CHAPTER VII

SUMMARY OF PART II

WE have now seen that the idioplasm of the fully-formed individual animal- or plant-cell may exhibit a considerable amount of difference as regards its degree of complexity; and before going further, it may be as well to state clearly in what this difference consists.

We suppose that the process in the idioplasm which brings about the ontogeny of a multicellular organism is due to the thousands of determinants, which constitute the germ-plasm of the fertilised ovum, becoming systematically separated into groups, and distributed among the successors of the egg-cell. This separation into smaller and smaller groups of determinants continues to take place, until each cell contains determinants of one sort only, and these then either control a single cell, or, in case the hereditary character ('determinate') is constituted by a group of cells with a common origin, the control is exerted over this whole group.

All the determinants are not active at the same time; every cell, in fact, which appears in the entire course of ontogeny is controlled by one determinant. This is effected by the disintegration of the determinant into its constituent biophors, which migrate into the cell-body. Even in the earlier stages of ontogeny, in which the idioplasm of a cell consists of a still larger number of different kinds of determinants, the cell is also controlled by only one of them in this manner. The rest of the determinants have in any case an important function with regard to the course taken by ontogeny, for each of them has its own rate of increase, and thus an alteration is produced in the proportion of the various determinants originally present in the germ-plasm, and consequently its definite architecture also undergoes alteration, the subsequent disintegration being controlled by the determinants which have thus been rearranged. These determinants are therefore only *inactive* with respect to

the cell in which they are situated, and not as regards development as a whole.

Various circumstances may, however, produce complications in this simple course of development of the idioplasm.

In the first place, it is necessary that the organism should be able to replace losses of substance. In order that this may be possible, the final cells of ontogeny, at any rate, —*i.e.*, those of the various tissues, — must be rendered capable of producing others similar to themselves. The possession of this power necessitates that each cell shall be capable of unlimited multiplication, so that the *single* determinant which controls it can likewise grow and multiply. This would result in the cells being able to produce others of a like character by cell-division.

We find, however, that regeneration is not limited to this very simple form of restoration: more complex tissues can also be reproduced; and even entire organs, such as limbs, and still larger parts of the body, such as the head and tail, may, in certain groups of animals, undergo restoration when they have been lost. These facts are to be explained in terms of the idioplasm by supposing that in these cases also the determinants for the groups of cells which are to be capable of regeneration have undergone an increase, and have been supplied to certain cells in the course of ontogeny in the form of *inactive accessory idioplasm*. The equipment of such cells with determinants for regeneration is due to adaptation, and is only connected with the degree of organisation of the animal in so far as the difficulty of providing a large number of cells with accurately graduated determinants for regeneration increased as the number of cells from which regeneration had to proceed became larger, and as the number and degree of differentiation of the organs to be restored also increased. An increase, both as regards cells and organs, takes place in correspondence with the complexity of structure, and the 'regenerative power,' therefore, as a rule, gradually undergoes a proportionate decrease.

Cells which possess the regenerative power are therefore those which contain, in addition to their own active determinants, a larger or smaller group of inactive determinants: these latter belong to those cells and cell-series which are capable of taking part in the reconstruction of that part of the body which has been lost, and which is situated distally to them when the determinants become active. The occurrence of regeneration in

a high degree is only rendered possible by the cells in a definite transverse plane of the body being regularly equipped with various groups of suitable supplementary determinants which are capable of acting together as a whole.

This form of regeneration leads directly to the process of *reproduction by fission*, which simply consists in the employment of a marked power of regeneration for the purpose of increasing the number of individuals.

While the possession of the regenerative power in a low, as well as in a high degree, is due to the equipment of cells with certain larger or smaller groups of determinants in the form of 'unalterable' accessory idioplasm, the *development of new persons by gemmation* depends either on the fact that a *single* cell contains all the determinants of the species in an inactive and unalterable condition, in the form of accessory idioplasm; or else is due to two or three cells in the different layers of the body containing large groups of determinants as accessory idioplasm, which *together* constitute all the determinants possessed by the species — *i.e.*, germ-plasm.

