lated by Robison and Morgan[9] from the products of yeast fermentation.

The enzyme has been only partially purified and still contains the enzymes which transform glucose-6-phosphate into glucose-1-phosphate and into fructose-6-phosphate, but the most simple explanation of the chemical changes observed is the equation

UDPG + glucose-6-phosphate ⟶ UDP + trehalose phosphate

(9) R. Robison and W. T. J. Morgan, *Biochem. J.*, **22**, 1277 (1928).

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PATHWAYS OF GLUCOSE CATABOLISM[1]

Sir:

The catabolism of glucose via the Embden–Meyerhof glycolytic pathway would be anticipated to result in the simultaneous contributions to carbon dioxide of carbon atoms 1 and 6 of glucose. By an alternative oxidative pathway via 6-phosphogluconate,[2] known to occur in various biological systems, the appearance of C-1 as carbon dioxide would precede that of C-6.

Glucose-1-C^{14} and glucose-6-C^{14}, the latter kindly supplied by Dr. John C. Sowden, have been compared as precursors of $C^{14}O_2$ when incubated with rat diaphragm sections, kidney slices and liver slices. The experimental conditions were identical with those described.[3] No significant differences in radiochemical yields of $C^{14}O_2$ between the two substrates was noted with diaphragm slices. The ratio

$$\frac{\text{Yield of } C^{14}O_2 \text{ from glucose-6-}C^{14}}{\text{Yield of } C^{14}O_2 \text{ from glucose-1-}C^{14}}$$

is close to unity. With kidney slices, the value of this ratio is approximately 0.9. With liver slices the mean value of this ratio is 0.36.

From studies[3] in which glucose-1-C^{14}, uniformly labeled glucose-C^{14}, lactate-1-C^{14}, lactate-2-C^{14} and lactate-3-C^{14} were compared as precursors of $C^{14}O_2$, no evidence was found supporting the occurrence of a non-glycolytic pathway in rat diaphragm sections. With kidney slices the data suggested the presence of an active non-glycolytic pathway, whereas with liver slices it appeared that the bulk of the carbon dioxide derived from glucose arose by a non-glycolytic route. A quantity, E_{max}, was defined as the maximal contribution of the glycolytic pathway to the over-all conversion of glucose to carbon dioxide. This was calculated to be 0.91, 0.72 and 0.23 for diaphragm, kidney and liver, respectively. These quantities are to be compared with the ratios obtained in the present experiments, and satisfactory agreement is to be noted.

The present experimental approach to the question of the estimation of various pathways of glucose catabolism is simpler than that previously employed and its interpretation requires fewer assumptions.

TABLE I

IN VITRO CONVERSION OF GLUCOSE-C^{14} TO $C^{14}O_2$

Tissues were incubated for 3 hours at 37.8° with 5.5 ml. of bicarbonate buffer containing 50 μM. each of glucose, gluconate, lactate and acetate. The location of the isotope in the labeled glucose is indicated below. Radiochemical yields of $C^{14}O_2$ are calculated per 500 mg. of tissue.

Tissue	Radiochemical yield of CO_2 from glucose, % -1-C^{14}	-6-C^{14}	Ratio $\frac{\text{G-6-}C^{14}}{\text{G-1-}C^{14}}$
Diaphragm sections	3.76	4.41	1.17
	3.79	3.54	0.93
	3.63	3.90	1.07
	3.89	3.56	0.92
Kidney slices	5.46	5.03	0.92
	5.38	5.02	0.93
	5.04	4.38	0.87
Liver slices	7.64	2.62	0.34
	7.19	2.46	0.34
	6.76	2.14	0.32
	10.4	3.76	0.36
	8.49	3.57	0.42

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ALKALOID STUDIES. II.[1] ISOLATION OF RESERPINE AND NARCOTINE FROM *RAUWOLFIA HETEROPHYLLA* ROEM. AND SCHULT.

Sir:

Extracts of the Indian plant *Rauwolfia serpentina* Benth., characterized by an abundance of alkaloids,[2] have been used for some time in India for the treatment of hypertension and other clinical conditions.[3] Acute interest was created by the recent report[4] of the isolation from *R. serpentina* of a crystalline alkaloid, named reserpine, possessing pronounced sedative and hypotensive properties.[5] Several *R. serpentina* extracts of varying degrees of purity are already being employed clinically in this country.

At least one *Rauwolfia species*—*R. heterophylla* Roem. and Schult.—is indigenous to Central and South America and in connection with our present investigations of natural products from Latin American sources it appeared of interest to examine this plant. Such a study seemed especially pertinent because of the report[6] that the Guatemalan *R. heterophylla* ("chalchupa") contains two amorphous alkaloids—chalchupine A and B (m.p. (?) *ca.* 170 and 240°, respectively)—to which were assigned the rather implausible formulas $C_{14}H_{21}N_3O_{12}$ and $C_{15}H_{24}N_6O_{11}$. The presence of the

(1) This work was carried out while Dr. Ben Bloom held a Postdoctoral Fellowship from the Atomic Energy Commission.

(2) B. L. Horecker, in W. D. McElroy and B. Glass, "Phosphorus Metabolism," The Johns Hopkins Press, Baltimore, Md., Vol. I, (1951) p. 117.

(3) B. Bloom, M. R. Stetten and D. Stetten, Jr., *J. Biol. Chem.*, **204**, 681 (1953).

(1) Paper I, C. Djerassi, N. Frick and L. E. Geller, THIS JOURNAL, **75**, 3632 (1953).

(2) *Cf.* A. Stoll and A. Hofmann, *Helv. Chim. Acta*, **36**, 1143 (1953), and references cited therein.

(3) *Inter al.*, M. D. Chakravarti, *Brit. Med. J.*, 1390 (1953).

(4) J. M. Müller, E. Schlittler and H. J. Bein, *Experientia*, **8**, 338 (1952). No empirical formula for reserpine was established.

(5) H. J. Bein, *ibid.*, **9**, 107 (1953).

(6) E. C. Deger, *Arch. Pharm.*, **275**, 496 (1937).