mainly tropical, apart from *C. europœa*, and ranges through tropical and south Africa, the Mascarenes, western China, the Indian subcontinent, Malaya and Australasia. It does not occur in the New World. *Olea chrysophylla*, to which several species have been reduced, has the widest range throughout the greater part of Africa south of the Sahara and in Asia from Afghanistan to western China. In the Sudan and the southern Sahara there are plants intermediate between *O. chrysophylla* and *O. europœa*, and others occur also in Madeira. In particular, specimens named *Olea laperrini* from the Hoggar Mountains and from Jebel Marra are of great interest.

The place, time and immediate ancestry of the cultivated olive are unknown. It is frequently referred to in the Old Testament and in ancient Greek literature. The legends of Greek mythology point to its origin outside Greece and its introduction as a plant already in full cultivation. In ancient Egypt, the olive was certainly known, even in pre-dynastic times, and recent archæological evidence suggests that it was of greater importance than was formerly thought. Unfortunately, there is no known reliable evidence of *Olea* as fossils, and the few cytological studies published throw no light on the origin of the cultivated olive. After a careful consideration of various possibilities, it is concluded that *Olea europœa* may have arisen from *O. chrysophylla* in northern tropical Africa and that it was introduced into the countries of the Mediterranean Basin via Egypt and then Crete or Palestine, Syria and Asia Minor.

In outlining the history of the more important cereals, Dr. G. D. H. Bell pointed out that the chief centres of origin of these are the Mediterranean basin, Persia, Abyssinia, far-eastern Asia, south-eastern Asia, central Asia, and South America. These centres for the most part coincide with areas of ancient civilization. The genera mainly considered by Dr. Bell were *Triticum, Secale, Hordeum* and *Avena*. The oats are taxonomically quite distinct from the first three of these genera, for which a prototype with $2n = 14$ chromosomes has to be postulated. In the genus *Triticum*, mutations gave rise to various species and were followed by polyploidy. Wheat, however, did not evolve within the one genus. A cross between a diploid *Triticum* and a diploid *Agropyron* followed by allopolyploidy gave the chromosome number of $2n = 28$. A second intergeneric cross between a *Triticum* with $2n = 28$ and an *Aegilops* with $2n = 14$, again followed by chromosome doubling, gave the important wheats with $2n = 42$. Cytogenetical researches on barley and rye have thrown much light on the constitution and origin of these cereals; but the history of cultivated oats is less well understood in spite of the fact that they are of more recent origin than the other plants here considered. The infinite range of morphological and ecological types of the cultivated cereals was emphasized.

Dr. J. G. Hawkes reminded the meeting that the potato was introduced into Europe at the end of the sixteenth century and was regarded as one species until the early part of this century. Now about fifteen species are recognized in place of *Solanum tuberosum*. The basic chromosome number of these is $x = 12$. South Peru and north Bolivia, centres of ancient Andean civilizations, are included in the range of the *Tuberosa* series. Chromosome numbers ranging from diploid to pentaploid occur in the cultivated potatoes and to hexaploid in wild species. Probably wild tetraploids were taken into cultivation. In nearly all areas of western South America there occur wild potatoes with long stolons. These grow in places where competition with natural vegetation is not great and where the soil is rich in nitrogen. Hence they take full advantage of areas disturbed by man. They survive from one season to the next by pieces of the long stolons being left behind in the soil by the early users of the tubers. The original ancestor of the cultivated potato, however, probably no longer exists—it was all taken into cultivation. No doubt the modern potatoes show little resemblance to the first cultivated plants.

ANIMALS AND FORESTRY

SECTIONS D (Zoology) and K* (Forestry) of the British Association held a combined symposium at the recent meeting in Edinburgh in order to discuss the relation of animals to forestry. Dr. F. Fraser Darling, a member of the Scottish Committee of Nature Conservancy and formerly director of the West Highland Survey, opening the symposium with a contribution on mammals, said that the relation of mammals to forest growth is a critical one, for its survival or extinction, and it is one of the most dramatic complexes in Nature. The advent of pastoral, agricultural and civilized man has complicated the situation ecologically. Forests are either climaxes or stages well on the way to the climax, a feature of which is the increasing variety of organic forms and degree of stability. This stability may be interpreted as self-regulation, and the biological system becomes a continuum. Climaxes are constantly being broken by natural catastrophes such as hurricane and fire, but in limited areas, so that the set-back in ecological succession creates edge effects and allows the continued existence of forms which could not endure in the absolute climax. The over-all biological picture is enriched by periodic natural catastrophe.

