a long time, until, finally, a stronger wave of excitation effaces these inhibitory points.

The same mechanism of auto-suggestion produces in a hysterical person a multitude of other symptoms, some of which are rather ordinary and frequent and some extraordinary and highly peculiar.

Any slight sensation of pain or the slightest anomaly in any organic function engenders in a hysterical person the fear of becoming seriously ill; and this suffices not only to maintain these sensations, again by means of the above-described mechanism, but to reinforce them and bring to such a pitch of intensity as to render the subject invalid. However, this time it is not the positive aspect of the sensation that is responsible for its frequent reproduction and predominant action in the cortex, as is the case in war hysteria, but, on the contrary, its negative aspect. This, naturally, makes no difference as regards the essence of the physiological process. Unquestioned cases of phantom pregnancy accompanied by corresponding changes in the mammary glands, by an accumulation of fat in the abdominal wall, etc., are examples of peculiar manifestations of hysterical auto-suggestion. This is further confirmation of what has been said in the physiological introduction to this article concerning the cortical representation not only of the activity of all organs, but of separate tissues. At the same time this testifies to the extreme emotivity of hysterical persons. It is true that in this case the maternal instinct, powerful in itself, reproduces by auto-suggestion such a complex and specific state of the organism as pregnancy, at least certain of its components. The same mechanism is responsible for the states and stigmas of religious ecstatics. It is a historical fact that the Christian martyrs endured their tortures with patience, even with joy, and when dying, lauded those for whom they sacrificed themselves; this is striking proof of the power of auto-suggestion, i.e., of the strength of concentrated excitation in a

definite cortical region, excitation accompanied by a very intense inhibition of all other parts of the cortex representing, so to speak, the fundamental interests of the entire organism, its integrity, its existence. If the power of suggestion and auto-suggestion is so great that even the destruction of the organism can take place without the slightest physiological resistance on its part, then, in view of the already proved high ability of the cortex to influence the processes of the organism, it is easy to understand from the physiological point of view the partial violation of the organism's integrity produced by suggestion and auto-suggestion by means of trophic innervation, the existence of which has been also proved.

It is, therefore, impossible not to see the erroneousness of the extreme point of view put forward by Babinski,[56] although in general he correctly appraises the fundamental mechanism of hysteria. In his view the only symptom that should be regarded as hysterical, is the one provoked or eliminated by suggestion. This conclusion overlooks the extreme intensity and incessant action of the given emotivity, which cannot be produced in a full measure deliberately by suggestion, especially since the real cause and nature of this emotivity may remain unrevealed.

Finally, it is necessary to touch on the fantasticism of hysterical persons, on their detachment from reality and frequent twilight states. It can be assumed that these symptoms are interconnected. As shown by the observations made by Bernheim[57] and others on hypnotised normal subjects, as well as by our observations on dogs mentioned in the physiological part of this article, we must distinguish in hypnotism a number of gradations, beginning with a state, which hardly differs from wakefulness and ending with complete sleep.

In order to embrace and fully understand all the degrees of hypnosis, especially in man, I think it is neces-

sary to dwell on the following problems, which have not only been insufficiently elaborated by science, but are not even properly formulated.

Life clearly reveals two groups of human beings: artists and thinkers. There is a striking difference between them. The first group, artists of all kinds—writers, musicians, painters, etc., perceive reality as a single whole, i.e., the entire living reality without breaking it up or decomposing it. The other group, the thinkers, on the contrary, dismember it, thereby, as it were, killing it and making of it a kind of temporary skeleton; only afterwards do they gradually as if anew assemble its parts and try to revive it, but this, however, they are unable fully to accomplish. This difference is particularly manifest in the so-called eudetism of children. I recall a case which greatly amazed me forty or fifty years ago. In a family of a marked artistic disposition the parents used to entertain their two- or three-year-old child (and amuse themselves at the same time) by showing him a collection of twenty or thirty photos of different relatives, writers, actors, etc., and simultaneously pronouncing their names. The effect was that the child memorised the photos and then called all the persons represented on them by their proper names. But how great was the general surprise one day when it was discovered that the child could give the right names by looking even at the back of the photo. Apparently in this case the brain, the cerebral hemispheres, perceived the optic stimulations in exactly the same way as a photographic plate reacts to the fluctuations of the intensity of light or as a phonographic disc records the sounds. And this, perhaps, is the essential feature of any kind of artistic faculty. Generally, such an integral reproduction of reality is inaccessible to a thinker. That is why the combination in one and the same person of great artist and great thinker is an exceedingly rare phenomenon. In the overwhelming majority of cases they are represented by

different individuals. Of course, in the mass there are intermediates.

I believe that there are definite physiological grounds, although as yet not very convincing, for interpreting the matter in the following way. In the artist the activity of the cerebral hemispheres, while developing throughout their entire mass, least of all involves the frontal lobes and concentrates mainly in other parts; in the thinker, on the contrary, it is most intense in the frontal lobes.

Repeating what I have just said, for the sake of systematisation, I view the higher nervous activity as a whole like this. In higher animals, including man, the first system establishing complex correlations between the organism and the external environment is represented by the subcortex adjacent to the cerebral hemispheres with its highly complex unconditioned reflexes (in our terminology), or instincts, drives, affects, emotions (in the usual diverse terminology). These reflexes are produced by a relatively limited number of unconditioned external agents, or in other words, those which act right from the day of birth. Hence, a limited capacity of orientation in relation to the surrounding world and at the same time a low degree of adaptation. The second system is represented by the cerebral hemispheres, excluding, however, the frontal lobes. It is here that a new principle of activity arises with the help of conditioned connection or association—the signalisation of a limited number of unconditioned external agents by a countless number of other agents, which at the same time are constantly subjected to analysis and synthesis and ensure very wide orientation in relation to the same medium and thereby a much higher degree of adaptation. This is the only signalling system in the animal organism and the first signalling system in man. In the latter another system of signalisation is added; it can be assumed that this system relates to the frontal lobes,[58] which in animals are much less developed than in man. It represents a signalisation of the first signalling system by means of

speech and of its basis or basal component—kinesthetic stimulations of the speech organs. In this way a new principle of nervous activity arises—abstraction and at the same time generalisation of the countless signals of the first signalling system which is again accompanied by analysis and synthesis of the new generalised signals—a principle which ensures unrestricted orientation in relation to the surrounding world and the highest degree of adaptation, namely, science, both in the form of human universal empiricism and in specialised forms. This second system of signalisation and its organ, representing the latest acquisition in the process of evolution, are bound to be most fragile and susceptible to diffused inhibition when it arises in the cerebral hemispheres at the initial stages of hypnosis. Then, instead of the activity of the second signalling system, usually predominant in the alert state, the activity of the first system comes to the fore, liberated from the regulating influence of the second system; at first it takes the more stable form of reverie and fantastic imagination and subsequently the more acute form of a twilight state or light sleep (corresponding to the intermediate state between sleep and wakefulness or to the state of falling asleep). Hence the chaotic character of this activity, which no longer reckons with reality, or if it does, then only slightly, and is mainly dependent on the emotional influences of the subcortex.

From what has been said it will not be difficult to appreciate from the physiological point of view what the clinicians term disturbance of psychical synthesis in hysteria (the expression used by Pierre Janet) or the split "ego" (Raymond's expression). Instead of a co-ordinated and well-equilibrated activity of the three systems mentioned, in hysteria this activity is continually dissociated, and the natural and law-governed interdependence of the systems is deranged; meanwhile the interconnection and proper interdependence of the work of these systems con-

stitute the foundation of a sane personality and underlie the integrity of our "ego".

In the final analysis, different combinations of the following three particular physiological phenomena are constantly manifest and make themselves felt against the fundamental background of cortical weakness in hysterical persons: quick susceptibility to varying degrees of hypnotic states due to the fact that even normal life stimuli are super-powerful and are accompanied by transmarginal diffused inhibition (the paradoxical phase); extreme fixation and concentration of the nervous processes in definite points of the cortex due to the predominance of the subcortex; and, finally, undue intensity and extensity of negative induction, i.e., of inhibition caused by low resistibility of the positive tone of other cortical parts.

In conclusion, I take the liberty of saying a few words about hysterical psychoses. A case of this kind of psychosis has been demonstrated to me; it is a case of hysterical puerilism in a woman of more than forty, who became ill as a result of severe shocks experienced in family life. She was unexpectedly deserted by her husband who some time later also deprived her of her child. After an attack of stupor and a general prolonged paresis the woman sank into dotage. At present she behaves like a child, without, however, manifesting any obvious general defects in the intellectual and moral sphere or in personal life. A closer examination of the patient shows that everything seems to be accounted for exclusively by the absence of the analytical inhibition which always accompanies our behaviour, our movements, words and thoughts and which distinguishes the adult from the child. Does not the development of our personality consist in the fact that under the influence of education and religious, social and civic requirements, we gradually learn to inhibit, to repress that which is not admitted, which is prohibited by the factors just mentioned? Is not our behaviour in the family circle or in the company of friends quite different in all respects

from that under other conditions? The universal experiments of life prove this beyond all doubt. Do we not constantly encounter the fact that in fits of passion, which overcome the cortical inhibition, men speak and act in a manner which they regard as inadmissible when they are calm? And do they not bitterly regret such behaviour when the fit of passion recedes? This is particularly evident in the state of alcohol intoxication when all brakes are abruptly switched off, as aptly expressed in the Russian proverb: to the drunkard the sea seems up to his knee.

Will this patient ever return to a normal state? Well, it depends. The psychiatrists affirm that in youth such a state persists only for hours or days, although it is sometimes more protracted. In the given case it is a state of relative calm and satisfaction; it is probably determined by the previously described nervous mechanism, which makes the patient take refuge in illness in order to escape the difficulties of life and owing to which this pathological state may in the end become irremediably habitual. On the other hand, the disturbed and overstrained inhibition may weaken and disappear altogether.

Is hysteria in general a curable disease from the physiological point of view? In this respect everything depends on the type of nervous system. It is true that the predominant and encouraging impression produced by our work on conditioned reflexes in dogs is that the cerebral hemispheres offer great possibilities for their training, although naturally these possibilities are not unlimited. When dealing with an extremely weak type we can, in exceptional, so to speak, hot-house experimental conditions, obtain an improvement, a regularisation of the animal's general conditioned reflex activity, and nothing more. A durable transformation of the type is, of course, out of the question. But since certain hysterical reactions of a general physiological character can also take place in more or less strong types as a result of powerful stimulations or violent shocks, a full return to the normal is, of course, possible

in this case. However, the return can occur only if the series of shocks and excessive stimulations do not overstep their limits.

While it is impossible to read without keen interest the really brilliant pamphlet by Kretschmer on hysteria, in which the author reveals a strong and almost constant tendency to interpret the hysterical symptoms physiologically, Hoche's article in *Deutsche Medizinische Wochenschrift* in its January issue this year, makes a strange impression. Is it really the case that modern physiological knowledge does not throw any light on the mechanism of hysteria, that the clinic and physiology "have halted before hysteria as they would at closed doors"? The following reasoning in Hoche's article seems quite strange. Adhering to the view that analgesiae and paralyses constitute the fundamental feature of hysteria, he addresses the supporters of the theory of the pathogenic force of motives in hysteria with the question: Why would the strong indignation felt by some of his listeners and readers in consequence of his adverse opinion of the above-mentioned theory not render them insensitive to pain, if it were caused by a faradic current of high intensity? Then he cites other analogous cases: for example, why are the patients not cured by a similar method, i.e., by a strong desire to get rid of their illness, of their neuralgiae? In this connection I recall an instance from my student days which deeply impressed me and all who witnessed it. A young woman was undergoing a plastic operation on her nose which had been dreadfully deformed by some disease. Right in the middle of the operation the woman, to everyone's surprise, suddenly made a calm remark in response to something said by the professor performing the operation. Evidently, the anaesthesia (which was general) had practically no effect. Yet the same woman attracted general attention by the fact that during the daily dressing of the post-operative wound she exhibited extreme sensitivity to pain. Clearly the strong desire to get rid of the deformity, probably inten-

sified by sexual emotion, rendered the woman insensitive to the operation trauma and made her hope and believe that the surgical intervention would end in complete success. But after the operation, at any rate for a period immediately after it, when the coarse, strange-looking artificial nose bitterly and cruelly disappointed her, the same emotion, on the contrary, rendered her highly sensitive even to what was now carefully done to her nose.

Many cases of this kind are met in everyday life, as well as in history. When dealing with such cases, it is necessary to take into account: in strong and normal individuals the harmonious complex of strong emotions and of predominant cortical associations accompanied by an equally strong negative induction in all other parts of the cerebral hemispheres; in the weak nervous type—the hysterical mechanism described above.

PHYSIOLOGY OF HIGHER NERVOUS ACTIVITY[59]

Since this, I suppose, is my last opportunity to address a general meeting of my colleagues, I shall take the liberty of calling your attention to the general, most systematised and summarised results of my recent work, which I have carried out jointly with my esteemed fellow-workers and which comprises a full half of my entire physiological activity; naturally, I shall repeat many of the already published facts. I pass on to you the results of our work, passionately dreaming of the majestic, ever-widening horizon opening up before our science, and of the ever-growing influence exerted by science on human nature and human destiny.

For the anatomist and histologist the cerebral hemispheres have always been as accessible and tangible as any other organ or any other tissue, i.e., that they possess similar workability and are susceptible of investigation, but, of course, commensurately with their specific properties and construction. Quite different was the position of the physiologist. Every organ of the animal body, the general role of which in the organism is known, its actual function, and the conditions and mechanism of this function, are objects of study. As to the cerebral hemispheres, their role is well known—they effect the organism's most complex relations with the environment; but the physiologist did not engage in a further study of their activity. For him the study of the cerebral hemispheres did

not begin with the concrete reproduction of their activity, only after which the gradual analysis of the conditions and mechanism of this activity is possible. The physiologist possessed many facts relating to the cerebral hemispheres, but these facts were not manifestly and closely connected with their usual normal activity.

Today, after thirty years of diligent and ceaseless work jointly with my numerous collaborators, I make bold to say that the situation has radically changed, that while remaining physiologists, i.e., the same objective observers as in all other branches of physiology, we are studying at present the normal activity of the cerebral hemispheres and at the same time constantly analysing it in ever-increasing measure. The generally recognised criteria for every true scientific activity, namely, precise prevision and control over phenomena, testify to the serious character of this study, which is irrepressibly advancing, overcoming all obstacles. An ever-growing number of relations which constitute the most complex external activity of the higher animal organism, unfolds before us.

The central physiological phenomenon in the normal work of the cerebral hemispheres is that which we have termed the *conditioned reflex*. This is a temporary nervous connection between numberless agents in the animal's external environment, which are received by the receptors of the given animal, and the definite activities of the organism. This phenomenon is called by psychologists *association*. The fundamental physiological significance of this connection is as follows: in the higher animal, for example, in the dog which was the object of our investigations, the basic, most complex correlations established between the organism and the environment in order to preserve the individual and the species, are determined first of all by the activities of the subcortex which is nearest to the cerebral hemispheres; this was demonstrated long ago in Goltz's experiment with the extirpation of the cerebral hemispheres in a dog. These activities include the

search for food, or the alimentary activity; the avoidance of injurious factors, or the defensive activity, etc. They are usually called instincts or inclinations; psychologists term them *emotions*, but we designate them by the physiological term *most complex unconditioned reflexes*. They exist from the very day of birth and are indispensably called forth by definite, though very limited in number, stimuli which are sufficient only in early childhood, under the conditions of parental care. It is this latter circumstance that makes an animal with extirpated cerebral hemispheres disabled, incapable of a self-dependent existence. The basic physiological function of the cerebral hemispheres throughout the subsequent individual life consists in a constant addition of numberless signalling conditioned stimuli to the limited number of the initial, inborn unconditioned stimuli, in other words, in constantly supplementing the unconditioned reflexes by conditioned ones. Thus, the objects of the instincts exert an influence on the organism in ever-widening regions of nature and by means of more and more diverse signs or signals, both simple and more complex; consequently, the instincts are more and more fully and perfectly satisfied, i.e., the organism is more reliably preserved in the surrounding nature.

The basic condition for the formation of a conditioned reflex is a single or repeated coincidence in time of indifferent stimuli with unconditioned reflexes. This is the same principle of coincidence in time, on the basis of which groups of various agents or elements of nature, both simultaneous and consecutive, are synthesised by the animal into units. In this way the *synthesis* is effected in general.

But owing to the complexity of the permanent movement and variation of the natural phenomena, the conditioned reflex must, of course, also undergo certain changes, i.e., be constantly corrected. If for some reason or other the conditioned stimulus in the given conditions is not accompanied by its unconditioned stimulus, then, when repeated, it quickly loses its effect, however, temporarily, being re-

stored spontaneously, after a certain lapse of time. If the conditioned stimulus constantly and greatly precedes in time the moment when the unconditioned stimulus is added, then its distant part, which is, so to speak, premature and violates the principle of economy, proves ineffective. When the conditioned stimulus, connected with another indifferent one, is permanently not accompanied by an unconditioned stimulus, it remains, in this combination, ineffective. Finally, if agents closely akin to the given elaborated conditioned stimulus (for example, close tones, other spots of the skin, etc.) are usually effective immediately after the elaboration of the first one, they gradually lose their effect when repeated later on without the accompaniment of the unconditioned stimulus, or, in our usual terminology, without reinforcement. All this ensures the differentiation, the *analysis* of the surrounding world with all of its elements and moments.

In the long run, the cerebral hemispheres of the dog constantly effect in the most varying degrees both the *analysis* and *synthesis* of stimuli coming to them, and this can and must be termed *elementary, concrete thinking.* And it follows that this thinking is responsible for the perfect adaptation of the organism, for its more delicate equilibration with the environment.

This real activity of the cerebral hemispheres and of the nearest subcortex, just described in general outline, the activity which ensures normal complex relations between the organism as a whole and the external world, must be rightly considered and denoted as *higher nervous activity*, the external behaviour of the animal, instead of "psychical" as it was termed previously; it should be distinguished from the activity of other parts of the brain and of the spinal cord which are mainly in charge of the correlations and integration of separate parts of the organism; this activity should be termed the *lower nervous activity.*

Now the following questions arise: What intrinsic processes and laws govern the higher nervous activity? What

has it in common with, and how does it differ from, the lower nervous activity which until now has been the predominant object of physiological study?

The basic processes of the entire central nervous activity are, obviously, always the same, namely, the excitatory and inhibitory processes. There are sufficient grounds for assuming that the fundamental laws governing these processes are also of a constant nature—irradiation and concentration of the processes and their reciprocal induction.

It seems to me that experiments with conditioned reflexes on the cerebral hemispheres, given normal conditions, permit a more complete and exact formulation of these laws than was possible on the basis of experiments performed mainly on the lower parts of the central nervous system, and which, in most cases, were acute experiments.

Concerning the cerebral hemispheres we can say that the following phenomenon is observed in them: when the excitatory and inhibitory processes are weak, then, under the action of corresponding stimuli there takes place irradiation, diffusion of the processes from the point of origin; when they are of medium strength, a concentration of the processes occurs at the point of application of the stimulus, and when they are very strong, irradiation is again in evidence.

In the entire central nervous system, on the basis of irradiation of the excitatory process, a summation reflex sets in, i.e., a summation of the spreading wave of excitation with a local manifest or latent excitation; in the latter case the latent tonus becomes revealed—a phenomenon already known for a long time. While in the cerebral hemispheres the confluence of waves irradiating from various points leads to a quick development of a temporary connection, to an association of these points, it bears a momentary, transient character in the remaining part of the central nervous system. This connection in the cerebral hemispheres probably owes its emergence to their

extremely high reactivity and ability to impress, and is a permanent and inherent property of this part of the central nervous system. Moreover, in the cerebral hemispheres the irradiation of the excitatory process instantly and for a short period of time eliminates, washes off the inhibition from the inhibitory, negative points of the hemispheres, converting these points for the same period of time into positive ones. This phenomenon is called disinhibition.

Under the irradiation of the inhibitory process there is observed a decline or complete disappearance of the effect of the positive points and an increased effect of the negative points.

When the excitatory and inhibitory processes are concentrated, they induce the opposite processes (both at the periphery during their action and in the place of action upon its termination); this is the law of reciprocal induction.

In the entire central nervous system when there is a concentration of the excitatory process, we meet with phenomena of inhibition. The point of concentration of the excitation is encircled to a greater or lesser extent by the inhibitory process; this is the phenomenon of negative induction. This phenomenon manifests itself in all reflexes, develops at once and in full measure, persists for some time after the termination of excitation and exists both between the small points and the large parts of the brain. We call this external, passive, unconditioned inhibition. This phenomenon, which has also been known for a long time, was sometimes called the conflict of centres.

There are in the cerebral hemispheres also other kinds or cases of inhibition, in all probability, having one and the same physicochemical substratum. This is, in the first place, the inhibition effecting the correction of the conditioned reflexes, already mentioned and arising when the conditioned stimulus in the above-indicated conditions is not accompanied by its unconditioned stimulus; it gradually grows, becomes stronger and can be trained and perfected; this, too, is due to the exceptional reactivity of

the cortical cells, and hence to the particular lability of inhibition in them. We call this inhibition internal, active, conditioned. The stimuli, which are thus converted into permanent agents of inhibition in the points of the cerebral hemispheres, are called by us inhibitory, negative. Similar inhibitory stimuli can be also obtained in another way—if we repeatedly apply indifferent stimuli during the inhibitory state of the cerebral hemispheres (experiments of Prof. Volborth[60]). As is known, the initial inhibitory reflexes are also developed in the lower parts of the brain and in the spinal cord; but here they appear at once in a finished and stereotyped form, while the same inhibitory reflexes of the cerebral hemispheres arise gradually and are always observed by us in the process of formation.

There is one more case of inhibition in the cerebral hemispheres. All other conditions being equal, the effect of conditioned stimulation, as a rule, is proportionate to the intensity of the physical strength of the stimulus, but to a certain maximum (and probably to a certain minimum, too). Beyond this limit the effect does not increase; it either remains unchanged or declines. We have grounds for assuming that beyond this margin the stimulus together with the excitatory process evoke also an inhibitory process. We interpret this fact in the following way. The cortical cell possesses a certain limit of efficiency, and beyond this point there arises inhibition which prevents an excessive functional exhaustion of the cell. The limit of efficiency is not constant; it undergoes both acute and chronic changes—in cases of inanition, hypnosis, disease and in old age. This inhibition, which can be called transmarginal, arises sometimes instantaneously and sometimes manifests itself only when the super-powerful stimuli are repeated. It can be assumed that analogical inhibition also exists in the lower parts of the central nervous system.

Peculiar internal inhibition could also be considered as transmarginal inhibition, in which case the intensity of excitation is, as it were, replaced by its long duration.

Any inhibition irradiates in the same way as excitation but the irradiation of internal inhibition is particularly distinct in the cerebral hemispheres where it is very easily observed in various forms and degrees.

There is no doubt that inhibition, when spreading and deepening, calls forth different degrees of a hynotic state, and when irradiating to the utmost from the cerebral hemispheres down the brain, produces normal sleep. Particularly manifest, even in our dogs, is the diversity and multiplicity of the stages of hypnosis, which at first hardly differs from the wakeful state. In respect of intensity of inhibition the following stages are worth mentioning: the so-called equalisation, paradoxical and ultraparadoxical phases. Now conditioned stimuli of different physical strength produce either an equal, or even an inversely proportional effect; in rare cases only the inhibitory stimuli act positively, and the positive stimuli are converted into inhibitory ones. In respect of extensity of inhibition, functional dissociations in the cortex itself are observed, as well as between the cortex and the lower parts of the brain. In the cortex the motor region is particularly often isolated from other regions, and even within this region a distinct functional dissociation sometimes comes to the fore.

Unfortunately, the rivalry of what the clinicians and some experimenters designate "the centre of sleep" prevents these facts from being generally recognised and properly utilised for an understanding of the multitude of physiological and pathological phenomena. However, it is not difficult to reconcile and combine these facts. Sleep can be originated in two ways—either by irradiation of inhibition from the cortex, or by limiting the stimulations reaching the higher parts of the brain both from without and from within the organism. Strümpell[61] long ago produced sleep in a patient by means of drastic limitation of external stimulations. Recently Prof. Speransky and Galkin[62] by means of a peripheral destruction of the olfactory, auditory and visual receptors in dogs obtained a very

deep and chronic sleep (lasting weeks and months). Similarly, as a result of a pathological or experimental exclusion of stimulations, constantly reaching the higher part of the brain there sets in due to the vegetative activity of the organism an exaggerated and more or less profound and chronic sleep. It can be recognised that in some of these cases too, sleep, in the final stage, is produced by similar inhibition which becomes predominant when the number of stimuli is limited.

The law of reciprocal induction begins to operate when there is a concentration of the inhibitory process, just as it does when there is a concentration of the excitatory process. The point of concentration of the inhibition is to a greater or lesser extent encircled by the process of heightened excitability; this is the phenomenon of positive induction. The heightened excitability arises either instantly or gradually and persists not only during the action of inhibition, but for some time after, and in some cases even for a quite considerable length of time. The positive induction manifests itself between the small points of the cortex, when the inhibition is fragmentary, as well as between the large parts of the brain, when it is more diffused.

The permanent operation of the above-mentioned laws helps us to understand the mechanism of the origin of the numerous separate phenomena (among which are many peculiar, at first sight enigmatic, phenomena) of the higher nervous activity; however, I cannot dwell on them here. I shall refer only to one of a series of similar cases which for a long time completely baffled comprehension. It relates to the complex influence of accessory stimuli on the delayed conditioned reflex (experiments performed a long time ago by our colleague Zavadsky).

Let us suppose that a delayed conditioned reflex is being elaborated, the conditioned stimulation constantly lasting three minutes before the unconditioned stimulus is added to it. When such a reflex has been elaborated, the conditioned stimulus does not produce any effect during the first

minute. Half-way through or towards the end of the second minute the stimulus begins to produce a certain effect, and maximum effect is attained only during the third minute. Thus, the conditioned reflex consists of two external phases—ineffective and effective. Special experiments, however, have established that the first phase is not a zero phase, but an inhibitory one.

Now, if simultaneously with the conditioned stimulus there are applied accessory stimuli of different intensity calling forth only an orienting reaction, a number of changes are observed in the delayed reflex. When the stimulation is weak the ineffective phase becomes effective, that is, the special effect of the conditioned stimulus is manifested; the effect of the second phase either remains unchanged or is slightly increased.

When the stimulation is more intense the same thing occurs with the first phase, but the effect of the second phase drastically declines. Under the strongest stimulation the first phase again remains ineffective, while the effect of the second completely disappears. At present, on the basis of the latest, not yet published, experiments carried out by our colleague Rikman, we interpret all these phenomena as a result of the operation of the following four laws: 1) irradiation of the excitatory process, 2) negative induction, 3) summation, and 4) the law of maximum. Given a weak orienting reflex the spreading wave of excitation eliminates the inhibition of the first phase; this reflex, which soon all but disappears when the same stimulation is continued, either does not influence the second phase at all, or, owing to a slight summation, somewhat intensifies it. With a more considerable orienting reflex the effect persists longer; consequently, along with the disinhibition of the first phase, due to a considerable summation of the effective phase of the conditioned reflex with the irradiated wave of excitation of the orienting reflex, transmarginal inhibition takes place during the last minute of the delayed reflex. Finally, given a very strong orienting

reflex there takes place a complete concentration of excitation accompanied by a strong negative induction which merges with the inhibition of the first phase and abolishes the effective phase.

Despite the fact that a multitude of particular relations between the excitatory and inhibitory processes have been studied by us, the general law of the interconnection of these processes cannot, as yet, be exactly formulated. As for the profound mechanism of both processes, many of our experimental facts incline us to the point of view that the inhibitory process is probably connected with assimilation, just as the excitatory process is naturally connected with dissimilation.

As for the so-called *voluntary volitional movements,* in this field, too, we have accumulated some material. In keeping with earlier investigations we have shown that the motor region of the cortex is first of all a receptor one, like all its other regions—visual, auditory, etc., since the animal's passive movements, i.e., the kinesthetic stimuli of this region can be transformed by us into conditioned stimuli in the same way as all external stimuli. Another ordinary phenomenon, reproduced by us also in the laboratory, is the temporary connection established between various external stimuli and passive movements which in response to certain signals evokes definite active movements of the animal. However, it is still not clear whether the connection between the kinesthetic stimulus and the corresponding motor action is of an unconditioned or of a conditioned character. Beyond this extreme point the entire *mechanism of volitional movement is a conditioned associative process* which obeys all the above-mentioned laws of the higher nervous activity.

The cerebral hemispheres are continually receiving countless stimuli both from the external world and the internal medium of the organism itself. These stimuli are conducted from the periphery along definite and numerous paths and, consequently, they first of all come to definite

points and areas in the mass of the brain. Thus we have before us in the first place a highly complex structure, a mosaic. Countless and varied positive processes enter the cortex along the conductor paths, and in the cortex itself they are joined by inhibitory processes. From each of the separate states of the cortical cells (and there is an infinite number of such states) a specific conditioned stimulus may arise, as constantly observed by us in the course of our investigation of the conditioned reflexes. All these meet, collide, must come together and be systematised. Thus, in the second place, we have a vast dynamic system.[63] We observe and study in the conditioned reflexes of our normal dogs this continual systematisation of the processes, this, one may say, constant tendency towards a dynamic stereotype. Here is a most illustrative fact. If we elaborate in an animal a number of conditioned positive as well as inhibitory reflexes from stimuli of different intensity, and apply them during a certain period of time from day to day at regular intervals between the stimuli and always in a definite order, we establish thereby a stereotype of processes in the cerebral hemispheres. This can be easily demonstrated. If we now repeatedly apply throughout the experiment at equal intervals only one of the positive conditioned stimuli (better, one of the weak stimuli), it will reproduce in the proper sequence the fluctuations in the strength of the effects, as they were represented by the entire system of the various acting stimuli.

Not only the establishment, but a more or less lasting maintenance of the dynamic stereotype, is a nervous task of considerable difficulty, the degree of which depends on the complexity of the stereotype and on the individuality of the animal. There are, of course, nervous tasks the solution of which requires even from animals of the strong nervous type painful efforts. Other animals react to any simple change in the system of conditioned reflexes, such as the introduction of a new stimulus, or even to a certain

transposition of the old stimuli, by complete loss of the conditioned reflex activity, sometimes lasting for a considerable period. Some animals can retain the proper system only if there are recesses in the experiments, i.e., if they are allowed certain rest. And finally, some animals show regular work only under a very simplified system of reflexes, consisting, for example, of two stimuli, both of them positive and of equal intensity.

It can be assumed that the *nervous processes in the cerebral hemispheres, when establishing and maintaining a dynamic stereotype,* are what we usually call *senses* in their two categories—positive and negative, and their extensive gradation of intensity. The processes of establishing a stereotype, of fully accomplishing it, of its maintenance and derangement are subjectively different positive and negative senses, and that has always been manifested in the motor reactions of the animals.

Our entire work gradually enabled us to establish various types of nervous system in our animals. Since the cerebral hemispheres are the most reactive and supreme part of the central nervous system, their individual properties, naturally, must determine to a great extent the principal nature of the general activity of each animal. Our systematisation of types coincides with the ancient classification of the so-called temperaments. There is the type with a strong excitatory process, but a relatively weak inhibitory process. Animals belonging to this type are aggressive and unrestrained. We call them strong and excitable or choleric. Next comes the type of strong and at the same time equilibrated animals, in which both processes are of equal strength. This is an easily disciplined and highly practical type which is met in two variations—quiet, sedate animals and active, lively ones. We name them respectively phlegmatic and sanguine. And finally, there is the weak inhibitable type, in which both processes are weak. We call such animals weak and also inhibitable since they are highly susceptible to external inhibi-

tion. They are cowardly and fussy and can be also characterised as melancholic, since everything constantly upsets them.

That our investigation of the higher nervous activity has taken the right road, and our definition of its phenomena, as well as our analysis of its mechanism are correct, is most convincingly proved by the fact that at present we are able in many cases to produce with great exactitude its functional chronic disturbances, and at the same time subsequently to obtain a return to the normal at will. We know which type of our animals can be easily turned into neurotics, we know how to achieve this, and the kind of disorder that will set in. The strong, but unequilibrated, excitable and weak inhibitable types prove to be the best objects for the elaboration of experimental neuroses. If an excitable animal is persistently offered such tasks, the solution of which requires strong inhibition, then it loses it completely and is deprived of the ability to correct the conditioned reflexes, i.e., ceases to analyse, to distinguish the stimuli reaching it as well as the intervals of time. Stimulations produced by the strongest agents have no noxious pathological influence in this case. With equal ease the weak inhibitable type becomes ill both under slightly strained inhibition and under the action of very strong stimuli; it either fully loses its conditioned reflex activity under our experimental conditions, or manifests it in a chaotic way. As for the animals of the equilibrated type, we did not succeed in inducing nervous disorders in them even by colliding the opposite processes, which is a particularly morbific method.

Bromide proved to be the most reliable remedy against neuroses, just as it is in the human clinic; as shown by our numerous and in many respects instructive experiments, it has a special bearing on the inhibitory process, greatly tonifying it. However, very strict dosage is essential; for the weak type the dose of bromide must be from five to eight times smaller than that for the strong type. Rest,

i.e., a recess in the experiments, often produces good results.

Among animals of the weak type there are frequent instances of natural neurotics.

We already have and we can even produce certain symptoms of psychotics: stereotypy, negativism and circularity.

Last year I specially acquainted myself with the clinic of human hysteria, which is regarded as being entirely or predominantly a mental disease, as a psychogenic reaction to the surroundings; as a result, I have become convinced that its symptomatology can, without any hesitation, be interpreted physiologically, from the point of view of the described physiology of the higher nervous activity, and I have expressed the conviction in the press.[64] However, some particulars of this symptomatology made us guess the existence of an addition which should be taken into consideration in order to get a general idea of the human nervous activity as well.[65] This addition relates to the speech function, which signifies a new principle in the activity of the cerebral hemispheres. If our sensations and notions caused by the surrounding world are for us the first signals of reality, concrete signals, then speech, especially and primarily the kinesthetic stimuli which proceed from the speech organs to the cortex, constitute a second set of signals, the signals of signals. They represent an abstraction from reality and make possible the forming of generalisations; this constitutes our extra, *specially human, higher mentality* creating an empiricism general to all men and then, in the end, science, the instrument of the higher orientation of man in the surrounding world and in himself. The extreme fantasticism, the twilight states of hysterical persons, and the dreams of all men, are nothing more than the vitalisation of the imaginative and concrete first signals, as well as of the emotions; the oncoming hypnotic state first of all switches off the organ of the system of the second signals—the most

reactive part of the brain, which always predominantly functions in the wakeful state, and which regulates, and at the same time to a certain degree inhibits both the first signals and emotional activity.

The frontal lobes, in all probability, represent the organ of this additional purely human mentality, but it can be assumed that it is subordinated to the same general laws of the higher nervous activity.

The foregoing facts, as well as the considerations based on them, are bound to lead to the closest connection between physiology and psychology—a development particularly observed in American psychology. In the 1931 Address of Walter Hunter, President of the American Psychological Association, despite strenuous efforts on the part of the speaker—who is a psychologist-behaviourist—to detach physiology from his psychology, it is absolutely impossible to see any difference between them. But even psychologists not belonging to the camp of behaviourists admit that our experiments with the conditioned reflexes have been of great help to the association theory of the psychologists. Other facts of a like nature could be cited.

I am convinced that an important stage in the development of human thought is approaching, a stage when the physiological and the psychological, the objective and the subjective, will really merge, when the painful contradiction between our mind and our body and their contraposition will either *actually* be solved or disappear in a natural way. Indeed, when the objective study of the higher animals, for example, the dog, reaches the level when the physiologist is able to foresee with absolute exactitude the behaviour of this animal under any conditions (and this level will be reached), then what will be left to prove the independent, separate existence of the subjective state, which the animal, of course, possesses but which is as peculiar as our own? When that occurs will not the activity of any living thing, man included, be indispensably regarded by us as a single, indivisible whole?

EXAMPLE OF AN EXPERIMENTALLY PRODUCED NEUROSIS AND ITS CURE IN A WEAK TYPE OF NERVOUS SYSTEM[66]

Last year I reported to the International Neurological Congress in Bern on our experimental neuroses only in most general outlines. Today I shall cite in detail an individual example of neurosis but recently thoroughly studied by Petrova, one of my oldest and most valuable collaborators.

In questions of pure experimental neuroses we cannot fail to begin with the question of the types of nervous system of animals (in our case—dogs). We distinguish three basic types: *strong*, even very strong, but *unbalanced*, in which inhibition is weak in relation to the excitatory process; *strong* and *balanced*, i.e., with both antagonistic processes on the same level, and *weak*, i.e., with both weak processes, but sometimes with either one or the other particularly weak. Of course, there are also different degrees or variations of these types, especially, the weak type. We have a considerable number of tests by which we determine these types and their degrees. We elaborate these tests gradually and in some cases must use them all for an unmistakable diagnosis.

Until now we have been able to produce pure experimental neuroses, i.e., caused only by difficult conditions of nervous activity, difficult nervous tasks, without any organic disorders only in the animals of the extreme types.

In them we can do it easily and by several methods. I shall now describe a case of a repeated neurosis in a dog of the weak type.

This dog looks like a cross between a mongrel and a fox terrier and weighs about 12 kg. By outward behaviour, work with conditioned (food) reflexes and some tests as to type, this dog was at first taken to be even a strong and balanced animal, but two subsequent tests, incontestably characterised it as a weak type. These were increased food excitability (leaving the dog without food on the eve of the experiment) and administration of considerable doses of bromides.

With increased food excitability in animals of strong types, either the effects of all conditioned positive stimuli increase (if the effects of the strong are not marginal), or (on the contrary) only the effects of the weak ones approximate to the strong.

Even large doses of bromides administered daily for many weeks and even months produce no impression on them, whereas in the strong and unbalanced types they produce even a useful effect, strengthening their inhibitory function and thus helping to regulate their nervous activity.

In our dog both these methods resulted in diminution, disturbance of the conditioned reflex activity: the effects of the positive stimuli diminished and the negative stimuli ceased to evoke total inhibition. In this case it was found that by gradually reducing the dose of bromides it was possible to reach a dose which was not only well tolerated, but which also somewhat improved the nervous activity. Earlier we made a mistake in our conclusion at this point: without suitably dosing the bromides we thought that for weak animals bromides were never beneficial and in a larger dose were even harmful.

Thus our animal belongs to the weak type, but of a moderate degree. Under usual conditions it works quite satisfactorily, since the system of six positive stimuli of different quality and strength and one negative, inhibitory

stimulus, stereotypically reproduced in the same succession and with the same intervals between the stimuli every day, constantly produces the same corresponding effects in this dog. The behaviour of the dog during the experiment is rather alert and uniform. In other words, it is an object fit for studying the conditioned reflexes. We have observed this situation for a period of 5 months.

Then we produce the neurosis.

Until now the inhibitory stimulus always acted only for a period of thirty seconds. During the next experiment we continue it for five minutes. The next day we repeat a five-minute inhibition. And this is enough radically to change everything in the dog, to make the dog acutely ill.

Not a trace has been left of the regular work with conditioned reflexes. Each day there is a new picture of the work. All the positive reflexes have uncommonly diminished and some have disappeared altogether. The inhibitory reflex has become disinhibited. Sometimes the ultra-paradoxical phase comes to the fore, i.e., the positive stimulus remains ineffective, and the inhibitory stimulus differentiated from it produces a positive effect. During the experiment the dog is extraordinarily excited, sometimes it has intense dyspnoea, and is very uneasy, or falls deeply asleep and snores, or manifests the highest degree of excitatory weakness by reacting sharply to the most negligible variation in the situation. It often refuses food, which is usually offered after each positive conditioned stimulus. In a word, any systematic work with conditioned reflexes on this dog is out of question and only a constantly extremely chaotic state of nervous activity is observed. The same thing is observed in the general behaviour of the dog. It has become difficult to put the dog in the stand and make it ready for the experiment, as well as to take it out of the stand after the experiment, because it is very impatient and unrestrained. Out in the open it also behaves very unusually and even strangely: for example, sprawling on the floor it lies on one side and in this manner reaches out

to somebody, etc., something it was never observed to do before. The attendants who bring the dog and take it away say that it has become rather mad.

Neither suspension of the experiments, i.e., rest, nor discontinued application of the inhibitory stimulus with its positive stimulus have exerted any favourable influence on the state of the animal. This state has not in any way improved and, rather deteriorating, has lasted for two months.

Then we have instituted treatment. Thirty or forty minutes before each experiment we give the dog 0.5 g of sodium bromide. Improvement is clearly marked on the following day and on the third day the dog becomes normal in every respect. Administration of bromides is discontinued after twelve doses. The dog is normal for another ten days.

We perform another experiment.

Among the old conditioned positive stimuli, instead of the loud, although not particularly loud, crackling, we use for 30 seconds, like all the other positive stimuli, extraordinarily loud crackling, which even our ears can barely tolerate, and then offer to the dog some food. The dog displays an intense reaction of fear, tries to get out of the stand and does not take food even after cessation of the stimulus. However, it responds with the usual reaction and takes food to the two usual stimuli that follow. Application of the extraordinary stimulus is limited to this one incident, but the following day the afore-described pathological state of the dog fully returns and, despite the additional interruptions for long periods (10-15 days) and regular rests for one or two days this state has persisted unchanged for more than a month.

The dog is given the same dose of bromides again; improvement is noted on the third day and towards the sixth-eighth day we have a quite healthy, normal animal. After ten doses administration of bromides is suspended.

We have thus ended the experiments before the beginning of our present vacations.

I think we can say without exaggeration that these experiments are, as it were, of a machine character. In the first place they show two disease-producing factors for the nervous system: overstrain of the inhibitory process and very strong external stimulation. Then, as a therapeutic factor, the great importance of restoring and strengthening the inhibitory process is clearly emphasised in both cases, since, on the basis of many of our other experiments, besides the foregoing experiment, we must ascribe to bromides a direct bearing on the inhibitory process, precisely as an agent which restores and strengthens it. And, lastly, exact doses of bromides corresponding to the types and degrees of nervous system must be considered of paramount importance.

FEELINGS OF POSSESSION *(LES SENTIMENTS D'EMPRISE)* AND THE ULTRAPARADOXICAL PHASE[67]

(Open Letter to Prof. Pierre Janet)

Would you deem it interesting to print this letter in your journal and at the same time express your views on the points made by me after careful study of the article published by you last year: "Emotions of the Persecution Delusion"?

I am a physiologist and of late, together with my colleagues, have devoted myself exclusively to study of the physiological and pathological work of the higher part of the central nervous system in higher animals (dogs), which corresponds to our higher nervous activity, usually called psychical activity. You are a neurologist, psychiatrist and psychologist. It seems that we should give proper consideration to our reciprocal work and co-operate in our research, for, after all, we are investigating the activity of one and the same organ (concerning which there can hardly be any doubt now).

The third part of your article attempts to interpret the feelings of possession. The basic phenomenon is that the patients objectivise their weakness, their imperfections, and attribute them to others. They want to be independent, but they are adamant in believing that other people regard them as slaves who are obliged to execute orders. They

want to be respected, but it seems to them that they are being insulted. They want to have their own secrets, but it appears to them that their secrets are constantly being disclosed. Like everybody else, they have their own intimate thoughts, but in their imagination these thoughts are being stolen from them. They have annoying habits or painful fits, but they ascribe them to other people.

You interpret this phenomenon in the following way. Many of the ordinary circumstances of life are very difficult, unbearable and painful for these patients. For instance, the presence at the dinner table of two ladies of the patient's acquaintance, towards whom she had never been ill-disposed before. This constant difficulty and the natural frequent failures fill the patients with anxiety and fear, and inspire in them the desire to get away from it all. Like children or savages, they attribute all their troubles to the malignant actions of others, and this signifies deliberate objectification. Further, you devote attention to the following detail: in all the cases cited by you, we have to do, in your terminology, with binary social acts: to be master or slave, give or steal, strive for solitude or seek company, etc. These contrasts are confused by the patients when they are in a state of depression, the disagreeable opposite usually bearing an objective character and relating to other people. For example, the patient passionately wants to be alone, locked up in her room, and actually she remains alone, but she is tortured by the thought that some malevolent person has contrived to get into the room and is watching her.

One cannot but agree with all the foregoing, which represents an extremely interesting psychological analysis. But I take the liberty of disagreeing with you on the interpretation of the last point. You repeat more than once that, contrary to the general belief, these contrasts are not so easily distinguishable. You say: "*To tell* and *to be told* form a single whole and the one is not easily distinguished from the other, as is usually believed." And further: "*The*

act of insulting and the act of being insulted are united by the general concept of insult; but the disorder shows that they may be confused, that one may be mistaken for the other." You explain this confusion by a rather complex combination of feelings.

Availing myself of the facts established and systematised by you, I have resolved to take another way and to interpret them physiologically.

Our general notion (category) of contraposition is one of the fundamental and indispensable general notions, which, along with all others, facilitates and controls normal thinking and even makes it possible. Our attitude towards the surrounding world, social environment included, as well as towards ourselves, would be distorted to a very great degree if there were constant confusion of opposites: I and not I; mine and yours; I am simultaneously alone and in company; I offend and I am offended, etc. Consequently, there must be a profound reason for the disappearance or weakening of this general notion, and, in my opinion, this reason can and must be sought in the fundamental laws of nervous activity. I think that in present-day physiology there are definite indications to this effect.

In the course of our study of the higher nervous activity by the method of conditioned reflexes we observed and investigated in our experimental animals the following precise facts. In different states of depression, inhibition (more often in various hypnotic states) the equalisation, paradoxical and ultraparadoxical phases are manifest. This signifies that the cortical nervous cells, instead of normally producing (within certain limits) effects proportional to the intensity of the stimulating agents, in states of various inhibition, begin to produce effects either of equal strength, or inversely proportional to the intensity of the stimulus, and even of an entirely opposite character; this means that the inhibitory stimuli produce a positive effect, and the positive stimuli a negative effect. I make so bold as to suppose that it is precisely this ultraparadoxical phase which

causes the weakening of the notion of contraposition in our patients.

All the conditions necessary for the development of an ultraparadoxical state in the cortical cells of our patients, are in evidence and have been clearly established by you. When these patients, being of weak constitution, come up against a multitude of life situations, they easily fall into a state of depression, anxiety and fear; they can, however, still desire or not desire something, they have their emotionally-reinforced and possibly concentrated ideas of what is desirable or undesirable (I am the master, not the slave; I want to be alone and not in company; I want to have secrets, etc.). And in such conditions this is sufficient to evoke in a fatal way an opposite idea (I am a slave; there is always somebody near me; all my secrets are being disclosed, etc.).

The physiological explanation of this phenomenon would be as follows. Let us suppose that a definite frequency of the metronome acts as a conditioned food positive stimulus, since its application is accompanied by feeding and, because of this, evokes a food reaction. Another frequency of the metronome acts as a negative stimulus, since it is not reinforced by feeding and produces, therefore, a negative reaction: the animal turns away when it is applied. The frequencies of the metronome beats constitute a physiological pair, the components of which, being opposites, are associated and at the same time reciprocally induced, i.e., one frequency stimulates and reinforces the action of the other. This is an exact physiological fact. Further, if a positive frequency acts on a cell which for some reason or other is in a weak state (or in a hypnotic state), then this frequency, according to the law of maximum, which is also a strictly established fact, inhibits the cell. This inhibition, in conformity with the law of reciprocal induction, conditions a state of excitation instead of inhibition in the other component of the associated couple. That is why the

stimulus related to the latter now provokes excitation, not inhibition.

This is the mechanism of negativisim or contralism.

If food is offered to a dog when it is in a state of inhibition (or hypnosis), i.e., when you induce it to positive activity—to the act of eating—it turns away and rejects the food. But when the food is moved away, i.e, when you give the dog a negative impulse aimed at inhibiting the corresponding activity, at discontinuing the act of eating, the dog, on the contrary, begins to reach for the food.

Evidently this law of reciprocal induction of opposite actions must also be applied to contrary ideas, which, naturally, are connected with definite (verbal) cells and also constitute an associated pair. Due to a state of depression or inhibition (in our experiments any difficulty arising in the higher nervous activity is usually reflected by inhibition), more or less intense stimulation of one idea leads to its inhibition and, by means of the same mechanism, induces the opposite idea.

It is easy to see that this explanation naturally embraces the peculiar symptom of the schizophrenics—ambivalence—which arises under a highly extended and profound ultraparadoxical state.

Many people, even scientifically-minded people, are moved almost to the point of anger by the attempts to give a physiological interpretation of psychical phenomena; they retort that such explanations are "mechanical", since they want to stress as strongly as they can the obvious inaptitude and absurdity of trying to link subjective feelings and mechanics. In my view this is an obvious misunderstanding.

At present, of course, there can be no talk of representing our psychical phenomena *mechanically, in the full sense of the word.* We are also far from being able to do this with regard to all physiological manifestations; the same thing applies, although in lesser degree, to chemical phenomena, and it applies fully to physical phenomena. A

truly mechanical interpretation is still the goal of natural-science research; the study of reality as a whole, including ourselves, is advancing very slowly towards this goal, and much time will be required before it is reached. Modern natural science as a whole is but a series of many *stages of approximation* to this mechanical interpretation, stages linked throughout by the supreme principle of causality or determinism, according to which there is no action without cause.

