The integrity both of the individual and of its species is ensured first of all by the simplest unconditional reflexes, as well as by the most complex ones which are usually known as instincts. But the equilibrium attained by these reflexes is complete only when there is an absolute constancy of the external environment. Since the latter, being highly varied, is always fluctuating, the unconditional, or constant, connections are not sufficient; they must be supplemented by conditional reflexes, or temporary connections... The temporary nervous connection is the most universal physiological phenomenon both in the animal world and in ourselves.

Ivan Pavlov, (1934): Big Medical Encyclopedia

Ivan Pavlov (1849–1936) has become almost as famous as Darwin. It is very widely known that he performed experiments showing that dogs salivated to a bell which was regularly sounded just before they were given food; and that he called this reaction a 'conditioned reflex'. Nevertheless, most people would find it much harder to say anything about the significance of Pavlov's research or the general nature of its findings than about Darwin's achievements. In fact, many have felt that Pavlov's reputation has been completely undeserved; one person, for example, who was particularly derisive about Pavlov was George Bernard Shaw.

In 1932 Shaw wrote a story called The Black Girl in Search of God. As the black girl travels through the African forest she meets a number of odd characters. One of them is a very shortsighted old man in spectacles, sitting on what appears to be a log. He explains that in responding, as she had just done, with terror to the sound of a lion's roar she was acting on a conditioned reflex. 'This remarkable discovery cost me twenty-five years of devoted research, during which I cut out the brains of innumerable dogs, and observed their spittle by making holes in their cheeks for them to salivate through instead of through their tongues. The whole scientific world is prostrate at my feet in admiration of this colossal achievement and gratitude for the light it has shed on the great problems of human conduct.'

'Why didn't you ask me?' said the black girl, 'I could have told you in twenty-five seconds without hurting those poor dogs.'

'Your ignorance and presumption are un-speakable', said the old myop. 'The fact was known of course to every child; but it had never been proved experimentally in the laboratory; and therefore it was not scientifically known at all. It reached me as an unskilled conjecture; I handed it on as science.'

Unlike the old man in the forest Pavlov never claimed as his discovery the fact that a hungry dog produces spittle in anticipation of food; as noted earlier this had been general knowledge since at least the time of Robert Whytt. Moreover Pavlov did not see his experimental work as a process for transforming what is already known to babes into a firm body of scientific facts. His contribution began with the realization that a commonplace observation, and one that had already been familiar within his own laboratory for some years, namely that a dog will salivate when given a signal that food is imminent, could provide the basis for studying two fundamental problems. As he hesitantly suggested in his first paper on conditioning, it seemed possible to devise from this observation a tool for examining the 'seeming chaos of relations' with which the behaviour of an animal comes to adapt to its world and for identifying general laws that govern changes in behaviour. Such research would also grapple with the second problem, that of understanding the basis of such laws in terms of the functioning of the brain. Now, half a century since Pavlov died, the brain mechanisms responsible for learning remain as mysterious as ever; although he always insisted on calling himself a physiologist, Pavlov's major achievement was in the realm of psychology, that of discovering many of the basic principles of learning.

Pavlov had an enormous effect on both Russian physiology and Western psychology because he completely changed general beliefs about the scope of physiological ideas and methods and about the appropriate way to study psychological issues. Although a change of this kind had been advocated by others, many of whom have been discussed in
previous chapters, Pavlov was the first major scientist both to argue for the extension of experimental physiology into psychology and actually to demonstrate on a grand scale how it could be done.

Pavlov's career is remarkable for the late age at which he began to study conditioning; his professional interest in psychological issues did not begin until he was already fifty years old. Up to this point Pavlov had spent twenty-five years on physiological work that concentrated on traditional problems. It was also highly productive and widely esteemed. This makes it all the more unusual that the whole direction of his research should have shifted dramatically, so that the problems investigated in his laboratory began to lie well outside what for many decades had been regarded as the bounds of physiology. The fact that his interest in psychology did not develop early in his career was a crucial ingredient of his success, since the work on conditioning would have made little progress without the assets he already possessed: prestige, ample funding, technical facilities, a stream of eager co-workers and superb judgement in planning and supervising experiments.

It has become commonplace in recent years to distinguish between two kinds of scientific activity: normal science and revolutionary science. According to a standard version of this distinction, normal science consists of work which proceeds within a stable conceptual framework widely held by people active in the particular field of study. This kind of activity is occasionally interrupted by an abrupt change in fundamentals, which occurs as the result of the efforts of young rebels within the field and is usually bitterly resisted by their older and better established colleagues. This kind of change has been called a 'paradigm shift' by Kuhn.4

One assumption inherent in this point of view is that scientists are very conservative with respect to their basic beliefs. In general this appears to be true. Despite a commitment to scepticism, to maintaining an open mind and to grounding beliefs on empirical evidence, early in their careers most scientists adopt ways of thinking about their subject, beliefs about appropriate methodology and judgements about the relative importance of various problems, all of which remain immune to even major discoveries and theoretical developments within their field. Significant changes in someone's scientific approach usually occur only when there has been a very major shift in their interests; and where this does happen it seems to require a complete change of discipline.

Pavlov's career provides a striking exception to this general rule. Moreover, as well as giving animal psychology the concept of the conditioned reflex and a host of important facts about conditioning, Pavlov also provided a powerful model of what it is to be a successful scientist. Few of his successors have come close to imitating his career, but since Pavlov there have been many students of conditioning who have to some extent adopted a similar style of science, one that involves complete dedication, unrelenting regularity, wariness with respect to theory and confidence in the productiveness of experimental work so long as it is skilfully and thoroughly carried out. These characteristics developed during Pavlov's early work in conventional physiology. Before describing this, some discussion is appropriate of his place in the intellectual currents of late nineteenth-century Russia.

Pavlov is easily seen as a direct successor to Sechenov and as a central figure within the radical tradition which produced a materialist science and the 1917 revolution. Indeed in his old age this is how Pavlov was regarded in Soviet Russia; in 1921 Lenin arranged special privileges for him and later Pavlov was proclaimed a Hero of the Revolution. In a very real sense Pavlov's work on conditioning represents the extension of physiology into psychological issues in just the way Sechenov said it should happen, even if Sechenov himself was not specific about what particular issues physiologists should study or what particular methods they might employ. Thus, it seems quite appropriate to view Pavlov as a follower of Sechenov, even if he was a little slow in developing his interest in psychology. But if the interests and outlook of scientists like Sechenov within the radical tradition are examined more closely, Pavlov's position becomes less obvious.

Sechenov had been a leading figure among the young scientists and writers who had been inspired by the reforms and the new intellectual currents of the 1860s. As the century went by, various forms of government oppression steadily increased opposition to the Czarist system among the intelligentsia. Hostility towards political and bureaucratic organizations went with a rejection of other aspects of Russian culture and with a readiness to embrace Western ideas. Sechenov's belief in the liberating influence of modern science was widespread among his contemporaries and an enthusiasm for experimental physiology was surpassed only by the degree of interest young Russians showed in theories of evolution.

As in Western Europe and America the works of Charles Darwin and Herbert Spencer were immensely popular. Three independent translations into Russian of Darwin's *Descent of Man* appeared within a year of its publication in England and the other major books
by Darwin, and by Spencer too, were translated almost as promptly. To disaffected young Russians Darwinism was a new revelation, establishing materialist faith ever more securely. Its reception made Dostoyevsky angrily remark that what others regard as plausible speculation becomes indisputable dogma in Russia. Sechenov was certainly an ardent Darwinian; he was responsible for one of the three translations of the Descent of Man.

There was not the same conflict between Darwinism and traditional religion in Russia as there was elsewhere. The Russian Orthodox Church with its greater emphasis on ritual and mysticism and smaller concern with theology than other varieties of Christianity saw little threat from either evolutionary theory or the general spread of a scientific outlook. So, although the radical intellectuals tended to be both devotees of Darwin and critics of the Orthodox Church, the latter attitude mainly reflected a general desire to reform Russian society.

Pavlov does not fit easily into this pattern. His social background was much closer to the peasantry than that of most of the academics, writers and scientists of his time. In his childhood he was steeped in Orthodox traditions and, although he lost his faith in God, he always retained a sympathetic attitude towards the church. He could praise at times the energy or the efficiency of the Anglo-Saxons, but he was never pro-Western in his general sentiments. On the contrary he displayed an intense form of nationalism which seems to have been the main factor governing his political beliefs; so that, for example, one of his more severe criticisms of the Czarist regime was for the humiliation it had led Russia to suffer in the Russo-Japanese War of 1904-5.

Pavlov did share with his contemporaries an interest in evolution. As a boy he was excited by popular accounts of Darwin’s theories and later he became a great admirer of Spencer. But there is little in his work that shows even an indirect effect of evolutionary ideas. What made a more specific and lasting impression on Pavlov was the translation of an English book written at the same time as The Origin of Species, but which hardly even mentions evolution. The book was George H. Lewes’ Physiology of Common Life. Pavlov read it first in his teens and as an old man could still quote long sections from it.

In this book Lewes gave the general English reader of the 1860s with an interest in physiology what thirty years later William James was to provide for the American reader interested in psychology: an intelligent, detailed and very readable review of recent experimental work, mainly that from the research laboratories of the German universities; to this was added generous helpings of the author’s own theories and philosophy, plus engaging comments on everyday life.

An unusual aspect of Lewes’s book is the emphasis placed on food and digestion. The book appeared in two volumes; while the second of these largely contains a lively and accurate account of the nervous system, the first volume is almost completely devoted to various aspects of feeding. The subject was of great significance for Lewes. ‘Hunger is indeed the very fire of life, underlying all impulses to labour’, he wrote. ‘Look where we may, we see it as a motive power that sets the vast machinery in action... Hunger is the invisible overseer of the men who are erecting palaces, prison houses, barracks and villas. Hunger sits at the loom... Hunger labours at the furnace and the plough coercing the native indolence of men into strenuous and incessant activity. Let food be abundant and easy to access, and civilization becomes impossible; so indissolubly dependent are our higher efforts on our lower impulses.’

The scientific tradition to which Pavlov kept throughout his career was that of German experimental physiology, whose early achievements were so ably summarized by Lewes. Furthermore the focus of much of Pavlov’s research reflects Lewes’ interest in food. Except for one early period, all of the many hundreds of experiments carried out by Pavlov and his co-workers measured what was happening at one point or another along the digestive tract.

If in 1900 a gipsy with a crystal ball had told Pavlov that before his death he would become world famous as a scientific revolutionary and be acclaimed a hero of a new communist society, his scorn would have been exceeded only by that of his colleagues at the University of St Petersburg. At that point the kind of experimental physiology he pursued so energetically had been entirely within the mainstream of his time; and outside the laboratory his behaviour and attitudes could be characterized as a cautious, uninvolved conservatism, which was remarkable only because of the time and place in which he lived. The beginnings of research on conditioning are interesting in terms of the preconceptions most people hold about the age and character of those responsible for a new scientific paradigm, quite apart from their importance in the development of animal psychology.

