THE OHIO JOURNAL OF SCIENCE

VOL. XXXVIII SEPTEMBER, 1938 No. 5

STUDIES IN ANTIBIOSIS BETWEEN BACTERIA AND FUNGI[1]

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The observations reported herein are the first results of a series of studies in antibiosis between bacteria and fungi, which were begun in the Biological Laboratories of Kent State University in October, 1935. The aim of these investigations is to determine if any of several common species of bacteria are able to inhibit the growth of fungi when grown in close association with them in culture, and to obtain some information regarding the nature of such inhibition.

These studies were undertaken with a number of cultures of bacteria and fungi which were on hand for use in instructional work. The organisms employed are as follows:

Schizomycetes:

Staphylococcus aureus Ros.
Micrococcus ureae Cohn.
Serratia marcescens Bizio.
Klebsiella pneumoniae (Schr.) Trev.
Escherichia coli (Mig.) Cast. et Chalm.
Proteus vulgaris Hauser.
Alcaligenes faecalis Cast. et Chalm.
Bacillus subtilis Cohn.
Bacillus cereus Frank. et Frank.
Bacillus megatherium DeBary.
Actinomyces albus Krainsky.

[1]A resumé of this paper was read before the Ohio Academy of Science at Columbus, Ohio, at the annual meeting of the society in May, 1937.

Eumycetes:

Zygorhynchus mülleri Vuill.
Glomerella cingulata (Stonem.) Sp. et v. Schr.
Anthostomella sp.
Physalospora cydoniae Arn.
Gloesoporium affine Sacc.
Gloeosporium musarum Cke. et Mass.
Colletotrichum lindemuthianum (Sacc. et Magn.) Bri. et Cav.
Botrytis tulipae (Lib.) Hopk.
Cephalothecium roseum Cda.
Volutella fructi St. et H.

In order to determine the effect of the bacteria upon the growth of fungi, each bacterium was grown together with each fungus on dextrose agar, and on corn meal agar, in Petri dishes. The fungous inoculum was placed in the center of the Petri dish. At two centimeters from it, on opposite sides, the agar was inoculated with the bacterium to be tested. Fungi were inoculated at the same time as the bacteria except in experiments in which *Zygorhynchus mülleri* and *Anthostomella* were used. In these two cases, because of the rapid growth of the mycelium, it became necessary to inoculate the bacterium 24 to 36 hours before the fungus, so that the bacterial colonies could become established before the fungous colony was very large. Fungi which sporulated freely, were inoculated by means of a loopful of water suspension of spores. Others were inoculated by means of mycelial transfers. Bacteria were inoculated by using a small loopful of a heavy, water suspension of cells and dividing it between the two points of inoculation in the same Petri dish.

Twelve cc. of Difco agar were used to the Petri dish in all cases. The agar was neutralized with NaOH or HCl. pH determinations were made colorimetrically using a W. A. Taylor comparator. Measurements of fungous colonies were taken with a millimeter rule at intervals of 24 hours, beginning 24 hours after inoculation and continuing until a distinct inhibitory influence was evident, or until the fungous and bacterial colonies were in contact. All tests were carried out in triplicate. Two diameters at right angles to each other were measured on each fungous colony, and the average of the three colonies in each test was recorded. At the first sign of definite inhibition, the

shortest distance between the fungus and the inhibitor was measured. This distance is recorded as "Inhibitory distance."

Of the bacteria employed, *Serratia marcescens*, *Bacillus subtilis*, and *Actinomyces albus* inhibited the growth of fungi. All other bacteria had no appreciable effect upon the growth of any of the fungi against which they were tested. (Plates I and II).

In order to conserve space, only the figures pertaining to the tests with the inhibitor organisms are given in Table I, and contrasted with the controls in each case. The diameters of the fungous colony, are the averages for three cultures. The first figure is the diameter directly between the two bacterial colonies; the second is the diameter at right angles to the first. In the case of the controls, the averages of the minimum and maximum diameters of the three colonies in each test are recorded. The column marked "Inhibitory distance" gives the average minimum distance between the fungous colony and the inhibitor colonies at the time of the first evidence of definite inhibition.

