CHAPTER 10

The Recurrent Situation

10/1. Wrruh the previous chapter we came to the end of our study of how the organism changes from the unadapted to the adapted condition. But this simple problem and solution is only a first step towards our understanding of the living, and especially of the human, brain. To the simple ultrastable system we must obviously add further complications. Thus the living organism not only becomes adapted, but it does so by a process that shows some evidence of efficiency, in the sense that the adaptation is reached by a path that is not grossly far from the path that would involve the least time, and energy, and risk. Though 'efficiency' is not yet accurately defined in this context, few would deny that the Homeostat's performance suggests something of inefficiency. But before we rush in to make 'improvements' we must be clear about what we are assuming.

10/2. Let us return to first principles. 'Success', or 'adaptation', means to an organism that, in spite of the world doing its worst, the organism so responded that it survived for the duration necessary for reproduction.

Now 'what the world did' can be regarded as a single, life-long, and very complex Grand Disturbance (I. to C., Chapter 10), to which the organism produces a single, life-long, and very complex Grand Response; how they are related determines the Grand Outcome—success or failure. In the most general case, the partial disturbances that make up this Grand Disturbance, and the partial responses that make up the organism's Grand Response (I. to C., S. 18/8) may be interrelated to any degree, from zero to complete. (The interrelation is 'complete' when the Grand Outcome is a function of all the partial responses; it would correspond to an extremely complex relation between partial responses and final outcome.)

The case of the complete interrelation, though fundamental theoretically (because of its complete generality), is of little importance in practice, for its occurrence in the terrestrial world is rare (though it may occur more commonly in models or in processes of adaptation set up in large computers). Were it common, a brain would be useless (I. to C., S. 18/5). In fact, brains have been developed because the terrestrial environment usually confronts the organism with a Grand Disturbance that has a major degree of constraint within its component parts, of which the organism can take advantage. Thus the organism commonly faces a world that repeats itself, that is consistent to some degree in obeying laws, that is not wholly chaotic. The greater the degree of constraint, the more can the adapting organism specialise against the particular forms of environment that do occur. As it specialises so will its efficiency against the particular form of environment increase. If the reader feels the ultrastable system, as described so far, to be extremely low in efficiency, this is because it is as yet quite unspecialised; and the reader is evidently unconsciously pitting it against a set of environments that he has restricted in some way not yet stated explicitly in this book.

10/3. The chapters that follow will consider several constraints of outstanding commonness and will show how the appropriate specialisations exemplify the above propositions in several ways. They will consider certain ways in which the ordinary terrestrial environments fail to show the full range; and we will see how these restrictions indicate ways in which the living organism can specialise so as to take advantage of them.

The recurrent situation

10/4. In this chapter we will consider the case, of great importance in real life, in which the occasional disturbances (class 2 of S. 9/14) are sometimes repetitive, and in which a response, if adaptive on the disturbance's first appearance, is also adaptive when the same disturbance appears for the second, third, and later times.

We must not take for granted that one response will be adaptive to all occurrences of the disturbance, for there are cases in which what is appropriate to a disturbance depends on how many times it has appeared before. An outstanding example is given by the rat facing that environment (a natural one by S. 8/1) in which food
will appear on two successive nights at the same place, followed, on the third night, by a lethal mixture of the same food and poison (the method of "pre-baiting"). Environments such as this are intrinsically complex. Complete adaptation here (under the assumptions made) demands the reaction-pattern: eat, eat, abstain. This reaction-pattern is more complex than the simple reaction-pattern of eating, or of abstaining: for the three parts must be related, and the triple organised holistically.

In this chapter we shall consider the other case, of frequent occurrence, in which what is appropriate to the disturbance is conditional on which disturbance it is, but not on when it occurs in the sequence of disturbances.

So far, the ultrastable system (represented, say, by the Homeostat) has been presented (e.g. in the Figures throughout Chapter 8) with changes of parameter-value such that the later value is merely different from the earlier; now we consider the case in which the parameter takes a sequence of values, e.g.

\[ P_2 P_5 P_3 P_1 P_6 P_4 P_0 P_1 P_2 \ldots \]

in which repetitions occur at irregular intervals, and in which a response to \( P_n \), say, if adaptive on \( P_n \)'s first occurrence, is also adaptive to \( P_n \) on its later occurrences.