Pavlov’s early career

As a child Pavlov lived in Ryazan, a small town some two hundred and fifty miles to the south-east of Moscow, where his father was a parish priest. A
Russian priest enjoyed a humbler social position than his Western equivalents and was expected to be more or less self-supporting by tilling his land like a peasant. Only the exceptional priest had time and inclination for intellectual work as well. Pavlov’s father was one such exception and he succeeded in inspiring at least three of his sons with a love of learning and determination to obtain a university education. From his father Pavlov also acquired a lifelong love of gardening and of hard physical exercise.

At the age of nine Pavlov suffered severely from a fall off a wall and as a consequence there was a delay of two years before he entered the local school. During this period he spent a large amount of time with his godfather who was abbot of a monastery near Ryazan. The abbot was as influential a figure in Pavlov’s childhood as his father. He led a simple, spartan existence and devoted himself unceasingly to his monastic duties and studies. As an adult Pavlov believed in science instead of God, but otherwise the way of life he later adopted was very much like that of the abbot: simple, regular to an unusually precise degree and displaying an other-worldly lack of concern for anything but his work.

Pavlov’s formal education began at the local Ecclesiastical High School in 1860 and a few years later continued at the Ryazan Theological Seminary. By then the exciting new ideas and discussions frothing in Moscow and St Petersburg of the early 1860s had even reached theological seminaries in towns such as Ryazan. In 1866 a new climate of reaction was triggered by an attempt to assassinate Alexander II and this reaction quickly began to affect education. Count Tolstoy, the Minister of Education, introduced into the state high schools a much more rigid curriculum that excluded the teaching of science. However, as a result of attending a religious institution, Pavlov was able to gain a progressive and stimulating education, in which there was plenty of opportunity for him to follow his own intellectual inclinations and to learn a good deal of science, when this had become impossible in the harshly disciplined setting of the secular high schools.1

Pavlov left Ryazan for good at the age of twenty-one to study natural sciences at the University of St Petersburg, where he was to spend almost all of his life. He walked the whole way, a distance of many hundreds of miles. His arrival in 1870 coincided with Sechenov’s departure and so Pavlov’s first formal introduction to physiology came from the lectures of Sechenov’s successor to the chair of physiology, Ilya Cyon.

Cyon was a fine surgeon, a researcher with an international reputation and an inspiring lecturer. Unfortunately a large number of his colleagues resented the way in which he had been appointed and his unpleasant personality subsequently offended many more. A merciless attitude towards students who did poorly in his examinations helped to spread his unpopularity. Four years after Pavlov’s arrival Cyon failed so large a proportion of the students taking the course in physiology that there was a riot and this set in train a series of events leading to his resignation and departure from Russia.2

Unlike many of his fellow students Pavlov came to respect Cyon highly and by his third year his childhood interest in physiology had turned into a decision to devote his life to research in the subject. Under Cyon’s supervision he began an experimental study of the pancreas which delayed his graduation by a year, but enabled him to start to acquire the delicate and rapid surgical techniques that became a key ingredient of his later success. The project also gained him a gold medal and a four year scholarship for post-graduate study.

Cyon must have been equally impressed by Pavlov. He offered the young man a research assistantship when he graduated. This would have provided an excellent supplement to Pavlov’s modest scholarship, and made for a convenient arrangement by which Pavlov could both continue to gain training in research and to keep to his decision to study for a second degree in medicine. However, with Cyon’s departure from St Petersburg, Pavlov had to look for another post.

He eventually found an assistantship in the Veterinary Institute. Here his research switched to the study of blood circulation and of the innervation of the heart; these remained his main interests for the next twelve years. Meanwhile his medical studies gained him his second degree in 1879. By this time Pavlov had come into contact with the final major figure of his student years, Sergei Botkin.3

It was Botkin who had attended du Bois-Reymond’s lectures of 1856 in Berlin with Sechenov. Over the next twenty years Botkin had become one of the most influential men in Russian medicine, having been largely responsible for making experimental physiology as central a part of the training of physicians in Russia as it had been for some time in Germany. This was particularly the case for students in St Petersburg where Botkin had become the professor of clinical medicine at the Military-Medical Academy. In keeping with the doctrine of ‘experimentalism’ that he preached, Botkin maintained an animal laboratory which, however, consisted of
Fig. 5.1. Botkin's laboratory. Pavlov is second from the right with his hand resting on the dog. The dog's harness shown here is essentially identical to that used in Pavlov's conditioning experiments, even though this photograph was taken almost twenty years before Pavlov became interested in the conditioned reflex.

little more than a wooden shed in the garden of his clinic. His administrative, teaching and clinical commitments left Botkin no time to become closely involved in research. In 1878 he needed a new director for his small laboratory. Pavlov was highly recommended and, although relatively young and unqualified, was appointed.

The new post provided an unusual degree of independence for someone still enrolled as a student. It also offered plenty of opportunity for learning how to direct other people's research, since Pavlov had to spend a great deal of time and effort, which brought him no immediate gain, in advising the many fellow students who were carrying out research projects under Botkin's nominal supervision. One of the earliest changes imposed upon the universities by Count Tolstoy was an increase in the importance of direct experience of research. Professors of natural science were strongly encouraged to involve their students in experimental projects since, as a highly time-consuming kind of work, such participation would make a student less likely to engage in 'illegal extracurricular activities', a label given to any group activity not explicitly organized by the authorities. From 1879 onwards research projects became a much more important element of a first degree in science in Russia than elsewhere.4

One consequence of this policy was that a scientist without the financial means to hire assistants could nonetheless remain highly productive as long as he could first attract and then rapidly train sufficient unpaid labour from students anxious to complete a satisfactory project. Students would compete to work in the laboratory of anyone with a reputation for providing an interesting topic for a project, for giving adequate guidance in how to carry out and report an experiment and, most importantly, for essentially guaranteeing that this particular requirement for the degree would be completed in time. Pavlov later acquired just such a reputation among the medical students of St Petersburg and the bulk of his research came to be based on student projects. This reputation was well deserved; his effectiveness in supervising such work clearly owed a lot to his early experience of helping fellow students who had signed up to work for Botkin.
The experimentalist approach to medicine that Botkin advocated had by the 1870s already become so pervasive in the medical faculties of St Petersburg that Pavlov might well have absorbed such an outlook even if he had never come into personal contact with Botkin. Until quite late in his career Pavlov took it for granted that the experimental study of some problem in physiology, no matter how abstract, was the most beneficial way of contributing to medical practice.

The new scientific medicine of the nineteenth century was anxious to rid itself of any vestiges of traditional beliefs in the importance of ‘bodily humours’. Old ideas that various ailments reflected disruption and imbalance among the body’s fluids were rejected in favour of new kinds of explanation, notably ones involving invasion of the body by micro-organisms; in this respect the discoveries made by Louis Pasteur were particularly influential. Alternatively, as within the Berlin school of physiologists, the nervous system tended to be seen as an all-pervasive influence in the way that the humoral system had previously been viewed. This doctrine of ‘nervism’ is still embedded in our language; someone’s abnormal state may well be explained in everyday English as due to the state of his or her nerves as an alternative to blaming some hormone, or a virus or germ.5

Botkin strongly believed that understanding the nervous system was of paramount importance to medicine. In this case direct acquaintance with Botkin probably was an important factor in Pavlov’s similar commitment to nervism.

In 1881, three years after his appointment to Botkin’s laboratory, Pavlov married. When he had first arrived in St Petersburg the burden imposed by his complete indifference towards worldly matters—he never so much as bought himself a pair of shoes—had fallen upon his brother, who had taken full responsibility for finding the two of them somewhere to live and enough to eat. Through his brother Pavlov first met his future wife, Sara.6

At the time of their meeting Sara was a lively and independent young woman in her early twenties, training as a teacher and with a passion for modern literature. Pavlov was immediately enchanted by her, but it was two years or so before Sara took much notice of this shy man, six years her senior, who talked so earnestly of his current enthusiasm for the works of Herbert Spencer and was so surprisingly lacking in radical views for a student of his generation. He courted her with persistence and with the kind of idealism that remains insensible of the material benefits it is likely to confer.

The full extent of Pavlov’s lack of concern for the ordinary things of life only became apparent on their wedding day when it turned out that he had no money whatsoever to contribute towards the wedding or to pay the return railway fare to St Petersburg. Sara had soon to take charge of all financial decisions, which were made the more difficult by Pavlov’s refusal to let her find a job. They lived in unrelenting poverty. When a group of colleagues managed to raise money to pay Pavlov for giving some lectures so that the young couple’s situation would be eased for a while, Pavlov simply used the money to buy extra experimental animals.

Poverty was not the only cause of the grim state of their early married life. During Sara’s first pregnancy Pavlov insisted that their regular long walks continue and that she keep pace with his rapid stride; as a result she had a miscarriage. Their lack of a home of their own and his single-minded devotion to his experiments meant that they were often apart; she would stay with a friend while he spent day and night in the laboratory. During her second pregnancy Pavlov was more attentive; a son was born but, partly due to their
lack of money, the child fell sick and died within a year.

What sustained Sara was belief in her husband's genius and in the supreme value of his work. In the early years of marriage they agreed upon a pact which both were to keep for the rest of their long life together. If she was to devote herself entirely to his welfare so that there would be nothing to distract him from his scientific work, then he was to regulate his life accordingly; she made him promise to abstain from all forms of alcohol, to avoid card games and to restrict social events to visits from friends on Saturday evenings and entertainment, in the form of concerts or the theatre, to Sunday evenings. His life was to be as ascetic as that of his uncle.

During the 1880s Sara's belief in her husband's future success began to be confirmed, as he continued as a full-time researcher, working partly as director of Botkin's laboratory and partly on his own projects. The results from his medical degree examinations earned him a second gold medal and a further small fellowship. In 1883 he submitted a dissertation on the innervation of the heart and gained his Doctorate of Medicine. This was shortly followed by his appointment as a lecturer in physiology at the Military-Medical Academy. A further fellowship enabled him to study abroad.

Within a year of Sara's miscarriage Pavlov departed alone to work in Germany for two years. Some of this time he spent, like a large number of the physiologists of his generation, at Carl Ludwig's laboratory in Leipzig. The remainder was spent with Rudolf Heidenhain, the professor of physiology at Breslau, whom Pavlov had visited for a couple of months some years earlier. Heidenhain shared Pavlov's interests in both the heart and the digestive system, was an expert on glandular secretion and was famous for his surgical skills.

In subsequent years Pavlov said little about his experience abroad. He appears to have regarded these two years simply as an opportunity to learn more physiology and improve his experimental techniques. It certainly did not leave him with any special love of Germany or of foreign travel. His nationalism was unusual for a scientist of that era. He never became fluent in any language but Russian. It is said that in old age, whenever he returned from a scientific trip abroad, he would bow down to kiss his native soil; and that when he needed to undergo a serious operation he insisted that it be carried out by a Russian surgeon and not by a foreign specialist.

