORATORY, INSTITUTE EXPERIMENTAL MEDICINE, 1925-29; ASSOCIATE IN PSYCHIATRY AND DIRECTOR PAVLOVIAN LABORATORY, JOHNS HOPKINS UNIVERSITY

With the Collaboration of

G. VOLBORTH, M.D.

FORMER ASSISTANT TO PROFESSOR PAVLOV AT THE MILITARY MEDICAL ACADEMY; PROFESSOR OF PHYSIOLOGY, UNIVERSITY OF KHARKOV

And an Introduction by

WALTER B. CANNON, M.D., S.D.

GEORGE HIGGINSON PROFESSOR OF PHYSIOLOGY, HARVARD UNIVERSITY

INTERNATIONAL PUBLISHERS, NEW YORK

Printed in the U. S. A.

Third Printing, 1943

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LIST OF ILLUSTRATIONS AND DIAGRAMS

To BLANCHE FERRY HOOKER

Affectionately inscribed.—W.H.G.

TRANSLATOR'S PREFACE

THIS book is one of three which Professor Pavlov has written during his life of nearly four score years. The first covered his researches on the functions of the digestive glands, and appeared in Russian in 1897, and later in German, French, and English. A large part of our knowledge of the physiology of the digestive system is based on the discoveries of this investigator.

Over a quarter of a century ago Pavlov began, "after persistent deliberation," to study the activity of the higher parts of the brain by physiological methods, mainly through the use of his conditioned reflexes. This book shows the historical development of the subject from the very beginning to the present, and it contains most of the important facts which he has discovered. As the subject is a new and somewhat difficult one, the many repetitions in varying form will probably not be unwelcome to the reader.

Because the facts and methods described in the following pages cover most of Pavlov's important work on conditioned reflexes, it seemed worth while to us to make the translation from the original Russian. The labour bestowed on this task has not been given grudgingly; on the other hand, we have often felt the joy and privilege of thus paying a personal debt of gratitude to the Author by helping to disseminate the truths described herein—the products of an unusual life inspired by a passionate, untiring, and uninterrupted search for Scientific Truth.

Feeling, therefore, the importance of the book, we have taken pains to preserve every slightest shade of meaning of the Author. We regret we were not able to translate the fiery ardour which glows in the original—the zeal for the hunt of scientific facts.

The present volume contains five new chapters from the Author besides those of the third Russian edition from which the translation was made. We personally have put in all the italics, the explanatory footnotes, the chapter epitomes, and the biographical sketch, with the hope that these additions would help to bring the book to a wider circle of readers. The biography is an attempt to give some idea of the life of this remarkable man, though to do so adequately is, we confess, a well-nigh hopeless goal. Furthermore, it is included on our own initiative, without the cognisance of the Author; for we fear he would consider it a useless and superfluous appendix to the work. The photographs are

our own original snapshots, and they were taken, sometimes after many hours of waiting, without the knowledge of Professor Pavlov.

In such epochal researches as those described in this book, we felt the desirability of enlisting the aid of experienced physiologists, and the collaboration we have obtained has proved a highly fitting and happy choice.

Dr. G. Volborth, the translator of the German edition, and for many years one of Pavlov's chief collaborators, shares the responsibility for this book. His assistance has been indispensable from beginning to end. He read and corrected the first drafts of the translation—not a light task—and contributed many of the footnotes.

Dr. Cannon has unselfishly devoted much labour and consideration to the physiological expressions, idioms, and style of this volume, having assiduously perused every word of it. His modifications form an integral part of the book.

Also others have willingly dedicated their time in aiding with its production: Dr. Spirov has rendered invaluable help in the actual work of translation, and my secretary, Miss S. Kiryanova, in the preparation of the manuscript; Dr. Babkin has compared it with the original Russian and verified its accuracy. K. Chukovsky, the Russian literary critic, and P. S. Kupalov have given me suggestions; and Chehkonin, a prominent contemporary Russian artist, has made the portrait for the frontispiece. Last but not least, we, as well as the readers, are indebted to A. H. Easley for having advanced the funds for the completion of the translation, thereby making possible its appearance in English. Many friends have thus united in preparing this edition, and we gratefully thank each of them. Furthermore, the publishers deserve credit for the patience and careful attention which they have devoted to the numerous details; and all the more so because of the difficulties necessitated by the great distance separating the translator and them.

W. Horsley Gantt.

Leningrad, September 1, 1928.

IVAN P. PAVLOV: A BIOGRAPHICAL SKETCH

By W. Horsley Gantt

I

Seventy-nine years ago, September 26, 1849, there was born in Ryazan, a peasant town of central Russia, the first son of a poor priest. The name of this boy was Ivan Petrovitch Pavlov. In the family in which the child grew up an earnest though friendly spirit ruled, and the atmosphere of his home life was conducive to fostering a certain seriousness with which he looked upon the questions confronting him.

Even from early childhood we can find those tendencies which characterise the adult Pavlov. Whenever the boy Ivan, or "Vanya" as he was called, undertook to do a thing he put heart and soul into it until the goal was attained—whether in play or athletics, physical or school work. In later years he showed the same zeal in the discussions and disputes of the lecture hall and laboratory. He was not so much concerned with excelling his rivals as he was in applying to each task all his might and knowledge—his whole being—in order that it should be done in the most perfect way of which he was capable.

For the following facts concerning his ancestry and boyhood life we are indebted to Prof. V. V. Savitch, one of Pavlov's oldest and most revered collaborators and pupils, who has given us a vivid picture of the early life of his famous teacher.[1] We have by the kind permission of Prof. Savitch drawn freely on his interesting biography without making separate acknowledgment in every instance.

The father, Peter Dimitrievitch Pavlov, was a village priest, and the grandfather was only a sexton of a country church. The life of the rural clergy at that time was very hard and especially so for those who were lower in rank. They had to work for their daily bread, and their mode of living was just the same as that of any peasant. Agriculture was the chief source of income. This strenuous physical work together with a degree of intellectual development produced a generation which was strong, healthy, and energetic. Constant need tempered those robust natures, and a certain amount of intelligence made them strive to fight their way under the difficult conditions of life at that period.

Intellectually Peter Dimitrievitch was a marked contrast to the other clergy of that parish. He always had a great liking for reading, and, even in those backward times, indulged in buying books; and these purchases, owing to his restricted means, were real family festivities. Prof. Pavlov often gratefully recalls his father's instructions to read a book twice in order to understand it thoroughly. Peter Dimitrievitch gained general respect among the clergy, and besides standing high intellectually, possessed other exceptional characteristics. Very exacting of others, he was also exacting of himself. He was

[1] "Ivan Petrovitch Pavlov, A Biographical Sketch," *Pavlov's Seventy-fifth Anniversary Volume*, Moscow, 1924 (Russian).

intensely persistent, had a determined will and great physical strength. From his parents he had inherited the love of the soil; and forced to live in town he devoted his attention to his orchard and vegetable garden, where he did all the work himself. Of all the children only Ivan Petrovitch had this same liking.

When the question of daily bread had become less acute, the excess of energy sought for an outlet. Thus it happened that the paternal uncle of Prof. Pavlov used to take part in the fist-fighting which flourished at Ryazan. These combats and the conversation about them created and kept up high spirits in the family. Because of this display of energy there was an unusual liveliness in the Pavlov household. The cheerfulness, laughter and humour of this uncle were irresistible. Doubtless a great comedian was lost in him, but being of the clergy he suffered constant rebuffs from his superiors, and was even reduced to the position of a sexton. His children inherited those qualities, which made them welcome members of every social party.

Also Ivan Petrovitch's mother, Varvara Ivanovna, came from a clerical family. All the schooling she had was given her at home—in those times it was not considered necessary that daughters of the clergy should be educated. In her youth Varvara Ivanovna had excellent health, which was inherited by three of her children, Ivan, Dimitry, and Peter. All of these finished the theological seminary and the university, and received posts at the university or at the academy. One of his brothers was later an assistant to Mendeleév. After the birth of these three sons, the mother had a serious illness, and the next six children died from epidemics at an early age. The last two, Serge and Lydia, were not as gifted as the first three. Serge Petrovitch finished only the seminary and remained as a priest at Ryazan: he died of typhus during the revolution.

Thus Ivan Petrovitch grew up with his younger brothers, companions in his games and tricks while the parents were busy with their daily tasks. The mother loved and spoiled her children, but as she was usually busy, she allowed them great liberty, and they grew up free-spirited. They soon made friends with the neighbouring children, and spent much time in the streets with their playmates, taking part in the ordinary sports of the village, the chief of which was *gorodkee* (a Russian country game like ninepins), which Pavlov plays to this day.

Ivan Petrovitch played with his left hand; his father also was left-handed. The son developed his right hand only by constant training, so that now he can use both hands alike, even while operating. However, his left hand is stronger and he makes use of it when special skill or power is necessary. He writes with his right hand, but can do so equally well with his left, with which he can also write mirror fashion.

His education began at the age of seven when he learned to write and read from an old lady. Those lessons were not attractive to the restive boy, for digging the ground in the garden with his father was more to his taste, and he enjoys this work even now. He learnt a little carpentry and lathe work while a house was being built. Thus from his early youth Ivan Petrovitch had a great inclination for every sort of physical exercise. Later that changed into a passion for sport, and he was the soul of the Physicians' Gymnastic Society. Prof. Pavlov often says that the feeling of gratification after successful muscular work was much greater with him than the joy of having solved some important mental problem. He calls it "muscular gladness."

At about the age of ten he fell from a fence on a brick pavement. Though previously healthy, he was now often ill, and at one time his parents feared he had lung trouble. This accident delayed his education. He was already eleven years old when he entered, together with his brother Dimitry, the second class of the church school at Ryazan.

Fighting was a custom there, and as Ivan Petrovitch was in poor health he often had a bad time of it. This led him to try to strengthen himself by muscular exercise. His father made the necessary arrangements for gymnastics in the garden. It was noticeable here that Ivan Petrovitch showed the greatest persistency, while his brothers soon grew tired of gymnastics and sought other pleasures. And "when the boys were sent to the orchard to gather raspberries, Ivan Petrovitch tried to fill his basket quickly, while his brother Dimitry (like all boys) tried to fill his mouth." Thus from his early youth Ivan Petrovitch showed great tenacity in fulfilling the tasks which had been set, whatever they might be.

Having finished the church school, the Pavlov brothers entered the theological seminary at Ryazan. The curriculum was made up mainly of courses in the ancient languages. Logic and rhetoric were also on the programme, and not only elementary philosophy was studied, but the several philosophical systems furnished the material for frequent debates. Here Pavlov was thoroughly drilled in logical reasoning and in its application. It was now that Pavlov became seriously interested in science. He says he was first attracted to it by the Russian translation of G. H. Lewes' *Practical Physiology,* and to-day he treasures with pride the well-worn copy of that book which he began to read when a boy of fifteen.

The great wave of enlightenment which swept over Russia during the reign of Alexander II, ushered in by the abolition of serfdom and a certain amount of self-government, was also felt in the seminaries. Teachers and pupils united to form a single front in which the older generation endeavoured to give their best to the younger, and the latter strove with might and main to take advantage of this.

At the doors of the library throngs would be waiting to rush in and get at the latest literature. The Pavlov brothers used to stand in these crowds, though there was little chance of getting in first, as there were many competitors. Endless discussions followed the reading of the new books of that period. And it happened often that the peaceful town of Ryazan witnessed groups of students debating loudly all over the streets. Among those debaters Ivan Petrovitch was prominent; for his animated arguments were always accompanied by energetic gesticulations. These discussions, however, had the effect of teaching him to be careful in his criticism, because those who made evident flaws were held up to ridicule.

Pavlov recalls the liberal atmosphere of his school with gratitude, and particularly the fact that if a pupil made great progress in one subject, he might devote less attention to other studies which interested him less, thus giving him the opportunity to advance along the line of his special tastes.

In 1870 Pavlov relinquished the idea of becoming a priest, and left without finishing the seminary to enter the University of St. Petersburg.

He lived with his brother, and by degrees the common tasks of every-day life fell to Dimitry's lot. This went so far that he even used to order Ivan Petrovitch's clothes. After the latter's marriage it was his wife who used to buy her husband's boots and wearing apparel. "Sometimes the young Pavlov

would unexpectedly get a suit of clothes and his choice of colours would be such as to make his friends laugh and his family angry."

The two brothers used to spend their summers with their father at Ryazan. Ivan Petrovitch generally stayed at home, and never went hunting as the others loved to do. Many friends visited them and their usual pastime was *gorodkee;* for hours one could hear the clashing of sticks, interrupted by explosions of laughter, and outbursts of rival yells of enthusiasm. Even in this Ivan Petrovitch's character stood out prominently. He was excitable by nature, but he could nevertheless keep his temper and hurl the clubs with great force and precision. He was passionate in all he undertook, but this passion was always controlled and checked. Evidently the processes of strong emotion were well regulated and limited by the necessary inhibition, as described in some of the chapters of this book.

II

While at the university he sat under such talented professors as Mendeleév (inorganic chemistry) and Buttlerov (organic chemistry). To the brilliant physiologist Elie Tsyon, however, Pavlov feels that he owes the most. We have heard him say what a deep impression he retains of the demonstration by this investigator of the experiment with the stimulation of the anterior and posterior spinal roots in the dog; and that Tsyon worked so cleanly that he often operated in a frock coat and white gloves to avoid the necessity of going home to dress for a faculty meeting.

In 1874 while in his third year at the university Pavlov became an active collaborator of Tsyon, and definitely took up physiology as his major subject.

His first scientific investigation, made with Afanasiev, concerned the pancreatic nerves, and for this he was awarded the gold medal at the Academy. "The clinical subjects did not attract him and he even failed at one of the examinations (internal medicine). But the advances of surgery at that time made the greatest impression on him. His interest for chemistry was not great, and he gave most of his attention to the neural control and the nerve connections of the organism" (Savitch).

His university life was spent quietly, his time being divided between the studies, including laboratory work and a zealous application to scientific literature, and recreation. His chief diversions were sports, belletristic literature, and association with his brothers and a narrow circle of friends.

In 1875, being ready to pass from the University to the medical academy, Pavlov accepted the offer of an assistantship to Tsyon. A characteristic incident now took place. Tsyon unexpectedly went to Paris, and though his successor invited the young Pavlov to remain with him, he defiantly refused—even though he was faced with the necessity of finding something to live on—because the new professor had recently endorsed "the transgressions of a man simply because he had an important post and influence, without any regard for the truth." Then, as in later life, Pavlov would not sacrifice his convictions for the sake of worldly goods, in spite of the fact that he was in great need.

In December, 1879, after finishing the course at the Military Medical Academy, he passed the state examination and became an approved physician. He received a fellowship, awarded on the basis of merit, enabling him to spend two more years in research at the Academy. In 1883 he completed his dissertation for the degree of Doctor of Medicine.

Most graduates, on entering their profession, begin to plan their careers, to ask themselves Whither? and Why?

Such questions never troubled Pavlov. In his scientific investigation he had discovered the joy of bringing to light some hidden truth so that it was solved beyond the shadow of a doubt, and he applied himself to this task with an unwonted enthusiasm. In this he was like Sir William Osler, who said that it was one of his cardinal principles to do the immediate work of the day without thought for the morrow. His whole life was to be dedicated to this work of revealing ever new facts; his entire energy was devoted to science. Practical questions, such as securing a position, pecuniary difficulties, etc., did not exist for him.

He and his brother continued living together in cramped quarters, poverty-stricken, though happy and cheerful, with a small circle of friends.

In 1880 he made the acquaintance of a young and attractive student of pedagogy, Serafima Karchevskaya, and was married to her a year later in Ekaterinoslav. Here a comical incident occurred. Savitch tells us Pavlov had no money, and the bride's sister had to forward the necessary means without which the young couple could not leave the town. This again shows how little Pavlov cared about the needs of every-day life.

In Petersburg they continued living in the small apartment with Pavlov's brother. Both of them had to work to earn enough to live on. It is fortunate for science that he found a woman so loving, kind, and admirably fitted to make him a happy home. It is perhaps due to her that he has always spent his entire evenings in the quiet recesses of his home, in this fortress protected from the routine world of cares—serene, as comfortable as possible with limited means, and contented. The practical affairs of life he has always preferred to leave to others, and he has rarely even travelled alone. How few of the ordinary duties Pavlov has had to attend to is shown by a remark of his wife in 1927—that he had never so much as bought a pair of shoes for himself; only in the difficult years following the war and revolution did Pavlov undertake any of the home chores.

Having received the Wylie fellowship, Pavlov spent the years 1884-86 with two of the greatest physiologists of that time—Ludwig in Leipzig and Heidenhain in Breslau. Strict economy was necessary, but for him financial questions hardly rose to the threshold of consciousness.

On returning to St. Petersburg, he received several appointments as assistant, one of which was with the noted clinician S. P. Botkin, who made it a practice to control his therapeutics by experimental pharmacology. In this laboratory Pavlov performed his famous experiments with the cardiac nerves and his first great research upon the nerves of the digestive glands.

In 1888 he discovered the secretory nerves of the pancreas, which, because of the difficulties in repeating the experiments, were recognised universally only twenty years later. The next year he published together with Simanovsky the renowned experiments with sham feeding.

At the same time with such progress in science he was rather unsuccessful in his professional career. He bore this failure easily, though his financial affairs were in a sad plight. "His attention was so much taken up by the study of the chrysalid's transformation into a butterfly that he quite forgot his misfortunes" (Savitch).

With the growth of his family it became necessary to look for a more lucrative place, and Pavlov applied for the chair of pharmacology in Tomsk.

He never accepted this, however, as in 1890 he was elected, on a ballot of seventeen to five, Professor of Pharmacology in the Military Medical Academy of St. Petersburg.

Soon after Pavlov's election to this position, he came into open collision with the rector, Pashootin, a "despotic man to whom most of the professors were obsequious." Pavlov used to oppose him in the most decided manner, though most of the faculty were on the side of the rector. Pavlov was punished for his unsubmissiveness; for his appointment to the professorship of physiology in 1895 was not confirmed till 1897. Both at that time and afterward he has constantly upbraided his countrymen for their servility. From 1895 he held the chair of professor of physiology continuously until his resignation in 1924.