When this is the case, the opportunity exists for advantage to be taken of the fact that \( P_n \) can be responded to at once on its later occurrences, without the necessity of a second exploratory series of trials and errors.

This case is particularly important because (S. 8/10) it includes the case in which the changes of \( P \)-value correspond to changes from one environment to another. Suppose, for instance, that a wild rat learns first to adapt to conditions in a stable \( (P_s) \), then to conditions in a nearby barn \( (P_b) \), and so on. Having adapted first to the stable and then to the barn, its survival value would obviously be enhanced if it could return to the stable and at once resume the adaptations that it had previously developed there. An organism with such a power can accumulate adaptations.

10/5. To see what is necessary, let us see what happens in the Homeostat. A little reflection, or an actual test, soon shows that the present model is totally devoid of such power of accumulation. Thus in Figure 8/4/1 the reversal at \( R_s \) restores the external conditions to which it was already adapted at \( D_1 \); yet after the events following the first reversal (at \( R_1 \)), the first adaptation (at \( D_1 \)) is totally lost; and the Homeostat treats the situation after \( R_s \) as if the situation had occurred for the first time.

In general, if the Homeostat is given a problem \( A \), then a problem \( B \), and then \( A \) again, it treats \( A \) as if it had never encountered \( A \) before; the activities during the adaptation to \( B \) have totally destroyed the previous adaptation to \( A \). (The psychologist would say that retroactive inhibition was complete, S. 16/12.)

This way of adapting to \( A \) on its second presentation cannot be improved upon if the environment is such that there is no implication that the second reaction to \( A \) should be the same as the first. The Homeostat's behaviour might then be described as that of a system that "does not jump to conclusions" and that "treats every new situation on its merits". In a world in which pre-baiting was the rule, the Homeostat would be better than the rat! When, however, the environment does show the constraint assumed in this chapter, the Homeostat fails to take advantage of it. How should it be modified to make this possible?

10/6. The Homeostat has, in fact, a small resource for dealing with recurrent situations, but the method is of small practical use. In S. 8/10 we saw that the Homeostat's ultimate field is one that is stable to all the situations, so that a change from one to another demands no new trials.

10/7. This method, however, cannot be used extensively in the adaptations of real life, for two reasons. The first is that when the number of values is increased beyond a few, the time taken for a suitable set of step-function values to be found is likely to increase beyond anything ordinarily available, a topic that will be treated more thoroughly in Chapter 11. The second is that the adaptation, even if established, is secure only if the set of parameter-values is closed, i.e. so long as no new value occurs. Should a new value occur, everything goes back into the melting-pot, and adaptation to the new set of values (the old set increased by a new member) has to start from scratch. Common observation shows, of course, that each new adaptation does not destroy all the old; evidently the method of S. 8/10 is of little practical importance.
The accumulator of adaptations

10/8. To see what is necessary, let us take for granted that organisms are usually able to add new adaptations without destroying the old. Let us take this as given, and deduce what modifications it enforces on the formulation of S. 7/3. Suppose, then, that an organism has adapted to a value $P_1$, then adapted to $P_2$ by trial and error as in S. 7/23, and that when $P_1$ is restored the organism is found to be adapted at once, without further trials. What can we deduce?

(The arguments that culminated in S. 7/3 apply here without alteration, so we can take for granted that the adaptation to each individual value of $P$ takes place through the second feedback, with essential variables controlling step-functions as in S. 7/7. The modification to be made can be found by a direct application of the method of S. 4/12, seeing whether variation at one variable leads to variation at another.)

To follow the argument through, let us define two sub-sets of the step-mechanisms in $S$ that affect $R$ (Figure 7/5/1):

$S_1$: those step-mechanisms whose change, with $P$ at $P_2$, would cause a loss of the adaptation to $P_1$, i.e. those step-mechanisms that are effective towards $R$ when $P$ is at $P_1$;

$S_2$: those step-mechanisms that were permanently changed in value after the trials that led to the adaptation to $P_2$.