By the end of the 1880s Pavlov had become widely known as one of Russia's most distinguished young physiologists. But at forty years of age he still had no stable position with a respectable salary. His various fellowships and appointments brought him prestige, but little money. A reputation for being outspoken about the lack of scientific merit and reliability of even those in important places and an unwillingness to compromise did not help his applications for the few permanent academic posts that became available.

Pavlov's situation was symptomatic of a crisis in higher education in Russia of the 1880s. Some of the problems were as elsewhere; the end of the expansionary period of the sixties and early seventies left a large number of able young Russian scientists eyeing academic positions likely to be occupied for a very long time by men only a few years older than themselves and in many cases far less distinguished.

This also happened in Germany, but the position of science in Russian universities was made much worse by special political factors. The authorities continued to regard science with ambivalence. It was appreciated that research based in the universities played a vital role in the necessary modernization of the economy; and the material benefits preferred by applied science were much enjoyed. But the critical attitudes that arose with the spread of a scientific outlook were highly suspect; they were seen as important in the growing resistance to the autocratic system. In justifying the elimination of science from the high school curriculum Count Tolstoy had written: 'In the study of ancient languages -- and sometimes in the study of mathematics -- all knowledge imparted to the students is under constant and nearly errorless control, which discourages the formation of independent opinions. In all other subjects, particularly in the natural sciences, the student's interpretation of the knowledge he acquires is beyond the teacher's control. For this reason these subjects may engender personal opinions and differing views.'

In 1884 direct government control of the universities was re-imposed and any remaining elements of academic freedom were abolished. The Czar's bureaucracy took all decisions on appointments, curricula and examinations. In doing so the role of the university as a centre of research was usually ignored. Subsequent decrees restricted access to education to various social classes; thus, in what became notorious as the 'Cooks letter', Tolstoy's successor at the Ministry of Education ruled that 'the sons of coaches, servants, cooks, laundresses and small shopkeepers' should not be allowed to enrol in state schools.

These developments produced a general decline in the number of students attending university which
was particularly severe in the medical faculties. In 1880 medical students formed just under a half of the student body at the University of St Petersburg, by 1899 this proportion had decreased to less than a quarter.19

Earlier in the century the new German universities had promoted scholarship and research on the grounds that an effective teacher needs to be an active participant in his subject. Later it became clear that finding and maintaining the right balance between teaching and research is not an easy matter. A heavy emphasis on research can produce inadequate teaching, just as too much time spent on teaching and administration can impoverish research.

By the end of the 1880s a number of influential Russians had become extremely concerned about the future of science in their country. The solution that they found was one that led to a larger degree of separation between research and university education. The efforts of the Academy of Science and of some wealthy individuals led to the establishment of research institutes that had only tenuous links with the local university. This solution was also adopted in Germany and elsewhere in Central and Eastern Europe. It has persisted ever since in these countries where much more research takes place in institutions which play no part in undergraduate education than is the case in North America, for example, where the kind of two-tier university introduced by Gilman at Johns Hopkins has in the main served to keep a large proportion of research within a university context.

One of the earliest and most richly endowed of the new institutes in Russia concerned with medical research was the Institute of Experimental Medicine. This was founded in St Petersburg by a rich aristocrat, Prince Oldenburgski, who had been inspired by Pasteur’s work in Paris and wished to see a Russian equivalent of the Pasteur Institute. The research it supported was intended to be directly concerned with the causes of diseases such as cholera and the plague.20

In 1890 Pavlov’s situation was changed quite abruptly. The day after the offer of a chair at a Siberian university he was elected professor of pharmacology at the Military-Medical Academy and so could stay in St Petersburg. Less than a year later he added to this chair the post of director of the Physiology Department at Oldenburgski’s Institute of Experimental Medicine. Here he was able to undertake on a generous scale the work on digestive processes that he had started a few years earlier, even though this did not have as direct a relationship to disease as the founder might have liked.

Pavlov came to spend most of his time at, and owe primary allegiance to, the institute which, as well as providing ample space and facilities, gave him considerable independence from the university and its internal politics. With his odd ways, uncompromising integrity and insistence on wearing civilian clothes Pavlov was an unconventional figure at the Military-Medical Academy and was detested by its rector. Pavlov’s success in attracting students needing project supervision and in ensuring that most finished in time did not endear him to many colleagues in this era of dwindling student numbers. The rector did what he could to impede Pavlov’s research by withholding normal professorial privileges; no research assistants were assigned to him and permission to travel abroad was blocked for Pavlov and for anyone who worked for him.21

Apart from improvement in his personal finances, the major benefit conferred by Pavlov’s continued links with the academy, first as professor of pharmacology and then as professor of physiology, was the constant flow of eager student labour. In return he gave regular series of lectures, but this was about all; he was never very much involved in either the academy or university affairs in general. The Institute of Experimental Medicine insulated him from the turmoil that almost tore apart Russian society and its universities over the next three decades, and provided a setting in which the study of conditioning could begin without serious intrusions from the world outside.22

How Wolfsohn, Snarsky, Tolochinov, Pavlov and Babkin began to experiment upon conditional reflexes

A complicated illustration of the digestive tract in a mammal, which Lewes included in The Physiology of Common Life, had caught Pavlov’s imagination at an early age; it is reproduced here in Figure 5.3. He became fascinated with the problem of discovering the operating principles of such an intricate system which he liked to compare to a complex chemical factory. How is it that just the right amount of the right kind of chemical is released at exactly the time it is needed as a particular foodstuff passes down the gut? The exquisite integration of processes involved in digestion must depend on an interlocking set of reflexes; what are these components and how are they integrated?

Early in his scientific training Pavlov rejected the then prevalent technique of using ‘acute’ preparations to study physiological problems; that is, to carry out operations that allow the study of some particular part of the body only in the short while before death occurs. Pavlov regarded such an approach, which he
from the immediate impact of surgery has occurred, the only lasting change is that the experimenter now has access to events that formerly could not be observed.

A good example of this approach is provided by one of Pavlov's earliest studies of digestion. The purpose of the operation was to establish an isolated part of the stomach wall, a 'gastric pouch', which would still contain the nervous pathways serving this part of the gastrointestinal tract. In 1879 Heidenhain had almost achieved this, but his operation involved cutting fibres of the vagus nerve. Pavlov worked out a way of establishing a pouch that left all the neural connections intact. This gave him a preparation in which, once the dog had recovered, he could study during the animal's normal feeding the release of gastric juices that were uncontaminated by food or saliva and that were isolated from any possible chemical, as opposed to neural, control.

This stomach pouch operation was particularly difficult and it is an example that also illustrates Pavlov's perseverance. It took almost six months, about thirty dogs and the rejection of expert advice that the operation was impossible, before he was successful.

As this early study indicates, despite his opposition to 'vivisection' methods Pavlov was prepared at times to carry out studies resulting in the deaths of his subjects. In this he differed from Sechenov, who confined his work to frogs and refused to experiment with any warm-blooded animal. Pavlov's view was that, as long as we slaughter and hunt animals and kill thousands of our fellow men in wars, one could not object 'to 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'. In practice it was very rare for Pavlov to sacrifice any animal. His experimental methods depended both on rapid, delicate surgery and on very high standards of animal care to ensure that after surgery his subjects lived long lives in perfect health.

An outstanding feature of the new laboratory at the Institute for Experimental Medicine was that it had excellent facilities for keeping dogs. It seems also to have contained the first surgery in the world which was specifically designed for animals and in which anaesthetic and aseptic conditions were used from the very beginning. With ample space for housing and plenty of animal caretakers the dogs were treated like favoured pets.

One surgical preparation became particularly common in the laboratory. This involved two operations. One was to establish a tube, or fistula, leading
outside the body from a dog's esophagus so that, when required, 'sham feeding' could take place whereby any food taken by the dog into its mouth subsequently dropped out through the fistula before reaching the stomach. The second operation was to insert into the stomach a second tube which could then be used to collect gastric juice. This preparation was initially devised to study the effects of oral stimulation on gastric secretion without allowing food to enter the gut. It was subsequently important for both financial and intellectual reasons.

For some years gastric juice became very popular around St Petersburg as a remedy for certain stomach complaints. As Pavlov was able to supply gastric juice in relatively large quantities and of a particularly pure quality by using the sham feeding preparation, the proceeds from its sale became considerable, to the extent of almost doubling the laboratory's income when this already far surpassed that of any comparable Russian laboratory.

The other reason sham feeding became significant was that it turned a phenomenon whose existence had hitherto been controversial into an everyday event. It soon became well-known to everyone in the laboratory that a dog would secrete gastric juice as a response, not just to the presence of food in its mouth, but also to the sight of food; or, for that matter, to the sight of anyone who regularly came to feed him. Since the effect was held to be caused by the dog's psychological state of expecting food, it was labelled a 'psychic secretion' and considered to be quite different from the physiological secretions routinely studied in the laboratory. Until the end of the 1890s little serious attention was paid to the phenomenon.

Meanwhile research proceeded in a steady, productive fashion. By this time Pavlov had adopted the routine he was to keep for the rest of his life. From the beginning of September until the end of May he would spend all seven days of the week at work. Every day at the Institute started at nine o'clock with a precision that allowed clocks to be set by his arrival and ended equally punctually at six in the evening. A day's duties consisted of some mixture of surgery, supervision of the several current experiments, administrative jobs to do with the laboratory and some paperwork; it was interrupted only by the half-hour he allowed himself for lunch which he took alone. On returning home he would dine with his family and afterwards sleep from seven until nine o'clock. Then, with the possible exceptions at the week-end allowed in the agreement with Sara, an hour of further social intercourse with the family over cups of tea would be followed by further work in his study from eleven to one o'clock in the morning. This schedule was maintained until the summer, when he would go to the country for three months to spend his time on gardening, cycling and reading novels; physiology or any matter to do with science rarely intruded.

Although a very regular routine is an essential ingredient of work with animals, no one else engaged in such research has ever imposed so precise and ordered a pattern upon their whole life. It was obsessional to a degree that would be considered deranged in any context but that of science or religion. Pavlov insisted that military punctuality be shown by all members of the laboratory, at least during their working hours. Years later an assistant was ten minutes late for the beginning of an experiment and explained that he had been delayed by the revolution that was erupting in the streets outside; Pavlov's reply was: 'What difference does a revolution make when you have work in the laboratory to do?'

Pavlov may have seemed uncomfortably strange and remote to his colleagues and peers, but he was highly popular with students. He was far from being the traditionally authoritarian professor; his lectures were among the few in which students were encouraged to interrupt when they did not fully understand some point. The demonstrations that formed a crucial part of these lectures were prepared with great care. Science was presented as a collaborative enterprise in which mutual trust should extend even to the newest member. Pavlov's laboratory was renowned for its atmosphere of friendly cooperation and for the amount of attention Pavlov himself would give even to a new student spending just a few months there. Unlike many of his contemporaries, he opened his laboratory to both women and Jewish students. He could be irritable and explode with anger over a mistake; yet the most junior member knew that he could approach Pavlov at almost any time for help or advice on an experiment, or even to ask him to take it over for a while so that the student could take a break.

