LIFE AND DEATH

DR. C. H. GADD

How long should a tea bush live? This question, which often arises when the future treatment of old tea areas is discussed, is based on the view that to every species, animal and plant, is allotted a limited span of years, and, as that period expires, death follows as a natural consequence. By 'death from old age' is meant death resulting from inner causes connected with ageing, and *not* from accidental causes external to the species. Accidental death may occur at any time as a result of pests, parasitic diseases or physical violence; but natural death, the consequence of senescence, must occur at the end of a more or less definite period, the life span of the species. Youth, maturity, senescence is the usual sequence in animals, but do plants, and the tea bush in particular, pass through similar stages terminating with death due to old age?

Horticulturists classify their plants as annuals, biennials and perennials, but these categories, though convenient, are not so clear cut as their names suggest. An *annual* is usually defined as one which lasts for a year only, though the life span of many, from seed germination to seed shedding and death, may be but a few weeks, while others may live for more than a year, particularly if flowering is prevented. *Biennials* normally live for two years; in the first, they accumulate stores of food to be expended during the second in production of flowers and fruits. Occasionally, a biennial may flower or fruit in its first season, *e.g.*, beetroot, when it is said to 'bolt.' The main characteristic of both annuals and biennials is that the plants die soon after fruiting. This suggests a connection between fruiting, or sexual reproduction, and death,— as though all the vital resources of the parents are poured into the seed to ensure the propagation of the species. A similar connection between sexual reproduction and death exists also in the animal world. A moth or butterfly after emerging from the chrysalis in all the glory of its new body may live for a few days only, during which time it mates and lays eggs. Reproduction is its life's climax.

Perennials persist for indefinite periods. The American giant redwoods (*Sequoia gigantea*) are known to have survived more than 2,000 years, but no tea planter expects his bushes ever to approximate that age! Some perennials behave like annuals in that death occurs after first fruiting. The talipot palm (*Corypha umbraculifera*) for instance, may live for 50 years or more and then, for no apparent reason, it bursts into flower and dies, almost before the fruits are ripe. The great majority of perennials, however, reproduce their kind annually without fatal consequences. Their ability to propagate is regarded as indicative more of vitality and vigour than of senescence and approaching death. In such perennials there can be no connection between sexual reproduction and natural death; which merely goes to show that there is no one universal law of mortality.

The period of useful existence of a machine is sometimes termed its 'life.' A new motor car usually requires little more than a periodic tightening of a few nuts and other minor adjustments at first, but later, as it grows older, parts begin to wear, necessary replacements and repairs become more and more numerous until at last, in its old age, upkeep becomes uneconomic and the car is relegated to the scrap heap. The length of its life depends upon several things — its make or design (Ford v. Rolls Royce), the care and maintenance it has received, and the rate and mileage it has been driven.

Nature in some instances seems to act in much the same manner as the car owner. Throughout life, repairs and replacements have to be made to the body, and with the passage of time the upkeep problem becomes more and more difficult, till at last the effort towards maintenance is abandoned and life ceases. The length of life of an organism seems to depend upon factors corresponding fairly closely to those affecting the car — its species (make), its ability to regenerate parts (maintenance) and its rate of living (mileage and speed).

What are the repairs and replacements a living organism is required to make? Some replacements are well known. A snake casts off its old skin; the deer sheds its horns; a tree drops its leaves; and a tea bush has to make good the ravages of plucker and pruner. Such lost parts are replaced by new ones. Other, but much less obvious repairs also have to be made. We know that when respiration has ceased, if only for a few minutes, the human body is dead. Respiration is one of the signs of life; it is indicative of one of the many chemical changes continuously occurring within all living tissues. The exhaled carbon-dioxide results from a destructive change, a breaking down of complex molecules into simpler forms, some of which, like the carbon-dioxide itself, are waste products and must be got rid of. Such destruction necessitates rebuilding and repair. Throughout life these processes, destruction and repair, are continuous; they are so complex that one may well wonder, not so much why life has a limited span, as why it survives at all. Efficiency in getting rid of waste products and in executing repairs may well be deciding factors in determining the span of life.