The profound benign or depressive influence of mammals in the natural chequerboard of climax forest, secondary growth and primary colonization is clearer if the animals are classified according to what they do—predators, browsers and grazers, rodents and insectivores. The predators as a group, of which several species have been lost by extinction, form the insurance company, ensuring the forest as a continuum by controlling the populations of rodents and grazers and browsers. The insectivores share with birds and predatory insects the control of invertebrate populations which tend to depress forest growth. Control is never absolute and no one species is critical; control rests with the complex. The depletion of the predators in the interests of particular forms of land use has endangered the maintenance of old forests and is a grave handicap to the establishment of new ones. Dr. Darling suggested that human ingenuity is not yet equal to controlling small rodents in an extensive habitat, for example, wood mice (*Apodemus*) and squirrels. Their vast numbers and fecundity, their smallness and capacity for evasion are too much for us. A good and varied stock of small carnivores is not only our best insurance but also the cheapest.

The grazers and browsers are comparatively few in numbers, but represent a considerable bio-mass. Although depressive to forest, a low density (the ratio of 1 red deer to 133 acres or thereabout in the Forest of Fontainebleau was cited) may be positively useful. Nevertheless, said Dr. Darling, it is doubtful whether the new artificial forest of Britain can endure the red deer, or even the fallow. Natural forest as a continuum, used by man on a selective felling basis, can accommodate deer with advantage, but not the plantation intended to be clear-felled and replanted. Some North American forests were described, where the upset in natural predation on deer is leading to some serious situations through over-population. The success of Theodore Roosevelt's promotion of the sporting and sentimental status of deer has been immense in the United States, but there is a lag in public opinion between the conditions of scarcity half a century ago and those of the present day when, in a country of much secondary growth, there are probably more deer than there have ever been before. Dr. Darling asked for much more enlightened critical appreciation of forest health, which would make us sensitive to damage in woodlands before situations become irremediable. The animal populations are more flexible than the forest habitat. The deer-forest era in Scotland, which encouraged an artificially high density, was responsible for the slow death of much natural forest. Forest growth in our day needs constant and highly skilled wild-life management, and the woodlands of Britain are not getting it. The wild-life complex is an immanent entity, benign in habitat maintenance if it is in a state of gentle oscillation, but a menace to our own survival if a warped complex begins to oscillate violently and percussively.

Mr. J. M. D. Mackenzie, formerly of the Indian Forest Service, described his work with nest boxes for birds in woodlands in Britain. The 1½-in. hole is desirable for many small species, and, though orientation is important, a clear fly-way to the box is more so. A desirable height for small boxes is 5–6 ft.; but the degree of human interference makes a height of 10–15 ft. much safer. There are specific preferences, for example, a concave bottom is essential for woodpeckers, which do not use nesting material. To get optimum numbers of birds (that is, below the level of intra-specific competition) a fifty per cent surplus of boxes is desirable. Spacing is important, not only for the species of birds but also for the size, species-type and age of the woodland. Mixed forest cut on a selection basis carries the biggest and most varied populations, a finding in line with Dr. Darling's remarks.

The employment of nest boxes, said Mr. Mackenzie, can throw light on problems of distribution, in that it would seem that the presence or absence of nesting sites is often crucial when food may appear abundant. The spread of the pied flycatcher is an interesting example in that this is a species on the increase, but one which has occupied some valleys only after the provision of boxes. The flycatchers arrive in Great Britain when other species have already occupied most of the nesting sites. Interspecific competition is real. In 1947, after the hard winter, resident tits using boxes in the Forest of Dean fell from 54 to 20. Migrant flycatchers rose from 39 to 54, doubtless taking advantage of vacant sites.

