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ATMOSPHERIC TEMPERATURE AS AN ESSENTIAL FACTOR IN THE PROPAGATION OF Yellow Fever

BY

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Chief Sanitary Officer.

HAVANA, CUBA

1907

Printing Office 133 and 135, Obispo St.

HAVANA

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ATMOSPHERIC TEMPERATURE AS AN ESSENTIAL FACTOR IN THE PROPAGATION

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DR. CHARLES J. FINLAY.

HABANA.

Few events in medical science have had the privilege of being so carefully and thoroughly investigated by highly competent experts from scientific institutions of different Nations, and under varied conditions of geographical site and tropical surroundings, as have been the findings of the U. S. Army Yellow Fever Commision of Habana in 1900 and 1901, confirmatory of my mosquito theory of yellow-fever transmission. And so unanimous has been the consensus of opinion among all subsequent investigators regarding the fact that the bites of the "stegomyia calopus" constitute the regular channel through which the disease is normally transmitted from man to man, that all the Governments directly interested in the matter have agreed to consider that principle as the only sound basis for an efficient prophylaxis of the disease.

The time has come, therefore, when further investigations should be made into the secondary factors which are known either to inhibit or to intensify the faculty possessed by the stegomyia of first becoming contaminated with the immature germs contained in the blood of a yellow fever patient and of thereafter inoculating the matured germ to nonimmunes. Above all should our attention be directed to the *modus operandi* of atmospheric temperature which has at all times been held responsible for the yearly alternations of an epidemic and a non-epidemic season in the endemic centres of former days, when the disease was allowed to pursue its natural course unhampered by human interference of any kind.

As far back as 1882 and 1883, having no doubt in my mind as to the fact that the stegomyia calopus or fasciata was the natural transmitter of yellow fever, I had taken much pains to determine the influence of atmospheric temperature on the functional activity of that species of mosquito, then known in Havana as the Culex mosquito (Robineau Desvoidy); and by a series of careful experiments I endeavoured to ascertain for that in-

sect the five temperature-limits which Van Tieghem, in his "Traité de Botanique" (Paris, 1884, p. 88) considers *critical* for seeds and plants, namely:

Nº 1. A low temperature-limit, below which the external manifestations of life are suspended although vitality persists in a latent condition. I have observed this to occur with the Havana stegomyia when the temperature is lowered to between 15º and 19º C. This would be the limit for "apparent death by cold."

Nº 2. A high temperature-limit, above which the stegomyia drops into a state of lethargy, apparently dead, but may completely revive in a lower temperature. This is observed to happen when the temperature is raised to 37º or 38º C. This is "apparent death by heat."

Nº 3. An intermediate temperature-limit, at some point between Nº 1 and Nº 2, at which all the vital functions are accomplished in the most perfect manner. This optimum-limit I have not been able to determine in the adult insect; but taking as a criterion the mean temperature of days when the successive phases of development, from the ovum to the imago, are most rapidly accomplished, I am inclined to place this limit at some point between 29º and 31º C. These being also the mean temperatures which are most frequently recorded during the acme of severe epidemics.

Nº 4. A still lower temperature, below Nº 1, at which life ceases altogether; this being "real death by cold". I have observed it, in Havana, when the temperature was artificially lowered to -1º C. or -4º C.

Nº 5. A high temperature-limit, above Nº 2, at which life is also completely extinguished beyond the possibility of revival. This is the limit of "real death by heat", which I have observed in some of my experiments during the winter season, when the temperature was raised to between 39º and 40º C.

But the five temperature–limits scheduled above leave entirely out of consideration precisely the two most essential ones so far as the transmission of yellow fever and the multiplication of the transmitting insect are concerned. I refer to the temperature-limits below and above which the stegomyia may be unable to bite and to suck blood. It might be thought that almost simultaneously with the recovery of its general motility, after having been previously benumbed by excess of heat or of cold, a stegomyia which is seen to fly and to move about with ease or to feed readily on sugar or sweet juices, would be also in a condition to bite and to suck blood. But my personal observations have long since satisfied me that this is not always the case. I have seen occasionally in Havana, during the winter season, stegomyias flying about in the room and others, in captivity, feeding on sugar and flying when the temperature was not above 22º C. I have also seen them drive their sting as far as it could reach into the skin, evidently eager to get a feed of blood, but unable to do so so long as the atmospheric temperature remained below 23ºC. Nor have I ever, as far as my records show, witnessed a successful bite by a mosquito of that species, including the sucking of a fair quantity of blood, when the atmospheric temperature was less than 24ºC.

From these data I have inferred that the lowest temperature–limit at which, during the winter season, the Havana stegomyia can accomplish such a bite as will enable it to become contaminated from a yellow fever patient or to lay successive batches of ova for the propagation of its own species, lies between 23° and 25° C., a condition of things which obtains in Havana, at certain hours of the day, when the diurnal mean temperature reaches 23° C.

Regarding the *hot* temperature–limit beyond which the stegomyia should be prevented, by excess of heat, from accomplishing a successful bite, I do not believe that it ever occurs, in the shade, in this part of the Island, for all hours of the day; but it is possible that the occurrence of such a limit in the vicinity of the equatorial line may have contributed to retard the extension of the yellow fever infection, along the Atlantic coasts of America, from the Northern to the Southern hemisphere.