From the figures given in Table I it will be seen that *Actinomyces albus* is the most universal inhibitor of the three under consideration. It inhibits all of the fungi against which it was tested, on both kinds of agar. *Bacillus subtilis* inhibits the growth of 5 of the 10 fungi, on dextrose agar, and that of 8 fungi on corn meal agar. *Serratia marcescens* inhibits the growth of 3 fungi on dextrose agar, and 5 fungi on corn meal agar.

The greatest single amount of inhibition was detected in the case of *Bacillus subtilis* against *Cephalothecium roseum* on corn meal agar. In several tests carried out, the conidia of the fungus used as inoculum, produced germ tubes, but failed to develop further. In one case, a colony was actually developed which, however, failed to reach a diameter exceeding 5 mm.

In all but one case, inhibition, when it occurred, was greater on corn meal agar than on dextrose agar. No correlation exists between rate of growth and degree of inhibition. Rapidly growing fungi may be inhibited as greatly as slowly growing fungi; slowly growing bacteria may inhibit as much as, or more than rapidly growing ones. The inhibitory effect was more pronounced on corn meal agar than on dextrose agar in spite of the fact that all three of the inhibitors grew much more luxuriantly on dextrose agar.

TABLE I

GROWTH OF TEN SPECIES OF FUNGI ON DEXTROSE AGAR AND CORN MEAL AGAR, GROWN IN ASSOCIATION WITH THREE SPECIES OF INHIBITOR BACTERIA, EXPRESSED IN TERMS OF AVERAGE DIAMETERS, IN MILLIMETERS, OF THREE CULTURES

DEXTROSE AGAR

FUNGI	AGE OF FUNGOUS COLONIES IN DAYS						INHIBITORY DISTANCE
	1	2	3	4	5	6	
INHIBITOR ORGANISM—*Serratia marcescens*							
Z. mulleri + bacteria	15x15	39x39	.. ..	.. ..	.. ..	.. ..	..
Control	12x14	40x40					
G. cingulata + bacteria		9x10	14x13	24x25	34x38		
Control		8x 8	17x18	28x29	38x38		
Anthostomella sp. + bacteria	22x23	65x66					
Control	20x21	64x65					
P. cydoniae + bacteria		18x18	28x37	28x44	29x52		2 mm.
Control		19x19	35x35	43x43	55x55		
G. affine + bacteria		12x12	21x21	27x28	33x34		
Control		13x13	21x21	30x30	34x35		
G. musarum + bacteria		21x21	38x38				
Control		20x21	38x38				
C. lindemuthianum + bacteria		17x17	32x44				
Control		17x18	44x45				
B. tulipae + bacteria		11x10	20x21	25x38	29x47		2 mm.
Control		9x 9	21x21	39x39	47x48		
C. roseum + bacteria		10x10	27x36	27x48	27x64		2 mm.
Control		10x10	34x36	51x53	62x65		
V. fructi + bacteria		8x 8	14x14	21x22	27x29	31x35	
Control		6x 6	12x12	20x20	26x26	31x32	
INHIBITOR ORGANISM—*Bacillus subtilis*							
Z. mulleri + bacteria	17x18	41x41					
Control	12x14	40x40					
G. cingulata + bacteria		8x 8	15x16	26x28	35x37		
Control		8x 8	17x18	28x29	38x38		
Anthostomella sp. + bacteria	20x18	60x68					
Control	21x21	64x65					
P. cydoniae + bacteria		18x19	31x35	31x42			2 mm.
Control		19x19	35x35	43x43			
G. affine + bacteria		13x13	21x21	25x30	27x35	28x40	2 mm.
Control		13x13	21x21	30x30	34x35	39x40	
G. musarum + bacteria		20x20	33x36				
Control		20x21	38x38				
C. lindemuthianum + bacteria		18x17	39x44				3 mm.
Control		17x18	44x45				
B. tulipae + bacteria		9x10	20x20	32x36			
Control		9x 9	21x21	38x39			
C. roseum + bacteria		4x 4	10x11	14x19	14x26		17 mm.
Control		10x10	34x36	51x53	62x65		
V. fructi + bacteria		6x 7	12x12	16x19	19x25	20x29	3 mm.
Control		6x 6	12x12	20x20	26x26	31x32	