And if possibilities are now opening up for explaining the so-called psychical phenomena physiologically, they can be regarded as a certain, slight, very slight degree of approximation towards a mechanical interpretation. It seems to me that in many cases these possibilities are opening up.

Being now at the psychological stage of your research, you are interpreting the feelings of possession, establishing the conditions under which they arise, reducing them to their elementary components and, in this way, elucidating their general structure, i.e., you are also dealing with their mechanics, with their general structure, but in your own way. I, in the physiological stage of my research, am trying to bring our common problem a bit nearer to true general mechanics, interpreting your fact concerning confusion of opposite ideas, as the specific interaction of elementary physiological phenomena—nervous excitation and inhibition. In their turn chemistry, and, finally, physics, will further disclose these phenomena and their mechanism, thus steadily approaching the solution of our problem.

ATTEMPT AT A PHYSIOLOGICAL INTERPRETATION OF COMPULSIVE NEUROSIS AND PARANOIA[68]

New laboratory facts obtained in studying conditioned reflexes on dogs served as the point of departure for a physiological interpretation of these pathological forms.

When conditioned stimuli are elaborated from various external agents (let us take, for example, conditioned food reflexes), the first reaction to the formed conditioned stimulus is usually a movement towards this stimulus, i.e., the animal turns to the location of this stimulus. When this stimulus is within our animal's reach, the latter tries to come in contact with it, especially by its mouth; for example, if the conditioned stimulus is a flashing bulb, the dog licks it, and if the conditioned stimulus is sound, the dog even catches air with its mouth (in cases of very high food excitability). Thus the conditioned stimulus really fully replaces, as it were, food for the animal. With different conditioned stimuli coming from different points in the environment the animal naturally turns to all of them.

Among other stimuli a conditioned stimulus of extraordinarily weak noise coming from under the right side of the table on which the animal stood was formed in one of our dogs (I. Filaretov's experiments). On perceiving this sound the animal stood on the very edge of the table, sometimes even placed one of its legs beyond the edge of the table and lowered its head as much as possible towards the source of the sound. The other conditioned stimuli were

located in various other places, but the dog preferred to turn to the location of the noise even when the other stimuli were used.

This fact appeared particularly strange when the noise was no longer used as a conditioned stimulus during continuation of the experiments with other stimuli. The motor reaction in the direction of the former location of the noise invariably existed and still continues to exist to date, eighteen months after suspension of this stimulus. During application of all the other stimuli, wherever they may have been, there was movement only in the direction of the location of the noise until the moment the dog was given food, when it, finally, turned to the feeding box.

Towards the end of the usual interval between applications of conditioned stimuli, i.e., before the next stimulus, dogs often develop certain food excitation (reflex of time) and turn to the location of the feeding box or to the location of some other conditioned stimulus. This dog continued to turn only to the location of the old noise.

This reaction must apparently be recognised as pathological, since it made no sense at all, i.e., it was coarsely, sharply at variance with the actual relations. Regarding it as such we decided to cure it. And if we could cure it, it would, of course, be further confirmation of its undeniable pathological character. We chose a suitable dose of bromides as a therapeutic agent, since we had already had many cases in which bromides had decisively helped in our experimental neuroses and even in certain inborn defects of the nervous system in general. Our expectations were justified. The reaction sharply diminished. With other conditioned stimuli it disappeared altogether, giving way to a legitimate, appropriate motor reaction to the location of these stimuli.

The same phenomenon was later also observed on some other dogs; in one of them bromides eliminated this abnormal reaction completely.

It is clear that what we have in the afore-described

facts is a pathological disorder of the function of nerve cells, a change in the normal relations between the two aspects of their activity (excitatory and inhibitory processes), i.e., the excitatory process abnormally prevailed. This was also attested by the favourable effect of bromides as an agent which is known to intensify the inhibitory function of the cell.

Overstrain of the excitatory process must most appropriately be regarded as the cause of the pathological phenomenon in the foregoing experiment, since the exceptional weakness of the external stimulus caused extraordinary strain of the orienting motor apparatus, the general locomotor, as well as the special, i.e., adjusting apparatus of the receptor of the given stimulation.

Another analogous fact was soon added to the aforedescribed fact. In one dog of the weak type, but of a stronger variant, and in castrated dogs of various types we attempted to investigate the solution of a difficult problem by them, namely, transformation of conditioned action into its opposite—a pair of metronomes with different frequencies of beats having antagonistic conditioned significance: positive and negative, i.e., transformation of a stimulus evoking the process of stimulation in the cerebral cortex into a negative stimulus, and of a stimulus eliciting the inhibitory process into a positive stimulus (Petrova's experiments). For this purpose the metronome having a well-elaborated positive effect was now used without accompaniment with food, and, contrariwise, with the inhibitory stimulus we now gave the dog food. In one of the castrates of an exceptionally strong type the transformation was quite successful; in the other animals experimented upon it seemed to begin, but then things came to a special pass. In some animals it even seemed that the aim was quite accomplished: the use of metronomes produced results corresponding to the new conditions of the experiment several times on end, but then, gradually or at once, everything completely returned to the old relations, although the trans-

formation procedure, already used dozens of times, was continued without interruption.

What did this mean, then? Did everything concerning the character of the excitatory and inhibitory processes now really remain unchanged in the cell despite the external similarity in the action of the metronomes at this stage of the experiments with their former action?

This had to be settled by a special investigation. The experiments we performed revealed serious disturbances of normal relations in the nerve cell. The excitatory process was now not what it had been before: it became more stable, less, so to speak, inclined to yield to the inhibitory process; or else we had to take it that the inhibitory process was very weak with the result that the excitatory process relatively predominated. Here are these experiments. When the metronome which evoked this modified excitatory process was used in the same experiment several times without reinforcement with food, i.e., it was extinguished, it diminished much less and much more slowly than the other positive stimuli under the same conditions. There was another peculiarity: after extinction of the stimulus that was being transformed we frequently scarcely noticed diminution in the usual scope of action of the other conditioned stimuli that followed it (secondary extinction). This denoted insufficient participation of the inhibitory process in the procedure of extinguishing this stimulus. On the other hand, during extinction (and even to zero) of other conditioned stimuli the stimulus we were investigating immediately after them often remained unchanged or was weakened but little, whereas the other positive stimuli diminished very much and were found to have a lesser effect even on the following day. Clear stability of the excitatory process of the cell together with weakening of the inhibitory process. At the same time our attention was further attracted by the fact that now there was a sharp difference between the other acoustic conditioned stimuli as regards the stability of the excitatory process.

The tone stimuli, farthest removed from the metronome in the character of sound, remained normal, while the stimuli with an element of knocking came closer, as regards stability, to the pathologically acting metronome.

In the experiment with transforming the effect of the metronome we, consequently, obtained the same abnormality as in the formerly described experiments; there—in the cells of the motor analyser, here—in the cells of the auditory analyser; there—during overstrain of the excitatory process, here—during collision of the antagonistic processes; both here and there bromides effected a return to the normal relations. The latter gave us one more reason to see one of the mechanisms of the new pathological phenomenon in the weakening of the inhibitory function of the cell and to understand why this phenomenon was observed on the castrated animals of the strong type. We had long since known that one of the essential effects of castration was weakening of the inhibitory function of the cell.

The aforesaid pathological phenomenon may be given several descriptive names: stagnancy, uncommon inertness, intensified concentration, and extraordinary tonicity.

From now on we shall prefer to use the term "pathological inertness".

The foregoing new facts are confirmation and extension of our old and more general fact that in the cerebral cortex it is possible to obtain experimentally by the functional method (i.e., without mechanical influence) a very limited pathological point. In our former experiments such a point represented a paradoxical or ultraparadoxical state, i.e., the stimulus related to it produced a greater effect when it diminished in strength and not contrariwise, as when it was normal, or even produced a negative instead of a positive effect. At the same time the given point could remain in such a state without affecting all the other points of the hemispheres or pass into the next stage of the pathological state in which stimulation of it with an appropriate stimulus led to disturbance in the activity of the

entire cortex manifested in general inhibition of this activity. Now we also had isolated pathological points of the cerebral cortex whose pathological state represented a special phase and was manifested in that the process of excitation in them became abnormally inert.

Thus we have adequate reason to assume that under the influence of various pathogenic causes of a functional nature *sharply isolated pathological points* or *regions* may arise in the cerebral cortex; at the same time we can expect this experimental fact to take place and be of great importance in the pathology of man's higher nervous activity.

I find it possible to assume that in stereotypy, iteration and perseveration as symptoms, as well as in the essence of the compulsive neurosis and paranoia, the basic pathophysiological phenomenon is the same, namely, what came to the fore in our experiments and what we have designated by the term "pathological inertness". Stereotypy, iteration and perseveration are a pathological inertness in the motor area of the cortex (general skeletal, as well as special speech motion), while in compulsive neurosis and paranoia it is a pathological inertness in other cortical cells connected with our other sensations, feelings and ideas. These last sentences must not, of course, exclude the possibility of emergence of the same pathological state also in the underlying parts of the central nervous system.

Let us go on to the, so to speak, clinical atmosphere in the different neuroses and psychoses of this pathological phenomenon, as one of the manifestations, one of the phases of the pathological state of the nerve cells. Stereotypy and perseveration form one of the frequent symptoms, for example, of hysteria. One hysteriac complains that once she begins to comb her hair she cannot stop, cannot finish it in due time. Another hysteriac cannot, as a result of a short catatonic attack, utter a word without repeating it many times in order to finish his sentence. These phenomena are encountered still more often in schizophrenia, even

characterise it, especially its catatonic form. Pathological inertness in the motor sphere is manifested now at individual points, and now embracing the entire system of skeletal muscles, as can be observed in some catatonic patients whose any group of muscles passively set in motion repeats this motion an enormous number of times.

Later we shall dwell especially on compulsive neurosis and paranoia as separate, independent diseases in which the phenomenon we are interested in is the main characteristic symptom or almost the whole disease.

To be sure, we can hardly contest the fact that, if pathological inertness is obvious and must be accepted as a fact in motor phenomena, the same thing is quite admissible, legitimate also as regards all the sensations, feelings and ideas. Who can doubt that the aforesaid phenomena are normally, of course, a manifestation of the activity of the nerve cells and, consequently, that compulsive neurosis and paranoia are a pathological state of the corresponding cells of the cerebral cortex, in the given case their pathological inertness. In compulsive neurosis and paranoia we have excessively, illegitimately fixed ideas, feelings and then actions which do not correspond to the proper natural and special social relations of man and therefore lead him into difficult, distressing, harmful conflicts with nature, as well as other men and, primarily, of course, with himself. But all this pertains only to the morbid ideas and sensations, while outside their sphere the patients think and act like quite healthy people and may even be higher than average persons.

Compulsive neurosis and paranoia are usually sharply distinguished as morbid forms clinically (the former is a neurosis and the latter—a psychosis). However this sharp distinction is not recognised by all neurologists and psychiatrists; some of them assume transitions from one form to the other, reducing their differences to degrees or phases of the pathological state and certain additional features.

The following are quotations from these authors. Pierre ınet says: "The delusion of persecution is closely related obsessive ideas and I am surprised that they have been ıtirely separated from each other." Kretschmer says: "In .e old disputable question of whether there are any essen-ıl differences between delusions and obsessive ideas we ın arrive at the exact conclusion in a negative sense." Mallet says: "In delusion and obsession ... the organic ımage is of the same nature."

The two pathological forms in question differ from each her in two basic features. In compulsive neurosis the ıtient is cognisant of the morbid nature of his pathologi-l state and as far as possible fights it, although on the ıole, unavailingly; the paranoiac does not have this crit-ıl attitude to his illness, he is in its power, in the power persisting sensation, feeling and idea. The second dif-ɾence is the chronic course and incurability of paranoia. But these distinguishing features of the two given forms not essentially exclude the identity of their basic symp-m. This is the more true since many clinicians observed lubitable transitions, both acute and chronic, of obses-ın with criticism into obsession without criticism. The ɔunds on which the general main symptom arose and ıat actually evoked it in each individual case could serve the difference between the two forms, as a basis for ɛir clinical distinction.

A few words about the basis and causes of the disease question, according to our laboratory material. We have ıg since observed on our animals that succumbing to dif-ent experimental neuroses under the influence of the ne pathogenic procedures depends on the inborn type of ɾvous system: only representatives of the weak type and ɛ strong but unbalanced type easily succumb to the dis-ɜe. Of course, by intensifying the pathogenic procedures was possible, in the long run, to overcome, break down ɔo the balanced strong type, especially if some organ-trauma, for example, castration, was added beforehand.

In particular, during the transformation of antagonistic conditioned reflexes as a procedure with which we produced the afore-described pathological inertness, there was an enormous variety of results, both within normal limits and with pathological deviations, depending on the individuality of the animals. In strong and entirely normal types this transformation proceeds properly to the required end, but in a very different tempo and with different variations and details of the transformation. In a giant of nervous power (even after castration), whose equal I never saw during the thirty years of my work on conditioned reflexes, this transformation began from the first time and without any variations was entirely ready by the fifth time. In others, numerous repetitions of the procedure failed to produce complete results: sometimes the new positive stimulus remained weaker than the former one, and sometimes the new inhibitory stimulus failed to come down to zero, as the former one. In one animal it was the positive stimulus that was transformed sooner, in another it was the negative. All this concerns cases of successful transformation. The same diversity was observed in pathological deviations during the solution of this problem: as already mentioned in the beginning of this article, we observed now one of these deviations and now another. The pathological inertness, as one of the morbid phasic consequences of the transformation, similarly rapidly passes into another form of the disease or remains more or less constant. In the weak type the pathological inertness usually quickly passes into another pathological state. Chronic pathological inertness is often observed in castrated animals of the strong type.

I have intentionally dwelt somewhat longer on our laboratory material in order to show how different the solution of the same life's problem must be in people, depending on the difference in the types of nervous system, and how different the pathological consequences must be when abnormal types fail to solve this problem.

So much for the basis. As for the immediate causes of the disease in question, we have seen in our present experiments (as yet not numerous) two causes producing it: in one case it is a strong and prolonged stimulation, i.e., overstrain of the process of excitation, and in another case it is a clash of the antagonistic processes.

When we deal with people, we must naturally also bear in mind different causes, as well as different bases which must, of course, lead to different degrees, as well as a different course, even if of the same basic pathological disorder.

The very first cause studied on our animals opens a long series of possible cases of the disease investigated in man. Both, an abnormal development and a temporary aggravation of one of our emotions (instincts) as well as the pathological state of some internal organ or a whole system may send to corresponding cortical cells, at a certain time or continuously, incessant or excessive stimuli and thus, at last, evoke in them a pathological inertness—an obsessive idea or sensation, when the real cause has already ceased to act. The same thing could be effected by some strong, staggering life's impressions. No fewer, if no more, cases of pathological inertness should also have been produced by our second cause, since all our life is a continuous struggle, a clash of our basic strivings, desires and tastes with the natural, as well as the special social conditions.

The aforesaid causes could concentrate the pathological inertness of the excitatory process at different points of the cerebral cortex—now in the cells directly stimulated by the external, as well as internal agents (first signalling system of reality), now in different cells (kinesthetic, auditory and visual) of the verbal system (second signalling system), and at both points with different degrees of intensity: once on the level of ideas, and the next time bringing the intensity up to a power of real sensations (hallucinations).

On our dogs we observed that sometimes, owing to pathological inertness, the effect of an appropriate stimulus sharply rose above the healthy effects of the other stimuli.

As for the basis, it must naturally be the same for compulsive neurosis and paranoia, i.e., susceptibility to disease, as in our laboratory material; but this will be, however, either the weak type or the strong but unbalanced type of nervous system. And we know from our laboratory experience how essential this difference is for the immediate character of the disease. In this respect one can hardly raise any objections to the legitimacy of transferring this conclusion from animals to man. Of course, besides the inborn basis, cases of unstable, fragile nervous system engendered by unfortunate events are inevitable; these include injuries, infection, intoxication and life's great misfortunes.

Thus the difference between our two pathological forms, as regards their chronic nature and incurability, is determined by the difference in the immediate impulses to the disease, as well as the types of nervous system. The immediate impulses may be, on the one hand, temporary, transitory, and on the other, continuous and constant, till the end of life. In its turn the excitatory process is either generally relatively weak, unstable in its nature, and easily yields to the inhibitory process in the weak type, or is strong from the very beginning, stable, and generally predominates over the inhibitory process. It stands to reason, that during pathological inertness there are few or no chances at all in the latter case that this inertness may sometimes be entirely eliminated or reduced to the lowest degree which is relatively normal for the given animal. To confirm this we can cite the following fact from our laboratory material. Whereas in one of the dogs with a compulsive movement, belonging to the rather strong type, bromides have only sharply weakened, limited this compulsion, in a dog of a clearly weak type the compulsion entirely disappeared under the influence of bromides. Moreover, as

was mentioned before, a more chronic pathological inertness was most frequently encountered in castrates of the strong type. In connection with this E. Bleuler's remark is of some interest; in the latest edition of his textbook he says that he would not like to regard as accidental, in the cases well studied by him, the coincidence of paranoia with sexual inadequacy.

As for the other sign of difference between the two forms in question (absence of critical attitude to the pathological symptom in paranoia and its presence in the compulsive states), it must naturally be reduced to the difference in intensity of pathological inertness. As the aforesaid indicates, the strong type must have considerable pathological inertness of the excitatory process and this will naturally be connected with greater independence and even its invulnerability to the influence of the healthy regions of the cortex, which physiologically conditions the absence of a critical attitude. Besides, it is probable that the inert excitatory process of considerable intensity must produce on the periphery, on the basis of the law of negative induction, strong and widespread inhibition, which must again lead to the same result, i.e., exclusion of the influence of the rest of the cerebral cortex on it.

We shall illustrate our general considerations by particular examples taken from life. Let us take a person of the excitable type, i.e., one in whom the excitatory process is not balanced with the inhibitory process. Let a rather frequent striving for domination prevail in his emotional (instinctive) make-up. Since childhood he has always strongly wished to advance, to be the first, to lead the others, elicit admiration, etc. But at the same time nature failed to endow him with any outstanding talents, or, if he did have them, they were unfortunately not recognised in due time, or else, the conditions of his life prevented him from making due application of them, and he concentrated his energies on activity for which he was unfit. Inexorable reality naturally prevented him from achieving his goal: he

had won neither influence nor success, but, on the contrary, deserved rebuff and knocks, i.e., he never had any luck. All he could do was to submit, reconcile himself to the role of a modest worker, i.e., inhibit his aspirations. And yet there was no necessary inhibition, while this emotion constantly and imperatively demanded its satisfaction.

Hence, at first, further extraordinary but vain efforts in his hapless occupation or change to another with the same results and then, according to the property of his type (strong), a shrinking into himself with his internal satisfaction and constant vivid idea of his real or imaginary gifts and vital rights and privileges together with the additional idea of the intended hindrances and persecution on the part of those around him. This naturally results in a sufficiently conditioned phase of pathological inertness at the corresponding points of the cortex, which has destroyed the last remnant of inhibition in them. And now we see the absolute power of the idea which, not by active inhibition on the basis of other associations, other signals, witnesses of reality, but by passive inhibition, a process of negative induction, has excluded all that does not suit it and has become transformed into a fantastic idea of imaginary greatness, imaginary successes. Since the emotion lives to the end of the subject's life, the pathological idea also exists with it but remains isolated without interfering with anything that does not come in contact with it. Before us is true paranoia in Kraepelin's sense.

Now I take concrete cases from Kretschmer's[69] book *Der sensitive Beziehungswahn.* It is a question of two girls of the rather weak type, but practical, modest, and pretentious only as regards their religious, moral and social decency and not their life's rights and privileges; the pretence of the latter kind is very frequently, nearly always, combined with the strong excitable type.

A mature girl experiences normal sexual desire for a young man, but the individual, ethical and social requirements have not allowed, have always hindered her from

gratifying this desire, i.e., there is a clash of nervous processes. The result is a difficult state of nervous activity and it is manifested in pathological inertness in the parts of the cortex which are connected with the struggling feelings and ideas. The girl acquires an irresistible, obsessive idea that her face shows the sexual urge in the form of coarse sensuality. In the clinic she hides her face into a pillow even from the physician. Naturally, she has already avoided going out into the street because she thought that everyone looked at her, spoke about the expression of her face and laughed. Until then, however, it had all remained within the limits of the really possible, although imaginary. Then comes a leap which is unintelligible as the work of even pathologically fixed thought. Under the influence of a chat with a girl-friend who asserted that in the Garden of Eden Eve had talked to the serpent not as to a mental, but as to a sexual seducer, our patient immediately developed an unexpected and irresistible idea and sensation that she had a serpent in her which was constantly moving and that sometimes its head reached her throat. Here we see a new inert idea. But how, by what process did it arise? Kretschmer called this phenomenon inversion, considering it a reflex inversion (*reflektorische Umschlag*).

As regards an identical phenomenon in another clinical case Kretschmer says that "it has emerged reflexly, without logical mediation, even in direct contradiction to it". But what kind of reflex is it? Where does it begin and how does it end? We have this process, we know it in the laboratory and can interpret its physiological mechanism. Moreover I deem it essential to say, to emphasise, that in this case the physiological and psychological particularly clearly overlap, merge, and, one may say, become identical.

Let us recall the two antagonistically acting metronomes, one stimulatory and the other one—inhibitory. If general inhibition develops in the cortex, for example, in the form of hypnosis, or local inhibition in the region of the metronome's action, the positively acting metronome becomes

negative and the negatively acting one—positive. This is the so-called ultraparadoxical phase.

It is this physiological fact that we encounter in the afore-described leap in our patient. The girl had a strong and constant idea of her sexual purity, inviolability, considering it, under certain conditions, morally and socially shameful to have sexual desire, even though suppressed and not in the least gratified. On the basis of general inhibition, in which state our patient found herself and which in weak nervous systems usually accompanies a difficult state, this idea was irresistibly physiologically transformed into its opposite (slightly disguised), into an idea even bordering on a sensation of having the sexual seducer in her very body. This is exactly what happens in the delusion of persecution: the patient wants to be respected, and yet he is tormented by a contrary and erroneous idea of being constantly insulted, or he wants to have secrets, and yet he has the obsessive idea, the contrary thought, that all his secrets are discovered by others, etc. I have already expressed this physiological interpretation in an open letter to Professor Pierre Janet as regards the feelings of possession (*les sentiments d'emprise*).

This delusion is based on two physiological phenomena —pathological inertness and the ultraparadoxical phase, now existing separately, now appearing together, and now replacing each other.

On the whole, almost the same thing happened to the second girl. The same clash of the natural sexual desire with the practical and persistent thought of the incompatibility of ages: the object of her love was much younger. The same results, to the point of inversion; moreover, this patient was tormented by the absurd idea that she was pregnant, whereas the object of her love did not even note her dispositon for him because she was restrained in manifesting her feelings.

In this case traced by Kretschmer over a period of many years one could clearly see how the obsessive ideas and

sensations sometimes reached a degree of ideas and sensations which, according to the patient herself, were very real and which, she did not know, were pathological, how they persisted in this form for some time and then were again interpreted by the patient objectively as manifestations of disease. This was connected with life's trials and tribulations and, consequently, with a change in the state of the nervous system, which now recovered and now was again depressed and weakened. Finally, as time wore on, everything naturally ended well.

I was very happy to come across the theory of the French psychiatrist Clérambault in one of the few books on neurology and psychiatry I have read. This theory considers the appearance of what he calls "mental automatism", "parasitic words and ideas", about which the delusion later systematically develops, the primary symptom of paranoia. What else can we interpret as mental automatism, but the point of a certain pathologically inert excitatory process about which all that is close, similar and related concentrates (on the basis of the law of generalisation) and from which everything that is alien is repulsed, according to the law of negative induction?

I am not a clinician (I have always been a physiologist) and now, so late, I shall, of course, have no time and shall be unable to become a clinician. For this reason in my present observations, as in my former excursions into neuropathology and psychiatry, I dare not, in discussing corresponding material, claim sufficient competence from the clinical point of view. But I shall probably not be mistaken now if I say that clinicians, neurologists and psychiatrists must, in corresponding fields, inevitably regard as fundamental the following pathophysiological facts: the complete isolation of the functionally pathological (in the etiological sense) points of the cortex, as well as the pathological inertness of the excitatory process and the ultraparadoxical phase in them.

GENERAL TYPES OF ANIMAL AND HUMAN HIGHER NERVOUS ACTIVITY[70]

The mode and standards of our own behaviour, as well as of the behaviour of the higher animals close to us and with which we are in constant vital relations (for instance, dogs), represent a great, a truly boundless variety, if behaviour is considered as a whole, in its smallest details, especially as manifested in man. But since our behaviour, as well as that of higher animals, is determined and controlled by the nervous system, it is possible to reduce the above-mentioned variety to a more or less limited number of basic properties of this system, with their combinations and gradations. This makes it possible to distinguish between the types of nervous activity, i.e., between these or other complexes of the basic properties of the nervous system.

The observation and study of a large number of dogs, using the method of conditioned reflexes, carried out in our laboratory for many years, have gradually disclosed to us these properties in their vital manifestations and combinations. These properties include: in the first place, the *strength* of the basic nervous processes—excitatory and inhibitory—which always constitute the sum total of nervous activity; in the second place, the *equilibrium* of these processes; and, finally, in the third place, their *mobility*. It is obvious that while all these properties exist and act simultaneously, they provide the highest adaptation of the ani-

mal's organism to the surrounding world, or, in other words, the complete equilibration of the organism as a whole with the external environment, i.e., they secure the organism's existence. The significance of the strength of the nervous processes is clearly shown by the fact that in the surrounding medium there arise (more or less often) unusual, extraordinary developments, powerful stimuli, and that, naturally, other external conditions of a similar and even greater force not infrequently necessitate the suppression or retardation of the effects of these stimuli. And the nervous cells must endure this extraordinary tension in their activity. From this also follows the importance of equilibrium between both processes, their equal strength. Since the organism's external environment is constantly—and often powerfully and abruptly—fluctuating, both processes must, so to speak, keep pace with these fluctuations, i.e., they must possess great mobility and be able, in compliance with the demands of the external conditions, rapidly to recede, to give preference to one stimulus, to excitation before inhibition and vice versa.

Leaving aside the gradations and considering only the extreme cases, only the limits of fluctuation, viz., strength and weakness, equality and inequality, lability and inertness in both processes, we obtain eight combinations, eight different complexes of basic properties of the nervous system, eight types of the nervous system. If we also take into account that in the absence of equilibrium the predominance may, generally speaking, be on the side now of the excitatory, now of the inhibitory process, and that in the case of mobility, inertness or lability may also become a property now of one, now of the other process, then the number of possible combinations increases to twenty-four. And finally, if we also take into consideration even the rough gradations of the three basic properties, we shall thereby again greatly augment the number of possible combinations. However, only extensive and thorough observation can establish the presence, frequency and intensity of

these or other actual complexes of basic properties, of the actual types of nervous activity.

Since normally our general behaviour, as well as that of higher animals (we imply here healthy organisms), is directed by the higher part of the central nervous system—by the cerebral hemispheres and the adjacent subcortex—the study of this higher nervous activity under normal conditions by the method of conditioned reflexes is bound to lead to knowledge of the actual types of nervous activity and the basic standards of behaviour of human beings and higher animals.

It seems to me that this problem was solved—of course, only in general outline—by the Greek genius in his system of the so-called temperaments, where the basic components of the behaviour of human beings and higher animals were exactly emphasised and advanced, as we shall show in our further exposition.

But before proceeding to our factual material, I must touch on one very substantial and so far almost insurmountable difficulty connected with the definition of the type of nervous activity. Human and animal behaviour is determined not only by congenital properties of the nervous system, but also by the influences to which the organism is continuously subjected during its individual existence; in other words, it depends on constant education and training in the broadest sense of these words. This is due to the fact that along with the above-mentioned properties of the nervous system, another very important property incessantly manifests itself—its high plasticity. Consequently, since this is a question of the natural type of nervous system, we must take into account all the influences to which the organism has been exposed from the day of its birth to the present moment. With regard to our experimental material (i.e., our dogs) in the overwhelming majority of cases the fulfilment of this requirement still remains a passionate desire. We shall be able to fulfil it only when our dogs are born and reared before our eyes.

under our unremitting observation. We shall soon have convincing corroboration of the importance of this requirement. So far there is only one way of overcoming the above-mentioned difficulty: it is necessary to increase and to diversify the forms of our diagnostic tests as much as possible in the hope that in this or that case we shall succeed in bringing to light the specific changes in the natural type of nervous system that were determined by the definite influences of the individual existence; in other words, by means of a comparison with all other features of the type we shall reveal both the more or less disguised natural features and the elaborated, acquired ones.

Right from the very beginning of our experiments with dogs based on the method of conditioned reflexes we (like others) were struck by the different behaviour of the bold and the cowardly dogs. The former offered no resistance when led to experimentation; they remained quiet in the new experimental conditions, both when they were placed in the stands mounted on tables, and when certain apparatuses were attached to their skin and even placed in their mouths. When food was given to them by means of an automatic device, they began to eat it at once. Such was the behaviour of bold animals. But the cowardly animals had to be accustomed gradually to the procedure—a process which required days and even weeks. Another difference was observed when we began to elaborate conditioned reflexes in these dogs. In the first case the conditioned reflexes developed rapidly, after the application of two or three combinations; they reached considerable strength and remained constant, no matter how complicated the system of reflexes. In the second case, on the contrary, the conditioned reflexes were formed very slowly, after many repetitions; their strength increased at a very low rate, and they never acquired stability, being sometimes even at zero, no matter how considerably their system was simplified. It was, therefore, natural to assume that in the first dogs the excitatory process was strong, while in the second

it was weak. In the bold dogs the excitatory process, which from the biological point of view arises properly and in time, for instance, at the sight of food, constantly resists minor influences, remaining, so to speak, legitimately predominant. In the cowardly dogs the strength of the excitatory process is insufficient to overcome conditions which are less important in the given case and which produce what we term external inhibition; for this reason we say that such dogs are inhibitable. In the bold dogs even physically excessive external stimuli, when conditionally connected with physiologically important functions, continue to serve their purpose without bringing the nerve cell to a pathological state; thus they represent an exact index of the intensity of their excitatory process, of the strength (i.e., working capacity) of their nerve cells.

It is here that the specific difficulty, which I have just mentioned made itself felt. All the dogs which seemed to us cowardly, i.e., which only very slowly became accustomed to our experimental conditions and formed conditioned reflexes with difficulty (since their entire conditioned reflex activity was easily disturbed by insignificant new external influences), were regarded by us, quite groundlessly, as belonging to the weak type of nervous system. This even resulted in a blunder—at one time I regarded these dogs as experts in inhibition, i.e., as being strong in this respect. The first doubts as to the correctness of this diagnosis arose in connection with the external behaviour of these animals in their habitual surroundings. Further, it seemed strange that their conditioned reflex activity, despite its high complexity, should be of a perfectly regular character so long as the surrounding conditions remained strictly uniform. But the final solution was found thanks to a special investigation. We (Vyrzhikovsky and Mayorov) took a litter of puppies and divided it into two parts: half of the puppies, from the very day of their birth, were kept in the kennel, the others were given complete

freedom. All the animals of the first group turned out to be cowardly and susceptible to inhibition given the slightest changes in the surroundings; in the animals of the second group nothing of the kind was observed. It became clear that when the puppies first appeared in the external environment they were provided with a special reflex, sometimes referred to as a panic reflex, but which I suggest should be termed an initial and temporary reflex of natural caution. The moment acquaintance with the new environment begins it is necessary to wait some time for the consequences of any new stimulation, no matter which receptor it affects, i.e., to abstain from any new movement and to repress the existing movement, since it is not known what the new phenomenon promises the organism, whether harmful, useful, or of no consequence at all. And only in the course of the gradual acquaintance with the environment is this reflex replaced, little by little, by a new, special, investigatory reflex, and, depending on its effect, by other corresponding reflexes. The puppy, which is not given the opportunity to gain this practical experience independently, retains the persisting temporary reflex for a very long time if not for life, and the reflex constantly disguises the real force of the nervous system. What a vital pedagogical fact this is! A sure sign of this unduly persisting feature, apart from the fact that in many respects it contradicts other stable inborn features, is the inhibitory action not so much of the particularly strong stimulations but of the new stimulations—no matter how weak they may be in themselves (Rozental, Petrova).

Thus, the strength of the excitatory process was regarded by us as the first property of the type of nervous system. Hence the initial division of all our dogs into strong and weak ones.

Another property of the nervous system, clearly observed by us and according to which the animals are subdivided into new groups, is the equality or inequality of the two opposite nervous processes—excitation and inhibition. We

imply here the higher active cortical inhibition (or according to the terminology used in the theory of conditioned reflexes—internal inhibition), which, together with the excitatory process, continuously maintains the equilibration of the organism with the surrounding medium and helps (on the basis of the analysing function of the organism's receptors) to distinguish between the nervous activity corresponding to the given conditions and moments and that which does not (extinction, differentiation and retardation).

The significance of this property was first observed by us in dogs with a very strong excitatory process. We soon noticed that whereas in such dogs positive conditioned reflexes were formed rapidly, inhibitory reflexes, on the contrary, were elaborated very slowly, with obvious difficulty; this was often accompanied by a violent resistance on the part of the animal; it was manifested either in destructive actions and barking, or, on the contrary, in stretching out the forepaws, as if imploring the experimenter to release it from the task (the latter, however, is rarer). At the same time, these reflexes are never fully inhibited; they are often disinhibited, i.e., greatly deteriorate in comparison with the degree of inhibition obtained previously. The following phenomenon is usually observed: when we subject the cortical inhibition in such animals to severe strain by means of very delicate differentiation, or by a frequent or protracted application of difficult inhibitors, their nervous system becomes fully, or almost fully, deprived of the inhibitory function; real neuroses set in, typical and chronic nervous diseases, which must be treated either by allowing the animals a very long rest, i.e., by a complete discontinuance of the experiments, or by giving bromide. Together with such animals, there are others in which both nervous processes are at an equally high level.

Consequently, the strong animals are divided into two groups—equilibrated and unequilibrated. Unequilibrated

animals belonging to the category described above are met with quite often. It might seem that there should also be unequilibrated dogs of another kind, namely, with a predominance of the inhibitory process over the excitatory. But so far we have not met with such absolutely incontestable cases, or at least we have not been able to discern them. However, we have had fairly obvious and not infrequent cases when, after a time interval and with the help of gradual and repeated exercises, the initial disequilibrium levelled out to a considerable degree. And this is just another instance when the natural type of nervous system proved to be disguised to a great measure as a result of lifetime training.

Thus, we have a perfect group of strong and equilibrated dogs. However, the animals with this type of nervous system differ greatly, even in appearance. Some are extremely reactive, mobile and lively, i.e., as it were, extremely excitable and alert. Others, on the contrary, are only slightly reactive, sluggish and self-contained, i.e., in general, so to speak, little susceptible to excitation, inert. This difference in the general behaviour must, of course, be due to a specific property of the nervous system and may be best accounted for by the mobility of the nervous processes. Like everybody else we long ago observed this external difference between animals, but we lag considerably in elucidating, on the basis of the conditioned reflex activity, its cause—the mobility of the nervous processes. Only now is this mobility being systematically investigated on two dogs—strongly pronounced representatives of the latter group. Strong and equilibrated, these animals differ greatly in external behaviour. On the one hand, we (Petrova) have an exceedingly lively and reactive animal, on the other (Yakovleva)—an extremely inert and indifferent one. The different mobility of the nervous processes in these animals is distinctly manifested in their conditioned reflex activity which, unfortunately, was not investigated in identical experiments.

The first animal ("Boy") even in the course of usual experimentation with conditioned reflexes displays an amazingly rapid transition from extreme excitation at the beginning—when being placed in the stand and equipped with the apparatus—to a state of petrifaction, to a statuesque posture, and, at the same time, to a good working state in the course of the experiment. In the intervals between the conditioned food stimuli the animal remains in a very strained posture, evincing no reaction to extraneous accidental stimuli; but under the action of conditioned stimuli a strictly recurring salivary reaction sets in immediately, and the dog gulps the food placed before it. Subsequently, this high mobility of the nervous processes, their rapid interchange, manifested themselves, so to speak, with incredible force also in the course of special experiments. In our "Boy" we long ago elaborated two opposite conditioned reflexes to a metronome; one frequency of the metronome acted as a positive conditioned food stimulus, while the other acted as a negative inhibitory one. We then began to reverse the action of the metronome. The negative stimulus was reinforced, i.e., it had to be transformed into a positive stimulus, while the positive one was no longer accompanied by feeding and had to be converted into an inhibitory stimulus. Next day we were able to observe the onset of this reversal and by the fifth day it had been fully accomplished—a rare case of such rapid transformation. One day later an error was made—the metronomes were applied in accordance with their previous significance, namely, the old positive stimulus was again reinforced, while the old inhibitory stimulus was left without reinforcement; as a result, the old relations were immediately re-established. When the error was corrected, the new relations again quickly reappeared. But this dog presented a truly wonderful, unprecedented example of the formation of a delayed reflex. Generally the elaboration of a delayed reflex, when one and the same stimulus during different periods of its action produces now an inhibitory,

now an excitatory effect, is in itself a difficult task. But its elaboration after a long experience of short-delayed reflexes, and even during it, is a truly complicated task, one that cannot be accomplished by the overwhelming majority of dogs and which in successful cases requires much time, even many months. Our dog accomplished this task in the space of a few days. What an extraordinary rapid and free use of the two opposite processes!

All that has been said about this dog entitles us to state that it represents the most perfect type, since it ensures strict equilibration with all that is taking place in the external environment, no matter how strong the stimuli are—both those to which the response must be positive activity, and those the effect of which must be inhibited—and no matter how quickly these different stimuli may interchange. It should be added that these extremely difficult tests were endured by the dog after it had been castrated.

The very opposite, in relation to the property of the nervous system under consideration, is the other dog ("Zolotisty", used by Yakovleva), whose general behaviour has been characterised above. Particularly manifest in the study of the conditioned reflex activity of this dog was the impossibility of obtaining a constant and adequate salivary food reflex; it fluctuated chaotically, often falling to zero. What did this signify? If the reflex tended to be strictly related to the moment of reinforcement, i.e., of feeding, why did it fluctuate and not become constant? This could not have been caused by insufficient inhibition, since we knew that the dog could endure protracted inhibition. Besides, the absence of preliminary salivation is by no means a manifestation of perfection; on the contrary, it indicates an obvious defect. Indeed, the importance of this salivation consists in the fact that the food introduced into the mouth immediately meets with the substance it needs. That this interpretation conforms to reality is proved, in the first place, by its universality, and, in the second

place, by the fact that the extent of the preliminary salivation, which is biologically indispensable and important, always strictly corresponds to the amount of food. The natural explanation for the peculiarity of our dog must be sought in the fact that the initial inhibition, which exists in each delayed conditioned reflex—the period of retardation (or the latent period, as we called it previously)—although strong, is obviously insufficiently labile to keep within the proper time, and owing to inertness, oversteps the normal limits. None of the measures aimed at obtaining a constant salivary effect was successful.

Since the excitatory and inhibitory processes were strong in the dog, it was offered a very difficult task, one, however, that is satisfactorily solved by some other dogs. Among other elaborated conditioned stimuli, and at different moments of this system of reflexes, a new stimulus was applied four times in the course of the experiment, but it was reinforced only when applied the last time; this was a task which required all the resources of the nervous system, and above all a high mobility of the nervous processes. Our dog did its best to solve this problem in a roundabout way, holding on everything which could be a simple, ordinary signal of the fourth reinforced application of the new stimulus. First of all it made use of the noise produced by the food receptacle which was moving before its eyes; during the first three applications of the new stimulus, when no food was offered and consequently no movement of the food receptacle took place, the dog remained in sitting posture. When, during the intervals between the stimulations, empty food receptacles were placed before it in order to deprive it of the signal connected with the reinforcement, it looked into them to see whether there was any food, and only when this was the case, did it stand up (usually it was sitting). When the receptacle was placed too high so that the dog could not see whether it contained anything, it rejected the food altogether, remaining in sitting posture regardless of the

stimulus applied. In the case of a positive stimulus, it was necessary to enter the chamber and show the dog that the receptacle contained food, i.e., to invite it to eat, and only then did it begin to eat. Then both the new stimulus and the presentation of empty receptacles were discontinued. Only the old stimuli were applied, of course accompanied by reinforcement. And only *gradually* did the dog begin to rise under the action of the stimuli and to eat. Again the reflex evoked by the empty receptacle was extinguished. The dog continued to rise under the action of the old conditioned stimuli but—which was the usual thing with it—did not always exhibit any preliminary secretion of saliva. Now the new stimulus was again applied four times, being reinforced only the last time; during the first three applications the food receptacle was not placed before the dog, since, as has just been mentioned, the reflex to it had been extinguished. This time, too, the problem was solved by means of a simple, but new signal, namely, a complex stimulus formed from the new stimulus plus the noise of the moving food receptacle. When the new stimulus was applied for the first three times without the addition of the last stimulation, there was no reaction. But when during these first applications the receptacle was placed before the dog, but with no food in it, i.e., when the complex stimulus was depreciated, the dog, after rising several times in vain, definitely and completely ceased to react to the new stimulus, rising only under the influence of all the other stimuli. Then it was decided to restore the extinguished reflex to the new stimulus, abolishing all other stimuli and reinforcing the new stimulus eight times in succession in the course of the experiment. The rehabilitation of the reflex proceeded *very slowly*. The new stimulus was reinforced in the course of two days, that is, sixteen times, but despite the fact that the experimenter entered the chamber more than once and during the action of the new stimulus showed the food to the dog (only after which it rose to its feet and began to eat) it never

stood up by itself under the action of the new stimulus. At first the same thing was observed on the third day; only during the nineteenth application of the new stimulus, when it was prolonged after the expiration of the usual thirty seconds and when new food receptacles were placed at intervals of ten seconds, did the dog, at the fourth presentation of a food receptacle, rise and eat the food. And only later, at first with considerable omissions on the part of the animal, a motor food reflex formed; for the purpose of accelerating its full restoration the dog was more than once left without food for a space of twenty-four hours. Afterwards, on the fifteenth day, there finally developed a full reflex accompanied by a preliminary secretion of saliva, but, inconstant, as usual. On the twentieth day, in order to obtain a constant salivary reflex, the dog was given only half the usual portion of food and this reduced ration was offered for a period of ten days. But the aim was not achieved—the salivary reaction remained inconstant, and even the motor reaction manifested itself either at the end of the action of the conditioned stimulus or only after the presentation of the food receptacle. What striking inertness of the *inhibitory* process! After this, for a period of fourteen days, the dog was given only a quarter of the normal quantity of food, but this, too, hardly changed the picture as far as the reflexes were concerned.

Against this background we began once again to elaborate a new and extremely simplified differentiation: in strict alternation the new stimulus was now reinforced, now not; it was necessary to elaborate reflexes to a single rhythm. In a period of eight days we failed to observe even the slightest trace of a reflex. What striking inertness of the *excitatory* process! Thinking that this phenomenon was partly due to excessive alimentary excitability we increased the quantity of food to half the usual ration. As a result, the difference in the extent of the salivary reaction under reinforced and non-reinforced stimuli now began gradually to manifest itself, and finally a stage was reached when,

in the case of reinforced stimuli, the reaction became very considerable, while in the case of non-reinforced stimuli it fell to zero. However, the motor reaction persisted in all cases, although under positive stimuli it appeared quicker. When the experiments were prolonged in order to obtain a complete differentiation also of the motor reaction, the dog began to whine, at first before the experiment and then in the course of it, and tried all the time to escape from the stand. The motor reaction under a non-reinforced stimulus was fully differentiated in some experiments only when it came first in the experiment. The more time passed, the more difficult became the state of the dog; it no longer entered the experimental chamber of its own accord and when taken forcibly would turn back and run away. While in the chamber it kept on howling and barking. Under the action of stimuli the howling and barking became louder. This general behaviour was in striking contrast with the previous behaviour of the animal over a period of three years. In order to help the dog to attain complete differentiation, it was given a full daily ration of food; it gradually calmed down, went to the stand willingly, stopped howling and barking. At the same time a secretion of saliva was observed also under the action of a non-reinforced stimulus; then the salivary secretion induced by the action of the two kinds of stimuli began steadily to diminish until it reached zero. Finally, the motor reaction to a repeated stimulus also fully disappeared. The dog refused to perform its task and lay quietly throughout the experiment, searching for fleas or licking its body. After the experiment it devoured its food with avidity.

Thus, during the long period of the elaboration of a differentiation (the latter being at first difficult, and then quite simple), we observed the extreme inertness both of the excitatory and inhibitory processes. Particularly interesting and clear as to its mechanism was the last period—when a simple differentiation was being elaborated. Owing to a considerably heightened alimentary excitability this

differentiation was at last almost completely worked out, but it was accompanied by extreme excitement on the part of the animal; this testified to the difficult state of its nervous system. But when the alimentary excitability declined to the level usually displayed by all the dogs during the experiments, our previous success in keeping the opposite nervous processes within the time limits required by the external conditions was reduced to naught. It proved more difficult for the dog to interchange the excitatory and inhibitory processes at intervals of five minutes, i.e., to maintain the almost elaborated procedure, the already formed nervous stereotype, than to repress the rather strong alimentary excitation, under which all our dogs worked quite satisfactorily during the experiments; this excitation was also in evidence in our dog, as proved by the fact that it eagerly devoured the food placed before it after the experiments. This fact strikingly testifies to the great importance of the normal mobility of the nervous processes, as well as to its obvious and considerable insufficiency in our dog, whose nervous processes, however, possessed great strength.

It is now possible clearly to see how the Greek genius, personified (individually or collectively) by Hippocrates, succeeded in discerning the fundamental features in the multitudinous variations of human behaviour. The singling out of melancholics from the mass of people signified the division of the entire mass of human beings in two groups —the strong and the weak, since the complexity of life must, naturally, tell with particular force on individuals with weak nervous processes and darken their existence. Thus, the paramount *principle of strength* was clearly stressed. In the group of strong individuals the choleric is distinguished by his impetuousness, i.e., inability to repress his temper, to keep it within the proper limits; in other words, he is distinguished by a predominance of the excitatory process over the inhibitory. This, consequently, established the *principle of equilibrium* between opposite

processes. Finally, by means of a comparison between phlegmatic and sanguine types the *principle of the mobility* of the nervous processes was established.

There remains the question whether the number of basic variations of human and animal behaviour is confined to the classical figure "four". After years of observations, and as a result of numerous investigations on dogs, we acknowledge at any rate, for the time being, that this number conforms to reality; at the same time we admit that there are minor variations in the basic types of nervous system, especially in the weak type. In the strong unequilibrated type, for example, the animals with a particularly weak inhibitory process and, at the same time, quite a strong excitatory process, stand out. In the weak type the variations are, above all, based on the same properties which underlie the subdivision of the strong type into equilibrated and unequilibrated, active and inert animals. But in the weak type the feebleness of the excitatory process, so to speak, depreciates the significance of these other properties and actually makes this type, to a greater or lesser degree, an invalid one.

Now I shall dwell in more detail on the methods, on the more or less definite forms of experimentation already mentioned and which clearly disclose the basic properties of the types; I shall also touch on other, less manifest, forms, which are capable of demonstrating the same properties, though not so distinctly, and at the same time reveal to a greater degree the complexity of the type, even its entire outline. It should be added, however, that many forms of our experiments have not yet assumed definite importance in the solution of the problem of types. Of course, were our knowledge of the subject complete, everything observed by us in our animals, everything recorded by us, would find its proper place in this problem. But this is still far from being the case.

We have already mentioned a definite method of ascertaining the strength of the excitatory process, believing

that this strength is most inherent in the strong type. It is a physically most powerful external agent which the animal is able to endure and to turn, along with other less powerful stimuli, into a certain signal, a conditioned stimulus, which remains active for a long period. For this purpose we usually apply very strong sounds produced by a special rattle which our ear endures with difficulty. In some dogs this stimulus, when reinforced, could be developed, equally with all others, into a real conditioned stimulus, and even take first place among them by virtue of the law of proportionality between the extent of the effect and the intensity of the external stimulus. In other dogs, in accordance with the law of maximum, its effect declined compared with the other strong conditioned stimuli, however, without interfering with the action of the other stimuli. In still other dogs, when applied, it led to the inhibition of the entire conditioned reflex activity, without becoming a conditioned stimulus. And finally, there were dogs in which one or two applications of this stimulus immediately evoked a chronic nervous disorder—a neurosis which did not disappear of itself and had to be treated.

The second method employed in the case of conditioned food reflexes consists in augmenting alimentary excitability by means of a more or less protracted state of hunger. As a result, in dogs with a strong excitatory process the effects of the strong stimuli, in some cases, are increased; however, there also takes place a relatively greater increase of the effects of weak stimuli, so that they fully or almost fully approximate to the effects of the strong stimuli. In other cases the effects of the strong stimuli remain unchanged, since they have reached their limit and have even somewhat overstepped it; and only the effects of weak stimuli increase, to the degree that they may even exceed the effects of strong stimuli. But in dogs with a weak excitatory process, a heightened alimentary excitability usually leads to a decline in the effects of all stimuli.

The two methods make it possible to determine directly

the maximum possible tension of the nerve cell, the limit of working capacity, either directly by the application of extremely strong external stimuli or through the action of stimuli of average strength, provided there is heightened reactivity of the cell, that its state is labile, which is essentially the same thing.

The third method consists in administration of caffeine. In the strong type a definite dose of caffeine increases the effect of the excitatory process; in the weak type it diminishes this effect, causing the cell to overstep the limits of its working capacity.