Compared to an equivalent of today, Pavlov remained remarkably free from the various commitments that can compete strongly with active involvement in the work of a laboratory. None of his time was spent on writing grant proposals or reviewing those of others. He did not serve on committees, help edit journals or organize scientific conferences. He was a poor correspondent; in comparison both to the typical eminent scientist of later generations and, for example, to the British evolutionists of a generation earlier, Pavlov wrote very few letters to scientific colleagues. He did not even devote much time to writing reports of his research; most of the experi-
ments were described only in the dissertation of the student who carried them out in the first place, although with considerable guidance from Pavlov where necessary. Frequently no other form of detailed report was ever published.

This reluctance to make public his research is also seen in the only two books he ever produced, which were both rewritten versions of a set of lectures. The first of these appeared during the calmly productive era of the 1890s. This was the *Work of the Principal Digestive Glands* of 1897. It described in a general way the findings that had been obtained in his laboratory over the previous nine years. It contained a passing reference to psychic secretion, but there was no hint that this was later to provide the central focus of Pavlov's research.

It was a number of years before this remarkable shift of interest and outlook was complete. Two phases can be discerned. The first involved the discovery that methods routinely employed in physiological experiments could equally well be used to study psychological phenomena; in this phase some of his students seem to have anticipated Pavlov's interest. The second phase led to the conclusion that psychological phenomena have to be described and explained in physiological terms or else they cannot be understood. It ended with a decision to devote the resources of the laboratory to this task. The transition from a dualist to a materialist position involved in this second phase made it the more dramatic and painful of the two. But somehow this change was made more rapidly by the fifty-year-old scientist who for decades had kept a very fixed outlook on his science and on life, and had done so profitably, than by many of the much younger students and co-workers around him.

The study of psychic reflexes began in 1897, the year that Pavlov's book on digestion was published, when a student named Stefan Wolfssohn carried out experiments on the first glands in the digestive tract, namely, the salivary glands. Some three years earlier a technique for inserting a fistula that made possible the measurement and extraction for analysis of saliva had been developed by one of Pavlov's assistants. By a striking coincidence this crucial first step in the study of conditioning in Russia occurred at exactly the same time as Thorndike at Columbia University in New York began to test his dogs and cats in puzzle boxes; later Wolfssohn and Thorndike both submitted their dissertations in the same year, 1898.

Initially Wolfssohn simply checked out in a systematic way a claim, made by Claude Bernard, that the set of reflexes involved in salivation is highly sensitive to differences in oral stimulation. Thus, the quantity and constitution of spittle varies widely according to what has been placed in the mouth. Dry food will induce the flow of a large quantity of particularly watery saliva, as will the insertion of some dilute acid or a handful of sand. In contrast, small stones and most wet foods produce very little salivation, while certain foods cause the glands to produce saliva containing a high concentration of mucous. In every case investigated it turned out that the salivary response obtained was beautifully adapted either towards the digestion of the particular foodstuff or towards the elimination of a potentially harmful irritant.

Wolfssohn next started to measure the salivary response obtained when a dog was simply shown various things, and discovered that it was equally sensitive to appropriate visual stimuli. Thus, when sand had been repeatedly inserted into its mouth, a dog would start to salivate at the sight of sand and the secretion would have the same characteristics as that produced by sand-in-the-mouth. This secretion was regarded as a psychic secretion like the one seen with the gastric juice preparation. It seemed clear to Wolfssohn and everyone else in the laboratory that it was caused by the dog learning to expect that sand would shortly enter its mouth; that is, it involved mental, and non-physiological, processes.

This was very much the view of Anton Snarsky, the next student who began to work on this problem; it seems that he did so without a great deal of encouragement from Pavlov. Snarsky's main contribution was to show that apparently arbitrary signals could be as effective as the normal appearance of some substance in eliciting psychic secretion. One of his experiments can be seen as the first deliberate attempt to produce a psychic reflex. He coloured some acid black before introducing it into a dog's mouth and found that after a few repetitions profuse salivation would also occur to water that was coloured black or to the sight of any bottle containing black liquid.

For a while arbitrary stimuli, such as the black colouring used by Snarsky, were termed 'artificial' stimuli in Pavlov's laboratory, while those of the kind investigated by Wolfssohn - for example, the normal appearance of some substance - were termed 'natural' stimuli. Snarsky also showed that some apparently natural stimuli need to acquire their effectiveness in eliciting salivation. Thus, it turned out that a dog would initially show no salivary reaction at all to the smell of aniseed; but once aniseed oil had been placed in its mouth a few times, then its odour alone became an effective stimulus for the secretion of saliva. Later
experiments by one of Snarksy’s successors showed that a dog hit to fed only on milk similarly displayed no reaction to the smell of meat until it had experienced meat-in-the-mouth.

Snarksy must have been an independent-minded and stubborn young man. In trying to make sense of his results he decided on a particular account of the dog’s thoughts, feelings and desires during the course of its experimental trials and stuck to the account even though Pavlov favoured another. Their arguments became heated, while their differences remained puzzlingly unresolved. As Pavlov wrote many years later, it was ‘an incident which had no precedent in our laboratory. We considerably diverged in our interpretation of this internal world; further attempts failed to bring us to a common conclusion, contrary to the usual laboratory practice, according to which new experiments undertaken by mutual agreement generally led to the settlement of all differences and disputes. Snarksy clung to his subjective interpretation of the phenomena, while I, astonished at the bizarre character and scientific barrenness of this approach to the problem, began to seek for another way out from this difficult situation.’

By 1902 when Snarksy was at last allowed to submit his dissertation, Pavlov had begun to find a way out. Since no empirical means were available for resolving discrepancies between theories based on subjective processes, the solution was to reject all such theories. ‘After persistent deliberation, after a considerable mental conflict, I decided finally in regard to so-called psychic stimulation to remain in the role of a pure physiologist, that is, an objective observer and experimenter.’ Pavlov rarely referred to Snarksy afterwards and, when he did, it was with a degree of anger that seems accountable only if Snarksy had become a symbol for the set of beliefs that Pavlov himself had previously held and only with great difficulty relinquished.

About a year before the final break with Snarksy, Pavlov had been joined by a co-worker who became a close friend, but who was no more sympathetic than Snarksy towards the attempt to find a new way of understanding psychic reflexes. Ivan Tolochnov collaborated with Pavlov on the first experimental study of the phenomenon that came to be known as extinction. They found that the reactions to visual stimuli described by Wolfsohn depended on the continued application of the ‘physiological’ stimulus. For example, the sight of some familiar food would continue to evoke the appropriate kind of salivation only as long as its appearance was usually followed by its ingestion; if, instead, a dog was repeatedly shown

the food, but not allowed to consume it, then the salivary reaction disappeared.

The fact that our mouths, or those of dogs, water at the sight, or even the thought, of something appetizing was in no sense discovered by Pavlov and his colleagues. However, that such effects persist only if certain specifiable conditions hold was indeed a new contribution from his laboratory.

Conditioning was still a side issue and most of the experiments in the laboratory were concerned with much more familiar kinds of process further down the digestive tract. It was in this context that the disturbing preliminary report of an experiment carried out in England by two physiologists, Bayliss and Starling, became known early in 1902. This shook the nervist foundations on which Pavlov’s studies of digestion had been based.

Pavlov’s fundamental assumption was that the integrated activity of the digestive system is based exclusively on the transmission of information via reflex arcs from sensors at one point in the tract to glands lower down. Thus, receptors in the mouth sensitive to taste, volume, texture and so on can give advance warnings of the arrival of a certain substance to various gastric glands by means of neural impulses; these impulses stimulate the glands to produce the appropriate chemical environment by the time the substance has descended to the stomach. The significant aspect of the experiment by Bayliss and Starling was to show that advance information may also be conveyed by chemical signals, or hormones. It turned out that the pancreas was at least partially under humoral control, under certain conditions the intestines release a hormone, pancreatic secretin, which triggers secretion from the pancreas.

At first Pavlov did not accept the evidence. Then in the Autumn of 1902, when Bayliss and Starling’s full report was published, he asked one of his assistants to repeat their experiment. The whole staff of the laboratory gathered to watch in silence as the replication was performed. The effect of secretin soon became obvious. Pavlov disappeared into his office. He returned a half hour later, simply saying: ‘Of course they are right. We cannot aspire to a monopoly of discovering new facts’.

From that point on the amount of laboratory activity devoted to the digestive system declined, while that to conditioning increased.

The international reputation earned by Pavlov’s book of 1897 began to produce invitations to give lectures at prestigious conferences abroad. In April 1903 he attended the International Congress of Medicine in Madrid. Instead of discussing his work on
digestion he chose to deliver the first public report of experiments on conditioning. 13

In Madrid Pavlov still used the term ‘psychical reflex’ and had not yet made a full commitment to an entirely physiological account of conditioning. By that time he had been joined by a young researcher, B. P. Babkin, whose results were finally to persuade Pavlov that nothing was to be gained from trying to explain the phenomena of conditioning in subjective terms. As a student in 1902 Babkin first carried out a dissertation project on the pancreas. Afterwards he became a full-time assistant in the laboratory and began to follow up Tolochinov’s experiments on extinction.

Babkin discovered two further effects. One was spontaneous recovery. A hungry dog was repeatedly shown at intervals of a minute or two a dish containing meat powder that he was prevented from eating. Once the salivary response had died away nothing happened for a few hours and then the dish was again presented. Babkin found that the salivary response now occurred once more and at almost full strength. The second effect was also a form of recovery from extinction and became known as disinhibition. Once he had extinguished the salivary response to the sight of meat powder — again by displaying it without allowing a dog any opportunity to eat — Babkin found that he could also restore the response by interpolating some other strong, although irrelevant, stimulus. In the initial experiments this was achieved by using another salivary reflex, that elicited by inserting a few drops of dilute acid into the mouth; a few minutes later the sight of meat produced as great a flow of saliva as ever. Later experiments showed that any kind of intense stimulation would have the same disinhibitory effect. For example, if the sudden slam of a door or the burst of an unfamiliar light occurs shortly before, or even during, the presentation of a stimulus that has just been extinguished, the latter’s ability to elicit a response is temporarily restored. 14

This work provides an interesting contrast to the concerns of the British evolutionists and early American animal psychologists of this era. In trying to understand how behaviour can be adaptive it is clearly as important to find out how and why reactions that are no longer appropriate to a certain situation disappear as to explain how they become established in the first place. An emphasis on intelligence and on the solving of problems made Western psychologists concentrate almost exclusively on the acquisition of new patterns of behaviour. It was many decades before they paid very much attention to extinction, which then turned out to present enormous theoreti-
cal problems. On the other hand, in Pavlov’s laboratory concentration on phenomena related to extinction marked the pioneer experiments described here and continued throughout his lifetime. Correspondingly little experimental or theoretical effort went into the study of acquisition.

