While these paragraphs were being written two reviews of the same book have appeared, a lengthy one in *Mental Hygiene* of July 1936, and a very short note in the *Lancet* of August 22. While that in *Mental Hygiene* is very fulsome in its praise, the note in *Lancet* is very lukewarm; and hardly just to the author. "He has high hopes of what may be done for civilisation by the use of psychological knowledge; of those major threats, which make optimism difficult for Europeans, he scarcely speaks at all." One often feels that the problems of dictatorship, tyranny, aggression, and of mob hysteria agitating Europe have in spite of a common human background aspects which are purely individual to Europe, and a non-European cannot deal with these problems with the same authority as a European can. What constitutes progress is only a point of view, and Dr. White with his experience of forty years has lectured on what he feels he could speak with authority, on subjects which he thinks need comment, and in a field in which he has not been an idle spectator, in contrast to the many compilers of recent advances. One cannot quarrel with Dr. White on this count.

Just as in other books, which are compilations of lectures, in this book also there seems to be a lack of coherence and sequence; a certain amount of repetition and disproportion. One notes also with regret a tendency to soar from facts to 'beyondness,' in a way out of keeping with past form,—a failing noticeable in many other great men, for example Jeans and McDougall, and latterly in Jung.

Every intellectual revolution which has ever stirred humanity to greatness has been a passionate protest against inert ideas. A great idea in the background of dim consciousness is like a phantom ocean beating up on the shores of human life in successive waves of specialisation. Wholes can no more be studied without reference to parts than parts without reference to wholes. *Twentieth Century Psychiatry* is in large part a contribution by man to a knowledge of himself.

M. V. GOVINDASWAMY.

Senescence and Death in Invertebrate Animals.

THE causes of death in mankind due to disease or old age have been the subjects of investigation by man ever since he began to show scientific curiosity in these phenomena. In his attempts to prolong his wonderfully interesting life, man has wandered into the pathless regions of speculation in regard to life, death and the soul of the individual, and stumbled on the sciences of Chemistry, Biology, Medicine and Hygiene. Man's interest in his domestic pets, chiefly of the mammalian and avian species, led him to investigate the problems of old age and death in Vertebrates other than man, and the phenomena of parasitism and of monstrosity in plants and Invertebrate animals of economic value. Not until recent years, however, was systematic attention focussed on the phenomena of senescence and death in various groups of Invertebrate animals. The great volume of literature on this subject, when critically examined, shows that it is essential to distinguish clearly between two types of data, (1) relating to changes in the organisation of Invertebrate animals due to normal physiological conditions, and (2) relating to changes due to pathological conditions.

What are the signs of senescence observed amongst the Invertebrates of the various phyla of the Animal Kingdom, does senescence actually lead to death in these animals, and what are the various views held in regard to the causes and significance of senescence? Illuminating answers to these questions are given by Dr. István Szabó of Budapest in an excellent summary of the literature on the subject in *Rivista di Biologia*, XIX, Fasc. III, 56 pp. (1935) to which is appended a fairly exhaustive list of references.

There are two fundamental views held in regard to the process of ageing. The earlier view held by Weismann and others was that ageing is a wearing out of the tissues, while the more recent one held by Minot, Baer and others is that it is a part of the developmental process of the animal, or as Raymond Pearl holds that senescence is not an indispensable peculiarity of life. Between these two extremes, and explanatory of the one or the other extreme is a variety of views in regard to the causes of senescence and consequent physiological death. One view is that senescence and death are caused by aggregation of living cells as in multicellular

organisms and by organic differentiation, a second view is that they are brought about by the poisoning influence of metabolism, or by the insufficiency of excretory processes or of metabolism, a third view attributes old age and death to the decay of assimilatory activity, a fourth view to the exhausting effect of the reproductive processes, a fifth view holds that death is an essential aspect of life, a sixth holds the struggle for existence between different parts of the organism as responsible for its old age and death, a seventh attributes senescence and death in animals to the colloid character of living substance. According to the last mentioned view, death of the organism is caused by the increasing density of the protoplasm. Szabó thinks that as each individual repeats the ancestral history according to the Biogenetic law, the colloids thicken gradually leading to senescence. One author atributes the thickening of the protoplasm to the law of gravitation, which holds good for all living matter.

Among Protozoa destruction of the nucleus and other parts of the organism seem to represent the changes due to senescence. The occurrence of peculiar modes of reproduction (by fission and reorganisation) in the Protozoa by which the parent organism divides itself into daughter organisms has earned for this group the reputation of being potentially immortal, but the loss of individuality sustained by the parent organism provides an argument for holding the opposite view. In Protozoa death can only be considered as external, that is to say, Protozoa are exempt from physiological death. Nevertheless, senescence in Protozoa is as much potential as immortality. The classical experiments of Child, Prowazek and others with young and old individuals of various kinds of Protozoa show that they suffer old age without resulting in death, and that the continuity of life is maintained indefinitely by a process of rejuvenation.

