the mark and cool the contents of the flask quickly to room temperature and complete the volume to 200 cc. and mix thoroughly. After standing a few minutes the precipitate settles so clearly that 50 cc. of the clear supernatant liquid can usually be pipetted off for titration of the copper which it contains; or the supernatant liquid may be poured through a quantitative filter and 50 cc. of the filtrate pipetted for the titration. The titration should be carried out as recommended by Peters in the article referred to above. At the same time, another 25 cc. of Fehling's solution should be accurately measured into another 200 cc. flask, the volume made up to the mark, and a 50 cc. aliquot pipetted out and titrated for its copper content. The difference between the thiosulfate used for the titration of this 50 cc. and that obtained from the reduction by the solution under investigation gives the thiosulfate equivalent of one-fourth of the copper reduced by the sugar in the aliquot used for the reduction. From these data the maltose content of the digested solution can be computed. From this should be deducted the reducing sugars, calculated as maltose, found in the blank from the same volume of extract as was used for the starch digestion. This gives the maltose produced by the action of the diastases in the volume of extract used. The equivalent amount of maltose reduced by the extract from 1 gram of material can then be calculated, or the data used to calculate the "diastatic strength" of the material to any other basis of comparison which may be selected.

DIVISION OF AGRICUTURAL CHEMISTRY,
AGR. EXPT. STATION, ST. PAUL, MINN.

THE ELIMINATION AND RETENTION OF ARSENIC AS DETERMINED BY THE KOCH-NORTON METHOD.

BY R. ADAMS DUTCHER AND MATTHEW STEEL.

Received January 14, 1914.

A great majority of the investigational work on arsenic feeding and poisoning has been done from the physiological and pharmacological standpoint. It had been noticed by Hunter, Brodie and Home[1] that arsenic, when applied to abraided surfaces, passed to the stomach where a specific action was noted. There are many contributions by Rutter, Hugo,[2] Eulenberg, Geis,[3] and others on the physiological action of the drug. Also Esser, Bintz and Arakie[1] have studied the action of arsenic on the tissue. Orfila, Scolosuboff,[4] Ludwig[5] and Chittenden[6] have worked on the elimination and retention of the drug.

[1] "Poisons, Their Effect and Detection." Blyth, 1906.

[2] *Ibid.*

[3] "Über den Einfluss des Arsens auf den Organismus," *Arch. Path. Pharm.*, **8**, 182.

[4] *Bull. soc. chim. belg.*, **24**, 124.

[5] *Med. Jahrbuch.*, 1880.

[6] *Am. Chem. J.*, **5**, 8.

As Ekeley[1] and others have shown, there is a decided disagreement in the results obtained by the different investigators who have worked on the retention of arsenic in the body. Scolosuboff found the arsenic to be deposited in the largest amount in the spinal marrow; the brain, liver and muscles came next in order. Ludwig, on the other hand, found that the arsenic deposit ran in the following order: liver, kidney, muscle and brain. Chittenden found the greatest amount in the intestines, and the liver, lungs, spleen, stomach and gullet followed in their respective order.

Having used, with much satisfaction, in toxicological work, the Koch-Norton method[2] for the quantitative determination of arsenic in the presence of organic matter, the writers thought that it would be of interest to conduct a short experiment using this method. The method is quite rapid compared to the gravimetric methods and consists essentially in a modification of the Gautier method for the destruction of the organic matter and the subsequent titration of the arsenic with a very dilute iodine solution.

Two dogs were used in the experiment. Dog A was fed 35 milligrams of arsenic trioxide and was killed 24 hours after feeding. The organs were weighed, and analyzed according to the Koch-Norton method. No elimination took place between the time of feeding and killing, consequently all of the arsenic was retained in the body. Upon opening the body, the digestive tract and bladder were found to be absolutely empty, due to the 48 hour fast that the animal underwent previous to the feeding of the drug.

Dog B was also fed 35 milligrams of arsenic trioxide, but was fed and watered in a metabolism cage for 20 days. Urine and feces were collected daily and analyzed. It was found at the end of 20 days that 71% of the arsenic had been eliminated in the urine. In no case, throughout the experiment, was it possible to find arsenic in the feces. On the 21st day Dog B was killed and the same analyses were made as in the case of Dog A.

The urine samples were evaporated to moist dryness and the organic matter destroyed with as small amount of sulfuric acid as possible. In some instances small amounts of nitric acid were added to assist in the oxidation. When nearly all of the sulfuric acid had volatilized, each sample was made up to volume and aliquot parts were taken for analysis. The portions were neutralized with sodium bi-carbonate and titrated with iodine in the usual manner.

The iodine solution was very dilute and was standardized against resublimed arsenic trioxide. One cubic centimeter of the iodine solution

[1] THIS JOURNAL, **35**, 483.

