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THE PERSISTENCE (SURVIVAL) OF MICROORGANISMS

FINAL REPORT OF LITERATURE SURVEY

carried out by

THE UNIVERSITY OF TEXAS - MEDICAL BRANCH

for

P D DIVISION

THE BIOLOGICAL LABORATORIES, CHEMICAL CORPS, CAMP DETRICK

On Contract DA - 18 - 064 - CML - 463

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## LIST OF SECTIONS

- I. The Persistence (Survival) of Organisms in Air.
- II. The Persistence (Survival) of Organisms in the Body and Body Materials.
- III. The Persistence (Survival) of Organisms in Culture.
- IV. The Persistence (Survival) of Organisms in Food.
- V. The Persistence (Survival) of Organisms in Insects.
- VI. The Effects of Pressure on the Persistence (Survival) of Organisms.
- VII. The Effects of Radiation on the Persistence (Survival) of Organisms.
- VIII. The Persistence (Survival) of Organisms in Soil.
- IX. The Persistence (Survival) of Organisms on Surfaces.
- X. The Persistence (Survival) of Organisms in Water.

## DESIGNATION OF TABLES

- A**        The Persistence (Survival) of Organisms in AIR.
- B**        The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
- C**        The Persistence (Survival) of Organisms in CULTURE.
- F**        The Persistence (Survival) of Organisms in FOOD.
- I**        The Persistence (Survival) of Organisms in INSECTS.
- P**        The Effects of PRESSURE on the Persistence (Survival) of Organisms.
- R**        The Effects of RADIATION on the Persistence (Survival) of Organisms.
- S**        The Persistence (Survival) of Organisms in SOIL.
- Su**       The Persistence (Survival) of Organisms on SURFACES.
- W**        The Persistence (Survival) of Organisms in WATER.

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LIST OF TABLES ON PERSISTENCE (SURVIVAL) OF BACILLUS SPECIES  
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- A1 The Persistence (Survival) of Organisms in AIR.
- B1 The Persistence (Survival) of Organisms in the  
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- C1 & 2 The Persistence (Survival) of Organisms in CULTURE.
- F1 The Persistence (Survival) of Organisms in FOOD.
- P1 The Effects of PRESSURE on the Persistence (Survival)  
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- R1 The Effects of RADIATION on the Persistence (Survival)  
of Organisms.
- S1 The Persistence (Survival) of Organisms in SOIL.
- Sul The Persistence (Survival) of Organisms on SURFACES.
- W1 The Persistence (Survival) of Organisms in WATER.

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- C 23     The Persistence (Survival) of Organisms in CULTURE.
- I 2      The Persistence (Survival) of Organisms in INSECTS.
- I 18     The Persistence (Survival) of Organisms in INSECTS.
- W 6      The Persistence (Survival) of Organisms in WATER.

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- A 2 The Persistence (Survival) of Organisms in AIR.
- B 3 The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
- C 5 The Persistence (Survival) of Organisms in CULTURE.
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- I 3 The Persistence (Survival) of Organisms in INSECTS.
- R 4 The Effects of RADIATION on the Persistence (Survival) of Organisms.
- S 2 The Persistence (Survival) of Organisms in SOIL.
- Su 2 The Persistence (Survival) of Organisms on SURFACES.
- W 3 The Persistence (Survival) of Organisms in WATER.

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- C 6      The Persistence (Survival) of Organisms in CULTURE.
- F 3      The Persistence (Survival) of Organisms in FOOD.
- I 4      The Persistence (Survival) of Organisms in INSECTS.
- S 3      The Persistence (Survival) of Organisms in SOIL.
- Su 3     The Persistence (Survival) of Organisms on SURFACES.
- W 4      The Persistence (Survival) of Organisms in WATER.

(see also A 3, B 4 under general)

LIST OF TABLES ON PERSISTENCE (SURVIVAL) OF  
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- A 5 The Persistence (Survival) of Organisms in AIR.
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- C 9 The Persistence (Survival) of Organisms in CULTURE.
- F 4 The Persistence (Survival) of Organisms in FOOD.
- I 5 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival)  
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- R 6 The Effects of RADIATION on the Persistence (Survival)  
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- S 4 The Persistence (Survival) of Organisms in SOIL.
- Su 4 The Persistence (Survival) of Organisms on SURFACES.
- W 5 The Persistence (Survival) of Organisms in WATER.

\*Coliform includes Escherichia, Aerobacter and Paracolobactrum  
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LIST OF TABLES OF PERSISTENCE (SURVIVAL) OF  
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- B 5 The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
- C 8 The Persistence (Survival) of Organisms in CULTURE.
- I 7 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival) of Organisms.
- R 6 The Effects of RADIATION on the Persistence (Survival) of Organisms.
- S 4 The Persistence (Survival) of Organisms in SOIL.
- Su 4 The Persistence (Survival) of Organisms on SURFACES.
- W The Persistence (Survival) of Organisms in WATER.

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- C 22 The Persistence (Survival) of Organisms in CULTURE.
- F 11 The Persistence (Survival) of Organisms in FOOD.
- I 7 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival) of Organisms.
- R 15 The Effects of RADIATION on the Persistence (Survival) of Organisms.
- S 13 The Persistence (Survival) of Organisms in SOIL.
- Su 16 The Persistence (Survival) of Organisms on SURFACES.
- W 17 The Persistence (Survival) of Organisms in WATER.

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF  
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- R 18 The Effects of RADIATION on the Persistence (Survival)  
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- S 6 The Persistence (Survival) of Organisms in SOIL.
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- W 20 The Persistence (Survival) of Organisms in WATER.

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF  
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- B 7 The Persistence (Survival) of Organisms in the  
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- C 15 The Persistence (Survival) of Organisms in CULTURE.
- I 14 The Persistence (Survival) of Organisms in INSECTS.
- R 11 The Effects of RADIATION on the Persistence (Survival)  
of Organisms.
- S 10 The Persistence (Survival) of Organisms in SOIL.
- W 7 The Persistence (Survival) of Organisms in WATER.



LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF  
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- A 7 The Persistence (Survival) of Organisms in AIR.
- B 9 The Persistence (Survival) of Organisms in the  
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- C 12 The Persistence (Survival) of Organisms in CULTURE.
- F 8 The Persistence (Survival) of Organisms in FOOD.
- I 12 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival)  
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- R 9 The Effects of RADIATION on the Persistence (Survival)  
of Organisms.
- S 9 The Persistence (Survival) of Organisms in SOIL.
- Su 10 The Persistence (Survival) of Organisms on SURFACES.
- W 11 The Persistence (Survival) of Organisms in WATER.

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- A 8 The Persistence (Survival) of Organisms in AIR.
- 
- B 12 The Persistence (Survival) of Organisms in the  
BODY and BODY MATERIALS.
- C 14 The Persistence (Survival) of Organisms in CULTURE.
- I 13 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival)  
of Organisms.
- Su 12 The Persistence (Survival) of Organisms on SURFACES.
- W 13 The Persistence (Survival) of Organisms in WATER.

**LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF RICKETTSIAE**

- A 9**      **The Persistence (Survival) of Organisms in AIR.**  
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- B 13**      **The Persistence (Survival) of Organisms in the**  
**BODY and BODY MATERIALS.**
- C 16**      **The Persistence (Survival) of Organisms in CULTURE**
- F 6**        **The Persistence (Survival) of Organisms in FOOD.**
- I 15**      **The Persistence (Survival) of Organisms in INSECTS**
- W 14**      **The Persistence (Survival) of Organisms in WATER.**

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF  
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- B 14 The Persistence (Survival) of Organisms in the  
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- C 17 The Persistence (Survival) of Organisms in CULTURE.
- C 18 The Persistence (Survival) of Organisms in CULTURE.
- F 9 The Persistence (Survival) of Organisms in FOOD.
- I 16 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival)  
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- R 13 The Effects of RADIATION on the Persistence (Survival)  
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- S 11 The Persistence (Survival) of Organisms in SOIL.
- Su 13 The Persistence (Survival) of Organisms on SURFACES.
- W 15 The Persistence (Survival) of Organisms in WATER.

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- C 20 The Persistence (Survival) of Organisms in CULTURE.
- F 10 The Persistence (Survival) of Organisms in FOOD.
- I 17 The Persistence (Survival) of Organisms in INSECTS.
- R 14 The Effects of RADIATION on the Persistence (Survival) of Organisms.
- S 12 The Persistence (Survival) of Organisms in SOIL.
- Su 15 The Persistence (Survival) of Organisms on SURFACES.
- W. 16 The Persistence (Survival) of Organisms in WATER.

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF  
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- A 11 The Persistence (Survival) of Organisms in AIR.
- B 10 The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
- C 21 The Persistence (Survival) of Organisms in CULTURE.
- F 5 The Persistence (Survival) of Organisms in FOOD.
- I 10 The Persistence (Survival) of Organisms in INSECTS.
- P 1 The Effects of PRESSURE on the Persistence (Survival) of Organisms.
- R 7 The Effects of RADIATION on the Persistence (Survival) of Organisms.
- Su 7 The Persistence (Survival) of Organisms on SURFACES.
- W. 8 The Persistence (Survival) of Organisms in WATER.

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF  
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- B 17      The Persistence (Survival) of Organisms in the  
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- C 24      The Persistence (Survival) of Organisms in CULTURE.
- F 12      The Persistence (Survival) of Organisms in FOOD.
- I 19      The Persistence (Survival) of Organisms in INSECTS.
- R.16      The Effects of RADIATION on the Persistence (Survival)  
of Organisms.
- W. 18      The Persistence (Survival) of Organisms in WATER.

(see also A 3, S 7, Su 8 under General)

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF VIRUSES

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A	13	" " " " " "
B	18	The Persistence (Survival) of Organisms in the <u>BODY and BODY MATERIALS</u>
C	3	The Persistence (Survival) of Organisms in <u>Culture.</u>
C	25	" " " " " "
F	13	The Persistence (Survival) of Organisms in <u>FOOD</u>
I	20	The Persistence (Survival) of Organisms in <u>Insects.</u>
P	1	The effects of <u>Pressure</u> on the Persistence (Survival) of Organisms.
R	3	The Effects of <u>RADIATION</u> on the Persistence (Survival) of Organisms.
R	17	" " " " " "
S	14	The Persistence (Survival) of Organisms in <u>SOIL</u>
Su	17	The Persistence (Survival) of Organisms on <u>SURFACES</u>
W	2	The Persistence (Survival) of Organisms in <u>WATER</u>
W	19	" " " " " "



LIST OF TABLES ON SURVIVAL OF ORGANISMS (GENERAL)\*

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A	9	" " " " " "
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B	19	" " " " " "
C	7	The Persistence (Survival) of Organisms in <u>CULTURE</u>
C	10	" " " " " "
C	11	" " " " " "
C	13	" " " " " "
C	19	" " " " " "
F	6	The Persistence (Survival) of Organisms in <u>FOOD</u>
F	7	" " " " " "
I	6	The Persistence (Survival) of Organisms in <u>Insects</u>
I	9	" " " " " "
I	11	" " " " " "
P	1	The Effects of <u>PRESSURE</u> on the Persistence (Survival) of Organisms.
R	2	The Effects of <u>RADIATION</u> on the Persistence (Survival) of Organisms.
R	8	" " " " " "
R	10	" " " " " "
R	12	" " " " " "
S	5	The Persistence (Survival) of Organisms in <u>SOIL.</u>
S	7	" " " " " "
S	8	" " " " " "
Su	5	The Persistence (Survival) of Organisms on <u>SURFACES</u>
Su	8	" " " " " "
Su	9	" " " " " "
Su	11	" " " " " "
Su	14	" " " " " "
W	9	The Persistence (Survival) of Organisms in <u>WATER</u>
W	10	" " " " " "
W	12	" " " " " "

\* (Includes isolated data on some specific organisms where only 1 or 2 reports exist)

## INTRODUCTION

The work on this project was carried out over the period of 1 April, 1951 to 28 February, 1953.

Considerable interest has evidenced itself since the study of microbiology was begun to determine the survival or death of organisms under the influence of nature, as well as physical factors under laboratory conditions. The reports of these studies are scattered throughout the biological literature. They have never been collected in a survey in an effort to bring all of the available data together for correlation of the material.

A survey of the literature has been made on the survival and persistence of microorganisms under varying conditions as follows:

### Methods and Materials

1. Information on the stability, persistence or survival of microorganisms under natural or experimental conditions may be found in bacteriology textbooks, scientific biological journals, abstracting journals and in indices such as the Quarterly Cumulative Index Medicus.
2. A systematic survey of these sources gave as full a coverage of the literature as possible for this project.
3. The primary sources for material in this project were:
  - (a) Bacteriology texts by: Topley and Wilson, Zinsser, Dubos, Rivers, and other texts.
  - (b) Biological Abstracts
  - (c) Chemical Abstracts
  - (d) Quarterly Cumulative Index MedicusOriginal articles were then obtained from the original journals.

4. The range of information collected appears in a selected outline below:

(a) Source

1. Air

bacteria  
fungi  
microorganisms  
rickettsia  
viruses,  
survival of  
persistence of  
recovery of

2. Body (as under air)

3. Culture Media (as under air)

4. Food (as under air)

5. Insects (as under air)

6. Pressure (as under air)

7. Radiation (as under air)

8. Soil (as under air)

9. Surfaces (as under air)

10. Water (as under air)

(b) Organisms (general)

1. Bacteria

persistence of  
survival of  
recovery of  
in water or ice  
in air  
on or in insects  
in soil  
in milk  
in food  
in feces  
on surfaces (wood, glass, concrete, etc.)  
under natural conditions

2. Microorganisms (as under bacteria)

3. Rickettsia (as under bacteria)

4. Viruses (as under bacteria)

5. Yeasts, molds and fungi (as under bacteria)

(c) Particular (organisms) diseases

1. Anthrax - Bacillus anthracis
2. Brucellosis - Brucella abortus, melitensis, suis
3. Cholera - Vibrio comma
4. Coccidiomycosis - Coccidiodes immitis
5. Dysentery - Shigella spp.
6. Encephalitides - viruses
7. Influenza - virus
8. Plague - Pasteurella pestis
9. Poliomyelitis - virus
10. Psittacosis - virus (and other viral diseases)
11. Tularemia - Pasteurella tularensis
12. Tuberculosis - Mycobacterium tuberculosis
13. Typhoid - Salmonella typhosa
14. Typhus - Rickettsia (and other rickettsial diseases)
15. And others

5. The material in the textbooks was covered chapter by chapter on each genus or species of organism and original references to the literature as well as general statements in the text were recorded on a special form. Information relating to each species was recorded on individual sheets. Specific references from the body of the text and bibliography of the chapter were recorded with specific data on a special form on a 5" x 8" file card.

6. The Abstracting Journals were searched as follows. For each Biological and Chemical Abstracts, a complete list of the index titles which might yield information pertaining to the project was prepared and was used as a guide for searching through each yearly index. References of apparent value were taken on a form listing

subject and abstract numbers. After completing a yearly index, the abstracts were checked from the numbers recorded to determine if they had information on survival and persistence. If not, the reference was discarded. If questionable, the title was taken to check the original article. If pertinent, specific data was recorded on the face of the file cards and general methods were recorded on the back of the card.

The original article was obtained wherever possible and read for further data and to check the data in the abstract for accuracy. General information on methods was recorded on the back of the card. References in these articles to original work were recorded on separate file cards and the original articles obtained and read for appropriate data and information.

7. The Quarterly Cumulative Index Medicus titles were surveyed and a list of titles which might yield information pertaining to the project was prepared. Since only titles of articles, and not abstracts, appeared in this publication, the appropriate titles were taken directly to the file cards. The original articles were checked as were the articles found in the abstracting journals, read, and data recorded.

8. The Library of the University of Texas Medical Branch has an extensive number of domestic and foreign scientific journals. However, since some original articles appeared in journals not available in our library, reprints were requested whenever possible from the authors, or requested from the microfilm service of the Army Medical Library in Washington, D. C.

9. The cards were filed according to subjects: Air, Body, Culture, Food, Insects, Pressure, Radiation, Soil, Surfaces and Water with cross reference cards in each section where an article had information

on persistence of organisms in or on more than one of the topics listed. From the cards, the data were transferred to forms, collecting all of the particular information on one group of organisms together. This information was then tabulated on multilith stencils and a survey of the data prepared for each section.

Note here! Because of the tremendous amount of data, it has been impossible to collect it in a form to suit all who may need turn to it for reference. It is recommended for those who have a particular interest in one factor affecting the survival of organisms or the factors affecting the survival of one organism that they use these tables as a guide and refer to original work in the references for more complete information.

It is certain that with a large report of this type that one might, by close reading, be rewarded some misspelled words, some occasional organisms slightly misplaced and some of the references listed by wrong volume or page. It should be noted also that the literature covered in the report is from 1885-1953. During that time the names of organisms have changed several times with the result that old or outdated names may appear in certain places in the report.

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## THE SURVIVAL OF ORGANISMS IN AEROSOLS

One of the important methods of transmission of disease producing organisms is through the air--air borne infections. An aerosol is a suspension of particles in air, in this particular instance a suspension of microorganisms in air. In nature, organisms may get into the air from the wind blowing over water and soil, raising microscopic water particles and dust particles into the air and suspending them there. Potential pathogens get into the air of human environment from sneezing, coughing and expectorating as well as from clothes, bedding, sweeping of floors and other similar sources. Under such conditions these factors affect spread of infection (1) the organism virulence; (2) the host susceptibility; (3) effect of environment on organism preventing or aiding it in survival.

Aerosols of microorganisms may be set up experimentally by man in open or closed areas to study various factors affecting survival. These factors may be divided for convenience as to (1) environmental factors and (2) organism factors.

These aerosols may be of organisms not usually considered as air borne infection organisms as we usually consider them in nature.

### Environmental Factors Affecting:

There are many major and minor factors which may affect the ability of an organism to survive in an aerosol. The medium in which the organism is grown and the medium from which it is suspended for spraying may aid or adversely affect the organism. The growth medium may supply nutrients for production of active, well-developed cells. The suspending medium provides osmotic effect as well as protection against drying too rapidly or slowly, protection against radiation and other forces.



The temperature of the air may affect the survival of an organism in an aerosol to a certain extent. Usually at higher temperature lower recoveries may be expected if the relative humidity (RH) is constant.

The RH of the air is very important in the survival of organisms. Various organisms may respond differently to high and low RH but usually at a 50% RH greater destruction of the organisms result. At high or low humidities better recovery may occur. As noted, individual organism types may respond differently to different humidity levels. Some organisms are killed if they dry too rapidly so low RH levels are detrimental. Others appear to give lower recoveries if sprayed into very high humidity air. From theoretical grounds this might be explained on the basis that particles sprayed into saturated air may act as nuclei of rain drops and precipitate out or may merely hit one another and form large particles which stick together and then precipitate out of suspension.

The amount of radiation present affects the rate of organism survival in an aerosol. Organisms are destroyed in sunlight and artificial sources of ultra violet more readily than if present in an aerosol in semi-darkness or in absence of all light or artificial radiation. The sunlight accounts for a great amount of destruction of air organisms along with desiccation.

The method by which organisms are rendered air-borne is important in their survival as aerosols. In nature, organisms covered with a film of moisture or soil or oily film of dust will be protected against desiccation and radiation. In experimental aerosol production, the type of spray device is of importance. The rate of spray, amount of shearing force put on the cell and the size of particle developing will affect survival in the air. Some sprayers

may destroy the cells by the force of spray; others form large particles which do not stay air borne for long periods. For infecting animals, particles smaller than 10 micra in diameter must be formed and viable organisms must be present.

In nature the amount of air movement is important in keeping the organisms suspended. Also important is the resuspension of organisms as secondary aerosols by air and wind movement as well as by human and vehicle traffic.

The method of sampling aerosols is important in evaluating the results. If present as large particles (over 10 micra in diameter) then they will settle out rapidly and may be sampled on "drop-plates". Various types of samplers may collect particles within a certain range--some particles may be too big and others too small. This must be taken into consideration. As mentioned previously, particles above 10 micra in diameter are too large to be respired by animals so that aerosols of particles may be quite viable but too large to cause respiratory infection.

#### Organism Factors Affecting:

Each genus and species of organism may have its own characteristics which may protect it from destruction when present as an airborne organism. The individual strain of organism sometimes has certain characteristics which allow it to remain viable more or less long than closely related strains and species. Some organisms may be protected by their presence as a spore or by their capsule or resistant cell wall. All of these characteristics resist the forces of nature--desiccation, radiation and temperature changes as well. The size and shape of the organism and rigidity of the cell wall aid an organism to resist the forces present in spraying procedures.

The age of the cells (in the growth curve) at the time of spraying determines to a certain extent their resistance to desiccation, radiation and other factors. The length of storage before spraying may be another factor. The numbers of organisms in the spray medium and the total numbers of organisms will also affect the length of survival of the aerosol.

#### SUMMARY

\*Bacillus (Table A 1) B. anthracis spores resisted ozone for 4 hours and could withstand direct sunlight for days. B. subtilis resisted UV and remained viable in air for 5-7 days, experimentally. B. anthracis apparently survived 200 F. for 24 hours. B. megatherium was transported for many miles by storms.

\*Brucella (Table A 2) Brucella melitensis survived in dust for 30-44 days experimentally. In nature it survived equally long. High rainfall areas have Brucellosis - arid areas none. Sunlight quite effective in killing organisms.

\*Clostridium (Table A 3) Vegetative cells susceptible to oxygen.

\*Corynebacterium (Table A 3) The diphtheria organism survived in dust for 7-102 days or longer. Organisms found in air from diphtheria patients. It survived 48 hours in air.

\*Lactobacillus (Table A 3) The organisms (L. acidophilus) settle out of air rapidly (5-10 minutes). Radiation is not too effective against it.

\*Neisseria (Table A 3) The N. meningitidis organism can travel and infect in wards up to 5 feet in distance.

\*Vibrio comma (Cholera) (Table A 3) During the cold months the organism dries and dies. Experimentally dried in air it may survive up to 108 hours.

\*Diplococcus pneumoniae (Table A 4) Survives only 42 minutes in sunlight but 42 hours in dark. RH of 50% is very lethal but not with NaCl removed. The lethal effect is raised with larger particles and higher temperatures. Organisms in floor dust for over one month. Usual survival in air is short but many survive for 48 hours.

\*Escherichia coli (Table A 5) Recoveries up to 25% may be obtained in air. Faintly resistant to ultra-violet especially with increased humidity. Cigarette smoke protects from chemicals in air. It may survive up to 4 years in dust.

\*Microorganisms (Table A 6) General factors affecting survival of organisms at altitudes are presented. Some organisms found up at 70 thousand feet. In experimental studies factors affecting survival of organisms in general are presented (temperature, radiation, chemicals, air conditioning). Scattered reports are listed for Erwinia, Hemophilus, Malleomyces, Micrococcus, Proteus, Pseudomonas and Sarcina. Several reports are present for Serratia as follows: The organism survives as long as one day in air. One report indicates using nose as sampler. Nose and throat fluids are toxic to Serratia. Low humidity destroys organism rapidly. Reports on Proteus suggest survival of 2-12 days.

\*Mycobacterium tuberculosis (Table A 7) Organism survives 8-14 days in dust and 4-7 days in sputum droplets but 2 months in sputum. Ultra-violet and glycols tested against organism.

\*Pasteurella (Table A 8) The plague organism dies rapidly on drying but is infective by air route. The tularemia organism is inhaled from grain dust to infect.

\*Protozoa (Table A 9) E. hystolytica cysts did not survive when air dried.

\*Phage (Table A 9) Survives air drying and can be disseminated through air.

\*Rickettsia (Table A 9) Typhus may be transmitted through air. C. burneti is reported in goat barn. Rickettsiae grown in egg and sprayed survive 30 minutes in air.

\*Salmonella (Table A 10) Sprayed into air, the organisms survive 8-24 hours. Higher Rh and temperature lower recovery. Dust protects the cells and organism survives sun rays for 4-10 hours.

\*Staphylococcus (Table A 11) RH of 50% is lethal. Survives 3 days in air. Ozone not very toxic. Survives in floor dust for several days. May be quite resistant to UV light.

\*Streptococcus (Table A 12) Killed by sunlight in 4 hours but lives in dark for at least 65 hours and perhaps up to 2 weeks. Good survival in high and low humidity, but not 50% RH. Infective as small particles (2 micra). Particles near 12 micra diameter not as infective. Survives in air for 48 hours. Sunlight and UV are detrimental. Organisms from air may survive in blankets for 4 months. There may be 40 per 10 cubic feet of air in hospital wards or up to 378 per cubic foot. Glycols may reduce population 90%.

\*Viruses (Table A 13) May be found at high altitudes.

Influenza - Survives in dust less than 3 weeks. 50% RH more effective in destroying virus than higher RH. Some disagreement, however, exists over RH effect. Virus from air on blankets survives drying. It may survive many days in air but glycols and sunlight destroy it rapidly.

Vaccinia - Survives in air 8 hours, being more susceptible to destruction than Streptococci. Resists radiation like bacteria.

Foot and Mouth - Survives 1 week in outdoor air and in dust.

Smallpox - Seasonal incidence indicates low humidity favors the disease.

Infectious Jaundice - Virus carried in air by being dust-borne.

\*Yeasts, Molds and Fungi (Table A 14) Some of these species are found at 10 thousand to 36 thousand feet high. Some may travel 100 miles or 300-400 miles or even as far as 1200 miles to infect plants. Some species isolated in Antarctica. Resistance to UV is high. Certain human diseases are affected by low RH and wind to dry and carry spores (coccidiomycosis) while others need high RH and lower temperatures such as Sporotrichosis.

## SURVIVAL OF ORGANISMS IN THE BODY AND BODY MATERIALS

The importance of the persistence of microorganisms in the body materials during life and after death has been recognized as a major problem and hazard for a long time. The disposal of body excreta, tissues and carcasses themselves have been influenced by the realization that potentially pathogenic organisms might survive in them for long periods depending on certain factors of nature.

The handling of blood, tissues, and other specimens in laboratories and hospitals require precautionary measures since some pathogens may remain alive for a short time and others survive for long periods. The length of survival affects culture procedures for isolation of the organisms since the organism may die off readily. On the other hand, some organisms are kept in blood or tissue in the laboratory because the organisms survive in them for a very long time.

A distinct hazard and problem is the persistence of pathogens in secretions and excretions such as sputum, urine or feces. The proper disposal methods depend on organism survivals and persistence in these materials.

Of interest also is the survival of animal, plant and human pathogens in meats and meat products or on plants or plant products which are to be handled or eaten by susceptible individuals or which are to be disposed of without danger to other susceptibles.

The factors involved in the survival and persistence of microorganisms in the body and body materials may be divided into (1) body or body material factors; (2) factors in nature and (3) organism factors.

### Body or Body Material Factors Affecting:

Microorganisms may survive in body tissues, fluids or carcasses

for varying lengths of time. The body materials may on one hand provide food and protection from outside influences or on the other, may through pH of stomach or intestine, antagonistic organisms in the intestinal tract or antibodies or other antibacterial factors destroy the pathogens. Some organisms will survive for long periods in whole blood or serum at low temperature. Other organisms will be in tissues and be viable for long periods. Some organisms expelled in urine and feces are not destroyed readily by pH and antagonistic organisms but will be protected and survive. In sputum some organisms are destroyed but may survive well when suspended or dried outside the body. Body fluids through protective colloids are able to allow organisms to withstand forces of nature.

#### Forces of Nature or Environment Affecting:

Most organisms will persist for longer periods at lower temperatures. At temperatures high enough to allow metabolism to take place, the organisms will grow but kill themselves sooner with detrimental end-products such as acids, aldehydes and other substances. The amount of radiation will affect organism survival, depending on the amount of protection the cells have by organic matter. Wind and rain can wash away and dilute the organisms. Freezing and thawing also may affect the survival of members of cells as well as the heat of the sun if the organisms are near the surface. Another factor affecting survival of organisms in body materials in nature would be the RH if exposed to air. The interplay of temperature and RH is important. If not at soil surface, then the depth at which the body or body material is buried will affect survival.

#### Organism Factors Affecting:

The general and specific characteristics which are a part of a



particular cell will affect its ability to survive in the body and body materials. The virulence of the cell and its ability to invade certain tissues are important in determining its presence and survival there. Its resistance to light and other radiation, heat and cold, freezing and thawing, desiccation and temperature, and humidity changes will determine its survival and persistence. Ability to grow at low temperatures or survive at low temperatures, the presence of protective capsules or a spore stage or a particularly resistant cell wall and protoplasm all are important.

## SUMMARY

\*Bacillus anthracis (Table B 1) Survival data suggest 60-90 days in blood either moist or dry; in guinea pig blood at 25-30 C. for 1-9 months or at 5-10 C. up to 159 days; the organism may be found in feces and urine of cases. Skin apparently inhibits the organism. In body tissue, survival is given for several days up to 9 months, depending upon condition.

### \*Spirochetes (Table B 2)

Borrelia - Survival is listed at refrigeration temperature for 100 days in blood, at -48 C for 27 months; in feces for 4 weeks and tissues for 1 year.

Leptospira - Survival in blood for 7 days in dark, in feces for 24 hours but in urine for weeks or months. At refrigerator temperature in tissues survival of 26 days is given but at -20 C. 100 days survival is listed.

Treponema - In blood survival is only for a few hours at body or room temperature but in refrigerator for several days and at -20 to -78 C. survival of months to 3 years is given. In tissues at 5 C. for several days in bodies. Some tissues may stay with viable organisms for 7-10 days or longer. At frozen conditions -10 C to -78 C survival of 2 months to 3 years is given.

Spirillum - Survives 1-5 years frozen and in rabbit blood.

\*Brucella (Table B 3) In blood the organisms may live for 3-6 months or up to 5-9 years depending on reports. In feces, data suggest 100 days in dark or 20 days in manured soil. In a patient the organisms were found in feces during 16th month of disease. Skin apparently inhibits the organisms. In urine survival of 6-30 days is listed. In tissues persistence may be for a month to 7-9 months.

\*Microorganisms (Table B 4)

Clostridium - C. tetani found in tissues for 4-6 months and feces for 16 days. Gas gangrene organisms found in wound areas for five years. Botulism organisms found in intestines for 4 months.

Corynebacterium - Diphtheria organisms in blood for 13 years in laboratory. In tissues for 9 weeks to 4 months and in throats for 6 months in virulent form.

Erysipelothrix - Alive in tissues for a month, in sunlight for 10-12 days and in buried carcass for months.

Hemophilus - H. influenzae survival in blood for a short period but H. pertussis lived for weeks.

Lactobacillus - Alive for over 5 years in blood.

Malleomyces - From blood and urine remained alive 16-27 days.

Microbacterium - Found alive in blood for 5 years.

Proteus - In blood survivals of 3-9 years are reported. On skin survival was better than on filter paper.

Pseudomonas - Five year survival in blood is noted and resistance to drying on skin better than on filter paper.

Serratia - Organisms remained alive for 5 years in blood. Survivals on skin were better than on filter paper. Drying appeared to be important in destruction on skin.

\*Diplococcus pneumoniae (Table B 5) Studies in blood suggest survival of a few months when dried on surfaces and of 5-9 years in tubes. In sputum, persistence of 4 months is reported; when dried on surfaces, a few hours in sunlight to 30-40 days in dark is reported.

\*Escherichia coli (and coliforms) (Table B 6) Survival in feces in dark or light, fluid or dried varies with report from 3 days in sun to over a year or two. On skin organisms alive for a few minutes to hours. In urine the organisms may live over 100 days. Aerobacter aerogenes in feces 9-16 days, inhibited by normal skin and alive in blood 3-9 years.

\*Metazoa and Protozoa (Table B 7)

Bartonella - In blood for less than 3 days. Heating and chilling destroy it rapidly.

Entamoeba - Transient viability in feces stored at high temperatures (a few hours) but up to 14-17 days at low temperature. On skin cysts survive only a few minutes.

Necator - In feces plus urine for 2-3 weeks, in feces in lab for 13 months and for 3-7 months in soil. In sunlight destruction was in 1-2 hours for larvae.

Ascaris - In sunlight for a few hours but in fecal soil for days to a few weeks.

Trichuris - In fecal material survival of 14 days to 3 months. Increased temperature destroyed the organism readily.

Trichomonas - In pus for 3 hours and vaginal discharge for over 5 days. In laboratory with gastric mucin survival of 2-4 years.

Trypanosomes - Do not develop in blood of bats at low temperature.

Trichinella - Survives a few hours at sub-freezing temperatures.

Plasmodium - In blood at -50 to -70 C. for 10-15 days.

\*Molds, Yeasts and Fungi (Table B 8)

M. audouini - In hair survives for 125-420 days.

Tricophyton - Remains viable in toe scrapings for 300 days.

Coccidioides - In sputum in soil for 30 days as vegetative form and 240 days as parasitic form.

\*Mycobacterium tuberculosis (Table B 9) In blood survival of 14 days while controls in saline live 10 weeks. In fecal material persistence of a few days to several months in nature and 2 years artificially in fecal material. In pus for 3-4 months and skin for 7 years. Sputum samples vary in viability from 1-7 days to over 180 days depending on temperature, light and humidity. In urine it lived for several months.

In tissues death resulted rapidly in light and when dried but at low temperatures and if buried survival of 90-167 days reported or even 1-3 years in lung tissue.

\*Micrococcus species (Table B 10) (Staphylococcus) In blood for 9-19 years. In feces the effect of sunlight is negligible. On skin drying seems to be the antibacterial factor; low pH affects some while the presence of dirt or fat seems to protect organisms. In pus organisms survive at room temperatures for 2.5-3.5 years with no loss in pathogenicity. The organisms resist pH changes considerably. Gaffkya may live in blood for 5 years, Sarcina are killed rapidly in throat.

\*Neisseria (Table B 11) The gonococcus stays alive in serum for 7-8 weeks to 16 months. In urethral discharges the organism lives for a few hours at room temperatures. Reduced temperature gives longer survival. In body it may live almost 3 years. The meningococcus may live in nasopharynx for an average of 6 months. In dried secretions viability of several days is reported. In blood the Neisseria live 6 weeks to 3 months.

\*Pasteurella (Table B 12) The plague organism remained viable for 100 days in blood, 3 months in urine, in tissues reports of several weeks in carcasses to 1-2 years in refrigerator to 7 years glycerinated at -15 C. Frozen tissues give 6-42 month survival of P. tularensis and up to 10-13 years in glycerinated tissues at -14 C. Pasteurella may live in feces for a few days in nature to several weeks experimentally.

\*Rickettsia (Table B 13) Certain of the rickettsia exist for only 12 days in blood refrigerated, others for 95 days at -70 C. and others for 610 days. In feces survival of 6 years is reported. In tissues at freezing temperatures viability of nearly a year is suggested, for almost 2 years with another while at 5 C. 2-3 months survival is recorded.

\*Salmonella Species (Table B 14) In blood under lab conditions survival of 7 years is reported. In feces, 8 days to over 8 months is listed. On skin survival of 10-20 minutes on clean skin to several hours on dirty or fatty skin is suggested. Frozen turkey skin harbors the organism for over a year. In tissues the organisms withstand heat for short periods.

\*Salmonella typhosa (Table B 14) In blood for at least 7 years, one strain for 18 years, others up to 10 years in virulent state. In feces for a few days to 5 months with varying conditions. The normal skin does not allow survival but for a short time. In urine for 2-3 days at high room temperatures to 14 weeks. In tissues existence for 140-160 days is suggested.

\*Shigella (Table B 15) In feces under varying conditions survival of a few hours on fruit to over 200 hours in desert to several days and even up to 113 days in dried feces. In urine at room temperatures up to 40-50 days. Gastric juice was germicidal.

\*Streptococcus (Table B 16) In blood survival of a few weeks (4-8) to 7-19 years is recorded. On skin streptococci survive for 1-2 hours. In sputum viability may be as long as 150 days. In tissues 3 month to 6 month survival is recorded.

\*Vibrio (Table B 17) In blood the organism exists for 47 hours to 8 days and longer (5 weeks) in blood broth. In feces under adverse conditions of pH and sun and temperature viability varies from 24 hours to 30 days. In urine extremes of 6-40 days are recorded.

\*Viruses (Table B 18)

Hoof and Mouth - In blood and serum at low temperatures for several weeks to months for survival and in lymph existence for over 2 years is listed. In feces survival of 2 months to almost a year is suggested at low temperature. In tissues viability of the virus remained for 2-5 months at refrigerator temperatures.

Herpes - Alive only 40 minutes in normal rabbit serum, 10 minutes in serum plus UV. In brain suspension it lived for 100 hours.

Yellow fever - In blood it was viable for 154 days when frozen but in blood and liver at -10 C., 2 weeks.

Rift Valley - Long viability in refrigerator at 82 days or 2 years. In serum survival at refrigerator temperature was longer-1048 days.

Infectious jaundice - In dried fecal dust, the virus lived for 31 days.

Newcastle - The virus was present in chicken feces. On skin and carcass 96 days and in bare and unplucked carcass, 134-196 days viable.

Psittacosis - In fecal material the virus remained for 10 days.

Poliomyelitis - Fecal material harbored the virus for hours after passage. Storage at low temperature protected the virus to allow survival of 7-8 weeks up to 6 months. Virus found in stools from 7th day of disease to 123 days following attack. In tissue survivals of 20-30 days reported, in nasopharynx for a number of days (5-9) after onset of disease. The virus remained viable in an amoeba culture for less than 3 days.

Rabies - In brain material viability of 47 to over 68 days is reported. Exposed to liquid air destroyed in 24 hours and at high and low pH levels in a few hours.

Influenza - On human skin the virus was destroyed in less than 1 hour. In tissues at -30 C. survival was less than 6 months, lower temperature of -78 C. protected for 6 months in broth and in rabbit testes for 3 years.

Fowlpox - Two year survival in dried lesions reported.

Vaccinia - The virus from pustules survived up to 8 hours. In mouse brain survival of 6 months to 2 years is noted. In calf lymph equal survival is given.

Smallpox - In dried crusts, the virus remained for periods over a year in the light and dark.

Rinderpest - In rabbits and storage viability of 7 days.

Encephalitis viruses - Storage of 1 year in 50% glycerin, loss of virulence on drying. If frozen, survives over 3 months. Jap B in mouse brain survives at -78 C. for 6 months.

Lymphogranuloma inguinale - In rabbit testes survival of 10 months at -78 C. is reported.

Pneumoenteritis - Loss of virulence on storage is listed at 6 days if frozen and in 20 days if dried and refrigerated.



## THE SURVIVAL OF ORGANISMS IN CULTURE MEDIA

One of the foremost problems in the field of microbiology has been the culturing and storage of organisms in the laboratory in such manner as to maintain viability as well as their characteristics of morphology, metabolism and virulence. A multitude of reports on this subject have been made from myriads of experiments with more or less unanimity of results. The factors involved in the storage of cultures are numerous. Several main methods have been used for maintenance of stock cultures: (1) low temperature storage; (2) drying by lyophilization or other procedure; (3) exclusion of air and maintenance of moisture; (4) use of a combination of the various methods.

The factors involved in survival may be discussed in general as to environmental factors or organism characteristics.

### Environmental Factors Affecting:

The term "culture media" is used loosely here to cover the survival of organisms in vitro in media of all types whether liquid, solid or dried, in various containers under experimental conditions primarily in the laboratory.

The medium in which the organism is grown or stored plays an important role in determining the length of survival and maintenance of characteristics of organisms. The presence of inorganic buffers protect against extreme pH changes but may on occasion be toxic for some organisms. If fermentable carbohydrates are present, toxic acid, aldehyde, alcoholic or other end products might slowly pile up to kill the organism. Some salts are necessary for osmotic effect but can be toxic if in large concentrations in the medium. The organic substances in the medium may supply buffering capacity against

pH and other changes but may provide in metabolism a source of toxic end-products.

The physical state of the medium may affect survival time of organisms. Survival in liquid, on solid surface or in dried state may vary with certain organisms. The amount of medium may offer protection against physical forces of temperature and radiation or oxidation-reduction potential changes which might be detrimental to some of the anaerobes particularly.

The temperature of storage is one of the most important factors in determining length of survival. Organisms maintained at temperatures which allow metabolism of the organism to take place will not only produce toxic, limiting end-products but will age to become more susceptible to detrimental action of physical and chemical forces. Usually the higher the temperature the more rapid the death rate. Low temperature of storage obtained in refrigerators (approximately 5 C.) prevents active metabolism of most microorganisms and serves well in maintaining numbers and general characteristics of organisms. Even lower temperatures have been used, ranging from -5 C. (deep-freeze) to -75 C. (dry ice) to temperatures of liquid oxygen. In studies below the freezing point, the rate of freezing is a factor in the survival of organisms. Usually rapid freezing allows greater survival. Repeated freezing and thawing destroys many organisms probably through rupture of cell walls by formation and dissolution of the ice crystals. Presence of protein in concentration protects against such destruction.

Desiccation is usually considered as destructive to most organisms. Maintenance of cultures at low temperatures prevents loss of water content through evaporation. Materials such as cultures at room temperatures (25 C.) or incubator temperature (37 C.) may be

sealed or covered by various means including wax or rubber stoppers or screw-caps. Lyophilization, drying from the frozen state, has been exploited as a means of maintaining organisms. The suspending medium, rate of freezing, rate of drying and subsequent storage method are important factors in the success of the procedure. Usually a protein suspending medium with rapid freezing and rapid drying with the material then being sealed off under vacuum and stored at refrigerator or colder temperature gives the best results. The total dryness affects survival since a small amount of water in the end-products allows deterioration. In some instances inert gas such as nitrogen has been used instead of keeping organisms under vacuum. Storage may or may not be at low temperature. The lyophilization procedure may result in the destruction of many organisms in the preparation but those remaining viable retain their characteristics for long periods without throwing off variants.

Radiation of various types affects survival of organisms in cultures. Storage of cultures in the dark away from direct or diffuse daylight allows longer survival. Exposure of cultures to artificial sources of UV or of other radiation not only increases the death rate but increases the development of aberrant forms as mutants.

Removal of oxygen and substitution of an inert gas will prevent metabolism and allow long storage. The use of sterile mineral oil over cultures prevents desiccation and excludes oxygen as well, thus slowing down metabolism and allowing survival for long periods.

Many studies have been made on these various factors affecting survival for better maintenance of microbial cultures. The cultures have also been exposed to extremes of temperature, desiccation, pH, eH, radiation, chemicals and pressure to determine the ability of

different organisms to withstand these forces. Some of these studies are reported here.

Organism Factors Affecting:

The survival of an organism in culture media is not only dependent upon the media and other environmental factors but also upon the intrinsic characteristics of the particular organism itself. The genus, species and strain are important in that they may have characteristics providing resistance to physical and chemical forces. The presence of spores, capsules, especially rigid cell walls or other cellular components may aid in survival. The presence or development of more resistant variants or mutants may play a role in persistence. The rate and type of metabolism plays a part also in the pile-up of toxic end-products which might destroy the organism more rapidly. In all survival studies the number of organisms exposed and the age in the growth curve at time of storage or exposure are important factors in the survival or persistence of organisms.

## SUMMARY

\*Bacillus anthracis (Table C 1) Dried cultures survived 4½-35 years with good immunizing property, low temperature kept virulent forms alive for 8 years. In liquid form survival up to 1877 days in glycerin-serum at room temperatures. In sunlight killed in hours. May live for 11-14 years at 5-10 C. Liquid air killed in 6 hours, liquid hydrogen 10 hours. On solid media viability apparently low. May survive sun for 1½-4½ hours depending on season.

\*Bacillus species (Table C 2) Dried cultures survive for 4-5 years. Liquid cultures for long periods. Spores resist sun for 5-6 hours. B. globigii was found to be resistant to heat, gentian violet and streptomycin. On solid media 8 month survival. At freezing temperature over 80 week survival noted.

\*Bacteriophage (Table C 3) Dried typhoid phage lived for 26 years, others for 3 years. Resistance to heat aided by dryness. Freezing and thawing destroys phage. Lyophilization of dysentery phage inactivates much of the activity. Sunlight is toxic. Coliphage may be active for 7-17 years. When dysentery phage dried, no loss in 6 months. Phage resistant to pH changes.

\*Spirochetes (Table C 4)

Borrelia - At -78 C. the organisms survive for a year. Lyophilizing destroys many cells and may live only 192 hours.

Leptospira - Ten month viability in tissue broth at -78 C. In temperatures of 29-42 C. survival varies upwards from 5 days to 16 months.

Spirillum - In mouse blood at -78 C. for 1 year.

\*Brucella (Table C 5) When dried, cultures live 4-5 years. In liquid viability ranges from 15 days to 400 days. On solid media no loss in 8 days. On storage colony forms change. Storage at 37 C. shows 4 year

survival. Sunlight and drying lowers disease incidence. In lyophilizing high temperature lowers recovery while slow rate of drying gives better survival. Storage at 2-5 C. yields 80% viable in 100 days.

\*Clostridium (Table C 6) Dried cultures live for 3-5 years. Organisms survive lyophilizing. In liquid form exposed to various changes of temperature, pressure and pH fair survival is listed. On solid media Cl. tetani lived for 38 years. Cl. botulinum showed 140 day survival at 5 C. The spore stage of these organisms protected against high temperature and sunlight for short periods.

\*Corynebacterium (Table C 7) In the dried state 4-5 year viability found. The organisms resist sunlight when dried. In liquid media 6 month survival is usual. Organisms resist drying and sunlight well. On solid media 7-18 month viability reported.

\*Erysipelothrix (Table C 7) When dry the cultures live for 4-5 years.

\*Diplococcus (Table C 8) In dry form the organism may exist for 4-8 years depending on temperature of storage. Lyophilized strains show good survival numbers for at least 3 years. Liquid cultures live over 6 months. On solid media viability of 50 days-3 months is listed. Low pH is detrimental as are temperatures above 56 C.

\*Escherichia coli (Table C 9) Survival in dry state of 4-5 to over 10 years is listed. Early studies showed shorter periods. Freezing and thawing for lyophilizing destroyed many. In liquid exposed to increased temperature, freezing temperatures and chemicals, short periods of survival (in hours) are shown. In ordinary cultures at room temperature, viability over 1 year is found. Increasing salt concentrations destroy the cells. Very low temperatures destroy some cells rapidly (-195 C.). A temperature of 69 C. with high humidity is resisted for 7-10 hours. On solid media 91 day to over 11 month survivals are listed. Sunlight during various seasons is resisted for 1½ to 4½ hours.

Viability for 14 years noted in one instance at R.T. in dark. Wide variations in temperature affect survival adversely.

\*Microorganisms (Table C 10)

Alcaligenes - In dried form, survival of 4-5 years is reported.

Aerobacter - For 4-5 years in dried state, 31 days dried on paper at 37 C. Reports suggest the organism resists alkaline pH.

Hemophilus - Various species including H. pertussis lived for 5 years in dry state. In blood broth at -15 to 20 C. a few hours. On agar for 4-8 months.

Klebsiella - When dried, survival of 4-5 years listed, in serum at 37 C, 43 days, while in sealed tubes on agar 12-13 year viability has been demonstrated.

Lactobacillus - At 37 C. in dry state poor survival but at lower temperatures 3-4 year survival is shown. It resists liquid hydrogen for 7 hours and -10 to -80 C. for long periods. Rapid freezing aids survival. On solid media, 2 year viability was found.

Proteus - When dried, 4-5 year survival. In liquids good survival was reported. On solid media, 8 month viability found for some, 4-5 years for others and 19 years when on agar in sealed tubes at R.T.

Pseudomonas - Survival similar to Proteus, 4-5 years when dried, in liquid and on agar good survival found. It is slowly destroyed by pH up to 11.5.

Flavobacterium - In liquid media at -5 to 15 C., survival of less than 77 days revealed.

Achromobacter - Grows at low temperatures (0 C).

Azotobacter - Viability of 10 years on dried dextrin agar is reported.

Malleomyces - At low temperatures of 1-4 C. under vacuum, 25 month survival is listed.

Erwinia - Low RH aids survival in exudates.

\*Microorganisms (General) (Table C 11) Generalizations on effects of temperature, freezing, drying are given. Better survival with covering of paraffin oil is indicated..

\*Mycobacterium (Table C 12) In dried state reports vary from 6-12 months to 4-5 years and one report of 17 years following vacuum desiccation. In liquid preparations, reports of several months to several years are reported. On the various isolation media, 4-8 month survival up to 6 years is listed. Low temperatures gave poor viability. Drying gives good survival. Low pH destroys but not too rapidly.

\*Neisseria - (Table C 13) These organisms are very sensitive to drying and sunlight. Under freeze-drying conditions, 4-5 years of survival listed and up to 18 years in others. But in nature in sunlight only a few hours may kill. Liquid cultures of the meningococcus at low temperature (frozen) survive for months and up to 2 years. In serum, 16 month survival is listed. On solid media it lives for 8-27 weeks at low temperatures. The gonococcus survival is poorer except when dried, 4-5 years up to 18 years. In liquid media 7-8 week survival is listed, pH of 7.4-7.6 allow best survival. On solid media, 8 month viability is given.

\*Pasteurella (Table C 14) Dried materials live 3 to 4 days when not in sun, 3-4 hours in sun. When dried in lab for stock, 4-5 year survival obtained. Liquid materials of P. pestis may survive a few months at freezing temperatures. Solid media survival of 20-25 years is reported. P. tularensis may live for months in frozen conditions. Other Pasteurella strains have somewhat similar persistence characteristics.

\*Protozoa and Metazoa

Entamoeba - Three day to 3 week viability in Ringer's and other solutions and 10 days in powdered starch medium.



Plasmodium - In chicken red cell suspension, 72 hours without loss.

Trichomonas - Survival of 4-13 days at 25-37 C. in media; at low temperature, 2-3 week survival. Only 6 hours when dried.

Trypanosomes - In blood agar tubes, various species lived for 3-4 months at 25 C.; survival varied at freezing temperature of a few hours to a few months.

Schistosoma - Ten to 18 day persistence in vitro in serum.

Leishmania - Four month persistence in blood agar at room temperature.

Ascaris - Freezing temperatures inactivated in 6-20 days; high temperatures (60-70 C.) destroyed in a few minutes.

\*Rickettsia (Table C 16) For lyophilizing, sucrose was found effective.

At room temperatures survival of a few hours to 1 week are recorded; at refrigerator temperatures, 2 week viability is listed while at freezing temperatures near -20 C, several month viability is found.

With glycerol added, 10 month at -10 C. is reported.

\*Salmonella species (Table C 17) When dried at natural temperatures several hours of viability is found but lyophilizing allows viability of 4-5 years or as long as 10 years. In liquid cultures, 3-4 weeks is the usual report with occasional suggestion of 12 month viability. On solid media survival of nearly 2 years on blood gelatin and 98 day viability on gelatin are reported.

\*Salmonella typhosa (Table C 18) When desiccated, thin layers survived 5-15 days and thick layers lived for months. In liquid media such as saline survival over 6 days was found, at -20 C., 4½ months are listed and 10 years in tryptic digest. Resistance to liquid air, ultra violet, heat and freezing are given. On solid media, 91 day to over 8 month resistance was found. Other survival of 3 years to 8 years is listed on artificial media at room temperatures while lyophilized strains survived for about 4 years.

\*Serratia (Table C 19) Lyophilized strains lived for 4-5 years. In liquid, marscescens may survive for 20 years. Centrifuging destroys cells as well as radiation from the sun.

\*Shigella (Table C 20) Desiccated organisms may live only 20-25 days, but lyophilized cultures live for 4-5 years. Liquid or agar cultures may persist for 3-5 years. The organisms may live at 37 C. for 2 weeks. Sunlight destroys cells in a few hours but cultures remain viable for 900-1500 days in the dark.

\*Staphylococcus (Micrococcus) (Table C 21) Dried cultures have remained viable for 30 years. Stock lab cultures on media sealed remained alive for 11-12 years. At room temperatures, cultures remain alive for 1½-2 years. Lyophilized strains were alive for 4-5 years. Exposure to saline, freezing, vacuum drying, extreme freezing temperatures result in lessened survival.

\*Streptococcus (Table C 22) Dried cultures may live over 97 days but if lyophilized, viability of 4-7 years has been reported. Liquid cultures may live 30-60 days, if tissue added then lives 11-12 months. On solid media sealed tube cultures lived 11-12 years. Increased humidity over cultures lowers survival from 3 years to 8 weeks.

\*Treponema (Table C 23) When dried under varying conditions of humidity and temperature, the cells were killed in several hours to several days. Survival at freezing temperature in media for several weeks to 2 months. At sub-freezing temperatures survival of 1-3 years was obtained when tissue added. Exposure effects of heat, pH changes and freezing temperatures are given.

\*Vibrio comma (Table C 24) Dried preparations survived 4 years. Lyophilized preparations were viable for about 4-5 years. Liquid cultures lived for 4-5 weeks. On solid media lived under lab conditions for 6 weeks to 20 weeks. Some agar cultures dried, lived only 2-11 days.

At extremely low sub-freezing temperatures, viability for over a year was found.

\*Viruses (Table C 25)

Herpes - Dried virus at -5 C. survived over a year; at 37 C. for 2 months. Lyophilized, survival given at 4 weeks only. Liquid preparations at 37 C. for 100 hours and at 42.5 C. for 30 to 80 hours. UV radiation destroyed in 10 minutes. At -70 C. viability of over 1 year was found.

Hoof and Mouth - In dried form survived high temperatures for short periods. Ten day viability at room temperature is listed. In liquid preparations such as blood 2-5 days viability found; in buffered lymph over 2 year viability, high pH and repeated freezing did not destroy in 124 days. In solid media, 162 day survival is reported.

Influenza - Dried in talc for 30 minutes destroyed virus. Lyophilized, viable and infectious for 14 months. At -78 C. viability of 6 months to 3 years is noted in broth plus tissue. At -20 C. less than 6 month survival is recorded. Low pH was found to be detrimental. Temperatures over 40 C. destroyed the virus quickly.

Poliomyelitis - When dry, 52 C. for 30 minutes necessary for destruction. In glycerin, survival of 6 years is reported by one, others report over 2 year survival in glycerin. Concentration of glycerin and storage temperature are important. At 38 C., virus destroyed in 7 days.

Smallpox - Dried and stored at 37 C., 80 day survival but at 4-6 C. only 24 hour survival. In media, viable only 30 minutes at 35 C.

Vaccinia - Dried virus at 4 C. lived 12-18 months; 229 days when dried, temperature not given; lyophilized, lived for 10 months. In glycerin, at -70 C. 21 month survival, at refrigerator temperature it was avirulent in 12 months. In lymph for 2 years; in

allantois at low temperature, for 15 years. Dry lymph in tropics survived for 18 years.

Tobacco Mosaic - When dried it remained active for many years.

Laryngotracheitis - The virus remained active for 3 years following lyophilization and storage at 4 C.

Lymphogranuloma inguinale - Ten month viability has been reported for the virus in rabbit testes in infusion broth at -78 C. At 37 C. viability of 2-4 days reported with 56 C. destroying in 10 minutes and -70 C. allowing viability for over a year.

Lymphocytic choriomeningitis - Frozen dried material at 5 C. remained active for over a year.

Meningopneumonitis - Viability for 3 years in broth plus tissue at -78 C.

Encephalitis, St. Louis - Frozen dried preparations at 5 C. were active for over 833 days. At 40 C. and pH 8.4, 3 week viability was found. Heat at 56 C. for 30 minutes necessary for destruction.

Encephalitis, Jab B - In tissue plus serum at -20 C., 6-12 month survival reported. pH levels above 7 inactivated the virus rapidly, 60-70 C. destroyed it in 10 minutes.

Encephalitis, equine - Acid pH inactivated it readily as did alkaline pH levels.

Enteritis - At pH 7, the virus survived only 20 days.

Measles - In 50% glycerin, the virus existed for at least 3 months.

Mumps - At -20 to 30 C., the virus was viable for only 6 months or less. Acid and alkaline pH levels inactivate readily.

Newcastle - In 50% glycerin at pH 7.6, the virus was viable for 95 days at 25 C. and at 5 C. was viable for a year. At 37 C., one report lists 126 days of activity.

Psittacosis - Viability in broth for 29 days at lab temperatures, while at -70 C. for over 2 years active virus was present.

Rabies - The virus is apparently quite stable, surviving 56 C. for an hour, -185 C. for 3 months and living at 25 C. for several weeks. Extraction with ether at -65 C. still gives active virus after 1 year.

Coxsackie - Temperatures of 53-55 C. for 30 minutes inactivate. Acid and alkaline pH levels inactivate in 1 day.

Yellow Fever - Aqueous suspensions are viable for 10 days, with glycerol, 8 months viability is found. Dried and frozen the virus is active for years.

Cowpox - At sub-freezing temperatures survival of 1-4 days is revealed.

Rinderpest - Desiccated virus viable for 15 days. In tissue at 4 C. over 4 month survival.

"Cold" virus - At 4 C., the filtrates are active for 3 days, at 10 C. for 27 days and at -76 C. for 2 years.

\*Yeasts, Molds and Fungi (Table C 26)

Actinomyces - Dried cultures survive from 1-5 years.

Saccharomyces - When dried the cells are quite resistant. Ten month survival in plaster of paris. Lyophilized cultures were viable for 1-2 years. In liquid cultures survival of 5 weeks to over 160 weeks at -15 C. are reported. In 10% sucrose, 8-10 year viability found. On solid media at -70 C., survival of a week is listed. At -10 C. over a year survival is reported while at 37 C. 5 month viability was found. Some grow at refrigerator temperatures.

Aspergillus - At sub-freezing temperatures survival of 4 days was observed, while at 7 C. on agar over 2½ year viability was found. At 25 C. in the dark, 6 year storage was reported for one while others lived 10-16 years.

Epidermophytes - Survived for several weeks at sub-freezing temperatures.

Blastomyces - Over 20 months at 25 C. on agar covered with oil.

Candida - Survival of 20 months at 25 C. on agar covered with oil.

Coccidioides - On agar at 25 C., survival of 20 months when covered with oil.

Cryptococcus - Recovery of 20 months on agar slants covered with oil stored at 25 C.

Nocardia - 20 month survival observed.

Streptothrix - 420 day survival reported.

Others - Many fungi such as Penicillium, Rhizopus and others survived over 2½ years on agar at 7 C.

## SURVIVAL OF ORGANISMS IN FOOD

One of the main avenues of invasion of disease producing organisms and toxins is by the oral route. Many, but not all, pathogens can infect this way and not all of those that enter by that route are true intestinal pathogens in the strict sense of the word. Poliomyelitis virus would be an example.

Food such as green vegetables and fruit may get contaminated in the gardens from fecal material or handling. If eaten raw without proper washing the organisms of typhoid, dysentery and certain parasites of protozoa and worm types may cause infection.

One of the major methods by which pathogens get into food is by improper, unsanitary methods of handling. In one way or another, the organism in fecal material or other excreta get from humans or animals into the food. Very few withstand mild heat. Proper cooking would destroy all of the potential pathogens.

In some instances, the pathogens are present in animal materials used as food. That is the milk, milk products or meat may contain animal pathogens with which the animal is infected. Some of these pathogens may also infect humans. If the organisms persist in the milk products which are not treated by pasteurization (milk) or proper cooking as in the case of meat, the infection may occur. Sometimes the pathogens transmitted by the milk or meat are from the food handlers and not from the animals at all.

A few of the potential pathogens may actually grow in the food. This increase in numbers of organisms may result in such numbers as to cause "food poisoning" when eaten. Examples would be Salmonella organisms. A few such as the Staphylococcus and Cl. botulinum organisms produce toxins in the food which also cause "food poisoning".

The factors affecting survival of organisms in food may be grouped as to (1) food factors affecting and (2) organism factors affecting.

Food Factors Affecting:

The general type of food product will affect the survival of any organism in it. Particular characteristics would be: (1) amount of moisture present to allow or prevent multiplication of the organism; (2) presence or absence of antagonistic organisms; (3) the use of the food by the organism as nutrient increasing the number and for producing detrimental end-products for survival; (4) the pH of the food; (5) the presence of inhibiting quantities of sugar, salt, spices or other preservatives; (6) the temperature under which it is stored; (7) if frozen, the rate of freezing and (8) the amount of light or radiation.

Organism Factors Affecting:

An organism may survive or persist in foods for varying lengths of time depending upon (1) the inherent resistance of the genus and species under test; (2) the particular strain of organism studies; (3) the presence of a protective stage of the organism such as a spore; (4) the presence of a protective covering on the cell, such as a capsule; (5) the age (in the growth curve) of the inoculum; (6) the numbers of organisms inoculated; (7) the ability of the organism to multiply in the food under the conditions presented.



## SUMMARY

\*Bacillus (Table F 1) Bacillus anthracis was found to survive in milk for 10 years, was present on oats and on corn roots for 50 days and beans for 6-11 days. Other Bacillus species were found commonly in margarine and to survive on fruit for long periods at low temperatures.

\*Brucella (Table F 2) In milk the bovine strain lived for 5-10 days. In sheep milk persistence of 22-40 days was observed at refrigerator temperatures. In dairy products such as butter, 142 days survival and with cheese, 1-2 months most common but as long as 1 year was listed. Ice cream kept for 5-7 years at -23 C. still had Brucella present. In unsmoked ham survival of 21 days was reported. Brucella survive for an hour in wines and up to 3 days in beer.

\*Clostridium (Table F 3) The organisms are present in cheese and other milk products, on vegetables, meats and on fish, usually in the spore states. Clostridium botulinum was able to exist for over 2 years on vegetables at -16 C. as well as a large variety of foods at similar temperatures. Low pH inhibits the organisms as does high temperature. .

\*Coliforms (Table F 4) The organism may be present in milk and dairy products for long periods depending on pH and temperature. Some cheeses harbor it for 12 months or more. In frozen eggs E. coli recovered, even after 5 years. It is present in sea foods and may live in sausage for 13 days. Vegetable surfaces may have the organism on for long periods. Storage at -4 F. allowed survival for a year. Fruit surfaces are also contaminated and can live for 2-4 months at low temperatures. Beverages such as milk and beer may have the organism present.

\*Micrococcus (Table F 5) Micrococcus species were present in milk, eggs, meat, sauces, on vegetables and fruits. Some 56% of margarine

samples had *Micrococcus* species present. In eggs at -9 C. survival for 1 year is listed. In meat, survival of over 60 days at 22-37 C. was reported. Some survival of 16-144 hours in mayonnaise was found even at low pH. On vegetables at -17 C. 8 month survival is reported. Fruit at -18 C. contained organisms for 6 months while juices at -4 C. lost viable counts at 50 hours.

\*Microorganisms (Table F 6)

Corynebacterium - In frozen cream for over 4 days, butter for 1 month and sausages for 24 hours.

Lactobacillus - Present in milk for long periods and on peas for over 2 years at 15 F.; in butter for 275-462 days.

Rickettsia - In milk for at least 24 hours and probably 7-30 days. Cheese for 46 days and butter for 41 days.

Achromobacter - Viable in butter for 239 days.

Bacterium linens - 4 month survival in cheddar cheese at low temperature and pH.

Trichinella - In pork, survival for a few minutes to 36 hours at sub-freezing temperatures.

Pasteurella tularensis - Present in grain and food contaminated with rat excreta.

Pseudomonas - On plants for 69 days.

Proteus - In fruit juices at sub-freezing temperature for almost a month.

\*Microorganisms (General) (Table F 7) The general effects of low temperature in keeping bacterial flora of milk and milk products low are given. Similar reports are given for eggs. Temperature and humidity effects on survival in meat are shown as well as temperature reduction of organisms in fish. Organisms were present in frozen vegetables for over 4 years at -18 C. Temperatures of 65-80 C. did not destroy organisms. Low temperature and moist soil plus organic matter allow

pathogens to survive. On fruit surfaces many organisms may be present. They survive at low temperature for long periods up to 3 years. Low pH destroys them rapidly.

\*Mycobacterium tuberculosis (Table F 8) In milk, survival of 10 days to 2 years is listed. Low temperature allows long survival. Sour milk destroys organism. Temperatures of 60-80 C. kill rapidly. In dairy products at 15-22 C., 2-30 day viability is listed depending upon pH. Cheese may harbor the organism for 2 weeks to nearly a year depending on type (of cheese). Ice cream kept for 4-6½ years yielded live organisms. The organism survived pasteurization in butter. Several reports on food suggest that fat protects organisms.

\*Salmonella species (Table F 9) The major proportion of reports on organisms in food dwells on Salmonella species. In milk, Salmonella types may survive at refrigerator temperatures about 170-324 days. Many experiments with lowered pH show decreased survival. At pH 4.7 for 11-63 days and pH 4.2, no survival. Different species and strains vary as to sensitivity to acid. Sterile milk plus Salmonella give good survival suggesting antagonism may destroy them. In dairy products such as butter 117 day survival is suggested, for curds only 48-96 hours, for ice cream about 6-7 years at -23 C., in butter 49 to 212 days, buttermilk for 10-15 days, cheese for 24-30 days or even to 6-10 months, depending on the species and inoculum size.

In eggs at -1 to -18 C. some 11 month survival reported, while dried egg at 35 F. allowed viable forms at 65 weeks. Egg albumin was contaminated almost always and the organisms lived for 20 days at 120 F.

In meats of all types, Salmonella were present in some 1 to 26% of samples. In chicken at -25 C., 270 day survival is listed. In corned beef, 60 day viability is given. In oysters, 4 to 24 day survival is given. In other sea foods 4-40 day survival was found at  
(F 5)

low temperature.

In sauces such as salad dressing, survival of 1 to 144 hours was found. In cereals and breads 4½-6 month survival. On vegetables Salmonella may stay for a few days to several weeks at body and refrigerator temperatures or up to 25-31 days at room temperature. Several reports suggest 200 day-3 year persistence in canned vegetables. In frozen foods, 12 week survival. On greens for salad, 12 hour to 21 day survival has been observed. In or on fruit these organisms live for a few days in low pH juices or as long as 1-3 months in frozen fruit or for 68 days on surfaces. In beverages survival of Salmonella may be for 38 days or more in cold beer or for 1 hour in wine.

\*Shigella species (Table F 10) In milk at refrigerator temperature, 18-27 day survival is listed with 53 days in pH 4.8 milk but only 3 days at lower pH. In milk products survival varies from curds with no survival to butter at 18 day viability. Cheese may harbor the Shigella for 9 days. Eggs may be contaminated for 3 months at -9 C. Meats contain viable organisms for over 3 weeks. Cereals and bread may have Shigella present for 1 day up to 45 days with decreasing temperature. Fruit have been contaminated for 2-10 days.

\*Streptococcus species (Table F 11) Some of these organisms are quite common in milk, but length of survival apparently is not too long. Reports suggest 8-48 hours in fresh and sterilized milks. In dairy products pyogenic streptococci have been found for varying periods such as in cheese from 9 days to over 18 weeks depending on type of cheese and in butter for 17 days. Other streptococci may exist for 6 months in butter. Ice cream may be contaminated for 12 hours to 18 days. Eggs may contain these organisms for a few hours while meats have been harboring them for 13-60 days. Frozen vegetables may have streptococci in them for a year.

\*Vibrio species (Table F 12) The cholera organism survives in milk for short periods of a few hours at room temperature to 8 days in sterilized milk. In dairy products such as butter, viable organisms have been found for 21-over 98 days with low temperatures extending the period of survival. Cheese does not allow very long survival with reports varying from 8 hours to 4-5 weeks. Curds and whey showed poor survival. In fish eggs, the vibrios lived from 12 hours to over 8 days at low temperatures. The organisms were present in various fish and meat preparations for varying periods. In fish, the usual survival was for a few hours to a few days. When salted and/or at low temperature low viability was found in fish. In meat, a report of 45 weeks was found but another report suggested 2 weeks at 3-8 C and 7-10 days in hot weather. The vibrios survive in sauces from 1 hour to about 24 hours. In cereals, 8-15 hours and on vegetables, for 4-5 weeks; on fruit as long as 4 days are also reported.

\*Viruses (Table F 13)

Poliomyelitis - The virus resists heat in milk better than in water. In butter, 91 day viability was observed. The virus was found on fresh fruit and vegetables.

Foot and Mouth - The virus has been found in milk. It exists in beef at -4 C. for 24 hours and at -20 C. for 4 months. Some reports of its presence on cereals suggest 4-20 week persistence.

Newcastle - In eggs, survival of 126-538 days is listed. At 36 C. over 100 days and at 3-6 C. over 500 day survival was found. In mash, 56 to over 538 day viability was observed. At pH 5 and 37 C. 56 days was the extent of persistence while at pH 5 and 3-6 C. over 500 day existence of virus was observed.

Fowl Pox - In dried eggs, survival of 1928-3598 days (10 years) is reported.

Encephalitis, Jap B - In eggs at 4 C., only 6 hour survival was found.

Pigeon Pox - In dried eggs, viability of 1099-3605 days has been demonstrated.

\*Yeast and Mold (Table F 14) Yeasts are reported in milk and in margarine (46% of samples). Vegetables contain yeasts after being frozen but 90% are destroyed. Yeasts survive for 7 months to 3 years on or in fruit at low temperature. In foods, in general, yeasts survive 3-15 months.

Molds or fungi may be found in 42% of margarine samples. In or on vegetables they may live for 16 months but 90% are destroyed by the freezing process.

On fruit or in fruit juices at low temperature, viability of 7 months to 3 years has been demonstrated.

## SURVIVAL OF ORGANISMS IN OR ON "INSECTS"

The duration of survival of potentially pathogenic as well as saprophytic organisms in or on insects of various types has received considerable interest. Some insects have been found to play an important role in the transmission of certain diseases. Below is given a classification of arthropods and the diseases in which they play an important medical role. The common names for the insects are given within the parentheses and the list of diseases in which the particular insects play a role are capitalized.

### CLASSIFICATION OF ARTHROPODS OF MEDICAL IMPORTANCE

#### PHYLUM-ARTHROPODA

- I. Class - Insecta (Hexapoda) - insects
  - A. Order - Orthoptera (cockroaches)
  - B. Order - Hemiptera (true bugs)
    1. Triatoma spp. (reduviid bugs) - CHAGAS DISEASE
    2. Bedbugs
  - C. Order - Anoplura (sucking lice)
    1. Phthirus pubis (pubic or crab louse)
    2. Pediculus humanus capitis (head louse)
    3. Pediculus humanus corporis (body louse) - EPIDEMIC RELAPSING FEVER, EPIDEMIC TYPHUS AND TRENCH FEVER.
  - D. Order - Coleoptera (beetles)
  - E. Order - Siphonaptera (fleas)
    1. Xenopsylla cheopis (rat flea) - PLAGUE, ENDEMIC TYPHUS.
    2. Ctenocephalides canis (dog fleas) - DIPYLIDIASIS and HYMENOLEPLIASIS.
    3. Tunga penetrans (Chigoe flea).
  - F. Order - Hymenoptera (bees and wasps)
  - G. Order - Lepidoptera (butterflies and moths)

## H. Order - Diptera (flies & mosquitoes)

1. Anopheles spp. (mosquitoes) - MALARIA and FILARIASIS
2. Culex spp. (mosquitoes) - FILARIASIS and ENCEPHALITIS
3. Aedes spp. (mosquitoes) - YELLOW FEVER, DENGUE FEVER, and FILARIASIS
4. Mansonia spp. (mosquitoes) - ENCEPHALITIS and FILARIASIS
5. Culiseta spp. (mosquitoes) - ENCEPHALITIS
6. Hemagogus spp. (mosquitoes) - JUNGLE YELLOW FEVER
7. Simulium spp. (black flies) - ONCHOCERCIASIS
8. Phlebotomus spp. (sand flies) - SANDFLY FEVER, VERRUGA PERUANA and LEISHMANIASIS
9. Culicoides spp. (biting gnats) - MANSONELLIASIS, and ACANTHOCHEILONEMIASIS
10. Chrysops spp. (deer flies) - TULAREMIA and LOIASIS
11. Glossina spp. (tsetse flies) - AFRICAN SLEEPING SICKNESS
12. Hippelates spp. (eye gnats) - YAWS

## II. Class - Arachnida

### A. Order - Acarina (ticks and mites)

1. Ornithodoros spp. (soft ticks) - ENDEMIC RELAPSING FEVER
2. Dermacentor spp. (hard ticks) SPOTTED FEVER, TULAREMIA, COLORADO TICK FEVER, and TICK PARALYSIS
3. Ixodes spp. (hard ticks) - RUSSIAN SPRING-SUMMER ENCEPHALITIS
4. Rhipicephalus spp. (hard ticks) - FIEVRE BOUTONNEUSE and KENYA TYPHUS
5. Trombicula spp. (mites) - SCRUB TYPHUS
6. Allodermanyssus spp. (mites) - RICKETTSIALPOX
7. Sarcoptes spp. (scabies mites) - SCABIES
8. Bdellonyssus spp. (tropical rat mites)
9. Eutrombicula spp. (chiggers)
10. Demodex spp. (follicle mites)
11. Pediculoides spp. (grain itch mites)

### B. Order - Araneida (spiders)

1. Latrodectus spp. (black widow spiders)

### C. Order - Scorpionida (scorpions)

There are some 10,000 kinds of mites, ticks and insects which affect man with bites or allergic reactions and infect man with one or another type of disease. Some of these "insects" carry disease by accident or only occasionally. Some of the diseases are not directly man to man through insects but may be carried among cattle and other livestock as well as wild animals, then from these reservoirs back to man.



Some insects are considered only as mechanical carriers. This is where they walk over infected material and/or eat the contaminated materials and then transfer the infectious organism by defecation, vomiting or merely crawling over food or susceptible host. Other insects act as mechanical vectors by picking up organisms when biting an infected human or animal and carrying on itself until it bites a new host.

A different and more complex relationship exists in some insects where the organism grows or multiplies in the insect and then is transmitted. In certain insects the organism may go through the life cycles and continue to be infectious following defecation or vomiting. In a few instances the parasite may go through a portion of its life cycle in the insect before becoming infectious for humans or animals. This type of relationship is difficult to assess in survival and persistence studies undertaken here.

The organisms carried by insects may be viruses, bacteria, fungi, protozoa and even the larger roundworms and tapeworms. Some are transmitted by the insect. Experimentally, some insects have been contaminated with organisms and the rate of survival studied but under field conditions the organism may or may not ever be found to be associated with insects in general and the one under study in particular.

The following tables list numerous pathogenic and saprophytic organisms found associated with insects. For the most part, data on medically important microorganisms are presented. In some cases organisms closely related to the pathogens have been included for comparative purposes. Wherever exact data on inoculum size and recovery rate in experimental studies were available the information was recorded. Experimental transmissions or survivals have been

noted as such (exptl.). Where studies were made under field conditions and the organism was found, recovery has been recorded as "present". Where no numerical figures or quantitative studies were available and the organism was found, recovery has also been recorded as "present". In some instances studies were made to see if the insects could transmit a particular disease organism. If the results were positive it has been recorded as "transmitted".

Factors of Nature Affecting:

The climate, namely temperature and relative humidity play a role in survival of some organisms on insects. Low RH and high temperature adversely affect many organisms. The seasons of the year as well as rainfall are important. Some diseases are not important in certain areas because the insect vectors cannot survive or live there. Certain factors such as presence of food and favorable climate as well as intermediate hosts are important in the survival of the insect as well as the organism.

Factors of Insect Affecting:

Insects vary in their importance as vectors of pathogenic organisms because of their living habits. Some do not live near places where the organisms exist. Others while living close to humans and their organisms do not feed on contaminated material whether it be food, excreta or by biting or sucking on infected hosts. Thus, they do not play an important role as vectors. Some organisms are carried by some insects for varying periods but are not transmitted for various reasons such as the numbers might be too small, or the organism must be transmitted into the blood stream and the insect does not bite, or the organism is not in the biting-parts. Some insects do not provide proper food or conditions

for survival of the organism. It might contain antagonistic chemicals as well as other antagonistic organisms which would prevent survival.

Factors of Organism Affecting:

The inherent properties of an individual genus, species and strain may determine whether it survives in or on a particular insect for any length of time. Presence of a spore or capsule or other resistant cell components help in survival or persistence of the organism. Some cell walls are more resistant to the drying conditions of air and aid in persistence of the organism when on insects. Other organisms can grow in insects thus providing greater numbers and longer survival. Others may resist insect digestion and antagonistic organisms for survival while others may pass into new generations by transovarian passage.

**SUMMARY**

\*\*Bacillus (Table I 1) The important organism of this group (B. anthracis) was studied in bedbugs, beetles, cockroaches, flies and ticks. It was found present in bedbug feces, experimentally it remained in stomach and feces for 24-96 hours. In beetles the organism was reported present as was true for cockroaches. The organism was found present and could be transmitted by flies, passing through the life cycle. This was true also in ticks, the organism being in feces for at least 100 d.

\*\*Borrelia (Table I 2) Organisms of this group are reported in bedbugs, lice, reduviids and ticks. Experimental studies with bedbugs indicated survival in but no transmission by bite. In lice B. recurrentis existed for at least 19 days and could be transmitted by Pediculus corporis. In triatoma B. duttoni lived for 6 days. Much

work was done with many species of ticks and with several types of Borrelia. B. recurrentis lived for 5-6.5 years in Ornithodoros. species and could be transmitted by numerous species. Other Borrelia are reported as present and transmitted by Ornithodoros, Rhipicephalus and Argas genera.