In 1891 the first (in the world) surgical department of a physiological laboratory was constructed according to the plans of Prof. Pavlov in the new Institute of Experimental Medicine founded in that year by the Prince of Oldenburg. It was here that Pavlov first had the opportunity to carry on the so-called chronic experiments, described in Part IV of this biography, as prior to this there were no provisions made for the care of the animals.

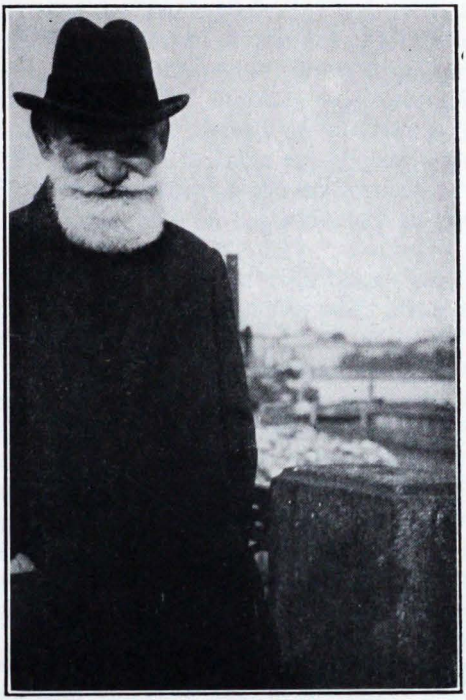
In 1904 Pavlov was awarded the Nobel Prize for his researches on the activity of the digestive glands, and in 1906 he was elected a member of the Russian Academy of Sciences. His work at that time was conducted in the three above mentioned laboratories.

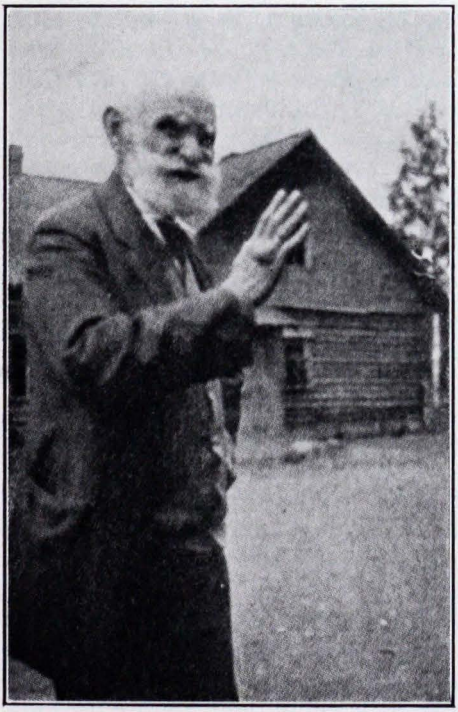
His fame abroad, however, as is often the case, created a certain amount of envy at home, where he had not a few enemies. After he had received the Nobel Prize, the attacks on his researches with the digestive glands ceased. But even more vituperative were the criticisms of the work with conditioned reflexes. It was stated "this is not science; every dog trainer knew it long ago." The irritation against him grew to such a point that the conference of the Military Medical Academy even disapproved of the dissertations from his laboratory. Shortly afterwards his enemies became so active that they prevented his becoming president of the Society of Russian Physicians of which he had been vice-president. This was chiefly because his laboratory produced many more papers than any of the others.

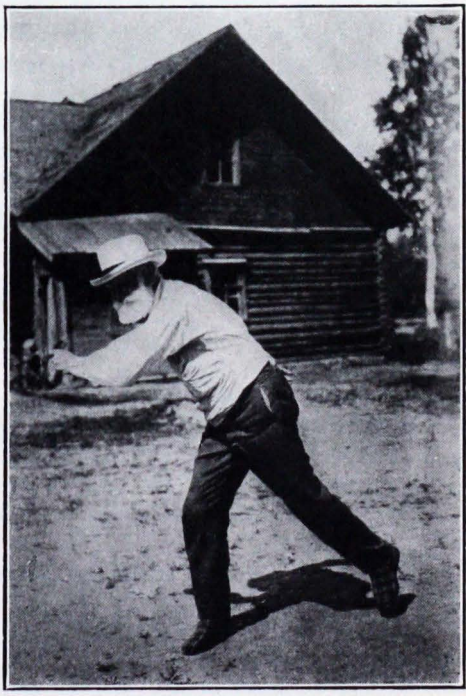
III

Now we may consider some of the characteristics of Pavlov as an investigator. Prominent among these is one which has guided and governed his whole life—the fervent desire to obtain knowledge, and the energy and singleness of purpose with which he has always championed scientific truth. As the noted physiologist, Robert Tigerstedt, said of him in 1904, "Pavlov's life can be summed up in this: an untiring search for truth has led him to the attainment of scientific facts of the first order." The element of personal welfare as a motive for action has always been absolutely foreign to his nature. And this was not because fortune placed him in such a position that he could spurn the ordinary practicalities of life. Hard necessity and bitter need, on the contrary, were his companions from birth. But his scientific investigation never slackened; his first thought was ever in his work.

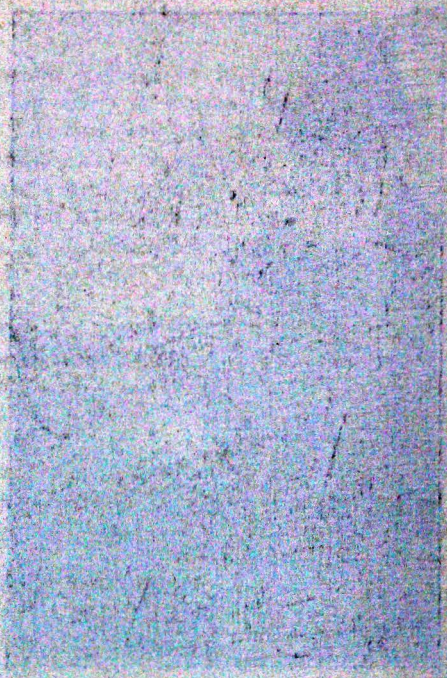
In the beginning of his laboratory experience, he had no means of properly caring for the dogs, so he would take an animal home with him to his small lodging where he nursed it after an operation. And some of this time, due

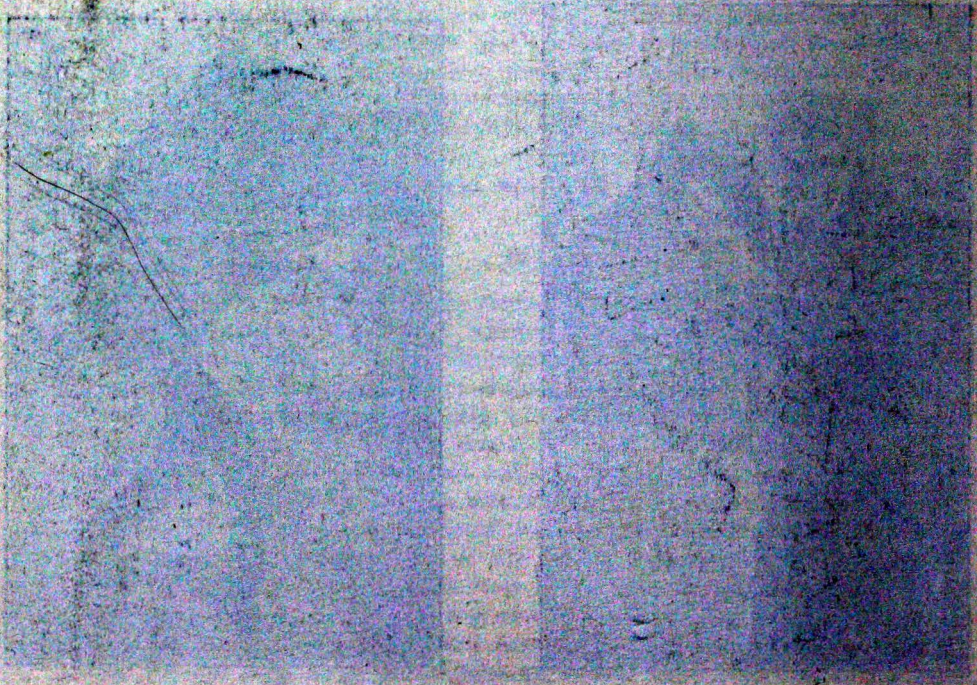






FIGS. 1-2-3: PROFESSOR PAVLOV OUTDOORS AND AT PLAY.





to lack of money, he could not afford independent quarters, but had to live with his friend, N. P. Simanovsky, removed from his devoted family.

Not only has Pavlov diligently sought truth, but the question is for him the ruling passion of his life. Not in the vague philosophical way of a Diogenes wandering the daylit streets with his lantern, but through unswerving and passionate attention to all the concrete details of laboratory research. With an unwavering conviction that truth and science are the only worthwhile goals in life, Pavlov has always promptly rejected all compromises, all considerations which seem to him dishonourable, and he has zealously thrown his whole being on the side of truth and right.

Along with his spiritual gifts, the love of the truth, and the ability to forget everything for his work, we find in Pavlov still other traits which mark him as a capable investigator.

His rare memory is one of the most extraordinary of these. The smallest details in the order of an experiment or in its results, even though it had been performed more than a decade previously, can be recalled by Pavlov at will. Former assistants or pupils, on returning to the laboratory for a visit, have often been astonished when the master in discussing some physiological problem would suddenly mention accurately and in detail all the figures of an experiment they themselves had performed years ago and long since forgotten, or would name the dog with which they had worked, and this in spite of the fact that during the interval hundreds of animals had passed before his eyes. Once having seen the protocols of a collaborator, he has never forgotten them, although before the war he personally directed the work of as many as thirty investigators at one time, and recently even more.

With the passing of the three quarter century mark, Pavlov has resorted at times to the use of a notebook, and he remarks that his memory is not so good as formerly. But even at this it would be the envy of any one of half his years. It may be stated almost as axiomatic that, "once having seen a figure, he never forgets it."

A vivid example of this came to our notice in 1925. Pavlov was curious to know the significance of a medal one of his collaborators was wearing. When told it was given for a race, he being interested in athletics of all sorts, examined it more closely. A few months later when the subject of races came up again the medal was referred to, and some one asked how long it took to run this distance. The owner of the medal had himself forgotten the exact time, though he had been wearing it for fifteen years. Pavlov, who had seen it only once, however, immediately remembered it to the fifth of a second—and answered, "10:11⅘."

We have this evidence from Dr. Thomas R. Elliott of the University of London (written May 14, 1928): "I saw Prof. Pavlov at the Croonian Lecture and also at a dinner of the Royal Society. He was in splendid form and his energy and charming personality delighted every one. He astonished me by remembering my face and the exact occasion on which he had met me in England nearly twenty years ago."

Probably Pavlov's memory is based in some way upon his power to concentrate, and also to select. But it is just as typical of him, that he does not clutter his mind with a mass of trivial, ordinary details, such as are carried in the newspapers, popular journals, etc. For Pavlov rarely ever reads or attends to these, and he has a remarkable power of apparently keeping out of his field of consciousness events and data which have no relevant bearing on

his direct interests, nor will he even venture opinions on any subject with which he is not thoroughly familiar nor for which he does not possess an ample number of facts. This ability to look only at bare facts, to judge solely on the basis of facts as well as at once to divine the relations between them, are characteristics paramount in Pavlov.

This brings us to another quality which he possesses in a high degree—the ability to analyse, to penetrate immediately beyond the veil of trivialities into the essential, and to bring order to a series of seemingly chaotic events. To do this he often boldly plans new experiments, perhaps in varying form, and spares no energy to execute them. Pavlov says that the most difficult part of the work of an investigator is the assigning of problems to collaborators.

By play and sport Pavlov developed great physical agility and suppleness. One sees these same qualities in his skill at operating; for his dexterity in this direction was extraordinary (he has not operated regularly for the past five years on account of the demands of his other work and the less acute vision of his advanced age, although as late as March, 1928, he performed a new operation on the pancreas). He is ambidextrous, operating equally well with either hand. The late Tigerstedt said of him: "Pavlov does a simple operation so rapidly that it is finished while the onlooker thinks it has only begun" (*Archives des sciences biologiques,* vol. xi, 1904). To say his movements are lightning-like is apt analogy; for they are made so quickly that one has to look carefully to discern them. Severing of the spinal cord from the brain in the dog is carried out by Pavlov in about 30 seconds; and to find, tie, and divide either the vagus or the sciatic nerve takes him only three to five seconds from the time the skin incision is commenced. As a matter of comparison to those not familiar with the operation, it might be mentioned that the fastest that this can be done by any of his assistants is 90 seconds, and this is not by any means slow.

Instead of being prejudiced in favour of the results of his own experiments, the reverse is true of Pavlov—*viz.,* he has the ability not only never to overestimate his results, but to look at them impartially or even hostilely. A theory when it does not correspond to new facts is ruthlessly rejected, and he begins to plan another structure on the basis of these new findings; for facts are the fundamentals upon which Pavlov constructs every theory, the guide-posts which constantly direct him to new generalisations and conceptions. Never does he attempt to force a fact into a theory when there is a misfit. In this he is of a like mind with the late Sir William Bayliss, who said,

> There must never be the least hesitation in giving up a position the moment it is found to be untenable. It is not going too far to say that the greatness of a scientific investigator does not rest on the fact of his having never made a mistake, but rather on his readiness to admit that he has done so, whenever the contrary evidence is cogent enough.

The following incident, related by Savitch, illustrates this:

> It was I whom Ivan Petrovitch asked to verify the results obtained by Bayliss and Starling with secretine. We started the experiment in his presence and it wholly confirmed their opinion. Ivan Petrovitch stood silently for a time, then went to his study, returned in half an hour and said: "Of course, they are right. We cannot aspire to the monopoly of discovering new facts." That question was definitely settled; facts and results always decide any question for him. He considered theories as worth while only for finding new ways and accumulating facts. However, the action of the secretory nerves on the pancreatic gland was denied abroad

until these experiments were demonstrated in England by one of Ivan Petrovitch's collaborators (Anrep).

Another striking example occurred with the heredity of conditioned reflexes in mice. Pavlov stated in 1923 from his preliminary experiments that he believed he had obtained inheritance of conditioned reflexes in these animals, and that many facts of every-day life agree with this view. More refined methods undertaken in 1925, have failed to confirm the first trials, and Pavlov, instead of defending his former hypothesis and experiments which had become widely published, at once repudiated them, and has absolutely withheld any further opinions till the facts will have been proved beyond doubt.

As a result of his disagreement with Pashootin, Pavlov had no permanent collaborators till the beginning of the twentieth century, and all who worked with him were deprived of the privilege of going abroad. His early co-workers were general practitioners entirely unprepared for physiological investigation.

In reviewing Pavlov's work in the laboratory, Savitch tells us:

> He was the soul of the laboratory, and where he was the work went on with the greatest intensity. He attended to the smallest details, and often used to count the millimetres of the Mett tubes of his collaborators. He was very punctual and always kept appointments; he was not very exact in other things; he answered letters tardily if at all.
>
> As a teacher in the laboratory, his individuality was marked. Being animated and sociable, he inspired his collaborators with the keenest interest for investigation. He is romantic, as Ostwald might call him. His impulsiveness makes him explosive at times during discussions. He easily flares up at trivialities; the elements of activity and of fighting are too deeply rooted in him.

Pavlov has modified the method of laboratory control with the different periods of his life. At first he gave all his attention to one or two investigations, and spent nearly the whole time with those collaborators. Then more time was given to the others as their work would progress. We might call it the principle of concentration. Since the renewal of laboratory work in 1919 Pavlov commenced to direct the experimentation in another way: We may compare him to a chess player who moves many pieces with a concerted plan; facts obtained from one collaborator's researches go to advance that of another. Just now conditioned reflexes attract most attention in his laboratory, especially among the younger collaborators. This teaching is creating a novel conception of the psychical life of man, and it will sooner or later be the foundation of a new philosophy.

"Pavlov intuitively grasps all the relationships in an experiment. When a new fact is observed it is repeated; then begins a period of doubt, criticism and verification and numbers of theories are considered and rejected" (Savitch).

IV

And now we can pass to the work itself.

Three territories of physiology have successively demanded Pavlov's attention. He began his independent investigations with experiments on the circulatory system, and these were performed chiefly between 1878 and 1888. But when Pavlov became professor of pharmacology, his interest gradually turned toward the digestive glands, and finally his whole laboratory was devoted exclusively to this subject. Since 1902, however, Pavlov's energies have taken still another

direction, and work on the digestive glands has receded into the background. Now his whole attention is devoted to the investigation of the processes of the central nervous system by the method of conditioned reflexes.

Pavlov's work concerning the circulation of the blood falls into two groups. One of these has to do with the regulation of the blood pressure. During these experiments Pavlov desired to have as nearly normal conditions as possible. In the usual procedure, a skin incision is made, the blood vessel is found, and a glass tube inserted—an undertaking requiring tying of the dog. Pavlov, however, so skilfully accustomed the animal to the operation that he would voluntarily jump upon the table, and permit the procedure without being bound. Pavlov's operative technic was so quick and accurate that there was barely any pain. Thus it was that Pavlov was able to obtain on this dog certain new and exact facts concerning the normal blood pressure and its daily oscillations. Further, by the use of drugs and by cutting various nerves, he arrived at the laws governing the regulation of the blood pressure.

Another series of studies on the circulatory system concerned the regulation of cardiac activity. These experiments required great perseverance. In order to immobilise the experimental animal, poisoning through narcotics had to be avoided; and the pain reflexes were eliminated by severing the spinal cord. The animal was then rendered immobile. The chest cavity was opened and the separate nerve filaments from the cardiac plexus to the heart dissected out. Great difficulties are encountered here on account of the fineness of the work, and these are heightened by the fact that there is considerable variation in the anatomical course of the nerves, with the result that nerves which are identical in their position may be very different in their functions. In every case the activity of each nerve had to be tested. By assiduously doing this in a large number of experiments Pavlov was able to correlate the anatomical positions with the functions.

As a result of this exhaustive work, Pavlov came upon an important discovery which was also arrived at independently by Gaskell. He found that certain nerve fibres had a special effect on the heart muscle, increasing or decreasing the strength of the beat, but not affecting the rhythm. After stimulation of these nerves in a fatigued heart, the beat is stronger and the amount of work performed greater.

