material considered. The scope is rather wide, however, and frequently the more interesting and striking features are emphasized. Thus attention is directed to the noteworthy cases of insect pollination in the fig and the *Yucca*. Similarly, the spectacular culturing of fungi by the leaf-cutting ants of the tropics and the courting home of the bower bird are described.

The aim of the author is to emphasize the functional rather than the morphological approach. In general the details of structure presented are no more than are sufficient for an understanding of the activities of the plants considered. The point of view is conservative, in certain respects perhaps too much so. Care is used in the introduction of technical terms, so that their meaning may be easily comprehended; and a glossary is appended. Selected review questions on the material covered in each of the chapters further enhance the pedagogical value of the book.

In part six, on "The Different Kinds of Plants," the Thallophyta are emphasized comparatively strongly, 103 pages being devoted to this division, and only 53 pages to the remainder of the plant kingdom. But this allotment of pages seems justified, since the other parts of the book deal especially with higher plants.

The style throughout is simple and easy to follow, though occasionally it smacks of the paternal. Elementary students should have no difficulty in using this text; those who do will profit especially by its simplicity and its logical presentation.

A Textbook of General Botany. By RICHARD M. HOLMAN and WILFRED W. ROBBINS. xiii + 626 pp. 463 figs. 3d edition. John Wiley and Sons, New York. 1934. $4.00.

THE third edition of this popular text-book obviously merits the approval with which the two previous editions were received. A little more than half of the book—Part I—is devoted to "The Structure and Physiology of Seed-bearing Plants." The first chapters deal with topics of wide import. Then follow chapters on the cell and on the nature and functions of the plant organs. Each of these is executed with exceeding care and thoroughness. A chapter of 63 pages, for instance, deals with the structure and physiology of the stem; one could hardly find a clearer and more concise treatment of the gross features, development, histological characters and physiology of the stem. The discussions of the other organs are equally good. Chapter 8, for example, deals with the fruit, seed and seedling in masterly fashion. The concluding chapter of Part I, on the "Relation of the Plant to its Environment," contains an excellent treatment of the conditions to which the plant is exposed, in addition to presenting the rather difficult subjects of plant invasion and plant succession.

Part II is a survey of the plant kingdom. The important groups are presented in clear, almost diagrammatic fashion. The authors include a fairly limited number of forms—for a large book—and present them in considerable detail. This makes for ease of understanding. In the chapter on the Spermatophyta the tendencies in the evolution of the flower are traced, and some of the possible relationships are indicated by means of charts. The concluding chapter deals with evolution, heredity and fossil plants. Modern literature has received consideration in the preparation of this treatise, and reference books are listed in the appendix.

Throughout, the style is simple and direct; there are frequent enumerations of significant points, and summaries are rather extensively introduced. Also, boldface type and paragraph headings facilitate the use of the book. These features no doubt are in part responsible for the wide-spread popularity of this text. Unusual care has been taken in the preparation of the original illustrations, so that they are diagrammatically clear and well labeled; those that are borrowed have been judiciously selected. These many virtues make this text an outstanding one; it covers the field of modern botany in clear, concise fashion.

The subject is treated similarly, but much more briefly, in "Elements of Botany" by the same authors.

EDWIN B. MATZKE
SAM F. TRELEASE
COLUMBIA UNIVERSITY

SPECIAL ARTICLES

CHEMICAL RELATIONSHIPS BETWEEN COMPOUNDS OF PHYSIOLOGICAL IMPORTANCE HAVING THE PHENANTHRENE NUCLEUS

THE following chart summarizes the chemical relationship between numerous classes of physiological compounds as given by investigators in many laboratories at present. About 1769 the main constituent of gallstones was isolated and soon recognized in bile itself. Chevreul gave it the name cholesterine from the Greek *chole,* meaning bile, and *steros,* solid. The name was later changed to "cholesterol" because it was shown to possess an alcoholic hydroxyl group. Sterols have been found in the cells of every class of living being so far investigated. They are especially abundant in nervous tissue of animals. That animals really can synthesize sterols has been demonstrated by ex-

periments with sterol-deficient diets. On diets containing sterols only limited amounts and kinds are absorbed by the gut. In general plant sterols (phytosterols) are not absorbed but the animal sterol, cholesterol, is absorbed. Vitamin D, which has been identified as a sterol, is likewise absorbed by the animal. Ergosterol, a plant sterol, has been shown to be absorbed to a small extent. In the gut there are anerobic organisms which produce coprosterol, the reduction product of the stereoisomer of cholesterol, allocholesterol. This compound has not been found in the animal tissues, although it can be produced in the laboratory by the action of HCl on cholesterol. The normal reduction product of cholesterol is β cholestanol. This is found in the tissues to the extent of from 2 to 3 per cent. of the total sterol.