The weakness of the excitatory process is manifested with particular distinctness, perhaps, in the following experiment; it relates to the course of the excitatory process during the period of the isolated action of the conditioned stimulus; the ascertainment of the effect is facilitated by dividing this period into smaller time units. Three cases are possible: the effect of stimulation may increase regularly and progressively until it is joined by the unconditioned stimulus; it may, on the contrary, be considerable at the beginning and then gradually diminish; and finally, fluctuations of the effect may be observed—now increasing and now declining during the above-indicated period. This fact can be interpreted in the following way. The first case might indicate the presence of a strong excitatory process developing irresistibly under the unceasing action of the external stimulus. The second case, on the contrary, can be interpreted as the manifestation of a weak process for the following reason. In particular cases, for example, after local extirpations of the cerebral cortex, when under usual conditions the effect of the corresponding stimulus disappears, it is still possible to re-establish it in a very weak form in the course of the following experiment. At first the corresponding stimulus is applied several times, being reinforced each time almost immediately after the beginning of its action (in one or two seconds); then, when there is a considerable delay (twenty to thirty seconds),

a positive effect is observed immediately after the beginning of the stimulation, which, however, declines rapidly, falling even to zero by the end of the isolated action of the stimulus. This is an obvious manifestation of the weakness of the excitatory process. Finally, the third case which is simply a struggle of opposite processes; the isolated action of the conditioned stimuli leads first to the development of inhibition, since each of our conditioned reflexes is a delayed reflex, i.e., one in which the excitatory process, being premature, must, for a longer or shorter period, be preceded by an inhibitory process and temporarily eliminated.

An absolute, and not relative, determination of the strength of the inhibitory process can be effected, above all, by testing its duration, i.e., by finding out how long the nerve cell can endure a state of continuous inhibition. As mentioned above, the main principle underlying this distinction is as follows. The strong, but unequilibrated, animals, as well as the weak ones, cannot endure a protracted inhibition, with the result that the entire system of conditioned reflexes is temporarily disturbed, or a chronic nervous disorder—neurosis—sets in. The strong animals cannot endure this, since they possess a very strong excitatory process to which the inhibitory process, being sufficient in itself, does not correspond as far as intensity is concerned; this is a case of relative weakness of the inhibitory process. In weak animals both the excitatory and inhibitory processes may be weak—this would be a case of absolute weakness. When the inhibitory process is strong (specially differentiated) its instantaneous or chronic prolongation to a period of five to ten minutes may not evoke any disturbance at all, or cause only a very slight one. But when the inhibitory process is weak, its chronic prolongation, for example, to thirty seconds instead of fifteen, often cannot be effected without causing serious consequences; a prolongation to five minutes, even if effected once, is sufficient to cause a failure of the entire

conditioned reflex activity in the form of a persistent neurosis.

The second essential index of the strength of the inhibitory process is its ability rapidly and exactly to concentrate. Usually when an inhibitory process begins to develop at a definite point, it invariably first irradiates and produces a prolonged, successive inhibition. But as soon as the animal possesses a strong inhibition, the latter inevitably begins to concentrate to an ever-increasing degree and, finally, the successive inhibition wholly or almost wholly disappears. When the inhibition is weak, it may remain forever in a more or less pronounced form. The concentration of a strong inhibition entails an acute positive induction, i.e., one which appears immediately or after a short period of time; it is manifested in heightened excitability both in relation to the stimulus closest in time, and to the positive stimulus at the point of inhibition (on its termination).

Another index of the strength or weakness of the inhibitory process is the duration of the development of the inhibitory conditioned reflexes; the delay in elaborating an inhibitory reflex may be due to the very great strength of the excitatory process and, consequently, to the relative weakness of the inhibitory process, as well as to an absolute weakness of inhibition. But the end of the elaboration is still more instructive. No matter how long the elaboration of an inhibitory process may last, it remains incomplete forever; more often this takes place when the excitatory process is strong, when there is a relative weakness of the inhibitory process. In some cases the inhibitory process is obviously insufficient and reveals constant fluctuations, even to the extent of complete disappearance; this usually occurs in weak animals with an absolutely weak inhibitory process.

The weakness of the inhibitory process is also expressed in the fact that an almost complete inhibitory conditioned reflex can be obtained only when in the course of the

experiment it is evoked first, before any of the positive conditioned reflexes; but if it is evoked in between the latter, it becomes considerably or almost completely disinhibited.

Finally, the absolute weakness of the inhibitory process may also be seen from the animal's attitude towards bromide. In weak dogs only very small daily doses of bromide, not more than a few centigrammes, or even milligrammes, and at most amounting to several decigrammes, prove to be efficient and useful, i.e., maintain a considerable conditioned reflex activity. This fact is explained as follows: since bromide undoubtedly bears a relation to the inhibitory process, in the sense that it strengthens it, only a slight intensification of this process under the influence of bromide can be endured when there is an inborn weakness of the inhibitory process.

Probably the following phenomenon, too, should be taken into consideration when determining the strength or weakness of the inhibitory process. When a differentiation is elaborated along with a positive stimulus, two contrary consequences are usually observed: either the effect of the positive stimulus increases, or, on the contrary, there is a decline of the effect compared with the level before the differentiation. What do these facts signify with regard to the strength of the nervous processes? It can be assumed that here it is a question of the strength or weakness precisely of the inhibitory process. In the first case a strong inhibitory process concentrates and causes a positive induction; in the second case, being weak, it irradiates and continuously reduces the effect of its positive stimulus. A comparison with other more precise indicators of the strength of the nervous processes may help to establish exactly the mechanism of this phenomenon.

As regards determining the mobility of the nervous processes, until recently we, as mentioned above, did not pay special attention to this particular property of the nervous processes: hence, we do not possess, or to be more exact,

have not contemplated any special methods for determining it. Consequently, the job of elaborating them still remains, or the corresponding experimental forms must be selected from among those already at our disposal.

Perhaps a special and most precise method could be elaborated by means of trace conditioned reflexes. By changing, on the one hand, the duration of the indifferent stimulus, which must be turned into a special trace conditioned stimulus, and, on the other hand, the interval between the end of the indifferent agent and the beginning of the unconditioned stimulus that reinforces it, we shall be able directly to measure the degree of inertness or lability of the given nervous system. It can be anticipated, for instance, that, depending on the time needed for the disappearance of the trace of the stimulus which has ceased to act, the above indicated interval will be of essential importance for a quicker or slower elaboration of a trace conditioned reflex, or even for the possibility of its elaboration in general. The duration of the indifferent stimulus will likewise make itself felt. It is conceivable that in a particularly inert nervous system there will be specially and rapidly revealed for this stimulus the minimum duration under which it is still possible to elaborate a trace reflex.

Next come the methods already tried on two of our dogs which exhibited a striking contrast with regard to the mobility of their nervous processes and which have been cited above as examples. We shall now dwell on them in more detail, partly for the purpose of their further methodical examination and possible perfection, and partly, with the object of elucidating the mechanism of their action.

It might seem that the last method, applied to the inert dog and consisting in a regular rhythmic reinforcement or non-reinforcement of one and the same stimulus, which determined the elaboration of the respectively interchanging excitatory and inhibitory processes, is specially designed to reveal the mobility of these processes. However,

this must be proved in a more precise way. By varying systematically in one and the same dog, as well as in dogs belonging to different types of nervous system, the duration of the interval between the reinforced and non-reinforced stimuli and by comparing the results, one can become fully convinced of the essential role played in this respect precisely by the mobility of the nervous processes. This has been just tested on the dog in question. After the summer recess last year the dog finally coped with the required rhythm at usual intervals of five minutes between the stimuli. When the intervals were reduced to three minutes, the rhythm became markedly disturbed. Consequently, the successful elaboration of a rhythm in different animals depends on the intervals, that is, on the degree of mobility of the nervous processes. The longer the required interval, the lower the mobility, and vice versa.

In order to elucidate the mechanism, I must speak in more detail about the complicated experiment (unsuccessfully performed on the same dog) consisting in an unusual elaboration of a conditioned stimulus from an external agent; this stimulus repeated several times in the course of the experiment among other elaborated conditioned stimuli was reinforced only when applied the fourth time. Successful solution of the problem could be attained subject to complete exclusion of the action of all other reflexes on the repeatedly applied agent. Only on this condition was it possible to establish a differentiation between the first repetitions of the agent and its last application. This probably occurs in the same way as the elaboration of a differentiation between particular moments of a protractedly acting stimulus in the case of a considerably delayed conditioned reflex, when at the initial phases of the action of one and the same prolonged stimulus there develops an inhibitory reflex, and at the later phases—a positive reflex. Otherwise, i.e., under the action of other stimuli, the excitatory process evoked by the repeatedly applied agent would not show regular fluctuations depending exclusively

on the repetition of the agent, but would fluctuate accidentally and irregularly, depending in each case on the diverse influences of previously applied changing stimuli; hence, no differentiation between particular applications of the repeated agent could be elaborated. Consequently, only a high mobility of the nervous processes, i.e., a rapid development and discontinuance of the processes caused by all the other stimuli applied in the experiment, including, of course, the process of eating, could ensure the successful solution of the problem. It should be added that this difficult problem was, nevertheless, solved by another dog, although after a longer period of time and with much greater and more painful strain (experiments of Vyrzhikovsky). The effect produced by the first three applications of one and the same new external agent, varying its place in the system of other positive and negative conditioned stimuli, was inhibited; only the last, fourth, application became a constant, durable conditioned stimulus. Since in this dog the conditioned salivary reaction always preceded the addition of the unconditioned stimulus, our inert dog naturally could not make use of any extraneous signals, and consequently, the differentiation between particular applications of one and the same agent could take place only due to the distinction made by the peripheral receptor and the corresponding nerve cell between the last and the first three applications.

Hardly anything can be added to what has already been said about the methods and experimental forms testifying to the lability of the nervous processes in our first dog. The transformation of contrary conditioned stimuli into stimuli of opposite action is obviously determined, above all, by the mobility of the nervous processes which rapidly adapt themselves to the requirements of the new external conditions. This is generally proved by the greater or lesser difficulty with which this procedure is endured even by many strong equilibrated animals, to say nothing of weak and almost all castrated animals, which, as a rule,

fall into a chronic morbid state. Similarly the other experimental form applied to this dog, namely, the rapid elaboration of a considerably delayed conditioned reflex among other short-delayed conditioned reflexes applied much earlier, of course, directly testifies to the high mobility of its nervous processes. The new excitatory process, despite the firmly established stereotype in the action of other stimuli, rapidly adapted itself to the requirements of the new condition, at first being replaced by a durable inhibitory process and then just as quickly reappearing after slight modification in the course of its development, a modification which more closely coincided with the application of the unconditioned stimulus.

Experiments with a direct transition from an inhibitory to an excitatory process and vice versa should likewise be included in the category of experimental forms ascertaining the mobility of the nervous processes. We know that in certain dogs this transition is accomplished easily and with exactitude. Sometimes, in particularly perfect types, the direct precedence of the inhibitory process, owing to its positive induction, determines even an increased effect of the positive stimulus; but in weak types this is usually accompanied by a breakdown, i.e., by a more or less serious nervous disorder.

The so-called reshaping of the stereotype, that is, a certain change in the sequence of a repeatedly applied system of the same conditioned reflexes (for example, a fully inverted sequence) must also be related to this category of experimental forms. In some dogs this change does not exert even the slightest influence on the effects of the different stimuli; in others it is sometimes accompanied by complete disappearance of the conditioned salivary reaction for days (in the case of food conditioned reflexes).

In old age it often happens that the systems of conditioned reflexes, previously reproduced in a regular and stereotype way, i.e., with precise effects of the stimuli, become irregular and chaotic; the precision and constancy

of the effect can be re-established only by a simplification of the system—either by the exclusion of negative reflexes, or by a simultaneous reduction of the number of positive reflexes. It would be most natural to explain the mechanism of these facts by a decline, above all, in the mobility of the nervous processes, brought about by old age, as a result of which the inertness and duration of the processes, at previously established intervals, lead to a confusion and collision of the effects produced by the different stimuli.

Certain morbid disturbances observed in our dogs when they have to solve difficult nervous tasks, expressed in pathological states of definite cortical points, should be also ascribed to pathological changes in the mobility of the nervous processes; such are the inertness and explosiveness of the excitatory process. On the one hand, it was frequently observed that the excitatory process of an isolated point of the cortex became abnormally tenacious: the effect of the conditioned stimulus connected with it was not susceptible to inhibition by preceding inhibitory reflexes to such a degree as the effects of other stimuli; its extinction proceeded much more leisurely, and this stimulus did not lose its positive action, in spite of the fact that it was not reinforced systematically for weeks and months (Filaretov, Petrova). On the other hand, the previous stimulus, which had acted normally and whose moderate effect appeared after a certain delay, increasing after the addition of natural food stimuli and ending in the normal act of eating upon presentation of food, now, under a pathological state of the corresponding point of the cortex, began to produce a tremendous (secretory and motor) effect, arising and ending abruptly. When food was offered, the dog violently and obstinately rejected it (experiments of Petrova). It is clear that an extreme lability of the excitatory process was in evidence and that the latter, especially due to its summation with natural food stimuli, rapidly reached the limit of working capacity of the cortical cell and evoked a very strong transmarginal inhibition.

Thus, I repeat, the possible variations of the basic properties of the nervous system, as well as the possible combinations of these variations, determine the types of nervous system; as calculated, their number amounts at least to twenty-four. But life shows that the actual number is considerably smaller: we distinguish four types which are particularly distinct and strongly pronounced, and, what is most important, differ in their adaptability to the external environment and their resistibility to morbific agents.

We must admit a type of *weak* animals, characterised by a manifest weakness both of the excitatory and inhibitory processes; they never fully adapt themselves to the conditions of life, are easily broken, often and quickly become ill and neurotic as a result of difficult life situations, or, what is the same thing, of the difficult nervous tasks which we place before them. But of still greater importance is the fact that this type, as a rule, cannot be improved to any considerable degree by training and discipline; it becomes fit only under particularly favourable, deliberately created, conditions, or, as we usually say, in hot-house conditions.

The type is in contrast to the types of *strong* animals which in their turn markedly differ.

Among the latter, in the first place, is the *strong*, but *unbalanced* type with a strong excitatory process, but with a weaker, and sometimes even a considerably weaker, inhibitory process, in view of which this type is also easily subject to pathological disturbances when inhibition is required. This, predominantly, is a fighting type, but not adapted to everyday life with all its fortuities and exigencies. Nevertheless, being strong, it is capable of disciplining itself to a considerable degree, improving thereby the originally insufficient inhibition. We term it the *excitable type*, but to avoid misunderstanding and confusion it would be better to use the adjective *impetuous*, which directly stresses its defect and at the same time obliges us to regard it as a strong type.

From this strong type one must single out the *strong* and *equilibrated* animals.

But these animals, in their turn, differ greatly, first of all in external behaviour, and this, as we already know, is precisely due to the mobility of the nervous processes. In order to designate these *strong* and *equilibrated* types we can correctly accord them the attributes *calm* and *lively*, in conformity with their mobility.

Such are the principal types which exactly correspond to the ancient classification of the so-called human temperaments—melancholic, choleric, phlegmatic and sanguine.

As for the less significant variations, they are most frequently met with, as already mentioned, in the weak type, but they have not yet been fully investigated and systematised by us.

In conclusion I wish to say a few words about the frequency of these types among the multitude of dogs of various breeds that have passed through our laboratories during our study of the conditioned reflexes. The *weak* type in all its variations and the *lively*, sanguine type are the most frequent; then comes the *impetuous*, choleric type; rarest is the *calm*, phlegmatic type.

Basing ourselves on the elementary physiological principles underlying the classification of the types of nervous system in animals, we must admit the same types in the mass of human beings—a classification already made by Greek classical thought. Thus, Kretschmer's classification of nervous types, which has obtained almost universal recognition, especially among psychiatrists, must be regarded as mistaken or inadequate. Kretschmer found his types in the clinic, among the ill. But are there not absolutely healthy individuals? And why must all human beings indispensably carry nervous and mental disorders in embryo?

Kretschmer's types represent only a part of all human types. His cyclothymics are closest to our excitable, impetuous type, or to Hippocrates' cholerics, and his schizo-

thymics—to our weak type, or to Hippocrates' melancholics.

Since the first type lacks a proper abating and restorative process—the process of inhibition—its excitatory process often considerably exceeds the working capacity of the cortical cells. This causes a derangement of the proper interchange of normal work and rest, which manifests itself in extreme morbid phases of the excitatory and inhibitory states, both with regard to intensity and duration. Hence, the eventual development of a manic-depressive psychosis under particularly difficult circumstances of life, or under certain unfavourable conditions of the organism.

In the second type both processes are weak, and because of this it cannot endure individual and social life with its severe crises, which mostly fall on a still young, not sufficiently adjusted and hardened organism. This may lead, and often does lead, to a complete destruction of the higher part of the central nervous system, unless some lucky chance in life, or, more often, the protective function of the inhibitory process, does not save it from disastrous overstrain during this difficult period. It can be rightfully assumed that for those representatives of the weak type who end up with schizophrenia there are certain specific conditions, such as a particularly irregular course of development, or permanent auto-intoxication, causing extreme fragility of the nervous apparatus. Aloofness or reticence which, according to Kretschmer, is the main feature of schizothymics from childhood, does not present anything specific; in the case of a weak nervous system it is merely a general indication of the extreme complexity of the social environment; hence the natural withdrawal from it. Is it not a widely recognised and current fact that the mere transfer of a nervous person to a clinic or sanatorium, that is, the simple act of removing the patient from his everyday surroundings, affords relief and is even of curative importance?

It should be added that reticence or aloofness from society is by no means an exceptional feature of schizothymics, i.e., of weak individuals. Even strong persons may be reserved, but for quite different reasons. This type of person leads a strenuous but at the same time one-sided subjective life; he early becomes possessed by a certain inclination, concentrates on a single aim and is dominated and carried away by a single idea. Other people are not only undesirable; they even disturb him and distract him from the principal object of life.

Naturally, there are many great men also among cyclothymics (the strong type). But it is understandable, that, being unequilibrated, they possess a particularly fragile nervous system. Hence, the widespread and vividly discussed problem: genius or insanity?

And then comes, of course, the multitude of human beings more or less strong and even exceedingly so, and at the same time equilibrated, the phlegmatics and the sanguines, the people who make the history of mankind either by their systematic mundane but indispensable labour in all branches of life, or by the exploits of their mind, lofty emotions and iron will. Of course, as far as great men are concerned, no matter how strong they may be, they are also subject to breakdowns, since the scale of their activity is extraordinary, and there is a limit to any strength.

EXPERIMENTAL PATHOLOGY OF THE HIGHER NERVOUS ACTIVITY[71]

First I should like to say a few introductory words concerning the complicated fate of our work in the sphere of physiology and pathology of the higher nervous activity, assuming that the adjectives "higher nervous" conform to the adjective "psychical".

Thirty-five years ago I was engaged in the investigation of digestion—previously a special subject of mine—and among other things I investigated the so-called "psychical secretion of saliva". Intending to subject it to further analysis, I soon became convinced that if we adopted the psychological standpoint, that is, if we started guessing what the dog feels, thinks, etc., nothing would come of it and no exact knowledge could be obtained. It was then that I first decided to treat this psychical phenomenon, this "psychical salivation" as objectively, that is, solely from without, as everything else is studied in physiology. Soon Dr. Tolochinov became my associate and we began this work together. Helped by numerous collaborators we have been carrying on this work incessantly for the last thirty-five years.

At the outset the work was marked by a slight but interesting occurrence in our laboratory life. When I decided to continue the work along those lines, one of my collaborators, a very clever and alert young man who had worked with me on another, ordinary physiological subject,

expressed his astonishment and even indignation. "How is that?" he said. "For goodness' sake! Is it conceivable to study psychical activity on dogs, and in the laboratory?" And this, as it appeared subsequently, was very significant. Twelve years later, when I travelled to London for the jubilee celebrations of the Royal Society, I met the leading British neurophysiologist Sherrington. "You know," he said to me, "your conditioned reflexes would hardly be popular in England, since they have a materialistic flavour."

Well, and how do matters stand at present? I must tell you that these first impressions of our new work are still typical of the attitude to it of a considerable part of the educated public; and because of this work I am regarded by many as a very odious person.

Now, what about science? Here, too, the situation is far from being definite. True, in England, the country with which Sherrington tried to frighten me, there is an altogether different situation. There, the theory of the conditioned reflexes is now taught in all schools. It has been widely recognised also in the United States. But this is a long way from being the case in all countries. In Germany, for instance, the approach towards this theory is far from being such. Not very long ago a German professor of physiology visited Kharkov: in the course of a conversation with Professor Volborth—one of my former assistants—about conditioned reflexes, he plainly stated that this was "keine Physiologie".

It should be added that in general physiologists still cannot exactly determine the proper place of conditioned reflexes in the textbooks on physiology. It seems to me that these reflexes must be rightfully advanced to the fore when expounding the physiology of the cerebral hemispheres, since they represent the normal, objectively established work of these hemispheres. Analytical data accumulated up to the present time by means of stimulations, extirpation and other methods of investigating the

cerebral cortex, must follow, naturally, the description of the normal activity.

I do not know what impression our modern physiology of conditioned reflexes expounded by Prof. Podkopayev has made on you, but in submitting the pathology of these reflexes, I make so bold as to think that you will see for yourselves how expedient and fruitful our method of treating the subject is. That is why I deemed it necessary to begin with this short introduction.

Now for the subject itself. I am very glad that Prof. Podkopayev delivered his lectures on the physiology of conditioned reflexes, prior to me, before this very audience; this relieves me of the need to make any preliminary explanations. I take it for granted that all of you are in possession of the basic physiological data, and so I shall proceed directly to an exposition of the purely pathological facts.

The nervous activity, as all physicians are aware, consists of two mechanisms, or two processes—excitatory and inhibitory. With regard to these two processes we distinguish three fundamental elements, namely, the strength of both the excitatory and inhibitory nervous processes, the mobility of these processes—their inertness or lability—and finally, the equilibrium between these processes.

Certainly, the entire normal higher nervous activity, or in the usual terminology, the psychical activity, not only of animals, but also of man, is based on the normal course of these processes with their inherent properties. At least our experiments with dogs, our usual objects of investigation, have convinced us that all their intricate and highly complex relations with the surrounding world fully come within the bounds of our research into the above-mentioned processes and their properties; they are comprehended by us to the extent permitted by the possibilities of our experiments.

We can divert all these processes with their basic properties from their normal path and cause them to become

pathological. For this purpose we have quite definite methods at our disposal. There are three of these methods —overstrain of the excitatory process, overstrain of the inhibitory process and overstrain of the mobility of the nervous processes. As to the latter methods, it should be pointed out that the expression "overstrain of the mobility of the nervous processes" is actually used by me for the first time; usually we referred to it as collision of the excitatory and inhibitory processes.

How to weaken the excitatory process, to make it pathological? For this purpose it is necessary to act upon the cell, within which the excitatory process is produced, by an external agent of a very great, extraordinary strength; by doing so we overstrain the work of the cell, its excitatory process, as a result of which the latter becomes pathological.

In a similar way, that is, by overstrain, the inhibitory process can also be made pathological.

You already know how we obtain inhibition by means of negative conditioned stimuli. Let us suppose that a given conditioned inhibitory stimulus has constantly evoked in its cell inhibition of half a minute duration and that the cell has endured it very well. I then expressly prolong the action of the same stimulus for five or ten minutes. A strong cell is able to sustain it, but in a weak cell the inhibition breaks down; the work of the cell becomes pathological and changes in different ways.

Finally, the third method. It is possible to make both the excitatory and inhibitory processes pathological by means of abruptly transforming, without any intervals, the inhibitory state of the cell into a state of excitation, or vice versa. We usually refer to this as a collision between the excitatory and inhibitory processes. It is obvious that a certain amount of time is required for a corresponding change in the activity of the cerebral cells, just as it is required for any other activity. Under such collisions only those cells may remain unaffected and intact where the

basic nervous processes are strong and especially where these processes are highly labile.

Now, what results from the action of these morbific methods? How does deviation from the normal occur? How is the pathological state of the cells originated? A general weakening of the cell takes place. As to the excitatory process, the cell becomes incapable of performing the work which it performed previously, i.e., the limit of its working capacity decreases, and this manifests itself in the following pathological phenomena.

You are aware that if we have before us an absolutely normal cell and that if we apply external agents of different physical strength as conditioned stimuli, the conditioned effects of these stimuli more or less correspond to their physical strength.

Now, if we break this cell down, i.e., if we overstrain it and thus make it pathological, its relation to the stimuli becomes different. In some cases conditioned positive stimuli of different physical strength produce an equal effect, and then we say that this is the equalisation phase of the cell's activity. In other cases, when the weakening of the cell, i.e., the decrease in the limit of its working capacity, is progressing, a state sets in in which strong stimuli produce a lesser effect than weak ones; this is the paradoxical phase. Finally, a further disturbance of the cell's activity manifests itself in the fact that the cell no longer responds to the positive stimulus, whereas the inhibitory stimulus produces a positive effect; we have termed this phase the ultraparadoxical phase.

Besides the decline in the limit of working capacity, i.e., the weakening of the excitatory process in the cell, there can also be observed other changes of the excitatory process. One of the most striking of these—particularly interesting and particularly applicable in neurology and psychiatry—is the inert state of the excitatory process, i.e., a state in which the excitatory process becomes more tena-

cious, persistent, and gives way more slowly to normally arising inhibitory influences.

I shall dwell for a while on inertness. The excitatory process normally, even in healthy people, varies not only in strength, but also in another respect—in mobility. With some people the excitatory process is less mobile, i.e., it is more susceptible to stimulation, reacts more quickly under the influence of stimulation; at the same time, when the stimulation is over, its effect disappears sooner than with other types of normal people.

On this basis we, like Hippocrates, divide the equilibrated, strong animals into two categories—the phlegmatic and the sanguine. The phlegmatics, it follows, will be characterised by a relatively slow development of the excitatory process, the sanguines—by a quick one.

But this is within the bounds of normalcy. If, however, I act on the cell by means of morbific methods, I can make the inertness of its excitatory process excessive and pathological so that its state of excitation becomes exceedingly persistent.

Concerning the pathological changes of the excitatory process the following addition should be made. Two morbid changes in its mobility are observed. One of these I have just mentioned—pathological stagnation. Given other morbific conditions we get a diametrically opposite state of the nerve cell, namely, pathological lability. In neurology this is known as excitatory weakness, i.e., a state in which the cell becomes very alert, very rapidly reacts to stimulation, and at the same time quickly becomes bankrupt and weakens. We call this the state of explosiveness.

In the same way it is possible to break down (in our usual laboratory terminology) the inhibitory process as well, to make it pathological. By means of a sudden, and not gradual, considerable extension of the duration of the inhibitory state in a cell through the action of a corresponding external stimulus, we can greatly weaken the inhibitory function of the cell and almost fully destroy it.

It should be pointed out that in this respect the inhibitory process has been investigated to a lesser degree than the excitatory one.

The inhibitory process, too, usually manifests itself in different ways with regard to its mobility. Sometimes it develops rapidly and just as rapidly vanishes; sometimes, on the contrary, it assumes a more protracted character.

Thus, the inhibitory process is either normally inert or normally labile. However, it can also be brought to a pathological state with regard to inertness. In our laboratory there is a dog which has been exhibiting pathological inertness for the past three years. In this animal under the influence of frequent collisions, the positive stimulus began to evoke, instead of the normal excitatory process, an inhibitory one, and of such a persistent nature that although we constantly reinforced it under favourable conditions in the course of the three years, we just could not restore its initial positive effect. Only recently did we find a means of changing this state of affairs, but I shall speak about that at the end.

Thus, you have before you, in general outline, the changes which occur under the action of morbific agents—the change in the excitatory process, the change in the inhibitory process and, hence, as a result, a derangement of the proper correlations between the excitatory and inhibitory processes. But the normal activity of the nervous system is, of course, determined by an equilibrium between these basic processes with their normal properties.

I must tell you that often it is quite easy to obtain a pathological state of the higher nervous activity with the help of the methods I have just mentioned. But, depending on the types of nervous system, one can observe a great difference in the facility with which this pathological state is attained.

In equilibrated and strong animals, i.e., those in which both the excitatory and inhibitory processes are of equal strength and whose lability is normal, it is, of course,

likewise possible to produce a nervous disorder; however, it would take considerable time and labour, since it necessitates trying different methods. In excitable and weak animals this is very easily attained. As you already know, we classify as "excitable" that type of animal in which the excitatory process is very strong; the inhibitory process is probably also considerable, but the two processes do not conform. The excitatory process strongly predominates, and therefore in this type the negative stimuli hardly ever reach zero. This type can be broken down rather easily, i.e., made pathological. As soon as it is offered a series of tasks calling for a considerable degree of inhibition, it becomes quite weak—the animal can no longer discern anything, inhibit anything, i.e., it becomes neurotic.

As regards animals of the weak type, they can be easily made abnormal by all our methods.

The neurotic state manifests itself in the fact that the animal does not properly respond to the conditions in which it exists. This relates both to its laboratory characteristics and general behaviour. With regard to the latter everyone will admit that whereas previously the dog was normal, it is now ill.

In the laboratory we usually apply a system of conditioned reflexes—positive and negative—which are elaborated on the basis of various unconditioned stimuli: positive reflexes to stimuli of different physical strength and negative reflexes of different kinds. This entire system is normally governed by strict rules: the positive effect depends on the strength of stimulation; the inhibitory stimulus produces a greatly diminished or a zero effect, etc. Under the influence of our morbific methods all or many of the normal reactions become weakened and distorted.

The disturbed nervous equilibrium is clearly observed not only by us in the system of conditioned reflexes; our attendants also notice it. The dog obeyed them previously, behaved orderly, it knew where to go when led to an experiment. Now everything has abruptly changed. And the

attendants simply say that the dog has become stupid and even has gone mad.

The pictures of neuroses in diseased animals vary considerably owing either to the different intensity of the disorder, or to the appearance in the foreground of this or that pathological symptom. Recently we have observed a particularly large number of such neuroses and neurotic symptoms on an organically pathological basis, namely, on castrated animals. It goes without saying that castration itself disturbs the normal relations within the nervous system. I shall, therefore, briefly touch on the post-operative state of our dogs, as far as their nervous system is concerned.

One of the most striking of the morbid, neuropathological symptoms appearing almost immediately after castration is an enormous decline of the inhibitory process, of the inhibitory function, so that the dog, which prior to the operation acted in an exemplary manner, in full accordance with the conditions influencing its nervous system, now becomes quite chaotic. Normally one sees day after day an absolutely uniform and perfectly exact system of conditioned reflexes, but after castration no day is similar to another; there is a series of entirely different days and there is no order whatsoever.

One more very important detail manifested itself shortly after castration and surprised even us. In the case of strong types, the action of the animals after castration, as I have just said, is extremely distorted and instead of being strictly regular, becomes chaotic. In the case of weak types the reverse is the case. For some time after the operation the dogs behave better and more orderly than before. True, this different condition exists only temporarily—for one, one and a half or two months. Then the nervous activity in these dogs, too, becomes weakened just as that in strong dogs. I shall revert to this question later and show on what this difference is based and how we interpret it.

Then, after months of entirely chaotic activity a circu-

larity sets in which did not exist before, i.e., the dogs do not work and manifest their system of conditioned reflexes in a disorderly manner constantly, i.e., from day to day, but their activity now periodically changes. It is chaotic for a while and then for a certain period it greatly improves in a spontaneous way and becomes more orderly. And as time goes on, the more distinct this periodicity becomes; the periods of better work are more frequent and of larger duration, until after some years everything becomes normal. This, obviously, denotes the existence of certain adaptability in the organism.

Of course, since we know the system of endocrine glands, which to a certain degree assist and replace one another, it is conceivable that in time the defect sustained by the organism immediately after castration becomes more or less levelled out. But the return to the apparent normal after castration takes place in different dogs after different periods; with some it occurs after one month, with others it takes years, and there are dogs in which this state has so far not set in at all. This is obviously connected with the initial strength of the nervous system.

It is clear that in these castrated dogs, after their full or partial recovery, it is possible to produce various neuroses much more easily than in absolutely normal dogs, since in the former the equilibrium has already been disturbed, and naturally they are, so to speak, more fragile than normal dogs. Thus, we can produce in them numerous neurotic disturbances by means of the above-mentioned morbific methods.

To a considerable degree the pathological nervous states produced by us conform to the so-called psychogenic diseases in human beings. The same overstrain and the same collisions of the excitatory and inhibitory processes are also encountered in our own lives. For instance; somebody has deeply insulted me and I for some reason or other have not been able to respond to it by corresponding words, or, moreover, by a certain action, with the result that I had

to overcome the struggle or conflict between the excitatory and inhibitory processes within myself. And this was repeated more than once. Or let us take another case from the literature on neuroses. A daughter is at the sick-bed of her father whom she loves deeply and who is living his last days; however, she must pretend that everything is all right and that everybody expects his recovery, whereas in reality she is weighed down by unbearable anguish and sorrow. This often leads to breakdowns, to neuroses.

Indeed, can we find any essential physiological difference between such breakdowns and those which we obtain in our experimental animals by colliding the excitatory and inhibitory processes?

But in addition to these neuroses, there must be, owing to the extreme complexity of our brain in comparison with that of the higher animals, special human neuroses, to which I ascribe psychasthenia and hysteria. These states cannot be produced in dogs, since in cases of this kind the division of the human brain into a higher, purely human part, connected with speech, and a lower part, which, just as in animals, receives the external impressions and directly analyses and synthesises them in a certain way, makes itself felt. But neurasthenic states of different kinds can be fully reproduced in animals.

In view of the fact that our data seemed to me sufficient for a physiological interpretation of the mechanisms of nervous diseases, I decided, two or three years ago, to visit the neurological and the psychiatric clinics (of course, devoting only a little time to the matter). As far as the neurological clinic is concerned, I can say that practically all the neurotic symptoms and pictures observed there can be understood and connected with our pathophysiological laboratory facts. And this is not only my personal opinion, the opinion of a physiologist, it is also the opinion of neuropathologists who acquainted me with the clinic and who admit that our physiological interpretation of neuroses is not fantastic, that we are really laying a solid foundation

for constant contact between our laboratory facts and human neuropathological phenomena.

Before passing to another category of our facts I shall explain a phenomenon which I have mentioned but have not analysed in detail.

Why is it that animals with strong nervous systems immediately after castration become chaotic, and only later, after a certain time, does their behaviour more or less level out, while animals with weak nervous systems, on the contrary, immediately after castration behave better, in a more regular manner than before castration, and only later become disabled?

We think that this phenomenon should be explained in the following way. Since an animal possesses sex glands, it experiences sexual excitation; consequently, additional impulses come to the brain and tonify it; but the brain is weak. Hence the deficiency in the general nervous activity. With the removal of the sex glands the additional stimuli disappear, the nervous system is eased, and its activity in all other respects assumes a more expedient character. There is nothing fantastic in this explanation. We clearly observe the same in another, more tangible case. The degree of appetite in the experimental dog is of great importance in our system of conditioned reflexes. If you have a strong dog and increase its food excitability by means of a certain method (while performing experiments with food reflexes), then all its conditioned effects are increased. On the contrary, with a weak dog a heightened food excitability usually leads to a decline of the conditioned reflexes, i.e., the additional excitation cannot be endured by the dog, and is accompanied by inhibition, which we, therefore, call protective.

Now I shall proceed to another category of facts. The development of definite pathological states in the nervous system with the aid of our definite methods is, of course, based on the fact that our concept of the mechanism of this system is to a certain degree correct. The power of

our knowledge over the nervous system will, of course, appear to much greater advantage if we learn not only to injure the nervous system but also to restore it at will. It will then have been really proved that we have mastered the processes and that we can control them. Actually, this is the case. In many instances we not only bring on disease, but eliminate it with great exactitude, one might say, to order. Of course, in this case it was necessary, above all, instead of reasoning and searching for various remedies at random, to be guided by the indications of medicine. Thus, bromide plays a very important role with us. But in order to apply this remedy accurately thorough knowledge of the mechanism of its action was necessary.

With regard to bromide we have definitely established, without the least doubt, that its action is quite different from that hitherto assumed and possibly still assumed by pharmacologists. The physiological effect of bromide consists not in decreasing excitability or in weakening the excitatory process, but in intensifying the inhibitory process. Bromide bears a special relation to the inhibitory process, and this can be proved by numerous experiments. Here, for example, is a very simple experiment which we always apply when need arises.

You have an excitable type of dog—the type in which the excitatory process is extremely strong and the inhibitory process relatively weak. Consequently, the dog cannot bring its inhibitory reflexes to a complete zero—its inhibition is insufficient. You administer bromide to the dog and immediately obtain complete inhibition. You often observe in this case also a greater positive effect than previously, before the administration of bromide. But there is another, no less important side to the effect of bromide.

Although bromide has been rightly used as a remedy for nervous diseases for years (I do not know exactly for how many years but not less than sixty or seventy), it is an absolute truth that to this day medicine has not always

used this powerful instrument of nervous therapy in a proper way, often committing a very serious error.

You administer bromide in a case of a neurotic state. Let us suppose that the bromide produces no effect. Then you increase the dose thinking that the previous dose was too small. But this is true only in one series of cases. In other cases, and probably in the overwhelming majority of them, the dose must be decreased and not augmented. Often you must even decrease the dose to a very considerable degree. The gradation of the useful doses of bromide is highly extensive; in our dogs its limits are approximated to a thousandfold. This is absolutely true and we all guarantee it. Consequently, a very important correction must be made in medicine in this respect. If you administer an excessively large dose, you may obtain an injurious instead of a beneficial effect; you may cause the patient serious injury.

There can be no question, of course, that this is true only of dogs, and that with nervous people matters are different. The neuropathologists in our clinic have observed that when they took these facts into consideration it turned out that in many cases successful treatment necessitated not an increase in the doses of bromide but reduction to decigrammes and centigrammes. The general laboratory rule is: the weaker the type of nervous system and the given nervous state, the smaller must be the dose of bromide.

As is also well known in medicine, rest, too, provides a certain curative effect in laboratory neuroses. If a dog has been made neurotic by us, it is often helpful not to work with this dog every day, since a daily system of our conditioned reflexes is undoubtedly a difficult task, which in this state is beyond the dog's strength. As soon as you introduce a regular two-or three-day recess between the experiments, the nervous system begins to recover.

In some cases it has been observed that rest, as it were, substitutes bromide. Suppose you have a dog whose work

after castration is chaotic. You can help it in two ways: either you make it work (that is, you experiment with it) not every day, but once in two or three days, with the result that its work considerably improves; or you administer a suitable dose of bromide which produces the same effect.

It should be pointed out that we are now applying another extremely important method of treatment, but as yet we are not entitled to say definitely that it is an agent of radical treatment. Still, it is impossible not to pay attention to it and not to look upon it with great hope.

With the help of our morbific methods, which make the whole cerebral cortex pathological, it is also possible to cause a completely isolated region of the cortex to become ill; this is an extremely important and highly impressive fact. Suppose you have a dog with a series of different acoustic conditioned stimuli: beats of the metronome, a noise, a tone, a crackling or a gurgling sound, etc. From all these stimuli it is not difficult to obtain only one which would prove noxious and evoke a sharp deviation from the normal. So long as you apply the other acoustic stimuli, the animal's behaviour is orderly and its work is quite regular. But the moment you touch the point of application of the morbific stimulus, not only is the reaction to it distorted in one degree or another, but thereafter the entire system of conditioned reflexes becomes deranged, and its harmful effect spreads over the whole cerebral cortex. This fact in itself leaves no room for doubts, since it has been frequently produced and is being produced now by many experimenters.

But here I would like to draw your attention to the following. When I enumerated all our sounds, it was obvious that they were of a more or less complex nature. How, then, are we to picture the disorder of the cerebral cortex in relation to separate sounds? It can hardly be assumed that to each sound applied by us there corresponds a par-

ticular group of nerve cells receiving the elementary acoustic stimuli of which the sound is formed. It is more probable that in the case of each of our acoustic stimuli it is a question of a dynamic structural complex, whose elements, the corresponding cells, enter also into other dynamic complexes when other complex sounds are applied. And it is the results of the difficulties created by our morbific methods in the process connecting and systematising the dynamic complexes that are responsible for the destruction and disturbances in those complexes.

Isolated pathological points can be obtained in all parts of the cerebral hemispheres. Here is an example. You elaborate conditioned positive stimuli from a mechanical stimulation of different spots of the skin. You can obtain such a state when in two points of the skin the excitatory process does not call forth any pathological effect while the third is functionally pathological.

We now have a dog of the excitable type, i.e., one in which the excitatory process is extremely strong but in which the corresponding inhibition is insufficient. This dog has been castrated. Being of a strong type it recovered rather quickly. Since it was excitable much time and effort was required prior to castration to elaborate in it a differentiation to the metronome. For a period after castration our laboratory sustained some trouble: there was a shortage of food for the animals and they became emaciated. Due to the general nervous exhaustion the reflex of our dog to the metronome, which had been complicated by a difficult differentiation, became morbid, while all other conditioned reflexes remained unaffected. As soon as metronomes were applied, normal work with conditioned reflexes became impossible. We tried to exclude the inhibitory metronome as the more difficult one, and to make use only of the positive metronome, but that did not change the picture. Bromide proved ineffective, which, for some unknown reason, is generally the case in disorders of isolated points of the cerebral hemispheres.

Then the question arose whether the same thing would occur in another part, in another analyser of the cerebral hemispheres where the excitatory and the inhibitory processes would collide. In order to obtain an answer to this question we selected the cutaneous region, where we could apply an easier differentiation, i.e., make one spot of the skin positive and another inhibitory. The stimulation of one spot was reinforced by feeding, while that of the other spot was not. The effect was the same. So long as the positive conditioned stimulus alone was being elaborated, the dog behaved quite normally, and the entire system of reflexes was in order. But as soon as the inhibitory stimulus began to manifest itself, all the reflexes diminished and became distorted; the dog became extremely violent, so that the experimenter could not attach the apparatus to the skin or take it off without the risk of being bitten.

Now I wish to direct your attention to the following interesting phenomenon. When we had such isolated points in the cerebral cortex of other dogs, their harmfulness and morbidness were expressed only in the fact that their stimulation resulted in the derangement or destruction of our entire system; but our observations showed that this was never accompanied by a manifestation of pain in the animals. However, in this case there was a distinct impression that the touch to the skin became painful. How is this phenomenon to be explained?

As a matter of fact the only difficulty during the collision of the excitatory and inhibitory processes was in the brain, and this difficulty made itself felt in the system of conditioned reflexes. What, then, caused the pain in the skin? Apparently this may, and should, be explained in the following way. In a certain point of the cerebral cortex of the dog there arises a considerable difficulty, which must cause pain, just as you feel a kind of heaviness, a very disagreeable sensation in your head when you tackle an extraordinary difficult problem. We must assume a sim-

ilar state in our dog. But in the course of these experiments the dog apparently formed a conditioned connection between the attaching of the apparatus to the skin and the difficult state of the cutaneous analyser in the brain; conditionally the dog transfers the struggle against this difficult state in the brain to the moment of skin stimulation, exhibiting resistance to any contact with the skin. However, this is not a hyperaesthesia of the skin. Consequently, this is an extremely interesting case of objectification of an internal cerebral process, a manifestation of the strength of its connection with the stimulation of the skin. As for the brain, we must assume merely a special kind of heavy sensation in it, a peculiar kind of pain. It is not without reason that psychiatrists have described melancholia as a mental pain, or a cortical pain, the sensation of which differs from the pain caused by wounds or disorders of different parts of the organism.

Thus, for a long time we could not do anything with this dog. At last, however, a favourable way out was found thanks to the good fortune of one of my oldest and most valuable associates, Dr. Petrova. Formerly Petrova worked as a therapist, but later she was enticed into the study of conditioned reflexes and has devoted herself entirely to it for many years. I had an interesting experience in this connection. I must tell you that although I began my professorship as a pharmacologist, I have always had a strong prejudice against introducing several substances at a time into the organism. It always struck me as strange whenever I saw a prescription containing three and more drugs. What a brew! And I had always been against such combinations of pharmaceutical remedies in the physiological analysis of phenomena; in this I proceeded from the principle that the simpler the conditions of the phenomena are, the better the chances for elucidating them. I admitted bromide to our laboratory as a single drug basing myself on medical practice; caffeine was also introduced as a separate stimulant related to the excitatory process. But I

was always against using them in combination. However, the therapist, being used to combinations, insisted on a trial, and proved to be right. The effect was extraordinary and miraculous. When a mixture of bromide and caffeine was given to the dog mentioned above, the persistent neurosis immediately disappeared without leaving the slightest trace. We acted carefully. Having administered the mixture of bromide and caffeine for two days, we at first tried only the positive mechanical stimulation of the skin. The effect proved to be normal; the animal was absolutely quiet and no derangement of the system of conditioned reflexes was observed. A little later, being encouraged by the results of the trial of the positive stimulus, we applied the negative one. In this case too the effect proved to be the same—there was not the slightest trace of the former morbid reaction.

Post factum it was not difficult for me to build a respective theory. Now I presented the matter to myself in the following way. Certainly it must be assumed that in the overwhelming majority of cases a disorder of the nervous system is a disturbance of the proper correlations between the excitatory and inhibitory processes, as it appeared in the course of application of our morbific methods. Now since we have, so to speak, two levers in the form of pharmaceutical remedies, two communicators towards the two chief apparatus, i.e., towards the two processes of nervous activity, then by putting into action and correspondingly changing the strength now of one, now of the other lever, we have a chance of restoring the disturbed processes to their former place, to their proper correlations.

We have another similar case. I have already mentioned the case of the dog in which the pathological inertness of the inhibitory process lasted for three years, i.e., its positive process became pathological and the positive stimulus turned into an inhibitory one. Although we have been constantly reinforcing this stimulus for three years now,

i.e., we have been creating the conditions under which it ought to be positive, we have always had it inhibitory. No matter what we tried—bromide, rest, etc.—nothing helped. Under the influence of the mixture of bromide and caffeine this stimulus which for such a long time produced a morbid reaction, has now assumed a normal positive effect.

In the same dog, parallel with the pathological inertness of the inhibitory process, there was pathological lability of the excitatory process on another stimulus, i.e., it developed its action not gradually but impetuously, in an explosive manner; but a negative phase set in quickly in the course of the excitation. At the first moment of the application of this conditioned stimulus the dog makes a violent effort to reach the food receptacle and exhibits a profuse salivary secretion, but soon, already in the course of excitation, the salivation stops; when you begin to reinforce the stimulus and offer food, it does not take it and turns away. This pathological phenomenon, too, disappears under the action of our mixture, the morbific stimulus becoming quite normal in its action.

Interesting too is the following fact. We administered the mixture to this dog for ten days and then decided to find out whether the cure was radical. But this was not the case. When we ceased to administer the mixture the old relations returned. Of course, much more time is probably required to eliminate the disturbances entirely. But one can also assume that we really establish correct relations between both processes changing them temporarily, but do not treat the processes themselves, or at least both of them simultaneously. It is clear that should it be the first case, it is a great triumph for therapy. In any event, in the present-day palliative, and possibly future radical treatment by means of a mixture of bromide and caffeine, it is necessary to take into account the extreme precision of the dosage of both drugs, reducing them, especially in the case of caffeine, even to milligrammes.

In conclusion, I shall briefly touch on the question of the application of our laboratory results to the neuropathological and psychiatric clinics. As for the first, there is no doubt that our human neuroses can be explained quite satisfactorily in the light of the laboratory analysis. But it seems to me that in psychiatry, too, certain things have been clarified by our laboratory research.

At present I am writing a series of booklets entitled *Latest Papers on the Physiology and Pathology of the Higher Nervous Activity*. Two brief articles published in the last issue have been translated into foreign languages. One of them has already been published in French, the other has been sent to an English psychiatric journal, and it goes without saying that I eagerly await the reaction of our own and foreign experts.

Now you are aware that in the laboratory we are able to make pathological, and besides, in a functional way, an isolated point of the cerebral cortex, leaving all other points absolutely intact. I wish to make use of this phenomenon of isolated disorders for interpreting a very interesting and very enigmatic psychiatric form, namely paranoia. As is known, paranoia is characterised by the fact that a mentally normal person, who, like all healthy people, reckons with logic and reality, and sometimes may even be gifted, as soon as it comes to one definite subject, distinctly turns into a lunatic, acknowledging neither logic, nor reality. It seems to me that this form can be understood on the basis of our laboratory findings relating to isolated disorders of separate points in the cerebral cortex.

One can hardly dispute that the stereotypies of skeletal movement can and should be understood as the expression of the pathological inertness of the excitatory process in the cortical cells which are connected with movement, and that perseverations should be similarly looked upon only in the cells of speech movement. But at first sight it is more difficult to explain obsessive ideas and paranoia in

the same way. However, it seems to me that the understanding of isolated pathological points of the cerebral cortex not only in a purely crude anatomical sense, but also in a structurally-dynamic one (as mentioned above) has eliminated this difficulty to a sufficient degree.

Here is another case of a neurosis which is very close to a psychosis.

In persecution mania the patient sometimes firmly regards as reality that which he fears and wants to avoid. For example, he wants to have a secret and it seems to him that all his secrets are constantly being disclosed in some way. He wants to be alone, and although he is alone in his room and everything lies open before his eyes, he still imagines that somebody else is with him. He wants to be respected, and it seems to him that at every moment he is being insulted in some way or other by signs, words, or facial expressions. Pierre Janet has described this as feelings of possession, as if somebody is taking hold of the patient.

