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The action of a high dry climate in the cure of tuberculosis

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THE ACTION OF A HIGH DRY CLIMATE IN THE CURE OF TUBERCULOSIS

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THE ACTION OF A HIGH DRY CLIMATE IN THE CURE OF TUBERCULOSIS.

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The value of a high dry climate in the cure of tuberculosis, is generally admitted to be considerable; as evidence of this value we have many facts: the natives of such regions are comparatively free from tuberculosis, and the same is largely true of those who have later emigrated to them. Again, many who have suffered an attack of tuberculosis and emigrated to the high dry regions have recovered or have had their lives considerably prolonged. Finally, the United States government with its extreme conservatism in matters of health, has established two sanatoria, one for consumptive sailors, the other for consumptive soldiers, in the high dry climate of New Mexico. The results obtained at these sanatoria have been most gratifying to the officers in charge.

EARLIER EXPLANATIONS OF CLINIC ACTION.

Many explanations have been offered to account for the favorable action of high dry climates, but up to the present time none of these have proved satisfactory in accounting for the facts observed. Among these explanations the following may be considered as the more important:

A. A high dry climate leads to greater lung capacity and increased respiration which results beneficially for the patient. The observations of Maltby (Hadley Climat. Bul. Vol. III, No. 2, 1901) seemed to confirm this view but more recent work by the writer has shown that the spirometer used was defective and gave too high reading. It is very doubtful whether any material increase results, and, in some instances at least, an actual decrease takes place. At any rate, the lung capacities of the natives of these regions are as a rule below normal (data to be published later).

Perhaps a better understanding of the above assumption is gained by viewing the matter from a physiological standpoint. The lungs are organs intended primarily to provide the blood with the oxygen necessary to oxidize tissues and liberate energy; and secondarily, to remove certain wastes. For these purposes a large margin of safety in lung capacity is provided, the average inspiration and expiration being about 30 cubic inches, while the total capacity is approximately 200 cubic inches. This margin of safety (500%) more than counterbalances the rarefaction in the air which at an altitude of 5,000 feet amounts to about one-sixth or 17%. Again, in normal respiration there is always a large margin of safety in the amount of oxygen inhaled over the amount absorbed. There is, then, no valid reason for expecting an increased lung capacity in high altitudes.

B. The highly ozonized air hypothesis has not been substantiated by facts, for the ozone in high dry climates is exceedingly small. Further, experiments in breathing highly ozonized air have not met with gratifying results.

C. A very generally accepted assumption is that the dry air assists in drying up and curing the lesions in the lungs. When it is remembered that the air in the lungs is saturated with water vapor in all climates, it is difficult to understand why this assumption was ever made. The nature of the tuberculous lesion in the lungs precludes the possibility of any considerable desiccation taking place.

D. Others have assumed that the sparce population and lack of industries insures the breathing of pure fresh air, which is of undoubted benefit. But it is apparent that the air is equally pure in many country districts and virgin woods and prairies in low moist climates. This factor cannot, therefore, be considered distinctive for the benefit noted in high dry climates.

E. The increased amount of sunlight especially in blue, violet and ultra violet rays, in dry climates has also been held to be the beneficial factor. Undoubtedly the increase exists, but recent observations do not confirm the reputed beneficent influence. The writer has carried out several experiments with tubercular guinea pigs in blue, green, red, colorless and dark cells, but as yet there is no evidence decidedly in favor of any one cell. The experiment is a difficult one and requires many more repetitions, but thus far there is no reason to expect any helpful result.

F. Still another hypothesis is that a high dry climate affords greater opportunities for out-door life and exercise, the real benefit being due to one or more of the causes already discussed. It has already been shown that several of these factors may have little or nothing to do with the problem; others undoubtedly do exercise a favorable hygienic influence, and probably other factors, such as change of work, exercise, food, scenery and habits of life exercise a helpful influence also. There is no intention to ignore or even minimize the

importance of these factors, but it remains true that practically all of them may be provided in other places.

There is, then, no adequate explanation to account for the important fact that high dry climates are especially favorable in their action on tuberculosis. The attempt will be made to give a rational explanation which it is believed will account for the facts observed.

PROPOSED EXPLANATION OF CLIMATIC ACTION.