The immediate effect of Babkin’s discoveries was to confirm Pavlov in his conviction that explanations in terms of commonly available psychological concepts were useless. All attempts by himself, and by others whom he questioned about these issues, to explain spontaneous recovery and disinhibition by appealing to the dog’s beliefs and to changes in its awareness of the stimuli seemed ludicrously inadequate. 15 He stopped using the term ‘psychic reflex’ and, since the reactions he was investigating seemed to differ from more familiar reflexes only in that certain conditions had to be met for them to become established and be maintained, he started to call them ‘conditional reflexes’. Later the Russian word was mistranslated into English as ‘conditioned’ and it has stayed this way ever since. 16

By the time an account of Babkin’s research was published in 1904, Pavlov knew that he was to be the first physiologist and the first Russian scientist to receive the Nobel Prize. This was for his work on digestion, but, rather than incline him to return to this field, it helped provide the confidence needed to continue with conditioning. The reaction of his fellow physiologists to the new direction he had taken ranged from alarm to complete dismay. Many advised him to ‘drop that fad’. Even in its early days the Nobel Prize conferred such distinction that its recipients needed no longer be too concerned with the opinions of their scientific peers. It provided a licence to explore areas considered by general consensus to be too treacherous for lesser mortals.

The new field continued to prove very fertile as many further discoveries were made and the power of conditioning procedures became more apparent. The distinction between natural and artificial conditioned reflexes was now abandoned, since it seemed that even the most unlikely form of stimulation could become as effective a signal, or conditioned stimulus, as the smell or appearance of some very familiar food. For example, even though an event such as briefly cooling a small and arbitrary area of the skin had presumably never been remotely connected with feeding behaviour in the whole lifetime of a dog or, for that matter, during the evolutionary history of the species, it could easily be endowed with the property of eliciting saliva. All that was needed was a number of trials in which cooling was shortly followed by the
arrival of meat powder. Examples like this persuaded Pavlov and many later students of conditioning that there was normally little to be gained from looking at the natural history of the animal used in their experiments.

The final point in Pavlov's steady change of outlook was reached by 1906. He moved beyond the belief that to understand conditioning a physiological, not psychological, approach was needed to the much more ambitious view that a physiological analysis of conditioning provided a means, and the only scientific means, of understanding the brain. On October 1st of that year he gave the Thomas Huxley Memorial Lecture at the Charing Cross Hospital in London. After a brief survey of his general ideas on conditioning and of recent experimental data he ended with the following comments on the relationship between physiology and psychology. The investigation of conditioned reflexes is of even greater importance for the physiology of the highest parts of the nervous system. Hitherto this department of physiology, throughout most of its extent, has been cluttered with foreign ideas, borrowed from psychology, but now there is a possibility of its being liberated from such harmful dependence. As an unconscious echo of Descartes' lords and masters of creation, Pavlov went on to suggest the advantages stemming from an understanding of the brain. The conquest which physiology has yet to make consists for the most part of the actual solution of those questions which hitherto have vexed and perplexed humanity. Man-kind will possess incalculable advantages and extraordinary control over human behaviour when the scientific investigator will be able to subject his fellow men to the same external analysis as he would employ for any natural object, and when the human mind will contemplate itself not from within but from without. Science had not yet been put to the kind of use that would make a reader from later in the century sense the cold chill in such a message.

Vladimir Bechterev and Objective Psychology

The study of conditioning began during a period of dramatic political developments in Russia. When the new Czar, Nicholas II, began his reign in 1894 there was widespread hope that he would end the long era of repression and revive the reforms of the 1860s. He did nothing to encourage such hope. On the contrary the government began to react in a heavy-handed manner even to suggestions for minor
changes in the political system or for minimal increases in personal freedom. As a result, opposition to the Czar's authority became deeper and more extensive than ever. In 1901 the first mass demonstrations by students took place in the streets of St. Petersburg. In 1903 the first general strike was staged by industrial workers in the south. A year later the series of Russian withdrawals in the face of the Japanese armies marked the first major military defeat of a European by a non-European nation in many centuries, faith in the Czarist system ebbed further. In 1905 a revolt by the peasants broke out on a scale not seen in Russia for over a century.1

Early in January, 1905, a deputation of unarmed workers wishing to present a petition to the Czar was fired upon by troops. The day became known as Bloody Sunday and these killings triggered the further series of upheavals — strikes, demonstrations and mutinies within the armed forces — that has since been known as the 1905 Revolution. The Czar's ministers uncertainly mixed efforts to put down the rebellion by force with the granting of some reforms. Thus, in April a degree of religious toleration was allowed whereby a Russian subject might leave the Orthodox Church for some other variety of the Christian faith without incurring any penalty.

The universities were at the centre of this political strife. The lives of almost all academics and scientists were affected to some degree by a general belief that profound changes in Russian society both were needed and were about to happen. At the 1904 congress of the country's leading medical society, for example, it was resolved that the fight against diseases could only be generally successful 'under conditions guaranteeing the broad spread of information about their causes and prevention and, for this, full freedom of person, speech, press and assembly are necessary prerequisites'.2 This Pirogov Society, whose meetings Pavlov attended, had developed its own plans for combating an outbreak of cholera in southern Russia, but these had been blocked by the government.3

In August, 1905, the universities were given back the autonomy that had been taken from them in 1884. They became the scenes of mass meetings that could now be held without interference from the police. From such meetings in the University of St. Petersburg emerged the first workers' council, or soviet, of which one prominent member was Leon Trotsky. This began to act as an alternative government for a large part of the city. In October a general strike forced the Czar to make a further crucial concession: a government manifesto announced that a representative assembly, the Duma, would be established and given some legislative powers, and the manifesto promised major changes in the laws on civil rights.

The educational and other reforms enacted during the 1905 Revolution were later gradually eroded. The Czar's manifesto divided opposition to the government and from early in 1906 the Czar steadily regained his power. Within three years measures such as the ban on any kind of student society, the exclusion of women from universities and restricted quotas for Jewish students had been brought back. By 1911 it became common for wholesale expulsions of students from the universities to be carried out and for uniformed police or detectives to attend most lectures. But before the heavy and inept hand of repression descended there was for a while an air of excitement and confidence in the future like that of the sixties when Sechenov had published his Reflexes of the Brain.

Pavlov was no political radical like Sechenov. The sole extent of Pavlov's participation in the events leading up to the 1905 Revolution appears to have been the addition of his signature along with those of forty-two other scientists to a memorandum of 1900 enumerating the defects of a secondary education biased strongly towards the classics.4 Yet, as a scientist searching for a consistent framework for the new study of conditioning, Pavlov eventually adopted a materialist outlook identical to the one advocated by Sechenov forty years earlier. By that time Sechenov was dead.

As a young man Pavlov had read Sechenov's Reflexes of the Brain and as an old man he admitted that he may have been unconsciously, but nonetheless strongly, influenced by the book. However, there is no indication that Pavlov made any effort to study Sechenov's work or even to meet him.5 One suspects that until his interest in conditioning was fully developed Pavlov's attitude towards Sechenov may well have been a mixture of respect for the very early work on inhibition and regret that this had not developed into a steady and substantial body of experimental data, due to Sechenov's unfortunate interest in philosophical issues and his tendency to involve himself in political affairs.

A contemporary of Pavlov, Vladimir Bechterev, was in many respects more like Sechenov. Bechterev shared Sechenov's interest in a broad range of scientific subjects and similarly participated in life outside the laboratory. Pavlov disapproved of Bechterev, and one of the reasons that Pavlov found the shift to a physiological analysis of psychological phenomena so painful may well have been because this meant the adoption of a point of view already
identified with Bechterev. Pavlov viewed Bechterev's work as chaotic and careless to an extent that debased science, so that it must have been difficult to make what was in effect a public admission within the medical world of St Petersburg that he, Pavlov, now agreed with Bechterev on this matter.

Bechterev was almost eight years younger than Pavlov, but had made much quicker progress up the educational ladder. He entered the Military-Medical Academy at the age of sixteen and obtained a first degree in medicine in 1878, one year earlier than Pavlov, who had been older when he first entered university and had obtained a natural science degree before beginning medical studies. In contrast to Pavlov's student involvement in experimental physiology, Bechterev developed an interest in psychiatry. He spent three years training in a hospital specializing in mental and nervous diseases, which ended when he submitted a doctoral dissertation on body temperature in certain forms of mental illness.

From 1881 Bechterev studied abroad, visiting the laboratories of a range of famous physiologists and psychologists. These included du Bois-Reymond in Berlin, Charcot in Paris, where a new approach to the study and treatment of neuroses was arousing wide interest, and Wundt, whose laboratory of experimental psychology in Leipzig was still very new. Bechterev spent most of his time in Leipzig, but in the laboratory of Flechsig, a leading neuro-anatomist. Within four years Bechterev's papers on topics in both psychiatry and neuro-anatomy had made him famous enough to be invited to return to Russia and become professor of psychic diseases at the University of Kazan. This was a remarkable tribute in an age of university recession.

At Kazan Bechterev was enormously energetic. He set up a department for the study of mental disease, was involved in the founding of a new psychiatric hospital and began the first Russian laboratory of experimental psychology. He also managed to complete a scholarly book on the anatomy of the nervous system which became a standard handbook in Russia.

While still in Kazan Bechterev began to develop ideas about a new approach to psychological phenomena. One aspect of this appeared in his clinical work. He came to the conclusion that much more was to be gained from studying in an objective manner the changes that occurred in a neurotic patient's life than from attempts to analyse his subjective experience. The second aspect was related to his studies of brain function. Some of his experiments involved training dogs to perform tricks such as begging, making dancing movements or offering a forepaw and then determining in which areas of the brain a surgical lesion abolished such skills. In 1893 Bechterev returned to St Petersburg as professor of psychiatry at the Military-Medical Academy. He continued to be as busy an organizer as ever; he set up new clinics and laboratories, extended the work on neurological diseases at the hospital attached to the academy, founded a 'Society for Normal and Pathological Psychology' and started a journal that published papers in psychiatry, neurology and experimental psychology. His involvement was not confined to founding and editing the journal: he was the author of fifteen out of the forty-five papers in its first volume, and continued to maintain this proportion over the next few years. In many ways his activities mirrored those of his nearest American equivalent, G. Stanley Hall.

His research associates and the many students who chose to carry out experiments in his laboratories saw little of him. Consultation about an experiment that he had first suggested took place on the run, if it occurred at all. Although able to work for eighteen hours each day, his commitments would always overwhelm. He needed at most five hours of sleep, so that consultations with colleagues or patients could be made for after midnight and many of his papers were written as he sat in bed with his wife sleeping beside him. And yet everything was still done in a great rush. A new student was given a bewildering degree of freedom, in complete contrast to Pavlov’s laboratory where it was insisted that a student first repeat an experiment already carried out at least once in the laboratory – which served both to train the student and to check on the replicability of earlier data – before starting a more original piece of work whose aims and details were usually quite closely specified in discussion with Pavlov.