On completing this, Pavlov turned his energies again to the study of the digestive glands. His investigations were conducted along two lines: the analysis of the mechanism through which the glands are innervated and regulated; and secondly, the study of the part played by these glands during the normal conditions of life.

Pavlov had previously shown that the process of operating on the animal has a marked inhibitory action on certain glandular activity. Owing to this inhibition, negative results were often obtained in acute operative experiments. From this new point of view Pavlov now performed all his operations. He attempted to exclude every central as well as peripheral inhibitory process, partly by using combinations of various experiments, and partly by speed and accuracy of the operation. Thus it came about that from nerves which his predecessors had found to be without action, he was able to elicit a secretory effect.

The experimental proof of secretory nerves to the stomach and pancreas was a great scientific feat at that time, and it placed Pavlov in the front rank of experimenters. As proof of the extreme difficulty of solving this

problem of the activity of the pancreas, we quote the great Breslau experimenter, Heidenhain: "During the course of three years I have only too often experienced the numerous perplexities which the pancreas more than any other gland of the digestive system presents to the would-be investigator. How many times I have seen the matter conclude not in any definite answer, but with a series of new questions!"

But Pavlov found the answer. He had demonstrated that the older experimental methods were unsuitable for work with the circulatory system and digestive glands. Therefore he now discarded the acute experiment, and decided to observe the activity of the glands under normal conditions of life. At that time there existed not even the barest suggestion of any appropriate method of investigation, and Pavlov had to discover one.

That all physiological processes are, to a certain degree, distorted by operative interference, as has been stated, is a fundamental idea of Pavlov's. He says:

> We can not calmly consent to the rough breaking of this mechanism, the hidden secrets of which have occupied our thoughts for long years, perhaps for life. If the mechanic often refuses to alter or to interfere with some delicate machine on the ground that it would be a pity to spoil so fine a mechanism; if the artist reverently fears to touch his brush to the production of some great master—then should not the physiologist, who deals with the finest mechanism of all, the supreme creation of nature, have this same feeling?

The above mentioned experiments on blood pressure were performed under normal conditions insofar that the experimental subject had been thoroughly accustomed to the whole procedure. Even in these first experiments one can see an indication of the direction which his later work was to take.

In the post-operative care of such higher animals as the dog and the cat Pavlov employed the same precautions as were used in human surgery—*viz.*, anæsthesia, asepsis, narcosis, etc. After operation, the dogs are put into clean and well-heated rooms, and nursed with much the same attention as is used with patients. He has always emphasised the importance of having healthy and well-cared-for animals. Special operative rooms and a dog clinic were designed by him for this purpose.[2] This new type of laboratory, first constructed by Pavlov nearly a third of a century ago, is now essential to every good physiological institute.

That Pavlov has been humane with his animals is shown further by his following discussion of vivisection:

> As is known, vivisection has excited in many countries of Europe an energetic objection from the uninitiated. These protests have at times seriously interfered with the progress of biological investigation (for example in England). But what is the basis for this? The feeling of pity. . . . But the experimenter also has this feeling. I. M. Setchenov, the father of Russian physiology, never performed experiments on warm-blooded animals.
>
> In spite of our measures inspired by the feelings of mercy and pity, there are, nevertheless, painful and violent deaths of animals. Is there justification for this? The human mind has no other means of becoming acquainted with the laws of the organic world except by experiments and observations on living animals. . . . If we continue to permit the hunting of animals, *i.e.*, their suffering and death for our own recreation; if we slaughter them for our food; if we consent to the torture and killing of thousands of even our fellow-men in wars: then how can we object to

[2] See I. P. Pavlov: *Work of the Digestive Glands*, chapter i, Griffin and Co.

the sacrifice of a few animals on the altar of the supreme aspiration of man for knowledge in the service of a high ideal, the ideal of attaining to truth! [3]

The general principle which Pavlov employed in his study of the digestive glands was the following: an operation is made on the organ to be investigated so that its juice, which normally flows into the gastro-intestinal canal, is conducted to the outside of the body, where it can be collected in pure form. Special care must be taken not to injure the nerves. During the operation, the isolated part of the organ or the duct of the gland is transfixed and permanently attached to the skin so that after healing of the wound no further procedure is necessary, except to prevent loss of the juice on the skin and erosion therefrom. When one desires to collect the juice for experimentation he has only to insert a cannula into the transfixed duct and connect it with a graduated receptacle. The animals become so well accustomed to the experiments that, as a rule, they will remain standing in the supporting harness for seven or eight hours without even complaining.

This method of making a permanent opening into the intestinal canal has received the name of the "Method of the chronic fistula." But as the procedure can be applied to other organs as well as to those of the digestive system for the purpose of studying physiological functions while the animal is living under normal conditions, it is generally termed the "chronic experiment." This has now to a large extent replaced the older "acute experiment" of the vivisectionist. The operative method, the post-operative care of the animals, and the principles of observation in the chronic experiment have been for the main part worked out by Pavlov. By severing certain nerves much information has been obtained with this method concerning the innervation of the glands of the digestive system. We may even say that in Pavlov's hands the method has yielded the basic results upon which most of our knowledge of the normal functions of the digestive apparatus is built up.

However, other and more far-reaching results sprang out of the work with the chronic experiments. It had been observed that the activity of the digestive glands was called out not only when the food was in the mouth or had passed further along the digestive tube, but by agents acting from a distance, such as the sight, odour, etc., of the foodstuff. During the chronic experiments it was seen that in addition to the properties of the food *per se* (sight, odour, etc.), accidentally associated stimuli, coinciding normally with the beginning of the feeding, such as the dish in which it was presented, or the footstep of the person who brought it, were also able to evoke identically the same reaction as the food itself.

The intrusion of these facts into the normal course of the experiments demanded Pavlov's special attention, and led him to the investigation of what was then known as psychical reactions. The salivary glands presented certain advantages for the study of the actions of agents at a distance ("psychical reactions"), as described in chapters i, ii, and iii.

It was very difficult in dealing with such complicated reactions, which had up until this time been considered as mental activities, to avoid the use of psychical conceptions, and in the first chapters of this book Pavlov often refers to "psychical" activity, but he usually adds the word "so-called" psychical. To circumvent the employment of psychological terms in his physiological researches, Pavlov substitutes "disappearance of the reflex," "restoration of

[3] Vivisection,' *Encyclopedia of Medical Science*, St. Petersburg, 1893 (Russian).

the reflex," etc. Further, all anthropomorphic and psychological conceptions were avoided by considering and measuring the secretory component in preference to the movement reaction of the animal.

As soon as Pavlov had persuaded himself to look at the reactions in this new light, as objective and physiological occurrences in the organism, there was no difficulty for him to study them according to a physiological plan. The reactions of the salivary glands to food in the mouth had for a long time been classed as a physiological reflex. It remained now to show that the new reactions did not arise spontaneously, but always had as their cause the stimulation of special receptor organs, as the eye, ear, nose, etc.

In the first part of chapter iv Pavlov explains why these new reactions must be considered as reflexes. To distinguish them from what had already been known in physiology as reflexes, the new reactions were called *conditioned* (acquired) reflexes and the old ones *unconditioned* (inherited), as it was seen that the chief difference consisted in the large number of circumstances to which the conditioned reflexes were subject. (Compare Pavlov's statement in chapter iv.)

Pavlov's interpretation of the new phenomena can be briefly characterised as follows. The old conception of a reflex as the answering reaction to certain stimuli, an inborn relation conditioned by the function of the structure of the given nervous system—this conception was extended by Pavlov to "psychical" reactions. He postulated the existence in the highest parts of the central nervous system of a special functional property, the property to form new connections between certain agents and the responding activities of the organism. Thus a purely physiological explanation can be given to such a fact, for example: a sound stimulus which in the given animal called out no special response, by coincidence with some other agent evoking a specific reaction, finally comes to produce the same reaction as the original effective agent.

When the chief importance of the brain process is considered as the ability to form new functional reflex paths, it is immaterial for the experiment whether these paths are formed between the receptor body surfaces and the motor activity or between the receptor body surfaces and the secretory reaction of the experimental object. The process of formation is the same in each case. The reasons why Pavlov selected the latter reaction are mentioned in many places of this book. (See chapters x, xiii, paragraph 3.)

The analysis of the whole procedure led Pavlov to the belief that the accidental properties of a food substance (sight, odour, etc.) become the stimulators of the salivary secretion because they have since birth constantly coincided in time with the activity of the salivary glands (from the stimulation of the mouth cavity by the food). (See chapters ii and iii.)

In order to prove this hypothesis, experiments had to be carried out in which various agents of the external world are made to coincide with stimulations of the mouth cavity which produce a salivary secretion. The results of these experiments are clearly explained in chapter iii toward the end, in chapter iv, and also in chapter x.

The further physiological questions as to which parts of the central nervous system participate in the formation and function of the conditioned reflexes is taken up in chapters xv and xvii. Chapters v, vi, and ix also contain some additional material on this point.

Ensuing experiments showed that there is a special spreading or wandering

of the nerve processes—of inhibition as well as of excitation—in the brain, and this led to the laws of *concentration* and of *irradiation.* (See Index.)

The process of *sleep,* which in the early work often disturbed the course of the experiments, was eventually shown to have many properties in common with the process of inhibition, and in fact to be a kind of flooding of the brain by inhibition. (See chapter xxxii.)

Induction, which had already been known in the lower parts of the central nervous system, was shown to play a part also in the higher brain processes. (See Index.)

And presently the cerebral hemispheres appear as a nerve tissue in whose mass occur the delicate equilibrations between the processes of excitation and inhibition which form the functional substratum conditioning the reactivity of the highest parts of the central nervous system. (Chapter xxi; see also Index under equilibration.) Finally, in the concluding three chapters of the book, there is material showing how this normal activity can be modified by strain or functional destruction of parts of the cortex, and also concerning the various types of nervous systems, temperaments and neuroses.

Thus from the observation of such a simple fact as "the mouth waters" at the sight of food, there developed in Pavlov's mind an entirely new teaching of the functions of the highest parts of the central nervous system, a teaching which even at the present can explain physiologically, be it only schematically and partially, many riddles of human activity. (Refer to chapters xxvii, xxviii, xxix, xxxv, xl.) Does not this represent an important extension of physiology and a forward march of science?

And with the conclusion of chapter xli Pavlov's work is not yet ended. It goes forward unhaltingly and every step reveals important new facts of the higher nervous activity which are brought into strict physiological alignment.

The early years of the work with conditioned reflexes were fraught with doubt, discouragement and criticism, not only from Pavlov's enemies but from his friends. Sir Charles Sherrington, the great British physiologist, told Pavlov in 1912 that the teaching of conditioned reflexes would not be popular in England because it would be considered too materialistic, and his close friend, the late Robert Tigerstedt, advised him to "drop that fad and return to real physiology."

What of the future of conditioned reflexes? Pavlov says it has already made important contributions to the nature of sleep, neuroses, and temperament. He has the strongest conviction that this method will bring untold happiness to the human race by enabling the individual to understand himself, and that when we know the laws governing the higher nervous activity we shall have freedom of the will and control over our actions just as we have acquired power over nature with the solution of her secrets. He says, "the study of the dog has helped me not only to understand myself but also others."

But he thinks the laws of the higher nervous phenomena must first be worked out on the simpler nervous systems of animals, and that the application to the human can be made only slowly and cautiously.

One may make his own decision as to whether Pavlov is a materialist; many say that he is. Political leaders in Russia have drawn upon his teaching for their materialistic point of view. But he himself claims that he is not. He explains that the teaching of conditioned reflexes is science, that it has nothing to do with materialism. As long as the dualistic theory is accepted and mind and matter are considered separate entities, it is difficult to recon-

cile the new facts with this belief; but according to Pavlov, "We are now coming to think of the mind, the soul, and matter as all one, and with this view there will be no necessity for a choice between them." (Personal conversation, April, 1928.) The dualistic theory in his opinion has kept physiologists from working with the higher nervous phenomena.

V

It will doubtless now be of interest to the reader of these lectures to know something of the personal habits of so successful an investigator.

One of Pavlov's most striking traits is his systematic regularity in all the details of life. He goes to work and leaves with military punctuality, and it is extremely rare that he is a minute behind in arriving, or more than a few late in leaving.

The following incident is related by one of Pavlov's assistants:

> During the revolution it was very difficult to get to the laboratory at all, because besides other things there was often shooting and fighting on the streets. However, Pavlov was generally present, even though nobody else was. One of those days when I was about ten minutes late for an experiment, I found Pavlov already there punctually, though no one else had come. Seeing that I was not on time, he immediately lit into me with his customary vivaciousness. "Why are you late, Sir?" I asked him if he did not know there was a revolution going on outside. "What difference does a revolution make when you have work in the laboratory to do!"

Formerly he came to work at nine o'clock and left at six, taking one-half hour for lunch; but having passed the three score years and ten, he has reduced the working day by two hours from 10 A.M. to 5 P.M. Before the revolution he also spent holidays in the laboratory, even New Year and Christmas. He has said that he never missed a day from September first to June first. "On Sundays I remained only till three o'clock, and afterwards went for a walk somewhere. It was quieter then, and I could work and observe the animals undisturbed." He does not advocate work every day in the week for others though, and never required his assistants to be present on Sundays or holidays.

But he is just as regular in his habits of rest. It is almost never that he remains in the laboratory after the accustomed time for him to leave; the stroke of the clock is for him like the factory whistle to an employé. After dinner he plays one or two hands of solitaire, no more, and then lies down from seven to nine. It is an invariable rule with him not to see any one at this time, and the telephone is always cut off. From nine until ten or eleven in the evening he has tea and converses animatedly with his family or visitors. From this hour till about one or two o'clock he reads and studies or writes. Part of the evening is given to calisthenics or gymnastics.

He has always taken two or three full months of rest during the summer. Until the war he had a country house in Esthonia, but since the loss of that he has gone to Finland or elsewhere. When vacation comes every physiological journal and medical book is banned, and he religiously avoids routine mental work, although he includes in his reading poetry and his three chief poets are Shakespeare, Goethe, and Pushkin. Most of his vacation time is taken up in muscular exercise, either gardening or such sports as cycling, and *gorodkee*. He continued to ride a bicycle until only a few years ago. We last saw him

playing *gorodkee* in the summer of 1926 when in his seventy-sixth year (illness prevented this in 1927), and he entered into the sport with all the glee of a youngster at baseball or cricket. His muscular energy is remarkable, for at the age of seventy-six he not only outplayed men of one-half his years, but after three days of continued exercise for eight hours daily at this strenuous game, he alone had enough reserve left to want to resume the play on the fourth day.

Pavlov considers physical work and exercise the best recreation from mental activity, and believes there is just as much benefit in ordinary agricultural labour for this purpose as in sport.

During the summers he spent much time in raising flowers, his favourites being stock-gilliflowers. He used to go to his country place in May to prepare the beds for them, and would then work so hard that he could not sleep for exhaustion. Thus Pavlov always had the greatest interest in all that surrounded him: he delighted in everything: in a good book, a flower, a butterfly, a game of *gorodkee*. He therefore has retained his mental and physical buoyancy notwithstanding his age. Darwin, on the other hand, became an invalid very early, and his life was kept up by the care of his family.

While resting every summer in the country from his laboratory work, Pavlov began to collect first butterflies, and later stamps, and at last paintings. At first he used to say that he collected the butterflies for his son, which was in reality only an excuse. He was accustomed to be constantly amassing facts in the laboratory so that he must needs be interested in always gathering and collecting, even though in the summer it took new forms. Here again he went about it passionately. While stealthily approaching a butterfly which he wanted very much, he would whisper kind words that it might not fly away.

Doing everything with a will he led, by example, all his collaborators to take to work and sport in the same way. The Physician's Gymnastic Society owed its long existence to this ability of his to lead others by his example. The Society lasted until 1914 when the war deprived it of most of the members. Being very animated and energetic, Ivan Petrovitch had the capacity of inspiring the most apathetic characters with energy and interest for their work (Savitch).

Pavlov says that he attributes his long and healthy life to three things mainly: heredity, regularity of habits (proper periods of work, rest, exercise, etc.), and temperance (abstinence from alcohol, smoking, etc.).

Pavlov's highly developed sense of time—the reflex of periodicity—is probably at the basis of his self-control, and because he has control over himself he can lead others. Rarely does he permit his interest or energy to violate the law of periodicity. He is never late for an appointment, and no matter how much a thing interests him he does not allow it to upset his routine.

Other traits which Pavlov possesses to a remarkable degree are impetuosity, uncompromising honesty, straightforwardness, and insuperable energy. Nearly all of his life has been spent between the laboratory and his home, and he would probably never have travelled further from either than to a convenient place to play *gorodkee* in the summer, had not medical meetings called him abroad (he has never even beheld his native and beloved Volga, the Mecca of Russians), so that we might expect to see a person who is at least stiff and formal if not flat and insipid; but the rare combination of the above-mentioned qualities existing in such a marked degree has produced a man irresistibly lively and interesting. It is hard to conceive of one who could be as excitable, as subject to strong emotion, and as absolutely carried away by the vigour of his feelings, and yet at the same time retain perfect control over himself so

that every emotion is subjugated to his will just as savage Bengal tigers may be to their trainer. To watch Pavlov's face is a study in itself—fascinating, like peering into the rapids of some Niagara. One is both amazed and captivated by his vigour, animation, variety of expression. At times his countenance is placid and smiling like that of a benevolent Santa Claus: on other occasions, when some subject is under discussion on which he has decided and vehement opinions, we have seen it assume a fierceness and his whole being a tensity that awed into silence and nothingness all those about him. No actor could better portray the various emotions than he. With Pavlov, these emotions are nearly always those of the positive, active type—almost never negative and dejected. We have not heard of a case in which Pavlov's excessive energy and strong feeling caused him to commit any grievous error which he later recognised as such, although there have been instances where his impetuousness and hot-headedness in trivialities carried him a little beyond what would have been his limit under less exciting circumstances.

When disturbed he can swear energetically, though the strongest terms he is known to use are, "the devil take it!" and "to Hell with it!" and these are favourite and every-day expressions with him and freely interspersed in both lectures and conversation, in the laboratory and at home. On an occasion when the constant repetition of these phrases, uttered vociferously, scoldingly, and with apparent feeling, during an operation, caused an assistant to become somewhat discouraged and disgruntled, Pavlov seeing this afterwards, told him not to mind what he said any more than the dog's barking outside. Babkin related how Pavlov once in a state of excitement whipped an unruly dog with a towel, and then shortly afterwards penitently came to Babkin to admonish him never to beat the animals as it would spoil the experiment.