TABLE I—Continued

DEXTROSE AGAR—Continued

FUNGI	INHIBITOR ORGANISM—*Actinomyces albus*						
	AGE OF FUNGOUS COLONIES IN DAYS						INHIBITORY DISTANCE
	1	2	3	4	5	6	
Z. mulleri + bacteria	17x17	31x39	34x69	.....	.....	.....	2 mm.
Control	12x14	34x35	68x71	.....	.....	.....	.....
G. cingulata + bacteria	.....	9x 9	19x19	22x30	27x40	30x51	5 mm.
Control	.....	8x 8	17x18	28x29	38x38	47x48	.....
Anthostomella sp. + bacteria	20x20	25x65	27x90	.....	.....	.....	5 mm.
Control	20x21	64x65	90x90	.....	.....	.....	.....
P. cydoniae + bacteria	.....	17x19	24x34	26x40	26x50	.....	5 mm.
Control	.....	19x19	35x35	43x43	55x55	.....	.....
G. affine + bacteria	.....	13x13	19x20	24x29	26x34	28x39	6 mm.
Control	.....	13x13	21x21	30x30	34x35	39x40	.....
G. musarum + bacteria	.....	21x22	30x40	30x54	30x78	.....	3 mm.
Control	.....	20x21	38x38	51x52	76x77	.....	.....
C. lindemuthianum + bacteria	.....	18x17	26x44	28x57	28x62	.....	5 mm.
Control	.....	17x18	44x45	55x57	62x64	.....	.....
B. tulipae + bacteria	.....	11x11	20x20	24x37	28x46	28x64	7 mm.
Control	.....	9x 9	21x21	38x39	47x48	61x63	.....
C. roseum + bacteria	.....	10x10	31x40	31x50	31x60	.....	1 mm.
Control	.....	10x10	34x36	51x53	62x65	.....	.....
V. fructi + bacteria	.....	7x 6	13x13	18x20	20x26	21x31	7 mm.
Control	.....	6x 6	12x12	20x20	26x26	31x32	.....

CORN MEAL AGAR

	INHIBITOR ORGANISM—*Serratia marcescens*						
Z. mulleri + bacteria	19x18	40x42	.....	.....	.....	.....	.....
Control	13x13	36x36	.....	.....	.....	.....	.....
G. cingulata + bacteria	.....	8x 9	16x15	26x25	34x34	.....	.....
Control	.....	7x 8	15x16	27x28	33x34	.....	.....
Anthostomella sp. + bacteria	15x16	29x50	33x81	.....	.....	.....	3 mm.
Control	13x15	51x52	84x85	.....	.....	.....	.....
P. cydoniae + bacteria	.....	21x21	35x35	.....	.....	.....	.....
Control	.....	21x21	36x37	.....	.....	.....	.....
G. affine + bacteria	.....	11x12	18x20	25x30	30x38	34x45	7 mm.
Control	.....	10x10	18x18	26x27	36x36	42x42	.....
G. musarum + bacteria	.....	19x19	32x35	37x46	.....	.....	3 mm.
Control	.....	18x19	33x33	44x44	.....	.....	.....
C. lindemuthianum + bacteria	.....	16x16	35x39	.....	.....	.....	.....
Control	.....	15x16	38x40	.....	.....	.....	.....
B. tulipae + bacteria	.....	14x15	23x24	37x38	45x47	.....	.....
Control	.....	15x15	24x24	38x38	46x46	.....	.....
C. roseum + bacteria	.....	8x 9	20x27	22x36	24x47	.....	8 mm.
Control	.....	8x 9	26x29	34x37	46x50	.....	.....
V. fructi + bacteria	.....	7x 7	12x12	17x18	23x25	26x31	3 mm.
Control	.....	7x 8	12x13	18x19	23x24	30x30	.....