The most characteristic difference between a high dry and low moist climate is the great difference in range of temperature; this is small in low moist places, and usually great in high dry ones where it may reach 30° to 50° F. daily. If we compare St. Louis as an example of the former type with Colorado Springs as representing the latter, we find that in the former the nights in summer are uncomfortably warm and afford poor opportunity for refreshing sleep, while in the latter the nights are always cool and invigorating. This point counts for perhaps more than all the other so-called hygienic factors put together; while not new, it has never received adequate emphasis. But there is also a difference in the above places in the winter climates, although not so marked as the one just treated; this is that the daily variation continues to be greater at Colorado Springs. This variation acts as a stimulation to the body and invigorates it, thus enabling it to better combat the disease. This stimulation may be better understood by comparing it with a cold bath the invigorating qualities of which are well known. In this factor — the great daily temperature variation — really lies the great virtue of a high dry climate, and so far as the writer is aware has not been pointed out before.

A number of observations lead to the above conclusion. In my work on blood changes due to high altitude (Hadley Climat. Bul. Vol. III, No. 9) it was shown that the increase in red blood cells was temporary.

TABLE I.—BLOOD-COUNTS OF SPECIAL CASES AT HIGH ALTITUDES.

Date.	Time.	Weight.	Sp. Gr.	Hemoglobin (per cent.).	Red Cells (per c.mm.).	Colorless Cells (per c.mm.).	Time in High Altitude (days).
Case 55.							
7/24/02	10:30	125	1.060	.....	5,573,000	12,000	8
7/28/02	10:00	......	1.060	85	6,155,000	12,000	12
7/31/02	2:30	......	....	......	6,431,000	12,000	15
9/ 4/02	3:00	......	....	......	5,791,000	11,000	48
12/10/02	10:00	123	1.060	87	5,395,000	14,000	.....
Case 75.							
9/20/02	3:00	150	1.061	84	5,093,000	6,000	4
1/27/02	11:30	......	1.061	......	5,382,000	10,000	11
10/ 3/02	11:30	......	....	......	5,777,000	14,800	17
10/21/02	11:30	......	....	......	5,928,000	14,800	35
10/31/02	11:30	......	1.062	78	6,280,000	13,000	45
11/20/02	10:00	......	1.063	88	5,591,000	6,000	65
12/11/02	3:45	155	1.061	82	5,218,000	6,000	86

TABLE 2.—BLOOD COUNTS OF RABBITS AT HIGH ALTITUDES.

Date.	Time.	Weight.	Sp. Gr.	Hemoglobin (per cent.).	Red Cells (per c.m m.).	Colorless Cells (per (c.m m.).	Days in Mountains.	Days After Return to Albuquerque.
Rabbit 16.		Lbs.						
8/21/02	9:30	4½	1.056	78.0	6,666,000	4,000	......	......
8/28/02	3:00	......	....	......	7,742,000	13,000	5	......
11/ 8/02	1:00	5¼	1.060	86.0	6,671,000	8,500	72	......
12/ 5/02	1:30	6¼	1.058	86.0	6,786,000	2,500	......	27
Rabbit 18.								
8/21/02	1:45	6¼	1.057	73.0	5,849,000	9,000	......	......
8/29/02	10:30	......	....	......	5,875,000	14,000	6	......
11/ 8/02	3:30	7¼	1.058	85.0	7,760,000	7,500	72	......
12/ 6/02	3:30	8	1.056	84.0	7,391,000	4,000	......	28
Rabbit 19.								
8/21/02	3:00	3¼	1.058	73.0	6,022,000	10,000	......	......
8/29/02	9:20	......	....	......	6,929,000	11,000	6	......
11/ 8/02	11:00	5¼	1.061	80.0	6,835,000	7,000	72	......
12/ 4/02	2:45	5.6	1.060	81.0	6,702,000	6,500	......	26

The above data could not be interpreted at the time. The experiment with rabbits sent to higher levels was continued, but accident brought it into the cold of winter. The rabbits were kept in a warm, sunny basement. To make the experiment a fair test, the animals were first placed in the cold, outdoor temperature before sending them to the mountains.

TABLE 3.—BLOOD COUNTS OF RABBITS KEPT IN COLD AND LATER SENT TO A HIGHER ALTITUDE, BUT AT APPROXIMATELY THE SAME TEMPERATURE. PART 1.