In my view, this case is based physiologically on the ultraparadoxical phase, which I have already mentioned and which, as you know, consists of the following.

Suppose we have two metronomes of different frequency which act as conditioned stimuli, one of them with 200 beats per minute being the positive stimulus and the other with 50 beats—the negative one. Now, if the nerve cell becomes pathological or simply falls into a hypnotic state, the effect is reverse: the positive stimulus turns into an inhibitory one, and the inhibitory becomes positive. This is an absolutely exact and constantly recurring laboratory phenomenon. Therefore, I interpret the state of the above patient in the following way: when he wanted to be respected or to remain alone, this was a strong positive stimulus, which evoked in him an opposite idea involuntarily and irresistibly in accordance with the rule of ultraparadoxicality.

Thus you see that in the field of pathology our method of work, the method of an objective attitude towards the higher phenomena of the nervous activity, is fully justifiable for animals, and the more we apply it the more it is justified. At present we are making, as it seems to me, warrantable attempts to apply the same method to human higher nervous activity which is usually called psychical activity.

That is all I wanted to tell you.

THE CONDITIONED REFLEX[72]

When the developing animal world reached the stage of man, an extremely important addition was made to the mechanisms of the nervous activity. In the animal, reality is signalised almost exclusively by stimulations and by the traces they leave in the cerebral hemispheres, which come directly to the special cells of the visual, auditory or other receptors of the organism. This is what we, too, possess as impressions, sensations and notions of the world around us, both the natural and the social—with the exception of the words heard or seen. This is the first system of signals of reality common to man and animals. But speech constitutes a second signalling system of reality which is peculiarly ours, being the signal of the first signals. On the one hand, numerous speech stimulations have removed us from reality, and we must always remember this in order not to distort our attitude to reality. On the other hand, it is precisely speech which has made us human, a subject on which I need not dwell in detail here. However, it cannot be doubted that the fundamental laws governing the activity of the first signalling system must also govern that of the second, because it, too, is activity of the same nervous tissue.

The most convincing proof that the study of the conditioned reflexes has brought the investigation of the higher part of the brain on to the right trail and that the functions of this part of the brain and the phenomena of our

subjective world have finally become united and identical, is provided by the further experiments with conditioned reflexes on animals reproducing pathological states of the human nervous system—neuroses and certain psychotic symptoms; in many cases it is also possible to attain a rational deliberate return to the normal—recovery—i.e., a truly scientific mastery of the subject. Normal nervous activity is a balance of all the above-described processes participating in this activity. Derangement of the balance is a pathological state, a disease; and often there is a certain disequilibrium even in the so-called normal, or to be more precise, in the relative normal. Hence the probability of nervous illness is manifestly connected with the type of nervous system. Under the influence of difficult experimental conditions those of our dogs are quickly and easily susceptible to nervous disorders which belong to the extreme—excitable and weak—types. Of course, even in the strong equilibrated types the equilibrium can be deranged by applying very strong, extraordinary measures. The difficult conditions, which chronically violate the nervous equilibrium, include: overstrain of the excitatory process, overstrain of the inhibitory process and a direct collision of both opposite processes, in other words, overstrain of the mobility of these processes. We have a dog with a system of conditioned reflexes to stimuli of different physical intensity, positive and negative reflexes which are called forth stereotypically in one and the same order and at the same intervals. We sometimes apply exceptionally strong conditioned stimuli, sometimes we greatly prolong the duration of the inhibitory stimuli; we now elaborate a very delicate differentiation, now increase the quantity of inhibitory stimuli in the system of reflexes; finally, we either make the opposing processes follow each other immediately, or even simultaneously apply opposite conditioned stimuli, or at once change the dynamic stereotype, i.e., convert the established system of conditioned stimuli into an opposite series of stimuli. And we see that in all

these cases the above-mentioned extreme types fall with particular ease into chronic pathological states differently manifesting themselves in these types. In the excitable type the neurosis is expressed in the following way. The inhibitory process, which even in a normal state constantly lags behind the excitatory process in relation to strength, now becomes very weak, almost disappearing: the elaborated, although not absolute, differentiations become fully disinhibited; the extinction assumes an extremely protracted character, the delayed reflex is converted into a short-delayed one, etc. In general, the animal becomes highly unrestrained and nervous during the experiments in the stand: it either behaves violently, or—which is much less frequent —falls into a state of sleep; this had not been observed before. In the weak type the neurosis is almost exclusively of a depressive character. The conditioned reflex activity becomes highly confused, and more often completely vanishes; in the course of the experiment the animal is in an almost continuous hypnotic state, manifesting its various phases (there are no conditioned reflexes at all, the animal even refuses food).

Experimental neuroses in most cases assume a lingering character lasting for months and even years. Some therapeutic remedies have been successfully tested in protracted neuroses. Already long ago bromide was applied in the study of the conditioned reflexes when certain experimental animals could not cope with the tasks of inhibition. And it was of essential help to these animals. A prolonged and diverse series of experiments with conditioned reflexes on animals proved beyond all doubt that bromide bears no special relation to the excitatory process and does not decrease the latter, as was generally believed, but influences the inhibitory process, intensifying and tonifying it. It is a powerful remedy, regulating and rehabilitating the disturbed nervous activity, on the indispensable and essential condition, however, that it is exactly dosed according to the types and states of the nervous system. In the case

of a strong type and when the state of the dog's nervous system is still strong enough, large doses of bromide are to be administered—from two to five grammes a day; for the weak type the dose must be reduced to centigrammes and milligrammes. Such bromisation for a period of one or two weeks sometimes proves sufficient to cure a chronic experimental neurosis. Recent experiments have shown even a greater therapeutic effect, especially in very severe cases, of a combination of bromide and caffeine, but again subject to very precise dosage of both substances. Sometimes recovery was also attained in animals, though not so quickly and fully, exclusively by means of a regular prolonged or short rest from laboratory work in general, or by the abolition of the difficult tasks in the system of conditioned reflexes.

The described neuroses in animals can best be compared with neurasthenia in human beings, especially since some neuropathologists insist on two forms of neurasthenia—excitatory and depressive. Besides, certain traumatic neuroses may correspond to them, as well as other reactive pathological states. It may be assumed that recognition of two signalling systems of reality in man will lead specially to an understanding of the mechanisms of two human neuroses—hysteria and psychasthenia. If, on the basis of the predominance of one system over the other, people can be divided into a predominantly thinking type and a predominantly artistic type, then it is clear that in pathological cases of a general disequilibrium of the nervous system, the former will become psychasthenics and the latter hysteriacs.

Along with elucidation of the mechanisms of neuroses, the physiological study of the higher nervous activity provides a clue to an understanding of certain aspects and phenomena in the pictures of psychoses. We shall dwell first of all on some forms of delusion, namely, on the variation of the persecution delusion, on what Pierre Janet calls "senses of possession", as well as on Kretschmer's

"inversion". The patient is persecuted precisely by that which he particularly wants to avoid; he desires to have his own secret thoughts, but he is certain that they are constantly being disclosed and made known by others; he wishes to be alone, but he is tormented by the persistent sensation that someone else is in the room, although there is nobody there except himself, etc.; according to Janet, these are senses of possession. Kretschmer refers to two girls who, having entered the period of puberty, and being sexually attracted by certain males, for some reason suppressed this attraction. As a result, they were first seized with an obsessive idea; to their great grief, it seemed to them that their countenance betrayed their sexual excitation and that everybody noticed this; at the same time they greatly valued their chastity, their virginity. Afterwards one of the girls suddenly began to imagine and even to sense that the sexual tempter—the serpent which had seduced Eve in the Garden of Eden—was inside her and was even reaching towards her mouth. The other girl imagined that she was pregnant. It is this latter phenomenon that Kretschmer terms inversion. In respect of its mechanism it is obviously identical with the sense of possession. This pathological subjective experience can, without undue strain, be interpreted as a physiological phenomenon of the ultraparadoxical phase. The idea of sexual inviolability, being a very strong positive stimulus, on the background of the state of inhibition or depression in which both girls found themselves, turned into an equally strong opposite negative idea, reaching the level of sensation; in one girl it was the idea of a sexual tempter existing inside her body, in the other—the idea of pregnancy as a result of sexual intercourse. Exactly the same thing is experienced by the patient with the sense of possession. The strong positive idea "I am alone" turned, under the same conditions, into a similar negative idea—"there is always someone near me"!

In the course of experiments with conditioned reflexes

in various difficult and pathological states of the nervous system it is often observed that temporary inhibition leads to a temporary improvement in these states; in one dog there was twice observed a patent catatonic state, which resulted in a marked decline of a chronic and persistent nervous disorder, almost in a return to the normal for several days in succession. In general, it should be pointed out that in experimental disorders of the nervous system almost always separate phenomena of hypnosis are observed, which gives the right to assume that this is a normal physiological remedy against morbific agents. Hence, the catatonic form or phase of schizophrenia entirely consisting of hypnotic symptoms, can be regarded as physiological protective inhibition, limiting or fully excluding the work of the disordered brain which, owing to the action of a certain, still unknown, noxious agent, has been threatened by serious disturbances or complete destruction. Medicine knows very well that the first therapeutic measure, which must be applied in the treatment of almost every illness, is to ensure a state of rest for the diseased organ. That such a concept of the mechanism of catatonia in schizophrenia conforms to reality, is convincingly proved by the fact that only this form of schizophrenia shows a considerable rate of recovery, despite the protracted character of the catatonic state, which sometimes persists for years (twenty years). From this point of view any attempt to act on catatonics by means of stimulating methods and remedies is definitely injurious. On the contrary, a very considerable increase in the rate of recovery can be expected when physiological rest (inhibition) is supplemented with deliberate external rest for such patients, when they are kept away from the action of constant and strong stimuli emanating from the surroundings, kept away from other, restless patients.

In the course of the study of conditioned reflexes, along with general disorders of the cortex, there were frequently observed extremely interesting cases of disorders experi-

mentally and functionally produced in very small points of the cortex. Let us take a dog with a system of various reflexes and among them conditioned reflexes to different sounds—a tone, a noise, the beat of a metronome, the sound of a bell, etc.; it is possible to induce a disorder only at one of the points of application of these conditioned stimuli, while all other points remain normal. The pathological state of an isolated cortical point is produced by the methods described above as morbific. The disorder manifests itself in different forms and degrees. The mildest change effected at this point is expressed in its chronic hypnotic state: instead of the normal relation between the strength of the effect induced by the stimulation and the physical intensity of the stimulus, the equalisation and paradoxical phases develop at this point. Proceeding from the above, this, too, can be interpreted as a physiological preventive measure under a difficult state of a cortical point. When the pathological state develops further, the stimulus in some cases has no positive effect at all, provoking only inhibition. In other cases the opposite occurs. The positive reflex becomes unusually stable: its extinction proceeds more slowly than that of the normal reflexes; it is less susceptible to successive inhibition by other, inhibitory conditioned stimuli; it often stands out in bold relief for its strength among all other conditioned reflexes, which was not observed prior to the disorder. This signifies that the excitatory process at the given point has become chronically and pathologically inert. The stimulation of the pathological point sometimes remains indifferent to the points of other stimuli, and sometimes it is impossible to touch this point with its stimulus without deranging in one way or another the entire system of reflexes. There are grounds for assuming that in the case of disorder of isolated points, when now the inhibitory, now the excitatory processes predominate at the diseased point, the mechanism of the pathological state consists precisely in the derangement of equilibrium between the opposed processes:

there takes place a considerable and predominant decrease now of one process, now of the other. In the case of pathological inertness of the excitatory process bromide (which reinforces the inhibitory process) often fully eliminates the inertness.

The following conclusion can hardly be considered fantastic. If stereotypy, iteration and perseveration, as is perfectly obvious, have their natural origin in the pathological inertness of the excitatory process of the different motor cells, then obsessional neurosis and paranoia must also have the same mechanism. This is simply a matter of other cells or of groups of cells connected with our sensations and notions. Thus, only one series of sensations and notions connected with the diseased cells becomes abnormally stable and resistant to the inhibitory influence of other numerous sensations and notions, which to a greater degree conform with reality because of the normal state of their cells. Another phenomenon, frequently observed in the study of pathological conditioned reflexes and having a direct bearing on human neuroses and psychoses, is circularity in the nervous activity. The disturbed nervous activity manifested more or less regular fluctuations. There was observed at first a period of extremely weakened activity (the conditioned reflexes were of a chaotic character, often fully disappeared or declined to the minimum); then, after several weeks or months, as if spontaneously, without any visible reason, there took place a greater or lesser, and even complete, return to the normal, which was again superseded by a period of pathological activity. Sometimes periods of weakened activity and abnormally increased activity alternated in this circularity. It is impossible not to see in these fluctuations an analogy with cyclothymia and the manic-depressive psychosis. The simplest way would be to ascribe this pathological periodicity to the derangement of normal relations between the excitatory and inhibitory processes, as far as their interaction is concerned. Since the opposite processes did not limit each

other in due time and in the proper measure, but acted independently of each other and excessively, the result of their activity reached its maximum—and only then was one process superseded by the other. Thus, there developed a different, namely, exaggerated, periodicity, lasting a week or a month, instead of the short and very easy periodicity of one day. Finally, it is impossible not to mention a phenomenon which so far has manifested itself with exceptional force only in one dog. This is the extreme explosiveness of the excitatory process. Certain individual stimuli or all the conditioned stimuli produced an extremely violent and excessive effect (both motor and secretory), which, however, abruptly disappeared already during the action of the stimulus—when the food reflex was reinforced, the dog did not take the food. Obviously, this was because of the high pathological lability of the excitatory process, which corresponds to the excitatory weakness of the human clinic. In certain conditions a weak form of this phenomenon is often observed in dogs.

All the pathological nervous symptoms described above are manifested in corresponding conditions both in normal dogs, i.e., not subjected to surgical operation, and (especially some of these symptoms, for example, circularity) in castrated animals, being, consequently, of an organic pathological nature. Numerous experiments have shown that the most fundamental property of the nervous activity in castrated animals is a considerable and predominant decline of the inhibitory process, which in the strong type, however, is greatly levelled out with the passage of time.

To sum up, we must emphasise once more that when we compare the ultraparadoxical phase with the sense of possession and with inversion, and the pathological inertness of the excitatory process with obsessional neurosis and paranoia, we see how closely the physiological phenomena and the experiences of the subjective world are interconnected and how they merge.

TYPES OF HIGHER NERVOUS ACTIVITY, THEIR RELATIONSHIP TO NEUROSES AND PSYCHOSES AND THE PHYSIOLOGICAL MECHANISM OF NEUROTIC AND PSYCHOTIC SYMPTOMS[73]

Of the vast material relating to the study of the higher nervous activity in dogs by the method of conditioned reflexes I shall now dwell only upon three points because of their particularly close connection with morbid disturbances of this activity. They are: the strength of the two basic nervous processes—excitation and inhibition—then the correlation of their intensities, or their equilibrium, and finally their mobility. These properties constitute, on the one hand, the basis of the types of higher nervous activity, types which play an important part in the genesis of nervous and so-called mental diseases, and on the other hand, typical changes taking place under pathological states of this activity.

Two thousand years ago the great genius of ancient Greece—the artistic genius, of course, not scientific—was able to discern in the immense diversity of variations of human behaviour its fundamental features in the form of four temperaments. And only now is the study of the higher nervous activity by the method of conditioned reflexes in a position to base this systematisation on a physiological foundation.

According to the strength of the excitatory process (i.e., according to the working capacity of the cerebral

cells) our dogs were divided into two groups—strong and weak. The strong group, in its turn, was divided into equilibrated and unequilibrated, depending on the correlations between the intensities of the excitatory and inhibitory processes. And finally the strong and equilibrated dogs were divided, according to the mobility of the processes, into quiet and lively ones. Thus, there are four basic types: the strong and impetuous type, the strong, equilibrated and quiet type, the strong, equilibrated and lively type, and the weak type. And they correspond to the four Greek temperaments—choleric, phlegmatic, sanguine and melancholic. Although there are different gradations of these types, life clearly shows that it is just these combinations that are more frequently met with and bear a more pronounced character. It seems to me that this coincidence of types in animals and human beings is convincing proof that such a systematisation conforms to reality.

However, to obtain a full and clear idea of the variations of human behaviour, normal and pathological, it is necessary to add to these types, which are common in man and animals, certain particular, purely human types.

Before the appearance of the family of homo sapiens the contact of the animals with the surrounding world was effected solely by means of direct impressions produced by its various agents which acted on the different receptor mechanisms of the animals and were conducted to the corresponding cells of the central nervous system. They were the sole signals of external objects. In the future human beings there emerged, developed and perfected, signals of the second order, signals of these initial signals, in the shape of speech—spoken, auditory and visible. Ultimately these new signals began to denote everything taken in by human beings directly from the outer, as well as from the inner world; they were used not only in mutual intercourse, but also in self-communion. This predominance of the new signals was conditioned, of course, by the tre-

mendous significance of speech, although words were and remain but second signals of reality. We know, however, that there are large numbers of people who, operating exclusively with words and failing to base themselves on reality, are ready to draw from these words every possible conclusion and all knowledge, and on this basis to direct their own life as well as the life of others. However, without entering deeper into this important and very broad subject, it is necessary to state that thanks to the two signalling systems, and by virtue of the long-established different modes of life, human beings in the mass have been divided into artistic, thinking and intermediate types. The last-named combines the work of both systems in the requisite degree. This division makes itself felt both in individual human beings and in nations.

Let us pass now to pathology.

In our experiments on animals we constantly obtained convincing proof that chronic pathological derangement of the higher nervous activity under the influence of morbific agents arises with particular ease in the impetuous and the weak types, where it assumes the form of neurosis. Impetuous dogs become almost completely deprived of inhibition; in weak dogs the conditioned reflex activity either fully disappears, or is of a highly chaotic character. Kretschmer, who recognises only two general types corresponding to our impetuous and weak types, correctly, as far as I can judge, associates the first with the manic-depressive psychosis, and the second with schizophrenia.

Having some very limited clinical experience (during the last three or four years I have regularly visited the nervous and psychiatric clinics) I take the liberty of advancing the following supposition concerning human neuroses. Neurasthenia is a pathological form inherent in the feeble-general and intermediate human types. A hysterical person is the product of the feeble-general type combined with the artistic type, and the psychasthenic (to use the terminology of Pierre Janet) is the product of the

feeble-general type combined with the thinking type. In hysterical persons, general weakness, naturally, has a special effect on the second signalling system, which in the artistic type in any case yields pride of place to the first system, while in normally developed persons the second signalling system is the highest regulator of human behaviour. Hence the chaotic character of the activity of the first signalling system and of the emotional fund in the form of pathological fantasies and unrestrained emotivity with profound destruction of the general nervous equilibrium (sometimes paralyses, or contractures, or convulsive fits or lethargy) and in particular, synthesis of personality. In psychasthenics the general weakness, naturally, again affects the basic foundation of the correlations between the organism and environment, namely, the first signalling system and the emotional fund. Hence the absence of a sense of reality, continual feeling of inferiority of life, complete inadequacy in life together with constant fruitless and perverted cogitation in the form of obsessions and phobias. This, in general outline, is how I conceive the genesis of neuroses and psychoses in connection with the general and particular types of human higher nervous activity.

Experimental study of pathological changes in the basic processes of the nervous activity of animals makes possible a physiological understanding of the mechanism of the mass of neurotic and psychotic symptoms, both taken separately or as components of certain pathological forms.

Weakening of the excitatory process leads to the predominance of inhibition, both general and diversely partial, in the form of sleep or of a hypnotic state with its numerous phases, of which most characteristic are the paradoxical and ultraparadoxical phases. This mechanism, I believe, is responsible for a particularly large number of pathological phenomena, such as narcolepsy, cataplexy, catalepsy, feelings of possession—*les sentiments d'emprise* (according to Pierre Janet), or inversion (according to

Kretschmer), catatonia, etc. The weakening of the excitatory process is caused either by its overstrain, or by its collision with the process of inhibition.

Under certain laboratory conditions which are not yet quite clear there takes place a change in the *mobility* of the excitatory process in the form of *pathological lability*. This phenomenon, long known in the clinic under the name of excitatory weakness, consists in an extremely high reactivity or sensitivity of the process followed by its rapid consecutive exhaustion. Our conditioned positive stimulus produces an instantaneous and extraordinary effect, which, however, falls to zero and becomes inhibited already during the normal period of stimulation. We sometimes call this phenomenon explosiveness.

But in our experimental practice we also meet with quite the opposite pathological change in the *mobility* of the excitatory process—with *pathological inertness*. The excitatory process persists despite a prolonged application of conditions, under which normally the excitatory process is superseded by inhibition. The positive stimulus is not susceptible or slightly susceptible to successive inhibition evoked by preceding inhibitory stimuli. This pathological state is in some cases caused by a moderate, but continuously growing intensity of the excitatory process, and in other cases by collisions with the inhibitory process. It is quite natural to attribute the phenomena of stereotypy, obsessive ideas, paranoia, etc., to this pathological inertness of the excitatory process.

The inhibitory process can also be *weakened* either by its overstrain, or by collisions with the excitatory process. This weakening leads to an abnormal predominance of the excitatory process in the form of a derangement of differentiations, retardation and other normal phenomena in which inhibition intervenes; it also manifests itself in the animal's general behaviour in the form of fussiness, impatience and violence, and finally in the form of pathological phenomena, for example, neurasthenic irritability.

In man it takes the form of submanic and manic states, etc.

This year phenomena of pathological lability of the inhibitory process have been observed in our animals by my old colleague, Prof. Petrova, who has enriched experimental pathology and therapy of the higher nervous activity with quite a considerable number of important facts. A dog which previously took its food, placed at the edge of a staircase, with ease, without any hesitation, ceases to do so, hurriedly avoids the food and moves away from the edge. The matter is quite clear. When a normal animal, approaching the edge of a staircase, stops and does not move farther, this means that it is able confidently to hold itself back, as much as is necessary to prevent it from falling down. In our case this retention is exaggerated; the reaction to depth is excessive and keeps the dog, to the detriment of its interests, much farther from the edge of the staircase than is actually necessary. Subjectively this is an obvious state of dread or fear, a phobia of depth. The phobia could be induced, and could be eliminated, i.e., it was under the experimenter's control. The condition responsible for its emergence is what we may call the torture of the inhibitory process. I will demonstrate this fact in a few days' time at the international physiological congress in Leningrad. I think that in many cases persecution mania can also be accounted for by the pathological lability of inhibition.

We have already examined the pathological *inertness* of the inhibitory process.

A difficult task still remains to be accomplished—it is necessary to determine with precision and in all cases when and in what particular conditions one or another pathological change arises in the basic nervous processes.

THE PROBLEM OF SLEEP[74]

Dear Comrades,

Although something extraordinary, one might say, even distressing, befell me yesterday, with the result that I am now, so to speak, not quite myself, I thought it necessary, nevertheless, to be present at the conference. Why? Because I believe that in a discussion of a scientific matter such as sleep, which is essential both from the practical and clinical points of view, my judgement will be not without interest, especially since I, jointly with my colleagues, have been studying the phenomena of sleep for thirty-five years in the course of our research into the higher nervous activity of dogs.

We came up against the phenomena of sleep at an early stage in our research; we were obliged to consider it, to subject it to special investigation, which now gives me the right to speak on this subject. That is why, despite my somewhat disturbed state, I decided to come here and to say a few words.

I

I should like first of all to make a general remark. The more perfect the nervous system of the animal organism, the more centralised it is, the more its higher part controls and regulates the entire activity of the organism, even though this is not clearly manifest. It might seem

to us that in higher animals many functions are effected independently of the influence of the cerebral hemispheres, but this is not so in reality. The higher part controls all the phenomena which develop in the organism. This was established long ago in the phenomena of hypnotic suggestion and auto-suggestion. It is well known that during hypnotic sleep it is possible to influence many vegetative processes by means of suggestion. On the other hand, we know of cases of auto-suggestion, such as symptoms of phantom pregnancy, accompanied by an active state of the lacteal glands and the accumulation of fat in the abdominal walls, simulating pregnancy. All this originates from the head, from thoughts and words, from the cerebral hemispheres in order to influence such a peaceful and genuinely vegetative process as the growth of the adipose tissue.

If the cerebral hemispheres, as everybody knows, are concerned with the slightest details of our movements, bringing some into action and suppressing others, just as it takes place, for example, when one plays the piano, one can easily imagine the minuteness of the degree of inhibition: one movement of a certain intensity is effected, while another, neighbouring movement, even the smallest one, is suppressed and retained. Or take, for example, our speech movements. What a multitude of words we have for expressing our thoughts! Nevertheless, we are precise in conveying the sense; we never use unnecessary words, employing only those which are most suitable in the given case, etc. Consequently, if the cerebral hemispheres constantly interfere even with these minute everyday activities and regulate them, it would be strange to suppose that the division of our activity into wakeful and sleeping states does not depend on the cerebral hemispheres. It is clear that here, too, supreme power belongs to the cerebral hemispheres and all of us are well aware of this.

Now, at a certain time of the day we become drowsy, and, since we are tired, sleep sets in. But we can do with-

out sleep a whole night, and even for two or three nights in succession. And it is our head, our cerebral hemispheres which, of course, control this phenomenon.

I shall now turn to the details.

It is clear, and everybody is aware of this now, since it has become a widespread and established physiological truth—that our entire nervous activity consists of two processes—excitatory and inhibitory—and that our whole life is a continuous interaction of these two processes.

When we began our objective study of the higher nervous activity by the method of conditioned reflexes, and began to elucidate the laws of the particular functions and tasks accomplished by the cerebral hemispheres, we, of course, immediately encountered the two processes. Every physiologist knows that these processes are inseparable, that they are always present not only in the nerve cell, but in each nerve fibre.

I must make a certain reservation. If I begin to speak about conditioned reflexes this would take a lot of time, and I do not know when I would end. Since we have been working on conditioned reflexes for thirty-five years and have published the results of our work in special papers and books, allow me to assume that knowledge of conditioned reflexes is widespread and consequently, there is no need to treat this subject in an elementary way, i.e., to begin all over again.

When we applied our conditioned stimuli and then carried out a detailed investigation of the activity evoked by them at every given moment, we constantly observed a spontaneous development of inhibition side by side with excitation. In other cases we produced the inhibition ourselves when we wanted to separate different phenomena.

Since you are acquainted to a degree with the conditioned reflexes, you undoubtedly know that we have, on the one hand, external stimuli which produce an excitatory process in the central nervous system, and, on the other hand, stimuli which produce an inhibitory process in the

cerebral hemispheres. Right at the beginning of our research we observed that as soon as we applied the inhibitory stimulus, a somnolent state of the animal, in the form of drowsiness or sleep, immediately intervened. This was of a constant character. We had to conclude, therefore, that these phenomena are closely interconnected and that certain efforts and resources are necessary to get rid of this drowsiness or sleep in the course of experimentation. Thus, when an inhibitory process arises in the cerebral hemispheres, establishing in them a certain differentiation either between the stimuli or between different moments of stimulation, etc., a state of drowsiness inevitably develops.

You can see, as we have seen during the past thirty-five years, that every time a cortical inhibition sets in which analytically assigns its proper place to everything, giving free rein to one process and suppressing the other, a state of drowsiness or in its ultimate stage of development—a state of sleep—simultaneously and invariably appears. The view that drowsiness and sleep are phenomena related to the cerebral hemispheres and that they are the result of the action of definite stimuli, is strictly obligatory for us. Surely a phenomenon observed every day is beyond any doubt.

That, of course, leads to the next question. How does this come about? What has this to do with sleep when it is simply a matter of differentiation between stimuli? They appear to be different things having nothing in common.

But the matter is quite simple. If we admit that everything can be explained by a constant interaction between the excitatory and inhibitory processes, then we shall have no difficulty in understanding the phenomena. Every time you produce an inhibition, a physiological inhibition, i.e., when you want to separate the active state from the inactive, drowsiness, as I have already said, immediately begins to manifest itself. But you can always eliminate

this drowsiness, suppress it, and, on the contrary, ensure the predominance of the excitatory process. This is within your power, within your experimental possibilities, and it is what we do. The moment a state of drowsiness develops in the dog during an experiment, i.e., the moment inhibition takes the upper hand, we apply a stimulation, thereby eliminating the drowsiness, limiting the inhibition and confining it within definite bounds.

How, then, is this matter to be further interpreted? It must be admitted that both excitation and inhibition are dynamic processes, which, on the one hand, may irradiate and spread, and, on the other, may be driven into definite narrow confines and concentrated there. This is the main point, the whole secret, and it is this that we use in all our physiological activity.

The basic property of both processes consists in the fact that on the one hand, when they arise, they tend to spread, to occupy an undue area; on the other hand, they can, given the corresponding conditions, concentrate in definite regions and remain there. When the inhibition is irradiated, diffused, you have the phenomenon of drowsiness or sleep.

Everybody knows, of course, that sleep does not set in instantaneously, that it is a gradual process. Similarly one does not awake all of a sudden; certain time is required before one gradually becomes active and, so to speak, completely throws off the fetters of sleep.

I advise everybody who values scientific truth, who does not want to reconcile himself to superficial knowledge, who is tormented by the thought "is this right or not?", to make a thorough study of two articles in my book *Twenty Years of Objective Study of the Higher Nervous Activity (Behaviour) of Animals* which is the result of thirty-five years of intense reflections. One of the articles is entitled "On Inhibition and Sleep" and the other, written jointly with M. K. Petrova,—"Physiology of the Hypnotic State of the Dog".

In any case, in order to give you a more or less clear illustration of this phenomenon, I shall cite one of our experiments.

I must tell you that when you observe the genesis of drowsiness and its first manifestations, you become convinced, and unshakably so, that hypnosis and sleep are, of course, one and the same process. In essence, hypnosis does not differ from sleep; it differs only in certain peculiarities. Hypnosis, for example, is sleep which develops very slowly, i.e., it is at first confined to a very small and restricted area and then begins to spread farther and farther until it finally descends from the cerebral hemispheres to the subcortex, leaving untouched only the centres of respiration, of the heart-beat, etc., though somewhat weakening these too.

I shall now submit to you one of the numerous cases investigated by us in the course of thirty-five years. Let us take a dog which is falling into a state of drowsiness, sleep or hypnosis. What do we observe in this animal? Our experiments with conditioned food reflexes show the following: at first the dog works and eats quite normally; then its tongue comes out of the mouth in a strange manner, and gradually begins to fall down. This is the first manifestation of a certain functional paralysis, of a diminution of activity, of inhibition of the minute centre in the motor region of the cortex which controls the movement of the tongue. This centre becomes inactive, as a result of which the tongue is paralysed and falls out of the mouth.

A certain period of time passes, and you give the dog food. You see that its tongue functions very slowly and awkwardly; later, you also observe—not at once, but perhaps after the second or third offering of food—that the dog uses its jaws with difficulty, that its mastication is utterly impeded, since the mouth opens and closes very slowly. Thus you witness a weakening of the activity of the masticating musculature, its inhibition or sleep.

At the same time, however, you notice that when food is offered to the dog, which until then was standing with its head turned away or with its eyes fixed on the ceiling, it easily and quickly turns its head towards you and falls upon the food.

But as time goes on, you observe in the course of the experiment that although the dog turns towards you, it brings its head to the food with great difficulty. Consequently, the inhibition or sleep has already seized other points of the skeletal movement, namely, those which control the movement of the neck.

You then see that the dog is unable even to turn towards the food, that it does not move the neck and does not take the food. And finally, you observe the onset of a general passivity of the skeletal musculature: the dog hangs limply in the straps, it is in a state of sleep. Thus, inhibition gradually develops before your eyes in a very obvious and concrete manner; at first it affects the tongue, then it spreads to the cervical muscles, from there to the general skeletal musculature until, finally, sleep sets in.

When you observe this development you can hardly doubt that inhibition and sleep are one and the same process.

The articles to which I have just referred contain numerous similar facts. And anyone who makes a thorough study of them will be convinced that inhibition and sleep are one and the same phenomenon. The only difference is that when the most minute points of the cerebral hemispheres are inactive, it is inhibition and, at the same time, sleep of an isolated cell; but when this inhibition, duly or unduly, spreads under the influence of certain conditions, it embraces more and more new areas of cells and is manifested in a passive, inactive state of the numerous organs dependent on these regions.

It is a pity that cinematography appeared too late and could not be utilised by us and our physiological laborato-

ries. Had it been as accessible then as it is now, all these phenomena could have been very easily comprehended. We could now demonstrate them to you in the space of fifteen minutes, and you would leave us with the deep conviction that inhibition and sleep are one and the same process. But while inhibition is a concentrated process, hypnosis and sleep represent an inhibition which spreads over more or less vast areas.

This spread of inhibition is of great importance for the comprehension of numerous nervous phenomena.

The British mind, as far as I have been able to follow it, has fully realised and caught up this idea. Thus, Wilson, one of the outstanding British neurologists, now considers all cases of narcolepsy and cataplexy precisely from this point of view. And we, who have observed all these phenomena in dogs, fully agree with him. In our opinion, Wilson is undoubtedly on the right trail.

Such, in general outline, of course, is our understanding of the phenomena relating to alternating sleep in the cerebral hemispheres, as well as to the sleep of the entire brain, following the mobile inhibition.

II

I shall pass now to other facts which to a certain degree compete with the concept just developed by me.

First of all I draw your attention to an extremely important fact recently obtained in the Soviet Union by Prof. Galkin, in A. D. Speransky's laboratory. It should be pointed out that this fact had been observed long ago in the clinic, but only once. Of course, much consideration was given to it at the time, and it was even properly understood by some researchers; but a single fact is not sufficiently convincing. This fact concerns an observation made long ago by Strümpell on a patient, in whom most of the sense organs were damaged and who could communicate with the external world only through two open-

ings which remained intact—one eye and one ear. When he covered these openings with his hands he inevitably fell asleep.

This phenomenon is now being reproduced in the laboratory, and in the following way. We destroy three distant receptors in the dog, namely, smell, hearing and sight; this means that we section the *fili olfactorii*, sever the *n. optici* or extirpate the eyes and damage both cochleae. After this operation the dog sleeps twenty-three and a half hours a day. It wakens only when the elementary functions of the organism begin to annoy it—the necessity to eat, to evacuate the urinary bladder or the bowels, etc. But it is extremely difficult to awake the animal in the middle of the day. For this purpose it is not sufficient to stroke the dog, it is absolutely necessary to shake it; and then, before your eyes, it slowly awakens, stretches itself, yawns, and finally stands up. Such is the fact, and it is an exact fact. We repeated the experiment several times and the result was always the same.

The character of the operation performed on the dog excludes any supposition that its nervous system has been damaged. If the operation is done thoroughly, the dog comes through it more or less easily; the fact that two days after the operation it is able to eat shows best the ease with which it endures the loss of the above-mentioned receptors.

However, I must direct your attention to a minor detail. If you destroy the receptors gradually, i.e., at first one of them, the second two or three months later, and in another period of three months the third, then sleep does not set in. The dog, of course, is not as active as the animal which sees and hears normally; indeed, if it has lost the sense of smell and is unable to see, what can make it move? And it is perfectly understandable that for the most part it lies rolled up. But the moment you touch the intact receptor, for example, by stroking the dog, it immediately rises and begins to act.

When, however, you deprive the cerebral hemispheres of a large quantity of stimulations at once, the dog falls into a state of deep sleep. This indubitable fact, which must be reckoned with, naturally gives rise to the following question: How is this phenomenon to be interpreted? And in this connection there arises the problem of two kinds of sleep—the passive sleep caused by the abolition of a large quantity of stimulations usually reaching the cerebral hemispheres, and the active sleep which, in my understanding, is an inhibitory process, since the latter must be undoubtedly regarded as an active process and not as a state of inactivity.

Then the following question of principle arises: Does not the nervous system experience three different states—excitation, inhibition, and a certain indifferent state, when the first two are absent?

But proceeding from the general biological data we have grounds for doubting the existence of a neutral state. Life is a continuous interchange of destruction and restoration, in view of which a neutral state is simply inconceivable. On the whole, the problem can be reduced to the following: Is not the passive sleep, which differs from the usual sleep developing under the above-mentioned conditions, also a result of active inhibition?

I think that certain considerations can be submitted which make it clear that the case of sleep observed in dogs, operated upon in accordance with the method of Speransky and Galkin, could be also accounted for by inhibition; it is an active inhibition greatly favoured by the circumstances, since now there is no need for the inhibition to struggle against an extensive excitatory process and train itself, and as a result the stimulations falling upon the dog extremely facilitate the sleep. Why is this so? Because when the dog is mostly in a lying posture, certain points of its skin are continuously stimulated both mechanically and thermally. It is, therefore, conceivable that the passive sleep is evoked by a continu-

ous and monotonous stimulation of the remaining receptors. And we know the fundamental rule according to which each cell, under the influence of continuous and monotonous stimulations, inevitably becomes inhibited. Consequently, it is possible to interpret this sleep as a result of inhibition proceeding from the remaining receptors subjected to a prolonged monotonous stimulation.

This is partially confirmed also by the following fact. When these dogs are transferred to new surroundings, they at first become more active, are wakened more easily, etc.; in other words, for a time they appear to be more lively.

It can be assumed, therefore, that here, too, due to a decline of the tonus, to the weakening of the excitatory process, the inhibition easily takes possession of the cerebral hemispheres and that weak, monotonous stimulations arise provoking an inhibitory process.

Then comes the following question: What happens to the dogs in which the cerebral hemispheres are extirpated? As a matter of fact, they, too, fall into a state of sleep. And this circumstance is often used as a serious objection to what I have just said, namely, to the statement that normally sleep originates in the cerebral hemispheres.

But I do not regard this objection as being physiologically grounded. It is clear that since sleep is a diffused inhibition, and the latter spreads over the nervous system up to the lower limit of the spinal cord, and since there is a central system and a nerve fibre, inhibition must indispensably take place. In cases when the cerebral hemispheres are absent, why should the inhibition not develop in the lower parts of the central nervous system, now in a concentrated, now in an irradiated form? This is all the more likely since dogs possess lower levels of distant receptors—*corpora geniculata* (one relating to the ear, and the other—to the eye), and we know that a dog deprived of the cerebral hemispheres reacts to acoustic and visual stimuli. Consequently, the conditions remain the same as when the cerebral hemispheres are intact, and

sleep in this case is not excluded—it must inevitably manifest itself. So long as there exists inhibition and there is a cell which, as a result of excitation, is bound to become fatigued and fall into a state of inhibition, all the conditions for the development of inhibition are present. But in the absence of the cortex sleep begins from the subcortical formations. Hence, there is no contradiction here as far as the fundamental facts are concerned, that is, the interchange of excitation and inhibition, their concentration and irradiation. If all these phenomena take place also in the lower part of the central nervous system, then why should sleep not develop there as well? Therefore, I regard these objections as being physiologically groundless; they cannot refute our statement about the initiative of the cerebral hemispheres in the development of sleep in normal conditions.

Next come more important facts. On the one hand, a clinical fact—the encephalitic sleep or somnolence, and on the other, the physiological apparatus advanced by the Swiss physiologist Hess, which, as it were, rivals my concept about sleep originating in the cerebral hemispheres.

As for clinical sleep, the clinical concept of the centre of sleep is well known to clinicians; it is based on the fact that after an infection of the brain, the so-called encephalitis, which is accompanied by somnolence, considerable changes take place in the hypothalamus. On the basis of this fact the simple conclusion is made that the centre of sleep must be located there.

However, I make bold to say that this reasoning, which is based on the fact that there is, on the one hand, sleep, and on the other, a destruction of the hypothalamus, is oversimplified. The above conclusion is, therefore, too hasty.

Firstly, all that we know about the work of the cerebral hemispheres makes the concept of the hypothalamus as the actual centre of sleep doubtful and incomprehensible. It is difficult to assume that an infectious process arising in the brain should in no way tell upon its most reactive

part—the cerebral hemispheres. It is likewise difficult to assume that the toxins should remain exclusively in the subcortex, without spreading to the cerebral hemispheres. I fully realise, of course, that bacteria favour definite chemical media, and that there must be a very delicate difference between the above-mentioned parts of the brain in respect of their chemical composition. It is quite conceivable that this is true, that the process in question concentrates mainly in the hypothalamus and produces in the nerve cells changes which can be afterwards revealed microscopically. But it may be that in the cerebral hemispheres these changes have only a functional character and manifest themselves in the weakening of the excitability of the hemispheres; at the same time they may be inaccessible to microscopic investigation. It can be supposed that there is a certain gradation of the patho-anatomical changes—from visible phenomena to purely functional, and, finally, invisible ones.

On the basis of what we observe in the hypothalamus it is difficult to assert with confidence that these infections do not exert any influence on the cerebral hemispheres. I would regard such a conclusion as being too hasty.

Secondly, I do not contest the fact that encephalitis is accompanied by sleep, and that this phenomenon is related to the hypothalamus and complies with it. However, I am inclined to interpret this fact in the same way as I have done with regard to the fact established by Speransky and Galkin. Here is what I have to say in this connection. There is no doubt that the hypothalamus is a wide route with definite centres where the stimulations coming from the internal world, i.e., from all the internal organs, are accumulated; its destruction leads to the isolation of the cerebral hemispheres from the entire internal world, from the entire activity of the organs; in other words, it provokes a state analogous to that which arises when all three receptors are destroyed, i.e., when the cerebral hemispheres are deprived of external stimulations. The stimulations

proceeding from the internal organs, although we are not conscious of them, constantly maintain a heightened tonus of the cerebral hemispheres. This is proved in the first place by the fact that, as I have already mentioned, dogs with extirpated cerebral hemispheres are in a continuous state of sleep. Further proof is provided by a pigeon deprived of the cerebral hemispheres and remaining constantly immobile and somnolent. But the moment there arises the necessity to eat or to evacuate the excretory organs, the pigeon awakes. Consequently, there is no doubt that these stimulations act on the cerebral hemispheres and bring it to a state of wakefulness.

On the other hand, we know very well that in certain, particular cases, we feel the heart-beat, the movements of the intestines, etc.

Another long-established fact shows that internal stimulations contribute to the maintenance of the cortex in an alert state, to its tonus. This fact was recently confirmed in America, in laboratory conditions, on a person in whom the ability to resist sleep for a long time was investigated. The following phenomenon was observed. A person who like yourself is interested in this particular investigation and who tries hard to keep awake as long as possible, despite a strong desire for sleep, successfully resists the state of somnolence only when he walks or when he is in sitting posture. The moment he lies down, i.e., relaxes the musculature, he immediately falls asleep.

Thus you clearly see that our internal stimulations greatly contribute to the maintenace of a certain tonus in the cortex.

In my view, encephalitic sleep is caused by the separation of all internal stimulations from the cerebral hemispheres due to an affection of the hypothalamus; it is, consequently, the same drastic decline of the tonus that is observed when the external receptors are destroyed.

There remains one more important fact which supports the reasoning of the clinicians concerning the centre of

sleep. I have in mind the experiments of Hess, in the course of which sleep was evoked by electric stimulation of definite parts of the brain. I am not going to contest this fact either. I fully admit it and believe that it will be reproduced by other investigators; but I consider it necessary to say a few words about its proper interpretation and the objections which can be raised to the conclusion drawn by Hess.

The first thing which attracts attention is that the above fact does not fully accord with the clinical fact, since the points in the latter case do not coincide with those stimulated by Hess.

Hess himself emphasised this circumstance and stated that his experiments would disappoint the clinicians, since anatomically the points which produced sleep did not coincide.

Whereas the lesions caused by encephalitis are located in the region of the third ventricle, in its lateral walls, etc., Hess subjected to stimulation the lowest part of the brain, almost reaching the brain stem.

How is this fact to be interpreted? It must be pointed out that a phenomenon observed in the given organism under normal conditions, as in our case, is one thing, and a phenomenon observed under pathological conditions, especially when they are artificially produced in the laboratory, as, for example, the stimulation of the brain, is another thing. They are, of course, absolutely different phenomena. While in the latter case maximum simplicity can be attained, in the normal state the phenomena become complicated. But in the given case even Hess, who obtained a definite state in dogs by stimulating certain points in the brain, stated that this could be an excitation not only of the cells of an imaginary, fantastic "centre of sleep", but of centrifugal or centripetal fibres; at the same time he drew attention to the fact that the points used by him for producing a state of sleep had been very limited.

Then I am fully entitled to ask the following question:

Is not this simply a reflex sleep originating from the same cerebral hemispheres? Indeed, we know very well that a monotonous irritation of the skin, both in our laboratory experiments on dogs and in our experiments on human beings, produces a hypnotic state, a state of sleep. There is nothing surprising in the fact that certain stimulations of the nerve paths may provoke sleep. Consequently, these experiments do not prove that sleep is a stimulation of a definite centre. Along with hypnotisation by means of passes, which, undoubtedly, is a reflex inhibition caused by monotonous stimulations, a hypnotic state can also be evoked with the help of the verbal method. The latter is addressed to the cerebral hemispheres. In our laboratory we produce a state of sleep in dogs by means of a weak electric stimulation of the skin; this sleep is so persistent that after several experiments the place where the electrodes were fixed becomes a conditioned hypnogenous stimulus: it suffices to touch this place or to cut the hair on it, and the dog immediately subsides into deep sleep. Such is the effect of peripheral stimulations.

What, then, is the value of Hess' proof, especially since he himself states that his sleep is produced with the help of a weak electric current, and besides, a special (faradic, and not direct) one? Consequently, this could be a very weak stimulation corresponding to that which we obtain in the laboratory by means of a weak electric current.

I find, therefore, that the Hess experiment, which was so highly convincing in the eyes of the author himself, and even more so in the eyes of the clinicians, can be rightfully contested and reduced to what I have already said, the existence of a special centre of sleep being out of the question. In my opinion, the crude idea that there is a special group of nerve cells which produce sleep, while another group produces the state of wakefulness, is, from the physiological point of view, contradictory. We observe the phenomenon of sleep in every cell; what reason have we, then, for asserting that there is a special group of

hypnogenous cells? If a cell exists, it inevitably produces a state of inhibition, which irradiates and renders all the neighbouring cells inactive; and when inhibition continues to spread, it produces sleep.

Such is my firm conviction.

DISCUSSION

Question: What is responsible for the absence of sleep in dogs whose distant receptors were extirpated at different times?

Answer: As you know, the inaction of one receptor always leads to an intense training of all others. It is a well-known fact, for example, that blind people have a highly sensitive touch. The same thing occurs in the given case with the reception of the external world when the olfactory receptor is removed; the activity of the latter is made up by the reinforced activity of the ear or the eye. It is, therefore, obvious that successive extirpation of the receptors makes possible such a training, while simultaneous extirpation excludes it.

It should be pointed out that there are indications which show that with the lapse of time, in the course of years, the dogs to a certain extent train themselves with the help of the remaining receptors (that is of the oral and cutaneous receptors) and in the end become more active. In any case this fact was manifested in dogs which have been used for these operations.

Question: From the point of view of inhibition how do you explain a sleep accompanied by abundant dreams?

Answer: As I have already said, sleep is an inhibition which gradually and steadily spreads to the lower levels of the brain. It is clear, therefore, that when sleep and fatigue begin to set in, the highest part of the cerebral hemispheres, which controls verbal activity (I call it the second signalling system of reality), becomes inhibited first, since we constantly operate with words.

I can add now—for the sake of brevity I omitted it in my talk—that this inhibitory process has its external and internal stimuli.

Among the internal stimuli of inhibition is the humoral element, or consequently, certain cellular metabolites, which evoke this inhibition. On the other hand, the external inhibitory stimuli, as I have already mentioned, are monotonous and weak. Naturally, it is the highest part of our brain, the verbal part of our higher cortical activity which functions in the daytime. Fatigue calls forth inhibition, and this part becomes inactive. But along with the verbal function of the cerebral hemispheres there is a function which we share with animals and which is termed by me the first signalling system, i.e., the reception of impressions produced by all the stimuli acting on us.

It is quite clear that when we are in an alert state, the part of the cortex controlling our speech, inhibits the first signalling system; that is why in the alert state we (except the artistic type of man whose constitution is of a peculiar character), when speaking, never imagine the object which we designate by words. I close my eyes and think of the person sitting in front of me, but I do not see him in my thoughts. Why? Because the excitation of the higher part inhibits the lower part. That is why when sleep begins and embraces only the higher part of the hemispheres, the adjacent lower part bearing a direct relation to impressions prevails and is manifested in dreams. When there is no pressure from above, a certain degree of freedom sets in. And even here a new fact must be added, a fact encountered in physiology, namely, positive induction. When one point becomes inhibited, the other, on the contrary, becomes excited. And if we grant this, i.e., if we assume positive induction, the phenomenon of sleep becomes particularly clear.

Question: Judging by what you have said, there is no centre of sleep. How, then, are we to explain the fact that for such an important function as sleep there is no centre,

while there are centres for other, even less important functions of metabolism, for example, a sugar centre, a water centre, etc.?

Answer: The explanation is quite simple. Inhibition and sleep exist for each cell. Consequently, they do not need any special cellular groups.

Question: How should the problem of fatigue be considered from this point of view?

Answer: I have already said that fatigue is one of the automatic internal stimuli of the inhibitory process.

Question: How do you explain the occurrence of fits during sleep?