TABLE I—Continued

CORN MEAL AGAR—Continued

FUNGI	INHIBITOR ORGANISM—*Bacillus subtilis*						
	AGE OF FUNGOUS COLONIES IN DAYS						INHIBITORY DISTANCE
	1	2	3	4	5	6	
Z. mulleri + bacteria	17x17	36x38	.....	.....	.....	.....	.....
Control	13x13	36x36	.....	.....	.....	.....	.....
G. cingulata + bacteria	.....	9x 9	14x15	25x26	34x35	.....	.....
Control	.....	7x 8	15x16	27x28	33x34	.....	.....
Anthostomella sp. + bacteria	15x16	33x51	34x83	.....	.....	.....	3 mm.
Control	13x15	51x52	84x85	.....	.....	.....	.....
P. cydoniae + bacteria	.....	21x21	30x35	37x42	.....	.....	3 mm.
Control	.....	21x21	36x37	41x42	.....	.....	.....
G. affine + bacteria	.....	11x11	19x19	25x29	26x37	27x43	4 mm.
Control	.....	10x10	18x18	26x27	36x36	42x42	.....
G. musarum + bacteria	.....	19x19	29x34	37x45	.....	.....	3 mm.
Control	.....	18x19	33x33	44x44	.....	.....	.....
C. lindemuthianum + bacteria	.....	16x16	25x31	35x39	.....	.....	5 mm.
Control	.....	15x16	38x40	49x51	.....	.....	.....
B. tulipae + bacteria	.....	16x16	25x25	33x39	42x49	.....	3 mm.
Control	.....	15x15	24x24	38x38	46x46	.....	.....
C. roseum + bacteria	.....	0x 0	0x 0	0x 0	0x 0	.....	20 mm.
Control	.....	9x 8	26x29	34x37	46x50	.....	.....
V. fructi + bacteria	.....	8x 8	11x11	14x18	17x24	19x29	11 mm.
Control	.....	7x 8	12x13	18x19	23x24	30x30	.....
	INHIBITOR ORGANISM—*Actinomyces albus*						
Z. mulleri + bacteria	21x21	25x33	29x64	.....	.....	.....	7 mm.
Control	13x13	36x36	66x66	.....	.....	.....	.....
G. cingulata + bacteria	.....	8x 9	15x18	16x27	18x35	20x42	10 mm.
Control	.....	7x 8	15x16	27x28	33x34	45x46	.....
Anthostomella sp. + bacteria	14x16	16x37	17x63	.....	.....	.....	11 mm.
Control	13x15	51x52	84x85	.....	.....	.....	.....
P. cydoniae + bacteria	.....	18x20	23x23	23x39	23x49	.....	10 mm.
Control	.....	21x21	36x37	41x42	49x50	.....	.....
G. affine + bacteria	.....	10x10	13x17	15x25	19x30	21x34	12 mm.
Control	.....	10x10	18x18	26x27	36x36	42x42	.....
G. musarum + bacteria	.....	15x17	15x26	17x33	19x43	.....	10 mm.
Control	.....	18x19	33x33	44x44	63x64	.....	.....
C. lindemuthianum + bacteria	.....	13x16	15x34	16x42	16x47	.....	12 mm.
Control	.....	15x16	38x40	49x51	57x58	.....	.....
B. tulipae + bacteria	.....	13x13	16x22	16x26	17x30	17x34	10 mm.
Control	.....	15x15	24x24	38x38	46x46	56x57	.....
C. roseum + bacteria	.....	7x 8	18x23	21x31	23x41	.....	10 mm.
Control	.....	8x 9	26x29	40x42	46x50	.....	.....
V. fructi + bacteria	.....	7x 7	9x12	9x15	9x16	10x16	13 mm.
Control	.....	7x 8	12x13	18x19	23x24	30x30	.....

When these facts were established, experiments were begun to obtain some information regarding the cause of inhibition. Three factors which seemed important to investigate as probable causes of inhibition were: First, a change in the pH of the medium induced by the inhibiting organism; second, a food depletion of the medium by the inhibiting organism; third, a secretion of some soluble substance which was toxic to the fungi. All three of these factors have been reported in the literature (1, 2, 3, 4, 6, 7, etc.) as causes of one type of inhibition or another in microorganisms.

The experiments undertaken were limited to the effect of *Actinomyces albus* on the growth of *Colletotrichum lindemuthianum*, on dextrose agar and nutrient agar prepared as follows: Fifteen flasks, each containing 100 cc. of neutral Difco dextrose broth, were inoculated with *Actinomyces albus*, one every two days. The organism was allowed to grow until thirty days had elapsed from the time of the inoculation of the first flask. Thus, a series of flasks was obtained which contained *Actinomyces* colonies ranging in age from 2 to 30 days. Another series of flasks containing Difco nutrient broth was treated in the same manner. At the end of the thirty-day period, the organism was removed from the broth by filtration through filter paper. The water lost by evaporation was added, and the liquid in each flask was divided into two 50 cc. portions. To one of these portions, the same proportion of dehydrated medium was added as was originally used in the preparation of the medium, to replace that which had been used by the *Actinomyces*. Additional food was withheld from the second 50 cc. portion; 1½% agar was added, and the media were distributed into test tubes and sterilized in the autoclave at fifteen pounds for fifteen minutes. The agars to which more food was added shall be referred to henceforth as "Fortified-dextrose-inhibitor agar" and "Fortified-nutrient-inhibitor agar." The agars from which additional food was withheld shall be referred to as "Dextrose-inhibitor agar" and "Nutrient-inhibitor agar."

