The Interconnection of Economic Botany*

And Chemical Industry

By Edward Wheeler, A.C.G.I., A.I.C.

By economic botany is understood the study of those plants, cultivated or wild, which are or may become industrially important. The work of an economic botanist is firstly to investigate the characteristics of plants of ascertained or prospective value with the factors of yield and distribution; secondly, to determine how far the conditions of soil, manuring, and climate influence the yield and quality of the raw material obtained; and thirdly, to endeavor to improve the plant by seed selection or breeding experiments so as to obtain a strain best suited to different localities and ranges of climate, or most immune to diseases.

The aim of economic botany has been recently very tersely summarised by Rendle, who stated that "improvement from an economic point of view implies co-operation of the botanist and plant breeder. The student of experimental genetics, by directing his work to plants of economic value, is able, by means of agriculture and horticulture, to produce forms of greater economic value."¹

A brief consideration of the problems met with in the manufacture of the principal products prepared by the different chemical industries from the raw materials furnished by the economic botanist will indicate how far economic botany has assisted chemical industry, and in what directions further work is desirable.

1. VEGETABLE DYESTUFFS.

One of the chief obstacles to the successful cultivation of the indigo plant, namely, its liability to the disease known as "wilt," brought about by the constantly wet condition of the soil, has been overcome by discovering the most suitable planting areas and seasons², and by breeding a strain of the plant immune to the disease³. Again, the yield of indican has been found to be dependent on the conditions favoring the maximum absorption of nitrogen from the air by the root nodules of the plant⁴.

The recent work of Howard and Davis in India in studying the fermentation changes taking place in the vats, whereby the indican is converted into indigo, has demonstrated the importance of controlling these changes for the production of a higher yield of dye and a more uniform product⁵.

There are many other less important vegetable dyestuffs which by improved methods of cultivation, of breeding and selection of the plants, or of extraction of the coloring matter, might be successfully exploited, as in so many cases the crudest methods of production were still in use when coal tar dyes replaced the natural products.

2. CELLULOSE PRODUCTS.

Cellulose for industrial purposes is obtained from (a) the pecto-celluloses such as cotton, ramie, flax, and hemp, (b) the ligno-celluloses such as jute and the woods, (c) cereal straws and grasses⁶. The problems met with in the cultivation of the plants and isolation of cellulose may be briefly alluded to⁷.

Cotton.—For the successful cultivation of the cotton plant (*Gossypium*) attention has to be paid to the climate and soil, as slight variations in these factors always give rise to variations in the cotton crops from season to season as regards yield of waste on spinning and general quality of the fibre. Recent work in Egypt has aimed at obtaining a pure strain of cotton plant which will yield cotton of greater regularity in length and tensile strength⁸.

Flax.—In the case of flax (*Linum usitatissimum*) study has been devoted to the cultivation necessary to obtain good yields of both fibre and seed,⁹ the latter furnishing linseed oil. Research into the isolation of the fibre from the stems by retting—a fermentation process—has led to the use of pure bacterial cultures in order to obtain fibre of good quality and uniformly.¹⁰

The grasses.—The grasses include the straws, bamboo, and esparto. Interest in the use of straw cellulose¹¹ has recently revived owing to the increased production of cereals in this country, while the utilisation of bamboo cellulose has been carefully studied by Pearson and Raitt in India.¹²

The woods.—The study of the best conditions of growth in relation to climate and soil, rate of growth, pathology of trees and allied investigations carried out by the Forest Departments will prove of increasing value to the cellulose industries.¹³

Paper.—Constant investigations are being carried out by various workers and by the Imperial Institute as to the suitability of various vegetable fibres for papermaking. In time special crops may be cultivated solely for the production of papermaking materials.¹⁴

Cellulose nitrates.—The cellulose nitrates are generally manufactured from waste cotton obtained from the textile factories. For nitration purposes uniformity of cotton is most important. It has been claimed that cotton produced in a cold, wet season does not nitrate so readily as cotton grown under more favorable conditions.¹⁵ Consequently improvements tending to give cotton of greater uniformity will also affect favorably the uniformity of the waste cotton.