**\*\*Brucella** (Table I 3) Reports are present on bedbugs, cockroaches, fleas, flies and ticks. Bedbugs were host to the organism for over 3 months but not transmitted by bite. They lived for only 24 hours in roach feces. Organisms were found present in flea feces but not transmitted. Flies harbored the organism for over 96 hours in the gut. In ticks, the Brucella organisms lived for over 3 months passing through to eggs and larvae and being transmitted by bite.

**\*\*Clostridium** (Table I 4) Studies were made on beetles and cockroaches. Cl. tetani and Clostridia of the gas gangrene group were reported present in the feces of selected beetles and roaches.

**\*\*Coliforms** (Table I 5) Findings are discussed for beetles, cockroaches, and flies. Most reports indicate coliform organisms (E. coli, A. aerogenes and paracolon organisms) present in the insects listed with transmission by the Periplaneta americana roach. Particular interest was shown in flies where growth in the flies was reported and increased numbers in unsanitary areas.

**\*\*Corynebacterium** (Table I 6) Studies are reported on these organisms in beetles, cockroaches and flies. Diphtheroids were found in beetles and roaches while the diphtheria organism was observed in the intestinal tract and on legs of roaches. Experimental survivals in flies suggested survival of a few hours on legs and wings to slightly over 24-50 hours in the intestinal tract.

**\*\*Diplococcus** (Table I 7) The diplococcus of pneumonia was reported present in cockroaches, fleas and in lice. It was reported present

on legs of roaches, in feces of roaches, fleas and lice.

\*\*\*and Streptococcus (Table I 7) Various streptococcus species were found in cockroaches, flies and reduviids. Reports are on S. fecalis, equinus and pyogenes as being present. Transmission of S. fecalis by triatoma is indicated.

\*\*\*Fungi, Yeasts and Molds (Table I 8) Brief data is presented on these microorganisms in cockroaches. Experimental inoculation of torula suggested recoveries up to 6 days.

\*\*\*Malleomyces (Table I 9) Studies on beetles, cockroaches, fleas, and mosquitoes are listed. It is reported present in feces of all but mosquitoes. In fleas survival is given at 50 days with transmission for M. pseudomallei with transmission also listed for Aedes aegypti.

\*\*\*Micrococcus (Table I 10) Brief notes are made for the presence of various Micrococcus species in beetles, cockroaches, flies, lice, mosquitoes and ticks. Survival studies are listed for Staph. aureus in the gut (8 days) and feces of flies at 3-5 days. Staph. citreus passed through the life cycle and lived for 9 days after maturity. Lice were able to transmit Micrococci. Staph. aureus lived for at least 24 hours but not 7 days in the gut of Aedes aegypti.

\*\*\*Microorganisms (Table I 11) This section contains a few isolated reports on several gram negative organisms including Klebsiella, Proteus, Pseudomonas, Serratia and Neisseria.

Klebsiella - found to be present in feces of beetles and roaches.

Proteus - present and transmitted by roaches; present in flies.

Pseudomonas - present and transmitted by roaches; present, passes through life cycle of flies and transmitted by flies.

Serratia - experimental throughout life of roach; exptl. in flies lived 4-5 days in crop, 18 days in intestines but only one day in pupae of Musca domestica.

\*\*\*Mycobacterium (Table I 12) Reports are listed on the presence of M. tuberculosis in beetles, cockroaches, and flies; and for M. leprae in bedbugs, cockroaches, flies, lice and mosquitoes. The studies with M. tuberculosis reveal it to be present in beetles, present for 2-5 days and transmitted by roaches, present in flies, survive 13 days in flies intestines and feces and to be transmitted by flies. M. leprae (or similar organism) is reported to be present for 5-16 days on and in bedbugs, to exist up to 169 days in roaches, to be present in the stomach of fleas and to live for several days in flies and mosquitoes as well as being found in lice.

\*\*\*Pasteurella (Table I 13) Various insects including bedbugs, fleas, flies, lice, mites, mosquitoes and ticks have been recorded as harboring Pasteurella organisms for varying lengths of time. The important organisms are Pasteurella pestis of plague and Pasteurella tularensis of tularemia.

P. pestis - The insect of importance is the flea. History has recorded its role in the transmission of plague from rat to man. Representative reports reveal its survival and growth in fleas with survival in the flea for periods up to 21 days and 4-5 weeks in flea feces. The organism was also found in ticks and to be transmitted by ticks.

P. tularensis - In bedbugs survival was for 136 days with transmission. Fleas were found to contain the organism and transmit it as well. The same was true for certain flies, lice, mites and mosquitoes. Tularemia is transmitted more often through ticks. The organism survived in Ornithodoros for 674-701 days, was able to survive the life cycle of Dermacentor and could be found in Ixodes.

\*\*\*Protozoa and Metazoa (Table I 14) Data are presented on bedbugs, cockroaches, flies, lice, mosquitoes, reduviids and ticks.

Trypanosomes - reported transmitted by bedbugs, transmitted by  
(I 8)

flies (*Glossina* species), lice, mosquitoes and reduviids with survival in the triatoma for 2-6 days.

Leishmania - found to be present and transmitted by flies (*Phlebotamus*) and survived in reduviids for one day with 25 day survival in ticks plus transmission.

Endamoeba - present in roaches for 72 hours, present in flies for short periods (2-3 days) at most.

Giardia - found in roaches and survived up to 12 days experimentally, also present in flies for a few days.

Chilomastix - present in flies.

Endolimax - present in flies

Worms - hookworm found in roaches and flies, tapeworms reported in roaches, roundworms present in roaches and flies.

Filaria - present and transmitted by mosquitoes.

Plasmodia - in mosquitoes with survival and transmission given under varying conditions of temperature and relative humidity in various mosquitoes.

Babesia - present and transmitted by ticks.

\*\*Rickettsia (Table I 15) Studies on *Rickettsia* in insects were limited to a few reports in bedbugs, fleas, lice and mites with many reports on ticks. *Rickettsiae* were found to be present in bedbugs, survive from 24 hours to 10 days but not to be transmitted. *Rickettsia* of typhus fever were found present in fleas, could survive up to 52 days within the flea and be transmitted. Survival studies of *Rickettsia* in lice and louse excrement are reported with persistence for 10 days to 4 months. In feces under varying conditions of temperature and humidity the *Rickettsia* lived for 11-12 days up to 147 days and could be transmitted to susceptible animals. Typhus fever and other *Rickettsia* were present naturally and could be transmitted by numerous types

of mites. Data presented on survival and persistence in ticks are extensive. Typhus fever, rocky mountain spotted fever, bullis fever and Q fever Rickettsia constitute the major reports. R. rickettsi is reported surviving 345 days. It is present in numerous types of ticks naturally and experimentally transmitted to susceptible animals. Other rickettsia (RMSF) pass through the life cycle and may survive over 1000 days in ticks. Coxiella burneti is reported present and transmitted by ticks surviving 600-900 days and being transmitted 400-700 days. In tick feces viability up to 586 days is listed.

\*\*Salmonella (Table I 16) These organisms are reported from bedbugs, cockroaches, fleas, especially from flies, and in one or two reports from lice, mosquitoes and ticks. Their importance is in intestinal diseases where the organisms may be deposited on food in feces primarily. In bedbugs experimental survival is noted for 2-3 weeks without transmission. A number of papers on cockroaches reveal Salmonella to be present naturally and to be transmitted. Experimental findings suggest survivals from 7 days to 42 days with survival within the body and in the feces. Reports on experimental work with fleas indicate 96 hour survival in the body, less than 24 hours in the feces but transmission was possible. One report revealed natural presence with transmission. Salmonella of typhoid fever were present in flies. Experimental survival and transmission could be followed up to 23 days. One report suggested multiplication of the organism in the gut. Experimental results on survival of other Salmonella revealed persistence from 10 days up to 4 weeks. Salmonella were reported in lice. In mosquitoes survival of Salmonella experimentally was for 1 hour in one finding but with a different organism and mosquito a 3-4 week persistence is reported. In tick feces one Salmonella species survived for 35 days.



- \*\*Shigella (Table I 17) One brief report on ants suggests survival on feet for 24 hours. All other reports are on flies. Several Shigella species are reported as present with survival for 5-11 days. One report suggests multiplication of S. dysenteriae in the house fly.
- \*\*Spirochetes (Table I 18) Two papers report Treponema pertenuis to be present in and transmitted by flies. One report is on experimental survival of leptospira in Triatoma.
- \*\*Vibrio (Table I 19) Reports are available on the survival of the cholera vibrio in cockroaches and flies. Persistence for 79 hours in roach feces is listed. The organism is reported as present in flies with experimental survival for 30-48 hours.
- \*\*Viruses (Table I 20) Studies are listed on bedbugs, cockroaches, flies, lice, mites, mosquitoes, reduviids and ticks.

Yellow Fever - present in bedbugs for 2 days; in mosquitoes where nature and history have shown transmission to be important; survival of 39 days in Culex with transmission, presence and transmission in Haemogogus, in Aedes survival throughout life of mosquito (approximately 200 days) is reported with the virus present in nearly all tissues. The virus was also found to survive in Triatoma for a week but without transmission. In ticks survival lasted about 6-23 days but was not transmitted by bite of tick.

Lymphocytic Choriomeningitis - Experimentally survived in bedbugs for a few minutes (10) to 85 days. It was found in cockroaches and experimentally survived in and was transmitted by mosquitoes. The same was true in ticks.

Poliomyelitis - The virus was found present, survived from 1-15 days in experimental studies in roaches with excretion for at least two weeks. In flies the virus is probably present in nature. Experiments suggested survival of 2 days to 3 weeks in different

species with possible transmission reported. Survival of 3 weeks in mosquitoes is revealed.

Coxsackie - In cockroaches experimental persistence and transmission up to 15 days is suggested.

Mouse Encephalitis - A period of 7 days for survival in roaches is given for experimental results.

Eastern Equine Encephalitis - The virus was found present in lice and mites. The mosquito is the important vector with the virus being present in numerous species of Aedes. Transmission up to 2 months was reported. The virus was also found to be experimentally transmitted by ticks.

St. Louis Encephalitis - Reports indicate its presence in mites with transmission. Aedes, Culex and Anopheles mosquitoes were found able to harbor and to transmit the virus.

Western Equine Encephalitis - This virus was found in mites. Experimental findings revealed transmission by various Aedes and Culex mosquitoes. Also reported is transmission by Triatoma.

Jap B Encephalitis - Reports of experimental transmission in Culex and Aedes showed survival from 15-91 days.

Venezuelan Equine Encephalitis - Transmission was revealed for Anopheles, Aedes and Mansonia species. Survival for 17 days was noted in Triatoma but no transmission.

Rift Valley - This virus is reported as being present in mosquitoes and of being transmitted.

Russian Spring and Summer - Ticks are able to harbor the virus for varying periods up to 40 days with transmission by Ixodes and Ornithodoros.

Dengue - The virus survived for periods up to 174-200 days in mosquitoes. Low temperatures and serial passage lowered infectivity.

Colorado Tick - This virus was found present in Dermacentor and could be transmitted.

\*\* Headings for major groups of organisms.

## THE EFFECT OF PRESSURE ON THE PERSISTENCE (SURVIVAL) OF ORGANISMS

Small amounts of pressure do not affect microorganisms particularly, but may increase the rate of some chemical reactions. If "super-pressures" in the order of 5,000 atmospheres are applied, the pressures are able to denature proteins, kill bacteria, inactivate viruses and detoxify toxins. The temperatures necessary for such activity are not raised above 20-25 C.

### SUMMARY (Table P 1)

\*Escherichia coli - Some 5,000 atm. of pressure destroy the cells in 45 minutes. When exposed to approximately 500 lbs/sq.in. of argon, nitrogen, nitrous oxide or carbon dioxide, some destruction of the cells occurred. Pressure at 5,000 lbs/sq.in. affected the rate of disinfection, depending upon the temperature. When 1,000 lbs/sq.in. of pressure was applied to cultures at temperatures below 37 C., growth was retarded but accelerated above 37 C.

\*Aerobacter aerogenes - Very high pressures of 100,000 lbs/sq.in. destroyed in 4-5 minutes, while 50-65,000 destroyed in 10 minutes and 30-45,000 killed in 1 hour.

\*Salmonella - These organisms were destroyed at 5,000 atm. of pressure in 45 minutes.

\*Bacteriophage - Some strains are destroyed by 4500 atm., while others are not.

\*Viruses - Rabies, herpes, yellow fever, foot and mouth, encephalitis and smallpox viruses were exposed to pressures of 3000 to 7000 atm. with resulting destruction in 30-45 minutes. Some differences in susceptibility are noted.

\*Mold and Yeast - Pressures of 30-35,000 and 85,000 lb/sq.in. were tested with resulting destruction in 5 minutes-1 hour.

\*Bacteria, General - Vegetative cells may withstand 6,000 atm. for 14

hours, while spores withstand 12,000 atm. for the same period. Marine bacteria may remain viable under 400-600 atm. at 30 C. for 4 days.

\*Streptococcus - Exposed to 30-100,000 lbs/sq.in., these organisms survived for 4-5 minutes at the high pressures and 1 hour at the low pressures.

\*Micrococcus - Some 3000 to 6000 atm. of pressure were tried on these organisms with recovery at 45 minutes with the lower pressure but not at 6000. Other experiments showed that 5000 atmospheres destroyed the organisms in 45 minutes as well.

\*Mycobacterium - At 3000 atm., the cells survived 45 minutes but not with 6000 atm. of pressure.

\*Pasteurella - When exposed to over 2000 atm. of pressure, survival of 30 minutes was obtained.

\*Serratia - At 3000 atm., the cells lived 45 minutes but not with 6000 atm. When subjected to 30-100,000 lbs/sq.in., survival of less than 1 hour was observed.

\*Corynebacterium - These organisms were destroyed by pressures of 40-45,000 lbs/sq.in.

\*Diplococcus - Pressures of 5,000 atm. destroyed the organisms in 45 minutes.

## THE EFFECT OF RADIATION ON THE PERSISTENCE (SURVIVAL) OF ORGANISMS

Studies on radiation have shown certain ranges of the electromagnetic spectrum to be deleterious to microorganisms. This includes (1) ultraviolet (200-300 m $\mu$ -or 2000-3000 Å units); (2) X-rays (0.005-1 m $\mu$ ); (3)  $\gamma$  rays (short x-rays); (4)  $\beta$  rays, or cathode rays or high velocity electrons; (5)  $\alpha$  rays or high velocity helium nuclei and (6) neutrons.

It has been suggested that gamma, x-ray and UV radiation of media and organism produces toxic substances which destroy the organisms. The death rate in the organism suspensions is considered as a logarithmic one in relation to the energy absorbed. This has been shown with numerous organisms and various types of radiation. Heat is probably not the predominant factor in death of the cells.

Some reports suggest the amount of radioactive lethal doses involved necessary for killing vegetative cells and spores of different organisms at between 4-200 r x 10<sup>3</sup>. Ultraviolet energy expended approaches 1-50 ergs x 10<sup>3</sup>/cm<sup>2</sup>. Sometimes a correlation may be made between chemical sensitivity and radiation sensitivity. No exact relationships have established between sensitivity to radiation and taxonomic classification.

Several mechanisms or modes of action for radiation effects on microbial cells have been proposed. The energy must first hit and be absorbed by the cell. UV hits particularly the nucleic acids of the cell at 260 m $\mu$ . The other rays hit the cell substances in general. With x-ray, gamma and beta radiation the fast moving electrons damage the cells probably by the collisions involved. Perhaps this is true of alpha and neutron radiation which also form ionization tracks through the cells.

One of the theories on radiation action is the so-called target theory whereby destruction on the logarithmic order occurs following a "hit" on the cell by radiation energy. Temperature does not affect the rate of destruction so it is assumed that no actual chemical reaction takes place in the destruction since temperature rise increases rate of chemical reaction. Areas of the so-called sensitive target of a cell have been estimated by the amount of radiation necessary to destroy the cells.

One theory suggests that a lethal mutation has taken place in the cell hit by radiation. This suggests that a particular chemical entity is changed so that life processes cannot go on. Some experiments observing cells attacked by radiation show that one or two divisions may take place and then stop--with resulting death before visible colonies can develop.

Ionizing and ultraviolet radiation may result in certain decomposition products such as quantities of formic acid or hydrogen peroxide. There is a great amount of evidence in favor of enzyme inactivation by the radiations. These inactivations or transformations in enzyme activity may result in complete inactivation of certain processes of the cell and allow others to progress resulting in the overproduction of products which pile-up and become toxic to the cells. This results in stopping of metabolism and stopping of multiplication and then in death.

In nature, the sunlight contains varying amounts of infra-red through ultraviolet radiations. The ultraviolet is especially active in the destruction of microorganisms so that cells exposed to sun rays may be destroyed much more readily than if in the dark or shaded to be protected from the sun radiation.

## SUMMARY\*\*

\*\*see also surfaces and soil for sunlight effects.

\*Bacillus species (Table R 1) Radiation of the UV at  $452 \text{ erg/m}^2$  at  $2537 \text{ \AA}$  destroys 90% of cells. The spores and vegetative forms did not differ in susceptibility greatly. Death time ranged from 5 seconds to 30 minutes depending on exposure. Exposed to sunlight, the organisms survive for 2-6 hours on plates to 36 hours in blood. Presence of air seems to aid destruction. Ultrasonic at 320 kc destroyed cells (99%) in 45 minutes. Electrons were active in 1 second.

\*Bacteria (General) (Table R 2) Some general effects of ultraviolet, sunlight, x-ray, ultrasonic and electric current are presented.

\*Bacteriophage (Table R 3) Dysentery phage at  $1.5 \text{ erg/m}^2$  per second at  $2537 \text{ \AA}$  (UV) was inactivated. In sunlight phage was destroyed slowly. Ultrasonic destroyed phage in 30-60 minutes. Phage resisted radium radiations for 3 days.

\*Brucella (Table R 4) Light of tropics at 44 C. destroyed cells in 45 minutes. In nature, there is a lower incidence of the disease where there is an abundance of sunlight and low humidity. Ultrasonic at 2641 kc formed rough from smooth cells in 3 hours.

\*Diplococcus pneumoniae (Table R 5) These cells are reported less susceptible than some other bacteria for perhaps the capsule protects. In sunlight the organism lived in sputum for less than 5 days while in diffuse light 30 days and in the dark for 35 days. Neon light destroyed the cells.

\*Coliforms (Table R 6) Much work has been done using the coliforms as an indicator of sensitivity to UV radiation. Low RH was found to increase UV action. Various ranges of the spectrum were used with most of the studies at  $2537 \text{ \AA}$  where it was most active. Other strains were less resistant. Usual destruction time is in a few minutes. Rate de-



depends on UV source and distance from organisms. Organic matter protects organisms. X-ray studies suggest younger cells more susceptible. Removal of oxygen slows down killing rate. A. aerogenes was reduced to 37% by 14,000 R. Ultrasonic studies reveal resistance in one report and 99.9% loss in 15 minutes in another. Coliforms have also been exposed to electrons with 10,000 volts destroying in 1 hour, and to neon with no results and to radium with no growth.

\*Micrococcus (Table R 7) Numerous reports of these organisms suggest that the Micrococci are quite resistant to UV. Various ranges of UV were used and different levels of energy used against several strains. Direct sunlight killed cultures at 23 F. in one hour while through glass several hours were necessary. X-rays at 3600-4400 level destroyed 63%. Ultrasonic killed 90% in 45 minutes. Low velocity electrons killed the organisms, as well as 10,000 volts, in one hour. Neon also destroys in 1 minute.

\*Microorganisms (Table R 8)

Alcaligenes - Two species showed wide difference in susceptibility to UV, one destroyed in 15 seconds, the other in 30 minutes.

Corynebacterium - These organisms were found more susceptible to UV than Bacillus, Staph. and others. At 55 C. in tropical sunlight, no organisms survived for 45 minutes. Cultures kept in the dark lived 1/3 to 1/2 longer than those exposed to light.

Hemophilus - Were very susceptible to UV.

Klebsiella - Almost completely destroyed after 3 minutes exposure to UV.

Lactobacillus - Populations of this organism were reduced by UV.

Proteus - Three minute exposure killed most cells, older cells more susceptible. Neon light was not effective in destroying them or was 10,000 volts during a 30 minute period.

Serratia - This organism was quite readily destroyed by UV. In 40 seconds to 5-15 minutes all cells killed. 10,000 volts destroyed the organism. in 1 hour.

Azotobacter - Light from sun destroys the organism in the upper layers of the soil.

Leptospira - Exposed to sun, it survived for 7 days.

Pasteurella - The plague organism was destroyed in tropical sunlight at 40 C. in 5 minutes.

Treponema - Diffuse sunlight killed the organism in 11½ hours.

\*Mycobacterium tuberculosis (Table R 9) Reports reveal this organism to be more resistant than Bacillus spores. Various times are given for kill, from 3 minutes to 40 minutes. In daylight, killing is in 2-5 hours in direct sunlight and 6-8 days in diffuse light. X-ray may destroy in 64 hours. Ultrasonic at 320 kc reduces 75% in 75 min.

\*Neisseria (Table R 10) UV at 2800-2540 kills. The meningococcus exposed to daylight is killed in 2 hours. When sunlight passes through gauze, 30 hour survival is obtained and 6-7 days when daylight diffuses through towelling and wool. In the dark, the organism survives 7-10 days at 25 C.

\*Protozoa and Metazoa (Table R 11)

Amoeba - Short exposure to UV destroys.

Paramecium - Short exposure to UV destroys.

Necator - Exposed to light, 1 week survival is found but 5½ weeks in partial shade and 7-9 weeks in dense shade. Under varying conditions of sun and water, survival of 1 week to 6 weeks were found. In drying soil, 5, 10 and over 30 day survival was found in increasing shade. In fecal material in direct sun survival over 2 hours was observed.

\*Pseudomonas (Table R 12) Variable results with UV are reported

against this organism. The fluorescent strains are more resistant. In sunlight, the organisms may survive for 1½ hours at 44 C. Neon does not destroy easily. X-ray at 1000-1200 r kills 63%. Exposed to radium, the organism does not grow.

\*Salmonella (Table R 13) UV at various wavelengths and intensities is active against Salmonella after a brief exposure. Some 214 erg/mm<sup>2</sup> at 2537 Å reduced population 90%. Sunlight is effective against the organisms in thin layers of water. In glass tubes, cultures may survive 1 year exposed to diffuse light. In direct sun, agar cultures are destroyed in 10-60 minutes to 4-10 hours. Neon was not effective against the organisms. X-ray did not affect in ½ hour exposure. 10,000 volts destroyed cultures in 1 hour. Radium prevented growth of the organisms.

\*Shigella (Table R 14) UV between 2800-2840 Å killed the cells quickly. Some 168 erg/mm<sup>2</sup> at 2537 Å, reduced population 90%. In sunlight, these organisms were killed in less than 30-60 minutes in strong light, in diffuse light cultures in tubes lived for 75-1049 days. Ultrasonic at 680 kc and 320 kc reduced numbers 88% in 30 minutes. Neon light was not effective.

\*Streptococcus (Table R 15) Exposed to UV, Streptococci are reduced 90% by 200 ergs/mm<sup>2</sup> at 2537 Å. Air irradiation destroys these as air borne infecting organisms. Some reports suggest them to be more susceptible than spores and tuberculosis organisms. Sunlight destroys the organisms in 40 minutes to 4-6 hours, diffuse sunlight may take almost 7 days while cells survive 14 days or more in the dust in the dark. Apparently larger strains are more resistant to light. Tropical sun at 49-50 C. destroys in 15-30 minutes. Neon light was effective. Organisms exposed to 10,000 volts were destroyed in 1 hour.

\*Vibrio (Table R 16) UV is reported as very effective against the cholera organisms in culture and water. Sealed cultures exposed to sunlight were killed in 3 days while the cultures lived 1044 days in the dark. Diffuse light exposure allowed survival for 279 days. In sea water the organisms lived for 8 hours, exposed to the sunlight. The temperature affected recovery slightly when at 49 C. as compared to 18-30 C. Polarized light at 24 C. did not affect for 13-30 hours. Radium prevented growth of the organisms.

\*Viruses (Table R 17)

Poliomyelitis - UV destroys in 30 minutes to 60 minutes usually, or shorter time, depending on distance of source. Direct sun kills within 30 minutes. Ultrasonic does not destroy rapidly but high speed electrons inactivate the virus.

Influenza - Survives UV better than many bacteria.

Vaccinia - 40 ergs at 2537 Å destroys while light plus chemicals destroys rapidly.

Herpes - Survives from less than 15 minutes to 40 minutes exposure to UV.

Encephalomyelitis - Survives only 40 minutes exposure to UV.

Tobacco Mosaic - UV inactivates this virus over a range of 3100-2652 Å.

African Horse-sickness - The virus is inactivated by UV.

Measles, chicken pox, mumps - All are susceptible to UV radiation.

Foot and Mouth - Intense sunlight exposure destroys organism in 1 hour when dried. Diffuse sunlight is resisted for over 1 hour.

\*Yeasts, Molds and Fungi (Table R 18) UV radiation is effective against yeasts and molds when exposed at different wavelengths and amounts of energy. Older organisms are less resistant, in some experiments dark color of some protect against UV. Sunlight destroys in long periods

of exposure. Ultrasonic reduces population at 680 kc to 15% in 30 minutes. Electron bombardment is resisted under certain conditions but 10,000 volts destroy in 1 hour.

## SURVIVAL OF ORGANISMS IN SOIL

The importance of potentially pathogenic organisms in soil has been recognized. Some of the Clostridia may cause gas gangrene or tetanus when soil gets into wounds. Some intestinal pathogens such as the organisms of typhoid and dysentery may get into the soil in excreta to contaminate foodstuffs. Certain of the protozoa and worms survive for considerable lengths of time or may live part of their life cycle in the soil entering the body through foods and sometimes through the intact skin. The organism of anthrax may survive in soil for long periods in the spore stage. Animals grazing in this area may contact the disease and die. Some areas are so contaminated that they are restricted so cattle may not graze on them. Other disease producing organisms might enter the soil from human and animal excreta or carcasses. The factors affecting the survival of many microorganisms in the soil might be grouped as to (1) soil factors (2) organism factors.

### Soil Factors Affecting:

In general, the factors affecting the survival of any organism in soil would be (1) the general type or nature of the soil under study, whether sand, clay, loam or mud; (2) the amount of organic matter present or added with the organisms; (3) the amount of moisture in the soil; (4) the firmness or looseness of the soil; (5) the pH; (6) the presence or absence of antagonistic organisms; (7) the depth of the organism in the soil; (8) the temperature of the soil and air; (9) the relative humidity (RH) of the air; (10) the amount and duration of radiation from the sun.

**Organism Factors Affecting:**

A particular organism may survive in soil for varying periods depending up (1) the inherent resistance of the genus and species of organism under study; (2) the particular strain of organism; (3) the presence of a protective stage of the organism such as a spore; (4) the presence of a protective covering on the cell, such as a capsule; (5) the age (in the growth curve) of the inoculum; (6) the numbers of organisms inoculated and (7) the ability of the organism to multiply in the soil under the conditions presented.

## SUMMARY

\*Bacillus species (Table S 1) B. anthracis may survive in spore stage in soil where carcasses buried for 15-20 years. Other data suggest 12 years in surface soil and shorter periods in exposed places.

Other Bacillus species survive for over 80 days in mud and other soils and may be present in 500-600 meter deep soil.

\*Brucella species (Table S 2) In sand the organisms live for about 120 days. In dirt dried rapidly it lives less than 4 days but up to 66 days in moist dirt. Viability of 1-10 weeks is reported in various soil samples. It is suggested that on pasture cover the cells do not survive long even though excreted in large numbers.

\*Clostridium species (Table S 3) The organisms of tetanus, botulism and gas gangrene are fairly permanent residents of the various types of soils.

\*Coliforms (Table S 4) E. coli exists in loam for weeks to months and even to 4 years if moist; if dry, only 11-25 day survival results. In sand and mud 11 week viability is reported. E. coli usually absent from virgin soil while A. aerogenes usually present. Survival of Aerobacter in soil is for many months up to almost 4 years.

\*Corynebacterium diphtheriae (Table S 5) In dried sand at 37 C. viable cells were present for almost 30-50 days while in sand alone 98 to 175 day recovery was found. In soil, 98-208 day survival was found but in dried soil less than 25-35 day recovery was obtained.

\*Fungi, Yeasts and Molds (Table S 6) A large part of the microbial flora is made up of Actinomyces and fungi besides the bacterial population. Actinomyces did not live well in acid peat soil. Malleomyces (not a fungus but of the Parvobacteriaceae) survives in pastures up to 1 year making them unsafe. Actinomyces bovis is more or less a permanent organism in soil. Radiation from sun lowers the soil flora at



surface level. Yeasts may live in soil for long periods in winter months.

\*Microorganisms (Table S 7)

Agrobacterium - In clay and loam viability over 500 days and in sand for over 600 days was reported.

Pasteurella tularensis - In muds both contaminated and uncontaminated the organism was present for 12 weeks.

Diplococcus pneumoniae - Dried culture in sand lived for 2 days and in volcanic ash for 6 days.

Vibrio comma - This organism was able to survive for 1-2 days in soil without moisture but for more than 33-68 days in moist soil. On sand 4 day to over 174 day viability is given.

Leptospira - In polluted soil 3 day survival is found. It may live for months on wet ground and high humidity in air.

Azotobacter - Large numbers in rich soil, few in acid or sunlit soils, many in dark sun-protected soil. Pure culture in soil lived for 40-85 days or more.

Pseudomonas - Survival of 45 days in soil was observed.

\*Microorganisms (General) (Table S 8) Various factors of temperature, pH, fertility, moisture and radiation are presented for legume bacteria, lactic acid bacteria, nitrifying bacteria, sulfur and iron bacteria, aerobes and anaerobes.

\*Mycobacterium tuberculosis (Table S 9) In soil from fecal material, the organisms may live for 2-6 months and even a year exposed to all types of weather conditions. Animals were infected from the soil in this manner.

\*Protozoa and Metazoa (Table S 10)

Ascaris - On soil surfaces for 2 months to 160 days in summer, for 150-180 days in winter, are examples of soil survival. Found on vegetation where soils manured with human feces.

Necator - Survival in soil for 9-15 days is routine, some larvae live for 7-9 weeks in shade or even for 84 days. Sun, temperature and moisture affect survival.

Trichuris - In shaded soil viability for at least 35 days has been observed.

Entamoeba - Cysts may remain alive for 4-8 days in soil at room or lower temperatures. Vegetation manured with human feces was found to contain cysts.

Eimeria - Oocysts remain viable for periods of less than 1 year in soil in sun or in shade.

Sheep Nematodes - Viability of 3 months is reported in pasture soil.

Toxacara canis - The parasite remains over winter in soil under snow.

\*Salmonella species (Table S 11) In dry clay 3 week survival and 6 week in wet clay was found. Similar results with loam for rainy weather survival of 120 days as compared to 49 days in plain loam. In mud survival of 5 weeks to 2 months was recorded. In peat, 1 day to 30 day recovery depending on pH, moisture and temperature were the findings. In sand, 6 day survival with sewage inoculum was observed but with sterile sand then dried, 82 day recovery was found. Variable results in soil depending on type of soil, moisture and temperature were reported with survivals ranging from a week to over 16 months. Vegetables were found contaminated from human fecal manure for at least 7 days.

\*Shigella species (Table S 12) The few reports suggest survival of 12 days on sand, over 100 days at temperatures of 1-15 C. and in dry soil at 12-30 days while wet soil provided 40-90 day survival. On vegetables in soil, 7 day survival was recorded.

\*Streptococcus species (Table S 13) These organisms live for periods of 26 days to 11 weeks in loam and mud. On sand, viable cells were  
(So 5)

recovered after 33-66 days. With chicken manure on soil 160 day recovery was observed.

\*Viruses (Table S 14)

Foot and Mouth - In sand at room temperatures and 50% humidity the virus survived for 14 days.

Newcastle - At body temperature and pH, 25 day viability was observed; at 3-6 C. 235 day survival and at -26 C. 538 day survivals were found. In chicken pen soil, 1 month viability was observed.

Bacteriophage - Typhoid phage was found in soil at 3 foot depth.

temperature changes; the humidity of the air will determine the rate of desiccation. Some organisms are killed rapidly by drying; others survive better in the dry state. The rate of drying is important in killing some organisms. If a surface provides protection from radiation, rain, wind and other elements then survival will be longer.

Organism Factors Affecting:

As under other circumstances there are a number of qualities in a particular organism which make it more or less resistant and allow it to survive for longer or shorter periods. The strain of organism as well as the genus and species is important since there are inherent properties of the cells which determine their ability to survive or persist in nature. The presence of a spore stage or a capsule protect certain organisms. Others apparently have resistant cell walls which protect against drying and destruction by other factors. The age of the cell at time of inoculation is important - if the cells are from old cultures, then they are more easily destroyed. Of great importance also are the numbers of cells placed on surfaces and the amount of organic matter in which the organisms are suspended. Organic matter buffers against pH and other chemical changes as well as protecting against heat, desiccation and other forces of nature. Natural secretions such as sputum and feces provide some protection to organisms.

## SUMMARY

\*Bacillus (Table Su 1) Bacillus anthracis because of its spore stage is able to exist for long periods. On fabrics such as canvas exposed to room temperature, low humidity and diffuse sunlight, the spores lived for 10-22½ years; enclosed in envelopes survival of over 34 years on canvas and in blood on gauze 40 year viability was reported. On glass or porcelain, survival of a few days to 2 years was found. On paper exposed to sun, 8 hour survival was found. Long survival in brushes of animal bristles was found. Other Bacillus species survived for long periods on fabrics, glass, metals and plastics.

\*Brucella (Table Su 2) In dust, the Brucella lived for 20 days to 6 weeks. On fabrics such as bags and sacks, 5 days to 30 days have been observed as survival times. On glass, some survival for several days has been noted.

\*Clostridium (Table Su 3) On fabrics, these sporeformers may live for at least 3½ months. Cl. tetani on glass lived for 18 years as it did also on rusty metal. Tetanus spores may exist in wounds for 6 months and in talc through autoclaving procedures. Cl. sporogenes remained viable on sutures in alcohol or toluol for over 17 days.

\*Coliforms (Table Su 4) Cultures on cotton swabs survived for 8-48 hours. When dried on glass or in high humidity, survival of 22-98 days is reported. If exposed to sunlight when on glass, the cells are killed in a few minutes. On paper, survivals vary as to method of drying. Survivals on paper are given as 1 day to 143 days. Exposed to the sun, survivals of 2-10 minutes were observed. E. coli lived for 84-168 days in plaster. On utensils, coliforms are frequently found. On wood, coliforms exist for extended periods of a few days to 228 days. Coliforms also found on metal doorknobs, water filters and in grease of water pumps.

\*Corynebacterium (Table Su 5) The diphtheria organism has been found in dust for a few days to 175 days. On fabrics, survival of 2 weeks to 20 weeks has been observed, with the variations due to drying procedures, the number of organisms, and the type of fabric and amount of organic material. On glass, survival of 1-2 days to over 98 days was listed. Exposed to sunlight, death occurs in 2 minutes. On paper, 6 to 159 day viability occurred but exposed to sunlight, the cells were killed in 2-10 minutes. On plaster, viability of 37 to 75 days was found and on utensils such as knives, the diphtheria organism lived for 86 days. On wood, 7-8 day persistence was reported.

\*Diplococcus pneumoniae (Table Su 6) The organisms may live in dust for 2-8 days and on fabrics for extended periods of 2-13 months. On cotton swabs, cultures kept viable for 8-48 hours. On glass, the pneumococci kept alive for 2-12 months, 2 months at 80 F. and 12 months at 40 F.

\*Micrococcus (Table Su 7) These organisms live for long periods on surfaces. On fabrics, such as handkerchiefs, the organisms are viable for a month or more. On glass, the cultures may remain alive when dried for from 8-10 days to 90 days at 16-18 C. When lower temperatures were studied (-195 C.), 4-15 week survival was reported. At 37 C. viability was limited to almost a week. In sunlight, the organism might survive 10-90 minutes. Organisms dried on paper survived 51-70 days under optimum conditions, but in sunlight they survived up to 71 hours. On plaster, persistence of 38 to 100 days at room temperatures was found. Organisms on rubber were easily removed. On utensils, short-term viability was reported using cleansing methods. On knives, viability of 86 days was found. Cultures inoculated on to wood samples lived 35-130 days. Micrococcus species on tinfoil were reduced readily by washing off and by UV. The organisms were found on telephones and doorknobs consistently.

\*Microorganisms (Table Su 8)

Proteus - Survive in dust for 2-19 days, on moist culture swabs for 2-48 hours, on blankets for over 81 days, on paper for 11-20 days.

Rickettsia - Survives on laundry to cause infection. On paper, viability of 21 days has been recorded.

Treponema - Lives on cloth at 21-25 C. in diffuse light for 11 $\frac{1}{2}$  hours. On glass in sun, 2 minute survival but may live in dark for several days. On paper money, 4 hour viability was shown. On dishes 2-8 day survival was found.

Vibrio - Survives on dried threads for 30 days to 7 months; the same is true on clothing. Culture swabs do not stay viable for 8 hours with few exceptions.

Pseudomonas - On glass in sunlight, 2 minute viability was found but over 7 month viability has been found on occasion.

Sarcina - When dried on glass in sun or not survival of 25-60 minutes has been found.

Bacterium linens - On filter paper survival of 90 days is reported.

Trichomonas - On an enamel paint surfaces viability of less than 7 hours was found.

Alcaligenes - Were found on telephones.

Hemophilus - On cotton culture swabs lived 8-48 hours at 16-22 C.

\*Microorganisms (General) (Table Su 9)

Dust - Organisms survive in and on dust particles and are airborne with dust.

Fabrics - Oiled fabrics contain fewer organisms, organisms may survive in towels for at least 24 hours and on blankets for 6 months.

Glass - Organisms are killed easier on smooth surfaces and than on cloth or paper or agar surfaces. Temperature increases and  
(Su 5)

humidity decreases give lower survival. Survival of 8 days to months on glass is reported. Drinking glass samples may have millions of organisms on them.

Metals - These surfaces have antibacterial and antiviral activity, especially silver and copper.

Paper - Organisms may live for long periods when dried on paper.

Wood - Various types have been tested, some allow survival longer than others.

\*Mycobacterium tuberculosis (Table Su 10) Dust may contain viable organisms for days to weeks depending on amount of sun--two days in direct sun and 5 days in diffuse light have reported. Organisms have been found on fabrics (clothes and handkerchiefs) for 18-30 hours up to 39-70 days and possibly 110 days. When dried on glass, organism will live for 4 months. On paper or books live organism may live only a few hours but reports suggest over 35 days or up to 3½ months in sputum dried on books. A number of general reports show survival decreased by sunlight but survivals of 309 days listed for dark areas or 74-100 days exposed to electric light.

\*Neisseria (Table Su 11) These organisms are usually low in survival rate. On fabrics, 5 minutes to 24 hour viability is shown for the gonococcus and up to 7 days for the meningococcus. On glass, a few hours of survival is usual but with dried blood up to 45 day survival has been found with the meningococcus. The g c organism lives only 2-5 hours on glass covered from the sun. On wood, dried films live for a few hours exposed to sun but unexposed the meningococcus exists for 8 days. Other studies suggest a few hours on metal and for several weeks on other surfaces.

\*Pasteurella (Table Su 12) Studies of the plague organism suggest survival on fabrics is of short duration, on glass for 3 hours to



6-9 days when organic matter was present and on paper survival of 3 to 8 days with better survival at higher humidities. On filter paper the tularemia organism lived for 20 days at 20 C. in feces. On plaster the plague organism was viable for 5-11 days. On various wood samples, survival at different humidities was from 1 hour on moist pine to 36 days but survival of 2-3 months at 37 C. may be obtained and 260 days at 25 C. when unexposed to the sun.

\*Salmonella (Table Su 13) Studies with these organisms in dust gave survivals of 20 to 130 days under varying temperature and humidity conditions. On fabrics, viability on towels was for 2 days, on cotton culture swabs for at least 1-2 days, on cotton linen and woolen cloth for 60-150 days or even longer. On glass and porcelain, survival of 2-4 days was found as minimum time but for 34-44 days when dried under optimum conditions of temperature, humidity and with protein organic material for protection. On paper, survivals of 5-10 days are given as low recovery figures with survival in fecal material on paper for 55-137 days for S. typhosa and 240-421 days for S. paratyphi. On plaster, the typhoid organism may live 83-101 days. On various wood samples at 16-18 C., viability of 9 to 119 days was reported with pine wood giving poor results and lime wood, long viability. The Salmonella have been found to survive well on bread surfaces and on metals such as iron, copper and tin for 20-30 days.

\*Serratia marcescens (Table Su 14) This organism is used frequently as an indicator organism for air, water and surface studies because of its distinctive colony color. Studies on fabrics were made with exposure to ozone with 95% killed in 45 minutes at 21 C., 89% RH and .06 ppm. ozone. Studies on glass gave similar results. Recovery in 2 minutes was obtained in sunlight. On paper short term survival was obtained exposed to ozone and to sunlight (2-20 minutes).

\*Shigella (Table Su 15) The Shiga organism was found in dust over a 10 day period. Various fabrics were studied for survival of dysentery organisms with data suggesting 4-150 days depending on temperature and light. At room temperature in the dark, 150 day survival was found, while at 37 C. only 11 day persistence was shown. The Shiga organism does not live as long on the Flexner bacillus, which is more frail than the S. sonnei. On paper, survival from 4-9 days to 270 days is recorded. Sunlight destroyed in 5 minutes. At 38 C. only  $\frac{1}{2}$ - $\frac{1}{4}$  the survival time than at 17-20 C. When dried on wood, organisms lived for 4-9 days at 17-20 C., which was 2-5 times longer than at 38 C. These organisms were able to exist for 30 hours to 2 months on bread crusts.

\*Streptococcus (Table Su 16) Many studies have been carried out on streptococcus survival under natural conditions in dust, air and on surfaces. Studies on dust indicated streptococci would live 4-25 and 44 days. On fabrics, such as cotton, blankets, bedding, linen and towelling, the organisms survived for 2 days to over 4 months. Oil on bedding lowered air count and blanket counts of streptococci. Organisms on glass and dishes lived for about 14 days. When exposed to ozone a large per cent were killed on glass and paper. One report suggests 44 day viability when dried on paper. Some studies were carried out on rubber and on telephones and metal.

\*Viruses (Table Su 17)

Foot and mouth - Dust allowed survival at 62 F. and 52% RH for 11 days. On glass, exposed to sun, 1 hour viability was found but when dried in dark it remained for 10 days in one case and 2 years in another. On paper, it remained active for 2 days. In nature the virus remains infective up to 345 days.

Influenza - The virus may survive in dust for at least a week and probably up to 3 weeks. On fabrics such as blankets, the

virus survives at 37 C. for less than a day but over 3 days at 22 C. If dried in saliva on blanket, viability of over 1 month has been found. Similarly, on glass, 1 week at 37 C. and over 1 month at 22 C. When dried on rubber, it remained active only 40 minutes. When dried with mucin, the virus was active for 45 days but less than 22 days in talc.

Newcastle - This virus survived over 50 days on burlap sacks at high and low temperatures, even when exposed to mercurials. At 11-36 C., 538 days of viability were observed. On glass at low temperatures, it remained active for months. On paper, the survival was similar to burlap.

Smallpox - Vesicle fluids on glass remained active in dry state for 84 days in dark and 35 days in daylight. Other reports suggest that smallpox crusts remain viable for many years.

Tobacco mosaic - On cured tobacco leaves, this virus remained active 31 years.

Swine Fever - The virus apparently was able to withstand high temperatures when on bricks or hay but was readily destroyed by chemicals.

\*Yeasts, Molds and Fungi (Table Su 18) These microorganisms remain active in dust for long periods and may be carried by dust in air.

Tricophyton - The dermatophytes survived on cloth for several months and on occasion up to 346 days. On paper, viability of 102-346 days was observed.

Microsporum - On fabrics such as wool or cotton for 78-235 days and on hair for 420 days.

Molds - These microorganisms on cardboard exposed to UV lived for long periods. They are found on many surfaces and even telephone receivers.

Yeasts - They are found on various surfaces.

Fungi - Large numbers found in dust, on paper, wood and surfaces such as telephones.

## SURVIVAL OF ORGANISMS IN WATER

Water has been known for a long time as a vehicle for transmission of various intestinal disease-producing organisms. Water may harbor other pathogenic or saprophytic organisms as well. It is of importance to study the effect of certain factors on the survival of organisms.

The general factors affecting survival may be listed as follows:

### Water Factors Affecting:

The general nature of the water is important whether it is sea, lake, stream or well water, as well as the degree of pollution. The concentrations of salts will affect survival and also the organic content plays an important role. The salts may be toxic while the organic matter supplies protection as well as possible nutrients for growth. The presence of other antagonistic organisms such as bacteria, algae or phage may be important. The presence of toxic chemicals of industrial or human addition such as chlorine or sulfites affect survival adversely. The depth and turbidity of the water affect the amount of light and other radiation coming in contact with the cells. The temperature of the water affects the rate of survival as well as ability of organisms to grow. Low temperatures give longer survival. Flowing water in nature may dilute out occasional contamination.

### Organism Factors Affecting:

The type of organism being studied is of importance in the length of survival. While the genus and species of organism is important, also the strain under study determines to a certain extent the persistence of the organism. The presence of a spore stage of the organism or a protective capsule will aid a particular organism to survive. The total number of organisms inoculated

is of great significance in length of survival as well as the age of the cell (of growth curve) when inoculated. Some organisms have the ability of growing when only a few salts are present in the water. The pathogens usually require more complex media. A few can grow on the organic matter of polluted waters depending upon the temperature. Some pathogens may grow over a range of 15-40 C. Organic matter may also protect cells from destruction even if they do not provide nutrients. Selection of resistant strains may provide greater survival of the organism under certain conditions to which they are exposed. An organism selected for resistance to increased temperature in water may not show increased resistance to some chemicals in water, but does to some chemicals.

## SUMMARY

\*Bacillus anthracis (Table W 1) In natural water, survival is of long duration. Organisms have lasted up to 12 years in lake water, and have been found viable in rivers and stagnant pools. Under laboratory conditions, survival of 18½ years has been reported. In general, survival was better at room than at body temperature in either tap or sterile water. At low temperatures, around 10 C., survival was usually about 3 days. In distilled water, survival ranged from 30 days to 30 months. When culture medium was added and room temperature maintained survival was similar to that in natural water. Survival was reported up to 20 months in sea water. When culture medium was added, the interval was much shorter. In sewage, the organisms lasted up to 16 months.

\*Bacillus species (Table W 1) Bacillus cereus was adversely affected by pH level below 7. Bacillus megatherium was similar but less drastically affected. pH above 7 likewise decreased recovery.

\*Bacteriophage (Table W 2) The death rate of E. coli phage in tap water was found to be of the first order. It was extremely susceptible to irradiation while in distilled water. In sea water, a small percentage of organisms survived after 30 days. Survival in physiological saline was not as good.

Salmonella phages varied seasonally in natural waters, increasing in the summer months. In sea water they could be recovered up to 7 days after inoculation. Survival in physiological saline was not as good.

Shigella phage survived in sea water up to 30 days. This was longer than in physiological saline.

\*Brucella (Table W 3) Brucella melitensis and Brucella suis survived up to 10 weeks in natural waters. Brucella abortus in pasture water survived between 8 and 30 days. Brucella species in general were

sensitive to pH levels above 8 and below 6.6.

\*Clostridium (Table W 4) Clostridium botulinum was present in ice kept at -16 C. for a month. It survived processing and heating in sewage sludge.

\*Escherichia coli (Table W 5) In well water, Escherichia coli survived 2-5 months. In river water, it was found up to eighty-seven days after inoculation. Cold temperatures encouraged survival in natural waters. At 37 C., a pH of 5-6 was optimum for persistence. Radiation, natural or artificial destroyed the organisms in a few seconds. Stagnant water did not support it. One report states that after 20 years in water stored in the dark, the organism survived.

Organisms were recovered from distilled water, kept at 0-8 C. after 16 months. Increase in temperature resulted in a decreased survival rate. pH 6-8 was most favorable for survival.

Ice was found quite suitable for survival of E. coli. After 163 days at -20 C., organisms could be isolated. They were more resistant to freezing than to thawing.

In some cases E. coli could not be isolated from sea water. When organisms were inoculated they survived as long as 39 days depending on size of inoculum. Addition of culture medium lengthened the survival time.

Organisms persisted in physiological saline for over 31 months at room temperature but not as long at 37 C. At pH 8, 0.145 M NaCl allowed better survival than a greater or a smaller molarity of NaCl. Low pH or very high were unsuitable for survival at any molarity. In sewage, counts were higher in the summer. The organism could be isolated after 65 days.

\*Aerobacter aerogenes (Table W 5) The organisms were well preserved at 18 C. in river water for up to 73 days. Lower or higher tempera-



tures were not as effective in preserving the viability. Survival was poor in raw river water. The presence of E. coli had little effect on recovery rate. Survival in sewage was similar to E. coli.

\*Leptospira icterohaemorrhagiae (Table W 6) This organism survived in sterile or unsterile tap water up to a month at neutral pH. When serum was added to the water, recovery was positive at more than 3 months. When inoculated into stagnant water, at pH 7.6 and temperature 25-32 C., the organisms remained viable up to 115 days. Likewise in distilled water, persistence was fair, in sea water, poor. Sewage was more heavily infected during the warm months. Organisms survived in feces and tap water for 55 days.

\*Metazoa and protozoa (Table W 7) Entamoeba histolytica survived in water at room temperature for 5 weeks. At higher temperatures, survival was poor. Ultra violet rays were quickly effective in killing the organism, sunlight more slowly so. In distilled water at 12-22 C. viability was positive after 153 days. Entamoeba coli survived even longer. In sewage, survival was from a few days to a month.

Trichomonas vaginalis survived 45 minutes. Ancylostomae species persisted from 12-18 months. In sewage sludge they survived 5 days.

Necator americanus lasted 18 months at 60 F.

Giardia intestinalis survived over 2 months in distilled water at 12-22 C. At the same temperature Chilomastix mesnili survived 187 days.

Ascaris lumbricoides eggs survived 151 days at 103 C.

Taenia saginata persisted in sewage sludge for 6 months.

Trichuris trichuria in the same medium lasted 22 days.

Paramecium did not survive well in sewage.

In general, if protozoa and bacteria were both present there tended to be an increase in protozoa, decrease in bacteria.

\*Micrococcus species (Table W 8) survival of this organism in water for up to six days was usual. Addition of pus or culture medium greatly increased the survival time. Temperature range of 20-35 C. had little effect on survival. In distilled water, survival was about the same. The organism was recovered from ice after 66 days. It survived in sea water up to 36 days. In physiological salt solution, survival was not quite as good.

\*Miscellaneous Micro-organisms (Table W 9 & 10)

Alcaligenes fecalis was found constantly in river water. It survived 18 days in distilled water.

Corynebacterium diphtheriae survived 30 hours to 3 days in sterile water, depending on the temperature.

Neisseria gonorrhoeae was viable for 22 minutes in sterile tap water or sterile distilled water at 37 C. At a lower temperature survival was longer. It survived in ice 9-15 days and recovery was high in physiological saline, with culture medium added, after 6 hours.

Bacterium phosphorescens was viable after one week in fresh water.

Lactobacillus casei survived in ice and was more resistant to freezing than thawing.

Bacterium salmonicida survived up to 67 days in sewage.

Erysipelothrix was viable in sea water after 1 week and for a slightly shorter time in drinking water.

Serratia marcescens survived about 100 days in tap water, much longer in impure well water. It was susceptible to ultra-violet treatment of water. In ice there were positive cells after 51 days.

Proteus species were isolated from river water. Proteus vulgaris survived 103 days in ice. In physiological saline some species survived 40 days.

Pseudomonas pyocyanea flourished in all kinds of water. Survival

in distilled water was best at a low temperature. Recovery from ice was high and from physiological saline, fairly good.

Klebsiella pneumoniae survived over 31 months in distilled water. Survival was also good in saline.

\*Mycobacterium species (Table W 11) Mycobacterium tuberculosis survived more than a year in tap water. Other reports on survival in natural water varied from a few days to 6½ months. In distilled water, organisms persisted after 16 months. Low temperatures appeared to promote survival. Survival in ice after 12 weeks was reported. The organisms remained viable up to 13½ months in physiological saline at 37 C. In sewage, Mycobacteria could be recovered from 1 hour to 35 days after inoculation. The lower temperature permitted longer survival. Manure kept at room temperature allowed survival up to 6½ months.

The avian strain persisted 73 days in stream water or sewage.

Mycobacterium paratuberculosis was recovered 163 days after inoculation of river water. Persistence of 9 months was also reported.

#### Factors Affecting Survival of Organisms in Water (Table W 12)

The effectiveness of ultraviolet radiation against water borne bacteria may be influenced by minerals in the water. Changes in salinity and osmotic pressure are better tolerated by fresh water than by marine organisms. The coliform group is not entirely reliable as an indicator of sanitation as illustrated by outbreaks of enteric disease caused by "potable" water, antagonism of some organisms against coliform cells, great resistance of some non-coliform organisms to chlorination, presence of pathogenic viruses and role of non-lactose fermenting gram negative rods in enteric disease.

In lake water, bacteria were found in greater numbers in autumn and winter. However, organisms stored in glass containers increased

more at high temperatures. Mechanical dishwashers reduced bacterial count. Sunlight was almost as effective in killing organisms on the bottom of 50 cm. of water as those on the top.

Snow, with a large dust content, carried many bacteria. Clear ice was more free of organisms than bubbly ice or snow. A great variety of bacteria have been isolated from snow.

Bacteria in sea water are more thermosensitive than are terrestrial organisms. At 40 C., 80% were killed in 10 minutes. At -16 C. organisms in sea water outlast those in distilled water or broth. The protozoa serve to rid sea water of Salmonella. When plankton are present, bacteria are virtually non-existent. The pressure bacteria experience in the sea retards terrestrial organisms. Reports were favorable as to the action of sunlight on organisms in sea water.

Bacteria in sewage, while they may survive sometimes, are subject to the action of antagonistic saprophytes. E. coli is attacked by putrefactive bacteria.

\*Pasteurella (Table W 13) Pasteurella tularensis has been reported to survive in water as long as a year. Natural waters become contaminated by infected animals. Other animals can be infected by inoculation of contaminated water.

Other Pasteurella species survive up to 4-5 hours in distilled water.

\*Rickettsia (Table W 14) Coxiella burneti survives 7 days in water at room temperature.

Rickettsia prowazeki has been found in well water. Both tap and distilled water and also saline have an adverse affect on viability.

\*Salmonella (Table W 15) Salmonella typhosa at outside temperature survived up to 40 days in well water. At room temperature, the survival sometimes was longer. In river water, low temperatures aided  
(W 8)

survival. At 0 C., viable organisms were cultivated after 8 weeks, whereas at 37 C., the bacteria survived 1 week. In pond water at temperatures around 10-15 C., survivals of 4 days were reported. In tap water, storage in the dark at temperatures of 68-72 C. preserved viability for 43 days. At warmer temperatures or in the light, the cells died off more rapidly. They survived 36 days in aquarium water, up to a month in mineral water. Well water infected with urine remained positive up to 14 days. The presence of other pathogens decreased the survival time.

Salmonella typhosa survived 32 months in distilled water at room temperature. Survival rate was also high at 37 C. and at 0-8 C. In ice, the organism was viable after 7 months at 0 C. Another report found 99.9% reduction in 8 days.

Filtered sea water supported the organism for 32 days. Contaminated sea water greatly diminished the length of positive recovery interval. S. typhosa survived in physiological saline at room temperature for 32 months.

In raw sewage, the organism survived 3 days at room temperature or longer at lower temperature. In activated sludge, it was alive longer than 24 hours. Aeration of the sludge decreased this time. Lack of aeration increased it. Sterilized sewage supported the bacteria over 3 months.

Salmonella paratyphi A survived only 2 days in tap water. Boiling the water increased the survival 5 times. Filtering the water and placing it at incubator temperature increased survival interval 25 times. The organism survived 86 days in filtered rain, 42 days in distilled water at incubator temperature.

In non-contaminated sea water S. paratyphi A survived 18 days. If the waters were contaminated survival was cut to 1/3 this time.

In saline it persisted 33 days, in sterile sewage at room temperature, 7½ months.

S. paratyphi B survived 86 days in filtered rain, 42 days in boiled tap water and 22 days in unboiled tap water. Reports of survival in distilled water range from 32 days to 25 months, depending on temperature. Survival in ice was reported to be 17 days. Contaminated sea water supported the organism 12 days, sterile water up to 38 days. In physiological saline the bacteria persisted 73 days and in sewage, 24 hours to 3 weeks. Sludge activation cut the number in half in 1 hour.

Salmonella typhimurium survived in outside well water for 30 days when E. coli was also present. In contaminated sea water, it survived 7 days or 3 times longer in sterile sea water.

Salmonella enteritidis survived only 5 days in contaminated sea water, 23 days in non-contaminated. This organism lasted 13½ months at 37 C. in physiological saline. It was sometimes found in city sewage.

\*Shigella (Table W 16) Shigella dysenteriae survived in well water at outside temperature for 30 days. At room temperature, reports varied from 11-71 days. Sterile water preserved the viability from 24-30 days. Results in unsterile water were very variable. In distilled water, the organisms retained viability from 7-73 days, in ice up to 2 months, in sea water, under some conditions, 5 months and in physiological saline 13½ months.

Shigella paradysenteriae (Flexner) persisted up to 38 days in natural water and up to 73 days in distilled. In physiological saline 53 days was the longest survival time reported.

Shigella paradysenteriae (Sonne) was isolated from tap water. In well water it survived 30 days. S. paradysenteriae spp. survived as

long as 32 days in sea water that had been filtered and autoclaved.

\*Streptococcus (Table W 17) Streptococcus agalactiae was reported to survive 66 days in natural water. S. pyogenes remained viable in well water for 66 days. It survived in other natural waters up to a week, in sterile distilled water up to 87 days, in physiological saline, 12 days. S. faecalis survived 1 hour in chlorinated swimming pool water. Under the same conditions, S. salivarius survived 5 minutes. In 0.85% NaCl, S. mitis was alive after 13½ months.

\*Vibrio (Table W 18) Vibrio comma was reported to have survived 391 days in tap water. Other reports ranged from a few days to a few weeks. In well water it was found up to 62 days after inoculation. In raw river water, less than 2 weeks, in springs, various lengths of time, depending on the treatment of the water. Distilled water supported viability up to 29 days or sterile distilled water, 39 days. Organisms were recovered from ice up to 7 days after inoculation. The longest survival of the organism in sea water was 122 days. Others reported survivals much shorter than this. Vibrio was viable in sewage 48 hours. If the sewage was autoclaved, survival was not as good. Sterile sewage supported the organism.

\*Viruses (Table W 19) Poliomylitis virus survived 100 or more days in tap water at ice box or room temperature. Exposure to direct sunlight cut survival down to 45 minutes. In chlorinated lakes, the virus was killed in less than 10 minutes. In treated well water, the virus disappeared in about 1 hour.

In sewage, poliomyelitis virus survived up to 2 weeks. At 4 C. survival was even better. It was found regularly when cases were reported.

Lymphocytic choriomeningitis virus survived 3-7 days in chlorinated drinking water at room temperature.

Western equine encephalitis in the same situation, survived a maximum of 5 days and St. Louis encephalitis survived up to 4 days.

The virus of yellow fever survived 10 years in distilled water in the ice box.

\*Yeasts and fungi (Table W 20) *Aspergillus* survived 56 days in tap or distilled water. In distilled water at room temperature, the following survived 1 year: *Cladosporium masoni*, *Aleurisma castellani*, *Actinomyces*, *Monilia*, *Geotrichum*, *Epidermophyton flaccosum*. In ice, *Saccharomyces* survived 28 weeks at pH 6.5-5, 15 weeks at pH 3.7.



THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN AIR

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TABLE A1 THE SURVIVAL OF BACILLUS SPECIES IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>B. anthracis</u>		
Spores, dist. water, 25C. Direct sun, strong wind.	Inoc. 8,000 Colonies. Recov. 0, 2 h.	Kruse 1895
Ozone, 4 h., 37 C.	No effect	Ransome 1901
Sunlight with air	2 1/2 h.	Roux 1887
" without air.	> 83 h.	"
Steam under pressure, autoclave, 15 lbs.	30 min.	Smyth 1922
<u>B. subtilis</u>		
Spores, spray drying.	Show small mortality	Eullock 1942
Air inlet temp., 180 C.	Show small "	"
" " " 75 C.	10% killed	"
" " " 55 C., liquid suspension, 30 sec.	50% killed	"
Dried state, 70 C., 40 min.	"	"
" " 110C., 1 h.	Complete destruct.	"
Moist container, 7.2%, 90C., 1 h.	Destroyed.	"
Dust filters & precipitators effect against bacterial droplets when it is considered at the present no made bacteria free.	occupied space can be	DallaVelle 1944
Exposed to U.V.	Innumerable colonies 1 min., 1/2, 3 min.	Hart 1939
Suspended in air	62,225 ( $\pm 72\%$ ) ergs/cm <sup>2</sup> necessary for sterilization of air.	Sharp 1940
Broth sprayed in air	2.6 bacteria/ft. <sup>3</sup> air after 5 d.	Wells 1934
Dist water sprayed in air.	10 bact./10 ft. <sup>3</sup> air after 7 d.	"
Infection depends more on viability of organism than on settling rate.		"
<b>OUTDOOR</b>		
<u>B. anthracis</u>		
Dry air, 200 F.	24 h.	Smyth 1921
<u>B. megatherium</u>		
Dust	Evidence of transport during storm	Soule 1934

TABLE 4 - THE SURVIVAL OF BRUCELLA SPECIES IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>B. melitensis</u>		
Dust contaminated with urine.	30 d.	Chief 1944
Dust.	44 d.	Kennedy 1905
Ozone 1/4 h., 22 C.	No effect	Ransome 1901
<b>OUTDOOR</b>		
<u>B. melitensis</u>		
Dry dust of Malta	20-28 d.	Horrocks 1906
Dry sterile dust	20 d.	"
Damp sterile soil	72 d.	"
Dry sterile manure	69 d.	"
Moist " "	7 d.	"
" unsterile "	20 d.	"
<u>B. spp.</u>		
Incidence of infection high where total rainfall high and negligible in semi-arid areas. The sterilizing effect of continuous sunlight seems to be paramount in checking dissemination while humidity, rainfall, sunlessness & congestion of animals favors spread.		Polding 1950

TABLE #3 THE SURVIVAL OF CLOSTRIDIUM, CORYNEBACTERIUM, LACTO-BACILLUS, NEISSERIA & VIBRIO SPECIES IN AIR.

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>C. diphtheriae</u> Ozone, 4 h., 37 C.	Growth resumed after 8 d. incub.	Ransome 1901
Air	2 d.	Wells 1936
<u>C. xerose</u> Maleic & phthalic anhydrides are more active than their corresponding acids. The effective vapor concentration is 25% saturation for chemical disinfection of air.		White 1944
<u>Lactobacillus acidophilus</u> Those which became suspended in the air from liquid media either by natural or artificial means settle out rapidly in 5-10 min. Bacterial population somewhat reduced by radiation but not consistently.		DuBuy 1947 DuBuy 1948
<u>Vibrio cholera</u> Water spray, cocoon thread. Recov. 0, 1 1/2 h.		Kirstein 1900
" " silk threads	Recov. 0, 72-108 h.	"
In Calcutta	Death rate increases with temperature	Ray 1950
<b>INDOOR</b>		
<u>Corynebacterium diphtheriae</u> Floor, dust, dark, in vitro	7-102 d.	Crosbie 1941
Floor dust sweepings.	5 wks.	"
In air after oiling floor.	Untreated, there were 7 colonies.	"
During 3 after sweeping	7 col. Gravis	"
" quiet period	8 " Mitis	"
" bed making	1 " Gravis	"
Diphtheria patients	Expulsed from resp. tract by 10 of 50 patients.	Duguid 1946
Drying, R.T., 25 min.	Inoc. 204 col., Recov. 0, 1 h.	Jochimsen 1928
" " 60 min.	" 13 " " "	Ouchterlony 1949
Dust, dried, R.T.	175 d.	Pressman 1937
Dust	Long periods	
In talking & coughing, diphtheria patients frequently omit droplets containing viable bacilli		Teague 1913
Air	48 h.	Wells 1935
Floor dust (Gravis str.)	1 mo.	Wright 1941
Floor dust	2 mo.	"
<u>Neisseria meningitidis</u> Can be carried at night from a carrier to his neighbor unless bed space is > 5 feet.		Eagleton 1919
<b>OUTDOOR</b>		
<u>Clostridium welchii</u> Only sporulating forms survive when influenced by oxygen under pressure or atmospheric air conditions		Ernst 1900
<u>Corynebacterium diphtheriae</u> Air, drying.	Surv. long time in dust.	Ernst 1900
<u>V. cholera</u> Coldest month of year, dries out.		Rogers 1944

TABLE A4 THE SURVIVAL OF DIPLOCOCCUS SPECIES IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>D. pneumoniae</u>		
Daylight, in simulated room environment	42 min.	Buchbinder 1942
Dark, simulated room environment.	12 h.	"
Spraying into atmosphere from large susp. of broth, saliva or 0.5% saline produced high mortality rate at 50% R.H. At R.H. above or below this the survival was prolonged.		Dunklin 1948
When saline free liquid used, the sharp peak in death rate at intermediate R.H. disappeared. The lethal effect of intermediate R.H. on pneumococci atomized from saliva containing suspension is increased when the particle size of the droplets is increased or when the temperature is raised. A narrow range of R.H. near 50% is rapidly lethal for organisms freshly sprayed in air.		Dunklin 1948
<b>INDOOR</b>		
<u>D. pneumoniae</u>		
Organisms susp. in fresh atomized saliva	Recov. 95.3 immed. after spraying.	
Outside body 22 D., R.H. 50-80%	Recov. 329 after 75 min. Brief duration Within 10 min. all the pneumo. had disappeared from air at 50% R.H.	Robertson 1942 Robertson 1947 " 1948
Floor dust, Types I & II Air	>1 mo. 48 h.	Stillman 1917 Wells 1935

TABLE A 5THE SURVIVAL OF ESCHERICHIA COLI  
IN THE AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
Air aerosols, after atomization	25 % viable	Ferry 1951
Exposed to ultra violet	Innumerable colonies at 1, 3, 8 minutes	Hart 1939
Ozone, 4 hrs.	60 seconds	Ransome 1901
Air	1 day & 8 hrs.	Wells 1936
Broth & air, atomized, dark room	120 min.	Wells 1935
Ultra violet lamp off	30 min.	
Ultra violet lamp on	12 min.	
Ultra violet lamp covered	15 min.	
Increased Humidity	Increases resistance to germicidal energy	Luckiesh 1942
Susp'n in air	24,800, plus or minus 5.4% erg/cm <sup>2</sup> necessary for sterilizing air.	Sharp 1940
With ultra violet the bactericidal action is greatest at low humidity. In an atmosphere of 45% RH it is about 10 times as lethal as at 90% RH.		Elford 1942
Cigarette smoke has no germicidal effect & nulls germicidal activity of 10% hexyl resorcinol in propylene glycol.		Twort 1940
<b>OUTDOORS</b>		
Humid	Max. growth when most humid	Kopeloff 1922
Dust	4 yrs.	Savage 1903

TABLE A-6 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
<b>ALTI TUDE</b>		
Bacteria & mold spores. Nutrient agar, 22 C., pH 7.2, 5,700 ft. above surface	Found at 70,000 Ft.  103 colonies. Numerous bacteria carried along with dust into atmos- phere are not killed by light, heat & dryness of desert air.	Armstrong 1936
Higher bacterial counts in clouds.		Brown 1930
Lower count bacteria in clouds due to loss of electro- static charge that caused dislodging of particles which adhered to plane		Dillon 1929
Bacteria, moist film, ozone	More easily killed than when in dry state.	Durham 1941
Bacteria sprayed into air. RH 66%, ozone, .15 ppm, 21 C., 15 min.	>99% killed	Alford 1942
Ozone conc. in excess of 1 ppm. in an atmosphere of 60-80% R.H. required to produce good sterilization.		"
Ten times as many germs in foggy days as on foggy days.		"
Subnormal sunshine & precipitation deemed respon- sible for survival of infectious agents in air. High cooling power due to strong winds reduced resistance of people		LeGuyon 1931
Decreasing number of bacteria proceeding from basement to 4th floor.		Meissner 1940
Chance association with dust particles increases survival of air borne organisms.		Parvis 1948
4 cases described bitten by insect native to S. America in Mojave desert.		Personnel of Navy Res. 1943
Study of # of organisms found in upper atmosphere ranging from 28 to 280		Schlotthauer 1940
Agar plates at 19,000 to 28,000 ft. produced no organisms.		Timmon 1949
<b>EXPERIMENTAL</b>		
Rats, G.P. & rabbits ex- posed to aerosol of bact. spores.	Certain areas of large spore conc. The greater the volume of tidal air, the greater the # of organisms in the lungs.	Ames 1949
Propylene glycol less efficient than phenol when applied as a paint & better than phenol when evap.		Baker 1944
A number of air borne bacteria were able to survive for a given time but decreased by raising R.H. from 40 to 60% or higher		Baker 1941
Sterilizing of air by U.V. radiation effective when the organisms are dispersed in droplet nuclei, the smallest particles being most vulnerable		1946 Bourdillon

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
<p><b>EXPERIMENTAL, CONT.</b> Air from sneezing</p>	<p>100,000 bacteria remain in air over 1 min. 16,000 still in air over 30 min.</p>	<p>Bourdillon</p>
<p>Air with hypochlorite spray, 65 F., R.H. 66%</p>	<p>All or most of bacteria emitted can be killed in 3-4 min. by spray of NaHClO in conc. of 2.1 cc./1,000 cu. ft. air. Lower limit of effective humidity is below 60% at 70 F.</p>	<p>1942 " "</p>
<p>Apparatus for determination of penetration of particulate air borne material through nose described. Particles greater than 5 micra are filtered out. In general, moving hot air is more effective in sterilizing of plane polished surface than still hot air of same temperature</p>		<p>Boyland 1947 Breinl 1935</p>
<p>Size of aggregates of micellae increased with concentration of saline, with increase time in sedimentation chamber.</p>		<p>Dautrebande 1948</p>
<p>Fan distribution of droplet nuclei. Disappearance of 90% in 30-60 min. Nuclei greater than 8 micra in diameter survived 20 min. Nuclei greater than 4 micra survived 90 min. Smaller nuclei survived 30 h.</p>		<p>Duguid 1946</p>
<p>Bacteria carried in handkerchief after 2 days use liberated on mild manual shaking. Recov. 14,720</p>		<p>Dumbell 1948</p>
<p>Organisms heated in presence of steam are maintained in state of intermediate hydration which makes them more susceptible to killing action of high temps. than would be the case if allowed to dry out completely.</p>		<p>Dunklin 1948</p>
<p>50% solution calcium chloride spread on floor will prevent dust 4-6 weeks.</p>		<p>Galambos 1942</p>
<p>Technic outlined for determining particle size distribution of viable air borne bacteria</p>		<p>Goldberg 1950</p>
<p>Means of sampling bacterial aerosols</p>		<p>" 1951</p>
<p>Wave length of 2537 Å highly efficient in inactivating many disease agents.</p>		<p>1946 Hollaender</p>
<p>Factors which influence efficacy of glycol vapors: 1) RH.H. 30-50% 2) Greater below 72 F. than above. 3) More effective with dirt &amp; dust than alone.</p>		<p>Harburger 1945</p>
<p>The physiological &amp; biological concepts for bactericidal irradiation of air have been fairly well-established by various investigators.</p>		<p>Hart 1944</p>
<p>Relatively low intensity U.V. of 2537 Å will interfere with cellular division &amp; readily inactivate many disease agents which are not protected by other substances.</p>		<p>Hollaender 1942</p>



TABLE A-6 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL, CONT.</b>		
House dust, 30-35 C., R.H. 53-63%	Recov. 225/10 cu. ft. after 30 min.	Hollaender 1944
The bactericidal effect of glycols varies markedly with changes in temperature & in humidity, decreasing rapidly with temperature rise & reaching maximum between 40 & 60% R.H.		Krueger 1944
Bacteria, oxygen, exposed to sunlight	3 h.	Kruse 1895
Bacteria, hydrogen, exposed to sunlight	> 7 h.	"
Indicates that inhalation of dust borne pathogens may be important mode of spread within group.		Lemon 1948
Construction of apparatus for experimental study of respiratory infections.		Leif 1950
At a constant saturation level of glycol vapor, there was found to be approximately a two-fold increase in the rate of bactericidal action with each 15 F. increase in temperature.		Lester 1950
At high humidities the particles in equilibrium contain so much water that highly bactericidal concentration of glycol are unattainable. A limit of 290 F. should be employed in vaporizing.		Lester 1950
Equation given for determining effect of radiation on bacterial population.		Lidwell 1948
Air suspension, Low R.H.	Bactericidal effect	"
The falling off in effectiveness at lower humidities of all bactericides considered appears to be a function of the bacteria carrying particles themselves. The maximum killing rate is attained only at vapor concentration near or in excess of sat.		"
Vapors of most common aerial disinfectants disappears from the air at an appreciable rate by one or more of a number of processes which include aerial oxidation, condensation upon surfaces, adsorption by surfaces. The disappearance of the vapors from the air approximated a logarithmic law over a range of concentrations.		Lidwell 1948
Lactic acid is cheap bactericide. Reached peak between 60-85% R.H.		"
Bactericidal illumination is much slower with dust than with culture spread on slides or Petri dishes at room R.H. (60%). Low intensity U.V. & fluorescent lighting of good intensity appeared to destroy the various organisms about five times as fast as natural death rate in dark.		Lidwell 1950
The treatment of cotton & woolen bed clothes and other fabrics with oil emulsion is not readily affected by changes in R.H., temperature or small variation in concentration of oil emulsion used.		Loosli 1946
Aliphatic alpha hydroxy carboxylic acids are good bactericidal agents for air disinfection.		Lovelock 1948

TABLE A-6 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL, CONT.</b>		
One gram of propylene glycol aerosol in 2,000,000 of air effected complete sterilization of an atmosphere containing as many as 500,000 bact./l. of air.		Miller 1942
Filters prepared from gelatin permit the most successful total recovery by culture procedures from an inoculum of a known number of organisms in contaminated dust.		Mitchell 1949
Air, U.V. 20 micro watts per sq. cm. (2,537 Å)	Adequate disinfection 250-500 sec.	Mudd 1944
U.V. 30 micro watts per sq. cm. (2,537 Å)	167-334 sec.	"
Review of methods used in preparing aerosols		Muller 1940
The two primary conditions for the successful application of U.V. for disinfection of air are:		
1) the supplementary irradiation with dust suppression measures since U.V. light is not efficient against bacteria protected by dust 2) attain a radiation of sufficient intensity but not so high as to affect the eyes or skin.		National Res. Council 1947
Glycols are most effective at R.H. between 40-60% and temp. below 60F.		Niles 1946
Effectiveness of any compound as an aerial germicide depends upon the extent of condensation of its vapor on air suspended bacteria & on the rate at which the resulting conc. of germicide can produce death of the organism. At any R.H. the killing action is greater the more closely the germicide vapor concentration approaches the saturation point.		Puck 1947
Glycol vapor conc. maintained at a level just below the fogging point were found to be as effective as supersaturated atmosphere. Presence of visible mist of glycol in no way harmful.		Puck 1945
Air, 80 F. and below., R.H.		
45-70%, sprayed with propylene glycol	Maximum bactericidal action.	Puck 1943
Ozone shows no remarkable effects on pathogenic bacteria		Ransome 1901
No difference of U.V. bactericidal action over a R.H. range of 35-95%.		Rontschler 1940
Temperature of organisms (within viability range) has no effect on action of U.V.		" 1941
Air borne bacteria about 1/10 as resistant to U.V. radiation as when in liquid suspension or on agar. More resistant at high R.H. than in low R.H.		
Lethal radiation less if bacteria first exposed to heat.		"
Short intense dosage of bacteria with U.V. is less lethal to E. coli than long mild exposures		" 1939