The basic unit of biological matter is termed a *cell*. It is usually of microscopic size, and consists of a cell wall or membrane within which is the slimy, living substance, *protoplasm*, a part of which forms a denser sphere known as the *nucleus*. This basic structure and the one living substance, protoplasm, are common to all forms of living organisms, plant or animal, large and small.

The smallest living things consist solely of one cell, capable of independent existence. Though microscopic in size they have the longest lives; in fact they have been claimed to be potentially immortal. One of their most notable characteristics is an ability to transform each body into two new ones. It is as though an old motor car transformed itself more or less suddenly into two brand-new, unworn cars of the same make and pattern, with the worn parts of the old one only going into the making. First, a constriction encircles the one-celled body about its middle; the constriction deepens and ultimately divides the body into two equal parts. Finally, the two halves separate and each grows until it attains the size of the original. Under favourable conditions the whole process may take less than half-an-hour, and may be repeated an indefinite number of times. Each time it happens the older organism is replaced by two young ones; but there is no death and no corpse. The process is obviously a method of reproduction in which sex plays no part.

Bacteria are a group of unicellular organisms having this ability to 'multiply by division.' When growing on a solid substance they do not migrate but remain where they were formed, more or less in a heap, termed a *colony*. Although one bacterium is invisible to the naked eye, the colony it forms is easily seen after a few days' growth, if conditions, including food supply, are favourable. The growth of the colony is not due to an increase in size of the individuals but to an increase in numbers, and it is continuous so long as food is available, and accidents are avoided. But for the limitation of food there appear no very obvious reasons why certain species do not cover the world. Bacteria are well known as germs which cause serious disease; a few do, but the great majority do not.

Other well-known microbes are the fungi. Some cause disease in plants, others (mushrooms) are edible, and many (moulds and mildews) grow in all sorts of unwanted places. The 'body' of a fungus is usually a microscopically-fine thread, termed a *hypha*, which grows by increase in length and by repeated formation of lateral branches. The felt-like mass formed by much branched hyphae is termed a *mycelium*. Growth in length of filamentous fungi occurs at the apex of each hypha. The terminal cell divides transversely, never lengthwise, but instead of the two halves separating, as with bacteria, they remain attached, separated only by a thin wall, and each grows to normal size. In some fungi the dividing walls are suppressed; then the mycelium consists of a single, much-branched, undivided thread containing many nuclei. In a laboratory fungi are frequently grown on plates (petri dishes) containing a solidified nutrient medium. If growth is not interfered with, the fungus forms a circular mycelium, the diameter of the circle steadily increasing till the plate is filled. Small pieces of mycelium transferred to fresh plates grow in like manner; there appears to be no limit to the number of plates which can be filled by one fungus, nor to the time growth can be continued.

Good examples of the unlimited growth of fungi are to be seen in the 'fairy rings' of dark-green grass in poor pastures. Early literature is filled with tales of superstition concerning them, such as, that they marked the paths of dancing fairies, and that they marked places of treasure which could be secured only with the aid of fairies or witches. That supernatural influence brought about their formation was a common belief until scientists gave a less fanciful account of them. Now, it is known that 'fairy rings' indicate the progress in growth of a fungus through the soil. The annual increment in the diameter of the ring is indicative of the rate of growth of the fungus, and so affords a means of estimating its age. Such estimates can only be approximate because the annual rate of enlargement of the ring, *i.e.*, the rate of advance of the fungus, depends upon climatic conditions. In dry years little or no growth may be made, whereas in others, more favourable, an appreciable advance may occur. Some of the largest rings in Colorado (Shantz and Piemeisel 1917) are over 650 feet in diameter, and have been estimated to be more than 400 years old. A fungus with such a body can hardly be regarded as a microbe; it is one of the largest and oldest living things.

