An interesting series of transparent 50 per cent oil-water systems was described. If amyl alcohol is added to an emulsion stabilized by sodium oleate, the system becomes transparent, and is believed to contain suspended droplets of the order of 100–200 A. in diameter. Amyl alcohol can be replaced by other amphipathic compounds, their efficiency depending on the ratio polar/non-polar. This was investigated in the series of aliphatic alcohols, from C_1 to C_{10}, and it was found that with benzene as the 'oil', the continuous phase changed from water to oil when the chain-length exceeded 5. These results are explicable in terms of the formation of mixed films of soap and alcohol at the interface; such films are known to be stable from experiments in monolayers.

Between these two extremes of structureless and highly ordered systems lie many of considerable importance, which may be treated as approximating more or less closely to one extreme or the other. Two papers discussed the structure and deformation of cellulose gels in the light of the work on ideally elastic rubber-like bodies. Theoretical treatments of the latter have been based on a model consisting of long randomly linked chains joined at a few points into a complete three-dimensional network. A statistical mechanical analysis of this model leads to expressions for the free energy of deformation, and the orientation birefringence. Swollen cellulose shows a limited degree of rubber-like elasticity, but in order to account for this quantitatively it has been necessary to assume a very high degree of cross-linking. It may be considered doubtful whether much significance is attached to the model when the estimated number of statistical chain elements between junction points falls so low as one or two.

The swelling of nitrocellulose is more complicated than that of a purely amorphous polymer, on account of its definite structure. Two types of swelling were reported, depending on whether the crystalline part is affected or not.

The swelling of protein fibres in organic solvents was discussed from the point of view of the fibre structure. The relative effectiveness of a range of acids, amides and alcohols suggests that swelling involves the breakdown of the fibre structure by chemical interactions between the liquid and localized groups in the fibre. No simple generalization of these results, such as may be made for the swelling of non-polar polymers, was found to be valid in this case.

The phenomena of swelling and shrinking are of great importance in many widely divergent fields. In the technical use of materials capable of absorbing water, or other liquids, the resultant change of volume may be less serious than the stresses and strains which are produced. A thermodynamic analysis of the swelling of wood was presented, in which the cell structure was represented by a hollow cylinder of initially isotropic material surrounded by a rigid sheath, so that swelling could only occur into the central lumen. It is then possible to deduce the dependence of the vapour pressure at fixed moisture content on the elastic constants of the swollen cell wall. The swelling of laminated plastics represents a closely related problem. Imbibition of moisture by the reinforcing fibre is mechanically restrained by the surrounding film of polymer, which in general will itself be swollen to a smaller degree.

A very different field of application of the general ideas developed in this conference is presented by systems of biological interest. On the simplest view, a red cell may be treated as a balloon-like body surrounded by a semi-permeable membrane of very low modulus of elasticity. The volume of the cell, which can now be measured with some accuracy, should thus be dependent on an osmotic equilibrium, and would vary with the medium in which the cell is immersed. Experimentally, there are found to be discrepancies which are not at present fully understood. Complications were pointed out also in the swelling of protoplasm. It is not yet clear how far the various physical processes occurring in living matter may be treated as though they are *identical* with those of the dead chemical constituents of the systems. Without in the least suggesting any vitalistic hypothesis, it is necessary to bear in mind the essentially dynamic nature of living cells, and the simultaneous occurrence of complex chemical and physical changes.

GEOFFREY GEE

THE MOON AND PLANT GROWTH

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BELIEFS that the phases of the moon have a differential effect on the rate of development of plants are both ancient and world-wide. Proof by rational experiment seems to have been sought more than two hundred and fifty years ago by La Quintinye, the horticulturist, and some years later by Duhamel du Monceau[1], the forester. Neither obtained any positive evidence of lunar influence. Since then, scientific interest in the subject has been revived intermittently, either by the 'rediscovery' of lunar rites in the agriculture of civilized countries, or by the impact on Europeans of the impressive faith of primitive peoples, particularly in the tropics and sub-tropics.

The literature on the moon and plants can be assigned to two groups: one comprising reiterations of peasant beliefs, myths and rules, both ancient and modern, and similar unsubstantiated statements; the other comprising experiments supported by numerical data capable of statistical analysis. This second group consists of (*a*) experiments mainly of the anthroposophical school, which demonstrate the existence of lunar effects on the growth of plants; and (*b*) experiments of professional horticulturists and foresters, which prove that there are no such effects, or that, if they do exist, they have no value in agricultural practice.

The beliefs which dominate primitive rural economy and the emphatic reports of credulous observers are very numerous, but they provide no significant evidence. Only experimental data need be considered; they may be briefly summarized as follows:

(*a*) *Kolisko's work.* According to the investigations of L. Kolisko[2] in Stuttgart during 1926–35, the particular phase of the moon at the time of sowing does influence the period and the percentage of germination, as also the subsequent growth of the plant. The most favourable date to sow is two days before the full moon for leaf- and fruit-bearing garden crops (such as cabbages, peas, tomatoes), for root-crops (such as radishes, beetroots, carrots), for flowering garden annuals, and for wheat, maize, etc. In general, these plants show better germination, more vigorous growth, and greater yields than those sown just before the new moon. Kolisko affirms that the lunar influence is not fully effective unless there is rain or artificial watering during the germination period, but the stimulus once acquired remains decisive throughout the periods of growth, flowering and fruiting. As regards growth during a lunar phase, she found that on the whole the response of wheat is greater during the waxing than the waning phase.