TABLE A 6 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL, CONT.</b>		
Treatment of bedclothes with medicinal paraffin reduces amount of dust that can be liberated from blankets by 90%.		1941 Van den Ende
Epidemic spread of contagion depends upon deficiency of air supplied per susceptible person. The ten-fold increase in winter ventilation or its equivalent in U.V. radiation does control epidemic spread.		Wells 1943
Methods of standard bacteriologic procedure		Wells 1946
Examination at autopsy failed to reveal any difference between animals kept in glycolized air & those in ordinary room atmosphere.		Wise 1947
<b>INDOOR</b>		
Triethylene glycol acts as dehumidifying & germicidal agent. Introduced as vapor shows 90% reduction of bacteria in air.		Barrett 1947
Definite decrease in incidence in severity of infections of the upper part of respiratory tract noted among children kept in irradiated ward as compared with control.		Bayenberg 1940
Irradiated materials had much greater bactericidal action than non-irradiated material		Beckhold 1937
# of colonies diminished proportional to care taken in use of caps & masks.		Brown 1916
90-95% fewer organisms obtained from oiled blankets than from control blankets.		Dingle 1946
Gram negative bacteria in air. R.T., Combined spectrum killed most bacteria in 15-30 sec. of U.V. radiation. Preceding freezing with liquid air makes gram negative bacteria more strongly susceptible to U.V. than gram positive spore formers.		Gartner 1947
Analysis of bacteria found in large rural central schools. 207 Strep. isolated from rooms irradiated with U.V, compared to 318 from non-irradiated rooms		S. Gilcreas 1950
Marked decrease observed in total rate of incidence of upper respiratory infections following use of propylene glycol vapors.		Harris 1945
Gives various organisms detected in operating room.		Hart 1938
Bacteria have definite variations in rate of multiplication & amount of growth with changing conditions of moisture		Kopeloff 1922
Filters of air conditioner more effective when partially clogged with dirt. Neither furnace heat nor centrifuge action of blower appears to have any influence on # of organisms recirculated.		Lemon 1944
Fluorescein dispersed into air of room as powder.		
Recovered from dust after 20 sweepings.		Lowbury 1950
Saliva in air	36 h.	Luckiesh 194
Organisms sprayed in air.	3000 org. /cu. ft. air. 14% of initial value, 2h. "	
37 C., textile mill	Colonies grew more than at R.T.	Matuso 1943

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
INDOOR, CONT.		
Bacteria counts higher in Jan., March, April, Dec. Lowest in Aug. & Sept.		Matuso 1943
If the entrance to lab. is hung with cloth soaked in carbolic acid & the window locked tightly there is considerable reduction in bacterial content of air in the room		Oesterle 1938
Bacterial content of morning air in operating room twice that of afternoon. Count is lower in the summer		Rice 1941
Use of U.V. lamps in ducts of air conditioner significantly reduced bacterial count.		Robertson 1940
Room with oiled floors had 70% reduction in air borne bacteria during maximum activity		" 1944
U.V. lamps effective in reducing bacteria & preventing spread in air ducts.		" 1939
R.T., R.H., 15-40%, glycol saturation 40-100%	2-3 min.	" 1949
The higher the concentration of glycol the more rapid the bactericidal action. Concentrations of 70-80% produced rapid killing.		" 1948
Air in nursery. No nurse in cubicle for 1 h.	9 col./10 cu. ft. air.	Rosenstern 1948
Nurse in cubicle 10 min. for diapering infant.	299 col./10 cu. ft. air.	"
No air conditioning, count aloud from 1-50 without face mask	25 col./10 cu. ft. air.	"
Air conditioning alone did not prevent spread of respiratory cross infection. Germicidal irradiation of upper air together with air conditioning reduced # of respiratory cross infections. Flannel gauze mask worn by attendants of value in preventing cross infection.		Rosenstern 1948
Prevention of cross infection by U.V. air condit.		Sauer 1942
Tabulation of 1,342 infections acquired in the laboratory. Recognized accidents in 215 instances 308 cases research, 455 cases diagnostic work, 25 cases product of biologicals, 29 cases class.		Sulkin 1951
Air before sweeping.	0.7/cu. ft.	Thomas 1941
" during "	24.1/cu. ft.	"
" after "	30 min.	"
Treatment of bed clothes with liquid paraffin causes 95% reduction in # organisms distributed in air during bedmaking.		"
Samples of air from U.V. hospital ward averaged 5 organisms /cu. ft.		Wells 1940
U.V. irradiation checked epidemic spread of contagious diseases during cold weather, when air dry. Not effective during moist weather		" 1943
Bacterial reductions of 20-25% with use of U.V. irradiation in barracks.		Willimon 1948

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
<b>INDOOR, CONT.</b>		
<p>Rate of disappearance of bacteria from air follows logarithmic relation with respect to time. Disappearance rate increases as R.H. increases. Temp. did not effect rate of disappearance. NaOCl aerosol can effect reduction in the bacteria in the air but requires a high mist conc. The RH of air influences effectiveness of aerial bactericides. The vapor pressure of the bactericides influences its use &amp; effectiveness as aerosol. Low R.H. more favorable than high for viability of air suspended organisms.</p>		<p>1942 Williamson</p>
Indoor dust	3-5 million bacteria/gm.	Winslow 1912
<b>OUTDOOR</b>		
<p>Strong proteolytic protein, 20 C., Incub. 7 d.</p>	<p>Aeration stimulates bact. growth, decomposes casein, produces ammonia, decreases nitrogen.</p>	<p>Allen 1940</p>
<p>10 to 11 mg/cu. meter of absolute humidity or greater allows organisms to survive long enough for infect.</p>		<p>Bey 1948</p>
<p>Air of sewers does not give off germs.</p>		<p>Jacobi 1894</p>
<p>Organisms in air, heavy rain. 80% reduct., 4 h.</p>		<p>Lewis 1907</p>
<p>" " light " 30% "</p>		<p>" "</p>
<p>" " R.H. under 70% 214/sq. ft.</p>		<p>" "</p>
<p>" " " between 70 &amp; 80%</p>	<p>144/sq. ft.</p>	<p>" "</p>
<p>Air windward of town.</p>	<p>11/sq. ft./min.</p>	<p>" "</p>
<p>" leeward " "</p>	<p>27/sq. ft./min.</p>	<p>" "</p>
<p>R.T., textile mill</p>	<p>Colonies from external air thrive more than at 37 C.</p>	<p>Matuso 1943</p>
<p>Effectiveness of U.V. light increases rapidly with increasing R.H. above 55 or 60%. The rays are more efficient against small particles than large.</p>		<p>Perkins 1947</p>
<p>Samples of outdoor country air average 14.5 cu. ft. air/lactose fermenting organism. Samples of outdoor city air average 10.2/cu. ft.</p>		<p>Wells 1940</p>
<p>Street dust</p>	<p>49,200,000 bact./gm.</p>	<p>Winslow 1912</p>
<p>Air borne marine bacteria very resistant but killed by U.V. radiation just as readily as fresh water or terrestrial species.</p>		<p>Zobell 1942</p>
<p>Marine organisms collected on towers 30 miles inland. Terrestrial organisms collected 130 miles at sea. Collections were proportional to wind velocity.</p>		<p>Zobell 1936</p>

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR (ADDENDUM)

Factor(s)	Survival	Reference
<b>ALTITUDE</b>		
Can be transported almost limitless distances horizontally depending on ability to survive atmospheric environment		Jacobs 1940
Bacteria found above 19,000 ft. at -26 C. survived >48 h.		Proctor 1934
Numerous bacilli, staphylococci & micrococci found above 20 thousand feet.		" 1935
Windy weather prior to flights resulted in increased counts.		" 1942
Flights 50-60,000 meters. Bacterial distribution was Coccaceae 50.3%, Bacteriaceae 3.65%, Bacillaceae 39.8%, Actinomycetaceae 3.10 %, Spirillaceae 0.15%.		Skrsynska 1949
<b>EXPERIMENTAL</b>		
<u>Erwinia amylovora</u> R.H. close to 0.	Viable & infectious after 1 yr.	Rosen 1936
<u>Hemophilus pertussis</u> Air	1 h.	Wells 1936
<u>Malleomyces mallei</u> Ozone 4 h, 37 C.	Growth resumed after 8 d. incubation.	Ransome 1901
<u>Micrococcus candidus</u> Aerosols, air, after atomization.	Resistant to shock. Same vitality in aerosol as in suspension.	Ferry 1951
<u>Proteus vulgaris</u> Exposed to U.V.	61 col. 1 min.; 2 col. 3 min.	Hart 1939
<u>Pseudomonas pyocyaneus</u> Exposed to U.V.  Ozone 4 h.	Innum. col. 1 min.; 38 col. 3 min. 60 sec.	" Ransome 1901
<u>Pseudomonas aeruginosa</u> Suspension in air.  Sprayed into air Air	16,00(± 4.7%) ergs/cm <sup>2</sup> necessary for sterilizing air < 1 d. < 1 d.	Sharp 1940 Wells 1934 " 1936
<u>Sarcina lutea</u> Swabbed on tongue, nasal mucosa & tonsil crypts.	Usually impossible to recover.	Bloomfield 1919
<u>Sarcina spp.</u> Air, R.T., R.H. 70-72%, Triethylene glycol vaporized with hot air.	82% killed, 24 h.	Gruen 1949
<u>Serratia marcescens</u> Suspension in spray reduced to dust, R.T.	Disappeared at rate of 1.5-0.17 mm/second. Remained floating in quiet air of room 4 h.	Flugge 1897
Water spray	Recov. 0, 27-33 h.	Kirstein 1900

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR (ADDENDUM)

Factor(s)	Survival	Reference
<b>EXPERIMENTAL, CONT.</b>		
<u>Serratia marcescens</u>		
Ozone, 4 h.	60 sec.	Ransome 1901
Air breathed in thru nose and mouth.	Recov. 91%, 10 min. after spraying bacteria in air.	
Size of particles important:		
Large particle	87% during spraying	
Med. particle	85% 6 sec. after spray	
Small "	62%, 10 min after "	Rooks 1939
Greater recoverability of a dynamic cloud in wet than in dry atmosphere.		Rosebury 1947
U.V. light	15 min.	Rosenstern 1942
Suspension in air	20,700 (4.7%) ergs/cm <sup>2</sup> necessary for sterilizing air.	Sharp 1940
Air, 29 C., sun shining	3 min. after spraying, 6,000 col.	Teague 1912
	30 min. after " 1 col.	"
Pure cult. in nasal passage.	Shows nearly all organisms destroyed before reaching nasopharynx.	Thomson 1896
Sprayed into air	< 1 d.	Wells 1934
Air	< 1 d.	" 1936
Form & structure of organisms may be factors affecting persistence & viability & this may be related to infectivity.		Ferry 1951
Wave length 25 micra acts stronger against Gram neg. organisms. Chromogenic bacteria showed conspicuous stimulation at 313 micra. Spores were killed by U.V. just as fast as vegetative forms.		Gartner 1947
The rate of kill of air dried bacteria was highest at low humidity (15-20%); with rising R.H. the death rate decreased. As air-drying period increased, the rate of kill by glycol diminished. Glycol vapor was effective against particles as large as 8-10 micra in diameter but not killed as rapidly as those of 5-4 micra or less.		Robertson 1951
<b>INDOOR</b>		
<u>Proteus morgani</u>		
Dust of ward	2-12 d.	Hoare 1943
Bacteria counts in test barracks lower than control following U.V. radiation. At the end of the study open plates were found to be a poor method of air sampling because stray irradiation at 5 ft. level induced a 19% reduction in counts.		Jarrott 1948
Respiratory microbes, air, U.V., 2537 Å.	Recov. 0.5%, 2 h.	Knowles 1950
Concentration of air-borne bacteria in army barracks depended on (1) # of men present at one time (2) amount of and type of activity (3) largest # bacteria found during greatest activity.		Lemon 1944

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR (ADDENDUM)

Factor(s)	Survival	Reference
<p>INDOOR, CONT.</p> <p>Air borne bacteria in major surgery roughly proportional to # of people present in surgery &amp; to activity on floor proper of surgery</p> <p>Microbes in air.</p> <p>Air, ward, during bed making</p>	<p>Longer in humid than in dry air.</p> <p>Quiet, 22/cu.ft. air.</p> <p>Beds in making, 510/cu. ft. air.</p>	<p>Nisbet 1938</p> <p>Rochaix 1931</p> <p>Rountree 1946</p>
<p>OUTDOOR</p> <p><u>Hemophilus influenza</u></p> <p>Death rate high during 4 mo. period of high R.H.</p>		<p>Barreto 1948</p>



TABLE 47 THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
Water droplets carry microbes. G.P. not infected after inhaling dry tubercle bacilli for 1 h., but infected in few seconds inhaling humid ones. Rain does not play important pathogenic role. Fog does play pathogenic role		Aimes 1933
Droplets on plate, 45 C., 20-38 cm. from speaking or coughing persons mouth.	300-600 times increase in count.	Flugge 1921
Loud speaking	40-1,000 Times increase in 30 min.	"
Drops from bronchial tree in 20 coughs.	100-8,000 times inc.	"
Sputum of tuberculous patient. 50,000 bacilli/mg.		"
Tubercle bacilli can be recovered from macroscopically normal lung tissue of rabbits several weeks after primary infection		Heppleston 1949
When radiant energy of low intensity, it reduces the incidence of T.B.		Lurie 1944
U.V. of 2537 Angstroms exercised protective influence against natural air borne contagion.		"
Ozone, 37 C., 4 h.	No effect	Ransome 1901
Use of saline solution in the Wells centrifuge will not permit collection of tubercle bacilli in atmosphere. Because of size, the bacilli fall out of atmosphere rapidly. When expelled from mouth they are enclosed in albuminous material which tends to stick to whatever it contacts.		Sim 1939
<b>INDOOR</b>		
Dust in air of rooms of tuberculous persons, R.T.	1 of 50 G.P. inoc. with dust died with T.B.	Augustine 1929
Surface dust from rooms of tuberculous families, R.T.	Found in dust six of 24 observations.	"
Dust from clothing of tuberculous families, R.T.	10 of 62 inoc. G.P. died of T.B.	"
Washings from childrens hands, R.T.	No results	"
Open pulmonary tuberculous patient.	Expulsed from resp. tract by 10 out of 20 patients.	Duguid 1946
0.5-0.1 mg. cult./cc water sprayed in G.P. vicinity	Bacilli in bronchi 1-72 h. Negative 144 h.	Heymann 1908
Dust	8-14 d.	Kirstein 1905
Sputum droplets	4-7 d.	"
Hypochlorite & quaternary ammonium compounds.	Weak tuberculocidal effect	Klarmann 1951
More emphasis than usual should be laid upon measures to prevent contamination of air. Specific experimentation has proved that U.V. has marked favorable effect.		Long 1951

TABEE 47 THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS IN AIR

Factor(s)	Survival	Reference
<b>INDOOR (CONT)</b>		
The use of glycols as vapors	is suggested for killing tubercle bacilli in closed spaces.	Potter 1944
Dust	Long periods	Pressman 1937
Aspiration of 1.4 cu. ft. air/min.	not efficient for air sampling for isolation of T.B.	"
Sputum in air shaft	45 d.	Ransom 1905
Dust of T.B. wards.	Can withstand drying	Rogers 1920
Sputum of floor	2-2½ mos.	Sawizky 1891
Dust, room, hospital & home	Long periods	Thomas 1941
<b>OUTDOOR</b>		
Dust, sunlight, dry	72 h.	Caldwell 1925
Mixed with sterile dust, direct sun rays	5 h.	Sweany 1919
Inhalation of a few tubercle bacilli in the nuclei of droplets coughed or sneezed into atmosphere is of greater consequence than from larger number of organisms in coarse particles which are strained out in the upper resp. passage & ingested.		Wells 1948

THE SURVIVAL OF PASTEURELLA SPECIES  
IN THE AIR

Factor(s)	Survival	Reference
GENERAL		
<u>P. pestis</u> Dust	Dries rapidly	Eskey 1938
<u>P. tularensis</u> Streams & grain in Russia	Rats and mice are vectors	Maximow 1947
Tularemia infection acquired by inhalation of dust from threshing mills contaminated by infect- ed rodents		Ayres 1948

TABLE: 49 THE SURVIVAL OF PROTOZOA, METAZOA, BACTERIOPHAGE AND RICKETTSSIAE SPECIES IN AIR.

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>Bacteriophage</u>		
Transmitted through air with droplets & dust in manner entirely analogous to transmission of bacteria		Colvin 1932
Colloids protect bacteriophage against drying both in vacuo or in air.		Kriss 1948
<u>Rickettsiae spp.</u>		
Dyer Nine Mile, Henzerling str.; saline susp. yolk sac.	30 min.	Ransom 1951
<b>INDOOR</b>		
<u>Rickettsiae, typhus</u>		
May be transmitted by air.		Löffler 1942
<b>OUTDOOR</b>		
<u>Entamoeba histolytica, cystic</u>		
Air dried	Recov. 0	Kuenen 1913
<u>C. burneti</u>		
Air of goatery	Known infection in herd contaminates air considerably.	Lennette 1951

TABLE A/0THE SURVIVAL OF SALMONELLA SPECIES  
IN THE AIR.

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>S. typhosa</u>		
Paper slips in vapor of 35 gms. phenol/1000cu. ft.	Recov. 0, 1 hr.	DeOme 1944
Water spray	Recov. 0, 27-30 hr.	Kirstein 1900
Ozone, 4 hrs.	60 seconds	Ransome 1901
Ozone, 4 hrs, 22 C.	No effect	
Air	8-24 hrs.	Wells 1936
<u>S. dysenteriae</u> (Hiss Y)		
Air	8-24 hrs.	Wells 1936
<u>S. paratyphosa</u>		
Air	8-24 hrs.	Wells 1936
<u>S. pullorum</u>		
Increasing RH from 15-80% increases death rate. Given RH with increase from 28-37 C Death rate increased. The combined effect of increased temp. & RH appears to be cu- mulative.		DeOme 1944
<b>INDOOR</b>		
<u>S. pullorum</u>		
Air, 28 C, RH 15%	50% death, 27.5sec.	DeOme 1944
Air, 28 C, RH 46%	50% death, approx. 7 seconds.	
Air, 37 C, RH 42%	50% death, 5 sec.	" "
When dispersed from broth into dust-free air its death rate was greatly decreased indicating that certain materials dispers- ed with bacteria may have a marked protec- tive action		
<b>OUTDOOR</b>		
<u>S. typhosa</u>		
Direct rays of sun	4-10 hrs.	Osler 1901
<u>S. enteritidis</u>		
Open air, broth plate	Recov. on 5 occa- sions.	Hewlitt 1905

TABLE A 11 THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL</b>		
<u>S. albus</u>		
0.2 mg/l. of propylene glycol, R.H. 41% : Immed. after spraying	Control, 9750 col., 1 cu. ft. test.	
15 min. after spraying	Control 9360, 1 cubic. ft.	
30 min. " " "	" 9260, " "	
60 " " "	" 3220, " "	Bigg 1944
Sprayed into air, R.H. 50% R.H. on either side of "	Lethal for organisms. Prolongs survival	Dunklin 1948
Sprayed in aerosol. Safe in R.H. 100-90% exerted	ozone conc. (0.04 ppm) disinfectant action	Elford 1942
Exposed to U.V.	66 colonies 1 min., 2 col. 3 min.	Hart 1939
<u>U.V. LIGHT</u>		
Suspended in air	26,200 ergs/sq.cm. suffi- cient to kill all sus- pended bacteria present with exposure of 1.06 <sup>2</sup> sec.	Sharp 1938
	23,300 (±5.1%) ergs/cm <sup>2</sup> necessary for steril. air.	Sharp 1940
<u>S. aureus</u>		
Dried in nasal secretion in handkerchief.	Surv. # surv. > 1 mo.	Duguid 1948
Suspended in air	26,500 (±5.7%) ergs/cm <sup>2</sup> necessary for sterili- zing air.	Sharp 1940
Sprayed into air	3 d.	Wells 1934
<u>S. citreus</u>		
Exposed to U.V.	102 col., 1 min, 6 col. 3 min.	Hart 1939
<u>S. pyogenes</u>		
Greater numbers released in dust than by sneezing. 50% reduction when wearing surgical gown.		Duguid 1948
<u>S. spp.</u>		
Killed rapidly at 70-90% R.H. with sprayed HClO. Bactericidal effect reduced in atmosphere of ex- tremely low carbon dioxide content (0.001%) com- pared with behavior in N <sub>2</sub> . Organisms in finely dis- persed mixture killed more rapidly than those in heterogeneously sprayed particles.		Elford 1945
Wounds cross infected	18 of 28 surgical wounds.	Rountree 1947
<b>INDOOR</b>		
<u>S. albus</u>		
Air during % after clean- ing.	Found in air during 1st & 2nd hours.	Furtherer 1946
Dried on glass, 15-16 C., R.H. 15-60%, Exp. to Exposed to ozone for 5, 6 & 9 hrs.	No killing or inhibition of bacteria.	Galli-valerio 1914

TABLE All THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN AIR

Factor(s)	Survival	Reference
INDOOR (CONT.)		
<u>S. aureus</u>		
Air during & after cleaning	Found in air during 1st & 2nd hrs.	Furtherer 1946
Most of infections from air contaminated by operating room personnel & patient.		Hart 1937
Floor dust	Several days.	Lidwell 1950
Survives better at low than at high R.H.		"
Air of operating room	Survived in U.V. light.	Phelps 1939
<u>S. spp.</u>		
R.H. 5-80%	Maximum humidity effect between 60 & 70%	Robertson 1946
OUTDOOR		
<u>S. aureus</u>		
Conc. calcium chloride,	Least growth with minimum humidity.	Kopeloff 1922
R.H. 35-48%		

TABLE A12THE SURVIVAL OF STREPTOCOCCUS SPECIES  
IN THE AIR

Factor(s)	Survival	Reference
<b>ALTITUDE</b>		
<u>S. spp.</u> Sprayed with 5 ml. of 1% hypochlorite sol'n. Oiled blanket, plates exposed 5 min. during and after beating Uncoiled blanket, plates exposed 5 min. during and after beating	95% killed; 5% recov.  170 colonies  1030 colonies	Andrews 1940  " "
<b>EXPERIMENTAL</b>		
<u>S. pyogenes</u> (Group A) Exposed to daylight in simulated room environ. Dark, simulated room environ. Sprayed in air, settle on filter paper, day- light.	252 min. 65 hrs.  6 hrs.	Buchbinder 1942 " " Buchbinder 1941
<u>S. pyogenes</u> (Group B) Exposed to daylight in simulated room environ. Dark, simulated room environ. Sheep blood agar, 18 hrs, 37C., dark room, susp'n in air.	66 min. 132 hrs.  Remain viable in dust of room at least 2 wks.; some impairment of virulence	Buchbinder 1942  Buchbinder 1941
Exposed to ultra-violet, 1 min. 3 min.	98 colonies 12 colonies	Hart 1939
Air and triethylene gly- col, CO <sub>2</sub> , 70F., RH 40%	10-15 min.	Wise 1949
Bactericidal effect of irradiation of beta strep. appeared to depend on both RH and the susp'n med. Organisms in films prepared from serum broth cult. containing dust behaved like those of dust and were more resistant under dry conditions. Org. in films from extracts of dust or from serum bro- th culture were more sensitive under dry condit.		" "
<u>S. pyogenes</u> (Group C) Sprayed into air, RH 50%, Sprayed into air, RH a- bove or below 50%	Rapidly lethal  Increases survival	Dunklin 1948 " "
Propylene glycol vapor conc. 0.2mg/l, RH 42%, 1 cu. ft. immediately after spraying, 15 min. after spraying 30 min. after spraying 60 min. " "	4166 colonies 3120 " 1760 " 442 "	Bigg 1944 " " " "
Sprayed in aerosol. Ozone in safely tolerated conc (0.04ppm) in RH of 160-90% exerted a disinfectant action.		Elford 1942



TABLE 12 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES  
IN THE AIR

Factor(s)	Survival	Reference
<b>EXPERIMENTAL (cont'd)</b>		
<u>S. pyogenes</u> (Group C)		
Infections mainly due to particles smaller than 1.8u in diameter. As bacteria median diameter increases from 1-12u the aerosol dose had to be increased 10,000 times to kill 50% of animals. Pulmonary infection occurred much more readily than URI.		Sonkin 1951
<u>S. pyogenes</u>		
Sprayed into air	Rapidly killed in dry atmos., but protected in moist.	Wells 1942
RH 40-70%	Disinfection most apparent here.	" "
Sprayed into air	Many float for many hrs. after all droplets have evaporated.	Buchbinder 1938
Exposed to room environ.	No evidence that propriety of any strains were adversely affected	Buchbinder 1941
Oiling blankets, bed linen, garments, and floors reduced bacteria and hemolytic strept. of air during bed making to 91-98% below control ward		Cruickshank 1947
<u>S. viridans</u>		
Exposed to daylight in simulated room environ.	44 min.	Buchbinder 1942
Dark, simulated room environ.	26 hrs.	
Sprayed in air, settled on filter paper, sunlight	50%, 5 min.	Buchbinder 1941
In dark and sunlight	Survival ranged from 14-93%	" "
Wounds	3 of 82 surgical wound	Rountree 1947
<u>S. salivarius</u>		
Sprayed in aerosol. Ozone (0.04ppm.) in RH of 160-90% exerted a disinfectant reaction.	in safely tolerated conc	Elford 1942
<u>S. zooepidemicus</u>		
Atomization reduced chain length by 50%. Recov. of viable organisms decreased with distance from atomizing nozzles when conc. cell susp'n used no. of mo. required to infect was larger by air-borne route than by direct nasal route.		Shechmeister 1950
<u>S. spp.</u>		
70-90% RH, HClO spray	Killed rapidly	Elford 1945
Irradiation classrooms	207 colonies	Gilcreas 1950
Non-irradiation of classrooms	318 colonies	
Strep. susp'n in air remain viable at least 2 wks in dust of room with some impairment of virulence		Buchbinder 1941

TABLE 4/2 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE AIR

Factor(s)	Survival	Reference
<b>INDOORS</b>		
<u>S. pyogenes</u>		
Blankets, ENT ward	14,400-7,344,000/cu. ft. of air	Rountree 1946
Use of oil, water, and Roccal emulsion	Reduced no. in air 33-63%	Shechmeister 1947
Air	48 hrs.	Wells 1935
Dust	25 das.	White 1936
Floor dust	67% of 185 samples	Williams 1949
Air from patient with cellulitis, PM.	3 recovered	Willits 1941
AM.	40 "	
while making bed	6 "	
while making bed briskly	14 "	
Room air, scarlet fever ward, blood agar plates, exposed to air 3 hrs.		
AM.	334 colonies	Allison 1937
Afternoon	228 colonies	
PM.	19 colonies	
Air in infant ward	Total counts for air in UV wards consistently lower than control ward	Brooks 1942
Air in scarlet fever ward	Absent at night, rise in AM, slowly falls in PM	Brown 1937
Found in congregation in cities	-----	Buchbinder 1938
Dust	Several weeks	Cruickshank 1938
Oiled beds	26 of 307 cult. positive	Dingle 1946
Uncoiled beds	160 of 441 ", positive	
Droplets from cough	39 of 87 pts. were throat carriers	Duguid 1946
Hospital dust, air settled on filter paper in Petri dish, dark	65 hrs.	Garrod 1944
sunlight	4 hrs.	
Hospital floor dust, R.T. dark	195 das.	
diffuse sunlight	Bactericidal	" "
Air in dormitory	0.22 inf. particles/cu.	Green 1945
Air in movie	0.33 inf. particles/cu ft	
Air in school room	0.63 " " "	
Air in recreation room	0.38 " " "	
Infections appreciable only when premises occupied		
Diminished to low level very quickly after vacation.		" "
Information relative to occurrence in air of hosp.		Hamburger 1944
Nasal carriers desperse 80-100 times as many strep as do throat carriers alone.		Robertson 1947
Some influence of humidity on death rate as in pneumococci(10), but effect less pronounced		Robertson 1948

TABLE 112 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES  
IN THE AIR

Factor(s)	Survival	Reference
INDOORS (cont'd)		
<u>S. pyogenes</u>		
Talking	-----	Robertson 1948
Relative dry air, saliva suspended, triethylene glycol vapor	Highly susceptible after 5 hrs. desiccation	Robertson 1951
Air, low RH, saliva, suspended in air, triethylene glycol vapor	Slower rate of kill after desiccating 20 h	
Droplets from coughing	Practically none expelled.	Robertson 1948
Blankets	> 4 mos.	Robertson 1947
Floor dust	Several das.	Lidwell 1950
Army barracks, air. Contamination high in spring, low in winter and summer. Bedding of persons with positive culture showed higher count. Highest counts obtained during max. activity.	From war wound infections	Locali 1948
Air and dust in hospital wards	40/10 cu. ft. of air	Miles 1940
Air in barracks during heavy activity	2/10 cu. ft. of air	Miller 1948
Air in barracks during moderate activity	20% alive, 14 das.	Phelps 1939
On floor, petri dish, dark	< 1% alive, < 7 das	
diffuse light	Practically all settled in 48 hrs.	
Sprayed culture	Millions recovered	Hamburger 1946
Air, single noseblow by carriers.	Relatively few recov.	
Air, coughing by carriers.	Very few recovered.	
Sneezing by carriers	88.6-54% reduction	Hamburger 1945
Triethylene glycol, RH 40-50%, bed making	Diminution of bacteria of 32-75% during periods of glycolization	Hamburger 1945
Air, hospital wards, glycol vapor	Persisted over 15 min.	Duguid 1948
Air after shaking cloth	In low conc. of air, UV markedly reduced bacteria	Henle 1942
<u>S. pyogenes</u> (Group C)		
Ultra violet	Not killed as fast as those in low humidity. floating for 5 hrs.	Robertson 1951
Freshly atomized	Killed twice as fast as those exposed after atomization	
RH 15-20%, floating in air for 5 hrs.		

TABLE 4/2 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES  
IN THE AIR

Factor(s)	Survival	Reference
<b>INDOORS (cont'd)</b>		
<u>S. pyogenes</u> (Group A)		
Bedding and floor dust	4 das	Lemon 1944
Air	378/ cu. ft.	
Air, droplet nuclei expelled by sneezing	50%, 20 min.	Robertson 1948
<u>S. salivarius</u>		
Vapors of lactic acid, mandelic acid & triethanolamine, RH 70%, 15-21 C.	Gave good kills of org in sprayed saliva	Lovelock 1944
<u>S. spp.</u>		
Air, dust, R.T.	2 wks.	Phelps 1941
Dust	Long periods	Pressman 1937
Blankets and air	Many months	Robertson 1944
Glycol vapor	Caused 70% reduction in bacteria	
Room, floor & blankets treated with triethylene glycol	90% reduction	" "
Survive better at low than at high RH.		Lidwell 1950
Dust, oiled linens and floors	Survive 19 wks. 92.3% reduction during bed making. 79.1% reduct. during sweeping.	Bigg 1947
1st hour after cleaning	Found in air; not found after 2 hrs.	Furtherer 1946
Air drying	Many mos.	Ernst 1900
<b>OUTDOORS</b>		
<u>S. pyogenes</u>		
Air after shaking clothes	Persisted over 15 min.	Duguid 1948
<u>S. spp.</u>		
Air, drying	Many mos.	Ernst 1900

TABLE 413 THE SURVIVAL OF VIRUSES IN AIR

Factor(s)	Survival	Reference
<p><b>ALTITUDE</b>            Numerous viruses are carried along with dust into the atmosphere, many of which are not killed by light or heat.</p>		<p>Lange 1927</p>
<p><b>EXPERIMENTAL</b>  <u>Influenza</u>            Vapors of lactic acid            Moisture, stagnating moist air, ammonia, &amp; other alkaline substances in the air increase incidence of grippe. Presence of acid substances in the air and dry clear weather counter-act grippe epidemics.            Dust, drying            Air of experimental tank 1 h.            Aerosol over water (PR8)            Influenza virus dispersed in air is killed more quickly in humid than in dry air. Exposure to bright daylight increases the rate at which sprayed organisms die off in air.            56-57C. for 30-45 min.            Atomized suspension, R.H. 50%            Atomized suspension, R.H. 30-80%            Atomized, dialysed susp. R.H. 50%            27-29 C., R.H. 80-90%            " " 45-55%            " " 17-24%            Dust dried in floor sweepings. (PR8)  <u>Vaccinia</u>            Chorio-allantoic memb. chick, sprayed in air            Virus retained virulence in all gases for 3 wks. when kept at 4 C. Became avirulent at 37 C. Pure oxygen or carbon dioxide gas destroyed virus at 18 C.            Susceptibility of virus to irradiation is of same order as bacteria</p>	<p>Sterilized nebulized allantoic fluid infused with influenza            Inoc. <math>1 \times 10^4</math> after dry. Recov. 0, 3 wks.            Reduction in infectivity 90%, 30 min; 99%, 1 h. 100%, 3 h.            Necessary for inactivat.            Death of 22.5% exposed mice            Death of 100% exposed mice.            Death of all " mice.            Infectivity time 1 h.            " " 6 h.            " " 24 h.            22 h.            8 hrs. More susceptible to room environ. than strep.</p>	<p>Catalano 1948            Cauer 1949            Edwards 1941            " 1943            " "            " "            Hirst 1943            Lester 1948            " "            " "            Loosli 1943            " "            " "            " "            Buchbinder 1941            " "            Noguchi 1918            Rivers 1928</p>
<p><b>INDOOR</b>  <u>Influenza</u>            Sterile blanket</p>	<p>Survives drying</p>	<p>Krueger 1942</p>

TABLE A/3 THE SURVIVAL OF VIRUSES IN AIR

Factor(s)	Survival	Reference
<b>INDOOR, CONT.</b>		
<u>Influenza</u>		
Dispersed into air (A)	Killed more swiftly in humid than in dry air.	Loosli 1943
Dust	Long periods	Pulvertaft 1947
Mice exposed 20 min. [PR8)	Recov. in 0 mice, 20 min.	Robertson 1942
Air	Infected mice after 3 h.	Robertson 1943
Dust	Survived for days	"
Air, R.H. 80-90%, 1cc. triethylene glycol vapor.	< 1 h.	" 1944
Air, R.H. 25-30%, 1cc. triethylene glycol vapor.	36 h.	"
Air, dry, after shaking canvas floor covering	6 d.	"
Air	Many days.	"
Lab. conditions, 1 cc. vaporized triethylene glycol.	Highly lethal	" 1949
R.T., R.H. 15-40%, vapor of triethylene glycol saturation 40-100%	Killed in 2-3 min.	"
R.T., R.H. 15-40%, vapor saturation of glycol 70-90%	Exposed mice completely protected against lethal concentration of virus.	"
Salt free virus atomized into an atmosphere of R.H. 50%. All mice died indicating that lethal effect of 50% humidity had been abolished by removal of salt.		Robertson 1948
Air, sprayed with glycol	40-60 min.	" 1943
Dispersed into air, R.H. 20-30%, Mice exposed.	22% died at R.H. 45-60% Death rate inc. to 80% R.H. when all mice died.	Robertson 1948
Type A. The % recovery of the virus aerosol was independent of initial concentration of atomized suspension. High aerosol recovery obtained in extreme ranges of 32-68% R.H.; minimum recovery 60% R.H. The mean diameter of influenza virus aerosol was < 0.5 micra. Characterized by greater infectivity when introduced by air borne methods rather than intra-nasal routes.		Shackmeister 1950
R.H. 32-65% (A)	High aerosol recovery	"
" 60%	Minimum " "	"
<b>OUTDOOR</b>		
<u>Foot &amp; mouth</u>		
Normal atmospheric cond.	1 wk.	Burbury 1928
Related epidemiologically to distribution in dust.		Ostertag 1943

TABLE 413 THE SURVIVAL OF VIRUSES IN AIR

Factor(s)	Survival	Reference
<b>OUTDOOR, CONT.</b>		
<u>Infectious jaundice</u>		
Dust borne dried excreta	carries causative organisms. Less common in towns than rural districts.	Anderson 1947
<u>Influenza</u>		
Mucin in air (Type A)	Recov 0, 15 h.	Parker 1944
Air current	Recov. 2, 72 h.	"
Dried with talc in air.	" 0, 22 d.	"
R.H. 80-90%, lcc. glycol vapor	< 24 h.	Post 1945
Dry	36 h.	"
<u>Smallpox</u>		
Epidemic in India	Lower incidence of disease	
Humidity rise	Lower incidence of disease	
Low absolute humidity favors disease.	Seasonal rises in incidence	Rogers 1928
R.H. low absolute	Seasonal rises in incidence	" 1948
<b>GENERAL</b>		
Air borne viruses killed as easily as Strep. salivarius by HClO mists.		Edwards 1943
Animal viruses have sensitivity similar to bacteria at wave length of 2537 Å.		Hollaender 1943
Means of obtaining infections in lab: 1) by use of Waring blender 2) Opening sealed glass ampoule. 3) Inhalation of infectious material 4) Inadequate disposal of contaminated material. 5) Inadequate handling of autopsy material		Smadel 1951

TABLE 112 THE SURVIVAL OF YEASTS, MOLDS & FUNGI IN AIR

Factor(s)	Survival	Reference
<b>ALTITUDE</b>		
<u>Alternaria</u>		
Air	Found up to 16,000 ft.	Stakman 1923
<u>Black stem rust spores</u>		
Viable up to 10,000 ft.	in the air.	Cotter 1931
<u>Cronertium ribicula</u>		
Air	Found 110 miles beyond limit of pines	Pennington 1925
Aeciospores in air	Carried 300-400 miles in Pacific coast region.	Lachmund 1941
<u>Fungi imperfecti</u>		
Air	Found at 36,000 ft.	Rogers 1936
<u>Gymnosporangium</u>		
Air	Viable basidiospores found up to 2,000 ft. Good % viable sev. d.	MacLachlan 1935
<u>Molds</u>		
Found above 19,600 ft.	in the air	Proctor 1934
<u>Pestalazzia</u>		
Air	Viable spores at 18,000 ft. over Washington, D. C.	Meier 1933
<u>Phaeocryptopus gaumanni</u>		
Spores	Blown across North Sea from England to Denmark.	Buchwald 1939
<u>Puccinia graminis</u>		
Spores	Blown from south into Dakota & Minn. in 2 d.	Lambert 1929
Spores collected at 10,000 to 16,500 ft. in Southern U.S. in spring.		Proctor 1942
Triticum carried 50-250 kilometers over sea without losing viability.		Roussakov 1926
Air, blown from South to Dakotas & Minn. in 2 d.		Stakman 1934
<u>Ragweed pollen</u>		
Air during flights.	Greatest conc. pollen at 3500 ft.	Heise 1948
<u>Rust</u>		
Spores	From height of 5,000 ft. in 30 mi. wind may travel up to 1,200 mi. 3 mi. high	Proctor 1942 Stakman 1923
Spores		
<u>Sclerospora philippinensis</u>		
Air	Viable spores travelled 8-80 ft.	Weston 1923
<u>Uredospores</u>		
Found viable up to 5,000 ft. at Norway House, Manitoba which was assumed that they had been carried horizontally for at least 200 mi. Of leaf & stem rust.	Found up to 10,000 Ft.	Bailey 1928 Stakman 1923
<u>General</u>		
The influence of winds aloft on the concentration of solid particles is of minor importance compared to lapse rate.		Heise 1949



TABLE 1/2 THE SURVIVAL OF YEASTS, MOULDS, & FUNGI IN AIR

Factor(s)	Survival	Reference
<b>ALTITUDE</b> <u>General, cont.</u> Four species isolated from Antarctica where mean temp. is -20 C.		McLean 1918
<b>EXPERIMENTAL</b> <u>Aspergillus</u> Exposed to U.V.	10 min. immum. col., 20 min., 0 col.	Hert 1939
<u>Geotrichum</u> Exposed to U.V.	3 min., immum. col., 10 min., 0 col.	"
<u>Monilia</u> Exposed to U.V.	1 min., 200 col., 5 min., 0 col.	"
<u>Muco</u> Exposed to U.V.	1 min., immum. col., 5 min. 25, 10 min., 0 col.	"
<u>Penicillium</u> Exposed to U.V.	10 min., immum. col., 20 min., 0 col.	"
<u>Pink yeast</u> Water spray	Viable 10-14 d.	Kirstein 1900
<u>Saccharomyces albicans</u> Ozone, 4 h.	60 sec.	Ransome 1901
<b>INDOOR</b> Fungi paralleled bacteria except more abundant in textile room with high R.H.		Matusc 1935
<b>OUTDOOR</b> <u>Coccidioides</u> Chlamydo spores in dust. Infection rates highest in dry seasons & dusty conditions. Rate of infection diminished by dust control. Southern climates have highest inf. rate.	Lastly transported in air.	Dickson 1938 Smith 1946
<u>Molds</u> Spores in sea air	Long periods of time	Zobell 1942
<u>Fusicladium melvaccarium</u> Moist atmosphere, 1 C.	50 d.	Cohen 1946
<u>Phytophthora malvacera</u> Wind-blown rain	Important factor in dissemination	Faulwetter 1917
<u>Sporotrichosis</u> 15-20 C., High R.H., abundant rainfall	These conditions must exist several days for contraction of disease.	Mackinnon 1949

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
sp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

**THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN THE BODY  
(AND BODY MATERIALS)**

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THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN THE BODY  
(AND BODY MATERIALS)

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TABLE B1 THE SURVIVAL OF BACILLUS ANTHRACIS IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
Blood, R.T., moist spores	60-90 d.	Minett 1950
" " dry	"	"
G.P. blood, 25-30 C., opened before decomposition	1-9 mos.	Stein 1947
G.P. Blood stored 5-10 C.	35-159 d.	"
<b>FECES</b>		
G.P. feces	Spores in 7 of 19	Stein 1947
<b>SKIN</b>		
100% inhibited by normal human skin		Hill 1933
<b>URINE</b>		
Urine of G.P.	Vegetative forms in 19 of 28 cases	Stein 1947
<b>TISSUE, GENERAL</b>		
Muscle, G.P., 25-30 C., Opened before decomposition	6-7 mos.	Stein 1947
Liver & bone marrow, G.P., 25-30 C., opened before decomposition	6 mos.	"
Spleen, opened before decomposition, R.T.	3 mos.	"
Stored 5-10 C.	14-24 d.	"
Continuous freezing, spleen, -60 to -70 C., G.P.	Destroyed in 90 d.	"
Carcass of unopened G.P., 25-30 C.	Few alive in 72-80 h.	"
Carcass of unopened G.P., 5-10 C.	4 wks.	"
Carcass of unopened G.P., R.T.	9 mos.	"

TABLE B2 THE SURVIVAL OF BORRELIA, LEPTOSPIRA, SPIRILLUM AND TREPONEMA SPECIES IN THE BODY. (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>B. recurrentis</u>		
Defibrinated, refrigerated sheeps blood	195 d.	Beck 1937
Infected blood, Inoc. into physiol. saline with boiled egg white	Still viable 3-4 wks.	Krantz 1925
At ice box temp.	" " 4 d.	" "
Rat blood, -48 C.	Remained infective for mice 27 mos.	Lofgren 1945
Iceed blood	1 wk.	Toyoda 1931
Rat blood, -12 to -20 C.	Infectivity markedly reduced, 6 wks.	Turner 1939
" " -78 C., Cooling	2-6 h.	" "
-78 C. to 0 C.	2-6 H.	" "
Clotted blood, R.T.	6 d.	Wynns 1935
0 C.	100 d.	" "
<u>L. icterohemorrhagica</u>		
Blood, defibrinated, R.T. light of day, 45 C.	Still infective 7 d.	Uhlenhuth 1916
	" " 15 min.	" "
<u>S. minus</u>		
Frozen	1 yrs.	Turner 1939
<u>S. rubrum</u>		
Sterile rabbit blood susp.	at least 5 yrs.	Frobisher 1947
<u>T. pallidum</u>		
Citrated blood & plasma stored at 5 C.	Occasionally at 48 & 72 hrs. Not after 72 hrs.	Bock 1941
Human blood & plasma, 5 C.	72 h.	Kolmer 1942
Serum exudate from chancre, R.T.	121 d.	Lacy 1921
10% rabbit serum, -20 C.	2 mos.	McLeod 1949
Frozen plasma, -78 C.	3 yrs.	Ravitch 1942
Blood, ice box.	96 h. non-infectious	Ravitch 1949
Plasma, -20 C.	> 48 h., non-"	" "
Rabbit plasma, 5 C.	6 d.	Selbie 1943
Blood of G.P., 14 C.	2-33 d.	Sergent 1938
" " 20 C.	33-60 d.	" "
" " 0 C.	7-8 wks.	" "
" " 10 C.	1 d.	" "
Citrated whole blood, 5 C.	72 h.	Turner 1941
Plasma, 5 C.	62 h.	" "
Human serum, physiol. saline under vaseline, R.T.	5 d.	Zurhelle 1927
In organ parts, R.T.	3 d., 17 hrs.	" "
<b>FECES</b>		
<u>Borrelia spp.</u>		
Feces	4 wks.	Gowen 1945
<u>L. icterohemorrhagica</u>		
Feces	24 h.	Noguchi 1918
Urine, Body temp.	wks. or mos.	Sawers 1938
<u>L. icterohemorrhagica</u>		
R.T.	Still infectious 2 d.	Uhlenhuth 1916



TABLE B2 THE SURVIVAL OF BORRELLIA, LEPTOSPIRA, SPIRILLUM AND TREPONEMA SPECIES IN THE BODY. (CON'T) (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>TISSUES, GENERAL</b>		
<u>B. duttoni</u>		
Mouse tissue, -78 C.	1 mo.	Oag 1939
Frozen rabbit testes, -78 C.	1 yr.	Turner 1939
<u>L. icterohemorrhagica</u>		
Infected G.P. liver in ice	26 d.	Buchanan 1927
Whole pig liver blocks, -20 C., frozen	Viable & virulent 100 d.	Stravitsky 1945
Whole pig liver blocks, lyophilized	0	"
Frozen rabbit testes, -78 C.	10 mos.	Turner 1939
Decomposing liver, R.T.	27 hrs.	Uhlenhuth 1916
Infected liver, R.T.	3 d.	"
Infected G.P. liver, ice	26 d.	"
<u>Treponema pallidum</u>		
Dead autopsy tissue, 5 C.	3-5 days after death	Armuzzi 1926
Rabbit testis, heavy susp.	72 hrs.	Block 1941
Citrated rabbit blood, 3-5 C., mixed with testis	96 hrs.	"
Testicular in vitro x-tract, 39 C.	5 hrs.	Boak 1932
	40 C.	"
	41 C.	"
	41.5 C.	"
Dead bodies of cong. syphilitic children, refrig.	24-36 h.	Hoffman 1926
Rabbit testes dried in vacuo from frozen state	nil.	Hampf 1951
Corpse of cong. syphilitic child	5 d.	Koch 1911
Corpse of " " child, dried & incub. 37 C.	Recov. 0 72 hrs.	Kratzeisen 1923
Liver & sterilized call.	Recov. 0 72 hrs.	"
Liver with bouilloh.	" "	"
Liver with NaCl	" "	"
Liver with	" "	"
Human autopsy material, Ice box	48 hrs.	Lacy 1921
Chancre	7 d.	"
Saline susp., rabbit testicle, R.T.	58 d.	"
Rabbit testicle, ice box.	58 d.	"
Rabbit testes, 5 C.	Recov. in 3 d.	Levaditi 1946
Autopsy mat'l. from syphilitic patients, 5 C.	Recov. in 3 d.	"
Susp. rabbit testes, -78 C.	1 yr.	McLeod 1949
Tissue susp., 37 C.	24 h.	Miyao 1930
Syphilitic mat'l. 10 C.	3 h.	Neisser 1911
" " ice chest	24 h.	"
" " 48 C.	30 min.	"
Tissue susp., 0 C.	2 h.	Miyao 1930
Autopsy mat'l. in ice box.	7 d.	Rosahn 1935
Rabbit testes	10 d.	Perry 1948

TABLE 32 THE SURVIVAL OF BORRELLIA, LEPTOSPIRA, SPIRILLUM AND  
 TREPONEMA SPECIES IN THE BODY (CON'T). (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<u>TISSUES, GENERAL, CON'T.</u>		
<u>Treponema pallidum</u>		
Frozen exudates	13 mos.	Shuntzoff 1949
Testicular extracts, -10 C.	2 mos.	Turner 1938
" " -20 C.	"	"
" " -78 C.	1 yr.	"
Testes of rabbit, -78 C.	3 yrs.	Turner 1939
Excised chancre, R.F.		
Dried in vacuum	68 hrs. to 4 d.	Zurhelle 1927
<u>T. pertense</u>		
37 C. tissue susp.	2 h.	Miyao 1930
Testicular extracts, -78 C.	1 yr.	Turner 1938
Testes of rabbits, -78 C.	3 yrs.	Turner 1939

TABLE 29 THE SURVIVAL OF BRUCELLA SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>B. abortus</u> Sterile rabbit blood susp.	At least 5 yrs.	Frobisher 1947
<u>B. bronchiseptica</u> Sterile rabbit blood susp.	9 yrs.	"
Broth culture, 0 C.	43 d.	Hampil 1932
<u>B. melitensis</u> Sterile rabbit blood susp.	3 mos.	Frobisher 1947
Normal skin of G.P. more vulnerable to <i>B. melitensis</i> entry than digestive tract.		Hardy 1929
<u>B. spp.</u> Cltrated 4C. from convalescing patient.	6 mos.	Spink 1950
<u>B. suis</u> Sterile rabbit blood susp.	3 mos.	Frobisher 1947
<b>FECES</b>		
<u>B. abortus</u> Isolated from patient's stool in 10% CO <sub>2</sub> , aerobically and anaerobically.	Surviving in 16th month of infection.	Amoss 1929
<u>B. melitensis</u> Dry, sterile manured soil.	72 d.	Horrocks 1906
moist, sterile " "	7 d.	"
" unsterile " "	20 d.	"
<u>B. suis</u> Feces, sterile, dark.	100 d.	Anonymous 1933
" " "	100 d.	Cameron 1933
<b>SKIN</b>		
<u>B. melitensis</u> 34% inhibited on normal human skin	--	Hill 1933
<b>URINE</b>		
<u>B. melitensis</u> Favorable conditions	6 d.	Bang 1894
Urine contam. with dust.	30 d.	Chief 1944
<b>TISSUES, GENERAL</b>		
<u>B. abortus</u> Uterus of cow, P.P.	9 mos.	Bang 1897
Uterine exudate "	7 mos.	"
Hog, lymph nodes.	Found in packing house	McCullough 1949
Dogs fed aborted fetus, placenta & lymph nodes.	Virulent 151 d.	Morse 1951
<u>B. melitensis</u> Uterus, P.P.	6 d.	Bang 1897
Colon at autopsy	More prevalent in cold wet season than dry & hot.	Eyre 1908
<u>B. suis</u> 37-39 C., In vivo	Did not persist for prolonged periods.	Braun 1951
Hog tissue, -10 F.	Still viable, 30 d.	Huddleson 1933
Spleen	Recov. small #., 40 d.	"
Swine tissue, -10 F.	Recov. good %, 40 d.	"
Spleen, 40 F.	45 d.	"

TABLE B4 THE SURVIVAL OF CLOSTRIDIUM, CORYNEBACTERIUM, HEMOPHILUS, LACTOBACILLUS, MALLEOMYCES, MICROBACTERIUM, PROTEUS, PSEUDOMONAS, SERRATIA & ERYTHROPHAGUM IN THE BODY--(AND BODY MATERIALS)

Factor(s)	Survival	References
<b>BLOOD</b>		
<u>Clostridium tetani</u> Free spores from animals dying of tetanus. Inject. subcutaneously May remain dormant at site long as 4 mos.	Recov. up to 17th d. of injection for as	Canfora 1907 Francis 1914
<u>Corynebacterium pseudotuberculosis (Preisz-Nocard)</u> Horse serum in flask, light	11 mos.	Urbain 1930
" " " dark	13 mos.	"
" " test tube, light	1 mo.	"
" " " dark	11½ mos.	"
<u>Corynebacterium diphtheriae</u> Washed, dried in sunlight (serum) Sterile rabbit blood susp.	121 d. Hundreds of strains survived 13 yrs.	Abel 1893 Frobisher 1947
<u>Hemophilus influenzae</u> Sterile rabbit blood susp. Blood broth, -15 C. " " -20 C.	6 wks. or less 2½ hrs. 1½ hrs.	Frobisher 1947 Hampil 1932 "
<u>Hemophilus pertussis</u> Sterile rabbit blood susp.	6 wks. or less	Frobisher 1947
<u>Lactobacillus acidophilus</u> Sterile rabbit blood susp.	At least 5 yrs.	Frobisher 1947
<u>Microbacterium, spp.</u> Sterile rabbit blood susp.	5 yrs.	"
<u>Proteus spp.</u> Sterile rabbit blood susp.	3-9 yrs.	"
<u>Pseudomonas spp.</u> Sterile rabbit blood susp.	5 yrs.	"
<b>FECES</b>		
<u>Cl. botulinum</u> Feces "	No survival No survival in human & animal following ingestion	Burke 1919 Easton 1924
<u>Cl. tetani</u> Dog feces	16 d.	Sormani 1891
<u>Malleomyces pseudomallei</u> 26-27 C., culture 1% phenol, 37 C. 1% formalin, 40 C.	27 d. 24 h. 24 h.	Fletcher 1928 " "
<b>SKIN</b>		
<u>Proteus spp.</u> Proteus species survived longer on skin than on filter paper 1.6% inhibited on normal skin		Hellat 1948 Hill 1933
<u>Pseudomonas aeruginosa</u> Survived longer on skin than on filter paper 4.4% inhibited on normal skin		Hellat 1948 Hill 1933

TABLE R<sup>4</sup> THE SURVIVAL OF CLOSTRIDIUM, CORYNEBACTERIUM, HEMIPHILUS, LACTOBACILLUS, MALLEOMYCES, MICROBACTERIUM, PROTEUS, PSEUDOMONAS, SERRATIA AND CRYSIPELOTHRIX IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SKIN (CONT.)</b>		
<u>Serratia marcescens</u>		
Skin or arm, cult. dil. 1:1,000, dry	Inoc. 718, Recov. 94 after 5 min.	Arnold 1934
Skin, cult. dil. 1:1,000 moist	Inoc. 696, Recov. 151 after 5 min.	"
Skin of back, not washed	Inoc. 1,000, Recov. 1 after 30 min.	Arnold 1930
Skin, body temp., dirty or fatty.	Recov. 0, 30 min.	"
Skin, 37 C., before drying	Inoc. 34,000, Recov. 0 in 15 min.	Bryan 1933
Skin, 37 C., after drying	Inoc. 51,000, Recov. 0 in 10 min.	"
Sterile rabbit blood susp. Survived longer on skin than on filter paper	At least 5 yrs.	Erobisher 1947
16.1% inhibited on normal skin		Hellat 1948
Palmar surface, clean hand	Inoc. 1,200, Recov. 0 after 2 min.	Hill 1933
Washed hide	Inoc. 520, Recov 0., after 20 min.	Norton 1932
Palms of hands.	Inoc. 1,200, Recov. 112, after 1 min.	"
Kept moist by water vapor	Inoc. 920, Recov. 1,000 after 30 min	Norton 1931
Dry surface of skin	Inoc. 770, Recov. 900, after 70 min.	"
Skin of forearm	0-40 min.	"
Skin, moist with water vapor.	Inoc. 310, Recov. 150, 30 min.	"
Unwashed tanned hide, dry.	Inoc. 3,000, Survive 4 hrs. 15 min.	"
Washed tanned hide, dry.	Inoc. 2,440, Survive 1 h. 20 min.	"
Dirty or fatty skin	Several hrs.	Singer 1929
<b>URINE</b>		
<u>Malleomyces pseudomallei</u> 26-27 C., culture	16 d.	Flotcher 1928
<b>TISSUES, GENERAL</b>		
<u>Clostridium botulinum</u> Intestinal tract, 22 C.	4 mos.	Burke 1919
<u>Cl. sporogenes</u> War wounds.	5 yrs.	Anonymous 1923
<u>Cl. tertius</u> War wounds.	5 yrs.	"
<u>Cl. tetani</u> Liver, spleen, bone marrow, lungs, lymph glands. Free spores from dying animals.	Recov. up to 55 d.	Canfora 1907
Kidney, spleen	Found at site of inoculation after 26 hrs.	Koser 1917

TABLE B4 THE SURVIVAL OF CLOSTRIDIUM, CORYNEBACTERIUM, HEMOPHILUS, LACTOPACILLUS, MALLEOMYCES, MICROBACTERIUM, PROTEUS, PSEUDOMONAS, SERRATIA & ERYSIPELOTHRIX IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
TISSUES, GENERAL (CONT.)		
<u>Cl. tetani</u>		
Horse intestine	4 mos.	Noble 1915
Fresh G.P. feces	16 d.	"
Remain viable at site of inoculation	6 mos.	Semple 1911
Recovered from liver, spleen kidney, lungs & bone marrow following subcut. inject.	11d to 3½ mos.	Tarozzi 1906
<u>Corynebacterium diphtheriae</u>		
Small dried pieces	9 wks.	Abel 1893
Inoc. on membrane	4 mos.	"
Throat of boy after attack	Virulent 6 mos.	Macgreggor 1898
<u>Erysipelothrix rhusiopathiae</u>		
Dried, dark	1 mo.	Hill 1917
Sunlight	10 12 d.	"
Salted or pickled meat	3 ¼ mos.	"
Carcass of buried animals	mos.	Loski 1896
<u>Erysipelothrix spp.</u>		
18-20 C., carcass	mos.	Hettche 1937
<u>Serratia marcescens</u>		
Mouth, 28 G.	16 h.	Teague 1912

TABLE B5

THE SURVIVAL OF DIPLOCOCCUS  
PNEUMONIAE IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
R.T., sealed tubes, dark	-----	Arkharow 1892
Broth, saliva, or 0.5% saline susp'n, R.H. 40-55%, Type I	Very high mortality rate	Dunklin 1948
Broth, saliva, or 0.5% saline susp'n, R.H. above or below 50%, Type I	Long periods	
Inject into g.p., 37C.	65 1/2 hrs.	Emmerich 1894
Sterile rabbit blood susp'n	5 of 8 strains--5yrs. 11 strains, 9 yrs.	Frobischer 1947
Fluid, defibrinated blood	2 mos.	Gilbert 1896
Rabbit blood dried, 80F., glass & gauze, light & dark, Type II(smooth)	2 mos.	Stillman 1940
40F., in ice box, dark, glass & gauze, Type II(smooth)	12 mos.	" "
80F., on glass, daylight, dried, Type I	1 mo.	" "
80 F., on glass, dark, dried Type I	2 mos.	" "
40F. in icebox dark, Type I glass;	12 mos.	" "
gauze	9 mos.	" "
80F. daylight, glass & gauze, Type III(smooth)	5 mos.	" "
80F. dark, glass, Type III	7 mos.	" "
80F. dark, gauze, Type III	11 mos.	" "
40F., dark, icebox, glass	13 mos. (Type III)	" "
40F., dark, icebox, gauze	12 mos.	" "
<b>SPUTUM</b>		
37C., with dust, air dried	Recov. in 25 das	Germano 1897
37C., dried	4mos.	Guarnieri 1888
Dried in test tubes, 80F., diffuse daylight, Type III	20 wks	Stillman 1940
Dried, ice box, 40F., dark	40 wks.	" "
Dried, Type I	4 wks.	" "
Dried sputum, dark;	35 days	Wood 1905
diffuse light	30 days	" "
Moist sputum, 22 C., dark;	11 days	" "
0 C., dark	35 days	" "
Moist sputum, 22C., strong light	45 days	" "
Dried, sunlight	24 hrs.	" "
Powdered, dark	1-4 hrs.	" "
Powdered, sunlight	1 hr.	" "
Sprayed	24 hrs.	" "
Moist sputum	42 wks	" "
Dried, dark	35 days	" "
diffuse light	30 days	" "
<b>GENERAL</b>		
32-35 C. Abdominal cavity	4-5 days	Foa 1888

TABLE B6

THE SURVIVAL OF ESCHERICHIA COLI, AEROBACTER AND PARACOLOBACTRUM IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
Normal rabbit serum, drying	Death rate logarithmic so that it is proportional to conc. of surviving bacteria.	Chick 1912
M.O. added to normal rabbit serum.	Living bact. remain stationary.	" "
<b>FEACES</b>		
Cow feces	2-3 hrs.	Cohn 1950
Fl. stool, R.T., dark	>55 days	Dold 1944
Stool, dried on filter paper, R.T., dark	>45 days	" "
Watery stool, R.T., dark	>143 days	" "
Thin watery stool dried on filter paper	>143 days	" "
Fluid stool, R.T., dark	6 mos.	" "
Fl. stool, dried on filter paper, R.T., dark	Recov. pure cult. >8 mos.	" "
Fl. stool, R.T. dark	>5 mos., 16 days	" "
Stool, dried on filter paper, dark, R.T.	2 mos., 21 days	" "
Fl. stool in dark, R.T.	>3 mos., 19 days	" "
Dried stool in dark, R.T.	71 days	" "
Fl. stool in dark, R.T.	1 mo.	" "
Dried stool in dark, R.T.	1 mo.	" "
Fl. stool, dark, R.T.	>94 days	" "
Dried stool, dark, R.T.	>54 days	" "
Fecal susp'n., 20 C.	8 weeks	Jordan 1926
37 C.	20 days	" "
10 C.	22 weeks	" "
11 C.	18 weeks	" "
R.T.	2 mos.	" "
Feces, 10 F to 30 F, exposed to open air.	>100 days	Lu-Ti-Huan 1930
Fecal emulsion, dilute, diffuse sunlight inside window	3 days	Mc Naught 1910
test tube, direct sunlight	11 days	" "
Feces, saline susp'n., 37 C.	19 hrs.	" "
Feces, saline susp'n., ice-box temp.	<3 mos	Parr 1937
Feces, 37 C.	599 days	" "
Feces, 40 C.	1 yr. 8 mos.	" "
Feces, 11 C.	2 yrs.	" "
Feces, ice-box temp.	2-3 mos.	" "
Feces, animal, 61 F., inoc. 1-3 thos. 52 F.	359 days	" "
Feces, on stump, blizzard	Recovered 3-10 in 4 wks.	Savage 1917
inoc. 512,000/gm.; on stump, spring, inoc. 11,800/gm.;	Recovered none, 18 das.	Tonney 1931
on stump, warm season; pure cult, stump, winter, inoc. 323,000/gm.	Recovered none, 153 das. 172 days	" "
	Recovered none, 22 das.	" "



TABLE B6 (CONT'D) THE SURVIVAL OF ESCHERICHIA COLI, AEROBACTER AND PARACOLOBACTRUM IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SKIN</b>		
Palmar surface, clean, inoc. 4,000	Recovered 1 after 10 min	Arnold 1930
Skin, body temp. dirty or fatty.	Several hours	
Skin, palmar surface, clean, hand, body temp.	Recovered 0 after 10 min	
Skin, 37 C., inoc. 78,000	Recovered 0 after 10 min	Bryan 1933
Wiping hand with towel		Grubb 1947
Survived longer on skin than on filter paper		Hellot 1948
33% inhibited on normal human skin		Hill 1933
Palm of hand	Entirely destroyed in 10 min.	Krueger 1942
Skin, desiccation, high R.H.; 99%, 96 F.	8 hrs. 2 wks	Rebell 1950
<b>URINE</b>		
Exposed to open air, -8 F to -30 F.	>100 days	Lu-Ti-Huan 1930
<b>GENERAL</b>		
Stomach-absence of free HCl.	Coliforms found in abundance	Lohr 1927
Isolated from frozen shrimp	more frequently than any other coliform organism.	Holmes 1949
<b>FECES</b>		
<u>Aerobacter aerogenes</u>		
Crude, dil. 1/100,000	Not given	Atkinson 1934
Sterile rabbit blood susp.	3-9 yrs.	Frobisher 1947
Found by many workers in human feces		Gray 1932
Fresh, R.T.	16 d.	Jordan 1926
Pure cult. on stump during blizzard in winter	9 d.	Tonney 1931
<b>SKIN</b>		
<u>Aerobacter aerogenes</u>		
5% inhibited on normal human skin		Hill 1933
<b>BLOOD</b>		
<u>Paracolo bacterium aerogenes</u>		
Sterile rabbit blood susp.	3-9 yrs.	Frobisher 1947

TABLE B7THE SURVIVAL OF METAZOA AND  
PROTOZOA IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>Anaplasmosis (Bartonella bovis)</u> Dried blood Blood submitted to heating and chilling over period of 6 das.	< 3 das 0	Dypstra 1948
<u>Plasmodium vivax</u> -50 to -70 C.	10-15 das	Saunders 1947
<u>Trypanosoma equiperdum</u> Bats kept at low temp. 10 C to 3-4 C. 33 C. to 37 C.	Do not develop Develop in blood in short time	Kalabuchov 1935
<b>FECES</b>		
<u>Entamoeba histolytica</u> Feces 37 C. Feces, 25-30 C. Feces, 6-8 C. Infected feces, 27-30C. 37 C. Infected feces, with fec salt mixture, freezing. inoc. 50 cysts Stool emulsion, R.T., allowed to dry on fingers Dried feces Very dilute feces Feces with free Cl <sub>2</sub> in water, 1:10,000 0 G., 16 hr. cult. 16-20 C. 0 C. washed & conc. cysts 16-20 C., washed & conc. suspension. Human feces, cult. tube R.T. 4 hrs., and 14 C. for 14 hrs. Soil plus stool plus water R.T., 1 hr 14C. 12 hrs. 28-34 C. Feces	2-4 hrs. 5-8 hrs. 8-10 hrs. 9 das. 3 das. Recov. 13 dead in some hrs. 10 min. Instant death > 1 mo. No effect in several hrs. 9 das. 7 das. 17 das. 10 das. 14 das. 2 das. 6 das. 4 das. 8 and 4 days. 3 das.	Gurevitch 1947 Kuenen 1913 Spector 1934 Wenyan 1917 York 1926 Dobell 1936 Beaver 1949 " " Rudolfs 1951
<u>Entamoeba coli</u> Human feces, 1-2C., culture cysts Stool emulsion, R.T., allowed to dry on fingers	4 1/2 mos. More resistant than <u>E. histolytica</u>	Dobell 1936 Spector 1934
<u>Entamoeba coli marcoccarum</u> Monkey feces, naturally infected	4 1/2 yrs.	Dobell 1936

TABLE B7 (CONT'D)THE SURVIVAL OF METAZOA AND  
PROTOZOA IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>FECES (CONT'D)</b>		
<u>Hookworm</u>		
Night soil, dil. with urine, summer temp.	99% killed, 2-3 wks.	Cort 1925
Night soil dil. with urine, summer temp.	99% killed, 2-3 wks.	Cort 1926
Human feces, direct sunlight	Lethal even in moist tropics	Faust 1924
Moist feces, lab. temp.	13 mos.	Galli 1905
Water, moist feces, larvae	7 mos.	Leichtenstern 1887
Fecal mat'l in abandoned latrine in brickyard	3 mos.	
60 F., strong sunlight	>2 hrs (larvae)	Nicoll 1917
Strong sunlight under glass	1 hr.	
<u>Necator americanus</u>		
45 C.	2 hrs.	Nicholls 1939
<u>Ascaris lumbricoides</u>		
Human feces on sand in sun, ova	21 days	Brown 1927
Human feces on sand in shade	Recov. 90.8%, 35 das.	
Clay in sun	71% motile, 21 das.	
Clay in shade	85% motile, 21 das.	
Loam in shade	89.3% motile, 21 das.	
Human feces, in shade	72-92% motile, 4 wks.	Caldwell 1928
Pig feces, in shade	99% motile, 4 wks.	
Human feces, drying in sunlight, 130 F.	35-40% disintegrated	
Pig feces, sunlight, 130 F.	> 7 1/2 hrs.	" "
Human and pig feces, lying shade	5-30% disintegrated in > 7 1/2 hrs.	
Human feces moist with constant temp. 40-50C.	Recov. 0, 2 wks.	
Pig feces, moist with constant temp. 40-50 C.	38% ova disintegrated in 14 das.	" "
45 C. compost	40% ova disintegrated in 14 das.	" "
54-55 C.	3 mos.	Nicholls 1939
Fecal susp'n of eggs	3-5 min.	Nolf 1932
	All degenerate in 27-35 das.	Rudolfs 1951
<u>Trichuris trichuris</u>		
Human feces, 30 C. on cover slip, incubator, moisture, sat'd, inoc. 1000	Recovered 0, 29 das.	Nolf 1932
-12 C., 4 das. incubation before exposure	6 das.	
-9 C., 4 das incubation	Recovered 40%, 8 das.	
Sand in shade, human	74% motile, 35 das.	Brown 1927
Eggs of <u>T. trichiura</u> , as well as <u>N. americanus</u> , <u>A. lumbricoides</u> , <u>T. saginata</u> , <u>S. haematobium</u> , pass thru cockroach unharmed.		Macfie 1922

TABLE B7 (CONT'D)THE SURVIVAL OF METAZOA AND  
PROTOZOA IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>URINE</b>		
<u>A. lumbricoides</u> Human urine	No survival	Yoshida 1920
<u>Trichomonas vaginalis</u> Urine, 20C., inoc. with vaginal secretion	Few alive in 20 hrs.	Jirovec 1948
<b>GENERAL</b>		
<u>T. vaginalis</u> Vaginal discharge Vaginal discharge, R.T., Paraffin sealed cover- slips.	Recov. 2-4% in 6 hrs. >5 das.	Kessel 1950 Kirby 1943
Pus, dry	3 hrs.	Swift. 1937
<u>E. histolytica</u> Cysts drying on human hand	5 min.	Spector 1934
Cysts pass through cockroach	unharmed	Macfie 1922
<u>T. batrachorum</u> In Rana pipiens, R.T., distilled water, and gastric mucin	6 yrs & 11 mos.	Wenrich 1949
<u>T. wenyani</u> In white rats, R.T., with distilled water and gastric mucin.	4 yrs.	" "
In amphiuma, R.T., with gastric mucin	4 yrs. (T. prowezeki)	" "
<u>T. augusta</u> In Rana pipiens, R.T., with water & gastric mucin.	2 yrs.	" "
<u>T. hominis</u> In man, 32-34 C., in water and gastric mucin.	3 yrs.	" "
<u>T. species</u> From Crotalus horridus	2 yrs.	" "
<u>Trivitus parva</u> From Triturus viridescens	4 yrs.	" "
<u>Monocercomonoides</u> From Lipulid larvae	4 yrs.	" "
<u>T. spp.</u> From Japanese beetle lar- vae.	4 yrs.	" "
<u>Trichinella spiralis</u> G.p., rat muscle, pork, pork sausage, -35 C. -17.8C.	2 Hrs. 53 hrs.	Blair 1934
<u>Tr. spp. (larvae)</u> Pork, -27C.	36 hrs.	Gould 1949
-30C.	24 hrs.	
-33C.	10 hrs.	
-35 C.	40 min.	" "
-37C.	2 min.	