In cases where budding originates in a single cell, as in the Hydroid-polypes, the blastogenic idioplasm concerned in the process must be regarded as a modification of the germ-plasm, which consists of all the determinants of the species, though these have a different arrangement to that which obtains in the germ-plasm proper of the fertilised egg-cell. The fact that a bud may originate in two or three cells does not show that these cells contain exactly those groups of determinants which correspond to those of the two or three germinal layers of the Metazoon in question. In fact, the combination of the determinants differs more or less in all known cases, and is adapted to the circumstances under which budding occurs. This proves that in the embryogeny of the species, divisions of the accessory idioplasm occur quite independently of the ordinary divisions in the mass of determinants, and these result in certain cells being provided with a definitely constituted accessory idioplasm.

The blastogenic germ-plasm must be contained in the germ-plasm of the sexual cells in the form of special ids, for buds can vary independently of the persons which produce them. On the other hand, primary idioplasm must also be supplied to the bud during its development, and this may be effected by means either of special cells which contain the idioplasm in an unal-

terable condition, or else of certain ids of the primary idioplasm being added in an unalterable condition to the blastogenic germ-plasm when it becomes separated from the primary idioplasm.

As, apart from plants, gemmation only occurs in comparatively low forms of animals, viz., in the Cœlenterata, Polyzoa, and Tunicata, we may infer that the addition of this blastogenic idioplasm, consisting of accurately graduated groups of determinants, eventually reaches a limit, owing to the increasing complexity of the structure of the animal and to the surprising extent to which the number of determinants increases.

According to our view, the cells of the Metazoa and Metaphyta may not only be provided with the above-mentioned *accessory* idioplasm, but may in addition contain *primary germ-plasm*, and these cells are to be found along the '*germ-tracks*,' — that is to say, they are situated in the direct line of development which leads from the ovum to the germ-cells which are eventually formed from it. As each somatic cell is only controlled by one of the large number of determinants belonging to the germ-plasm, and as determinants cannot be produced spontaneously, those cells which are to give rise to germ-cells must contain unalterable germ-plasm in addition to the active determinants which control them; and the former can only be derived from the cell to which the whole organism owes its origin, for this alone contains the whole of the determinants organically united to form germ-plasm. A series of cells containing germ-plasm in the form of unalterable accessory idioplasm, must therefore be traceable from the egg-cell to that region of the body which sooner or later gives rise to germ-cells; that is, there must be a continuity of the germ-plasm.

The number of germ-tracks in the lower plants and animals is a very large one; under normal circumstances, germ-cells are not only found in very many parts, especially in the case of animal- and plant-stocks, but new persons may in exceptional cases be formed in many regions by budding, especially when injuries to the stock have occurred; and these persons can again produce germ-cells. In the case of the Hydroid-polypes and Polyzoa, a large number of cells of the stock must be provided with germ-plasm, although it is impossible to say whether these are the same as those which contain blastogenic idioplasm, or whether the latter is situated in other adjacent cells which also

take part in the formation of the bud. In any case blastogenic idioplasm and the germ-plasm of the ovum are not identical, even if, as in plants and Hydroid-polypes, the former contains the whole of the determinants of the species. The determinants must at any rate have another arrangement: not infrequently, indeed, the blastogenic idioplasm must consist of entirely different kinds of determinants, and in the case of the alternation of generations of the Medusæ of far more numerous ones.

The cells of the germ-tracks are somatic cells; that is to say, each of them is controlled by a special determinant, and contains germ-plasm in an inactive as well as in an unalterable condition. In the latter state, it only again becomes capable of disintegration when the cells in which it is situated give rise to germ-cells, and begin to undergo development into embryos. This germ-plasm, like the unalterable blastogenic idioplasm, may be contained in young cells with only a slight amount of histological differentiation, as well as in cells with a sharply defined histological character.

We thus see that in many cases the cells of the adult organism contain an accessory idioplasm in addition to the determinants which control their special character, structure, and physiological activity for the moment: the former may become active in the ordinary course of development, — as occurs in the normal formation of germ-cells and in multiplication by fission and gemmation; or its activity may be due to abnormal causes only, — such as those resulting from injuries and mutilations, — from which the processes of regeneration or gemmation in the first place originated.