Another assistant he often referred to in the laboratory as "no better than a cobbler," though at other times as "his beloved collaborator." It has also been mentioned above that Pavlov often has been irreconcilably at variance with certain colleagues, but in these cases, Pavlov's action seems to have been based more on honest principle than on personal prejudice, and in many instances these antipathies were forgotten after a while.

The longer one knows Pavlov, the more one becomes impressed with his simplicity. Not only in his habits and routine but even more in his thinking. There are no curves in his mind, no compromising, no beating about the bush; all his thoughts move in straight lines. Like thoughts, like deeds; for Pavlov, though often harsh and bitter in his attacks, never hits below the belt; his blows though straight from the shoulder and at times savage, are not foul. He is free from all intrigue and backbiting; his honesty is transparent. Examples are numerous, such as the following one, which though seemingly trivial is important for this very triviality. Pavlov not long ago was asked to carry a certain letter with him abroad to avoid the censorship of the mails. However, he refused to violate the law even in so simple a matter. Besides Pavlov, we are not acquainted with any who we believe would be so scrupulous.

And with all his greatness he is unassuming and entirely lacking in ostentation or any show of arrogance, and extremely democratic in his actions. He has been known to rebuke severely a laboratory *Diener* who, when asking for a raise in salary, addressed him as "Barin"[4] (personal communication from

[4] *Barin* is an old term of respect formerly used by servants, etc., in Russia to their superiors, and somewhat equivalent to the employment of the word "Master" by the Negroes in some parts of the South. It is not the same as the title "Baron."

Babkin), though Pavlov himself always uses the term "Gentlemen," and "Sirs" (Gospoda) to his students and collaborators in preference to the modern one of "Citizen" or "Comrade."

With strangers he is warmly cordial and hospitable if they are interested in his work, but frankly brusque to those who are evidently more concerned with him than with his researches, regardless of their rank or station. In fact, we have often seen him particularly unattentive to officials who might expect or could give favours owing to their position. Anything that smacks of pure extolment or panegyric he usually condemns or neglects, though at times tolerates.

As the reader of these lectures can discern for himself, Pavlov is an ardent investigator whose prodigious energy has been dedicated to facts and objectivity. Although it is upon these that he lays the chief values, he is not by any means lacking in an appreciation of art, music, religion, etc. In a burst of enthusiasm we have heard him exclaim, facetiously perhaps, that he would gladly exchange his accomplishments for a voice like Chaliapin's, and his love of pictures is borne witness to by the rare paintings with which he has surrounded himself.

During the utter dissolution of life in Russia following the Great War, Pavlov like other of his countrymen suffered "the slings and arrows of outrageous fortune." Besides the loss of two sons, he was at one time in very difficult material circumstances, having to subsist on a ration of black bread and half rotten potatoes, and in lodgings so cold that some days he had to remain in bed to keep warm. The vegetables he raised in his own garden helped to furnish his table. More intolerable for him than these discomforts was the impossibility of carrying on successful research in the laboratory, on account of the death of animals from starvation, the absence of light and heat, etc. "He was greatly depressed by the Russian Revolution, especially because he thought that the devastation of economic life would hamper science for a long time, and of his conviction that only science can lead the human race to a bright future without war, revolution or catastrophes" (Savitch). These overwhelming events, however, did not crush Pavlov nor break his spirit, and he said to us in 1927, with much defiance and a certain fierceness, that he had survived and could view these misfortunes not from beneath, as most of his countrymen, but from above.

There is one matter which cannot be conscientiously neglected in spite of its controversial nature. And that is the stand which Pavlov has always taken in regard to politics, and particularly since the Revolution. Pavlov did not by any means approve of the old Tsarist government, although it seems that he did not give quite the same vent to his feelings then as now. But he is recorded as saying that he is not sure but that no government at all would not have been better than the Tsarist. Pavlov is a Russian patriot. As he said in one of his lectures, "Gentlemen, I do not know what you have become, but I was, am, and will remain a Russian citizen, a son of my native country!" At the present time, Pavlov is even more vehement in pointing out, decrying, and protesting against politics and political errors. Here, as in everything about which he has an opinion, he states it boldly and even fiercely. We have heard him shout out in the laboratory with all the ire and righteous indignation of his nature terms of vituperation toward the government that not only in Russia but in any country, especially under revolutionary conditions, might have been suppressed as treason. His recent public speeches abound in phrases

that Theodore Roosevelt would have hesitated to employ against his worst political enemies. Yet these invectives have usually been based on those facts which Pavlov has seen, and on principle and not mere expressions of hatred. No personal elements enter into the question. He expresses himself with the same force now when he is receiving all that he needs and wants for his work as during the years when, due to impoverished conditions, he got nothing. He has always championed the cause which he considers right. When religion was attacked, he came out in a public lecture and said it was the highest of all conditioned reflexes, and the one that distinguished man from beast; when the portrait of the Prince of Oldenburg was removed from the institute founded by him, Pavlov hung it in his own office; when certain students including many sons of priests were expelled from the medical schools, Pavlov himself resigned from the chair of physiology at the Military Medical Academy as a protest, stating that he also was the son of a priest.

We desire to give Pavlov's views without entering into a controversy, but at the same time it should be stated that the Soviet Government has sincerely endeavoured to further Pavlov's work. Pavlov's life and art place him above all forms of politics. The Soviet Government has wisely recognised this, and has given him full liberty to speak and act as he pleases even when the object of his criticism is themselves, and this at a time when the granting of such licence to others would result in a state of anarchy. No higher proof of their interest in science exists.

He is not only revered by the Soviet Government and esteemed by the intelligenzia, but honoured far and wide all over Russia. Lenin exerted his influence to improve the conditions so that Pavlov might continue to work in Russia after the Revolution when he was contemplating the necessity of going abroad; and on January 24, 1921 the *Sovnarkom* (Council of People's Commissars) passed a decree requiring the Petrograd Soviet to do their best to favour Pavlov's scientific researches. But it is important to note that Pavlov expressed himself boldly and defiantly in 1917 and 1918 during the civil war when to do so was extremely dangerous, and before it was known how the new government would look upon him.

Pavlov is Russian in his intellectual powers, depth of insight, incapacity to accept foregone conclusions, freshness of outlook, originality, etc., but unlike most Russians, and more like the Anglo-Saxon, he subjugates feeling to action, fancy to fact. In some ways he is comparable to his countryman Tolstoi, albeit their philosophies and natures are rather opposite, one being active, the other passive; albeit the spiritual world is to Pavlov somewhat more than the material was to Tolstoi. But the place he occupies in Russia to-day is as singular as that taken by Tolstoi twenty-five years ago.

It is highly characteristic of Pavlov that in the spring of 1927 he decided to undergo the difficult operation for gallstones, an ordeal which many younger men would have shunned. But even at his advanced age he did not shrink from the pain and possible danger, and he furthermore declined the invitation of the government to obtain the best possible foreign surgeon to perform this (the Russian surgeons naturally preferred that some one else do it), and with his characteristic patriotism, averred that he would have only a Russian to operate upon him. One thought was uppermost in his mind—was there not some cure for his malady that would restore the ability to carry on his scientific work? After an unwilling absence of several months from the laboratory, and a persistent and faithful trial of all the prescribed measures, in view of his

deepening jaundice, loss of weight, and increasing weakness, he resolutely faced the fact that operation was his only hope. During all his illness he complained more of his inability to work than of the paroxysms of pain. The operation was performed, and even though followed by pneumonia, his indomitable will and energy and his fanaticism for science saved him.

In view of the characteristics already mentioned, it is hardly necessary to add that all Pavlov's lectures are delivered with extraordinary zeal and animation. For the students the explanations are so clear and simple that every new scholar can readily understand them. His lectures are always the most popular, and on many occasions, especially when he is to discuss some timely theme, the auditorium is packed as tightly as are the grand stands of a Thanksgiving football match between two rival colleges. It is unfortunate, however, that not many outside of Russia have ever been able to witness this unusual display of dynamic energy; for there are few who understand the only language (Russian) in which he is fluent. He has lectured abroad on many occasions, went to America in 1923, lectured at the Sorbonne in Paris in 1925; and this year at the age of seventy-eight, he went to England to deliver the Croonian Lecture. He says that it always stimulates him to participate in a scientific meeting.

Not only is Pavlov an indefatigable worker himself, but his spirit and his soul pervade the atmosphere of his laboratories. What he means to his coworkers is attested to by the following comment written in 1922 by an assistant. Although it may seem like extravagant praise to those not knowing Pavlov, it is reality for all who have come in contact with him:

> As a contrast to this picture [the conditions in the laboratories after the war] we see before us the personality of Prof. Pavlov, a living and bright model of inflexible devotion to science, passionately convinced of the fact that scientific research alone, leading to true knowledge, can hold out hopes of a better future to humanity. If all the aforementioned circumstances have undermined little by little the strength and energy of the workers of the laboratory, and sometimes have tended to banish the very desire for work, personally Pavlov has always done his utmost to feed the sacred fire of science and to lend energy to the desire for work without counting the cost of either effort or deprivation, and this through a personal example of passionate seeking after the truth. No difficulties or barriers could exist for Professor Pavlov which were able to force him to leave off any investigation begun; he could therefore be seen working on cold days in the laboratory in a winter coat, fur cap, and snow boots. When the whole city was immersed in darkness on the short winter days by the absence of electric light, and no candles or petroleum could be had, Prof. Pavlov used to continue his experiments in the laboratory by the light of wood torches. Only one who has himself been able to witness this strained and passionate struggle in order not to stop for one single moment the path of scientific investigation, can evaluate this human endurance of the highest sort to attain those truths on the work of the central nervous system, which according to the conviction of the author of these lines will become the pride of contemporary physiology.

His extraordinary energy stood out in bold relief:

> The personal qualities of I. P. Pavlov are alone responsible for the fact that notwithstanding the worst conditions of life, and under nearly impossible conditions for scientific work, both this and the lectures in physiology at the Military Medical Academy have continued without a break. If there was no electric light, the demonstrations were carried out before an auditorium of 200 people by the light of one kerosene lamp, and we had to hurry during the big vivisectional experiments because the immobilized animals froze rapidly in the low temperature. But

nevertheless, all experiments necessary to the lectures of Prof. Pavlov were done in full, as well as the practical studies with the students.

Those who have been privileged to see him in the midst of his creative work do not soon forget it. H. G. Wells after meeting him in his laboratory in 1922, wrote, "Pavlov is a star which lights the world, shining down a vista hitherto unexplored." (*New York Times,* November 13, 1927.) And the following case mentioned by Savitch is characteristic:

An interesting example shows how the work of Pavlov's laboratories impressed his collaborators: During the disorderly retreat of the army after the defeat at Lau-Yan (Manchuria) I met at Mukden a typical military doctor of those times. They all forgot their medical studies and became mere officers. But when he saw me he dashed at me and started speaking enthusiastically of Pavlov's laboratory, and of his dogs, especially "Hector" that had given such excellent results during the experiments. The war and the Japanese were completely forgotten!

And whoever sees him to-day will be struck not only by the simplicity of his manner and conversation, but also by the sudden ardour which dominates the great master of science when the subject turns to something in which he is intensely interested. A grey-haired contemporary, returning to the laboratory in 1926, said exultingly, though Pavlov's face had become that of an old man, when he opened his mouth and began to speak he saw it was the same Ivan Petrovitch of thirty years ago.

Pavlov's personality has been well characterised by Yerkes:

For his remarkable personal qualities I was unprepared. To meet Prof. Pavlov, even at the age of three score and fifteen, was stimulating and invigorating—like facing a fresh breeze from the sea. He was interested in everything, alert, generous in his praise, but also in his constructive criticism, sympathetic—a citizen of the world because a disinterested and devoted searcher for the truth.

What a pleasure it was to learn from his own lips about the progress of his investigation, his plans, expectations and hopes. The years fell away as he talked and his being radiated opinions and strength. (*Pavlov's Seventy-fifth Anniversary Volume,* Moscow, 1924.)

All his working life has been devoted to the discovery and analysis of facts. But Pavlov is not only a successful laboratory investigator. He is a great scientist, and a prophet, whose voice sounds above the din and confusion of the world with a challenge to find and face the facts, to subject our pride and prejudice in conformity to them, and to follow where they lead us. This is the goal toward which his energies converge. But did Pavlov's interest lay in politics or wealth instead of in facts, what limits his fame might have reached!

His epitaph might be written in his own words, uttered with a reverberation of his whole being and with such awe-inspiring force that it compelled silence daring protests made to unwelcome statements in one of his lectures: "I am speaking only the scientific truth, and whether you will or no you must hear it!"

NOTE: For a discussion of the life and work of Ivan Pavlov from 1928 to 1936, the year of his death, see pp. 11-39 of *Conditioned Reflexes and Psychiatry,* the second volume of his *Lectures on Conditioned Reflexes.—Tr.*

INTRODUCTION TO THE ENGLISH TRANSLATION

THIS volume is a collection of reports of progress. For about twenty-five years Professor Pavlov prepared no comprehensive account of his highly interesting and important experiments on the functions of the more complex parts of the brain; instead he presented the results of his researches in occasional lectures. Such a presentation has both defects and virtues. Chief among what will be regarded as defects is repetition. In successive lectures the same phenomena are defined again and again. Usually, however, these common phenomena become the basis for describing new developments; and as the developments become more and more complex a frequent return to the fundamental features of the researches makes a more intelligible approach to the new observations.

As a series of reports of progress the volume has importance both as a collection of historical records and as a disclosure of the gradually developing methods and interpretations of a master-workman in physiology. We learn about the first hints and the earliest attempts at what has grown to be a highly elaborate system of facts and ideas concerning the functions of the cerebral cortex, and we have the opportunity of watching stage by stage from its simple beginnings the building of the system. As a revelation of the modes of action of Professor Pavlov's own cortex the book is valuable not only to the professional scientific investigator but to all who are interested in human nature. It discloses his free and bold application of the concept of a *reflex* to all forms of behaviour. Who else would discourse simply and frankly on the "reflex of freedom" and the "reflex of slavery"? It discloses his ingenuity in devising novel and significant experiments which lay before us the movements and relations of the nerve impulses in the brain. The higher strategy of scientific research is here admirably displayed. The book discloses also the readiness of a great investigator to let his imagination play over the facts and give them meaning.

The reader who has heard of "behaviourism" will find here the words of the chief scientific exponent of that manner of regarding the responses of animals. Emphasis is laid strictly on the objective study of these responses. They result from contractions of muscles; the muscular contractions are caused by nerve impulses discharged from the

brain; the brain in turn has been disturbed by nerve impulses discharged from surface receptors; these receptors or "sense organs" are stimulated by changes in the environment. The linkage of events throughout is followed on the physiological level. This emphasis on the physiological aspect of complex responses to the environment has already led to new views regarding the relations of processes in the higher nervous centers. It is certain to lead to a formulation of laws of action and interaction of these processes—laws the knowledge of which may reasonably be expected to have highly important significance for the control of conduct. Recognising the stupendous benefits which science has conferred we are led to share fully Professor Pavlov's faith in that result of the analysis of intricate behaviour by scientific methods.

Professor Pavlov is modest in his claims. He recognises that the new territory which he has discovered is vast. It is rich with interesting possibilities. It is difficult to explore. Many years of patient labour by many workers will be required for its conquest. The splendid example of industry and devotion to science which the first explorer has given during his long life will be an incentive to all who will follow after him and push further into the unknown.

WALTER B. CANNON.

Harvard Medical School, Boston, September, 1928.

AUTHOR'S PREFACE TO THE ENGLISH TRANSLATION

This book concerns the investigation of the physiology of the cerebral hemispheres by the strictly objective method of conditioned reflexes. It is a collection of articles, reports, lectures, and addresses which appeared during the twenty-five years when these investigations were being conducted, and it represents the historical advance of our researches, assuming at times a fairly popular character. The lectures are documented and are set forth in detail.

The present volume has been rendered into English owing to the initiative of Dr. Gantt. Others participating in this translation have been, on the one hand, my highly esteemed collaborators in these experiments, G. V. Volborth of the University of Kharkov, and B. P. Babkin of Dalhousie University, Halifax, both of whom are familiar with English as well as with Russian; and, on the other hand, my friend, Dr. Cannon, of Harvard University, who has kindly undertaken the task of perfecting the English rendition. To all these, beginning with Dr. Gantt, I am deeply and sincerely grateful.

IVAN P. PAVLOV,

Member of the Academy of Sciences.

Leningrad, August, 1928.

PREFACE TO THE FIRST RUSSIAN EDITION

BEGINNING OF THE WORK WITH CONDITIONED REFLEXES—ADOPTION OF PHYSIOLOGICAL POINT OF VIEW AND REJECTION OF THE SUBJECTIVE METHODS OF PSYCHOLOGY —SIMULTANEOUS BEGINNINGS OF OBJECTIVE EXPERIMENTAL METHODS BY AMERICAN PYSCHOLOGISTS, THORNDIKE, WATSON AND OTHERS—DIFFERENCES BETWEEN THEIR AND PAVLOV'S WORK—BECHTEREV—GOAL AND IDEALS OF TRUE SCIENCE—THE CONDITIONED REFLEX—REASONS FOR COMPLETING THIS BOOK, ITS SHORTCOMINGS AND CONTENTS.