TABLE B8 THE SURVIVAL OF MOLDS, YEASTS & FUNGI IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SKIN</b>		
<u>M. oudouini</u>		
Hair	420 d	Farley 1921
Hair in well stoppered bottles	125 d	Robinson 1948
<u>Trichophyton interdigitale</u>		
Scrapings from toes	300 d	Mitchell 1922
<b>SPUTUM</b>		
<u>Coccidioides immitis</u>		
Sputum, sun with earth	Vegetative form, 30 d Parasitic stage, 240 d	Rosenthal 1950

TABLE 39

THE SURVIVAL OF MYCOBACTERIUM  
SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>M. tuberculosis</u> Saline soln., R.T.	10 weeks	Coulthard 1951
In arachis oil	10 weeks	
In saline and arachis oil	At least 26 weeks	
Human whole blood	14 days	Davies 1939
Hemoglobin inhibits the growth of the tubercle bacillus. Effects proportional to conc. of hemoglobin.		
<b>FECES</b>		
<u>M. tuberculosis</u> Feces, R.T., dark, summer	1 day	Abe 1949
fall	3 days	
winter	9 days	
Feces, 8 C, Dung	Still virulent, 3 1/2 mo	Gärtner 1898
	Virulent tubercle bacillus remained after 178 days	Maddock 1933
Feces, No. of M.O. in feces of sputums	proportional to those	Nüssel 1923
Feces, cool, stored in jars with loose lids, natural infected	12 mos.	Stenhouse 1930
Feces, cellar, dark, with muslin to exclude insects		
artificially infected	2 years	
Liquid manure	4 mos.	
Liquid manure, winter, artificially infected	5 mos.	
spring	2 mos.	
fall	4 mos.	" "
autumn	4 1/2 mos.	
Cow feces, exposed on pastureland, winter	5 mos.	" "
spring	2 mos.	
autumn	4 mos.	
summer	2 mos.	
Cow feces, protected from sunlight, summer	4 mos.	" "
autumn	6 mos.	
<u>M. paratuberculosis</u> Infected feces, atmospheric conditions	246 days	Lovell 1944
<b>PUS</b>		
<u>M. tuberculosis</u> Pus, room temp., dark	Viable 4 mos.	Abe 1949
Pus, R.T., in half dark	Viable 3 mos.	
<b>SKIN</b>		
<u>M. tuberculosis</u> Human tubercle bacillus in reed capsule placed under skin of cattle	7 years	Heymans 1927

TABLE 57 (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SPUTUM</b>		
<u>M. tuberculosis</u>		
Sputum, R.T., dark	Viablo 4 mos.	Abe 1949
Sputum, half dark	Viablo 3 mos.	" "
Sputum, 37 C.	Persistence time 10 das., recovery time 0	" "
Sputum, direct sunlight		
summer	50-80 min.	" "
fall	60-110 min.	
winter	90-240 min.	
Sputum, diffuse light		
summer	8 days	" "
fall	7 days	
winter	5 days	
On window of room		
spring	13 days	" "
fall	18 days	
summer	20 days	
Sputum, exposed to sun- light, 12-14 C, R.H. 50%, afternoon	9 min, recovery 12 1/2	Albini 1940
noon	1-4 min.	
diluted 1:2(5:00 PM.)	1 min., recovery 3 1/2	
diluted 1:25	-----	
Sputum, exposed to sun- light, 7-9C., R.H. 40%		
afternoon	1 min., recovery 3 1/2	" "
diluted 1:2	4 min., recovery 1/2	
diluted 1:25	-----	
Sputum, 43-35 C. R.H. 40%	-----	" "
Sputum, dried, surface of wooden tongue blade	Infective for g.p. 4 - 18 weeks	Arms 1912
Dried or moist	No viable after 3 yrs.	Burns 1917
Mixed with dust and expo- sed to sunlight up to 72 hrs.	Viable when inject. into g.p. 2-72 hrs.	Caldwell 1925
Droplets, 15-20 C	30-40 days	Chausse 1912
Droplets, 10-15 C.	50 days	
Direct sunlight	Few mins. to few hrs.	Cornet
Diffuse sunlight	Several days	
Dried in layers not too thin.	Several mos. to 1 yr.	"
Desiccated, 30-40 C.	9-10 mos.	De Thomas 1886
Sputum	6 mos.	Cornet 1904
Droplets from speaking or coughing, 45 C.	300-600 times increase in count	Flügge 1921
Loud speaking, droplets 45 C.	30 min.	
Drops from bronchial tree	-----	" "
Dried sputum	Several months	Harder 1913
Coughed on paper, stored in bell jar, dried 24 hr.	>50% infect. in 2 das., none infect in 31 das.	Kenwood 1915

TABLE 37 (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SPUTUM (CONT'D)</b>		
<u>M. tuberculosis</u>		
Droplets,	4-7 days	Kirstein 1905
Desiccated	Several mos.	Koch 1882
Alternately dried and moistened	12 days	Malassez 1883
Sunlight	Few minutes to 48 hrs.	Mayer 1924
Ultra-violet lamp for 3 min. at distance of 5".	Required 25 min. to destroy all organisms	" "
Thin layer, dried	Still virulent, 30 min.	Migneco 1895
Direct sunlight	None recovered, 24-30 hrs.	
Dried in sun	18 hrs.	
Exposed to light and air in June & July	<45 days	Ransom ----
Little or no air and dark	16 days	
Dried 24 hrs., dark	>1 day	"
Dried 24 hrs, dark, exposed to little air	>35 days	"
Dried sputum	179 days	Schill 1884
Desiccated	Several months	
Direct north roomlight, 45-76 F., R.H. 17-62%	4 hrs. to 5 days	Smith 1942
Direct north roomlight, darkness	9 das. to 5 mos.	
45 F., R.H. 17-62% , dark	6 1/2 - 14 mos.	" "
70F., 83% R.H., dark, cover slip	142 days	
63 F., 77% R.H., dark, water susp'n.	15 days	" "
72F., 79% R.H. dark	18 days	
In India, direct sunlight	6-8 days	Soparkar 1917
Desiccated in dark	309 days	
Direct sunlight	6-8 hrs.	
Decomposing sput., test tube	20-26 days	" "
Dried in thin smears	4 mos.	Sormani 1886
Dried sputum	10 mos.	
Fluid sputum	8-11 days	Toma 1886
Dark, moist box in paraffined bottles	Produce lesion in 170 das. Produce no lesion in 188 das.	Twichell 1905
Dark closet	Lesion in 160 das, no lesion in 188 days.	" "
Dark moist box, bottle stoppered with cotton	Lesion in 157 das., no lesion in 172 days.	
Diffuse light, ordinary room, paraffined bottle	Lesion 124 days, no lesion in 175 days	" "
In ice	Lesion in 102 days, no lesion in 153 days	
Dark closet, bottles stoppered with cotton	Lesion in 100 das, no lesion in 141 days	
Moist, light place in sand	Lesion in 123 das, no lesion in 148 days.	" "



TABLE B9 (CONT'D)THE SURVIVAL OF MYCOBACTERIUM  
SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SPUTUM</b>		
<u>M. tuberculosis</u>		
Out of doors, winter mos. open bottles Handkerchief	Lesion in 110 das, no lesion in 132 das.	Twichell 1905
Woolen blanket	Lesion in 70 das, no lesion in 110 das	" "
Wood	Lesion in 70 das, no lesion in 110 das.	" "
In thermostat	Lesion in 33 das., no lesion in 70 das.	" "
Dry light place, sand	Lesion 30 das., no les- ion 70 das.	" "
Carpet	Lesion in 39 das, no lesion in 70 das.	" "
Direct sun	Lesion in 1 hr., no lesion in 7 hrs.	" "
Dried, R.T.	Infective 70 days	Twichell 1906
Dried on carpet 20 C., dark	Infective 39 days	Vidal 1934
2 C.	4 mos.	
Dried	12 mos.	Villemin 1869
	Several weeks	
<u>M. paratuberculosis</u>		
Electric light	74-100 days	Soparkar 1917
Direct sunlight	10-12 hrs.	
Diffuse light	30 days	" "
Diffuse daylight	6-8 days	" "
<b>URINE</b>		
<u>M. tuberculosis</u>		
Room temperature, dark; in half dark	Viable 4 mos. Viable 3 mos.	Abe 1949
2-3 C.	Viable 100 mos.	
60 C.	Recovered 0 in 1.5 hrs.	Nasta 1930
Refrigerator	Recovered 0 in 30 days	" "
Inject into peritoneum of S.P.	Lose power in 30-40 das.	" "
<b>GENERAL</b>		
<u>M. tuberculosis</u>		
Dried or broken up org- anic matter	Still virulent at 43 & 38 das. respectively	Cadesc 1888
Pieces of lung -1 to -8C. exterior windowsill	< one week	
Lung tissue inoc. and buried	167 days	
Bacilli remain in phthisical cadavers for several years		Calmette 1920
Distilled water, 37 C.	< 1 day	Davies 1939
0.9% saline, 37 C.	< 4 days	
Lung of rabbit, .80 meter underground	> 23 days	Galtier 1887
In bile	Growth more rapid than in susp	Larson 1922

TABLE B9 (CONT'D)THE SURVIVAL OF MYCOBACTERIUM  
SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>GENERAL (CONT'D)</b>		
<u>M. tuberculosis</u> Rabbit tissue, buried in zinc box	3 mos. 6 das	Petri 1921
Buried lung	2 1/2 yrs.	Schottelius 1890
Intestinal contents, cow, not infect. autumn summer	4 mos. 2 mos.	Stillman 1938
Lung	3 years	Stone 1891
Rabbit lung, liver, spleen kidney, 20 C., sterile, in vitro	5 days.	Vidal 1934
Rabbit tissue, 2 C.	10-30 days	
Lymph node emulsion in incubator in salt soln.	87 days	Webb 1921
Lymph nodes coated with collodion	7 days	
Liver and spleen coated with collodion	3 wks.	
Rabbit lung	14 mos. per rabbit following exposure to air	Wells 1941
Dead buried fowls	At least 1 yr.	Schalk 1928
<u>I. paratuberculosis</u> Intestinal scrapings mixed with river water, outdoor temp.	Recovered in 163 das.	Lovell 1944
<u>B.C.G.</u>		
Spleen of g.p.	53 days	Gernz-Rieux 1950
Axillary lymph nodes	175 days	

THE SURVIVAL OF MICROCOCCUS  
SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>M. spp.</u> Sterile rabbit blood suspn	24 strains viable 9 yrs. 15 strains viable 19 yrs	Frobisher 1947
<b>FECES</b>		
<u>M. pyogenes var. aureus</u> Feces, sunlight with heat	Bactericidal effect not marked	Lenmann 1931
<b>SKIN</b>		
<u>M. pyogenes var. aureus</u> Skin, 37 C., inoc. 161,000	Recov. 34,000 in 15 min.	Bryan 1933
Skin, left palm, expose m.o. 8 min., inoc. 2568	Washed off 1414	Burtenshaw 1938
Dead skin, expose 10 min. inoc. 2568	Washed off 1560	
Skin, inframammary fold, down	80% recov. in 1 hr.	Cornbleet 1932
up	20% recov. in 1 hr.	
Skin, axilla, arm up; arm down	32% recov. in 30 min. 61% recov. in 30 min.	" "
Interdig. spaces of toes, together;	73% in 30 min.	" "
apart	24% in 30 min.	" "
Perianal fold, closed;	76% recov. in 30 min	
open	28% recov. in 30 min	
Palms, clasped;	53% recov. in 30 min.	
open	6% recov. in 30 min.	" "
Growth in sweat of skin	Alkaline areas slower than acid in self steri- lizing action	" "
Nail beds and areas sur- rounding nail beds	Less effective at steri- lizing than normal areas	" "
Keratotic areas	No more effective at re- moving <u>M. aureus</u> than normal areas	" "
Moist areas	Depression of steriliz- ing power	" "
Denuded epithelium	Not as effective in re- moving Staph. as intact areas.	" "
Previous exposure to U.V.	Does not enhance des- tructive power against Staph.	" "
Skin of persons with fur- unculosis	Remain longer than in skin of others	" "
Psoriatic lesions, bereed of scales	Free themselves of Staph faster than lesions with scales.	" "
Survived longer on skin than on filter paper		Hollot 1948
17.2% inhibited on normal skin		Hill 1933

TABLE B/0 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SKIN (CONT'D)</b>		
<u>M. pyogenes var. aureus</u> Washed hide, inoc. 900	Recov. 360 in 30 min.	Norton 1932
Washed hide, inoc. 1,000	Recov. 25 in 20 min.	
Wounds	Recov. in 18 of 82 wound	Rountree 1947
Dirty or fatty skin	Several hours	Singer 1929
<b>SPUTUM</b>		
<u>M. pyogenes var. aureus</u> Increased survival time dried sputum		Bordoni 1891
<b>GENERAL</b>		
<u>M. pyogenes var. aureus</u> Body temp. Pus, R.T.	Recovery 0 2 1/2-3 1/2 years. none of pathogenicity lost	Arnold 1930 Bormann 1940
Exposed to long chain fatty acids	Lethal	Burtenshaw 1945
Pus, sunlight & heat	Bactericidal effect not marked	Lehmann 1931
Boils, 11 strains, pH 2.6 pH 5.0 pH 10.0	8 viable at 24 hrs. 3 viable at 24 hrs. 10 viable at 24 hrs.	Hall 1921
Boils, 11 strains, pH 2.6 pH 5.0 pH 8.0 pH 10.0	10 viable at 7 days 1 viable at 7 days 1 viable at 7 days 10 viable at 7 days	" "
Abscesses, 4 strains pH 2.6 pH 5.0 pH 8.0 pH 10.0	2 viable at 24 hrs. 2 viable at 24 hrs. 0 viable at 24 hrs. 1 viable at 24 hrs.	" "
Abscesses, 4 strains pH 2.6 pH 5.0 pH 8.0 pH 10.0	2 viable at 7 days 2 viable at 7 days 0 viable at 7 days 1 viable at 7 days.	" "
Spinal fluid showed various pH ranges		" "
<u>M. pyogenes var. albus</u> Sputum, antrum nose, skin, throat, urine and uterus showed various pH ranges		" "
<b>BLOOD</b>		
<u>Gaffkya spp.</u> Sterile rabbit blood susp.	5 yrs.	Frobisher 1947
<b>GENERAL</b>		
<u>Sarcina lutea</u> Swabbed in large amounts on tongue, nasal mucous membranes, crypts of tonsils. Impossible to recover in very short time		Bloomfield 1919

TABLE 5 //

THE SURVIVAL OF THE NEISSERIA  
SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>N. gonorrhoeae</u> Sterile serum sealed with layer of paraffin	16 mos.	Ungerman 1918
Sterile serum sealed with layer of paraffin	7-8 weeks	
<u>N. meningitidis</u> Below 16C., soaked in sterile horse serum	< 24 hrs.	Downie 1940
Nasopharynx, body temp.	Avg. 6 mos. (longest 608 das.; shortest 34 das)	Embleton 1919
<u>N. spp.</u> Sterile rabbit blood susp	Neisseria--6 wks-3 mos.	Frobischer 1947
<b>URINE</b>		
<u>N. gonorrhoeae</u> Male with urethritis 20-26C, pH 5-8.5	----- Two colonies survived 48 hrs.	Charles Carpenter 1933
Sediment 22C., pH 5.0-8.5	8 cols. survived 36 hrs.	
Sediment 4 C., pH 5.0-8.5	13 cols. survived 36 hrs.	
pH increments of from 5.0 to 8.5	Strains isolated--8, 23, 17, 19, 15, 0, 2	
Temperature	-----	Allison 1942
<b>GENERAL</b>		
<u>N. gonorrhoeae</u> Urthral secretion, -5 to 2 C., pH 7.4-7.6, grown on ascitic agar; plus 12 C, pH 7.4 plus 22 C, pH 7.4	1 hr. some reduction	Hamptman 1930
Urethra, body conditions	8 hrs. some reduction	
Fresh pus, 22-23 C.	12 hrs. some reduction	
Cases successfully treated & operated on.	< 3 yrs	Keyes 1911
	Still viable 24 hrs.	Schofield 1927
	No survival times	Cohn 1946
<u>N. meningitidis</u> Dried human secretions	Several days	Jungleblut 1935

TABLE B12

THE SURVIVAL OF PASTEURELLA  
SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>P. pestis</u> Blood allowed to putrefy in test tube	100 das.	Ostertag 1908
<u>P. of hemorrhagic septicemia</u> Physiological serum	5 mos.	Jacotot 1926
<b>FECES</b>		
<u>P. of swine plague</u> swine feces, 8 C.	Recov. 0 in 4-5 das	Gartner 1898
<u>P. spp.</u> Sterile feces	Still alive 2 wks-4 mos.	Gladin 1898
<b>SPUTUM</b>		
<u>P. pestis</u> Droplets	-----	Teague 1912
<b>URINE</b>		
<u>P. pestis</u> Sterile, R.T.	Still alive 3 mos.	Gladin 1898
<b>GENERAL</b>		
<u>P. pestis</u> Spleen of infected g.p., -15 C.	Virulent 14 mos., slight- ly vir. 2 yrs. 7 mos., dead 3 yrs. 5 mos.	Francis 1932
R.H. >37%, temp. >40 F.	Restricted to areas with these factors	Nonr 1951
Corpses of <u>C. pygmaeus</u>	Viable 23rd day after death	Novikova 1934
Frozen cadavers in Manch- uria	Viable 3 mos. after death	Strong 1942
Cadavers with putrid spl- een	4 days -	" "
Cadavers after burial	3-30 das.	
Glycerine in spleen, -15C.	Viable 7 yrs.	Frances 1932
<u>P. tularensis</u> 23-26 C., internal organs	3 das.	Anon. 1947
Human tissue	Viable M.O. obtained from human tissue 2-3 mos. after pt. recov.	Foshay 1936
Spleens glycerinated, -14C.	10-13 yrs.	Hull 1947
Frozen animal cord	42 mos.	
Frozen brain	36 mos.	
Frozen spleen	18 mos.	
Frozen muscle	12 mos.	" "
Frozen bone marrow	6 mos.	

TABLE B13 THE SURVIVAL OF RICKETTSIAE IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>R. conorii</u> Human blood, ice box	12 d	Blanc 1932
<u>R. rickettsii</u> Frozen brain, -70C	95 d	King 1930
<u>R. tsutsugamushi</u> Mice blood and tissues	610 d	Fox 1948
<b>FECES</b>		
<u>R. andersoni</u> Feces	6 yrs.	Philip 1948
<b>TISSUES, GENERAL</b>		
<u>R. rickettsii</u> -70C, frozen brain	321 d	King 1930
<u>R. prowazeki</u> Brain, 5C	79 d	Macchiavello 1937
Tunica vaginalis, 5C	92 d	" "

TABLE 14 THE SURVIVAL OF SALMONELLA SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
<b>BLOOD</b>			
Sterile rabbit blood susp.	1 yrs.	Probst	1947
<b>FECES</b>			
<u>S. enteritidis</u>			
Fluid stool, R.T., dark	8 d.	Dold	1947
Fluid stool, R.T.	8 d.	"	1943
Fluid Stool, R.T., dark	11 d.	"	1947
Dried stool, dark, R.T.	53 d.	"	"
<u>S. paratyphi</u>			
Original feces	74 d.	Dold	1947
Dried feces	421 d.	"	"
Fluid stool, dark, R.T.	18 d.	Dold	1944
Stool dried on paper, R.T.	>8 mos.	"	"
Fluid stool, dark, R.T.	20 d.	"	"
Stool dried on paper, R.T.	>5 mos, 16 d.	"	"
<u>S. paratyphi B</u>			
Fluid stool, R.T., dark.	115 d.	Dold,	1944
Fluid stool, R.T.	115 d.	"	1943
<u>S. schottmülleri</u>			
Fluid stool, R.T., dark	18 d.	Dold	1944
Stool dried on paper, R.T.	>8 mos.	"	"
Fluid stool, dark	20 d.	"	"
<u>S. species</u>			
Not found in feces of cockroaches		Macfie	1922
Rat feces, R.T.	148 d.	Welch	1941
<u>S. typhimurium</u>			
Original feces	74 d.	Dold	1947
Dried "	421 d.	"	"
<b>SKIN</b>			
<u>S. enteritidis</u>			
Palmar surf., clean, R.T.	Recov. 0, 10 min.	Arnold	1930
Dirty hands, Body temp.	5% gone, 30 min	"	"
Hands, after washing	100% gone, 30 min.	"	"
Palm of hand	Destroyed in 10 min.	Kruege.	1942
Dirty or fatty skin	Several hrs.	Singer	1929
<u>S. Paratyphi</u>			
Dirty or fatty skin	Several hrs.	"	"
<u>S. typhimurium</u>			
Turkey skin, frozen	13 mos.	Browne	1949
<b>TISSUE, GENERAL</b>			
<u>S. typhimurium</u>			
Chicken tissue, 93-96 C.	Inoc. $3.15 \times 10^9$ /gm.	Husseman	1951
after broiling	Recov. .18% in 42 min.		
after roasting	Inoc. $9.36 \times 10^8$ /gm.		
	Recov. 0.1% in 140 min.	"	"





TABLE 314 THE SURVIVAL OF SALMONELLA TYPHOSA IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>FECES, -CONT.</b>		
Fresh feces, 17-22 C. weakly acid.	Viable 115 d.	Uffelmann 1889
Fresh feces, 17-22 C. neutral	Viable 121 d.	"
Fresh feces & urine, -22 to 5 C., weakly alkaline	Viable 36 d.	"
Old feces & urine, 17-22 C. alkaline	Viable 115 d.	"
Old feces, 10 C. alkaline	Viable 116 d.	"
Fresh feces, weak acid	" 44 d.	"
Feces & urine in moist garden soil, 23-0 C.	" 5½ mos.	"
Fresh feces & urine, neutral, 10 C. or less.	" 66 d.	"
Fresh feces & urine, weakly alkaline, 10 C. or less	" 21 d.	"
Human feces on:		
dates	2 d.	Vasquez 1924
vinegar	1 h.	"
mango	2 d.	"
banana	2 d.	"
apple	4 d.	"
<b>SKIN</b>		
Self sterilizing ability of skin against organism due to drying		Dold 1919
Palm of hand	Entirely destroyed 10 min.	Krueger 1942
Washed hide	Inoc. 550, Recov. 1, 30 minutes	Norton 1932
Dirty or fatty skin	Several hours	Singer 1929
<b>URINE</b>		
Soaked in urine, dark	Inoc. 240,000, Surv. 10 d.	Hewlett 1909
Soil & urine, dry, lab. temp.	Inoc. 12,000/gm soil, Recov. 330/gm. soil, 7 d.	Horrocks 1911
Garden humus with urine, exposed on veranda, no rain, dry.	Inoc. 1,660/gm. soil, Recov. 280/gm. soil, 10 d.	" "
Warm temp.	< 20-40 d.	Lu 1933
-8 to -30 F., exposed to open air	40-50 d.	Lu-ti-huan 1930
12-17 C.	Viable after 4-12 d.	Schiller 1890
Urine infected water from well	A few days.	Vacek 1932
7% urine, dil. Ringers with 1% glucose	14 wks.	Zeller 1948
<b>TISSUE, GENERAL</b>		
Skin, clean	Inoc. 4,000, Recov. 1, 10 min.	Arnold 1930
Body temp., dirty fatty skin.	Several hrs.	Arnold 1930
Palmar surf., clean, body t.	Recov. 0, 10 min.	"
Human bile	>160 d.	Beckwith 1921
Beef bile	>141 d.	"
Oyster juice & stomach, 50-60 F., Ice broth cult.	30 d.	Foote 1895

TABLE B15 THE SURVIVAL OF SHIGELLA SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>FECES</b>		
<u>S. ambigua</u>		
Desert temp., in open box with flies	297 h.	Stewart 1944
<u>S. dysenteriae</u>		
R.T., 15-18 C.	From 5 to 15 d.	Cruickshank 1942
Fluid stool, R.T., dark	5-14 d.	" 1940
Original feces	31 d.	Dold 1947
Dried feces	113 d.	"
In artificially infected fecal material, the bacilli were detectable	3-4 d. when liquid and 33 d. dried.	"
(Ruhr bacillus), Fluid stool	8.2 d.	" 1943
" " Dried stool	27.2 d.	" 1944
" " Fluid, R.T., dark.	10 d.	"
" " Dried in dark.	1 mo.	"
" " Fluid, dark, R.T.	28 d.	"
Feces, 1.5-15 C. mixed with earth	> 101 d.	Hampil 1932
Stool, cool, dried	1-2 wks.	Joo 1950
Fresh feces	5 d.	Kusama 1925
-8 to -30 F., Exposed to open air.	Up to 55 d.	Lu-ti-huan 1930
Not found in feces of cockroach		Macfie 1922
Desert temp., out of sun.	11 d.	Stewart 1944
Human feces on mango.	1 h.	Vasquez 1924
" " banana	1 h.	"
" " apple	1 h.	"
<u>S. paradysenteriae</u>		
40 C. (flexneri)	96 h.	Barnard 1946
20 C. "	48 h.	"
30 C. "	24 h.	"
R.T. "	Dried out quickly in fecal specimens	Cruickshank 1940
Dried feces "	32 d.	Dold 1947
Original feces (Paradys.)	97 d.	"
Dried feces "	270 d.	"
Original feces (Hiss Y)	3 d.	"
Dried feces "	12 d.	"
Original feces (flexneri)	31 d.	"
Dried feces "	113 d.	"
Desert temp., out of sun	273 d.	Stewart 1944
Direct sun, all day.	1 hr. 20 min.	"
Human feces on mango	5 hrs.	Vasquez 1924
" " banana	2 h.	"
" " apple	4 d.	"
<u>S. sonnei</u>		
20 C.	72 h.	Barnard 1946
30 C.	24 h.	"
37 C.	6 h.	"
R.T.	6-11 d.	Cruickshank 1940
Feces	1-14 d.	Lowbury 1943

TABLE B15 THE SURVIVAL OF SHIGELLA SPECIES IN THE BODY. (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<p>URINE  <u>S. dysenteriae</u>            Urine, warm, indoor,            -8 to -30 F., Exposed to            open air.</p>	<p>40-50 d.            55 d.</p>	<p>Lu 1933            Lu-ti-huan 1930</p>
<p>TISSUES, GENERAL  <u>S. dysenteriae</u>            Filtered human gastric juice,            pH 4.5</p>	<p>Germicidal for Sonne-            Duval strain of            S. dysenteriae</p>	<p>Felsen 1939</p>

TABLE B1b THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>S. fecalis</u> Sterile rabbit blood susp.	7-19 yrs.	Frobiher 1947
<u>S. hemolyticus</u> R.T., liquid paraffin, arachis oil	8 wks. 4 wks.	Coulthard 1951
Refrig., liquid paraffin, arachis oil	4 wks.	"
Saliva, R.H., 40-55%	> 37 wks.	"
Sterile rabbit blood susp.	Mortality rates smaller than pneumococcus.	Dunklin 1948
" " "	Alive 18 yrs. (Beta)	Frobiher 1947
" " "	" 9 yrs. (Alpha)	"
<u>S. liquefaciens</u> Sterile rabbit blood susp.	7-19 yrs.	"
<u>S. spp.</u> Horse serum, 45 C. 37 C. for 3 hrs., defibrin- ated. Sprayed from chamber.	-- Increased from 600 org. per unit to 50,000/unit in 1-7 days.	Belin 1933 Buchbinder 1941
<b>SKIN</b>		
<u>S. pyogenes</u> Fingers, exposed 2 min.	Inoc. 1270, wash off 329	Burtenshaw 1938
" " 54 min.	" 1228, " 190	"
" " 118 "	" 339, " 3.1	"
Palm, exposed 2 min.	" 1270, " 50.6	"
" " 54 min.	" 1228, " .32	"
" " 118 min.	" 339, " 96	"
Forearm " 2 min.	" 1971, " 157	"
" " 60 "	" 1228, " 78	"
" " 120 "	" 339, " 78	"
Dead skin, " 3 min.	" 1971, " 88	"
" " 65 min.	" 1228, " 232	"
" " 120 "	" 339, " 14	"
Left palm, exposed 1/4 min.	" 48, " .22	"
Right palm, " 1/4 min.	" 48, " 0	"
Exposed to long chain fatty acids.	Lethal	Burtenshaw 1945
<u>S. hemolyticus</u> Normal skin of hand, R.T. From broth culture.	Recov. 30 million, 3 min. " 1.7 " 1 h. " 7,000 2 h.	Colebrook 1930 "
Hands of normal person	Group A isolated from hands of 7 out of 181. Non-hemolytic on nearly all of hands.	"
Skin of hands. Washed hide	6% viable, 1 h. Inoc. 1400, Recov. 400 30 min.	Krueger 1942 Norton 1932
Surface, washed hide	Inoc. 1,000, Recov. 75, 30 min.	"
Wounds	Alpha strep. found in 3 of 82 wounds.	

TABLE B/6 (CONT.) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>SKIN (CONT.)</b>		
<u>S. pneumoniae</u> Exposed to long chain fatty acids	Lethal	Burtenshaw 1945
<u>S. viridans</u> Exposed to long chain fatty acids.	Lethal	"
<b>SPUTUM</b>		
<u>S. hemolyticus (Beta)</u> Dried, 37 C. Saliva	Viable at 150 d. In 20% no strep. demonstrable. 80% same strep. as in throat culture.	Germano 1897 Hamburger 1944
<b>TISSUE, GENERAL</b>		
<u>S. hemolyticus (Beta)</u> Dried membrane, 37 C. Nasal secretion	Viable after 3 mos. Recoverable after last normal hand washing.	Germano 1897 Hamburger 1946
Nose & throat, sulfadiazine 1 gm/day.	More marked sensitivity in nose than throat.	"
Survived longer on skin than on filter paper.		Hellat 1948
Throat swabs, ice box, dried. 1/2 yr.		Jettman 1927
<u>S. spp.</u> Animal excreta, 61 F.	Inoc. 1-3, Recov. .03 in 7 d.	Savage 1917

TABLE B17 THE SURVIVAL OF VIBRIO SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>V. comma</u>		
R.T., dry, glass smear, fowl.	8 d.	Skidmore 1932
Turkey blood, 5 C., dried on glass	47 h.	"
Turkey blood, 37.5 C., dried on glass	47 h.	"
Beef bouillon, 37.5 C. in test tubes	Viable 6 wks.	"
<b>FECES</b>		
<u>V. comma</u>		
Flies in contact with material rich in organisms.	Found in feces	Alossandri -
Abs. humidity, 10-11 mg/cu. meter	Long enough for infection	Bey 1948
30 C.	Recov. 0 in 10 d.	Gartner 1898
8 C.	" " 5 d.	"
Rice water stools, dark cool weather	7-8 d.	Greig 1913
Rice water stools, dark warm weather.	1-2 d.	"
-8 to -30 F., Ex used to open air.	6-30 d.	Lu-ti-huan 1930
Feces	14 d.	Schiller 1890
Liquid manure	13 d.	"
Fresh feces & urine, 17-22 C., weak acid	Viable 24 h.	Uffelman 1889
9 C., weak acid	Viable 24 h.	"
Old feces, thin with water.		
17-22 C., weak alk.	Viable 96 h.	"
9 C., weak alkaline	Viable 24 h.	"
Fresh feces & urine, 17-22 C.	Viable 72 h.	"
9 C. or less	Viable 24 h.	
Diarrheic feces & urine, 17-22 C.	Viable 48 h.	"
9 C. or less	Viable 48 h.	"
Human feces on chico, cucumbers, papaya, lettuce	Overnight	Vasquez 1924
Human feces on cut cucumb.	> 20 hrs.	"
" " " papaya	< 44 hrs.	"
" " " shrimp	22 hrs.	"
" " " oysters	46 h.	"
" " " inside		
open clam.	4 d.	"
" " " dates	2 hrs.	"
" " " vinegar	1 h.	"
" " " mango	2 d.	"
" " " banana	2 d.	"
<b>URINE</b>		
<u>V. comma</u>		
Urine, warm, indoor.	< 20-40 d.	Lu 1933
-80 to -30 F., open air	6-30 d.	Lu-ti-huan 1930
Urine	14 d.	Schiller 1890

TABLE B18

THE SURVIVAL OF VIRUSES  
IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>BLOOD</b>		
<u>Hoof &amp; Mouth virus</u> -20C., thawed at R.T., 24 hrs. previous to test.	6-7 weeks	Henderson 1948
-10 to -20 C., thawed when tested	5 3/4 mos.	
G.p. lymph, pH 7.5, in phosphate buffer	2 yrs and 20 das.	Sichert-Modrow 1930
Dried lymph 70 C., dried in P <sub>2</sub> O <sub>5</sub> in vacuo	2 1/2 hrs.	
Dried lymph 122 C., dried with P <sub>2</sub> O <sub>5</sub> in vacuo	3 min.	" "
Dried lymph of g.p., 52 C in P <sub>2</sub> O <sub>5</sub>	Still infectious 14 hr.	
Dried lymph of g.p., R.T.	Still infectious 10 das	" "
Dried serum, R.T.	Still infectious 5 das.	
Dried plasma, R.T.	Still infectious 7 das.	
Dried preserved serum, R.T.	Still infectious 48 das	" "
Fresh g.p. lymph, 2-7 C., stored in cold room	Retained virulence 190 das.	Stockman 1926
<u>Herpes</u>		
U.V. radiation, fresh normal rabbit serum	10 min.	Gunderson 1932
Normal rabbit serum	40 min.	McKinley 1926
<u>Mexican typhus</u>		
Blood and tissue, 5 C.	79 das.	Macchiavello 1937
<u>Yellow Fever virus</u>		
Blood dried in vacuum while frozen	154 das.	Sawyer 1929
Monkey blood with liver, -10 C., in sealed sterile test tube	2 wks.	Sellards 1928
<u>Rift Valley Fever</u>		
Blood, refrigerator	62 days	Smithburn 1949
Blood, refrigerator (stored, fluid)	2 yrs.	
Serum, refrigerator	1048 das.	" "
<b>FECES</b>		
<u>Hoof &amp; Mouth virus</u>		
Inoc. g.p. tissue & stored -20C.	2-3 mos.	Andrews 1931
Moist, cool, 3.5-5.5 C., for 105 das., dried rapidly in vacuum, R.T.	283-345 Days	Hull 1947
<u>Infective Jaundice</u>		
Dust borne, dried	31 das.	Anderson 1947
<u>Newcastle virus</u>		
Dried chicken feces, pH 6.3 and 6.8		Olesiuk 1951
<u>Psittacosis</u>		
Exposed to HCOH, 0.2%, R.T.	Infective up to 10 das	Hull 1947



TABLE B/8 (CONT'D)

THE SURVIVAL OF VIRUSES  
IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>FECES (CONT'D)</b>		
<u>Polio virus</u>		
3-4 C.	>6 mos.	Kramer 1940
Stools	7-8 wks.	Horstmann 1944
Feces of child	Recov. 7 das, after onset of illness	Kramer 1939
Stools, virus found in stools, inactivated by inactivated sludge and chlorination		Krumblegel 1944
Stools of convalescents	25 and 123 das. after mild abortive polio	Lepine 1939
Feces of polio victims & carriers	Possibly a matter of hrs	Maxcy 1943
Stool	<6% viable	Paul 1941
Stool in transatlantic mail	16 das.	Paul 1939
Aqueous stool suspn., ice box.	2 1/2 mos.	Paul 1940
Refrigerated	10 wks.	Trask 1938
Stools of convalescents	25-123 das. after abortive cases	
Refrigerated	75 days	" "
<b>SKIN</b>		
<u>Influenza virus</u>		
Human skin, inoc. 0.2cc virus suspn.	50% recov. in 10 min.	Krueger 1942
Suspended in chick allantoic fluid, skin of hand	45-50 min.	Parker 1944
<u>Vaccinia virus</u>		
Light reduced 1/2	Pustule up to 8 hr.	Herzberg 1933
<b>SPUTUM</b>		
<u>Virus spp.</u>		
R.T.	Recovery positive, 92 das	Arloing 1927
<b>GENERAL</b>		
<u>Hoof &amp; Mouth virus</u>		
Inoc. g.p., 2 C.	2-3 mos.	Andrews 1931
Beef, -20 C, buffered sol.	4 mos.	Henderson 1948
Tissues, liver, kidney, rumen, 4 C.	24 hrs.	
Liver, rumen, lymph node, -10 to -20 C., thawed when tested	5 3/4 mos.	" "
4 C. pH 5.6	<3 das.	" "
-20 C., pH 6.8, thawed in buffered sol'n.	11 das	
120 C., pH 6.6, thawed in buffered sol'n.	4 mos.	" "
Muscles, near 0	1 wk	Rubino 1929
Bone	At least 40 das	
Carcass, -20C., pH 6.8	4 mos.	Henderson 1948
thawed at R.T.		
<u>Kinderpest virus</u>		
Live rabbits & storage	7 das.	Hadow 1947

TABLE B (CONT'D)THE SURVIVAL OF VIRUSES  
IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>GENERAL (CONT'D)</b>		
<u>Polio virus</u>		
Brain tissue, 37 C., in ascitic fluid kidney	20 but not 30 das.	Flexner 1915
Polio stored in animal tissue over long period of time does not retain viability.		Flexner 1917
Nasal washings of child	Recov. 5 das. after onset of illness	Kramer 1939
Nasopharyngeal washing	Recov. 9 das. after onset of illness	
Pharynx	Recov. 10% viable	Paul 1941
Fresh prep. in amoeba proteus	< 3 das.	Toomey 1948
<u>Rabies</u>		
Rabbit brain, 5 C.	> 68 das.	Remlinger 1934
Brain in glycerin, in disintegrator	47 das	Barrat 1904
Brain susp'n in liquid air, dil. 1:10	24 hrs.	
pH 2,	1 hr.	Dresel 1934
Acids & alkalis harmful in proportion to conc.		
<u>Herpes virus</u>		
20% susp'n of rabbit brain in buffered physiological saline, 37 C.	100 hrs.	Book 1940
Brain emulsion	40 min	McKinley 1926
U. V. radiation, cornea	< 15 min.	Gunderson 1932
<u>Yellow Fever virus</u>		
Liver, -12 C.	> 1 mo.	Sawyer 1929
Mouse brain, 8 C.	Non-virulent, 160 das.	Theiler 1930
Mouse brain plus 50% glycerin, stored at 2-4C.	Infective after 58 das. but not after 100 das.	
Mouse brain in whole monkey serum, -78 C.	6 mos.	Turner 1938
<u>Influenza virus</u>		
Palmar skin	Recov. 10 in 10 min.	Anon. 1943
Mouse brain susp'n in N rabbit serum, -20 to -30C.	< 6 mos.	Olitsky 1949
Mouse lung susp'n in 10% brain broth, -78C	6 mos.	Turner 1938
Frozen rabbit testes, -78 C.	3 yrs.	Turner 1939
<u>Newcastle Disease virus</u>		
Skin, eviscerated carcass, 34 F., exp. infected	96 das	Asplin 1949
Bone marrow	134 das	
Unplucked carcasses, skin;	160 das	
bone marrow	196 das	" "
<u>Fowlpox virus</u>		
Dried material from lesions	2 yrs.	Loewenthal 1906

TABLE B7C (CONT'D)THE SURVIVAL OF VIRUSES  
IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>GENERAL (CONT'D)</b>		
<u>Polio virus</u>		
Brain tissue, 37 C., in ascitic fluid kidney	20 but not 30 das.	Flexner 1915
Polio stored in animal tissue over long period of time does not retain viability.		Flexner 1917
Nasal washings of child	Recov. 5 das. after onset of illness	Kramer 1939
Nasopharyngeal washing	Recov. 9 das. after onset of illness	
Pharynx	Recov. 10% viable	Paul 1941
Fresh prep. in amoeba proteus	< 3 das.	Toomey 1948
<u>Rabies</u>		
Rabbit brain, 5 C.	> 68 das.	Remlinger 1934
Brain in glycerin, in disintegrator	47 das	Barrat 1904
Brain susp'n in liquid air, dil. 1:10	24 hrs.	
pH 2,	1 hr.	Dresel 1934
Acids & alkalis harmful in proportion to conc.		
<u>Herpes virus</u>		
20% susp'n of rabbit brain in buffered physiological saline, 37 C.	100 hrs.	Book 1940
Brain emulsion	40 min.	McKinley 1926
U. V. radiation, cornea	< 15 min.	Gunderson 1932
<u>Yellow Fever virus</u>		
Liver, -12 C.	> 1 mo.	Sawyer 1929
Mouse brain, 8 C.	Non-virulent, 160 das.	Theiler 1930
Mouse brain plus 50% glycerin, stored at 2-4C.	Infective after 58 das. but not often 100 das.	
Mouse brain in whole monkey serum, -78 C.	6 mos.	Turner 1938
<u>Influenza virus</u>		
Palmar skin	Recov. 20 in 10 min.	Anon. 1943
Mouse brain susp'n in N rabbit serum, -20 to -30C.	< 6 mos.	Olitsky 1949
Mouse lung susp'n in 10% brain broth, -78C	6 mos.	Turner 1938
Frozen rabbit testes, -78 C.	3 yrs.	Turner 1939
<u>Newcastle Disease virus</u>		
Skin, eviscerated carcass, 34 F., exp. infected	96 das	Asplin 1949
Bone marrow	134 das	
Unplucked carcasses, skin;	160 das	
bone marrow	196 das	" "
<u>Fowlpox virus</u>		
Dried material from lesions	2 yrs.	Loewenthal 1906

TABLE B18 (CONT'D)THE SURVIVAL OF VIRUSES  
IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>GENERAL (CONT'D)</b>		
<u>Vaccinia virus</u>		
Mouse brain, 4 C., Dried over CaCl <sub>2</sub> in sealed glass vessels	Still virulent to mice in 71 hrs.	Haagen 1939
Mouse brain tissue, 20% glycerin in water, strain II Neurolapine R.G.A.	Recov. after 28th passage-10 mos.	" "
Mouse, brain, temp. of freezing-drying apparatus, strain II Neurolapin R.G.A.	Recov. after 1 yr 9 mos	" "
Mouse brain tissue, 4 C., strain II L 3 b.	Recov. after 2 yrs.	" "
Mouse brain tissue plus glycerin, refrigerated, Strain II L 3 b.	Not virulent after 1 yr.	" "
Mouse brain, temp. of freezing-drying apparatus, Strain II L 3 b	Still showed skin reaction after 1 yr.	" "
Mouse brain plus glycerin Strain II L 3 b	Still showed skin reaction after 6 mos.	" "
Chorion plus calf lymph, temp. of refrigerator, Strain III Breslan	Still showed skin reaction after 2 yrs.	" "
Chorion plus calf lymph, temp. of refrigerator, Strain IV Dresden	Still virulent after 2 yrs.	" "
Chorion, 4 C. Strain V Hanover	Not given	" "
<u>Neurotropic viruses</u>		
-20 to -30 C.	9 mos.	Olitsky 1949
<u>Encephalitides</u>		
Brain tissue, 50% glycerin Dried	1 yr.	Hull 1947
Frozen	Lose virulence	
pH below 5.5	>3 mos.	
pH 9.2	Lose viability	" "
Mouse brain susp'n in N rabbit serum -20 to -30C (Jap.B encephalitis)	Viability returns <6 mos	Olitsky 1949
Mouse brain emulsion in plain broth, -78C.	6 mos.	Turner 1938
<u>Meningo-meningitis</u>		
Frozen rabbit testes, -78C	3 yrs.	Turner 1939
<u>Lympho-granuloma inguinale</u>		
Frozen rabbit testes, -78C.	10 mos.	
<u>Smallpox virus (Variola)</u>		
Dry crusta, R.T., daylight and dark	Long periods >1 yr.	Downie 1947

TABLE B18 (CONT'D)THE SURVIVAL OF VIRUSES  
IN THE BODY  
(AND BODY MATERIALS)

Factor(s)	Survival	Reference
<b>GENERAL (CONT'D)</b>		
<u>Pneumoenteritis virus</u>		
Calf lung, 60, filtered thru Berk. or Seitz filter	Recov. 0 in 10 min.	Gallo 1948
55 C., filtered, dried	Still active in 10 min.	
Dried lung in refrigerator	No activity, 20 das.	"
Frozen dried lung	No activity, 6 das.	"
<u>Virus spp.</u>		
Some viruses retain their activity in vitro for several yrs. Some bacteriophage endure for a long time in bacteria free filtrate		Boycott 1928
Leukocytes and spleen tissue, 4 C., dried by ppt. by cold acetone	>2 mos.	Das 1949
4 C. dried over calcium chloride in vacuum	>4 mos.	
37 C.	15 das.	

TABLE BM THE SURVIVAL OF GENERAL BACTERIA IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	REFERENCE
Gastric juice	Organisms recovered 5 $\frac{1}{2}$ hrs. after feeding dogs 500 cc. alk. milk with organisms.	Arnold 1926
Sweat. Freshly secreted. May have mild antiseptic value due to acid pH imparted by lactic acid.	environment rich in bacteria as respiratory and digestive tract have strong inhibitory effect on bacteria which is lacking on tissue surfaces of the body cavities such as pleura, pericardium, peritoneum. Saliva plays important role since it contains inhibitors sensitive to cold, soluble in water and precipitated by alcohol, chloroform, and acetone.	Bergeim 1943
Tissue surfaces in contact with environment rich in bacteria as respiratory and digestive tract have strong inhibitory effect on bacteria which is lacking on tissue surfaces of the body cavities such as pleura, pericardium, peritoneum. Saliva plays important role since it contains inhibitors sensitive to cold, soluble in water and precipitated by alcohol, chloroform, and acetone.	Deltoid area: aerobic 70 organisms. Anaerobic 37 "	Dold 1947
4 days since bath. Skin scrapings.	Scapular area: aerobic, 47 organisms. anaerobic, 10 "	Evans 1950
7 days since bath. Skin scrapings.		
Saliva sprayed in air	36 hrs.	Lukriech 1947
Hands & arms.	Inoc. 1,580,000, Recov. 1,000,000 after scrubbing 14 min.	Price 1938
Sores on man & beast, 110-120 F	* Organisms destroyed.	Sternberg 1894
Sun on sores.		

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN CULTURE

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THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN CULTURE

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TABLE Q / THE SURVIVAL OF BACILLUS ANTHRACIS IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
Dark, R.T.	4½ yrs. and 35 yrs., retained full immunizing properties	Novel 1947
Attenuated, 5-10C	Viable and virulent for G.P. after 8 yrs.	Stein 1947
37C, 2 mos. old, dried rapidly	6 hrs.	Swann 1924
<b>LIQUID</b>		
Liquid air	6 hrs. required to kill	Becquerel 1910
Bouillon tubes	2 mos.	Duclaux 1885
Broth tubes, killed with 1% formaldehyde with caporite soln & 1% active Cl	2 hrs.	Hailer 1948
Broth tubes, killed by Chloramine soln with 1% active Cl	4 hrs.	" "
Bouillon susp., R.T.	10 wks.	Kirstein 1902
Bouillon, 18C, strong wind, direct sun	Inoc. 1,254 Col., Recov. 0, 80 d.	Kruse 1895
Bouillon, 37C, in dark	Inoc. 4,158 Col., Recov. 94, 80 d.	" "
Liquid air, -185C	No impaired vitality, 20 hrs.	MacFayden 1899
Broth emulsion with unsterilized milk, liquid air	No impaired vitality 7 d	MacFayden 1900
Liquid H <sub>2</sub> , -252C	10 hrs.	" "
Serum, 37C	69 d.	Panisset 1925
Nutrient, sunlight, air	24 hrs.	Roux 1887
Nutrient, sunlight, no air	83 hrs.	" "
Bouillon	30 hrs.	Sanfelice 1893
Attenuated spores in N. saline & glycerine, 5-10C	Viable for G.P. after 11-14 yrs.	Stein 1947
Phys. serum with glycerine 20-30C	dil. 10 <sup>9</sup> 114 d.	Velu 1931
" " "	dil. 10 <sup>8</sup> 1072 d.	" "
" " "	dil. 10 <sup>7</sup> 1072 d.	" "
" " "	dil. 10 <sup>6</sup> 1877 d.	" "
Bouillon cult., direct sunlight on paper slips	8 hrs. for bacteria, 5 hrs. for spores	Weinzirl 1914
Liquid air in glass	No change 90 min.	White 1901
<b>SOLID</b>		
Plate cultures	30 hrs.	Arloing 1885
Spores, bouillon, test tube	2 hrs.	" "
Agar & gelatin plates, exposed to sunlight	1½ hrs. (July, Mar., Aug.) 2½ hrs. (Nov.) 4½ hrs. (winter)	Dieudonne 1894
Agar plates, R.T.	2-3 wks.	Jones 1942
Agar, 37C	18½ hrs.	Lauder 1932
Nutrient agar tubes, ozonized air thru tube	No change at 8 d.	Ransome 1901

TABLE C / THE SURVIVAL OF BACILLUS ANTHRACIS IN CULTURE

Factor(s)	Survival	Reference
<p>SOLID, (cont'd)</p> <p>Agar, incub. temp. Agar cult. 2-3 days old.</p> <p>Agar cult. 8 mos. old, kept over fused CaCl<sub>2</sub></p> <p>Gelatin agar, 180C, sun- light for 6 d.</p>	<p>Viable 24 hrs. 5% incapable of germin- ating 7 hrs.</p> <p>7 hrs.</p> <p>2-6 hrs.</p>	<p>Sanfelice 1893</p> <p>Swann 1924</p> <p>" "</p> <p>Ward 1892</p>
<p>GENERAL</p> <p>80C. (Str. R1009)</p> <p>Best time &amp; temp for heating suspected infected with anthrax 5 min @ 65C.</p> <p>Continuous freezing at -60 to -70C, blood susp.</p> <p>18 hr. serum broth cult. -5 to -10C.</p> <p>Boiling</p>	<p>Inoc. 234, Recov. 200 after 2 hrs. expos. to alkali</p> <p>Organisms destroyed in 90-124 d.</p> <p>Viable for G.P. after 10 yrs, 8 mos.</p> <p>10 min.</p>	<p>Jones 1942</p> <p>" "</p> <p>Stein 1947</p> <p>" "</p> <p>Topley 1936</p>

TABLE 7. THE SURVIVAL OF BACILLUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>B. spp.</u> Dried	4-5 yrs.	Proom 1949
<b>LIQUID</b>		
<u>B. cereus</u>		
Broth, before centrifug.	100% survive	Winslow 1927
" after "	56% "	"
1 hr. later	71% "	"
Peptone, before centrifug.	100% survive	"
" after "	43% "	"
1 hr. later	53% "	"
Meat extract, before cent.	100% "	"
" " after "	51% "	"
1 hr. later	57% "	"
1/2 Locke-Ringers, before centrifuge	100% "	"
" " after cen.	3% "	"
1 hr. later	1% "	"
<u>B. pasteurii</u>		
" "	8-16 min.	Davis 1948
" "	Inoc. 100 million spores, Recover 0.16 min.	"
Gaussian violet, H <sub>2</sub> O <sub>2</sub> , Streptomycin 98.5 F.	Resistant to action	"
<u>B. megatherium</u>		
Bouillon cult. direct sunlight on paper slips	Spores, 6 h.	Weinzirl 1914
<u>Preisz-Nocard bacillus</u>		
Serum in flask, light	11 mos.	Urbain 1930
" " dark	13 mos.	"
<u>B. radiclecola</u>		
Solution	142 d.	Alicante 1926
<u>B. radiobacter</u>		
Solution	10 min	"
<u>B. subtilis</u>		
High press., 17,600, R.T.	45 min.	Basset 1932
Alcohol & alcohol	6 mos.	Hite 1938
Bouillon cult. sunlight	Bact. 8.5 h., spores 5h.	Weinzirl 1914
<u>B. vulgaris</u>		
Bouillon cult. sunlight	5 h.	"
<b>SOLID</b>		
<u>B. alcaliphilus</u>		
Agar, Exp. to UV 30 min.	Acquired slight germi- cidal properties.	Tanner 1930
<u>B. fluorescens putridus</u>		
Agar & gelatin plates exp. to sunlight	2 1/2 hrs.	Dieudonne 1894
<u>B. megatherium</u>		
Agar covered with sterile 10% cane sugar, 10 C.	8 mos.	Keith 1913
Agar, Exp. to UV, 30 min.	Acquired slight germi- cidal properties	Tanner 1930



TABLE C 2 THE SURVIVAL OF BACILLUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID</b>		
<u>B. proteus</u> Nutrient agar, 0-50	No growth	Haines 1934
<u>B. Subtilis</u> Agar cov. with sterile cane sugar, -100	Survived	Keith 1913
Agar, exp. to UV, 30 min.	Acquired slight germi- cidal prop.	Tanner 1920
<b>GENERAL</b>		
<u>B. megatherium</u> -5 to -150	Resisted better than higher temp. >272° C.	Campbell 1932 Lal 1921
<u>B. mesentericus</u> Broth, -13 to -150 Salt soln., -13 to -150	>80 wks. >90 wks.	Tanner 1928 " "
<u>B. subtilis</u> Broth, -13 to -150 Salt soln., -13 to -150	>80 wks. >80 wks.	" " " "
<u>B. globigii, B. thermocic- curans, B. subtilis</u> Factors had little if any Heat resistant spores were developed. Resistance to phenol and iodine paralleled heat resistance.	Amino acids & growth effect on sporulation. development. Resistance paralleled heat resistance.	Williams 1948
<u>B. brevis, B. subtilis, B. megatherium, B. lobi- gii, B. cereus</u> Spore forming bacilli that produce spores of un- equal heat resistance. Spores of B. cereus were not affected by any of the amino acids, growth factors, or yeast nucleic acids as nutrients.	Species of aerobic produce spores of un- equal heat resistance. Spores of B. cereus were not affected by any of the amino acids, growth factors, or yeast nucleic acids as nutrients.	Williams 1951
<u>B. mycoloides</u> Bouillon cult., direct sun on paper slips.	Survived 6 hrs., spores 5 hrs.	Reboul 1911
<u>Bacterium linens</u> Litreus milk, 20C " " R.T.	Inc. 152,000,000/ml. 1/1., 17 C. 4 hrs.	Albert 1944 " "

TABLE 3 THE SURVIVAL OF BACTERIOPHAGE IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Typhoid phage</u> 32% NaCl dehydrated in Raust-Heim apparatus.	Viable 26 yrs.	Marcuse 1949
<u>Phage, general</u> Dried in vacuo Dried	3½ yrs. More resistant to heat	Campbell 1947 Vodder 1939
<b>DRIED, LYOPHILIZED</b>		
<u>E. coli and staphylococci</u> 78 C. and thawed 20X " " " " " " " " 10th " " " " " " " " 100th " " " " " " " "	Did not lose activity 16% failed to survive 86% " " " 99% " " "	Sanderson 1945 " " " "
<u>Dysentery phage</u> Addition of 1% gelatin with lyophilized destroyed lytic activity of dysentery phage. Raw egg whites protected phage for inactivating effect of glyco- gen. Difco yeast, difco brain heart infusion, fresh aqueous extracts of heart, muscle, liver, pancreas, brain, thymus, & kidney effective in promoting stability of sensitive phage during lyo- philization. Lecithin extracted from raw egg yolk gave protection to sensitive phage equal to that afforded by egg yolk itself. Stable on exposure for 48 h. to temp. of 55 C. Passage thru 0.5% HCl causes loss of lytic activity. Loss of activity followed desiccation. No particular pH favors lytic activity. Addition of cysteine, ascorbic acid & removal of O <sub>2</sub> prior to lyophil. failed to affect stability.	Schade 1944	
<b>GENERAL</b>		
<u>Staphylococcus phage</u> .01 1% methylene blue, indirect sunlight	5 min.	Clifton 1931
<u>E. coli phage</u> 2-5 C. (R1) " (R1 & R2)	11 yrs. 7-17 yrs.	Raketen 1947 "
<u>Dysentery phage</u> Powdered & kept dry, 37 C.	No loss in activity after 6 mos.	Schade 1943
Addition of meat, gelatin, dried egg alb., peptone, gastric mucin, human serum & human plasma. pH 3.3-4.3. 48 hrs, 18 C. Less resistant to same pH at 37 C. in acid med. pH 10-9-55, 24 h, 18 C. More resistant to same pH levels at 37 C. More resistant to pH than corresponding organism.	No constant protection for phage  Survives  Survives	Schade 1944  Sierakowski 1930  "  "

TABLE C 4 THE SURVIVAL OF BORRELIA, LEPTOSPIRA & SPIRILLUM IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, LYOPHILIZED</b>		
<u>Borrelia</u>		
-78C (duttoni) Blood drawn early in disease regains motility better than blood drawn late. (novyi)	1 yr.	Turner 1939
-78C. (novyi) Rat blood, -12 to -20C (recurrentis)	1 yr.	Lofgren 1945 Turner 1939
Warming from -78C to 0C. over 2-6 hrs. period (swellengrebel)	Infectivity reduced 6 wks.	" "
-78C (tickmouse) Dried from frozen state (vincenti)	Kills most of organisms 1 yr.	" "
Lyophil. vaccine has greater stability than regular liquid vaccine.	192 hrs.	Hampp 1947
<u>Leptospira icterohemorrhagiae</u>		Verwey 1950
Rabbit testes in infusion broth, -78C	10 mos.	Turner 1939
20% tissue susp. in infusion broth, -78C	Actively motile 10 mos.	" "
<u>Spirillum minus</u>		
Mouse blood & peritoneal fluid, -78C	Viable for mice, 1 yr.	Turner 1939
<b>LIQUID</b>		
<u>Leptospira icterohemorrhagiae</u>		
Serum Ringers soln., 42C	5 d.	Anjow 1928
Physiol. saline, 29C	20 d.	Reitano 1939
Physiol. saline. variable temp.	8 mos.	" "
Serum, 37C	6 wks.	" "
" 30C	3 mos.	" "
" variable	7 mos.	" "
.2% guinea pig blood, 30C	16 mos.	" "

TABLE C5 THE SURVIVAL OF BRUCELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
DRIED, GENERAL <u>Brucella, species</u> Dried	4-5 yrs.	Proom 1947
LIQUID <u>Brucella abortus</u> Broth, 15-20 F., dry Saline, 62 C.	400 d. all dead 1 min.	Feldman 1935 Seelemann 1938
<u>Brucella melitensis</u> Broth	15 d.	Bellelli 1928
<u>Brucella suis</u> Aerated broth cult. with dextrose & ascorbic acid. 20-25 C.	2 mos.	Elberg 1947
<u>Brucella, species</u> Soln. buffered to pH 7.2	4-5 wks.	Zobell 1932
SOLID <u>Brucella melitensis</u> Nutrient gel, 22 C.	No change 8 d.	Ransome 1901
GENERAL <u>Brucella abortus</u> Incub. 30 d. @ 37 D.  The three smooth types were similar in virulence, antigenic prop. The three differed in resistance to alanine which accumulates in culture fluid. Original smooth type will grow in alanine. Elevation in temp causes reduction in # of viable cells. Recovery when difference between temp. of ice film & surface of surrounding sample is small. At high moisture % of viable cells is very low. Increase in dryness increases survival after storage. Slow rate of drying increases % viable cells. Recovery of viable cells after freezing-drying low unless NaCl present. 2-5 %  Optimum pH 7-7.4 <u>Brucella melitensis</u> Stored 37 C. <u>Brucella, species</u> Sunlight and drying	Smooth replaced by Smooth X at end of 30 d.           Innoc. 25 b/cc. Recov. 20.2 b/cc, 100 d.	Goodlow 1951 " Hutton 1951  Verwey 1950 Zobell 1932  Stamp 1947  Polding 1947

TABLE 96 THE SURVIVAL OF CLOSTRIDIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Cl. novyi</u>	4-5 yrs.	Proom, 1949
<u>Cl. perfringens</u>	3-4 yrs.	" "
<u>Cl. septicum</u>	3-4 yrs.	" "
<u>Cl. spp.</u>	4-5 yrs.	" "
<b>DRIED, LYOPHILIZED</b>		
<u>Cl. botulinum</u> Sorenson buffer soln. pH 6.9, frozen with carbon dioxide	±20C for 9 days had no effect on spores, slow or quick freezing had no effect on spores.	James 1933
<b>LIQUID</b>		
<u>Cl. tetani</u> Glycerine under high pressure. (13,500 atm)	20% active 45 min.	Basset 1932
<u>Cl. botulinum</u> Uninoculated dextrose broth exposed to O <sub>2</sub> for 1 hr.	Recov. 32-81%	Dack 1929
" pH 6.8 Unbuffered salt soln. Subcult. in beef heart 100C with 4% peptone Above plus PO <sub>4</sub> Casein digest	Recov. 0-57% Recov. 0-37%	" "
10C refrig. foods	Recov. in 1½-2½ hrs. Recov. in ¼ hrs. Heat resist. 4½ hrs. Most resistant in 4-8 day cultures.	Sommer 1930 " " " "
5C " "	Growth only after 27 d.	Tanner 1940
Glucose, beef infusion broth, heated in water bath 70-73C	No growth up to 108 d. 10 min.	" " Thom 1919
10% salt broth, R.T., Lg. # strains ranging from 1-10 not inhibited when in alkaline med.	>49 d.	Wyant 1920
<u>Cl. tetani</u> Grown in dextrose bouillon 3 mos.	Viable 2½ mos.	Wesbrook 1896
<b>SOLID</b>		
<u>Cl. tetani</u> Sealed agar tubes Agar, 37C	38 yrs. 20-25 d.	Boventer 1947 San Felice 1893
<b>GENERAL</b>		
<u>Cl. botulinum</u> >5F 100C, moist, 5 hrs., pH 6.8-7.0	140 d.	Campbell 1932
105C, " 2 " "	Spores destroyed " "	Tanner 1923 " "

TABLE C 6 THE SURVIVAL OF CLOSTRIDIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
GENERAL (cont.)		
110 C., 1.5 h, pH 6.8-7.0	Spores destroyed	Tanner 1923
115 C., 40 min, "	"	"
120 C., 10 min., "	"	"
16 C.	Young spores more resis.	"
" in fruits and veg.	14 mos.	" 1931
Direct sunlight, cotton plugged tubes	> 2 yrs.	"
Diffuse light, "	24-40 h.	Thom 1919
100 C.	2 mos.	"
100 C. pH 7.5	1 h.	"
105 C. "	Killed 5 h.	Weiss 1921
120 C. "	40 min.	"
	6 min.	"
	Decrease in thermal resistance as spores age.	
	H ion decreases resistance of spores to heat.	
<u>Cl. fragilis</u>		
37 C.	24-30 h.	Repaci 1910
Refrig.	1 mo	"
<u>Cl. moniliformis</u>		
37 C.	4 wks.	"
R.T.	2½ mos.	"
<u>Cl. perfringens</u>		
37 C.	3 d.	"
Refrig.	1 mo.	"
<u>Cl. tetthoide</u>		
37 C.	6 d.	"
R.T.	6 wks.	"

TABLE 7 THE SURVIVAL OF CORYNEBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>C. diphtheria</u>		
Dried	4-5 yrs	Proom 1919
<u>C. Magnusson-Holth</u>		
Dried, dark	6 wks.	Ottosen 1945
Daylight	2-4 wks.	"
<u>C. pyogenes</u>	4-5 yrs.	Proom 1940
<u>C. spp.</u>		
Dried	4-5 yrs.	"
<b>LIQUID</b>		
<u>C. diphtheria</u>		
Bouillon	Recov. o, 24 h.	Abel 1893
Washed serum, dried in daylight	121 d.	"
Susp. in physiol. salt soln., washed -48 C.	6 mos.	Cordova 1949
2% glycerine, - 48 C.	6 mos.	"
phosphate buffer, - 48 C.	6 mos.	"
Proteose peptone, - 48 C.	6 mos.	"
Old bouillon	1 cult. viab. 6 mos.	Kasaňsky 1899
Bouillon susp. from diph. memb., R.T.	Innoc. 100,000 col. recov. 8, 21 h.	Kirstein 1902
" in daylight	24-48 h.	"
Bouillon susp., R.T., cellar	5 d.	"
Bouillon	523 d. (Bombay Str.)	Lal 1921
Broth emuls., unster. milk, liquid air,	No impaired vitality 7 d	MacFayden 1900
Liquid hydrogen, -252 C.	10 h.	"
Physiol. saline, r.t., absolute drying over sulfuric acid in vacuo	Innoc. blood or serum agar. Viable for mos.	Otten 1930
Sensit. with Met. violet	Recov. o, 5 min.	Philibert 1926
Pure culture swabs, dark	60 d. Pathogenic following isolation.	Schofield 1916
Liquid air in glass	Pathogenic 50 hrs. following dessic. with light.	
Recov. 35% in 2 hrs.		White 1901
<u>C. Magnusson-Holth</u>		
.5% formaldehyde	Killed in 3 h.	Ottosen 1945
<u>C. pyogenes</u>		
Pure culture	30 d.	Kirstein, 1902

TABLE (7) The SURVIVAL OF CORYNEBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID</b>		
<u>C. diphtheria</u> Gelatine Gelatine in dark Agar cult. Agar cult. in dark, R.T. Loefflers, -23.5 C., old cult., 24 d. Loefflers, 23.5 C., old cult. 24 d. " " Glycerine agar tubes 37 C., ozonized air aspirated thru tube	18 mos. still alive 331 d. 7 mos. Still viable 171-172 d.  Viable 86 d.  Viable 86 d. Str. 2, no growth. 86 d. Str. 5, 2 colonies viable 86 d. No change at end of 8d.	Abel 1893 " " " Abel 1895 " " " Ransome 190
<b>GENERAL</b>		
<u>C. diphtheria</u> Incubator, dried, R.T.	7 mos.	Abel 1893
<b>ERYSIPELOTHRIX RHUSIOPATHIAE</b>		
<b>DRIED</b>		
Dried Stored at 37 C.	4-5 yrs. 2.6% survived 4 yrs.	Proom 1949 Stamp 1947



TABLE C 8 THE SURVIVAL OF DIPLOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>D. pneumoniae</u>		
Dried and formalized with modified gastric mucin	9 weeks, agglutinated 4 weeks, capsules dis-integrated	Bourn 1947
Dried 38 C.	7-8 yrs.	Lal Kalra 1948
Less than 17 C.	6-8 yrs. 4-5 yrs.	Patella 1922 Proom 1949
<b>DRIED, LYOPHILIZED</b>		
<u>D. pneumoniae</u>		
Dried, frozen, plain broth	3 yrs	Stillman 1944
"	Type 1, recov. 42% 3 yr.	"
"	" 2, " 69% 3 yrs.	"
"	" 3, " 62% 3 yrs.	"
"	" 8, " 72% 3 yrs.	"
Dextrose agar	> 3 mos.	Swift 1921
<b>LIQUID</b>		
<u>D. pneumoniae</u>		
Broth, saliva or 0.5% saline susp. RH 50%	high mortality	Dunklin 1948
Physiol. saline, R.T., abs. drying in vacuo.	Innoc. on blood or serum agar. Viable mos.	Otten 1930
Sensit. with Met. violet	Recov. 0-15 min.	Philibert 1926
36-38 C. with Hb.	50-60- d.	Rymowitsch 1902
Beef bouillon	36 h.	"
"T" med. with 2 vol. 15% gel. in phys saline, ice-box temp.	> 6 mos.	Truche 1912
Blood with glucose or serum broth, ice box, hermetically sealed	several mos.	Yourevitch 1930
<b>SOLID</b>		
<u>D. pneumoniae</u>		
1 part nutrient agar and 5 parts sterile ascitic or pleuritic fluid.	Short incubation > 3 mos.	Wadsworth 1903
Stock agar cult. covered with thin layer rabbit blood.	50 d.	Washbourn 1896
<b>GENERAL</b>		
<u>D. pneumoniae</u>		
37 C.	> 132 d.	Lal 1921
Change in pH from 7.80 to 4.47 from 13 h. to 1 h.	Progressive increase in death rate	Lord 1922
80 F., daylight	Type 3, Smooth 5 mos.	Stillman 1940
110 C., dry	30-60 min.	Yesair, J
56 C., moist	< 60 min.	"

TABLE C 9 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
Dried in desiccator	10 d.	McNair 1910
Dried	1 1/2 yrs.	Boyer 1919
Vacuum dried, 195 C.	4 d.	Boyer 1919
Air dried, dark	1 d.	"
<b>DRIED, LYOPHIL</b>		
Susp. in broth, -185 C. Frozen and thawed 12 times	Immed. 180,000,000 Recov. 40,000	Rivers, T. 1927
<b>LIQUID</b>		
Saline susp. 6-11 C., RR 70-85%, CO <sub>2</sub> 5-14%		Acad. 1931
1% glucose or lactose in 1/2% Witte peptone & 1/2% di potassium in dist. water	Immed. 100,000,000 after 24 hrs, recov. 0.5 d.	Burling 1918
Dextrose bouillon. Freezing vacuum desicc., freeze 47 h.	2 1/2 d.	1918
Culture age 48 hrs.		
Above with culture age 2 1/2 h. freezing 2 1/2 h	57 d.	"
Bouillon culture 5 d.	Immed. 1,200,000,000/cc Recov. 190,000,000/cc in 62h.	Boberg 1932
	Immed. 15,000,000/cc Recov. 1500/cc, 1 3/4 h	
	Immed. 14,500,000/cc Recov. 7,000/cc, 2 1/2 h.	
Glucose soln. -6 C.	10% dead	Hilliard 1918
Glucose, tap water, 10 C.	3 hrs.	"
Glucose soln. 0.5 C.	3 hrs.	"
" 1.5 C.	3 hrs.	"
" 5 C.	3 hrs.	"
M/15 10% buffer 2 C., irradi. O <sub>2</sub> tension lowered	Partial destruction of 90% or more when frozen in tap water for 3 hrs. Showed 1/3 sensitivity when oxygen tension lowered by saturating with N <sub>2</sub> or CO <sub>2</sub> . Protect. given by adding glucose or addition of cysteine	Hollander 1951
Sterile buffer soln. 15.5 C.	Kill 80%, 10 min.	Horwood 1950
With ultra sonicator	" 80%, 15 min.	"
1% soap soln., 4-8 C.	" 99%, 40 min	"
2% " "	6 h.	Jelle 1895
8% " "	6 h.	"
8% " " 18% 30 C.	30 min	"
6% " "	1 h.	"
2% " "	6 h.	"
1% " "	2 1/2 h.	"

TABLE 9 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID (Cont.)</b>		
Buffered media, 5 C.	Maximal survival	Jordan 1948
pH 6.5-6.6	610 min. 90% mortality	"
pH 7.0-6.4	abnormally sensitive	"
pH 2.8	99% mortality 11 h	"
	" 12 min	"
.85% NaCl, 252 C	3 h	Kadisch 1931
NaCl soln	Still recoverable 6 wks	Karaffa 1912
5.42% G.P. glycerine, 20 C	Large % alive 6 mos.	Keith, 1923
susp. in water		
Cultures, R.T., dark in	358 d.	MacConkey 1905
inverted Pasteur dish		
185 C Liquid air	No impaired vitality 20%	MacFayden 1899
Broth emulsion with steril		
milk, liquid air	No impaired vitality 71	MacFayden 1900
Quill tubes, liquid air		"
Liquid H <sub>2</sub> O, 252 C, sealed	10 h	"
Lactose peptone water	5-18 d	Oshii 1920
Serum, 37 C	30 d	Penisset 1925
Sensit with mat. violet	Recover 0.2 h	Philibert 1926
Saline, 78 C, freeze in	21.5%	Proom 1949
CO <sub>2</sub> ice.		
Broth " " "	52%	"
Broth, R.T.	43.3%	"
Saline, -78 C.	64.6%	"
Ringers soln, pH 2	Recover 1% 4 h	Shaugnessy, 1925
" " 6	" 198% 4 h.	"
" " 8	" 65% 4 h.	"
" " 11	" 0% 4 h.	"
NaCl soln 1.45 M, pH 2	" 2% 4 h.	"
" " pH 6	" 65% 4 h.	"
" " 8	" 0% 4 h.	"
" " 11	" 0% 4 h.	"
NaCl soln. 725 M, pH 2	" 0% 4 h.	"
" " pH 6	" 41% 4 h.	"
" " 8	" 4% 4 h.	"
" " 11	" 0% 4 h.	"
NaCl soln. 0145 M, pH 2	" 1% 4 h.	"
" " pH 6	" 88% 4 h.	"
" " 8	" 50% 4 h.	"
" " 11	" 0% 4 h.	"
CaCl <sub>2</sub> soln 1.45 M, pH 2	" 0% 4 H.	"
" " pH 6	" "	"
" " 8	" "	"
" " 11	" "	"
Balanced salt soln may be		
distinctly favorable to		
bact. vib. in water at		
optimum react. while dis-		
tinctly unfav. in slightly		
more alk. soln. Acid soln.		
kills rapidly. Neutral pH		
favours viability		

TABLE C 4 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
LIQUID, (Cont.) NaCl Soln	buffering capacities reduced with all strengths used	Shaughnessy, 1921
CaCl <sub>2</sub> soln	buffering capac. partial abolished in all solns which were non toxic at favorable pH.	"
NaCl and CaCl <sub>2</sub>	Showed no material inc. in buffering capac over that of the soln cont. CaCl <sub>2</sub> alone	"
NaCl soln.	Still recoverable 6 wks	Stadler 1937
Broth, 13 to 15 C.	Recov. 1% 8 wks	Tanner 1938
Salt soln "	" 1% 12 16 wks.	"
10% sucrose susp., 195 C	Inoc. 6,000,000/ml	Weiser 1946
" denitrified "	48.6% reduct., 2½ h.	"
" crystallized "	Inoc. 6,000,000/ml	"
	55.1% reduct., 2½ h	"
	Inoc. 10,000,000/ml	"
	37.0% reduct. 2 h.	"
Peptone buffer mix 195 C	Death slow and difficult to detect, 10 h	Weiser, 1945
pH 7.0, susp. 20 h cult	100% survival	Winslow 1927
Broth, before centrifug	70% "	"
" after "	70% "	"
" 1 h after "	8 h	Winslow 1911
Broth cult. mixed with sea sand, 69 C, RH 90%	10 h	"
Above with RH 72%	7 h	"
Above, temp 70C, RH 60%	7 h	"
Above, temp. 69C, RH 90%	8 h	"

TABLE 9 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID</b>		
Raw milk on 1% lactose agar & added to litmus milk, incub. 15 d. @ 20 C.	Generation time lengthened	Allen 1923
Agar & gelatin plates, exposed to sunlight Nov.	1 1/2 H. (March, July, Aug) 2 1/2 h (Nov.) 4 1/2 h. (Winter)	Dieudonne 1894
Salt media	91 d.	Frank 1940
Nutrient agar, R.T. stored in dark	Many viable cells 14 yrs	Sears 1946
Agar exposed to U.V. 30 min	Acquired slight germicidal power	Tanner 1938
Agar " " X ray	C-9 mutant strains produced	Tatum 1945
Nutrient agar with Na. 37 C.	Less toxic than Ca. Mixt of Ca and Na less toxic and Bact. inc.	Winslow 1926
CaCl <sub>2</sub> 0.00145 M NaCl 0.0145 M	Recov. 152% 24 h Innoc 100%, Recov 140% 24 h	Winslow 1923 "
Gelatin 20 C., 1% acid add to phenolphthalein	2 1/2 mos	Worth 1919
<b>GENERAL</b>		
Cells of E. coli were found to remain dormant for 16 d. 85% develop in 48 h		Burke 1925
Heat shocked 30 min. 53 C	Innoc 1,457,000, Recov. 120,000, 38 hrs.	Elliker 1938
" " 78 C.	Innoc 1,674,000, Recov. 570,000, 37 h.	"
" " 50.5 C	Innoc 1,510,000, Recov. 427,000, 42 h.	"
" " 38.5 C	Innoc 1,341,000, Recov. 875,000, 20 h.	"
" " 40 C	Innoc. 1,413,000, Recov. 267,000, 10 h.	"
Culture med. (1 1/2 - 3 yrs old) 100 following growth at 45 C	95% reduction in 1 h. due to temp. change	Hegarty 1940
Susp E. coli, non strep. & acid fast saprophytes heated various lengths of time. Inc. in counts greatest in plates heated longest. Greatest inc in E. coli and strep. 14 1/2 h		Isaac 1930
Growth in culture	1,562 d.	Lal, 1925
Dessicated	Death proceeds logarithmically	Heller 1941
In fluid state	Viable for longer periods than when dessic.	"

TABLE C4 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
<p><b>GENERAL</b> Dist. water, saline, salicin, tryptophane, glucose, xylose, sucrose</p>	<p>% reduction in desicc. microorganisms changes from 83.8% to 8.0% in 1 d.</p>	<p>Heller 1941</p>
<p>With similar cpds. in fluid control, the % reduct. changed from 33% to 6.0%</p>	<p>Ratio drops in 2 hrs. then climbs and reaches maximum of 1 at 8 hrs.</p>	<p>Regnier 1938</p>
<p>Variation of resistance in relation to age of cult.</p>	<p>30 min.</p>	<p>Ruska 1941</p>
<p>60 C. 100 C., broth, dist. water, dried on collodion film.</p>	<p>Viable 1 h.</p>	<p>Ruska "</p>
<p>62 C., watery medium 5-7 C.</p>	<p>1 h. 24 h.</p>	<p>" "</p>
<p>Liquid air, -183 C. -78 C., thawed 20 times 45 C., changes suddenly to 10 C.</p>	<p>Did not lose activity 95% reduction, 1 h. Not affected when changes in temp. take place gradually</p>	<p>Sanderson 1925</p>
<p>Young cells, 1 C.</p>	<p>Inoc. 8,600,000, Recov. 0, 42 d.</p>	<p>Sherman 1934</p>
<p>Mature cells, 1 C.</p>	<p>Inoc. 650,000,000, Recov. 10,400,000, &gt;62 d.</p>	<p>" 1942</p>
<p>Stored at 37 C. 8 C. rise in temp. at a given conc. NaOH</p>	<p>12% survive 4 yrs.</p>	<p>Stamp 1947</p>
<p>Double conc. of NaOH</p>	<p>K inc. by 35-109% Increases K 10 times</p>	<p>Watkins 1932</p>
<p>Lime treatment, pH 9-9.5</p>	<p>&gt;540 min.</p>	<p>Wattle 1943</p>
<p>" " " 9.5-10.0</p>	<p>&gt;600 "</p>	<p>"</p>
<p>" " " 10.0-10.5</p>	<p>&gt;600 min.</p>	<p>"</p>
<p>" " " 10.5-11</p>	<p>&gt;600 "</p>	<p>"</p>
<p>" " " 11-11.5</p>	<p>&gt;300 "</p>	<p>"</p>
<p>Rate of storage death at the higher freezing temp. is very rapid &amp; is much greater at the temps. above -30 C. than -30 C. &amp; below. Repeated freezing more lethal than simple freezing or storage in frozen state for similar intervals of time. Freezing much more lethal than supercooling. Repeated fluctuations of temp. of frozen susp. between -30 C. &amp; -78 C. appear to result in lower mortality than storage at either temp. but this protective effect not noted at temp. ranges above -30 C. nor below -78 C. Immediate death occurs at a brief stage in freezing process during which extracellular ice formation is being completed. Mortality due to immediate death does not vary with intensity and freezing time. Rate of storage death at higher freezing temps. is rapid at temps. above 30 C. than less than 30 C. Repeated freezing is more lethal than single freezing or storage in frozen state for intervals of time.</p>	<p>higher freezing temp. is very rapid &amp; is much greater at the temps. above -30 C. than -30 C. &amp; below. Repeated freezing more lethal than simple freezing or storage in frozen state for similar intervals of time. Freezing much more lethal than supercooling. Repeated fluctuations of temp. of frozen susp. between -30 C. &amp; -78 C. appear to result in lower mortality than storage at either temp. but this protective effect not noted at temp. ranges above -30 C. nor below -78 C. Immediate death occurs at a brief stage in freezing process during which extracellular ice formation is being completed. Mortality due to immediate death does not vary with intensity and freezing time. Rate of storage death at higher freezing temps. is rapid at temps. above 30 C. than less than 30 C. Repeated freezing is more lethal than single freezing or storage in frozen state for intervals of time.</p>	

TABLE C9 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL</b>		
Stored at -1.5 C.	99.3% reduct. 180-210 min.	Weiser 1945
" -15 C.	85.2% " 120-225 min.	"
" -30 C.	55.3% " 225-270 "	"
" -78 C.	47.6% " 270-315 "	"
" -195 C.	39.7% " 285-330 "	"
Fluctuated at -1.5 to -15 C. 35 times.	98.4% " 180 min.	"
Fluctuated at -15 to -30 C. 44 times.	57.0% " 220 min.	"
Fluctuated at -78 to -195 C. 46 times.	50.0% " 220 min.	"
Acid action on microorganisms is specific		Yaoi 1924
-78 C., thawed 20 times	Did not lose activity.	Sanderson 1925

TABLE C/O THE SURVIVAL OF MICROORGANISMS IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Alcaligenes, spp.</u> Dried	4-5 yrs.	Froom 1949
<u>Aerobacter, spp.</u> Dried	4-5 yrs.	"
<u>Hemophilus</u> Dried (spp.) " (pertussis)	4-5 yrs. "	" "
<u>Klebsiella</u> Drying	months	Loewenberg 1874
Dried	4-5 yrs.	Froom 1949
<u>Lactobacillus</u> Dried (spp.) " 30-37 C. (bulgaricus)	3-4 yrs. Became inactive in short time	Froom 1949 Rogers 1914
<u>Proteus spp.</u> Dried	4-5 yrs.	Froom 1949
<u>Pseudomonas</u> Dried (spp.) Dried in vacuo (pyocyanus)	4-5 yrs. Still alive 4 mos.	" Shattock 1911
<b>DRIED, LYOPHILIZED</b>		
<u>Lactobacillus bulgaricus</u> 10 cc. milk freeze dry in vacuo, 3-4 hrs.	90-110%	Rogers 1914
<u>Pseudomonas aeruginosa</u> Frozen, -24 C., thawed repeatedly at 25 C.	35.6% mortality 1st freezing.	Stille 1943
<b>LIQUID</b>		
<u>Aerobacter aerogenes</u> Peptone and water susp. spray dried Freeze dried, peptone & water susp.	Recov. 1% Recov 10%	Bullock 1947 "
<u>Flavobacterium spp.</u> -5 to 15 F.	Recov. 0, 77 d.	Campbell 1932
<u>Hemophilus influenza</u> Blood broth, 15 C. " " 20 C.	2 1/2 h. 1 1/2 h.	Ononato 1902 "
<u>Klebsiella</u> Serum, 37 C. (Friedlanders)	43 d.	Panisset 1925
<u>Lactobacillus</u> Broth emulsion with un- ster. milk, liquid air, (acidophilus) Liquid H <sub>2</sub> O -252 C. NaCl susp., -10 to -80 C. (acidophilus) .85% NaCl (acidophilus) Milk & lactose, 40-43 C. (bulgaricus)	7 d. 10 h. Undiminished count Decreased little in 3 d. Innoc. 1 X 10 <sup>9</sup> /ml. Recov. 100 X 10 <sup>4</sup> /gm.	MacFayden 1900 " Mejlbo 1941 Zeug 1920 Rogers 1914



TABLE C110 THE SURVIVAL OF MICROORGANISMS IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID</b>		
<u>Lactobacillus casei</u> Nutrient broth	Rapid freezing caused less injury than slow freezing	Lund -
<u>Proteus vulgaris</u> NaCl soln.	3 wks.	Karaffe 1912
Liquid air, -185 C.	No impaired vitality 20h.	MacFayden 1899
Broth emulsion with unster. milk, liquid air,	No impaired vit., 7 d.	" 1900
Liquid H <sub>2</sub> , -252 C.	10 h.	"
<u>Pseudomonas pyocyaneus</u> 24 h. peptone water cult., vacuum dried	7 mos. & 7 d.	Shattock 1912
24 h. peptone water cult., air dried	4-6 d.	"
<b>SOLID</b>		
<u>Achromobacter, spp.</u> Nutrient agar, 0 C.	Rapid growth, 5 d.	Haines 1934
<u>Aerobacter spp.</u> 24 h. agar cult. in dist. water on filter paper in dry incubator, 37 C.	Alive 31 d. Alive 96 d.	Hastings - "
Dry corn starch, R.T.	3½ yrs.	"
<u>Azotobacter chroococcum</u> Dextrine agar, dried	10 yrs.	Omeliansky 1926
<u>Hemophilus pertussis</u> Agar, 20 C.	8 mos.	Worth 1919
<u>Lactobacillus bulgaricus</u>	>657 d.	Lal 1921
<u>Malleomyces mallei</u> Glycerine agar tubes, 37 C. ozonized air aspir. thru tubes.	No change at end of 10 d.	Ransome 1901
<u>Proteus vulgaris</u> Agar, 10% sterile cane sugar soln., -10 C.	8 mos.	Keith 1913
<u>Pseudomonas</u> Agar, covered with 10T sterile cane sugar, -10 C. (fluorescens)	8 mos.	"
Agar, full radiation of Hg. arc. (pyogenes)	1 h. at 5 cm. 15 min. at 8 cm.	Fazzoni 1914
Nutrient agar, 0 C. (spp.)	Rapid growth, 5 d.	Haines 1934
<b>GENERAL</b>		
<u>Aerobacter aerogenes</u> Excess lime, pH 9.5-10	>6 min.	Wattle 1943
" " " 10-10.5	>600 min.	"
" " " 10.5-11	>540 min.	"
" " " 11-11.5	>600 min.	"
<u>Erwinia amylovora</u> Exudate, 16 C., RH 0-45%	22 d.	Rosen 1938

