TABLE IV.

Experiment No.	Vaginal applicator temperature		Rectal temperature		Urethral temperature		Duration	
	Initial	At end	Initial	At end	Initial	At end	Hr.	Min.
1	98.	52.	98.	73.5	98.	72.	1	
2	95.	52.5	99.	82.	97.5	90.5	1	25
3	90.	51.	97.	78.	97.	82.		30
4	98.	52.	98.	73.5	98.	93.	1	
5	93.5	47.5	96.5	73.	97.3	87.5	2	20
6	71.5	47.	99.2	70.	99.2	91.		50

the urinary bladder. During the subsequent 40 minutes the bladder temperature diminished from 91.8° to 86°F.

Conclusions. These observations show that it is possible to cause a substantial lowering of the temperature of the tissues of the living human body at a distance from a cold applicator placed in contact with the body surfaces. An explanation for this phenomenon is the occurrence of vasoconstriction and conductive cooling. These findings offer a basis for the therapeutic application of cold and indicate possibilities for its more extended use in the treatment of disease.

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Blood Volume Changes in the Mammary Gland.*

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In the studies of the metabolism of the mammary gland made by arteriovenous differences either no cognizance has been taken of blood volume changes or the data taken have been corrected on the basis of such changes. Blackwood and Stirling[1] were unable to demonstrate any blood volume changes in the mammary gland from their analyses of bloods for iron hemoglobin and cell volume. Lintzel[2]

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1 Blackwood, J. H., and Stirling, J. D., *Biochem. J.*, 1932, **26**, 357.

2 Lintzel, W., *Z. Zucht.*, Reihe B., 1934, **29**, 219.

from determinations of hemoglobin by the Newcomer method observed no appreciable concentration changes between arterial and mammary venous bloods. Similarly Graham, Jones and Kay[3] from hemoglobin values obtained by the Palmer method reported that water losses to the mammary gland were insignificant. Graham, Peterson, Houchin and Turner,[4] however, observed blood volume changes by the use of Newcomer's method and corrected their data upon nitrogen partition of the blood accordingly but presented no data as to the magnitude of the blood volume changes.

In a study of blood precursors of milk, hemoglobin determinations were made in triplicate by the method of Evelyn[5] using the Evelyn photoelectric colorimeter. Blood fats were determined by Allen's[6] method. The blood sugar was determined by the Shaffer and Somogyi[7] method. Large variations in blood volume were observed which will, in part, explain some of the conflicting results that have been reported.

Arterial and venous bloods were drawn simultaneously. The arterial blood was drawn in a manner similar to that described by Graham, Kay and McIntosh.[8] The venous blood was taken from the subcutaneous abdominal mammary vein. Errors due to dilution were avoided by drawing the same quantities of arterial and venous blood into vessels oxalated with identical quantities of potassium oxalate. During the drawing of the samples any excitation of the animal was noted and recorded. By using ethyl chloride to anesthetize the skin at the point of venipuncture we were able to obtain a large number of samples from a few animals without exciting them. Likewise, a large number of samples were drawn from animals which were in an excited state. Data are presented in Table I showing the results of this series of experiments. It will be observed that of the 23 experiments reported in which the animals were not excited the blood volume change exceeded 1% in only 3 cases. In 15 of the cases the blood volume change was less than 0.5%, which is within the error of the method. However, an entirely different picture is presented in those experiments in which the animals were

[3] Graham, W. R., Jr., Jones, T. S. G., and Kay, H. D., *Proc. Roy. Soc. London,* Series B, 1936, **120**, 330.

[4] Graham, W. R., Jr., Peterson, V. E., Houchin, O. B., and Turner, C. W., *J. Biol. Chem.*, 1938, **122**, 275.

[5] Evelyn, K. A., and Salter, R. W., 1936, *Proc. Roy. Soc. Can.*

[6] Allen, N. N., *J. Dairy Sci.*, 1934, **17**, No. 5.

[7] Shaffer, P. A., and Somogyi, M., *J. Biol. Chem.*, 1933, **100**, 695.

[8] Graham, W. R., Jr., Kay, H. D., and McIntosh, R. A., *Proc. Roy. Soc. London,* Series B, 1936, **120**, 319.

TABLE I.
Effect of Excitation upon Blood Volume Changes in the Mammary Gland.

No Excitation			Slight or Marked Excitation		
Hemoglobin %		Venous blood volume change, %	Hemoglobin %		Venous blood volume change, %
Arterial	Venous		Arterial	Venous	
10.10	10.10	0.00	10.50	11.32	— 7.81
9.80	9.82	—0.20	10.33	10.82	— 4.74
8.30	8.30	0.00	9.24	9.55	— 3.35
8.23	8.23	0.00	7.80	7.96	— 2.05
8.65	8.63	+0.23	7.34	7.80	— 6.27
8.22	8.39	—2.07	11.40	10.49	+ 7.86
8.65	8.65	0.00	10.34	10.98	— 6.19
7.83	8.21	—4.85	8.39	9.61	— 4.54
8.94	8.94	0.00	6.13	6.44	— 5.06
9.55	9.55	0.00	11.35	11.80	— 3.96
8.55	8.62	—0.90	11.83	11.48	+ 3.89
5.95	5.95	0.00	9.55	9.86	— 3.24
10.77	10.84	—0.65	10.17	10.65	— 4.71
10.83	10.84	—0.09	10.57	9.55	+ 9.65
8.92	8.96	—0.45	8.22	8.36	— 1.70
10.25	10.49	—2.34	9.86	9.52	+ 3.45
10.82	10.78	+0.37	11.23	12.08	— 7.52
8.08	8.08	0.00	13.67	13.46	+ 1.54
9.86	9.86	0.00	12.08	13.83	—14.49
8.87	8.95	—0.90	13.67	14.33	— 4.83
9.55	9.55	0.00	11.15	11.48	— 2.06
7.45	7.52	—0.94	10.84	11.35	— 4.70
8.72	8.79	—0.80	12.48	13.41	— 7.45
Avg 9.00	9.07		10.33	10.70	
Mean deviation		0.643			5.70

either slightly or markedly excited. In all cases the arteriovenous blood volume change was considerably in excess of 1% with a mean deviation of 5.7.

