Knowledge as to the composition of sweat is as yet fragmentary and many points are subject to dispute. Reasons for this are numerous, some of the more obvious being the difficulty of making satisfactory collections, variation in composition of sweat elaborated by different regions of the body, and the fact that exploratory work cannot be done on animals. The subject assumes considerable importance, however, when it is realized that in the tropics and hot deserts sweat production may amount to 5 to 12 liters a day (Dill (8) and Dill et al. (9)) and that this sweat is by no means a simple excretion of a dilute salt solution. If vitamins are lost in sweat, as has been claimed recently, there is a possible basis of support for such claims as that of Mills (22) that vitamin requirements are elevated in hot climates.

This paper is a report on the composition of sweat with special reference to vitamins and some organic substances and to variations in composition of sweat collected from different parts of the body and at different times. Great care was taken in the sampling procedures and in the analytical methods used.

Subjects and Experimental Conditions

All subjects were "normal" young men who were free from known physical defects. Some of the subjects were soldiers of the 710th M. P. Battalion; others were college students. All were moderately active physically but none was in real athletic training.

All of the studies were carried out in the late fall, winter, and early spring, so that the subjects were not acclimatized at the outset. The subjects were studied, and in some cases housed continuously for some days at a time, in an experimental suite with controlled temperature and...
humidity. The majority of the sweat collections were carried out in an environmental temperature of 49° and humidity of about 25 per cent relative saturation. In some cases an equivalent “effective” temperature (Houghton and Yagloglou (15)) was achieved with lower temperatures and higher humidities. Collections were made on resting subjects and on subjects during or immediately following moderately hard work on the motor-driven treadmill. The conditions were generally such as to provoke an average sweat loss of 5 to 8 liters a day. Water drinking was allowed ad libitum. Diet was controlled to insure that standard conditions prevailed. In some cases salt or vitamin intakes were restricted or augmented above normal. In all cases salt, water, and vitamin intakes were measured.

Analytical Methods

Chlorides were estimated by the mercurimetric titration of Cavett and Holdridge (3) and by the Volhard method of Keys (16). Glucose was estimated by the method of Folin and Wu. Lactic acid was determined by the method of Friedemann, Cottonio, and Shaffer as modified by Edwards (11). Urea analyses were made by a modified Folin-Svedberg method. Ammonia was estimated by the same procedure with omission of urease. Creatinine was determined by the method of Folin and Wu modified for use with the photoelectric colorimeter.

Ascorbic acid was estimated by a modification of the Mindlin and Butler technique (23). The analysis for thiamine involved a direct oxidation of the vitamin by means of alkaline potassium ferricyanide. The thiochrome was extracted with isobutyl alcohol and then read in a photofluorometer. Blanks were always run on the same samples without the addition of potassium ferricyanide.

Riboflavin analyses were made both by the microbiological method of Snell and Strong (29) and by the fluorometric method of Conner and Straub (5). Nicotinic acid was determined by the microbiological assay of Snell and Wright (30).

Methods of Sweat Collection

In all cases the skin from which sweat was to be collected was carefully washed with soap and water, rinsed with distilled water, and then dried. Profuse sweating was then induced, the first sweat being quickly sponged off with distilled water and the skin dried before collections were started for analysis.

Sweat from the arm and hand was collected in arm length, duprene gauntlets, without fingers, attached to a 25 cc. Florence flask. The flask was suspended in a bathing cap filled with cracked ice, so that the sweat was chilled and kept cold during the collection period. The top of the gauntlet
MICKELSEN AND KEYS

was tied snugly around the upper part of the biceps. In some experiments arm length, neoprene gauntlets, complete with fingers, were used.

In the first experiments with sweat from different parts of the body the room humidity was elevated, profuse sweating induced, and sweat was collected by scraping the skin with a small beaker or pus basin. Just before each sample was taken in this way the skin was quickly sponged with distilled water and dried. This procedure was relatively satisfactory for the back and chest when sweat production was so profuse that samples were obtained within 2 or 3 seconds after the skin was prepared.