Pavlov and Bechterev were colleagues who came to share the view that the study of conditioned reflexes – 'association reflexes' was the term strongly preferred by Bechterev – was central to a scientific study of the mind and both were unrelentingly energetic in their devotion to science. In all other respects they differed greatly.

Bechterev was an inspired innovator, a genius at initiating all kinds of projects, but not as good at carrying things through to completion. He clearly had little taste for the repetitive tedium and thoroughness demanded for most experiments. When Pavlov warned his students against spending too much time reading and advised that it was usually fatal for a
The major contribution by Bechterev to animal psychology began with a paper, called Objective Psychology, which appeared in 1904. This expressed his dissatisfaction with current psychology and summarized his views on the direction that the subject should take. He argued that introspection was a totally inadequate method for understanding the mental processes even of normal, educated adult human beings and had no contribution whatsoever to make to the wider range of problems with which psychology should be concerned, such as mental testing, psychiatric disorders and animal behaviour.

Following Sechenov, Bechterev viewed the reflex as a key concept for the new objective psychology and, also like Sechenov, he worried about the fact that in all but simple reactions there is often little correspondence between the intensity of a stimulus and the intensity of the reaction it may produce. However, in the forty years since Sechenov had first discussed this issue, technology had devised means of detecting all kinds of previously imperceptible reactions. By measuring slight changes in heart, pulse or breathing rates, in glandular secretions or in skin resistance it should become possible, Bechterev suggested, to measure human reactions to any kind of stimulus. This should allow the objective study of processes such as thinking that had previously seemed to be accessible only to introspection. He summed up his general rejection of the prevailing dualist approach to psychology in the following words: ‘It is evident that objective psychology has no need of metaphysical terms such as the “soul”, “intelligence”, “will”, “imagination” . . . objective psychology excludes them completely as useless material’.13

The first discussion of objective psychology appeared at the same time as a report by Tolochinov on the conditioning research he had carried out in Pavlov’s laboratory. Bechterev already knew a little about this work, but its significance for his own general views had yet to sink in. But within three years conditioning experiments with dogs were being carried out in the laboratory as well. Some involved the recording of salivary reactions, but in general Bechterev was much more interested in the use of skeletal movements rather than secretion from some gland, since he felt that the former were much more important for human psychology. He had the good fortune to be joined by a man named V. P. Protopopov who was evidently an ingenious experimenter and someone who could work in a productive and independent way under the conditions of Bechterev’s
laboratory. In 1908 Protopopov worked out a convenient method for studying dogs which could also be applied in experiments with human subjects.

The situation used by Protopopov was one in which a dog stood with one paw resting on a metal plate; a voltage could be applied to the plate of just sufficient intensity to make the dog's leg flex. The standard procedure was to switch on a light, a sound, or both together, at the same time as shock was delivered to the dog's paw. After repeating this for a number of trials one of the stimuli was presented alone and, all being well, was found to elicit flexion of the leg in the absence of any shock. No surgery was needed, nor special expertise. With near identical equipment one could study the conditioning of a leg movement or the jerk of a finger in a human subject.¹¹

For Pavlov the study of conditioning provided a major insight into the brain's basic functions. Bechterev's interest was somewhat different. He was much more committed than Pavlov to the view that the brain’s various activities can be precisely localized, and consequently a major question for him was often where in the brain does such-and-such occur. The early research in Kazan on brain lesions that would abolish trained movements was an attempt to locate the new neural connections that must underlie some acquired skill such as begging or offering the paw. Conditioning appeared to offer a promising new technique for answering such old questions; set up a well-defined conditioned reflex and then determine where in the brain lesions will cause it to disappear.

Conditioning also offered a means of keeping the promises made for objective psychology. A critic might scoff at the idea of studying perception other than by using human observers to report their perceptual experience; Bechterev would show that the perceptual world of a dog could be perfectly well explored in an objective manner by means of conditioning. After first establishing some specific event—for example, a tone of fixed intensity and precise frequency—one could vary some parameter of the stimulus by small degrees—change just its intensity, for example—and look for a corresponding change in the intensity of the conditioned response. Such a change would indicate that the animal had perceived the difference in the stimulus.

A description of Protopopov's procedure and a discussion of the importance of conditioning was included in a book which Bechterev published in 1910. *Objective Psychology* expanded on the arguments he had put forward six years earlier in his paper of the same title, and added new material on conditioning and animal behaviour. It was a clear, systematic and stimulating book which showed the author's familiarity and understanding of an impressive range of contemporary research. It should have added greatly to Bechterev's reputation. Unfortunately by the time it appeared the inevitable confrontation with Pavlov had occurred.

Bechterev had made two particular claims on the basis of his students' work which Pavlov did not believe. One was in the area of perception, and the other was to do with brain localization. Some experiments in Bechterev's laboratory showed that, after exposure to a procedure involving lights varying in colour, a dog's conditioned response to one light could be distinguished from the response to another. Bechterev took this result to mean that dogs can distinguish between different colours.¹⁵ In Pavlov's opinion the possible importance of intensity differences, which would give rise to variations in perceived brightness, had not been adequately controlled. Experiments in his own laboratory gave no sign of any canine perception of colour. No one decisive study resolved the issue, but general opinion then, as ever since, held that Pavlov was correct.

The other major controversy began earlier and came to a dramatic climax in 1909. Some of Bechterev's early research, begun when he was still in Kazan, had been on areas of the cerebral cortex that can be stimulated to produce some salivary secretion, and hence were termed 'salivary centres'. Prompted by the new work in Pavlov's laboratory, Bechterev's interest returned to these centres and in 1906 one of his students, named Belitsky, claimed that removal of the cortex in this area abolished conditioned salivary reflexes.

This claim was challenged by results obtained by a number of Pavlov's co-workers. They found that after apparently similar cortical ablations reflexes that had been conditioned prior to surgery remained and new ones could still be established. Pavlov seized on this discrepancy as an opportunity to show up the low quality of work in Bechterev's laboratory. He discussed the issue in public at a meeting of the Russian Society of Physicians in 1907 where, to the embarrassment of his students, he ended by appealing to the authority of his own reputation, proudly quoting from Sеченov's autobiography a brief comment that Pavlov was believed to be the most skilful surgeon in Europe.

The controversy became increasingly bitter. Further papers reporting experimental results from Bechterev's laboratory that supported Belitsky's original claim were challenged by contrary results obtained by Pavlov's students. After two further
meetings of the society that were marked by pro-
longed and heated argument, Bechterev and his
associates remained silent at subsequent meetings
whenever an experiment from Pavlov’s laboratory
was reported or discussed.

Finally, Bechterev entrusted a further student,
named Spirtov, with the task of repeating one of the
apparently crucial experiments carried out by Pavlov’s
workers. Spirtov obligingly showed that the claims
made by Pavlov’s group were wrong and those made
by Bechterev were right; in two dogs with appropriate
cortical ablations conditioned reflexes established
before surgery were lost, and Spirtov was unable to
establish any new reflexes. Bechterev decided on a
public demonstration and took the two dogs to the
next meeting of the society. Spirtov tested them in full
view of the audience which could see for itself that a
visual stimulus that had previously served as a
conditioned stimulus now no longer elicited a drop of
saliva.

At the end of this demonstration Pavlov came up
to the front and, despite protests from Bechterev and
Spirtov, insisted on testing the dogs himself then and
there. He simply poured a little dilute acid from a test
tube into the dogs’ mouths a number of times and
showed that subsequently the sight or sound of the
acid splashing in the tube was sufficient to elicit
salivation. This impressive demonstration of expertise
left the crowded room in no doubt as to who was the
superior scientist; it was much more effective than the
appeal to Sechenov two years earlier. Pavlov was now
not just Russia’s only Nobel prize winner; he had
publicly triumphed over the only other major sci-
entists with a comparable reputation in Russian
neuroscience.

Following this encounter and the publication of
Objective Psychology Bechterev’s involvement in animal
research declined rapidly. Conditioning studies using
human subjects continued in his laboratory, but a new
interest in child development and a renewed interest
in psychiatric issues became his main preoccupations.

Pavlov’s later work

The conventional experimental approach in
nineteenth-century physiology was based on the
intensive study of a few individual subjects. To
answer a question about the function of some organ
one set out to obtain a suitable ‘preparation’. A
considerable number of animals might be used in the
course of developing appropriate surgical techniques,
for example, but once an effective method had been
developed the organ could be studied in a single
animal. If there were any doubt surrounding the
reliability of some aspect of the results, then the
experiment might be repeated in another animal or
two. As we have seen, it was routine in Pavlov’s
laboratory for the first task given to a new student to be
that of attempting to reproduce in a new dog the
results obtained by one of his predecessors.

When Pavlov shifted his research from conven-
tional physiology to conditioning he retained his
commitment to the study of individual animals. No
other approach could have been so productive during
the early years following the shift. Within an amaz-
ingly brief period Pavlov’s experiments had unco-
covered a whole range of important phenomena; hardly
a salient characteristic of conditioning was left for
subsequent workers to discover. But, after entering a
new field and locating most of the highly robust and
general effects, what comes next? One possibility is to
deveive a systematic theory that covers the known
phenomena and then to test its implications. Another
is to continue in an exploratory vein with imprecise
and largely implicit theories as a guide, but with the
problem that the phenomena now become more
elusive and variable. Under these conditions it can be
dangerous to draw general conclusions from results
obtained from just one or two animals.

The dispute with Bechterev appears to have
diverted Pavlov from such issues. It was acceptable to
use very few animals in the research on the effect of
brain lesions, which was undertaken mainly for the
purpose of refuting Bechterev’s claims. Similarly, a
limited number of subjects was satisfactory in the
perceptual studies carried out during this era, which
also reflect Bechterev’s influence.

From about 1910 onwards the problem of vari-
bility kept on intruding. It occurred, for example, in
some phenomena Pavlov termed ‘induction’ and
‘irradiation’ effects; they could be clearly obtained in
some dogs, less so in others. There was also the
problem of sleep: from the early experiments onwards
it was found that many dogs became quite drowsy and
unresponsive in the experimental situation, which
was, after all, designed to be as lacking as possible in
all stimulation except what was occasionally provided
by the experimenter; some animals proved to be
impossible to use as experimental subjects for this
reason.