First it follows that the sets $S_1$ and $S_2$ are disjunct, i.e. have no common member. For if there were such a common member it would (as a member of $S_2$) be changed in value when $P_1$ was applied for the second time, and therefore (as a member of $S_1$) would force the behaviour at $P_2$ to be changed on $P_1$'s second presentation, contrary to hypothesis. Thus, for the retention of adaptation to $P_1$, in spite of that to $P_2$, the step-mechanisms must fall into separate classes.

(That the step-mechanisms must be split into classes can be made plausible by thinking of the step-mechanisms, in any ultra-stable system, as carrying information about how the essential variables have behaved in the past. When $P_1$ is presented for the second time, for the behaviour to be at once adaptive, information must be available somewhere about how the essential variables behaved in the past (for by hypothesis they are to give none now, and they are the only source). Thus somewhere in the system there must be this information stored; and these stores must not be accessible while $P_2$ is acting, or they will be affected by the events and the stored information over-written. Thus there must be separate stores for $P_1$ and $P_2$, and provision for their separate use.)

Next, consider the channel from the essential variables. In condition $P_2$, the channel from them to the step-mechanisms in $S_2$ was evidently open, for events at the essential variables (whether within physiological limits or not) affected what happened in $S_2$ (by the ordinary processes of adaptation). On the other hand, during this time the channel from the essential variables to the step-mechanisms in $S_1$ was evidently closed, for changes in the essential variables were followed by no changes in the step-mechanisms of $S_1$. Thus the channel from the essential variables to the step-mechanisms $S$ must be divisible into sections, so that some can conduct while the others do not; and the determination of which is to conduct must be, at least partly, under the control of the conditions $P$, varying as $P$ varies between $P_1$ and $P_2$.

Finally, consider the channels from $S_1$ and $S_2$ to the reacting part $R$. When $P_1$ is applied for the second time, the channel from $S_1$ to $R$ is evidently closed, for though the parameters in $S_2$ are changed (before and after $P_2$), yet no change occurs in $R$'s behaviour (by hypothesis). On the other hand, that from $S_1$ is evidently open, for it is $S_1$'s values that determine the behaviour under $P_1$, and it is the adapted form that is made to appear.

10/9. To summarise:—Let it be given that the organism has adapted to $P_1$ by trial and error, then it adapted similarly to $P_2$, and that when $P_1$ was given for the second time the organism was adapted at once, without further trials. From this we may deduce that the step-mechanisms must be divisible into non-overlapping sets, that the reactions to $P_1$ and $P_2$ must each be due to their particular sets, and that the presentation of the problem (i.e. the value of $P$) must determine which set is to be brought into functional connexion, the remainder being left in functional isolation.

Thus if the diagram of Figure 7/5/1 is taken as basic, it must be modified so that the step-mechanisms are split into sets, there
must be some gating mechanism \( \Gamma \) to determine which set shall be on the feedback circuit, and the gating mechanism \( \Gamma \) must be controlled (usually through \( R \), as this is the organism's structure) by the value of \( P \).

\[ \text{Figure 10/9/1.} \]

Figure 10/9/1 presents the diagram of immediate effects, but the Figure is best thought of as a mere mnemonic for the functional relations, lest it suggest some anatomical form too strongly. The parameter \( P \) can be set at various values, \( P_1, P_2, \ldots \). The step-mechanisms are divided into sets, and there is a gating mechanism \( \Gamma \), controlled by \( P \) through the environment and the reacting part \( R \), that determines which of the sets shall be effective in the second feedback via the essential variables.

10/10. The diagram of Figure 10/9/1 and the behaviour of the gating mechanism may seem somewhat complex, but we must beware of seeing into it more complexity than is necessary. All that is necessary is that the step-mechanisms involved in any particular problem \( P \) be distinct from those involved in the others, that if \( S_i \) be affected by the essential variables then \( S_i \) shall be the mechanisms that affect \( R \), and that there shall be a correspondence between the problems and the sets of step-mechanisms. This latter correspondence need not be orderly or 'rational'; it may be perfectly well set up at random (i.e. determined by factors outside our present view) provided only that if the presentation of a particular problem \( P_i \) got through to some set \( S_o \), then always when \( P_i \) is presented again the actions shall again go through to \( S_o \). Such a case would occur if the connexions were, say, electrical and made by plugging connexions at random into a plug-board. Once made, they would ensure that recurrence of \( P_i \) would give the same pattern for the selection of \( S_o \); and the change from \( P_i \) to some other problem, \( P_j \), say, by involving some change in the sensory input to \( R \), would cause some change in the distribution over the step-mechanisms.