[2] *Ibid.*, **27**, 1247.

was made equivalent to 0.00034 g. of As_2O_3. Blanks were run in every case, on the reagents.

In the case of the vital organs and feces, a different procedure was necessary. The weighed samples were placed in large casseroles and covered with nitric acid. A few cubic centimeters of sulfuric acid were added and the mixture was allowed to digest on a steam bath. It was necessary to exercise care at this point in order to prevent loss of sample due to rapid oxidation. Stirring was found to be necessary during the first part of the heating.

After the acid mixture had completely liquefied, it was allowed to evaporate to a syrupy consistency, care being taken to prevent carbonization. The liquid was finally heated over a small flame to drive off the nitric acid. Upon dilution with hot water, filtering and washing, the arsenic was dissolved and removed from a large part of the organic matter. The filtrate was evaporated to small volume, digested with sulfuric acid in Kjeldahl flasks and the arsenic determined as in the urine samples.

The following tables show the order in which the arsenic was retained in the various organs:

TABLE I.—SHOWING PER CENT. As_2O_3 IN THE ORGANS.

	Dog A. 24 hours after feeding.			Dog B. 20 days after feeding.	
1.	Spinal cord	0.0017	1.	Heart	0.0004
2.	Heart	0.0011		Brain	0.0004
3.	Muscle	0.0010	2.	Liver	0.0002
	Brain	0.0010		Intestine	0.0002
4.	Liver	0.0009		Spinal cord	0.0002
5.	Intestine	0.0008		Spleen	0.0002
	Spleen	0.0008		Muscles	0.0002
6.	Stomach	0.0006	3.	Kidney	0.0001
7.	Lung	0.0004		Stomach, Lung, Blood, Skin	None
	Kidney	0.0004			
8.	Blood	0.0002			
9.	Skin	0.0001			

TABLE II.—SHOWING GRAMS As_2O_3 RETAINED IN THE ORGANS.

	Dog A. 24 hours after feeding.			Dog B. 20 days after feeding.	
1.	Muscle (305 g.)	0.0030	1.	Muscle (268 g.)	0.0005
2.	Liver	0.0027	2.	Liver	0.0008
3.	Intestine	0.0017	3.	Intestine	0.0006
4.	Blood	0.0016	4.	Heart	0.0004
5.	Skin	0.0014	5.	Brain	0.0003
6.	Heart	0.0009	6.	Kidney, Lung, Spleen, Skin, Stomach, Blood, Spinal cord	None
7.	Stomach	0.0007			
8.	Brain	0.0007			
9.	Spinal cord	0.0003			
10.	Spleen	0.0003			
11.	Lung	0.0003			
12.	Kidney	0.0001			

As was expected, no arsenic was eliminated at any time in the feces. The arsenic that was not eliminated was absorbed rapidly by the tissues.

The elimination ceased to be quantitative so far as the Koch-Norton method was concerned, when about 71% of the arsenic had been eliminated.

Our results indicate that, when arsenic is not fed in sufficient amount to disturb metabolism, it is eliminated in about 15 days.

Although the total weight of muscle was not known, the analyses show that the muscles retained the largest amount of arsenic in grams.

In the case where the dog was killed 24 hours after feeding, the arsenic was found in the largest quantity in the muscle, liver and intestine, in their respective order. The same holds true after an elimination of 21 days has taken place.

When the dog was killed 24 hours after administration of the poison, the blood holds fourth place and the skin fifth place in retention of the drug. After an elimination of 21 days they have had sufficient time to eliminate the arsenic to the point where it could not be determined by this method.

Another interesting fact is brought forth in the table on grams of arsenic retained, namely that the heart, although one of the smaller and least heavy organs, holds sixth place 24 hours after feeding and fourth place at the end of 21 days.

The spleen, spinal cord, lung and kidney are lowest in grams of arsenic retained in both cases. Of course the last mentioned organs hold higher positions in the percentage table but owing to their small weight they do not play an important part in the storing up of the drug in the system.

The tendency of the blood and the skin is to eliminate the poison as rapidly as possible.

DEPARTMENT OF PHYSIOLOGY, UNIVERSITY OF MISSOURI.

NEW BOOKS.

Vom Kohlenstoff. Vorlesungenen über die Grundlagen der reinen und angewandten Chemie. By HENRI LECHATELIER. Translated by Barschall with a preface by F. Haber. Halle: W. Knapp, 1913. xiv + 324 pp. Price M. 18.

This interesting volume is a translation of the first eighteen lectures of LeChatelier's course in general (*i. e.*, physical) chemistry. They appeared in French in 1908, and the changes from original are very few in number.

In his preface, the author calls attention to the difference between the traditional modes of instruction in physics and in chemistry. In the former science, we deal with facts that can be generalized, and omit the details concerning single substances. We teach the laws and relations, and omit the numerical values of densities, specific heats, and other constants.