Discussion. The above experiments show that short-term treatment with large doses of D.C.A. causes thymus atrophy. The fact that entirely negative results have been obtained by other investigators[15,18,19] can probably be explained by the relatively small doses of D.C.A. employed. On the other hand the length of the treatment is also important since Selye[20] has shown that continued treatment with D.C.A. not only fails to cause atrophy but increases the size of the thymus.

It must be remembered that thymus atrophy is elicited not only by corticoids. Selye[21] has shown that in chronically-treated rats all steroid hormones cause a certain degree of atrophy in this gland and that all hormonally active steroids have some folliculoid activity. Furthermore this author[22] claimed that in adrenalectomized animals the only hormones which are able to cause thymus involution are the corticoids and the folliculoids.

It has not been proven yet, whether or not the antithymic action of D.C.A. is due to its folliculoid property. This possibility should not be neglected. In this regard it will be interesting to determine whether folliculoids influence the thymus and the lymphatic organs in the same manner as do the glucocorticoids, namely whether they cause lymphocyte breakdown and release of gamma globulins which are not influenced by D.C.A.[23,24] in the doses employed.

Summary. In short-term experiments, large doses of desoxycorticosterone acetate cause marked thymus atrophy. Thus it appears that this effect is not the exclusive characteristic of the glucocorticoids and furthermore that the nonspecific damage of D.C.A. has not been operative since the result was obtained in adrenalectomized rats.

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Prolongation of Consciousness in Anoxia of High Altitude by Glucose.*

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Dietary factors relating to anoxia tolerance in the human have been put to test recently in the investigations of King *et al.*,[1] Green *et al.*,[2] and Eckman *et al.*[3] These workers have been concerned with the effects of diet on visual, psychomotor, and mental performance in persons exposed to intermediate degrees of oxygen deprivation such as occur at altitudes of 15,000 to 17,000 feet. The comparisons made show the contrasting effects of meals varying with re-

* The views expressed in this paper do not necessarily reflect those of the Army Air Forces. The experimental work was done in the Altitude Training Section at Drew Field, Fla.

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2 Green, D. M., Butts, J. S., and Mulholland, H. F., *J. Av. Med.*, 1945, **16**, 311.

3 Eckman, M., Barach, B., Fox, C. A., Rumsey, C. C., and Barach, A. L., *J. Av. Med.*, 1945, **16**, 328.

spect to carbohydrate, protein, and fat content. High carbohydrate diets were found to increase significantly performance at these comparatively low altitudes.

The work herein reported was started prior to our knowledge of the studies cited above. While dealing with the same general problem, it represents a different approach, for 3 reasons. First, the carbohydrate and/or vitamin C are here added to a diet of choice. Second, the data are obtained at higher altitudes (27,000 and 30,000 ft.) where fulminating anoxia rapidly leads to unconsciousness and death. Third, in our experiments the time between disconnection of the oxygen mask and unconsciousness serves as the measure of the effect of the supplementary feedings. From the standpoint of their application to the practical problems of high altitude flight, these data are highly pertinent. In critical situations such as bail out, loss of cabin pressure, or failure of oxygen systems additional seconds of consciousness can mean the difference between life and death.

Methods. Details of the testing procedure with samples of handwriting criteria are given in a previous publication devoted to the establishment of an altitude versus time curve for the duration of consciousness.[4] The same endpoint for measuring the duration of "useful consciousness" was employed in the present investigation. Thus, inability to continue writing served as a definable index of a person's degree of helplessness. Whereas in some cases recollection of events and the self-realization of inability to perform were reported afterwards by our subjects, even here there was an undeniable condition of dependence upon the intervention of another person to prevent complete insensibility.

Subjects used in the main series of tests were members of B-17 combat crews in training at Drew Field. The interval between their previous meal, which was any meal of the day, and the time of supplemental feeding varied from ½ to 3 hours, averaging approximately 2 hours. In one separately conducted series of tests nonflying personnel of the Medical Detachment served in experimental and control groups. These men ingested the solutions approximately one hour after breakfast.

The fliers were tested during their crew's regularly scheduled training flight in the altitude chamber. They were given only the information that volunteers were needed for an experiment on the effect of vitamins and sugar on a flier's ability to withstand oxygen lack. It was desired that 4 of their number drink the apparently identical solutions, and that during the course of the subsequent chamber flight they disconnect their masks at high altitude, and write dictated dittys as long as possible. Assurance was of course given that they would be reconnected whenever they showed inability to continue writing.

From among the volunteers 4 individuals drew lots to determine which one of the differently numbered solutions each was to drink. The contents of the solutions were as follows:

1. 0.2 g saccharine and 1.0 g ascorbic acid.
2. 0.2 g saccharine and 0.1 g citric acid.
3. 80.0 g dextrose (anhydrous) and 1.0 g ascorbic acid.
4. 80.0 g dextrose (anhydrous) and 0.1 g citric acid.