Strecker in 1848 discovered that associated in the bile with cholesterol were the bile acids, especially glycocholic acid and taurocholic acid. He showed that these could be split by acids and alkalies into cholic acid, and glycine and taurine, respectively. In 1919 Windaus oxidized the hydrocarbon prepared by the reduction of coprosterol to the cholaic acid, the same compound Wieland had produced from the bile acids.

By 1933 Rosenheim and King, Windaus, Wieland, Butenandt and others had agreed that the phenanthrene-cycolpentane structure, now known as the cholane nucleus, met the specifications as the nucleus of the sterols and bile acids from both the physical and chemical points of view.

Upon irradiation of the plant sterol ergosterol, a nearly colorless resinous mass is obtained, from which a crystalline substance, calciferol, has been isolated. This compound has high antirachitic potency. Calciferol was considered to be vitamin D. Chemically, calciferol is isomeric with ergosterol, the change involving a shift in the position of the double bonds.

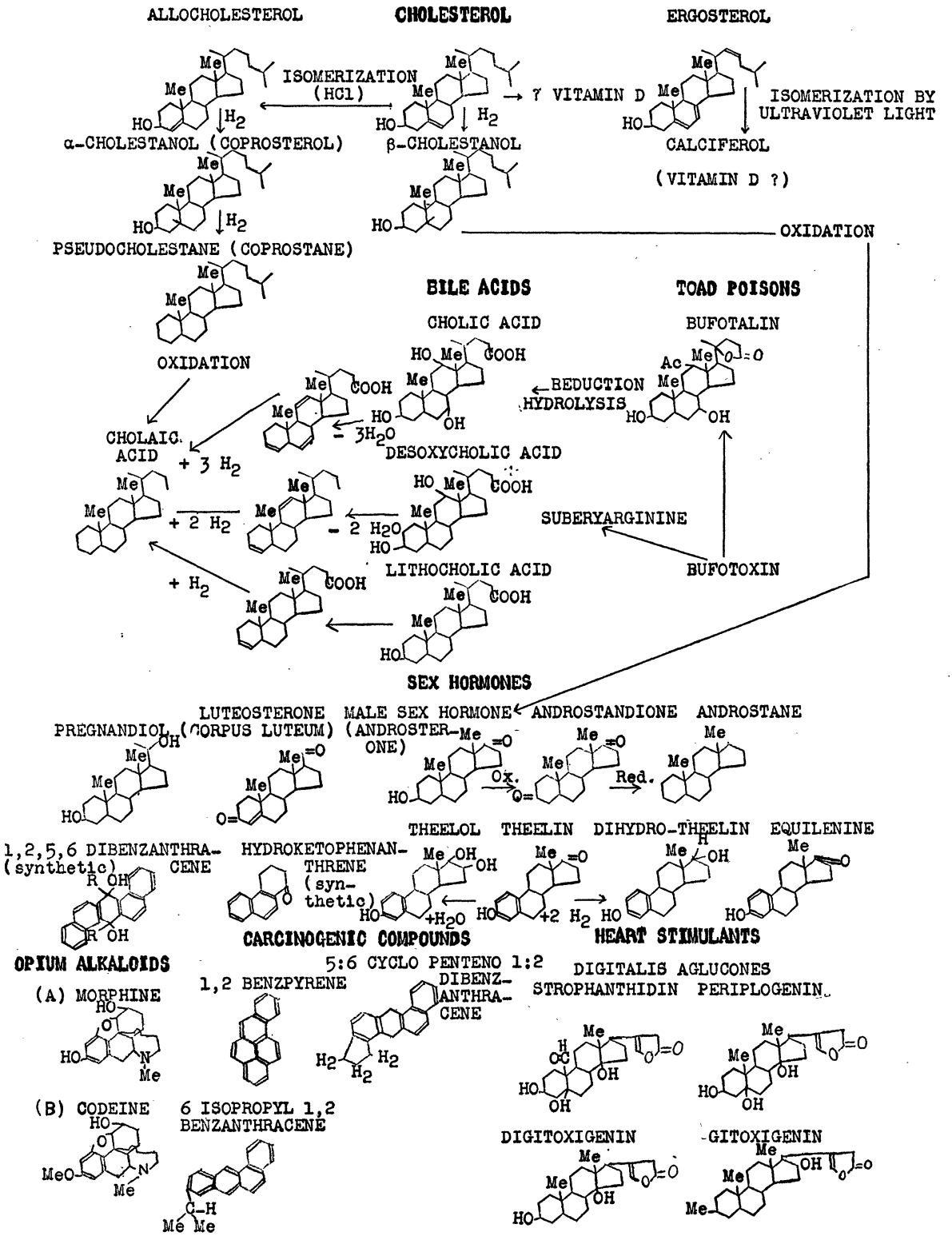
There is increasing evidence that cholesterol itself might be the precursor of an antirachitic substance. In 1933 Ender showed physical and chemical differences between calciferol and the vitamin D concentrate from tuna fish liver oil which contains the same vitamin D as cod liver oil but is 100,000 times more concentrated with the vitamin.