My surmise that during the winter season in Havana, a diurnal mean temperature from 23°C. upwards should be considered as characteristic of days when the local stegomyias are in a condition to become infected and to transmit the yellow fever infection, received a practi-

cal confirmation in the course of an investigation which I undertook in 1893.—As far back as our yellow fever statistics reached at that time, and more particulary regarding the 13 years' period from 1880 to 1892, only once could I find in the records of the Belen Observatory an entire month without a single day showing a diurnal mean temperature as high as 23°C. This happened in the month of January 1886; and in the following month (February 1886) there had been only two such days, one with a mean temperaturc of 23° and another of 24°C.—And coincidently with these excepcionally low mean temperatures, I found, also as a unique exception in a long series of years, that during the first five months of that year (1886) only two cases with no deaths had been recorded at the Havana Military Hospital, while in the Civil population (where only the deaths were recorded) only eight deaths had ocurred (4 in January, two in April and two in May) with the circumstance that the 4 deaths in January had occurred in the first week of that month so that the infection in these 4 must have been acquired in the preceding month. Such a marked decline in the number of yellow fever invasions was an unprecedented event in Havana, and was all the more remarkable inasmuch as no measures had been taken to control the propagation of the disease or to prevent its importation from outside. In fact it virtually amounted to an almost complete extinction of the infection through purely natural causes.

In view of these remarkable facts I have drawn separate charts for each of the 13 years (1880 to 1892) referred to in the preceding paragraph and have appended them to this paper for the benefit of members who are particularly interested in the subject; but their construction being different from other charts of this kind, I beg leave to explain briefly the plan on which they have been drawn.

Bearing in mind that yellow-fever patients infected in the last 4 days of a given calendar month, as a rule, are only taken sick or reported in the following month, and my purpose being to show the mean temperatures of days of possible infection, I have included in each column corresponding to the yellow fever invasions recorded at the Military Hospital in a given month the mean temperatures of the last 4 days of the preceding month, omitting on the order hand those of the 4 last days of the calendar month under consideration. Moreover the mean temperatures are not tabulated in their order of succession but merely distributed so as to show in each column the number of days which have shown a certain degree (centigrade) including all decimals between it and the next degree above.

These charts clearly show the close relation which formely existed in Havana between the number of days of possible infection which had presented mean temperatures favourable for the functional activity of the stegomyia calopus and the number of yellow fever invasions recorded at the Military hospital.

The three hottest years of the series (1880, 1882 and 1883,) were the only ones in which upwards of one thousand yellow fever invasions were recorded at the Military hospital. And, in each individual year, the calendar month in which the greatest number of yellow fever invasions had occurred proved almost invariably to have been the one in which the days of possible infection with mean temperatures between 27° and 31°C. had been most numerous.

On the other hand, the year 1886 which showed lower mean temperatures than any other in the series, was at the same time remakable for the small number of yellow fever invasions during the first five months of that year; an event which could only be attributed to the low mean temperatures recorded in January and February, leading to an almost complete extinction of the infection from purely natural causes.

One of my objects in publishing these data has been to solicit similar ones from other yellow fever centres, so that it may be known to what extent the stegomyia calopus is able to accomodate itself to different temperature conditions under the influence of climatic variations. Indeed I cannot but attach considerable importance to the study of the habits of the stegomyia as well as of other insects which are known to transmit infectious diseases, being of opinion that without such knowledge our means of control must always be imperfect.

TABLES SHOWING THE RELATION

BETWEEN THE MEAN TEMPERATURES OF DAYS OF POSSIBLE INFECTION AND THE NUMBER OF YELLOW FEVER INVASIONS AND DEATHS RECORDED AT THE HAVANA MILITARY HOSPITAL DURING EACH CALENDAR MONTH IN A SERIES OF THIRTEEN YEARS (FROM 1880 TO 1892).

CHART No. 1

1880

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—79 to 27/1—80	28/1 to 25/2	26/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°													
31° — 31°9	.....	.....	.....	.....	.....	.....	2 ds.	.....	.....	.....	.....	.....	2
30° — 30°9	.....	.....	.....	.....	.....	2 ds.	4	1 d.	1 d.	.....	.....	.....	8
29° — 29°9	.....	.....	.....	.....	.....	7	14	15	6	.....	.....	.....	42
28° — 28°9	.....	.....	.....	.....	1 d.	6	7	11	17	2 ds.	.....	.....	44
27° — 27°9	.....	.....	3 ds.	3 ds.	5	7	4	2	3	15	5 ds.	.....	47
26° — 26°9	.....	.....	7	9	10	6	.....	2	1	6	11	2 ds.	54
25° — 25°9	2 ds.	2 ds.	9	8	9	2	.....	.....	2	8	9	9	60
24° — 24°9	9	9	8	5	6	.....	.....	.....	.....	.....	4	2	43
23° — 23°9	17	12	4	2	.....	.....	.....	.....	.....	.....	0	4	39
22° — 22°9	1	3	.....	3	.....	.....	.....	.....	.....	.....	1	4	12
21° — 21°9	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	8
20° — 20°9	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	5
19° — 19°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2
18° — 18°9													
17° — 17°9													
16° — 16°9													
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	18	17	25	65	61	259	384	336	205	62	16	22	1470
Yellow fever. Deaths	4	4	7	30	18	88	234	84	39	32	8	10	558
Civil population													
Yellow fever. Deaths	11	5	13	14	22	19	88	78	32	0	11	4	297