The volume of each solution was 350 cc. Citric acid served as the control ingredient for the vitamin C. Saccharine sweetened the solutions not containing dextrose. Comments made by the subjects about the taste of the solutions showed that they were unable to discern any differences. No subject entered into the experimental results more than once.

The order of testing the subjects at altitude was randomized so as to eliminate any constant difference in time interval before testing the effect of a particular solution and to control differences in mental attitudes of subjects who had or had not observed anoxic performances of fellow crew members before it was their turn. In the experiments conducted at 27,000 ft. the first of the 4 anoxic

[4] Mackenzie, C. G., Riesen, A. H., Bailey, J. R., Tahmisian, T. N., and Crocker, P. L., *J. Av. Med.*, 1945, **16**, 156.

TABLE I.

Prolongation by Glucose of the Duration of Consciousness in Trained Fliers Exposed to Anoxia at 27,000 ft. in the Altitude Chamber. Tests Were Conducted 30 to 50 Minutes Following the Oral Administration of Supplements. Quantities for the Solutions Are Given in the Text.

	Solutions			
	1 Saccharine, ascorbic acid	2 Saccharine, citric acid	3 Glucose, ascorbic acid	4 Glucose, citric acid
No. of cases	19	20	19	19*
Mean duration of consciousness (sec.)	192.1 ± 12.9	182.9 ± 10.8	252.3 ± 17.7	269.6 ± 25.8
S.D.	54.3	47.7	74.2	108.4

	Solutions	
	1 & 2 combined (no glucose)	3 & 4 combined (glucose)
No. of cases	39	38*
Mean duration of consciousness (sec.)	187.4 ± 8.2	260.9 ± 15.1
S.D.	51.3	93.3

* One additional case lasting over 900 sec. omitted from calculations.

episodes was begun either half an hour or one hour after the ingestion of the solutions. All 4 subjects were then tested within a period of 20 minutes. On the 30,000 ft. flights only the shorter (half hour) interval was used.

Results. At 27,000 ft. the effects of preflight ingestion of carbohydrate and/or vitamin C on our measure of the duration of consciousness 30 to 50 minutes later are shown in Table I. Mean durations with their standard errors are given in seconds. Comparing the effect of solution No. 1 with No. 2 and that of No. 3 with No. 4 we find no significant differences between the means of each pair, the *t*-values being 0.5 and 0.6, respectively. This absence of any measurable effect of the vitamin C was consistent in all groups tested.

Comparing group No. 3 with its saccharine-fed control group, No. 1, gives a value of *t* of 2.8, and a comparison of No. 4 and No. 2 a value of 3.2, either of which taken separately indicates significance at the 1% level. A critical ratio of 4.3 results if No. 1 and No. 2 are combined for a comparison with No. 3 and No. 4. The difference of 73.5 seconds between the means of the combined groups represents an advantage of 39% in the duration of consciousness for the men receiving glucose over those in the control groups.

TABLE II.

Effect of Glucose on Mean Duration of Consciousness of Air Crew Members Exposed to Anoxia at 30,000 ft. in the Altitude Chamber, and Tested 30 to 50 Minutes After Ingestion of the Solutions.

	Solutions	
	1 & 2 (no glucose)	3 & 4 (glucose, 80 g)
No. of cases	14	16
Mean duration of consciousness (sec.)	126.0 ± 7.2	147.6 ± 6.0
S.D.	25.7	23.1

At 30,000 ft. (Table II) the increase associated with glucose ingestion is less both in absolute terms and relative to the performance of the controls, the increase being 17%. The small numbers of cases render these figures less reliable than in the tests at 27,000 ft., and contribute to the lesser degree of significance found in the difference: $t = 2.3$, significant at the 5% level.

The results when a longer time interval followed drinking of the solutions are given in Table III. As compared with the men tested 30 to 50 minutes after treatment (Table I), a much smaller increase in the duration of consciousness is shown by the air crew members with 60 to 80 minutes elapsing between the ingestion of glucose and the tests at 27,000 ft. The difference at this longer interval in the experienced subjects

TABLE III.
Effect of Glucose on Mean Duration of Consciousness of Trained Fliers and of Nonflying Personnel Exposed to Anoxia at 27,000 ft. in the Altitude Chamber. All Tests Were Conducted 60 to 80 Minutes Following the Oral Administration of Supplements.

Subjects		Solutions 1 & 2 (no glucose)	Solutions 3 & 4 (glucose, 80 g)
Air crew members	No. of cases	26	21
	Mean duration of consciousness (sec.)	201.9 ± 10.3	223.8 ± 17.4
	S.D.	51.7	78.0
Nonflying personnel	No. of cases	17	18
	Mean duration of consciousness (sec.)	170.8 ± 10.8	218.0 ± 12.2
	S.D.	43.3	50.9

does not meet the statistical criterion for significance.