Examination No.	Date.	Hour.	Place.	Altitude in feet.	Time in mountains.	Weight	Sp. Gr.	Hemoglobin	Cell volume	Cell diam.	No. of red cells	No. of white cells	Increase in red cells.	Remarks.
	1901.				Rabbitt No. 8 Old male, in good condition.									
1	Feb. 19	11.00 A	Albuquerque	5000	....	6 lbs.	1058	....	44%	6.36μ	6,290,000	17,000	....	Kept in warm basement.
2	Mar. 25	3.30 P.	"	5000	See remarks	6 "	1060	75%	49%	6.52 "	6,730,000	7,500	+440,000	In cold 27 days.
3	Apr. 12	3.00 P.	Camp Whitcomb	7000	14 Days	6 "	1060	75%	46%	6.38 "	6,658,000	10,000	—72,000	Exam. at Albuquerque.
	1901				Rabbit No. 10. Male, about one year old, in good condition.									
1	Feb. 28	......	Albuquerque	5000	....	4 lbs	1060	......	38 %	6.1	5,658,000	10,000	....	Kept in warm basement.
2	Mar. 26	2.45 P.	"	5000	See remarks	4½ "	1062	82 %	54 %	6.55 "	7,720,000	6,600	+2,062,000	In cold 26 days.
3	Apr. 13	10.45 A.	Camp Whitcomb	7000	14 days	4½ "	1060	80 %	47 %	6.48 "	6,290,000	10,700	—1,430,000	Exam. at Albuquerque.
	1901				Rabbit No. 12. Male, about one year old, fat.									
1	Feb. 28	3.00 P.	Albuquerque	5000	....	6⅛ lbs	1059	....	....	5.96 "	6,564,000	7,000	....	Kept in warm basement.
2	Mar. 28	2.00 P.	"	5000	See remarks	6 "	1060	83 %	52 %	6.55 "	6,689,000	9,000	+125,000	In cold 24 days.
3	Apr. 13	3.30 P.	Camp Whitcomb	7000	14 days	6 "	1059	82 %	47 %	6.9 "	5,884,000	13,000	—805,000	Exam. at Albuquerque.
					PART 2									
	1901				Rabbit No. 13 Female, full grown; had young about ten weeks old.									
1	Apr. 19	3.30 P.	Albuquerque	5000	....	4¾ lbs	1052	70 %	39 %	.....	5,449,000	.....	....	Out-doors in cold 3 days.
2	May 3	3.15 P.	"	5000	See remarks	5 "	1058	76 %	43 %	.....	6,911,000	.....	+1,462,000	" " 17 "
3	May 17	4.00 P.	Camp Whitcomb	7000	13 days	5 "	1060	77 %	46 %	....	6,302,000	.....	— 609,000	In from mount. to-day.
	1901				Rabbit No. 14. Female, full grown; had young about fourteen weeks previous to experiment.									
1	Apr. 18	3.30 P.	Albuquerque	5000	....	5½ lbs.	1058	80 %	51 %	.....	6,773,000	.....	....	Out-doors in cold 2 days.
2	May 3	10.45 A.	"	5000	....	5¾ "	1058	72 %	44 %	....	5,404,000	.....	—1,369,000	" " 17
3	May 17	8.10 A.	Camp Whitcomb	7000	13 days	5½ "	1058	80 %	45 %	......	6,795,000	.....	+1,391,000	In from mount. to day.
	1901				Rabbit No. 15 Female, young, about fourteen weeks old.									
1	May 2	2.30 P.	Albuquerque	5000	....	3¾ lb.	1062	90 %	49 %	.....	7,368,000	.....	....	Out doors in cold 16 dys.
2	May 18	9.00 A.	Camp Whitcomb	7000	13 days	3¾ "	1062	87 %	50 %	......	7,297,000	.....	—71,000	In from mount. one day.

The results in Table III showed that on placing the animals in the cold, they underwent the altitude phenomena, namely, increased specific gravity of the blood, increased volume of red cells, and increased number of red cells; but when the animals were sent to a higher level no further increase in these factors took place. It was also noted that blood counts are higher in winter than in the summer season as shown in the following table.

