tions, some in two colors, and a pair of colored spectacles is provided for use with the anaglyphs. The pocket also contains a colored self-folding dodecahedron and a set of cards for mathematical movies. Perhaps "visual mathematics" describes the general character of the recreations. Wisely, the author has refrained from attempting to teach anything, although any one who can turn the pages without learning something must be singularly stupid. As in all good recreations, the concealed mathematics sometimes lies very deep. In this sense the book is scientific. But it can be enjoyed by any one with a grammar-school education.

As the contents are so unusual, we give a partial summary of the topics touched so lightly and so effectively by the author (who, by the way, is a distinguished mathematician). We find: dissections of rectangles; noughts and crosses; the slide rule; chess problems, Euler's 36 officers, the 15 puzzle; musical scales; simple nomograms; the golden section, Fibonacci's sequence and phyllotaxis; tesselations; the triangle of forces; Peaucelier's linkage; anaglyphs; straight-edge constructions, roulettes, cams; Minkowski's lattice theorem; the limaçon, conics, the tractrix; space-filling curves; the regular solids, crystals, densest packing, soap-bubbles; orthodromes and loxodromes; ruled surfaces; the resolution of cusps on skew curves; topological problems—unicursal patterns, the bridges of Konigsberg, knots, Möbius' strip, existence of a bilateral surface with a knotted edge, the map problem for a torus; Pascal's triangle and the "board of fortune," the Gaussian distribution—amusingly illustrated by an experiment on digitalized frogs, which inspires the author to rechristen the normal curve "the frog-line"; the law of biologic growth, and finally, a somber mortality graph for the U. S. in 1910. Scholarly historical and mathematical notes (184) conclude this most fascinating book. It should perform a genuine service by popularizing mathematics.

E. T. BELL

SPECIAL ARTICLES

CHARACTERIZATION OF GONADOTROPIC HORMONES OF THE HYPOPHYSIS BY THEIR SUGAR AND GLUCOSAMINE CONTENT[1]

CHEMICAL purification of the anterior pituitary hormones has been impeded by their protein nature and by time-consuming bioassays. In the case of the gonadotropic hormones, the situation is further complicated by their established interrelations. Chemical differences in these hormones traced by quantitative analytical routine would naturally prove a boon in purification efforts. Thus the purification and crystallization of insulin speedily followed the discovery of the high sulfur content of this hormone.

It has recently been found[2, 3, 4] that gonadotropic preparations from the pituitary as well as from other sources are rich in *carbohydrate*. We therefore determined the carbohydrate content (orcine method) of the 40 per cent. alcohol extracts of acetone dried sheep pituitaries which served as our starting material, and of purified FSH and ICSH fractions prepared therefrom. The method of fractionation was based on salting-out procedures[5] and subsequent acid-acetone fractionation. When assayed in our hypophysectomized female rats the total M.E.D. of the best FSH and ICSH preparations was between 0.005 mg and 0.01 mg. The starting material contained about 9 per cent. carbohydrate. FSH fractions have a high carbohydrate content (10.3 to 13.1 per cent.) increasing with purification; ICSH fractions[6] a conspicuously lower carbohydrate content (5.4 to 3.6 per cent.), decreasing with purification. All other available hormone fractions from the pituitary showed a low carbohydrate content (see table 1). Although, as mentioned, FSH fractions have an increasing carbohydrate content with increasing purity, a high carbohydrate content in any pituitary fraction can not be taken as a measure of its FSH potency, for inert proteins isolated from FSH mother-liquors had a content of 19 per cent. carbohydrate.

In search for a more specific chemical characterization of gonadotropic hormones, *glucosamine* was determined by the Elson-Morgan method. Gonadotropic fractions contained more glucosamine than any other pituitary preparations investigated. Glucosamine increased with the increasing purification of both FSH and ICSH. The best FSH contained 8 per cent. glucosamine, ICSH 3.8 per cent., while inactive fractions contained approximately 3 per cent., thyrotropic hormone approximately 3 per cent., growth hormone 1.8 per cent. and lactogenic and adrenotropic no glucosamine. Thus glucosamine determination may well be taken as a measure of gonadotropic potency in pitui-

[1] Aided by grants from the Board of Research of the University of California and Rockefeller Foundation of New York.

[2] M. Hartman and F. Benz, *Nature*, 142: 115, 1938.

[3] G. Fleischer, E. Schwenk and K. Meyer, *ibid.*, 142: 835, 1938.