In regard to Sponges, Bidder, Minot and Arndt consider that there is no senescence, although degeneration and reduction of parts may take place as a result of starvation or of other unfavourable conditions. Szabó thinks that the question of senescence in sponges can only be settled by further careful observations.

In regard to Coelenterates, the works of Hertwig, Boecker, David, Gross, Hartlaugh and Schlottke are reviewed showing the divergence of opinion amongst authors with reference to the causes of senescence and death. Hertwig observed that the same causes which result in the death of *Hydra fusca* in cultures may also lead to the development of reproductive organs, the only difference between the two phenomena being the degree of intensity of depression in cultures, the greater producing death and the lesser sexual reproduction. Boecker and Goetsch found that organisms in cultures recovered from depression, and therefore considered depression as a sign of pathological phenomenon and of cessation of feeding, bud-forming and assimilation. According to Hartlaub, the approach of death is heralded by the cessation of sexual reproduction. David and Gross thought that *Hydra* was potentially immortal. Schlottke found that all except the interstitial cells in *Hydra* were subject to senescence and death, and the latter category of cells gave rise to other cells. He, therefore, thought that *Hydra* was potentially immortal.

In *Rotifera* the signs of senescence were studied by various authors. Noyes observed in *Proales decipiens* that although old animals fed continuously digestion and defecation did not take place. Jennings and Lynch found that in old *Proales sordida* the movements were slow, feeding process inefficient, and the tendency for the head to get attached by some secretion. Plate observed swelling of the middle parts and the tucking in of the extremeties in *Collidina magna* as the signs of senescence. In *Rotifera vulgaris* Speman found that the signs of old age were creeping instead of swimming, slower reactions to external stimuli, shrinkage of the body and crumpling of the integument, loss of elasticity of muscles, and cessation of reproduction. In *Lecane inermis* Szabó, M., observed slower movements, the tendency to remain rooted to one place for long periods and to fall to a side from which position they cannot raise themselves. The animals, however, fed till death, but stopped defecation 21 hours earlier. In all the species of *Rotifera* studied, ciliary movements in the cells of the Oesophagus and the excretory organs continued till death whatever the changes due to senescence.

In the Nemertine worms Sekera observed decrease in body size and heavy pigmentation of the integument as the signs of senescence.

In the Polychæte worm *Hydroides pectinata*, Harms observed signs of senescence to be less irritability, stagnation of blood in abdominal vessels, irregular peristalsis in the gut, and gradual degeneration of the segments of the abdomen from behind forwards. Provided that the animal is able to get rid of its degenerating abdomen from the thorax, the latter can regenerate a new abdomen. The deeper cause of senescence seems to lie, however, in the central nervous system, in particular the parts which control the blood-vessels, where degeneration sets in while the rest of the tissues are histologically normal. Even after the whole brain has almost degenerated and the cell-outlines are obliterated, irritability seems to persist. Harms did not consider the appearance of pigment in worms, as also in Coelenterates and Arthropods, as a sign of senescence. Stolz observed shrinkage of the body, cessation of budding and degeneration of the digestive system in *Aelosoma hemprichii*. In the asexual oligochætes of all ages (*Nais communis* and *N. variabilis*) Stolte found symptoms of old age in slow movements, in reduction of peristaltic activity in the gut and of pulsation in the blood-vessels, in the flattening of muscle epithelium and muscle layers, in the accumulation of metaplastic material (chloragogen bodies), and in the death of the intestinal and nerve cells. He was of opinion that senescence and physiological death were caused by the discontinuance of the production of reserve cells and by degeneration of the mass of nerve fibrils in the visceral ganglia, although the latter were less striking. Szabó concludes from Stolte's studies that physiological death is caused primarily by degeneration of the gut-chloragogen system.

In Crustacea senescence changes have been observed by Walter in *Cyclops viridis* to begin in the nervous system, chiefly brain, as atrophy of cells, leading to the breaking off of setæ, clumsy and unbalanced movements, and cessation of feeding.

Changes similar to those observed in *Cyclops viridis* were described by one author in the case of Phasmidæ, but these have been contradicted by a later observer. Metschnikoff found in moths cessation of excretion and accumulation of excretory products. Other observers like Krumbiegel, Blunck, Janish, Pixell-Goodrich and Schmidt, to name only a few, have studied the changes of senescence in beetles, wasps, bees and other insects. In these, deposition of metaplastic substances and pigments, general signs of atrophy or hyperplasia or both were the changes observed.