TABLE 10 THE SURVIVAL OF MICROORGANISMS IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>Erwinia</u> Combinations of moderate temp. & moderate or high humidities proved conducive to short life. Equally high temp. with low R.H. made for long life when organisms in exudate.		Rosen 1938
<u>Hemophilus influenzae</u> Blood agar slope, 37 C. Physiol. NaCl soln., R.T. sealed tubes. Absolute drying over sulfuric acid in vacuo	>132 d.  Viable for mos.	Lal 1921  Otten 1930
<u>Klebsiella</u> Stock lab. cult., R.T., sealed tubes.	12-13 yrs.	Ahuja 1935
<u>Malleomyces mallei</u> Vacuum, 1-4 C.	25 mos.	Velu 1942
<u>Proteus spp.</u> Stock lab. cult., R.T. sealed. 14-30 C. (P. morgagnii) None given	19 yrs. 103 d. 1,562 d. "	Ahuja 1935 Hilliard 1918 Lal 1925 "
<u>Pseudomonas</u> (Aeruginosa) Freezing 50 h. cult. age 24 h. (Pyocyanous) Excluded from light Excess lime, pH 9.5-10 " " " 10-10.5 " " " 10.5-11 " " " 11-11.5	17 d.  3 mos. >420 min. >300 min. >240 min. >120 min.	Hammer 1911  Shattock 1911 Wattle 1943 " "

TABLE (1) THE SURVIVAL OF MICROORGANISMS IN CULTURE (GENERAL)

Factor(s)	Survival	Reference
<b>LIQUID</b>		
Broth or dist. water, -16C. -185 C.	Shorter than in sea water. No impairment of vitality, 20 h.	Hess 1934 MacFayden 1899
Horse serum, vacuum over phosphorus pentoxide.	83% viable 14 yrs.	Rhodes 1950
<b>SOLID</b>		
Nutrient agar, 22 C., pH 7.2 Nutrient agar slants, 37 C. or 30 C. with 572-25,320 R. X-ray.	103 colonies  Order of decreasing resistance: Staph. aureus, E. coli, A. aerogenes, S. marcescens, P. aeruginosa, P. fluorescens.	Brown 1930  Fram 1950
Greatest in resistance observed with readily absorbed cations.	Petroff medium, bottles evacuated, left in ice box.	Harris 1949
Petroff medium, bottles evacuated, left in ice box.	11 mos. (acid fast)	Harris 1933
<b>GENERAL</b>		
Spring temp	< 40 d.	Duclaux 1885
Summer temp.	< 20 d.	" "
Dried organisms more resistant to high temp.		Flasdorf 1938
Slow freezing allows conc. of salts & protein deactivation.		Greaves 1944
Destruction of microbial forms at -10 C. faster than at -20 C. compares favorably with other reports.		Haines 1934
Resistance to U.V. light lower in non-pigmented microorganisms than in those producing pigment but not excreting it into medium. Carotenoids have protective effect. Microorganisms excreting pigment to medium are as sensitive to U.V. as colorless org.		Imshenetski 1946
Low temp alone does not destroy bacteria but appears to favor longevity.		Keith 1913
Storage temperature approaching 0 C. results in a greater decrease in bacterial numbers than that observed at lower temp.		Kiser 1942
120 C. steam is effective in sterilizing spores of soil bacteria		Konrich 1935
28 C., sea water	4 d.	Lipman 1926
Organisms survive equally well at temp. colder than solid CO <sub>2</sub> . Survive temp. ranging from that of liquid oxygen (-183C) to that of liquid He (-296 C.) In rapid freezing the water in the cell is not changed to ice crystals but to a glass-like amorphous mass & this results in less injury than freezing at slower rates.		Luyet 1938
Most organisms live longer under sterile paraffin oil.		Morton 1938

TABLE 11 THE SURVIVAL OF MICROORGANISMS IN CULTURE (GENERAL)

Factor(s)	Survival	Reference
<b>GENERAL</b>		
23 cultures enteric bacteria preserved on nutrient agar. Original character unchanged 11-37 yrs.	from suspected food	Pergola 1950
Death during storage is a function of storage temp. Moisture presence most important factor contributing to loss of viability. Presence of O <sub>2</sub> deleterious. Dry nitrogen atmosphere superior. Survived best when protective colloids such as serum & broth used. Survival lowest in saline. Young cultures more resistant to drying.		Proom 1949
Viable in frozen fruits after 3 yrs. at 15 F. Agar slants held at 16 F. for 1 yr.		Smart 1935
7-10 C. below optimal temp.	Maximum tolerance observed.	1949 Van Eseltine
High temp. resulted in spores of increasing resistance in peptone water with added salts of magnesium phosphate		Williams 1929
Sodium favors viability but toxic in high conc.		
Calcium opposite effect of sodium in low conc.		
Pb & Hg, though toxic, stimulate viability in high dilution.		Winslow 1928
Marine bacteria very sensitive to heat		Zobell 1939
Cult., -15 C.	160 wks.	Tanner 1928

TABLE C/2 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>M. tuberculosis</u>		
Frozen culture, dessicated, refrigerator	3 yrs.	Cohn 1939
Natural cultures	6 mos.-1yr.	"
Incubator, dessicated	"	"
Drying	Shortens viability	Corper 1923
17 years dessication in vacuo on Lowensteins or Dubos medium	9 strains, none grew	Frobisher 1949
Petroffs medium, in evac. bottle in ice box 11 mos.	10 strains, 11 mos.	Harris 1933
Dessicated in vacuo	17 yrs.	Frobisher 1949
Dried	4-5 yrs.	Proom 1949
<b>LIQUID</b>		
<u>M. tuberculosis</u>		
NaCl soln., 0.9%, inject into guinea pig	24-31 d.	Bartel 1908
NaCl soln., 0.9% 2 h. after g.p. inoc.	43 d.	"
" 8 h. after inoc.	29 d.	"
" 24 h. " "	100 d.	"
" 48 h. " "	88 d.	"
Old culture	43 d.	"
Dist. water and glycerine inject into G.P.	13 d.	"
" after 2 d.	-	"
" " 33 d.	155 d.	"
Potato with glycerinated bouillon susp. in Lowensteins med. 1 C.	567 d.	Boquet 1943
Petroffs gentian violet and egg.	Viable 4-8 mos.	Corper 1923
Buffered isotonic soln. pH 7		
Temp. 60 C.	few min.	"
" 50 C.	5 h.	"
" 45 C.	8 d.	"
Broth, whole egg, 50 C.	5 h.	" 1938
" " 55 C.	1 h.	"
" " 60 C.	15 min.	"
Petroffs gentian violet or 5% glycerol agar in icebox or incubator	4-8 mos.	" 1923
Physiol. saline, 5-10 C.	Alive and virulent >1 yr.	Feldman 1932
Saline susp. -76 C. frozen, dried	>6 mos.	Glover 1946
Dorsets	6 yrs.	Gloyne 1920
Purified casein and glycerol, 37 C.	2 yrs.	Hastings 1923
.85% NaCl, -252 C.	50 h.	Kadisch 1931

TABLE C 12 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
LIQUID, CONT.		
<u>M. tuberculosis</u>		
Bouillon, R.T., Petri dish	5 d.	Kirstein 1902
Liquid air in steel tube, -30 C. Stored in dark ice box. (Avian)	No growth after 6 yrs.	Kyes 1939
-192 C., liquid air (Avian)	Did not destroy all viable bacilli but decreased rate of surviving bacilli multiplication in culture & produced TB in animals	"
Stored daily for 21 hrs. in CO <sub>2</sub> bath	All animals showed TB in spleen following infection	"
Culture stored 6 yrs. -3 C. in PO <sub>4</sub> soln.	Inj. into rabbits (4cc) All died 3-4 wks. Failure to show any effect on 1 wk. old chicks. Lost pathogen after 1 hr. R.T.	"
200 X alternate freezing in liquid N <sub>2</sub> (-195 C.) and thawing in water at 34-36 C.	Still showed some viable organisms	"
Egg medium	Growth	Larson 1922
1% castor oil, soap soln.	No growth	"
0.8% NaCl soln.	3 d.	Moriya 1909
Beef decoction	9 mos.	"
glycerol bouillon	9 mos.	"
.8% NaCl 37 C.	98 d.	"
.8% " ice box	152 d.	"
Beef broth infusion, ice box	156 d.	"
Glycerin bouillon, ice box	156 d.	"
Glycerine agar, 37 C., sealed and incub. (Avian)	Viable 20 d. Non-viable 30 d.	Potter 1939
Glycerine agar, 37 C., culture, 2-4 wks. sealed in glass (human)	Infectious power retained	"
Glycerine agar cult. 38 C., glass sealed, incub. (bovine)	Loss of infect., 2 mos.	Potter 1942
Hohn, Lowenstein, Petrananã deprived of O <sub>2</sub> , stored in dark. 2-5 wks. (human)	Non-viable 1 mo.	"
.85% NaCl	800 d. does not infect guinea pig	Pugrati 1929
Glycerine agar tubes with ozonized air, 37 C.	No change in 10 D.	Ransome 1901

TABLE C 12 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID, CONT.</b>		
<u>M. tuberculosis</u>		
Physiol. saline soln. .85%, near freezing	310-330 d.	Shope 1926
Lymph node emulsion in salt soln.	87 d.	Webb 1921
Egg	30-50 min.	Weinzirl 1907
<b>SOLID</b>		
<u>M. tuberculosis</u>		
Glycerol agar, 37.5 C.	4-8 mos. (max. 16 mos)	Cooper 1923
Glycerol "	Dead in 6 yrs	
Petroffs medium in bottle	(M. phlei dead in 4 yrs)	Gloyne 1920
evac., left in ice box	(Human) 11 mos.	Harris 1933
11 mos.	(Bovine) 11 mos.	"
Agar, pH 6.6	(Avian) 11 mos!	"
	Grew well	Isaacs 1930
	Heating decreases # of survivors able to grow during lag phase. Un- less grown at pH 7.6 more survivors grew but the lag period was not decreased	
Artificial media	10 yrs	Karwacki 1928
Solid media in pyrex tube sealed in vacuo	(Avian) viable 8 mos.	Pottor 1935
Pyrex tube, R.T., sealed in vacuo	(Str. P4) viable 80 d.	"
Dark, 37 C.	5 mos.	"
<b>GENERAL</b>		
<u>M. tuberculosis</u>		
40-50 F.	7-19 mos. Bovine more resistant than human	Cooper 1923
37 C. incub. in glycerol broth	12 yrs, 42% human viab.	"
-9.4 to -19.9 C.	" 44% bovine viab.	"
-1.0 to -8.0 C.	Viable 1st 24 h.	Homma 1927
-7.0 to -14.3 C.	Viable 2nd 24 h.	"
-17.3 to -29.2 C.	Viable 3rd 24 h.	"
-10.6 to -23.9 C.	Viable 4th 24 h.	"
-13.4 to -26 C.	" 5th "	"
-11.5 to -24.3 C.	" 1st 24 h.	"
-8.7 to -17.4 C.	" 2nd 24 h.	"
Below 0 C.	" 3rd 24 h.	"
Above 0 C.	623.5 h.	"
Mixed with quinine	216.5 h	"
Deprived of O <sub>2</sub> and H <sub>2</sub> O for 24 hrs.	Requires 25 min. exp. to U.V.	Mayer 1924
Dark, no O <sub>2</sub> R.T., Dessic.	Survive as viable path- ogens	Potter 1935
Dark, 37C., H <sub>2</sub> Dessic.	(Str. P4) 2 yrs	Potter 1937
	(Str. P7) 1 yr	"

TABLE C 12 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL, CONT.</b>		
<b>M. tuberculosis</b>		
Deprivation of O <sub>2</sub> kills tubercle bacilli. Rapid desiccation favors survival. Avian bacilli at body temp. survive for more than 1 yr. with only trace of O <sub>2</sub> and H <sub>2</sub> O while at R.T. they survive 2 yrs.		Potter 1937
pH 2.55	168 h.	Prudhomme 1935
" 1.95	48 h.	"
" 0.97	24 h.	"
Nucleic acids have no specific action on tb bacillus. Tb bacillus destroyed by pH < 2. Acetic acid has no effect.		"
100 C.	--	Ruska 1941
Ice box, near freezing	330 d.	Swope 1926
Cult., protected from light	3 wks.	Simmons 1923
Darkness and moisture conducive to prolongation of life, while dryness and thermostat temp. hastened destruction.		Twitchell 1906
2 C.	12 mos.	Vidal 1934
<b>BCG, DRIED, LYOPHILIZED</b>		
5% gelatin, 4 C.	12 mos.	Ungar 1949
" " 26 C.	12 mos.	"
Sterile serum, 4 C.	12 mos.	"
" " 6 C.	12 mos.	"
Lowensteins egg med., 38 C. before freeze drying.	No difference in number of colonies between, before & after.	Van Dejnse 1950
Keeps viability in 50% glucose better than lactose, amylase or serum in cylinder with paraffin oil, -50C. R.T.	Dimished # living organisms, 20% at end of 1st mo.	"
Stacked in ice box, 5 C.	No mortality during 1st 3 mos., 10% after 6 mos.	"
Stored at R.T.	2 mos.	"
<b>BCG, LIQUID</b>		
Lowensteins egg medium, 1:10 dil., 2-4 C.	2 yrs.	Birkhaug 1951



TABLE 2/3 THE SURVIVAL OF NEISSERIA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Neisseria intracellularis</u> Dried on garnets and glass in dark	24 h.	Flugge 1905
Diffuse daylight	10 h.	"
Dark	25 h.	"
Dried	4-5 yrs.	Proom 1949
<u>N. gonorrhoea</u> Dried	4-5 yrs.	"
<u>N. species</u> Dried	4-5 yrs.	"
Drying	Little resistance	Rhodes 1950
<b>DRIED, LYOPHILIZED</b>		
<u>N. intracellularis</u> Dried in frozen state	18 yrs	Elser 1935
Frozen and dried 16 hr. cult. on 10% rabbit blood pneumococcus agar plate in vacuo	151 d.	Rake 1935
Above with two wk. old stock strains	> 89 d.	"
Above with four fresh strains	> 151, > 89, > 41 d.	"
2cc broth	> 72 mos.	Swift 1921
<u>N. gonorrhoea</u> Dried in frozen state	18 yrs.	Elser 1935
<b>LIQUID</b>		
<u>N. intracellularis</u> Bouillon, diffuse light, dried, ascitic agar, 37 C.	24 h. (Raul str.)	Beltencourt 1904
Bouillon, 20-25 C., 80% RH	3 h.	"
Bouillon susp. of 24 h. with ascitic agar, 50 C.	3 min.	"
" " " 55 C.	1 min.	"
" " 60, 70, 80 C.	30 sec.	"
" " 100 C.	30 sec.	"
Bouillon culture, 0-70 C.	1 mo. or longer	"
Ringers, 20 C.	8-10 d.	"
Saline, 50 C.	poor	Flexner 1907
" 20 C.	fair	"
" 37 C.	good	"
Physiol. saline, R.T., abs. drying in vacuo	Viable for months.	Otten 1930
Pure, undil. neutral glycerine, -15 C.	No change in viability 2 yrs.	Pabst 1935
Saline broth, dried at R.T. or from frozen state	42%	Proom 1949
Broth, R.T.	.69%	"
Saline, -78 C.	36.2%	"
Sterile serum sealed with paraffin layer	16 mos.	Ungerma 1918

TABLE C 13 THE SURVIVAL OF NEISSERIA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID</b> <u>N. intracellularis</u> Culture, 104th generation	3-4 yrs.	Van Albrecht 1901
<b>SOLID</b> <u>N. gonorrhoeae</u> Pigeon blood, pH 6.6 " " " 6.8 " " " 7.0 " " " 7.2 " " " 7.4 " " " 7.6 " " " 7.8 " " " 8.0 Lactic acid plates in ice box 4-7 C., Pre- incub. in moist chamber. Physiol. saline, R.T., abs. drying in vacuo Gentian violet, 20-26 C. Physiol. NaCl, R.T., on ascitic agar, 24 h. cult. Ringers soln., R.T. on ascitic agar, 24 h. cult. " " " 18 C. " " " 22 C. Physiol. NaCl, 48 h. cult. on ascitic Levinthal med. " " " 18 C. " " " 22 C. Ringers soln. 48 h. cult. on ascitic Levinthal med. " " " 18 C. " " " 22C. Saline broth, dried at R.T., Saline broth dried from frozen state Broth, R.T., saline, -78C. Sterile serum sealed with paraffin layer	No growth, 12 d 108 d. 108 d. 123 d. 159 d. 189 d. 189 d. 76 d. Viable 9-15 d. Viable for mos. 24 h. Recov. 79.2%, 6 h. Recov. 71.8% in 6 h. Recov. 30.7 % in 24 h. Recov. 57.9% in 6 h. Recov. 21% in 24 h. Recov 70.9%, 6 h. Recov. 16% 24 h. 1.5% 15% 0.93% 7-8 wks.	Lal 1925 " " " " " " " Lorentz 1924 Otten 1930 Peizer 1949 Pieper 1930 " " " " " " " " Proom 1949 " " " "
<b>SOLID</b> <u>N. intracellularis</u> Serum agar, 37 C., Pigeon blood agar, 37 C. Serum agar 3.5-8.5 C. Pigeon blood agar, 3.5- 8.5 % Yeast agar, 37 C. Agar surface, 2 C. " " 32-37 C.	8 wks 10 wks. 27 wks. 31 wks. >5 mos. Poor Good	Dharmendra 1940 " " " Eberson 1920 Flexner 1907 "

TABLE C 13 THE SURVIVAL OF NEISSERIA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID, CONT.</b>		
<u>N. intracellularis</u>		
Glucose agar slant, -150.	No loss of viab. 8 moq.	Pabst 1935
Gelatin 37 C., 1% acid added to phenolphthalein	>7 mos.	Worth 1919
<u>N. gonorrhoeae</u>		
Gelatin 37 C., 1% acid added to phenolphthalein	>8 mos.	"
<b>GENERAL</b>		
<u>N. intracellularis</u>		
Various nutritive substances alter the survival period		
37 C.	> 86 d.	Foa 1887 Lal 1921
Survival shortened at 37 C. and prolonged in ice box, 6-10 C.		Miller 1944
-5 C.	4 d.	Murray 1929
Icebox, 0-5 C.	5 d.	Pabst 1935
" 65 C.	48 h.	Von Albrecht
" 80 C.	1 h.	" 1901
" 100 C.	Few min.	"
Stoppered with gutta percha, 19-21 C.	Immediate	"
Dried and stoppered with gutta percha, incub. temp.	4-5 d.	"
	185 d.	"
<u>N. gonorrhoeae</u>		
40 C.	99.7% 10 hrs.	Carpenter 1933
41 C.	99% 4-5 hrs.	"
41 C.	100% 11-23 hrs.	"
41.5 C.	7-20 hrs.	"
42 C.	5-15 hrs.	"
50 C.	Few min.	"
Gentian violet, ice box	Stored 8 wks.	Peizer 1949
-20 C.	10 d.	Luniere 1914
-195 C.	24 h	"

TABLE C 14 THE SURVIVAL OF PASTEURELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Pasteurella pestis</u> 37 C.	Most dead in 3 d.	Gladin 1898
Bubo juice, R.T., ex- posed to sun, dried.	3-4 h.	Kitasato 1894
Bubo juice, R.T., dried on coverslip	< 4 d.	"
Dried	Viable 2 h	Tinker 1930
<u>P. tularensis</u> Susp. in mixt. of beef infusion, cystine & rabbit blood, dried, sealed	4 yrs.	Miller 1946
<u>P. species</u> Dried	4-5 yrs.	Proom 1949
<b>LIQUID</b>		
<u>P. multocida</u> Broth culture, R.T., in sealed ampule	(Avicida) 2 yrs	Nobrega 1950
Broth culture, 2-4 C. in sealed amp.	" 1 yr.	"
Broth culture, 37 C.	" 1 yr.	"
Serum, 37 C.	" 4.5 h.	Panisset 1925
<u>P. pestis</u> Pus on cover slip, 28- 30 C., innoc. to bouillon	4 d.	Abel 1897
Pus and cult. on cover glass, R.T.	Still viable 6-9 d.	"
Pure undil. glycerine, -150 C.	Fully virulent 2 yrs & 14 mos. Slightly, 2 yr. & 7 mos. Dead 3 yrs.	Francis 1932
Physiol. serum	5 hrs.	Jacotot 1926
Bouillon cult., -31 C.	5½ mos.	Kasansky 1899
" " -24 C.	Still viable for 9, 32, & 35 d. respectively for 1st & 2nd subcult. 33d for 3rd subcult.	
" " -1.8 C.	6th to 15th subculture, 12 mos.	"
Bouillon cult., 1 yr & 9 mos. old	Recov. 58.6%, 6½ yrs.	Lenskaja 1931
Bouillon, 48 & 24 hr. cult.	7 d.	"
Sealed culture tube of Hammerek medium, 100 C. dark.	Living >4 yrs.	Schultz 1901
Bouillon loops, 50 C.	Innoc. with original culture which is 2 yrs. and 10 mos. old. 1 to several days.	"
Twiks soln	2 h	Tinker 1930

TABLE C 14 THE SURVIVAL OF PASTEURILLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID</b>		
<u>P. pestis</u>		
Agar, 15 C.	3-4 d.	Abel 1897
" 8-10 C.	6 d.	"
Agar and gelatine Cult.	-	"
Plain agar 10 C., sealed for 9 yrs.	Viable at end of 9 yrs. with full virulence	Francis 1932
Plain agar 10 C. Subcultured every 3 mos.	Viable but non-virulent at end of 9 yrs.	"
Culture 5-10 C., inoc. into cork stoppered bottle.	25 yrs.	Francis 1949
Beef infusion agar, 10 C. on surface without transfer	Virulent 20 yrs.	Francis 1943
Agar cult. in sun, 39 C.	2 3/4 hrs.	Gladin 1898
Agar plate in sun, 40-46 C.	5 1/2 hrs.	"
Agar cult., -1.8 C.	1st subcult. still viable 4 mos.	Kasansky 1899
" - 31 C.	2nd and 3rd subcult. 5-5 1/2 hrs.	"
<b>GENERAL</b>		
<u>P. pestis</u>		
Artificial cold, -22 C.	2 h.	Gabritschewsky 1899
Natural cold, 0 to -20 C.	12-40 d.	"
Freeze and thaw daily, -20 C.	Still alive 40 d.	Gladin 1898
Stored 37 C.	1% survived 4 yrs.	Stamp 1947
Ice box culture	10yrs, 5 mos.	Wilson 1913
<u>P. pleurisepticus</u>		
Physiol. NaCl, R.T., abs. dried over H <sub>2</sub> SO <sub>4</sub> in vacuo.	Viable for months.	Otten 1930
<u>P. pseudotuberculosis</u>		
Sealed and viable.	Viable for a number of yrs.	Merling 1938
<u>P. species</u>		
Physiol. NaCl, R.T., Abs. dried over H <sub>2</sub> SO <sub>4</sub> in vacuo.	Innoc. into blood or serum, viable mos.	Otten 1930
<u>P. tularensis</u>		
Eggs, freezing	Recov. 1%, 3 mos.	Downs, 1947
Factors leading to population changes. 1) Type initial pH, 2) inoculum size, 3) One or more factors present in old cult. filtrates	comp. of med., 2) ini-	Eigelbach 1951

TABLE C 15 THE SURVIVAL OF PROTOZOA AND METAZOA IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID</b>		
<u>E. histolytica</u>		
Ringers' fluid & solid rice starch, body temp.	3 wks.	Dobell 1926
Dist. H <sub>2</sub> O, tap water, Ringers, physiol. saline, R.T.	14 d.	"
10-20 C., R.T.	3 d.	"
Sterile dist. water, R.T.	26 d.	Dobell 1927
N/20 HCl, R.T.	< 30 min	"
N/40 HCl; R.T.	at least 1 h.	"
N/15 HCl; R.T.	as long as 3 h.	"
N/20 HCl, 37 C.	1 h.	"
<u>Plasmodium gallinaceum</u>		
Susp. saline extract, R.T. in washed chicked rbc.	Little loss of infectivity 72 hrs.	Whitman 1948
<u>Trypanosoma cruzi</u>		
N.N. medium, R.T.	> 6 yr.	Packchaniian 1943
<u>Trichomona vaginalis</u>		
R.T.	8 d.	Mohr 1937
Bact. free in serum, Ringers soln. over liver infusion agar slants, 37 C.	4-6 d.	TRussell 1947
Cysteine, peptone broth, liver, maltose, R.T.	13 d.	"
<b>SOLID</b>		
<u>S. mansoni</u>		
Horse serum	14-18 d.	Ross 1950
Serum ultra filtrate	10-12 d.	"
100% N <sub>2</sub>	5 d.	"
<u>L. donovani</u>		
Blood agar, R.T.	4 mos.	Packchaniian 1943
<u>T. americanum</u>		
Blood agar, R.T.	4 mos.	"
<u>T. avium</u>		
Blood agar, R.T.	3 mos.	"
<u>T. duttoni</u>		
Blood agar, R.T.	4 mos.	"
<u>T. lewisii</u>		
Blood agar, R.T.	4 mos.	"
<u>T. malophagium</u>		
Blood agar, R.T.	4 mos.	"
<u>T. rotatorium</u>		
Blood agar, R.T.	4 mos.	"
<u>T. vaginalis</u>		
Semi-dry state	6 hrs.	Vazques-Calet 1936
<b>GENERAL</b>		
<u>E. histolytica</u>		
Powdered starch, R.T.	10 d.	Walker 1913

TABLE C 15 THE SURVIVAL OF PROTOZOA AND METAZOA IN CULTURE

Factor (s)	Survival	Reference
<b>GENERAL, CONT.</b>		
<u>T. vaginalis</u>		
3-5 C.	21 d.	Fischer 1935
10-15 C.	2-3 wks.	Florent 1948
Lactic acid .27 to .102 mg%, ice box	3 d.	Furushima 1936
<u>Trypanosoma equiperdium</u>		
-20 C.	3 1/4 hrs.	De Jong 1922
-145 C.	45 min.	"
-191 C.	31 d.	"
<u>Trypanosoma evansi</u>		
-20 C.	1 1/4 hrs.	"
-191 C.	9 min.	"
<u>Ascaris lumbricoides</u>		
-6 to -17 F.	Inactive 20 d.	Cram 1924
12-18 F.	Active 30 d.	"
10-18 F.	Few active 6 d.	"
-2 to -16 F.	Few active 6 d.	"
-6 to -17 F.	40 d.	"
60 C.	5 min.	Ohba 1923
70 C.	10 sec.	"

TABLE 16 THE SURVIVAL OF RICKETTSSIAE IN CULTURE

Factor(s)	Survival	Reference
<b>DRYING, LYOPHILIZED</b>		
<u>R. tsutsugamushi</u> Soln. 0.2 M. sucrose plus buffer salts	Superior to skim milk medium	Jackson 1951
<b>LIQUID</b>		
<u>Coxiella burneti</u> (Dyer, nine mile and Henzerling str.) Saline susp. yolk sac. 60 C. " " " 50 C.	30 min. 15 min.	Ransom 1951 "
<u>R. mooseri, &amp; prowazeki</u> Yolk sac material, -72 C. 0.05 glutamate, pH close to 7, basal salt soln., high in K ions, 1 to 1% serum albumin. Tissue cult., in serum with Tyrodes, 37 & -20 C. " " " 20 & -40 C.	Survival favored by these. Several mos. Week or two	Bovarnick 1950 Nigg 1935 "
<u>R. prowazeki</u> Sterile skim milk, 26-28 C. Broth, 26-28 C. 20% normal yolk sac, 26-28 C.  Tyrodes soln. 26-28 C Tyrodes, G.P. serum, 26-28 C. 56 C. Blood spec 2-4 C. " " 37 C Dessicated, R.T. G.P blood, R.T. Carbon tet. or benzene, CS <sub>2</sub> , 25% NH <sub>3</sub> , ether, cresol, ethylene Cl <sub>2</sub> , tetramine Physiol. saline with tap water	24 h. 6 h. (Breine str.)  50% mortality, 6 hrs. (Bogota epidemic Str.) 6h. 6 h. 30 min 1 or more h. few hrs. Few hrs. few hrs. Viable >1 h.  <7 min. Affects viability dele- teriously.	Anderson 1944 " " " Rivers 1948 " " " Schlote 1948  Topping, 1940
<u>R. species</u> Aqueous susp. Chick embryo dil. 1/10 N. saline, 50 C. Chick embryo dil. with Tyrodes & horse serum. Chick memb., -14 C., with carbon snow in presence of P <sub>2</sub> O <sub>5</sub> , sealed under H <sub>2</sub>	40 hrs. 1 wk. Not viable after 20 d. 13 d.	Latarjet 1951 Payzin 1947 " "
<u>R. rickettsi</u> Pure glycerol, -10 C. Rocky Mtn. Spotted Fever Dessicated, R.T. Guinea pig blood, R.T.	10 mos. few hrs. 1 wk.	Spencer 1924 Rivers 1948 "



TABLE 1/6 THE SURVIVAL OF RICKETTSIAE IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID</b>		
<u>Rocky Mtn. Spotted Fever</u>		
G. P. blood, cold room	2 wks.	Rivers 1948
G. P. blood, brain & spleen, -7 C.	1 yr.	"
<u>Typhus</u>		
Broth, pH 7.69	Trace 48 hrs.	Elford 1944
Fermented broth, pH 8.10	Trace 96 h.	"
Saline, pH 6.85	Trace 48 h.	"
Serum & saline, pH 7.93	" 48 h.	"
Water, pH 6.95	" 2 h.	"
Peptone water, pH 7.06	" 2 h.	"
Tyrodes soln, pH 8.18	" 2 h.	"
<b>GENERAL</b>		
<u>R. burneti</u>		
-70 C.	Long time	Rivers 1948
Infection spread by means of air borne droplets.		Commen. on Resp. Dis. 1946
<u>R. prowazeki</u>		
Dry heat, 39 C.-41 C.	1 h	Schlote 1948
<u>Scrub typhus</u>		
-70 C.	long time	Rivers 1948
<u>Typhus</u>		
77 C., pH 5.8-8.8	4 mos.	Elford 1944
-10 or 0 C.	2-3 days.	"
37 C.	Trace 48 h.	"
23 C.	" 2 h.	"
0 C.	" 48 h.	"
-10 C.	Present 8 d.	"
-77 C.	" 8 d.	"

TABLE C/7 THE SURVIVAL OF SALMONELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>S. Paratyphi</u> Dried.	Viable > 2 h.	Orskov 1925
Nutrient gel with ascorbic acid. Dessic. 3 d.	Recov. 55.7% 23 d.	Stamp 1947
Nutrient gelatin & ascorbic acid. Dried over P <sub>2</sub> O <sub>5</sub> at 100-300 mm Hg.	> 4 yr. survival	"
Stored in vacuo, R.T.		"
<u>S. Species</u> Dried	4-5 yrs.	"
<b>DRIED, LYOPHILIZED</b>		
<u>S. choleraesuis</u> Broth culture	10 yrs.	Schoening 1949
<b>LIQUID</b>		
<u>S. choleraesuis</u> Glucose-peptone water	7 d.	Oshii 1920
<u>S. enteriditis</u> NaCl soln.	4½ wks.	1912
<u>S. hiss</u> Glucose peptone water	1,283 d.	Karaffa-Korbutt
NaCl soln.	5-7 d.	Lal 1925
<u>S. morbificans</u> NaCl soln.	Recov. 0, 4½ wks.	Oshii 1920
NaCl soln.	3 wks.	Stadler 1899
<u>S. paratyphi A</u> Tryptic digest	Recov. 0, 3 wks.	Karaffa-Korbutt 1912
Bouillon, 63 C.		Stadler 1899
Saline, 0.9%, 62 C.	3,259 d.	Lal 1925
Lactose peptone water	Viable 1-4 min.	Orskov 1925
NaCl soln, R.T., dried in vacuo	< 5 min.	"
<u>S. paratyphi B.</u> Muttan, agar	3-5 d.	Oshii 1920
Bouillon 63 C.	Viable mos.	Otten 1930
Lactose-peptone water		
NaCl soln. R.T., dried in vacuo	3.259 d.	Lal 1925
<u>S. schottmulleri</u> Broth & water, frozen	4 min	Orskov 1925
<u>S. species</u> Bouillon cult., in glass capillaries	3-6 d.	Oshii 1920
<u>S. typhimurium</u> Bouillon & beer wort, exposed to U.V. 10-15 min.	Viable mos.	Otten 1930
	17 d.	Thomas 1925
	> 1 yr.	Wesselinoff 1949
	1-15 sec.	Gilles 1935
<b>SOLID</b>		
<u>S. enteriditis</u> transmitted by rat fleas		Eskey 1949

TABLE   (17)   THE SURVIVAL OF SALMONELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID</b>		
<u>S. enteritidis</u> Blood gelatin	> 649 d.	Lal 1921
<u>S. Paratyphi B.</u> Crust of rye bread, R.T.	-	Bachmann 1943
<u>S. typhimurium</u> Gelatin	98 d.	Glass 1946
<b>GENERAL</b>		
<u>S. choleraesuis</u> -	> 657 d.	Lal 1921
<u>S. gallinarum</u> Stored at 37 C.	1,562 d.	Lal 1925
<u>S. Paratyphi C</u> -	28.4% surv. 4 yrs.	Stamp 1947
<u>S. typhimurium</u> Stored at 37 C.	50 d. 14% surv. 4 yrs.	Kister 1928 Stamp 1947
<u>S. typhisuis</u> Stored at 37 C.	18.4% survived 4 yrs.	Stamp 1947
<u>S. typhisuis</u> Stored at 37 C.	16.2% " "	"

TABLE C 18 THE SURVIVAL OF SALMONELLA TYPHOSA IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
Dried in thin layers	5-15 d.	Osler 1901
" " thick layers	mos.	"
Vacuum dried, -195 C.	4 d.	Shattock 1912
Air dried, dark	4 d.	"
<b>DRIED, LYOPHILIZED</b>		
Standardized susp., -192 C.	10 d.	Turner -
<b>LIQUID</b>		
.85% NaCl, freezing	> 6 d.	Balten 1918
Bouillon culture, continuous freezing @ -20 to -16 C.	Survived 4 1/2 mos.	Brehme 1901
Watery susp. of fresh cult. placed on petri dish in sunlight.	Innoc. 100. 95-99% reduct. in 10-15 min.	
1% soap soln, 4-8 C.	100% reduct. 1/4-4 hrs.	Clark 1903
6% " " "	12 h.	Jolles 1895
1% " " 18 C.	15 min.	"
6% " " "	24 h.	"
5% " " "	30 min.	"
3% " " "	1 h.	"
Bouillon susp., R.T., Fall on Petri dishes	12 h.	"
Tryptic digest -185 C., liquid air	24 h.	Kirstein 1902
	3,838 d.	Lal 1925
Broth emulsion with liquid air.	No impaired vitality	
Sealed tubes, liquid air.	20 h.	MacFayden 1899
Liquid H <sub>2</sub> , -252 C.	No impaired vitality,	
Beef-peptone agar in sun	7 d.	MacFayden 1900
Bouillon, 63 C.	6 mos.	"
Lactose peptone water	10 h.	"
Thick susp., R.T., dried in vacuo over H <sub>2</sub> SO <sub>4</sub>	10 min. to 1 h.	Minck 1896
	Viable 1-2 min	Orskov 1925
NaCl soln., R.T., dried in vacuo	3-5 d.	Oshii 1920
Bouillon, neutral pH	Innoc. to blood or serum	
Peptonized beef bouillon freezing, -17.8 C.	agar, 2-5% survived	
" -190 C. in liquid air.	24-48 h.	Otten 1930
Peptonized beef bouillon, frozen -17.8 C.	Innoc. to blood or serum	
Huntoon broth, frozen	agar. Viable mos.	Otten 1930
Susp. in agglut. immune serum	82 d.	Remy 1900
Emulsion 24 hr. bouillon cult. in salt soln. heated at 80 c. for 10 min.	Recov. 1/45, 2 h.	Smith 1905
Liquid air in glass	Recov. 2/60, 2 h.	"
	99.5% killed 2 h.	"
	.5% recov. 2 h.	"
	13 d.	Thomas 1925
	No effect on surv. time.	Tinti 1923
	2-8 hrs. (6X as much needed to kill spores.	
	Recov 25% 2 h.	Weinzirl 1914
		White 1901

TABLE C THE SURVIVAL OF SALMONELLA TYPHOSA IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID</b>		
Crust of rye bread, R.T.	4½ mos.	Buchanan 1943
Agar, full radiation Hg arc under glass, water cooled.	10 min. at 10 cm.	Bazzoni 1914
Agar & gelatin plates	1½ h (July, March, Aug.)	Dieudonne 1894
" " "	2½ h (Nov)	"
" " "	4½ h (Winter)	"
Salt media	91 D.	Frank 1941
Nutrient gel tubes, 22 C.	No change in 8 d.	Ransome 1901
Action of H ions on micro-org. is very rapid & is increased by raise in temp. By changing the temp. from 20 to 45 C. the pH at which typhoid bacilli are killed shifts from 4.2 to 5.1.		Sierakowski 1924
Gelatin, 20 C., 1% acid added to phenolphthalein	> 8 mos.	Worth 1919
<b>GENERAL</b>		
Artificial media	> 5 wks.	Houston 1912
"	> 929 d.	Lal 1921
113 C.	living	Lal 1923
120 C.	Dead	"
R.T., Dark	2,906 d.	"
60 C.	10 min.	Osler 1901
-50 C.	18 wks.	"
-2 to -7 C.	22 wks.	Park 1924
45 C.	Dried after 46th change	Spencer 1942
Storage at R.T.	50% surv. 4 yrs.	Stamp 1947
" " "	5.6 " "	"
" " "	18.8% " "	"
" " "	1.3% " "	"
" " "	16.7 " "	"
Sunlight has no appreciable	inhibiting effect	Stimson -
Ice cream, -19 C.	1 yr.	Tanner 1928
Excess lime, pH 9-9.5	> 540 min.	Wattie 1943
" " " 9.5-10	> 540 min.	"
" " " 10-10.5	> 540 min.	"
" " " 10-5-11	240 min.	"
" " " 11-11.5	120 min.	"

TABLE C19 THE SURVIVAL OF SERRATIA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b> <u>S. spp.</u> Dried	4-5 yrs.	Proom 1949
<b>DRIED, LYOPHILIZED</b> <u>S. marcescens</u> Stored at R.T., dark.	Survivals 100%. Viability lost when stored in air.	Naylor 1946
<u>S. rubidaeum</u> Frozen at -24 C.	82.2% killed in 1st freezing	Stille 1943
<b>LIQUID</b> <u>S. marcescens</u> Standard nutrient broth, R.T. Bouillon susp., R.T. Broth, -13 to -15 C. Salt soln. " " Broth, before centrifug. " after " " 1 hr. later	29-21 yrs. 24 h. Recov. .1%, 8-9 wks. " .1%, 12-16 wks. 100% survival 44% " 37% "	Deacon 1932 Kirstein 1902 Tanner 1928 " " Winslow 1927 " " "
<b>SOLID</b> <u>S. marcescens</u> Agar & gelatin plates, March, July, Aug.	1½ h.	Diéudonne 1894
<b>GENERAL</b> -10 to 1 C. ( <u>S. marcescens</u> ) <u>S. marcescens</u> - Stored at 37 C.	51 d. 658 d. 16% recov., 4 yrs.	Hilliard 1918 Lal 1921 Stamp 1947

TABLE C 20 THE SURVIVAL OF SHIGELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED GENERAL</b>		
<u>S. spp.</u>		
Dried	4-5 yrs.	Proom 1949
Dessicated	20-25 d.	Vaillard 1903
<b>LIQUID</b>		
<u>S. dysenteriae</u>		
Bouillon	920 d.	Lal 1921
Mutton, agar slope	1,562 d.	Lal 1925
Thick susp., dried in vacuo over H <sub>2</sub> SO <sub>4</sub> , R.T.	Innoc. to blood or serum agar. Recov. .05-.005% 24-48 h.	Otten 1930
NaCl soln. R.T., dried in vacuo	Innoc. blood or serum agar. Viable mos.	"
Saline, -78 C., freeze in CO <sub>2</sub> .	25%	Proom 1949
Broth, -78 C.	96.5%	"
Broth, R.T.	32.2%	"
Saline, -78 C.	42.3%	"
<u>S. paradysenteriae (Flexner)</u>		
Bouillon	> 1,044	Lal 1921
Mutton, agar slope	1,562 d.	Lal 1925
<u>S. paradysenteriae (His Y)</u>		
Mutton, agar slope	1,562 d.	Lal 1925
<u>S. pseudodysentery</u>		
Physiol saline, R.T.	-	Otten 1930
<u>S. spp.</u>		
Alcohol, ether, chloroform, 37 C.	few hrs.	Vaillard 1903
<b>SOLID</b>		
<u>S. dysenteriae</u>		
Crust of rye bread, R.T. placed on Drigalski med.	Viable 20 d.	Bachmann 1943
Crust of rye bread, R.T.	66 d.	"
Solid substance (Y type)	5 d.	Tashiro 1932
<u>S. Paradysenteriae (Flexner)</u>		
Crust of rye bread, R.T. placed on Drigalski med.	Viable 23 d.	Bachmann 1943
Crust of rye bread, -5 to -25 C.	Viable 45 d.	"
<u>S. sonnei</u>		
Crust of rye bread, R.T.	Overgrown with spores of bacillus	"
<b>GENERAL</b>		
<u>S. dysenteriae</u>		
48 hr. cult., 37 C.	13 d.	Bamberger 1936
" " 22 C.	15 d.	"
" " 10 C.	24 d.	"
72 h. cult. 37 C.	13 d.	"
" " 22 C.	16 d.	"
" " 10 C.	24 d.	"
Bouillon, strong sun	< 30 min	"

TABLE C 20 THE SURVIVAL OF SHIGELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL, CONT.</b>		
<u>S. dysenteriae</u>		
Dark, R.T.	10 d.	Kister 1928
Stored 37 C.	920 d.	Lal 1925
Excess lime pH 9.5-10	4.5% survived 4 yrs.	Stamp 1947
" " pH 10-10.5	> 300 min	Wattie 1943
" " pH 10.5-11	> 300 min.	"
" " pH 11-11.5	180 min.	"
" " pH 11-11.5	75 min.	"
<u>S. equuli</u>		
Cult., R.T., pH 7.4,	3-4 mos.	McCollum 1951
Stored in dark.		
<u>S. ambigua (Schmitz)</u>		
Cult. in bouillon, strong sunlight	< 40 min.	Bamberger 1936
<u>S. kruse</u>		
48 h. cult., 37 C.	12 d.	Bamberger 1936
" " 22 C.	15 d.	"
" " 12 C.	24 d.	"
72 h. cult., 37 C.	13 d.	"
" " 22 C.	15 d.	"
" " 12 C.	24 d.	"
Bouillon, strong sun	< 30 min.	"
<u>S. paradysenteriae (Flexner)</u>		
Bouillon, strong sun.	< 60 min.	"
R.T., dark	1,049 d.	Lal 1925



TABLE ( 2 / THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>S. albus</u>		
Stock lab cult., sealed, R.T.	11-12 yrs. 523 d.	Ahuja 1935 Lal 1921
Material obtained from sputum, antrum, nose, skin, throat, urine, uterus & put in broth & adjusted with HCl and NaOH. Or 12 strains used 7 viable at pH 2.6; 4 at pH 5.0; 1 at pH 8; 8 at pH 10 for 24 h.		Hall 1921
<u>S. aureus</u>		
-	524 d. (Bombay str.) > 692 d.	Lal 1921 " "
Dark, R.T.	657 d.	Lal 1925
Matl. obtained from boil, abscess, sycosis, spinal fluid, in broth.	11 strs. viable at pH 2.6; 6 at pH 8; 13 at pH 10 in 24 h.	Hall 1921
<u>S. citreus</u>		
-	523 d.	Lal 1921
<u>S. spp.</u>		
Dessication 60-100 C., in broth & dist. water, dried on collodion	30 yrs.	Fasquelle 1950
Very resistant to drying.	cell membrane separated	Ruska 1941 Rhodes 1950
<b>MICROCOCCUS SPECIES</b>		
<b>GENERAL</b>		
<u>M. melitensis</u>		
-	523 d.	Lal 1921
<u>M. neoformans</u>		
-	523 d.	" "
<u>M. pyogenes</u>		
Sensitive to .85% NaCl		Zeig 1920
<b>SOLID</b>		
<u>M. aurococcus</u>		
Agar covered with sterile 10% cane sugar soln. & holding at 10 C.	8 mos.	Keith 1913
<u>M. candidans</u>		
Nutrient gel, 22 C.	No change, 8 d.	Ransome 1901
<u>M. catarrhalis</u>		
20 C.	3 mos.	Worth 1919

TABLE C 2 / THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>S. aureus</u>		
Dry ice & ether	wks.	Paul 1907
Liquid air	125 d.	"
Dried on small stones in vacuo at low temp.	Recov. 40%	"
Vacuum dried, 195 C.	16-22 d.	Shattock 1912
Air dried	16-22 d.	"
<u>S. spp.</u>		
Dried on garnets, R.T.,	Innoc. 90,000, Recov. 300, 32 d.	Paul 1909
" " ice box	Innoc. 88,800, Recov., 550, 32 d.	"
" " temp. of Liquid air	Innoc. 65,990, Recov., 67,900, 32 d.	"
Dried	4-5 yrs.	Proom 1949
<b>LIQUID</b>		
<u>S. albus</u>		
.85% NaCl, -252 C.	50 h.	Kadisch 1931
<u>S. aureus</u>		
Saline susp., 6-11 C., R.H. 70-85%, CO <sub>2</sub> 5-4%	70% destruct., >8 d.	Arai 1931
High pressure, R.T., 3000 atmospheres.	45 min.	Basset 1932
Broth	15 d.	Bellelli 1928
Pus culture, R.T., sealed glass tubes	2 1/2-3 1/2 yrs.	Belin 1933
Dextrose, bouillon cult., freezing, 48 h., vacuum desiccated.	54 d.	Hammer 1911
Bouillon susp., R.T., in cellar, fine drops	35 d.	Kirstein 1902
Pure culture	28 d.	"
Liquid air, -185 C.	No impaired vitality 20 h.	MacFayden 1899
Liquid air	6 mos.	" 1900
Liquid H <sub>2</sub> , -252 C.	10 h.	"
Physiol. NaCl soln., R.T., Dried in vacuo over H <sub>2</sub> SO <sub>4</sub>	Viable for mos. Up to 11 d.	Otten 1930
Serum, 37 C.	Recov. 0, 1 min.	Panisset 1925
Met. violet		Philibert 1926
Saline, -78 C., Freeze in CO <sub>2</sub> ice.	100%	Proom 1949
Broth, freeze in CO <sub>2</sub> , 37 C.	100%	"
	Viable 2 yrs.	Rhodes 1950
<b>SOLID</b>		
<u>S. spp.</u>		
Nutrient agar, below 100.	No growth	Haines 1934

TABLE 22 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>S. species</u>		
Dried	7 yrs.	Lal 1948
Dried	4-5 yrs.	Iroom 1949
Dried	2/3 of original, 97 d.	Stark 1931
<b>DRIED, LYOPHILIZED</b>		
<u>S. hemolyticus</u>		
Dried 12 h.	51 mos.	Swift 1921
Frozen and dried	many yrs.	Swift 1937
<b>LIQUID</b>		
<u>S. hemolyticus</u>		
Citrate, gelatin, R.T.,	> 3 d.	Moleney 1924
Lockes gelatin, 37 C.	> 12 h.	"
Bacteria indifferent to osmotic pressure. Bi-valent & univalent salts antagonize each other at certain levels.		"
Susp. in broth or saliva in dry air.	Highly suscept. to tri-ethylene glycol vapor after 5 h. dessicat.	Robertson 1951
" " " low R.H.	Slower rate of killing at least 60 d. (alpha)	"
Veal infusion broth, 22C.	At least 30 d.	Surgalla 1940
" " " 37 C.		"
<u>S. spp.</u>		
Egg white, 50 c.	4 h.	Belin 1933
Peptone 1/20	3 h.	"
Alanine 1/20	5 h.	"
Glycochol 1/100	13.5 h.	"
leucine 1/100	13.5 h.	"
Physiol NaCl, R.T., absolute drying in vacuo.	Viable months	Otten 1930
Sprayed culture	All organisms settled in 48 hrs.	Phelps 1939
Sensitized with methyl violet	Recov. 0, 30 min.	Philibert 1926
Brain tissue, glycerol 50%	> 303 d	Roads 1929
<u>S. salivarius</u>		
Serum broth, 17 C., RH 77%		
Ozone .6-4 PPF	> 99% killed	Elford 1942
<b>GENERAL</b>		
<u>S. agalactiae</u>		
RH 0	mos.	Watts 1941
RH 75%	3 yrs.	"
RH 55%	8 wks.	" 1945
RH 25%	26 wks.	"
RH 10%	156 wks.	"
	156 wks.	"
<u>S. aureus</u>		
Stored at 37 C.		Stamp 1947
<u>S. faecalis</u>		
Stock lab. cult., sealed test tube, R.T.	11-12 yrs.	Ahuja 1935
<u>S. hemolyticus</u>		
Capillary tubes, 17 to -18C.	2 wks.	Citovicz 1928

TABLE 22 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference
GENERAL, CONT.		
<u>S. hemolyticus</u> 42 C.	Can stand numerous trans- fers	Spencer 1942
<u>S. lactis</u> Young cells, 1 C.	Inoc. 28,000,000, Re- cov. 620,000, 62 d.	Shorman 1942
Mature cells, 1 C.	Inoc. 350,000,000, Re- cov. <1, 51 d.	"
<u>S. spp.</u> RH 70-90%	rapidly killed	Elford 1945
Death rate of S. spp. decreased in certain carbo- hydrates when dessicated. Using progressively dust, water, xylose, saline, tryptophane, sali- cin, glucose & sucrose the % death rate decreased from 66.8 to 5.0 dessicated compered with 81.6 to 88.0 for the same fluid controls.	Using progressively	Heller 1941
Varies in resistance to methylene blue 60-100 C., 4-24 h. broth or agar cult.	Plasmolysis	Louros 1923 Ruska 1941

TABLE (23) THE SURVIVAL OF TREPONEMA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>T. pallidum</u>		
40 C.	2 hrs.	Besseman 1930
42 C.	1 hr.	"
Dried	1-2 d.	Landsteiner 1906
Dried in vacuo, R.T.	No movement, 4 d.	Zurhelle 1927
Under paraffin, liquid, R.T.	Movements 3 d, 17 hr.	"
Under paraffin, ice box	Movements 5-7 d.	"
Dried in vacuo, R.T.	No movement 68 h.-4 d.	"
Dried in Petri dish, R.T.	Still viable 65 hrs.	"
<b>DRIED, LYOPHILIZED</b>		
<u>T. pallidum</u>		
7 mo. cult., dried from frozen state. Stored 8 C.	168 hrs.	Hampp 1947
Rabbit testes in infusion broth, -78 C.	3 yrs.	Turner 1939
-10 C.	< 2 mos.	Turner 1938
-20 C.	< 2 mos.	"
-78 C.	1 yr.	"
-78 C.	1 yr.	"
<u>T. pertenuis</u>		
Rabbit testes in infusion broth, -78 C.	3 yrs.	Turner 1939
-78 C.	1 yr.	"
<b>LIQUID</b>		
<u>T. hispanicum</u>		
Blood of G.P., 14-20 C.	29 samples; 25 virulent 2-33 d.	Sergent 1938
" " 0 C.	6 samples; 0 virulent 33-60 d.	"
" " 0 C.	20 samples; 18 virulent 2d-7wks.	"
" " 10 C.	1 d.	"
Chorioallantoic memb. of 150 h. chick embryos.	< 4 h.	Sterzi 1939
<u>T. pallidum</u>		
Saline susp. 45 C.	Killed 7-10 min.	Bronfenbrenner 1913
10% rabbit serum, -10 C.	> 15 d.	Kindle 1934
$\frac{1}{2}$ inactive dog serum, $\frac{1}{2}$ physiol salt soln., 20.4-3.65 abs.	4 h.	Jahnel 1938
Above at 1.7 abs.	2 $\frac{1}{2}$ h.	"
Serum exudate from chancre R. T.	121 d.	Lacy 1921
Saline susp. rabbit testes, R.T.	58 d.	"
Brewers fluid, thioglycolate below 37 C. incub. with rabbit testes	Improved survival	Nelson 1948
Expos. to 5% CO <sub>2</sub> with isotonic PO <sub>4</sub> buffer, pH 7.0	Prolonged survival	"

TABLE C 23 THE SURVIVAL OF TREPONEMA SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID, CONT.</b>		
<u>T. pallidum</u>		
Isopropylidene with TPS factor, 147-148 C.	Prolonged survival	Rice 1951
Rabbit plasma, 5 C.	6 d.	Selbie 1943
Chorioallantoic memb. of 150 h. chick embryos.	< 4 h.	Sterzi 1939
Physiol NaCl & human serum under vaseline, R.T.	Motionless, 5 d.	Zurhelle 1927
<b>SOLID</b>		
<u>T. spp.</u>		
Deep tubes of agar anaerobically under paraffin oil at R.T. and 37 C. in dark was not satisfactory.		Rosebury 1950
<b>GENERAL</b>		
<u>T. pallidum</u>		
Culture, 39 C.	5 h.	Boak 1933
" 40 C.	3 h.	"
" 41 C.	2 h.	"
" 41.5 C.	1 h.	"
-16 C.	3 mos.	Kissmeyer 1928
2 C.	Some days	"
Cult. between 0 & 5 C.	>101 h.	Krantz 1923
10 C.	Lost power of producing lesion, 3 h.	Landsteiner 1906
Ice chest	24 h.	"
48 C.	30 min.	"
37 & 0 C.	4 h.	Miyao 1930
Syphilitic matl., 10 C.	3 h.	Neisser 1911
" " ice chest	24 h.	"
" " 48 C.	30 min.	"
Crystalline bovine alb., Na pyruvate, inorg. PO <sub>4</sub> buffer, glutathione, cysteine, vitamins & NaHCO <sub>3</sub> , 30 C., under 5% CO <sub>2</sub> -95% N <sub>2</sub>	8-10 d.	Nelson 1948
Culture of rabbit testes	10 d.	Perry 1948
Stored in solid CO <sub>2</sub>	5-20 mos.	Rosebury 1950
Chick embryos, 35 C.	>8 d.	Wile 1941
Aerobic, damp chambers, R.T.	4 d.	Zurhelle 1927
" " " 37 C.	48 h.	"
" " " ice box.	Still viable 3 d., 17 h.	"
<u>T. pertenuis</u>		
60 C.	15 min.	Marchoux 1938
37 C.	2 h.	Miyao 1930
0 C.	<15 min.	"
<u>T. spp.</u>		
Temp ranging from that of liquid O <sub>2</sub> to that of liquid He	Survived	Luyet 1938

TABLE C 24 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>V. comma</u>		
Peptone, water cult. dried in vacuo over P <sub>2</sub> O <sub>5</sub> . R.T. Sealed glass tubes.	4 yrs.	Campbell-Renton 1942
(Schillong 653)	Orig. count, 9 X 10 <sup>6</sup> After 4 yrs., 240	"
(Rangoon R)	Orig. count, 6 X 10 <sup>6</sup> After 4 yrs., 50	"
(Schillong 1077)	Orig. count, 9 X 10 <sup>6</sup> After 4 yrs., 50	"
(Schillong 610 R)	Orig. count, 125 X 10 <sup>7</sup> After 4 yrs., 0	"
Dried <u>V. foetus</u>	4-5 yrs.	Proom 1949
Dried	3-4 yrs.	"
<b>LIQUID</b>		
<u>V. comma</u>		
Sterile sat. soln. NaCl in water	< 1 d.	Arguelles 1927
Fish extract, sterile Bouillon cult. with	125 d.	"
Cont. freeze -10 to -16C.	57 d.	Brehme 1901
Bouillon, -8 to -18 C.	Perished in 5 d.	"
Peptone, water cult., R.T. Dried in vacuo, sealed tubes over P <sub>2</sub> O <sub>5</sub>	4 yrs.	Campbell-Renton 1942
0.3 g. NaCl & 10 cc agar 38 C. (El tor)	Normal & invol. forms.	Eisler 1909
38 C., .3 gm NaCl	Invol. & normal forms.	"
0.3 gm NaCl & 0.05 gm Ca(NO <sub>3</sub> ) <sub>2</sub>	Normal forms.	"
0.3 gms NaCl & 0.1 g. Ca(NO <sub>3</sub> ) <sub>2</sub>	Invol. & Normal forms.	"
Meat infusion	4-5 wks.	Hesse 1889
Ham broth	4-5 wks.	"
Bouillon susp. R.T., Bouillon cult., 106 D. old.	10 h.	Kirstein 1902
dried in air	2 d	Kitasato 1889
dried in exicator	3 d.	"
Bouillon cult., 15 d. old.		"
dried in air	3 d.	"
dried in exicator	3 d.	"
Bouillon cult., 1 d. old.		"
dried in air	30 h.	"
dried in exicator	40 h.	"
Bouillon cult., 40 h. old.		"
dried in air	40 h.	"
dried in exicator	40 h.	"

TABLE C 24 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID</b>		
<u>V. comma</u>		
-	>894 d.	Lal 1921
- (Bombay str.)	>657 d.	"
- (Lister str.)	>658 d.	"
Liquid air, -185 C.	No impaired viability 20 h.	MacFayden 1899
Peptone broth, liquid air, -252 C.	No impaired vitality 10h.	" 1900
Broth emulsion with un- ster. milk, liquid air.	No " " 7 d.	"
Liquid H <sub>2</sub> , -252 C.	10 h.	"
Thick susp. R.T., dried in vacuo over H <sub>2</sub> SO <sub>4</sub>	1 out of 100,000 survive 24-48 h. after innoc. into blood or serum.	Otten 1930
Physiol. NaCl, R.T., abs. drying in vacuo	Innoc. blood or agar cult., Viable mos.	"
Saline	12%	Proom 1949
Broth	47%	"
Broth, R.T.	5.5%	"
Saline, -78 C.	4.7%	"
1/5,000 peptone with salt	3 d.	Read 1939
Ster. salt, water, ice 0.5-7.0 C.	6-7 d.	Renk 1893
" " "	Innoc 1,483,000/cc. Re- cov. 62,445/cc after 24 h.	"
Beef bouillon in cotton stoppered test tube.	Viable & path. 5 wks.	Skidmore 1932
30% sat. NaCl	24 h.	Tohyama 1925
1 & 5% soln. 5th class table salt	4 d.	"
Peptone water	11 d.	"
Bouillon	26 d.	"
NaCl 20 & 25%, -70 C.,	24 h.	Tohyama 1930
Peptone water, -60 C.	Innoc. 40,000/cc, Re- cov 0, 1 mo.	"
Bouillon, -60 C.	Innoc. 40,000/cc, Re- cov. 0, 40 d.	"
1 to 25% saline	Survived 3 d.	"
20% NaCl, -70 C.	Innoc. 390,000/cc, Re- cov. 0, 24 h.	Tohyama 1930
Physiol. NaCl, -70 C.	48 h.	"
Peptone water, pH 7.9	>108 d.	"
Bouillon, pH 7.9	>108 d.	"
Peptone, 5-6.5 C.	21 d.	Weiss 1894
Bouillon, 22-25 C., dark	16 d.	"
<b>SOLID</b>		
<u>V. comma</u>		
10 cc. agar, 38 C., 0.46 gm. NaCl	Many invol. forms.	Eisler 1909



TABLE 024 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

Factor(s)	Survival	Reference
<b>SOLID, CONT.</b>		
<u>V. comma</u>		
10 cc. agar, 38 C., plus .46 gm. NaCl & .05 Ca(NO <sub>3</sub> ) <sub>2</sub>	Dispersed invol. forms.	Eisler 1909
.4 gm. NaCl & .1 Gm. Ca(NO <sub>3</sub> ) <sub>2</sub>	Normal	"
0.1 gm. LiCl	Many invol. forms.	"
0.1 g. LiCl & .05 g. Ca(NO <sub>3</sub> ) <sub>2</sub>	Many normal, some invol.	"
.05 g. Mg(NO <sub>3</sub> ) <sub>2</sub>	Invol. & normal	"
.05 g. Mg(NO <sub>3</sub> ) <sub>2</sub> & 1g. NaCl	Many normal, few invol.	"
Thiol, 26 C., PH 6.8	At least 150 d., Max. growth 4 d.	Huddleson 1949
Beef peptone gelatine cult.		
-12.5 C., indoors	Lived 2 wks. after.	Kasanky 1895
-31.8 C., outdoors	Lived 20 d.	"
-30 to -31.8 C.	Viable 114 d.	"
Gelatine cult., 102 d. old.		
Dried in air	2 d.	Kitasato 1889
" "	30 h.	"
Dried in exicator	5 d.	"
" "	40 h.	"
Gelatine cult. 12 d. old.		
dried in air	3 d.	"
dried in exicator	3 d.	"
Gelatine cult. 4 d. old.		
dried in air	4 d.	"
dried in exicator	5 d.	"
Agar cult. 20-22 C., 14 mos. old, 10 d. in in- cubator. Dried in air	4 d.	"
" " Dried in exicator	7 d.	"
Agar cult. 20-22 C. 50 d. old, 12 d. in incub.		
dried in air	4 d.	"
dried in exicator	11 d.	"
Agar cult. 20-22 C., 9 d. old., 1 d. in incub.		
dried in air	4 d.	"
dried in exicator	9 d.	"
Agar cult. 20-22 C., 1 d. old., 1 d. in incub.		
dried in air	3 d.	"
dried in exicator	11 d.	"
Potato cult, 17 d. old.		
8 d. in incub		
air dried	2 d.	"
dried in exicator	5 d.	"
Potato cult. 8 d. old.		
8 d. in incub.		
air dried	4 d.	"
dried in exicator	5 d.	"

TABLE C 24 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

Factor(s)	Survival	Reference
<p>SOLID, CONT  <u>V. comma</u>                      Gelatine agar, liquid                      air, -190 C.                      Agar slant</p>	<p>No impaired vitality 7d                      42 d.</p>	<p>MacFayden 1900                      Tohyama 1925</p>
<p>GENERAL  <u>V. comma</u>                      Stock lab. cult., R.T.,                      sealed                      -40 F.                      45 F., thawed and held                      61-105 d.                      -5.5 to -8 C.                      - (Bombay str.)                      - (Hog cholera)                      20 C. exposed to polar-                      ized light                      24 C., Exp. to unpolar.                      light                      105 C.                      110 C.                      Dark, R.T.                      -21 C.                      -15 C.                      37 C.                      Stored at 37 C.                      Lives more than 1 mo, when                      and repeated freezing &amp; thawing has not influence                      on vitality.</p>	<p>Failed to show growth                      after 12-18 yrs.                      425 d.                      Lasting immunity when                      used with hog cholera                      antisera                      Recov. 0, 10 d.                      &gt; 524 d.                      &gt; 657 d.                      Innoc. 1/100,000 diln.                      Recov. 121, 13 hrs.                      Innoc 1/100,00 diln.,                      Recov. 17, 30 h.                      Living                      Dead                      1,044 d.                      1 mo.                      &gt; 1 mo.                      dead at 2 yrs.                      0% survive after 4 yrs.                      lowest temp. is -32.5 C.                      and repeated freezing &amp; thawing has not influence                      on vitality.</p>	<p>Ahuja 1935                      Cole 1951                      "                      Finkelburg 1901                      Lal 1921                      "                      "                      1926                      "                      "                      Lal 1923                      "                      "                      Rapschewski 1901                      "                      Rhodes 1950                      Stamp 1947                      "                      Wuknow 1893</p>

TABLE (25) THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Allantoid</u> Dried & ppt. at 4 C.	6 mo..	Fasquelle 1950
<u>Aphteuse</u> Dried & left at 37 C.	2 yrs.	"
<u>Herpes febrilis</u> Ice box dried in vacuum over H <sub>2</sub> SO <sub>4</sub> with reduced press., -5 C., Recov. in Lockes soln.	>1 yr.	Hawkins 1929
<u>Herpétique</u> Dried & left at 37 C.	2 mo.	Fasquelle 1950
<u>Hoof &amp; Mouth</u> Dried with 0.5 g. P <sub>2</sub> O <sub>5</sub> at 70 C. in vacuo	2½ hrs.	Sichert-Modrow 1930
Lymph, 122 C., dried with 0.5 g. P <sub>2</sub> O <sub>5</sub> in vacuo.	3 min.	"
Dried lymph of G.P., 52 C. in atm. of P <sub>2</sub> O <sub>5</sub> .	Still infectious, 14 h.	"
" " " R.T.	10 d.	"
<u>Influenza (Melbourne str.)</u> Dried talc	30 min.	Parker 1944
<u>Polio, (Aycock str.)</u> Heat 30 min. at 50 C. " " 52.5 C.	Remained infective Non-infective	Shaughnessy 1930 "
<u>Smallpox</u> 37 C., dried	80 d.	Hornibrook 1951
4-6 C., dried	24 h.	"
<u>Tobacco mosaic</u> Dessicated	many yrs.	Stakman 1942
<u>Vaccinia (testicular str.)</u> Dried, 4 C.	12-18 mos.	Noguchi 1918
Dried	229 d.	Paschen 1908
<b>DRIED, LYOPHILIZED</b>		
<u>Foot &amp; mouth</u> Dried in vacuo & refrig.	93 d.	Lepine 1937
<u>Herpes</u> 0.5 fresh brain emuls. with Lockes soln.	4 wks.	Rivers 1927
<u>Influenza</u> Lyophilized	Infect. for ferret 14 mos.	Horsfall 1940
Infusion broth, rabbit testis, -78 C.	3 yrs.	Turner 1939
Mouse lung, 10% plain broth, -78 C.	6 mos.	Turner 1938
<u>Laryngotracheitis (fowl)</u> Lyophil. & stored 4 C.	3 yrs.	Hoffstadt 1946
<u>Lymphoeruloma inguinale</u> Infusion broth, rabbit testes, -78 C.	10 mos.	Turner 1939
<u>Lymphocytic choriomeningitis</u> Frozen, dried, 5 C.	378 d.	Wooley 1939

TABLE C 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, LYOPHILIZED (cont'd)</b>		
<u>Meningopneumonitis</u> Infusion broth, rabbit testes, -78C	3 yrs.	Turner 1939
<u>St. Louis encephalitis</u> Frozen, dried, 5C	833 d.	Wooley 1939
<u>Vaccinia</u> Frozen, dried Lockes soln., -185C Frozen & thawed 22X	mos.	" "
Lyophil apparatus appears to be useful also in maintaining the viability of virus strains without continuous animal passage. (10 mos.)	No reaction, rabbit skin	Rivers 1927
		Flosdorf 1935
<b>LIQUID</b>		
<u>Coxsackie</u> Susp., 53-55C " pH 2.3-9.4 " pH 4.8	30 min. 1 d. 7 d.	Robinson 1950 " " " "
<u>Enteritis</u> PO <sub>4</sub> buffer, pH 7 1/1,000 dil. 1/10,000 dil. 1/100,000 dil.	<20 d. Killed 75% of mice " 25% " " None killed	Gallo 1948 " " " "
<u>Equine encephalitis</u> Acidic saline with agitation, bubbling, gases & shaking, pH 6.4	Rapidly inactivated	McLimans 1947
<u>Foot &amp; mouth</u> GP blood 37C, citrated " " " defibrinate M/45 buff. PO <sub>4</sub> soln., OC pH 7.6, purified pH 7.6, unpurified	4.9 d. 2.1 d. Inoc. dil. 1/100,000 Recov. dil. 1/100, 97 d. Inoc. dil. 1/100,000 Recov. dil. 1/1,000, 126 d.	Brooksby 1948 " " Galloway 1936 " "
Saline, 37C 50% glycerine GP lymph., pH 7.5 in PO <sub>4</sub> buffer.	24 hrs. 174 d. Still infectious, 2 yrs. 20 d.	Lepine 1937 " " Sichert-Modrow 1930
Ammonia brine, repeated freezing	Did not destroy, 124 d.	Stockman 1926
Fresh GP lymph, 2-7C	Retained virulence 190 d.	" "
<b>Herpes</b>		
20% susp. of infected rabbit brain in buff. physiol. saline, 37C " " " 41.5C " " " "	100 hrs. 70-80 hrs. (Frank str.) 30 hrs. (Go str.)	Boak 1940 " " " "
Fresh normal rabbit serum with UV radiation	10 min.	Gundersen 1932
Tissue cult., 40.2C	Did not survive	Thompson 1942

TABLE Q25

## THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID, (CONT.)</b>		
<u>Influenza</u>		
Single heat, chorio-allantoic fluid, (PR 8 unadapted) 60 C.	< 5 min.	Jones 1945
Single heat, chorio-allantoic fluid, (PR 8 Heat adapted) 60 C.	< 5 min.	"
" " " 56 C.	> 45 to < 60 min.	"
Mouse brain susp. with rabbit serum, -20 to -30 C. (A & D)	< 6 mos.	Olitsky 1949
Saline & horse serum		
" " " pH 3.05	1 h.	Stock 1940
" " " " 4.04	1-20 h.	"
" " " " 4.99	48 h.	"
" " " " 5.35	48 h.	"
" " " " 5.98	> 72 h.	"
" " " " 6.98	72 h.	"
" " " " 7.0	72 h.	"
" " " " 5.0	1 h.	"
" " " " 7.5		"
with .001 N. oleic acid.	90 min.	"
50% glycerine	3-4 wks.	Wilson 1919
<u>Japanese B. encephalitis</u>		
Mouse brain susp. with rabbit serum, -20 to -30 C.	6 mos.	Olitsky 1949
<u>Lymphogranuloma inguinale</u>		
Aqueous susp.	40 hrs.	Latarjet 1951
<u>Measles</u>		
50% glycerine	3 mos.	VanRooyen 1940
<u>Mumps</u>		
Mouse brain susp. with rabbit serum, -20 to -30 C.	< 6 mos.	Olitsky 1949
Chorio-allantoic fluid, 4 C., pH 6.5-7	Most stable	Weil 1948
Chorio-allantoic fluid, 4 C., pH above 7.9	Rapidly killed	"
Chorio-allantoic fluid, 4 C., pH 5.8-8	99% inact., 4 wks.	"
Penicillin & streptomycin	No inact. effect 14-28 d.	"
Chorio-allantoic fluid, 37.5 C.	Greatest & most rapid increase, 7 d.	"
<u>Myxoma</u>		
Tissue cult., 42.2 C.	Did not survive	Thompson 1942
<u>Neurotropic</u>		
Mouse brain susp. with rabbit serum, -20 to -30 C.	9 mos.	Olitsky 1949
<u>Newcastle</u>		
50% glycerine, R.T., pH 7.6	95 d.	Prier 1950
" " " 50, " "	353 d.	Prier 1950

Factor(s)	Survival	Reference
<b>LIQUID, (CONT.)</b>		
<u>Noguchi Str. (Vaccinia)</u>		
Tissue cult., 45.1 C.	< 4 d.	Thompson 1942
<u>Poliomyelitis</u>		
Glycerol	6 yrs.	Flexner 1917
Spinal cord in 50% glycerol, 4 C.	> 25 mos.	" 1914
Glycerol (M.A. str.)	> 11 mos.	"
0.5% phenol	74 d.	"
Filtered, 37 C.	20 d.	" 1910
-2 to -4 C.	40 d.	"
4 C.	50 d.	"
45-50 C.	Killed after 30 min.	"
50% glycerol	> 7 d.	"
" " -15 C.	2 yrs.	"
Aqueous susp.	10 d.	Latarjet 1951
Physiol. saline, 45-60 C. 30 min.	Becomes inactivated. The more dil. the susp. the less heat is req. to inactivate.	"
50% glycerol	8 yrs.	Rhoads 1929
100 % glycerol, 18 C. 1st passage.	Viable 59 d.	Romer 1910
50% glycerol, 3rd pass.	14-31 d.	"
50% glycerine	Some mos.	Wilson 1919
<u>Psittacosis</u>		
Beef saline	29 d.	Rivers 1948
<u>Rabies</u>		
Brain susp. in glycerine in disintegrator 1 h.	47 d.	Barrat 1904
Susp. brain, liquid air	Still virulent 24 h.	"
Buffer soln., glycerol	15-17 wks.	Grycz 1949
Aqueous susp.	40 hrs.	Latarjet 1951
Undil. neutral glycerol, R.T.	Several wks.	Rivers 1948
Liquid air, -185 C.	3 mos.	McFayden 1900
Neutral glycerol, refrig.	Several mos.	Rivers 1948
Aqueous susp., 54-56 C.	1 h. or less	"
" " sub-freezing.	1 or more yrs.	"
<u>Streptobacillus virus</u>		
Bouillon, 100 C., 48 h. cult., 1-100 dil. (Str. # 1776)	No growth	Bingel 1947
<u>Vaccinia</u>		
Glycerine susp. (28628, rabbit testicular)	33 d. & 6 hrs. after 61st transfer	Armstrong 1929
Chorio-allantoic memb.	8 hrs.	Buchbinder 1941
Glycerine, mouse brain, water	Inoc. .05 cc of 1:100 dil., Recov. after 24th passage, 10 mos.	Haagen 1939
Glycerine, mouse brain, water, freeze-dry temp.	1 yr. 9 mos.	"
Glycerine, mouse brain, refrig. temp.	Avirulent 1 yr.	"

TABLE C 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>LIQUID, CONT.</b>		
<u>Vaccinia</u>		
Chorion & 1 drop calf lymph, Refrig. temp. (Str. 3, Breslau) (Str. 4, Dresden)	2 yrs.	Haagen 1939
Allantois of chick embryo, low temp., Present in glycerine, Ringers soln. from 1933-49	Capable of multiplication and still pathogenic after 15 yrs.	Lehmann 1949
Pure glycerol, 18 C.	5 d.	Noguchi 1918
" " 37 C.	24 h.	"
Ringers soln. with .54 and 1% phenol and water	Still active 1 yr.	"
Physiol saline, -13 C.	7.4% showed count over 30,000 after 4 yrs.	
	41 % after 10 yrs.	Schartner 1939
Tissue cult., 45.1 C.	-	Thompson 1942
Liquid air	15 min.	White 1901
<u>Variola</u>		
Saline soln., 35 C.	30 min.	Gordon 1925
<u>Yellow fever</u>		
Physiol. saline	Better than dist. water.	Bauer 1940
Aqueous susp.	10 d.	Latarjet 1951
Glycerol	8 mos.	Rivers 1948
<b>SOLID</b>		
<u>Foot &amp; mouth</u>		
Congeaed state	162 d.	Lepino 1937
<u>Vaccinia</u>		
Levinthal, blood agar, -13 C.	Recov. 11% after 4 yrs., 58.3% after 10 yrs.	Schartner 1939
<b>GENERAL</b>		
<u>Colorado tick fever</u>		
Ice compartment	3½ yrs.	Rivers 1948
<u>Cow pox</u>		
Culture, -70 C.	< 108 h.	Pictet 1884
" -130 C.	< 20 h.	"
<u>Dengue</u>		
Stogomya, 22 C.	Up to 85 d.	Blanc 1929
" 16.5 C.	" "	"
" 22.5 C.	Up to 17½ d.	"
<u>Encephalitis</u>		
40 C., pH 8.4 (St. Louis)	Still viable 3 wks.	Duffy 1946
pH 3.5-11.5 (Equine)	Greatest stability after 1 h.	Finkelstein 1938
pH 7.5-8.5, (Equine)	Greatest stability " 1 wk.	"
20% saline with 10 cc. defibrin. rabbit blood temp 29.4-32 C., high humidity (Jap. B.)	Transmission occurred by bite of Culex spp. mosq. in 3 days following blood meal	Hammon 1949

TABLE Q 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>Encephalitis</u>		
-20 C., glass tubes (Jap B.)	12 mos.	Melnick 1946
-20 C., corked tubes (Jap B.)	1000 fold loss	Melnick 1946
Filtered, 56 C. (St. Louis)	30 min.	Rivers 1948
pH 8.4-8.8 (St. Louis)	3 wks.	"
pH 7-10 (Jap B)	Inact. rapidly	Rivers 1948
Susp. 70 C. (West. equine)	10 min.	"
Filtrates, 60 C. " "	10 min.	"
<u>Fowl plague</u>		
pH 6-99	Range of stability	Pyl 1938
<u>Foot &amp; mouth</u>		
Guinea pig vesicle fluid R.T.	3-6 mos.	Anonymous -
<u>Herpes simplex</u>		
-70 C.	> 1 yr.	Rivers 1948
<u>Influenza</u>		
10% normal horse serum, shaken 24 h. (PR8 Str.)	Held titer better than 0.2% bovine albumin	Dick 1949
10% normal monkey serum, shaken 24 h. (French neurotropic)	Held titer better than 0.2% bovine albumin dil.	"
Tissue culture, 60 C. (PR8)	>5 min, <7 min	Jones 1945
" " 55 C.	>30 min, <45 min.	"
" " 50 C.	>120 min, <180 min.	"
Tissue culture, heat adapted, 60 C.	>5 min, <7 min.	"
" " 55 C.	>45 min, <60 min.	"
" " 50 C.	>180 min.	"
After storage, (PR 8) 25.5 C.	Unadapted 28 d., heat adapted 49 d.	"
" " 37 C.	Unadapted 18 d., heat adapted 22 d.	"
" " 41 C.	Unadapted 8 d., heat adapted 14 d.	"
40 C. (Inf. A) R.T.	2-3 mos.	Rivers 1948
0-40 C.	6 wks	Scherp 1938
	1 wk.	"
<u>Inclusion conjunctivitis</u>		
Refrigerated	Sev. days	Rivers 1948
<u>Looping ill</u>		
Mouse brain, 80 C.	30 sec.	"
" " 60 C.	2 min.	"
" " "	10 min	"
<u>Lymphogranuloma venereum</u>		
37 C.	2 1/2 d.	"
56 C.	10 min.	"
70 " 30 C.	> 1 yr.	"



TABLE C 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>Mumps</u> -70 C.	10-mos.	Rivers 1948
<u>Measles</u> -72 to -35 C. Freezing	4 wks. 25 hrs.	Rivers 1948 Van Rooyen 1940
<u>Newcastle</u> pH 5.5-7.5 Incub. 37 C., undil. amniotic fluid	- Viable 126 d.	Elford 1948 Olesniuk 1951
<u>Papilloma</u> Neutral to pH 4.2 weakly alkaline On acid side of pH 7 the high until at pH between suddenly. At pH 10.1 to observed. (Shope virus)	Least loss of activity. Gradual loss of activ. virus activity remains 2.9 & 3.3 it is lost 10.2 immediate inactiv.	Beard 1938 " Nyckoff 1937
<u>Poliomyelitis</u> More effective when sus- pended in low pH. Infective after heating at 55-58 C. Emulsion of hemocytes of flies & cockroaches -38.5 C., 2800-3100 A. Berkefeld filter, 38 C. 35 C. 37 C. -70 to -20 C. With <i>E. histolytica</i> 50 C.	(Armstrong mouse adapted) - Produced paralysis in mice in 12 & 15 d. respectively. Complete destruction 1-30 min. 7 d. 2 hrs. 21 d. No loss in infectivity 12 mos. Settles out 3 min.	Hammon 1941 Howitt 1930 Hurlbut 1950 Jungleblut 1937 Landsteiner 1910 Leiner 1910 Levaditi 1913 Melnick 1946 Young 1949 Shaughnessy 1930
<u>Pseudolymphocytic chorio meningitis</u> Mouse brain, 56 C.	30 min.	Rivers 1948
<u>Psittacosis</u> Broth, 40 C. -70 C.	Several wks. > 2 yrs.	Rivers 1948 "
<u>Rabies</u> Fats & lipids extracted from desiccated rabies vaccine with various solvents and injected into mice fail to give protection or provoke evidence of toxic response when given subdurally or intra- peritoneally. When extracted at low temp (-65 C.) with ether, the virus is not destroyed. After 1 yr. amount of living virus has not decreased.		Harris 1948
<u>Rift valley fever virus</u> Light, met. blue	40 min.	Rivers 1948
<u>Rinderpest virus</u> Leucocytes & spleen 4 C. Dried & ppt. with acetone. > 2 mos.		Das 1949

TABLE (25) THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
<b>GENERAL, CONT.</b>		
<u>Rinderpest virus</u>		
Leucocytes & spleen 40 C.	>4 mos.	Das 1949
Dried over CaCl <sub>2</sub> in vacuo.		
" " " " 37 C.	15 d.	"
<u>Semlike forest virus</u>		
60 C.	1 h.	Rivers 1948
<u>Trachoma</u>		
Refrigerate	1 wk.	Julianelle 1942
<u>Vaccinia</u>		
Ottens d., 1944, tropical temp and R.H.	18 yrs.	Collier 1950
Gases at 4 C.	Retained virulence 3wks.	Noguchi 1918
Gases at 37 C.	Became avirulent	"
Pure O <sub>2</sub> or CO <sub>2</sub> , 18 C.	Destroyed virus complete.	"
Sonic vibrations	>15 min. partial inact.	Rivers 1937
<u>Yellow fever</u>		
10% N. monkey serum shaken 24 h.	Held titer better than 0.2% bovine alb. dil.	Dick 1949
Dessicated, frozen	many yrs.	Rivers 1948
<u>Cold virus filtrates.</u>		
-76 C., dry ice	2 yrs.	Andrews 1949
-10 C.	27 d.	"
4 C.	3 d.	"

TABLE (25) THE SURVIVAL OF YEASTS, MOLDS AND FUNGI IN CULTURE

Factor(s)	Survival	Reference
<b>DRIED, GENERAL</b>		
<u>Actinomyces</u>		
Desiccated (wentii)	>1 yr.	Wehmer 1897
" (niger)	3 yrs.	"
" (oryzae)	>4 yrs.	"
Dried (spp.)	405 yrs.	Froom 1949
<u>Brewers yeast</u>		
Dried with plaster paris	10 mos.	Pasteur 1876
<u>Saccharomyces pastorianus</u>		
Diffuse light	< 3 yrs.	Kayser 1889
<u>Yeast, spp.</u>		
More resistant in dry state than in moist.		Kayser 1889
<b>DRIED, LYOPHILIZED</b>		
<u>Ascomycetes</u>		
Culture suspended in normal horse serum, quick frozen, dried in high vacuum & sealed quickly.	0.2% survival rate in 3 mos.	Atkin 1949
<u>Saccharomyces cerevisiae</u>		
Bouillon & beerwort, exp. 10-15 min. to U.V.	More time req. for gelatinized media	Gilles 1935
Frozen at -24 C. & thawed at 25 C.	28% killed	Stille 1943
<u>Yeasts, spp.</u>		
Lyophilized in vacuo	1 yr.	Dopter 1949
Lyophilized	2 yrs.	Wickerham 1946
<b>LIQUID</b>		
<u>Aspergillus</u>		
Nutrient media, -6 to -11 C.	4 d.	Bartetzko 1910
1% glucose, -12 C.	2 h.	"
<u>Epidermophytes</u>		
.85% NaCl, -20 to -30 C.	34 d.	Kadisch 1931
<u>Saccharomyces</u>		
Broth, salt soln., -13 to -15 C. (cerevisiae)	>160 wks.	Tanner 1928
Broth, -13 to -15 C. (ellipsoideus)	5 wks.	"
Salt soln., -13 to -15 C. (ellipsoideus)	18 wks.	"
Broth, -13 to -15 C. (maxicans)	>160 wks.	"
Salt soln., -13 to -15 C. (maxicans)	14 wks.	"
Broth, -13 to -15 C. (pastorianus)	58 wks.	"
Salt soln., -13 to -15 C. (pastorianus)	>160 wks.	"
<u>Yeasts, spp.</u>		
10% sucrose	Of 25 strs., 15 retained viability 10 1/4 yrs., 9 dead in 8 1/2 yrs.	Meissner 1911
Nutrient broth & fruit juices, -23.3 C.	3 yrs.	Tanner 1934

TABLE 26 THE SURVIVAL OF YEASTS, MOLDS AND FUNGI IN CULTURE.