TABLE 4.—COMPARATIVE BLOOD COUNTS IN SUMMER AND WINTER SEASONS.

Case No.	Sex.	Age.	Condition.	Summer.				Winter.				
				Date.	Hour.	Sp. gr.	Red cells.	Date.	Hour.	Sp. gr.	Red cells.	Increase in winter.
27	Male	Adult	Tuberculous; recovered.....	Aug. 5, 1900	11.00 A.M.	....	4,737,000	Dec. 19, 1900	10.45 A.M.	1060	5,351,000	614,000
34	Male	28	Tuberculous; recovered. ...	Aug. 4, "	6.15 P.M.	1055	3,640,000	Jan. 22, 1901	11.00 A.M.	1058	5,640,000	2,000,000
21	Male	Adult	Tuberculous.................	June 20, "	9.30 A.M.	....	6,242,000	Jan. 24, "	12.15 P.M.	1061	5,738,000	—504,000
28	Male	25	Tuberculous..........	Aug. 1, "	2.45 P.M.	1060	5,031,000	Jan. 28, "	2.30 P.M.	1062	5,413,000	382,000
22	Male	41	Tuberculous.	July 18, "	9.30 A.M	....	5,737,000	Jan. 30, "	10.40 A.M.	1059	6,200,000	463,000
32	Female	22	Pneumonia; recovered......	Aug. 3, "	11.40 A.M.	1057	5,711,000	Feb. 2, "	11.00 A.M.	1059	5,920,000	209,000
31	Female	22	Tuberculous; recovered.....	Aug. 3, "	9.30 A.M.	...	3,422,000	Feb. 2, "	11.15 A.M.	1058	5,035,000	1,613,000
10	Male	Adult	Tuberculous..........	May 11, "	10.15 A.M.	....	6,072,000	Feb. 4, "	3.45 P.M.	1058	5,980,000	—92,000
6	Male	22	Normal	May 23, "	2.00 P.M.	....	5,000,000	Feb. 13, "	11.00 A.M.	1062	5,431,000	431,000
33	Female	27	Tuberculous; recovered.....	Aug. 3, "	4.30 P.M.	1055	4,147,000	Feb. 23, "	2.30 P.M.	1060	4,844,000	697,000
24	Male	15	Normal	July 20, "	12.00 M.	....	5,404,000	Mar. 3, "	3.15 P.M.	1062	5,493,000	89,000
38	Male	15	Normal	Aug. 25, "	10.00 A.M.	....	4,764,000	Mar. 7, "	2.20 P.M.	....	5,162,000	398,000
20	Female	Adult	Tuberculous; recovered.....	July 19, "	11.00 A.M.	....	4,822,000	Mar. 21, "	3.30 P.M.	1058	4,835,000	13,000
											Average	485,000

Further, blood counts made during the summer season at an altitude of 7,000 feet were normal, or below as shown in Table 5. All these cases, however, had resided some time at high altitudes.

TABLE 5. — BLOOD COUNTS OF CASES TAKEN AT CAMP WHITCOMB — ALTITUDE 7,000 FEET.

Case Number.	Sex.	Age.	Condition.	Date.	Time in Mountains	Number of Red Cells per Cu. mm.	Number of White Cells per Cu. mm.	Specific Gravity.	Red Cells. Above Normal.	Red Cells. Below Normal.
26	M	44	Tuberculous. Bacilli few	July 31, 1900	35 days	5,431,000	14,800	1052	....	69,000
27	M	?	Tuberculous. Well.	August 5, 1900	65 "	4,737,000	....	....	....	763,000
28	M	25	Tuberculous..........	" 1, 1900	101 "	5,031,000	18,000	1060	....	469,000
29	F	26	Tuberculous..........	" 2, 1900	22 "	4,360,000	14,800	1055	....	640,000
30	M	?	Recovered from Pneumonia	" 2, 1900	43 "	4,578,000	22,200	1055	....	922,000
31	F	22	Weak Lungs. Tuberculosis (?)..........	" 3, 1900	31 "	3,422,000	8,000	....	....	1,578,000
32	F	22	Slight Pneumonia. Well	" 3, 1900	31 "	5,711,000	15,400	1057	711,000	....
33	F	27	Tuberculous. Well	" 3, 1900	20 "	4,147,000	8,600	1055	....	853,000
34	M	28	Tuberculous. Well	" 4, 1900	82 "	3,640,000	9,200	1055	....	1,860,000
35	M	50	Normal	" 5, 1900	? "	4,462,000	....	....	....	1,038,000
3	M	29	Tuberculous. Well 3 years	" 7, 1900	12 "	5,147,000	....	....	....	353,000
36	F	....	Tuberculous. Well (?)	" 24, 1900	21 "	4,831,000	22,000	....	....	169,000
37	M	30	Normal	" 24, 1900	21 "	5,657,000	....	....	157,000	....
38	M	16	Normal	" 25, 1900	60 "	4,764,000	....	....	....	736,000
39	M	32	Tuberculous. No Bacilli	" 31, 1900	41 "	5,764,000	....	1056	264,000	....
40	F	35	Normal	Sept. 1, 1900	41 "	5,284,000	....	....	284,000	....