Mr. Mackenzie's paper, which was accompanied by interesting comparative graphs, showed that the careful use of nest boxes and the results to be obtained from them after a series of years can be useful tools in the hands of the investigator into problems of forest ecology involving the dynamics of avian populations and their insect prey—a field in which there is little certain knowledge at the present time.

Dr. R. N. Chrystal, of the Department of Forestry, University of Oxford, dealt with the role of insects in forestry. He divided the forest regions of the world into those of temperate and tropical regions, indicating that the temperate forests consist of large areas of conifers of various kinds, some pure hardwood stands, such as oak, beech and birch, and some mixtures of conifers and hardwoods, whereas the tropical forests consist mainly of mixed stands of hardwoods of varying types. The insects can be classified into clearly recognizable biological types—defoliators, bud and seed borers, bark and wood borers, and the immense host of predators and parasites which attack the other insects at all stages of their lives. Insect control, indeed, largely rests with the predatory and parasitic Hymenoptera and Coleoptera.

Insect attack on the growing stand is most obvious in the temperate regions and particularly in solid coniferous forests. It is much less severe in mixed conifer–hardwood stands and at a minimum in hardwood areas. Insect attacks on the highly complex mixtures of tropical jungle forests are negligible. Thus, Dr. Chrystal expressed in his own way the principle emphasized by Dr. Darling and endorsed by Mr. Mackenzie, that the climax mixed forest as a continuum can accommodate a vastly richer fauna than the coniferous stand which in Nature is but a successional phase. Dr. Chrystal drove his point home in discussing the plantation forestry which is being established in Britain, in parts of Europe and in the Antipodes. Faulty choice of species may lead to failure through insect attack—for example, silver fir in some parts of Britain and Denmark—and if we see things aright, such attacks should be looked upon as indicators of unsuitability of site rather than an uncomplicated building-up of insect assault. The artificial coniferous plantation is a hostage to fortune from the nursery to maturity, insects becoming pests which are innocuous in the natural forest. The wood wasp *Sirex* is attacking *Pinus radiata* in New Zealand and acts as carrier of a fungus which helps to cause death of the trees. The present laborious method of trapping *Hylobius* and *Hylastes* beetles with fresh pine logs and bark is quite unecological and must be looked upon as a makeshift until forestry establishment itself adopts ecological principles.

Britain has as yet suffered little compared with some of the coniferous forests of Europe and North America, and the root causes of insect attacks in these places has still to be accurately determined. Hurricanes, for example, favour virulent attacks on the fallen trees by several species of Coleoptera. Human warfare, causing neglect of forest hygiene, must also be considered as a contributory factor in the large-scale attack of bark beetles in the forests of central and southern Europe. Fire damage in the Landes of Gascony has helped to establish the conditions for attack by the spruce bark beetle, *Ips typographicus*. Conversely, killing attacks of bark beetles of the genus *Dendroctonus* increase fire risk. Drought is another predisposing factor to the build-up of beetle attack. The intermixture of aspen and birch with conifers is now recommended in America, and we are gradually reaching the notion in Great Britain that a conifer–deciduous ratio must be determined and put into practice. All would agree with Dr. Chrystal that such a departure from the pure stand would be as pleasing to the eye as it would be some insurance against fire and insects.

Mr. A. B. Duncan, a landowner and member of the Nature Conservancy, discussed birds in relation to forestry and reached the conclusion that they are of little importance. He confessed to a greater interest in forestry in relation to birds, and described vividly the different associations of birds characteristic of different kinds and phases of forests and plantations. From the pipit–wheatear–merlin association of the bare moor, the very young plantation passes to the short-eared owl–kestrel association when voles are the prey, on to the willow warbler–yellowhammer grouping and then the tit–chaffinch–woodpigeon–crossbill phase. Prof. H. G. Champion, of Oxford, emphasized in discussion that as forestry gets into going order in Britain all these phases will be in evidence, and there should be no impoverishment of the avian fauna by destruction of habitat.

Sir Henry Beresford-Peirse, in summing up, remarked that the fact which crystallized from the symposium was the widely ramifying consequences of interference by man, and that we had much to learn as to how our inevitable continued interference might be wisely done.