Factor(s)	Survival	Reference
<b>LIQUID, CONT.</b>		
<u>Yeasts, spp.</u>		
10% sucrose in Freudenreich flasks	many yrs.	Will 1909
.85% NaCl soln., -20 to -30 C.	> 2 mos.	Kadisch 1931
<b>SOLID</b>		
<u>Absidia</u> Potato dextrose agar, 7 C.	10 used, 8 viable, 2 yrs. 8 mos.	Hesseltine 1947
<u>Actinomucor</u> Potato dext. agar, 7 C.	1 used, 1 viable, 2 yrs. 8 mos.	"
<u>Alternaria</u> Potato dext. agar, 7 C.	3 used, 3 viable, 2 yrs. 8 mos.	"
Agar slant, -29 C.	> 4 mos.	Bartram 1916
<u>Ascomycota</u> Agar slant, -29 C.	> 4 mos.	"
<u>Aspergillus</u> Potato dext. agar, 7 C.	98 used, 48 viable, 2 yrs., 8 mos.	Hesseltine 1947
3% gelatin, -10 to -13 C.	12 h.	Lindner 1915
<u>Blastomyces</u> Sabourauds dextrose agar, R.T., cov. with mineral oil.	20 mos.	Ajello 1951
<u>Candida</u> Sabourauds dextrose agar, R.T., cov. with mineral oil	20 mos.	"
<u>Cephalothium</u> Agar slant, -29 C.	> 4 mos.	Bartram 1916
<u>Chartomium</u> Potato dext. agar, 7 C.	8 used, 7 viable, 2 yrs., 8 mos.	Hesseltine 1947
<u>Circinella</u> Potato dext. agar, 7 C.	2 used, 2 viable, 2 yrs., 8 mos.	"
<u>Coccidioides</u> Sabourauds dext. agar, R.T., cov. with mineral oil.	20 mos.	Ajello 1951
<u>Cryptococcus</u> Sabourauds dext. agar, R.T. cov. with mineral oil	20 mos.	"
<u>Fusarium</u> Potato dext. agar, 7 C.	15 used, 11 viable 2 yrs., 8 mos.	Hesseltine 1947
<u>Mucor</u> Agar or liquid Raulins med., -70 to -110 C.	2 h.	Chodat 1896

Factor(s)	Survival	Reference
<b>SOLID</b>		
<u>Mucor</u> Potato dext. agar, 7 C.	59 used, 53 viable, 2 yrs, 8 mos.	Hesseltine 1947
<u>Nocardia</u> Sabourauds dext. agar, R.T. Cov. with mineral oil.	20 mos.	Ajello 1951
<u>Phycomyces</u> Potato dext agar, 7 C.	3 used, 3 viable, 2 yrs., 8 mos.	Hesseltine 1947
<u>Penicillium</u> Potato dext. agar, 7 C. (spp.)	2 yrs., 8 mos.	"
3% gelatin, -10 to -13 C. (glaucum)	12 h.	Lindner 1915
<u>Rhizopus</u> Potato dext. agar, 7 C.	17 used, 13 viable 2 yrs., 8 mos.	Hesseltine 1947
<u>Saccharomyces cerevisiae</u> Agar slants, -70 C.	1-8 d.	Karcher 1931
<u>Syncephalastrum</u> Potato dext. agar, 7 C.	2 used, 2 viable, 2 yrs. 8 mos.	Hesseltine 1947
<u>Trichoderma</u> Potato dext. agar, 7 C.	7 used, 7 viable 2 yrs. 8 mos.	"
<u>Yeast, spp.</u> Nutrient agar, 0 C	Rapid growth. 5 d.	Haines 1934
<b>GENERAL</b>		
<u>Aspergillus</u> Dark, lab. temp. (flavus)	6 yrs.	McGrae 1923
" " (fumigatus)	10 yrs.	"
" " (glaucus)	16 yrs.	"
<u>Mold, spp.</u> Dark, lab. temp. (spores)	20 yrs.	"
Below freezing	Very few living, 16 mos.	Tanner 1931
<u>Saccharomyces</u> Subfreezing temp, Sucrose conc. >30-35%, pH 3.6-3.7	Retards destruction	McFarlane 1940
<u>Streptothrix</u>	420 d.	Lal 1921
<u>Yeasts, spp.</u> Incubator, 28 C.	< 3 yrs.	Kayser 1889
Sub-freezing, -9.9 C. in agar slant	> 1 yr.	Smart 1935
Found in frozen fruits, 15 F. -15 C.	After 3 yrs. 160 wks.	" Tanner 1928
<u>Yeasts, spp.</u> Agar, 37 C.	5 mos.	Eberson 1920

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN FOOD

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F10	Shigella species	2
F11	Streptococcus species	2
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TABLE FL

## THE SURVIVAL OF BACILLUS SPECIES IN FOOD

Factor(s)	Survival	Reference
<u>MILK</u> <u>B. anthracis</u> Milk from udder of cow that had died of the disease	10 yr.	Morris 1921
<u>DAIRY PRODUCTS</u> <u>B. sp.</u> Margarine	Recov. 72%	Foltz 1951
<u>CEREAL</u> <u>B. anthracis</u> Oats	Present	McFadden 1895
<u>VEGETABLES</u> <u>B. anthracis</u> Roots of corn Plants, lima bean	50 d. Recov. 6-11 d.	Beranek 1948 Russell 1893
<u>FRUITS</u> <u>B. mycoides</u> Fruits, -5F	Resisted -5 and 15F better than higher temp.	Campbell 1932



TABLE E2

## THE SURVIVAL OF BRUCELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Br. abortus</u>		
Cream, 8C	Bovine strain 8 d.	Carpenter 1928
" "	Bovine & human strain 10 days	" "
Sour milk	5 d.	Honda 1938
Milk, home pasteurized	Inoc:100,000/ml; 5-10min	Huddleson 1949
Raw milk	---	Jones 1943
Raw cream	Recov: 11 out of 13	Pullinger 1935
Sterilized and raw milk	Some after 50 min. recov	Seelemann 1938
Milk, 145F	30 min.	Smith 1932
" flash pasteurization	Org. survived	" "
Milk, 4-8C, 18-19C, 22-24C	Inoc:0.5 cc milk, 1-7 d.	Stockmayer 1935
Milk+0.25% Boric acid, 4-8C, 18-19C, 22-24C	" " " "	" "
Milk+0.5% Boric acid, 4-8C, 18-19C, 22-24C	" " " "	" "
Milk+1% Boric acid, 4-8C, 18-19C, 22-24C	" " " "	" "
Milk+2% Boric acid, 4-8C, 18-19C, 22-24C	" " " "	" "
Milk, R. T.	3-4 d.	Van Drimmelen 1948
<u>Br. melitensis</u>		
Sheep's milk, 16C, pH 6.8-6.0	22-40 d.	Versilova 1937
Sheep's milk, 16C, pH 4-5	30 d.	" "
Milk, 37C	Few days	" "
<u>Br. suis</u>		
Milk, 62C, open coil pasteurizer	4 min.	Murray 1932
Milk foam in outlet, 63C	30 "	" "
<b>DAIRY PRODUCTS</b>		
<u>Br. abortus</u>		
Butter, 8C	81-32 d.	Carpenter 1928
" 46F	142 d.	" "
Cheese	60 d.	Daklberg 1946
Butter, 8C	Inoc:artificial;32-142 d.	Fitch 1933
Ice cream	Present ---	" "
Cheese	Few days	Pullinger 1935
Ice cream, 30F	1 mo.	Thompson 1933
Roquefort cheese	2 mo.	" "
Cheese	2 "	Voille 1931
Ice cream, -23.2C	7 yr.	Wallace 1938
Butter and cheese	Few days	T & W 1946
<u>Br. melitensis</u>		
Goat cheese	Present ---	Eyre
Cheese	Most common	Fabian 1947
Cheese of infected goat milk	6-20 d.	Peres 1936
Cheese from unpasteurized goat milk	38 d.-1 yr.	Stiles 1945
Brynza cheese, 11-14C	45 d.	Versilova 1937

TABLE E2 (cont'd) THE SURVIVAL OF BRUCELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>DAIRY PRODUCTS (cont'd)</b>		
<u>Br. melitensis</u>		
Ice cream, -23.2C	5 yr. 30 mo. +	Wallace 1938 " "
<u>Br. suis</u>		
Ice cream, -23.2C	4 yr. 30 mo. +	" " " "
Ice cream		
<u>Br. (spp.)</u>		
Butter from infected cow, salted and unsalted	4 mo.	Bryan 1944
Cheese, 4.4C	Inoc:1,000/ml; >6 mo. <1 yr.	Gilman 1946 " "
Cheddar cheese	Inoc:700-800/ml; >3 mo. <1 yr.	
" " , 1.1-2.7C	>41 d.-84 d.	
Cheese	Acidity decreases viabil- ity of org.	Lerche 1931
<b>MEAT</b>		
<u>Br. melitensis</u>		
Cured ham, nat. infection, in ice box	21 d, none after smoking	Hutchings 1951
<b>BEVERAGES</b>		
<u>Br. abortus</u>		
Beer	3 d.	Serpa Santos 1939
Wines	1 hr.	" " "

TABLE E3

## THE SURVIVAL OF CLOSTRIDIUM SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>DAIRY</b>		
<u>Cl. (spp.)</u>		
<u>Cheese</u>	Most common	Fabian 1947
<b>MEAT</b>		
<u>Cl. botulinum</u>		
Cooked meat and fish	Spores present	Editorial 1926
Canned salmon, beef, sardines, clam juice, duck	" "	" "
<u>Cl. sporogenes</u>		
Putrid meat, 50C	No growth in 9 d.	Haines 1944
<u>Spore forming anaerobes</u>		
Roast beef, canned in 1824	3 strains viable	Wilson 1938
Tripe, canned 1880	Not found	" "
<u>Cl. (spp.)</u>		
Salted fish	---	T & W 1946
Cooked meat and fish	---	" "
<b>VEGETABLE</b>		
<u>Cl. tetani</u>		
Various vegetables	Present	Dubovsky 1922
<u>Cl. botulinum</u>		
Home canned string beans, corn, asparagus, spinach, pineto, pickles	Spores present	Editorial 1926
Vegetables grown in contaminated soil	Present	Parry 1946
Peas, string beans, corn, and spinach; 10-12C, 19-21C, and 24-26C	> 3 mo.	Starin 1926
Peas, 10F	No toxin was produced when containers were defrosted and immediately examined or when stored in ice box 3 d.	Straka 1932
Peas, frozen, 42F, pH 5.6-6.5	Inoc.100,000,000;Recov.0;<7 d.	Straka 1938
Peas, frozen, 50F	Inoc:conc;Recov.0;>7 d.	" "
Peas, frozen, 60F, pH 4.6-6.7	>3 d.	" "
Peas, frozen, 60F, pH 4.6-6.2	>6 d.	" "
Peas, frozen, 80F, pH 4.3-6.6	Inoc:conc;>2 d.	" "
Vegetables, -16C	>2 yr.	Tanner 1931
" "	14 mo.	" "
" 100C	90-80 min.	Weiss 1921
" 105C	30-70 "	" "
" 110C	10-20 "	" "
<u>Spore forming anaerobes</u>		
Carrots, canned 1885	Not found	Wilson 1938
<u>Cl. (spp.)</u>		
Cans of spinach	Inoc:800,000;50% of the org. died in 18 hr.	Koser 1921

TABLE F3 (cont'd) THE SURVIVAL OF CLOSTRIDIUM SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>FRUIT</b> <u>Cl. sporogenes</u> Dried fruit, 45C <u>Cl. (spp.)</u> Fruit, -5F " -16C	Grown in 24 hr.  140 d. >2 yr.	Haines 1944  Campbell 1932 Tanner 1931
<b>GENERAL FOOD</b> <u>Cl. botulinum</u> Various foods, 35C, arti- ficially contaminated Variety of foods, -16C Acid foods, 100C " " 105C " " 110C Various types of food	Recov: certain toxin; 1 yr.  1 yr. 50 min. 30 " 15 "  ---	Schoenholz 1923  Wallace 1933 Weiss 1921 " " " " T & W 1946

TABLE FA THE SURVIVAL OF ESCHERICHIA COLI IN FOOD  
ALSO PARACOLOBACTRUM & AEROBACTER

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>E. coli</u> Cream, 30% butter fat, freezing at -15C	Reduction 61% in 3 hr.	Hilliard 1915
Milk dil., frozen	Less dil. the larger the survival	Keith 1913
Milk, -21 to -78C	Inoc. 100,000/ml., more resistant to freezing than thawing	Lund -
" pH 4.2	Growth checked	Palladina 1935
" plus 5% NaCl, pH 4.6	24 hr.	" "
Skim milk or cream, 20C	Well	Robinton 1945
<b>DAIRY PRODUCTS</b>		
<u>E. coli</u> Milk curds	48-96 hr.	Bhat 1949
Cheese	12 mo.	Crossley 1942
Margarine	Isolated from 8%	Foltz 1951
Ice cream	In 90% of samples	Murgia -
Butter and margarine, rapid develop. of acid- ity and prompt salting	Check growth	Palladina 1935
Butter, 14F	8 wk.	Rice 1938
" 60F	Did not mult. but sur- vived long	" "
<b>EGGS</b>		
<u>E. coli</u> Frozen eggs	Recov. 50% colonies ex- amined were coliform	Colien 1942
" " , -9C	14 mo.	Hartsell 1951
Egg whites, -15C	Recov. 0, 3 mo.	Johns 1946
Frozen eggs (white)	" <10, 5 yr.	Schneiter 1943
" " (yolk)	" 4000, 5 yr.	" "
<b>MEAT</b>		
<u>E. coli</u> Salt fish blocks, 5-6C	72 d.	Frank 1941
Frozen shrimp	In 60% of all samples	Holmes 1949
Fish and meat		Ignatovich 1935
Sausage, 6 d. drying	13 d.	Mueller-Claus 1938
" 35C	>24 hr.	" " "
<b>VEGETABLES</b>		
<u>E. coli</u> Veg, 20C	Recov. 60% out of 70 for 1 yr.	Burton 1949
Cantaloupes, -4F	>1 yr.	" "
Veg.	In 90% of samples	Murgia -
Tomatoes with bacteria sprayed on	5 min.	Rudolfs 1951
Mushrooms, -9.4C	6 mo.	Smart 1934
<b>FRUITS</b>		
<u>E. coli</u> Fruits	In 90% of samples	Murgia -
Fruit in cold water	Recov. 100%, few min.	Spain 1944

TABLE F4 (CONT'D) THE SURVIVAL OF ESCHERICHIA COLI IN FOOD  
ALSO PARACOLOBACTRUM & AEROBACTER

Factor(s)	Survival	Reference
<b>FRUITS (cont'd)</b>		
<u>E. coli</u> Fruit in boiling water	Recov. 70%, few min.	Spain 1944
Cherries, -17.8 and -40C	2-3 mo.	Wallace 1933
Cherry juice, -17.8 and -40C	<4 mo.	" "
Good oranges, 17.8C, pH 3.64	Inoc. 12,300/cc, Recov. 2,800/cc, 7 mo.	Wolford 1948
Soft rotten oranges, 17.8C, pH 3.74	Inoc. 31,500,000/cc, Recov. 1,250,000/cc, 8 mo.	" "
<b>BEVERAGES</b>		
<u>E. coli</u> Beer	Contained many, from water to dilute beer	Buttiaux 1949
<b>MILK</b>		
<u>A. aerogenes</u> Milk, pH 4.2	Growth checked	Palladina 1935
" 5% NaCl, pH 4.6	24 hr.	" "
<b>DAIRY PRODUCTS</b>		
<u>A. aerogenes</u> Butter, 14F	8 wk.	Rice 1938
Salted butter, 60F	Did not mult. but survived long	" "
<b>EGGS</b>		
<u>P. sp.</u> Turkey and chicken egg albumin, incubated	Slight effect on bacteria	Gregory 1948
<b>VEGETABLES</b>		
<u>A. aerogenes</u> Cantaloupes, -4F	>1 yr.	Burton 1949
<b>BEVERAGES</b>		
<u>A. sp.</u> Beer	Contained 1000/ml	Buttiaux 1949

TABLE 15

## THE SURVIVAL OF MICROCOCCUS SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>M. aureus</u> Milk, 65-81C " -21 to -78C	Recov. 0, 1 d. Inoc. 100,000/ml., more resistant to freezing than thawing	Lazarus 1890 Lund -
<b>DAIRY PRODUCTS</b>		
<u>M. sp.</u> Margarine	56%	Foltz 1951
<b>EGGS</b>		
<u>M. aureus</u> Egg powdered, R.T., stor- ed in packet Frozen eggs, -9C	Inoc. 2,000, Recov. 20, 70 d. 12 mo.	Haines 1944 Hartsell 1951
<b>MEAT</b>		
<u>M. aureus</u> Putrid meat, 44C Canned roast beef, 22-37C	No growth Inoc. 30-5000 org./gm., >60 d.	Haines 1944 Surgella 1945
<b>SAUCE</b>		
<u>M. spp.</u> Salad dressing and mayon- naise, Mayonnaise, 37C, pH 3.8, 0.48% acid Salad dressing, 37C, pH 3.2, 1.1% acid Mayonnaise with egg yolk, 0.51% acid, pH 4.0, fresh Mayonnaise with egg yolk, 0.51% acid, pH 4.0, emulsol Salad dressing with egg yolk, 1.02% acid, pH 3.30, fresh Salad dressing with egg yolk, 1.02% acid, pH 3.30, emulsol Mayonnaise, pH 5.0, 0.15% acid Salad dressing, pH 5.0, 0.15% acid	M. more resistant than S. 96 hr. 30 hr. 78 hr. 72 hr. 48 hr. 16 hr. 144 hr. 144 hr.	Wethington 1950 " " " " " " " " " " " " " " " "
<b>VEGETABLES</b>		
<u>M. aureus</u> Plants, lima beans	Recov. 3, 13 d.	Russell 1893
<u>M. sp.</u> Asparagus, -17.8C Spinach, -17.8C Peas, -17.8C	Inoc. 255% Recov. 85.8%, 8 mo. Inoc. 8.6%, Recov. 63.2%, 8 mo. Inoc. 21.3%, Recov. 44.4%, 8 mo.	Lockhead 1938 " " " "

TABLE 25 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>VEGETABLES (cont'd)</b>		
<u>M. sp.</u> Beans, -17.8C	Inoc. 7.0%, Recov.72.0%, 8 mo.	Lockhead 1938
Corn, "	Inoc.20.7%, Recov.78.7%, 8 mo.	" "
<b>FRUITS</b>		
<u>M. aureus</u> Dried fruit, 44C	No growth	Haines 1944
Sliced sweetened straw- berries, -18C	Inoc. 500/gm., 6 mo.	McCleskey 1941
<u>M. sp.</u> Orange juice, -4C	50 hr.	Beard 1932



TABLE Ek

## THE SURVIVAL OF MICROORGANISMS IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Corynebacterium diphtheriae</u> Cream, frozen Milk	>4 d. Present	Bolten 1918 Trevelyan 1898
<u>Lactobacillus casei</u> Milk, -21 to -78C	Inoc. 100,000/ml., more resistant to freezing than thawing	Lund -
<u>Lactobacillus acidophilus</u> Milk, 116C	15 min.	Morrison 1930
<u>Rickettsia spp.</u> Ster. skim milk, 26-28C	Inoc. 0.5ml. of $2 \times 10^{-1}$ cotton rat liver, 24 hr.	Anderson 1944
Raw milk <u>Rickettsia</u> <u>Coxiella burneti</u> Milk, R.T. " 37C, air dried stored	Not given 7 d. 30 d.	Huebner 1948 Babudieri 1950 "
<b>DAIRY PRODUCTS</b>		
<u>Achromobacter delmarvae</u> Butter " and margarine, rapid develop. of acid and prompt salting	239 d. Growth checked	Berry 1927 Palladina 1935
<u>Bacterium linens</u> Cheddar cheese, 10C, pH 5.13	4 mo.	Albert 1944
<u>Corynebacterium diphtheriae</u> Butter	1 mo.	Minn. St. Bd. of Health 1911
<u>Rickettsia</u> <u>Coxiella burneti</u> Cheese made with in- fected milk	46 d.	Babudieri 1950
Butter, below freezing	41 d.	Jellison 1948
<u>Lactobacillus sp.</u> Butter	275-462 D.	Tanner 1944
<b>MEAT</b>		
<u>Corynebacterium diphtheriae</u> Sausage, 85C for 70 min.	24 hr.	Mueller-Claus 1938
<u>Animal parasites</u> <u>Trichinella spiralis</u> Pork, -15C	24-36 hr.	Tanner 1944
<u>Trichina larvae</u> Pork, -27C	Recov. 0, 36 hr.	Gould 1949
" -30C	" " 24 hr.	" "
" -33C	" " 10 hr.	" "
" -35C	" " 40 min.	" "
" -37C	" " 2 min.	" "

TABLE E6 (CONT'D)

## THE SURVIVAL OF MICROORGANISMS IN FOOD

Factor(s)	Survival	Reference
<b>CEREAL</b>		
<u>Pasteurella tularensis</u>		
Grain	Present	Ayres 1948
" contaminated with urine or feces of infected mice	"	Zeiss 1943
<b>VEGETABLES</b>		
<u>Lactobacillus cucumeris</u>		
Peas, 15F	>2 yr.	Berry 1933
<u>Lactobacillus spp.</u>		
Veg., -10C	2 yr.	" "
Peas, -10C	2 yr.	Weiser 1951
<u>Pseudomonas aeruginosa</u>		
Plants	Recov. many, 69 d.	Russell 1893
<u>Bacteria and parasites</u>		
Veg., from irrigation water	Found	Wright 1950
<b>FRUIT</b>		
<u>Proteus vulgaris</u>		
Cherry juice, -17.8C and -40C	<4 wk.	Wallace 1933
<b>GENERAL</b>		
<u>Pasteurella tularensis</u>		
Food stuff	Present	Schuller 1943
Food, contaminated with urine or feces of infected mice	"	Zeiss 1943

TABLE E1

## THE SURVIVAL OF MICROORGANISMS IN FOOD (GENERAL)

Factor(s)	Survival	Reference
<b>MILK</b>		
Milk, frozen and stored	Lowers no. of bacteria	Babcock 1947
Raw milk	Germicidal action decreases no.	Chambers 1920
Cream, -5 to -10F	Decreases during storage and freezing	Fabian 1943
Powdered skim milk, R.H. 5-20%	Inoc. 11,100/g. at 37C and 23,800/g at 30C, Recov. Max. survival, 48 wk.	Higginbottom 1948
Whole milk, 37C, R.H. 10-20%	Inoc. 91,000/g., Reduct. 99.9%, 72 wk.	" "
Milk used in coffee or tea	Present	Hill 1909
<b>DAIRY PRODUCTS</b>		
Margarine	42% had plate cts. of 100/ml. or less	Foltz 1951
Ice cream	Lower in winter mo.	Tanner 1944
<b>EGGS</b>		
Powdered egg, 60C	99% reduct. 1 d., decrease proportional to increase in temp.	Gibbons 1943
Egg whites, frozen	Low cts.	Verge 1928
" yolks, "	" "	" "
" whites, R. T.	High cts.	" "
" yolks, " "		" "
" , OF	Greater destruction of bacteria than at lower temp.	Winter 1947
<b>MEAT</b>		
Chicken-a-la-King	In $\frac{1}{2}$ samples of precooked food	Buchbinder 1949
Hamburger steak, unfrozen	Recov. > 24,300/gm.	Geer 1933
" " frozen	" > 1,100,000/gm.	" "
Dehydrated meat, 15C, in air, R.H. 4.5%	Inoc. 700,000, Recov. 9,400; 10 wk.	Haines 1944
Dehydrated meat, 15C, in air, R.H. 2.0%	Inoc. 2,000,000, Recov. 37,000; 6 wk.	" "
Dehydrated meat, 15C, in air	Inoc. 24,000,000; Recov. 29,300; 7 mo.	" "
Dehydrated meat, 15C, in nitrogen	Inoc. 24,000,000; Recov. 669,000; 12 mo.	" "
Shrimp, -40C	Recov. greatly reduced in peeled, >12 mo.	Holmes 1949
" -12C	More destructive than lower temp.	" "
Meat	Present	Jensen 1945
Lamb chop (fat), -6.6C	Recov. 38,300, 6 wk.	Prescott 1932
" " " -12C	" 44,400 " "	" "
" " " -18C	" 67,700 " "	" "
Fish (haddocks), -4C	Start 47, Recov. 260, 7 wk.	Prescott 1932
" " -6.6C	Start 47, Recov. 820 7 wk.	" "

TABLE E7 (CONT'D) THE SURVIVAL OF MICROORGANISMS IN FOOD (GENERAL)

Factor(s)	Survival	Reference
<b>MEAT (cont'd)</b>		
Fish (haddocks), -12C	Start 47, Recov. 560, 7 wk.	Prescott 1932
" " -18C	Start 47, Recov. 75	" "
<b>VEGETABLES</b>		
Frozen veg., -18C	>4 yr.	Berry 1937
Vegetable tissue	Present	Galippe 1887
Dried veg., 65-80C	"	Haines 1944
Frozen veg., 10, 0, -10F	Inoc. 50,000/g., Recov. no increase	Hucker 1951
Pickled veg.	Intestinal pathogens	Lin 1945
Vined peas, <40F	95% reduction	Link 1949
Frozen packed veg., -17.8C	Some present 9 mo.	Lockhead 1936
Peas, -20C, brine packed	24 wk.	MacFarlane 1940
Spinach, -6.6C	Start 2170, Recov. 1190, 6 wk.	Prescott 1932
" -12C	Start 2170, Recov. 1,350 6 wk.	" "
" -18C	Start 2170, Recov. " 6 wk.	" "
Veg., bact. in soil	No results	Remlinger 1909
Peas and whole kernel corn frozen in liquid air or in air blast	Did not mult.	Van Eseltine 1948
Veg.,	Low temp., moist soil, organic matter increase viability of pathogens and other pathogens reduce survival	Rudolfs 1950
<b>FRUITS</b>		
Berries, airtight, frozen	Large decrease, greater decrease at high temp.	Berry 1933
Apple juice, -70 to -21C	Reduced 90-96% 1 mo.	" 1932
" " -5, -9.4, 6-7C	Survival <10% 1 mo.	" 1934
Frozen berries,	Death more rapid at -9.4C than at -20.6C	" 1936
Cherries, washed in NaCl	Cts. 1200 to 600,000	Roder 1928
Blackberries	present even after	" "
Currants	3rd. washing	" "
Yellow Plums	"	" "
Pears	"	" "
Damson plums	"	" "
Fruits, moist	>15 d.	Mills 1925
Fruits, decayed portion	7-42 d.	" "
Cider, -10C	31 wk.	MacFarlane 1940
Raspberries, -20C	26 wk.	" "
Strawberries, -6.6C	Start 1900, Recov. 280, 6 wk.	Prescott 1932
" -12C	Start 1900, Recov. 960, 6 wk.	" "
" -18C	Start 1900, Recov. 2200, 6 wk.	" "

TABLE E7 (CONT'D) THE SURVIVAL OF MICROORGANISMS IN FOOD (GENERAL)

Factor(s)	Survival	Reference
<b>FRUITS (cont'd)</b>		
Raspberries, -6.6C	Start 50500, Recov. 275, 6 wk.	Prescott 1932
" -12C	Start 50500, Recov. 638, 6 wk.	" "
" -18C	Start 50500, Recov. 1520 6 wk.	" "
Orange juice, -6.6C	Start 2410, Recov. 1100, 20 d.	" "
" " -12C	Start 2410, Recov. 1090, 20 d.	" "
" " -18C	Start 2410, Recov. 1160 20 d.	" "
Fresh strawberries, 15F	Inoc. fungi, yeast, bact., 1-3 yr.	Smart 1934
Strawberries in sealed tins	3 yr.	" "
Fruits, -9.4C	>3 yr.	" 1935
Blueberries, frozen	Inoc. before freezing >100,000/gm., Recov. ≤1%, 7 mo.	" 1937
" in 50% sugar syrup, -6.7C	99.9% reduct., 9 mo.	" 1939
Blueberries, in 50% " syrup, -17.8C	60% " " "	" "
Blackberries packed in 40% B. syrup	More recovered at -20C than -10C	Weiser 1951
<b>CEREAL</b>		
Soy beans, alfalfa	Viable 6-9 mo.	Fellers 1919
Pop corn, unpopped	Contained 100,000/g.	Breazeale 1951
" " popped	" 10/g.	
<b>GENERAL</b>		
Frozen foods	Fats and sugar soln. protect and acids destroy	James 1933
Food, -25.2C	>10 hr.	Tanner 1944
Food, pH 2	Practically all destroyed	Virtanen 1940

TABLE 18 THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Human</u>		
Milk	10 d.	Heim 1889
Sour milk	4 wk.	Honda 1938
Milk, 58C, pH 6.7, 6.3, 6.0	30 min.	Katrandjiev 1929
Milk, 60C-63C, pH 6.7, 6.3, 6.0	" "	" "
Sour milk, 200cc., R.T., pH 4-5	Inoc. 1 loop cult., viable 7 d.	Kliewe 1937
Cream, 60C-80C	2 min.	Mohler -
Milk, frozen, -8C to -20C	2 yr.	McCallum 1934
Ster. milk, 30C	Inoc. 500-2000/ml., 20 d	Mattick 1946
Raw cream	Recov. 16 out of 31 samples	Pullinger 1935
<u>Bovine</u>		
Sour milk	10 d.	Honda 1938
Sour milk, 200cc., R. T.	Inoc. 1 loop cult., viable 20 d.	Kliewe 1937
<b>DAIRY PRODUCTS</b>		
<u>Human</u>		
Butter, 15-22C	30 d.	Ham <del>Heim</del> 1889
Curds, " "	2 d.	" "
Whey, " "	14 d.	" "
Cheese, " "	" "	" "
"	2 mo. (summer)	Kankaapaa
"	140 d.	Kastli 1948
Emmenthal and Gruyere cheese	Inoc. >1/cc, 20-30 d.	" 1949
Munster and Camembert cheese	Inoc. " 47 d.	" "
Tilsit cheese	" " 232 d.	" "
Cheese with low fat milk	" " 326 d.	" "
White cheese	>14 d.	Loncin 1950
Butter of milk held at 145F for 30 min.	Present	Smith 1932
Ice cream	6 1/2 yr.	Wallace 1938
" "	30 mo.	" 1933
Butter from t.b. milk, pasteurized at 55, 60, and 70C	Survived pasteurization	Cookson 1926
<u>Bovine</u>		
Ice cream	6 1/2 yr.	Wallace 1938
" "	30 mo.	" 1933
<u>Avium</u>		
Ice cream	4 1/2 yr.	" 1938
" "	30 mo.	" 1933

TABLE Eq

## THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>S. paratyphi A</u>		
Milk, ice box	170 d.	Berry 1927
Milk, 37C, 1 lactic acid to 250 milk	Inoc:1 loop 24 hr. cult; Recov:0; 72-60 hr.	Kaiser 1921
Raw milk, 18C, pH 5.04-4.84	11 d.	Kliewe 1935
<u>S. paratyphi B</u>		
Milk, 37C, 1 lactic acid to 250 milk	Inoc:1 loop of 24 hr. cult; Recov:0; 12-60 hr.	Kaiser 1921
Milk, 37C, 1 lactic acid to 500 milk	Inoc: 1 loop 24 hr. cult; Recov:0; 72 hr.	" "
Milk, 37C, 1 lactic acid to 1200 milk	Inoc:1 loop 24 hr. cult; Recov:0; 60 hr.	" "
Milk, ice box temp.	324 d.	Berry 1927
Raw milk, 18C, pH 5.04-4.84	11 d.	Kliewe 1935
Milk, pH 4.2	Growth checked	Palladina 1935
Milk, 5% NaCl, pH 4.6	24 hr.	" "
Milk, pH 4.7-5.1	63 d.	Wilson 1945
<u>S. paratyphi</u>		
Ster. milk, 17-20% acid, 37C	Recov:0; 1-2 wk.	Kliewe 1935
Ster. milk, 24.13%, 20C	Viable 29 d.	" "
" " 18.50%, 37C	Recov:0; 9 d.	" "
" " 2.6-15.0%, 20C	" " 14 d.	" "
" " 20.6%, 8C	" " 36 "	" "
" " 33%, 20C	Viable 4-5 wks.	" "
" " 26%, 8C	6-7 wk.	" "
Raw milk, 27.04%, 37C	Recov.0; 14 d.	" "
" " 33.25%, "	" " 4 d.	" "
" " 27.36-18.3%, 37C	" " 12 d.	" "
" " 31.51%, 20C	" " 13 d.	" "
" " 17.82%, "	" " 7 d.	" "
" " 20.15%, "	" " 3 "	" "
" " 22.61%, "	" " 7 "	" "
" " 22.80%, 8C	" " 14 d.	" "
Sour milk, pH 5.04-4.84	11 d.	" "
Milk, R.T., acidity .7	4 d.	Marsh 1918
" suspn, 63C, in an open reagent glass	15 min.	Orskov 1925
Milk suspn, 63C, in water bath in glass with rubber stopper	Recov: 0; 3 min.	" "
Milk suspn, 63C, warmed at 48C until a 1.5cm. ring of dried milk forms	" " 50 min.	" "
Milk, pH 4.8	63 d.	Wilson 1945
<u>S. enteritidis</u>		
Milk, ice box temp.	180 d.	Berry 1927
Evapor. milk; 37C, 6-9C, 20C; pH 5.2, 7.2, 5.4	7 d.	Koser 1922

TABLE F9 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK (cont'd)</b>		
<b><u>S. typhimurium</u></b>		
Ster. milk, 22.28%, 20C	Viable 32 d.	Kliewe 1935
" " 16.50%, 37C	Recov: 0; 13 d.	" "
" " 24.13%, 8C	" " 47 d.	" "
" " 33%, 20C	Viable 4-5 wk.	" "
" " 25%, 8C	6-7 wk.	" "
Raw milk, 12.15%, 37C	Recov: 0; 14 d.	" "
" " 33.20%, "	" " 4 d.	" "
" " 25.77%, "	" " 13 d.	" "
" " 35.22%, 20C	" " "	" "
" " 25.05%, "	" " 10 d.	" "
" " 25.54%, "	" " 6 d.	" "
Milk, pH 4.2	Growth checked	Palladina 1935
" , 5% NaCl, pH 4.6	24 hr.	" "
Sour milk, 9.75-13% acid, 8C	Recov: 0; 11 d.	Kliewe 1935
<b><u>S. typhosa</u></b>		
Raw milk, 0.27% acid	5 d.	Bassenge 1903
" " 0.36% "	6 d.	" "
" " 0.63% "	24 hr.	" "
Milk	Recov: 0; 2 hr.	Belin 1933
" , ice box and R.T.	(Miss.) 290 d. and 187 d.	Berry 1927
Sour milk, 1 d. old	Inoc:100cc + cc; typhoid	Bolley 1898
" " 2 " "	1 mo.	" "
" skim milk	Inoc:15cc+5cc; 5 d.	" "
Sweet milk	" 100cc+1cc cult; 5d.	" "
	" " + 24 hr. cult;	" "
	1 mo.	" "
Past. milk	Inoc:100cc, 1/5cc cult; 10d.	" "
Whole ster. milk	" loop; 1 mo.	" "
Sweet cream	" 200cc, 8cc cult; 4 mo.	" "
Milk ster. by discount past., loop inoc.	Loop inoc; 4 mo.	" "
Milk, 56C for 20 min.	" " "	" "
Fresh milk drawn in ster. tube	" " 3 mo.	" "
Cream, freezing	Inoc:5cc of cult; >4 d.	Bolten 1918
Sour cream strongly acid	" 1 loop cult; 10 d.	Bruck 1903
Milk	" 1 g.; several days	Cautley 1897
Sour milk, R.T., 2.25% acid	6-8 d.	Demme 1925
Milk, 13-18C	Viable <48 d.	Heim 1889
Ster. milk	4 mo.	Hesse 1889
Milk, alternate freezing	Reduction <93-99%	Hillard 1918
Ster. milk, 17-20% acid, 37C	Recov:0; 4 hr.	Kliewe 1935
Ster. milk, 30% acid, 8-20C	Recov. 0; several wk.	" "
" " 25 min. in autocl, 5.25% acid	Viable 13 d.	" "
Ster. milk, 8.80-7.50% acid, 20C	" 14 d.	" "
Ster. milk, 23.88%, 20C	" 28 d.	" "
" " 23%-20.5%, 37C	Recov. 0; 24 hr.	" "



TABLE F9 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
MILK (cont'd)		
<u>S. typhosa</u>		
Ster. milk, 25.85% acid, 8C	Recov. 0, 44 d.	Kliewe 1935
Ster. milk, 33% acid, 20C	Viable 2 wk.	" "
" " 26% " 8C	Recov. 0, 6 wk.	" "
Raw milk, 37C	" " 3 d.	" "
" " " , 14.97% acid	" " 12 d.	" "
" " " 33.73% "	" " 4 d.	" "
" " " 17.81% "	" " 11 d.	" "
" " 20C, 38.25% "	" " 12 d.	" "
" " " 31.51% "	" " 6 d.	" "
" " " 24.45% "	" " 3 d.	" "
Sour raw milk, 20C, 9.75-16.50% acid	" " 3 d.	" "
Raw milk, 8C, 20.38-22.35% acid	" " 12 d.	" "
Raw milk, 8C, 18.75-20.90% acid	" " 14 d.	" "
Raw milk, 18C, pH 7.17-6.94	Inoc. 2 loops, Recov. 0, 48 hr.	" "
Raw milk, 37C, pH 5.02-3.56	Inoc. 2 loops, Recov. 0, 24 hr.	" "
Raw milk, 1 loop B. coli, 18C, pH 3.94-7.93	Inoc. 1 loop, " " 12 d.	" "
Raw milk, 37C	3 d.	Kredba 1935
Sour cream, R.T.	Inoc. 7 million, Recov. 0 48 hr.	Krumwiede 1914
Cream, soured overnite in sterilizer	Inoc. 7 million, " " 120 hr.	" "
Cream, R.T.	Inoc. 375,000, Recov. 0, 96 hr.	" "
Milk, 66C-74C	Recov. 0, 1 d.	Lazarus 1890
Milk, R.T, acid .7	5 d.	Marsh 1918
Fresh milk, acid 19-1.4	1-2 d.	" "
Sour milk	3 mo.	Osler 1901
Milk, pH 4.2	Growth was checked	Palladina 1935
Fresh milk, 7-10C	Inoc. suspn. of agar, viable 11-13 d.	Pfuhl 1902
Milk, 3C	2 d.	Seitz 1886
Milk, 0.71% acid	8 d.	Wade 1928
" 0.53% "	30 d.	" "
" with S. lacticus, 0.84% acid, R.T., and 0.65%, ice box temp.	5 d. and 27 d.	" "
Milk, with diplococcus "x", 0.88% acid, ice box	86 d.	" "
Milk, with diplococcus "x", 1.04% acid, R.T.	34 d.	" "
Milk, 0.90% acid	1 d.	" "
Milk, 0.74, 0.78, 0.81%	4 d.	" "
Milk " , pH 4.9-5.1	20 d.	Washburn 1908
	63 d. plus	Wilson 1945

TABLE Eg (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>DAIRY PRODUCTS</b>		
<u>S. paratyphi A</u>		
Butter	117 d.	Berry 1927
<u>S. paratyphi B</u>		
Butter	212 d.	" "
Milk curds	48-96 hr.	Bhat 1949
Yoghurt, 1.87% acid	Inoc. 1 loop 24 hr. cult Recov. 0, 48-108 hr.	Kaiser 1921
" 0.29%-0.82% acid	Inoc. 1 loop 24 hr. cult Recov. 0, 12 hr.	" "
" 1.89%-2.14% "	Inoc. 1 loop 24 hr. cult Recov. 0, 60-72 hr.	" "
" 2.35% acid	Inoc. 1 loop 24 hr. cult Recov. 0, 120 hr.	" "
" 1.07% "	Inoc. 1 loop 24 hr. cult Recov. 0, 24 hr.	" "
Butter and margarine, rapid develop. of acid and prompt salting	Growth checked	Palladina 1935
Buttermilk	15 d.	Stever 1941
<u>S. paratyphi types</u>		
Milk curds	48-96 hr.	Bhat 1949
Butter (English), 15C	<112 d.	Pullinger 1938
" " 3C	>112 d.	" "
Buttermilk	15 d.	Stever 1941
Cheese	Most common	Fabian 1947
<u>S. sp. (Type Newport)</u>		
Butter, contaminated by cooling water	Present ---	Eriksson 1941
<u>S. enteritidis</u>		
Butter	228 d.	Berry 1927
Milk curds	48-96 hr.	Bhat 1949
Butter (English), 15C	<112 d.	Pullinger 1938
" " 3C	=112 d.	" "
Ice cream, -23.2C	7 yr.	Wallace 1938
" " freezing	30 mo. +	" 1933
<u>S. typhimurium</u>		
Butter	239 d.	Berry 1927
Ice cream	98 d.	Glass 1946
Butter and margarine, rapid develop. of acid and prompt salting	Growth checked	Palladina 1935
Cheese, 43-48F	Inoc. colby cheese, 302d.	Tucker 1946
Ice cream, -23.2C	6 yr.	Wallace 1938
" " freezing	30 mo. +	" "
<u>S. choleraesuis</u>		
Butter	49 d.	Berry 1927
<u>S. typhosa</u>		
Buttermilk, strongly acid	Inoc. 1 loop cult, 10 d.	Bruck 1903
" 22C	" 2 " 24 hr. cult	Fraenkel 1898
" 37C	3 d.	" "
" pH 3.5-4.4	Inoc. 2 loop 24 hr. cult 24 hr.	" "
	2-3 d.	Marsh 1918

TABLE Eq (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>DAIRY PRODUCTS (cont'd)</b>		
<b><u>S. typhosa</u></b>		
Buttermilk, pH 3.1-4.5	1 d.	Marsh 1918
" R.T.	3 d.	Rubenstein 1902
" incubator	24 hr.	" "
Cheese infected by water	6-10 mo.	Anon. 1944
Butter	22 d.	Berry 1927
"	110 d.	" "
Milk curds	48-96 hr.	Bhot 1949
Fresh creamery butter	Inoc. spots, 5 d.	Bolley 1898
" " "	" germs mixed, 5 d.	" "
" " "	" 1 loop, 5 d.	" "
" " "	" " " "	" "
salt 4 oz./lb.		
Unsalted churned butter	" 200cc&8cc cult, 10 d.	" "
Salted churned butter, 10 oz./lb.	Inoc. 200cc & 8cc cult, 10 d.	" "
Fresh creamery butter, kept in cold storage	None found	" "
Fresh creamery butter salted, in cold storage	" "	" "
Cheese	80 d.	Bawman 1942
Butter, strongly acid	Inoc. 1 loop cult, 27 d.	Bruck 1903
Cheese, 58-60F	3 mo.	Campbell 1944
" 40-42F	6-10 mo.	" "
" cheddar	<3 mo.	Foley 1945
Butter, 13-18C	Viable 21 d.- 1 mo.	Heim 1889
Cheese, 35C, alkaline	" 3 d.	" "
White cheese, 35C	" =24 hr.	" "
Curds, 35C	" 1 d.	" "
Whey	" 1 d.	" "
Cheese	4 wk.	Hesse 1889
Butter, weakly acid	4-5 d.	Laser 1891
Butter	6 d.	Lafar -
Cheese, 60F, artificially infected	34-36 d.	Meyer 1944
Ice cream, frozen	Inoc. 70,000/cc, Recov. 450,000/cc in 24 hr.	Mitchell 1915
" " " Knox gelatin added	Inoc. 400,000/cc, Recov. 60,000/cc in 24 hr.	" "
Butter made from infected cream	Several days	Osler 1901
Butter and margarine, rapid develop. of acid and prompt salting	Growth checked	Palladina 1935
Fresh butter, 7-10C	Inoc. agar cult. ground in agar mortar, 24 d.	Pfuhl 1902
Gervais cheese	Inoc. agar cult, "	" "
Ice cream	>2 yr.	Prucha 1926
All classes of butter	At least 80 d.	Pullinger 1938
Sweet and sour curds, pH 4.2-4.7	Inoc. 4 drops cult, Recov 0, <1 hr.	Panja 1945

TABLE EQ (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>DAIRY PRODUCTS (cont'd)</b>		
<u>S. typhosa</u>		
Cheese, R.T.	26 d.	Ranta 1941
" ice box	=75 d.	" "
Ice cream, -19C	1 yr.	Tanner 1928
Colby cheese	45 d.	Thomasson 1944
Cheddar cheese, from contaminated milk, 1.04% acidity	36 d.	Wade 1928
Cheddar cheese (commercial)	63 d.	" "
Cheese, 1.12% acid, exposed to air	16 d.	" "
Cheese, 0.94% acid, exposed to air	13 d.	" "
Cheese, 0.97% acid, exposed to air	"	" "
Cheese, 0.98% acid, no air	7 d.	" "
<b>EGGS</b>		
<u>S. typhimurium</u>		
Defrosted whole egg; -1, -9, and -18C	11 mo. +	Hartsell 1950
<u>S. typhosa</u>		
Defrosted whole egg	" " "	" "
<u>S. sp. (Type Oranienburg)</u>		
Defrosted whole egg; -1, -9, and -18C	" " "	" "
<u>S. spp.</u>		
Fermented albumen, R.T., dried	Recov. 100%	Ayres 1949
Fermented " 120F, dried	20 d.	" "
Eggs	0.6% of samples	Felsenfield 1950
" powdered	3% "	" "
Spray dried eggs	Recov. in 9.9% of samples	Med. Res. Coun. 1947
Duck eggs	Present	Mallam 1946
Powdered egg, 35F	65 wk.	Wilson 1948
<u>S. pullorum</u>		
Raw egg	Inoc. feces, present	Mitchell 1946
<b>MEAT</b>		
<u>S. paratyphi B</u>		
Chicken chow mein, -25.5C	Inoc. $230 \times 10^5$ /gm, Recov. $19 \times 10^5$ /gm, 270 d.	Gunderson 1948
<u>S. paratyphi types</u>		
Livers, brains, hamburger steak, fresh pork, sausage, pork and beef loaf, kidney, cooked pork, smoked sausage cured ham and bacon, beef, lamb, calf sweetbreads, and chicken livers	Present	Cherry 1942

TABLE Eq (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MEAT (cont'd)</b>		
<u>S. paratyphi types</u>		
Beef	1 of sample	Felsenfield 1950
Birds (inspected)	0.9% of samples	" "
" (uninspected)	10.8% of "	" "
Pork (inspected)	14.3% of "	" "
" (uninspected)	26.8% " "	" "
Hamburger	17.6% " "	" "
<u>S. enteritidis</u>		
Corned beef	Inoc. 30-5000/gm, Recov. 30x10 <sup>6</sup> , = 60 d.	Surgella 1945
<u>S. typhimurium</u>		
Chicken chow mein, -25.5C	Inoc. 167x10 <sup>5</sup> /gm, Recov. 34x10 <sup>7</sup> /gm, 270 d.	Gunderson 1948
<u>S. anatum</u>		
Chicken chow mein, -25.5C	Inoc. 100x10 <sup>5</sup> /gm, Recov. 4.2x10 <sup>5</sup> /gm, 270 d.	" "
<u>S. gallinarum</u>		
Chicken chow mein, -25.5C	Inoc. 68.5x10 <sup>5</sup> /gm, Recov. 4.8x10 <sup>5</sup> /gm, 270 d.	" "
<u>S. sp. (Type Newington)</u>		
Chicken chow mein, 25.5C	Inoc. 75.5x10 <sup>5</sup> /gm, Recov. 2.2x10 <sup>5</sup> /gm, 270 d.	" "
<u>S. typhosa</u>		
Souse meat	3 mo.	Duff 1942
Salt fish blocks, 5-6C	22 d.	Frank 1941
Chicken chow mein, -25.5C	Inoc. 12.8x10 <sup>5</sup> /gm, Recov. 4.8x10 <sup>5</sup> /gm, 270 d.	Gunderson 1948
Oysters	10 d.	Herdman 1899
Shell oysters, 5-8C, floated 1 hr. in sea water to which typhoid is added	3 strains 21-24 d.	Jordan 1925
Oysters, 10C and -2.8 to 14.4C	15 d.	Kinyoun 1925
Oysters, wet	Inoc. 160,000,000, Recov. 320, 4 d.	Klien 1905
" dry	Inoc. 160,000,000; 1220, 7 d.	" "
" wet, infected water	Inoc. 744,000/cc; 44; 6 d.	" "
Oysters, dry, infected by water	Inoc. 744,000/cc; Recov. 90-9 d.	" "
Oysters, sterile sea water, wet	Inoc. 2,250,000; Recov. 105; 3 d.	" "
Oysters, sterile sea water, dry	Inoc. 2,250,000; Recov. 714; 4 d.	" "
Cockles in sea water	Inoc. 4 million/cc	" "
Mussels " " "	" 5,170,000/cc	" "
Oysters	7-11 d.	" "
Sausage, 4 d. drying	13 d.	Mueller-Claus 1938

TABLE 19 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MEAT (cont'd)</b>		
<u>S. typhosa</u>		
Sausage, 35C	24 hr.	Maurel 1910
Tuna, -3 to 22.5C	Inoc. 3371 g, Recov. 0, 39 d.	Tetsumoto 1930
Mackerel, -3 to 22.5C	Inoc. 3435 g, " " 38 d.	" "
Cuttle fish, -3 to 22.5C	Inoc. 3399 g, " " 40 d.	" "
Oyster, -3 to 22.5C	Inoc. 3262 g, " " 45 d.	" "
Sea cucumber, -3 to 22.5C	Inoc. 3413 g, " " 31 d.	" "
Tuna, 22.5 - 31C	Inoc. 3498 g, " " 22 d.	" "
Mackerel, 22.5 - 31C	Inoc. 3391 g, " " 20 d.	" "
Cuttle fish, 22.5 - 31C	Inoc. 3444 g, " " 22 d.	" "
Oyster, 22.5 - 31 C	Inoc. 3365 g, " " 24 d.	" "
Sea cucumber, 22.5 - 31C	Inoc. 3415 g, " " 20 d.	" "
Shucked oysters, 98F	Inoc. 74,000,000/cc; Recov. 0, 1 d.	Tonney 1925
" " 70F	Inoc. 74,000,000/cc; Recov. 0, 4 d.	" "
" " 45 F	Inoc. 74,000,000/cc; Recov. 0, 22 d.	" "
Shell fish	---	T & W 1946
<b>SAUCES</b>		
<u>S. spp.</u>		
Salad dressing, 37C, pH 3.8, 0.48% acid	12 hr.	Wethington 1950
Mayonnaise, 37C, pH 3.2, 1.10% acid	6 hr.	" "
Mayonnaise, with egg yolk, 0.51% acid, pH 4.0 fresh	18 hr.	" "
Mayonnaise, with egg yolk, 0.51% acid, pH 4.0, emulsol	12 hr.	" "
Salad dressing, with egg yolk, 1.20% acid, pH 3.30, fresh	8 hr.	" "
Salad dressing, with egg yolk, 1.20% acid, pH 3.30, emulsol	1 hr.	" "
Salad dressing, pH 4.4, 0.4% acid	144 hr.	" "
Mayonnaise, pH 5.0, 0.15% acid	144 hr.	" "

TABLE Eg (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>CEREAL</b>		
<u>S. sp.</u> Crust of rye bread, R.T.	6 mo.	Bachmann 1943
<u>S. typhosa</u> Bread, after baking, R.T.	3 hr. (same results when smeared with fecal suspn.)	Alves 1935
Crust of rye bread, R.T.	4½ mo.	Bachmann 1943
<b>VEGETABLES</b>		
<u>S. enteritidis</u> Corn and spinach	3 yr.	Doyle 1930
Canned peas	200 d.	" "
Spinach, 20C and 6-9C	7 d.	Koser 1922
String beans, 20C and 6-9C	7 d.	" "
Corn, pH 6.2-6.0, 20C and 6-9C	7 d.	" "
Peas, pH 5.8-6.0, 20C and 6-9C and 37C	7 d.	" "
<u>S. typhimurium</u> Canned spinach	3 yr.	Doyle 1930
Corn, R.T.	Inoc. 700,000/cc; 100 d.	" "
Canned peas	200 d.	" "
Green veg., R.T.	3-7 wk.	Felsenfield 1945
" " refrigerator	5-11 wk.	" "
Peas, -9C, sharp frozen	Inoc. 14.55; Recov. 0, 9 wk.	Hartsell 1951
<u>S. pullorum</u> Green veg., R.T.	4-8 wk.	Felsenfield 1945
Onions	Not considerable time	" "
<u>S. sp. (Type Oranienburg)</u> Green veg., R. T.	2-7 wk.	" "
" " refrigerator	5-10 wk.	" "
Peas, -9C, sharp frozen at -25C	Inoc. 28.45x, Recov. 0, 0.273x, 12 wk.	Hartsell 1951
<u>S. sp. (Type Montevideo)</u> Green veg., refrigerator	5-10 wk.	Felsenfield 1945
" " R.T.	2-7 wk.	" "
<u>S. typhosa</u> Green washed herbs	Several days	Anon. 1923
Lettuce salad, washed at 1-6-12 hr. after infected with typhoid	As many at 12 hr. as at one	Ceredi 1929
Green veg., R.T.	25 d.	Creel 1912
" " exposed to rain and sun part of day	31 d.	" "
Green veg., exposed all day	10 d.	" "
Peas, -9C, sharp frozen at -25C	Inoc. 33.4x10 <sup>6</sup> ; Recov. 0.124x10 <sup>6</sup> ; 12 wk.	Hartsell 1951

TABLE F<sub>9</sub> (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>VEGETABLES (cont'd)</b>		
<u>S. typhosa</u>		
Mushrooms	4-5 wk.	Hesse 1889
Plants	3-5 d.	Lominsky 1890
Radishes, grown in contaminated soil	≈ 37 d.	Melick 1917
Lettuce, grown in contaminated soil	> 21 d.	" "
Cabbage, 80C, water	10 sec.	Omyoji 1931
Carrots, 80C, shaken in water	5 sec.	" "
Soy bean sauce, pH acid, 25-17C	Inoc. 1 loop, >24 hr.	Wang 1945
Soy bean sauce, pH " 36-38C	" " " <24 hr.	" "
<b>FRUITS</b>		
<u>S. paratyphi B</u>		
Watermelon	120 hr.	Bhat 1948
Sliced sweet strawberries -18C	1 mo.	McCleskey 1941
Cherries, -17.8 and -40C	2-3 mo.	Wallace 1933
Cherry juice, -17.8 and -40C	4 wk.	" "
<u>S. paratyphi types</u>		
Orange juice, -4C	170 hr.	Beard 1932
Sliced sweet strawberries -18C	Not recovered	McCleskey 1941
Orange juice, -4C, pH 3.5	96 hr.	Beard 1932
<u>S. enteritidis</u>		
Tomatoes, 20C and 6-9C	7 d.	Koser 1922
<u>S. typhimurium</u>		
Sliced sweet strawberries -18C	Inoc. 500/gm., 6 mo.	McCleskey 1941
Cherries, -17.8 and -40C	2-3 mo.	Wallace 1933
Cherry juice, -17.8 and -40C	4 wk.	" "
<u>S. typhosa</u>		
Sliced sweetened strawberries, -18C	Inoc. 500/gm., 6 mo.	McCleskey 1941
Uncut sweet strawberries	14 mo.	" "
Pears, > 80C, water	> 1 min.	Omyoji 1931
Surface of dates	68 d.	Smeall 1932
Cherry juice, -14C	Inoc. artificial, 2 wk.	Tanner 1931
" " -16C	" " 5 mo.	" "
" " -17.8 and -40C	< 4 wk.	Wallace 1933
Cherries, -17.8 and -40C	2-3 mo.	" "
Orange juice, -4C, pH 3.5	170 hr.	Beard 1932
<b>BEVERAGES</b>		
<u>S. typhosa</u>		
Beer, 22-37C	1-3 d.	Humpesch 1949
" 5 C	38 d.	" "
" with paratyphoid	5-10 wk.	" "



TABLE Eq (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>BEVERAGES (cont'd)</b>		
<u>S. typhosa</u>		
Beer, 4.86% alcohol, 1.79% acid	4 d.	SerpaSantos 1939
Wines	1 hr.	" "
<u>S. spp.</u>		
Beer, 22-37C, with para- typhoid	1-3 d.	Humpesch 1949
Beer, natural with para- typhoid	5-10 wk.	" "
Carbon dioxide drinks	Effect of CO <sub>2</sub> greatest at 19-23C	Koser 1922
Red wine, 15C, 4.90% sulphuric acid	Inoc. 2 drops, 2 hr.	Sabrazes 1907
White wine, 17-18C, 5% acid	" " " 1 hr.	" "
Cerons, 11-18C	" " " 5 min.	" "
<b>GENERAL</b>		
<u>S. sp.</u>		
Anaerobic sludge used for fertilizer	7 d.	Wolman 1924

TABLE Five

## THE SURVIVAL OF SHIGELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Sh. dysenteriae</u> Fresh milk, 7-10C	18-27 d.	Pfuhl 1902
Milk, pH 4.8-4.9	53 d.	Wilson 1945
<u>Sh. paradysenteriae (Flexner)</u> Milk, pH 4.5-4.7	53 d.	" "
<u>Sh. paradysenteriae</u> Sterile milk, 17-20C	Until it dries up	Frost 1905
Milk, R.T., acid 0.8	3 d.	Marsh 1918
<b>MILK PRODUCTS</b>		
<u>Sh. dysenteriae</u> Buttermilk	15 d.	Stever 1941
Butter	18 d.	Berry 1927
Curds	Do not survive	Bhat 1949
Fresh butter	Inoc. agar cult. ground in agar mortar	Pfuhl 1902
Gervais cheese	Inoc. agar cult., 9 d.	" "
Sweet and sour milk curds, pH 4.2-4.7	Inoc. 4 drops of cult. Recov. 0, <4 hr.	Panja 1945
<u>Sh. paradysenteriae</u> Curds	Do not survive	Bhat 1949
Buttermilk	15 d.	Stever 1941
<b>EGGS</b>		
<u>Sh. paradysenteriae</u> Albumin balls, 17-20C	1 d. or 1 mo.	Frost 1905
Frozen eggs, -9C	3 mo.	Hartsell 1951
<b>MEAT</b>		
<u>Sh. dysenteriae</u> Bacon and sausage, R.T.	>3 wk.	Buchanan 1918
<b>CEREALS</b>		
<u>Sh. dysenteriae</u> Bread after baking, R.T.	30 hr.	Alves 1935
Crust of rye bread	20 d. alive	Bachmann 1943
" " " " R. T.	66 d. dead	" "
Bread, rice, 17-20C	1 d. or 1 mo.	Frost 1905
" R.T.	11 d.	Stanley 1930
<u>Sh. paradysenteriae (Flexner)</u> Bread after baking, R. T.	30 hr.	Alves 1935
Crust of rye bread	23 d. alive	Bachmann 1943
" " " " -5 to -25C	45 d.	" "
<u>Sh. paradysenteriae (Sonne)</u> Crust of rye bread	Over grown with spores	" "
<b>VEGETABLES</b>		
<u>Sh. dysenteriae</u> Soy bean sauce, 25-17C	Inoc. 1 loop, >24 hr.	Wang 1945
" " " 36-38C	" " " <24 hr.	" "
<b>FRUITS</b>		
<u>Sh. dysenteriae</u> Orange juice, -40C	170 hr.	Beard 1932
<u>Sh. paradysenteriae (Sonne)</u> Tomato surface	48 hr.	Johnston 1935

TABLE E10 (CONT'D) THE SURVIVAL OF SHIGELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
FRUITS (cont'd)		
<u>Sh. paradysenteriae (Sonne)</u>		
Tomato tissue	10 d.	Johnston 1935
"	Inoc. artificial, 6 d.	" "
Apple	"                8 d.	" "

TABLE III THE SURVIVAL OF STREPTOCOCCUS SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Streptococcus cremoris</u> Sterilized milk, 30C	2 d.	Mattick 1946
<u>Streptococcus fecalis</u> Milk, 62.8 and 37C	Young cells more resistant than mature	Stark 1929
<u>Streptococcus spp.</u> Milk, 110C	Recov. 4 hr.	Belin 1933
Milk, ice box	17 d.	Berry 1937
Sour milk, 30C	48 hr.	Davis 1914
Dried milk	The lower the humidity the longer the survival	Watts 1945
Cultures 55: Milk of resistant cow	Inoc. 6336, Recov. 9185, 8 hr.	McCullough 1945
Boiled milk of resistant cow	Inoc. 7260, Recov. > 20160, 8 hr.	" "
Milk of young cow early in first lactation period	Inoc. 5356, Recov. 22464, 8 hr.	" "
Boiled milk of same cow	Inoc. 5068, Recov. > 36992, 8 hr.	" "
Freshly isolated strains: Milk of resistant cow	Inoc 7168, Recov. 41320, 8 hr.	" "
Boiled milk of resistant cow	Inoc. 7296, " > 16588, 8 hr.	" "
Raw milk of young cow early in first lactation	Inoc. 1344, Recov. 19120, 8 hr.	" "
Boiled milk of same cow	Inoc. 1197, Recov. > 30538, 8 hr.	" "
<b>DAIRY PRODUCTS</b>		
<u>Streptococcus pyogenes</u> Butter	17 d.	Berry 1927
Limburger cheese, moisture content 42.8	28-51 d.	Yale 1940
Limburger cheese, moisture content 49.3	9-14 d.	" "
Cheddar cheese, cured at 45F	>18 wk.	" "
Cottage cheese, low temp.	Not recovered	" "
<u>Streptococcus fecalis</u> Cheddar cheese, 50F	Inoc, 300/ml, Recov. 11x 10 <sup>6</sup> /ml, 180 d.	Kosikowsky 1948
" " 60F	Inoc; 300/ml, Recov. 13x 10 <sup>6</sup> /ml, 180 d.	" "
<u>Streptococcus spp.</u> Butter, from infected cow, salted	6 mo.	Bryan 1944
Butter, from infected cow, unsalted	6 mo.	" "

TABLE III (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>DAIRY PRODUCTS (cont'd)</b>		
<u>Streptococcus spp.</u>		
Ice cream	18 d.	Davis 1914
" " at 20C	No growth	" "
" " " 26C	Growth in 20 hr.	" "
" " refrigerator	Inoc. 45, Recov. 12 hr. 34,695 org.	Pennington 1907
" " R. T.	Inoc. 70, Recov. 34,491, 12 hr.	" "
" " incubator	Inoc. 18, Recov. 85844.4, 12 hr.	" "
<b>EGGS</b>		
<u>Streptococcus spp.</u>		
Egg white, 50C	Recov. 6, 4 hr.	Belin 1933
<b>MEAT</b>		
<u>Streptococcus pyogenes</u>		
Sausage, 4 d. drying	13 d.	Mueller-Claus 1938
Lobster meat	May remain alive in salad a considerable time	Scamman 1927
<u>Streptococcus viridans</u>		
Potted meat	Inoc. 30-5000/gm. meat, Recov. 30x10 <sup>8</sup> org, 60d.	Surgella 1945
<b>VEGETABLES</b>		
<u>Streptococcus fecalis</u>		
Veg., -20C	Recov. 89% out of 70 in 1 yr.	Burton 1949

TABLE F12

## THE SURVIVAL OF VIBRIO SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Vibrio comma</u>		
Milk, R.T.	11-63 hr.	Alessandrini -
" 37C	6-8-hr.	"
" boiled and uncovered	5-8 d.	"
Sour milk and cream	Lethal effect	Grattan 1939
Milk, 7-22C	6 d.	Heim 1889
Sterile milk, 22C	6-9 hr.	Lazarus 1890
" " 35C	12-24 hr.	" "
" " 62-70C	1 d.	" "
<b>DAIRY PRODUCTS</b>		
<u>vibrio comma</u>		
Curds	Do not survive	Bhat 1949
Cheese	8-15 hr.	Genevray 1938
Butter, R.T.	21 d.	Grattan 1939
" 37.5C	32 d.	Heim 1889
Curds, 35C, weakly acid	0 d.	" "
Whey, 35C, " "	2 d.	" "
Cheese, 35C	1 d.	" "
Cheese	4-5 wk.	Hesse 1889
Butter (English), 15C	>38 d.	Pullinger 1938
" " 3C	>98 d.	" "
Sweet and sour curds, pH 4.2-4.7	Inoc. 4 drops cult., Recov. 0, 5 min.	Panja 1945
<b>EGGS</b>		
<u>Vibrio comma</u>		
Salted salmon eggs, 23-33C	Inoc. 0.1cc., Recov. 0, 2 d.	Tetsumoto 1930
Grey mullet eggs, 23-33C	Inoc. 0.1cc., " " 3 d.	" "
Cod eggs, 23-33C	Inoc. 0.1cc., Recov. 0, >8 d.	" "
Salted sea-urchin eggs, 23-33C	Inoc. 0.1cc., Recov. 0, 12 hr.	" "
<b>MEAT</b>		
<u>Vibrio comma</u>		
Fish cooked in acid	4 d.	Arguelles 1927
" boiled in salt water	6 d.	" "
" washings	<1 d.	" "
Sterile fish washings	6 d.	" "
" " extract	125 d.	" "
Salted fish cooked	1 d.	" "
" " uncooked	<1 d.	" "
Uncooked small srimp	6 d.	" "
Cooked " "	4 d.	" "
Fresh cattle, blood sausage, ham broth	45 wk.	Hesse 1889
Meat	Well	Lal 1926
Fat	Poor	" "
Salmon skin 22.5-33C	18 hr.	Tetsumoto 1930
" ventral, 22.5-33C	18 hr.	" "
" flesh, 22.5-33C	18 hr.	" "

TABLE *Fig* (CONT'D) THE SURVIVAL OF VIBRIO SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MEAT (cont'd)</b>		
<b><i>Vibrio comma</i></b>		
Salmon skin (ster.), 23-33C	26 hr.	Tetsumoto 1930
Salmon ventral flesh (ster) 22.5-33C	19 hr.	" "
Salmon flesh (ster.), 22.5-33C	20 hr.	" "
Trout skin, 22.5-33C	26 hr.	" "
" ventral flesh, 22.5-33C	18 hr.	" "
Trout flesh, 22.5-33C	18 hr.	" "
" skin (ster.), 22.5-33C	25 hr.	" "
Trout flesh (ster.), 22.5-33C	18 hr.	" "
Aramahi salmon skin, 22.5-33C	38 hr.	" "
Aramahi salmon flesh, 22.5-33C	26 hr.	" "
Cod, 22.5-33C	8 hr.	" "
Ham, " "	26 hr.	" "
Yellow fish skin, 22.4-33C	27 hr.	" "
Yellow fish flesh, 22.5-33C	27 hr.	" "
Mackerel skin, 22.5-33C	27 hr.	" "
" flesh, " "	25 hr.	" "
" pike, " "	26 hr.	" "
Sardine, 22.5-33C	25 hr.	" "
Sea bream skin, 22.5-33C	38 hr.	" "
" " flesh, " "	32 hr.	" "
Horse mackerel, " "	38 hr.	" "
Flying fish	38 hr.	" "
Bacon	40 hr.	" "
Tuna	2 d.	" "
Sword fish	3 d.	" "
Trout	2 d.	" "
Shrimp	3 d.	" "
Salted cod, 16-27.5C	Recov. 0, 12 hr.	" "
" salmon, 16-27.5C	" " 36 hr.	" "
Aramahi salmon flesh, 16-27.5C	" " 25-40 hr.	" "
Mackerel, 16-27.5C	" " " " "	" "
Sardine, " "	" " " " "	" "
Flying fish	" " " " "	" "
Sardine (oiled), 19-34.5C	Inoc. 0.1cc, Recov. 0, 33 d.	" "
" (tomato), " "	Inoc. 0.1cc, Recov. 0, 31 d.	" "
" (yamaton), 19-34.5C	Inoc. 0.1cc, Recov. 0, 20 d.	" "