In the majority of cases following excitement the venous blood was more concentrated than the arterial blood. It will also be observed that the average arterial hemoglobin values were higher following excitement than in those experiments where the animal was undisturbed. Due to the fact that the arterial blood concentration does vary more or less independently of the arteriovenous changes in concentration, it is apparent that when arterial and mammary venous bloods are drawn for milk secretion studies they should be taken simultaneously.

The question immediately arises as to what effect excitation and the resulting blood volume changes may have upon the arteriovenous differences of freely diffusible and non-diffusible substances. In the case of blood fats we have been unable to obtain a reasonable value in those cases where the arteriovenous differences were corrected for any considerable blood volume change.

The data presented in Table II represent an attempt to correct for

TABLE II.
Effect of Large Blood Volume Changes upon Loss of Blood Fat to the Mammary Gland as Determined by Arteriovenous Differences.

No change in blood volume	Dilution of venous blood			Concentration of venous blood		
Loss of fat to the gland mg%	Dilution %	Loss of fat to the gland mg%	Corrected loss of fat to the gland mg%	Concentration %	Loss of fat to the gland mg%	Corrected loss of fat to the gland mg%
11.90	7.14	—21.47	—34.61	14.54	35.60	65.00
10.07	9.65	5.25	—11.24	4.71	15.30	24.74
10.30	1.54	—13.9	—16.99	5.10	12.83	18.71
11.07	2.33	3.34	0.44	5.26	19.14	28.25
9.55	2.47	8.38	5.10	5.40	4.80	13.69
10.00	4.40	—18.89	—27.74	4.85	4.00	15.27
9.45	4.14	7.89	1.66	1.70	14.70	19.37
8.83	3.75	9.61	2.38	3.96	7.43	15.38
Avg 10.15	4.43	— 2.49	—10.13	5.69	14.23	25.05

such changes. All of these samples were taken 4 or more hours after milking. In those experiments in which no blood volume changes occurred there was a rather uniform loss of fat to the gland with an average loss of 10.15 mg %. Such was not the case, however, when there was any considerable arteriovenous blood volume change. The fat losses to the gland varied greatly with an extreme range of –21.47 to 35.60. When these values were corrected for blood volume change there was a much greater variation than before.

When the uncorrected and corrected data obtained in the dilution experiments are compared with similar data in the concentration experiments some striking results are noted which seem to offer some explanation for the large variations observed. It will be noted that with a dilution of the venous blood there is either a concentration of fat in the same blood as compared to the arterial blood or the loss of fat to the gland has been diminished. In the dilution experiments there was an average gain of 2.49 mg % of fat in the venous blood which when corrected for this dilution is increased to 10.13 mg %. However, when there was any considerable concentration of the venous blood over that of the arterial the blood fat was always lost to the gland and in quantities far in excess of what one would expect. Averages previously reported by Shaw and Petersen[9] as well as data published herein indicate that the average fat loss to the gland is 10 to 12 mg %. The average fat loss in this case of 14.23 mg % upon correction for concentration becomes 25.05 mg %.

It thus appears that when any considerable quantity of fluid

[9] Shaw, J. C., and Petersen, W. E., *Am. J. Physiol.*, 1938, **123**, 183.

TABLE III.
Effect of Large Blood Volume Changes upon Loss of Blood Glucose to the Mammary Gland as Determined by Arteriovenous Differences.

	No blood volume changes	Large blood volume changes	
	Loss of blood glucose to the gland, mg%	Concentration or dilution (—), %	Loss of blood glucose to the gland, mg%
	11.4	11.20	10.0
	8.0	7.81	13.0
	12.6	4.74	9.0
	8.0	3.35	9.2
	10.0	6.27	12.4
	8.1	— 7.86	15.1
	11.6	— 7.14	13.5
	14.6	3.96	10.4
	12.6	4.71	16.6
	9.4	— 9.65	9.8
	16.0	3.45	16.8
	8.2	4.85	9.0
Avg	10.9		12.1
Mean deviation		6.25	

passes from the blood circulation to the gland or from the gland to the blood circulation it carries fat with it in varying amounts. Evidence is likewise accumulating showing that blood proteins are affected in very much the same way. An even more marked effect of disturbance of the animal than reported herein has been noted by Petersen and Shaw[10] in connection with arteriovenous carbon dioxide and oxygen ratios. Glucose on the other hand appears to pass in and out of the gland tissue with the water rather freely, as will be noted in Table III. The glucose differences reported in this table are similar to a much larger series of data previously reported by Shaw, Boyd and Petersen.[11] The apparent quantity of glucose lost to the gland in cases of blood volume changes does not differ materially from the quantity lost to the gland in those experiments in which blood volume changes do not occur.

Conclusions. 1. Large blood volume changes, not apparent in the undisturbed animal, occur in the mammary gland of the cow following excitation. 2. Arterial and mammary venous differences of non-diffusible blood substances are markedly affected by blood volume changes and cannot be corrected for on the basis of the observed changes in concentration.

[10] Petersen, W. E., and Shaw, J. C., to be published.

[11] Shaw, J. C., Boyd, W. L., and Petersen, W. E., PROC. SOC. EXP. BIOL. AND MED., 1938, **38**, 579.