Answer: There is nothing special in this, because we are aware of the resources of our nervous system, the cerebral hemispheres. The following phenomenon is often observed: inhibition spreads over the cerebral hemispheres and sleep sets in; nevertheless, certain points, which I call points on duty or on guard, may remain active. This is observed, for example, in the sleep of the miller who wakes up when the noise of the mill ceases, or in the sleep of the mother who wakes up at the faintest sound coming from her child, but who is not disturbed by much louder sounds. So that when the conditions for the excitation of a certain part arise, sleep does not prevent the development of the process.

Question: How can all the complicated reactions of a hypnotised person be explained, if we admit that in the state of hypnosis his entire nervous system is inhibited with the exception of the one point by means of which he communicates with the hypnotist?

Answer: I have pointed out that hypnosis is a kind of sleep which gradually spreads from a basic point.

Here is a fact which was observed in our laboratory. You have a dog which long ago was deprived of three receptors and which is in a constant state of sleep. Nevertheless, you can awaken it with the help of the remaining cutaneous receptors, bring it to the laboratory, place it

in the stand and perform experiments on it. Then the following, extremely interesting phenomenon is observed, a phenomenon analogous to the hypnotic state: you can elaborate only one reflex in a dog of this kind; it is impossible to form in it, as can be done in a normal animal, two, three, or four reflexes simultaneously. This is explained by the fact that the cortical tonus, i.e., the excitatory process in the entire cortex, is very weak; hence, when it concentrates on one stimulus, there is nothing left for other stimuli and they remain inactive.

In this way I explain also hypnosis and rapport. The cerebral hemispheres are not wholly embraced by inhibition, since certain points of excitation may be formed in them. Through such an excited point you evoke a response and suggest. And then the hypnotised person inevitably executes your order, for when you give it you have everything extremely restricted. Consequently, all the influence of the other parts of the cerebral hemispheres on that which is suggested by your words, on the stimulations which you produce, is fully isolated from all others. And when the hypnotised person wakes up after such suggestion, he is powerless to do anything with this isolated excitation, since it is detached from all others. Therefore, in hypnosis it is a question not of complete, but of partial sleep. That is the difference between hypnotic and natural sleep. Whereas natural sleep represents a general inhibition of the cerebral hemispheres, however, with the above-mentioned exception of the so-called points on duty and points on guard, hypnosis is a partial inhibition affecting only a definite point, all others remaining in an active state.

Question: How do you explain the regular interchange of sleep and wakefulness?

Answer: It is clear that our daytime activity is the sum total of the excitations which cause a certain amount of exhaustion; when this exhaustion reaches peak, it evokes automatically, in an internal humoral way, a state of inhibition accompanied by sleep.

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PAVLOV'S PHYSIOLOGICAL TEACHING AND PSYCHIATRY

By Professor Y. Popov,
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Pavlov's physiological teaching is important to psychiatry in two ways. On the one hand, in that it is connected with the philosophical aspect, the role which Pavlov's conception has played in the development of the materialist world outlook and, on the other hand, in that, in interpreting various psychopathological phenomena, psychiatry makes wide use of the particular regularities of physiology and pathology of higher nervous activity which were studied by Pavlov and his school in experiments on animals. Each of these two aspects of the problem must be examined separately.

This examination must be prefaced by one terminological observation without which a misunderstanding would be likely to arise. It is the question of the relations between the terms "higher nervous activity" and "the psychic". Pavlov himself regarded these two terms as synonyms. He wrote: "This ... activity of the cerebral hemispheres and of the nearest subcortex ... the activity which ensures normal complex relations between the organism as a whole and the external world, must be rightly considered and denoted as *higher nervous activity* ... instead of 'psychical' as it was termed previously."* And in another

* Present edition, p. 285.

place: "At present we are making, as it seems to me, warrantable attempts to apply the same method to human higher nervous activity which is usually called psychical activity."* As we shall see below, this equation of the conceptions of "higher nervous" and "psychical" activity is of great fundamental importance.

I

Observing diseases characterised by mental disorders man has always wondered about the causes of these disorders, and has always explained them primarily on the basis of his general philosophical world outlook. People adhering to the materialist position believed mental disorders to depend on disturbances in the activity of the brain as a material substrate of the mind. Adherents of idealist (or dualist) philosophy disconnected the mental disorders from their cerebral basis. In accordance with this the position of psychiatry among the other sciences was also given different interpretations. If the mental did not directly and immediately depend on the brain, the study of its (mental) pathology was not the concern of those who studied the human organism.

In keeping with this, the famous German idealist philosopher Kant held that, to decide whether the accused is mentally sound, philosophers and not physicians should be invited to court as experts.

According to Hildebrand, the competence of a psychiatrist appearing in the role of forensic expert is based not so much on his special scientific knowledge as on the strength of his philosophic judgement.

Kronfeld in his book *The Essence of Psychiatric Knowledge*** arrives at the conclusion that, strictly speaking,

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* Present edition, p. 377.

** Kronfeld, *Das Wesen der Psychiatrischer Erkenntnis*, Berlin, 1920.

psychiatry is generally not a science of naturalists and physicians and must, at any rate, be with no lesser justification classed with the sciences of the spirit (*Geisteswissenschaften*).

Already in his earlier works Kurt Schneider* inclined to the thought that the study of pathological cerebral processes which underlie mental disease is not at all the business of the psychiatrist; the psychiatrist has to attend only to the psychic in which there is generally no pathology, but only "variations".

We find the same point of view also expressed in the later statements of this author. For example, in his rectorial speech made at Heidelberg in 1951 and entitled *Psychiatry Today*** Schneider maintains that, owing to the radical difference between the physical and the psychic, "the subject of psychiatry transcends the framework of the consequences of brain diseases" and psychiatry proper is only a "science of psychic anomalies". If, in speaking of psychic disorders, we also imply the pathology of the brain, we only unite, according to Schneider, the physical and the mental under one roof. This becomes possible merely insofar as "we usually speak in the language of 'empirical dualism' ". "Thus, psychiatry in the final analysis actually becomes metaphysics."

Jaspers, as is well known, opposes the subjective psychological "understanding" (*Verstehen*) of psychopathological phenomena to their objective causal "explanation" (*Erklären*) on principle.

What does such "phenomenological psychopathology" lead to? This is significantly expressed by Kleist, representative of another trend, in the following words: "When I read Jaspers and the authors related to him in spirit I

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* *Reine Psychiatrie, symptomatische Psychiatrie und Neurologie.* Zeitschr. für die ges. Neurol. und Psychiatr., Bd. 49, 1919.

** Kurt Schneider, *Psychiatrie heute.* G. Thieme Verlag. Stuttgart, 1952.

always gather the impression that they see mental diseases as a sort of spectacle which they watch amazed and staggered, full of compassion and awe. They themselves are fascinated, they speak in sonorous expressions of the solemn procession of apparitions and are happy if they can accompany the patient travelling through these mysterious worlds at least part of the way, suffering at that time together with them."*

Freud, the founder of psychoanalysis, expressed his attitude to the problem of relations between psychic phenomena and processes in the brain thus: "The medulla oblongata is a very serious and beautiful object. I recall exactly how much time and effort I devoted to its study several years ago. But now I must say that I do not know of anything more indifferent to the psychological understanding of fear than the knowledge of the nervous path travelled by its excitations."**

Even Sherrington who worked so much precisely in the field of physiology of the nervous system stated in one of his works that there is no proof of any connection between mental activity and the brain. He wrote: "If nervous activity has anything to do with the mind . . .", etc. Pavlov was so surprised at this statement that at first he lost confidence in his knowledge of English and asked others to translate this sentence.

However, whereas the afore-mentioned scientists and the people who held the same views drew a sharp line between the psychic phenomena and the processes in the brain, as a matter of principle, the people adhering to materialist positions were also in difficult straits.

It was not enough to think that psychiatry should rest on physiology of the higher parts of the brain. It was yet necessary to create this physiology and, since there was no such physiology, the attempts of Meynert, Wernicke

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* Kleist, *Die gegenwärtigen Strömungen in der Psychiatrie.*

** Freud, Sigmund, *Gesammelte Werke.* XI. Bd., S. 408.

and their followers to throw light on the pathophysiological bases of mental disorders assumed the character of unsubstantiated hypotheses, absolutely unconvincing speculations. Theoretically declaring the principle of the natural-science approach these authors actually inclined to the scholastics of *a priori* invented schemes which were later given the ironic designation of "brain mythology" (*Hirnmythologie*).* It can be said with complete justification that during that period not only a true physiology of the higher parts of the brain failed to be created, but even the approaches to its study were not outlined. F. Lange, Neo-Kantian philosopher, in his *History of Materialism*** said the following on the problem of the connections between mental phenomena and the brain: "The reason for the barrenness of all the investigations of the brain conducted until now lies only partly in the difficulty of the subject. The main reason is apparently the total absence of a more or less suitable hypothesis or even only an approximate idea of the nature of the activity of the brain." The first edition of the *History of Materialism* was published in 1866, but already three years prior to that, in 1863, I. Sechenov, in his book *Reflexes of the Brain* gave precisely the "suitable hypothesis", the general idea of the activity of the brain of the lack of which Lange complained. I. Sechenov's main thought was that "all acts of the conscious and unconscious life are, by their origin, reflexes". "All mental acts without exception ... develop by way of reflexes."*** Thus the general principle of the work of the nervous system (reflex) was also applied to the activity

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* It is interesting to note that Wernicke understood how little many of his conceptions were based on facts and himself sometimes jestingly referred to the theories he developed as "his systematised delirium".

** F. A. Lange, *Geschichte des Materialismus*, first edition, 1866. Russian translation, St. Petersburg, 1899-1900.

*** I. Sechenov, *Selected Works*, Vol. I, U.S.S.R. Academy of Sciences, 1952, p. 94.

of the higher parts of the brain with which the mental functions are connected. The fact that the original title of I. Sechenov's book barred by tsarist censorship, was *Attempt to Reduce the Origin of Mental Phenomena to Physiological Principles*, deserves attention.

I. Pavlov appraised these statements thus: "The creation of the doctrine of cerebral reflexes by I. Sechenov appears to me as a brilliant flight of Russian scientific thought; the application of the idea of reflex to the activity of the higher division of the nervous system is a declaration and realisation of the great principle of causality to the extreme manifestation of animate nature."

It was now necessary to make the following step: to connect the psychological and physiological aspects within the framework of a separate, even if simple phenomenon. And this fundamentally important step was made by Pavlov in his teaching on conditioned reflexes. He himself said the following about it: "... the temporary nervous connection is the most universal physiological phenomenon both in the animal world and in ourselves. At the same time it is a psychological phenomenon—that which the psychologists call association, whether it be combinations derived from all manner of actions or impressions, or combinations derived from letters, words and thoughts. Are there any grounds for differentiation, for distinguishing between that which the physiologist calls the temporary connection and that which the psychologist terms association? They are entirely identical; they merge and absorb each other."*

Pavlov's historical contribution consists not only and not even so much in the fact that he discovered the conditioned reflex, as in the fact that he pointed out the material, cerebral basis for this phenomenon. Thus he indicated the possibility of studying higher nervous (psychic) activity from the physiological point of view.

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* I. P. Pavlov, *Selected Works*, Foreign Languages Publishing House, Moscow, 1955, p. 251.

Speaking during the discussions of V. Boldyrev's report on "Formation of Artificial Conditioned (Psychic) Reflexes and Their Properties" I. Pavlov said: "The results of this study are interesting in that they extend the already established possibility of systematically investigating the phenomenon known as psychic by means of objective physiological methods."*

On another occasion Pavlov said: "It is all a question of whether or not it is possible to analyse the so-called psychic phenomena by the objective scientific method. We assert that it is."**

To avoid misunderstanding, it should be noted that Pavlov did not deny the possibility and usefulness of studying the subjective aspect of psychic phenomena; nor did he deny the importance of psychology which he understood as a science of subjective phenomena. But Pavlov always emphasised the superiority of the objective physiological investigation of higher nervous (psychic) activity. He pointed out that the psychological designation of a phenomenon is mainly of a descriptive character, whereas the true explanation should be built on the basis of physiological understanding.

Pavlov's statements which we find in the "Pavlovian Wednesdays"*** deserve considerable attention in this respect. Concerning the question in which we are interested here Pavlov said: "Formerly I expressed myself particularly sharply about psychology and avoided any psychological expressions, etc. This was in large measure a fascination. Then I somewhat reconciled myself..." and "...it would be foolish to deny the subjective world. It goes

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* I. P. Pavlov, *Complete Works*, Moscow and Leningrad, 1951, 2nd Russ. ed., Vol. VI, p. 245.

** Ibid., p. 253.

*** *Pavlovian Wednesdays*, Moscow and Leningrad, 1949, Vol. II, pp. 415-16. Incidentally, it should be remembered that the shorthand records included in the *Wednesdays* were neither checked nor signed by Pavlov.

without saying that it does exist. Psychology, as a formulation of the phenomena of our subjective world, is a perfectly legitimate thing and it would be incongruous to argue against it." "It is a question of analysing this subjective world. Of course, the psychological analysis must be considered inadequate because of its thousand-year-old futile efforts to study and analyse the higher nervous system. But psychology, as a study of the reflection of reality, as the subjective world in a certain manner included in general formulas, is, of course, a necessary thing. Owing to psychology I can imagine the complexity of the given subjective state." "... It is with this that we must begin and then by imagining and conceiving this subjective reality we must approach it analytically, possibly with a still inadequate physiological analysis."

The foregoing point of view quite corresponds to Pavlov's other statements to the effect that it is a perfectly justified tendency to base phenomena of the so-called psychic activity on physiological facts. In another place I. Pavlov says that the "... physiological phenomena and the experiences of the subjective world are interconnected and ... merge".*

Thus Pavlov's teaching is important for psychiatry primarily in that it has opened before us the possibility of physiological, strictly objective investigation of the most complex cerebral phenomena which were formerly considered accessible to analysis only from the subjective psychological point of view. At the same time his discoveries prove the correctness and fruitfulness of the materialist approach to the study of the psychic and confirm that "the psychical, the mind, etc., is the highest product of matter (i.e., the physical); it is a function of that particularly complex fragment of matter called the human brain".**

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* Present edition, p. 386.

** V. I. Lenin, *Materialism and Empirio-Criticism*, Foreign Languages Publishing House, Moscow, 1952, p. 233.

II

The physiology of the higher parts of the brain developed by Pavlov and his school was bound to exert enormous influence on psychiatry also in another way. Laboratory studies have established the laws governing the activity of the cerebral cortex and adjacent subcortex under normal and pathological conditions. The knowledge of these laws has made it possible to find an explanation for a number of phenomena observed in the psychiatric clinic.

In connection with this it must be emphasised that those, who think that the studies of the conditioned salivary reflexes conducted in I. Pavlov's laboratories were only investigations of the regularities of secretion of one of the glands of the digestive tract, are absolutely wrong. As has already been repeatedly noted in literature, the method of salivation was but a way of discovering the general laws of higher nervous activity. By using a metaphor we can say that the salivary gland was merely a window through which it was possible to see what was going on in the cerebral cortex. The fact that the investigations conducted by the motor method confirmed the basic regularities established by the studies of conditioned salivary reflexes serves as convincing proof of the correctness of this propositon.

Pavlov not only created the teaching on higher nervous activity which was bound to become the basis for the pathophysiological analysis of the disorders observed in the psychiatric clinic, but also himself made a number of attempts at such analysis, at the same time advancing several highly fruitful and deep conceptions. Such an "attempt of a physiologist to digress into the domain of psychiatry" (using Pavlov's own expression) quite corresponded to his views of the relationship between the clinic and the laboratory. In his article "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" Pavlov wrote: "My earlier researches on the circulation of

the blood and on digestion led me to the firm conviction that the physiological mode of thinking may derive great help from the study of clinical cases, i.e., from the countless number of diverse pathological variations and combinations of the functions of the human organism. For this reason, during many years of work on the physiology of the cerebral hemispheres I often thought of making use of the world of psychiatric phenomena as an analytical auxiliary to this physiological study."*

In his "Lectures" Pavlov emphasised once more that in studying pathological material the physiologist may sometimes consider such phenomena which it is impossible to find normally: "... the pathological often opens before us, breaking up and simplifying, what is hidden from us, blended and complicated in the physiological norm. In the lecture on normal hypnotic states we reported that the particularly interesting states ... became a subject of our investigation only since they had clearly appeared before us in a pathological case".** As a matter of fact, Pavlov always systematically strove to establish contacts with the clinic. It is significant that already the first publication on the question of higher nervous activity, his speech at the International Medical Congress in Madrid in 1903 was entitled "Experimental Psychology and Psychopathology in Animals". Here psychopathology was still understood only as a result of experimental destruction of different parts of the brain. Pavlov described that stage of his work as "... systematic division and derangement of the central nervous system in order to see how the previously established relations change.... This will be the future and, I feel sure, the already approaching experimental psychopathology".***

Later Pavlov himself pointed out that such experimental

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* Present edition, p. 60.
** Ibid., p. 167.
*** Ibid., p. 28.

methods often prove too crude and that precisely for this reason they need supplementation by clinical observations. In 1919 Pavlov said in one of his reports: "Indeed, instead of applying our usual method which, as a mode of analysis, consists in destroying certain parts of the brain, and is very crude compared with the complexity and delicacy of the mechanism under investigation, one might expect in some cases to achieve a more distinct, precise and detailed decomposition of the work of the brain as a whole into its separate elements, to obtain a delimitation of its functions resulting from pathological causes, which sometimes reach a very high degree of differentiation."* Pavlov expresses himself even more definitely on this question in his "Lectures". "The cerebral hemispheres are a most complex and subtle structure developed by the creative power of terrestrial nature, while for studying it we turn to it with a brutal form of destruction, violent total separation of some of its parts. Imagine that we have to study the structure and function of an infinitely simpler tool made by human hands. Ignorantly, without distinguishing its parts or carefully taking it apart we would remove, for example, with the aid of a saw or some other destructive tool, now one-eighth and now one-quarter of it, etc., and would thus collect material for judging the structure and function of this tool. And this is essentially what we usually do with respect to the cerebral hemispheres and other parts of the brain. With hammer and chisel or saw we break up their dense receptacle, open their several membranes, tear up their blood vessels and, lastly, exert various mechanical influences on them (concussion, pressure, distension) separating from them pieces of the size we require."**

In Pavlov's works we find his thoughts, the thoughts of a physiologist, on a number of disorders which he chanced

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* Present edition, p. 60

** I. P. Pavlov, *Complete Works*, 2nd Russ. ed., Vol. IV, pp. 336-37.

to observe in the psychiatric clinic. In his articles, speeches, reports and lectures he touched upon schizophrenia, the manic-depressive psychosis, epilepsy, paranoia, delirium, neurasthenia, hysteria, psychasthenia, obsessive states, types of human nervous system, hypnosis, and the mechanism of action of various drugs on the nervous system used in the psychiatric clinic. We shall now try to trace and systematise I. P. Pavlov's main statements on these questions.*

III

I. Pavlov encountered the problem of different types of nervous system in the experimental animals (dogs) during the very early stage of his investigations.

His observations of the so-called "experimental neuroses" served as the point of departure. In a number of cases the overstrain of the nervous system in the experimental dogs led to functional disorders.** The differences discovered in this respect between the different animals furnished the grounds for classifying the types of nervous system. The obvious analogies between the disorders revealed in the laboratory and some neurotic symptoms noted in the clinic served as the point of departure for the physiological analysis of neuroses.

By producing experimental neuroses in dogs it was, first of all, possible to establish that this was not always equally easy. In some dogs even a slight overstrain of the nervous system produced a neurosis. In others it was

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* In this article we shall not deal with Pavlov's views of schizophrenia, because this question is treated specifically in L. Rokhlin's article.

** Various methods were used to produce them. Subsequently it was established that all these methods formed three categories: 1) overstrain of the excitatory process, 2) overstrain of the inhibitory process, and 3) overstrain of their mobility, i.e., too rapid alternation of excitation and inhibition.

achieved with great difficulty. There were also dogs in which it was at first impossible to produce a neurosis by any method. Only later did the experimenters learn to produce neurosis in these animals by giving them particularly difficult tasks and by weakening their nervous system (for example, by castration).

The second series of facts showed that the picture of neurosis differed in the different dogs: in some it was mainly the inhibitory reflexes that were disturbed and the positive preserved, in others, on the contrary, the inhibitory reactions clearly prevailed over the positive reactions which weakened or disappeared altogether.

On the basis of these data, on the one hand, and depending on how easily the various conditioned reflexes were elaborated, on the other hand, the dogs were at first divided into three groups: the excitable type, inhibitory type and intermediate or balanced type. Furthermore, the intermediate group was in its turn divided into two types: the barely active type and the lively type. These types were given designations borrowed from the Hippocratic teaching on temperaments: sanguine (excitable), melancholic (inhibitory), phlegmatic (intermediate, sedate), and choleric (intermediate, lively).

This initial division was subsequently reconsidered and revised. To begin with, it turned out that the inhibitory type was interpreted incorrectly. It was assumed that "...the dogs of this type are, as it were, specialists in inhibition and all types of internal inhibition are easily produced in them and persist...."* On the other hand, the process of excitation in these dogs was considered to be relatively weak. Later it developed that inhibition in these dogs was conditioned not by the prevalence of internal inhibition over excitation in them, but by weakness of both processes. "With equal ease the weak inhibitable type becomes ill both under slightly strained inhibition and under

* Present edition, p. 169.

the action of very strong stimuli."* Pavlov plainly says that this is "a weak type in which both processes are weak, especially, the inhibitory process".** Of course, when speaking of the peculiarities of inhibition in animals of the weak type, it is necessary to remember the difference between external and internal inhibition.

I. Pavlov writes: "In the weak type, with its weak internal inhibition, the external inhibition (negative induction) is, on the contrary, highly predominant and, above all, determines the entire external behaviour of the animal."*** Later, the characteristic of behaviour (more tranquil, sedate, very lively, active, etc.) was replaced with a purely physiological criterion of the mobility of nervous processes.

In the end the classification of types of nervous system was based on a combination of three factors: strength of basic nervous processes, balance between them and their mobility. Various combinations of these features made it possible theoretically to foresee the existence of eight or even twenty-four different types. Practically, however, four main types were set apart: strong, balanced and mobile (sanguine), strong balanced and barely mobile (phlegmatic), strong and unbalanced (choleric), and weak (melancholic). Pavlov emphasised that these properties of the nervous system were not constant and invariable, that they very greatly depended on the influence of the environment, greater or lesser training of the processes, etc. The observations of Vyrzhikovsky and Mayorov conducted in Pavlov's laboratory showed that pups which had been kept in a cage since the very day of their birth subsequently proved extraordinarily cowardly and were inhibited by the slightest changes in the environment. The reason for it was that artificial isolation from contact with the environment

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* Present edition, p. 295.
** Ibid., p. 252.
*** Ibid., p. 263-64.

inhibited the natural involution of the "reflex of caution", which is characteristic of pups and which, as a rule, subsequently disappears.

Since the aforesaid factors—strength, balance and mobility—are properties of the nervous system not only of the dog, but also of man, it is natural that the four types evolved in the laboratory (sanguine, phlegmatic, choleric and melancholic) must also be encountered with corresponding variations in man. Pavlov speaks of them as "general types of animal and human higher nervous activity". In additon to this, Pavlov also set apart special types characteristic only of man and connected with peculiarities of nervous structures inherent only in the latter.

As is well known, the idea of the multi-story structure of the nervous system is not new. It is recognised by most modern neurologists. The following levels are most frequently distinguished: spinal cord, medulla oblongata and pons, diencephalon, mesencephalon, central (basal) ganglia and, lastly, the cortex. Without dwelling on the question of the number and functional borders of these levels we may assume, as a general rule, that each underlying story is phylogenetically older than the overlying and that the overlying levels depress, inhibit the underlying levels. Pavlov applied this general idea to the cerebral cortex, holding that the latter could not be regarded as a single whole, but that it consisted of two parts—the first and second signalling systems.

The first signalling system receives the stimulations produced by the action of external objects on our "sense organs"; the first signalling system has to do with concrete images of the external world. "In the animal, reality is signalised almost exclusively by stimulations and by the traces they leave in the cerebral hemispheres, which come directly to the special cells of the visual, auditory or other receptors of the organism. This is what we, too, possess as impressions, sensations and notions of the world around

us."* "It is here that a new principle of activity arises with the help of conditioned connection or association—the signalisation of a limited number of unconditioned external agents by a countless number of other agents, which at the same time are constantly subjected to analysis and synthesis and ensure very wide orientation in relation to the same medium and thereby a much higher degree of adaptation. This is the only signalling system in the animal organism and the first signalling system in man."**

Over this first signalling system a second signalling system is superimposed in man. This system already has to do not directly with the signals which reach the first system, but with the signals of these signals, with words: "... speech constitutes a second signalling system of reality which is peculiarly ours, being the signal of the first signals".*** "In this way a new principle of nervous activity arises—abstraction and at the same time generalisation of the countless signals of the first signalling system which is again accompanied by analysis and synthesis of the new generalised signals—a principle which ensures unrestricted orientation in relation to the surrounding world and the highest degree of adaptation, namely, science, both in the form of human universal empiricism and in specialised forms."****

The interrelations of these two signalling systems create new types, characteristic only of man: artistic (predominance of the first signalling system), intellectual (predominance of the second signalling system) and intermediate (both systems are balanced).

It stands to reason that each normal person is capable of concrete-image and abstract-verbal thinking, and it is a question merely of the predominance of one or the other type in the given individual.

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* Present edition, p. 378.
** Ibid., p. 276.
*** Ibid., p. 378.
**** Ibid., p. 277.

Speaking of Pavlov's "artistic" type we cannot but recall the old statement made by the remarkable Russian literary critic V. Belinsky: "An artist thinks in images." We find a fine description of this method of thinking in Maxim Gorky's novel *My Apprenticeship*. The author describes the impression made on icon painters by M. Lermontov's poem *The Demon*. One of them said: "I could even paint the Demon: a dark shaggy body; flame-coloured wings are fire —red lead—with face and feet and hands a palish blue, like snow on a moonlit night." Here we see that a person with an artistic type of thinking and an artist by occupation finds it difficult to relate his impression in an abstract-verbal form, but this impression finds its expression in so concrete a visual image that we could even name the colours required.

Of course, Pavlov makes only a relative division between the two types of thinking. With its many-sided function the word can serve not only to convey abstract ideas, but also to designate concrete images. Therefore not only a painter, but also a writer can be an artist. The way the latter achieves his aim, indicating concrete sensuous details by means of the word, can be seen from the following example given by the critic in his analysis of L. Tolstoi's *War and Peace*. After the Battle of Borodino a physician, in a blood-stained apron near a tent for the wounded, holds a cigar in his blood-smeared hands, between the thumb and little finger in order not to soil the cigar. This position of the fingers reflects the continuity of the terrible work and lack of squeamishness, indifference to wounds and blood caused by long habit, fatigue, and desire to forget oneself. The complexity of all these inner states is depicted by means of a small detail—the position of two fingers.

As regards the interrelations between the first and second signalling systems it should be noted that either system may predominate over the other, or that they may be balanced on different levels. One of the signalling sys-

tems may prevail either because it is very strong or because the other system is very weak. Similarly the two signalling systems may be balanced under different conditions: both are weak, both are moderately strong or both are strong; in none of these variants does one signalling system prevail over the other. Pavlov himself pointed out Goethe and Leonardo da Vinci as persons in whom both signalling systems were extraordinarily strong.

The typological peculiarities which are common with the animal, as well as the specially human, which were discussed above, do not as yet indicate pathology. These variants are within the normal range, within the framework of the individual differences found among different people. But if the traits of weakness or unbalance reach the extreme limit, they go outside the normal variants and become various types of psychopathias which are connected with the normal states by a series of gradual transitions.

From the foregoing it follows that Pavlov distinguished four general and two special human types of nervous system. But, as Pavlov himself repeatedly pointed out, this number is not all-inclusive. Existence of other types, which we have as yet been unable to identify, may be assumed.

It should be noted that the terminology used by Pavlov has not remained unchanged. In his later works, for the purpose of separating the inborn peculiarities from the changes conditioned by lifetime influences, he began to speak of type and of character. Pavlov defines these two terms thus: "... type is a congenital, constitutional form of the nervous activity of the animal—the genotype. But since the animal is exposed from the very day of its birth to the most varied influences of the environment ... the ultimate nervous activity of the animal (phenotype, character) is an alloy of the characteristics of type and the changes produced by the external environment."*

* I. P. Pavlov, *Selected Works*, Foreign Languages Publishing House, Moscow, 1955, p. 260.

IV

Closely connected with Pavlov's research in experimental neuroses and types of nervous system are his views concerning the physiological basis of neurotic disorders in man —neurasthenia, psychasthenia and hysteria in the first place.

After the very first studies which made it possible to accumulate and systematise information on experimental neuroses in dogs, Pavlov began to draw an analogy between these states and certain disorders of the nervous system observed in man. This analogy could be the more easily drawn since Pavlov regarded human neuroses as psychogenic diseases. While fully appreciating the difference in the content and nature of the stimuli falling on the animals and man, Pavlov at the same time pointed out the common elements which could be subject to physiological analysis. He wrote: "To a considerable degree the pathological nervous states produced by us conform to the so-called psychogenic diseases in human beings. The same overstrain and the same collisions of the excitatory and inhibitory processes are also encountered in our own lives. For instance, somebody has deeply insulted me and I for some reason or other have not been able to respond to it by corresponding words, or, moreover, by a certain action, with the result that I had to overcome the struggle or conflict between the excitatory and inhibitory processes within myself. And this was repeated more than once.... This often leads to breakdowns, to neuroses. Indeed, can we find any essential physiological difference between such breakdowns and those which we obtain in our experimental animals by colliding the excitatory and inhibitory processes?"*

As is well known, the very first observations revealed two forms of disturbances of nervous activity in animals: in some cases the inhibitory process was greatly disturbed,

* Present edition, p. 364-65.

while the excitatory process exhibited no particular deviations; in other cases, on the contrary, the inhibitory process clearly predominated over the process of excitation. Pavlov voiced an assumption that the form characterised by prevalence of excitation corresponds to neurasthenia, and the one manifested by predominance of inhibition—to hysteria. This point of view was subsequently somewhat revised. The physiological bases of hysteria were later given by Pavlov in an entirely different light, whereas the analogy between experimental neurosis and neurasthenia was completely confirmed. This analogy holds good for the conditions of emergence of neurasthenia (overload, overstrain of the nervous system), as well as of the symptoms. In point of fact, almost all the basic symptoms forming the clinical picture of neurasthenia can be interpreted as results of inadequacy of the inhibitory process. Hence, the excessive ease of emergence and violence of reaction in the neurasthenics, inadequacy of inhibition which finds vivid expression in the entire behaviour of these patients, their rapid exhaustion in connection with the important role played by inhibition in restoring the nerve cell, and a good deal else. Later the understanding of the physiological bases of neurasthenia was additionally enriched by the discovery of the phenomenon of pathological lability, "explosiveness" of the excitatory process in the picture of experimental neurosis. In this case "certain individual stimuli or all the conditioned stimuli produced an extremely violent and excessive effect (both motor and secretory), which, however, abruptly disappeared already during the action of the stimulus".* As Pavlov points out, the similarity of this phenomenon with "excitatory weakness" which represents such a characteristic feature in the picture of neurasthenia cannot be doubted.

The assertion made by some clinicians that two forms of neurasthenia must be distinguished—one with predomi-

* Present edition, p. 386.

nance of excitatory phenomena and the other with prevailing symptoms of depression—is, in Pavlov's opinion, confirmed by facts and finds its conformity in the two basic types of experimental neurosis discussed above. (As we have already noted, Pavlov later relinquished his initial comparison of one of them with hysteria.)

Naturally, neurasthenia does not arise with equal ease in different people or in different animals. In both cases those who have a weak nervous system are particularly inclined toward development of this neurotic state. At the same time, as the similarities between the basic features of experimental neurosis and neurasthenia make it clear, the main role is played by the peculiarities of the nervous system common to man and animals and not specific for the former. Pavlov wrote: "Neurasthenia is a pathological form inherent in the feeble-general and intermediate human types."*

Naturally, neurasthenia may also develop in a representative of the strong type if the latter is extraordinarily overstrained.

Unlike neurasthenia, psychasthenia and hysteria are specifically human neuroses. Their development is directly dependent on disturbances in the normal interrelations between the first and second signalling systems (and, hence, can have no analogy in animals since the latter have no second signalling system).

Pavlov conceived psychasthenia essentially in accordance with the clinical description given by Janet. However, unlike the generally accepted point of view, Pavlov did not consider obsessive symptoms a characteristic sign of this disease. According to Pavlov, the obsessive states, as a rule, were based on foci of pathological inertness (see below) and could develop in persons with different types of nervous system, during neurasthenia and hysteria in particular. Phenomena analogous to obsession are observed

* Present edition, p. 389.

even in animals, whereas psychasthenia is characteristic of a special stamp of personality in which the two signalling systems are unbalanced, the second system predominating and the first signalling system and the emotions being relatively weak. Since the second signalling system is connected with the stimuli coming from the external environment through the first signalling system, its weakness involves an inadequacy of the "function of the real", a feeling of inferiority, imperfection of perception of the surroundings and, hence, the ensuing diffidence and indecision. At the same time the severance of the second signalling system from surrounding reality creates a predisposition to unproductive philosophising, fruitless reasoning, ungrounded apprehensions, etc. The inadequacy of the emotional-instinctive make-up finds expression in a weakness of the basic drives (food, sex, etc.). The question of the physiological bases of hysteria was answered by Pavlov fully and with remarkable insight into the essence of this disease.

As already mentioned, Pavlov at first regarded hysteria as a disorder analogous to the forms of experimental neurosis in which predominance of inhibition is observed.

Later Pavlov relinquished this point of view and advanced another, much deeper and more elaborate theory of the physiological bases of hysteria.

The question of pathogenesis of the latter has been, as is well known, a subject of numerous investigations since antiquity. Some investigators succeeded in correctly observing certain characteristic traits of hysteriacs: increased emotionality, suggestibility, escape into disease, inclination to fantasy, a peculiar disturbance in the unity of personality, etc. But before Pavlov we did not have any integral, convincing and physiologically substantiated theory of hysteria. Nor could we understand how the various peculiarities characteristic of hysteriacs were connected with each other, what united them and why these peculiarities generally emerged in the given personality.

Pavlov based his theory on the conception of the general weakness of the nervous system of hysteriacs combined with the unbalance of the signalling systems, the second signalling system being particularly weak. What are the consequences of this assumption? To begin with, the weakness of the cortex must involve an increased activity of the subcortex partly because the latter turns out to be free from cortical control and partly because of the positive induction from the cortex which easily lapses into a state of inhibition. This accounts for the increased emotionality of hysteriacs as well as their inclination toward violent affective discharges and primitive motor reactions which assume the form of attacks. The high inhibitability of the cortex conditioned by its weakness creates prerequisites for the emergence of a deep state of "hypnosis" and pictures of protracted torpor. On the other hand, the points of the cortex, which, under the influence of emotions, "are charged from the subcortex", easily prevail over the other foci of excitation and by strong negative induction exclude the control and influence of the latter. Hence, the "emotional logic" and tendency to act mainly under the influence of direct affective motives, characteristic of hysteriacs. The same phenomenon (strong negative induction from the point of concentrated excitation, especially supported by the subcortex, which easily depresses all the competing foci of excitation against the background of the generally low cortical tone) also explains the increased suggestibility and autosuggestibility of hysteriacs. Here the mechanism is the same as in hypnotic and posthypnotic suggestion. This is why the well-known characteristic of hysteriacs, as persons in a state of chronic hypnosis, is, as Pavlov points out, to a certain extent correct. The powerful influence exerted by emotional stimuli on the higher nervous activity of hysteriacs also elucidates the nature of the notorious "escape into disease": the reactions or forms of behaviour which, for particular reasons, have a positive emotional colouring, are easily consolidated, become ex-

tremely stable and tend to relapse. Thus, according to Pavlov, the factor of "desirableness", "advantageousness" is not at all necessary for the emergence of the hysterical reaction, but, where such a factor is on hand, the developed symptoms prove particularly stable and persistent as positively reinforced. Pavlov wrote: "We, therefore, have no sufficient grounds to affirm that this case represents a deliberate simulation of symptoms. In effect, it is a case of fatal physiological relations."*

The inclination of hysteriacs toward unbridled fantasy and day-dreaming, and, in extreme cases, twilight states, when the images of fantasy become so strong and vivid that they distort perception of surrounding reality, must be connected with the special weakness of the second signalling system. The latter easily sinks into an inhibited state thus freeing the first signalling system from its control, and the activity of the latter, strengthened and not properly guided, finds expression in the aforesaid forms (the first signals with their imagery and concreteness come into play).

Thus, the most diverse, and, at first sight, unconnected manifestations of hysteria are conditioned by the action of three physiological mechanisms: 1) easy liability to various degrees of the hypnotic state because even usual stimuli are supermaximal and cause transmarginal inhibition, 2) extraordinary fixation and concentration of nervous processes at individual points of the cortex owing to the predominance of the subcortex and 3) extraordinary strength and diffusion of negative induction due to the low resistance of the positive tone of the remaining parts of the cortex. These three physiological mechanisms are in their turn produced by one common cause—weakness of the cortex as a whole and of the second signalling system, in particular.

At the same time we must remember that weakness of the second signalling system may be not only inborn, but

* Present edition, p. 271.

also acquired. It is precisely for this reason that we sometimes see emergence of hysterical reactions (or, as some people put it, hysterisation of the personality) after physical injury to the head, after repeated psychic trauma, etc., in "constitutionally healthy" people. In such cases the preceding harmful factors weakened the second signalling system and thereby created physiological prerequisites for reaction in the manner of the hysterical type.

Thus we see that the theory proposed by Pavlov not only enables us to understand and knit into a single whole the different manifestations of hysteria, but also gives them a physiological explanation, and shows from which anatomo-physiological peculiarities and how these clinical symptoms arise. At the same time Pavlov does not reject the greater part of the preceding "psychological" theories of hysteria, but unites them, synthesises them and puts them on a pathophysiological basis. Together with Pavlov we recognise the importance of increased emotionality (Kraepelin, Déjerine), increased suggestibility (Babinski, Moebius), tendency to lapse into a state of "chronic hypnosis" (Charcot, Sollier), disturbances of the mental synthesis (Pierre Janet), split personality (Raymond), reaction by means of phylogenetically old mechanisms (Kretschmer), and the patient's interest in "escape into disease" (Bonhoeffer, Strümpell); but at the same time Pavlov shows us how all these signs combine and what peculiarities in the state of the brain condition them.

V

Phenomena of hypnosis* attracted Pavlov's attention early in his work. As far back as 1919, the article "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" pointed out various similar features between

* To avoid misunderstanding it should be remembered that Pavlov used the word "hypnosis" with two meanings. Firstly, he

the hypnotic state and certain manifestations of schizophrenia. In particular, he expressed the assumption that the mechanism of *flexibilitas cerea* in schizophrenia is the same as in hypnosis: inhibition of the cortex which conditions the release and strengthening of brain stem reflexes.

In his article "Concerning So-Called Hypnotism in Animals" published in 1921 Pavlov developed the hypothesis, according to which this state (hypnosis in animals) is a self-protective reflex of an inhibitory character elicited by extraordinary external stimuli. Pavlov was not the only one to hold this view. He himself wrote: "A number of other authors came to this same conclusion concerning hypnosis in animals."* Among other things we deem it necessary to mention that V. Danilevsky, well-known Kharkov physiologist, expressed an analogous point of view as early as 1878 in his report to the Kharkov Medical Society and in 1885, 1888 and 1889 in publications.** V. Danilevsky also held that the physiological mechanism of hypnosis in animals (and man) consisted in a reflex depression "of the voluntary muscles and reactions of sense perceptions".

Subsequently Pavlov's conception of hypnosis underwent a considerable evolution. The basic proposition that the essence of hypnosis consisted in inhibition of the cortex sometimes descending to the underlying brain stem apparatus remained unchanged. But the achievements made over a number of years in the studies of the very process of inhibition enabled him considerably to improve and develop his initial conception.

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employed this word in the usual sense, implying the phenomena pertaining to the field of hypnotism. Secondly, by the word "hypnosis" Pavlov designated the phenomena of partial sleep, inhibition, which has not reached complete development, but has attained only a particular intermediate stage which Pavlov called a "hypnotic phase".

* Present edition, p. 71.

** Subsequently V. Danilevsky fully substantiated and set forth his views in the monograph *Hypnotism* (Kharkov, 1924).

Whereas originally hypnosis in animals was regarded as reflex inhibition evoked by extraordinary stimuli, sudden brutal violence, later it was possible to establish that stimuli of moderate strength repeated for a long time could also produce the hypnotic state in the dog. Subsequently it was found that indifferent stimuli several times coinciding with inhibitory stimuli themselves became inhibitory ("negative conditioned reflexes"). For example, the situation in which sleep was induced in the dog, or the phenomena which preceded sleep, acquired a hypnotic effect.

Thus the three basic methods by which hypnosis is also produced in man were given their physiological explanation: 1) hypnosis by means of unexpected strong stimuli as induced by Charcot in hysteriacs, 2) hypnosis induced by means of weak but long-continued or monotonously repeated stimuli (fixation of a shining object, metronome beats, stroking, etc.), and 3) hypnosis induced by verbal suggestion of the sensations or physiological states which usually precede man's falling asleep.

The implication of the formula—inhibition is the basis of hypnosis—has also changed. In his very first works dealing with this subject Pavlov emphasised that it was a question of partial inhibition. But the term "partial" was originally understood, so to speak, purely regionally. It implied that inhibition did not embrace the entire cerebral cortex,* but only more or less considerable sections of it, mainly the motor divisions, that, against the background of this diffuse inhibition, there remained some sections which retained normal excitability and thereby ensured the connection between the subject and the hypnotist. Pavlov wrote: "... If there are no obstacles in the form of foci of strong excitation to prevent inhibition from spreading over the cerebral cortex, you have ordinary general sleep. If the inhibitory process embraces only part of

* Sometimes, as has been said, it descends to the subcortical structures.

the cerebral cortex, you will have partial sleep—the state usually called hypnosis."*

However, as the transition of the nerve cell from the state of normal excitation to that of complete inhibition was studied in greater detail, it became clear that inhibition could be partial also in another sense. The intermediate stages on the way of development of inhibition were investigated. It was these stages or "hypnotic phases" that proved especially characteristic of the state of hypnosis. In the "Lectures on the Work of the Cerebral Hemispheres" Pavlov, following the description of the different hypnotic phases (paradoxical, equalisation, ultraparadoxical, hypnotic) said: "It can hardly be doubted that the states of the hemispheres described in this lecture are what is known as hypnosis in its different stages and features."**

As is well known, the main, central phenomenon of hypnosis is increased suggestibility. On the basis of his conception of the nature of the hypnotic state Pavlov was able to give a physiological explanation also of this phenomenon (increase in suggestibility). Here there are two mechanisms which differ from one another but are both connected with inhibition. The first of these mechanisms is connected with phenomena of negative induction. "During hypnosis we observe even in a normal and strong cortex a lowered positive tone owing to irradiated inhibition. When the word or command of the hypnotist is directed to a definite point of such a cortex as a stimulus, the latter concentrates the excitatory process in a corresponding point and is immediately followed by negative induction, which, meeting little resistance on its way, spreads over the entire cortex; thanks to this, the word or command is completely isolated from all influences and becomes an absolute, irresistible stimulus, continuing to oper-

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* I. P. Pavlov, *Complete Works*, 2nd Russ. ed., Vol. III, Book 2, p. 393.

** Present edition, p. 146.

ate even subsequently, when the individual returns to an alert state."*

Pavlov expressed the same idea also in another place: "The word of the person who begins hypnotising the given subject with a certain degree of inhibition developing in the cerebral cortex, concentrating the stimulation in a definite narrow region, according to the general law, at the same time evokes naturally deep external inhibition throughout the remaining mass of the hemispheres and thus excludes all competing influence of all the other present and old traces of stimulations. Hence, the great, almost irresistible power of suggestion as a stimulus during hypnosis and after it."** The other mechanism which conditions increased suggestibility during hypnosis is connected with the peculiarities of the paradoxical phase. Pavlov spoke of it as follows: "Suggestion in hypnosis can be rightly interpreted as such a phase of inhibition when weak conditioned stimuli (words) produce a greater effect than the evidently stronger, direct and real external stimuli."*** "The fact that the hypnotised subject may be suggested anything that is contrary to reality and a reaction diametrically opposed to the real stimulations—a sweet taste instead of a bitter taste, an unusual visual stimulation instead of a commonplace stimulation, etc., may be evoked—can be understood, without stretching the point, as the paradoxical phase in the state of the nervous system, when weak stimuli produce a greater stimulatory effect than do strong stimuli."****

On the basis of the same general propositions Pavlov also explained the other phenomena observed during hypnosis. He considered catalepsy a result of isolated inhibition of the motor area of the cortex, which does not de-

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* Present edition, p. 268-69.
** Ibid., p. 202.
*** Ibid, p. 84-85.
**** Ibid., p. 203.

scend to the underlying centres of bodily equilibrium. He regards echopraxia of the hypnotised as a manifestation of the "imitative reflex ... by means of which complex individual and social behaviour is elaborated in all of us during childhood".* Pavlov connected the performance of complex automatic (habitual) actions by the hypnotised with the narcotic phase, "when the strong and old reflexes persist while the weak and young ones disappear".**

In summary we must say the following. The phenomena of hypnosis were well described and systematised even before Pavlov, but we did not have any in any way satisfactory physiological explanation of these phenomena. Their essence appeared unintelligible and mysterious. And in this respect the facts and considerations produced by Pavlov have made a revolution, have laid the groundwork for physiological interpretation of hypnosis and have created the prerequisites for its further fruitful study.

VI

The ideas about the physiological bases of delirium and obsession expressed by I. Pavlov are of great interest.

Pavlov was impelled to consider these questions by his observations of certain disorders which occurred during "experimental neurosis" in dogs. Two phenomena in particular gave him grounds for comparison. The first of these is the so-called "pathological point". What characterises it? "With the help of our morbific methods, which make the whole cerebral cortex pathological, it is also possible to cause a completely isolated region of the cortex to become ill.

"... Suppose you have a dog with a series of different acoustic conditioned stimuli: beats of the metronome, a noise, a tone, a crackling or a gurgling sound, etc. From all these stimuli it is not difficult to obtain only one which

* Present edition, p. 201.
** Ibid., p. 202.

would prove noxious and evoke a sharp deviation from the normal."* This deviation from normal may be manifested variously: in some cases, in a chronic hypnotic state of the pathological point by violation of the law of the relationship of forces in it, and in other cases, in pathological inertness. The results of "contact" with the "pathological point" may also differ. "The stimulation of the pathological point sometimes remains indifferent to the points of other stimuli, and sometimes it is impossible to touch this point with its stimulus without deranging in one way or another the entire system of reflexes."** But, at any rate, we are dealing with a narrowly limited section, as though isolated in its pathology from the rest of the cortex which reveals no functional disorders as long as the "pathological point" is not touched.

Another phenomenon to which we must devote our attention in connection with the question we are concerned with is "pathological inertness". Usually a conditioned reflex can be quite easily extinguished or inhibited by another method (for example, by means of successive inhibition), a positive conditioned reflex can be transformed into an inhibitory reflex and vice versa. But in some cases a conditioned reflex once formed assumes the character of pathological stability, cannot be eliminated by any of the usual methods and sometimes persists for a number of years. As was already mentioned, the disturbances observed at the "pathological point" may also be manifested in the form of pathological inertness.

This peculiar combination of phenomena, the narrow limitation, "isolation" of the pathological focus from the rest of the cortex, on the one hand, and the excessive pathological stability of the once emerged reaction, on the other hand, served for Pavlov as the point of departure in the physiological analysis of certain obsessive phenomena.

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* Present edition, p. 369.

** Ibid., p. 384.

As a matter of fact, as has long since been noted in neuropsychiatric literature, obsessive phenomena are not infrequently of a nature of peculiar isolation, a separate pathological phenomenon, a "pathological point" against the background of, in other respects, unchanged or almost unchanged mental activity.* In particular, this finds its expression in that the patient treats his obsession critically, understands its pathological nature, but at the same time cannot rid himself of it.

Furthermore, clinical analysis often shows that in a number of cases an obsession may arise at first as an understandable, to a certain extent grounded, apprehension or desire, and assumes a pathological character only in virtue of its extraordinary strength. For example, intense hand-washing after contact with contagious patients, repeated check-up to make sure that the important documents are safe or that a large sum of money is still in the pocket, avoidance of a crowd in which the patient experiences panic and distress—all these may be considered a natural reaction. But persistence of such a reaction, when it ceases to be justified by external conditions, makes it inadequate, unfit for the situation, and the reaction continues to exist only because of pathological inertness. Pavlov had the following to say about this: "If stereotypy, iteration and perseveration, as is perfectly obvious, have their natural origin in the pathological inertness of the excitatory process of the different motor cells, then obses-

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* At this point it should be noted that Pavlov draws a clear line between obsessive phenomena, as phenomena which may develop for most diverse reasons, and psychasthenia, as a special constitution of the personality which finds its expression primarily in definite traits of character. Obsessive phenomena, as is well known, are observed in psychasthenics quite often. But it should be remembered, firstly, that obsessions are observed not only in psychasthenics and, secondly, that there are, although rarely, psychasthenics with all the characterological peculiarities distinctive of this type, but without strongly pronounced symptoms of obsession.

sional neurosis and paranoia must also have the same mechanism. This is simply a matter of other cells or of groups of cells connected with our sensations and notions. Thus, only one series of sensations and notions connected with the diseased cells becomes abnormally stable and resistant to the inhibitory influence of other numerous sensations and notions, which to a greater degree conform with reality because of the normal state of their cells."* And in another place: "In compulsive neurosis and paranoia we have excessively, illegitimately fixed ideas, feelings and then actions which do not correspond to the proper natural and special social relations of man and therefore lead him into difficult, distressing, harmful conflicts with nature, as well as other men and, primarily, of course, with himself. But all this pertains only to the morbid ideas and sensations, while outside their sphere the patients think and act like quite healthy people and may even be higher than average persons."**

The aforesaid is also true, in particular, of the obsessive fears, phobias. Even in his very early works Pavlov pointed out that these phenomena were connected with weakness of the nervous system and the resulting tendency to react with a passive-defensive reflex. Pavlov wrote that phobias might be regarded "as a natural inhibitory symptom of the pathologically weakened nervous system".*** In accordance with the views expressed by Pavlov later, phobias had to be interpreted not merely as an excessively easily arising reaction of fear, but precisely as a pathologically consolidated reaction of fear.