In the later experiments sweat was collected from different parts of the body in gauze bandages covered externally with dental rubber dam. The sweat was extracted from the bandage and rubber dam by a measured amount of distilled water. Both gauze and rubber dam were weighed dry and the combined sweat-bandage-rubber dam was weighed to measure the total sweat collected. This method proved very satisfactory for sweat collection from the face, axilla, thigh, and various parts of the torso, though some practice is needed to apply and remove the bandages properly.

In the past, much work on sweat composition has been done with sweat collected from the hand in an ordinary surgical rubber glove (Dill (8)). In order to compare such sweat with that of the entire body the subjects were clad in a full length union suit and heavy socks and wore the rubber gloves while walking briefly on the treadmill. The skin was previously prepared as usual and the garments had been carefully washed in distilled water, dried, and weighed. No sweat as such was lost from the system, body plus garments. At the end of the period of sweating the subject stood in an enamelled basin into which the garments were removed and the body rinsed with distilled water. The garments plus washings were weighed. The garments were then extracted with the distilled water and analysis for chloride was carried out on the diluted sweat and washings. Glove sweat was analyzed directly. Before and after the sweat collection the nude subject was weighed to ±6 gm. The total sweat production was large enough so that this weighing procedure allowed estimation of the volume with an error of about 1 per cent.

Results

Ascorbic Acid—A large number of recovery experiments showed that sweat collection for ascorbic acid estimation is very satisfactorily accomplished with the neoprene gauntlets in 15 minutes at 49°. Vitamin C destruction in the collection of sweat for analysis is negligible when the arrangement with ice-cold collecting vessels is used.

With subjects on ordinary diets the concentration of ascorbic acid was always very low, ranging from 0 to 0.18 mg. per 100 cc., with most of the
values below 0.10 mg. Experiments were then carried out to discover what relation, if any, may exist between vitamin C intake and the concentration of the vitamin in the sweat. In the first series we studied twelve subjects who were maintained on known fixed intakes for 4 to 7 days at a time. The two levels of vitamin C intake studied were 25 and 525 mg. per day. The results, summarized in Table I, clearly show that the ascorbic acid concentration in the sweat is not only low but does not reflect a great difference in dietary intake.

**Table I**

*Concentration of Vitamin C in Sweat Collected from Men on Different Levels of Dietary Intake of Vitamin*

<table>
<thead>
<tr>
<th>Intake (mg. per day)</th>
<th>No. of samples</th>
<th>Vitamin C, mean</th>
<th>Standard deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>525</td>
<td>30</td>
<td>0.0590</td>
<td>±0.0467</td>
<td>0–0.16</td>
</tr>
<tr>
<td>25</td>
<td>28</td>
<td>0.0603</td>
<td>±0.0559</td>
<td>0–0.18</td>
</tr>
</tbody>
</table>

**Table II**

*Concentration of Vitamin C in Sweat before and at 2 and 6 Hours after Ingestion of 60 Mg. of Pure Ascorbic Acid*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Before</th>
<th>2 hrs. after</th>
<th>6 hrs. after</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. O...</td>
<td>0.039</td>
<td>0.026</td>
<td>0.033</td>
</tr>
<tr>
<td>K. O...</td>
<td>0.027</td>
<td>0.032</td>
<td>0.038</td>
</tr>
<tr>
<td>K. E...</td>
<td>0.025</td>
<td>0.032</td>
<td>0.025</td>
</tr>
<tr>
<td>M. E...</td>
<td>0.026</td>
<td>0.037</td>
<td>0.050</td>
</tr>
<tr>
<td>R. O...</td>
<td>0.017</td>
<td>0.030</td>
<td>0.027</td>
</tr>
<tr>
<td>G. E...</td>
<td>0.032</td>
<td>0.027</td>
<td>0.039</td>
</tr>
<tr>
<td>Mean</td>
<td>0.028</td>
<td>0.027</td>
<td>0.035</td>
</tr>
</tbody>
</table>

In another series six men were studied before and at 2 and at 6 hours after ingesting 50 mg. of pure ascorbic acid. The results are given in Table II, which shows that any effect of this dosage is very slight at most. The appearance of an average increase in concentration of ascorbic acid in the sweat 6 hours after the 50 mg. dose is chiefly due to the result on subject M. E.