In the same way, if nerve-cells were to grow at random (i.e. determined in their growth by local temporary details of oxygen supply, mechanical forces, etc.) until their histological details were established, and if the paths taken by impulses depended on the concatenation of stimuli coming in, then the recurrence of \( P_i \) would always give access to \( S_o \), and a change from \( P_i \) to \( P_j \), by changing the sensory stimuli, would change the distribution.

An easy method by which \( \Gamma \) may be provided is given in S. 16/13. These details need not detain us. They are mentioned only to show that the basic requirements are easily met, and that the mechanism meeting them may look far less tidy than Figure 10/9/1 might suggest. In this sense the Figure, though helpful in some ways, is apt to be seriously misleading. In S. 16/12 we return to the matter.

10/11. In the previous sections, the various situations \( P_1, P_2, P_3, \ldots \) were arbitrary, and not assumed to have any particular relation between them. A special case, common enough to be of interest, occurs when the situations usually occur in a particular sequence. Thus a young child, reaching across the table for a biscuit, may have first to get his hand past the edge of the table without striking it, then the hand past his cup without spilling it, then past the jam without his sleeve wiping it, and so on: a sequence of actions, each of which calls for some adaptation. Much of life consists of just such sequences.

The system of Figure 10/9/1 can readily give such sequences in which every part is adapted to its own little problem. The situation of 'hand coming past the edge of the table and in danger of striking it' is \( P_1 \), say. Adaptation to this situation can occur in the usual way, by the basic method of the ultrastable system.
The sleeve passing near open jam is another situation, $P_2$; adaptation to this, too, can occur. And the alterations necessary in adaptation to $P_2$ will not, in our present system, cause loss of the adaptation to $P_1$.

Whether the whole situation can be adapted to by such a sequence of sub-adaptations (to $P_1$, to $P_2$, etc.) depends on the environment: only certain types of environment will allow such fragmentation. If such types of environment are frequent in an organism's life, then there will be advantage in evolution if the species changes so that each organism is provided, genetically, with a mechanism similar to that of Figure 10/0/1.

10/12. To amplify the point, we may consider the case of an organism that lives in an environment that consists of many sensorily-different situations, and such that each situation is adequately met by one of two reactions, eat or flee, say, so that the organism's problem in life is to allot one of the two reactions to each of many situations. In such an environment, the reacting part $R$ of Figures 7/5/1 or 10/9/1 could be quite small, for it requires only mechanism capable of performing two reflexes. The stores of step-mechanisms, however, would have to be large, and the gating mechanism $I$ perhaps elaborate; for here would have to be as many records as there are sensory situations. Each would require its own locus of storage, and the gating mechanism would have to be able to ensure that each situation led to its particular locus. In such a world we would, therefore, expect the organism to have a differently proportioned brain from one that lived in a world such as was presented to the Homeostat.

It should not be beyond the biologist's powers to identify a species with such an environment. Examination of the organism's nervous system might then enable some fundamental identifications to be made.

10/13. The objection may be raised that the specification deduced in this chapter is too vague to be of use to the worker who wants to find the corresponding mechanism in, say, the human brain. The reply must be that the specification is right to be vague; for what is given—that adaptation occurs with accumulation—specifies an extremely broad class of mechanisms, so that a very great diversity of actual machines could all show adaptation with accumulation. If they can all show it, a deduction would be patently wrong if, without further data, it proceeded to indicate some one of the class.

What the deduction has shown is that we must give up our naïve conviction that the outstanding behavioural properties of adaptation indicate some unique cerebral mechanism, or that they will provide the unique explanation of the features of the living brain. Many of these features cannot be related uniquely to the processes of adaptation, for these processes can go on in systems that lack those neurophysiological features, systems very different from the living brain, such as the modern computer. Only further information, beyond that assumed in this chapter, can take the identification further.