SEPARATION OF STABLE ISOTOPES BY ELECTROMAGNETIC MEANS

By W. D. ALLEN

Atomic Energy Research Establishment

DURING the War, the urgent need for large amounts of fissile material led to developments which, under peace-time conditions, would have matured much more slowly, if at all. Among these developments was the electromagnetic separation plant at Oakridge[1], based upon the research and development at Berkeley under E. O. Lawrence. Before the War, the production of ion beams (usually proton beams) of currents up to a few milliamperes was a normal laboratory problem: also the analysis of ion beams in the mass spectrometer, with mean currents of 10^{-10} amp. The production of large amounts of uranium-235, however, can be achieved only by developing much larger currents at high resolution: and the accomplishment of this in the space of two to three years represented a remarkable achievement.

Since the War, some of the plant at Oakridge has been used for the separation or enhancement of a wide range of elements in quantities ranging from one to several hundred grams[2]. At Harwell, a small separator has been operating since 1948 on the separation of milligram quantities of the lighter elements, chiefly boron and lithium. In 1950 a larger plant, based in broad principle on the Berkeley design, began separation. In Denmark, and also in Sweden, two small separators have studied problems chiefly concerned with gaseous isotopes; and in Holland, a medium-sized separator is nearing production.

As regards the description of the American project, some of the fundamental research reports on the ion source have been collected together by Guthrie and Wakerling ("Characteristics of Electrical Discharges in Magnetic Fields." U.S. National Nuclear Energy Series, vol. 1–5); but most of the technical detail is still classified. Some general comments about the quality of the products may, however, be made, together with a description of the types of experiments in which separated isotopes have been used.

Comparison with Other Methods

The performance of the present larger electromagnetic separation plants is that some tens of grams of almost all polyisotopic elements can be separated into enriched isotopes, the enrichment factor of which varies between approximately 20 and 1,000. As compared with other methods, the greatest advantage of this process is its versatility; in effect, the separation can be undertaken in a single stage of any element of which a vaporizable compound can be fed into the ion source. This means that almost all elements, except for a few in the platinum and rhodium groups, can be readily subjected to analysis. The other major advantage of the electromagnetic method is that all isotopes can be collected simultaneously: the range of mass is never very great (calcium, with six isotopes ranging from 40 to 48 has the widest relative spread), so that, provided the system of focusing covers a moderate range of mass, all the isotopes can be collected simultaneously—in theory. In practice, this sometimes involves minor technical difficulties; for the heavier elements, for example, the relative separation of neighbouring isotopes is small, and the close juxtaposition of many collectors is not easy. However, the difficulties are negligible compared with the problems which would be encountered in enhancing, say, some of the intermediate-weight tin isotopes by methods other than the electromagnetic method.

All other major methods of isotope separation which have been put on a practical basis (diffusion; thermal diffusion; electrolysis and fractional distillation; and chemical exchange) depend by contrast on the development of plant in which the enhancement per stage is small but the number of stages is large. Some of the methods have limited versatility; methods of diffusion and thermal diffusion, for example, are generally applicable to elements which have gaseous compounds and few isotopes. In general, however, a special method has to be worked out for each element: chemical exchange for nitrogen, fractional distillation for carbon (as carbon monoxide), thermal diffusion for helium, etc. Once these plants have been set up and developed, however, the running costs are very much less than the costs of producing parallel quantities by electromagnetic separation. Boron, for example, can be separated by electromagnetic methods; but the beam currents are not high, even compared with other elements, in the electromagnetic process, and the costs per gram are very large compared with boron enriched by other methods.

Enhancements

For most applications of separated isotopes, the degree of enhancement (or enrichment) is the most important factor of the separation process. For a two-component system, we define C, the concentration, as the fraction of the isotope compared with the element as a whole; and the isotope ratio as $C/(1-C)$. Then if C_0 is the initial concentration, and C_1 the final, the degree of enhancement is defined as the ratio of the isotope ratios after and before enrichment, that is

$$\left(\frac{C_1}{1-C_1}\right) \cdot \left(\frac{1-C_0}{C_0}\right).$$