Incidentally, it may be noticed that the values in Table II are considerably lower than those in Table I. It is believed that the lower values are more nearly correct. With our most recent analytical technique in which
large samples are used we have found the average ascorbic acid concentration in the sweat of twelve young men on ordinary college diets to average 0.033 mg per 100 cc., standard deviation = ±0.0064.

The concentration of ascorbic acid in the sweat is independent of that in the plasma, as might be inferred from the results cited above. In subjects with values for plasma vitamin C of from 0.31 to 1.41 mg per 100 cc. the sweat concentrations were entirely independent.

It should be noted that the decolorization of 2,6-dichlorophenol indophenol is not entirely specific for ascorbic acid. We can conclude that the concentration of ascorbic acid in the sweat is not greater than indicated above. It is clear, therefore, that even in the most extreme conditions, when the sweat volume may reach 10 liters per day, the maximal loss of ascorbic acid is less than 10 mg. Actually, the maximal losses we have calculated from studies in the laboratory and in extreme conditions in desert maneuvers with the United States Army would amount to 4 mg per day or less. The physiological rôle of ascorbic acid in resistance to high temperatures will be discussed in a separate paper.

Vitamins of the B Complex—Sweat contains a large amount of fluorescent substance but this is mostly not thiamine or riboflavin. When controls are run by omitting potassium ferricyanide and these are used in the calculation of the true thiamine content from the thiochrome procedure, it appears that the thiamine concentration of sweat is exceedingly small and accordingly very difficult to estimate accurately. In a series of twelve separate estimations of thiamine in sweat, values have ranged from 0.00 to 0.6 γ per 100 cc. The average is of the order of 0.15 γ per 100 cc. and even this may be an overestimate. If we accept the highest possible values, it appears that maximal loss of thiamine in sweat would be less than 50 γ per day; actually we believe the true maximal loss is considerably less than this amount.

Riboflavin similarly is found in sweat only in vanishingly small amounts. In order to achieve certainty on this point much care was taken in collection and large pooled samples were concentrated by evaporation in a vacuum at low temperature. Microbiological assays were carried out on the concentrated material and indicated about 0.5 γ of riboflavin per 100 cc. Accordingly, the maximal sweat loss of this vitamin is no greater than in the case of thiamine.

Nicotinic acid in sweat was measured in pooled samples and averaged about 100 γ per 100 cc. Both chemical and microbiological methods gave results in agreement.

Different Parts of Body—It is well known that lactic acid and urea as well as chloride occur in sweat in significant amounts. Accordingly, it was considered that the estimation of these substances in sweat collected simul-
COMPOSITION OF SWEAT

taneously from different parts of the body would help to describe the constancy or variability of the total sweat concentration produced in different regions as well as the concentration of the individual substances.

In the first series of experiments sweat was collected from the arm by the gauntlet and from the back and abdomen by rapidly scraping the free flowing sweat as previously described. The temperature was 38° and the humidity was 65 per cent relative saturation. Collections and analyses were carried out so as to minimize evaporation and destruction of lactate. The results of these analyses on sweat from six subjects are summarized in Table III.

**Table III**

Composition of Sweat Collected Simultaneously from Different Parts of Body

In each case the values for the back and for abdominal sweat are expressed as percentages of the value of the same substance in the arm sweat collected at the same time from the same subject.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Source</th>
<th>Chloride</th>
<th>Lactate</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. E.</td>
<td>Back</td>
<td>128</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>147</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>P. A.</td>
<td>Back</td>
<td>119</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>143</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>M. J.</td>
<td>Back</td>
<td>140</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>133</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>D. U.</td>
<td>Back</td>
<td>184</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>133</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>M. A.</td>
<td>Back</td>
<td>176</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>162</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>P. E.</td>
<td>Back</td>
<td>154</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>143</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>Back</td>
<td>150</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>“</td>
<td>Abdomen</td>
<td>144</td>
<td>92</td>
<td></td>
</tr>
</tbody>
</table>

There are very marked variations in the concentrations of these substances in the sweat collected from different parts of the body and these cannot be explained as the result of different rates of evaporative water loss from the sweat in different regions. In general the arm sweat was least concentrated in chloride but most concentrated in lactate and tended to be most concentrated in urea.

