

Studies on the Self-Disinfecting Power of the Skin*

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ARNOLD and his coworkers¹ have reported experiments from which they conclude that the skin possesses some inherent power to destroy bacteria. This disinfecting property was more marked with clean than with dirty skin. More recently similar experiments have been made with yeasts by Cornbleet and Montgomery.² In view of the importance of these conclusions from the standpoint of the spread of communicable disease and the influence of cleanliness as a factor in such spread, it seemed desirable to repeat the work.

The laboratory technic as described by Arnold, *et al.* was followed, *B. prodigiosus* being the test organism. Briefly, this consisted of immersing the hands in a dilute suspension of bacteria, gently rubbing a sterile cotton swab over a designated surface of the skin, inoculating an agar plate from the swab, incubating, and counting the colonies. Table I shows the results obtained, which coincide with those of Arnold. When the skin is rubbed with vaseline no such striking disappearance of bacteria is obtained. The experimental results were somewhat irregular but in general confirmed Arnold's findings. Similar results were obtained when the skin of the forearm was used instead of the hands, and the area inoculated by means of a gauze sponge which had been dipped in the bacterial suspension (Table II).

Since it is well known that viable bacteria exist in the skin, it seemed possible that some factors other than germicidal activity of the skin might account for the results. The technic was first investigated. It was found that in the streaking of the agar plates with the swab, some organisms were not removed. This is shown in Table III. After inoculating the agar surface, the swab was placed in a tube of broth and incubated over night. In a majority of instances the test organism, *B. prodigiosus*, was found. In some cases a skin organism, *Staphylococcus albus*, was present. These experiments were qualitative rather than quantitative and did not account for the observed de-

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TABLE I
DISAPPEARANCE OF BACTERIA FROM THE SURFACE OF CLEAN HANDS
Colonies on Agar Plates
B. prodigiosus

Experiment No.	Time in Minutes							
	Palmar Surface				Dorsal Surface			
	0	10	20	30	0	10	20	30
1.....	47	0	0	7	16	0	0	0
2.....	288	0	0	0	384	0	0	0
3.....	In.*	48	84	0	480	3	2	0
4.....	300	0	0	0	56	0	0	0
5.....	80	8	0	0	200	24	0	0
6.....	1,450	0	0	0	840	0	0	0
7.....	1,010	0	0	0	490	0	0	0
8.....	650	1	0	0	550	0	0	0
9.....	2,240	149	0	0	850	0	0	0
10.....	580	1	0	0	420	2	4	0
11.....	290	4	24	0	260	730	13	0
12.....	138	1	0	0	29	0	0	0

* In. = too many colonies to count.

TABLE II
DISAPPEARANCE OF BACTERIA FROM THE SKIN OF THE FOREARM
Bacteria Applied with a Gauze Sponge

Experiment No.	Time in Minutes							
	A				B			
	0	10	20	30	0	10	20	30
1.....	1	1	0	0	22	4	0	0
2.....	51	0	1	1	94	17	0	4
3.....	57	0	0	1	65	3	2	0
4.....	168	0	0	3	170	3	2	1
5.....	120	0	0	10	8	8	0	1
6.....	0	0	0	0	1,200	3	0	0
7.....	2	0	0	0	180	0	0	0
8.....	1,350	1	0	1	510	0	2	1
9.....	98	0	2	3	370	1	0	0
10.....	750	0	0	0	1,300	13	1	0
11.....	850	0	2	0	320	19	20	10
12.....	111	0	0	0	500	25	22	2

A = swab rubbed gently over skin to remove bacteria.
B = swab rubbed over skin with pressure.

crease in bacteria. However, they served to show that the organisms were never entirely destroyed on the skin as might be concluded from

the agar plate counts. It was thought that the technic used gave comparable results.