The isolation of a pure crystalline substance highly potent in producing estrus in castrated female rats was announced first by Doisy but independently by Butenandt and Dingemanse in 1929. In 1931 it was established that the compound was a hydroxy-ketone; Doisy named it "theelin." Marrian in 1930 isolated from pregnancy urine a slightly different compound in crystalline form, also active, which proved to be a trihydroxy compound whose formula differed from that of theelin by one molecule of water. It was called "theelol." Butenandt in 1931 showed that the two were present in the original urine and that theelol could be dehydrated to theelin by laboratory methods. On the basis of further chemical studies Butenandt recognized the similarity in properties between these compounds and the sterols. In 1931 he assigned a tentative formula for theelin and theelol on the basis of the old sterol nucleus. By the time the new sterol nucleus was accepted it was only necessary to add the groups and double bonds to write the present formulae for these compounds.

In 1934 Butenandt crystallized the male hormone and obtained a series of derivatives which suggested it to be in the class of compounds as theelin and theelol. It has been called "androsterone." Recently Ruzicka has synthesized the male hormone. It has the same skeleton as the female hormone but differing in the saturation of one ring and the presence of a methyl group. The hydroxyl is alcoholic rather than phenolic, as in the female hormone. Together with androsterone, in the male urine is the corresponding hydrocarbon androstane, but this is physiologically inert.

The corpus luteum secretes luteosterone, whose function it is to bring about changes in the uterine mucosa so that the ovum may become imbedded. This hormone has likewise been identified as having a phenanthrene cyclopentane nucleus.

Soon after the discovery of the relation of the sex hormones to the phenanthrene nucleus Cook and Dodds decided to test the estrogenic properties of organic compounds whose structure resembled the sex hormones. Phenanthrene itself was completely inactive, but the partly reduced compound 5, 6, 7-hexahydro-8-ketophenanthrene was found to possess definite estrogenic activity. When this compound was injected in doses of 100 mg into castrated rates, it was found that within 40 hours full estrus had developed. It produced puberty in immature females. Another series of compounds investigated were the derivatives of 1, 2, 5, 6-dibenzanthracene. The activity depends on the substituted groups. If the R's are both propyl and activity is 40 times that of the diethyl and 400 times that of the unsubstituted compound, and is even more active than theelol itself, Cook and Dodds showed that these compounds not only produced estrus but gave the positive plumage tests on capons. This test is based on the fact that the brown leghorn capon retains its male plumage and if large doses of theelin are injected subcutaneously the plumage changes from that of the male to the female. Aschheim and Hohlweg in 1933 showed that by the extraction of a wide variety of bituminous substances, certain coals and mineral oils, products were obtained which possessed estrogenic activities. Of great importance is the fact that phenanthrene and many of its derivatives are present in bituminous material.


ALLOCHOLESTEROL
CHOLESTEROL
ERGOSTEROL
ISOMERIZATION (HCl)
? VITAMIN D
ISOMERIZATION BY ULTRAVIOLET LIGHT
α-CHOLESTANOL (COPROSTEROL)
β-CHOLESTANOL
CALCIFEROL
(VITAMIN D ?)
PSEUDOCHOLESTANE (COPROSTANE)
OXIDATION
BILE ACIDS
TOAD POISONS
CHOLIC ACID
BUFOTALIN
OXIDATION
REDUCTION HYDROLYSIS
CHOLAIC ACID
DESOXYCHOLIC ACID
SUBERYARGININE
LITHOCHOLIC ACID
BUFOTOXIN
SEX HORMONES
LUTEOSTERONE (CORPUS LUTEUM)
MALE SEX HORMONE (ANDROSTERONE)
ANDROSTANDIONE
ANDROSTANE
PREGNANDIOL
Ox.
Red.
THEELOL
THEELIN
DIHYDRO-THEELIN
EQUILENINE
1,2,5,6 DIBENZANTHRACENE (synthetic)
HYDROKETOPHENANTHRENE (synthetic)
CARCINOGENIC COMPOUNDS
HEART STIMULANTS
OPIUM ALKALOIDS
5:6 CYCLO PENTENO 1:2 DIBENZANTHRACENE
DIGITALIS AGLUCONES
(A) MORPHINE
1,2 BENZPYRENE
STROPHANTHIDIN
PERIPLOGENIN
(B) CODEINE
6 ISOPROPYL 1,2 BENZANTHRACENE
DIGITOXIGENIN
GITOXIGENIN