Both cotton and wood cellulose have been used as raw materials for cellulose nitrate for artificial silk manufacture, though the "silk" made from the former was found to be superior to that made from the latter.¹⁶

Cellulose xanthate.—Cellulose xanthate (known in solution as viscose) has been most successfully utilised for the manufacture of artificial silk, wood cellulose being the raw material employed.¹⁷ Variations obtained in tenacity and dyeing properties of artificial silk are sometimes ascribed to the original wood cellulose used. A study of the best time of cutting the wood, the best type of tree, and its conditions of growth in relation to the wood cellulose produced from it would be of value in relation to papermaking and artificial silk manufacture.

3. POTASH AND IODINE.

Our knowledge as to the most profitable kinds of waste wood and plants to exploit as sources of potash is very meagre, and there is much need for a systematic survey of the potash content of the ashes from such waste material. Thus it is only recently that the use of bracken and hedge clippings¹⁸ and of banana skins and stalks¹⁹ has been advocated for potash production.

Extended workings of seaweed for potash and iodine have been commenced recently in British Columbia and the United States, but the results so far have not altogether realised expectations.²⁰ As Hendrick has pointed out, a survey of the seaweed supplies and their rate of renewal, the potash and iodine distribution in different varieties, and the best methods of isolating the products, are all questions to be answered if the industry is to hold its own economically.²¹

4. VEGETABLE OILS, FATS, AND WAXES.

Among products prepared from natural oils, fats, and waxes for soaps are required mainly a cheap and plentiful supply of suitable oils, for food products as margarine an almost colorless, odorless, and tasteless oil, for paints and varnishes good drying oils, and for lubricants non-drying or less strongly drying oils. The number of oils satisfying such requirements are many, and the work of the economic botanist is chiefly concerned with the question of increasing the existing sources of supply and studying the physiological processes underlying the nutrition of the plant, and the

effect of fungoid and insect diseases in relation to their oil-bearing capacity.²²

5. VARNISHES AND LACQUERS.

The qualities required of an oil varnish are good color, consistence, drying properties, lustre, durability, and flexibility. These are furnished *par excellence* by the fossil copals; but there seems no reason why, in the future, present day trees should not furnish as good material as the fossil products provided that the economic botanist or forest expert is able to control the methods of cultivation and tapping of the trees, so as to accentuate such qualities in modern resin.²³

There is a considerable need for physiological and chemical research in order to understand the conditions necessary for the formation and exudation of all resins and the changes undergone by them whereby they become of value as raw materials for varnishes and lacquers.

6. INDIARUBBER.

*Hevea brasiliensis*²⁴ has been carefully studied as regards the influence of climate, soils, manuring, straight *versus* forked trunks, etc., on the yield of latex and the best conditions and times for tapping.²⁵ Generally it has been found that plantation rubber lacks uniformity and shows variations in its appearance, especially noticeable in its behavior on vulcanisation.

As Dunstan pointed out in 1914²⁶ the origin, nature, and functions in the tree of the latex, which carries the rubber, are not known precisely.

7. VEGETABLE TANNINS.

The scientific exploitation of the tannin-yielding plants has recently increased; thus in India the investigation of the best species of mangrove for the production of mangrove tannin has been undertaken,²⁷ while in Natal *Acacia mollissima* has been acclimatised and successfully cultivated, good yields of wattle tannin being obtained.

A considerable amount of work has also been done in Sicily,²⁸ India,²⁹ and America on the cultivation of sumac, questions as to the kind of planting, methods and seasons of harvesting, and age of plant being correlated with the yield of tannin, work which might be usefully extended to other sources of tannin.

A research into the physiological processes involved in the formation of tannins in the barks of woods would probably yield useful knowledge as to the best periods and methods of harvesting.

8. (a) SUGARS.