In regard to Mollusca the investigations on senescence changes are more varied. Burnett Smith observed in Gastropods the following changes amongst others: passing of the shoulder tubercles and spines into a shoulder keel, protrusion of the mantle in the region of the anal siphon, stromboid form of the outer lip of the aperture, tendency towards looseness of the coils, irregularity of growth lines, thickening of the shell, tendency to the formation of smooth and rounded whorls, and discontinuous or recurrent ornamentation. Myonier de Villepoix found that in *Helix aspersa* the gland cells of the mantle disappear, and the cells of the mantle epithelium only are capable of dividing. Szabó, I. and M., studied the changes due to senescence in various forms of Mollusca (*Helix*, *Arion*, *Agriolimax*, *Coretus*, *Planorbis*, *Limnæa* and *Viviperus*) from the points of view of morphology and histology and came to the conclusion that the cause of senile death lies in the liver as in *Agriolimax agrestis* or in the nervous system as in *Limax flavus*, the two species which were investigated in great detail by the authors. One of these two might be primary and the other the secondary cause of death. In the liver it is the increase of connective tissue, and in the nervous system the accumulation of pigment, which causes death.

In addition to the various signs of senescence such as atrophy of cells, accumulation of pigment, increase of connective tissue, loss of weight, etc., Szabó considers the change occurring in the proportion of the nucleus to the cytoplasm as not the least important. But opinion in regard to the nucleo-plasm ratio seems to be divided. One set of observers working on Vertebrates and other Metazoa holds that it is the cytoplasm which increases in proportion to the nucleus during senescence, while another set working on Protozoa holds the opposite view, namely, that the nucleus increases in proportion to the cytoplasm. But considerable doubt has been thrown on this point by the work of Günther Hertwig who showed that such changes as occur in the ratio of nucleo- and cytoplasm were due to the effect of fixatives. Szabó, however, is of the opinion that chemical tests as applied by various investigators (Masing, Schæffer,

Robertson and others) indicate the occurrence of a change in the nucleo-plasm ratio as one of the signs of senescence.

The changes produced by senescence are not uniform in the various species of animals. In one species the signs of senescence are observed in the nervous system, in another in the alimentary system, in a third in the genital system or other organs. In some species all organs show signs of senescence simultaneously as in ants, while in others the genital organs are primarily affected. For every species, therefore, there seems to be a characteristic mode of senescence. Even among individuals of the same species senescent changes may differ as shown by Szabó in *Agriolimax*, by Jennings and Lynch in *Proales*, by Stolz in *Aelosoma* and by Gross in *Hydra*.

Concluding this systematic survey of facts known in regard to the modes of senescence in various groups of animals, Szabó discusses certain general aspects of the subjects of senescence, rejuvenation and potential immortality.

With regard to the influence of germ cells on senescence Szabó is of the opinion that atrophy of these cells cannot be a primary cause of death. Reproductive activity may perhaps weaken an organism, and the state of the germ cells in this weak condition may influence the speed of senescence. In *Agriolimax agrestis*, Szabó, I. and M., observed the scarcity of undifferentiated germ cells (which the authors have designated as the Polimanti cells) in young and egg-laying individuals, and the aggregation of these cells to form a definite tissue (the Polimanti tissue) in non-egg-laying animals with a long span of life. Where this tissue was well developed, genuine atrophy in other cells of the body did not occur. So the conclusion was drawn that the presence of Polimanti cells in some way increases the span of life by maintaining the metabolic rate unchanged and thus delaying atrophy.

Szabó then discusses the results of Child's experiments on senescence and rejuvenation. Child studied the reactions of various animals of all ages such as *Planaria*, Coelenterates, Crustacea and larval amphibians in various media, such as cyanides, ethylalcohol, chloroform, etc., under constant temperature conditions, both in high and low concentrations, and observed how long animals of different ages lived in media of high concentration or acclimatised themselves to media of low concentration. Because of the varying rates of metabolism in animals of different ages, the younger animals were observed to die sooner in concentrated media than the adults, while in media of low concentration they lived longer than the adults. Whether the mode of reproduction is sexual or asexual, the degree of susceptibility depends only on differences in age. Child also observed that in Invertebrates with highly developed power of regeneration, the process of senescence often led to rejuvenation, whether the mode of reproduction was primarily sexual or asexual. From the point of view of senescence and rejuvenation the sexual and asexual modes of reproduction are, therefore, fundamentally similar processes.

The question of potential immortality is discussed by Szabó in detail. If a cell or an individual is potentially immortal, then it does not grow old, or its senescence is balanced by certain processes by which the cell or individual is rejuvenated. In the Metazoa the continuity of the germ-cells is generally accepted as a sign of potential immortality, and from experiments on the tissue culture of Vertebrates it seems likely that cells of tissues of the body other than those of the reproductive organs have a tendency towards potential immortality. In the Protozoa the individuals have a tendency to grow old, but rejuvenation arrests the progress of senescence and maintains the continuity of life. In the lower Metazoa such as worms, Coelenterates, etc., parts of the body are potentially immortal. Immortality seems, therefore, to be a primitive characteristic of unicellular and multicellular lowly-organised animals. It may mean that the animal as a whole or particular tissues do not grow old or that senescence is compensated for occasionally by rejuvenation. For this reason the author suggests that the physiological experiments on potentially immortal organisms should be verified by careful microscopical examinations of the tissues to detect the minute changes due to senescence.

Reviewing the field of literature, death in organisms apart from pathological causes and accidents seems to be the result of cells living together—a heavy price to pay for corporate existence.

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