Also shown in Table III are data with men inexperienced in flight, either actual or as simulated in the altitude chamber. When no glucose was administered these groups became incapacitated in a somewhat shorter time than corresponding groups made up of air crew members. However, the increase in the duration of consciousness produced by glucose feedings proves to be significant at the 1% level, $t = 2.9$. The lesser degree of variability in this group is presumably at least in part a reflection of the greater constancy of the time elapsing after the preceding meal. The carbohydrate had an effect which apparently counteracted factors that were operating in this group to reduce its average period of performance, so that after glucose the inexperienced subjects did as well or better than did the fliers in the control group.

Discussion. Our results show that the duration of consciousness at high altitudes following interruption of the oxygen supply is extended by the previous administration of glucose. This is compatible with the increase in performance observed by King *et al.*[1] and Green *et al.*[2] at lower altitudes following high carbohydrate meals.

The more marked increase in duration of consciousness at 27,000 ft. as compared with 30,000 ft. was to be expected from our earlier findings[4] on the relation between the duration of consciousness and altitude. At 26,000 ft. lowering the actual altitude by 2,000 ft. resulted in a greater prolongation of consciousness than decreasing any higher altitude by the same amount.

The greater tolerance to anoxia of the *untreated* fliers as contrasted with the *untreated* nonflying personnel is in harmony with our previous demonstration that men who have received training in the reactions to anoxia, as had the fliers, become unconscious less rapidly than do untrained individuals. Presumably this is due to a minimizing of the excitement and fear engendered by contemplating and experiencing the sudden loss of supplementary oxygen, and to the greater confidence in and familiarity with the oxygen mask and related equipment. Fear and excitement are believed to be potent factors in reducing tolerance to anoxia.

King *et al.*[1] and Green *et al.*[2] are of the opinion that high carbohydrate meals increased the performance of individuals in their tests at 15,000 to 17,000 ft. because of the higher carbon dioxide yield together with a minimum metabolic need for oxygen. The parallel physiological and psychological measurements of Eckman *et al.*[3] have furnished experimental confirmation of this hypothesis. The improvement in performance reported by King and associates, however, was somewhat greater than that found or accounted for by Eckman *et al.*

While our own conditions are not strictly comparable to the work cited above either with respect to the method of administering carbohydrate or with respect to the type of anoxia studied, it is reasonable to suppose that the beneficial effect obtained with glucose at high altitude was likewise associated with an increase in the R.Q. The temporal relationships also offer some evidence on the mechanism involved. Protection against anoxia in the experienced fliers was greater

30 to 50 minutes after glucose ingestion than it was after 60 to 80 minutes. The former time corresponds closely with the occurrence of the maximum level of glucose in the blood in glucose tolerance tests on normal individuals. Unfortunately it was impossible for us to measure blood glucose or R.Q.

Conclusions. 1. The preflight administration of a single dose of glucose in water to individuals on a normal diet produced a significant increase in the resistance to unconsciousness from anoxia at 27,000 and 30,000 ft. 2. The protection afforded flying personnel by the glucose solution was greater 30 to 50 minutes following its administration than after an interval of 60 to 80 minutes. 3. At 27,000 ft. the mean duration of consciousness was increased by approximately 40%, or more than one minute, by the preflight ingestion of glucose solution. 4. Vitamin C, either alone or in conjunction with glucose, had no demonstrable effect on the duration of consciousness.

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Total Peptic Activity of Gastric Juice. A Method of Determination.*

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It is the purpose of this paper to assess critically the present status of tests for the determination of pepsin and to describe an improved method.

Since different proteins differ in their rate of digestibility, it is necessary to choose either a highly purified protein for use as a substrate, or at least a substance of constant composition so that results be reproducible with different lots of substrate. Partial denaturization of a protein by coagulation renders it a mixture of different proteins. Because one can rarely be sure denaturization is complete, tests using coagulated protein substrates[1-3] are subject to error. Gelatin has been employed as a substrate protein,[4,5] but it is not ideal since it hydrolyzes in acids without pepsin.[6] One test uses fresh milk as a substrate.[7] Although the composition of "Klim," dried milk powder, is quite constant, individual samples of fresh milk are not constant.[8]

Pepsin is unlike many inorganic catalysts whose presence in traces is sufficient to bring about a change. With pepsin, the rate of conversion is directly proportional to the concentration of active enzyme and active substrate; *i.e.*, the reaction follows the law of mass action. However, the reaction rate is not uniform for more than a brief period (Fig. 1) because peptones formed during digestion combine with the enzyme to form an inactive pepsin-complex.[9] Pepsin + Peptone $\rightleftarrows$ pepsin-peptone. It is the concentration of peptone that determines how much pepsin is active. When the reaction rate has leveled off, the addition of a sizable increment of pepsin will but slightly increase the rate of digestion because of the high concentration of peptones already present. Dilution by decreasing the concentration of the inhibitor allows digestion to continue.[9] The

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