CHART No. 2

1881

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—80 to 27/1—81	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9						2 ds.	1 d.						3
30° — 30°9						4	12	1 d.					17
29° — 29°9						16	10	16	6 ds.				48
28° — 28°9				1 d.	2 ds.	3	5	7	10				28
27° — 27°9			3 ds.	3	16	2	2	4	10	15 ds.	2 ds.		57
26° — 26°9			6	4	11	3	1	3	4	15	19		66
25° — 25°9	6 ds.		1	4	1					1	5	6 ds.	24
24° — 24°9	5	5 ds.	2	5	1						1	6	25
23° — 23°9	11	10	4	3							2	7	37
22° — 22°9	5	7	3	4							0	11	30
21° — 21°9	1	4	5	3							1	1	15
20° — 20°9	0	2	2	3									7
19° — 19°9	2		5										7
18° — 18°9	1												1
17° — 17°9													
16° — 16°9													
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	6	4	10	4	7	54	252	74	209	115	25	22	782
Yellow fever. Deaths	4	1	3	4	4	27	67	9	41	8	3	8	179
Civil population													
Yellow fever. Deaths	4	2	0	2	0	11	29	66	54	31	32	27	258

CHART No. 3

1882

	JAN.	FEB.	MAR.	APR.	MAY	JUN,	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12--81 to 27/1—82	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9	.....	.....	.....	.....	.....	2 ds.	.....	.....	.....	.....	.....	.....	2
31° — 31°9	.....	.....	.....	.....	1 d.	3	1 d.	1 d.	.....	.....	.....	.....	6
30° — 30°9	.....	.....	.....	2 ds.	0	5	7	2	.....	.....	.....	.....	16
29° — 29°9	.....	.....	.....	2	5	12	16	13	7 ds.	.....	.....	.....	55
28° — 28°9	.....	.....	.....	5	0	7	6	10	14	2 ds.	.....	.....	44
27° — 27°9	.....	.....	1 d.	6	11	1	1	2	8	16	3 ds.	.....	49
26° — 26°0	.....	.....	1	6	13	.....	.....	3	0	7	4	.....	34
25° — 25°9	.....	5 ds.	9	5	1	.....	.....	.....	1	6	4	3 ds.	34
24° — 24°9	9 ds.	14	13	0	.....	.....	.....	.....	.....	.....	8	11	55
23° — 23°9	13	6	3	3	.....	.....	.....	.....	.....	.....	8	6	39
22° — 22°9	3	2	2	1	.....	.....	.....	.....	.....	.....	1	2	11
21° — 21°9	1	1	2	.....	.....	.....	.....	.....	.....	.....	1	1	6
20° — 20°9	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	6	10
19° — 19°9	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	2
18° — 18°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
17° — 17°8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
16° — 16°9													
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	6	3	4	10	130	347	270	100	85	81	80	39	1155
Yellow fever. Deaths	0	1	2	4	49	85	76	34	33	45	32	16	377
Civil population													
Yellow fever. Deaths	9	10	13	15	34	92	119	29	24	11	8	7	381

CHART No. 4

1883

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—82 to 27/1—83	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9													
30° — 30°9	.....	.....	.....	1 d.	.....	6 ds.	4ds.	2 ds.	.....	.....	.....	.....	13
29° — 29°9	.....	.....	.....	3	1 d.	10	11	17	1 d.	1 d.	.....	.....	45
28° — 28°9	1 d.	.....	.....	1	5	6	10	9	12	10	.....	.....	53
27° — 27°9	0	.....	2 ds.	12	11	5	5	1	10	7	5 ds.	.....	58
26° — 26°9	1	.....	1	4	10	3	1	2	7	7	8	.....	44
25° — 25°9	0	14 ds.	4	4	4	.....	.....	.....	.....	6	11	.....	43
24° — 24°9	14	14	5	1	.....	.....	.....	.....	.....	.....	5	7 ds.	46
23° — 23°9	6	.....	9	3	.....	.....	.....	.....	.....	.....	1	13	32
22° — 22°9	4	.....	8	1	.....	.....	.....	.....	.....	.....	.....	5	18
21° — 21°9	2	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	2	6
20° — 20°9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	4
19° — 19°9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1
18° — 18°9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2
17° — 17°9													
16° — 16°9													
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	18	32	55	56	155	298	417	127	17	32	18	10	1235
Yellow fever. Deaths	8	10	21	32	71	154	132	86	14	12	11	9	560
Civil population													
Yellow fever. Deaths	5	1	1	2	6	9	42	167	37	63	42	36	411