Of course, the idea of obsession, as a phenomenon conditioned by pathological inertness, must not be applied to all its forms without exception. We may also assume the existence of other pathogenetic mechanisms (although

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* Present edition, p. 385.
** Ibid., p. 315.
*** Ibid., p. 206.

pathological inertness is apparently the most frequent and important of them). Thus "contrasting" thoughts and desires (for example, a desire to laugh at a funeral, an urge to insult a respected person, sacrilegious thoughts of a religious person or rudely cynical of a virtuous person) are probably physiologically based on the ultraparadoxical phase, as we tried to prove in one of our works. Towards the end of his life Pavlov himself voiced the assumption that bathophobia may, at least in some cases, be conditioned by pathological lability of inhibition. The reason for this conclusion was M. Petrova's observation of a dog which after excessive strain of the inhibitory process began to avoid approaching the edge of the stair-well. Pavlov explained this phenomenon by the fact that a normal animal in dangerous proximity to the edge of a stair must inhibit the movements which might result in its fall. This type of inhibition became extremely difficult to M. Petrova's dog and the animal therefore began to avoid situations connected with the necessity of exercising such inhibitory reactions. Later Petrova* herself explained this case differently on the basis of her subsequent observations, but this in no way diminished the fundamental importance of Pavlov's suggestions of the heterogeneity of the pathogenic mechanisms of obsession.

The very difficult and many-sided problem of delirium was treated by Pavlov only partly. In the first place his attention was attracted by the two peculiarities already mentioned above in connection with the phenomena of obsession: stability of the pathological phenomenon and its relative "isolation" from the other mental processes. This is why Pavlov considered precisely the delirium of the paranoiac especially convenient for physiological analysis. "As is known, paranoia is characterised by the fact that

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* M. Petrova, *The Role of the Functionally Weakened Cerebral Cortex in the Origin of Various Pathological Processes in the Organism*, Medgiz Publishing House, 1946.

a mentally normal person, who, like all healthy people, reckons with logic and reality, and sometimes may even be gifted, as soon as it comes to one definite subject, distinctly turns into a lunatic, acknowledging neither logic, nor reality. It seems to me that this form can be understood on the basis of our laboratory findings relating to isolated disorders of separate points in the cerebral cortex."* Pavlov connected the stability of paranoid delirium, its inaccessibility to logical influence and the impossibility of dissuading the patient with phenomena of pathological inertness, the presence of a focus of excitation which stubbornly resists inhibition.

Thus the two basic pathophysiological mechanisms mentioned in the analysis of obsessive phenomena (isolated "pathological point" and pathological inertness) were also used in the explanation of certain aspects of paranoid delirium. This is why Pavlov often referred to these two pathological phenomena simultaneously.

The cardinal difference between obsessive phenomena and delirium—the presence of a critical attitude in the former case—Pavlov ascribed to the relationship of forces. "As for the other sign of difference between the two forms in question (absence of critical attitude to the pathological symptom in paranoia and its presence in the compulsive states), it must naturally be reduced to the difference in intensity of pathological inertness. As the aforesaid indicates, the strong type must have considerable pathological inertness of the excitatory process and this will naturally be connected with greater independence and even its invulnerability to the influence of the healthy regions of the cortex, which physiologically conditions the absence of a critical attitude. Besides, it is probable that the inert excitatory process of considerable intensity must produce on the periphery, on the basis of the law of negative induction, strong and widespread inhibition, which must again lead

* Present edition, p. 375.

to the same result, i.e., exclusion of the influence of the rest of the cerebral cortex on it."*

It is perfectly clear that, proceeding from such propositions Pavlov concurred in the opinion of the psychiatrists who hold that obsessive and delirious ideas are related and that the former may develop into the latter. It should be noted that delirium is not a homogeneous phenomenon. In analysing patients Pavlov repeatedly pointed out that delirium may have a different origin in different diseases. The afore-mentioned physiological analysis applies mainly to delirium in paranoia and the related forms of psychogenic reactive formation of delirium.

Another phenomenon that attracted Pavlov's attention and was closely connected with the problem of delirium is the so-called inversion. It consists, as is well known, in the fact that some mental contents seem to transform into their opposites: a girl proud of her virtue begins to believe herself pregnant, a scrupulously honest employee suddenly begins to think that the people around him suspect him of theft or that he has really stollen something. Such phenomena have long since been described in psychiatric literature, but their nature remained entirely unintelligible. Pavlov has convincingly shown that inversion is connected with the ultraparadoxical phase during which inhibitory stimuli acquire the properties of positive stimuli and vice versa. The pages devoted to this question are a brilliant example of a simultaneously physiological and psychopathological analysis.

VII

The methods of investigating higher nervous activity elaborated by Pavlov have made it possible to study the influence of a number of medicinal substances on the brain so thoroughly as was theretofore impossible. Numerous

* Present edition, p. 320.

studies have thrown light on the mechanism of action of bromides, caffeine, luminal, chloral hydrate, alcohol and many other substances. It would be out of place to dwell on these in detail. We shall confine ourselves to a few examples.

Bromides have been used in the clinic for the treatment of neurotic states for a period of several decades. This medicine has also proved very effective in the treatment of experimental neuroses. Here, in the laboratories supervised by Pavlov and by his fine methods we obtained the information which has shown how little we, clinicians, really knew about the mechanism of action of this popular drug. It has developed that bromides do not in any way diminish excitability or weaken the stimulatory process, as was generally believed, but intensify the inhibitory process, and the inhibitory process favours restoration of the energy of the cell. That is why, after administration of bromides, the positive reflexes sometimes also increase in addition to intensification of the inhibitory reflexes—a fact absolutely unintelligible from the old point of view. This effect of bromides favouring restoration of the efficiency of the cell came in some cases very distinctly to the fore. Thus, for example, Pavlov reported about a certain castrated animal: "During the usual daily work the conditioned reflexes were chaotic. Three-day intervals between the experiments-conditioned an entirely normal functioning of the reflexes.... Administration of bromides restored and retained normal activity also during the daily experiments."* Thus administration of bromides ensures restoration of such efficiency of the nerve cells in the course of one day as formerly required, without the bromides, three days.

As regards the effect of ethyl alcohol on the central nervous system the opinion was often expressed that, like many narcotics of the fatty series, it produced excitation

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* Present edition, p. 252.

which was then replaced with inhibition. The possibility of isolated study of excitation and various forms of inhibition by the method of conditioned reflexes has revealed a different state of affairs. It has developed that the phenomena of excitation observed during the initial stage of the effect of alcohol are in no way a result of an intensified excitatory process, but are conditioned by weakened internal inhibition. Owing to this the usual equilibrium between the excitatory and inhibitory processes is disturbed in favour of the former. In this respect ethyl alcohol fundamentally differs from caffeine and phenamine (amphetamine) which are true stimulants of the excitatory process. The functional weakening of the nervous system noted at a later stage in the action of alcohol is not true inhibition, but a result of weakened excitation. Thus it was learned that alcohol paralyses both basic nervous processes, but excitation is paralysed first and inhibition (internal) afterwards.

The foregoing has made it clear that the apparent "hypnotic" effect of different drugs is also not homogeneous. It is necessary to draw a line between the true hypnotic effect connected with primary intensification of inhibition and the states conditioned by a weakening of the excitatory process, which states are in their physiological nature different varieties of narcosis.

The investigations of Pavlov's school made it necessary to re-examine the question of dosing medicinal substances. The very first studies of bromides showed that, to obtain the desirable effect, the dose of the particular substance had to be altered within the range of several milligrammes to several grammes per dose. Later it was found that the proposition concerning the enormous variability of doses in that case was also applicable to other drugs. It was also possible to discover the factor on which such variability of the reaction to different amounts of the drug depended. It turned out that the decisive role was played by the strength of the nervous system, the strength of excitatory and inhibitory processes, to be exact (it should be remem-

bered that in an unbalanced type one of these processes may be strong and the other—weak). The stronger the nervous system as a whole, or the particular process, the greater must be the dose of the drug, and the weaker they are, the less of the medicinal substance it takes to produce its characteristic effect. At the same time it should be noted that weakness of the nervous system may be not only a rather constant peculiarity of the given animal, but may also be conditioned by temporary weakness caused by disease, exhaustion, etc. In such cases, as the patient recovers and the nervous system concurrently grows stronger, the dose of the drug must be progressively increased.

VIII

Pavlov's works also touched upon other questions which are of great interest to the psychiatrist: effects of castration and aging on higher nervous activity, circularity of nervous activity as a result of disturbed relations between excitation and inhibition, relation of this circularity to manic-depressive psychosis, etc. We are in no position to treat of these questions here in detail.

We think that the aforesaid already suffices to show the tremendous contribution made by Pavlov to psychiatry, the great impulse he imparted to the development of this science.

We have confined ourselves mainly to exposition only of Pavlov's own thoughts. The ideas expressed by him have served as an impetus to numerous investigations conducted in different parts of the Soviet Union. The information obtained confirms the correctness of the conceptions advanced by Pavlov and contains their further development.

A systematic review of these works is outside the aims of this article and must form the subject of a special report.

PAVLOVIAN CONCEPTION OF SCHIZOPHRENIA

By Professor L. Rokhlin,
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Greatly interested in the study of psychiatry from the point of view of his teaching on higher nervous activity Pavlov naturally devoted considerable attention to the problem of schizophrenia which, as is well known, is the most widespread and severest mental disease. It is precisely in the observations of schizophrenics during his first visits to the psychiatric hospital at the Station of Udelnaya, near Leningrad, in 1918 that Pavlov saw "excellent demonstrations of points more or less explained in physiology...", and that "new aspects of the work of the brain were brought to light, new questions and unusual problems for laboratory investigation arose...". Pavlov summed up his observations in the article "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres"*, which is devoted to a physiological analysis of certain symptoms of the catatonic form of schizophrenia and which already contains outlines of Pavlov's pathophysiological interpretation of schizophrenia. Pavlov showed the same special interest in schizophrenia during his second "excursion" into psychiatry in 1929, when he resumed his observations of mental patients and regularly visited the psychiatric clinic, supervised by Professor P. Ostankov and located in the I. Balinsky Psychiatric Hospital in Leningrad.

* Present edition, pp. 60-61.

As V. Fyodorov* points out, in accordance with Pavlov's wish, during the initial period of his visits to the clinic only schizophrenic patients were demonstrated to him and were analysed jointly with him clinically and physiologically. These visits resulted in a new article which Pavlov entitled "An Attempt of a Physiologist to Digress into the Domain of Psychiatry"**; this article is also completely devoted to schizophrenia. In it Pavlov gives a more comprehensive physiological analysis of the catatonic form of schizophrenia and sets forth in detail his views of the pathophysiological bases of this disease.

In many of his other works Pavlov also repeatedly comes back to the physiological interpretation of the clinical manifestations of schizophrenia. These separate statements made by Pavlov are very valuable for a better understanding of his general conception of schizophrenia. His statements made at conferences of the collaborators of the laboratories and clinics supervised by him are also useful for a fuller understanding of his ideas of schizophrenia. These statements published in the form of protocols and shorthand records (*Pavlovian Wednesdays*, Moscow and Leningrad, 1949, Vols. I-III) contain many of his very interesting considerations on various questions of the clinical aspects and pathophysiology of schizophrenia. In a number of cases the latter are not firmly established scientific propositions or conclusions of finished scientific research, but are rather bold scientific conjectures, preliminary scientific hypotheses, thoughts and ideas on some particular question. However, their examination as a whole takes us, as it were, into the laboratory of Pavlovian thoughts and enables us to trace the sources and development of his conception of schizophrenia.

If we were to sum up briefly what Pavlov contributed to the teaching on schizophrenia by his investigations, we

* V. Fyodorov, "I. Pavlov's Visits to the Psychiatric Clinic in 1929-30". *Neuropathology and Psychiatry*, Vol. XX, Book 6, 1951.

** Present edition, p. 225.

should note, firstly, that Pavlov developed a harmonious theory of the general pathophysiology of schizophrenia and established a number of general regularities of the changes in higher nervous activity underlying the psychopathological phenomena observed in schizophrenia, secondly, that he gave an exhaustive pathophysiological explanation of the various psychopathological symptoms encountered in schizophrenia and, thirdly, that he furnished a deep pathophysiological substantiation of the therapy and regimen for schizophrenics. We shall consider each of these contributions separately.

1

To form a correct understanding of Pavlov's conception of schizophrenia, we must bear in mind the basic regularities established by him and underlying the pathology of the activity of the cerebral hemispheres. This pathology is conditioned by a number of factors and has different forms of physiological expression. It is primarily disturbances in strength, balance and mobility of the basic nervous processes—excitation and inhibition—produced by different causes. Of particular importance here is the inhibition developing in the cerebral hemispheres, its hypnotic phases and its protective role. A no less severe form of pathology emerging under the influence of different harmful factors is the disturbance in the concerted activity of the various parts of the brain, including the signalling systems. To get a better insight into Pavlov's views on this question, we must remember his interpretation of the interrelations between the cerebral cortex and the subcortical structures, as well as his physiological characterisation of the first and second signalling systems and their interaction. Lastly, for a complete evaluation of the pathology of higher nervous activity of the cerebral hemispheres we must take into consideration Pavlov's teaching on isolated pathological points conceived in a physiological and not an anatomical

sense. The possibility of selective disorders of the various physiological functions and the role of such disorders in the disintegration of higher nervous activity as a whole, completely explained in Pavlov's teaching on the "pathological points", must also always be taken into account in the analysis of a particular pathology of the cerebral hemispheres. As was already pointed out, Pavlov's special works devoted to schizophrenia analysed physiologically mainly the catatonic manifestations of schizophrenia. In his very first work entitled "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres", Pavlov arrived at the conclusion, by analysing two patients in catatonic stupor with catalepsy in one case and tonic reflexes in the other, that the pathological symptoms observed in these patients are based on "an isolated depression only of the motor area of the cerebral cortex" also known in other states in man and animals. On the basis of his observations of hypnosis and of his experimental studies of this phenomenon on his laboratory animals Pavlov drew an analogy between hypnosis and the pathological symptoms in the two schizophrenics described by him. He regarded hypnosis as partial, selective inhibition of individual sections of the cerebral hemispheres. In his second work entitled "An Attempt of a Physiologist to Digress into the Domain of Psychiatry" Pavlov wrote very definitely: "... one can hardly doubt that schizophrenia, in certain of its variations and phases, is actually a chronic hypnosis."* In the same work Pavlov strove to find out the causes of the aforesaid chronic hypnotic states in schizophrenia. He wrote: "In the final analysis, of course, this hypnosis is profoundly based on the weak nervous system, and especially the weakness of the cortical cells. For this weakness various causes, both hereditary and acquired, may be responsible."** In this article Pavlov did not dwell on these

* Present edition, p. 230.
** Ibid.

factors but studied in detail the consequences of this special weakness, fragility, frailty of the nervous apparatus of schizophrenic patients. According to Pavlov, the weakness of the nervous system is directly responsible for the low efficiency, low endurance and rapid exhaustion of the nerve cells of the cerebral hemispheres. He said: "... naturally, when such a nervous system encounters difficulties, more often in a critical physiological and social period of life, it inevitably becomes exhausted after excessive excitation. But exhaustion is one of the chief physiological impulses for the appearance of inhibition in the capacity of a protective process."* Pavlov's foregoing statements show that he regards the hypnotic states in schizophrenics as an expression of the protective mechanisms of the nervous system, as a manifestation of the protective function of inhibition. Here he formulated for the first time his proposition on the protective role of inhibition.

Thus, a special weakness of the nerve cells in the cerebral hemispheres and their tendency to lapse by virtue of this into inhibitory states are characteristic of schizophrenics. These inhibitory states play the role of a protective mechanism.

We have already mentioned that Pavlov left open the question of the causes of the aforesaid weakness of the nerve cells in schizophrenics. It should be observed, however, that he made certain assumptions, even if very cautious ones, on this question just the same. He touched upon this question in his very first article on schizophrenia "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres". It should be noted that in several of his hypotheses of the harmful factors likely to produce weakness of the nerve cells in schizophrenics, as well as the necessity for these cells to lapse into a protective inhibitory state, Pavlov voiced the assumption that one of these harmful factors may be "certain toxic action". In another place he wrote: "It can be rightfully assumed that

* Present edition, p. 230.

for those representatives of the weak type who end up with schizophrenia there are certain specific conditions, such as a particularly irregular course of development, or permanent auto-intoxication causing extreme fragility of the nervous apparatus."*

For a correct understanding of Pavlov's pathophysiological views of schizophrenia we must also bear in mind his conception of disease as a unity of pathological manifestations and physiological protective measures of the organism. Pavlov pointed out this dialectical unity by citing examples unrelated to mental diseases but having to do with the pathology of different internal organs, as for instance, hypersecretion of gastric juice during stimulation of the gastric mucosa with various inadequate chemical agents. Pavlov voiced the same idea in his pathophysiological explanation of the various clinical symptoms of schizophrenia. Concerning the latter, especially cases of catatonia, in which the aforesaid proposition is borne out particularly clearly, Pavlov wrote: "Consequently, this state is, on the one hand, pathology, since it prevents the patient from normal activity, and, on the other hand, according to its mechanism, it is still physiology, a physiological remedy, since it protects the cortical cells from the danger of being destroyed as a result of too heavy work."**

We get a more complete picture of the unity of the physiological and the pathological, of the teaching on the physiological protective symptoms in schizophrenia by going deeper into the works of Pavlov and his associates on hypnotic inhibition. The variety of pathological manifestations in schizophrenic patients is determined not only by the partial, limited diffusion and localisation of inhibition defined as hypnotic inhibition, but also by its depth and intensity whose physiological characteristics are given in Pavlov's teaching on hypnotic phases. The protective

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* Present edition, p. 353.

** Ibid., p. 230.

inhibition into which the pathologically weakened cortical cells of schizophrenics lapse in response even to adequate stimuli, which are customary for a healthy person, has its physiological expression precisely in various hypnotic phases. Hence, the peculiar reaction characteristic of each of these phases in the form of different psychopathological symptoms typical of schizophrenia. In the work "An Attempt of a Physiologist to Digress into the Domain of Psychiatry", already mentioned before, and in the work written jointly with M. Petrova and entitled "Physiology of the Hypnotic State of the Dog"* Pavlov made a physiological analysis of the phenomena of negativism characteristic of schizophrenia and explained them by the presence of the ultraparadoxical phase in the patient's brain. In his works published later Pavlov established a similar physiological mechanism for some forms of delirium observed in schizophrenia and ambivalence. Pavlov wrote: "... As long as the inhibitory process operates, the cortical cells are not gravely damaged, their full return to normal is still possible, they can recover from excessive exhaustion and their pathological process remains reversible. Using modern terminology, it is only a functional disease."** This Pavlovian proposition brings us to the discussion of the very important question of the relations between the functional and organic factors in schizophrenia. As is well known, some psychiatrists regard schizophrenia as a functional disease which has no organic basis. For example, Jung is one of the advocates of this point of view. Referring to the fact that during schizophrenic remission the dissociated parts of the personality unexpectedly reunite "as though nothing had happened", he arrived at the conclusion that schizophrenia is a purely functional disease. According to Jung, the aforesaid reversibility of pathological phenomena in schizophrenics is possible precisely because "nothing really happens", since in schizophrenia

* Present edition, p. 232.

** Ibid., p. 231.

there is no organic destruction of the personality. I. Vvedensky and A. Asseyeva, Soviet psychiatrists who, among the severe chronic cases of schizophrenia studied by them, established cases of recovery before death, arrived at an analogous conclusion. They wrote: "The schizophrenic process, even in its most severe, stable, chronic manifestations, remains purely dynamic, completely reversible, potentially retaining throughout its course the ability of reverse development within the limits inaccessible to any, truly organic mental disease."*

On the basis of the aforesaid statement made by Pavlov that "according to modern terminology, schizophrenia is still only a functional disease" should we not assume that he, too, like the foregoing authors, denies the organic nature of schizophrenia?

By analysing some of Pavlov's statements on this question we can very definitely answer it only in the negative. Particularly interesting is the fact that Pavlov generally rejects the metaphysical contraposition—schizophrenia is either a functional or an organic disease—and views the relations between the functional and the organic in schizophrenia in their dialectic complexity. Already in the aforecited quotation we must pay attention to the fact that Pavlov did not write simply that "schizophrenia was a functional disease", but that it "*is still* a functional disease". This "still" in Pavlov's statement has a deep meaning and reflects his general views on the relations between the functional and the organic. In his statement made on one of the "Wednesdays" on December 12, 1934 Pavlov said: "I assume no difference between the functional and the organic, believing that in many cases of functional diseases we are as yet unable to detect real changes by modern histological methods. Besides, under the prolonged effect

* I. Vvedensky and A. Asseyeva, "States of Schizophrenics before Death and the Problem of Schizophrenic Feeble-Mindedness". *Transactions of the Central Institute of Psychiatry*, Vol. II, Moscow, 1941, pp. 57-78.

of pathogenic causes a reversible disease may become irreversible. Hence, it is conceivable that functional diseases continuing for a long time become organic, i.e., so gross as to effect visible changes in the structure of the pathological point."*

On the same "Wednesday", comparing paranoia with schizophrenia, Pavlov said: "... In the case of paranoia you have an affection of a separate point, maybe a very small one, but in schizophrenia you have a massive, gross destruction easily discerned by a microbiologist or histologist," and moreover, "... here there is really a continuous chain, from the very weakest functional disease to complete destruction of a mass of cortical cells."**

From Pavlov's afore-cited statements it is clear that he was far from considering schizophrenia a merely functional disease and that it was no accident that in his work "An Attempt of a Physiologist to Digress into the Domain of Psychiatry", as we have already observed, he wrote "... *still* a functional disease...".

On one of the "Wednesdays" Pavlov himself explained how his article "An Attempt of a Physiologist to Digress into the Domain of Psychiatry" should be understood. In a protocol record of his speech made on the "Wednesday", November 2, 1932 we read: "Pavlov reports about an article in an American journal under the title of 'Schizophrenia—Chronic Hypnotic State', in which the author cites Pavlov's article on schizophrenia. Pavlov points out that the title is wrong, that he had never called schizophrenia 'chronic hypnosis', because this disease leads to destruction of the nervous system, something that never occurs in hypnosis. Hypnosis is but a phase, one of the symptoms forming part of the picture of schizophrenia."***

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* *Pavlovian Wednesdays*, Vol. II, Moscow and Leningrad, 1949, p. 600.

** Ibid.

*** *Pavlovian Wednesdays*, Vol. I, Moscow and Leningrad, 1949, p. 238.

Summing up all the aforesaid as regards Pavlov's general pathophysiological conception of schizophrenia we can note the following basic propositions:

1. Schizophrenics are noted for a special weakness, fragility of the cortical cells, their easy exhaustibility and tendency to lapse into an inhibitory state with emergence of various hypnotic phases.

2. Hypnotic inhibition in the cerebral cortex of schizophrenic patients is a protective mechanism because it safeguards the nerve cells against organic changes and destruction.

3. The functional-protective character of hypnotic inhibition in schizophrenics determines the unity of the physiological and the pathological in the clinical manifestations of schizophrenia and warrants the assumption that they are simultaneously a physiological measure of defence and psychopathological phenomena.

4. As regards the functional and organic in schizophrenia we must bear in mind their unity and the transition of the functional into the organic at a certain stage in the development of the disease, and the existence of a functional, reversible phase.

5. Both the weakness of the cortical nerve cells in schizophrenic patients and their tendency to lapse into an inhibitory state may, according to Pavlov, be conditioned by continuous auto-intoxication of a specific character.

2

The foregoing analysis of Pavlov's general pathophysiological conception of schizophrenia enables us to get a better insight into the physiological mechanisms of its various psychopathological symptoms established by Pavlov. Schizophrenia has, as is well known, numerous and diverse symptoms, and yet we can distinguish certain basic patterns and regularities whose development constitutes its

specific clinical manifestations. On the one hand, schizophrenics become reticent and inaccessible, shut themselves off from the real external world which they perceive in a special manner and sink into a fanciful inner world of their morbid experiences, and on the other hand, there is a sharp disturbance in the relationships between their feelings, thoughts and actions. They lose what is called the integrity of personality. Their behaviour is therefore often incomprehensible. Many psychiatrists reduce the symptomatological manifestations of schizophrenia to the following, in some measure common, denominator which characterises the clinical symptoms of the patients. S. Korsakov, outstanding Russian psychiatrist, who at the end of the nineteenth century described an analogue of acute schizophrenia under the designation of dysnoia, and the Swiss psychiatrist Bleuler, who proposed the term schizophrenia, essentially implied the same: a split personality as the most characteristic of this disease. The French psychiatrist Chaslin and the Viennese psychiatrist Stransky meant the same thing when the former wrote about discordant psychoses and the latter spoke of intrapsychic ataxia, as the main factors in the psychopathology of these patients. It is natural that in characterising the various symptoms of schizophrenia physiologically Pavlov could not but dwell on such important signs of the split personality in these patients as autism and disturbances in thought and speech.

Of considerable interest is the fact that in his statements, in addition to the physiological interpretation of the phenomena of autism, Pavlov also gives its clinical definition and points out its different subtypes. In the record of Pavlov's statement on the "Wednesday", February 18, 1931 we read: "Pavlov has familiarised himself with Bleuler's work on autistic thinking and finds a contradiction in the author's assertions, in that, on the one hand, autistic thinking is guided mainly by feelings and, on the other hand,

that sensual dullness is characteristic of schizophrenia. On the basis of this work Pavlov arrived at the conclusion that *any thinking that does not correspond to reality and is abstracted from reality is autistic*"* (italicised by author). Reproaching the psychiatrists for their use of the term autism without considering its multiform meaning Pavlov suggested, on the "Wednesday", February 10, 1932, the necessity for differentiating this idea. He said: "Autism is peculiar to phlegmatics who waste no energy on associating with those around them, but, immersed in themselves, do their work. Autism is observed in weak types who are inhibited by the environment and who, out of fear, cannot make contact with those around them. Lastly autism is found in schizophrenics during destruction of cortical cells, when the excitation effected by this exceeds the external stimuli."** Pavlov repeatedly speaks about destruction of nerve cells and the existence, in connection with this, of stronger internal stimulation.

Of no lesser interest are Pavlov's statements on so characteristic a symptom of schizophrenia as ataxia, and dissociation of thought, speech and behaviour. When Pavlov was shown on one of the "Wednesdays" a schizophrenic who in the toilet defecated into his hand and then threw the feces into a pot, Pavlov said that this made him think of dissociation, "severance" of the cerebral hemispheres, owing to which the different acts of behaviour were separated. Pavlov also saw a physiological basis for the dissociation of thought and speech in schizophrenic patients in the existence of limited pathological points in the cerebral cortex. He said that with an increase in the number of such weakened pathological points in the cortex "disintegration of the cerebral cortex and the split in the normal coherent work of the cerebral hemispheres also

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* *Pavlovian Wednesdays*, Vol. I, Moscow and Leningrad, 1949, p. 122.

** Ibid., p. 191.

increased".* Pavlov gave an extremely colourful description of the dissociation of speech in one of the schizophrenics shown to him. He said: "His speech is dissipated because there are already pathological points in the cortex, owing to which the thoughts wander and change abnormally from one to another."**

Pavlov made a complete physiological analysis of the catatonic phenomena in schizophrenics. He regarded a number of catatonic symptoms as conditioned by inhibition of various parts of the cerebral cortex in the patients and the loss of their proper physiological functions. Such, for example, is the catatonic stupor, total immobilisation of the patient, which is caused by selective inhibition of the nerve cells of the motor analyser distributed in various parts of the brain. Such a catatonic symptom as mutism is physiologically based, according to Pavlov, on selective inhibition of the part of the motor analyser which is connected with the function of speech.

Pavlov explained some catatonic symptoms by a special mode of cerebral reaction connected with the presence of various hypnotic phases at some points of the brain. From this angle he thoroughly analysed so important a catatonic symptom as negativism. He mentioned the physiological basis of negativism in his article "An Attempt of a Physiologist to Digress into the Domain of Psychiatry", but analysed this psychopathological symptom in schizophrenic patients in greater detail in an article written later jointly with M. Petrova under the title of "Physiology of the Hypnotic State of the Dog".***

As is well known, in the psychiatric clinic it often happens that a schizophrenic patient refuses to eat the food he is offered, but when an attempt to take this food away

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* *Pavlovian Wednesdays*, Vol. I, Moscow and Leningrad, 1949, p. 24.

** Ibid., p. 24.

*** Present edition, p. 232.

is made he does not give it up and eats it right there and then. This is one of the examples of unmotivated counteraction to any instruction coming from without, which is defined in the psychiatric clinic as negativism. Pavlov and Petrova jointly observed analogous behaviour in one of the experimental dogs in which the experimenters induced a hypnotic state. The dog turned away from the food offered to it in the feeding box and reached for the feeding box when the food was being taken away. Pavlov explained this behaviour of the dog as follows. The phenomena of negativism in the dog have two phases: the first phase—the dog turns away from the feeding box with the food, and the second phase—the dog reaches for the feeding box as it is being taken away. In the first phase the conditioned stimulus—the sight of the feeding box—reaches through the normally functioning part of the cortex (visual analyser) the point in the motor area of the cerebral cortex whose excitation normally evokes a movement towards the feeding box. But this point is weakened, it is in a state of lowered efficiency and therefore reacts to the conditioned stimulus which is beyond its strength unnaturally—not by excitation but by inhibition (ultraparadoxical phase). Therefore, the movement towards the feeding box does not take place. At the same time the conjugate centre of opposite movement, away from the feeding box, is excited by way of positive induction.

But when the feeding box is being removed, the formerly inhibited part of the brain with which the unperformed movements towards the feeding box are connected, is now excited by way of consecutive induction. Contrariwise, the excited point with which the movement away from the feeding box is connected is now inhibited. As a result, the dog moves towards the feeding box which is being taken away.

Thus the phenomenon of active negativism is in this experiment physiologically explained by the presence of the

hypnotic phase (ultraparadoxical) at a definite point of the motor analyser of the brain and mutual induction of this point and the conjugate point of movement in the opposite direction. Schizophrenic patients have the same physiological mechanism in their symptoms of negativism. But, to explain a number of catatonic symptoms physiologically, Pavlov did not confine himself to establishing the presence of a selective hypnotic inhibition in any particular phase; he also elucidated the question of how this inhibition affected the interrelations of the different parts of the brain, the cortex and subcortical structures in particular. In his very first work devoted to schizophrenia and entitled "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" he explained phenomena of catalepsy—*flexibilitas cerea*, tonic reflexes, by disinhibition of the normally depressed brain stem reflex of equilibration. According to Pavlov, the high level of excitation of the brain stem centre of this reflex in schizophrenic patients is conditioned by its positive induction caused by inhibition of the cortex. In his second work devoted to schizophrenia under the title of "An Attempt of a Physiologist to Digress into the Domain of Psychiatry" Pavlov applied the same principle of physiological interpretation to phenomena of hebephrenic foolishness and catatonic excitement. According to Pavlov, "these manifestations result from a developing general inhibition of the cerebral hemispheres; due to this the adjacent subcortex is not only liberated from constant control, from constant inhibition effected by the cerebral hemispheres in an alert state, but, because of the mechanism of positive induction, is even brought to a state of chaotic excitation affecting all its centres".* When inhibition in schizophrenic patients embraces the cerebral cortex to the extent that it eliminates the complex forms of behaviour acquired during the lifetime, the mechanisms of imitating the movements (echopraxia) and repeating the

* Present edition, p. 229.

words (echolalia) of other persons, which are characteristic of the early stages of development easily come into play.

As for the pattern characteristic of the catatonic form of schizophrenia and expressed in prolonged and monotonous movements repeated without any necessity, it is in large measure due to the fact that these movements are not opposed by the activity of the other points of the inhibited motor analyser.

We have elucidated in detail Pavlov's physiological interpretation of the various psychopathological symptoms in the catatonic form of schizophrenia. These symptoms belong to the field of pathology of the motor analyser, pathology of the motor sphere. But Pavlov also gave a physiological explanation of the various forms of delirium in schizophrenics. Here we must primarily note his statements on the pathophysiological bases of inverted delirium characteristic of schizophrenia. In his letter to the well-known French psychiatrist Pierre Janet published in the form of an article entitled "Feelings of Possession (*les sentiments d'emprise*) and the Ultraparadoxical Phase",* Pavlov analyses at length the physiological mechanism of this form of delirium. The latter is characterised by the fact that the patient's delirious judgements very clearly reveal the contrast between these judgements of reality and the patient's desire. In this case it is very important that the patient disowns his personal shortcomings and ascribes them to other people. To lay bare the physiological mechanism of this delirium, Pavlov at first dwells on the regularities of judgement in healthy people. He writes: "Our general notion (category) of contraposition is one of the fundamental and indispensable general notions, which, along with all others, facilitates and controls normal thinking and even makes it possible."** In delirium this category of

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* Present edition, p. 303.

** Ibid., p. 305.

contraposition necessary for correct judgement is perverted. The correct thought, the positive assertion is inhibited, while the opposite, incorrect thought, instead of being excluded by comparison, on the contrary, begins to dominate in the judgement. Thus, what had to be excited is inhibited and what had to be inhibited is excited. And this is the form of reaction of the brain which is characteristic of the presence of the ultraparadoxical hypnotic phase in it. Pavlov sees the physiological mechanism of the delirium of inversion, like that of the other forms of paranoid delirium, in the ultraparadoxical phase. According to Pavlov, the same physiological mechanism of the ultraparadoxical hypnotic phase is the basis of so characteristic a disorder of the schizophrenic patient's thinking as its ambivalence. Here, too, there is a disturbance in the category of contraposition which is a necessary condition of the healthy person's thinking. The simultaneous existence of two contrary, mutually exclusive thoughts, or their alternation within the framework of a single judgement, characterising the ambivalence of schizophrenic patients' thinking becomes physiologically intelligible if we bear in mind the ultraparadoxical reaction and reciprocal induction of those physiologically conceived points of the brain with which the contrasting ideas are connected.

In concluding this part of the article I must very briefly dwell on Pavlov's physiological explanation of the various psychopathological phenomena of such a physiological mechanism as the pathological inertness of the process of excitation in isolated pathological points of the brain. Concerning Pavlov's physiological interpretation of patterns we have already pointed out that the possibility of protracted repetition of the same unmotivated movements, such as stereotypy is, must be explained by the absence of counteracting sections of excitation in the cerebral cortex due to its inhibited state. Owing to the latter, inert excitation develops by way of positive induction in a particular part of the brain and continuous stereotypical movement

arises. But pathology of the mobility of the nervous processes in the form of inertness of excitation in the various isolated pathological points of the brain may also underlie certain disorders of schizophrenic patients' thinking. It is to this that Pavlov's article "Attempt at a Physiological Interpretation of Compulsive Neurosis and Paranoia"* is devoted. True, this article deals not with schizophrenia but with psychogenic diseases, such as paranoia and the neuroses, but paranoid delirium and obsessions are also observed in schizophrenics, and Pavlov's physiological views of these psychopathological phenomena therefore deserve our attention. It should also be noted that in this article Pavlov treats in greater detail the physiological mechanisms of delirium in general and the ideal-verbal automatisms described by the Russian scientist V. Kandinsky and the French scientist Clérambault.

Concentration of delirious judgements around some basic idea and the presence of a definite system, a united, internally coherent delirious conception, are characteristic of paranoid delirium. Outside of this delirious system the patient's judgements are correct and logical. But the delirious system itself, isolated from logic, is characterised by special stubbornness and power and is, as a rule, affectively charged, is real for the patient and determines all of the patient's behaviour. In schizophrenics this paranoid delirium rarely persists throughout the disease; it is for the most part only a stage in the course of paranoid schizophrenia and has a number of clinical peculiarities. It is not the aim of this article to elucidate these clinical peculiarities, and we shall therefore refrain from dealing with this question. We shall only note that it is precisely the systematic character of the delirium, its concentration on the same definite ideas, its particular stubbornness and power that have enabled Pavlov to interpret this form of delirium as a manifestation of pathologically inert excitation in an

* Present edition, p. 309.

individual, physiologically conceived, point of the brain. But the same mechanism underlies obsessive ideas, and Pavlov emphasises in his article the common elements of these psychopathological phenomena. It is well known, however, that delirium is incompatible with criticism, whereas obsessions, on the contrary, involve a critical attitude towards them. Pavlov saw the physiological basis for these differences in the different power and different degree of concentration of the pathologically inert excitation. In delirium the strength and concentration of inert excitation are particularly great, and strong inhibition therefore emerges around the pathological point of the brain. Owing to this the activity of the brain, with which sound ideas contrary to the delirious thoughts might be connected, is depressed. During obsessive states the power and concentration of inert excitation at the pathological point of the brain are weaker, and this is why the patients retain a critical attitude towards their disease. The excitatory process outside of the pathological point of these patients is strong enough for ideas opposed to the obsessive thoughts to arise. And yet it is not strong enough to inhibit the obsessive thoughts and the feelings and desires connected with them.

We have elucidated the physiological mechanisms established by Pavlov for paranoid delirium, but we must remember that he admitted the possibility of participation of both afore-mentioned mechanisms, i.e., the ultraparadoxical phase and pathologically inert excitation in the isolated pathological point in the formation of delusion. This is what he wrote in reference to this: ". . . Delusion is based on two physiological phenomena—pathological inertness and the ultraparadoxical phase, now existing separately, now appearing together, and now replacing each other."*

As for Pavlov's interpretation of the Kandinsky-Cléram-

* Present edition, p. 323.

bault syndrome we shall take the liberty of quoting his statement in the same article. He wrote: "What else can we interpret as mental automatism, but the point of a certain pathologically inert excitatory process about which all that is close, similar and related concentrates (on the basis of the law of generalisation) and from which everything that is alien is repulsed, according to the law of negative induction?"*

3

The general physiological conceptions of schizophrenia elaborated by Pavlov and his views of the physiological mechanisms of its psychopathological symptoms have found reflection in the practical questions of diagnosis, treatment and service of mental patients. Pavlov repeatedly emphasised that he was no clinician and spoke on clinical questions with the greatest of caution. It should be noted, however, that his statements proved extremely valuable and made a considerable contribution to psychiatric practice. We shall dwell briefly on some of them and shall establish a connection between his physiological views and clinical recommendations for diagnosis, treatment and service of mental patients.

Two of Pavlov's instructions with respect to diagnosis deserve attention. The first of them deals with diagnosing cases so that the delicate, vulnerable nervous system of schizophrenic patients may under no circumstances be hurt. When, on one of the "Wednesdays", December 11, 1929, during examination of a schizophrenic patient, psychiatrists began to ask the patient, who before his illness had been a man of high culture, a number of extraordinarily elementary questions, Pavlov immediately pointed out that such questioning of the patient constituted "a rude slighting" of the latter. He said: "If the nervous system of such

* Present edition, p. 324.

patients were trained mildly and cautiously, their behaviour would approximate to normal."*

Pavlov's second instruction deals with the methods of overcoming negativism, particularly mutism in schizophrenic patients (with catatonic manifestations). Since the cerebral cortex of such patients is in a state of protective inhibition with various hypnotic phases, and the stimuli of average strength are excessively strong for them and evoke or deepen this inhibition, Pavlov proposed to question the patients, who are in catatonic stupor, in whispers. This form of questioning is justified, since it is possible to make mute patients answer questions. Pavlov advised that no brute force should be used to overcome the motor negativism of catatonic patients, but, when necessary, this should be done mildly and gradually. Tested in the clinic, this Pavlovian instruction also proved useful.

Particularly valuable is Pavlov's physiological substantiation of sleep therapy of schizophrenics. Such treatment became very popular in the Soviet Union during the 1930s, soon after the Swiss psychiatrist Cloëtta proposed for this purpose his mixture of hypnotics and elaborated a method of treating schizophrenic patients with prolonged, continuous sleep. But we think that the foregoing term "sleep therapy" is inaccurate. It is essentially a question not of treating the patients with sleep but of inducing narcosis in them for a period of many days. On the basis of Pavlov's physiological conceptions regarding schizophrenia and his teaching on the protective role of inhibition Soviet psychiatrists modified Cloëtta's method and began to induce such sleep in schizophrenic patients with the aid of various hypnotics, as would be closest to physiological sleep. Pavlov manifested great interest in the treatment of schizophrenic patients with prolonged sleep. When the Moscow psychiatrist M. Sereisky, known for his thera-

* *Pavlovian Wednesdays*, Vol. I, Moscow and Leningrad, 1949, p. 29.

peutic research, reported to Pavlov the successful results of treating one of his patients with sleep, Pavlov immediately responded with a letter to Sereisky. Since this letter rather fully elucidates Pavlov's views of this question, we are reproducing its text according to the materials of Pavlov's personal archive.

Pavlov wrote: "I am very grateful to you for the report of your case in which schizophrenia was cured and for the material which you have sent me in reference to this case, as well as your works. I am greatly interested in this case. I have discussed it extensively with my collaborators and in the psychiatric clinic.* It opens up vast and happy prospects. If the disease that persisted unchanged for two years, yielded so soon, it means that the condition of this person's brain was not irreversible. We can therefore have still greater hopes for particular success in fresh cases of schizophrenia. In my mind this is connected with my first conclusion and conviction that in difficult states of a weak nervous system the latter defends itself by inhibition, i.e., suspension of excessively strenuous and destructive work. I think that, when the schizophrenic exhibits various symptoms of hypnotisation, it is a favourable sign. We must regard this as a useful reaction of the organism, the efforts of the organism to fight off the pathological effect of the work produced on the given nervous system, and must help it by guaranteeing the patient an atmosphere absolutely devoid of stimulation or even by inducing pharmaceutical sleep in the patient, as in your case. Of course, it would be better, if we could keep the patient in a state of chronic hypnosis, as it occurs spontaneously in extreme catatonia. I should be grateful to you for keeping me further informed of the condition of your patient. I think that even if his pathological condition ever returns, the fundamental importance of your case will still

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* *Pavlovian Wednesdays*, Vol. III, Moscow and Leningrad, 1949, p. 121.

retain its full value. Of course, we could not expect a ten-day pharmaceutic sleep to make the patient's nervous system strong, if it was weak before the disease. In the future everything will depend on whether his subsequent life's work will be within his power or excessively strenuous. In the latter case the disease may, of course, return.

"Please, let me keep the case history another two or three days.

"Sincerely yours,

I. Pavlov."*

As we see, at the end of his letter Pavlov writes of the great importance of the conditions of the patient's life to the successful struggle against mental disease. If it is particularly important, as was already noted, to protect the weakened nervous system of the schizophrenic patients from any traumatising and exhausting influences, it stands to reason that a protective, restful regimen must be set up in hospitals. Such a regimen is connected with a proper distribution of the patients, a quiet, comfortable atmosphere in the psychiatric hospitals, and a considerate and tactful treatment of the patients by the medical personnel. Already in his work entitled "An Attempt of a Physiologist to Digress into the Domain of Psychiatry" published in 1930, i.e., long before a psychiatric clinic was organised in his laboratories, Pavlov had expressed his ideas on a number of psychiatric questions of an organisational character, particularly as regards the principles of distributing mental patients in hospitals.

He wrote: "To keep patients, already possessing a certain degree of self-consciousness, together with other, irresponsible patients, who may subject them, on the one hand,

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* See "I. P. Pavlov's Manuscripts in the Archive of the U.S.S.R. Academy of Sciences". (*Transactions of the Archive*, Book 8, No. 48, p. 124.)

to strong stimulations in the form of screams and extraordinary scenes, and, on the other hand, to direct violence, in most cases, means creating conditions which to a still greater extent enfeeble the already weak cortical cells." He continued: "It is necessary as quickly and as timely as possible to place such mentally diseased in the position of patients suffering from other illnesses."*

It should be noted that this advice given by Pavlov began to be followed and mental patients were treated with neuroleptic agents which considerably altered the general atmosphere of psychiatric hospitals and in a number of cases eliminated the "strong stimulations in the form of screams and extraordinary scenes" pointed out by Pavlov.

Here it is not out of place to dwell on Pavlov's general pharmacotherapeutic views and analyse, in the light of these views, the modern development of the psychopharmacological trend in psychiatry and its achievements in the treatment of mental diseases, particularly schizophrenia. Pavlov's views on this question may be most briefly formulated in the following basic propositions.

The first of them deals with taking account of the specificity of each therapeutic agent. In using various drugs it is necessary to consider the individual peculiarities of each of them.

Pavlov wrote: "All of pharmacology is based on the fact that each agent has its own physiognomy, that each of them differs from the next closest agent."**

Modern psychopharmacology uses a great variety of medicinal preparations of the phenothiazine series. However, the general sedative character of these medicinal agents, manifested mainly in elimination or diminution of psychomotor excitation, aggressiveness and tenseness of mental patients does not do away with the great differ-

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* Present edition, p. 231.

** I. P. Pavlov, *Complete Works*, Moscow and Leningrad, 1951, Vol. VI, p. 53.

ences in the therapeutic effect of the agents forming this group despite the very slight differences in their chemical formulas. The following may serve as a vivid example. As is well known, the most diverse phenothiazine derivatives may, in addition to their indicated general sedative effect, completely eliminate or diminish certain psychotic manifestations of schizophrenia except symptoms of depression. Moreover, we must also consider the established fact that these neuroleptic agents may themselves, when administered for therapeutic purposes, produce complications in the form of depression, the so-called chlorpromazine depression. However, the slightest change in the chemical formula of levoperpromazine, one of the phenothiazine preparations, is enough for this preparation to acquire antidepressive properties and to prove effective in the treatment of schizophrenia with depressive-paranoid manifestations.

It should also be noted that tofranil (imipramin), one of the best known antidepressive agents today, is very closely related to phenothiazine in its chemical formula, although it is not a derivative of the latter.

The second important principle of pharmacotherapy, according to Pavlov, is analysis of the effect of medicinal substances on the basic nervous processes—excitation and inhibition. The foregoing pharmacotherapeutic principle is known as the "theory of two drives". After studying the effect of bromides and caffeine for many years Pavlov named these agents the "two drives", "two levers" of the main aspects of higher nervous activity—the processes of excitation and inhibition. He wrote: "Since we have, so to speak, two levers in the form of pharmaceutical remedies, two communicators towards the two chief apparatus, i.e., towards the two processes of nervous activity, then by putting into action and correspondingly changing the strength now of one, now of the other lever, we have a chance of restoring the disturbed processes to their former

place, to their proper correlations."* From this point of view we can also examine the modern classifications of "psychotropic" agents.**

Despite the differences in terminology and the particular subdivisions in these classifications the psychopharmacological agents are still divided into two main groups: sedatives (having to do with the process of inhibition) and tonics (bearing on the process of excitation). The well-known Canadian psychiatrist Lehmann divides the psychopharmacological agents he has named "phrenotropic" into agents "producing inhibition" and "producing excitation".***

It should be noted, however, that the use of Pavlov's "theory of two drives" requires that the entire complexity of the relation of the particular medicinal substance to the basic nervous processes—excitation and stimulation—should be infallibly taken into consideration. We must remember that this theory holds good only when certain conditions are observed. Pavlov proceeded from the assumption that the given normal physiological state of the central nervous system was a resultant of the most diverse phenomena of excitation and depression in its various divisions. He held that any "neural agent", regardless of its special action, first of all disturbed this mobile equilibrium, and he emphasised the possibility of producing even by opposite groups of substances (exciting and paralysing the nervous system) at first a very muddled and uncertain picture of general action. He wrote: "It is often extremely difficult to get a clear idea of the points of application of the action, the mode of action and its development and spread."**** This brings us to the basic and most important

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* Present edition, p. 373.

** Reference is made to the following classifications: S. Delay, N. S. Kline, S. E. Thuillier, S. B. Wortis.

*** H. Lehmann, *Psychopharmacology Frontiers*, Boston, 1959, p. 105.

**** I. P. Pavlov, *Complete Works*, Moscow and Leningrad, 1951, Vol. I, p. 528.

principle (formulated by Pavlov) of administering medicinal substances, which deals with the method of action and point of application of these substances. Pavlov described this principle in detail in his famous speech at the Fifth Pirogov Congress of Physicians in 1894. His speech was entitled "On the Inadequacy of the Modern Physiological Analysis of the Action of Medicines".*

Noting the reflex mechanism of action of medicinal substances Pavlov pointed out in this speech that all three links of the reflex arc could be the point of application of their action: the sensory endings of the afferent nerves, the central neural structures (i.e., the brain cells and synapses), and the endings of the effector nerves.