In later experiments to determine the depth to which the action of the moon penetrates the soil, Kolisko found that at a depth of 1 metre the effect on wheat is nearly identical with that at the surface; at 2–3 metres the maximum growth is generally reached in a full-moon period; between 5 metres and 16 metres the influence is weaker but is still shown by greater growth at the time of the Easter full moon. She considers that each year has a certain dominating lunar period, and that the Easter full moon has a special significance for the whole year. E. and L. Kolisko's recent book, "Agriculture of Tomorrow", reviews cosmic influences on plant growth.

(*b*) *Other investigators' work. Germination.* Experiments on the germination of garden crops have been done by Becker (1937–38)[3], Bergdolt and Spanner (1937–39)[4] at Munich; by Mather and Newall (1940–42)[5,6] at the John Innes Horticultural Institution; similar experiments with spruce seed were done by Rohmeder (1935–37)[7] at Munich. All these investigators agree that no consistent effect of the moon is observable, and that all chance variations possibly assignable to any one of the moon's quarters are evened out with an adequate number of repetitions. At meetings of the Société nationale d'horticulture de France in 1924, several horticulturists testified to the absence of lunar effects on sowings and seedling growth; earlier work of Arago, Flammarion and others in France between 1859 and 1909 was cited in confirmation[8].

Reproduction. Periodicity in the production of sexual cells of the marine alga, *Dictyota dichotoma*, has been demonstrated by Williams (1905)[9], Hoyt (1907)[10] and Lewis (1910)[11], but the period is fortnightly on the coast of Wales and Naples, and four-weekly in New Carolina, and the phase dates differ.

Polarized light. Semmens (1923)[12] showed that moonlight is plane-polarized and increases hydrolysis of starch with diastase. Esenbeck and Suessinguth (1930)[13] and Macht (1926)[14] showed that polarized light of low intensity may produce a very slight increase in growth in length of plants. Wright (1927)[15] found the highest degree of polarization of moonlight at the ends of the first and third quarters. The anthroposophists consider that the moon's influence works in darkness and below ground.

Felling dates and seasoning of timber. Moisture-content is the most important physical condition influencing the rate of decay of wood. The amount of water in the wood of a living tree is known from many careful determinations to differ with the species of tree, and for some species to vary seasonally, for others to be fairly constant throughout the year. No variation related to lunar phases is known for any tree, but Beeson and Bhatia (1936)[16] found a regular lunar rhythm of sap increasing from the full to the new moon and decreasing from the new to the full moon in *Dendrocalamus strictus* in India. Knuchel and Gäumann's (1930)[17] work with spruce and silver fir in Switzerland based on a sequence of fellings in the same phase of the moon is typical of the exact knowledge now available. The season of felling is proved to have no substantial influence on specific gravity, moisture-content, shrinkage, resin-content or working qualities, but it strongly influences the rate of seasoning. The effect of the season of felling on the rate of drying, and the effect of weather on the activity of decay organisms dominates any effect that may be due to the phase of the moon.

Borer damage. Numerous entomological records show that the liability of felled trees to attack (that is, oviposition) by borers depends on one hand on the dates of the emergence period and longevity of the adult insect, and on the other hand on the progress of drying out of bark and sapwood, or the amount of depletion of starch. The two latter factors can be controlled in many species of trees by logging procedure which entirely ignores lunar dates. Beeson and Bhatia (1936)[16] and Gardner (1945)[18] have proved that the intensity of *Dinoderus* damage to bamboos in India depends on the amount of starch present in the felled culm; the starch-content of the living culm varies seasonally, not according to the lunar phase, and no advantage is obtained by felling in relation to the phase date.

Lunar periodicity exists in some animals, but they are marine or aquatic species (Fox, 1924 [19]; Hora, 1929 [20]).

Yield of resin, latex, etc. Variations in the yield of resin, latex, maple syrup, gums and tannin are explicable in terms of tapping systems, genetic factors, weather and environmental conditions; experience is very considerable, but in no case has any advantage attributable to the moon been discovered. For example, Ferrand's work (1941)[21] on *Hevea brasiliensis* in the Belgian Congo revealed that the daily concentration of latex varies with weather conditions, and the local concentration in the same tree depends on the exposure to sunlight of the crown directly above the tapping-point. Changes in the gutta-content of the root of *Euonymus verrucosus* in the U.S.S.R. follow the seasonal development of the plant, and the resin-content varies in inverse proportion (Yurkevich, 1944)[22]. The maximum tannin-content of seeds of *Terminalia chebula* is found in seeds collected in January anywhere in India; this period is also that of optimal germinative capacity (Prasad, 1946)[23].

Summary. The only experimental evidence for the existence of lunar influence on the growth of land plants is that published by L. Kolisko. All other investigators in many parts of the world have been unable to discover any consistent correlation between the moon and the vital processes of land plants; some admit that if a lunar effect does exist it is so obscure as to have no value in agricultural practice.

A more detailed review of the subject will shortly be published by the Imperial Forestry Bureau, Oxford.

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