CHART No. 5

1884

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—83 to 27/1 —84	28/1 to 25/2	26/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9							7 ds.	1 d.					8
30° — 30°9				4 ds.	3 ds.	3 ds.	14	12	2 ds.				38
29° — 29°6				3	10	7	9	9	9	4 ds.			51
28° — 28°9			3 ds.	2	6	9	1	7	11	12			51
27° — 27°9			8	6	6	8		2	8	8	2 ds.	2 ds.	50
26° — 26°9		4 ds.	6	5	4	1				6	11	6	43
25° — 25°9	5 ds.	7	3	7	1	2				1	15	12	53
24° — 24°9	10	10	3	2	1						2	9	37
23° — 23°9	6	7	1	1								1	16
22° — 22°9	3	1	1									1	6
21° — 21°9	2		3										5
20° — 20°9	2		2										4
19° — 19°9	1		1										2
18° — 18°9	2												2
17° — 17°0													
16° — 16°9													
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases....	7	7	22	36	64	90	108	82	25	8	4	6	459
Yellow fever. Deaths.	5	2	7	19	27	30	57	36	13	4	0	4	204
Civil population													
Yellow fever. Deaths.	24	15	2	16	30	37	73	66	27	17	9	3	319

CHART No. 6

1885

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—84 to 27/1—85	28/1 to 24/2	25/2 t2 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9	.....	.....	.....	.....	1 d.	.....	.....	.....	.....	.....	.....	.....	1
30° — 30°9	.....	.....	.....	.....	1	1 d.	7 ds.	1 d.	.....	.....	.....	.....	10
29° — 29°9	.....	.....	.....	.....	2	9	16	15	2 ds.	.....	.....	.....	44
28° — 28°9	.....	.....	.....	.....	3	9	7	9	12	3 ds.	.....	.....	43
27° — 27°9	.....	.....	.....	2 ds.	9	3	0	2	7	6	.....	.....	29
26° — 26°9	.....	.....	3 ds.	11	9	2	1	3	7	8	2 ds.	1 d.	47
25° — 25°9	6 ds.	2 ds.	2	11	5	2	.....	1	2	4	2	1	38
24° — 24°9	11	3	5	6	0	3	.....	.....	.....	7	8	0	43
23° — 23°9	7	4	6	.....	1	1	.....	.....	.....	3	9	4	35
22° — 22°9	3	6	9	.....	.....	.....	.....	.....	.....	.....	4	3	25
21° — 21°9	3	8	4	.....	.....	.....	.....	.....	.....	.....	2	9	26
20° — 20°9	1	4	2	.....	.....	.....	.....	.....	.....	.....	2	6	15
19° — 19°9	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	0	2	2
18° — 18°9	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	1	2	3
17° — 17°9	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2
16° — 16°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
15° — 15°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0
14° — 14°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
Military hospital													
Yellow fever. Cases	5	2	1	3	6	2	40	24	25	6	4	2	120
Yellow fever. Deaths	3	2	1	2	4	2	12	21	15	3	0	1	66
Civil population													
Yellow fever. Deaths	3	1	1	0	0	2	3	11	19	40	23	6	109

CHART No. 7

1886

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible iniection	28/12—85 to 27/1—86	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9	.....	.....	.....	.....	.....	1 d.	.....	.....	.....	.....	.....	.....	1
30° — 30°9	.....	.....	.....	.....	.....	1	1 d.	.....	2 ds.	.....	.....	.....	4
29° — 29°9	.....	.....	.....	.....	.....	2	2	4 ds.	0	.....	.....	.....	8
28° — 28°9	.....	.....	.....	.....	2 ds.	8	16	12	8	.....	.....	.....	46
27° — 27°9	.....	.....	1 d.	.....	7	14	6	9	15	5 ds.	.....	.....	57
26° — 26°9	.....	.....	3	3 ds.	6	1	5	4	2	10	.....	.....	34
25° — 25°9	.....	.....	4	1	9	1	0	2	3	8	4 ds.	.....	32
24° — 24°9	.....	1 d.	7	7	6	1	0	.....	.....	5	10	.....	37
23° — 23°9	.....	1	4	11	1	1	1	.....	.....	3	8	2 ds.	32
22° — 22°9	4 ds.	6	3	3	.....	.....	.....	.....	.....	.....	7	9	32
21° — 21°9	9	1	6	1	.....	.....	.....	.....	.....	.....	1	10	28
20° — 20°9	7	8	1	1	.....	.....	.....	.....	.....	.....	.....	6	23
19° — 19°9	4	4	2	3	.....	.....	.....	.....	.....	.....	.....	3	16
18° — 18°9	1	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	8
17° — 17°9	4	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
16° — 16°9	0	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
15° — 15°9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
14° — 14°9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Military hospital													
Yellow fever. Cases	0	1	1	0	0	8	27	36	30	14	7	6	130
Yellow fever. Deaths	0	0	0	0	0	1	4	9	15	4	1	1	35
Civil population													
Yellow fever. Deaths	4	0	0	2	2	13	30	32	22	12	8	6	131

CHART No. 8

1887

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—86 to 27/1 —87	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9													
30° — 30°9													
29° — 29°9							5 ds.	11 ds.		1 d.			17
28° — 28°9				4 ds.		1 d.	16	15	3 ds.	2			41
27° — 27°9				4	2 ds.	10	7	4	14	5			46
26° — 26°9			2 ds.	2	19	9	2	1	9	9	1 d.		54
25° — 25°9			1	1	6	6	0		4	12	3		33
24° — 24°9	1 d.	7 ds.	1	3	4	3	1			1	8	2 ds.	31
23° — 23°9	2	13	6	7		1				1	4	10	44
22° — 22°9	8	7	9	4							12	8	48
21° — 21°9	7	1	5	2							0	6	21
20° — 20°9	3		6	2							1	4	16
19° — 19°9	2		0	1							1	1	5
18° — 18°9	2		1										3
17° — 17°8	2												2
16° — 16°9	2												2
15° — 15°9	2												2
14° — 14°9													
Military hospital													
Yellow fever. Cases	8	8	13	30	50	120	175	79	55	36	29	20	623
Yellow fever. Deaths	3	2	4	11	18	30	58	31	22	12	9	8	238
Civil population													
Yellow fever. Deaths	3	4	4	10	34	35	51	42	17	23	15	7	245