More than twenty years ago I began these experiments independently, passing to them from my former physiological work. I entered this field under the influence of a powerful laboratory impression. For many years previously I had been working on the digestive glands. I had studied carefully and in detail all the conditions of their activity. Naturally I could not leave them without considering the so-called psychical stimulation of the salivary glands, *i.e.*, the flow of saliva in the hungry animal or person at the sight of food or during talk about it or even at the thought of it. Furthermore, I myself had demonstrated a psychical excitation of the gastric glands.[1]

[1] In his *Work on the Digestive Glands*, 1897, Prof. Pavlov states that the excitation of the gastric glands which begins during eating (sham feeding) depends not only upon the stimuli from the mouth cavity, but that there is necessary an active motor reaction of the dog to the food (food reflex). This factor, which must be added to the stimuli from the mouth cavity in order to initiate the gastric secretion, Pavlov considered psychical, and he described it in *Work on the Digestive Glands* as follows:

Consequently, in sham feeding the excitation of the nerves of the gastric glands by the process of chewing and swallowing depends largely on a psychic factor which has here grown into a physiological one, that is to say, is just as much a matter of course and appears quite as regularly under these conditions as any other physiological result. Regarded from the purely physiological side, the process may be said to be a complicated reflex act. Its complexity lies in this, that the ultimate object is attained by the co-operation of many separate organic functions. The material to be digested—the food—is found only outside the organism in the surrounding world. It is acquired not alone by the exercise of muscular exertion, but also by the intervention of higher functions, such as judgment, will, desire. Hence the simultaneous excitation of the different sense-organs, of sight, of hearing, of smell and taste, is (much as in the case of the salivary glands) the first and strongest impulse which arouses the activity of the gastric glands. This especially applies to the two latter senses, since they are only excited when the food has come very near to or has already entered the organism. Through the medium of the response, Nature, resourceful and unerring, has linked the seeking and finding of food with the commencement of digestion. That this initiation of secretion should stand in closest connection with an every-day phenomenon of human life, namely, appetite, might easily have been surmised. Thus appetite, so important to life and so full of mystery to science, here at length assumes a tangible existence and becomes transformed from a subjective sensation into a concrete factor within reach of physiological investigation.

We are therefore justified in saying that appetite is the first and most potent exciter of the secretory nerves of the stomach, a factor which embodies in itself something able to compel the empty stomach of the dog during the fictitious meal

I began to investigate the question of psychic secretion with my collaborators, Drs. Wolfson and Snarsky. Wolfson collected new and important facts for this subject; Snarsky, on the other hand, undertook to analyse the internal mechanism of the stimulation from the subjective point of view, *i.e.*, he assumed that the internal world of the dog—the thoughts, feelings, and desires—is analogous to ours.[2] We were now brought face to face with a situation which had no precedent in our laboratory. In our explanation of this internal world we diverged along two opposite paths. New experiments did not bring us into agreement nor produce conclusive results, and this in spite of the usual laboratory custom, according to which new experiments undertaken by mutual consent are generally decisive. Snarsky clung to his subjective explanation of the phenomena, but I, putting aside fantasy and seeing the scientific barrenness of such a solution, began to seek for another exit from this difficult position. After persistent deliberation, after a considerable mental conflict, I decided finally, in regard to the so-called psychical

to secrete large quantities of the strongest juice. A good appetite in eating gives origin at the outset to a vigorous secretion of the most active juice; where there is no appetite this juice is absent. To restore appetite to a man means to provide him with a large stock of gastric juice wherewith to begin the digestion of a meal.

Further investigation and deliberation led him to assume that one has to deal in this case only with a special excitability of the organism by food, which can be considered as a phenomenon of the physiology of the nervous system without recourse to psychical conceptions. A fuller discussion will be found in chapter xiii. As "psychical secretion" is a widely used term, Pavlov employs it here for the sake of conciseness, in spite of his desire to divorce physiology from psychological and subjective expressions.—*Translator.*

[2] In the light of our present exact knowledge of nervous processes, and the laws which govern the salivary reaction, we are able to explain the variations in the secretion, and therefore Snarsky's account of this seems almost humorous. He wrote: "Under the influence of inedible substances one can see that the quantity of saliva does not answer to the degree of pleasantness of the substances; for example, much more saliva flows on sand or glycerine than on a solution of extract of quassia, that is, on an exceedingly bitter solution, although in the last case the grimace of disgust is stronger. . . . After sand the dog licks vigorously and smacks his lips, and it is clear that the grimace of disgust is not so prominent as the desire to cleanse the mouth." (A. T. Snarsky: *Analysis of the Work of the Salivary Glands in the Dog*, St. Petersburg, 1901.)

Snarsky described the different stages of the grimace of disgust, and wrote: "It must be mentioned that one of the experiments was not performed at the usual hour for the dog, but after six o'clock, *i.e.*, after the time when the dogs were usually fed. This change in time was evidently very disagreeable for the dog: he was agitated, he howled, secreted more saliva than usually, and the longer the experiment lasted the more. . . ."

"It was quite evident that the dog was not so much excited by the concentration of the acid solution used as by all the procedure itself, by being disturbed at an unusual hour in the day." (*Ibid.*, p. 28.) Comparing these descriptions with the present description, is it not clear that our present conception of this phenomenon is much simpler? Our explanation is that late in the day or toward the usual feeding hour there is an increased excitability of the central nervous system. (See chapter xiii.)—*Translator.*

stimulation, to remain in the rôle of a pure physiologist, *i.e.*, of an objective external observer and experimenter, having to do exclusively with external phenomena and their relations. I attacked this problem with a new co-worker, Dr. Tolochinov, and from this beginning there followed a series of investigations with my highly esteemed collaborators, which has lasted for more than twenty years.

When I began our investigations with Dr. Tolochinov, I was aware that in the extension of physiological investigation throughout the whole animal world (in the form of comparative physiology), dealing with other animals in addition to those common to the laboratory (dogs, cats, rabbits, and frogs), the physiologist is obliged to abandon the subjective point of view, to endeavour to employ objective methods, and to try to introduce an appropriate terminology (the doctrine of tropism of Jacques Loeb, and the objective terminology of Baer, Bethe, and Uxküll). Indeed, it would be difficult and unnatural to speak of the thoughts and wishes of an ameba or infusorian. But our study concerned the dog, the intimate and faithful companion of man since prehistoric times. And I take it that the most important motive for my decision, even though an unconscious one, arose out of the impression made upon me during my youth by the monograph of I. M. Setchenov, the father of Russian physiology, entitled *Cerebral Reflexes* and published in 1863. The influence of thoughts which are strong by virtue of their novelty and truth, especially when they act during youth, remains deep and permanent even though concealed. In this book, a brilliant attempt was made, altogether extraordinary for that time (of course, only theoretically, as a physiological outline), to represent our subjective world from the standpoint of pure physiology. Setchenov had made at that time an important physiological discovery (concerning central inhibition) which deeply impressed European physiologists. That was the first Russian contribution to this important branch of natural science, which just previously had been remarkably advanced through the successes of German and French physiologists.

The great effort which this discovery demanded, and the joy which it brought, mixed perhaps with personal emotion, gave rise to the ideas expressed by Setchenov, which are certainly those of a genius. Afterwards, it is interesting to note, he never referred to this theme in the same resolute manner as he did at first.[3]

Some years after the beginning of the work with our new method I learned that somewhat similar experiments on animals had been performed in America, and indeed not by physiologists but by psychologists.

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[3] Compare with the idea expressed in the last paragraph of chapter xx.—*Translator.*

Thereupon I studied in more detail the American publications, and now I must acknowledge that the honour of having made the first steps along this path belongs to E. L. Thorndike.[4] By two or three years his experiments preceded ours, and his book must be considered as a classic, both for its bold outlook on an immense task and for the accuracy of its results. Since the time of Thorndike the American work (Yerkes, Parker, Watson, *et al.*) on our subject has grown. It is purely American in every sense—in collaborators, equipment, laboratories, and publications. The Americans, judged by the book of Thorndike, set out on this new path of investigation in quite a different manner from us. From a passage in Thorndike one may conjecture that the practical American mind applied to everyday life found that it is more important to be acquainted with the exact outward behaviour of man than with guesses about his internal states with all their combinations and changes. With these considerations concerning man, the American psychologists proceeded to their laboratory experiments on animals. From the character of the investigations, up to the present, one feels that both the methods and the problems are derived from human interests.

I and my co-workers hold another position. As all our work developed out of physiology, so it has continued directly in that path. The methods and the conditions of our experimentation, as well as the scheme of the separate problems, the working up of the results, and finally their systematisation—all this has remained in the realm of the facts, conceptions and terminology of the central nervous system. This approach to our subject from both the psychological and the physiological sides enlarges the sphere of the phenomena under investigation. To my deep regret, I know absolutely nothing about what has been done on this question in America during the last four or five years; up to this time it has been impossible to obtain American literature on the subject here, and my request last year to go to America to learn of the recent work was not granted.[5]

Some years after we started, the problem was also taken up by Bechterev here and by Kalischer * in Germany. In our work we used an inborn reflex upon which all nervous activity is modelled, *viz.*, the food reflex and the defensive reflex against acid, the secretory component of which we had observed. Bechterev used instead the defensive reflex against destructive (painful) irritation of the skin in the form of a

[4] E. L. Thorndike: *Animal Intelligence—An Experimental Study of the Associative Processes in Animals*, 1898.—*Translator.*

[5] Since this preface was written Prof. Pavlov received permission and money from the Soviet Government to go abroad, and he spent the summer of 1923 in France, England, and America.—*Translator.*

* The claims of these as to any priority in such investigations are, of course, for any one having even a slight knowledge of the subject, wholly ephemeral.

movement reaction. Kalischer, however, employed as we did the food reflex, concentrating his attention on the motor reaction. Bechterev designated as "associative" these new reflexes which we called "conditioned," while Kalischer called the whole method the "*Dressurmethode*" (training method). If I may judge from what I saw in the physiological literature during my five weeks' stay in Helsingfors this spring (1923), the objective examination of the behaviour of animals has already attracted the attention of many physiological laboratories in Europe—in Vienna, Amsterdam, etc.

About myself I shall add the following. At the beginning of our work and for a long time afterwards we felt the compulsion of habit in explaining our subject by psychological interpretations. Every time the objective investigation met an obstacle, or when it was halted by the complexity of the problem, there arose quite naturally misgivings as to the correctness of our new method. Gradually with the progress of our research these doubts appeared more rarely, and now I am deeply and irrevocably convinced that along this path will be found the final triumph of the human mind over its uttermost and supreme problem—the knowledge of the mechanism and laws of human nature. Only thus may come a full, true and permanent happiness. Let the mind rise from victory to victory over surrounding nature, let it conquer for human life and activity not only the surface of the earth but all that lies between the depth of the seas and the outer limits of the atmosphere, let it command for its service prodigious energy to flow from one part of the universe to the other, let it annihilate space for the transference of its thoughts—yet the same human creature, led by dark powers to wars and revolutions and their horrors, produces for itself incalculable material losses and inexpressible pain and reverts to bestial conditions. Only science, exact science about human nature itself, and the most sincere approach to it by the aid of the omnipotent scientific method, will deliver man from his present gloom, and will purge him from his contemporary shame in the sphere of interhuman relations.[6]

The freshness of the subject in addition to the hope just expressed should inspire all workers in this new field. The work advances along a wide front. Much has been accomplished during the twenty-five years since its beginning made by Thorndike.

My laboratories have contributed not a little to this progress. Our

[6] This idealistic conception of scientific work, as a means for building the future happiness of mankind, is characteristic of Prof. Pavlov. He remarked to one of the translators in 1926 on seeing an aeroplane that this sight always stimulated him to think, allegorically, that the human mind would some time be able to rise as high above its present perplexities as the aviator does above the earth.—*Translator.*

investigations have continued unbrokenly up to the present time. A slackening of the work was caused in 1919 and 1920 owing to extraordinary difficulties (cold, darkness, starvation of the experimental animals, etc.). Since 1921 the conditions have improved, and now they approach normal except for lack of instruments and literature.[7]

Our data increases, the outline of our research becomes larger, and gradually there looms up before us a general system of the phenomena in this new field—in the physiology of the cerebral hemispheres, the organ of the highest nervous activity.[8]

These are at present the main features of our work. We are becoming better and better acquainted with the fundamental mode of conduct with which the animal is born,—with the congenital reflexes, heretofore usually called instincts. We observe and intentionally participate in building new reactions on this fundamental conduct, in the form of so-called habits and associations, which now increase, enlarge, become complicated and refined. According to our analysis, these are also reflexes, but *conditioned reflexes.* Step by step we approach the inner mechanism of these reflexes, become more accurately informed about the general properties of the nervous masses in which they move and have their being, and with the hard and fast rules by which they are governed. There pass before us several individual types of nervous systems highly characteristic, strongly expressed, showing us the different aspects and properties of nervous activity upon which is based the whole complicated behaviour of animals. And even more than this! The results of animal experimentation are of such nature that they may at times help to explain the hidden processes of our own inner world.

Such is the situation as I conceive it. The reason that I have not given a systematic exposition of our results during the last twenty years is the following. The field is an entirely new one, and the work has constantly advanced. How could I halt for any comprehensive conception, to systematise the results, when each day new experiments and observations brought us additional facts!

Five years ago, when I was confined to my bed for several months on account of a serious fracture of the leg, I prepared a general review of all our investigations. Then the Revolution began. This, of course, distracted my attention. It was, moreover, my habit to lay aside a written article in order to forget it, so that when I re-read it I could the better note its shortcomings. Thus it happened that what I had prepared was never printed. After half a year of uninterrupted work, it had become

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[7] The Soviet Government has greatly increased the funds for scientific work in the past few years, and in December, 1926, Prof. Pavlov told one of the translators that his laboratories were receiving all the money they needed.—*Translator.*

[8] This outline is described in greater detail in chapter xxxi.—*Translator.*

out of date, and at present it is not suitable for publication, and needs a thorough revision. But to perform such a task quickly and adequately, while living under the present painful conditions which obtain in Russia, is very difficult, indeed I might say, well nigh impossible. And I do not know myself exactly when I shall be able to fulfil this important duty of making an especial and final systematisation of the scientific data accumulated over so long a period. To study this material from the published papers of all my co-workers would be a task of exceeding difficulty, possible only for a few.

On this ground, I, complying with the numerous and repeated requests and desires of my closest collaborators, have ventured to publish in the present volume everything that I have written on our subject, in articles, reports, lectures and speeches, in Russia and abroad, during these twenty years. May this book be a substitute, even though incomplete, for a systematic exposition of the matter for those who are endeavouring to acquaint themselves with the subject or to work in this field. Certainly I see quite clearly the faults of this collection. The chief of these is the number of repetitions. They occurred for a quite comprehensible reason. The subject was new—it developed in the mind of the physiologist only little by little. And in order to comprehend it, to grasp it better, to get a conception of it, there was naturally a desire to expound and interpret every variation, however small it may have been.

But to select, condense, and arrange the material would be at present a difficult and unprofitable labour for me. Perhaps these repetitions and slight variations may not be entirely useless for the reader, especially as the articles are arranged in chronological order, so that before him passes the entire history of our efforts. He will see how little by little the facts expanded and were verified, how they gradually unfolded in our conceptions of the several sides of the subject; and how finally appeared before us a perspective of the highest nervous functions. Nevertheless I should admonish those who are not physiologists nor biologists, and, indeed, every one who will honour my book with his attention, to begin by reading in chronological order my speeches delivered in Madrid, Stockholm, London, the three in Moscow, and the two reports in Gröningen and Helsingfors.[9] Only after these would I advise him to turn to the other special treatments of the subject. In this way the foundation and the general tendency of our work will become clear for the reader, and the details will then show up more definitely on this background.

For those who wish to become acquainted with the original articles of my co-workers, I append at the end of the book a bibliography.

Petrograd, 1923.

I. P. PAVLOV.

[9] Chapters i, iii, iv, x, xi, xx, xxi, xxxi.—*Translator.*

LECTURES ON CONDITIONED REFLEXES

LECTURES ON CONDITIONED REFLEXES

CHAPTER I

EXPERIMENTAL PSYCHOLOGY AND PSYCHO-PATHOLOGY IN ANIMALS

(Read before the International Congress of Medicine, Madrid, April, 1903.)

EXPERIMENTAL BASIS FOR THE PHYSIOLOGICAL POINT OF VIEW—BEGINNINGS OF THE PHYSIOLOGICAL STUDY OF PSYCHOLOGICAL FACTS, FIRST WITH THE SALIVARY GLANDS—THE NORMAL FUNCTIONS OF THESE GLANDS, SHOWING APPARENT INTELLIGENCE—PHYSIOLOGICAL ANALYSIS OF THIS INTELLIGENCE—ACTION OF THE SALIVARY GLANDS TO SUBSTANCES AT A DISTANCE ("PSYCHICAL") SAME AS WHEN IN THE MOUTH ("CHEMICAL")—PROOF THAT THESE SO-CALLED "PSYCHICAL" REACTIONS ARE ONLY REFLEX IN NATURE—DISTANT, UNESSENTIAL PROPERTIES BECOME SIGNALS—REACTION DEPENDENT UPON CONDITION OF THE ANIMAL—"PSYCHICAL REACTIONS" (CONDITIONED REFLEXES) ARE ADAPTABLE AND CHANGEABLE—WISHES—TEMPORARY CONNECTIONS—DEVIATION OF EXCITATION PROCESS—ADVANTAGES OF THE METHOD OF CONDITIONED REFLEXES AND OF THE USE OF THE SALIVARY GLANDS IN THEIR STUDY—ADAPTABILITY—THE HOPE AND IDEAL OF SCIENCE—ANIMISM AND VITALISM.

ESTEEMING the language of facts as the most eloquent, I ask your attention to the experimental material which gives me the right to speak on to-day's subject.

First is the history of the physiologist's shifting his attention from purely physiological to so-called psychical questions. Though this transition was unexpected, it came about in a natural way, and it seems to me to be of great importance for science that this change occurred without abandoning the methodological front of physiology.

While studying, over a course of many years, the normal activity of the digestive glands, and analysing the constant conditions of this activity, I came upon facts (which had also been observed by others) of a psychical character, facts which could not be rationally neglected, as they participated constantly and prominently in the normal mechanism of the physiological processes.[1] I was obliged to consider them if I wished to make the most thorough possible study of my subject. But the question arose, How? And the following exposition will be in answer to this question.

From all our material I shall select only the experiments with the salivary glands—organs having apparently a very insignificant physiological rôle; nevertheless, I am convinced that they will be classical

[1] The word psychical is for Prof. Pavlov only a label for a set of phenomena. As they may be reproduced, he starts studying the circumstances under which they appear or disappear.—*Translator.*

objects in this investigation of a new type, the experiments of which I have the honour to describe to you to-day, in part as performed, in part as planned.