During the experiments described it was observed that the surface of the skin usually became dry by the end of 10 minutes. Arnold and

TABLE III
DISAPPEARANCE OF BACTERIA FROM THE HANDS AND INCUBATION OF SWAB IN BROTH
B. prodigiosus

Experiment No.	Time in Minutes							
	Palmar Surface				Dorsal Surface			
	0	10	20	30	0	10	20	30
1 AP.....	2,000	65	410	17	In.	580	400	0
Br.....				+				-
2 AP.....	410	6	0	0	320	0	0	0
Br.....	+	+	+	C	+	+	+	+
3 AP.....	600	C	3	0	3,000	180	22	8
Br.....	C	C	C	C	+	C	C	+
4 AP.....	780	15	6	3	1,200	12	15	1
Br.....	+	+	+	+	+	+	C	C
5 AP.....	330	1	1	0	1,300	C	0	1
Br.....	+	+	+	C	+	+	+	+
6 AP.....	580	15	C	1	950	300	1	0
Br.....	+	+	+	+	+	+	+	+
7 AP.....	1,700	0	900	75	1,500	900	100	100
Br.....	+	+	+	+	+	+	+	+
8 AP.....	820	32	28	33	750	320	5	4
Br.....	+	+	+	+	+	+	+	+
9 AP.....	650	13	11	0	840	0	0	0
Br.....	+	+	+	+	+	+	+	+
10 AP.....	700	112	0	0	1,000	0	0	0
Br.....	+	C	+	C	+	C	C	C
11 AP.....	500	130	0	0	700	2	0	8
Br.....	+	+	+	C	+	+	+	+
12 AP.....	910	1	0	0	750	3	0	0
Br.....	+	+	+	C	+	+	+	C

AP = colonies on agar plate.
Br = growth of test organism in broth culture inoculated with swab.
C = contamination with Staphylococcus.
In. = too many colonies to count.

TABLE IV
SURVIVAL OF BACTERIA ON SKIN KEPT MOIST BY WATER VAPOR

<i>Experiment No.</i>	<i>Time in Minutes</i>			
	0	10	20	30
1.....	920	500	850	1,000
2.....	In.	400	480	350
3.....	680	720	950	500
4.....	480	560	520	400
5.....	950	750	375	420
6.....	540	550	200	460
7.....	500	480	95	120
8.....	520	250	63	184
9.....	500	158	200	280
10.....	650	210	280	220
11.....	420	200	210	120
12.....	310	200	300	150

In. = too many colonies to count.

his associates recognized the possible influence of this factor and reported that holding the hand in steam during the experiments did not change the results. Cornbleet and Montgomery also mention, but do not stress, the influence of moisture. Our experience is shown in Table IV. Similar results were obtained when the skin was kept moist by covering with wet gauze (Table V). This latter procedure is subject to some error because of the possible removal of bacteria by the gauze.

TABLE V
SURVIVAL OF BACTERIA ON MOIST SKIN

<i>Experiment No.</i>	<i>Time in Minutes</i>			
	0	10	20	30
1.....	1,060	570	200	950
2.....	760	720	200	400
3.....	420	400	600	650
4.....	200	400	100	3
5.....	780	420	820	2
6.....	350	39	75	64
7.....	86	290	56	64
8.....	230	41	100	38
9.....	120	69	1	1
10.....	500	150	120	0
11.....	400	40	180	31

NOTE: In all cases the test organism was grown in broth inoculated with the swab used to streak the agar plates.

TABLE VI

DISAPPEARANCE OF BACTERIA FROM THE SURFACE OF THE SKIN IN RELATION TO DRYNESS

B. prodigiosus
Counts on Agar Plate

Experiment No.	Time in Minutes					
	0	10	20	30	40	50
1.....	3,360	3,300	3,900	2,400	630	0*
2.....	970	1,650	194	1,100	2,700 ¹	900 ²
3.....	2,760	2,400	2,400	2,100	2,100	18*
4.....	2,400	2,400	2,700	255*	0	
5.....	2,700	3,000	3,200	3,000	16*	
6.....	3,900	3,500	2,400	2,800	1*	
7.....	2,400	1,800	1,920	2,000	1,800	23*
8.....	In.	In.	1,800	133*	2	
9.....	In.	2,100	In.	31*	1	
10.....	1,800	2,000	2,100	2,100	88*	30
11.....	1,050	990	17*	70	0	

In. = too many colonies to count.
* = surface apparently dry.
1 = 50 minutes.
2 = 70 minutes.