CHART No. 9

1888

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—87 to 27/1—88	28/1 to 25/2	26/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9													
30° — 30°9	.....	.....	.....	.....	.....	.....	.....	2 ds.	.....	.....	.....	.....	2
29° — 29°9	.....	.....	.....	.....	1 d.	.....	8 ds.	12	.....	.....	.....	.....	21
28° — 28°9	.....	.....	.....	.....	1	7 ds.	14	14	10 ds.	1 d.	.....	.....	47
27° — 27°9	.....	.....	.....	1 d.	2	7	4	2	9	3	1 d.	.....	29
26° — 26°9	.....	.....	3 ds.	0	8	12	2	1	7	18	5	.....	56
25° — 25°9	.....	2 ds.	3	8	6	4	2	.....	4	5	8	.....	42
24° — 24°9	.....	7	3	15	8	.....	1	.....	.....	4	8	.....	46
23° — 23°9	10 ds.	4	4	6	4	.....	.....	.....	.....	.....	3	8 ds.	39
22° — 22°9	12	5	1	.....	1	.....	.....	.....	.....	.....	1	3	23
21° — 21°9	7	5	7	.....	.....	.....	.....	.....	.....	.....	2	9	30
20° — 20°9	0	5	6	.....	.....	.....	.....	.....	.....	.....	1	4	16
19° — 19°9	2	1	3	.....	.....	.....	.....	.....	.....	.....	0	4	10
18° — 18°9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	1	3
17° — 17°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0
16° — 16°9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	9	12	19	55	60	134	209	226	123	73	54	14	988
Yellow fever. Deaths	5	4	11	22	22	25	53	64	44	17	17	4	288
Civil population													
Yellow fever. Deaths	4	2	4	4	5	8	24	52	18	30	21	22	194

CHART No. 10

1889

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—88 to 27/1 —89	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9													
30° — 30°9													
29° — 29°9	.....	.....	.....	.....	.....	8 ds.	6 ds.	5 ds.	3 ds.	.....	.....	.....	22
28° — 28°9	.....	.....	.....	.....	.....	8	18	12	11	2 ds.	.....	.....	51
27° — 27°9	.....	.....	.....	1 d.	5 ds.	6	5	9	11	5	.....	.....	42
26° — 26°9	.....	2 ds.	.....	3	13	4	1	4	3	2	8 ds.	.....	40
25° — 25°9	.....	3	.....	9	5	4	1	1	2	10	13	.....	48
24° — 24°9	3 ds.	2	2 ds.	4	6	.....	.....	.....	.....	6	5	2 ds.	30
23° — 23°9	15	1	6	6	1	.....	.....	.....	.....	5	3	8	45
22° — 22°9	6	3	8	5	1	.....	.....	.....	.....	0	1	10	34
21° — 21°0	4	8	11	2	.....	.....	.....	.....	.....	1	.....	6	32
20° — 20°9	1	5	3	.....	.....	.....	.....	.....	.....	.....	.....	5	14
19° — 19°9	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
18° — 18°9	1	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
17° — 17°9													
16° — 16°9													
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	14	13	13	22	26	77	104	101	34	6	21	8	439
Yellow fever. Deaths	3	3	2	4	8	23	23	30	10	4	6	4	120
Civil population													
Yellow fever. Deaths	30	9	17	6	11	26	38	53	36	21	22	10	279

CHART No. II

1890

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—89 to 27/1—90	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/10	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9													
30° — 30°9	.....	.....	.....	.....	.....	.....	1 d.	.....	.....	.....	.....	.....	1
29° — 29°9	.....	.....	.....	.....	2 ds.	.....	8	.....	.....	.....	.....	.....	10
28° — 28°9	.....	.....	.....	.....	2	13 ds.	14	3 ds.	4 ds.	.....	.....	.....	36
27° — 27°9	.....	.....	1 d.	.....	7	11	5	18	11	3 ds.	.....	.....	61
26° — 26°9	.....	.....	0	1 d.	7	1	2	7	8	16	.....	.....	42
25° — 25°9	.....	.....	3	8	10	1	1	1	6	4	6 ds.	.....	40
24° — 24°9	1 d.	3 ds.	7	16	3	2	.....	2	1	2	11	1 d.	49
23° — 23°9	15	10	4	4	.....	2	.....	.....	.....	1	7	6	49
22° — 22°9	15	12	4	1	.....	.....	.....	.....	.....	.....	5	7	44
21° — 21°9	.....	3	5	.....	.....	.....	.....	.....	.....	.....	1	8	17
20° — 20°9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	4	5
19° — 19°9	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	4	7
18° — 18°9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	2
17° — 17°9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
16° — 16°9	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	7	11	10	26	70	151	188	179	20	19	17	6	704
Yellow fever. Deaths	2	2	3	8	15	32	42	32	12	9	7	2	166
Civil population													
Yellow fever. Deaths	9	2	1	4	11	12	31	28	20	22	16	10	166