Observing the normal activity of these glands, it is impossible not to be struck with the high degree in which they are adapted to their work. Give the animal some dry, hard food, and there is a great flow of saliva, but with watery food there is much less. Now it is clear that for the chemical testing of the food and for mixing it and preparing it as a bolus capable of being swallowed, water is necessary. This water is supplied by the salivary glands. From the mucous salivary glands there flows for every kind of food, saliva rich in mucin. This facilitates the passage of the food through the œsophagus. Upon all strongly irritant chemical substances, as acids and salts, there is also a free flow of saliva, varying to a certain degree with the strength of the stimulus. The purpose of this is to dilute or neutralise the irritant, and to cleanse the mouth. This we know from every-day experience. This saliva contains much water and little mucin. For, what could be the use of mucin here?

If you put some quartz pebbles into a dog's mouth he moves them around, or may try to chew them, but finally drops them. There is no flow of saliva, or at most only two or three drops. Indeed, what purpose could saliva serve here? The stones are easily ejected and nothing remains in the mouth. But, if you throw some sand in the dog's mouth (the same stones but pulverised), there is an abundant flow of saliva. It is apparent that without fluid in the mouth, the sand could neither be ejected nor passed on to the stomach. We see here facts which are exact and constant, and which really seem to imply intelligence.[2] The entire mechanism of this intelligence is plain. On the one hand physiology has known for a long time of the centrifugal nerves to the salivary glands which may cause either water or organic material to pass into the saliva. On the other hand, in certain regions, the lining of the oral cavity acts as a receptor for mechanical, chemical and thermal stimuli. These different stimuli may be further subdivided: the chemical, for example, into salts, acids, etc. There is reason for assuming the same in regard to mechanical irritants. From these special regions of the oral cavity the specific centripetal nerves take their origin.

All these reactions of adaptation depend upon a simple reflex act which has its beginning in certain external conditions, affecting only certain kinds of centripetal nerve endings. From here the excitation runs along a certain nerve path to the centres whence it is conducted to the salivary glands, calling out their specific function.

[2] The following statement shows the difference between the vague term intelligence and the successful analysis of the physiologist.—*Translator.*

In other words, here is a certain agent which calls forth in living matter a definite reaction. It is a typical example of adaptation and fitness. Let us consider somewhat closer these facts, which play such an important rôle in modern physiological thought. In what does the adaptation consist? It is nothing more, as we have seen, than the exact co-ordination of the elements of a complicated system, and of their complexes, with the outer world.

This, however, is exactly the same as one can see in every inanimate system. Take, for instance, a complex chemical substance. It can exist only so long as its individual atoms and groups are in equilibrium, and its whole complex is in equilibrium with the surrounding conditions.

In the same way the wonderful complexity of the higher and lower animals can exist as a whole only so long as all the delicate and exact balances of their constituents remain in equilibrium one with the other and with the outside world.[3]

The analysis of the equilibration of this system is the primary aim of physiological enquiry, as a pure, objective investigation. Upon this point there can hardly be two opinions. It is to be regretted that up to the present we have no scientific term to denote this fundamental characteristic of the organism—its ability to maintain an external and internal equilibrium. The words adaptation and fitness, used for it, continue to connote a certain subjectiveness (in spite of Darwin's scientific analysis), which leads to a misunderstanding in two opposite directions. The strict adherents of the physico-mechanical school see in these words an anti-scientific tendency—a retreat from pure objectiveness to speculation and teleology. On the other hand, the philosophically inclined biologists consider every fact which concerns adaptation or fitness as proof of the existence of a vital force, or, as we more and more often hear it called, a spiritual force (vitalism gives way, it seems, to animism), which sets its goal, chooses its means, and adapts itself.

Thus, in the foregoing physiological experiments we remain within the bounds of a strictly naturalistic problem. Now, however, we will proceed to other facts which seem to fall into another category.

All the foregoing substances, which when placed in the mouth influence specifically the salivary glands, act exactly the same upon these glands, at least in a qualitative way, when they are a certain distance from the dog. Dry food, even from a distance, produces much saliva; moist

[3] This is perhaps the most objective, naturalistic conception of living organisms, the objective study of all the phenomena of life. It led Pavlov to consider even the temporary or acquired reactions also as a mechanism of equilibration with the conditions of the outer world, altering at every moment and for every individual. It is plain that for a physiologist the mechanism of these new reactions in higher animals could be only a nervous one.—*Translator.*

food, only a little. To the stimulation by food at a distance, there flows into the mouth from the mucous glands a thick, lubricating saliva. Inedible substances also produce a secretion from all the glands, but the secretion from the mucous glands is watery and contains only a small amount of mucin. The pebbles when shown to the dog have no effect on the glands, but the sand provokes an abundant flow of saliva. The above facts were partly discovered, partly systematised by Dr. Wolfson in my laboratory. The dog sees, hears, and sniffs all these things, directs his attention to them, tries to obtain them if they are eatable or agreeable, but turns away from them and evades their introduction into the mouth if they are undesired or disagreeable. Every one would say that this is a psychical reaction of the animal, a psychical excitation of the salivary glands.

How should the physiologist treat such facts? How can he state them, how analyse them? Where do they stand in comparison with physiological facts? What are their common and what their individual characteristics?

To understand these phenomena, are we obliged to enter into the inner state of the animal, and to fancy his feelings and wishes as based on our own?

For the investigator, I believe there is only one possible answer to the last question—an absolute "No." Where does there exist so incontestable a criterion that one may judge by it, and may use it in understanding the internal state of an animal by comparison with our own, even though the animal be so highly developed as the dog? And further: does not the eternal sorrow of life consist in the fact that human beings cannot understand one another, that one person cannot enter into the internal state of another? Where is that knowledge, where is the understanding that might enable us to know correctly the state of our fellow man? In our "psychical" experiments on the salivary glands (we shall provisionally use the word "psychical"), at first we honestly endeavored to explain our results by fancying the subjective condition of the animal. But nothing came of it except unsuccessful controversies, and individual, personal, inco-ordinated opinions. We had no alternative but to place the investigation on a purely objective basis. The first and most important task before us, then, is to abandon entirely the natural inclination to transpose our own subjective condition upon the mechanism of the reaction of the experimental animal, and instead, to concentrate our whole attention upon the investigation of the correlation between the external phenomena and the reaction of the organism, which in our case is the salivary secretion. Reality must decide whether the elaboration of these new phenomena is possible in this direction. I dare to think that the fol-

lowing account will convince you, even as I am convinced, that in the given cases there opens before us an unlimited territory for successful research in a second immense part of the physiology of the nervous system as a system which establishes the relation, not between the individual parts of the organism with which we previously dealt, but between the organism and the surrounding world. Unfortunately, up to the present time, the influence of the environment on the nervous system has been explained for the most part subjectively, and this comprises the whole contents of the contemporary physiology of the sense organs.

In our psychical experiments we have before us definite, external objects, exciting the animal and calling forth in it a definite reaction—the secretion of the salivary glands. The effect of these objects, as has been shown, is essentially the same as in the physiological experiments in which they come in contact with the tongue and palate, as in eating. This is nothing more than a further adaptation, *i.e.*, that the object influences the salivary glands if it is brought even *near* the mouth.

What is the characteristic of these new phenomena compared with the earlier physiological ones? At first, it seems that the difference lies in the fact that in the physiological form of the experiment, the substance is brought into direct contact with the organism, whilst in the psychical, it acts from a distance. If one considers carefully, one sees that there exists no essential difference between these quasi-peculiar and the purely physiological experiments. The difference consists in the fact that in these cases the substances act upon other specific body surfaces—upon the nose, eye, ear—thanks to the surrounding medium (air, ether), in which the organism and the exciting substances are immersed. How many simple physiological reflexes start from the nose, the eye, and the ear, and therefore originate at a distance! The essential difference between these new phenomena and the purely physiological is not to be sought for here.

It is necessary to seek more deeply for this difference and, as it seems to me, in the following facts. In the physiological case the activity of the salivary glands is connected with those properties of the substance upon which the effect of the saliva is directed. The saliva serves to moisten and lubricate the material to be swallowed and to neutralise the effect of the chemically active substances. And this is exactly the function of the special stimulators of the specific mouth surfaces. Consequently, in the physiological experiments the animal is excited by the essential, unconditioned properties of the substance, *i.e.*, by those intimately connected with the physiologic rôle of the saliva.

In the psychical experiments the animal is excited by properties of

the external object which for the work of the salivary glands are unessential, or by even entirely accidental and unimportant properties. Visual, auditory, and even pure olfactory properties of our objects, *per se,* applied to other objects, remain without any influence on the salivary glands; for they, on their side, possess no business relation, so to speak, to these properties. In our psychical experiments there appear before us as stimulators of the salivary glands not only such properties (appearance, sound, odour, etc.) of the various objects which are unessential for the work of these glands, but absolutely all the surroundings in which these objects are presented to the dog, or the circumstances with which they are connected in real life. For example, the dish in which it is presented, the furniture upon which it is placed, the room, the person accustomed to bring it, and the noises produced by him—his voice, and even the sound of his feet—though at the moment he cannot be seen. Thus in the psychical experiment the connection of the objects exciting the salivary glands becomes more and more distant and delicate. Undoubtedly we have before us here an extreme degree of adaptation. We may admit that in this special case such a remote and fine reaction as that of the salivary glands to the characteristic step of the person who usually feeds the animal has no other physiological importance than its subtleness. Yet one need only remind oneself of a case in which the saliva of certain species contains poisons as a protection against other animals to see what a great significance for life this expectant production of the poison gland can have when enemies only approach, *i.e.,* when they are first seen or heard (signalling action). The importance of the remote signs (signals) of objects can be easily recognised in the movement reaction of the animal. By means of distant and even accidental characteristics of objects the animal seeks his food, avoids enemies, etc.

If that is so, then the chief difficulty of our subject is expressed in the question, Can all this seeming chaos of relations be included in a certain scheme? Is it possible to make the phenomena constant, to discover the laws which govern their mechanism? The examples which I shall present now give me the right, I think, to answer these questions categorically, "Yes," and to find at the basis of our psychical experiments always the same special reflexes as the common mechanism. In its physiological form our experiment—provided, of course, all extraordinary conditions are excluded—always gives the same results; this is an *unconditioned reflex.* The main characteristic of the psychical experiment is the inconstancy of its results and its apparent capriciousness. The results of a psychical experiment, however, recur with more or less constancy, otherwise we could not speak of it as a scientific experiment. The difficulty of the psychical experiment lies in the greater

number of factors which must be considered. Thus the reflex obtained is *conditioned.*[4]

Now I shall present the facts which bear testimony that our psychical material obeys certain laws. These data were obtained by Dr. F. Tolochinov in my laboratory.

It is not difficult to recognise in the first psychical experiments certain important conditions which insure constant results and guarantee the success of the experiment. You stimulate an animal (*i.e.*, his salivary glands) by food from a distance; the success of the experiment depends exactly upon whether the animal has been prepared by a previous period of fasting. In a hungry dog we get a positive result, but, on the contrary, in even the most avaricious and greedy beast we fail to get a response to food at a distance if he has just satiated himself. Thinking physiologically we can say that we have a different excitability of the salivary centre—in the one case greatly increased, in the other decreased.[5] One may rightly suppose that just as the carbonic acid of the blood determines the energy of the respiratory centre, the composition of the blood in the fasting or fed animal likewise regulates the threshold of excitability of the salivary centre, as noted in our experiment. From the subjective point of view this change in excitability could be designated as attention.[6] With an empty stomach the sight of food causes the mouth to "water"; in a satiated animal this reaction is very weak or may be entirely lacking.

Let us go further. If you only show the dog food, or some undesired substance, and repeat this several times, at each repetition you get a weaker result, and finally no reaction whatever. But there is a sure method of restoring the lost reaction: this is by giving the dog some food or by putting any undesired substance into the mouth. This provokes, of course, the usual strong reflex, and the object is again effective from a distance. It is immaterial for our result whether food is given or the undesired substance is put into the mouth. For instance, if meat powder, having been repeatedly brought before the dog, fails to produce a flow of saliva, we may again make it active by either giving it to the dog to eat (after showing it), or by putting an undesired substance into his mouth, *e.g.*, acid. Owing to the direct reflex, the irritability of the salivary centre has been increased, and now the

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[4] This is the first time we meet with the term "conditioned reflex." From the foregoing one will see why Pavlov gave this adjective to the new phenomena. It is explained in many other places in the book.—*Translator.*

[5] This is the essence of the theory developed in chapter xiii.—*Translator.*

[6] One will notice that here Pavlov tries to find correlations in the subjective world for the nervous phenomena leading to the production of the conditioned reflexes. At this stage the motor reactions were considered as the expression of desire, while the salivary reaction might be the effect of consciousness or thought.—*Translator.*

weak stimulus—the object at a distance—becomes strong enough to produce its effect. Does it not happen the same with us when, having no desire for food, an appetite comes as we begin to eat, or also when we have experienced shortly before some unpleasant emotion (anger, etc.)?

Here is another series of constantly recurring facts. The object acts upon the salivary glands at a distance not only as a complex of all its properties, but through each of its individual properties. You can bring near the dog your hand having the odour of the meat powder, and that will be enough to produce a flow of saliva. In the same manner the sight of the food from a further distance, and consequently only its optical effect, can also provoke the reaction of the salivary glands. But the combined action of all these properties always gives at once the larger and more significant effect, *i.e.*, the sum of the stimuli acts more strongly than they do separately.

The object acts from a distance upon the salivary glands not only through its inherent properties but also through accidental qualities accompanying the object. For example, if we colour the acid black, then water to which we add a black colour will affect the salivary glands from a distance. But these accidental properties of the substance become endowed with the quality of stimulating the salivary glands from a distance only if the object with the new property has been introduced into the mouth at least once. The black coloured water acts on the salivary glands only in case the black coloured acid has been previously put into the mouth. To this group of conditioned properties belong stimuli of the olfactory nerves. The experiments of Snarsky in our laboratory showed that there exist simple physiological reflexes from the nasal cavity acting on the salivary glands, and that they are conducted only through the trigeminal nerve; for example, ammonia, oil or mustard, etc., always produce a constant action in the curarised animal. This action fails, however, if the trigeminal nerves are cut. Odours without local irritating effects have no influence on the salivary glands. If you bring before a dog with a salivary fistula oil of anise for the first time, there is no secretion of saliva. If, however, simultaneously with the odour of anise you touch the oral cavity with this oil (producing a strong local reaction), there will afterwards be a secretion of saliva from only the smell of the oil of anise.

If you combine food with an undesired object, or even with the qualities of this object—for instance, if you show the dog meat moistened with acid—notwithstanding the fact that the dog approaches the meat, you note a secretion from the parotid gland (there is no secretion from this gland with pure meat), *i.e.*, a reaction to an undesired object. And further, if the effect of the undesired object at a distance, owing to

its repetition, is diminished, combining it with food which attracts the animal always strengthens the reaction.

As mentioned above, dry food causes a great flow of saliva, while moist food produces a very weak secretion or none at all. If you show the dog two such oppositely acting substances as dry bread and moist meat, the result, as judged by the salivary reaction, will depend solely upon that one which stimulates the dog more strongly. If, as usually happens, the dog is more strongly stimulated by the meat, then you will see only the reaction characteristic of the meat, *i.e.*, there will be no flow of saliva. In this way the bread, although lying before the eyes of the animal, remains without effect. You can impart the odour of meat or sausage to the bread and remove the meat and sausage so that only the odour remains; then the dry bread can act on the eye only, but the reaction is, notwithstanding, that from the sausage or meat. That is, the reaction to one of the properties of the meat, its odour, is the reaction which we saw to all the properties of the meat, *viz.*, to the presence of the actual meat.

The influence of objects at a distance can be inhibited in other ways. If another dog is fed with dry bread in the presence of a greedy, highly excitable dog, then the salivary glands, which at the sight of the bread formerly reacted strongly, fail to secrete. When a dog is brought for the first time on the stand, the sight of the dry bread, which called forth a marked flow of saliva when the dog was on the floor, now has not the slightest influence.

I have stated easily and exactly reproduceable facts. It is evident that many striking instances of animal training belong to the same category as some of our phenomena, and they have borne witness for a long time to a constant lawfulness in some of the psychical manifestations in animals. It is to be regretted that science has so long overlooked these facts.

Up to this point in my exposition I have not mentioned those manifestations which might correspond to what in the subjective realm are called wishes. In reality we have met no such phenomena. Our fundamental fact may be reiterated: to dry bread the dog will hardly turn, but nevertheless, the sight of it produces a strong flow of saliva; whereas meat, toward which the dog, breaking from his frame, rushes with avidity and which he snaps at with his teeth, is without action on the salivary glands from a distance. From this we can say that what in the subjective realm we call a wish was expressed in the animal only by a movement reaction, but that on the salivary secretion the wish did not manifest itself. Therefore, the statement that an ardent desire excites the salivary or gastric glands does not correspond to the facts. This fault of confusing evidently different things can be imputed also

to me in earlier articles. Indeed, we must discriminate sharply between the secretory and motor reactions of the organism in our experiments; and in regard to the work of the glands, if we would correlate our results with the phenomena of the subjective world, we must emphasise that not the wish of the dog, but his attention, is the chief condition for the success of the experiments. The salivary reaction of the animal might be considered in the subjective world as a substratum of pure, elementary representation of thought.

All the above facts lead, on the one hand, to important and interesting conclusions about the processes in the central nervous system, and, on the other hand, to the possibility of a more detailed and successful analysis. Let us now consider some of our facts physiologically, beginning with the cardinal ones. If a given object—food or a chemical—is brought in contact with the special oral surface, and stimulates it by virtue of those of its properties upon which the work of the salivary glands is especially directed, then it happens that at the same time other properties of the object,[7] unessential for the activity of these glands, or the whole medium in which the object appears, stimulate simultaneously other sensory body surfaces. Now these latter stimuli become evidently connected with the nervous centre of the salivary glands, whither (to this centre) is conducted through a fixed centripetal nervous path also the stimulation of the essential properties of the object. It can be assumed that in such a case the salivary centre acts in the central nervous system as a point of attraction for the impulses proceeding from the other sensory body surfaces. Thus from the other excited body regions, paths are opened up to the salivary centre. But this connection of the centre with accidental pathways is very unstable and may of itself disappear. In order to preserve the strength of this connection it is necessary to repeat time and again the stimulation through the essential properties of the object simultaneously with the unessential. There is established in this way a temporary relation between the activity of a certain organ and the phenomena of the external world. This temporary relation and its law (reinforcement by repetition and weakening if not repeated) play an important rôle in the welfare and integrity of the organism; by means of it the fineness of the adaptation between the activity of the organism and the environment becomes more perfect. Both parts of this law are of equal value. If the temporary relations to some object are of great significance for the organism, it is also of the highest importance that these relations should be abandoned as soon as they cease to correspond to reality.