TABLE EL2 (CONT'D) THE SURVIVAL OF VIBRIO SPECIES IN FOOD

Factor(s)	Survival	Reference
<b>MEAT (cont'd)</b>		
<u>Vibrio comma</u>		
Bointo (yamaton), 19-35.5C	Inoc. 0.1cc, Recov. 0, 6 d.	Tetsumoto 1930
Salmon, 19-34.5C	Inoc. 0.1cc, Recov. 0, 27 d.	" "
Whitebait, 19-34.5C	Inoc. 0.1cc, Recov. 0, 19 d.	" "
Crab, 19-34.5C	Inoc. 0.1cc, Recov. 0, 18 d.	" "
Shrimp, 19-34.5C	Inoc. 0.1cc, Recov. 0, 13 d.	" "
Sea-ear, 19-34.5C	Inoc. 0.1cc, Recov. 0, 25 d.	" "
Scallop, " "	Inoc. 0.1cc, Recov. 0, 22 d.	" "
Beef yamaton, 19-34.5C	Inoc. 0.1cc, Recov. 0, 12 d.	" "
Cuttle fish, 22.5-27.5C	Inoc. 0.1cc, Recov. 0, 5 hr.	" "
Fukujinzuke, 19-34.5C	Inoc. 0.1cc, Recov. 0, 6 hr.	" "
Control in saline, 19-34.5C	Inoc. 0.1cc, Recov. 0, 6 d.	" "
Fish, 5C-13C, natural oysters and clams, 22C, ster. with steam oysters and clams, 0-5C	8 d. - 2 wk.	Tohyama 1925
Fish meat, 80C	40 d.	" "
" " 70C	2 min.	" "
" " 60C	3 min.	" "
" " hottest day	7.5 min.	" "
" " 3-8C	7-10 d.	" "
	2 wk.	" "
<b>SAUCES</b>		
<u>Vibrio comma</u>		
Nudi-mam sauce	6 hr.	Genevray 1938
Shrimp past	6 hr.	" "
Fermented soy sauce	<1 hr.	" "
Soy bean sauce, 25-17C	Inoc. 1 loop, Recov. 0, >24 hr.	Wang 1945
" " " 36-38C	Inoc. 1 loop, Recov. 0, <24 hr.	" "
<b>CEREAL</b>		
<u>Vibrio comma</u>		
Soy bean milk	8-15 hr.	Genevray 1938
<b>VEGETABLES</b>		
<u>Vibrio comma</u>		
Potatoes	4-5 wk.	Hesse 1889
Veg.	Well	Lal 1926
<b>FRUITS</b>		
<u>Vibrio comma</u>		
Watermelon, pH 4.7	4 d.	Bharucha 1938



TABLE F12 (CONT'D) THE SURVIVAL OF VIBRIO SPECIES IN FOOD

Factor(s)	Survival	Reference
<u>FRUITS (cont'd)</u> <u>Vibrio comma</u> Watermelon Grapes  Berries (inside) Grape stems Grapes (inside) Fresh lime, pH 4.4	Inoc. artificial, 6 d. 4 d.  24 hr. 12 d. 24 hr. 30 min.	Bharucha 1938 Dobrosklonsky 1911 " " " " " " Panja 1945
<u>GENERAL</u> <u>Vibrio comma</u> Human food <u>Vibrio sp.</u> Skim milk, frozen, dried at 100m. press.	6 d.  681 d.	Vasquet-Colet 1924 Stockton 1950

TABLE E-3

## THE SURVIVAL OF VIRUS IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b>		
<u>Polio virus</u> Milk	Polio virus can stand more heat in milk than water	Lawson 1947
<u>Foot and mouth disease virus</u> Milk	Present ---	Jansen 1942
<b>DAIRY PRODUCTS</b>		
<u>Polio virus</u> Butter, ice box	91 d.	Kling 1931
<b>EGGS</b>		
<u>Newcastle disease virus</u> Eggs, 36C, incubator	up to 126 d.	Olesiuk 1951
" R.T., 20-30C	" " 235 d.	" "
" hen house, 36C	255 d.	" "
" ice box, 3-6C	538 d.	" "
<u>Foul-pox virus</u> Chicken eggs, in dry state	Active at 3593 d.	Beaudette 1948
Duck eggs, " " "	" " 1928 d.	" "
<u>Pigeon-pox virus</u> Chicken eggs, " " "	" " 3605 d.	" "
Duck eggs, " " "	" " 1099 d.	" "
<u>Jap. B encephalitis virus</u> Eggs, 4C	6 hr.	Morgan 1946
<b>MEAT</b>		
<u>Foot and mouth disease virus</u> Beef, -20C, thawed in buff. phosphate soln. at 37C	4 mo.	Henderson 1948
Beef, -4C	24 hr.	" "
<b>CEREAL</b>		
<u>Foot and mouth disease virus</u> Chopped hay, R. T.	15 wk.	Anon. 1927
Bran, R. T.	20 wk.	" "
Hay and bran, dried	15-20 wk.	Burbury 1928
Hay (saliva on it)	>1 mo.	Krueger 1942
<u>N. d. virus</u> Mash, pH 5.5, 37C	56 d.	Olesiuk 1951
" " " 20-30C	94 d.	" "
" " " 11-36C	172 d.	" "
" " " 3-6C and -26C	>538 d.	" "
<b>FRUITS</b>		
<u>Polio virus</u> Unwashed fruits and veg.	Present ---	Gebhart 1946

TABLE EL4 THE SURVIVAL OF YEAST AND MOLD IN FOOD

Factor(s)	Survival	Reference
<b>MILK</b> <u>Yeast</u> Milk, -21 to -78C	Inoc. 100,000/ml., more resistant to freezing than thawing	Lund -
<b>DAIRY PRODUCTS</b> <u>Mold</u> Margarine	Viable 42%	Foltz 1951
<u>Yeast</u> Margarine	" 46%	" "
<b>VEGETABLES</b> <u>Mold</u> Veg., frozen " below freezing	90% killed 16 mo.	Magoon 1932 Tanner 1931
<u>Yeast</u> Veg., frozen	90% killed	Magoon 1932
<b>FRUITS</b> <u>Mold</u> Fruit juices, -23.3C Good oranges, 17.8C Soft rotten oranges, 17.8C Strawberries, -9.4C, sealed tins	3 yr. Inoc. 10,900/cc, Recov. 2,600/cc, 7 mo. Inoc. 26,500,000/cc, Recov. 990,000/cc, 8 mo 3 yr.	Tanner 1934 Wolford 1948 " " Smart 1934
<u>Yeast</u> Good oranges, 17.8C Soft rotten oranges, 17.8C Grape juice, freezing Strawberries, -9.4C, sealed tins	Inoc. 10,900/cc, Recov. 2,600/cc, 7 mo. Inoc. 26,500,000/cc, Recov. 990,000/cc, 8 mo 18 wk. 3 yr.	Wolford 1948 " " Tanner 1944 Smart 1934
<b>BEVERAGES</b> <u>Yeast</u> Beer, freezing Beer,	Cells remain active 15 yr.	Melsens 1870 Tanner 1944
<b>GENERAL</b> <u>Yeast</u> Food, -9.4C Syrup, very dry condition isolated from acid syrup	3-15 mo. Several wk.	Smart 1936 Owen 1948

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## SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Dessic.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN INSECTS

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TABLE 2 / THE SURVIVAL OF BACILLUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>B. anthracis</u> Stomach 13-17C 37C	exptl; 48-96 hr. " 24-48 hr.	
Feces of bedbugs	" 1st 24 hr. after feeding	Nuttall 1899
Feces of Dermestes vulpinus	present	Proust 1894
<b>BETLES</b>		
<u>B. anthracis</u> Intestinal tract of Blaps mucronata Tentyria sp. Pimelia bifurcata " sardea	present	
Surface Feces of Ptinus sp. Attagenus pello Anthrenus museorum	present "	Cao 1898 Matheson 1950
<b>COCKROACHES</b>		
<u>B. anthracis</u> Intestinal tract of Blatta orientalis	present	Cao 1898
Feces of Blatta orientalis	present	Kuster 1902
<u>B. subtilis</u> Feces of Blaberus cranifer	present	Wedberg 1949
<u>B. cereus</u> in Blaberus cranifer	present	Wedberg 1949
<b>FLIES</b>		
<u>B. anthracis</u> Stomach Intestines of flies	present; transmitted " "	Bollinger 1874
Intestinal tract of Musca domestica Calliphora vomitoria Lucilia caesar Sarcophaga carnaria	survived through life cycle and 9 d after maturity	Cao 1906
in Calliphora erythroceph- ala Lucilia caesar	survived through life cycle and 15 d after maturity	Matheson 1950
in Tabanus striatus	exptl; present; trans- mitted	Mitzmain 1914
Gut Feces of flies	present; transmitted " "	Schuberg 1912

TABLE 2 / (CONT'D) THE SURVIVAL OF BACILLUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
<u>FLIES (cont'd)</u>		
<u>B. anthracis (cont'd)</u> in <i>Musca domestica</i> <i>Calliphora erythrocephala</i>	exptl; present; transmitted	
Feces of <i>Stomoxys calcitrans</i>	exptl; present; not transmitted; 72 hr.	Sen 1944
<u>B. cereus</u> Feces of <i>Musca domestica</i>	present	Hawley 1951
<u>B. megatherium</u> Feces of <i>Musca domestica</i>	present	Hawley 1951
<u>TICKS</u>		
<u>B. anthracis</u> in <i>Argas persicus</i> Intestines Feces	present; transmitted indefinitely at least 100 d	Delpy 1937
Intestines of <i>Argas persicus</i>	24 hr.	Hindle 1925
Intestines of <i>Boophilus decoloratus</i>		Martinaglia 1932

TABLE 2 THE SURVIVAL OF BORRELIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>B. recurrentis</u> in <i>Cimex lectularis</i>	exptl; present; not able to transmit by bite	Francis 1938
in <i>Cimex lectularis</i>	exptl; present; not able to transmit by bite	Rosenholz 1927
<b>LICE</b>		
<u>B. recurrentis</u> Tissues of <i>Pediculus corporis</i> in monkey louse - <i>Pediculus longiceps</i>	life of louse (19 d or more) exptl; present; not able to transmit	Chung 1936 Francis 1938
Gut, ovaries, testis and malpighian tubules of <i>Pediculus capitis</i> and <i>corporis</i>	present	
lice	exptl; present; 18 d	Mackie 1907 Wolman 1945
<u>B. persica</u> Tissues of <i>Pediculus corporis</i>	present; transmitted	Adler 1942
<b>REDUVIDS</b>		
<u>B. duttonii</u> Intestinal tract of <i>Triatoma infestans</i>	exptl; present; 6 d	Liem 1941
<b>TICKS</b>		
<u>B. recurrentis</u> in <i>Ornithodoros turicata</i> Starved 5 yr. after an infective meal	present; transmitted exptl; 5 yr.; transmitted	Burroughs 1944
1 meal in 6½ yr. in <i>Ornithodoros turicata</i>	exptl; 6½ yr.; transmitted	Francis 1938
in <i>Ornithodoros tholozani</i>	present; transmitted	Gambles 1948
in " <i>papillipes</i>	" "	Pavlovskii 1945
in " <i>tholozani</i>	" "	Pavlovskii 1946
in " <i>papillipes</i>	exptl; 134 d; transmitted	
in " <i>tartakovskii</i>	present; transmitted	Sofiev 1946
in " <i>moubata</i>		
in " <i>savignyi</i>		
in " <i>talaje</i>		
in " <i>rudis</i>		
in " <i>turicata</i>		
in " <i>hermsi</i>		
in " <i>parkeri</i>		
in " <i>erraticus</i>		
in " <i>tholozani</i>		
in " <i>tartakovskii</i>		
in " <i>nerensis</i>		Steinhaus 1947
in " <i>turicata</i>	present; transmitted	Weller 1930
in " <i>turicata</i>	present; transmitted	Wissemann 1945



TABLE 2 (CONT'D) THE SURVIVAL OF BORRELIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>TICKS (cont'd)</b>		
<u>B. duttoni</u>		
in <i>Ornithodoros moubata</i>	present; transmitted	Dutton 1905
in " "	present	Ross 1904
<u>B. duttoni var. crocidurae</u>		
in <i>Ornithodoros erraticus</i>	present; transmitted	Boiron 1949
<u>B. hispanica</u>		
in <i>Ornithodoros erraticus</i>	present; transmitted	Boiron 1948
in <i>Rhipicephalus sanguineus</i>	exptl; present	Seargent 1938
<u>B. anserina</u>		
in <i>Argas persicus</i>		
" <i>reflexus</i>		
" <i>Ornithodoros moubata</i>	Present; transmitted	Steinhaus 1947
<u>B. theileri</u>		
in <i>Margaropus decoloratus</i>		
" <i>Rhipicephalus evertsi</i>	present; transmitted	Steinhaus 1947

TABLE 3 THE SURVIVAL OF BRUCELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<p><b>BEDBUGS</b>  <u>Brucella spp.</u>                      Feces                      of bedbugs</p>	<p>&gt; 3 mos.; not transmitted by bite</p>	<p>Tovar 1947</p>
<p><b>COCKROACHES</b>  <u>B. abortus</u>                      Intestinal tract                      of <i>Periplaneta americana</i></p>	<p>24 hrs.</p>	<p>Ruhland 1941</p>
<p><b>FLEAS</b>  <u>Brucella spp.</u>                      Feces                      of fleas</p>	<p>present; not transmitted by bite</p>	<p>Tovar 1947</p>
<p><b>FLIES</b>  <u>B. abortus</u>                      in flies                      Intestinal tract</p>	<p>24 hrs.                      &gt; 96 hrs.</p>	<p>Patton 1931                      Ruhland 1941</p>
<p><b>TICKS</b>  <u>Brucella spp.</u>                      Feces                      of ticks</p>	<p>&gt; 3 mos.; transmitted by bite and transmitted to eggs and larvae</p>	<p>Tovar 1947</p>

TABLE 24 THE SURVIVAL CLOSTRIDIUM SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEETLES</b>		
<u>C. tetani</u> Feces of <i>Blaps mucronata</i> <i>Tentyria</i> sp. <i>Pimelia bifurcata</i> " <i>sardea</i>	present	Cao 1906
<u>C. chauvoei</u> Feces of <i>Blaps mucronata</i> <i>Tentyria</i> sp. <i>Pimelia bifurcata</i> " <i>sardea</i>	present	Cao 1898
<u>C. sporogenes</u> Feces of <i>Blaps mucronata</i> <i>Tentyria</i> sp. <i>Pimelia bifurcata</i> " <i>sardea</i>	present	Cao 1898
<b>COCKROACHES</b>		
<u>C. tetani</u> Feces of <i>Blatta orientalis</i>	present	Cao 1906
<u>C. sporogenes</u> Feces of <i>Blatta orientalis</i>	present	Cao 1898
<u>C. chauvoei</u> Feces of <i>Blatta orientalis</i>	present	Cao 1898

TABLE 5 THE SURVIVAL OF COLIFORM ORGANISMS IN INSECTS  
(ESCHERICHIA, PARACOLOBACTRUM & AEROBACTER)

Factor(s)	Survival	Reference
<b>BEETLES</b>		
<u>E. coli</u> Feces of <i>Blaps mucronata</i> <i>Tentyria</i> sp. <i>Pimelia bifurcata</i> " <i>sardea</i>	present	Cao 1898
<b>COCKROACHES</b>		
<u>E. coli</u> Feces of <i>Blatta orientalis</i>	present	Cao 1898
Legs and feces of <i>Blatta orientalis</i>	present	Longfellow 1913
Intestinal tract of <i>Blattella germanica</i>	present	Steinhaus 1941
<u>E. coli var. communior</u> Feces of <i>Blaberus cranifer</i>	present	Wedberg 1949
<u>E. freundii</u> Feces of <i>Blaberus cranifer</i>	present	Wedberg 1949
<u>E. spp.</u> Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
<u>Paracolo bacterium</u> sp. Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
Feces of <i>Blaberus cranifer</i>	present	Wedberg 1949
<u>A. aerogenes</u> Feces of <i>Blaberus cranifer</i> in cockroaches	present present	Wedberg 1949 Morrell 1911
<u>A. cloacae</u> in cockroaches	present	Morrell 1911
<u>A. spp.</u> Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
<b>FLIES</b>		
<u>E. coli</u> Feces of <i>Musca domestica</i> <i>Calliphora vomitoria</i> <i>Lucilia caesar</i> <i>Sarcophaga carnaria</i>	present	Cao 1898
Intestines of <i>Musca domestica</i>	present	Cox 1912
Body	Inoc; fed a suspension of 12,000-48,000 organisms Recov: multiplied in body present	
Feces of flies	present	Hawley 1948

TABLE 25 (CONT'D) THE SURVIVAL OF COLIFORM ORGANISMS IN INSECTS  
(ESCHERICHIA, PARACOLOBACTRUM & AEROBACTER)

Factor(s)	Survival	Reference
FLIES (cont'd)		
<u>E. coli (cont'd)</u>		
<u>Feces</u>		
of <i>Musca domestica</i>	Inoc: 12,000-900,000 bacteria Recov: 1st d - 10-10,000 6th d - 1- 200,000,000	Hawley 1951
Intestines of <i>Musca domestica</i>	present	Nicoll 1911
Intestines of <i>Musca domestica</i>	present	Scott 1917
Intestines of <i>Musca domestica</i>	present	Torrey 1912
<u>E. coli var. communior</u>		
Intestines of <i>Musca domestica</i>	present	Torrey 1912
Intestines of <i>Musca domestica</i>	present	Scott 1917
<u>E. coli var. acidilactici</u>		
Intestines of <i>Musca domestica</i>	present	Torrey 1912
Intestines of <i>Musca domestica</i>	present	Cox 1912
<u>E. coli var. neopolitana</u>		
Intestines of <i>Musca domestica</i>	present	Cox 1912
<u>E. coli var. mutabilis</u>		
Intestines of <i>Musca domestica</i>	present	Nicoll 1911
<u>A. aerogenes</u>		
External	Sanitary areas of city: 21,000-100,000/fly Unsanitary areas of city: 800,000-500,000,000/ fly	
Internal of <i>Musca domestica</i>	Sanitary areas of city: 100-10,000/fly Unsanitary areas of city: 10,000-333,000,000/fly	Cox 1912
of <i>Musca domestica</i>	present	Hawley 1951
Intestines of <i>Musca domestica</i>	present	Nicoll 1911
Intestinal tract of <i>Musca domestica</i>	present	Torrey 1912
<u>Colon group</u>		
Internally and externally of <i>Musca domestica</i>	Recov: 100,000 human faecal bacteria in a single fly	Graham-Smith 1909

TABLE 26 THE SURVIVAL OF CORYNEBACTERIUM SPECIES IN INSECTS

Factor(s)	Survival	Reference
<p><b>BEE TL ES</b>  <u>C. pseudodiphthericum</u>                      Intestinal tract                      Tentyria sp.                      Blaps mucronata                      Pimelia bifurcata                      " sardea</p>	<p>present</p>	<p>Cao 1898</p>
<p><b>COCKROACHES</b>  <u>C. pseudodiphthericum</u>                      Intestinal tract                      of Blatta orientalis  <u>C. diphtheriae</u>                      Legs and feces                      of Blata orientalis</p>	<p>present                       present</p>	<p>Cao 1898                       Longfellow 1913</p>
<p><b>FLIES</b>  <u>C. diphtheriae</u>                      Legs and wings                      Intestines                      Feces                      of Musca domestica                      Calliphora erythrocephala                      Intestinal tract                      of flies</p>	<p>exptl; few hrs.                      " &gt; 24 hrs.                      " 51 hrs.                       exptl; 24 hrs.</p>	<p>Graham-Smith 1910                      Graham-Smith 1913</p>

TABLE 27 THE SURVIVAL OF DIPLOCOCCUS & STREPTOCOCCUS SPECIES  
IN INSECTS

Factor(s)	Survival	Reference
<b>COCKROACHES</b>		
<u>Diplococcus pneumoniae</u> Legs and feces of <i>Blatta orientalis</i>	present	Longfellow 1913
<u>Streptococcus faecalis</u> Alimentary tract of <i>Blattella germanica</i>	present	Steinhaus 1941
<b>FLEAS</b>		
<u>Diplococcus pneumoniae</u> Intestinal tract of fleas	present	Pinto 1930
<b>FLIES</b>		
<u>Streptococcus faecalis</u> Intestinal tract of <i>Musca domestica</i>	present	Cox 1912
Intestinal tract of <i>Musca domestica</i>	present	Scott 1917
Intestinal tract of <i>Musca domestica</i>	present	Torrey 1912
<u>Streptococcus equinus</u> Intestinal tract of <i>Musca domestica</i>	present	Torrey 1912
<u>Streptococcus sp.</u> in flies	present	Schuberg 1914
<u>Streptococcus pyogenes</u> in <i>Musca domestica</i>	present	Scott 1917
Externally of flies	present	Shooter 1944
<u>Streptococcus agalactiae</u> in <i>Musca domestica</i>	present	Ewing 1942
in " "	present	Saunders 1904
<b>LICE</b>		
<u>Diplococcus pneumoniae</u> Feces <i>Pediculus capitis</i>	24 hrs.	Pierce 1921
<b>REDUVA</b>		
<u>Streptococcus faecalis</u> in <i>Triatoma infestans</i>	present; transmitted	Brecher 1944

TABLE 28 THE SURVIVAL OF FUNGI, YEASTS & MOLDS IN INSECTS

Factor(s)	Survival	Reference
COCKROACHES		
<u>Rhizopus nigricans</u>		
<u>Penicillium spp.</u>		
<u>Saccharomyces cerevisiae</u>		
<u>Actinomyces spp.</u>		
<u>Molds</u>		
<u>Yeasts</u>		
<u>Feces</u>		
of <u>Blaberus cranifer</u>		Wedberg 1949
<u>Torula rosea</u> (yeast)		
Feces	exptl;	
of <u>Blaberus cranifer</u>	Inoc: massive doses	
	Recov: present	
	6 d	Wedberg 1949
<u>Torula sp.</u>		
in <u>Periplaneta americana</u>	present; transmitted	Owen 1948



TABLE 29 THE SURVIVAL OF MALLEOMYCES MALLEI IN INSECTS

Factor(s)	Survival	Reference
<p><b>BETTERLES</b>  <u>M. mallei</u>                      Feces                      of <i>Blaps mucronata</i>  <i>Tentyria</i> sp.  <i>Pimelia bifurcata</i>                      " <i>gardea</i></p>	<p>present</p>	<p>Cao 1898</p>
<p><b>COCKROACHES</b>  <u>M. mallei</u>                      Feces                      of <i>Blatta orientalis</i></p>	<p>present</p>	<p>Cao 1898</p>
<p><b>FLEAS</b>  <u>M. pseudomallei</u>                      Body                      Feces                      of <i>Xenopsylla cheopis</i>                      in rat fleas</p>	<p>50 d; transmitted                      present; transmitted                      exptl; present; trans-                      mitted</p>	<p>Blanc 1941                      Blanc 1942</p>
<p><b>MOSQUITOES</b>  <u>M. pseudomallei</u>                      in <i>Aedes aegypti</i></p>	<p>exptl; present; trans-                      mitted</p>	<p>Blanc 1942</p>

TABLE 2/0 THE SURVIVAL OF MICROCOCCUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEEYLES</b>		
<u>M. albus</u> Intestinal tract of <i>Melolontha vulgaris</i>	present	Cao 1906
<u>M. aureus</u> Intestinal tract of <i>Melolontha vulgaris</i>	present	Cao 1906
<u>M. citreus</u> Intestinal tract of <i>Melolontha vulgaris</i>	present	Cao 1906
<b>COCKROACHES</b>		
<u>M. albus</u> in <i>Blattella germanica</i> in <i>Blaberus cranifer</i>	present present	Herms 1939 Wedberg 1949
<u>M. aureus</u> Antennae, feet and stomach of <i>Blattella germanica</i>	present	Herms 1939
Legs and feces of <i>Blatta orientalis</i>	present	Longfellow 1913
Feces of <i>Blaberus cranifer</i>	present	Wedberg 1949
<u>M. citreus</u> Legs and feces of <i>Blatta orientalis</i>	present	Longfellow 1913
<b>FLIES</b>		
<u>M. albus</u> External of flies	present	Scott 1917
External of flies in tabanid flies	present present	Torrey 1912 Joly 1898
<u>M. aureus</u> Feces of <i>Musca domestica</i>	present	Celli 1888
Feces of <i>Musca domestica</i> in tabanid flies	present present	Hawley 1951 Joly 1898
Feet of flies	present	Scott 1917
<u>M. aureus, 611</u> Gut	8 d	
Feces	3-5 d	Moorehead 1946
<u>M. citreus</u> Body and feces of flies	survived through life cycle and 9 d after maturity	Scott 1917
<u>M. spp.</u> in <i>Musca domestica</i>	present	Cox 1912
<u>Sarcina lutea</u> Feces of <i>Musca domestica</i>	present	Hawley 1951
<b>LICE</b>		
<u>M. pemphigicontagiosa</u> in <i>Pediculus capitis</i>	present; transmitted	Dewevre 1892

TABLE 2/10 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
LICE (cont'd) <u>M. spp.</u> in <i>Pediculus capitis</i>	present	Pierce 1921
MOSQUITOES <u>M. aureus</u> Gut of <i>Aedes aegypti</i>	at least 24 hr.; not after 7 d	St. John 1930
TICKS <u>M. aureus</u> in <i>Argas reflexus</i>	present	Galli-Valerio 1907

TABLE 011 THE SURVIVAL OF MICROORGANISMS IN INSECTS

Factor(s)	Survival	Reference
<b>BEE TL ES</b>		
<u>Klebsiella pneumoniae</u> Feces of <i>Blaps mucronata</i> <i>Tentyria</i> sp. <i>Pimelia bifurcata</i> " <i>sardea</i>	present	Cao 1898
<b>COCKROACHES</b>		
<u>Klebsiella pneumoniae</u> Feces of <i>Blatta orientalis</i>	present	Cao 1898
<u>Proteus vulgaris</u> Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
Legs and feces of <i>Blatta orientalis</i>	present	Longfellow 1913
Feces of <i>Blaberus cranifer</i>	present	Wedberg 1949
<u>Proteus morgani</u>		
<u>Proteus mirabilis</u>		
<u>Proteus rettgeri</u> Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
<u>Pseudomonas aeruginosa</u> Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
Feces of <i>Blaberus cranifer</i>	present	Wedberg 1949
<u>Serratia marcescens</u> Feces of <i>Blaberus cranifer</i>	exptl; duration of life of roach	Wedberg 1949
<b>FLIES</b>		
<u>Neisseria gonorrhoeae</u> Feet of flies	3 hrs.	Matheson 1950
<u>Neisseria meningitidis</u> (in- tracellularis) in flies	present	MacGregor 1917
<u>Proteus vulgaris</u> Feces of <i>Musca domestica</i> <i>Calliphora vomitoria</i> <i>Lucilia caesar</i> <i>Sarcophaga carnaria</i> in <i>Musca domestica</i>	present	Cao 1906 Scott 1917
<u>Proteus morgani</u> Feces of <i>Musca domestica</i> in <i>Musca domestica</i>	present	Hawley 1951 Morgan 1909
Intestines of <i>Musca domestica</i> in <i>Musca domestica</i>	present present	Nicoll 1911 Cox 1912

TABLE 9 // (CONT'D) THE SURVIVAL OF MICROORGANISMS IN INSECTS

Factor	Survival	Reference
<b>FLIES (cont'd)</b>		
<u>Pseudomonas aeruginosa</u>		
Intestinal tract of <i>Musca domestica</i>	survives through meta- morphosis; transmitted	Bacot 1911
Feces of <i>Musca domestica</i>	present; survived through the life cycle	
Calliphora vomitoria		
Lucilia caesar		
Sarcophaga carnaria		
Gut	present	Cao 1898
of <i>Stomoxys calcitrans</i>		
Intestinal tract	present; survives	Duncan 1926
of flies	through metamorphosis	Ledingham 1911
<u>Pseudomonas sp.</u>		
Feces	present	Hawley 1951
of <i>Musca domestica</i>		
<u>Serratia marcescens</u>		
Crop	exptl; large numbers recovered; 4-5 d	
Intestines	exptl; present; up to	Graham-Smith 1913
of <i>Musca domestica</i>	18 d	
Pupae	1 d	Ledingham 1911
of <i>Musca domestica</i>		

TABLE 2/2 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>M. leprae</u> Intestinal tract of Cimex lectularis	present	Long 1911
Proboscis Intestinal tract Feces of bedbugs	5 d 16 d present	Matheson 1950
<b>BETTERLES</b>		
<u>M. tuberculosis</u> Intestinal tract of Tentyria sp. Blaps mucronata Pimelia bifurcata " sardea	present	Cao 1898
<b>COCKROACHES</b>		
<u>M. tuberculosis</u> Intestinal tract of Blatta orientalis	present	Cao 1898
Feces of Blatta orientalis	present	Auster 1902
Feces of Periplaneta americana	present	Macfie 1922
Feces of Periplaneta americana	2-5 d; transmitted	Riley 1932
Feces of cockroaches	present	Tejira 1926
<u>M. leprae</u> Feces of Periplaneta americana	present	Macfie 1922
Gut Feces - dried of cockroaches	exptl; multiplied " 169 d	Moiser 1945
Intestines of cockroaches in cockroaches	present present	Riley 1932 Tejira 1926
<b>FLEAS</b>		
<u>M. leprae</u> Stomach of fleas	present	Munoz-Rivas 1946
<b>FLIES</b>		
<u>M. tuberculosis</u> Intestines and feces of Musca domestica	present; transmitted	Andre 1908
Intestinal contents and feces of Musca domestica	present	Celli 1888
Intestines and feces of flies	exptl; 13 d	Graham-Smith 1913
Intestines and feces of Musca domestica	present	Hofmann 1888
Intestines and feces of flies	present	Spielman 1887

TABLE 9/2 (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>FLIES (CONT'D)</b>		
<u>M. leprae</u>		
Intestinal tract and feces of <i>Musca domestica</i> <i>Sarcophaga palliner-</i> <i>vis</i> <i>Sarcophaga barbata</i> <i>Volencelle obesa</i> <i>Lucilia sp.</i> in <i>Stomoxys calcitrans</i> <i>Musca domestica</i>	several days         present	Currie 1910         Honeij 1914
<b>LICE</b>		
<u>M. leprae</u>		
in <i>Pediculus capitis</i>	present	McCoy 1912
<b>MOSQUITOES</b>		
<u>M. leprae</u>		
in <i>Aedes aegypti</i> Gut of <i>Aedes aegypti</i>	present at least 24 hr., not after 7 d	Riley 1938  St. John 1930

TABLE 9 / 13 THE SURVIVAL OF PASTEURELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>P. tularensis</u>		
in Cimex lectularis	136 d	Bozhenko 1935
Excrement	exptl; infective;	
of Cimex lectularis	present	Davis 1943
in Cimex lectularis	present	Francis 1927
in " "	exptl; present; trans-	
	mitted	Francis 1922
in bedbugs	present	Kamil 1936
<b>FLEAS</b>		
<u>P. pestis</u>		
Alimentary tract	greatly multiplied;	
of fleas	transmitted	Bacot 1914
Live	21 d; transmitted	
Dead	5 d; "	
Excreta	5 d; "	
of Pulex irritans		Blanc 1941
in Xenopsylla cheopis		
Nosophyllus fasciatus		
Orchopeasexdentatus		
sexdentatus		
Opisodasys nesiotus		
Megabothris abantis		
Malareus telchinom		
Diamanus montanus		
Echidnophaga gallinacea	present, transmitted	Burroughs 1947
Alimentary tract	present	
Feces	present in very small	
of fleas	numbers	Douglas 1943
Feces- dried	4 wk.; exptl.; trans-	
of fleas	mitted	Eskey 1938
Feces-dried, 66F.	5 wk.; exptl.; trans-	
of fleas	mitted	Eskey 1939
in fleas	Inoc: approx. 5,000	
	bacteria taken in at	
	a blood meal	
	Recov; multiplied	
	Epidemic- 15 d	
	Nonepidemic- 7 d	Herms 1950
in Xenopsylla cheopis	Present; transmitted	Lien-teh 1936
in fleas	" "	Liston 1905
in Diamanus montanus		
Hoplopyllus anomalus	present; transmitted	Meyer 1949
in fleas	exptl; present; survive	
	through hibernation	Prince 1947
in fleas		
50F., RH - saturated	present; favorable	
	conditions for sur-	
	vival	
>80F., RH- dry	present; adverse condi-	
	tions for survival	Topley 1932



TABLE 2/3 (CONT'D) THE SURVIVAL OF PASTEURELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>FLEAS (cont'd)</b>		
<u>P. tularensis</u>		
in <i>Spilopsyllus cuniculi</i>	present; transmitted	Green 1938
Tissues of fleas	present	McCoy 1911
in <i>Ctenocephalus pallex</i>		
" " <i>orientalis</i>	present; transmitted	Volferz 1934
in <i>Cediopsylla simplex</i>	" "	Waller 1940
<b>FLIES</b>		
<u>P. tularensis</u>		
in <i>Chrysops discalis</i>	present; transmitted	Francis 1921
in horse-fly, stable-fly and Rainfly	present	Olsofiev 1936
<b>LICE</b>		
<u>P. tularensis</u>		
in lice	present; transmitted	Davis 1935
in <i>Haemodipus ventricosus</i>	" "	Francis 1922
in <i>Polyplex serratus</i>	" "	Francis 1922
<b>MITES</b>		
<u>P. tularensis</u>		
in <i>Bdellonyssus bacoti</i>	exptl; present, transmitted	Hopla 1951
in <i>Gamasidae</i>	present, transmitted	Volferz 1934
<b>MOSQUITOES</b>		
<u>P. tularensis</u>		
Feces	present	
of <i>Culex apicalis</i>		Bozhenko 1936
in <i>Aedes cinereus</i>	present	Olin 1942
in mosquitoes	present	Olsofiev 1936
Intestines and feces of <i>Aedes nearcticus</i>	present; transmitted	
" <i>vexans</i>		
" <i>dorsalis</i>		
" <i>stimulans</i>		
" <i>caradensis</i>		
<i>Theobaldi indicens</i>		
<i>Culex tarsalis</i>		Philip 1932
<b>TICKS</b>		
<u>P. pestis</u>		
in <i>Hyalomma volgense</i>		
<u>P. schulze</u>		
<u>E. schlottke</u>		
in <i>Argas persicus</i>	present; transmitted	Borzenkov 1933
Tissues of ticks	" "	Foddeeva 1932
Tissues of ticks	" "	Lien-teh 1936
Tissues of ticks	" "	Matheson 1950
<u>P. tularensis</u>		
Tissues of ticks	Present; transmitted	Davis 1940
Tissues	exptl; not transmitted during feeding	
<i>Ornithodoros turicata</i>	674 d	
" <i>parkeri</i>	701 d	Davis 1940

TABLE 2/3 (CONT'D) THE SURVIVAL OF PASTEURELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
TICKS (cont'd)		
<u>P. tularensis</u> (cont'd)		
in Ixodes ricinus	present	Davis 1937
" californicus	present; transmitted	Francis 1927
Feces of Dermacentor andersoni	" "	Matheson 1950
in ticks	" "	Green 1931
in Dermacentor variabilis	" "	Kamil 1938
in Ornithodoros lahorensis	" "	Parker 1929
in Dermacentor occidentalis	" "	Parker 1924
in Dermacentor andersoni	survived life cycle	
in Dermacentor variabilis	stage to stage and generation to generation survival	Philip 1934

TABLE 2 / 4 THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>Trypanosoma cruzi</u> in <u>Cimex pilosellus</u>	exptl; present; trans- mitted	Wood 1951
<b>COCKROACHES</b>		
<u>Endamoeba histolytica</u> Hindgut and feces of <u>Periplaneta americana</u>	exptl; cysts present for 72 hr.	Frye 1936
Feces of <u>Periplaneta americana</u>	cysts present	Macfie 1922
<u>Giardia lamblia</u> in <u>Periplaneta americana</u> Colonic contents of cockroaches	cysts present exptl; 12 d	Macfie 1922 Young 1937
<u>Ancliyostoma duodenale</u> " <u>ceylanicum</u>		
<u>Necator americanus</u>		
<u>Ascaris lumbricoides</u>		
<u>Trichuris trichura</u>		
<u>Taenia saginata</u>		
<u>Schistosoma haematobium</u> Feces of <u>Periplaneta americana</u>	eggs present	Macfie 1922
<b>FLIES</b>		
<u>Chilomastix mesnili</u> Feces of <u>Musca domestica</u>	cysts present	Root 1921
<u>Endamoeba histolytica</u> intestinal contents of <u>Chrysomya megacephala</u> <u>Lucilia sericata</u> <u>Sarcophaga</u> spp. in <u>Musca domestica</u> in flies Dejecta " of <u>Musca domestica</u> <u>Lucilia pallescens</u> <u>Cochliomyia macellaria</u> <u>Phormia regina</u> <u>Sarcophaga miserio</u>	cysts present  cysts present " " trophozoites present cysts recovered 154-258 minutes; exptl.	Chang 1943 Frye 1932 Harris 1946
Crop Midgut External surface Rectum Vomit drop Faecal drop of flies Feces of <u>Musca domestica</u> Feces of <u>Musca domestica</u> Feces of <u>Musca domestica</u>	exptl; troph.      cysts 40 min.      210 min. 30 "      240 " "      4 " "      210 " 17 "      64 " "      254 "	Pipkin 1943
	exptl; cysts present	Pipkin 1949
	" " "	Root 1921
	" " "	Roubaud 1918
		Sieyro 1942

TABLE 914 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>FLIES (cont'd)</b>		
<u>Endamoeba histolytica</u> (cont'd)		
Feces and intestinal tract	cysts present	
" " " "	exptl; cysts present;	
of <i>Musca domestica</i>	2-3 d	Matheson 1950
<u>Endamoeba coli</u>		
in <i>Musca domestica</i>	cysts present	Frye 1932
Feces	exptl; cysts present	
of <i>Musca domestica</i>	" " "	Root 1921
Feces	" " "	
of <i>Musca domestica</i>		Roubaud 1918
Feces and intestinal tract	cysts present	
" " " "	exptl; cysts present,	
of <i>Musca domestica</i>	2-3 d	Matheson 1950
<u>Endolimax nana</u>		
in <i>Musca domestica</i>	cysts present	Frye 1932
<u>Giardia lamblia</u>		
Feces	cysts present	
of <i>Musca domestica</i>		Root 1921
Feces	cysts present	
of <i>Musca domestica</i>		Roubaud 1918
Feces and intestinal tract	cysts present	
" " " "	exptl; cysts present,	
of <i>Musca domestica</i>	2-3 d	Matheson 1950
in flies	cysts present	Frye 1932
<u>Leishmania braziliensis</u>		
in <i>Phlebotomus lutzi</i>		
" " intermedius	present, transmitted	Steinhaus 1947
<u>Leishmania donovani</u>		
in <i>Phlebotomus argentipes</i>	exptl; present; trans-	
	mitted	Napier 1933
Gut	present	
of <i>Phlebotomus argentip-</i>		Matheson 1950
Gut	present	
of <i>Phlebotomus major</i>		
var. <i>chinensis</i>		
<i>Phlebotomus sergenti</i>		Patton 1927
in <i>Phlebotomus argentipes</i>	exptl; present; trans-	
	mitted	Matheson 1950
in <i>Phlebotomus argentipes</i>	exptl; present; trans-	
	mitted	Smith 1936
in <i>Phlebotomus argentipes</i>		
" <i>perniciosus</i>		
<i>major</i>		
<i>longicuspis</i>		
<i>major</i> var.		
<i>chinensis</i>	present; transmitted	Steinhaus 1947
in <i>Phlebotomus argentipes</i>	exptl; present; trans-	
	mitted	Swanimath 1942
Gut	present	
of <i>Phlebotomus</i> spp.		Young 1927

TABLE 2/4 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>FLIES (cont'd)</b>		
<u>Leishmania tropica</u>		
in <i>Phlebotomus papatasi</i>	present; transmitted	Adler 1941
in " <i>sergenti</i>	" "	Adler 1939
in " <i>papatasi</i>	" "	Adler 1948
in " <i>sergenti</i>	" "	Adler 1948
in " <i>papatasi</i>	" "	Steinhaus 1947
in " <i>sergenti</i>	" "	Steinhaus 1947
<u>Trypanosoma rhodesiense</u>		
in <i>Glossina brevipalpis</i>		
in " <i>morsitans</i>	present; transmitted	Matheson 1950
in <i>Glossina morsitans</i>	" "	Bughorn 1912
in " "		
in " <i>swinnertoni</i>	present; transmitted	Steinhaus 1947
in " <i>palpalis</i>		
in " <i>brevipalpis</i>	exptl; present; transmitted	Steinhaus 1947
<u>Trypanosoma gambiense</u>		
Proboscis	<48 hrs; transmitted	
of <i>Glossina palpalis</i>		Bruce 1903
in <i>Glossina palpalis</i>	present; transmitted	Castellani 1903
in " "	" "	Kleine 1909
in " "	multiplied; duration of life; transmitted	Robertson 1917
in <i>Glossina tachinoides</i>	present; transmitted	Steinhaus 1947
in " <i>morsitans</i>		
in " <i>fusca</i>		
in " <i>pallidipes</i>		
in " <i>submorsitans</i>	exptl; present; transmitted	Steinhaus 1947
<u>Trypanosoma brucei</u>		
in <i>Glossina morsitans</i>	present; transmitted	Kleine 1909
<u>Ascaris lumbricoides</u>		
Intestinal tract	ova present	
of <i>Chrysomya megacephala</i>		
of <i>Lucilia sericata</i>		
of <i>Sarcophaga</i> spp.		
Externally	exptl; eggs present	Chang 1943
of <i>Musca domestica</i>		
of <i>Lucilia pallescens</i>		
of <i>Cochliomyia macellaria</i>		
of <i>Phormia regina</i>		
of <i>Sarcophaga miserio</i>		Pipkin 1943
<u>Enterobius vermicularis</u>		
Externally	exptl; eggs present	
of <i>Musca domestica</i>		
of <i>Lucilia pallescens</i>		
of <i>Cochliomyia macellaria</i>		
of <i>Phormia regina</i>		
of <i>Sarcophaga miserio</i>		Pipkin 1943

TABLE 214 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>FLIES (cont'd)</b>		
<u>Hookworms</u> - spp. not given Intestinal contents of <i>Chrysomya megacephala</i> <i>Lucilia sericata</i> <i>Sarcophaga</i> spp.	ova present	Chang 1943
<u>Hookworm - Necator americanus</u> Externally of <i>Musca domestica</i> <i>Lucilia pallescens</i> <i>Cochliomyia macellaria</i> <i>Phormia regina</i> <i>Sarcophaga miserio</i>	exptl; eggs present	Pipkin 1943
<u>Trichuris trichura</u> Intestinal contents of <i>Chrysomya megacephala</i> <i>Lucilia sericata</i> <i>Sarcophaga</i> spp.	ova present	Chang 1943
Externally of <i>Musca domestica</i> <i>Lucilia pallescens</i> <i>Cochliomyia macellaria</i> <i>Phormia regina</i> <i>Sarcophaga miserio</i>	exptl; eggs present	Pipkin 1943
<b>LICE</b>		
<u><i>Trypanosoma duttoni</i></u> in <i>Pediculus corporis</i>	present; transmitted	Heisch 1949
<b>MOSQUITOES</b>		
<u><i>Plasmodium flaciparum</i></u> in <i>Anopheles albimanus</i> Over 68F, opt. 86F RH - near 70% in mosquitoes in <i>Anopheles quadrimaculatus</i> <i>Anopheles albimanus</i>	present; transmitted " " " " exptl; present; transmitted 24 hrs.	Eyles 1949 Gill 1938 Jeffery 1950
35F in <i>Anopheles quadrimaculatus</i> Over 68F, opt. 86F RH at least 70% in mosquitoes	present; transmitted	King 1917 Matheson 1950
<u><i>Plasmodium malarie</i></u> in <i>Anopheles maculipennis</i>	exptl; present; transmitted	Young 1947

TABLE 214 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>MOSQUITOES (cont'd)</b>		
<u>Plasmodium vivax</u>		
in <i>Anopheles quadrimaculatus</i>	exptl; present; transmitted	Eyles 1948
Mean temp. between 60.8-68F; RH - not below 70% in mosquitoes	present; transmitted	Gill 1938
in <i>Anopheles maculipennis</i>	infective for nearly 6 mos.	James 1927
4-6C in <i>Anopheles maculipennis</i>	infective for 2½ yrs.	Matheson 1950
30F	2 d	
31F	4 d	
46F	17 d	
in <i>Anopheles quadrimaculatus</i>		King 1917
Over 62F, opt. 77F RH over 70% in mosquitoes	present	Matheson 1950
19-22.8C in mosquitoes	exptl; present; transmitted	Matheson 1933
in <i>Anopheles maculipennis freeborni</i>		
<i>Anopheles maculipennis occidentalis</i>		
<i>Anopheles punctipennis</i>	exptl; present; transmitted	Moore 1945
in <i>Anopheles barberi</i>	exptl; present; transmitted	Stratman-Thomas 1936
in <i>Anopheles quadrimaculatus</i>	exptl; present; transmitted	Watson 1945
in <i>Anopheles quadrimaculatus</i>	exptl; present; transmitted	Young 1952
in <i>Anopheles quadrimaculatus</i> <i>Anopheles maculipennis freeborni</i>	exptl; present; transmitted	Young 1945
<u>Plasmodium spp.</u>		
in mosquitoes	present; transmitted	Bastianelli 1898
in mosquitoes	" "	Manson 1898
Salivary glands		
59-83F for 6 d		
44-78F for remainder of time		
Diet - date juice & H <sub>2</sub> O in <i>Anopheles punctipennis</i>	68-92 d	Mayne 1922

TABLE 2/4 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>MOSQUITOES (cont'd)</b>		
<u>Plasmodium spp. (cont'd)</u>		
in mosquitoes	present	Ross 1898
in mosquitoes	"	Sambon 1900
in Anopheles quadrimaculatus		
Anopheles maculipennis		
" crucians		
" albimanus		
" pseudopunctipennis		
" tarsimaculatus		
" argyritarsis		
" darlingi		
" albitarsis		
" punctimacula		
" hectoris		
" bellator	present, transmitted	Simmons 1941
<del>Trypanosoma gambiense</del>		
in Mansonella uniformis	exptl; present; transmitted	Steinhaus 1947
<u>Wuchereria bancrofti</u>		
in Culex quinquefasciatus		
" annulirostris	exptl; present; transmitted	Cabrera 1951
in Culex fatigans	present; transmitted	Carter 1948
in Culex pipiens		
" quinquefasciatus	present; transmitted	Eyles 1947
in Culex pipiens		
Psorophora discolor	exptl; present; transmitted	Newton 1946
<u>Wuchereria malayi</u>		
in subgroup Mansonoides spp.		
Anopheles byrsonus	present; transmitted	Carter 1948
<u>Filaria sanguinis hominis</u>		
in Culex fatigans	present	Ross 1898
<b>REDUVIDS</b>		
<u>Leishmania donovani</u>		
in Triatoma spp.	exptl; no multiplication; 1 d	Packchanian 1948
<u>Leishmania tropica</u>		
in Triatoma spp.	exptl; no multiplication; 1 d	Packchanian 1948
<u>Trypanosoma cruzi</u>		
Feces	present; transmitted	
of Rhodnius prolixus		
in Triatoma megista	" "	Brumpt 1912
in " sanguisuga	" "	Chagas 1909
in Rhodnius prolixus		Elkins 1951
" pictipes	" "	Floch 1947
in Triatoma protracta	" "	Kofoid 1933



TABLE 24 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
<b>REDUVIIDS (cont'd)</b>		
<u>Trypanosoma cruzi (cont'd)</u>		
in <i>Triatoma megista</i>		
" <i>infestans</i>		
" <i>sordida</i>		
" <i>dimidiata</i>		
" <i>heidemanni</i>		
" <i>gerstaeckeri</i>		
" <i>sanguisuga</i>		
" <i>chazasi</i>		
" <i>geniculata</i>		
" <i>hegneri</i>		
" <i>vitticeps</i>		
" <i>longipes</i>		
" <i>rubida</i>		
<i>Rhodnius prolixus</i>		
" <i>pictipes</i>		
<i>Eratyrus cuspidatus</i>	present; transmitted	Steinhaus 1947
in <i>Triatoma gerstaeckeri</i>		
" <i>lectularis</i>		
" <i>protracta</i>		
" <i>sanguisuga</i>		
" <i>nectomae</i>		
" <i>rubida</i>	present; transmitted	Sullivan 1949
in <i>Triatoma protracta</i>	" "	Wood 1934
in <i>Triatoma protracta</i>		
" <i>rubida</i>		
" <i>longipes</i>		
dead for 15 days	present; transmitted	Wood 1942
in <i>Triatoma heidemanni</i>	" "	Wood 1943
in <i>Triatoma protracta</i>	" "	Wood 1950
<u>Trypanosoma gambiense</u>		
in <i>Triatoma</i> spp.	exptl; present; 4-6 d	Packchanian 1948
<u>Trypanosoma brucei</u>		
in <i>Triatoma</i> spp.	exptl; present; 4-6 d	Packchanian 1948
<u>Trypanosoma duttonii</u>		
in <i>Triatoma gerstaeckeri</i>	exptl; no multiplication; 2-3 d	Packchanian 1948
<b>TICKS</b>		
<u>Babesia bigemina</u>		
in <i>Boophilus annulatus</i>	present; transmitted	Dennis 1931
in " "	" "	Dennis 1932
in " "	" "	Smith 1893
<u>Babesia bovis</u>		
in <i>Ixodes ricinus</i>	present; transmitted	Steinhaus 1947
<u>Leishmania donovani</u>		
Gut	exptl; 25 d; transmitted	
of ticks		Feng 1949
<u>Trypanosoma cruzi</u>		
in <i>Ornithodoros furcosus</i>		
" <i>parkeri</i>		
" <i>amblus</i>	present; many wks. or mos.	Steinhaus 1947

TABLE 12 THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>R. typhi</u> in <i>Cimex lectularis</i>	exptl; not transmitted; 10 d	Gastaneda 1930
<u>R. rickettsi</u> in <i>Cimex lectularis</i> " <i>rotundatus</i>	exptl; 24 hrs.; present	Steinhaus 1947
<u>R. prowazeki</u> Coelomic cavity of bedbugs	present; harbors but does not transmit	Naudé 1941
<b>FLEAS</b>		
<u>R. typhi</u> in <i>Echidnophaga gallinacea</i>	exptl; present; trans- mitted	Olicata 1942
" in " " Tissues of fleas	present; transmitted at least 52 d; trans- mitted	Brigham 1941
in <i>Xenopsylla cheopis</i>	present	Dyer 1932
in <i>Ctenocephalus felis</i>	present; transmitted	Dyer 1931
in <i>Xenopsylla cheopis</i> <i>Ceratophyllus anisus</i>	present; transmitted	Irons 1944
Feces of <i>Xenopsylla cheopis</i>	<96 hrs.; transmitted	Liu 1944
in <i>Xenopsylla cheopis</i>	present; transmitted	Rickard 1951
in fleas	exptl; present	Savoor 1948
<u>R. prowazeki</u> in <i>Xenopsylla cheopis</i> in fleas	exptl; present " "	Weyer 1949
<u>Dyer</u> in <i>Xenopsylla cheopis</i> in fleas	exptl; present " "	Dyer 1934 Weyer 1949
<b>LICE</b>		
<u>R. typhi</u> in <i>Pediculus corporis</i>	present; transmitted	Liu 1944
in <i>Polyplax spinulosus</i>	" "	Mooser 1931
in <i>Pediculus corporis</i>	exptl; present; trans- mitted	Mooser 1930
in <i>Pediculus corporis</i>	exptl; present; 10 d	Snyder 1945
<u>R. prowazeki</u> Excreta - dry, room temp.	11-12 d	Arkwright 1923
in <i>Pediculus capitis</i>	present; transmitted	Atkin 1922
" <i>corporis</i>	exptl; present; trans- mitted	Blanc 1945
in <i>Pedicinus albidus</i>	exptl; present; trans- mitted	Cabasso 1947
in <i>Pediculus corporis</i>	exptl; present; trans- mitted	
Gut >32C	exptl; present; trans- mitted	
23C of lice	exptl; did not survive	DaRocha 1916
in lice	exptl; present	Mariam 1940
in <i>Pediculus capitis</i> " <i>corporis</i>	exptl; present; trans- mitted	Nicolle 1909

TABLE 215 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>LICE (cont'd)</b>		
<u>R. prowazeki</u> (cont'd)		
Feces - room temp. of Pediculus capitis	60 d	
" corporis in Pediculus vestimenti	present; transmitted	Nuttall 1917 Ricketts 1910
Feces RH - high RH hastened disappearance of rickettsia in feces of lice	8.9 d (guinea pig test) 19-147 d (louse test)	Shu-Hsian 1949
Intestines - dried at normal pressure	58 d	
dried at low pressure	35 d	
Feces	66 d	
lice - dried with chloride	21 d	
dead lice - which lived under normal conditions	7 d	Starzok 1936
<u>R. wolhynica</u>		
lice dried feces	exptl; present " " 2 1/2 yrs.	Weyer 1948
<u>R. quintana</u>		
Gut and feces of Pediculus corporis in Pediculus corporis	present; transmitted	Hindle 1921 Steinhaus 1947
Stomach lumen of lice	present	Toepfer 1916
<b>MITES</b>		
<u>R. typhi</u>		
in Liponyssus bacoti	present; transmitted	Dove 1931
in Schongastia indica Family Trombiculidae	present; transmitted	Gispen 1950
in Liponyssus nagayoi	" "	Kodama 1933
in " bacoti	" "	Liu 1944
in " "	" "	Liu 1947
in " "	" "	Pang 1941
<u>R. tsutsugamushi</u>		
in mites	present; transmitted	Kawamura 1931
in mites	" "	Kitashima 1918
in Trombicula fletcheri	" "	Kohls 1945
in " walchi	" "	
in " deliensis larvae	exptl; present; trans- mitted	Krishman 1949
in Trombicula deliensis	present; transmitted	Krishman 1949
in " "	present; transmitted	Mackie 1946
hatched eggs	" "	Miyajima 1917
in mites	present	Philip 1945
in Trombicula akamushi	present; transmitted	Steinhaus 1947
in " deliensis	" "	Tanaka 1899
in mites	" "	Traub 1950
in Euschongastia indica	" "	

TABLE 2/5 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>MITES (cont'd)</b>		
<u>R. akari</u>		
in <i>Allodermanyssus sanguineus</i>	present	Huebner 1946
in <i>Liponyssus bacoti</i>	exptl; present; transmitted	Phillip 1948
in "	exptl; present; transmitted	Phillip 1948
<b>TICKS</b>		
<u>R. typhi</u>		
in <i>Ornithodoros moubata</i>	exptl; present	Weyer 1948
in <i>Dermacentor andersoni</i>		
in <i>Otocentor nitens</i>		
in <i>Amblyomma</i> sp.	exptl; present; 12 d	Zinsser 1931
<u>R. rickettsi</u>		
in <i>Rhipicephalus sanguineus</i>	present; transmitted	Anigstein 1943
in <i>Dermacentor andersoni</i>	" "	Davis 1939
in " <i>variabilis</i>	present; transovarian transmission	Dyer 1931
in " <i>andersoni</i>		
in " <i>variabilis</i>		
in <i>Haemaphysalis leporispalustris</i>		
in <i>Amblyomma americanum</i>	present; transmitted	Parker - Unpublished expt.
in <i>Dermacentor occidentalis</i>		
in <i>Rhipicephalus sanguisuga</i>	transovarian transmission; survives winter in infected nymphal or adult ticks; at end of winter organism is non-symptom producing until its level of virulence is raised, either by heat or ingestion of blood	Parker 1937
in <i>Otocentor nitens</i>		
in <i>Dermacentor andersoni</i>		
in <i>Ornithodoros parkeri</i>		
in " <i>rudis</i>		
in " <i>turicata</i>	present; transmitted	Patino-Camargo 1941
All tissues of <i>Dermacentor andersoni</i>	present; transmitted	Steinhaus 1947
in ticks	present; transmitted	Badger 1932
in <i>Amblyomma cajennense</i>	" "	Bustamente 1946
in <i>Rhipicephalus sanguineus</i>	" "	Bustamente 1946
in <i>Rhipicephalus sanguineus</i>		
in <i>Ornithodoros furcosus</i>	present exptl; 345 d	Mariotte 1944 Mazzotti 1946

TABLE 15 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>TICKS (cont'd)</b>		
<u>R. rickettsi</u> (cont'd)		
in Haemaphysalis leporis-palustris	present; transmitted	Parker 1923
in Haemaphysalis leporis-palustris	present; transmitted	Parker 1951
in Dermacenter andersoni	" "	Ricketts 1906
<u>RMSF-like rickettsia</u>		
in Rhipicephalus sanguineus	present; transmitted	Bustamente 1947
in Rhipicephalus sinus	" "	Dick 1947
Haemaphysalis leachi	" "	Lackman 1949
in Amblyomma maculatum	" "	Parker 1940
in " "	" "	Parker 1939
in " striatum (Mexican spotted fever)	exptl; present; transmitted	Vallejo-Freire 1947
in Ornithodoros rudis (Tobia petechial fever)	exptl; 11 & 35 d	Parker 1942
in Ornithodoros parkeri (Tobia petechial fever)	exptl; 1,087 d	Patino-Camargo 1944
<u>R. prowazeki</u>		
in Ornithodoros moubata	exptl; present; 262 d	Weyer 1948
<u>R. wolhynica</u>		
in Ornithodoros moubata	exptl; present; 69 d	Weyer 1948
<u>R. conori</u>		
in Rhipicephalus sanguineus	>18 mos.; transmitted present	Brumpt 1932
Nearly all tissues		
in Rhipicephalus sanguineus		Hass 1936
in Ornithodoros moubata	exptl; >36 d	Parker 1942
in Rhipicephalus sanguineus	survives through life cycle	Steinhaus 1947
<u>Bullis fever rickettsia</u>		
in Amblyomma americanum	present	Pollard 1946
<u>Coxiella burnetii</u>		
in Hymnolomma mauritanicum	present; transmitted	Blanc 1949
in " savignyi	" "	Blanc 1946
in Dermacenter occidentalis	" "	Cox 1940
Amblyomma americanum	" "	Davis 1939
in Dermacenter andersoni		
Tissues and feces	exptl; present; transmitted	
of Rhipicephalus sanguineus		Callot 1950
in Ornithodoros moubata	exptl; infective 428 d persists 670 d	
Ornithodoros hermsi	" infective 772 d persists 979 d transmitted by both	Davis 1943

TABLE 9/15 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>TICKS (cont'd)</b>		
<u>Coxiella burneti</u> (cont'd)		
in <i>Dermacentor andersoni</i>	present	Matheson 1950
in <i>Haemaphysalis leachi</i>	present; transmitted	Giroud 1950
in <i>Ornithodoros moubata</i>	4 mos.	Jadin 1950
in <i>Otobius megnini</i>	present	Jellison 1948
in <i>Dermacentor andersoni</i>	present; transmitted	Parker 1938
in <i>Hyalomma savignyi</i>	present	Parker 1939
in <i>Amblyomma americanum</i>	present	Parker 1943
in <i>Phipicephalus sanguin-</i> <i>eus</i>	present	Parker 1949
Feces - dried	viable in storage as	
of ticks	long as 586 d	Philip 1948
in <i>Haemaphysalis humerosa</i>	present; transmitted	Smith 1940

TABLE 2/6 THE SURVIVAL OF SALMONELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>S. paratyphi</u> Stomach of <i>Cimex lectularis</i>	exptl; 2-3 wks.; not transmitted	Caspari 1939
<b>COCKROACHES</b>		
<u>S. typhosa</u> Body and feet of <i>Periplaneta orientalis</i>	present; transmitted	Antonelli 1930
Feces of cockroaches	present	Riley 1932
<u>S. typhimurium</u> Intestinal tract Appendages of <i>Periplaneta americana</i>	present	Beck 1943
Feces Alimentary canal of cockroaches	Inoc: 4-10 million exptl; 11 d " 7 d	Janssen 1952
Feces of <i>Blaberus craniifer</i>	exptl; Inoc: massive doses 12 d	Wedberg 1949
<u>S. paratyphi B</u> in <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
<u>S. oranienburg</u> in <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
Feces of <i>Periplaneta americana</i>	Inoc: 100 million 10 d	
Feces of <i>Blattella germanica</i>	Inoc: 100 million 12 d	
Tissues Feces of <i>Blatta orientalis</i>	Inoc: 100 million; 42 d " " " 20 d	Olson 1950
<u>S. bredeney</u> Hindgut of <i>Periplaneta americana</i>	present; transmitted	Bitter 1949
<u>S. bovis-morbificans</u> Appendages Intestinal tract of cockroaches	present	Mackerras 1948
<u>S. spp.</u> Intestinal tract Appendages	18-42 d	Mackerras 1948
<b>FLEAS</b>		
<u>S. enteritidis</u> Body and feces of <i>Xenopsylla cheopis</i>	exptl; present; transmitted	Eskey 1949
Body	exptl; 96 hr.; transmitted	
Feces of <i>Pulex irritans</i> - <i>Ctenocephalus canis</i>	exptl; <24 hr.; transmitted	Varela 1946

TABLE 2/6 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>FLEAS (cont'd)</b>		
<u>S. choleraesuis</u> in <i>Pulex irritans</i>	present; transmitted	Messerlin 1942
<b>FLIES</b>		
<u>S. typhosa</u>		
in flies	present	Bahr 1914
in flies	"	Bertarelle 1910
Feces	"	
of <i>Musca domestica</i>		Celli 1888
in flies	"	Cochrane 1912
Legs	exptl; present	
Feces	"	
of flies	greater trans- mission than legs; 16d multiplied	Faichnie 1909
Intestinal tract of flies		Faichnie 1929
in <i>Musca domestica</i>	exptl; 23 d; transmitted 5-23 d	Matheson 1950
Intestinal tract of flies		Fickler 1903
Intestinal tract of flies	present	Graham-Smith 1909
Intestinal tract of flies	exptl; present	Graham-Smith 1913
Externally	exptl; 11 d	
Intestinal tract	" 15 d	
Internally -		
killed with DDT	" 7 d	
" " fly paper	" 10 d	
of <i>Musca domestica</i>		Gross 1951
Intestinal tract of <i>Musca domestica</i>	present	Hamilton 1903
in <i>Musca domestica</i>	present	Howard 1911
In or on body of <i>Musca domestica</i>	23 d	Jordan 1908
in flies	present	Klein 1908
in <i>Musca domestica</i>	"	Ledingham 1911
in flies	"	Manson-Bahr 1919
in flies	"	Veeder 1898
<u>S. paratyphi B</u>		
in flies	exptl; 10 d	Faichnie 1909
Body	Inoc: fed a suspension of 12,000-48,000 org. Recov: multiplied in body	
Feces	present	
of <i>Musca domestica</i>		Hawley 1948
Feces	Inoc: 18,000-6,300,000 bacteria	
of <i>Musca domestica</i>	Recov: 1st d - 10- 200,000,000 6th d - 200,000,000	Hawley 1951
Intestines of <i>Musca domestica</i>	at least 11 d	Nicoll 1911



TABLE 2/6 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>FLIES (cont'd)</b>		
<u>S. paratyphi</u>		
Intestinal tract of flies	multiplied	Faichnie 1929
Externally Intestinal tract of Musca domestica	exptl; present; 3 d	Gross 1951
Intestinal tract of Musca domestica	present	Torrey 1912
<u>S. enteritidis</u>		
Intestinal tract of Musca domestica	present	Bahr 1914
Externally of Musca domestica	present	Cox 1912
Intestinal tract of flies	present	Fickler 1903
Intestinal tract of flies	present	Graham-Smith 1909
Intestinal tract of flies	exptl; present	Graham-Smith 1913
Intestinal tract of Musca domestica	present	Hamilton 1903
Intestinal tract of Musca domestica	present	Ledingham 1911
in Musca domestica	duration of life of fly (approx. 4 wks)	Ostrolenk 1942
<u>S. cholerae-suis</u> in Musca domestica	present	Scott 1917
<u>S. spp.</u> Feces of Musca domestica	present	Hawley 1951
<b>LICE</b>		
<u>S. typhosa</u> in Pediculus capitis " corporis	present; transmitted	Abe 1907
<u>S. enteritidis</u> in lice	present	Huang 1937
<b>MOSQUITOES</b>		
<u>S. paratyphi</u> Intestines of Culex pipiens	3-4 wks.	Felsenfeld 1947
<u>S. enteritidis</u> in Aedes aegypti	exptl; 1 hr.	Varela 1950
<b>TICKS</b>		
<u>S. enteritidis</u> Feces of Dermacentor andersoni in Dermacentor andersoni	35 d present	Parker 1943 Reitler 1946

TABLE 217 THE SURVIVAL OF SHIGELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
<b>ANTS</b>		
<u>S. paradysenteriae</u> Feet of ants	at least 24 hrs.	Griffitts 1942
<b>FLIES</b>		
<u>S. dysenteriae</u> Internal and external of Chrysomya megaceph- ala in flies Body	5-6 d  present Inoc: fed a suspension of 12,000-48,000 org- anisms Recov: multiplied in body present	Chow 1940 Dudgeon 1919
Feces of Musca domestica Feces of Musca domestica	Inoc: 12,000-6,300,000 bacteria Recov: 1st d - 10- 200,000,000 6th d - 200,000,000	Hawley 1948
Bowel of flies Feces of flies	5 d 11 d	Manson-Bahr 1920 Stewart 1944
<u>S. paradysenteriae</u> in flies in flies	present "	Graham-Smith 1909 Kuhns 1944
<u>S. paradysenteriae</u> (Flexner) in flies	273 hrs.	Stewart 1944
<u>S. ambigua</u> (S. dysenteriae- Schmitz) in flies	present; 297 hrs.	Stewart 1944
<u>S. spp.</u> Intestinal tract of flies Intestinal tract of flies Intestinal tract of Musca domestica Intestinal tract of Musca domestica Intestinal tract of Musca domestica	present present present present present present	Fickler 1903 Graham-Smith 1909 Hamilton 1903 Ledingham 1911 Nicoll 1911

TABLE 2/8 THE SURVIVAL OF SPIROCHETES IN INSECTS

Factor(s)	Survival	Reference
<p>FLIES</p> <p><u>Treponema pertenu</u>  in <i>Hippelates pallipes</i>  in <i>Musca domestica</i>  <i>Hippelates pallipes</i>  " <i>flavipes</i></p>	<p>present; transmitted</p> <p>present; transmitted</p>	<p>Kumm 1936</p> <p>Steinhaus 1947</p>
<p>REDUVIDS</p> <p><u>Leptospira icterohaemorrhagicae</u>  Intestinal tract  of <i>Triatoma infestans</i></p>	<p>exptl; present; 6 d</p>	<p>Liem 1941</p>

TABLE 2 19 THE SURVIVAL OF VIBRIO SPECIES IN INSECTS

Factor(s)	Survival	Reference
<p>COCKROACHES  <u>Vibrio comma</u>                      Feces                      of <i>Periplaneta americana</i>                      in <i>Periplaneta americana</i></p>	<p>79 hrs.                      present</p>	<p>Barber 1914                      Toda 1923</p>
<p>FLIES  <u>Vibrio comma</u>                      Feet, wings, body and                      feces                      of flies                      in flies                      in flies                      Intestinal tract                      Feces                      of <i>Musca domestica</i>                      in <i>Musca domestica</i>                      in <i>Musca domestica</i>                      in flies                      Feces                      of <i>Eristalis tenax</i>  <i>Calliphora vomitoria</i>                      in <i>Musca domestica</i>                      in flies</p>	<p>present; transmitted                      present                      exptl; present                      exptl; 48 hrs.                      " 30 hrs.                      present                      present                      present                      present                      present                      present</p>	<p>Alessandrini                      Cattani 1886                      Faichnie 1909                      Graham-Smith 1913                      Hamilton 1903                      Ledingham 1911                      Macrae 1895                      Maddox 1885                      Nicoli 1911                      Simmonds 1892</p>

TABLE 20 THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
<b>BEDBUGS</b>		
<u>Yellow fever virus</u> in <i>Cimex lectularis</i>	2 d	Kumm 1932
<u>Lymphocytic choriomeningitis virus</u> 22-25C in <i>Cimex lectularis</i>	exptl; present; 10 min. to 85 d	Milzer 1942
<b>COCKROACHES</b>		
<u>Poliomyelitis virus</u> Intestinal tract of cockroaches	present; 24 hrs.	Hsiang 1952
Tissues - 30C of cockroaches	exptl; 15 d	Hurlbut 1949
Hemocoel of cockroaches	exptl; 15 d; transmitted	Hurlbut 1950
<u>Poliomyelitis viruses -</u> <u>GDVII, C group A and</u> <u>human polio virus</u> Body Feces of <i>Periplaneta americana</i>	exptl; present " killing amounts excreted for 7-15 d	
<u>human polio virus</u> in <i>Periplaneta americana</i> <i>Supella supellactilium</i> <i>Blattella germanica</i>	natural vectors for Brunhilde, Minnesota and Mahoney strains	Syverton 1952
<u>Lymphocytic choriomeningitis virus</u> in <i>Blattella germanica</i>	present	Steinhaus 1944
<u>Coxsackie virus</u> Feces of cockroaches	exptl; 15 d; transmitted	Fischer 1951
<u>Mouse encephalitis virus</u> Feces of cockroaches	exptl; present; trans- mitted; 7 d	Syverton 1950
<b>FLIES</b>		
<u>Poliomyelitis virus</u> Lansing strain Theiler strain	exptl; 2 d " 12 d only when adult itself acquires virus by feeding	Bang 1943
in <i>Musca domestica</i> Surface and alimentary tract of flies	exptl; at least 48 hrs.	Flexner 1911
Surface and alimentary tract of flies	exptl; at least 48 hrs.	Howard 1912
Tissues 30C of <i>Musca domestica</i>	exptl; 12 d	Hurlbut 1949

TABLE 22 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
<b>FLIES (cont'd)</b>		
<u>Poliomyelitis virus (cont'd)</u>		
Hemocoel of flies in <i>Phormia regina</i> <i>Phaenicia sericata</i> <i>Musca domestica</i> <i>Sarcophaga</i> spp. <i>Cynomyopsis cadaverina</i>	exptl; 12 d; transmitted	Hurlbut 1950
Gut Feces of <i>Phormia regina</i> in Muscidae Calliphoridae	present exptl; 2 wks. " 3 wks.	Melnick 1949 Melnick 1941
Abdomen, feces, vomit (Lansing strain) of <i>Musca domestica</i> in Muscidae Calliphoridae	may harbor virus in nature exptl; 2 d	Paul 1941 Rendtorff 1943
in Muscidae Calliphoridae	may harbor virus in nature	Sabin 1942
in Muscidae Calliphoridae	may harbor virus in nature	Toomey 1941
in Muscidae Calliphoridae	may harbor virus in nature	Trask 1943
<b>LICE</b>		
<u>Eastern equine encephalitis virus</u> in <i>Eomenacanthus stramineus</i>		
	present	Howitt 1948
<b>MITES</b>		
<u>St. Louis encephalitis virus</u>		
in <i>Dermanyssus gallinae</i>	exptl; present; trans- mitted	Smith 1941
in <i>Dermanyssus gallinae</i>	present; transmitted	Smith 1944
in <i>Dermanyssus gallinae</i>	" "	Smith 1945
<u>Eastern equine encephalitis virus</u>		
in <i>Dermanyssus gallinae</i>	present	Howitt 1948
<u>Western equine encephalitis virus</u>		
in <i>Dermanyssus americanus</i>	present	Miles 1951
in <i>Liponyssus sylvarium</i>	"	Reeves 1947
in <i>Dermanyssus gallinae</i>	"	Sulkin 1945
<b>MOSQUITOES</b>		
<u>Yellow fever virus</u>		
in <i>Haemagogus capricorni</i>	exptl; present; trans- mitted	Bates 1944
in " "	present; transmitted	Bushell 1944
in " "	" "	Bugher 1944
In <i>Culex fatigans</i>	exptl; 39 d; transmitted	Davis 1933

TABLE 22 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
<b>MOSQUITOES (cont'd)</b>		
<b>Yellow fever virus (cont'd)</b>		
Most tissues of mosquitoes	Inoc: titer of 1 billion lethal doses/cc Recev: Immediately after - 1-2 million lethal doses 2 wks - 1% of inoc. exptl; 2 wks. present; transmitted	Davis 1933 Hadow 1948 Hargett 1944
in <i>Aedes africanus</i>	"	
in <i>Aedes aegypti</i>	"	
in <i>Aedes aegypti</i>	duration of life of mosquito (which may be over 200 d) present; transmitted	Herms 1950 Reed 1900
in <i>Aedes aegypti</i> in mosquitoes	30C for 14 d, 1.1-4.4C thereafter	
in <i>Haemagogus capricorni</i>	exptl; present; 32 d present; transmitted	Ross 1950 Shannon 1938 Smithburn 1949
in <i>Aedes africanus</i>	"	
Nearly all tissues of approx. 20 spp.	through life of mosquito	Steinhaus 1947
in <i>Aedes aegypti</i>		
killed with ether	4 hrs.	
" " tobacco smoke	20 hrs.	
" " KCN	45.5 hrs.	
" " Chloroform	1 hrs.	
starved	17.5 hrs.	
in <i>Haemagogus equinus</i>	present	Waddell 1945
" <i>spgazzinii</i>	exptl; present	Waddell 1948
in <i>Haemagogus capricorni</i>	" "	Waddell 1947
in " <i>equinus</i>	multiplied	Whitman 1937
in <i>Aedes aegypti</i>		
<b>Dengue fever virus</b>		
in mosquitoes	present; transmitted	Ashburn 1907
Temp. below 18C	lose infectivity	
" above "	regain "	
in mosquitoes	174 d; transmitted	Blanc 1929
in <i>Aedes aegypti</i>	present; transmitted	Chandler 1923
in mosquitoes	" "	Matheson 1950
in <i>Aedes aegypti</i>	duration of life of mosquito (which may be over 200 d)	Herms 1950
in <i>Aedes scutellaris</i>	exptl; present; transmitted	Mackerras 1946
in <i>Aedes aegypti</i>	present; virulence may lessen with serial passage; lives longer in live than dead tissues	Simmons 1931

TABLE 22 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
<b>MOSQUITOES (cont'd)</b>		
<u>St. Louis encephalitis virus</u>		
in <i>Culex tarsalis</i>		
" <i>pipiens</i>		
" <i>coronator</i>		
" <i>quinquefasciatus</i>		
<i>Aedes lateralis</i>		
" <i>taeniorhynchus</i>		
" <i>vexans</i>		
" <i>triseriatus</i>		
<i>Theobaldia incidens</i>	exptl; present; trans-	
<i>Culiseta inornata</i>	mitted	Hammon 1943
in <i>Aedes dorsalis</i>	present; transmitted	Hammon 1947
in <i>Culex tarsalis</i>	" "	Hammon 1943
in <i>Culex pipiens</i>		
" <i>quinquefasciatus</i>		
<i>Anopheles punctipennis</i>		
" <i>quadrimaculatus</i>		
<i>Aedes aegypti</i>		
" <i>triseriatus</i>		
" <i>vexans</i>	exptl; present; trans-	
	mitted	Smith 1941
in <i>Culex tarsalis</i>		
" <i>pipiens</i>		
<i>Culiseta inornata</i>	present; transmitted	Steinhaus 1947
<u>Poliomyelitis virus</u>		
in <i>Culex pellens</i>		
<i>Aedes acoopictus</i>	3 wks.	Paul 1947
<u>Eastern equine encephalitis virus</u>		
in <i>Culiseta melanura</i>	present; transmitted	Chamberlain 1951
in <i>Aedes vexans</i>		
" <i>sollicitans</i>		
" <i>cantator</i>		
" <i>atropalpus</i>		
" <i>triseriatus</i>	exptl; present	Matheson 1950
in <i>Mansonia perturbans</i>	present	Howitt 1949
in <i>Aedes aegypti</i>	at least 36 d; trans-	
	mitted	Kelser 1933
in <i>Aedes aegypti</i>		
" <i>sollicitans</i>	1,000-10,000 fold in-	
	crease; 63 d	Merrill 1934
All tissues of <i>Aedes aegypti</i>	present for duration of life but able to transmit only approx. 2 mos	Merrill 1935
in <i>Aedes albopictus</i>		
" <i>sollicitans</i>		
" <i>dorsalis</i>		
" <i>lateralis</i>		
" <i>geniculatus</i>		
" <i>vexans</i>	present; transmitted	Steinhaus 1947



TABLE 220 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
<b>MOSQUITOES (cont'd)</b>		
<u>Western equine encephalitis virus</u>		
in <i>Aedes dorsalis</i>	present; transmitted	Hammon 1947
in <i>Culex tarsalis</i>	" "	Hammon 1945
in " "	" "	Hammon 1943
in <i>Aedes taeniorhynchus</i>	" "	Kelser 1938
in <i>Culex coronator</i>		
<i>Theobaldia incidens</i>	exptl; present; transmitted	Steinhaus 1947
in <i>Culex tarsalis</i>		
" <i>pipiens</i>		
<i>Culiseta inornata</i>	present; transmitted	Steinhaus 1947
in <i>Aedes dorsalis</i>	" "	Thompson 1951
<u>Japanese B encephalitis virus</u>		
in <i>Culex tritaeniorhynchus</i>		
" <i>pipiens</i> var. <i>pallens</i>	exptl; present; transmitted	Hammon 1949
in <i>Culex tritaeniorhynchus</i>	present	Hammon 1949
in <i>Aedes chemnipoensis</i>	exptl; 15 d; transmitted.	
<i>Culex pipiens</i> var. <i>pallens</i>	exptl; 15 d; not transmitted.	Huang 1951
Temp. of 8-12C.	91 d	
in <i>Culex quinquefasciatus</i>		
in mosquitoes	exptl; multiplied-max. titer recovered; 17d	Hurlbut 1949
in <i>Culex quinquefasciatus</i>		Hurlbut 1951
" <i>annulirostris</i>	exptl; present	Hurlbut 1948
<u>Lymphocytic choriomeningitis virus</u>		
in <i>Aedes aegypti</i>	exptl; present; transmitted	Coggeshall 1939
Temp. of 26-34 C.	exptl; present	
Temp. of 37C, 25C, or lower	exptl; not present	
in <i>Culex pipiens</i>		
" <i>albopictus</i>		Milzer 1942
<u>Encephalomyocarditis virus (Mengo encephalomyelitis virus)</u>		
in <i>Taeniorhynchus fuscopennatus</i>		
<i>Taeniorhynchus</i> spp.	present	Dick 1948
<u>Venezuelan equine encephalitis virus</u>		
in <i>Aedes taeniorhynchus</i>		
<i>Anopheles neomaculipalpis</i>		
<i>Mansonia titillans</i>	present; transmitted	Matheson 1950