In referring to Pavlov's general pathophysiological conceptions of schizophrenia above we have already noted that disturbance in the proper induction relations between the cerebral cortex and the subcortical structures is of great importance in the origin of various clinical manifestations of schizophrenia. The important role of the nervous processes taking place in the reticular substance (reticuloactivating system) located on different levels of the brain stem has now been revealed by a number of physiological investigations (Magoun H., Moruzzi G., Fessard A., Penfield W.). The functional manifestations of this reticular formation discovered as far back as 1909 by the well-known Russian scientist V. Bekhterev are very important for understanding the mechanisms of the therapeutic action of neuroleptic agents on schizophrenic patients. Our aim does not include consideration of this complex problem as a whole since it can be a subject of only a separate, special discussion. We shall only dwell on the following question: How are we to understand, on the basis of Pavlov's aforesaid conceptions of schizophrenia, the sedative (tranquillising) ataractic effect of the neuroleptic agents? It should be noted that in his interpretations of the relationships

* I. P. Pavlov, *Complete Works*, Moscow and Leningrad, 1951, Vol. I, pp. 525-29.

between the subcortical structures and the cerebral cortex Pavlov brilliantly foresaw the modern physiological conceptions of the dynamic, tonic, nonspecific impulsation running to the cortex from the thalamic reticular formation which is very close to the cortex.

As far back as 1930, in his work entitled "Physiology and Pathology of Higher Nervous Activity" Pavlov wrote: "... The subcortex exerts a positive influence on the cerebral cortex, appearing *as the source of its power*.... The subcortex is the *source of energy** for higher nervous activity, while the cortex plays the role of a regulator with reference to this blind power by finely guiding and restraining it."**

But in schizophrenia the tonic impulsation of the cortex by the subcortical structures indicated by Pavlov may, as we have already pointed out, assume a pathological character and lead to "violence of the subcortex" and disintegration of cortical activity characteristic of schizophrenia.

Taking the foregoing into consideration it may be assumed that the role of the neuroleptic agents consists precisely in that they foster normalisation of the cortico-subcortical relations.

However, the neural mechanisms of this normalisation are not yet sufficiently clear. Some authors regard the action of the neuroleptic agents as a blocking of the pathological nonspecific impulsation which comes from the reticular formation of the higher parts of the brain stem. Other authors hold that it is a matter of direct sedative action of these agents on the cortex.

Of the other factors to be taken into account in analysing the effect of psychopharmacological agents on schizophrenic patients in the light of Pavlov's conceptions it is

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* Italicised by author.

** I. P. Pavlov, *Complete Works*, Moscow and Leningrad, 1951, Vol. III, Book 2, pp. 404-05.

important to remember his proposition that in prescribing medicinal substances it is necessary to consider their doses in relation to the therapeutic aims, type of nervous system and its functional state at the time of their administration. On the one hand, we must take into account the fact that the range of doses of the therapeutic preparations being administered may be very wide and, on the other hand, that even the slightest variations in the size of the doses may considerably modify the action of the medicinal substance. The studies in Pavlov's laboratories showed that the therapeutic doses of bromides varied between 0.001 and 8.0, i.e., had a 1:8,000 ratio. Of some interest is also the fact cited by Pavlov on his "Wednesdays" that the reduction of a certain patient's dose of bromides only by one spoonful a day produced a very tangible salutary effect. It should be remembered that, depending on the dose of the medicinal substance, the effect of the latter may change not only quantitatively but also qualitatively. The emergence and disappearance of the so-called "neuroleptic syndrome" in schizophrenic patients, depending on the dose of chlorpromazine or reserpine, may serve as a vivid example.

Pavlov conducted his research in the pathophysiology of schizophrenia in the 1920s-1930s. Some physiologists and psychiatrists, Pavlov's pupils and followers, began to develop his main conceptions while he was still alive. Since Pavlov's death (1936) and, especially, in connection with the Joint Session of the U.S.S.R. Academy of Sciences and the U.S.S.R. Academy of Medical Sciences held in 1950 and devoted to Pavlov's physiological teaching, a considerable number of studies has appeared in the field of pathophysiology of schizophrenia based on investigations of these patients' higher nervous activity.

It is impossible completely to review the aforesaid studies within the space of a short article. We shall therefore confine ourselves to a brief elucidation of their main and most important trends.

We shall begin our brief review of these trends with the analysis of the works of A. Ivanov-Smolensky, prominent Soviet physiologist and psychiatrist, and his collaborators.*

Patients with different forms of schizophrenia were studied experimentally. This enabled Ivanov-Smolensky to formulate his general conception of the pathogenesis and therapy of schizophrenia from the pathophysiological point of view and produce a pathophysiological substantiation of the various symptoms and syndromes observed in schizophrenia. Maintaining that it was wrong to ascribe the pathogenesis of schizophrenia either to cerebral or somatic factors alone Ivanov-Smolensky averred that schizophrenia was based on a disturbance in the interrelations between the brain and the internal environment of the organism, a disturbance in the encephalosomatic relationships. Inferior central regulation of the vegetative functions in schizophrenic patients elicits vegetative-metabolic disorders, primarily disorders of protein metabolism, and is responsible for the elective neurotropic endointoxication which becomes the immediate cause of schizophrenia.

Under the influence of this intoxication neurodynamic changes take place in the brain of the schizophrenic patients, pathological disorders closely interweaving with antagonistic protective tendencies. The protective tendencies include, but are apparently far from exhausted by, phenomena of protective inhibition in the cerebral cortex of different localisation, intensity and extent, and possibly the "vegetative storms" which are observed in the course of the disease.

During the initial stages of the disease the neurodynamic changes in the brain of schizophrenic patients are manifested mainly in phenomena of differently localised inert excitation, development of phasic phenomena which are

* A. G. Ivanov-Smolensky, *Essays on the Pathophysiology of the Higher Nervous Activity*, Moscow, 1954.

either of a diffuse or intrastructural character, and a disturbance of the interaction of the different levels and systems of the brain. During later stages which, however, may never occur, phenomena of destruction are added to the aforesaid pathological disorders. The inadequacy of central regulation of the vegetative and metabolic functions noted in the schizophrenic patients and creating prerequisites for a disturbance in the functional adaptation of the brain to changes in the external, as well as internal, environment is also responsible for the lowered resistance of these patients to various harmful somatogenic and emotiogenic factors, on which provocation of schizophrenic attacks by these harmful factors is based.

Of the different forms of schizophrenia Ivanov-Smolensky and his collaborators made a particularly extensive study of the catatonic form with the patients in the state of catatonic stupor. Their studies had established the following:

a) Sharp disturbance, in most cases, in the coupling function of the cortex. These patients were almost unable to develop and consolidate new conditioned reflex connections. In some cases there was a marked dissociation of conditioned reflex activity. While conditioned motor reactions did not form at all, vegetative reactions (two-phase respiratory, cardiovascular) formed well.

b) Spread of inhibition to the higher unconditioned reflexes (defensive, orienting) frequently with dissociation of the somatic and vegetative components and simultaneous disinhibition of the primitive, rudimentary reflexes (grasping, sucking, etc.).

c) Presence of vegetative dystonia (lowered reactivity, inverted reactions) with predominance of parasympathetic tone. There was an impression that the phasic phenomena also spread to the system of the vegetative-subcortical centres. Of interest in these patients is also unstable, poor nocturnal sleep and obliterated boundaries between waking and sleep.

d) Existence of different structures of catatonic stupor despite its external homogeneity, depending on the spread (localisation) of inhibition in the cortex and lower to the different levels of the stem, as well as on dissociation of the extent of disturbance in the somatic and vegetative functions.

The subdivision of catatonic stupor into its two subtypes by Ivanov-Smolensky* deserves attention. The first of these subtypes is the *receptor stupor* characterised by the presence of a focus of inert excitation (for example, when the patient is concentrated on definite affective experiences) which, inhibiting the entire cortex by way of strong negative induction, makes it entirely impossible for the patient to perceive surrounding reality; the second subtype is the *effector stupor* in which the cortex is inhibited selectively only in its motor analyser, owing to which these immobilised patients fully retain their perception of the surroundings. Ivanov-Smolensky established two similar subtypes in catatonic mutism, since he managed to establish contact with some of the patients by replacing oral speech with visual images, writing, gestures and pictures.

Unlike the patients with the catatonic form of schizophrenia, those with the paranoid form easily elaborate, according to Ivanov-Smolensky, positive and negative conditioned reflex connections which, however, are inductively inhibited by these patients' delusional and hallucinatory pathophysiological structures.

Of great interest is Ivanov-Smolensky's subdivision of the delirium of schizophrenic patients in two subtypes—image-bearing delirium not infrequently combined with visual hallucinations and predominantly connected with the first signalling system, and delirium which is mainly verbal, i.e., is a pathological disorder of the abstract, con-

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* A. G. Ivanov-Smolensky, "On Different Forms and Neurodynamics of Catatonic Stupor". *Archive of Biological Sciences.* Vol. XXXVI, Book 1, 1934, pp. 85-106.

ceptual human thinking, sometimes combined with auditory hallucinations and therefore predominantly connected with the second signalling system. Different hallucinatory phenomena observed in schizophrenic patients were also given differentiated pathophysiological substantiation in Ivanov-Smolensky's works.

Depending on the character of the hallucinations Ivanov-Smolensky explains their emergence either by inert excitation or phasic phenomena in different regions of the cerebral cortex in accordance with the central representation of the different analysers in the cortex.

Thus he connects pseudohallucinations with inert excitation in the visual and auditory areas of the cortex, whereas true hallucinations have their pathophysiological basis in the form of inert excitation which also spreads to the cortical projection of the visual and auditory accomodation. He explains the oneiric hallucinations by the presence of phasic phenomena in the cerebral cortex.

In analysing the neurodynamic relationships which form in the cerebral cortex of schizophrenic patients when the latter have symptoms of schizophasia, Ivanov-Smolensky connects the latter with disturbed relations between the first and second signalling systems due to inert excitation and phasic phenomena mainly in the second signalling system.

As regards the therapy of schizophrenia, the pathogenetic substantiation given by Ivanov-Smolensky to the different combined methods (sleep therapy + insulin shock therapy, electroconvulsive therapy + sleep therapy, etc.)* deserves special attention.

In his pathogenetic substantiation he proceeds from the point of view that the effect of active therapy of schizo-

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* A. G. Ivanov-Smolensky, *Experiment of Combined Therapy of Schizophrenia.* In Book: *Treatment of Schizophrenia. Transactions of the Central Neuropsychiatric Institute,* Vol. 11, Kharkov, 1939, pp. 403-09.

phrenia may have its pathophysiological basis not only in the deepening of protective inhibition and restoration of the efficiency of the nerve cells, but also violent vegetative changes which lead to a vegetative reorganisation of the patient's organism and foster its disintoxication.

Questions of the pathophysiology of schizophrenia were studied for many years on the basis of I. Pavlov's teaching by the well-known Soviet psychiatrist V. Protopopov and his collaborators.

As was already pointed out, Pavlov emphasised in his general pathophysiological conception of schizophrenia the importance of the development of a chronic hypnoid state of different localisation and intensity in the cerebral cortex of schizophrenic patients. Pavlov held that this hypnotic inhibition, as an expression of the protective functions of the weakened cortex resulting from certain harmful factors was responsible for a number of psychopathological syndromes in schizophrenic patients. In Protopopov's clinic this Pavlovian proposition concerning the hypnoid state of the cortex in schizophrenic patients was fully confirmed and further developed through experimental studies of these patients. The schizophrenic patients were given numerous tests by various conditioned reflex methods (defensive-motor, vascular, motor-food, motor, motivated by verbal instruction).* On the basis of these tests it was established that in schizophrenia there is "low efficiency and rapid exhaustibility of the nerve cells of the brain, diminished strength of the excitatory and inhibitory processes, tendency to their irradiation and inertness, sharply diminished ability to form positive and negative condition reflexes, instability of these reflexes and, lastly, a particular-

* V. P. Protopopov, "Pathophysiological Peculiarities in the Activity of the Central Nervous System During Schizophrenia". In Book: *Transactions of the Central Neuropsychiatric Institute*, Vol. 10, Kharkov, 1938, pp. 14-26.

ly important type of disorder manifested in the presence of hypnoid phases".* The studies of the second signalling system of schizophrenic patients conducted by Protopopov and his collaborators are of considerable interest.

Since the specifically human, abstract, verbal-conceptual thinking is connected with the second signalling system, Protopopov studied in the schizophrenic patients the disorders of abstraction and generalisation and their pathophysiological bases.

These studies were preceded by laboratory investigations of the same processes of abstraction and generalisation in higher animals (dogs and monkeys) conducted for methodological purposes. Types of disorders of abstraction and generalisation were discovered in schizophrenic patients and it was found that these disorders were also based on a hypnoid state of the brain, disturbances in higher analysis and synthesis.**

The confirmation and development of Pavlov's pathophysiological conceptions of schizophrenia by Protopopov were given practical application in the clinic with respect to the organisation of the regimen and treatment of these patients. Special studies conducted in Protopopov's clinic established the inexpedience of employing stimulatory and occupational therapy for schizophrenic patients in the acute initial stage of the disease with marked phenomena of protective inhibition. According to Protopopov, the conditions of the patients' maintenance in the hospital during this period of the disease, as well as their treatment, imperatively demand that the self-defensive protective inhibitory states developing in the nervous system of the pa-

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* V. P. Protopopov, "Summaries of the Studies in the Field of Psychiatry, Physiology and Pathophysiology of Higher Nervous Activity Conducted by Us During the Last Twenty Years". In Book: *Problems of Physiology*, Book 4, 1953, p. 240.

** V. P. Protopopov, "Processes of Abstraction and Generalisation in Animals and Man". In Book: *Studies of Higher Nervous Activity in Natural Experiment*, Kiev, 1950, pp. 157-77.

tients in connection with schizophrenia should be deepened. In the clinic of the Ukrainian Neuropsychiatric Academy in Kharkov, headed by Protopopov, a special department in which the patients were provided with a protective regimen to safeguard their nervous system was opened as far back as 1932. The patients were accommodated in small rooms, one or two patients each, in an atmosphere of total silence, with strict confinement to bed and all additional stimuli eliminated. Visits to the patients were reduced to a minimum or entirely discontinued.

Protopopov wrote the following about his experiment: "It goes without saying that we do not regard segregation as a measure that excludes all other forms of therapy." ..."We consider segregation merely a more natural method of protecting the central nervous system from superfluous activity and of fostering more sleep than waking and thus favouring restoration of the process in it."* To come still closer to this aim Protopopov began to prolong the sleep of the patients in this separate department to 18-20 hours a day by means of various hypnotics, continuing this prolonged artificial sleep for a period of 10-12 days and longer. Pointing out that his method of treating schizophrenic patients with prolonged pharmaceutic sleep is not a new method, but one that was introduced by Kläsi, Protopopov emphasises, however, his entirely different interpretation of the aim and mechanism of action of this form of treatment, since Kläsi, "was guided more by psychological than physiological considerations...".**

The pathogenetically substantiated sleep therapy of schizophrenic patients was employed on a large scale and, as we have already mentioned, won Pavlov's approval. On

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* V. P. Protopopov, "Principles and Methods of Protective Therapy". In Book: *Transactions of the Second All-Russian Congress of Psychiatrists and Neuropathologists*, Vol. 1, Moscow, 1937, p. 591.

** Ibid.

Pavlov's instructions this treatment also began to be administered in the psychiatric clinic of his laboratory under Ivanov-Smolensky's supervision. It should be noted, however, that on a number of questions—is it expedient to employ only intermittent, resembling physiological, prolonged sleep or may continuous prolonged pharmaceutical "sleep" of the nature of narcosis also be prescribed? what are the indications for and mechanisms of the different forms of sleep therapy? etc.—Soviet psychiatrists have not as yet reached full agreement and are conducting additional research.

Our description of Protopopov's research in schizophrenia would be incomplete without brief mention of his general conception of the pathogenesis of this disease. Proceeding from the postulate that psychosis is a disease not only of the brain but also of the whole organism, Protopopov conducted multiform investigations of the somatic processes and metabolism in schizophrenic patients and tried to unite them with the established cerebral disorders in a single pathogenetic chain.*

The general conception of the pathogenesis of schizophrenia developed by Protopopov and partly coinciding with the views of Buscaino, Reiter and Gjessing consists in the following. Inborn defects of nerve centres which regulate metabolism lead to disorders of metabolic processes, especially of protein metabolism, and a gradual accumulation in the organism of schizophrenics of toxic products with derivatives of the aromatic series predominating. Similar substances may additionally come from the intestines as a result of bacterial fermentation and greater permeability of the intestinal wall. The toxic products formed

* See V. P. Protopopov, "Pathophysiological Principles of Rational Therapy of Schizophrenia", Kiev, 1946. Also Book—*Problems of Pathophysiology and Therapy of Schizophrenia. Transactions of the Ukrainian Neuropsychiatric Institute*, Vol. XX, Book 2, Kiev, 1947.

endogenously and exogenously are not fully detoxicated in the organism of the schizophrenic patients owing to the constitutional defects in the detoxicating systems of the liver, the physiological system of the connective tissue (reticuloendoremia), etc., which leads to development of aminotoxicosis. These toxic substances also effect the central nervous system, in particular depressing the oxidative enzymes, which conditions lowered oxygen consumption by the cerebral tissue, anoxia and increased tissue disintegration and disorders of metabolism—nitrogen, lipoid and mineral—in the brain. An inferior endocrine system is also an essential inborn anomaly: hypofunction of the thyroid, hypophysis and the sex glands. This dysfunction gives rise to decreased basal metabolism and, consequently, lower energy of the oxidative processes.

A valuable contribution to the development of Pavlov's conceptions of schizophrenia was made by Y. Popov; the trend of his research work is characterised by a study of the pathophysiological basis of mental disorders from the point of view of Pavlov's teaching on higher nervous activity.

On the one hand, Popov's investigations are devoted to a pathophysiological study of various clinical manifestations and psychopathological symptoms observed in schizophrenic patients; on the other hand, they are aimed at developing a general hypothesis of the pathogenesis of schizophrenia.

In examining Pavlov's general pathophysiological conceptions above we pointed out that he had directly connected a number of symptoms observed in schizophrenic patients with inhibition of the cerebral cortex or had established their dependence on the disinhibition of the brain stem apparatus during failure of the cortex to control and restrain them.

Popov studied these pathophysiological mechanisms of the psychopathological phenomena in schizophrenic patients by the pharmacodynamic method. In his studies he

used different preparations which, as Pavlov called them, are "drives" for either of the basic nervous processes (excitation or inhibition). Thus he proved that by increasing excitation in the cerebral cortex by caffeine and other agents (phenamine, pervitin) it is possible for some time to weaken and even eliminate the catatonic symptoms. After administration of the afore-mentioned substances which enhance the excitatory processes in the cerebral cortex the patients' *conduplicato corpore, flexibilitas cerea,* catatonic excitation, speech disturbances and other symptoms disappeared. It is very interesting that Popov produced a similar effect by eliciting concentration of inhibition in the cerebral cortex by means of bromides and tincture *Cannabis indica.* By gathering around certain points of the cortex such concentrated inhibition releases the other regions of the cortex from inhibition. These studies revealed that the bromides and the tincture *Cannabis indica* produced a triphasic effect on the schizophrenic patients in the catatonic state. This triphasic effect was manifested as follows: small doses produced no visible change in the patient's condition; medium doses disinhibited the catatonic; with further increase in the dose this effect disappeared.

"It must be assumed," Popov pointed out, "that in the first and third cases inhibition, either weak or very strong, irradiates, according to the well-known rule, and the patient therefore remains inhibited; the inhibition of medium strength concentrates around certain initial points and thereby releases the motor area."*

The role of cortical inhibition in the emergence of various symptoms, catatonic in particular, in schizophrenic patients and the protective significance of this inhibition were further elucidated by the research conducted in Po-

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* Y. A. Popov, "Role of Inhibition in the Clinic of Mental Diseases". In Book: *Scientific Session Dedicated to the 100th Anniversary of the Birth of Academician I. P. Pavlov.* Theses of Reports, Moscow, 1949, p. 103.

pov's clinic and devoted to the study of sleep of schizophrenic patients in catatonic stupor, and by an analysis of the effect produced by hypnotics on the same patients. It was found that when patients were examined immediately after physiological sleep their catatonic symptoms temporarily disappeared. As for the effect of hypnotics on schizophrenic patients, the latter were noted to react to some barbiturates paradoxically. Small doses of barbiturates produced a hypnotic effect, whereas large doses proved ineffective.

Popov also devoted considerable attention to the study of pathological changes in muscle tone of the patients with the catatonic form of schizophrenia.* The studies have shown that in some cases these patients manifest tonic cervical reflexes and have a high percentage of extrapyramidal reflexes. Moreover, they have established a dependence of *flexibilitas cerea* in catatonics on an increase in local postural reflexes. They have also discovered regular changes in *flexibilitas cerea* under the effect of various pharmacological agents. At the same time it developed that agents enhancing excitation in the cortex, and these also included sympathicotonic agents (adrenalin, ephedrine, phenamine, etc.) weakened or eliminated the phenomena of *flexibilitas cerea*, whereas agents fostering emergence of inhibition in the cortex, particularly different parasympathicotonic agents (pilocarpine, etc.) intensified this symptom. These studies carried out by Popov experimentally confirmed Pavlov's afore-mentioned statements made as early as 1918 in his work "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres", that the phenomena of *flexibilitas cerea* in schizophrenic patients must be regarded as disinhibition of the brain stem equili-

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* Y. A. Popov, "On Pathophysiological Mechanisms of Catatonic Motor Disorders". In Book. *Problem of Motoricity in Neuropathology and Psychiatry. Transactions of the Central Neuropsychiatric Institute*, Vol. 8, Kharkov, 1937, pp. 190-99.

brating reflex, which occurs in connection with inhibition of the motor analyser in the cortex. Popov's studies in the pathophysiological analysis of the disorders of thinking in schizophrenic patients deserve particular attention. Is it a question merely of disorganisation of the intellectual processes in these patients or is it perhaps more correct to speak of their special reorganisation? Is schizophrenic thinking governed by any laws, even if they perhaps differ from those which govern healthy thinking, or is it characterised only by a disturbance in these latter laws? These questions arise in connection with the studies of the disorders of thinking in schizophrenic patients.

In one of his works devoted to this problem Popov writes: "On the basis of all of our clinical experience we are inclined to side with those who hold that schizophrenic thinking is built according to the type of thinking in sleep.... As a matter of fact, proceeding from Pavlov's views, we must admit that during sleep, as well as in schizophrenia, the process of internal inhibition spreads extensively over the cerebral cortex. It is natural to assume that the existence of a similar basis must lead to emergence of a certain similarity between the type of mental processes operating during sleep, on the one hand, and in schizophrenia, on the other."*

In addition to the general analogy which Popov draws between the loss of contact with the environment characteristic of the sleeping person, as well as withdrawal into the secluded world of his experiences, and schizophrenic autism, he also deeply analyses the disorders of thinking in schizophrenic patients and compares them with the characteristic peculiarities of dream-thinking. He analyses in schizophrenic patients: 1) the association of words and

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* Y. A. Popov, "On Certain Peculiarities of Schizophrenic Thinking and Its Assumed Physiological Mechanisms". In Book: *Transactions of the Ukrainian Neuropsychiatric Institute*, Vol. XXIV, Kharkov, 1949, pp. 121-27.

ideas, not in the form of abstraction and generalisation of the similar, but, on the contrary, as unification of what is different in them, without any inner sense, 2) replacement of these ideas with others which have a casual unrealisable element of similarity, 3) disturbances in reality relationships and inability to distinguish between the literal and the figurative, the concrete and the abstract.

Popov illustrates by a number of examples the presence in schizophrenic patients of the same mechanisms of thinking as operate in the dreams of healthy sleeping people. He does not confine himself to these, even though very convincing analogies, but reinforces his pathophysiological conception of schizophrenic disturbances in thinking by pharmacological experiments. Experimental studies conducted in his clinic have shown that with a number of preparations which eliminate sleep and enhance the excitatory processes in the cortex (caffeine, phenamine, etc.) it is possible temporarily to put in order the process of thinking in schizophrenic patients and to overcome the disturbances in the stream of thought. The analysis of certain pathophysiological mechanisms of disturbed thinking in schizophrenic patients (change in the signalling meaning of words, loss of discrimination between similar words, etc.) brings Popov to the study of a number of factors in the activity of the second signalling system.

The foregoing data of the pathophysiological analysis of different psychopathological phenomena in schizophrenia, conducted in Popov's clinic, show the importance of inhibition in the cerebral cortex for their emergence. However, we must not overlook the fact that clinicians not infrequently employ the conception of inhibition in a very general, undifferentiated sense. They speak of inhibition without taking into account the differences in its origin and localisation. In reference to this question Popov writes: "The general formula which has become widespread screens the concrete physiological essence of the phenomenon. A healthy person sleeps—diffuse inhibition,

a healthy person is hypnotised—also diffuse inhibition, a patient is in catatonic stupor—diffuse inhibition, this patient is asleep—the more so, diffuse inhibition, pharmacological sleep—again diffuse inhibition, narcosis—the same thing. But all these are indeed different states, although under certain conditions they may pass into each other."*

In the differentiated analysis of inhibition made by Popov in this direction two of the postulates established by him are of particular practical importance. Firstly: the inhibition found in schizophrenic patients is not always of a protective character and does not always have to be maintained or deepened.

At a certain stage of the disease such inhibition may lose its protective significance and become inert, in which case it must be eliminated. Secondly: the artificially produced inhibition in a form of prolonged pharmacological sleep employed for therapeutic purposes may be indicated in a number of cases of schizophrenia not only to deepen inhibition obtaining in the patient, but also during states of excitation.

We have already mentioned the fact that the agents employed in Popov's clinic for the purpose of changing the functional state of the cerebral cortex in schizophrenic patients by the pharmacodynamic method also included various sympathicotonic and parasympathicotonic substances. On the basis of these studies Popov advanced a hypothesis according to which the phenomena of pathological inhibition in the brain of schizophrenic patients are connected with definite changes in the state of the vegetative nervous system. This hypothesis was confirmed by his data which show that in the catatonic form of schizophrenia, as also in the other forms of schizophrenia, the parasympathetic tone predominates over the sympathetic tone. Popov's

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* Y. A. Popov, "Role of Phenomena of Inhibition in the Clinic of Mental Diseases". *The Pavlov Journal of Higher Nervous Activity*, Vol. V, Book 3, Moscow, 1955, p. 331.

studies established the possibility of intensifying or weakening schizophrenic symptoms by administering agents which enhance or, on the contrary, lower the tone of the parasympathetic system. Lastly, Popov discovered a regular correlation between the improved condition of the patients occurring spontaneously or as a result of treatment and the corresponding changes in the tone of the parasympathetic system. If these regularities have not always been very definitely and clearly pronounced, the interconnections and reciprocal influences between the functional state of the cerebral cortex in schizophrenic patients and the changes in the vegetative nervous system of the same patients cannot be doubted. With the same aim of elucidating the correlations between the cortical and somatic changes, the disturbances in carbohydrate metabolism in schizophrenia were studied in Popov's clinic. It developed that the discovered deviations were in some respects similar to those observed in animals during winter hibernation. By the method of the double sugar load it was established that the deviations in carbohydrate metabolism depended primarily on the changes in its regulation by the nervous system. By exerting different influences on the nervous system (hydration—dehydration, alkalosis—acidosis, constriction—dilation of vessels) it was possible to facilitate or impede the development of insulin coma.

On the basis of all these data Popov advanced his hypothesis of the pathogenesis of schizophrenia, according to which inhibition in the higher parts of the brain, the parasympathetic change and the disturbances in carbohydrate metabolism must be regarded as interconnected factors underlying a single biological complex.*

N. Tatarenko has been consistently developing the Pavlovian conceptions of schizophrenia. As V. Protopopov's

* Y. A. Popov, "Some General Questions of the Pathogenesis of Schizophrenia". In Book: *Urgent Problems of Neuropathology and Psychiatry*, Kuibyshev, 1957, pp. 150-57.

pupil, she was one of the first, as far back as 1926-28, to study the conditioned reflex activity in schizophrenia and to establish a number of regularities in the disturbances not only of the conditioned but also the unconditioned reflexes in these patients. On the basis of Pavlov's postulate on "representation" of unconditioned reflexes and somatic functions in the cerebral cortex Tatarenko investigated all these mechanisms for the purpose of characterising the different states of the basic nervous processes in the higher parts of the brain of schizophrenic patients and for studying the effect of various medical preparations on schizophrenic patients.

Tatarenko made a considerable contribution to the elaboration of adequate methods of investigating the basic nervous processes in the higher parts of the brain applicable to the psychiatric clinic.* Here we must mention, in the first place, that she was the first to introduce a test of the orienting reflex into psychiatric practice. This reflex was studied in the clinic headed by Tatarenko in two of its components—pupillary and vascular. The test of the pupillary reaction, by means of a specially designed instrument (pupillometer**), to the action of different contact and distant stimuli which elicit the orienting reaction have

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* N. P. Tatarenko, "New Methods of Physiological Research in the Clinic". *Vrachebnoye Delo*, 1954, No. 11. Also N. P. Tatarenko, "On the Pathophysiology of Schizophrenia". *The Korsakov Journal of Neuropathology and Psychiatry*, Vol. IV, Book 9, 1954, pp. 710-15.

** This instrument is a chamber with a bulb for illuminating the eye, a lens, and a scale for measuring the dilation of the pupil and for measuring the reaction (the scale makes it possible to measure reactions with an accuracy of 1/8 of its initial value). During the test the dilation or constriction of the pupil were recorded (dilation was marked by a — and constriction by a +), one plus like one minus marked a change in the size of the pupil by 1/8 of its initial size, absence of reaction was designated by a zero (0), while a slight reaction, difficult to measure, was marked as "twitching". The latent period of the reaction and the initial size of the pupil were also taken into consideration.

shown that, as a rule, this reaction is manifested as a dilation of the pupil. That the foregoing reaction is a component of the orienting reflex was established by the fact that it possesses all the properties of the latter (ability of being extinguished, disinhibited and restored). On the basis of the data obtained in numerous investigations Tatarenko emphasised the extraordinary reactivity and plasticity of the pupillary component of the orienting reflex and the practical expedience of testing it in diagnosing and appraising the patient's condition. The vascular component of the orienting reflex manifested in constriction of vessels was tested in Tatarenko's clinic by means of a specially designed plethysmograph*. It should be noted that the tests of the orienting reflex, especially its pupillary component, in schizophrenic patients have disclosed that the pupillary reaction is very frequently absent or distorted. According to Tatarenko, "the character of inhibition which conditions the absence, weakening or distortion of the reaction indicates beyond any doubt that it is transmarginal". We may note another peculiarity of the pupillary component of the orienting reflex in schizophrenic patients never encountered in normal people, namely, an intensification of the reaction and the practical impossibility of extinguishing it (by the continuous, as well as the intermittent method). As other methods of examination in the psychiatric clinic Tatarenko widely utilised the reaction (cutaneous and vegetative to nicotinic acid) which reveals extremely characteristic phenomena in schizophrenic patients differing from the phenomena in other patients—total absence or sharp diminution of erythema with an odd asymmetrical distribu-

* This plethysmograph designed by S. Shteinberg is a system which serves to perceive and record vascular reactions. It consists of a plethysmo-receiver (a rubber bag with a porous elastic rubber sponge inside), a pneumatic transmission (which connects the plethysmo-receiver with Marey's capsule), Marey's capsule and a system of two levers which intensify the vibrations and record them on tape.

tion in the form of individual spots, points, etc., running a temporary course, and other peculiarities. It had been earlier established in Tatarenko's clinic that the reaction to nicotinic acid was regulated by the higher parts of the brain, since the conditioned reflex elaborated to it was extinguished by suggestion.

Tatarenko studied the reactivity of the organism in connection with the states of the basic nervous processes in the higher parts of the brain and the higher nervous activity of schizophrenic patients not only to physiological (orienting), and chemical (nicotinic acid and various medicinal substances), but also to biological stimuli (infectious factors). By means of whooping cough vaccine she disclosed certain immunobiological regularities in schizophrenic patients. The immunobiological activity in initial stages of schizophrenia, especially in catatonic stupor, proved much higher than in healthy people. This difference was not observed in persons who were ill for a long time. It was also established that the concomitant infections in all forms of schizophrenia, except catatonic stupor, led to intensification of the excitatory process and weakening of the inhibitory process, which was manifested in disappearance or diminution of the phasic hypnotic states in the cerebral cortex. This apparently underlies the temporary improvement of the mental state in patients after infections.

The method of studying the higher functions of the cerebral cortex—abstraction and generalisation—proposed by V. Protopopov and Y. Rushkevich was widely utilised in the clinic headed by Tatarenko for purposes of pathophysiological research. By this method the clinic established strict regularities in the changes of the functions of abstraction and generalisation in schizophrenia, which differ from the same functions in other psychoses and confirm the existence of phasic phenomena and other states characteristic of schizophrenia. Tatarenko also studied the pathology of speech in schizophrenia and the pathophysiological mechanisms of oneiric states in this disease.

On the basis of the foregoing studies which confirm Pavlov's hypothesis on the pathophysiological mechanisms of psychopathological phenomena observed in schizophrenia Tatarenko has formulated her general conception of schizophrenia which includes questions of pathogenesis, course and outcome of the disease.* According to this conception, schizophrenia begins early and its first manifestations (various psychopathological symptoms, later becoming more or less normal) are phasic states in the higher parts of the brain. Later, as the affections grow deeper and compensation diminishes, "acute" states emerge, the phasic phenomena being already widespread and deep. These phasic phenomena arise in response to the disturbances in metabolism, endocrine functions and work of the internal organs now involved in the process because of the disturbed regulation of all functions of the organism by the higher parts of the brain. During the initial and "acute" period the developing phasic inhibition in the cerebral cortex is still of a protective character, but since this inhibition is not complete and the cortical cell is not fully excluded from activity, but continues to work under pathological conditions, the "protective function gradually ceases to be performed by this inhibition which later assumes an inert character. That is why it is necessary actively to combat this inert inhibition by various therapeutic methods during this stage of the disease".

Later the phasic phenomena increasingly blend with the phenomena of exclusion of the organically affected parts of the brain and of the compensation by its remaining normal parts, which is responsible for the different outcomes of the disease.

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* N. P. Tatarenko, "On the Character and Significance of the Hypnotic Phases During Different Periods of Schizophrenia". In Book: *Transactions of the Scientific and Practical Conference of Neuropathologists and Psychiatrists of the Baltic Republics*, Riga, 1956, pp. 175-86.

Nevertheless, the specificity of the psychopathological and somatic disturbances in this disease consists of four components: truly pathological, defensive-biological, defective and compensatory. And this is what produces the certain external variety of symptoms despite their common inner essence, which was excellently substantiated in Pavlov's hypothesis on the hypnotic phasic phenomena in the cerebral cortex of schizophrenic patients.

In conclusion we shall briefly dwell on the pathophysiological conceptions of schizophrenia developed by Pavlov's pupil V. K. Fyodorov.

Fyodorov based his views of schizophrenia on the marked weakness, delicateness and fragility of the "nervous apparatus" in schizophrenic patients observed by Pavlov. On the basis of a large number of observations (up to 500 cases) Fyodorov found that among the schizophrenic patients persons with the weak type of higher nervous activity constitute up to 60 per cent of the cases, among the patients with exogenous psychoses—up to 22 per cent and among mentally healthy people—up to 10 per cent. By comparing schizophrenic patients with those suffering from exogenous psychoses, according to the data characterising their premorbid type of higher nervous activity and the intensity of exogenous harmful factors preceding the disease, Fyodorov found that schizophrenic patients had a deeper, than the patients suffering from exogenous psychoses, affection of cortical activity produced by severe overstrain and the resultant damage to the nerve cells of the cerebral hemispheres, depending on the correlation between the stability of the type of nervous system and the nature of the external harmful factors. For schizophrenic patients this correlation is determined either by a very weak type of higher nervous activity or particularly potent and combined external harmful factors.

According to Fyodorov, "in the absence of a specific etiology of schizophrenia its pathogenesis is a result of the interaction of sufficiently grave harmful agents with a nerv-

ous system which is insufficiently stable in respect to these agents, the cortical cells being weakened to such an extent that they continue to be traumatised by usual stimuli which have become excessively strong for them. The latter, together with various somatic disturbances which complicate the disease, underlies the progress of the disease, the somatic disturbances being a result of wrong regulation of all functions of the organism by the affected cerebral hemispheres."*

In another work V. Fyodorov writes: "Now we do not regard schizophrenia as an endogenous psychosis; like the exogenous psychoses this disease also arises as a result of interaction of the organism with the environment. The difference lies in the degree of overstrain of the cortical cells, since after elimination of the factors causing the disease in so-called exogenous psychosis the cortical cells resume normal work, while in schizophrenia they are so weakened that the usual everyday stimuli prove excessively strong and continue to foster the destructive process. By taking into account the intensity of the harmful influences, on the one hand, and the type of higher nervous activity, on the other, we can draw conclusions about the overstrain of the nervous processes in the cerebral hemispheres."**

We cannot fail to recognise the great significance (noted by Fyodorov) of the inborn weakness of the nerve cells of the cerebral hemispheres characteristic of schizophrenic patients and the important role of the harmful external

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* V. K. Fyodorov, "Pathogenesis of Schizophrenia in the Light of Pavlov's Teaching on Types of Higher Nervous Activity." *Proceedings of the All-Union Scientific and Practical Conference Dedicated to the 100th Anniversary of S. S. Korsakov's Birth and Devoted to Urgent Problems of Psychiatry*, Moscow, 1955, p. 127.

** V. K. Fyodorov, "On the Problem of Pathogenesis and Distinction of Schizophrenia". In Book: *Problems of Physiology of the Central Nervous System* (book dedicated to the 70th Anniversary of Academician K. M. Bykov's birth), Moscow and Leningrad, 1959, p. 544.

factors which additionally weaken the nervous system of schizophrenics and thus foster the development of the schizophrenic process. However, we cannot agree with Fyodorov's rejection of a specific etiology of schizophrenia, as yet unknown, or with his ignoring the qualitative aspect of the pathological processes in the organism, especially in the brain, of the schizophrenic patient conditioned by its complex pathogenesis.

According to Fyodorov's foregoing conception, schizophrenia is not a processional disease, not an independent clinico-nosological unit, but only a certain type of pathological reaction, and this we believe to be wrong.

NOTES

[1] The article "Experimental Psychology and Psychopathology in Animals" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 23-39). It is the text of the speech delivered by Pavlov at the International Medical Congress in Madrid, April, 1903. The article was first published in the *Herald of the Military Medical Academy* (1903, Vol. 7, No. 2, pp. 109-21). It is Pavlov's first report on the theory of conditioned reflexes proving the legitimacy of studying mental activity physiologically and regarding it as reflex activity. Already in this article Pavlov pointed out the possibility of employing new methods of studying higher nervous activity, but as yet mainly through mechanical destruction of different parts of the brain. This work clearly revealed Pavlov's tendency physiologically to substantiate human psychology and psychopathology by experiments on animals. However, this tendency was realised at a later period of his scientific activity. p. 13

[2] The experiments of I. F. Tolochinov, Pavlov's first collaborator, were carried out in 1901 and were summarised by him in his work "Material for the Study of the Physiology and Psychology of Salivary Glands". It was the first work on conditioned reflexes and was reported to the Congress of Naturalists and Physicians of the North in Helsinki in 1902 and published in French in the Materials of the Congress. (I. F. Tolochinov, *Contribution à l'étude de la physiologie et de la psychologie des glandes salivaires.* Tòrhandlinger vid Nord. Naturforscara-och Löveremot, Helsingfors, 1903.)
On Tolochinov see also Note 15. p. 20

[3] The article "On Sleep" is an excerpt from I. P. Pavlov's speech delivered at the Meeting of the Ledentsov Society for Fostering Progress in Experimental Sciences and Their Practical Application (Moscow, 1910). The article was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 130-32). p. 31

[4] Here Pavlov is referring to the studies of the formation of conditioned reflexes to thermal stimuli conducted by his collaborators O. S. Solomonov and A. A. Shishlo. Pavlov's statement on sleep is essentially a summary of the data of their investigations. These investigations were set forth by the authors themselves in O. S. Solomonov's report "On Somniferous Reflexes" to the Society of Russian Physicians in Petersburg, March 25, 1910, which was published in the *Transactions of the Society of Russian Physicians* (St. Petersburg, 1911, 77th year of publication, pp. 159-71). p. 31

[5] "On Inhibition and Sleep" is an excerpt from Pavlov's article "Basic Rules of the Function of the Cerebral Hemispheres". The excerpt was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 162-71) The article "Basic Rules of the Work of the Cerebral Hemispheres" is a shorthand record of the report made by Pavlov to the Meeting of the Petersburg Society of Russian Physicians, March 24, 1911 (the meeting was dedicated to I. M. Sechenov's memory). Pavlov based his report mainly on the experimental studies of his collaborators N. I. Krasnogorsky and N. A. Rozhansky who demonstrated their experiments in the course of Pavlov's report. This report was first published in the *Transactions of the Society of Russian Physicians* (St. Petersburg, 1911, pp. 175-87).

Pavlov's article "Basic Rules of the Work of the Cerebral Hemispheres" begins with a brief description of the motion of the nervous process of excitation and then deals with the main subject of the report—the experimental data on the regularities of the spread of the process of inhibition. In the present edition the first part of this article was deleted. The end of the article in which Pavlov deeply criticised the psychological, so-called subjective, method of studying the higher nervous activity of animals was also deleted.

In the deleted first part of the article Pavlov emphasises the particularly great importance of the "brilliant" discovery of central inhibition made by I. M. Sechenov.

The article develops and substantiates the proposition formulated by Pavlov in the preceding article ("On Sleep") that "sleep is a depression, an inhibition of all the activity of the higher part of the brain".

On the basis of experimental data Pavlov very convincingly proves the common nature of the phenomena of inhibition and sleep, and the possibility of transition of different forms of inhibition to sleep by way of irradiation of inhibition through the cerebral hemispheres. In this work Pavlov does not as yet touch upon the question of the character of inhibition (external and internal) which passes into sleep. p. 34

N. A. Rozhansky's experiments cited by I. P. Pavlov subsequently formed the basis of Rozhansky's dissertation. (N. A. Rozhansky, *Materials on the Physiology of Sleep*. Dissertation, St. Petersburg, 1913, 94 pages.)

Rozhansky worked on his dissertation in Pavlov's laboratories January 1910-August 1912. The dissertation contains a detailed review of the literature on problems of sleep published by that time. In his philosophical views and later also in the physiological interpretation of the phenomena of sleep Rozhansky differed with Pavlov. p.37

[7] A detailed description of Krasnogorsky's experiment performed on the dog "Gnome" and cited by Pavlov is found in N. I. Krasnogorsky's dissertation. (N. I. Krasnogorsky, *On the Process of Depression and Localisation of the Skin Motor Analyser in the Cerebral Cortex of the Dog*, St. Petersburg, 1911.) p. 38

[8] The article "Conditions for Active and Resting States of the Cerebral Hemispheres" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 290-98). This article is the report (under the same title) made by Pavlov to the Petrograd Society of Biologists in 1915.

In this article Pavlov examines in detail two basic questions: 1) the conditions favouring the onset of sleep (significance of a decreased influx of external stimuli or the presence of monotonous, prolonged stimuli, the character of the stimuli and individuality of the animal) and 2) conditions impeding the onset of sleep (significance of a variety of stimuli and nervous processes, i.e., alternation of excitation and inhibition). As Pavlov directly points out in the text, I. M. Sechenov's statements in his famous *Reflexes of the Brain* were of particular importance to the question discussed in the article. It should be noted that Sechenov also dwells on the question of the onset of sleep or waking in one of his other works written much later under the title of *Participation of the Nervous System in Man's Working Movements*. In virtue of the special interest which these postulates laid down by Sechenov present we are citing the following excerpt from his works:

"*Waking*. This state is connected with the continuous effects of impulses from the external world on our sense organs and is demonstrated by accidental and, fortunately, extremely rare pathological observations on man. One such case witnessed by physicians happened in Germany. It was a case of a young man whose suffering consisted in the fact that of all the sense organs he retained functionally intact but one eye and one ear which served him as the only avenues of communication with the external world. As long as the eye could see or the ear could hear he was awake, but as soon as the physicians, by way of experiment, closed his healthy eye and stopped up the ear, the patient rapidly lapsed into sleep from which he awakened when these organs were acted upon by sensual stimuli.

"Another case occurred in Petersburg, in the Pokrovskaya community, and I was told about it by S. P. Botkin who was near and dear to all of us, Russians, during his lifetime and who still is near and dear to us by the memories he has left. A well-educated female patient retained intact only the sense of touch and the

muscle sense in one of her arms. According to the hospital personnel, she was almost always asleep and communicated with people in the following manner: a pillow was placed on her abdomen and her hand which retained its sensitivity was moved along the pillow so as to write the question to which the patient's answer was wanted. To this question the patient answered in words. The patient talked similarly with S. P. Botkin. For example, the words 'Botkin has come to see you' were written with her own hand and she answered: 'I am very glad', etc.

"Can there be any doubt, after such facts, that waking with its inevitable alternation of sensations of various kinds and orders is maintained by optic, acoustic, thermal, olfactory and frequently mechanical external influences on the senses? True, we do not know what happens in the central nervous system at this time, but we cannot doubt this fact a priori: the loss of all senses must necessarily be accompanied by a total loss of consciousness, since conciousness is manifested in nothing but conscious sensations. A total loss of the senses must correspond to deep sleep without dreams." (I.M. Sechenov, *Selected Philosophical and Psychological Works*, U S.S.R. Academy of Sciences, Moscow, 1952, p. 511.)
p. 44

[9] The case of Professor Strümpell which Pavlov mentions here and in some of his other works was the subject of a report made by Professor Strümpell to the Section of Internal Medicine at a meeting of naturalists in Munich in 1877 (this case is described in Strümpell's article "Beobachtungen über ausgebreitete Anästhesien und deren Folgen für die willkürliche Bewegung und das Bewusstsein", Deutsches Archiv für klinische Medicin, 1878, Bd. 22).
p. 44

[10] Pavlov also examines the question of the importance of the diminished influx of external stimuli to the brain for the onset of sleep in his other article "Problem of Sleep", referring to the experiments of B. S. Galkin who surgically eliminated in dogs simultaneously the visual, auditory and olfactory receptors (see I. P. Pavlov's article "The Problem of Sleep" in the present edition, p. 393).
p. 45

[11] Here Pavlov refers to M. K. Petrova's experiments summed up in her dissertation (M. K. Petrova, *On the Teaching on Irradiation of Excitation and the Inhibitory Processes*, St. Petersburg, 1914, 255 pages) and her work *Struggle Against Sleep. Work of Balancing the Stimulatory and Inhibitory Processes* (book dedicated to Pavlov's 75th birthday, Leningrad, 1924, pp. 275-85). Petrova's dissertation and her subsequent physiological investigations of sleep and related phenomena are a valuable contribution to Pavlov's teaching on sleep. The dissertation examines the different hypnotic effects of various conditioned stimuli (thermal, mechanical stimuli of the skin, acoustic, etc.), measures of struggle against sleep, transformation of strong faradic current into a somniferous agent, effect of the sentry reflex on the emergence of sleep, causes of special sleepiness of " lively", "excitable" dogs, etc.

According to M. K. Petrova, "sleep ... is characterised by a special relation of the central nervous system to external stimuli and special states of the muscles" (in the same dissertation). While sharing a number of N. A. Rozhansky's views of the physiological nature of sleep, Petrova differs with him in evaluating the significance of restraining the animal's movements for the onset of sleep, considering such restraint a secondary factor in determining the emergence of sleep. At the same time she attaches the decisive importance in the onset of sleep to the character of external stimuli, their quality, duration, strength, etc. In her opinion it is the protracted, monotonous conditioned stimuli, thermal and mechanical skin stimuli, in the first place, which have the necessary hypnotic effect. p. 51

[12] P. N. Vasilyev's experiments to which Pavlov refers are treated in Vasilyev's dissertation *Differentiation of Thermal Stimuli by the Dog (St. Petersburg, 1922).*

In his experiments Vasilyev alternated different conditioned thermal stimuli to struggle against sleep, he also used M. N. Yerofeyeva's method and elaborated a conditioned food reflex to strong faradic current. p. 52

[13] I. P. Pavlov's article (written jointly with L. N. Voskresensky) "Some Facts About the Physiology of Sleep" was translated from the text of the work published under the same title in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 299-305). This article is a report prepared for the press and made by Pavlov under the same title to the Petrograd Biological Society in 1915. It was first published in French in the journal *Comptes rendus de la Société de Biologie* (79,1079-1084, 1916). Besides, Pavlov's report "Some Facts about the Physiology of Sleep" was published in the *Herald of the Petrograd Biological Laboratory* (1917).

In this work Pavlov makes a close study of the "course of sleep", the "motion of sleep inhibition through the brain". The transitional states between sleep and waking, the phenomena of hypnosis became the object of his experimental research; by hypnosis Pavlov implies partial, limited sleep in its different manifestations. The work contains the experiments of L. N. Voskresensky who produced hypnotic states by conditioned reflexes. At the same time Pavlov also believes that hypnotic inhibition exists as an independent form of inhibition. This point of view was distinctly expressed by Pavlov in his article "Special Lability of Internal Inhibition: Hypnotic, External and Internal" (I . P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 1, Moscow and Leningrad, 1951, p. 275). p. 53

[14] Pavlov refers to his report made to the Petrograd Society of Biologists in 1914 and published as an article entitled "Special Lability of Internal Inhibition in Dogs" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 1, Moscow and Leningrad, 1951, p. 275). p. 59

[15] The article "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 346-54).