The sugar cane (*Saccharum officinarum*) has been cultivated for many years in tropical countries, and much work has been done in determining the best conditions as regards the choice of suitable fertilisers,³⁰ the selection of the best cane for different soils and climates as in Java³¹ and India,³² yet a recent writer has observed that so little is known as to the essential botanical characters of the various types of sugar cane that experiments on Mendelian lines should be started, as at present no fixity of type can be assured, for even if improved canes are produced they disappear in eight years.³³

The cultivation of the sugar beet (*Beta vulgaris*) has been most successfully carried out in European countries, where as a result of continuous research work, the sugar content has been raised from 5–6% to 14–18%,³⁴ while the ash content has been reduced from 3.8% to 2.7%.³⁵ Experimental agriculture carried out in this country has shown that the beet can be cultivated here as successfully as abroad.^{36 37}

²²Dunstan, J. Roy. Soc. Arts, 1914, 62, 772.

²³Livache and McIntosh, "Manufacture of Varnishes," Vol. I. (1904), Vol. II. (1908), Vol. III. (1911).

²⁴Potts, "Chemistry of the Rubber Industry" (1912).

²⁵Wright, "Hevea Brasiliensis" (1908). Parkin, Science Progress, 1909–1910, 4, 393.

²⁶Dunstan, J. Roy. Soc. Arts, 1914, 62, 770.

²⁷J. Roy. Soc. Arts, 1915, 63, 442; 1917, 65, 492.

²⁸J. Roy. Soc. Arts, 1917, 65, 526.

²⁹Puran Singh J. Soc. Chem. Ind., 1917, 36, 39.

³⁰Taylor, J. Soc. Chem. Ind., 1914, 33, 211. Geerts, J. Soc. Chem. Ind., 1917, 36, 934.

³¹McIntosh, "Technology of Sugar" (1916).

³²MacKenna, J. Roy. Soc. Arts, 1916, 64, 542. Sayer, J. Soc. Chem. Ind., 1916, 35, 552.

³³Molinari, "Treatise on General and Industrial Organic Chemistry" (1913).

³⁴Collins and Hall, J. Soc. Chem. Ind., 1913, 32, 929.

³⁵Golding and Hutchinson, J. Soc. Chem. Ind., 1907, 26, 512.

*Abstract from the Jour. Soc. Chem. Ind.

¹Rendle, Rep. Brit. Assoc., 1916, 478.

²Perkin, J. Roy. Soc. Arts, 1915, 63, 117.

³J. Roy. Soc. Arts, 1915, 63, 716.

⁴Howard, J. Roy. Soc. Arts, 1916, 64, 542.

⁵Chem. Trade J., 1917, 61, 81.

⁶The classification adopted is that given by Schwalbe in "Die Chemie der Cellulose," pp. 392, 459.

⁷Bowman, "The Structure of the Cotton Fibre" (1908).

⁸Balls, Science Progress, 1915–1916, 10, 81; Rep. Brit. Assoc., 1915, 721.

⁹Eyre, Science Progress, 1912–1913, 7, 596. Bull. Imp. Inst., 1917, 15.

¹⁰Matthews, "Textile Fibres" (1913). Rossi, J. Soc. Chem. Ind., 1917, 36, 79.

¹¹J. Soc. Chem. Ind., 1917, 36, 1043.

¹²Phillips, J. Roy. Soc. Arts, 1915, 63, 613. Pearson, J. Roy. Soc. Arts, 1917, 65, 487.

¹³Cross, Beban, and Sindall, "Wood Pulp and its Uses" (1911).

¹⁴Beadle and Stevens, J. Soc. Chem. Ind., 1913, 32, 259.

¹⁵Worden, "Nitrocellulose Industry," Vols. I. and II. (1911).

¹⁶Piest, "Die Zellulose" (1910).

¹⁷Wilson, J. Soc. Chem. Ind., 1917, 36, 820.

¹⁸Leaflet issued by the Board of Agriculture for Scotland, Aug., 1917. Russell, J. Soc. Chem. Ind., 1914, 33, 1216.

¹⁹Ellis, J. Soc. Chem. Ind., 1916, 35, 456 and 521. Billings and Christie, J. Ind. Eng. Chem., 1917, 9, 153.

