Germination of Seeds*

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THE ovule, which later becomes the seed, is enclosed in the fruit vessel or ovary, the covering provided by the mother plant. During its development, the offspring is protected and nourished by its mother, and the ovule gradually develops into the seed, with its own protective skins or coats, lying within the enlarged ovary, which in the course of time has become the fruit.

Examples of fruits with their contained seeds are such familiar objects as the fleshy-fruited tomato with its dry, flat seeds, the broad bean or the scarlet runner with the enclosed seeds or beans, and the Brazil nut, where the mother plant has provided a thick, woody, cannon-ball-like protective fruit—which can only be broken by a powerful hammer or cut across with a saw—enclosing the well-known hard-shelled 'nuts'.

Many seeds have been so well protected by the mother plant that the liberation of the seeds contained in the fruit is often a matter of some difficulty. The Brazil nut fruit is perhaps the most remarkable example. In other cases, however, the seeds are shed or scattered from the fruits with the greatest ease when the fruit is ripe, as any gardener knows only too well who attempts to save seed of an *Impatiens* (balsam), or collect the seeds of gorse, which are shot out from the fruit as if from a catapult. The horticulturist, of course, is concerned only with the seeds when he wishes to replenish his stock of plants. In the majority of cases he merely sows the seed, and germination, that is, the escape of the embryo from the protective seed-coats, takes place sometimes in a few days, sometimes after some weeks from sowing. In the case of willows and poplars the seed will germinate the day after it is sown, and if the minute seed should be kept for more than a few days it will completely lose its power of germination. In other cases seeds may remain viable for years. I remember well the late Sir Michael Foster showing me a pot of *Iris*, in which the seed was just beginning to germinate fourteen years after it had been sown ! Then there are the seeds of the Australian wattles (acacias), which rarely germinate until a fire has passed over the ground in which they are lying, or which, if sown at home, have to be scraped with a file, or treated with strong sulphuric acid, as is also the case with some other seeds, in order to induce germination, so strong and resistant is the seed-coat. It is known that seeds of *Acacia lophantha* will germinate after being stored for sixty-eight years and recently, in connexion with inquiries as to seed vitality, we have experimented at Kew with seeds long stored in bottles in our Museum and have successfully germinated seeds of *Anthyllis vulneraria* and *Trifolium striatum* both ninety years old, and seeds of four other leguminous plants, including the Spanish broom (*Cytisus scoparius*), all eighty-one years old.

How long the poppy seed, which germinated and flowered so wonderfully after the shelling of the Somme battlefield, had lain buried in the soil, or how long charlock seed will remain living when buried, we do not really know ; but it is truly remarkable that life can persist for so long a time in a body so minute as the embryo of a seed imprisoned within its seed-coats, when the seed is preserved under suitable conditions. What the nature of such life may be, and to what extent respiration, and the other functions we associate with living matter, may be carried on in dormant seeds, is scarcely within the scope of my text, nor could I throw much light on this arresting problem. For the moment we are concerned with the embryo prisoner, whether serving only a brief or a long sentence of confinement, and the nature of the prison.

There is a minute orifice in the seed, the micropyle, originally the point of entry of the pollen tube into the ovule, behind which ultimately the radicle or root tip of the embryo will lie in the mature seed. Through this minute and well-sealed pore, and also by absorption through the coats, moisture enters the seed when conditions become favourable for germination, and the radicle emerges at the micropyle. In the case of most seeds it is safe and usually advisable to store them through the winter and sow them in the spring, since the embryo is in the resting or dormant condition, whatever that may signify. There are, however, a few seeds which do not undergo any resting stage, but development is continuous, and the embryo is in an advanced stage of germination when the seed is shed. The prisoner effects his escape, as an Irishman might say, before he has been shut up ! Willow seeds, as I have mentioned, almost come within this class, but the mangrove, with its viviparous seeds, is a classic illustration. Here the seed in the inverted-pear-like fruit germinates while the fruit hangs on the trees. The long fusiform radicle grows downwards and eventually the young plant falls off into the water where it floats upright and gets carried to a safe landing in the mud of a tropical estuary. *Typhonodorum*, a giant aroid from Madagascar, behaves in a similar manner, and well-developed young plants, still attached to the large, bean-like seeds, are shed into the water where they float upright with the young leaves in the air.

In these cases, we might say that the embryo, realising how flimsy and insecure are its prison walls, considers it wiser to escape at once and so avoid the risk of being killed by insufficient protection, which might have happened should it

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have 'gone to sleep' for a period, like other embryos, after the maternal influences had ceased.