Equally marked differences were obtained by the method in which sweat was collected in gauze bandages, when evaporative losses were entirely excluded. In this second series of experiments creatinine and uric acid were added to the analytical battery. Typical results from two experi-
ments on one subject, carried out 2 weeks apart, are summarized in Table IV.

There is some evidence that the variation in concentration of lactate, urea, creatinine, and uric acid in sweat from different parts of the body is reduced in the subject acclimatized to the heat. Whether this is a result of profuse sweating continued for some days or some other factor involved in acclimatization cannot be stated. Illustrative results are tabulated in Table V.

### Table IV

**Composition of Sweat Collected Simultaneously from Different Parts of Body of Unacclimatized Subject**

The results of two experiments, performed 2 weeks apart, are tabulated here. Chloride values are in mM per liter; all other values are in mg. per 100 cc.

<table>
<thead>
<tr>
<th>Region</th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cl</td>
<td>Lac-tate</td>
</tr>
<tr>
<td>Torso</td>
<td>55</td>
<td>204</td>
</tr>
<tr>
<td>Face</td>
<td>101</td>
<td>157</td>
</tr>
<tr>
<td>Thigh</td>
<td>75</td>
<td>296</td>
</tr>
<tr>
<td>Axilla</td>
<td>114</td>
<td>186</td>
</tr>
<tr>
<td>Arm</td>
<td>55</td>
<td>250</td>
</tr>
</tbody>
</table>

### Table V

**Composition of Sweat from Different Parts of Body before and after Acclimatization to High Temperature**

Chloride values are in mM per liter; all other values are in mg. per 100 cc.

<table>
<thead>
<tr>
<th>Region</th>
<th>Before acclimatization</th>
<th>After acclimatization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cl</td>
<td>Lac-tate</td>
</tr>
<tr>
<td>Thigh</td>
<td>57</td>
<td>382</td>
</tr>
<tr>
<td>Torso</td>
<td>43</td>
<td>121</td>
</tr>
<tr>
<td>Face</td>
<td>57</td>
<td>144</td>
</tr>
<tr>
<td>Arm</td>
<td>29</td>
<td>174</td>
</tr>
</tbody>
</table>

**Chlorides**—The variability of chloride concentration in the sweat has been remarked by all investigators. It might be thought that the sweat chloride reflects, in an exaggerated manner, changes in the plasma chloride. This is not normally the case, as is shown in Fig. 1. There was no trace of a relation between the chloride concentration in the blood plasma and in the arm plus hand sweat in eighteen normal young men on either the 1st or the 2nd day of exposure to the heat. These men were on a diet slightly restricted in chloride. The chloride concentration in both fluids
COMPOSITION OF SWEAT

averaged somewhat less on the 2nd day than on the 1st but these differences were statistically insignificant.

Earlier in this paper we indicated important differences in the concentration of sweat collected from different parts of the body. The inference is that it may not be possible to calculate the total sweat loss of chloride from the analysis of a "sample." Such calculations have been made

![Graph](http://www.jbc.org/)

**FIG. 1.** The relation between the concentrations of plasma and sweat chloride during the first 2 days in the heat.

**TABLE VI**

Comparison of Average Chloride Concentration of Total Body Sweat with Chloride Concentration in Sweat Collected Simultaneously from Hand

Chloride concentrations are in milliequivalents per liter. "Weight loss, corrected" is the gross body weight loss corrected for R.Q. and insensible perspiration. The sweat collection periods ranged from 30 to 45 minutes each.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Date</th>
<th>Hand [Cl]</th>
<th>Body weight loss (gm)</th>
<th>Weight loss, corrected</th>
<th>Total Cl loss (mg)</th>
<th>Body [Cl] as percent of body [Cl]</th>
<th>Hand [Cl]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.</td>
<td>Feb. 23</td>
<td>62.0</td>
<td>266</td>
<td>237</td>
<td>10.7</td>
<td>45.1</td>
<td>138</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>&quot; 27</td>
<td>57.2</td>
<td>650</td>
<td>629</td>
<td>24.3</td>
<td>38.6</td>
<td>148</td>
</tr>
<tr>
<td>S.</td>
<td>Mar. 4</td>
<td>83.2</td>
<td>761</td>
<td>730</td>
<td>39.1</td>
<td>53.6</td>
<td>155</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>&quot; 4</td>
<td>65.8</td>
<td>713</td>
<td>682</td>
<td>26.1</td>
<td>38.3</td>
<td>172</td>
</tr>
</tbody>
</table>