pH determinations showed that the pH varied from 6.5 to 8.8 in the dextrose agars containing inhibitor filtrate, and from 6.4 to 8.8 in the corresponding nutrient agars. A series of dextrose agar and nutrient agar tubes of various pH values corresponding to those of the agars prepared from the *Actinomyces* filtrates, was then prepared. These served as

TABLE II

EIGHT DAYS GROWTH OF *Colletotrichum lindemuthianum* IN FORTIFIED-DEXTROSE INHIBITOR AGAR (COLUMN A), DEXTROSE-INHIBITOR AGAR (COLUMN B), AND DEXTROSE AGAR (CONTROL), EXPRESSED IN AVERAGE MAXIMUM DIAMETERS, IN MILLIMETERS, OF THREE CULTURES

Age of *Actinomyces*-Culture Filtrate from which Inhibitor Agars were Prepared	A		CONTROL		B		CONTROL	
	pH	Diameter in mm.	pH	Diameter in mm.	pH	Diameter in mm.	pH	Diameter in mm.
2 days	7.2	83	7.2	81	6.5	66	6.5	84
4 "	7.2	84	7.2	81	6.9	66	6.9	83
6 "	7.2	62	7.2	81	7.1	58	7.1	82
8 "	7.7	37	7.7	79	7.6	25	7.6	80
10 "	7.7	29	7.7	79	7.6	17	7.6	80
12 "	8.2	22	8.2	78	7.8	21	7.8	80
14 "	8.0	23	8.0	79	8.0	26	8.0	79
18 "	8.4	22	8.4	80	8.3	28	8.3	80
20 "	8.5	18	8.5	77	8.4	18	8.4	80
22 "	8.6	19	8.6	78	8.5	18	8.5	77
24 "	8.8	21	8.8	76	8.8	24	8.8	76
26 "	8.8	18	8.8	76	8.8	19	8.8	76
28 "	8.8	18	8.8	76	8.8	19	8.8	76
30 "	8.8	18	8.8	76	8.8	18	8.8	76

TABLE III

EIGHT DAYS GROWTH OF *Colletotrichum lindemuthianum* IN FORTIFIED-NUTRIENT INHIBITOR AGAR (COLUMN A), NUTRIENT-INHIBITOR AGAR (COLUMN B), AND NUTRIENT AGAR (CONTROL), EXPRESSED IN AVERAGE MAXIMUM DIAMETERS, IN MILLIMETERS, OF THREE CULTURES

Age of *Actinomyces*-Culture Filtrate from which Inhibitor Agars were Prepared	A		CONTROL		B		CONTROL	
	pH	Diameter in mm.	pH	Diameter in mm.	pH	Diameter in mm.	pH	Diameter in mm.
2 days	6.5	50	6.5	49	6.4	55	6.4	53
4 "	6.7	53	6.7	55	7.0	54	7.0	49
6 "	7.5	29	7.5	47	7.6	29	7.6	48
8 "	7.9	26	7.9	45	8.0	31	8.0	43
10 "	7.8	29	7.8	47	8.1	28	8.1	43
12 "	8.3	18	8.3	44	8.6	21	8.6	43
14 "	8.2	19	8.2	44	8.6	24	8.6	43
18 "	8.5	0	8.5	44	8.7	15	8.7	40
20 "	8.4	15	8.4	43	8.8	15	8.8	39
22 "	8.4	15	8.4	43	8.8	16	8.8	39
24 "	8.4	16	8.4	43	8.8	16	8.8	39
26 "	8.4	19	8.4	43	8.8	12	8.8	39
28 "	8.4	0	8.4	43	8.8	22	8.8	39
30 "	8.4	15	8.4	43	8.8	13	8.8	39

controls in testing the possibility that a change in pH was responsible for inhibition. After sterilization, the different agars were poured into Petri dishes and three plates of each kind of agar were inoculated with a loopful of a heavy, water suspension of *Colletotrichum lindemuthianum*. The colonies resulting were measured every 24 hours for eight successive days. The results are summarized in Tables II and III.

