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Biological Reserves

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Abstract

"Life," wrote McNair Wilson, "interested John Hunter to the exclusion of everything else, and he studied life as he had begun to see it—namely, as the supreme resistance to the blind forces which surrounded it and impinged upon it . . . Life, on this showing, was self protective." This "supreme resistance" of life leads in health to longevity, in disease or after injury to survival; and therefore it is of peculiar interest to surgeons. It appears to depend on an urge for continuing life common to all tissues, and easily demonstrated for certain cells in the laboratory by examining the resistance offered by renal and hepatic cells to a sequence of injuries produced by chemicals (for example uranium nitrate and carbon tetrachloride). Tissues differ from one to another in the tenacity with which they cling to life, some giving up before others. This may be of importance in the practice of the future, as the population of this and other countries ages. According to the Government Actuary's projection, provided the general mortality rate continues to decline and' the fertility rate remains about the same, between 1951 and 1979 the total population of this country may rise by 1 % to 52,250,000; the pensionable population may rise by 43% to 9,500,000, while the number of children may fall by about 4% to 10,500,000. Doctors (and incidentally hospital planners) will have to deal with and provide for more aged and ageing tissues and for fewer children; they will also be able to determine whether the tissues of children of the present generation, who are growing to be larger and who are maturing earlier than the children of 25 or 50 years ago, will in fact retain their "desire for life" to ages sufficient to project them into the pensionable groups (males over 65, females over 60), a possibility at present unresolved.

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BIOLOGICAL RESERVES

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"Life," wrote McNair Wilson, "interested John Hunter to the exclusion of everything else, and he studied life as he had begun to see it—namely, as the supreme resistance to the blind forces which surrounded it and impinged upon it . . . Life, on this showing, was self protective." This "supreme resistance" of life leads in health to longevity, in disease or after injury to survival; and therefore it is of peculiar interest to surgeons. It appears to depend on an urge for continuing life common to all tissues, and easily demonstrated for certain cells in the laboratory by examining the resistance offered by renal and hepatic cells to a sequence of injuries produced by chemicals (for example uranium nitrate and carbon tetrachloride). Tissues differ from one to another in the tenacity with which they cling to life, some giving up before others. This may be of importance in the practice of the future, as the population of this and other countries ages. According to the Government Actuary's projection, provided the general mortality rate continues to decline and the fertility rate remains about the same, between 1951 and 1979 the total population of this country may rise by 7% to 52,250,000; the pensionable population may rise by 43% to 9,500,000, while the number of children may fall by about 4% to 10,500,000. Doctors (and incidentally hospital planners) will have to deal with and provide for more aged and ageing tissues and for fewer children; they will also be able to determine whether the tissues of children of the present generation, who are growing to be larger and who are maturing earlier than the children of 25 or 50 years ago, will in fact retain their "desire for life" to ages sufficient to project them into the pensionable groups (males over 65, females over 60), a possibility at present unresolved.

At all levels of animal life, the desire for life expresses itself in the possession of three forms of biological reserve—*self-defence*, *self-repair*, and *self-adjustment*. As I intend to deal particularly with *self-adjustment*, I shall deal with *self-defence* and *self-repair* only briefly.

Self-defence

There are, of course, two contributory factors to self-defence: the general response, which is an immunological one, and the local response, which can also be examined by histological methods. Both these aspects can be investigated in the laboratory, for the general pattern of response in laboratory animals resembles that in man. What does vary is the efficacy of defence against the various forms of noxious stimulus; physical, chemical and bacterial. The possibility of differences in efficacy is present not only between laboratory animals and man (though they are not uniformly present), but also between the various species of laboratory animals. And more importantly, there may be such differences between human races. Thus the resistance of the peritoneal cavity of the African to pyogenic organisms is greater than that of the European or the Asian. This is obviously the kind of difference which will become of increasing importance as world distances are reduced by better and faster means of communication. It is already of great importance in prognosis for those who practise in multiracial societies.

Self-Repair

The capacity to repair injured tissues and to regenerate lost tissues appears early in animal life; it is found in those animals whose constituent cells increase in number after they first become individual. The capacity may be the expression of a physiological process necessary to replace the wear and tear of use in such epiblastic structures as skin and hair, and such mesoblastic structures as the cells of the liver and the pancreas, and those of the blood. The capacity may be extended to the replacement of tissues lost or interrupted, which is called healing. In lower animals, for example in the lizard, a complex structure such as a tail may be replaced not only in bulk but also in anatomical structure. Higher animals do not possess this useful capacity. In man the most complex repair is the restoration of the epithelial lining of the gut, which includes the restoration of glands appropriate to the segment of gut involved. Repair in the covering epithelium, the skin, includes the nails but not hair or glands. It is curious that the only other epiblastic structure which has the capacity for self-repair is peripheral nerve, because (to take a motor nerve as an example) it is merely the intermediate link in the function of movement, and neither the initiator of movements (the brain) nor their effector (the muscles) has the capacity to regenerate. In some mesoblastic structures in lower vertebrates (the liver of the dog for example) regeneration in bulk quickly occurs after removal of large parts of the organ. The removal must of course leave behind enough parenchyma to sustain life, but it is curious that the organ should at once set about rebuilding parenchyma far in excess of physiological needs.

The capacity to regenerate complex tissues decreases as the evolutionary scale is ascended; and finally includes—because of its survival value—only the replacement of commonly injured tissues. All other losses are replaced by connective tissue during the process of healing. I doubt the desirability of attempting to modify so fundamental a process, especially since departures from normal timing in the process of self-repair often lead to instability of the repair.