In 1911 a particularly interesting experiment was
carried out by one of Pavlov’s students named
Erofeyeva; the situation she used turned out to be one
in which dogs varied considerably in the way they
reacted. Erofeyeva used a mild electric shock applied
to the dog’s skin as a stimulus that preceded the
delivery of food. She found that the defensive
movements and signs of distress her dogs initially made in reaction to the shock disappeared, and instead the shock came to elicit calm salivation. This effect was subsequently termed counter-conditioning; it seemed to show that conditioning methods could be powerful enough to neutralize an aversive event and even turn it into an attractive one. It seems, however, that later attempts to replicate Erofeyeva’s specific results were not always successful.³

Two or three decades later it became common for researchers faced with such unexplained variability to use experimental designs employing groups of animals which could be compared with appropriate control groups in order to isolate the causes of variability. Pavlov employed such an approach very rarely and then only towards the end of his life.⁴ Instead he tended to fall back upon an appeal to possible difference in his subjects’ temperaments and inherited dispositions to explain variability. In later years distinguishing different ‘types’ of dogs in a systematic fashion became one of his major enthusiasms.

The counter-conditioning study by Erofeyeva is interesting for another reason. Seeing the potential of her techniques outside the laboratory she became an early proponent of natural childbirth methods.⁵ This marks the first attempt to develop applications of the study of conditioning. Pavlov himself did not discuss this particular by-product, but about this time he began to develop an interest in neurosis. In certain studies some dogs would remain in a distressed state for some time after an experimental session. They could perhaps be loosely described as having been made neurotic by the experiment. Treatment with bromide was very often followed by the dog’s return to a normal state. Pavlov became a great believer in this particular therapy.⁶

The evidence supporting such beliefs was slight and unsystematic. The occasional abnormal state of a dog could have occurred for a number of reasons besides the one preferred by Pavlov, that it was due to the exposure of a certain type of nervous system to a particular experimental procedure. Similarly, recovery following bromide treatment did not mean a great deal in the absence of systematic comparison with recovery rates when no bromide was given. This general kind of weakness arising from the study of individual subjects can often be overcome by repeating experimental manipulations a number of times in the same animal, but this is hard to do with something like ‘neurosis’.

Pavlov’s interest in problems of clinical psychology was an excursion into territory in which Bechtershev was the major Russian figure. For the first time Pavlov also began to suggest in public some possible implications of conditioning for matters of very general human interest. On learning of Erofeyeva’s experiments on a visit to St Petersburg the English physiologist, Charles Sherrington, lightly commented that now he understood the psychology of martyrs.⁷ Pavlov made such remarks with a good deal more seriousness. He started to discuss the ‘reflex of purpose’ and that of ‘freedom’. Ready physiological solutions were produced for complex psychological problems; for example, he suggested that ‘the tragedy of the suicide lies in the fact that he has an inhibition, as we physiologists would call it, of the reflex of purpose – most often a momentary and only rarely a continued inhibition’.⁸

Bechtershev was scornful of Pavlov’s ventures into human psychology and at the same time feared for the effect they might have on his own attempt to found a psychology based on the concept of the reflex; he felt that ‘the adversaries of the objective method in its application to the investigation of human personality are given a weapon’ by the simplistic nature of Pavlov’s claims.⁹ In connection with some speculation by Pavlov on the inheritance of a servile attitude, Bechtershev wrote as follows. ‘History shows that a slave’s child, when educated in a family of free citizens, becomes just as freedom loving as his fellow citizens and does not betray any sign of inherited slavery. All these facts are universally known to an extent which would make it unnecessary to mention them here, if this problem had not been recently touched upon by the authoritative physiologist, Professor I. Pavlov, who, disregarding the long and instructive history of this important problem, solves it negatively. Professor Pavlov bases his conclusion solely on his observations of one lively dog, with abundant and spontaneous salivation . . . The data which he cites in favour of the existence of an innate “freedom reflex” and a “slavery reflex” in dogs are absolutely inadequate; we have still less reason for extending these conclusions to man who according to Pavlov’s statement, also possesses an innate “freedom reflex”.’

A new public controversy between the two men over issues more philosophical than in the earlier disputes was prevented by the occurrence of the 1917 Revolution. Bechtershev was highly sympathetic towards the new government and for some years represented university students on the local Workers and Peasants’ Soviet. His general political outlook, as indicated, for example, by the quotation above, should have further endeared him to the communist
party. In contrast, Pavlov was often quite outspoken in criticizing aspects of the new regime. However, by now Pavlov had an unrivaled international reputation, whereas Bechterev’s was in decline.

The scorn Bechterev felt for Pavlov’s views on human behavior had been expressed in a large, rambling and barely readable book which had appeared just before the Revolution and was titled *General Principles of Human Reflexology*. One important reason for the subsequent lack of interest in Bechterev among English-speaking psychologists has no doubt been because this was his only book to be translated into English. Contemporaries have noted that he appeared to age rapidly over his last ten years or so of life. After the Revolution his Psycho-neurological Institute was renamed the V. M. Bechterev Institute for Brain Research and its funding was continued by the communist government. But after he died in 1927 at the age of seventy he was quickly forgotten.11

Pavlov lived on. Perhaps it was his strong belief in physical exercise, the extreme regularity of his life, or his abstinence from potentially debilitating activities, but, whatever the reason, he continued to direct his now several laboratories and to broaden his interests in as energetic a fashion as ever. The Great War, the Revolution itself and the extreme rigors caused by the economic upheaval and civil war that followed had never quite halted his research, even though there were periods when there was scarcely enough food for himself and his family, let alone the dogs, and even though most of his previous assistants and would-be students were tending the wounded and dying on one front or another.

In 1921 Lenin decreed that Pavlov, now 72 years old, was to receive exceptional treatment from the local soviet. The compatibility between Pavlov’s science and Lenin’s philosophy, together with the desire to demonstrate to the rest of the world that the work of a prominent scientist could flourish within a communist society, made Pavlov’s own political outlook of little import. He was provided with new facilities, new physiological institutes were opened and now there were more co-workers than at any previous time. So generous was his funding that by 1930 his critical attitude towards the Soviet government had very much softened.

His extensive resources allowed Pavlov to pursue all of his varied interests. Basic studies of conditioning were continued by many of his students, but the topics that Pavlov chose to talk about in the many addresses he was now invited to give were usually mental illness, sleep or personality. Even in this difficult period immediately following the Revolution he had begun to follow up his interest in human mental disorders. In the summer of 1918, instead of his usual holiday, he worked in a psychiatric hospital where his contact with patients confirmed him in his view that their disabilities could be explained in terms of the derangement of inhibitory processes in the brain.12 Occasional examples of ‘experimental neurosis’ in dogs continued to occur, as, for example, in some replications of Erofeyeva’s counter-conditioning study and also in some situations where a very fine perceptual discrimination was required. Particularly striking effects of this kind developed in an experiment in which food followed the presentation of a circle, but not that of an ellipse with almost equal ratios. In September of 1924 a severe flood in Leningrad reached the area where Pavlov’s animals were housed and there was great difficulty in rescuing them. Subsequently many dogs reacted in a very irregular fashion in their experiments; this was attributed to the effect of the traumatic experience on ‘weak’ nervous systems.13

There were also some entirely new departures. As elsewhere, Lamarckian inheritance had been widely accepted by Russian biologists during the nineteenth and well into the twentieth century. Pavlov was no exception, as one might expect for someone so greatly influenced by Herbert Spencer. But the issue became a live one again in the 1920s and Pavlov, as a committed experimentalist, decided to test his belief. He tried to detect the possible effects of establishing conditioned reflexes in one generation of mice on their descendants; the choice of animal reflected the speed with which Lamarckian inheritance was commonly believed to operate, as had Thorndike’s choice of chicks to look at the same problem over twenty years earlier. At first some positive signs were obtained, but eventually Pavlov decided that his data did not indicate any genetic effect of an animal’s conditioning history.14 This displayed an ability to question a long-held belief that would be creditable in someone of half Pavlov’s age and authority. Another departure that also involved the use of a new kind of experimental animal was to study the problem-solving abilities of chimpanzees in order to test claims being made for these animals by some researchers in American and German laboratories.

Despite its huge quantity the work carried out in Pavlov’s laboratory after the Revolution had a fairly limited impact outside the Soviet Union. The evidence he gave in support of his various claims was never very substantial or conclusive. Moreover there was no easy way of finding out in more detail about the research since it continued to be reported only in brief,
non-technical papers. Pavlov once explained that he had intended to prepare a systematic presentation of his work, but then the revolution had occurred. In 1924 he gave a series of lectures in Leningrad that formed the basis for a book, Conditioned Reflexes, which provides the only overall account of his ideas and which, after its translation into English in 1927, has provided the primary means by which his work has become known outside Russia. However, even this book failed to contain the detailed exposition which would have allowed serious assessment of his research. Pavlov never seems to have felt that the work had reached a ripe stage for taking stock. As he commented in Conditioned Reflexes, 'new problems are perpetually arising, and at the same time an equally large number of questions are still left unsettled. We often feel compelled to turn our attention from problems which directly confront us to some unexpected new phenomenon which introduces fresh problems or which necessitates a revision of old points of view.'

Pavlov believed himself to be a pioneer extending the domain of physiology beyond the limits set for it by the Berlin school. Yet very few physiologists outside Russia followed his lead in using conditioning as a method for studying the brain. Pavlov saw this failure as reflecting philosophical cowardice, as clinging to the idea that the mind should be left alone and as fear of the thorough-going materialism that Pavlov himself had adopted. From the perspective of post-revolutionary Russia it seemed that scientists still living in capitalist societies, which were rigidly divided into a ruling class that took decisions and a proletariat that provided physical labour, might well find it very difficult to escape from making an equivalent distinction between mind and body.

Whatever the truth of such a view there was another more prosaic reason why neurophysiology in general was little affected by Pavlov's work. The brain processes that Pavlov invoked to explain conditioning, neurosis or differences in personality made little sense to most physiologists from the 1920s onwards. For someone dedicated to understanding the brain Pavlov remained singularly uninterested in its anatomy or in the fundamental changes in neuroscience that began around the time he started the study of conditioning; namely, general acceptance that the nervous system is composed of individual nerve cells separated by synapses and that neural action consists of the transmission along the axones of nerve cells of
brief states of depolarization of the cell membrane, or 'spikes', which produce interactions at synaptic junctions. It was difficult to interpret Pavlov's references to 'waves' of excitation or inhibition, to 'weak' nervous systems or to the production of neurosis by the 'clash of the two antagonistic nervous processes' in terms of contemporary views of the nervous system. This problem was of major concern to one of Pavlov's most ardent admirers outside the Soviet Union, the Polish scientist, Jerzy Konorski.16

Another problem which also perturbed Konorski was later very prominent in debates over conditioning among Western psychologists. Many aspects of an animal's behaviour are profoundly affected by the past consequences of its behaviour; this is particularly true for skeletal activity or 'motor movements', but may not be true at all for the kind of glandular secretion that Pavlov studied. As discussed in earlier chapters, the Spencer-Bain principle was introduced to explain such learning and the development of motor habits as a result of past successes; following Morgan and Thorndike, animal psychology in North America concentrated upon this kind of issue. In complete ignorance of this tradition Konorski and his friend, Stefan Miller, who were medical students together in Warsaw of the late 1920s, were thrilled by Pavlov's work, but did not believe that his theory could be extended to what is now known as instrumental conditioning. They carried out a number of experiments which involved the use of a dog's leg movement as a response as well as the Pavlovian measure of salivation. The results suggested the conclusion that there are two distinct forms of conditioning, thus anticipating by a few years the outcome of debates among American psychologists as to whether Pavlov's conditioned reflexes could provide the basis of motor habits.17

Pavlov rejected the criticisms made by Miller and Konorski, but was sufficiently interested, impressed and generous to invite them to work in one of his laboratories. Some of his own students studied this problem and, following their work, Pavlov suggested a way in which his theory could explain why, when the delivery of a reward depends on the occurrence of a certain response, the response often occurs more frequently. The suggestion was sketchy and unconvincing.18 But what is relevant here is the way this issue of instrumental conditioning illustrates the very narrow empirical base for many of Pavlov's general claims. The almost exclusive concentration on the measurement of saliva for over thirty years was an excellent research strategy in many respects. However, to convince neurophysiologists and psychologists of the general importance of his ideas Pavlov needed in the long run to test them out across a broad spectrum of behaviour.