[7] One will notice that at this place is given a scheme of the origin of conditioned reflexes which was confirmed by experiment (chapter iv, footnote 3) and which up to the present remains unchanged.—*Translator.*

Otherwise the relations of the animal, instead of being delicately adapted, would be chaotic.

Let us consider another thing. How can we represent physiologically the fact that the sight of meat destroys the reaction of the parotid to the sight of bread, *i.e.*, that the saliva which flowed earlier at the sight of bread, is abolished by the simultaneous stimulation from meat? One can imagine that the strong movement reaction to meat corresponds to a strong irritation of a certain motor centre, and that in consequence of this, according to the above-mentioned law, the stimulation is diverted from the other parts of the central nervous system, and in particular from the salivary centres, *i.e.*, their excitability is decreased. This explanation is favoured by the other experiment, in which the salivary secretion at the sight of bread is inhibited by the sight of another dog who is eating. Here the motor reaction to the bread is greatly strengthened. Even more convincing would be an experiment in which, if possible, one could find a dog preferring dry food to moist, and showing a stronger motor reaction to it. In such an animal, under the above conditions, if the salivary secretion should fail or be much less for the dry bread than in the usual dogs, then we should be entirely right in explaining our experiment in this way. It is well known that often a very powerful desire may inhibit certain special reflexes.

Among the above-mentioned facts there are some which at present are with difficulty explained from the physiological point of view. For example, why does a conditioned reflex, if repeated, lose its activity? One would naturally think of fatigue, but this cannot be so, as we have to deal here with a weak stimulus. The repetition of a strong stimulus of the unconditioned reflex does not result in such early fatigue. Probably we have to deal here with quite peculiar conditions for the excitation which travels along the temporary centripetal paths.

From all the foregoing it is clear that our new subject can be considered entirely objectively, and that it is essentially a physiological subject. It is hardly possible to doubt that the analysis of this group of stimuli, affecting the nervous system from the outside world, will show us such laws of nervous activity and disclose its mechanism in such aspects as have been left entirely untouched or only suggested in the previous investigation of the nervous phenomena of the internal organism.

In spite of the complexity of the new phenomena, our method has certain advantages. In the contemporary study of the mechanism of the nervous system, first, the experiments are done on an operated and injured animal, and secondly, and this is worse, the stimuli are applied directly to the nerve trunks, *i.e.*, the excitation spreads simultaneously in the same manner over a mass of widely differing nerve fibres. Such

combinations never occur in reality. Thus, by our artificial stimulation, we throw the normal activity of the nervous system into a state of chaos and we are greatly hindered in the discovery of its laws. Under the normal conditions, as maintained in our new experiments, the stimuli are isolated and their intensity regulated.

This advantage relates in general to all psychical experiments, but in our psychical phenomena, observed in the work of the salivary glands, there is another special advantage. For the successful investigation of such a complicated subject it is important that it be in some way simplified. By our methods this simplification can be obtained. The rôle of the salivary glands is so evident that their relation to the organism must also be simple and easily available for investigation. One must not conclude, however, that all the services of the salivary glands are contained in their elementary function. By no means. Saliva is used by the animal, for example, to lick and promote healing of its wounds, as we constantly see. That is why we may obtain varieties of saliva from the stimulation of several afferent, centripetal nerves. But the complexity of the reaction of the salivary glands is much less than that of skeletal muscle; through the latter reactions, the organism is entangled with the outer world in an endless number of ways. Furthermore, the simultaneous comparison of the glandular (in particular the salivary) reaction with the motor will give us the possibility, on the one hand, of differentiating the special points from the general ones, and, on the other hand, of getting rid of the habitual and routine anthropomorphic conceptions and explanations which we have accumulated and which confuse our understanding of the motor reaction of animals.

After having established the possibility of analysis and systematisation of our phenomena, we come to the following phase of the work—the systematic division and destruction of the central nervous system in order to see how the previously established relations will be changed.[8] In this way will occur the anatomical analysis of the mechanism of these relations. This will constitute the future of an already approaching experimental psycho-pathology.

The salivary glands as objects of investigation will be of value even for this purpose. The nervous system having to do with movement is so intricately developed, and predominates to such an extent in the brain, that often only a slight injury of it produces an undesirable and exceedingly complicated result. The nervous mechanism of the salivary glands, owing to their minor physiological importance, constitutes, we may think, only a small portion of the brain substance, and is so slightly distributed that partial and isolated destruction of the brain

[8] See chapter v, footnote 1.—*Translator.*

will not give rise to those difficulties which ensue from the disturbance of the motor apparatus. Certainly psycho-pathological experiments had their beginning at the time when the first physiologists removed that or another part of the central nervous system, and observed the animals that survived the operations. The last twenty or thirty years have given us some capital facts. We already know the definite limitations of the accommodating capacity of animals having the cerebral hemispheres or a part of them removed. But the investigation of this theme is not yet arranged in such a way that its study might proceed without interruption according to a definite plan. The cause of this lies, I think, in the fact that the investigators do not possess at present any considerable detailed knowledge of the normal relations of the animal to its surroundings, by the help of which they might make an exact and objective comparison of the state of the animal before and after operation.

Only by proceeding along the path of objective investigation can we step by step arrive at the complete analysis of that infinite adaptability in every direction which constitutes life on this earth. The movement of plants toward the light and the seeking of truth through a mathematical analysis—are these not phenomena belonging to the same order? Are they not the last links in an almost endless chain of adaptabilities which appear everywhere in living creatures?

We can analyse adaptability in its simplest form by use of objective facts. What reason is there to change this method in studying adaptability in the higher orders!

Work in this direction began in different regions of life, and, not stopping at obstacles, has made a brilliant advance. The objective investigation of living matter, the initial study of tropisms of elementary living things, can and must remain the same when it reaches the highest manifestations of the animal organism, the so-called psychical phenomena of the higher animals.

Guided by the similarity or identity of the external manifestations, science will sooner or later bring the obtained objective results to our subjective world, and will at once illuminate our mysterious nature, will explain the mechanism and the vital meaning of that which eternally occupies the human mind—its conscience, and its tribulations. This is why I have admitted in my exposition some contradictory terms. In the title of my address and during my entire exposition, I have used the term "psychical," but at the same time I have brought forward only objective investigations, entirely neglecting everything subjective. The so-called psychical phenomena, although observed objectively in animals, are distinguished from the purely physiological, though only in degree of complexity. What can be the importance of how they

are designated—"psychical" or "complicated nervous"—in distinction from the simple physiological, once it is recognised that the duty of the naturalist is to approach them only from the objective side, in nowise taking into consideration the question of the essence of the phenomena?

Is it not clear that contemporary vitalism, that is, animism, confuses the different points of view of the naturalist and of the philosopher? All the marvellous successes of the first have been founded on the investigation of objective facts and their comparisons, ignoring on principle the question of essence and final causes. The philosopher, himself personifying the highest human aspiration to synthesise, though up to the present time this synthesis has been fantastic, striving to give an answer to everything that concerns man, must now create the whole from the objective and subjective. For the naturalist everything is in the method, in the chances of attaining a steadfast, lasting truth, and solely from this point of view (obligatory for him) is the soul, as a naturalistic principle, not only unnecessary for him, but even injurious to his work, vainly limiting his courage and the depth of his analysis.

CHAPTER II

THE PSYCHICAL SECRETION OF THE SALIVARY GLANDS (COMPLEX NERVOUS PHENOMENA IN THE WORK OF THE SALIVARY GLANDS) [1]

(From the *Archives Internationales de physiologie*, 1904.)

THE RÔLE OF SALIVA; AMOUNT SECRETED WITH VARIOUS SUBSTANCES WHEN IN THE MOUTH AND AT A DISTANCE—DISAPPEARANCE AND RESTORATION OF THE CONDITIONED REFLEXES—EFFECT OF HUNGER—ESSENTIAL AND UNESSENTIAL PROPERTIES—SUBJECTIVE AND OBJECTIVE METHODS—EXPERIMENT SHOWING DISAPPEARANCE OF CONDITIONED REFLEXES—EXPERIMENT OF RESTORATION—ADVANTAGES OF THE OBJECTIVE METHOD, ILLUSTRATED BY EXAMPLES—RELATION OF CONDITIONED REFLEX TO UNCONDITIONED REFLEX—DEPENDENCE OF CONDITIONED REFLEX ON CEREBRAL HEMISPHERES—PROPERTIES OF THE CONDITIONED REFLEX—EXPLANATION OF RESTORATION—RENUNCIATION OF PSYCHOLOGICAL METHODS NECESSARY.

RECENTLY the physiology of the salivary glands has brought into the limelight special phenomena of their activity, usually called psychical. The latest investigations of the work of the salivary glands by Glinsky, Wolfson, Henri and Malloizel, and Borisov * have demonstrated the beautiful adaptation of these glands to external stimulations, as had already been foreseen by Claude Bernard. Under the influence of hard, dry food introduced into the mouth, the salivary glands secrete a large quantity of saliva, and this makes possible the manifestation of the chemical properties of the food when in solution, and helps in its mechanical preparation, thus favouring its passage along the œsophagus into the stomach. On the other hand, the saliva is produced in much smaller quantity when the food contains much free water, and the more water, the less saliva. With milk, it is true, a great amount of saliva is secreted, but it must be taken into consideration that the addition of mucous saliva to milk prevents the formation of large curds in the stomach owing to strands of mucus; the saliva in this way aids the digestive effect of gastric juice on the milk. With water or with a physiological saline solution (*i.e.*, 0.9 per cent. of table salt), there is no trace of saliva secreted; for with them saliva would be useless. To all strong chemical excitants introduced into the mouth, saliva is secreted in an amount strictly conditioned by the stimulating strength of these

[1] The subject matter of this chapter is the same as the foregoing, but the processes are illustrated by experiments.—*Translator.*

* Glinsky: *Annals of the Society of Russian Physicians*, St. Petersburg, 1895. Wolfson: *Dissertation*, St. Petersburg, 1898. Henri et Malloizel: *Comptes rendus de la Société de biologie*, Paris, 1902. Borisov: *Russian Physician*, 1903, p. 869.

substances. In such a case saliva makes these substances more dilute, and rinses and cleanses the mouth. With food substances the mucous salivary glands secrete a saliva rich in mucus. With inedible, or chemical substances, there flows, on the contrary, a thin, watery saliva, containing little or no mucin. In the first instance the saliva serves as a lubricant for the passage of food into the stomach and to effect certain changes in it; in the second case, only as a cleansing agent. Pure sea- or river-sand introduced into the mouth calls forth a secretion of saliva; for it can be removed only by a flow of fluid. Clean quartz pebbles are simply ejected from the mouth without any salivary secretion; for their removal liquid is unnecessary and useless.

In all the foregoing cases special reflexes are involved which, thanks to the specific irritability of the peripheral endings of the centripetal nerves of the mouth (through various mechanical and chemical stimuli), condition the difference in the activity of the glands in their response to these stimuli.

The same relations are observed between the above mentioned stimuli and the activity of the salivary glands when these stimuli are not in contact with the mouth, but are at some distance from the dog. They need only attract the attention of the animal.

Now arose a question of great importance: how may these latter relations be investigated? Having tried several methods, we decided to persist in studying them objectively. This means that the experimenter, completely ignoring the imaginary and subjective state of the animal, must concentrate all his attention on those exact external conditions which might have an influence on the activity of the salivary glands.

The starting point for this investigation was the idea that the so-called psychical salivary secretion is fundamentally a specific reflex just like the secretion originating from stimuli in the oral cavity, but with this difference only, that the psychical reflex originates from stimuli acting on the other receptor surfaces, and that it is a temporary and conditioned reflex.[2] Thus the purpose of further investigations consisted in the study of the conditions under which these specific reflexes appear. The first experiments of this sort in our laboratory were performed by Dr. Tolochinov.*

His experiments showed convincingly, I think, that our subject can actually be investigated along these lines with great success. The following constant relations were established. The aforementioned reflexes

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[2] Here the conditioned reflex is first spoken of as a temporary connection.—*Translator.*

* *Comptes rendus du Congres des naturalistes et médecins du Nord à Helsingfors,* 1902.

with food substances as well as with those the dog refused, which excited the salivary glands from a distance, entirely disappear if the experiment is repeated several times at short intervals. But their effect can be easily restored under the following conditions. If for example meat powder is held in front of the dog without feeding it, and if this is repeated a number of times at short intervals, then the action of this stimulus from a distance gradually diminishes and finally vanishes entirely. But it is only necessary to give some of this powder to the dog to eat in order to restore its action from a distance. The same result may be obtained if, instead of feeding the dog with the meat powder, some acid is put into his mouth.

When the acid after some repetitions has lost its ability to call forth saliva when presented from a distance, then it is possible to restore the reflex from a distance by another method analogous to the aforementioned one (putting acid into the mouth or feeding with the meat powder); and this is by showing the dog meat which is moistened with acid. It should be mentioned that meat alone, as it is a watery food, produces only a weak salivary secretion, and often none at all from the parotid gland.

In the case of the food substances, their effect from a distance is markedly influenced by the state of hunger of the animal. When the animal is satiated the reaction is much less than it is in hunger, and on repetition of the stimulation by the food substances at a distance the reaction disappears much more quickly. The individual properties of a substance acting separately from a distance have a much weaker effect when one of these properties acts alone than when the substance with all of its properties and attributes acts; for example, a sniff alone of the meat powder produces less salivary secretion than if the meat powder stimulates not only the nose but also the eyes of the animal. One sees the same thing when the experiment on the distant action of the substance is repeated—the effect of the isolated action of the individual properties disappears more quickly than that of the object with all its attributes.

The conditioned reflex (reflex from a distance) can by certain means be quickly destroyed. If immediately after the production of a strong salivary secretion (by using dry bread at a distance), the dog is shown raw meat, then the secretion is instantaneously arrested. If a hungry dog is shown dry bread, and at the same time a neighbouring dog is given the bread to eat, the salivary secretion which had already begun in the first dog may suddenly stop. A dog which has never been used for such an experiment will give a reaction to the bread when the dog is on the floor, but it is only necessary to remove the animal to the stand on the table and the reaction ceases. The same phenomenon

can be reproduced by every substance which acts from a distance.

If acid which is coloured black with India ink is put into the dog's mouth several times, then only showing the dog water similarly coloured produces exactly the same effect. Now this connection between the coloured liquid and the secretion of saliva we can cause to disappear by putting repeatedly into the dog's mouth coloured (black) water, and then, we are able to restore it again by the introduction of coloured acid.

If some odour having no exciting local action on the nasal mucous membrane and issuing from a substance which the dog has never before met, acts on the dog, then this odour is entirely without effect on the salivary glands. But once this substance has been put into the dog's mouth and has produced a flow of saliva, its odour alone will suffice to evoke the secretion.

In the preceding chapter, I endeavoured to draw general conclusions of a scientific nature from all the investigations which had been published concerning the new type of reflexes in the work of the salivary glands, systematising our facts from a purely physiological point of view.

From this point of view, to understand thoroughly the basis of the new aspects of physiological investigation of the activity of the salivary glands, it is necessary to distinguish in the objects of the external world acting on the living organism, two series of properties: the *essential* properties, which determine absolutely a certain reaction in that or another organ; and the *unessential* properties, which act only temporarily and conditionally. Take, for instance, a solution of acid. Its action, as that of a definite chemical agent on the mouth cavity, is expressed among other things always by the flow of saliva, which, in neutralising, diluting and removing the acid, is of prime importance for the welfare of the organism. The other properties of this solution, its appearance, colour and odour, have no intrinsic relation to the saliva, or, vice versa, the saliva to them. But it is impossible not to be struck with a fact of great importance for the living organism,—that the unessential properties of a substance become stimuli of a given organ (in our case of the salivary glands) only when the action of these properties on the sensory receptor surfaces of the organism have coincided with the action of their essential properties. If, on the contrary, the unessential properties act repeatedly alone (without the interference of the essential), and if this continues for a long time or always, then they either lose their importance for the given organ, or never attain such importance. The physiological mechanism of this relation can be explained in the following way: suppose that the action in the oral cavity of those properties of the object essential for salivary secretion,

i.e., the stimulation of the lower lying salivary centre, coincides with the action of the unessential properties of the object on other receptor surfaces, or coincides with the influence of many phenomena of the external world (stimulation of the eye, nose, etc.); in this event the stimulation of the corresponding centre of the higher parts of the brain will have to choose between countless and different paths which are open to them, or, such of them as lead to the active reflex salivary centre. One is compelled to suppose that this latter centre, being in a state of high excitation, in some way attracts to itself the stimulations from other less strongly excited centres. This may be the general mechanism of all our observed phenomena of psychical stimulation of the salivary glands.

The fact that the salivary reaction to the appearance of bread at a distance decreases in intensity at the sight of another dog's being fed could be explained by the transference of the stimulation to another centre, the motor centre, which, as we may conclude in this case from the extreme increase of the energy of the animal's movements, is strongly excited.

The influence of the state of hunger or satiety on the result of the action of food at a distance may be explained by the changes in the irritability of the salivary centre, which in turn depends upon the different chemical composition of the blood in these two states.

Considering these phenomena from this point of view, the physiologist is hardly inclined to designate them as "psychical"; but in order to distinguish them from the nervous phenomena which until the present time have been analysed physiologically, he may classify them as "complex nervous phenomena."

Reviewing the above facts and results, the reader may say that everything which has been described here as "complex nervous phenomena" is comprehensible from the subjective point of view, and that in the physiological description of these facts there is nothing new. In this assertion there is a grain of truth. But by our physiological scheme, we intend to provide a basis for the collection and exposition of additional facts along this new path of investigation.

In the preceding chapter, I expressed the hope that the enumerated facts might be further studied with complete success. This hope, thanks to the further investigations in my laboratory, has been fully realised.