Again, blood counts of the same persons, taken in winter are higher than those taken during the warm summer season, as shown in Table 6.

TABLE 6. — COMPARATIVE BLOOD COUNTS IN SUMMER AND WINTER SEASONS.

Case No.	Sex.	Age.	Condition.	Summer. Date.	Summer. Hour.	Summer. Sp. gr.	Summer. Red Cells.	Winter. Date.	Winter. Hour.	Winter. Sp. gr.	Winter. Red Cells.	Increase in Winter.
27	Male	Adult	Tuberculous; recovered....	Aug. 5. 1900	11.00 A.M.	....	4,737,000	Dec. 19, 1900	10.45 A.M.	1060	5,351,000	614,000
34	Male	28	Tnberculous; recovered.....	Aug. 4, "	6.15 P.M.	1055	3,640,000	Jan. 22, 1901	11.00 A.M.	1058	5,640,000	2,000,000
21	Male	Adult	Tuberculous	June 20, "	9.30 A.M.	...	6,242,000	Jan. 24, "	12.15 P.M.	1061	5,738,000	—504,000
28	Male	25	Tuberculous	Aug. 1, "	2 45 P.M.	1060	5,031,000	Jan. 28, "	2.30 P.M.	1062	5,413,000	382,000
22	Male	41	Tuberculous.	July 18, "	9.30 A.M.	....	5,737,000	Jan. 30, "	10.40 A.M.	1059	6,200,000	463,000
32	Female	22	Pneumonia; recovered......	Aug. 3, "	11.40 A.M.	1057	5,711,000	Feb. 2, "	11 00 A.M.	1059	5,920,000	209,000
31	Female	22	Tuberculous; recovered.....	Aug. 3, "	9.30 A.M.	....	3,422,000	Feb. 2, "	11.15 A.M.	1058	5,035,000	1,613,000
10	Male	Adult	Tuberculous	May 11, "	10.15 A.M.	...	6,072,000	Feb. 4, "	3.45 P.M.	1058	5,980,000	—92,000
6	Male	22	Normal	May 23, "	2.00 P.M.	...	5,000,000	Feb. 13, "	11.00 A.M.	1062	5,431,000	431,000
33	Female	27	Tuberculous; recovered.....	Aug. 3, "	4.30 P.M.	1055	4,147,000	Feb. 23, "	2.30 P.M.	1060	4,844,000	697,000
24	Male	15	Normal	July 20, "	12.00 M.	....	5,404,000	Mar. 3, "	3.15 P.M.	1062	5,493,000	89,000
38	Male	15	Normal	Aug. 25, "	10.00 A.M.	...	4,764,000	Mar. 7, "	2.20 P.M.	....	5,162,000	398,000
20	Female	Adult	Tuberculous; recovered....	July 19, "	11.00 A.M	..	4,822,000	Mar. 21, "	3.30 P.M.	1058	4,835,000	13,000
											Average	485,000

These and other data lead to the conclusion that "cold is an important factor in accounting for the blood changes due to high altitude" (Am. Jour. Med. Sci. Aug. 1903).

The next experiment was to place rabbits at a somewhat elevated temperature (95° to 105° F.) in an incubator. These rabbits while remaining apparently healthy, showed diminished, rather than increased blood counts. The animals were placed in the incubator March 3rd, and kept there until the experiment ended.