CHART No. 12

1991

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—90 to 27/1 —91	28/1 to 24/2	25/2 to 27/3	28/3 to 26/4	27/4 ta 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9	.....	.....	.....	.....	.....	.....	1 d.	.....	.....	.....	.....	.....	1
30° — 30°9	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	4
29° — 29°9	.....	.....	.....	.....	.....	1 d.	9	6 ds.	.....	.....	.....	.....	16
28° — 28°9	.....	.....	.....	.....	1 d.	15	9	17	6 ds.	.....	.....	.....	48
27° — 27°9	.....	.....	.....	.....	0	13	6	3	15	.....	.....	.....	37
26° — 26°9	.....	.....	.....	2 ds.	5	0	1	4	7	3 ds.	.....	.....	22
25° — 25°9	.....	1 d.	2 ds.	7	10	1	1	1	1	10	.....	1 d.	35
24° — 24°9	.....	8	9	8	9	.....	.....	.....	1	11	11 ds.	3	60
23° — 23°9	2 ds.	10	12	5	6	.....	.....	.....	.....	6	10	13	64
22° — 22°9	1	6	2	3	.....	.....	.....	.....	.....	1	8	7	28
21° — 21°9	5	1	3	2	.....	.....	.....	.....	.....	.....	1	5	17
20° — 20°9	10	1	2	0	.....	.....	.....	.....	.....	.....	.....	2	15
19° — 19°9	7	1	0	0	.....	.....	.....	.....	.....	.....	.....	.....	8
18° — 18°9	3	.....	1	3	.....	.....	.....	.....	.....	.....	.....	.....	7
17° — 17°9	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
16° — 16°9	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases	15	16	8	5	12	104	243	188	135	83	49	24	882
Yellow fever. Deaths	6	8	3	1	3	28	50	43	38	14	11	7	212
Civil population													
Yellow fever. Deaths	5	3	1	4	4	16	13	23	26	23	16	11	145

CHART No. 13

1892

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR
Days of possible infection	28/12—91 to 27/1—991	28/1 to 25/2	26/2 to 27/3	28/3 to 26/4	27/4 to 27/5	28/5 to 26/6	27/6 to 27/7	28/7 to 27/8	28/8 to 26/9	27/9 to 27/10	28/10 to 26/11	27/11 to 27/12	
Centigrade scale													
32° — 32°9													
31° — 31°9													
30° — 30°9													
29° — 29°9.....	.....	.....	.....	.....	.....	.....	2 ds.	.....	1 d.	.....	.....	.....	3
28° — 28°9.....	.....	.....	.....	.....	.....	4 ds.	16	11 ds.	6	.....	.....	.....	37
27° — 27°9.....	.....	.....	.....	.....	4 ds.	12	10	13	9	.....	.....	.....	48
26° — 26°9.....	.....	.....	2 ds.	7 ds.	10	7	2	3	12	8 ds.	.....	.....	51
25° — 25°9.....	.....	.....	1	8	13	4	1	4	2	17	6 ds.	.....	56
24° — 24°9.....	.....	.....	1	6	4	2	.....	.....	.....	4	4	2 ds.	23
23° — 23°9.....	5 ds.	4 ds.	4	5	.....	1	.....	.....	.....	1	5	8	33
22° — 22°9.....	9	9	4	2	.....	.....	.....	.....	.....	1	4	5	33
21° — 21°9.....	6	6	2	1	.....	.....	.....	.....	.....	.....	9	10	34
20° — 20°9.....	3	6	10	1	.....	.....	.....	.....	.....	.....	0	5	26
19° — 19°9.....	2	3	4	.....	.....	.....	.....	.....	.....	.....	2	1	12
18° — 18°9.....	3	1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
17° — 17°9.....	3	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
16° — 16°9.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
15° — 15°9													
14° — 14°9													
Military hospital													
Yellow fever. Cases.....	24	16	14	14	17	39	76	62	73	51	52	19	457
Yellow fever. Deaths...	9	4	1	3	1	3	9	16	15	18	15	5	99
Civil population													
Yellow fever. Deaths...	6	6	0	5	6	10	19	52	58	35	37	30	264