²⁰Ebaugh, J. Ind. Eng. Chem., 1917, 9, 691; this J., 1917, 710.

²¹Hendricks, Rep. Brit. Assoc., 1915, 771; this J., 1916, 372 and 574.

8. (b) STARCHES.

The chief source of starch for alcohol production is barley, which has been carefully studied with a view to the production of the most suitable kinds for the brewing industry.³⁸ Other sources of starch for alcohol production are potatoes and maize,³⁹ the starch content of which has been materially increased by pedigree selection and breeding experiments for the purpose. Reichert has suggested that by methods of breeding it may be possible to produce plants containing starch with the desired properties for textile works more pronounced.⁴⁰

9. FERMENTATION PRODUCTS.

The study of mycology is of great importance to chemical industry in two respects: firstly, in regard to the study of those fungoid diseases which so often affect the yield and quality of many raw materials; secondly, in regard to the study of those decompositions which can be more readily and cheaply brought about than by other agencies.

Besides alcohol, other products are obtained industrially by means of the bacteria or moulds; thus lactic acid is obtained from sugar by means of *Bacillus Delbrückii* and *B. longissimus*; acetic acid from alcohol by means of *Bacterium aceti*; while the moulds *Aspergillaceae* ferment glucose solutions producing citric and oxalic acids.

Doubtless in the future many more products will be made industrially by such agencies; thus, for example, the study of the fermentation of cellulose waste is almost an unexplored field, while the extended knowledge of well-known fermentation processes may be of great benefit to chemical industry, e. g., in the cases of indigo and leather.

10. FOODSTUFFS.

The conditions affecting the regularity of the growth of wheat are dependent on its supply of food, water, warmth, air, light, the absence of poisons and pests, the possession of straw strong enough to support the plant, all of which have an influence in one direction or another on the strength of the flour.⁴¹ The work of Biffen and Howard on Mendelian lines in producing strains of wheat resistant to rust and giving the best results as regards yielding power and quality may be mentioned.⁴²

The methods involved in the cultivation and production of tea, coffee, and cocoa all necessitate careful control to enable the best quality to be put on the market.

11. PHARMACEUTICAL PRODUCTS.

Alkaloids.—The amounts of the three principal alkaloids present in *Papaver somniferum*, morphine, narcotine, and codeine, vary according to the variety of plant, methods of cultivation, collection, and preparation of the raw materials adopted, questions which are being studied in India at the present time.⁴³ In the case of the mydriatic alkaloids, considerable research work has been carried out in determining the influence of such factors as the effect of fertilisers,⁴⁴ weather conditions, time of collection,⁴⁵ and geographical area,⁴⁶ on the content of alkaloid in the plant. Again by suitable selection the content of quinine in cinchona bark has been raised from 3% to 10%.⁴⁷

There is undoubtedly much work to be done in similar directions with other alkaloids, while the study of the mechanism by which the alkaloids are synthesised in the plants may be of great importance to the plant breeder.⁴⁸

Essential oils.—Work has been carried out recently in India⁴⁹ and by Baker and Smith in Australia⁵⁰ in the direction of surveying trees available as sources of oleo-resin, in studying the most suitable methods of tapping them, and the quality and yields of turpentine obtainable from such resins.

A very careful study of the distribution and quality of camphor obtained from trees of different age has been recently carried out by the U. S. Department of Agriculture⁵¹—work of great importance if the nat-

ural product is to compete successfully with its synthetic rival.

The botanical survey that has been carried out in the eucalypts by Maiden⁵² and the chemical work by Baker and Smith⁵³ might with advantage be extended to many other species.

Generally in the essential oil industry there is much need for correlating the conditions of cultivation and breeding with the quantity and quality of the oil obtained. The metabolic processes underlying the production of the various constituents of the essential oils which in many cases render them so valuable are not understood.⁵⁴ Moreover, the right period for separation of the oil will only be found from a study of the physiological changes taking place in the plant.⁵⁵

CONCLUSION.