This latest interest in the analysis of instrumental conditioning was not at all typical. There is little discussion in Pavlov's published work of such fundamental conceptual questions as the conditions which lead to the development of conditioned reflexes or the form which they take. The phenomenon of overshadowing provides a useful example to illustrate this point.

Most of the theoretical statements in Pavlov's books on conditioning imply that temporal contiguity and repetition are sufficient conditions for the formation of a conditioned reflex; that is, if a neutral signal repeatedly occurs just before an unconditioned stimulus such as food, the signal will inevitably come to elicit a conditioned response. Overshadowing appears to provide an important counterexample to this assumption. In at least two independent studies carried out by Pavlov's students it was found that a signal of a kind that could become an effective conditioned stimulus when presented on its own remained ineffective if it was always presented in compound with some other stimulus.19 Thus, to take one of these experiments, a set of lights in front of a dog was regularly switched on just before food was delivered and soon came to evoke salivation; with other subjects the same visual stimulus was always combined during training with a muffled sound to one side of the dogs and in a subsequent test, when the lights were presented on their own for the first time, surprisingly they had no effect, whereas these subjects salivated to the auditory stimulus when this was presented alone. The presence of the auditory stimulus and its effectiveness as a signal for food had in some way overshadowed the lights.

If temporal contiguity between a conditioned and an unconditioned stimulus is all that is needed for conditioning to take place, why should the presence of another signal matter? The brief remarks Pavlov made about overshadowing show that he appreciated its potential importance, yet he did not develop a theory explicit enough to make its significance clear. Overshadowing is an interesting example because when, over forty years later, it was at last studied intensively it became one of a small set of phenomena that were central to the development of new theories of conditioning.20

It would be silly to fault Pavlov for not providing theories of the kind now current; and that is not the intention. The point is that Pavlov did not develop
anything like an explicit and coherent system, despite the impression he conveyed at times and despite the way his work was often regarded later, both by Western psychologists and even more by scientists within the Soviet Union. It was not the kind of thing that Pavlov liked or was good at. His skills were partly the technical ones needed in his kind of experimental work, but above all that of sensing what is an important question and knowing how to devise a suitable experiment to answer it. It is an ability that is easy to underestimate; often, after the event, it seems all too obvious that some particular study was an appropriate one to carry out, but few people in psychology have ever showed the consistency in producing fruitful empirical work that Pavlov displayed for so many years. This is what continued to give him delight. He once commented to Babkin: ‘Of course we strive to reach the highest goals in science . . . but do you not agree that what impels us to work in the laboratory is the satisfaction we get from our work’. By the mid-1920s experiments were proceeding on such a scale that Pavlov organized a weekly conference in order to keep in touch with the work of his students and associates. These became famous as his ‘Wednesdays’. Age, power and fame now separated him from his colleagues. He still commanded unbounded respect, but now considerable deference too. Although a brash young outsider like Konorski could argue his case with Pavlov, from the published records of ‘Wednesdays’ held in the early 1930s it appears that his own students and co-workers now considered it unwise to disagree with Pavlov on important matters. There was no longer a fine for using the word ‘consciousness’ in his presence, but the atmosphere of friendly co-operation that had distinguished his laboratory in pre-revolutionary days had also gone. The vast hierarchical system he now headed was like a model of the autocratic government of Czarist days.

Active and involved in research to the very end, Pavlov died in February, 1936 at the age of 86.

Concluding discussion

In simple terms the phenomenon now known as Pavlovian, or classical, conditioning can be described as a change in an animal’s behaviour that results from a temporal relationship between two events; such a behavioural change is most marked when the first event is at first of little interest to the animal, but it shortly precedes another event that is of considerable significance. As noted in earlier chapters, this phenomenon had long been known in a general kind of way. It had also occasionally been regarded as an important one, as in David Hartley’s suggestion on its relationship both to general functions of the nervous system and to speculative analyses of the association of ideas in the human mind. Likewise, nearly a century after Hartley’s ideas were published, Herbert Spencer gave conditioning a prominent place in his first sketch of mental evolution. Yet no one looked at the phenomenon closely until Pavlov and that is the first reason why he occupies an important place in the present history.

The above description of classical conditioning is deliberately neutral. It is not the way it has usually been described in textbooks of psychology. With some few exceptions conditioning has been viewed for over seventy years from the perspective provided by Pavlov, that of the ‘conditioned reflex’. This chapter has recounted in some detail how the first experiments on conditioning were carried out as a peripheral result of the large scale study of digestive processes carried out in Pavlov’s laboratory during the 1890s. It has discussed the various factors, ranging from the discovery of secretin to the revolutionary climate of those years, that played a part in the slow double shift of the focus of research in Pavlov’s laboratory from digestion to conditioning and of his philosophical outlook towards a materialist position on psychology. In view of the widespread extension of experimental methods to various aspects of the life sciences which took place around the turn of the century, it is not surprising that the first experiments on conditioning also date from this period. But this still leaves such questions as why they took place in Russia, why the results were interpreted in terms of reflex action and not in terms of the animal’s understanding of its environment, and why extinction and inhibition were regarded as central problems.

One of the reasons why this kind of experiment started in Russia is that Pavlov’s laboratory could provide more appropriate facilities than almost anywhere else in the world. Pavlov’s experiments were not the kind that anyone with sufficient ingenuity and spare time can carry out with some string and wax. Like most subsequent studies of conditioning they took a good deal of time, were labour intensive and required an expensively high standard of animal housing and maintenance. Furthermore, the topic was sufficiently unconventional and the theoretical framework so distasteful to many physiologists that the research might well have been dismissed or ignored if carried out by anyone commanding less prestige than Pavlov. In this context it is interesting that very few people at the time, and only a handful of
scholarly books since, paid any attention to the report in 1902 by a little known American scientist named Twitmyer on the conditioning of a knee-jerk reaction in human subjects.1

Another factor was the turbulent state of Russia and the identification of even medical science with opposition to prevailing laws and social institutions. This was a country with huge and increasingly developed resources, with scientists, writers and musicians the equal of any in the world, and yet with the kind of political system that had disappeared long ago from other European nations. In the land of the Czars the basic scientific outlook of questioning authority and of testing belief was itself a revolutionary attitude. The previous chapter pointed out the contrast between Sechenov’s place in Russian society and that of his teachers, particularly the Berlin physiologists, in Germany. Sechenov helped to prepare an intellectual climate which made the extension of physiological method into psychology more acceptable to scientists in Russia than to those elsewhere. It was Sechenov too who ensured that early Russian research on conditioning paid a great deal of attention to inhibitory effects.

This returns us to the nagging problem that Sechenov’s programme for psychology was begun by Pavlov, who of all the leading Russian physiologists at the end of the nineteenth century had probably the least in common with Sechenov. Many of Sechenov’s students became productive scientists and held leading positions in the Russian medical world by the 1890s. Yet none of them studied the brain or made a contribution to psychology.

The solution to this problem is to be found in the intensity of Pavlov’s belief in science. Although more cautious and conservative in general outlook than Sechenov and many of the latter’s students, Pavlov’s faith in the enlightening effect upon society of the spread of scientific knowledge was as strong as theirs. Moreover, Pavlov’s dedication to a scientific point of view was so complete that, if experimental results challenged even the most cherished and long-held belief, then he would not hesitate to change the belief.

The religious quality of Pavlov’s dedication to science is seen both in the integrity with which he applied the scientific method and also in the otherwordly, utterly regular pattern of his daily life. Many young Russians of that era, often students who had been expelled from a university after some disturbance or another, were prepared to sacrifice their lives in an attempt to assassinate a Czarist minister. The commitment to science shown by Pavlov took a different form, for which the only obvious inspiration was not some Christian martyr, but his uncle, the abbot. In a monastery the austerity and rigid adherence to a fixed sequence of daily rituals function to strengthen belief; in a scientific laboratory equally regular routines can be employed to test beliefs and establish new ones. Pavlov’s late commitment to the view that the mind can be explained only in physiological terms reflected the unusual extent to which he was willing to change his outlook to one wholly consistent with his experimental findings. At a time of life when most people rest content with the philosophy they have arrived at, and when many scientists may first begin to show some tolerance for more subjective points of view or other metaphysics, Pavlov moved in the opposite direction.

Pavlov’s research was not impelled by a search for discoveries that could be directly beneficial to mankind. Even though his career was sustained by the institutional framework of professional medicine which provided the resources for his work, he was not very interested in questions concerning the cure or prevention of illness. Throughout his studies of the heart and the digestive system of the 1880s and 1890s and during the first decade of research on conditioning his only concern was with the question of how the system normally functions.

His studies might well have carried on in this manner and continued to focus upon the central phenomena of conditioning for the last twenty-five years of his life. A major factor that led Pavlov to explore the wider implications of his research was his conflict with Vladimir Bechterev. Even before hearing of the early work on conditioning in Pavlov’s laboratory, Bechterev had begun to develop ideas about a new, objective kind of psychology that would work in close partnership with the neurosciences and would apply itself to problems in the real world, notably those related to mental illness. After severely bruising Bechterev’s reputation, Pavlov started to expand his own interests beyond central questions on the nature of conditioning into topics which Bechterev had previously studied, such as neurosis, as well as new ones, such as the basis of individual differences.

The old man whom Shaw’s black girl met in the forest was proud of the light he had shed ‘on the great problems of human conduct’. Pavlov’s claims about sleep, personality and experimental neurosis ensured that his conditioned reflex attracted a great deal of attention. In recent years these claims have not been widely respected; most have seemed either too simplistic or inadequately supported by convincing
evidence. Pavlov's lasting achievement for psychology has been the enormous amount of basic information on the nature of conditioning in animals that was gathered in his laboratory for nearly forty years, after Wolfsohn first discovered that the kind of spittle a dog produced at the sight of a handful of sand was identical to the spittle released when the sand was placed in its mouth.