[4] S. Gurin, C. Bachman and D. W. Wilson, SCIENCE, 89: 62, 1939.

[5] H. Jensen, M. E. Simpson, S. Tolksdorf and H. M. Evans, *Jour. Biol. Chem.* (in press).

[6] Attention must be drawn to the very striking difference in the carbohydrate content of pituitary ICSH (3.6 per cent.) and of chorionic ICSH—that in pregnancy urine (ca 18 per cent.).

TABLE 1

Pituitary fractions	Carbohydrate, per cent.	Glucosamine, per cent.
40 per cent. Alcoholic Extract of Sheep Pituitary Powder	9.2	3.0
FSH		
(IF66A)	13.1	8.1
(IF18)	10.3	7.8
ICSH		
(L49B)	3.6	3.8
(L45DI)	5.4	5.8
Thyrotropic hormone		
(Schering)	2.9	3.5
(U89OK)	1.2	2.5
Growth hormone		
(DAP14)	2.7	1.8
Adrenotropic hormone		
(L16A4)	0.41	0
Lactogenic hormone		
(L16L4)	0.25	0
Inert globulins	3.6	2.7
Inert albumins	19.1	3.7

tary fractions and may prove a useful tool in the purification of these hormones. On the other hand, the absence of glucosamine in our adrenotropic and lactogenic preparations is important further evidence that gonadotropic hormones do not contaminate these preparations.

While from the foregoing it is evident that carbohydrate determinations alone will not differentiate gonadotropic from other pituitary fractions, they are extremely useful when employed in conjunction with glucosamine determinations. Thus, glucosamine content enables one to differentiate between gonadotropic and other fractions from the pituitary, while carbohydrate content gives the clue as to the particular gonadotropic fraction with which one may be dealing. Though future research may modify the values for either hormone, we can safely state that a glucosamine-rich pituitary fraction will be mainly FSH if it contains more than 12 per cent. carbohydrate, and mainly ICSH if it contains less than 4 per cent. of the latter.

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A SELECTIVE ACTION OF URINE AND SERUM FROM PATIENTS WITH MALIGNANT TUMORS ON EMBRYONAL AND NEWLY GROWING TISSUES

SOME two years ago there came for examination a young man of twenty-four, who had a tumor, a large embryonic cancer, of the right testicle. His urine, injected into a virgin rabbit, gave the characteristic Ascheim-Zondek reaction. The tumor was removed, and for about a month the reaction was absent. It then returned and with the appearance of metastases later on, the reaction became stronger. Being curious to see what effect this patient's urine would have on the ovaries, 20 cc were injected daily, intravenously, into a 12-day pregnant rabbit. On the fifth day the animal aborted. As this was unexpected, the urine was injected into three other pregnant rabbits, with the same result as in the first.

It was thought that the embryonic character of the tumor was the important factor, and accordingly urines of patients with tumors of corresponding types —dysgerminoma of the ovary, teratoma of the testicle and the Wilms tumor—were tested. These all produced abortion. The urines of a large number of patients with other types of malignant tumors were then tested, and in all instances abortion occurred, usually within a period of five days. Blood serum of patients whose urine had the abortifacient effect also was effective. As a control the urine or serum of a considerable number of normal individuals and ward patients free of malignancy was injected, with negative results.

The uterine changes which are produced are striking. With daily injections of the urine, there occurs, starting at the inner border of the decidual cells, a progressive placental necrosis associated with infiltration of inflammatory cells. The zone of necrosis becomes increasingly broadened until it involves the entire embryonal mass on the decidua. With the removal or absorption of the foetal structures, the uterus eventually returns to a normal state. The foetus in its early period undergoes rapid loss of its structural form. In late pregnancy it is expelled without marked change in its structure.

In addition to the action of the urine on the placenta and foetus other effects have been noted. When injected into non-pregnant rabbits, changes were found in the ovaries. These consisted of definite degeneration or destruction of the graafian follicles, especially in the granulosa cell portion, the ovaries finally becoming small and sclerotic. Further, when injected into male rabbits, the testicles showed degeneration or complete absence of the spermatogenic processes.

In some other experiments the urine was injected into rats which had been grafted with No. 256 Walker carcinoma. The usual course of such tumors is that after a certain period of growth, necrosis and sloughing occur, this beginning centrally and only gradually extending to the periphery. The process is not of a hemorrhagic nature but of a suppurating type. In the urine-treated rats a different picture was seen. Necrosis occurred, but, instead of beginning in the center of the tumor, began at the periphery and in-