All these varieties of self-repair—physiological, replacement in form and replacement in bulk—can be studied in the laboratory, for in higher animals including man the primary structures—bone, muscle, and nerve tissue—are the same. It is of interest to recall the possibilities of repair indicated by Sir James Paget in his famous Lectures on Surgical Pathology (3rd edition, 1870).

1. In tissues formed entirely by nutrient repetition—blood, epithelia.
2. In tissues of lowest organization, or lowest chemical character—connective tissue, bone.
3. The tissues inserted into other tissues, connecting them with other structures—nerve fibres, blood vessels.

This classification might well be used today.

Self-Adjustment

The capacity for self-adjustment is most important for survival in the animal kingdom, and particularly so in man. It comprises two different kinds of adjustment. In the one, the patient "makes do" with what he has after some disease or injury has deprived him of completeness in some physiological function. An example of this type of adjustment are the trick movements possible after paralysis of certain peripheral nerves, as when in paralysis of the radial nerve extension of the wrist is partly carried out by strongly flexing the fingers and so tightening the extensor tendons.

In the other type of adjustment structures and viscera have to undertake to function under conditions imposed by the surgeon, for example after the transplantation of muscles from the preaxial to the postaxial aspect of the forearm to relieve radial palsy, or after anastomosis of the jejunum to the stomach in the operation of gastroenterostomy. In many of the operations of surgery the success and even the safety of the procedures depend on the capacity of the human body for self-adjustment. Wonderfully efficacious as this capacity usually is, it may often be improved, and its final attainment of maximum competence hastened, by the judicious use of all the social, mental and physical auxiliaries which are collectively called rehabilitation.

1. The simplest form of self-adjustment is seen after the destruction or removal of one of paired organs such as the kidney. The remaining organ, although containing ample parenchyma for physiological needs, usually enlarges a little, as if to provide a little biological reserve. Adjustment to the loss of single organs is not possible. Sometimes the loss is fatal if not artificially compensated (pancreas); sometimes it gives rise to profound changes in function of the most complex description (pituitary).

2. Sometimes adjustment is possible in virtue of the excess of parenchyma in an organ or tissue, over what is the minimum physiological requirement. The body adjusts itself at once to the loss of five or six hundred cubic centimetres of blood, as donors who give blood for transfusion well know. Such structures as the liver and the thyroid are constructed on such generous lines as almost to give the impression that they are prepared to lose portions from disease or from injury; it is difficult to associate this with any evolutionary process. On the other hand it seems a little odd that although other structures should have plenty of spare parenchyma, so important a structure as the pituitary gland should have little or none, which leaves it very vulnerable to disease.

3. Instead of using excess of parenchyma for making adjustments, the body may utilise the fact that there is overlapping of function between organs. Thus after removal of one cerebral hemisphere, not all cerebral control is lost over the contralateral side of the body; which helps to compensate for the lack of self-repair in the central nervous system. The stomach may be completely removed by the operation of total gastrectomy, after which the intestinal juices are capable of completing the digestion of food. Compensations such as these are not possible when there is no overlapping of function, as in the case of the pituitary or the pancreas, which are the only sources of their secretions.

4. One of the most important self-adjustments made by the body is to some extent a normal physiological process: the maintenance of the constant composition of the body fluids—the *milieu intérieur* of Claude Bernard. This composition is altered by a great variety of causes, ranging from the metabolic disturbances which follow injuries (including operations) to the complex alterations seen when the alimentary tract is obstructed. The rapidity and completeness with which the body can make these adjustments is much reduced by other factors to deal with which no completely satisfactory bodily mechanisms seem to have been evolved; extreme fatigue, extreme malnutrition, the presence of "stress," and in cases of trauma the presence of gross infection.

5. A vast number of adjustments can be made which are related to the conduits of the human body. The simplest division of these is into channels to which there is an alternative, and channels which are single.

Alternative channels can be subdivided again. There are those which are provided by nature, and which are already in existence, such as the anastomosing arteries, veins, and lymphatics which may form a collateral circulation when the main vessels are blocked by injury or disease. There are "relief" alternative channels the result of disease, as when an infected distended gall-bladder ruptures into the neighbouring duodenum; the anastomoses formed by these *internal fistulae* are seldom completely satisfactory from an engineering point of view, because of awkward and abnormal differences of pressure in the hollow structures so joined, and the lack of accurate union of their respective epithelial linings. Finally, there are those made by the surgeon, to which the body must accustom itself—such as gastro-enterostomy, or the deviation of the flow of urine into the bowel. Arrangements such as the latter may be only "one-way" affairs, for while urine-to-colon is an adjustable arrangement, faeces-to-urinary bladder is not.

When there is no alternative to a given conduit, the problems posed to the body differ. When the passage is a mere tube without muscular walls, such as the Aqueduct of Sylvius, then the body is powerless. When the conduit has muscular walls, the body uses for the necessary adjustment the capacity of plain muscle to hypertrophy, to ensure that an obstruction in the conduit will be at least temporarily overcome. This useful property of plain muscle was first noted by John Hunter; the possibility of hypertrophy is also present in cardiac muscle (to overcome vascular resistance) and in striated muscle (to increase capacity for work).

Tubes such as each ureter and the alimentary canal are not provided with alternative routes. But when they are totally obstructed the technical problems they present are different. The ureter is straight and has not excess length, so that the upper and lower ends cannot be brought together after a piece of it has been removed. On the other hand the alimentary tract is mobile, and excessively long, and the surgeon can make abnormal junctions between its proximal and distal parts, to which the body has been proved by trial to be capable of self-adjustment.

These three biological reserves—the capacity for self-defence, the capacity for self-repair and the capacity for self-adjustment are essential for the continuance of the human race. When the surgeon intervenes, it must be to provide a solution which has not been elaborated by the body itself in the process of evolution. And he must always be careful rather to aid the efforts of the body itself than to attempt to substitute his own.