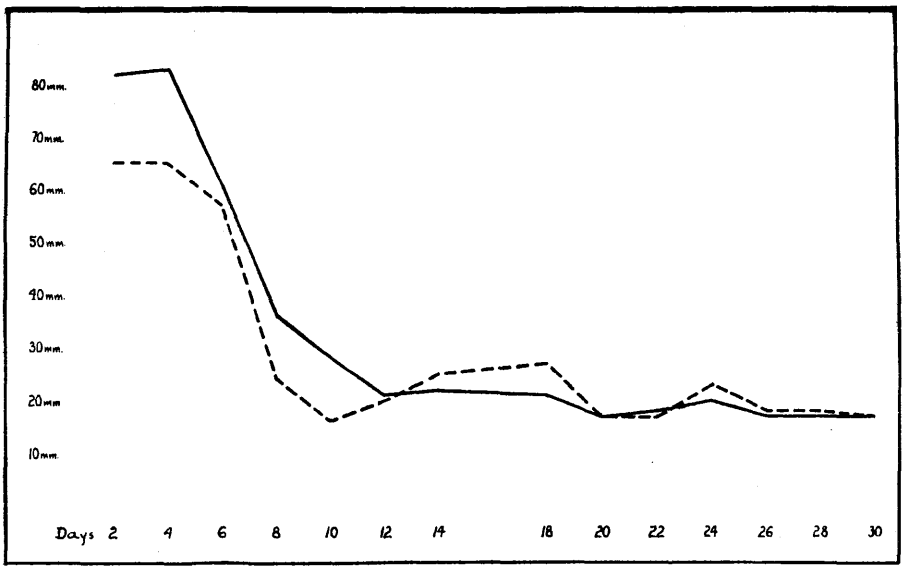

Fig. 1. Eight days growth of *C. lindemuthianum* on Dextrose-inhibitor agar and Fortified-dextrose-inhibitor agar, both prepared from filtrates in which *Actinomyces* had grown for different periods of time.
————————Fortified-dextrose-inhibitor agar.
----------Dextrose-inhibitor agar.

The results of these experiments establish the fact that the presence of the living *Actinomyces* itself is not necessary for the inhibition of fungous growth since sterilized filtrates of *Actinomyces* cultures produce similar inhibitory effects. As the brief discussion which follows will point out, neither food depletion of the medium (Fig. 1), nor a change in pH brought about by the *Actinomyces* (Fig. 2), is responsible for the inhibition of growth of *Colletotrichum lindemuthianum*. It seems quite probable, therefore, that the antibiotic phenomena herein described are due to the presence of some substance which is toxic to the fungus.

An analysis of the figures in Tables II and III reveals that food depletion of the medium by the *Actinomyces* was not a factor in the inhibition of growth of *C. lindemuthianum*. A comparison of columns A and B in Table II shows that the fungus grew better on fortified-dextrose-inhibitor agar prepared from filtrates of *Actinomyces* cultures 2 to 10 days old than on dextrose-inhibitor agar prepared from filtrates of *Actinomyces*