It has been known for a long time that tar workers and chimney sweeps are very often victims of cancer. Many cases of industrial cancer can be traced to tar. In 1915 two Japanese workers demonstrated that on application of tar to the skin of rabbits for from 9 to 12 months symptoms of cancer were produced. Through the work of Kennaway in 1924 and 1925 and Mayneord in 1927 the carcinogenic compounds in tar were identified as belonging to the condensed ring systems, the similar type which was later shown to have estrogenic activity. Cook and Dodds actually found that many of the compounds which had estrogenic activity also had carcinogenic activity. As pointed out by Dodds the same criterion of structure for estrogenic activities seems to hold for carcinogenic activity. There are, however, compounds having carcinogenic activity which do not have estrogenic activity and *vice versa*. A very interesting example is calciferol, which possesses estrogenic activity but not carcinogenic activity. A very potent carcinogenic compound isolated from coal tar is 1, 2-benzpyrene. In a paper last year Rofo showed that rats subjected to ultra-violet irradiation over a period of from 7 to 8 months developed tumors (carcinomas and sarcomas). Accompanying the malignancy there was a local increase in cholesterol in the same regions.

The phenanthrene nucleus is found in the opium alkaloids, morphine and codeine and their derivatives. Work on these compounds is going on in the laboratory of Eddy. The recent investigations of Jacobs and Elderfield have shown the cholane nucleus in the digitalis aglucones.

Among the principles isolated from toad poisons are compounds which have been shown in the laboratories of Wieland and of Chen and Chen to belong to the cholane ring system. Bufotoxin gives on hydrolysis suberyl arginine and bufotalin. The latter on hydrolysis and reduction gives cholic acid.

HAROLD P. LUNDGREN

MEDICAL SCHOOL
UNIVERSITY OF MINNESOTA

THE PRESENCE IN SELF-BLANCHING CELERY OF UNSATURATED COMPOUNDS WITH PHYSIOLOGICAL ACTION SIMILAR TO ETHYLENE[1]

THE characteristic petiolar curvature of the leaves of tomato plants that is produced in the presence of low concentrations of certain substances having carbon-to-carbon double linkages may be used as a highly sensitive qualitative test for the presence of these compounds. Crocker[2] states that the test is sensitive to one part in ten million of ethylene. This test was used in an attempt to ascertain whether or not an unsaturated compound is present in the blanched areas of celery.

The celery used was of the Golden Self-Blanching variety grown in the greenhouse in eight-inch pots. Harvey[3] has pointed out that the appearance of the leaves of this variety is frequently such as to indicate the presence of mosaic virus in the self-blanching leaves. Stalks and leaves were used when in such condition that the stalks were white and the leaves yellow, mottled with green. The tests were conducted in a building in which there were no illuminating gas connections in order to exclude an external source of unsaturated hydrocarbon. In some cases potted tomato plants were used; in others, the severed top of a tomato plant was placed in water and used. Suitable curvatures were obtained by either procedure.

Fifteen to twenty grams of stalks and leaves of Golden Self-Blanching celery were cut into pieces about an inch long without bruising and placed in a desiccator. The desiccator was evacuated at once to a pressure of about thirty millimeters of mercury with a vacuum pump and placed for two hours in an icebox kept at 12° to 14° C. At the end of this time it was connected by means of a one-inch section of rubber tubing to a bell jar containing a tomato plant. The pressure in the bell jar was reduced to half an atmosphere, and the gases contained in the desiccator were forced into the bell jar by filling the desiccator with tap water. Atmospheric pressure was restored in the bell jar, all connections were sealed, and it was allowed to stand for two and one half hours in a warm (25° to 30° C.) place out of direct sunlight. At the end of this time observation was made to determine whether any curvature of the leaves was produced.

In eight out of ten tests made upon celery which was strongly blanched, a marked curvature of the topmost leaf of the tomato plant was produced, with the lower leaves showing progressively less curvature.

The same procedure was carried through with the same apparatus but without the blanching celery. In no case was the characteristic curvature observed. In another series of experiments grass-green Winter Queen celery was used in place of the naturally blanching celery, with the result that no curvature was produced. This indicates that only celery which is in the blanching condition produced detectable amounts of the substance responsible for the curvature.

Since little was known as to the specificity of this test for unsaturation, a number of compounds were tested to determine whether or not they would produce the reaction. Propylene, butylene and

[1] Published by permission of the director of the Agricultural Experiment Station as Journal Series Paper No. 1337.

[2] Wm. Crocker, SCIENCE, 75: 1948, Suppl., p. 11. 1932.

[3] R. B. Harvey, Minn. Agr. Expt. Sta. Bul. 222, 1925.