SYNOPTICAL TABLE OF YELLOW FEVER CASES & DEATHS

1880–1892

YEARS	JANUARY Average mean temp. C°	JANUARY Military Hospital Cases	JANUARY Military Hospital Deaths	JANUARY Civil Pop'n Deaths	FEBRUARY Average mean temp. C°	FEBRUARY Military Hospital Cases	FEBRUARY Military Hospital Deaths	FEBRUARY Civil Pop'n Deaths	MARCH Average mean temp. C°	MARCH Military Hospital Cases	MARCH Military Hospital Deaths	MARCH Civil Pop'n Deaths	APRIL Average mean temp. C°	APRIL Military Hospital Cases	APRIL Military Hospital Deaths	APRIL Civil Pop'n Deaths
1880	25°4	18	4	11	25°7	17	4	5	25°3	25	7	53	25°8	65	30	14
1881	25°8	6	4	4	25°1	6	1	2	23°2	20	3	0	25°0	4	4	2
1882	25°1	6	0	9	25°6	3	1	10	25°0	4	2	33	26°9	10	4	15
1883	25°5	16	6	5	24°8	22	10	1	24°0	55	21	1	25°0	56	22	2
1884	25°0	7	5	24	25°4	7	2	15	24°7	22	7	2	26°1	36	19	16
1885	25°8	5	3	3	22°2	2	2	1	23°8	1	1	1	25°7	3	2	0
1886	26°1	0	0	4	21°1	1	0	0	22°8	1	0	0	25°5	0	0	2
1887	26°5	8	3	3	25°4	8	2	4	22°5	13	4	4	25°0	30	13	10
1888	25°2	9	5	4	22°7	12	4	2	23°1	19	11	4	24°2	55	22	4
1889	25°2	14	3	30	22°4	12	3	9	22°1	13	2	37	24°5	22	4	6
1890	25°0	7	2	9	22°2	11	2	2	22°4	10	3	1	24°0	26	8	4
1891	26°7	13	6	5	22°0	16	8	3	23°4	8	3	1	23°8	5	1	4
1892	26°9	24	9	6	21°5	16	4	6	21°7	14	1	0	25°0	14	3	5
TOTAL	......	137	53	117	......	142	43	60	......	195	65	57	......	326	140	84
General average	25°2	10.5	4.0	9.0	22°0	10.9	3.3	4.6	22°5	15.0	5.0	4.4	25°2	25.1	10.8	6.5

YEARS	MAY Average mean temp. C°	MAY Military Hospital Cases	MAY Military Hospital Deaths	MAY Civil Pop'n Deaths	JUNE Average mean temp. C°	JUNE Military Hospital Cases	JUNE Military Hospital Deaths	JUNE Civil Pop'n Deaths	JULY Average mean temp. C°	JULY Military Hospital Cases	JULY Military Hospital Deaths	JULY Civil Pop'n Deaths	AUGUST Average mean temp. C°	AUGUST Military Hospital Cases	AUGUST Military Hospital Deaths	AUGUST Civil Pop'n Deaths
1880	26°0	61	18	32	28°3	259	88	19	29°2	384	234	88	28°9	236	84	78
1881	27°1	7	4	0	29°5	54	27	11	29°3	252	67	29	28°5	74	9	46
1882	27°8	130	49	34	29°7	347	85	93	29°2	270	76	119	28°8	200	34	29
1883	27°4	155	71	6	28°9	298	154	9	28°7	417	132	41	28°7	227	86	167
1884	27°6	64	27	30	27°5	90	30	27	28°4	108	55	73	28°2	82	36	46
1885	27°2	6	4	0	28°4	2	2	2	29°2	40	12	3	28°6	24	21	11
1886	26°1	0	0	2	26°8	8	1	13	27°9	22	4	30	28°0	36	9	32
1887	26°1	50	18	34	26°3	130	30	35	28°5	175	58	51	28°3	79	31	42
1888	25°8	40	22	5	27°3	136	25	8	28°1	209	53	24	28°8	226	64	52
1889	26°1	26	8	11	27°9	77	23	26	28°4	104	23	38	27°7	101	30	53
1890	26°3	70	15	11	28°0	151	32	12	28°1	188	42	31	27°2	179	32	28
1891	25°4	12	3	4	28°2	104	28	16	28°6	243	50	13	27°9	168	43	23
1892	26°3	17	1	6	26°8	29	3	10	27°7	74	9	19	27°5	61	16	53
TOTAL	......	658	240	165	......	1685	528	290	......	2485	817	560	......	1614	495	709
General average	26°5	50.6	18.8	12.7	28°1	129.5	40.6	22.3	28°6	191.2	62.8	43.1	28°3	126.5	38.1	54.5

YEARS	SEPTEMBER Average mean temp. C°	SEPTEMBER Military Hospital Cases	SEPTEMBER Military Hospital Deaths	SEPTEMBER Civil Pop'n Deaths	OCTOBER Average mean temp. C°	OCTOBER Military Hospital Cases	OCTOBER Military Hospital Deaths	OCTOBER Civil Pop'n Deaths	NOVEMBER Average mean temp. C°	NOVEMBER Military Hospital Cases	NOVEMBER Military Hospital Deaths	NOVEMBER Civil Pop'n Deaths	DECEMBER Average mean temp. C°	DECEMBER Military Hospital Cases	DECEMBER Military Hospital Deaths	DECEMBER Civil Pop'n Deaths
1880	28°1	205	39	32	26°7	62	33	6	25°9	26	8	11	22°6	22	10	4
1881	27°9	200	41	54	26°9	115	8	31	25°6	25	3	31	23°4	22	8	27
1882	28°2	85	33	24	26°8	83	45	11	24°1	80	32	8	23°8	39	16	7
1883	27°9	17	14	27	27°1	37	12	63	25°4	18	11	42	22°9	10	9	26
1884	27°7	35	33	27	25°5	8	4	17	24°9	4	0	9	23°1	6	4	3
1885	27°5	25	15	19	25°4	6	3	40	23°2	4	0	22	20°8	2	1	6
1886	27°3	30	15	22	25°4	14	4	12	23°4	7	1	8	21°5	6	1	6
1887	27°3	55	22	17	25°8	56	12	23	23°2	29	9	13	22°1	20	8	7
1888	27°1	122	44	18	25°2	73	17	30	23°9	54	17	21	21°4	14	4	22
1889	27°9	34	10	36	25°1	6	4	21	24°8	23	6	22	22°4	8	4	10
1890	26°4	30	12	20	26°1	19	9	22	24°0	17	7	16	21°2	6	2	10
1891	27°1	135	39	30	24°6	85	14	23	23°4	49	11	16	22°8	24	7	11
1892	27°0	73	15	58	25°0	51	19	15	23°9	52	15	37	21°9	19	5	30
TOTAL	......	1036	311	390	......	586	182	328	......	376	120	260	......	198	79	179
General average	27°5	79.7	23.9	30.0	25°9	45.1	14.0	25.2	24°2	28.9	9.2	20.0	22°3	15.2	6.1	13.7