Dr. Babkin has added much to our knowledge of the disappearance [3] and restoration of new reflexes. Here I give a typical experiment:

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[3] Prof. Pavlov purposely uses here an expression only describing the fact, without suggesting its explanation. This phenomenon was later called *extinction* of the conditioned reflex, and in the following chapters the reader will meet with it under this name.—*Translator.*

TABLE I.

Time	*Stimulus*	*Duration of Action*	*Quantity of Saliva (cc.)*
2:04	Sight of Meat Powder	1 Min.	0.4
2:49	" " " "	1 "	0.3
2:52	" " " "	1 "	0.2
2:55	" " " "	1 "	0.1
2:58	" " " "	1 "	0.05
3:01	" " " "	1 "	0.05
3:04	" " " "	1 "	0.0

This vanishing of the reflex as a result of repetition takes place with exact regularity only when the conditions remain absolutely the same, *i.e.*, when the stimulation is produced by the same method, by the same person, and when this person makes the same movements and uses the same object (*i.e.*, the same vessel and the same contents). Consequently, this identity of the conditions relates especially to everything which is connected in one way or another with the act of eating, or with the introduction into the dog's mouth of inedible substances. Fluctuations of other conditions, if they do not call out any additional reactions from the animal, have no significance.

The speed with which the reflex disappears, occurring as a result of repetition, is undoubtedly connected with the length of the interval which separates the consecutive stimulations. The shorter the interval, the more quickly the reflex disappears, and vice versa. Here is an example. The stimulation is again produced by showing the meat powder exactly once every minute. If the stimulation is given every two minutes, the reflex disappears after 15 minutes. If an interval of four minutes between repetitions of the showing of the meat powder is used, the reflex vanishes after 20 minutes; with an 8-minute interval the reflex disappears after 54 minutes; and with a 16-minute interval the reflex does not disappear even after two hours. Again with the stimulation given every two minutes, the reflex vanishes after 18 minutes.

Once the stimulation has disappeared spontaneously, unless special measures are applied it sometimes does not return in less than two hours.

Every change in the details of the conditioned stimulus immediately augments or restores the salivary reaction. If the dog is stimulated by holding meat powder in the hand and raising and lowering the hand constantly during the stimulation, it is only necessary to stop moving the hand in order that the salivary secretion, which, owing to the repetition of the stimulation had already considerably decreased or even entirely ceased, be markedly increased. If a given stimulus ceases to act on repetition, when performed by a certain person, it immediately becomes active again if it is done by some one else.

Reasoning from this fact, it may be foreseen that if a certain con-

ditioned reflex has temporarily ceased to act, owing to repetition, this will not hinder the manifestation of another conditioned reflex. The following example illustrates this:

TABLE II

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
1:10	Sight of a glass of extract of quassia	0.8
1:13	" " " " " " "	0.3
1:16	" " " " " " "	0.15
1:19	" " " " " " "	0.0
1:22	" " " " " " "	0.05
1:25	" " " " " " "	0.0
1:28	Sight of Meat Powder	0.7
1:31	" " " "	0.3
1:34	" " " "	0.1
1:37	" " " "	0.05
1:40	" " " "	0.0

As has been shown in the experiments of Dr. Tolochinov, a conditioned reflex which has disappeared due to repetition, may at any time be restored. If a conditioned reflex, for example, meat powder at a distance, has lost its effect owing to repetition, it is necessary only to use the unconditioned reflex on the same meat powder or on some other food, or indeed on any inedible substance, in order to restore the lost conditioned reflex, *i.e.*, with meat powder at a distance. And even more. Other conditioned reflex stimuli whose effects have been lost by repetition, may restore the action of the lost reflex if the newly applied stimuli have considerable strength.

The restoring effect of these interposed reflexes (unconditioned as well as conditioned reflexes) is the greater and surer, the larger the salivary secretion provoked by them (*i.e.*, by the interposed reflexes) Here is an experiment illustrative of this:

TABLE III

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
11:34	Sight of Meat Powder	0.7
11:37	" " " "	0.4
11:40	" " " "	0.2
11:43	" " " "	0.05
11:46	" " " "	0.0
	TOTAL	1.35

At 11:49 the stimulation of acid at a distance (conditioned reflex) acting for one minute produces 1.2 cc. of saliva. Then the experiment with meat powder is immediately continued:

TABLE IV

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
11:52	Sight of Meat Powder	0.1
11:55	" " " "	0.0
	TOTAL	0.1

At 11:58 the acid is introduced into the mouth of the dog (unconditioned reflex), and produces 3.5 cc. of saliva. The experiment with meat powder is resumed as follows:

TABLE V

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
12:02	Sight of Meat Powder	0.4
12:05	" " " "	0.3
12:08	" " " "	0.1
12:11	" " " "	0.0
	TOTAL	0.8

At 12:14 a stronger solution of acid is put into the dog's mouth. It produces 8.0 cc. of saliva. The experiment with meat powder follows:

TABLE VI

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
12:20	Sight of Meat Powder	0.7
12:23	" " " "	0.4
12:26	" " " "	0.2
12:29	" " " "	0.15
12:32	" " " "	0.05
12:35	" " " "	0.0
12:38	" " " "	0.0
	TOTAL	1.5

The restoring effect of the interposed reflexes was strongest immediately after their application. The greater the interval between the interposed reflex and the first trial of the conditioned reflex, the weaker was the restoring effect.

The restoring effect of one and the same unconditioned reflex becomes smaller and smaller and finally disappears if it is often repeated. In this case the replacing of one unconditioned reflex by another unconditioned reflex will result in the new unconditioned reflex again restoring the conditioned reflex. In the following example this relation is

seen: the dog is given meat powder to eat, and 4.0 cc. of saliva is obtained.

TABLE VII

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
11:48	Sight of meat powder	0.8
11:51	" " " "	0.7
11:54	" " " "	0.5
11:57	" " " "	0.3
12:00	" " " "	0.2
12:03	" " " "	0.1
12:06	" " " "	0.0
12:09	" " " "	0.0
	TOTAL	2.6

At 12:10 the dog is given meat powder, and 3.4 cc. is obtained, after which the experiment with the conditioned reflex is continued:

TABLE VIII

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
12:14	Sight of meat powder	0.6
12:17	" " " "	0.4
12:20	" " " "	0.1
12:23	" " " "	0.0
12:26	" " " "	0.05
12:29	" " " "	0.0
	TOTAL	1.15

At 12:30 the meat powder is again fed to the dog, and 3.6 cc. of saliva is obtained. The experiment continues:

TABLE IX

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
12:34	Sight of meat powder	0.3
12:37	" " " "	0.2
12:40	" " " "	0.0
12:43	" " " "	0.0
	TOTAL	0.5

At 12:44 the dog is given meat powder, and 4.0 cc. of saliva is secreted: the experiment proceeds as follows:

TABLE X

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
12:48	Sight of meat powder	0.0
12:51	" " " "	0.0
	TOTAL	0.0

At 12:52, acid is put into the dog's mouth, and 4.9 cc. of saliva is secreted, and the experiment continues thus:

TABLE XI

Time	*Kind of Stimulus (acting for one minute)*	*Quantity of Saliva (cc.)*
12:56	Sight of meat powder	0.7
12:59	" " " "	0.4
1:2	" " " "	0.2
1:5	" " " "	0.1
1:8	" " " "	0.05
1:11	" " " "	0.0
	TOTAL	1.45

But the procedure of using again and again a new unconditioned reflex as a means of restoring the conditioned reflex lost in consequence of repetition, has its limits; a moment comes when further changes of the unconditioned reflex fail to bring about a restoration of the vanished conditioned reflex.

The material given so far comprises only a part of that which has been investigated by Dr. Babkin; we are indebted to him also for experiments demonstrating the rapid disappearance of conditioned reflexes. Previously the experiments of Tolochinov had brought out the fact that during some considerable motor stimulation of the dog, the conditioned reflex becomes weaker or disappears entirely. A general motor stimulation of the dog was produced in the experiments of Babkin either through strong irritation of the eye or of the ear (loud knocking on the door of the dog's experiment room, or an instantaneous flash of bright light into the previously darkened room), or by some entirely new and unusual irritation (playing of a gramophone). For example, one uses the conditioned reflex on meat powder. It displays its full strength. Now one tries on the dog the effect of the above described stimulations. Immediately after these stimulations, the conditioned reflex is without any effect. In the earlier tests as well as in the present, the conditioned reflex is purposely always accompanied by the unconditioned, *i.e.*, after the exhibition of the meat powder, it is given to the dog to eat, in order

not to weaken the conditioned reflex. In the second trial after these strong stimulations, there is during the conditioned irritation a certain salivary secretion which is still small, and only with further trials does it begin to grow and gradually reach its normal size.

In this category must be mentioned the following curious fact. In especially greedy dogs having a strong motor reaction at the sight of meat powder, there is often no flow of saliva from the parotid, whereas in less greedy and quieter ones, saliva flows. In the former animals, the secretion of saliva may start from the beginning of the stimulation with the meat powder, at its presentation, but afterwards, with the setting in and increase of the motor reaction, the salivary activity may cease.

The facts of this material are not detached and disconnected, but they form an introduction to the systematic study, the investigation and explanation of the new and complex phenomena which interest us. This new subject is very complicated, and its problems pile high one upon another; but such a complexity does not hinder an exact and ever deeper research. The experiments can be easily systematised. The laboratory results obtained by one worker have been readily confirmed by others on different dogs. It was evident that the way chosen for the study of the complex nervous phenomena was a fortunate one. At every turn one is convinced of the advantages of the objective way. The rapidity with which exact facts have been collected, and the ease of understanding them, presents a striking contrast to the uncertain and contestable facts of the subjective method. In order to make this difference clearer, let us take some examples.

In repeated stimulations by meat powder acting from a distance and not followed by feeding, there is soon a disappearance of the reflex. Why? Thinking subjectively, one would answer thus: the dog becomes convinced of the uselessness of its efforts to obtain the meat powder, and therefore ceases to give it attention. But let us consider the following experiment of Dr. Babkin. When meat powder acting from a distance has lost its effect in consequence of repetitions, the dog is given water to drink. It drinks, but as mentioned above, saliva does not flow. From the subjective point of view, what could one expect regarding the vanished conditioned reflex on meat powder? It might seem that the dog, having received water from the experimenter, would have reason to think that the powder would follow, and that the dog would concentrate his attention on this hope. In reality, however, the reaction on the meat powder remains nil. But now bring the acid before the dog. The acid calls out a salivary secretion, and afterwards meat powder from a distance will again be effective. How can these facts be explained?

From the subjective standpoint it would indeed be difficult.

Showing the dog acid alone, could hardly awaken his hope of getting the meat. The objective observer is content to state the real and concrete relations existing between the phenomena he observes. Consequently, he notices without especial difficulty that everything which produces in more or less degree a salivary secretion, forms the essential condition for the restoration of the vanished reflex.

Yet another example. The conditioned reflex disappears owing to repetition, and is restored of itself only after a considerable lapse of time. Why? From the subjective point of view one can say that the dog has forgotten the deception, owing to the large number of stimulations impinging upon it during this time. One can, however, during this interim, subject the dog to many different influences and stimuli, and the time necessary for restoring the lost conditioned reflex will not be shortened. You need only to bring before the dog some stimulus which calls forth saliva, and the animal immediately forgets the deception.

In this way, the objective investigation of those biological phenomena of the animal commonly called psychical, becomes a direct continuation and widening of physiological experimentation on the living organism, and the facts thus gathered and systematised must be treated from the physiological standpoint exclusively, if they are to form the basis for our conception of the properties and relations between the different parts of the nervous system. And by varying and repeating our experiments in which one or another part of the nervous system is excluded—now the central, now the peripheral—this conception will correspond closer and closer to reality.

Concerning this last experimental method, I shall give an example. On the basis of the facts given above, it is necessary to admit that every conditioned reflex arises because of the presence of an unconditioned one. A conditioned reflex forms even though the conditioned stimulus and the unconditioned stimulus have coincided in their time of action only once, and it disappears if this coincidence does not occur for a long time. The justification of such a relation for old and firmly established conditioned reflexes is of great interest, and has been made a subject of investigation in my laboratory by Dr. Zelheim.* These experiments were performed by Dr. Snarsky * before but they were not then sufficiently analysed. In Zelheim's experiments a series of conditioned and unconditioned reflexes to both food and non-food substances were formed, first in a normal dog. The lingual and glossopharyngeal nerves were then cut on both sides. When the animal had entirely recovered from the operation, all the elaborated reflexes were repeated. On the first trials there seemed to be no difference from the normal state; the salivary reaction had

* A. P. Zelheim: *Dissertation*, 1904, St. Petersburg; Snarsky: *Dissertation*, 1902, St. Petersburg.

almost the same strength as formerly, on both the presentation of objects from a distance, and their introduction into the dog's mouth. With the repetition of these experiments, however, we noticed that the reflexes to certain substances, such as an extract of quassia and saccharine, as well as a dilute solution of hydrochloric acid and sodium chloride, became gradually weaker. As the unconditioned reflex is characterised by its constancy on repetition, we are forced to the conclusion that for certain stimuli, the unconditioned reflex disappeared, and that the effect which remained after the operation was dependent upon the conditioned reflex, the more so because now the secretory effect of both stimuli was almost equal, no matter whether they were applied from a distance or brought into the mouth of the dog. On the repetition of these experiments after two weeks, the reflex to bitter substances entirely disappeared in both forms (its action from a distance and in the mouth), but the reflex to saccharine, acid and salt remained, though they were much weaker. If is plain that these last substances excited not only the special chemical fibres which were cut through, but other centripetal nerves responsible for the conduction of the remaining unconditioned reflexes.

Of great interest is the following question: what is the essential unconditioned stimulus of the food substances? The facts hitherto collected are not sufficient for the solution of this problem. In acute experiments by Dr. Heimann in my laboratory, it was shown that in animals which had been poisoned and immediately operated on, the chemical properties of the food substances, when they are brought into the mouth cavity, are entirely without effect on the salivary secretion. In these experiments, much more than in any other acute experiments, numerous defects were found in the acute experiment as an experimental method, and therefore the work of Dr. Heimann must be repeated and controlled. Dr. Zelheim, in his above-mentioned experiments with permanent salivary fistulæ, could not note any difference in the salivary secretion during the feeding of the animal before and after operation.

Now that I have explained this new material relating to the physiology of the salivary glands, it may not be superfluous if I revert to a most important point in the physiological significance of these phenomena. Surely these phenomena are much more complicated than we have described them here. But thanks to our new scheme, we are enabled to go forward in the exploration of our subject. This then is the meaning and justification of our plan.

The designation of "reflex" which we have given to these "complex nervous phenomena" is entirely logical. The phenomena are always the result of the stimulation of the peripheral endings of various centripetal nerves, and this stimulation spreads through the centrifugal nerves to the salivary glands.

These reflexes are, as are all natural reflexes, strictly specific (and therefore unlike the artificial reactions which are often produced in the laboratory by artificial stimulation), and they are the expression of a definite reaction of the organism, or of one or another of its organs, to a certain stimulus.

These new reflexes are the function of the highest structure of the nervous system of the animal, and they must be explained on the following basis. First, they represent the most complicated phenomena among nervous functions, and consequently they must be connected with the highest parts of the nervous system. Reasoning further from animal experiments with various poisonings or with total or partial extirpation of the cerebral hemispheres, we can conclude that the conditioned reflex demands for its formation the assistance of the hemispheres.

The reflexes are temporary and conditional, and these qualities characterise and separate them from the old simple reflexes with which physiology has concerned itself in the past. Their temporary character manifests itself in two ways: they can be formed when they did not previously exist, and they may disappear again forever; besides this, when they exist, they often fluctuate in degree even to vanishing, either for a short time, or under certain circumstances, permanently. As we have seen, their formation and extinction are determined by (one or several) coincidences in time of stimulation of the lower lying reflex centres, which govern some functioning organ, with the stimulation of different points of the cerebral hemispheres through the corresponding centripetal nerves. If the stimulation of these two centres coincides many times, then the paths leading from the higher to the lower centres become more and more passable, and the conduction of the excitations along them becomes easier and easier. When these coincidences occur more rarely, or cease altogether, the paths again become less permeable, and finally impassable.

What physiological explanation can be given for the rapid, and unfailing, though temporary, disappearance of a conditioned reflex, when it is repeated alone for several times at short intervals without the support of the unconditioned stimulus with which it was formed? Certain facts indicate, I think, that this event belongs to the category of exhaustion phenomena. First, the vanished conditioned reflex, if left alone without any stimulation from the experimenter, reappears after a certain time. Secondly, the disappearance of the conditioned reflex due to repetition occurs the more quickly, the smaller the interval between repetitions, and vice versa. Such an explanation would agree with the generally accepted opinion concerning the rapid exhaustion of the higher nervous centres brought about by repetition of monotonous stimulations.

The possibility of restoring a conditioned reflex, which has disappeared owing to repetition, and which is determined by the application of the

corresponding unconditioned or other conditioned reflex of sufficient strength can be thus explained: that, in spite of a certain degree of exhaustion in the higher nervous centre, its stimulation again penetrates to the lower lying salivary centre, and from that very moment the paths leading to this centre become especially permeable owing to the recent and especially strong stimulation. In favour of this explanation we may cite the above-mentioned experiments on the restoration of the vanished conditioned reflex by means of repeated feedings, though these feedings finally, however, lose their effect.

At the end of that experiment we had a fact which revealed the mechanism of this process as a very complicated one. When the repetition of feeding had lost its efficacy as a means of restoring the reflex, the introduction of acid into the mouth of the dog to assist this restoration was accompanied by a positive effect. Therefore we must bring new elements into our scheme of explanation. If, however, these experiments are continued, there finally comes a moment, whether or not the unconditioned reflexes are varied, when neither of these stimuli is effective, and when the conditioned reflex is restored *per se* only at the cost of a great interval of time.

It is evident that for a full decision of the suggested problems, further investigations are required.

In conclusion, we must count it an incontestable fact that the physiology of the highest parts of the central nervous system of higher animals can not be successfully studied, unless one utterly renounces the indefinite presentations of psychology, and stands upon a purely objective ground. What interest, for example, can there be for physiological analysis in the statements of some authors, that after extirpation of certain parts of the cerebral hemispheres, the animals become now fiercer, now gentler, less intelligent, etc., when these terms themselves represent very complicated conceptions requiring an exact scientific analysis?