chiefly from hand sweat collected in a rubber glove. The acceptability of this procedure was carefully checked in four experiments in which hand sweat was collected simultaneously with that of the rest of the body. The results are given in Table VI. It is clear that very large errors would result from the calculation of total body losses of chloride from the concentration of hand sweat and the weight loss.
DISCUSSION

The composition of sweat is of interest because of the possible effect of sweat loss on the requirements of the body for salt and vitamins in hot environments. In the case of salt (chloride) the loss may be large and its quantitative evaluation is important. However, it appears that such evaluation cannot be made accurately from samples taken from any one part of the body. In general, the total salt loss calculated from the concentration of sweat collected in a glove is considerably greater than the true salt loss from the whole body; this is well shown in the present study. The relatively low salt concentration of total body sweat is notable in the measurements of Hancock, Whitehouse, and Haldane (13), of Dill et al. (10), and of Lee et al. (19). It should be noted that the loss of water and salt through the skin is not independent of osmotic forces (Whitehouse, Hancock, and Haldane (32)), and it must be expected that the sweat concentration will vary according to whether the skin is immersed in sweat (as in a glove) or encased in salt (as in complete evaporation).

We have no ready explanation for the seemingly independent variation in the concentrations of different constituents in the sweat collected from different parts of the body. However, it should be remembered that the total sweat is the product of three different sources: (1) secretion of the eccrine glands, (2) secretion of the apocrine glands, and (3) presumably passive diffusion of water and possibly other constituents in the “insensible perspiration.” The concentrations of the several constituents differ in the “sweat” from the different sources and the relative amounts of the several sweats produced in different regions must vary according to the anatomy of the local skin (cf. Kuno (18)). The subject of chloride economy under different conditions will be discussed in a separate contribution.

Numerous statements are appearing to the effect that human vitamin requirements are increased in hot environments (cf. Mills (22)). Most of the factual reports concern ascorbic acid losses in sweat. Cornbleet, Klein, and Pace (7) and Bernstein (1) reported vitamin C concentrations in sweat of the order of 0.5 to 1.0 mg. per 100 cc. Such values could mean important losses in heavy sweating. However, other analyses indicate much smaller concentrations (Zselyonka and Nánássy-Mégay (34), Wright and MacLenathan (33), Hardt and Still (14)). The present results are still smaller and indicate that ascorbic acid loss in sweat is negligible. The higher values reported earlier probably reflect the fact that the analytical methods used are not very specific and other reducing substances readily enter as contaminants. We have observed this to be the case with some types of rubber gloves.

Hardt and Still (14) have suggested that thiamine losses in sweat may “cause serious physiological consequences.” Their values for thiamine
The concentration in sweat must be ascribed to analytical error; we found that the more exacting were our methods the nearer our results were to the zero thiamine level. Slater (28) has reported similarly low values for thiamine in sweat.

Many workers have reported significant amounts of glucose in sweat, 5 to 20 mg. or more per 100 cc. (e.g. Borchardt (2), Sylvers et al. (31), McSwiney (20)). We obtained similar values by the use of the ordinary methods. However, sweat contains a number of non-glucose reducing substances and the ordinary methods are not specific enough to allow conclusions as to the true glucose content of sweat. Schulze (26) and Schulze and Kunz (27) have shown that practically none of the substance in sweat recorded as glucose by the Hagedorn-Jensen method will form a phenyl-glucose osazone. The statement of Engelhardt (12) that sweat of diabetic patients may exceed 150 or 200 mg. of glucose per 100 cc. is certainly erroneous.

