our farms is used primarily in shortening and oleomargarine. Of the 369,760,000 pounds of soybean oil consumed in American factories during 1939, census reports show that 201,599,000 pounds were used in the manufacture of shortening. Another 70,822,000 pounds became an ingredient of oleomargarine.

The oil also is used in manufacturing candles, celluloid, core oil, disinfectants, electrical insulation, enamels, fuel, glycerin, insecticides, linoleum, lubricants, oilcloth, paints, printing ink, rubber substitutes, varnish, waterproof goods and food products such as butter substitutes, cooking oil, lard substitutes and salad oils and medicinal oil.

Lecithin is derived from soybean oil and is used as an emulsifier and in the manufacture of candies, chocolate, cocoa, margarine, medicines and in dyeing of textiles. (Egg yolk was the chief source before.)

Dried soybean flour is used in baked products, breakfast foods, candies, diabetic foods, health drinks, ice-cream cones, ice-cream powder, infant foods, macaroni products and as filler in meat products.

Soy sauce and sprouts are produced from dried beans.

Vegetable milk derived from dried soybeans is converted into casein, which is used in paints, size for paper, textile dressing and waterproofing. The meal is used for foods, fertilizers and manufacture of glue and celluloid substitutes.

More than a hundred named varieties of soybeans are grown in the United States, according to the Department of Agriculture. The cultivated soybean is derived from a variety which grows wild in eastern Asia.

The first record of the plant is in the writings of Emperor Shang Nung of China in 2838 B.C. In Chinese mythology, it was first planted by Hou Tsi, one of the Chinese gods of agriculture, and has for centuries ranked as one of the five sacred grains necessary to Chinese civilization—perhaps one of the oldest crops grown by man.

Europe knew of soybeans in the seventeenth century, and they were tried in Germany, England, France and Hungary, but were not commercially important until recent years. In 1898, the U. S. Department of Agriculture began introducing soybeans on a considerable scale.

In the United States, the soybean is grown chiefly in the cornbelt states. Illinois, Indiana, Iowa, Missouri and Ohio lead. Manchuria is the biggest soybean producer in the world. Chosen, Japan and South China rank high, too. In the Far East, foods based on the soybean supply the protein which is obtained from meats in the diet of western people.

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SPECIAL ARTICLES

RED CELL VOLUME CIRCULATING AND TOTAL AS DETERMINED BY RADIO IRON

RADIOACTIVE iron can be given to the anemic dog by mouth or by vein, and by its use we have recorded a rapid construction of new hemoglobin which contains the radio-iron within the newly formed red cells.[1, 3, 4] These red cells are now marked or *labelled by the isotope* and do not give up this iron until the cell breaks up.[2] During the long life of these red cells labelled with radio-iron, they can be used to determine the circulating mass of red cells in another dog whose own cells contain none of the isotope. The red cells containing the radio-iron are given by vein to the dog under study and the degree of dilution noted after varying periods allowed for mixing of the ordinary and labelled red cells (Table I). It is significant that the red cell mass in circulation *determined by this method* averages about 75 per cent. of the value as *computed* by the jugular hematocrit from the plasma volume (dye method).

It is now generally admitted that the dye methods, when properly done, give plasma volume determinations which are accurate, usually within an error of 5 per cent. Jugular hematocrits in the normal adult dog are usually about 50 per cent. If the plasma volume is about 4.8–5.0 per cent. of the body weight, then the *calculated red cell volume* is obviously the same, if one assumes a uniform mixing of red cells with plasma throughout the circulatory tree. It was pointed out many years ago[5] that in the capillaries and arterioles there is much more plasma than red cells—the "axial stream" in small arterioles and venules, and the "still space" in small vessels and capillaries. By means of dye (plasma volume) and carbon monoxide (hemoglobin volume) and Welker method (hemoglobin volume) done in the same dog,[5] it was concluded that the plasma volume was 4.8–5.0 per cent. of the body weight and the red cell mass 3.8–4.0 per cent. of the body weight. These values are in har-

[1] P. F. Hahn, W. F. Bale, E. O. Lawrence and G. H. Whipple, *Jour. Exp. Med.*, 69: 739, 1939.

[2] P. F. Hahn, W. F. Bale, J. F. Ross, R. A. Hettig and G. H. Whipple, SCIENCE, 92: 131, 1940.

[3] P. F. Hahn, J. F. Ross, W. F. Bale and G. H. Whipple, *Jour. Exp. Med.*, 71: 731, 1940.

[4] L. L. Miller and P. F. Hahn, *Jour. Biol. Chem.*, 134: 585, 1940.