The normal seed consists of two close-fitting coats, the inner usually membranous, the outer being either papery, leathery or woody, and often ornamented with most beautiful surface markings, which cover and protect the embryo. The embryo may be embedded in food material on which it can draw when germination commences—the type known as albuminous—or it may have absorbed into itself, during its development, all the nutritive materials supplied by the mother plant and stored them for future use in its seed leaves or cotyledons —which is known as the exalbuminous seed. In either case germination, with the majority of seeds, is simple and straightforward: the emergence of the radicle, the splitting open of the seed-coats and the withdrawal of the cotyledons or seed leaves follows in due course. In a few cases, of which the vegetable marrow (*Cucurbita*) is a good example, the young seedling takes special care to free itself from its seed-coat and develops a special peg-like outgrowth at the apex of its young root which presses on the lower valve of the seed-coat, while the arch of the young stem carrying the cotyledons lifts up the upper valve and so effects its escape. The youthful prisoner thus puts its foot on the floor of its prison house and raises the roof with its bent shoulders.

The palms show certain peculiarities in the germination of their seeds, which are unlike those of other plants. I will take the familiar date stone (*Phœnix*) as my example. Dates are fleshy fruits with a hard horny-like stone in the centre, which is the seed. In the middle of one side of the seed there is a small circular umbilicus or navel behind which lies the embryo. Owing to the horny nature of the endosperm of the seed, it would be well nigh impossible for the embryo to escape if the date attempted to germinate in the usual way, since the cotyledon and shoot apex could not get free from the seed, even though the root could grow out and push down into the ground. The problem is solved by the date, coco-nut, double coco-nut and other palms by transporting bodily the whole embryo out of the seed through the navel-like depression and burying it in the ground some distance below the surface of the soil. This is accomplished by the outgrowth of a closed germ-tube, the cotyledonary sheath, completely surrounding the embryo, which in the double coco-nut is a stout formidable looking article. Though the embryo has been taken out of the seed, however, and is being nourished by the supplies contained in the seed through the cotyledonary sheath or tube, the problem of its escape is not yet solved, since it is still a prisoner within its own tube-like sheath. It is as if the walls of its prison cell had become elastic and extensible and the cell had extruded itself through its window, carrying the embryo still imprisoned within the elongated cell; a procedure which may be compared to a person sliding down a tubular fire escape from a window.

The embryo, however, is able to solve the problem; for the young shoot with its seed leaf grows and forces its way through the wall of the germ tube and emerging into the air finally starts on an independent existence. This may take place in a fairly short time, but in the case of the double coco-nut several months elapse after the embryo is carried out of the seed before the young palm leaf of the seedling escapes into the daylight. The coco-nut and double coco-nut differ a little from the date in that the actual seed is enclosed in the innermost wall or endocarp of the fruit, and are thus similar to cases I am about to describe; otherwise the procedure is exactly like that exhibited by the date.

Turning now to those seeds which have an additional protection in the way of part of the fruit wall as well as their normal seed-coats, as in the coco-nut to which I have just referred, I may mention first the more simple cases of plums, cherries, almonds and olives. In these cases the edible flesh is part of the 'fruit' proper, but the stone is also a portion of the fruit wall, so that it is not strictly correct—botanically—to speak of plum or peach stones or coco-nuts as 'seeds', since the stone is a fruit structure and only the kernel is the actual seed.

The fruit wall or pericarp consists of three layers or coverings: the outer one which is the skin; the middle fleshy and edible portion, the mesocarp; and the hard, innermost layer, the stone or endocarp, which encloses the seed or seeds. Stones or stony endocarps of this nature may contain one, two or several seeds.

Cherry or plum stones afford good examples of stony endocarps containing a single seed, and the embryo has not only to solve the problem of escaping from its seed-coats, but also the more difficult task of getting out of the woody box-like stone, which has to be cracked by hand should one wish to obtain the kernel.

Careful examination of a plum stone shows the endocarp to consist of two similar and closely-united halves, only separable when the plane of weakness becomes softened. The cells of the stone do not cross the line of junction of the two halves of the stone, but are turned at right angles at the median line and the two distinct halves are firmly 'cemented' together. The stone thus easily splits into its two halves, after sufficient moistening, by the pressure exerted by the emerging radicle or root tip of the embryo, and in due course the cotyledons or seed leaves, with the young shoot apex between them, are successfully drawn out from the seed coats and enclosing stone, and expand in the air.

The walnut, *Juglans*, the shell of which again is a fruit structure, behaves much like the plum on germination, the shell splitting into its two component halves. Here, however, there is the difference that the shell is formed by the close adhesion of two carpels, each half of the shell being a separate entity.

(*To be continued.*)