It must not be imagined that the earth within the fairy ring is filled with the body of the fungus. In the centre, the mycelium has long been dead and has disappeared through decay. The only living part is usually just outside the ring of dark-green grass — dark-green, because the grass is stimulated by the release of plant nutrients from the decaying mycelium. But so long as the fungus remains alive at its periphery it grows ever outwards and never doubles back on its track. Its maintenance problem is solved by complete replacement and not by repair.

Something akin to fairy rings may be seen in tea fields where the fungus *Poria hypolateritia*, travelling slowly through the soil, kills the bushes in its path to obtain from their roots a food supply necessary for further advance. The progress of the fungus is marked not by the greenery of stimulated growth but by the ever-increasing number of its victims.

The phenomenon of unlimited growth appears to be a key to long life, if not immortality. It seems immaterial whether the growth is exhibited by increase in numbers, *non-sexually* as in bacteria, or by increase in size as in fungi.

Many plants, more perhaps than is generally recognised, exhibit this phenomenon of unlimited growth and horticulturists make use of it whenever vegetative propagation is employed. Vegetative propagation, as opposed to propagation by seed, is essential whenever plants of exactly similar characteristics are required. By dividing a plant into separate portions and culturing each part under suitable conditions, a number of plants exactly like the original may be obtained. These new plants are but severed parts of the same individual and have the same characteristics. For this reason fruit trees and many other plants are almost invariably propagated vegetatively. The tea planter still propagates from seed, and consequently, in tea fields the bushes are as unlike as the men of any town. Such variability is the normal result of sexual reproduction. Yet there is no reason why whole tea fields should not be covered by the severed parts of one bush, nor why all the leaf for a whole day's manufacture should not be obtained from one (much divided) bush, if it be desired.

If a part of a shoot is removed from a tea bush and planted in the ground the cutting will put out its own roots and continue to grow. The bush from which the shoot was removed will replace the lost part, much as a lizard will grow a new tail after losing its original. The removed shoot also will replace its lost parts by forming roots; but it would be 'news' if the lizard's discarded tail replaced the lizard. The cutting ultimately becomes a tea bush with exactly the same characters as the one from which it was taken. In fact it is still the same bush. Had the shoot not been removed it would have continued to grow, though certainly not to the same extent; that it was removed and put into the ground may be regarded as accidental. The area occupied by any one bush may be extended tremendously by means of cuttings, and provided that man occasionally performs the 'accident' of removing and planting a few shoots in suitable ground, there appears no reason why the selected bush should not survive as long as human life exists.

A tree exhibits continuous growth in other ways than by its ability to reproduce itself from cuttings. When its leaves grow old they are shed and replaced later by new foliage. The leaves decay, as the old mycelium within the fairy rings decays. What is not so obvious is that when the old leaves are replaced by new ones, the tissues which supplied them with water and which carried away the results of the leaves' activities are also replaced by new ones. We need here consider only one such tissue, the wood through which water is conveyed from the soil to the leaves. As a tree unfolds its new leaves, it also lays down new tissues to serve them (Priestley 1935). A newly-erected house in a town would be connected to the nearest existing water main; but each new leaf is provided with new pipelines extending to the source of its water supply, the soil. These new pipe-lines (wood) are formed on the surface of the existing woody cylinder, which in consequence increases in girth annually. Like a fairy ring, a tree grows ever outwards while the older tissues within die progressively. The age of any one part is much less than the age of the tree as a whole; the shoots plucked from a bush may be but a few weeks old whereas the age of the bush as a whole must be measured in years.

Wood, besides conducting water, has another function; it gives the tree mechanical strength to withstand storms. Unlike the fungus of a fairy ring, which has no further use for any of its dead parts, the tree must maintain its dead wood unweakened by decay to give stability. Protection against decay is provided by an unbroken covering of living tissues which entirely encloses the dead wood. A single hole in that protective sheath will let in the external agencies of decay, and begin the weakening of the timber. One injury may do little damage, but as injury succeeds injury the results are cumulative; the tree weakens, the trunk becomes hollow, and a limit is set to the length of its life. That limit is determined largely by the durability of the wood. The holes in the protecting sheath of living tissue may be caused by gales, or knives, by insects or other parasitic organisms — all are external agencies and largely preventable.