The article is a report made by Pavlov to a meeting of the Society of Psychiatrists in Petrograd in 1919. It was first published in the same year (*Russian Physiological Journal*, 1919, Vol. II, Book 4-5, p. 257).

During June-August 1918 Pavlov lived in his country home on Poklonnaya Hill in Udelnaya near Leningrad. During that period he visited the Skvortsov-Stepanov 3rd Psychiatric Hospital where with the aid of a number of psychiatrists, mainly A. V. Timofeyev, Chief Physician of the hospital, and physician V. P. Golovina, he observed mental patients in an endeavour to understand the peculiarities of their condition and behaviour from the point of view of general physiology of the nervous system, particularly the teaching on conditioned reflexes. As L. A. Orbeli points out, "his first impressions and statements manifested his admiration of the selfless work of psychiatrists who gave all their energies and knowledge to the difficult and at times dangerous work of caring for mental patients". The report made by Pavlov to the Society of Psychiatrists in Petrograd in 1919 and published in the article "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" is a summary of these observations of the mental patients in the Udelnaya Psychiatric Hospital. Of considerable interest is the fact that the case history (described in the article) of the 60-year-old Kachalkin who was in a catatonic stupor for more than twenty years has come down to us and was recently analysed by V. I. Velikojanov, research worker at the Pavlov Institute of Physiology. (V. I. Velikojanov, "On the History of Pavlov's Teaching on the Protective Role of Transmarginal Inhibition. Patient Kachalkin". *The Korsakov Journal of Neuropathology and Psychiatry*, Vol. 60, Book 4, pp. 484-87, 1960.) This patient had been admitted to the psychiatric hospital in 1893 and was observed by Pavlov only at the end of July 1918. It should also be noted that at that time I. F. Tolochinov was the patient's attending physician; although a psychiatrist, he carried on scientific work in Pavlov's laboratory and, as was already mentioned (See Note 2), wrote, under Pavlov's supervision, the first work on conditioned reflexes. The patient Kachalkin died of heart failure in September 1918 soon after Pavlov had discontinued his visits to the hospital. This article is significant not only for its deep physiological interpretation of one of the widespread and important symptoms of catatonia, the so-called *flexibilitas cerea*, but also because it already shows the basic features of Pavlov's harmonious physiological hypothesis of the catatonic form of schizophrenia. p. 60

[16] Moritz Schiff (1823-1896), Swiss physiologist who extensively studied the central nervous system and the trophic influence of nerves on the tissues. p. 62

[17] In Pavlov's attitude to the well-known British physiologist Charles Scott Sherrington the following is of some interest. Highly appraising Sherrington's works in his "Lectures on the Work of the Cerebral Hemispheres" Pavlov compares his works on the physiology of the brain with Sherrington's works on the physiology of the spinal cord (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. 4, Moscow and Leningrad, 1951, pp. 18-19).

In 1934, in his work "Experimental Pathology of the Higher Nervous Activity" Pavlov reverted to Sherrington again (see present edition, p. 355). He related that, while in London at the Anniversary of the London Royal Society, he had chanced to "meet the best British physiologist and neurologist C. S. Sherrington" and the latter said to him: "You know, your conditioned reflexes would hardly be popular in England since they have a materialistic flavour." Pavlov immediately noted that Sherrington's prediction had not come true. Pavlov wrote: "... In England, the country with which Sherrington tried to frighten me, there is an altogether different situation. There, the theory of the conditioned reflexes is now taught in all schools." (Present edition, p. 356.)

After familiarising himself with Sherrington's new book *The Brain and Its Mechanisms* in 1934 Pavlov, despite his positive appraisal of Sherrington as a physiologist, expressed his sharp disapproval of this book on the "Wednesday," September 19, 1934.

Pavlov said: "Comparing the laws of the brain and its mechanisms, he (Sherrington—*Editor*) draws a very strange conclusion. It appears that up to now he is not at all sure whether the brain bears any relation to our mind.... This is clearly expressed by him in the following, words: 'If nerve activity has relation to mind...' I did not trust my knowledge of English and so I requested others to translate it for me."

"How can it be that at present time a physiologist should doubt the relation between nervous activity and the mind?" Pavlov asks and answers: "This is the result of a purely dualistic concept. This is the cartesian viewpoint, according to which the brain is a piano, a passive instrument, while the soul is a musician extracting from this piano any melodies it likes" (I. P. Pavlov, *Selected Works*, Foreign Languages Publishing House, Moscow 1955, p.563).

Pavlov also sharply criticised Sherrington's agnosticism. "I am all the more surprised," Pavlov went on to say, "that for some reason or other he regards knowledge of this soul as something pernicious and clearly expresses this point of view; according to him, if the best of us acquire some knowledge of the nervous system this would be a most dangerous thing threatening the extinction of man on earth.... Why knowledge of the soul may be pernicious? I would like to know how on earth it can lead to the extinction of man. Socrates counselled. 'Know thyself'. How, then, can a scientist, a neurologist, say: 'Do not dare know thyself'?" (*Ibid.*, pp. 563-64.) p. 62

[18] See the article "Some Facts About the Physiology of Sleep", in the present edition, p. 53, and Note 13. p. 63

[19] The article "Concerning the So-Called Hypnotism in Animals", was translated from the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 359-60). It contains the report made by Pavlov to the meeting of the Branch of Physico-Mathematical Sciences of the Russian Academy of Sciences, November 9, 1921; in this report Pavlov formulates his physiological conceptions of hypnosis in animals. He considers hypnosis in animals one of the self-protective reflexes based on inhibition. The phenomena of catalepsy are regarded as inhibition of the motor area of the cortex. Pavlov also points out the transition of hypnosis to sleep during irradiation of inhibition to the other regions of the cortex. p. 70

[20] The article "Relations Between Excitation and Inhibition, Delimitation Between Excitation and Inhibition, Experimental Neuroses in Dogs" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, pp. 35-50, 1951). This article was first published in German in the *Skandinaviches Archiv fur Physiologie* (Bd. XLVII, H. 1-2, 1925, S. 1-14), the journal founded by R. Tigerstedt.

Although studies of the types of higher nervous activity and of experimental neuroses in animals had been started in Pavlov's laboratory long before this article was written (as early as 1909-11), these studies made particular headway in the 1920's. Considerable attention to this problem was stimulated by the great 1924 Leningrad flood described in the article. The building housing the experimental animals of Pavlov's laboratory was flooded. The conditioned reflex activity elaborated in the rescued animals experimentally was deranged. The peculiarities of the resulting neuroses and their elimination, depending on the type of nervous system in the dogs, was the subject of all-round studies in Pavlov's laboratories.

The present article sums up the studies (mainly during 1921-23) of the conditions under which neuroses emerged. By these conditions Pavlov implied overstrain of the basic nervous processes of excitation and inhibition and of their mobility. p. 72

[21] Reference is made to M. N. Yerofeyeva's work "Additional Data on Destructive Conditioned Reflexes", published in the *Herald of the Petrograd Lesgaft Research Institute*, Vol. III, 1921. p. 75

[22] This refers to N. R. Shenger-Krestovnikova's work "On the Question of Differentiation of Optic Stimuli and of the Limits of Differentiation in the Visual Analyser of the Dog" published in the *Herald of the Petrograd Lesgaft Research Institute*, Vol. III, 1921. p. 76

[23] Reference is made to M. K. Petrova's work "Different Types of Internal Inhibition Under a Particularly Difficult Condition" published in the *Transactions of Academician Pavlov's Physiological Laboratories*, Vol. I, Leningrad, 1924. p. 77

[24] Pavlov is referring to N. Razenkov's work "Change in the Process of Excitation in the Cerebral Cortex of the Dog Under Difficult Conditions of Work" published in the *Transactions of Academician Pavlov's Physiological Laboratories*, Vol. I, Leningrad, 1924. p. 78

[25] A. D. Speransky's work "Changes in the Relationships Between Excitation and Inhibition in the Dog After the Flood" mentioned here was published in the *Russian Physiological Journal* (Vol. VII, Book 3-4, 1925). p. 80

[26] For I. P. Pavlov's views of the investigations of N. Y. Vvedensky and his school see Note 35. p. 86

[27] The article "Normal and Pathological States of the Cerebral Hemispheres" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 51-62). It is Pavlov's report made in French at the Sorbonne, Paris, December 1925.

The article furnishes new data of the studies of experimental pathology of higher nervous activity conducted in Pavlov's laboratories. The characterisation of the reactivity of cortical nerve cells ("precipitate functional destructibility") and the indication of the significance of inhibition in limiting the afore-mentioned high reactivity, which stops "further functional destruction" deserves attention. p. 87

[28] The article "Inhibitory Type of Nervous System in Dogs" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 63-70). The article is Pavlov's report made in French at the Paris Psychological Society in December, 1925.

In this report Pavlov sets forth, for the first time, the teaching on types of nervous system and outlines a classification of types according to the predominance of either excitation or inhibition. Pavlov distinguishes extreme types (sanguine and melancholic) and a balanced type. This classification of types was subsequently modified. p. 100

[29] Reference is made to A. D. Speransky's experiments described in his work "Effect of Strong Destructive Stimuli on the Dog with the Inhibitory Type of Nervous System" (*Transactions of Academician Pavlov's Physiological Laboratories*, Vol. I, Book 1, Leningrad, 1924, p. 119.) p. 108

[30] I. P. Pavlov's article "Internal Inhibition and Sleep Are Essentially the Same Physicochemical Process" was translated from his lecture under the same title (Lecture 15) published in the "Lectures on the Work of the Cerebral Hemispheres" (I. P. Pavlov, *Complete Works*, 2nd ed., Moscow and Leningrad, 1951, Vol. IV, pp. 263-78). The lecture published in the present edition is a somewhat altered version of I. P. Pavlov's article "Internal Inhibition of Conditioned Reflexes and Sleep Are the Same Process" written by Pavlov in 1922 for a book to have been published in

honour of A. P. Karpinsky, then President of the U.S.S.R. Academy of Sciences. The book was not published and the article was printed in the journal *Scandinavishes Archiv für Physiologie* (Bd. LXIV, 1923) and simultaneously in the book *Twenty Years of Experience* (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 1, Moscow and Leningrad, 1951, pp. 373-90).

The principal propositions and content of the lecture and those of the article *Twenty Years of Experience* essentially coincide; the present edition contains the lecture published three years later (1926) than the article. Pavlov somewhat supplemented and revised the lecture.

Pavlov's basic proposition that "internal inhibition and sleep are essentially the same process" was first formulated by him somewhat earlier in the report made to the Society of Finnish Physicians in Helsingfors, April 1922. The report was entitled "Normal Activity and General Constitution of the Cerebral Hemispheres" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 1, Moscow and Leningrad, 1951, p. 365).

In the lecture published in the present edition the foregoing proposition was given thorough experimental substantiation. All-round experimental substantiation was also given in the lecture to Pavlov's propositions on the "transition of inhibition to sleep and vice versa", on "replacement of inhibition with sleep" and on "summation of sleep and inhibition". The lecture clearly reveals Pavlov's dialectical interpretation of inhibition as "partial" sleep, as irradiated inhibition, and formulates the idea of the protective significance of inhibition and sleep. Of great interest is the fact that Pavlov considered this work one of his most important works on sleep (see I. P. Pavlov's article "The Problem of Sleep" in the present edition, p. 393). p. 109

[31] I. P. Pavlov's work "Transitional Phases Between the Animal's Waking and Complete Sleep (Hypnotic Phases)" was translated from the text of the lecture under the same title (Lecture 16) published in the "Lectures on the Work of the Cerebral Hemispheres" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. IV, Moscow and Leningrad, 1951, pp. 176-87).

Using extensive experimental material the lecture sets forth the basic regularities observed in the transitional states from waking to sleep, regularities concerning the spread and depth of the processes of inhibition in the cerebral cortex, and data on different extent and intensity of sleep. The experimental data on this question contained in the lecture give an insight into Pavlov's teaching on hypnosis and hypnotic phases. p. 126

[32] See the detailed description of L. N. Voskresensky's experiments in the article "Some Facts about the Physiology of Sleep" written by I. P. Pavlov jointly with L. N. Voskresensky (present edition, p. 53, see also Note 13). p. 127

[33] Here Pavlov cites B. N. Bierman's experiments described in his monograph "Experimental Sleep" (Gosizdat, 1925).

Pavlov approved of B. N. Bierman's monograph "Experimental Sleep". In the preface to the monograph he wrote: "Dr. B. N. Bierman's present experimental work brings us much closer to the final solution of the problem of the physiological mechanism of hypnosis. Another two or three details and the physiologist will have at his disposal the whole mechanism which has long been an enigma, has been shrouded in mystery" (I. P. Pavlov, *Complete Works*, 2nd ed., Moscow and Leningrad, 1951, Vol. IV, p. 428).

The most important conclusions drawn by B. N. Bierman from his experimental studies are his postulates that "hypnosis differs from sleep in its limited spread of the inhibitory process", that hypnosis is "sleep with partial waking" and owes its existence to a "sentry point" in the cortex. p. 128

[34] Here Pavlov refers to I. P. Razenkov's experiments described in his work "Changes in the Stimulatory Process of the Cerebral Cortex of the Dog Under Difficult Conditions of Work" *(Russian Physiological Journal*, 1926, Vol. IX, Book 5-6). In this work Razenkov for the first time elucidated the main phasic states (hypnotic phases) in the cerebral hemispheres and gave their physiological characteristics. p. 132

[35] Although Pavlov disagreed with certain postulates in N. Y. Vvedensky's teaching on the physiological essence of inhibition, he highly appraised his research in this question. Pavlov recognised that the various phases (discovered by Vvedensky) in the process of transition of the peripheral nerve fibre from excitation to inhibition under the influence of strong stimuli may also take place in the vital activity of the nerve cells of the cerebral hemispheres.

Pavlov very definitely expressed his point of view on this question as far back as 1923 in his work "Latest Achievements in the Objective Study of Higher Nervous Activity of Animals". He wrote: "In studying these deviations in the direction of predominance of inhibition, weakening of the process of excitation, we have convinced ourselves that one of the discoveries of our outstanding, now deceased, physiologist N. Y. Vvedensky is absolutely correct. Vvedensky has contributed a great deal to nervous physiology; he has had the good fortune of finding important facts, but has been for some reason insufficiently appreciated by the foreign press. Among other things, he is the author of the book *Excitation, Inhibition and Narcosis* in which he establishes changes in the nerve fibre under the influence of strong stimuli and distinguishes several phases. It has now developed that these peculiar phases are completely reproduced in the nerve cells when you greatly intensify the struggle between the processes of excitation and inhibition. I have no doubts that after this coincidence Vvedensky's works will finally be estimated at their true worth" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 2, Moscow and Leningrad, 1951, p. 28). p. 133

[36] The article "Different Types of Nervous System. Pathological States of the Cerebral Hemispheres as a Result of Functional

Influences Exerted on Them" was translated from the text of the lecture under the same title (Lecture 17) published in the "Lectures on the Work of the Cerebral Hemispheres" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. IV, Moscow and Leningrad, 1951, pp. 299-316). This article already distinguishes four types: two "extreme" (excitable and inhibitory) and two "intermediate", balanced types. However, this classification of types was subsequently modified, since it did not completely correspond to the classification of temperaments proposed by Hippocrates by which Pavlov guided himself. The same lecture contains data on functional pathological states ("experimental neuroses") produced by overstrain of the processes of excitation, inhibition, and their mobility. p. 147

[37] The article "Pathological States of the Cerebral Hemispheres as a Result of Functional Influences Exerted on Them" was translated from the text of the lecture under the same title (Lecture 18) published in the "Lectures on the Work of the Cerebral Hemispheres" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. IV, Moscow and Leningrad, 1951, pp. 317-35).

This lecture, a continuation of the preceding one, further elucidates the derangements of higher nervous activity ("experimental neuroses") produced by difficult tasks imposed on experimental animals and overstraining the basic nervous processes in the brain and the mobility of these processes. p. 167

[38] The article "Application to Man of Experimental Data Obtained on Animals" was translated from the text of the lecture under the same title (Lecture 23) published in the "Lectures on the Work of the Cerebral Hemispheres" (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. IV, Moscow and Leningrad, 1951, pp. 414-33). In this last lecture Pavlov elucidates in detail the important and fundamental question of the justification of applying to man the experimental data obtained on animals. While recognising the possibility of such application, Pavlov calls for the greatest possible discretion considering the fact that it is precisely the higher nervous activity that "sharply distinguishes man from animals". This lecture for the first time raises the question of the peculiarities of man's higher nervous activity, the role of the word, speech, as a new physiological stimulus inherent only in man. In examining questions of hypnosis and suggestion Pavlov determines the peculiarities of these phenomena in man. Thus, Pavlov essentially for the first time expresses in this lecture his ideas on the second signalling system without as yet using this term. Concerning the teaching on neuroses, however, Pavlov still ascribes hysteria to neuroses in animals and does not consider it along with psychasthenia a specially human neurosis, as he did later. p. 187

[39] The work "Physiological Teaching on Types of Nervous System or Temperaments" was translated from the text of the article under the same title published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad,

1951, pp. 77-88). This article constitutes Pavlov's report to the meeting of the Pirogov Russian Surgical Society dedicated to N. I. Pirogov's memory on December 6, 1927. In classifying the types of nervous system in dogs Pavlov divides the "intermediate" balanced type, according to the character of mobility of its nervous processes, into two types—the "lively" and the "inert". Thus he distinguishes four types which correspond to the four temperaments established by Hippocrates. The "excitable" type formerly recognised by Pavlov as corresponding to Hippocrates' sanguine temperament in this work corresponds to Hippocrates' choleric temperament. p. 208

[40] Nikolai Ivanovich Pirogov (1813-1881), great Russian surgeon and anatomist whose works laid the groundwork for the anatomo-experimental trend in practical surgery. Of great interest to neuropathologists and psychiatrists in his works on battlefield surgery is the teaching on the closed craniocerebral trauma, shellshock, in which he emphasised that the latter affected the entire organism. p. 208

[41] Leonid Vasilyevich Blumenau (1862-1931), outstanding Russian neuropathologist, known for his scientific contributions to the anatomy and physiology of the brain. Blumenau was one of the first clinical neuropathologists to use Pavlov's teaching in explaining the pathogenesis of functional diseases of the nervous system, hysteria in particular. Here Pavlov refers to Blumenau's work *Hysteria and Its Pathogenesis*, Leningrad, 1926. p. 218

[42] Only part of the article "Some Problems of the Physiology of the Cerebral Hemispheres" is published in the present edition. Only the fourth part of the article devoted to classification of types of nervous system was translated (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 101-05). The article as a whole constitutes the Croon Lecture delivered by Pavlov to the London Royal Society, May 10, 1928. Specialists in the different branches of natural science are annually invited from all over the world to deliver a lecture for the Croon Prize. This work was published in English in the *Proceedings of the Royal Society*, Section B. Biological Sciences, Series B., Vol. 103, No. B. 721, 1928, pp. 106-10. p. 220

[43] The article "An Attempt of a Physiologist to Digress into the Domain of Psychiatry" was first published in the anniversary volume in honour of E. Gley and I. F. Heymans in the journal *Archives Internationales de Pharmacodynamie et Therapie* in 1930. It was also published under the same title in the booklet *Physiology and Pathology of Higher Nervous Activity* (Gosmedizdat, Leningrad and Moscow, 1930, pp. 37-45) and under the title of "Excursion of a Physiologist into the Field of Psychiatry" in the newspaper *Izvestia (Izvestia of the Central Executive Committee of the U.S.S.R.*, No. 122 [3969] May 5, 1930).

The article was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Mos-

cow and Leningrad, 1951, pp. 126-32) and develops Pavlov's ideas in regard to his physiological interpretation of schizophrenia set forth in his article "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" (see p. 60 of the present edition and Note 15).

In this article Pavlov thoroughly analyses a group of symptoms observed in schizophrenic patients: negativism, stereotypy, echolalia and echopraxia, muscular rigidity, phenomena of hebephrenic silliness, and catatonic excitement. Pointing out that such symptoms also appear in healthy people during hypnosis Pavlov postulates more definitely the conclusion already planned in his work "Psychiatry as an Auxiliary to the Physiology of the Cerebral Hemispheres" that the "schizophrenic symptoms are an expression of a chronic hypnotic state" and that "in certain variations schizophrenia is really chronic hypnosis". According to Pavlov, this inhibition (hypnosis) is based on a "weak nervous system, special weakness of the cortical cells (hereditary and acquired) which easily become exhausted since normal stimuli are also too strong for such weakened cells. The exhaustion of the nerve cells is an impulse to the emergence of inhibition in them. But as long as the inhibitory process is effective the cortical cell is not deeply affected". Pavlov thus formulates his teaching on the healing and protective role of inhibition in schizophrenic patients. This teaching proved to be a deep theoretical substantiation of the formerly empiric treatment of schizophrenic patients with prolonged, artificially induced sleep. It also determined Pavlov's line in questions of organising psychiatric aid; Pavlov's statements on these questions are also of considerable interest.

Pavlov demands humane treatment of mental patients and consideration of the fact that some patients regard their very commitment to the hospital as a "violation of human rights". "Consequently," I. P. Pavlov writes, "it is necessary as quickly and as timely as possible to place such mentally diseased in the position of patients suffering from other illnesses which do not offend human dignity so manifestly" (present edition, p. 31). p. 225

[44] Pavlov's article (written jointly with M. K. Petrova) "Physiology of the Hypnotic State of the Dog" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 133-46). This work was first published in 1932 (*Transactions of Academician Pavlov's Laboratories*, Vol. IV, 1932). In 1934 this article was published in English under the title of "A Contribution to the Physiology of the Hypnotic State in Dogs. Character and Personality", (Vol. 2, No. 3, 1934, pp. 189-200). In the *Twenty Years of Experience* it was published only in the sixth edition in 1938. The work offers a deep physiological analysis of hypnosis in animals. Some hypnotic phenomena are interpreted on the basis of experimental data in the light of localisation and motion of hypnotic inhibition, phenomena of reciprocal induction and interactions of the cortex and subcortex.

The physiological analysis of hypnotic inhibition and negativism in the experimental dogs contained in this work is also of considerable importance in explaining a number of phenomena observed in the psychiatric clinic, the psychopathological symptoms in patients with the catatonic form of schizophrenia in particular. p. 232

[45] See the lecture on the "Transitional Phases Between the Animal's Waking and Complete Sleep (Hypnotic Phases)" published in the present edition (p. 126) and Note 16. p. 232

[46] See the article "Some Facts About the Physiology of Sleep" written by I. P. Pavlov jointly with L. N. Voskresensky (p. 53 in the present edition). The article contains a detailed description of the experiments with production of the hypnotic state in dogs, determining dissociation of the motor and secretory components in the conditioned food reflex. p. 237

[47] Here Pavlov confines himself merely to a general mention of the "broad representation" of the "internal world of the organism" in the cerebral cortex, a mention which serves as the basis for understanding the physiological mechanisms of verbal suggestion during hypnosis in man, as well as the possibility of influencing the vegetative processes in the organism, the activity of its internal organs, by means of such suggestion and autosuggestion. In the studies of Academician K. M. Bykov (1886-1959), Pavlov's closest pupil, as well as those of Bykov's collaborators the question of the relationships between the cortex and internal organs was very fruitfully and extensively elaborated.

On the basis of numerous experiments K. M. Bykov and his collaborators have established bilateral connections between the cortex and the internal organs; on the one hand, it is a regulating influence of the cortex on the activity of the internal organs by means of a trigger and co-ordinating mechanisms, and, on the other hand, it is the all-round "information" of the cortex on the state of the internal organs by numerous signals conveyed from the latter to the cortex and the formation of interoceptive conditioned reflexes (see K. M. Bykov, *Selected Works*, Vol. II, "The Cerebral Cortex and the Internal Organs", Moscow, 1954.)

In his work "The Problem of Sleep" published in the present edition (p. 393) Pavlov examines in greater detail the questions of the physiological mechanism of influencing the tissue processes, metabolism and activity of the internal organs by suggestion and autosuggestion. In this work he also explains at great length the "imaginary, autosuggested pregnancy" in hysteriacs.

Pavlov's statements in the "Lectures on the Work of the Cerebral Hemispheres" are very important for elucidating the physiological mechanism of verbal suggestion during hypnosis in the light of his teaching on the second signalling system and its interaction with the first signalling system. Pavlov's following statement is particularly important:

"Of the hypnotic phenomena in man so-called *suggestion* justly attracts special attention. How should it be understood physiolo-

gically? Of course, for man the word is as real a conditioned stimulus as all the other stimuli which man has in common with animals, but at the same time it is also more all-inclusive than any others and in this respect cannot in any way be either quantitatively or qualitatively compared with the conditioned stimuli of animals. Owing to the entire preceding life of the adult human being, the word is connected with all the external and internal stimuli reaching the cerebral hemispheres, signals them all, replaces them all, and can therefore evoke all the actions, reactions of the organism, which those stimuli condition. Thus, suggestion is man's most simplified and most typical conditioned reflex (present edition, p. 202). p. 240

[48] Reference is made to Pavlov's article "Brief Outline of Higher Nervous Activity" written in 1932 (I. P. Pavlov, *Complete Works*, 2nd ed, Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 106-26). This article was also published in English in the American compilation *Proceedings and Papers* (New Jersey, the Psychol. Rev. Comp., Princeton, 1930, pp. 331-33). The article describes the successive spread of hypnotic inhibition in the motor area of the cortex in a certain dog during the act of eating. In this article Pavlov also dwells on the importance of "supermaximal stimuli" in the emergence of transmarginal inhibition and formation of phasic states in the cerebral cortex. p. 244

[49] Reference is made to V. V. Rikman's work "Discovery of Traces of Stimulation of the Centres of the Defensive Reaction as an Analogue of Traumatic Neurosis" *(Transactions of Academician Pavlov's Physiological Laboratories*, Vol. IV, p. 10, Leningrad, 1932). p. 245

[50] The article "On Neuroses in Man and Animals" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 147-50). It is a review of the article "The Somatic Basis of the Neurosis" by the well-known Viennese psychiatrist Schilder who later lived in the U.S.A. The article was published in the American *Journal of Nervous and Mental Diseases*, 70, 502, November 1929. The review was published by Pavlov in the *Journal of the American Medical Association*, 1932, Vol. 99, No. 12, pp. 1012-1013 and in *The Bulletin of the Battle Greek Sanitarium and Hospital Clinic*, 1932. In the review Pavlov criticises Schilder for denying the importance physiological studies of neuroses in animals have for understanding neuroses in man. Schilder held that clinical observations of the "mental mechanism" should help to understand the data of experimental studies of higher nervous activity in animals. Pavlov's very interesting statements in this article concerning the methods of studying neuroses in man also deserve attention. p. 247

[51] The article "Experimental Neuroses" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 189-94). The

article constitutes Pavlov's report to the First International Neurological Congress in Bern, delivered in German, September 3, 1931. This article was also published in the journals Deutsche Zeitschrift für *Nervenheilkunde*, 1932 Bd. 124, SS. 137-139; Ugeskr Laeg. 1932, Bd. 94, SS. 1135-1136. Of great importance in this article is Pavlov's exclusion of hysteria from the neuroses in animals. In his subsequent works he began to ascribe hysteria to specifically human neuroses. Pavlov's proposal to divide neurasthenia into two forms—hypersthenia (in the strong excitable type) and hyposthenia (in the weak inhibitory type)—also deserves attention. p. 251

[52] The article "Essay on the Physiological Concept of the Symptomatology of Hysteria" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 195-218). This work was also published as a separate booklet under the same title by the U.S.S.R. Academy of Sciences (1932) and in French in the journal *L'Encéphale*, t. XXVIII, No. 4, 1933. In *L'Encéphale* it was published in an abridged form with notes of the translator W. Drabowitch. This entire issue of the journal was devoted to the clinical aspects and pathogenesis of hysteria treated from the most diverse points of view. It also contained an article contributed by G.Marinesko and M. Nicolesko on hysterical amnesia, elucidating the pathogenesis of this disease on the basis of the teaching on conditioned reflexes. The same article contains references to a number of formerly published works of G. Marinesko, O. Sager and A. Kreindler on hysteria in the light of Pavlov's conceptions. (*Revue neurologique*, 1930, June 3-11, 1932.)

The translator points out that Pavlov apparently did not know these works of G. Marinesko et al., in which the authors arrived at a conclusion closely corresponding to the inferences made in Pavlov's work, but they did not adequately consider the role of the weakness of the cortex in the development of hysteria.

Pavlov attached great importance to the article "Essay on the Physiological Concept of the Symptomatology of Hysteria" and regarded it as a "test of the extent to which the teaching on conditioned reflexes is justified in claiming to serve as a physiological substantiation of mental phenomena".

In this article Pavlov makes a deep physiological analysis of all the most characteristic symptoms of hysteria, the acute hysterical reactions, as well as the hysterical traits of the personality. It should be noted that in this article Pavlov offers a physiological explanation of hysterical nosophilia, the so-called "escape into disease" of the hysteriacs not infrequently superficially interpreted as manifestation of simulation. According to Pavlov, this presumably deliberate behaviour of hysteriacs is determined by conditioned reflexes and is a case of fatal physiological relations". In his concluding lecture in the "Lectures on the Work of the Cerebral Hemispheres" (see Note 38) Pavlov only outlined his conception of the first and second signalling systems, whereas in the

present article he gives, for the first time, a broad definition of these two cortical signalling systems and describes the physiological peculiarities of each. In direct connection with the teaching of the signalling systems Pavlov offers, as a supplement to the classification of the types of nervous system in animals, a classification of specifically human types, depending on the interrelations between the first and second signalling systems. Using figurative expressions Pavlov divides people into "artists" and "thinkers" with an "intermediate" type between them. He establishes that the artistic type with its characteristic relatively weak first and relatively strong second signalling system is predisposed to hysteria. p. 255

[53] See Note 9. p. 261

[54] For the works of V. S. Galkin, A. D. Speransky's pupil, and the division of sleep into "passive" and "active" see the article "The Problem of Sleep" (present edition, p. 393 and Note 74). p. 261

[55] Rikman's experiments to which Pavlov refers were not published. p. 262

[56] The opinion that hysterical symptoms emerge only as a result of suggestion was expressed by the outstanding French neuropathologist Joseph Babinski (1857-1932) in 1907. It served as the subject of very heated discussions at many international congresses of neuropathologists and psychiatrists (see Babinski's work "Hysteriapithiatisme et troubles nerveux d'ordre reflexe en neurologie de guerre", P. 1917 (jointly with J. Froment). p. 274

[57] Reference is made to Bernheim's work "On Hypnotic Suggestion and Its Employment in the Treatment of Diseases". Odessa, 1887-88. p. 274

[58] Subsequently Pavlov relinquished the point of view that the second signalling system must be connected with the development of the frontal parts of the brain and generally doubted the legitimacy of localising the signalling systems anatomically. p. 276

[59] The article "Physiology of Higher Nervous Activity" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 219-34). It is Pavlov's report to the Fourteenth International Physiological Congress in Rome, September 2, 1932.

This article was also published in the journal *Priroda (Nature)*, 1932, No. 11-12, pp. 1139-56, and in the *Latest Reports on Physiology and Pathology of Higher Nervous Activity*, Book 1, Leningrad, 1939, pp. 5-25. p. 282

[60] G. V. Volborth, one of Pavlov's pupils, organiser (1921) and for many years head of the Laboratory of Conditioned Reflexes at the Ukrainian Neuropsychiatric Institute in Kharkov. Of his scientific works the studies in efficiency and fatigue are of the greatest interest. p. 288

[61] See Note 9. p. 289

[62] See the article "The Problem of Sleep" in the present edition (p. 393) and Note 74. p. 290

[63] Pavlov's theory of systematism in the work of the cerebral cortex and on dynamic patterns formed towards the beginning of the 1930's. Pavlov treated this question in great detail in his report to the Tenth International Psychological Congress in Copenhagen, August 24, 1932. See the article "Dynamic Stereotypy of the Higher Part of the Brain (*Complete Works*, 2nd ed., Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 240-44). p. 293

[64] See "Essay on the Physiological Concept of the Symptomatology of Hysteria" (present edition, p. 255). p. 296

[65] In Pavlov's new statement on the second signalling system quoted in the article, Pavlov's indication of the importance of the second signalling system as the physiological basis of *abstract*, specially human, higher thinking and the definition of science as the "instrument of man's higher orientation in the surrounding world and within himself" merit attention. As in the preceding statement on the second signalling system (see present edition, p. 255 and Note 52) Pavlov still adheres to the point of view, subsequently relinquished by him, that the second signalling system is anatomically connected with the frontal parts of the brain (see Note 58). p. 296

[66] The article "Example of an Experimentally Produced Neurosis and Its Cure in a Weak Type of Nervous System" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 235-39).

The article contains the report made by Pavlov to the Sixth Scandinavian Neurological Congress in Copenhagen, August 25, 1932. It was published in the *Latest Reports on Physiology and Pathology of Higher Nervous Activity*, Book 1, Leningrad, U.S.S.R. Academy of Sciences, 1933, pp. 27-32.

The data on the treatment of neuroses with bromides and Pavlov's emphasis of the effectiveness of such treatment, if a proper correlation of the doses of bromides with the types of nervous system is ensured, deserves special attention.

Considerable interest in the treatment of neuroses, with bromides in particular, was displayed in Pavlov's laboratories for many years. The first attempts at treating neuroses and the studies in experimental therapy were carried out simultaneously with the beginning of the research in experimental neuroses.

Pavlov's special attention to questions of pharmacotherapy of nervous and mental diseases was determined, on the one hand, by the fact that during a considerable period of his activity (1895-1900) Pavlov worked as a pharmacologist, and on the other hand, by the fact that with the aid of therapy he expected to acquire so important and decisive a criterion of truth as practice. Pavlov wrote: "The power of our knowledge over the nervous system will, of course, appear to much greater advantage if we learn not only to injure the nervous system but also to restore it at will." (Present edition, pp. 366-67.)

On the question of applying Pavlov's pharmacotherapeutic conceptions in the psychiatric clinic see L. L. Rokhlin's article "Principles of Pharmacotherapy of Disorders of Higher Nervous Activity in Mental Patients" (*Physiological Journal of the Ukrainian Academy of Sciences*, 1956, Vol. II, No. 4). p. 298

[67] The article "Feelings of Possession (*Les sentiments d'emprise*) and the Ultraparadoxical Phase" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 245-50). It is Pavlov's open letter to the well-known French psychologist and psychiatrist Pierre Janet.

This article was published in French in the *Journal de Psychologie* edited jointly by Pierre Janet and George Dumas in 1933 (No. 9-10, pp. 849-54) and in Russian in the *Latest Reports on Physiology and Pathology of Higher Nervous Activity*" (Book 2, Leningrad, 1933, pp. 5-11).

The thing that deserves attention in this article is I. P. Pavlov's frank appeal for collaboration between clinical psychiatrists, psychologists and physiologists. Pavlov wrote: "It seems that we should give proper consideration to our reciprocal work and cooperate in our research, for, after all, we are investigating the activity of one and the same organ (the brain—*Editor*) concerning which there can hardly be any doubt now."

Prompted by this striving Pavlov used the data on the ultraparadoxical phase, elaborated by that time in his laboratories, for physiological interpretation of certain forms of delirium described by P. Janet in the last part of his article "Feelings in the Delusion of Persecution" ("Les sentiments dans le délire de persecution"). This article was published by P. Janet in the *Journal de Psychologie*, 1932, pp. 161 and 401. It should be noted that in the French literature the role of the theory of conditioned reflexes in the interpretation of the pathogenesis of neuroses and mental disorders had been elucidated in a number of works of French authors as early as the 1920's-1930's (see Tinel, "Les réflexes conditionnels et les neuroses," *L'Encéphale*, XXIII, 1928; Delmas, "Le rôle des réflexes conditionnels en psychiatrie", *L'Encéphale*, XXV, 1930, etc.).

Pavlov also considered a number of other psychopathological phenomena—active negativism, controlism, ambivalence—to be based on the physiological mechanism of the ultraparadoxical hypnotic phase. During this hypnotic phase the reciprocal induction is perverted and responses to stimuli are contrary to adequate reactions. The phase itself emerges as a result of the exhaustion or weakening of the corresponding cortical cells to which the particular positive stimulus is addressed. In a number of his works Pavlov developed the idea of common physiological mechanisms for various psychopathological phenomena.

Pavlov displayed a special interest in P. Janet and repeatedly mentioned him in his statements on the "Wednesdays". On the "Wednesday" February 15, 1933 (*Pavlovian Wednesdays* Vol. 1,

Moscow and Leningrad, 1949, p. 287) he commented on the aforementioned open letter he had addressed to Janet. On the "Wednesday" February 20, 1935 he analysed two pathological cases from Janet's book *Beginning of Intellect*. At the same time he characterised Janet in an interesting manner.

He said: "Pierre Janet is an exceptional person. He is not a physician but a psychologist and, at the same time, a famous neuropathologist. He is undoubtedly an unusual, outstanding person." Then he evaluated Janet as a scientist. He said: "I am waging a big war against Pierre Janet as a psychologist and I shall do my best to vanquish him. But as a neuropathologist he is interesting. He has collected a mass of extraordinarily interesting and important pathological facts. I believe that as a psychologist he will in the end be defeated precisely by us, physiologists of higher nervous activity" (*Pavlovian Wednesdays*, Vol. III, Moscow and Leningrad, 1949, p 95). p. 303

[68] The article "Attempt at a Physiological Interpretation of Compulsive Neurosis and Paranoia" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 251-66).

It was also published in the booklet *Latest Reports on Physiology and Pathology of Higher Nervous Activity* (2nd ed., Leningrad, 1933, pp. 13-34), then in English in *The Journal of Mental Science* (1934, Vol. 80, pp. 187-97) and in French in L'Encéphale (1935, 30, pp. 381-93). This work is very important because it interprets physiologically such widespread and important psychopathological phenomena as delirium and obsession. For this purpose Pavlov utilised the theory of isolated pathological points and pathological inertness he had elaborated by that time on the basis of experimentally produced pathology of higher nervous activity in animals. On the basis of the conception of clinicians (P. Janet, E. Kretschmer, R. Malet) who held that obsessive ideas and delirium were closely related and could pass into each other, Pavlov underpinned these elements of clinical similarity with a similarity of physiological mechanisms: "pathological inertness of the process of excitation in a definite, physiologically conceived, isolated, pathological point of the brain". However, two reservations must be made here. Firstly, acknowledging the similarity Pavlov also sees the difference and points out "the degree of phases of the pathological state and certain additional features". The critical attitude during obsessive states and the uncritical attitude as a characteristic and invariable feature of delirium are determined by the different extent and intensity of the negative induction around the pathologically inert excited point and from the physiological basis in each of these psychopathological phenomena. Secondly, Pavlov does not establish the afore-described physiological mechanism for all, but only for a certain form of delirium, namely, delirium of a paranoiac structure. It should be noted that, in addition to recognising the possibility of a common physiological mechanism for the emergence of different psychopathological

phenomena, Pavlov also assumed the existence of different physiological mechanisms for the same type of psychopathological phenomena. This opinion is clearly illustrated in the article by a description of an inversion-type delirium which is based on the physiological mechanism of the ultraparadoxical phase. It is also important that the different physiological mechanisms of the same psychopathological phenomenon may, according to Pavlov, "exist separately or side by side, or alternately". It should be noted that Pavlov did not reduce the physiological bases of delirium of different structures to the two aforesaid physiological mechanisms (pathological inertness and the ultraparadoxical phase). For the deep feeble-minded, incongruous, megalomaniac delirium in patients with progressive paralysis he searched the physiological bases in the regulating role of the second signalling system. (*Pavlovian Wednesdays*, Vol. III, Moscow and Leningrad, 1949, p.140.) p. 309

[69] Pavlov appreciated E. Kretschmer for his talent and the physiological trend in some of his works. At the same time he disagreed with a number of Kretschmer's incorrect methodological principles: his disregard for the qualitative differences between the normal and the pathological, biologisation of social phenomena, and autogenetic constructions. Concerning Kretschmer's book *Bodily Structure and Character*, which Pavlov had recently read, he said on the "Wednesday" October 23, 1935 that the book "nonplussed" him, that Kretschmer made a mistake "by wanting to drive the entire human race inhabiting the earth into the framework of his two clinical types: schizophrenics and cyclothymics Of course, this is a wild statement of the question; why should the types prevailing in diseases and finally getting into psychiatric hospitals be regarded as basic? Indeed, the majority of humanity has nothing at all to do with these hospitals. Another strange thing is that he does not distinguish between type and character and this is, of course, also a flagrant mistake.

"We now firmly believe that man has inborn qualities and, on the other hand, qualities acquired in the course of life. This means that, if we speak of inborn qualities, we imply the type of nervous system, whereas, if it is a question of character, we refer to a mixture of inborn tendencies and drives and those instilled in him by the impressions he had received during his lifetime. Herein lies his mistake. He has confused it and has not made a clear distinction between the inborn type and the characteristics man acquires during his lifetime" (*Pavlovian Wednesdays*, Vol. III, Moscow and Leningrad, 1949, pp. 244-45). p. 321

[70] The article "General Types of Animal and Human Higher Nervous Activity" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 267-93). It was also published in the booklet *Latest Reports on Physiology and Pathology of Higher Nervous Activity* (3rd ed., Moscow, 1935, pp. 5-41).

This article most comprehensively sums up the many years of research in the types of higher nervous activity conducted in Pavlov's laboratories. Particularly important in it is Pavlov's conception of the types of higher nervous activity. The fact that he attached great importance to the conditions of life in forming the type of higher nervous activity deserves attention Pavlov wrote: "Human and animal behaviour is determined not only by congenital properties of the nervous system, but also by the influences to which the organism is continuously subjected during its individual existence, in other words, it depends on constant education and training in the broadest sense of these words" (Present edition, p. 327.)

The article lists the main criteria for determining the types of higher nervous activity (strength, balance and mobility of the nervous processes), clearly describes various types and examines different methods of studying them. Of considerable interest to psychiatrists are Pavlov's statements concerning the classification of types of people proposed by E. Kretschmer. Pointing out that Kretschmer's cycloid character coincides with his strong, unbalanced, "unrestrained" type (choleric temperament, according to Hippocrates) and the schizoid with the weak type (melancholic temperament, according to Hippocrates) Pavlov notes the inadequacy of this classification. He disagrees with Kretschmer in that the latter, proceeding from the data of the psychiatric clinic, from disease to health, rather than the other way round, dogmatically and schematically divides all people into two types—the schizothymic and cyclothymic. p. 325

[71] The article "Experimental Pathology of the Higher Nervous Activity" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 294-314).

It constitutes the lecture delivered by Pavlov at the Institute for Advanced Medical Training in Leningrad, May 10, 1934. This article was also published as a separate booklet in Russian, German, English and French (Leningrad, Biomedgiz, 1935), in the book *Modern Problems of Theoretical Medicine* (Vol. I, Moscow and Leningrad, 1936, pp. 46-61) and the journal *Clinique* (1936, pp. 159-64).

Of interest in this article which sums up the many years of research in experimental pathology of higher nervous activity are Pavlov's indications of the significance of this research for the psychiatric clinic. Pavlov writes: "To a considerable degree the pathological nervous states produced by us conform to the so-called psychogenic diseases in human beings." (Present edition, p. 364.)

The article offers, also for the first time, a pathophysiological substantiation of combined therapy (bromides + caffeine) of nervous and mental diseases; Pavlov sees this pathophysiological substantiation in the fact that bromides and caffeine are "so to speak, two levers in the form of pharmaceutical remedies, two

communicators towards the two chief apparatus, i.e., towards the two processes of nervous activity, then by putting into action and correspondingly changing the strength now of one, now of the other lever, we have a chance of restoring the distributed processes to their former place, into their proper correlations." (Present edition, p. 373.) p. 355

[72] The article "The Conditioned Reflex" is an excerpt from the work under the same title published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 335-43).

Published in the Big Soviet Encyclopedia and the Big Medical Encyclopedia (BSE, Vol. 56, 1936 and BME, Vol. 33, 1936) this article contains an extremely concise exposition of Pavlov's entire teaching on higher nervous activity. Besides, it was published in the *U.S.S.R. Physiological Journal*, (Vol. XIX, Book 1, 1935, p. 261). The concluding part of the article translated in the present edition deals with the parts of the teaching on higher nervous activity which are directly connected with the nervous and psychiatric clinics. In the teaching on types Pavlov's new statement on the interrelations of the inborn and the acquired deserves attention.

Pavlov writes: "The final, available nervous activity of the animal is an alloy of the type traits and the changes conditioned by the external environment—phenotype, character." (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 2, p. 334.)

The physiological analysis of man's emotional life given in this article is also of considerable interest. Pavlov connects man's emotional life in its positive or negative tone with the course (easy or difficult) of the basic nervous processes in the cerebral hemispheres. It should be noted that, as regards the physiology of feelings, Pavlov expressed himself quite fully also in his other work "Dynamic Patterns of the Higher Part of the Brain", where he connected the emergence of emotions with changes in the dynamic pattern of nervous activity.

"I believe", Pavlov wrote in this work, "that there are sufficient grounds for assuming that the above-described physiological processes in the cerebral hemispheres conform to what we use to designate subjectively as our *senses*, and in the form of their numerous nuances and variations due to different combinations and intensities. Among these are the senses of difficulty and facility gaiety, and fatigue, satisfaction and chagrin, joy, triumph, despair, etc. It seems to me that the painful senses which often accompany a change in the habitual mode of life, an interruption of customary work, loss of close relations or friends to say nothing of mental crisis and collapse of beliefs, are, to a considerable degree, physiologically caused precisely by the change, the disturbance of the old dynamic stereotype and the difficulty of elaborating a new one." (I. P. Pavlov, *Complete Works*, 2nd ed., Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 243-44.)

In this article Pavlov very concisely and clearly sums up all his

formerly expressed ideas regarding the physiological interpretation of the different, most important psychopathological phenomena and mental diseases. He offers one more definition of the second signalling system (present edition, p. 378). p. 378

[3] The article "Types of Higher Nervous Activity, Their Relationship to Neuroses and Psychoses, and the Physiological Mechanism of Neurotic and Psychotic Symptoms" was translated from the text published in the second edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 344-49). It contains the report made by Pavlov to a special conference arranged during the Second International Neurological Congress in London, July 30, 1935. The report was published in abbreviated form in the journal *Revue neurologique*, Vol. 64, No. 4, October, 1935, p. 633.

The new and most complete characterisation of the second signalling system deserves the principal attention in this article. In connection with this characterisation Pavlov again sets forth his teaching on specifically human types and on specifically human neuroses. Pavlov's clinical and pathophysiological characterisation of the basic forms of neuroses—neurasthenia, hysteria and psychasthenia—in this article is particularly clear and expressive. Although in his earlier works Pavlov had already mentioned pathological lability of the basic nervous processes, in addition to pathological inertness, in this article the question of pathological lability is most fully elucidated. p. 387

[4] The article "The Problem of Sleep" was translated from the text published in the second-edition of I. P. Pavlov's *Complete Works* (Vol. III, Book 2, Moscow and Leningrad, 1951, pp. 409-27). This article is a shorthand record of Pavlov's report to the Conference of Neuropathologists and Psychiatrists of Leningrad in December 1935. It was first published in the first edition of I. P. Pavlov's *Complete Works* (Leningrad, 1940, Vol. I, p. 410). In his recollections N. Krasnogorsky mentions that Pavlov told him two weeks before his death that he planned to write a book on sleep (see preface to N. I. Krasnogorsky's book *Development of the Physiological Activity of the Brain in Children*, Moscow, 1939).

"The Problem of Sleep" is Pavlov's last work on sleep in which he summed up all his preceding statements on this subject. Of considerable interest in this work is the direct indication of the importance Pavlov attached to physiological investigations of sleep, his own investigations in particular. New and important in this work is also the emphasis he laid on the cortical regulation of sleep and his classical formulation of the role of the cortex in the vital activity of the organism in general: "The higher part controls all the phenomena which develop in the organism" (present edition, p. 394).

Pavlov's report and his answers to the questions put to him cover the very broad problem of sleep and related phenomena. The report contains a number of important statements on the physio-

logical mechanism of sleep, hypnosis and dreams, the physiological mechanism of verbal suggestion, conditions of sleep, so-called "passive" sleep, etc. Pavlov criticises in his report the so-called "theory of the subcortical centre of sleep" and at the same time exhaustively explains in the light of his teaching the facts which formed the basis of this theory. According to the report, Pavlov no longer supports the proposition that sleep is irradiation only of internal inhibition, but holds that the initial moment in the emergence of sleep may be the process of inhibition of a most diverse character in the cortex. This coincides with F. P. Maiorov's statement that in a conversation with him on the question of classifying inhibitions in 1935 Pavlov noted that "hypnotic inhibition may be of either one or the other origin, i. e., it may develop from either "conditioned" or "unconditioned" inhibition (F. P. Maiorov, *History of the Teaching on Conditioned Reflexes*, Moscow, 1954, p. 296). p. 393

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И. П. ПАВЛОВ

ПСИХОПАТОЛОГИЯ И ПСИХИАТРИЯ

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