[5] H. P. Smith, H. R. Arnold and G. H. Whipple, *Am. Jour. Physiol.*, 56: 336, 1921.

mony with those tabulated below in Table I, in which we believe there is increased accuracy and great convenience for repetition.

Table I shows data from normal dogs except for one anemic (39–299) and one splenectomized (39–194). It is significant that the *red cell volume* as measured by dilution of the injected labelled red cells is almost the same after ten *minutes* as after one to three *days*. Average differences between these two values amount to only 3 per cent., and one hesitates to attach real significance to variations within 5 per cent. This would indicate that in the usual healthy dog the number of *immobilized red cells* in marrow, spleen and other vascular spaces does not exceed 10 per cent. of the circulating mass and may be considerably less.

It has been recognized that the true body hematocrit is always definitely below the jugular hematocrit, but this has always been a theoretical figure. If we divide the determined circulating red cell volume by the sum of it and the determined plasma volume, we arrive at a value for the *average body hemotocrit.* It can be seen in Table I that this is always lower than the hematocrit in the jugular blood, and sometimes considerably so. It follows that the mean hematocrit of the capillaries, arterioles and venules must be decidedly lower than the average body hematocrit shown in Table I.

The last column gives the ratio of the *true* circulating red cell volume and the red cell volume calculated from the plasma volume and jugular hematocrit. The average value of this ratio is 0.77, which means an inherent error of about 25 per cent. in red cell volumes values calculated from the plasma volume.

It is obvious that this method can be used to study human physiology, normal and abnormal. One must have a suitable donor with a large mass of red cells containing radio-iron. This perhaps is not an easy specification, but given a supply of red cells labelled with radio-iron some interesting observations could be made on shock, polycythemia, circulatory failure and other abnormal states.

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TABLE I

COMPARISON OF CIRCULATING AND TOTAL RED BLOOD CELL VOLUMES DETERMINED DIRECTLY AND INDIRECTLY

Dog	Red blood cell volume by radio-iron		Red cell volume calculated from plasma volume	Plasma volume by dye	Wgt.	Hemoglobin level	Jugular hematocrit	Body hematocrit	Ratio red cell volumes†
	Circulating 10 min.	Total 1–3 days							
					kg	gm %	%	%	
36–196	290	280	365	565	12.6	14.5	39	34	0.79
39–307	445	405	500	480	13.5	19.9	51	48	0.89
39–144	255	250	400	485	8.0	15.5	45	34	0.64
39–193	585	680	905	890	17.0	21.5	50	40	0.65
39–88	465	515	615	520	15.0	21.6	54	47	0.76
39–194*	375	...	490	720	17.1	14.6	40	34	0.77
40–149	380	(340)	425	525	10.7	15.1	45	42	0.89
39–299	155	180	170	645	14.5	6.1	21	19	0.91
Averages	370	380	485	605					0.79

* Splenectomized dog. Probable Bartonella infection which caused destruction of injected cells and did not allow a determination later for computation of total red cell volume.

† Ratio of red cell volume determined by radio-iron to red cell volume calculated from plasma dye volume and jugular hematocrit.

THE TURNOVER OF ACID-SOLUBLE PHOSPHORUS IN THE KIDNEYS OF RATS

THE mechanism whereby phlorhizin blocks the reabsorption of glucose by the renal tubules is still unknown. The hypothesis that this effect is due to an inhibition of the phosphorylating mechanism in the kidney[1] was not supported by later studies.[2,3] In order to investigate the possible connection between the phosphorus metabolism of the kidney and the mechanism of glucose reabsorption, the influence of phlorhizin on the exchange of phosphorus in the kidney, using radioactive phosphorus (P^{32}) as an indicator, was studied.

If the reabsorption of glucose in the kidney tubules is dependent upon some phosphorylating mechanism, then the formation and breakdown of organic phosphorus compounds must occur at a rapid rate. Hence if phlorhizin exerts its effect upon glucose reabsorption by inhibiting the phosphorylating mechanisms, the rate of phosphorus exchange should be diminished.

To test such premises, rats were given intravenous injections of phlorhizin dissolved in 0.1 N NaOH. Fifteen minutes later a solution containing radioactive phosphorus[4] in the form of sodium phosphate was injected subcutaneously. Thirty minutes later the ani-

[1] E. Lundsgaard, *Biochem. Zeits.*, 264: 209, 1933.

[2] E. Lundsgaard, *Skand. Arch. Physiol.*, 72: 265, 1935.

[3] A. M. Walker and C. L. Hudson, *Am. Jour. Physiol.*, 118: 130, 1937.

[4] For the supply of radioactive P we are indebted to Dr. L. A. DuBridge and Dr. S. N. Van Voorhis, of the Department of Physics, University of Rochester.