The influence of drying seemed sufficiently important to investigate further. A suspension of the test organism was placed on the palm of the hand and areas swabbed as before. Careful note was

TABLE VII

DISAPPEARANCE OF BACTERIA FROM THE SURFACE OF GLASS SLIDES

B. prodigiosus 37° C.
Counts on Agar Plate

Experiment No.	Time in Minutes				
	0	10	20	30	40
1.....	200	39	130	0*	
2.....	350	350	In.	65*	
3.....	In.	In.	In.	3*	1
4.....	In.	400	375	0*	0
5.....	1,600	1,600	1,400	400	0*
6.....	800	700	0	0*	0
7.....	600	450	In.	In.	40*
8.....	2,000	1,700	750	2*	1
9.....	750	1,200	600	17*	0
10.....	In.	In.	In.	870*	750
11.....	1,270	980	520	620	125*
12.....	1,900	1,100	1,200	400*	3

In. = too many colonies to count.
* = surface apparently dry.

taken of the time at which the surface of the skin was apparently dry. The results are given in Table VI. The times required for disappearance of bacteria are not comparable with those recorded in Tables I, II, and III, since larger amounts of liquid were used to inoculate the skin. These results show that the large and striking drop in the number of bacteria recovered is without exception coincident with apparent dryness of the skin surface.

Another possible factor is the absorption of bacteria into the skin. An attempt was made to study this by removing a portion of skin from a cadaver, repeating the above experiments, and then examining stained sections of the skin. It was not possible to demonstrate the presence of bacteria in these sections.

If drying is the main factor causing the disappearance of bacteria from the surface of the skin, it should be possible to obtain the same results on other materials. This was done on glass slides, tanned hide (before and after washing), and filter paper. The results are recorded in Tables VII, VIII, and IX. The materials were kept at body temperature during the experiments. Again the apparent dryness of the surface was correlated with the disappearance of bacteria. Cotton swabs were also used, a number being immersed in the suspension at

TABLE VIII

DISAPPEARANCE OF BACTERIA FROM THE SURFACE OF TANNED HIDE AND ITS RELATION TO DRYNESS

Experiment No.	Time in Minutes									
	Unwashed Hide					Washed Hide				
	0	10	20	30	40	0	10	20	30	40
1.....	3,000	3,600	3,000	2,900	0* ¹	96	0*	0	0	
2.....	1,600	1,120	1,200	1,150	0* ²	1,700	37	0	0	
3.....	2,400	2,100	1,140	0	5* ³	2,000	250	0*	0	
4.....	2,700	1,900	1,500	1,500	6* ⁴	2,400	2,500	1,800	1,800	0* ⁴
5.....	1,400	1,300	1,500	38*		1,600	1,500	750	0*	
6.....	1,750	1,200	1,500	1*		1,250	1,400	197*	10	
7.....	1,500	850	1,200	73*		1,500	1,750	100*	1	
8.....	1,200	1,600	200*	49		1,100	1,400	48*	172	
9.....	1,700	2,000	1,500*	1		1,800	0*	0	0	
10.....	2,100	2,200	2,000	50*		2,200	33*	1	0	
11.....	2,600	2,400	2,500	1,500	250*	2,500	2,000	42*	0	
12.....	2,400	2,400	2,400	300*		2,100	2,500	400*	45	

* = surface apparently dry.

1 = 4 hours 15 minutes.

2 = 1 hour 45 minutes.

3 = 65 minutes.

4 = 1 hour 20 minutes.