TABLE 7.—BLOOD COUNTS OF RABBITS KEPT AT ELEVATED TEMPERATURE, 95°105° F.

No. of Animal.	Date.	Wt. in grams.	Sp. gr.	Hemoglobin %.	Red Cells per cu.mm.	White Cells per cu.mm.
20	March 4	617	1064	85	6,391,000	5,000
20	March 14	622	1063	86	6,805,000	10,000
20	April 4	694	1063	83	6,564,000	11,000
20	April 25	670	1048(?)	85	6,448,000	8,000
21	February 24	971	1060	80	8,653,000	8,700
21	March 14	971	1058	81	5,089,000	13,000
21	April 4	982	1060	82	5,516,000	9,000
21	April 25	990	1057	......	4,910,000	10,000
22	February 28	620	1063	83	6,733,000	4,000
22	March 21	614	1062	81	6,533,000	8,000
22	April 25	585	1055	72	5,000,000	11,000

The importance of the above observations were not appreciated until other lines of evidence pointed to the fact that the temperature change was fundamental in the climatic problem.

Animals inoculated with tuberculosis and placed in colored glass cells when exposed to the sun invariably died in a much shorter time than was expected. While the hygienic conditions in these cells may have been unfavorable, it is believed that the high temperature produced by the sunlight was the main cause; in other words, the elevated temperature hastened the course of the disease.

Still another observation pointed to the same conclusion as the above. Consumptives residing in New Mexico improve faster during the fall and winter months, but tend to lose ground during the warm weather.

This observation was confirmed by the clinical experience of a number of physicians.

In order to understand the facts presented, it is only necessary to recall the physiological effect produced by heat and cold. Heat tends to diminish bodily exercise and activity as shown by the sluggishness of tropical man. This sluggishness causes a decrease in the elimination of waste products which exercise a detrimental influence on the body. On the other hand, cold when not excessive, stimulates body activity and heat production; as a result more food is required, digestion improves, and the body lays on fat as a reserve to meet the greater demands for heat. At the same time elimination of body wastes is more complete owing to greater activity, and hence, the physiological functions are better performed.

The influence of cold is shown most markedly by the woodsmen of the north. These men are out in the cold all day, and live on plain but nutritious food. The result is that almost invariably they lay on flesh during the cold winters.

It is scarcely necessary to make the application of these facts to the cure of consumptives. So long as the consumptive has sufficient vitality left to respond to the stimulative action of cold, he is almost certain to improve in bodily strength and vigor which is the first essential in the conflict with disease. If the patient's fighting forces are increased he is almost certain of gaining a victory; but when these forces are depleted by warm climates or other causes, then victory belongs to the invading tubercle bacillus.

That consumptives may do well in cold climates is shown by the gratifying results afforded at Muskoka, Canada, Saranac Lake, N. Y., and White Haven, Penn. There seems to be a feeling at Dr. Trudeau's sanitarium that one winter is worth two summers for the patient.

While intense cold may be endured even with profit by some consumptives, others are, perhaps, too sensitive to bear the continuous application, but they may be able to withstand and profit by the daily vibration of heat and cold afforded by the high dry climates. At any rate, the special virtue of a high dry climate appears to lie in this direction. This point appears to have escaped notice heretofore.

If the above explanation of the action of a high dry climate is correct, then we shall be in a better position to profit by such a climate. Only those with sufficient vitality to respond to the temperature variation can hope to be benefited, and physicians must make a careful selection of suitable cases, for it is evident that all who fail to respond must have their remaining energy depleted by the extra demands placed upon the body.

Perhaps the greatest benefit to follow from this presentation is the opening up of a new field of work, viz., the importance of temperature change in other diseases than tuberculosis. Plans are under way for the carrying out at an early date of a large series of experiments in the field.

To summarize: The action of a high dry climate in the cure of tuberculosis, consists essentially in the stimulation afforded to the body by the daily variation in temperature; altitude, dryness, and sunlight are important mainly as being instrumental in causing this daily variation. These factors by themselves exercise a certain hygienic influence, but the temperature change produces a true physiological reaction. Incidentally the variation in temperature affords cool nights with accompanying refreshing sleep. Together, these two factors afford the patient a vantage ground from which to wage a more successful combat against the forces of the disease.