Much work has been done by the Rothamsted and other experimental agricultural stations, by the different experimental stations connected with the rubber and sugar industries, by the different forest departments such as those in India⁵⁶ and the United States,⁵⁷ and by the Imperial Institute. Nevertheless, the manufacturer has to deal with raw materials received from a distance and is consequently often out of touch with the cultivation and preliminary preparation of the raw material he receives and is unable to indicate directly to the economic botanist what his special requirements are. Hence the formation of a Raw Material Research Association would seem desirable for studying the problems connected with the cultivation, breeding, and diseases of plants and the furnishing of the supply of raw materials in relation to the requirements of the different chemical manufacturers concerned, a special department or section being formed for each industry or raw material. In this way the interconnection of economic botany and chemical industry would be strengthened to the mutual advantage of science and commerce.

India Utilizing Native Timber

THE diminution of foreign imports into India has forced the Forest Department to exploit local sources of supply. Home-grown timber is now largely used for industrial purposes. Indian walnut has lately replaced the European variety for rifle-stocks; Chir pine has been found equal to that of Oregon for gun carriages, and Himalayan spruce is little inferior to the famous Sitka variety for the manufacture of aircraft. Materials for paper are being successfully utilized, and tar for the Calcutta jute industry is being distilled in the Punjab. A solution of gum from *Bauhinia retusa* has been successfully used as a binding material for making charcoal briquettes. On the whole, the efforts of the Forest Department to utilize indigenous resources have been well conceived, and promise to be financially successful.—*Nature*.

Treatment of Caustic Soda Burns

As the workmen in the kettle room of the caustic soda works are exposed to painful burns at the syphon line faucet while filling the drums as well as in handling the containers of the molten caustic, some emergency aid should be immediately available for treatments. Mr. M. Firsinger read a paper before the National Safety Convention at New York, in which he recommended a two per cent solution of acetic acid as an acid wash, followed by an oil dressing. Absorbent cotton should not be placed in immediate contact with the wound, but can be used on top of a lint-free pad saturated with vaseline, caron oil or other air excluder. Perhaps aluminium acetate would be a preferable form of neutralizer—especially in cases involving the eyes and lips. Aluminium soap would also be preferable to the lime water emulsions.—*Chem. and Met. Eng.*

Photographic Method for the Examination of Eggs

THE method consists in photographing the eggs directly, while illuminated by an arc or ordinary filament lamp. Before the method can be used practically it will be necessary to obtain more data regarding the increase in the volume of the air chamber in eggs on keeping and the effect of temperature, moisture, pressure, etc. on the same. The method appears to be useful for the examination of eggs preserved in cold-store, but would probably be difficult to apply to eggs pickled in sodium silicate, paraffin wax, limewater, etc.—*Note in Jour. Soc. Chem. Ind. on a paper by G. A. Le Roy in Am. Falsif.*

⁵⁰Maiden, "Critical Review of the Genus Eucalyptus," Parts I.—X., 1909.

⁵¹Baker and Smith, Rep. Brit. Assoc., 1915, 97; Rep. Brit. Assoc., 1916, 201.

⁵²Holmes, Rep. Brit. Assoc., 1916, 508.

⁵³Perf. and Essent. Oil Rec., May, 1917.

⁵⁴J. Soc. Chem. Ind., 1917, 36, 951.

Fat from Low Forms of Animal Life

DR. P. LINDNER, of Charlottenburg, has taken out a German patent (*Chemiker-Zeitung*), for obtaining fat from low forms of animal life. By populating suitable waste material with these minute forms he obtains material from which fat may be extracted. As examples he mentions decaying mushrooms and non-edible fungi, putrefying meat, gutter refuse, etc., grass and spoil hay, masses of dead leaves infested with plant-lice, and stale yeast. Dr. Lindner further states that certain materials may be inoculated with the germs of bacteria or micro-fungi and cultivated. The mass of prepared material is triturated and mixed with water, then heated, and the fat skimmed off; or it may be recovered chemically by treating the triturated mass with a solvent.

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