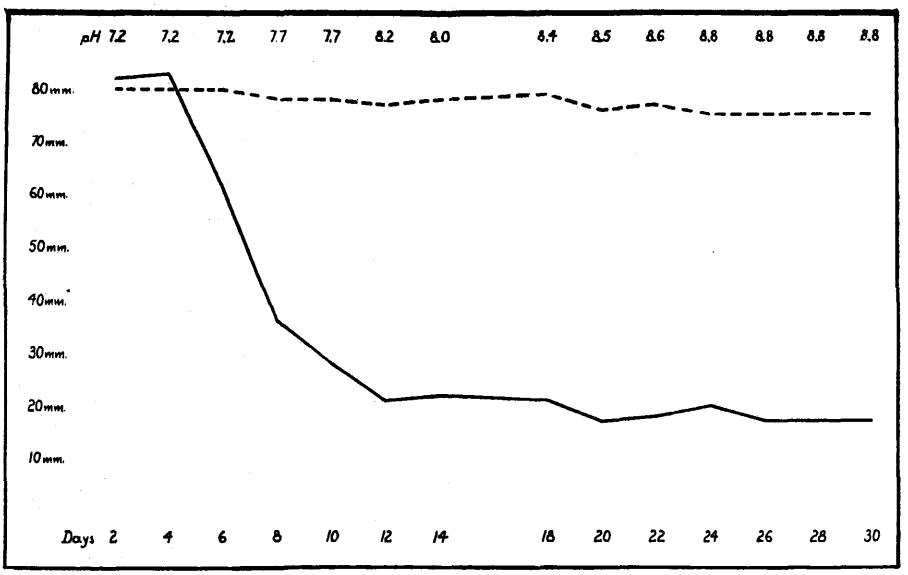

Fig. 2. Eight days growth of *C. lindemuthianum* on Fortified-dextrose-inhibitor agar prepared from filtrates in which *Actinomyces* had grown for different periods of time, compared with controls of comparable pH values.
————Fortified-dextrose-inhibitor agar.
----------Control, Dextrose agar.

cultures of similar ages. Since each 50 cc. portion of fortified filtrate received the same amount of additional dehydrated medium, and since food material already present was inversely proportional to the age of the colonies grown, the amount of food material in the fortified-dextrose-inhibitor agar varied up to almost double the original amount. In the inhibitor agars containing a small amount of inhibitory substance, an increase in growth due to greatly increased food supply is evident. However, with an increase in amount of inhibitory substance, variation in food supply does not seem to influence growth. This is indicated by the similar size of the colonies on fortified-

dextrose-inhibitor agar and dextrose-inhibitor agar made from the 12 to 30 day old culture filtrates.

From a comparison of the figures in Tables II and III it is evident that, in the presence of a large amount of food and a relatively small amount of inhibitory substance, the increase in growth of the fungus is entirely due to the dextrose contained in the food, the effects of which overbalance the inhibitory effects of the toxic substance. Dextrose agar and nutrient agar differ in composition only in that the former contains dextrose.

Although it cannot be denied that *C. lindemuthianum* apparently grows slightly better in an acid medium than in an alkaline one, as indicated by the growth of the controls, still the effect of pH is too slight to be considered as a factor in antibiosis between the organisms under consideration.

The antibiotic phenomena herein recorded, are quite probably due either to the secretion of a substance by the inhibitor organism, which is toxic to the fungus, or to the production of such a substance through an alteration of the medium by chemical reaction. This toxin is soluble in water, diffusible through agar, and to a large degree, at least, thermostable.

Organisms belonging to the genus *Actinomyces* have been reported in the literature as inhibiting the growth of fungi. Porter (5) mentions *Actinomyces* as a strong inhibitor of fungal growth. Millard and Taylor (4) report antagonism between two Actinomycetes in the soil, and Tims (3) has studied an Actinomyces which secretes a toxic substance which inhibits the growth of Pythium. During the past few years, the senior writer has observed that colonies of organisms belonging to this genus, occurring as contaminations in Petri dishes in the routine laboratory work with fungi, frequently inhibited the growth of many different fungi. Experiments, the results of which will be published soon, indicate that a large number of species of *Actinomyces* exhibit this property.

ACKNOWLEDGMENTS

The writers wish to express their appreciation to Prof. H. A. Cunningham, Head of the Department of Biology, Kent State University, for his continued interest and help during the progress of this investigation; to Dr. M. B. Palmer, of the

Department of Physical Science, Kent State University, for his help with certain phases of the work; to Dr. Francis Clark, of the Department of Bacteriology, University of Illinois, for supplying the bacterial cultures, and to all others who in any way contributed in the preparation of this paper. The photographs were prepared by Prof. J. T. Johnson, Department of Agriculture, Kent State University, to whom the writers are grateful.