TABLE IX
DISAPPEARANCE OF BACTERIA FROM THE SURFACE OF FILTER PAPER

B. prodigiosus
Counts on Agar Plates

Experiment No.	Time in Minutes			
	0	10	20	30
1.....	150	180	0	0
2.....	1,000	50	4	6
3.....	220	0	0	0
4.....	171	0	0	0
5.....	2,400	0	0	0
6.....	610	5	0	0
7.....	250	0	0	0
8.....	1,500	0	0	0
9.....	700	2	0	0
10.....	300	46	0	0
11.....	1,200	90	0	0
12.....	36	0	0	0

TABLE X
SURVIVAL OF BACTERIA ON THE SURFACE OF AGAR PLATES

B. prodigiosus
Counts on Agar Plates

Experiment No.	Time in Minutes						
	0	10	20	30	40	50	60
1.....	700	500	4	0	0		
2.....	250	120	In.	350	In.	300	
3.....	1,000	1,100	290	900	600	750	400
4.....	950	550	650	550	350	0	
5.....	In.	In.	680	—	800	750	900
6.....	880	600	650	350	410	270	540
7.....	500	150	300	300	In.	400	75
8.....	760	420	100	530	380	370	0
9.....	75	262	128	45	210	14	3
10.....	1,070	380	1	350	500	3	200
11.....	330	160	200	310	79	140	0
12.....	96	43	104	38	6	1	0

In. = too many colonies to count.

the same time and a different swab used at each time interval. Bacteria remained viable on these swabs for longer periods than on filter paper or hide. The surface of a 5 per cent agar jelly was then tried, since such a surface would dry more slowly than that of filter paper.

The results are shown in Table X and are such as might be anticipated.

Filter paper was kept moist by placing it on the surface of an agar plate. A comparison of Tables XI and IX shows the effect of moisture. However, it was not possible to restore the viability of bacteria from the dried surface by moistening. This is true not only for inert ma-

TABLE XI

SURVIVAL OF BACTERIA ON THE SURFACE OF FILTER PAPER KEPT MOIST

B. prodigiosus
Counts on Agar Plates

Experiment No.	Time in Minutes			
	0	10	20	30
1.....	960	540	400	0
2.....	750	550	450	820
3.....	470	65	1	0
4.....	600	840	640	580
5.....	250	460	300	290
6.....	82	750	800	169
7.....	15	400	410	500
8.....	420	1,100	450	1,050
9.....	320	370	980	1,100
10.....	480	570	700	650
11.....	290	320	300	550
12.....	21	500	440	510

TABLE XII

RECOVERY OF BACTERIA FROM FILTER PAPER

B. prodigiosus
Poured Agar Plate Counts

Experiment No.	Time in Minutes			
	0	10	20	30
1.....	In.	0	0	0
2.....	4,000	68	23	40
3.....	2,000	18	18	3
4.....	4,200	104	3	30
5.....	2,400	670	90	6
6.....	3,500	3,000	210	310
7.....	2,700	220	8	4
8.....	2,400	750	38	220
9.....	2,700	600	250	64
10.....	3,000	270	7	12
11.....	2,500	1,600	1	0
12.....	2,700	480	147	170

In. = too many colonies to count.

terials but for the living skin as well. The technic was also tested by placing the filter paper in broth after rubbing with the swab. The test organism was found to be present uniformly even when no colonies appeared on the agar plate. Poured agar plate counts were also substituted for Arnold's technic. The pieces of filter paper were macerated in sterile water at the end of each time interval and plate counts made in the usual manner. The results are shown in Table XII. These results are not so striking as those of Table IX, but a relatively rapid death of organisms is indicated.

SUMMARY

Bacteria applied to the skin diminish in numbers very rapidly. This is particularly noticeable during the first 10 minutes. In the experiments reported, *B. prodigiosus* was used as the test organism.

Similar results are obtained with inert materials such as glass slides, filter paper, and tanned hide.

The most important factor involved appears to be moisture. Marked disappearance of organisms was coincident with apparent dryness of the surface. On surfaces kept moist bacteria remain viable for much longer periods than when the surfaces are allowed to dry.

These experiments fail to indicate any inherent germicidal power of living skin.

REFERENCES

1. Arnold, Gustafson, Hull, Montgomery and Singer. *Am. J. Hyg.*, 11: 345, 1930.
2. Cornbleet and Montgomery. *Arch. Derm. & Syph.*, 23: 908, 1931.

NOTE: Since these results were obtained, Arnold has suggested that if the time interval between inoculation of the skin and the agar plate is shortened, his phenomenon is more striking; this is being studied at the present time.