The majority of the constituents in sweat are more dilute than in the blood plasma or interstitial fluid. Lactic acid, or lactate as it exists in sweat, is a notable exception. Values as high as 450 mg. of lactic acid per 100 cc. have been reported in the sweat of resting subjects (Pemberton (24)), but the best methods indicate that the values are usually below 100 mg. per 100 cc. unless the blood lactate level is elevated. The values recorded here reflect only moderate elevation in the blood lactate. Kosiakina and Krestownikoff (17) reported values as high as 1765 mg. per 100 cc. of sweat obtained in a marathon race.

Urea is also more concentrated in sweat than in the blood. In the present study thirty-eight samples of arm plus hand sweat averaged 67 mg. of urea per 100 cc., with a range of 23 to 156 mg. The bloods drawn at the same time averaged 18.1 mg. per 100 cc., with a range of 8.2 to 24.4 mg. These sweat values for urea are higher than those reported by McSwiney (20), Mezinesco (21), Chopra et al. (4), and Robinson et al. (25), but it may be noted that urea is not very stable in sweat and special precautions are needed to prevent its loss in the collected samples. The urease method used here is highly specific and was applied with great care; so considerable confidence is placed in the results.

It should be clear that sweat secretion is at least as complicated as urine secretion and sweat is, in its way, as complex as urine. But in the case of urine formation some regularity is apparent and the relations between the urine and the blood pressure are at least capable of partial definition. As yet few guiding principles for the quantitative appearance of various substances in sweat are discernible. Such substances as glucose, thiamine, riboflavin, and androgens (Cornbleet and Barnes (6)) are almost wholly excluded; phosphates, uric acid, and ascorbic acid appear in very small
amounts; and ammonia, urea, and lactate are greatly concentrated. Chloride ranges from twice the concentration in the plasma to perhaps one-fifth the plasma level. None of these substances reflects the blood concentration of the same substances unless the blood levels are markedly abnormal.

**SUMMARY**

1. Sweat was collected from various parts of the body of normal young men in rest and in moderate work. In most cases the temperature was 49°, the humidity 25 per cent relative saturation, but in some experiments humidities over 65 per cent relative saturation were maintained at an air temperature of 37–38°.

2. The concentration of ascorbic acid in sweat is generally less than 0.1 mg. per 100 cc., the true average being of the order of 0.03 mg. per 100 cc. The concentration is independent of the dietary intake of the vitamin.

3. The concentration of thiamine in sweat is of the order of 0.2 γ or less per 100 cc. Riboflavin concentration is of the order of 0.5 γ or less per 100 cc. of sweat.

4. The concentration of nicotinic acid or its biological equivalent in sweat is of the order of 0.1 mg. per 100 cc.

5. Lactate, urea, and ammonia are much more concentrated in the sweat than in the blood.

6. Sweat samples collected simultaneously from the hand, arm plus hand, face, torso, and thigh showed marked differences in total concentration and in concentration of individual constituents including chloride, lactate, urea, creatinine, and uric acid.

7. Hand sweat is more concentrated in chloride, by 30 to 70 per cent, than the total body sweat formed at the same time.

8. The concentration of chloride in the sweat is highly variable but it is independent of moderate variations in the concentration of chloride in the blood plasma.

9. Under conditions of continued profuse sweating losses of ascorbic acid, thiamine, and riboflavin are negligible from the standpoint of vitamin nutrition. The sweat loss of nicotinic acid under these conditions could be significant, however.

It is a pleasure to record our obligations to Colonel H. J. Keeley, Commanding Officer, Fort Snelling, to Lieutenant-Colonel J. J. Shy, Commanding Officer, 710th Military Police Battalion, and to the men of the 710th Military Police Battalion who served as subjects. This work would have been impossible without the generous help of the staff of the Laboratory of Physiological Hygiene, especially Mr. Howard Condiff and Miss Doris.
Doeden, Assistant Chemists, and Miss Angie Mae Sturgeon, Head Technologist. We are greatly indebted to Dr. J. S. Andrews of General Mills, Inc., for analyses for nicotinic acid and riboflavin.

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