YEARS	TOTAL YEAR Average mean temp. C°	TOTAL YEAR Military Hospital Cases	TOTAL YEAR Military Hospital Deaths	TOTAL YEAR Civil Population Deaths
1880	26°2	1470	558	297
1881	26°1	792	179	258
1882	26°4	1555	377	391
1883	26°4	1235	560	421
1884	26°0	439	204	309
1885	25°5	130	66	100
1886	24°7	130	35	131
1887	24°9	603	208	265
1888	25°1	908	298	194
1889	25°2	439	120	279
1890	25°0	704	166	166
1891	24°9	882	252	145
1892	24°5	437	99	264
TOTAL	......	9446	3102	3199
General average	25°4	726	238.5	246.10

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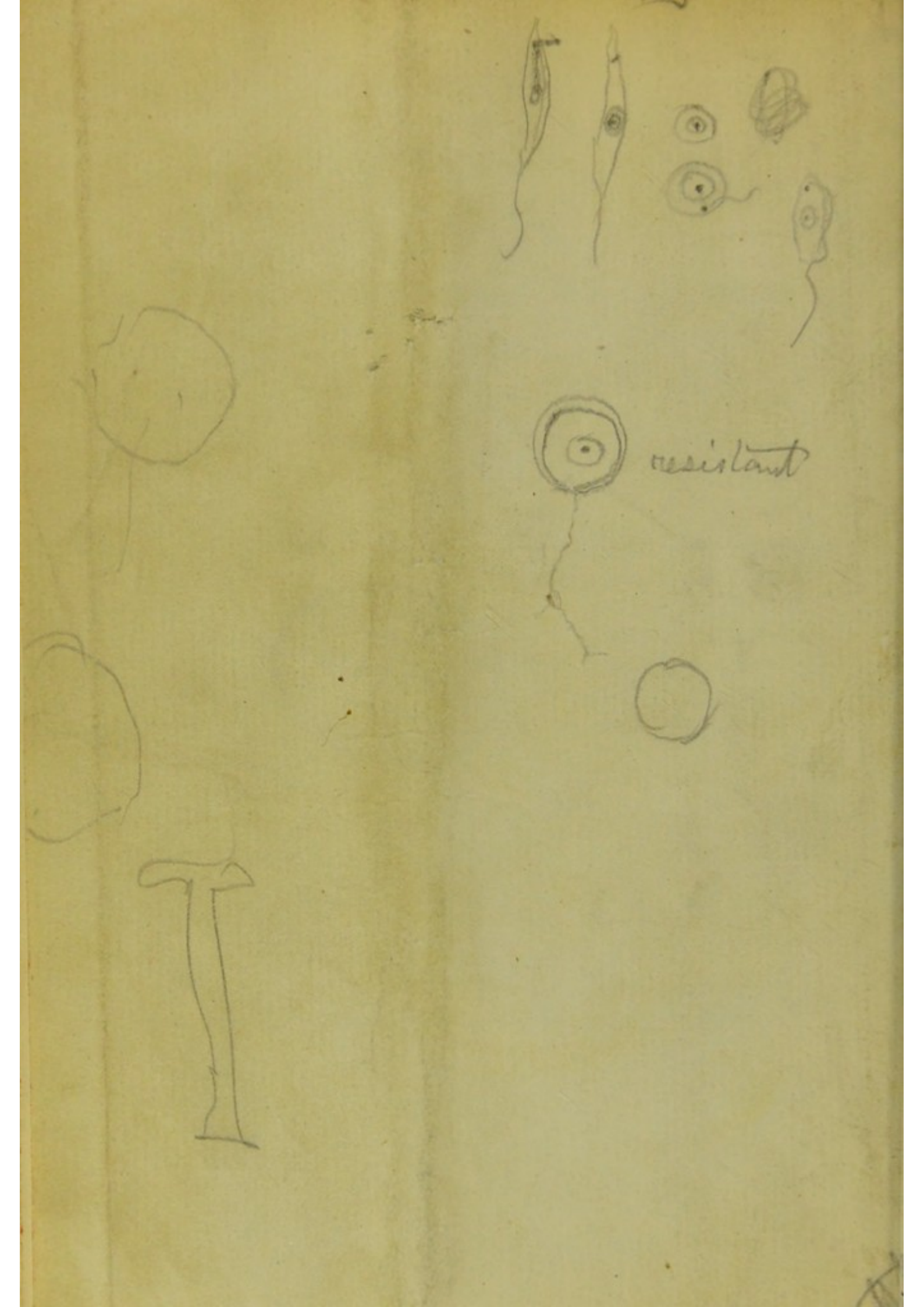
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