The tea bush is one of the most maltreated of trees. Its young shoots are pinched back (plucked) every week or ten days, and its branches are pruned severely every few years. Such wounds, holes in the bush's protective armour, appear necessary if the tea industry is to survive; but it is equally true that the survival of bushes depends upon their ill-effects being reduced to a minimum. This point of view is sometimes lost sight of when pruning estimates are under consideration. No single cultural operation can shorten a bush's expectation of life as effectively as bad pruning.

Mention was made earlier of the rate of living being a factor possibly affecting length of life. By rate of living is meant the time rate at which all vital processes, such as respiration, growth, sexual activity, etc., proceed. Temperature materially affects the rate of these activities. At lower temperatures, as in the hill country, tea grows less rapidly than at lower altitudes with higher mean temperatures, and consequently the bushes should age more slowly and live longer at the higher elevations. From experience one knows that the expectation of life of up-country bushes is certainly greater than of low-country bushes, but, in the writer's opinion, that is attributable less to the difference in the rates of living of the tea bushes themselves than to the different rates at which decay progresses at the different elevations. Old age in tea bushes is perhaps better measured by the amount of decay in their woody frames than by their years.

If the phenomenon of unlimited growth is truly a key to long life, the tea bush appears to have possession of it so long as it is *not* allowed to grow unhindered. If left unmolested, unplucked and unpruned it soon attains its maximum height and spread. Its height rarely exceeds 25 feet and no method of increasing it is known. But by suitable pruning the bush may be induced to increase its spread and to form a plucking table, in exceptional cases, with a diameter of 24 feet (Ukers, W.H. 1935). In a natural state definite limits are set to every tree's size. Increasing size brings with it increasing difficulties in transport, not only of water, but of all other materials, food and waste products, which have to be moved from one part to another. One view of the cause of senescence in animals is that it results, at least in part, from chronic poisoning of the organism by some of the waste products of life processes which the animal is unable to get rid of. Whether trees of maximum size suffer from similar disability, when transport of materials within them becomes difficult, is open to doubt. The long life of Giant Sequoias already mentioned does not suggest this to be the case, and no very strong evidence has yet been brought forward to show that trees exhibit a senescence comparable with that well known in animals.

A brief answer may now be given to the question with which this article opened. Given a constant supply of food, air and water, shelter from storm, and protection against its numerous enemies, there is no apparent reason why a tea bush should not live for ever. In short the length of its life will depend on the environment.

That a tea bush is potentially immortal may be only of academic interest; it certainly would not be an economic proposition to attempt to prove the theory in practice. The amount of protection which can be given to a crop is determined by the cash return. Complete protection, if it could be achieved, would probably prove to be mere extravagance; failure to provide any is assuredly false economy. Between the two extremes lies the road to agricultural success.

REFERENCES

Shantz, H. L. and Piemeisel, R. L. (1917).—Fungus fairy rings in Eastern Colorado and their effect on vegetation.—*Journ. Agric. Res.* 11, pp. 191-245.

Ukers, W. H. (1935).—All about Tea.—*New York*, Vol. 1, p. 432.

Priestly, J. H. (1925).—Sap ascent in the tree—*Science Progress*, 20, pp. 42-56.

ERRATA

The Tea Quarterly Vol. XVIII, Part 3

Page 82.—Taproots and Lateral Roots — 2nd column line 1, For "served" Read "severed."

Plate facing page 83.—Line 1 of legend.—For "Figs. 1-15" Read "Figs. 1-5."

T. R. I. Bulletin No. 27

Page 26, Line 10.—For "*Section 13*" Read "*Section B.*"

Page 34, Line 19.—For "After the craneflies had emerged, the roots of the seedlings were" Read "**Leather Jackets.**—In March a larger number of Tupulid larvae were"