LITERATURE CITED

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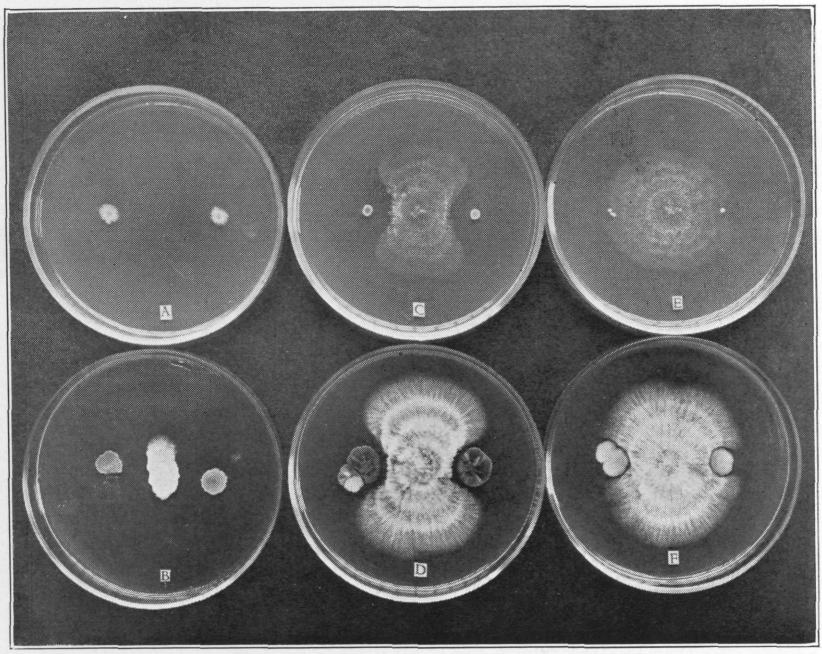
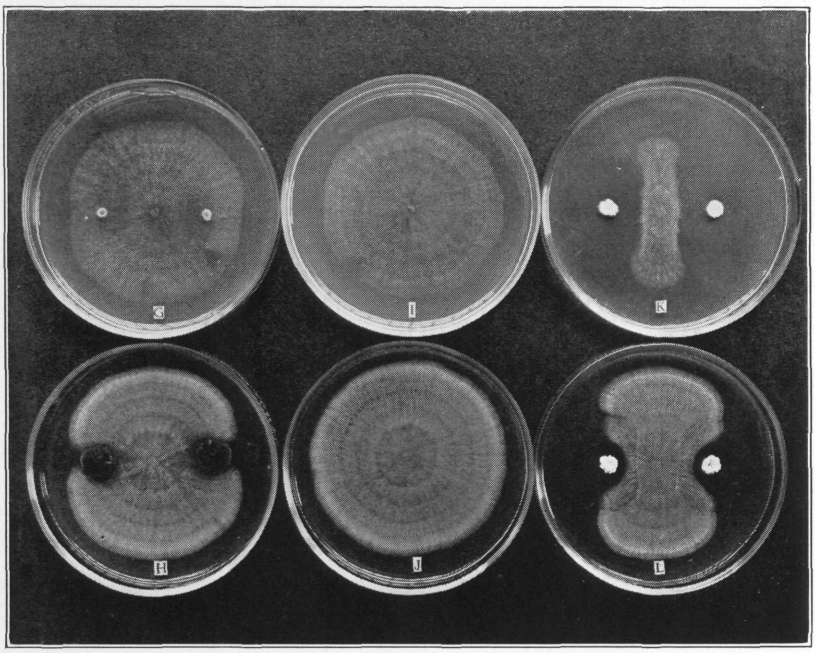


Fig. A. Complete inhibition of *Cephalothecium roseum* by *Bacillus subtilis* on corn meal agar.

Fig. B. Inhibition of *Cephalothecium roseum* by *Bacillus subtilis* on dextrose agar.

Figs. C, D. *Serratia marcescens* inhibiting growth of *Cephalothecium roseum* on corn meal agar (C) and dextrose agar (D).

Figs. E, F. *Alcaligenes faecalis* growing together with *Cephalothecium roseum* on corn meal agar (E) and dextrose agar (F). No inhibitory effect.



Figs. G, H. *Serratia marcescens* growing together with *Colletotrichum lindemuthianum* on corn meal agar (G) and dextrose agar (H). No inhibitory effect.

Figs. I, J. *Colletotrichum lindemuthianum*. Controls on corn meal agar (I) and dextrose agar (J).

Figs. K, L. *Actinomyces albus* inhibiting growth of *Colletotrichum lindemuthianum* on corn meal agar (K) and dextrose agar (L).