TABLE 2.20 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
<b>MOSQUITOES (cont'd)</b>		
<u>Venezuelan equine encephalitis virus (cont'd)</u> in <i>Aedes geniculatus</i> " <i>aegypti</i> " <i>albopictus</i>	exptl; present; transmitted	Roubaud 1941
<u>Neurotropic virus group</u> in <i>Aedes</i> spp. <i>Psorophora</i> spp. in mosquitoes	present; transmitted present	Laemmert 1947 Noca-Garcia 1944
<u>Rift Valley fever virus</u> in <i>Eretmapodites</i> spp. <i>Aedes</i> spp.	present; transmitted	Smithburn 1948
<b>REDUVIDS</b>		
<u>Yellow fever virus</u> in <i>Triatoma megista</i>	exptl; 1 wk; not transmitted by bite	Davis 1933
<u>Western equine encephalitis virus</u> in <i>Triatoma sanguisuga</i>	present; transmitted	Kitselman 1940
<u>Venezuelan equine encephalitis virus</u> in <i>Triatoma infestans</i>	exptl; present; not transmitted; 17 d	Lepine 1941
<b>TICKS</b>		
<u>Yellow fever virus</u> in <i>Amblyomma cajennense</i> <i>Argas persicus</i> <i>Rhipicephalus sanguineus</i> <i>Boophilus microphilus</i>	15 d; not trans. by bite 6 d; " " " " 23 d; " " " " 10 d; " " " " exptl.	Davis 1933
<u>Eastern equine encephalitis virus</u> in <i>Dermacentor andersoni</i>	exptl; present; transmitted	Syvertson 1941
<u>Russian spring and summer encephalitis virus</u> in <i>Ixodes persulcatus</i> in " " in <i>Ornithodoros moubata</i> All organs gut of <i>Ixodes persulcatus</i>	present; transmitted " " exptl; 40 d present 25 d	Chumakov 1939 Chumakov 1940 Parker 1942 Pavlovskii 1940
<u>St. Louis encephalitis virus</u> in <i>Dermacentor variabilis</i> temp of 12.5C in <i>Dermacentor variabilis</i>	exptl; present; transmitted exptl; 10 mos.; transmitted	Blattner 1941 Blattner 1944

TABLE 20 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
TICKS (cont'd)		
<u>Colorado tick fever virus</u>		
in <i>Dermacentor andersoni</i>	present; transmitted	Florio 1948
in " <i>variabilis</i>	exptl; present; transmitted	Florio 1950
in " <i>andersoni</i>	present; transmitted	Florio 1950
<u>Lymphocytic choriomeningitis virus</u>		
in <i>Dermacentor andersoni</i>	present; transmitted	Humphreys 1944
Feces of <i>Dermacentor andersoni</i>	exptl; present; transmitted	Shaugnessy 1939

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
sp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

THE EFFECT OF PRESSURE ON THE PERSISTENCE (SURVIVAL) OF ORGANISMS

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TABLE PTHE EFFECT OF PRESSURE ON THE SURVIVAL  
OF MICROORGANISMS

Factor(s)	Survival	Reference
<u>Escherichia coli</u>		
5,000 atm. hydrostatic pressure	45 min.	Basset 1937
10,000 bolts in an evacuated tube	1 hr.	Dognon 1930
500 lb./sq. in. of argon	0-7% burst	Fraser 1951
900 " " " " "	30-46% burst	" "
500 " " " " nitrogen	14-20% burst	" "
900 " " " " "	75% burst	" "
250 " " " " nitrous oxide	0-5% burst	" "
500 lb./sq. in. of nitrous oxide	54-78% burst	" "
750 lb./sq. " " " oxide	53-56% burst	" "
500 lb./sq. in. of carbon dioxide	48-56% burst	" "
20 ml. of log-phase cult., 37C, 500 lb./sq. in. of nitrous oxide	54-78% burst	" "
5,000 lb./sq. in. at high temp.	Increases rate of disinfection	Johnson 1946
5,000 lb./sq. in. at low temp.	Decreases rate of disinfection	" "
In presence of quinine 1,000-2,000 lb./sq. in.	Decreases rate of disinfection	" "
In presence of quinine 4,000-6,000 lb./sq. in.	Increases rate of disinfection	" "
1,000 lb./sq. in. at low temp.	Retards growth	" "
1,000 lb./sq. in. at high temp.	Accelerates growth	" "
Hydrostatic pressure of 1,000 lb./sq. in., below 37C	Retards growth	Lewin 1946
Hydrostatic pressure of 1,000 lb./sq. in., above 37C	Accelerates growth	" "
<u>Aerobacter aerogenes</u>		
85-100 thousand lb./sq. in.	4-5 min.	Hite 1914
50-65 " " " "	10 min.	" "
30-45 " " " "	1 hr.	" "
<u>Salmonella typhosa</u>		
5,000 atm. hydrostatic pressure	45 min.	Basset 1937
10,000 volts in an evacuated tube	1 hr.	Dognon 1930
40-45 thousand lb./sq. in.	Killed	Hite 1914
<u>Salmonella paratyphi A &amp; B</u>		
10,000 volts in an evacuated tube	1 hr.	Dognon 1930
<u>Salmonella typhimurium</u>		
High tension, low pressure ultraviolet lamp in test tube of liquid cult.	5 min.	Gilles 1935

TABLE P (CONT'D) THE EFFECT OF PRESSURE ON THE SURVIVAL OF MICROORGANISMS

Factor(s)	Survival	Reference
<u>S. typhosa bacteriophage</u> 4500 atm. of pressure	Resists	Basset 1937
<u>Bacillus subtilis bacteriophage</u> 4500 atm.	Resists	" "
<u>Bacillus megatherium bacteriophage</u> 4500 atm.	Resists	" "
<u>Rabies virus</u> 4000 atm	30 min.	" "
<u>Herpes virus</u> 7000 atm.	" "	" "
<u>Yellow fever virus</u> 3000 atm.	" "	" "
<u>Foot-and-mouth virus</u> 3000 atm.	" "	" "
<u>Encephalomyelitis virus</u> <6500 atm.	" "	" "
<u>Smallpox virus</u> 4500 atm.	45 min.	Waeser 1937
<u>Mold</u> 10,000 volts in an evacuated tube	1 hr.	Dognon 1930
<u>Yeast</u> High tension, low pressure ultraviolet lamp in a test tube of liquid cult.	10-15 min.	Gilles 1935
High tension, low pressure ultraviolet lamp over a gelatin plate	More time	" "
85 thousand lb./sq. in.	5 min.	Hite 1914
30-35 " " " "	1 hr.	" "
<u>Bacteria general</u> 6000 atm. pressure	Non-spore formers 14 hr.	Larson 1918
12,000 atm. pressure	Spores 14 hr.	" "
6000 atm.	Non-spore formers destroyed	Waeser 1937
400 atm. hydrostatic pressure, 30C	Marine bacteria 4 d.	Zobell 1950
600 atm. hydrostatic pressure, 30C	" " " "	" "

TABLE P (CONT'D)THE EFFECT OF PRESSURE ON THE SURVIVAL  
OF MICROORGANISMS

Factor(s)	Survival	Reference
<u>Streptococcus faecalis</u> 10,000 volts in an evacuated tube	1 hr.	Dognon 1930
<u>Streptococcus cremoris</u> 85-100 thousand lb./sq. in.	4-5 min.	Hite 1914
50-65 " " " "	10 min.	" "
30-45 " " " "	1 hr.	" "
<u>Micrococcus aureus</u> Liquid, 3000 atm. pressure, ordinary temp.	Recov. $\checkmark$ , 45 min.	Basset 1932
Liquid, 6000 atm. " ordinary temp.	" 0, time not given	" "
<u>Micrococcus spp.</u> 5000 atm. hydrostatic pressure	45 min.	" "
10,000 volts in an evacuated tube	1 hr.	Dognon 1930
<u>Mycobacterium tuberculosis</u> Liquid, 3000 atm., ordinary temp.	Recov. $\checkmark$ , 45 min.	Basset 1932
Liquid, 6000 atm., " temp.	" 0, time not given	" "
<u>Pasteurella sp.</u> > 2000 atm.	30 min.	Basset 1937
<u>Bacillus subtilis</u> Liquid at 17,600 atm., ordinary temp.	Recov. $\checkmark$ , 45 min.	Basset 1932
20,000 atm. hydrostatic pressure	> 45 min.	" 1937
<u>Bacillus anthracis</u> 10,000 volts in an evacuated tube	1 hr.	Dognon 1930
<u>Proteus vulgaris</u> 10,000 volts in an evacuated tube	1 hr.	" "
<u>Serratia marcescens</u> Liquid, 3000 atm., ordinary temp.	Recov. $\checkmark$ , 45 min.	Basset 1932
Liquid, 6000 atm., " temp.	" 0, time not given	" "
10,000 volts in an evacuated tube	1 hr.	Dognon 1930
85-100 thousand lb./sq. in.	4-5 min.	Hite 1914
50-65 " " " "	10 min.	" "
30-45 " " " "	1 hr.	" "
<u>Corynebacterium diphtheriae</u> 40-45 thousand lb/sq. in.	Killed	" "
<u>Diplococcus pneumoniae</u> 5000 atm. hydrostatic pressure	45 min.	Basset 1937
<u>Micrococcus bacteriophage</u> 1000, atm.	Recov. $10^6$ - $10^8$ , 30 min.	" "

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus



THE EFFECT OF RADIATION ON THE PERSISTENCE (SURVIVAL) OF ORGANISMS

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TABLE RI

## THE EFFECT OF RADIATION ON BACILLUS SPECIES

Factor (s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>B. anthracis</u>		
Uv.	Killed	Phelps 1939
Uv. 452 erg/mm <sup>2</sup> at 2537A°	Reduc. 90%	Sharp 1939
Uv.	Chief factor in sunlight and artificial light	Ward 1894
<u>B. subtilis</u>		
Uv. rays 2650 A°	Little difference in resistance of veget. and spore forms	Duggar 1934
Uv.	Inoc. innumerable, Recov. 42. 3 min.	Hart 1939
Uv. 62000 erg/cm <sup>2</sup>	Killed	" 1944
Uv.	"	Phelps 1939
Uv. 62000 erg/cm <sup>2</sup>	Lethal	Sharp 1940
Uv.	30 min.	Tanner 1930
Uv.	More susceptible than Staph., Diplococcus, and influenza virus	Wells 1945
Uv. 1100-1400 A°	Slight germicidal action	McCullough 1945
<u>B. megatherium</u>		
Uv. rays 2650 A°	Little difference in resistance of veget. & spore forms	Duggar 1934
Uv. 0.873	5 sec.	Hercik 1936
Uv.	More resistant than B. subtilis	Laurens 1938
Uv.	30 min.	Tanner 1930
<u>B. sp.</u>		
Uv. 2537 A°	Kills	Lea 1940
<b>LIGHT</b>		
<u>B. anthracis</u>		
Sunlight	Easily destroyed	Arloings 1885
Artificial light	" "	" "
Bouillon, 35-39C, sun	2 hr.	" "
Diffuse sunlight, dry	Reduc. 50%, few mo., 100% in 23 yr.	Graham-Smith 1930
Sunlight, nutrient medium air	24 hr.	Roux 1887
Sunlight " "	>83 hr.	" "
no air		
Sunlight, 40C	Inoc. 1 loop 24 hr. cult., Recov. 0, 15 min.	Ukil 1927
Sunlight	Partly killed, 1-1½ hr.	Ward 1890-94
Gelatin agar plates, 18C	2-6 hr.	" 1892-93
Sunlight	8 hr.	Weinzirl 1914
Blood from diseased cow dried on gauze in diffuse sunlight	Killed guinea pigs in 36 hr.	McCullough 1945
<u>B. subtilis</u>		
Sunlight	8 hr.	Weinzirl 1914
<u>B. megatherium</u>		
Sunlight	" "	" "

TABLE R1 (CONT'D) THE EFFECT OF RADIATION ON BACILLUS SPECIES

Factor(s)	Survival	Reference
<p><b>ULTRASONIC</b>  <u>B. anthracis</u>                      Saline, ultrasounds                      frequency 320 kc.  <u>B. megatherium</u>                      Ultrasounds frequency                      320 kc.</p>	<p>Inoc. <math>3.5 \times 10^9</math>, Reduc.                      97.5%, 45 min.                      Inoc. <math>4.4 \times 10^8</math>, Reduc.                      99.7%, 15 min.</p>	<p>Grabar 1945                      "</p>
<p><b>OTHER RADIATION</b>  <u>B. anthracis</u>                      10,000 v. in evacuated                      tube  <u>B. subtilis</u>                      High voltage cathode rays</p>	<p>1 h.                      1 sec.</p>	<p>Dognon 1930                      Porter 1947</p>

TABLE R2 THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
U.v. on water	Few sec.	Bujwid
" " bacteria of air	Kills	Buttolph 1945
" action on gram-positive bacteria	Became gram-negative	Cernovodeanu
Uv. action on acid-fast	Lost resistance	"
Short wave lengths on water borne bact.	Kills	Coblentz 1924
Uv. rays 1250-1600 A°	More easily destroyed by heat	Curran 1938
" " 26-52 A°	Reduc. 99.98%, 260 min.	Duggar 1934
" at 254 nm.	Maximum effect.	Gartner 1947
" on pathogenic org. in dist. water & different salt solutions.	Type of salt had no effect except in few cases	Gutfeld 1928
Uv. 3000 A°	Kills	Hollaender 1943
House dust with Uv.	Recov. 225/10 cu. ft., 30 min.	"
Uv.	Resistance lower in non-pigmented. Org. which excrete pigment to medium have low resistance	1946
Uv. 2537 A°, with room lights on, in air.	Respiratory org. recov. 0.5%, 2 hr.	Ishmenetski
Uv. partial radiation	Not given	Knowles 1950
" absorption	Bactericidal	Lidwell 1946
" open agar plate	15 min.	"
" 20 microwatts/sq. cm. 2537 A°, in air.	Recov. adequate disinfection, 250-500 sec.	Miller 1948
Uv. 30 microwatts/sq. cm. 2537 A°, in air	Recov. same, 167-334 sec.	Mudd 1944
Water contaminated with clay and turf, Uv.	Not so easily ster. as clear water	"
Uv. rays	The bactericidal effect not due to action of HNO <sub>2</sub> , O <sub>3</sub> or water but to direct action of rays on protoplasm	Chrom-Brom
" "	Older resting cells more resistant than younger cells in cell division	"
" "	Reduc. 80%, 0.2 sec.	Oster 1934
" "	Larger forms more resistant	Perkins 1929
" " on air	Bactericidal	"
" " "	1/10 as resistant in air as in agar. More resistant at high R.H.; Less resistant if first exposed to heat.	Rentschler 1940
Low press. Hg. discharge in Uv. transmitting glass	35% killed/4 tantalum units.	" 1941 " 1942

TABLE R2 (CONT'D) THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
Low press. Hg discharge in quartz	36.0% killed/4 tantalum units	Rentschler 1942
Open arc beta u carbon	46.6% killed " " units	" "
Quartz arc	36.0% killed " " units	" "
Uv. in air condition system	Bactericidal	Rentschler 1940
"	"	Robertson 1940
Uv. on thermobacteria	Inoc. 71,000,000, Reduc. 99%	Schnegg 1936
Uv. exposure on water	Inoc. 2,000/cc, Recov. 0, 25 sec.	Schwarz 1911
Uv. on water bact. in raw water	Inoc. 300, Recov. 0, 15 sec.	" "
Uv. exposure on water, flow 1 liter/min.	Recov. 0, 6 sec.	" "
Uv. on spore bact. in raw water	Inoc. 1500/cc, Recov. practically 0, 15 sec.	" "
Uv.	Twice as much energy needed to kill spore as veg. form	Sharp 1939
Uv.	Not given	Sterckx 1935
Uv.	The destruction depends on surrounding factors	Vaindrakh 1939
Uv. on high vacuum	Lethal	Wells 1929
Uv. dry air	More germicidal in dry air	" 1940
Uv.	The greater the R.H. the less the killing	Wells 1942
Uv. in air	Kills	Wells 1943
Uv. 0.002 foot watt min./cu. ft. of air	Lethal effect	Wells 1945
Uv.	10-20x more germicidal in dry air	Whisler 1940
Uv.	Energy for killing in uv., 100x greater than x-ray	Wyckoff 1932
Uv.	Most bactericidal at 2650 Å	Porter 1947
Uv.	When uv. is used bact. ct. 5x greater than when not used in surgery	Kraissl 1942
Uv. 2500-3000Å	Bactericidal	Rahn 1932
Carbon arc source, 3287-2265Å	Bactericidal	Downes 1877
Hanaver Hg lamp on gram /	Recov. 0, 1-2 min.	Gartner 1947
" " " " " "	Recov. 0, 15-30 sec.	Gartner 1947
<b>LIGHT</b>		
Sunlight in cities	Important in destruction	Clement 1886
Long continued, strong, direct sunlight	Bactericidal	DeLarequette 1918

TABLE R2 (CONT'D)

## THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference
LIGHT (cont'd)		
Sunlight	Lethal effect depending on oxidation	Downes 1877
"	Destroys	" 1878
Tissue made anemic by press. in sunlight, 4mm. depth	Recov. 0	Emmerson 1933
Sunlight	Kills best between 8AM-3PM	Meador 1926
" , waves shorter than 3100 Å	Lethal	" "
Subnormal sunshine and ppt.	Long survival of infect-agents in air	Meissner 1940
Sunlight	Not given	Rossi 1924
Sun on pathogenes	" "	Grancher 1889
Sunlight on sea bact.	Recov. 26 bact./cc at surf, 420/cc at 25 meters depth	Schmidt-Nelson 1901
Direct sunlight, 110-120F	Destruction of org.	Sternberg 1894
Sunlight	Not given	Ward 1894-95
Light	Bactericidal	Wells 1940
Direct sunlight, 2mm. deep, sea bact.	Inoc. 164/cc, Recov. 76/cc, 2 hr.	Zobell 1935
Direct sunlight, 10mm. deep, sea bact.	Inoc. 163/cc, Recov. 126/cc, 2 hr.	" "
Direct sunlight, surf	Inoc. 238, Recov. 121, 7 hr.	" "
Unexposed to sun, "	Inoc. 241, Recov. 190, 7 hr.	" "
" " " 10cm.	Inoc. 235, Recov. 188, 7 hr.	" "
" " " 20cm.	Inoc. 217, " 217, 7 hr.	" "
Water 50cm. in cylinders in sun, surface	Inoc. 4900, Recov. 0, 6 hr.	T. & W. 1946
middle	Inoc. 4510, Recov. 2, 6 hr.	" "
bottom	Inoc. 6781, " 8, 6 hr.	" "
Water 50cm. in cylinders in dark, surface	Inoc. 4900, Recov. 7261, 6 hr.	" "
middle	Inoc. 4510, " 9051, 6 hr.	" "
bottom	Inoc. 6781, " 12591, 6 hr.	" "
X-RAY		
Roentgen ray tubes	10-60 min.	Bean 1903
Soft roentgen radiation	Gram-neg. more sensitive	Gastaldi 1949
	Spore-formers less resistant	
Roentgen rays	Incidental morphological	Rozhin-Kokhanii 1948

TABLE R2 (CONT'D) THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference
<b>ULTRASONIC</b> Sonic energy Ultrasonic waves " " vibrations	Proteins interfere with germicidal action Death of cell Disintegration	Beckwith 1936 Kvasnikov 1941 Loiseleur 1945
<b>OTHER RADIATION</b> Electric energy Continuous current at 260- 320 milliamperes on bouil- lon, 98.5C Continuous current 48 milli- amperes, 37C Continuous current 100 " amperes, Photosensitivity Heat on thermophilic bact.	Not given 10 min. 2-3 hr. 75 min. Gram-neg. less suscepti- ble than gram - posit. No effect	Sugiyama 1951 Zeit 1901 " " " " Porter 1947 Arrhenius 1927

TABLE R3

## THE EFFECT OF RADIATION ON BACTERIOPHAGE

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>E. coli phage</u>		
Uv.	Proportional to its conc.	Fischer 1927
Uv. from alpine sun lamp 1 ft. away of 4.5 amps	Recov. 0, 40 min.	McKinley 1926
<u>Sh. dysenteriae phage</u>		
Uv. 6 or 1.5 erg/sq. mm. per sec. and 2537 Å°	Inactivated, larger phage more sensitive	Latarjet 1945
<b>LIGHT</b>		
<u>Micrococcus phage</u>		
Indirect sunlight on 0.01 -0.1% M.B.	5 min.	Clifton 1931
Sunlight 1:100,000 methy- lene blue	Greatest inactivation	Porter 1947
<u>Virus +<sub>2</sub> phage</u>		
Daylight bulb	Recov. 3%, 70 hr.	Latarjet 1951
<b>ULTRASONIC</b>		
<u>E. coli phage</u>		
Exposed to intense sonic vibration	Inoc. 70%-1 min., Recov. 40%, 30 min.	Anderson 1948
Exposed to intense sonic vibration	Inoc. 100%-1 min., 1.1%, 60 min.	" "
<b>OTHER RADIATION</b>		
<u>General phage</u>		
Radium 7.8 microcuries	3 d. contact	Bruynoghe 1925



TABLE B4 THE EFFECT OF RADIATION ON BRUCELLA SPECIES

Factor(s)	Survival	Reference
<p>LIGHT</p> <p><u>B. melitensis</u> Tropical sunlight, 44 C.</p> <p><u>B. sop.</u> Sunlight &amp; dryness</p>	<p>Inoc. 1 loop 24 h. cult., Recov. 0, 45 min.</p> <p>Lower incidence of dis- ease</p>	<p>Ukil 1927</p> <p>Folding 1947</p>
<p>ULTRASONIC</p> <p><u>B. melitensis</u> 2641 kc.</p>	<p>Cell in smooth phase yielded cells in rough phase in 3 h.</p>	<p>Rucci 1949</p>

TABLE B5

## THE EFFECT OF RADIATION ON DIPLOCOCCUS PNEUMONIAE

Factor(s)	Survival	Reference
ULTRAVIOLET Uv's	Less susceptible than other org. studied	Wells 1945
LIGHT		
Sunlight	Larger strains more resistant	Bolowey 1942
Tropical sunlight, 550	Inoc. 1 loop 24 hr. cult. Recov. 0, 45 min.	Ukil 1927
Dried sputum, dark	35 d.	Wood 1905
" " light (diffuse)	30 d.	" "
Moist sputum, strong light	< 5 d.	" "
Dried sputum, sunlight	< 4 hr.	" "
Powdered sputum, dark	4 hr.	" "
" " sunlight	1 hr.	" "
Neon light sensitized with methyl violet	Recov. 15 min.	Philibert 1926

TABLE R6THE EFFECT OF RADIATION ON ESCHERICHIA COLI  
AND AEROBACTER AEROGENES

Factor(s)	etc.	Reference	
TREATMENT			
<i>E. coli</i>			
Phys. salt soln., ultra-violet lamp (100v, 6-8 amps) dist. of 50cm	More resistant when sensitized with own immune serums	Akizawa	1935
U.v. rays, 15 units	40 sec.	Baker	1935
" at 3500 A <sup>0</sup>	1 hr.	Bayne Jones	1933
" 295-6 mm.	Shorter time	Brooks	1935
Wave lengths 2800, 2650-2700 & 2540 A <sup>0</sup>	150-300 min.	Brookline	1937
0.1 watt/sq. ft.	Kills	Bruger	1938
Agar broth cult., pH 7.4	Kills 100%, 1 min.	Rutolph	1941
60 kv.	24 hr.	Cavalli	1940
Wave lengths less than 2800 A <sup>0</sup>	Lethal effect	Coblentz	1934
U.V. 2510 A <sup>0</sup>	Killing	Christmann	1929
" , 45% R.H.	More lethal than at high humidity.	Christmann	1942
"	Inoc. Innumerable, Recov. 8-3 min	Deet	1939
" 24,000 erg/cm <sup>2</sup>	Kills	"	1944
" 200 erg/cm <sup>2</sup>	"	Horcik	1936
" 3500-4900 A <sup>0</sup>	Not given	Hollaender	1943
" without molecular oxygen	Photoreactivation	Johnson	1950
U.v., 200 erg.	Recov. 50%	Leterjes	1943
" rays of 2537 A <sup>0</sup>	Kills	Lea	1940
" " " "	Develops resistivity	Luckiesh	1942
" " " "	"	Horik	1951
" dist. of 17 cm	20 min.	Nobels	1928
" in raw water	Inoc. 1500/cc, Recov. Practically 0 15 sec.	Schwarz	1911
" 245 erg/cm <sup>2</sup> at 2537 A <sup>0</sup>	Reduc. 90%	Sharp	1939
" 24000 erg/cm <sup>2</sup>	Lethal	"	1940
"	Older strains less resist. than the younger	Stenstrom	1951
"	30 min.	Palmer	1930
" in broth and air	Recov. 1, 30 min	Palmer	1935
" 0.1 watt/sq. ft	Reduc. 99-99%, 10 sec.	"	1940
" on a flowing cylinder of air	Lethal	"	1945
U.v., dry air	Reduc. 99.99%	Winkler	1940
"	Relatively resistant	Witkin	1947
"	The shorter the wavelength the more lethal	Wyckoff	1932
Dist. water, full radiation of mercury 10 cm.	5 min.	Bazzoni	1914
Salt water, full radiation of mercury 10 cm.	" "	"	"
8mm. deep	" "	"	"
Water, full radiation of iron arc, 8 cm., 2mm. deep	" "	"	"

TABLE R6 (CONT'D) THE EFFECT OF RADIATION ON ESCHERICHIA COLI AND AEROBACTER AEROGENES

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b> <u>A. aerogenes</u> U.v.	Destroys the ability to grow on ammonia	Peacocke 1948
<b>LIGHT</b> <u>E. coli</u> Watery susp'n of fresh cult. placed on petri dishes in sunlight Stored water, sunlight Diffuse light on polluted water  Sunlight 49 C., in urine " 45 C., in feces  Broth and air in dark " " " light	Inoc. 1 cc., Reduc. 96%, 10-15 min.  4-5 wk. Inoc. pure cult., death rate was higher in polluted water Inoc. pure cult., 1 loop 24 h., Recov. 0, 3 h. Inoc. 1 loop 24 h. cult. Recov. 0, 3 h. Recov. 3/10 sq. ft., 120 min. Recov. 0, 120 min.	Clark 1903 1939 Raghavachari  Smit 1931 Ukil 1927 " Wells 1935 "
<b>X-RAY</b> <u>E. coli</u> X-ray " 2000,2200 roentgen Susp'n irradiated with 250 kv. x-rays at 40,000 r/hr.  X-ray <u>A. aerogenes</u> X-ray 14,000 Roentgens	Younger die quicker 37% survival Only 1/3 sensitivity when oxygen was reduced by saturation with N <sub>2</sub> , CO <sub>2</sub> , etc. Relatively resistant  37% survival	Cavalli 1948 Fram 1950  Hollaender 1951 Witkin 1947  Fram 1950
<b>ULTRASONIC</b> <u>E. coli</u> Ster. buffer soln., 15.5 C. crystal ultrasonicator used. Ultrasonic or standard phosphate buffer	Inoc. 6,000;66,000; 628,000 & 6,000,000/ml. Recov. 99%, 40 min. Inoc. 1x10 <sup>6</sup> /cc. Reduc. 99.9%, 15 min.	Horwood 1950 Whitney 1951
<b>OTHER RADIATION</b> <u>E. coli</u> 2300 v. of electrons 10,000 v. in evacuated tube Neon light sensitized with methyl violet Cult. of bouillon with radium	Recov. 50%  1 h.  No results in 2 hr.  0 multiplication, 48 h.	Dieckmann 1950 Dognon 1930 Philibert 1926 Bruynoghe 1925

TABLE R7

THE EFFECT OF RADIATION ON MICROCOCCUS SPECIES

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>M. aureus</u>		
Uv. at 3500A°	1 hr.	Bayne-Jones 1923
"	Shorter time	Brooks 1942
Wave lengths of 2800, 2650, 2700 and 2540 A°	Kills	Burger 1928
Uv. rays 2000-2950 A°	Reduc. et.	Cathcart 1942
" " 2660 A°	Bactericidal action	Gates 1929
"	"	Hart 1937-41
" 26000 erg/cm <sup>2</sup>	Killed	" 1944
"	"	Laurens 1938
"	Survived	Phelps 1939
" 260 erg/mm <sup>2</sup> at 2537A°	Reduc. 90%	Sharp 1939
" 26000 erg/cm <sup>2</sup>	Lethal	" 1940
"	More susceptible than Bacillus veget. and influenza virus	Wells 1945
<u>M. albus</u>		
Uv. at 3500 A°	1 hr.	Bayne-Jones 1923
Wave lengths of 2800, 2650, 2700 & 2540 A°	Kills	Burger 1928
Uv.	Inoc. innumerable, Recov. 2, 3 min.	Hart 1939-40
Uv. 23000 erg/cm <sup>2</sup>	Killed	" 1944
Uv. 26200 erg/sq. cm.	1.06 sed.	Sharp 1938
Uv. 23000 erg/cm <sup>2</sup>	Lethal	" 1940
Uv. 184 $\frac{10^6}{mm^2}$ at 2537A°	Reduc. 90%	" 1939
Uv. at $2 \times 10^6$ ergs	Killed	Wells 1931
Uv. at $5 \times 10^6$ " /mm. Hg in vacuum	"	"
Uv.	More susceptible than Bacillus veget. and influenza virus, Diplococcus, Serratia, S. aureus	" 1945
<u>M. luteus</u>		
Uv.	Not given	Boston 1950
<u>M. citreus</u>		
Wave lengths of 2800, 2650, 2700 & 2540A°	Kills	Burger 1928
Uv.	Inoc. 160, Recov. 6, 3 min.	Hart 1939
<u>M. roseus</u>		
Uv.	30 min.	Tanner 1930
<u>M. epidermis</u>		
Uv.	" "	" "
<u>M. spp.</u>		
Uv. 15 units	40 sec.	Baker 1926
Uv.	Reduc. marked, 5 min.	Bedford 1927
Uv. 2380-2940 A° u.	6 min.	Browning 1917
Uv. 410 erg at 2537 A°	Kills	Rivers 1928
Uv.	Older strains less resistant	Stenstrom 1931

TABLE R7 (CONT'D)

## THE EFFECT OF RADIATION ON MICROCOCCUS SPECIES

Factor(s)	Survival	Reference
<b>LIGHT</b>		
<u>M. aureus</u>		
Sealed cult. sunlight	657 d.	Lal 1923
Direct sun, 23F	1 hr	Meader 1926
Thru window glass, sun	3 3/4 hr.	" "
Sun thru thin window glass	2 3/4 hr.	" "
Sunlight. 43C	Inoc. 1 loop 24 hr. cult. Recov. 0, 2 hr.	Wkil 1927
<u>M. spp.</u>		
Dark, 55C	Inoc. 124, Recov. 41, 40 min.	Buchbinder 1941
" 50C	Inoc. 62, Recov. 60, 30 min.	" "
" 45C	Inoc. 187, " 71, 80 min.	" "
" 40C	Inoc. 139, " 100, 60 min.	" "
Hydrogen peroxide, sun	No growth	Burnet 1925
July sun	12 hr.	Duclaux 1887
<b>X-RAY</b>		
<u>M. aureus</u>		
X-ray 3600-4400	37% survival	Fram 1950
<b>ULTRASONIC</b>		
<u>M. aureus</u>		
Ringer soln., ultrasound frequency 320 kilocycle	Inoc. $40.2 \times 10^9$ , Reduc. 90.4%, 45 min.	Grabar 1945
<b>OTHER RADIATION</b>		
<u>M. albus</u>		
Low velocity electrons	Killed	Wells 1931
<u>M. spp.</u>		
10,000 v. in evacuated tube	1 hr.	Dognon 1930
Neon light sensitized with methyl violet	Recov. 0, 1 min.	Philibert 1926

TABLE R8

## THE EFFECT OF RADIATION ON MICROORGANISMS

Factor (s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>Alcaligenes melitensis</u> Uv. 15 units	40 sec.	Baker 1926
<u>Alcaligenes sp.</u> Uv. 15 units	30 min.	Tanner 1930
<u>Corynebacterium diphtheriae</u> Uv. on agar	Reduc. marked, 5 min.	Bedford 1927
Uv. 337 erg/mm <sup>2</sup> at 2537 A°	Reduc. 90%	Sharp 1939
Uv.	More susceptible than Bacillus, Serratia, Staph, Diplococcus, influenza virus	Wells 1939
<u>Corynebacterium pseudodiphtheriticum</u> Uv. on agar	Reduc. slight, 5 min.	Bedford 1927
<u>Hemophilus influenzae</u> Uv. 15 units	Shorter time	Brooks 1942
<u>Klebsiella pneumoniae</u> Uv.	Inoc. innumerable, Recov. 19, 3 min.	Hart 1939
<u>Lactobacillus acidophilus</u> Uv.	Reduced	Du Buy 1948
<u>Proteus vulgaris</u> Uv.	Inoc. innumerable, Recov. 2, 3 min.	Hart 1939
Uv.	Older strains less resistant	Stenstrom 1931
<u>Serratia marcescens</u> Uv.	Germicidal effect	Bachem 1933
Uv. 15 units	40 sec.	Baker 1926
Uv. presence of dyes	Not given	Boston 1950
Uv. 2810 A	Kills	Ehrismann 1929
Uv. 20,000 erg/cm <sup>2</sup>	"	Hart 1944
Uv. 2537 A°	"	Lea 1940
Uv. distance of 17 cm.	5 min.	Nobele 1928
Uv., air	Kills (more effective when air is moving)	Robertson 1939
Uv., air	15 min.	Rosenstern 1942
Uv. in raw water	Inoc. 250,000/cc, Recov. 15/cc, 15 sec.	Schwarz 1911
Uv. 220 erg/mm <sup>2</sup> at 2537 A°	Reduc. 90%	Sharp 1939
Uv. 20,000 erg/cm <sup>2</sup>	Lethal	" 1940
Uv. 135 cm. away	Recov. 0, 25 min.	Strebel 1901
Uv.	More susceptible than Bacillus, Staph., Diplococcus, influenza virus	Wells 1945
<b>LIGHT</b>		
<u>Azotobacter sp.</u> Soil in sun	Destroys	Dhar 1939
<u>Corynebacterium diphtheriae</u> Neon light sensitized with methyl violet	Recov. 0, 5 min.	Philibert 1926

TABLE 88 (CONT'D) THE EFFECT OF RADIATION ON MICROORGANISMS

Factor(s)	Survival	Reference
<b>LIGHT (cont'd)</b>		
<u>Corynebacterium diphtheriae</u> Pure cult. swabs in dark	60 d.	Schofield 1916
" " " light	30 d.	" "
Tropical sunlight, 55° C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 45 min.	Ukil 1927
<u>Corynebacterium</u> spp. Drying in dark	6 wk.	Uttosen 1945
" daylight	1/2 wk.	" "
<u>Leptospira icterohemorrhagica</u> Light, R.T.	7 d.	T & W. 1944
<u>Pasteurella pestis</u> Tropical sunlight, 40° C.	Inoc. 1 loop 24 hr. cult., Recov. 0, 5 min.	Ukil 1927
<u>Proteus</u> spp. Neon light	Not destroyed after 30 min.	Philibert 1926
<u>Treponema pallidum</u> On cloth, 21.5-25° C., dif- fuse light	1 1/2 h.	Zinsser 1934
<b>X-RAY</b>		
<u>Serratia marcescens</u> X-ray 1200-1300 roentgens	37% survival	Fearn 1950
<b>OTHER RADIATION</b>		
<u>Proteus vulgaris</u> 10,000 v. in evacuated tube	Not destroyed after 30 min.	Philibert 1926
<u>Serratia marcescens</u> 10,000 v. in evacuated tube.	1 h.	Dognon 1930



TABLE R<sub>4</sub>

## THE EFFECT OF RADIATION ON MYCOBACTERIUM TUBERCULOSIS

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
Saline, uv. 7620-2800 Å <sup>0</sup>	Inoc. 15ccm of susp'n, Recov. 0, 10 min.	Eidenow 1927
Saline, uv. 5720-2800 Å <sup>0</sup>	Inoc. 15ccm. of susp'n, Recov. 0, 30 min.	" "
Uv.	Death slower at low temp than high, pH has no effect	Howze 1926
Guinea pigs injected with 5cc urine, uv.	20-40 min.	Nasta 1930
Uv.	More resistant	Wells 1941
"	Less susceptible than Bacillus spores	" 1945
Quartz-Hg vapor at 5in. from a 300 hr. burner	3 min.	Mayer 1924
Quartz-Hg vapor as above plus quinine	25 min.	" "
<b>LIGHT</b>		
Mixed sputum in sunlight	Inoc. into guinea pigs, 2-7? hr.	Caldwell 1925
Sunlight	Inhibit development	De Carvalho 1933
Diffuse daylight	5-7 d.	Koch
Sunlight	< 2 hr.	" 1890
"	< 5 "	Laurens 1938
Direct sunlight	Destroys	Mayer 1921
Sputum in sunlight	Few min.-48 hr.	" 1924
" on cover slips in dark, 70F, R.H. 83%	Inoc. 1075000, 142 d.	Smith 1942
Sputum on blank table in water susp'n 63F, R.H. 77%, dark	Inoc. 0.1mg/cc, 15 d.	" "
Sputum, 72F, R.H. 79%, dark	Inoc. 575000, 18 d.	" "
Sputum in direct India sun	6-8 d.	Soparker 1917
Electrical light	(Bovine) 74-100 d.	" "
Sputum, dark	309 d.	" "
Direct sunlight sputum from lung of deer	10-12 hr. (Bovine)	" "
Diffuse light, sputum from lung of deer	(Bovine) 30 d.	" "
Diffuse light, " "	6-8 d.	" "
Sunlight, 53C	Inoc. 1 loop 24 hr. cult Recov. 0, 30 min.	Ukil 1927
"	Recov. 0, 20 min.	Weinzirl 1907
<b>X-RAY</b>		
X-ray on agar	64 hr.	Minck 1896
<b>ULTRASONIC</b>		
Saline, ultrasound frequency 320 kilocycles	Inoc. $3.8 \times 10^9$ , Reduc. 75%, 75 min.	Grabar 1945

TABLE *Rie* THE EFFECT OF RADIATION ON NEISSERIA SPECIES

Factor(s)	Survival	Reference
<p>ULTRAVIOLET  <u>N. catarrhalis</u>                      Wave lengths of 2800,                      2650, 2700, &amp; 2510 A.</p>	Kills	Burger 1928
<p>LIGHT  <u>N. meningitidis</u>                      24 h. cult., direct sun-                      light, 10AM-6PM, 35-37 C.                      24 h. cult. direct sun                      12 noon-evening                      24 h. cult., immersed in                      water bath; 50 C.                      55 C.                      60, 70, 80 C.                      100 C.                      24 h. bouillon cult. 0-7 C.                      Direct sunlight, dried in                      films on surface of                      glass, wood, cotton                      Diffuse daylight passing                      2 layers of gauze                      Diffuse daylight thru                      cotton towelling &amp; wood                      Glass beads, R.T., dark                      Wood " " "                      Cotton " " "</p>	<p>2 h.                      "                      3 min.                      1 min.                      1 min.                      30 sec.                      &gt;1 mo.                      Few hrs.                      30 h.                      6-7 d.                      10 d.                      8 d.                      7 d.</p>	<p>1904                      Beltencourt                      "                      "                      "                      "                      "                      "                      "                      Miller 1944                      "                      "                      "                      "                      "</p>

TABLE R11

## THE EFFECT OF RADIATION ON PROTOZOA AND METAZOA

Factor(s)	Survival	Reference
ULTRAVIOLET		
<u>Amoebae</u>		
Short exposure to uv.	Killed	Chamberlain
<u>Paramecium</u>		
Uv.	Killed	Tang 1937
LIGHT		
<u>Negetor anelisianus</u>		
Outdoors dense shade, incubated 6-7 d.	7-9 wk.	Augustine 1923
Outdoors moderate shade	5½ wk.	" "
Direct sun	1 wk.	" "
Water covered soil, dense shade	Reduc. 99%, 10 d.	" "
Water covered soil, dense shade	Recov. 0, <4 wk.	" "
Water covered soil, light shade	Reduc. 99%, 10 d.	" "
Water covered " " shade	Recov. 0, <4 wk.	" "
Water covered " " direct sun	" " 1 wk.	" "
Tap water, direct sun	" " " "	" "
" " moderate shade	" " 15 d.	" "
" " dense shade	Reduc. 96%, 20 d.	" "
" " " "	Reduc. 45%, 1½ mo.	" "
Alternating moist and drying soil	Recov. 0, 8 wk.	" "
Drying soil, dense shade	" " >1 mo.	" "
" " moderate " "	" " 10 d.	" "
" " direct sun	" " 5 d.	" "
Faces, strong sun	>2 hr.	Nicoll 1917

TABLE R12

## THE EFFECT OF RADIATION ON PSEUDOMONAS SPECIES

Factor(s)	Survival	Reference
<u>ULTRAVIOLET</u>		
<u>P. aeruginosa</u>		
Full radiation of Hg arc at 8cm. on agar cult.	15 min.	Razzani 1914
In water, full radiation of Hg arc, 8cm.	Recov. 0, 3 min.	" "
In water, full radiation of iron arc, 8 cm.	" " " "	" "
Uv.	Inoc. innumerable, Recov. 3 <sup>rd</sup> , 3 min.	Hart 1939
Uv. 16000 erg/cm <sup>2</sup>	Kills	" 1944
Uv.	Survived	Phelps 1939
Dosages of uv. which are ordinary lethal	"	Sharp 1940
Uv. 16000 erg/cm <sup>2</sup>	Lethal	" "
<u>P. fluorescens</u>		
Uv.	Not given	Poston 1950
Uv.	More resistant than non-fluorescens, convert short wave lengths into long	Burge 1915
<u>E. SP.</u>		
Uv.	Shorter time	Brooks 1942
<u>LIGHT</u>		
<u>P. aeruginosa</u>		
Tropical sunlight, 44C	Inoc. 1 loop 24 hr. cult. Recov. 0, 1 1/2 hr.	Ukil 1927
Neon light	Not destroyed after 30 min.	Philibert 1926
<u>X-RAY</u>		
<u>P. aeruginosa</u>		
X-ray 1000-1200 roentgens	37% survival	Fram 1950
<u>P. fluorescens</u>		
X-ray 1000-1100 " "	" "	" "
<u>OTHER RADIATION</u>		
<u>P. aeruginosa</u>		
Cult. of bouillon, media	2 cultivation, 45 hr.	Bruynoché 1925

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>S. typhosa</u>		
Phys. salt soln., Uv. at distance of 50 cm. (lamp 100 v., 6-8 amps)	More resistant when sensitized with own immune serums	Akiyama 1935 Baker 1926
Uv. rays, 15 units	40 sec.	
Agar, full radiation of Hg arc, 10 cm.	Recov. plus, 10 min.	Bazzoni 1914
Normal salt, full radiation of Hg arc, 5 cm.	Recov. 0, 30 sec.	"
Uv. on agar	Reduc. v ry slightly, 5 min.	Bedford 1927 Browning 1917
Fluid, pH 2, Uv.	2 sec.	
Wave lengths of 2800, 2650 2700 & 2540 A°	Kills	Burger 1928
Uv.	Inoc. 200 cc. emulsion, Recov. 0, 5 min.	Gilles 1935 Newcomer 1917
Uv. 2100-2800 A°	Very sensitive	"
Fe sparks, 1990-2005 A°	Recov. 4100, 10 min.	"
" " 2250-2270 "	" 6500, "	"
" " 2485-2510 "	" " "	"
" " 2645-2675 "	" 100 "	"
" " 2845-2385 "	" 700 "	"
" " 2945-2985 "	" 4500 "	"
Uv. 21 1/4 erg/mm <sup>2</sup> at 2537 A°	Reduc. 90%	Sharp 1939
Cu sparks, 2130-2140 A°	Recov. 5722, 10 min.	Newcomer 1917
" " 2205-2225 "	" 30 "	"
" " 1990-2105 "	" 1 "	"
<u>S. paratyphi A &amp; B</u>		
Uv. ray, 15 units	40 sec.	Baker 1926
<u>S. enteritidis</u>		
Uv. rays 2000-2950 A°	Reduced count.	Catheart 1942
<u>S. typhimurium</u>		
Uv.	The shorter the wave the more lethal	Wyckoff 1932
<b>LIGHT</b>		
<u>S. typhosa</u>		
Thin layer of water, suc	1 h.	Clark 1902
Water in bottles	5 h.	"
Watery susp'n of fresh cult. placed on petri dishes, sunlight	Inoc. 1 cc., Reduc. 95% 10-15 min.	"
Sealed cult. in dark	2906 d.	Lal 1923
" " in direct sun	60 d.	"
Sealed cult. in sunlight & diffuse light	365 d.	"
Sealed cult., diffuse	"	"
" " 37 C., dark	"	"
" " R.T. "	"	"
Beef peptone agar in direct sun	Recov. 0, 10-60 min.	Milner 1936
Beef peptone agar in diffuse light	" " 5-7 h.	"

TABLE R13 (CONT'D) THE EFFECT OF RADIATION ON SALMONELLA SPECIES

Factor(s)	Survival	Reference
<b>LIGHT (Cont'd).</b>		
<u>S. typhosa</u>		
Direct rays of sun Sunlight, 40 C.	4-10 h. Inoc. 1 loop 24 hr. cult. Recov. 0, 20 min.	Osler 1901 Ukil 1927
Neon light	Not destroyed after 30 min.	Philibert 1926
<u>S. paratyphi A</u>		
Sunlight, 42 C.	Inoc. 1 loop of 24 hr. cult., Recov. 0, 30 min.	Ukil 1927
<u>S. paratyphi B</u>		
Sunlight, 48 C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 1 h.	"
Neon light	Not destroyed after 30 min.	Philibert 1926
<u>S. enter. tidis</u>		
Tropical sunlight, 49 C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 3 h.	Ukil 1927
<b>X-RAY</b>		
<u>S. typhosa</u>		
Bouillon cult., 40 C.	Inoc. 1 loop, Recov. no difference in #, 3 h.	Minck 1896
<b>OTHER RADIATION</b>		
<u>S. typhosa</u>		
Irradiation 10,000 v. in evacuated tube	0 multiplication 1 h.	Bruynoghe 1925 Dognon 1930
<u>S. paratyphi A &amp; B</u>		
10,000 v. in evacuated tube	1 h.	"
<u>S. typhosa</u>		
Cult. of bouillon, radium	0 multiplication, 43 h.	Bruynoghe 1925

TABLE R14 THE EFFECT OF RADIATION ON SHIGELLA SPECIES

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>S. dysenteriae</u> Wave lengths 2800, 2650, 2700 & 2540 A°	Kills	Burger 1928
<u>S. paradysenteriae</u> Uv. 165 erg/mm <sup>2</sup> at 2537 A°	Reduc. 90%	Sharp 1939
<b>LIGHT</b>		
<u>S. dysenteriae</u> Strong sunlight, cultured in bouillon	< 30 min.	Bamberger 1936
Sealed cult. sunlight	20 d.	Lal 1927
" " direct sun- light & diffuse light	75 d.	"
Sealed cult., diffuse light	365 d.	"
" " 37 C., dark	"	"
" " R.T. "	"	"
Sunlight, 44 C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 2 min.	Ukai 1927
<u>S. paradysenteriae (Flexner)</u> Strong sunlight, cultured in bouillon	< 60 min.	Bamberger 1936
Sealed cult., sunlight	104 d.	Lal 1923
" " direct sun, and diffuse light	100 d.	"
Sealed cult. diffuse light	365 d.	"
" " 37 C., dark	"	"
" " R.T. "	"	"
Sunlight on feces	1 h.	Stewart 1944
<u>S. paradysenteriae (Sonne)</u> Strong sunlight, cultured in bouillon	< 30 min.	Bamberger 1936
<u>S. ambigua</u> Strong sunlight, cultured in bouillon	< 40 min.	"
<b>ULTRASONIC</b>		
<u>S. dysenteriae</u> Isotonic PO <sub>4</sub> , pH 7.3, ultrasound frequency 680 kilocycles	Inoc. 120.8x10 <sup>8</sup> , Reduc. 88%, 30 min.	Grabar 1945
<u>S. paradysenteriae</u> Ringer liquid, ultrasound 320 kilocycles	Inoc. 6.2x10 <sup>8</sup> , Reduc. 98%, 30 min.	"
<b>OTHER RADIATION</b>		
<u>S. dysenteriae</u> Neon light	Not destroyed after 30 min.	Philibert 1926

TABLE 815

## THE EFFECT OF RADIATION ON STREPTOCOCCUS SPECIES

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>S. pyogenes</u>		
Uv.	Shortened time	Brooks 1942
"	Inoc. innumerable, Recov. 12, 3 min.	Hart 1939
Uv. 216 erg/mm <sup>2</sup> at 2537 Å.	Reduc. 90%	Sharp 1939
<u>S. viridans</u>		
Uv.	Loss susceptible than Bacillus spores and t.b.	Wells 1945
<u>S. hemolyticus</u>		
Uv.	Less susceptible than Bacillus spores, t.b., & S. viridans	"
<u>S. salivarius</u>		
Uv. 200 erg/mm <sup>2</sup> at 2537 Å	Reduc. 90%	Sharp 1939
<u>S. spp.</u>		
Phys. salt soln., Uv. lamp (100 v., 4-5 amps) at distance of 30 cm.	More resistant when sensitized with immune serum	Akiyama 1935
Uv.	1946-44.4% present, 1949 -21.5%	Halverson 1950
Uv., 1 cu. ft. of air	Recov. 0	Henle 1942
Uv. irradiation of upper air	Kills	Jarratt 1948
<b>LIGHT</b>		
<u>S. pyogenes</u>		
Sunlight	Recov. 50%, 40 min.	Buehler 1941
Daylight	3 hr.	"
" , R.T.	42-252 min.	"
Dark, and R.T.	12-132 h.	"
On floor in petri dishes in dark	Recov. 20%, 14 d.	Phelps 1939
On floor in petri dishes in diffuse light	" < 1%, < 7 d.	"
<u>S. spp.</u>		
Visible light	Kills	Tuchbinder 1941
Sunlight	Recov. 50%, 5 min.	"
"	Larger strains more resistant to daylight	Solomon 1942
Tropical sunlight on pus 49 c.	Inoc. 1 loop 2 1/2 h. cult. Recov. 0, 15 min.	UHL 1927
Sputum, tropical sunlight 50 c.	Inoc. 1 loop 2 1/2 h. cult. Recov. 0, 30 min.	"
Neon light sensitized by methyl violet	Recov. 0, 30 min.	Fr. Libert 1926
<b>OTHER RADIATION</b>		
<u>S. faecalis</u>		
10,000 r, an evacuated tube.	L. b.	Dognon 1950



TABLE R16

## THE EFFECT OF RADIATION ON VIBRIO CHOLERAE

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
Uv.	Reduc. complete, 5 min.	Bedford 1927
Uv. in raw water	Inoc. 1500/cc, Recov. practically 0, 15 sec.	Schwarz 1911
<b>LIGHT</b>		
Sealed cult.	1044 d.	Lal 1923
" " direct sunlight & diffuse light	3 d.	" "
Sealed cult. diffuse light	279 d.	" "
" " 37C, dark	71 d.	" "
" " RT "	365 d.	" "
Sea water direct sunlight	8 hr.	Matsuda 1910
Tropical sunlight, 49C	Inoc. 1 loop 24 hr. cult. Recov. 0, 15 min.	Ukil 1927
Sunlight 30-18C	Inoc. 300,000 in 1cc water, Reduc. 99.9%, 5 hr.	Yesukawa 1933
Exposed polarized light, 24C	Inoc 1 in 100,000 dil'n, Recov. 121 colonies, 13-30 hr.	Lal 1926
<b>OTHER RADIATION</b>		
Cult. of bouillon, radium	0 multiplication, 48 hr.	Bruynocke 1925

TABLE R17

## THE EFFECT OF RADIATION ON VIRUSES

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>Polio virus</u>		
Uv.	> destruction than sun	Carlson 1942
Uv.	Inactivated	Dick 1951
Uv., < 38.5 c., 2800-3100 Å	30 min.-1 min.	Jungleblut 1937
Uv.	Recov. plus up to 2 h.	Levaditi 1942
Uv. at 8 in.	Inoc. 6cc of 1% susp'n., 75 min. (did not infect animals)	Toomey 1937
<u>Influenza virus</u>		
Uv.	Not given	Hollaender 1944
"	More resistant than E. coli	"
"	Killed	Wells 1936
"	Sensitive	" 1941
"	More susceptible than Bacillus veget.	" 1945
<u>Vaccine virus</u>		
Short wave Uv.	40 min.	Barkad 1932
Uv. 480 ergs at 2537 Å	Kills	Rivers 1928
<u>Herpes virus</u>		
Cornon, Uv.	< 15 min.	Gundersen
Fresh normal rabbit serum and Uv.	10 min.	"
Uv.	Recov. 0, 30 min.	Levaditi 1942
Uv. from alpine sun lamp 1 ft. away of 4.5 ergs.	Recov. 0, 40 min.	McKinley 1926
<u>Encephalomyelitis virus</u>		
Uv. from alpine sun lamp 1 ft. away of 4.5 ergs.	" "	"
Uv.	Not given	Taylor 1941
<u>Tobacco mosaic virus</u>		
Uv. 3100-2652 Å	Inactivation	Duggar 1934
<u>African horse-sickness virus</u>		
Uv.	"	Folson 1950
<u>Measles, chicken-pox, rumps</u>		
Uv.	Sensitive	Wells 1941
<u>Virus general</u>		
Uv. 2537 Å.	Sensitivity similar to bacteria	Hollaender 1945
Uv.	Correlation between in- activation dose & size	Lea 1947
<b>LIGHT</b>		
<u>Polio virus</u>		
Direct sunlight	30 min.	Carlson 1942
Sunlight	Rapidly killed	Flekner 1916
<u>Vaccinia virus</u>		
Thiazine, acridine & thio- xanthine dyes & light energy	< 5 min.	Herzberg 1933
<u>Foot &amp; mouth virus</u>		
Dried & exposed to noon August sun.	1 h.	Redson 1927

TABLE 817 (CONT'D) THE EFFECT OF RADIATION ON VIRUSES

Factor(s)	Survival	Reference
LIGHT (cont'd) <u>Foot &amp; mouth virus</u> Dried & exposed to winter light	> 1 h.	Bedson 1927
ULTRASONIC <u>Polio virus</u> Sonic vibration	Not affected	Scherp 1936
OTHER RADIATION <u>Polio virus</u> High speed electrons	Inactivated	Dick 1951

TABLE R18 THE EFFECT OF RADIATION ON YEASTS, MOLDS, & FUNGI

Factor(s)	Survival	Reference
<b>ULTRAVIOLET</b>		
<u>Yeasts</u>		
Uv., 24 C., high humidity	Recov. 0, 5 min.	Beauverie 1934
" light, 1200 candle power lamp at 20 cm.	7 min.	De Fazi 1921
Uv.	Recov. 0, 5 min. expos.	Giller 1935
"	Inoc. 32,000; Reduc. 99%	Schnegg 1936
"	Not given	Sterckx 1935
"	Effect may result from absorption of energy	Oster 1935
<u>Molds</u>		
Uv. in air	Kills	Luchiesh 1949
"	Older org. less resist.	Stenstrom 1931
"	Dark colored molds more resistant	Sutton 1941
Uv. on cardboard strips	Not entirely killed	Tanner 1941
<u>Fungi</u>		
Uv.	Lethal action, pigmentation is a defense	Chavarria 1924
" 2650 Å	Increased resistance with age	Diamond 1941
Uv. in petri dishes at 25 cm.	1-10 min.	Pever 1920
Uv.	Inoc. innumerable, Recov. 0, 20 min.	Hart 1939
Uv. 3,000 Å	Kills	Hollaender 1943
<b>LIGHT</b>		
<u>Fungi</u>		
Sunlight	Not given	Ward 1894
"	8 h.	Weinzirl 1914
<b>ULTRASONIC</b>		
<u>Yeasts</u>		
Ringer soln., ultrasound frequency 680 kilocycle	Inoc. $1.3 \times 10^9$ , Reduc. 85%, 30 min.	Grabar 1945
<b>OTHER RADIATION</b>		
<u>Molds</u>		
Electron bombardment in high vacuum	Survive	Cooper 1936
10,000 V. in evacuated tube	1 h.	Dognon 1930

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN SOIL

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S3	Clostridium species	1
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S 5	Corynebacterium diphtheriae	1
S 6	Fungi, yeasts & molds	1
S 7	Microorganisms	2
S 8	Microorganisms (General)	2
S 9	Mycobacterium species	1
S 10	Protozoa & metazoa	3
S 11	Salmonella species	3
S 12	Shigella species	1
S 13	Streptococcus species	2
S 14	Viruses	1
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TABLE 5

THE SURVIVAL OF BACILLUS SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>MUD</b>		
<u>B. subtilis</u> Black mud, dark, moist	Recov. 0, >80 d.	Rubentschik 1936
<u>B. cereus var. mycoides</u> Black mud dark, moist	Recov. 0, " "	" "
<b>GENERAL</b>		
<u>B. anthracis</u>		
Soil and manure 3 cm. deep	Spores-10 wk.	Beranek 1948
Surface soil	12 yr.	Pasteur 1881
Dry ster. soil, 3% moist.	Sporulation of possible	Minett 1950
Ster. muddy water stored in a pond on the plains of India	Survived over 2 yr.	" "
Soil	More or less permanent habitat	Sanyal 1941
Moist or dry earth	33 mo.	Sirena 1894
Soil over burial place of dead anthrax animals	15 yr.	Wencke 1900
Gravel, carcasses buried 20 yr.	20 yr.	" "
<u>B. subtilis</u>		
Soil 400 meters deep, 30C	Inoc. Bouillon & 27% watt extract with 2% agar, recov. growth, 1-8 d.	Lieske 1929
<u>B. spp.</u>		
<u>B. cereus, megatherium, and mycoides</u> in ster. soil	Multiply 1st. 40 d., dec. and at end of 85 still dec.	Katznelson 1940
Soil 500-600 meter deep, 30C	Inoc. into beef extract pepton-bouillon & 2% malt extract with 2% agar, growth 1-8 d.	Lieske 1929

TABLE 52

## THE SURVIVAL OF BRUCELLA SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>SAND</b>		
<u>B. suis</u> Sand	120 d.	Bryan 1934
<b>GENERAL</b>		
<u>B. abortus</u>		
Unheated cellar Oct., dried quickly	< 4 d.	Cameron 1932
Unheated cellar Feb., dried quickly	27 d.	" "
Test tubes, lab temp., dried slowly	37 d.	" "
Wet soil, unheated cellar	66 d.	" "
<u>B. melitensis</u>		
Soil, favorable conditions	10 wk.	Bang 1897
Damp ster. soil	72 d.	Horrocks 1906
Dry ster. manure soil	69 d.	" "
Moist ster. " "	7 d.	" "
" unster. manure soil	20 d.	" "
<u>B. suis</u>		
Soil	46 d.	Bryan 1934
<u>B. sp.</u>		
Soil in pastures where animals excrete large amounts of org.	Poor survival	Christiansen 1950

TABLE S3

## THE SURVIVAL OF CLOSTRIDIUM SPECIES IN SOIL

Factor(s)	Survival	Reference
<u>LOAM</u>		
<u>C. botulinum</u> Soil from counties in Md. where veg. grow	A, B, & C strains isolated	Damon 1926
<u>C. tetani</u> Sandy loam - corn	Isolated	" "
<u>SAND</u>		
<u>C. botulinum</u> Veg. grown in sandy soil in counties of Md.	Isolated	Damon 1926
<u>GENERAL</u>		
<u>C. botulinum</u> Soil in central N.Y., pH 4.25-8.5	Type A more predominant than type B, toxic cult. type A, greater % of toxic cult. from cultivated soil	Parry 1946
Soil	More or less permanent habitat	Sanyal 1941
<u>C. tetani</u> Soil	More or less permanent habitat	" "
" Soil of school ground	Found	Dubovsky 1922 Ishihara 1933
<u>C. perfringens (welchii)</u> Soil	More or less permanent habitat	Sanyal 1941
<u>C. tetani (cont'd)</u> Soil	Years	T. & W. 1946
English soil plus botulinum	Found	Haines 1942
Soil from alley near stable	"	Foraker 1941

TABLE 54

## THE SURVIVAL OF COLIFORM IN SOIL

Factor(s)	Survival	Reference
<b>LOAM</b>		
<u>Escherichia coli</u> Rich loam, R.T.	Recov. unchanged 1 mo.	Horrocks 1903
Virgin loam	" " 6 wk.	" "
Sandy and clay loam	" 5.4 logs/100gm, 0 wk.	Mallmann 1951
" " " "	Recov. 3.8 logs/100gm, 11 wk.	" "
<b>MUD</b>		
<u>E. coli</u> Mud with infected water outside temp.	Demonstrable 45 d.	Bartos 1947
Tidal mud	3 mo.	Savage 1905
<b>SAND</b>		
<u>E. coli</u> Virgin sand	Recov. unchanged 60 d.	Horrocks 1903
Sand	Recov. 4.9 logs/100gm. 0 wk.	Mallmann 1951
"	Recov. 0.8 " " " , 11 wk.	" "
1 cc. sea sand	Inoc. 48 hr. broth cult, Recov. 0.02/gm, 240hr.	Winslow 1912
Sand, 69C, R.H. 90%	Recov. 67.23/gm, 8 hr.	" "
" " " 72%	" 44.48/gm, 10 hr.	" "
" 70C, " 60%	" 37.46/gm, 7 hr.	" "
<b>GENERAL</b>		
<u>E. coli</u> Ordinary soil and sewage	53-65 d.	Firth 1902
Tomatoes grown on soil with sewage	1 mo.	Falk 1949
Soil fertilized with chicken manure, 72C	Inoc. $10^{-3}$ , Recov. $10^{-3}$ , 7 d.	Ostrolenk 1947
Soil fertilized with chicken manure, R.T.	Inoc. $10^{-7}$ , Recov. $10^{-2}$ 150 d.	" "
Normal feces stored with garden soil, R.T.	12 wk.	Jordan 1926
Normal feces stored with beach sand, R.T.	6-8 wk.	Chick 1900
Roads, dry	Short time	" "
" wet	Much longer	" "
Garden soil, ster. with dry heat	Inoc. $\frac{1}{2}$ soil strain & $\frac{1}{2}$ fecal strain, 2 mo., found in 2 gm.	Fellow 1923
Soil	Inoc. 1 bouillon/liter water, persistent 410d.	Klein 1935
Ster. soil, 18-20C, dark, moistened with ster. water	> 4 mo.	Koser 1924
Ster. garden soil	Living after 3 yr. 7 mo.	Kulp 1932
Soil, 60% moisture, steri- lized with dry heat	Isolated 17 mo. later	Fellow 1923



TABLE 54 (CONT'D)

## THE SURVIVAL OF COLIFORM IN SOIL

Factor(s)	Survival	Reference
<b>GENERAL (cont'd)</b>		
<u>E. coli</u>		
Soil, 40-20-10% moisture, ster. with dry heat	Isolated 17 mo. later	Fellow 1923
Soil, 100% moisture, air dried	None at end 1 mo.	" "
Soil, 60% moisture, air dried	" in 10 gm. in 2 mo.	" "
Soil, 40-20-10% moisture, air dried	Fecal & soil strain present at end of 34 mo.	" "
Dry soil	25 d.	Firth 1902
Soil	6-8 wk.	Horrocks 1903
"	6-8 wk.	Houston 1897
Virgin soil	E. coli generally absent	" "
Unfertilized soil, R.T.	Inoc. 10 gm., Recov. 10 <sup>-6</sup> gm., 66 d.	Ostrolenk 1947
Soil with pecans, R.T., artificial infection	Inoc. 10 <sup>-7</sup> , Recov. 10 <sup>-6</sup> , 106 d.	" "
Soil	8 mo.	Previtero 1945
"	Low temp., moisture, organic matter, and absence of other org. inc. the viability	Rudolfs 1950
Tomatoes grown on polluted soils	Death rate slow in storage, soaking in water at 60C for 5 min. most effective	" 1951
Street scrapings	4 yr.	Savage 1904
Soil	Inoc. 600,000, Recov. 5, 122 d.	Skinner 1926
"	Inoc. 9,000,000; Recov. 5, 176 d.	" "
" with E. coli and A. aerogenes	Inoc. 1,300,000; Recov. 5, 176 d.	" "
Dry soil	8 d.	Tanner 1944
Moist soil	>60 d.	" "
Ster. garden soil, 100% moisture	Recov. 0, < 1 yr.	Young 1923
Ster. garden soil, 60-40-30-10% moisture	" " >17 mo.	" "
Unster. garden soil, 1 cc. susp'n 100% saturation	1 mo.	" "
Unster. garden soil, 60% saturation of 1 cc. susp'n	2 mo.	" "
Unster. garden soil, 1 cc. susp'n 40-20-10% sat.	>17 mo.	" "
Soils	4 yr.	" "
<u>Aerobacter aerogenes</u>		
Ster. garden	Living after 3 yr. 7 mo.	Kulp 1932
Soil	Inoc. 13,000,000; Recov. 50, 218 d.	Skinner 1926
Soil, plus E. coli	Inoc. 800000, Recov. 80, 218 d.	" "

TABLE Sy (CONT'D)

## THE SURVIVAL OF COLIFORM IN SOIL

Factor(s)	Survival	Reference	
<b>GENERAL</b>			
<u>Enteric bacteria</u>			
Ster. originally contaminated soil, 3-19 C	>404 d.	Martin	1896
Above dried to powder, 3-19C	>4 d.	"	"
Ster. virgin peaty soil, 3-19C	<1 d.	"	"
Unster. soil, 3-19C	>50 d.	"	"
Ster. dry soil, 2-12C	57 d.	"	1898
Unster. dry soil, 2-12C	12 d.	"	"

TABLE 5

THE SURVIVAL OF CORYNEBACTERIUM DIPHTHERIAE IN SOIL

Factor(s)	Survival	Reference
<p><b>SAND</b>                      Fine sand, 37C with cult.                      dried in air                      Fine sand, 37C, with cult.                      dried over H<sub>2</sub>SO<sub>4</sub>                      Sand                      "</p>	<p>Recov. 0, 30 d.                      " " 50 d.                      175 d.                      &gt; 98 d., Recov. mostly                      with unimpaired toxic-                      ity</p>	<p>Germano 1897                      " "                      Laurell 1949                      Ouchterlony 1949</p>
<p><b>GENERAL</b>                      Soil at 37C, dried in air                      " " " " over                      H<sub>2</sub>SO<sub>4</sub>                      Soil                      Soil                      Soil drained</p>	<p>Recov. 0, 25 d.                      " " 35 d.                      208 d.                      &gt; 98 d., recov. mostly                      with unimpaired toxic-                      ity                      May be killed</p>	<p>Germano 1897                      " "                      Laurell 1949                      Ouchterlony 1949                      Sharp 1896</p>

TABLE 56

## THE SURVIVAL OF FUNGI, YEASTS AND MOLDS IN SOIL

Factor(s)	Survival	Reference
<b>PEAT</b>		
<u>Actinomyces</u>		
Strongly acid peat soil	Fewest occurred	Jensen 1930
<b>GENERAL</b>		
<u>Malleomyces mallei</u>		
Pasture	Unsafe for at least 1 yr.	Lovell 1944
<u>Actinomyces</u>		
Soil, April-May	150-160 million/g. dry soil	Eggleton 1934
Dry soil, hot summer mo.	110-120 " "	" "
Any " Sept. inc. in moisture	130-140 " "	" "
Soil, winter	110-120 " "	" "
Strongly acid pH < 5	Few	Jensen 1930
Soil, pH 6.8-8	Highest no.	" "
Field frozen over 2 mo., 20C	Actinomycetes made up 30% of total no.	Lochhead 1925
Field, 3C	No Actinomycetes found	" "
1 gm. of field soil	Contains 10T-20M	Waksman 1927
<u>Actinomyces bovis</u>		
Soil	More or less permanent habitat	Sanyal 1941
<u>Fungi general</u>		
Soil in autumn	Higher than spring	Eggleton 1934
1 gm. field soil	Contains 10T-20M fungi	Waksman 1927
<u>Yeasts general</u>		
Soil	< 1 mo.	Owen 1948
Spores in soil	Lasted thru winter	Tanner 1944
Yeast in soil under natural conditions	Live for long periods of time	" "
<u>Mold general</u>		
Soil, -2 to -14C	Activity was unaffected	Demoussy 1929
<u>Fungi general (cont'd)</u>		
Seed-bed soil	Disinfected by solar energy	Grushevoi 1940

TABLE 57

## THE SURVIVAL OF MICROORGANISMS IN SOIL

Factor(s)	Survival	Reference
<b>CLAY</b>		
<u>Agrobacterium tumefaciens</u> Clay	539 d.	Patel 1929
<b>LOAM</b>		
<u>Agrobacterium tumefaciens</u> Loam	587 d.	Patel 1929
<b>MUD</b>		
<u>Pasteurella tularensis</u> Mud naturally contaminated and stored in cold	12 wk.	Parker 1943
Uncontaminated mud	" "	Steinhaus 1945
<b>PEAT</b>		
<u>Vibrio comma</u> Independent of amount of moisture	24-26 hr.	Dempster 1894
<b>SAND</b>		
<u>Diplococcus pneumoniae</u> Dried cult. mixed with sand and veg. oil	2 d.	Germano 1897
<u>Agrobacterium tumefaciens</u> Sand	669 d.	Patel 1929
<u>Vibrio comma</u> White crystal sand	4 d.	Dempster 1894
Moist white crystal sand	> 7 d.	" "
Yellow sand	4 d.	" "
Moist yellow sand	> 33 d.	" "
Excess moist white crystal sand	> 28 d.	" "
Excess moist yellow sand	> 68 d.	" "
White crystal sand, mois- ture allowed to evap.	3-8 d.	" "
White crystal sand, mois- ture not evap.	> 47 d.	" "
White crystal sand, 1.57% moisture	27 d.	" "
White crystal sand, 0.66% moisture	30 d.	" "
White crystal sand evap. prevented, 7.1% moisture	> 174 d.	" "
<b>VOLCANIC ASH</b>		
<u>Diplococcus pneumoniae</u> Dried cult. and mixed with volcanic ash, kept moist	6 d.	Germano 1897
<b>GENERAL</b>		
<u>Leptospira icterohaemorrhagiae</u> Polluted soil	3 d.	Noguchi 1918
<u>Leptospira sp.</u> Wet ground from mines	months	Buchanan 1927
<u>Pseudomonas fluorescens</u> Soil	45 d.	Katznelson 1940
Dried blood or alfalfa added to soil	Disappeared from soils	" "

TABLE 51 (CONT'D) THE SURVIVAL OF MICROORGANISMS IN SOIL

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>Leptospira grippo-typhosa</u> High degree soil humidity with hot weather	Favors presence, may enter skin if person is in contact with mud or water that is infected	Kathe 1945
<u>Vibrio comma</u> Garden earth Moist garden earth Excess moist garden earth Soil, no moisture	4 d. > 33 d. > 68 d. 1-2 d.	Dempster 1894 " " " " " "
<u>Azotobacter spp.</u> Soil, dark Acid soils Lime and soil Lime and dextrose and soil Pure cult. in ster. soil	10X nos. in soil in sun < 24 hr. Survived Multiplied Multiplied upto 40 d. then dec. Still dec. at 85 d.	Dhar 1939 Katznelson 1940 " " " " " "
Indiam & Malayan soil, pH 3.6-3	Capable of growing but limit on acid side	Waksman 1940
Soil Soils most frequently fertilized with manure	Present Showed largest no. of azotobacter	Vandecavege 1934 Kanivets 1938

TABLE 58

## THE SURVIVAL OF MICROORGANISMS IN SOIL (GENERAL)

Factor(s)	Survival	Reference
<b>GENERAL</b>		
Cult. of legume bacteria in glass bottles, extended exposure to uv. light, on dried soil	No serious injury	Albrecht 1930
on natural soil	Viable 7 yr.	" "
Soil	Survives extremes of moisture & temp., absence of host, and wind and dust storms to some extent	Vandecaveye 1927
Lactic acid bacteria in ster. garden soil	5 yr.	Barthel 1924
Anthracite coal from Wales & Penna	5 hr. in autoclave does not kill all org., 50 hr. in hot air oven does not kill all org.	Lipman 1931
Denitrifying & ammonifying exposed to -20 and 7C	1-10 wk. were not injured	Bryan 1935
Nitrifying bacteria, -20 & 7C	1-10 wk. were injured	" "
Ammonifying, nitrifying & N-fixing org., -2 & 14C	Activity unaffected	Demoussy 1929
Bacteria in soil, April-May	150-160 million/g dry soil	Eggleton 1934
Bacteria in soil, hot summer mo., no moisture	110-120 million/g	" "
Bacteria in soil, Sept. moisture	130-140 million/g	" "
Bacteria in soil, winter	110-120 million/g	" "
Soil bacteria, 10C, cult. of synthetic glucose agar	Greatest survival 24 mo. produces a rather permanent change in their nitrifying flora	Greaves 1944
Soil bacteria, 40C, cult. of synthetic glucose agar	Least survival at 24 mo. materially reduced N-fixing powers	" "
Sulfur & Fe bacteria in soil 400-1089 meters deep, R.H. high, 30C, inoc. into beef extract-pepton bouillon & 2% malt extract with 2% agar	1-8 d.	Liesky 1929
Bacteria in 1 gm. of field soil	Contains 100 million - 3 billion	Waksman 1927
Addition to fresh soil of washed susp'n of living bacteria	Resulted in their rapid death	Waksman 1940
Sea water and mud, 30C	25% killed, 10 min.	Zobell 1940
Field soil frozen over 2 mo. developed on albumin agar, 20C	Non-sporulating short rods, non-liquifying or slow liquifying most abundant	Lochhead 1925

TABLE 58 (CONT'D) THE SURVIVAL OF MICROORGANISMS IN SOIL (GENERAL)

Factor(s)	Survival	Reference
<b>GENERAL (cont'd)</b>		
Field soil frozen over 2 mo. developed on albumin agar, 3C	Non-liquifying short rods predominated. No. of col. at 3C 10% of no. at 20C	Lochhead 1925
Aerobes in black mud of "dry estuaries" near Odessa stored since 1901 in sealed tube with CO <sub>2</sub> or H <sub>2</sub>	Inoc. 300,000-400,000/g. of mud, still alive	Rubenchik 1935
Anaerobes as above	Inoc. 64000-72000/g. of mud, still alive	" "
Bacteria activity closely correlated with solar energy as expressed in air, soil temp., & light intensity.		Feher 1930
Soil suppresses growth of microorg. in agar on petri dishes.		Novogroundsky 1948
Influence of pH, water, illumination, and air on microflora.		Bokor 1926
Sterilization of soil and its effect on bacteria.		Hall 1950
Bacteria in polluted soil.		Heiser 1917
Sporebearing bacteria found in soil.		Laubach
Microorg. in soil found in interior of vegetables.		Remlingen 1909
Microorg. in soil.		Rossi 1931
Bacteria salmonicida in river water and silt survives 12 wk.		Slack 1937
Inc. in no. of bacteria in frozen soils is result of breaking up of bacteria clumps rather than actual inc. in nitrifying bacteria.		Bryan 1935
Ordinary soil conditions unfavorable to high antibiotic production as a rule & also to sporulation of molds, inactivating agents are frequent in soil.		Ciferri 1949
CO <sub>2</sub> in soil result of activity of soil microbes. Definite correlation between seasonal changes in soil microbes and CO <sub>2</sub> production. CO <sub>2</sub> content of lower layer of the atmosphere beneath the forest is influenced by soil respiration.		Feher 1938



TABLE 27

## THE SURVIVAL OF MYCOBACTERIUM SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>M. tuberculosis</u>		
Under covering of snow, -10C	6 wk.	Galtier 1887
Soil	3-3½ mo. still virulent	Loesener 1896
Soil, dung and pasture, summer and autumn	Living and virulent at 178 d.	Maddock 1933
Cow's feces exposed on pasture land, 8-7 lb., winter	Recov. 0, 5 mo.	Williams 1930
spring	" " 2 mo.	" "
autumn	" " 4 mo.	" "
summer	" " 2 mo.	" "
Cow's feces, 7-8 lb. exposed on pasture land, protected from sun in summer	4 mo.	" "
protected from earthworms in autumn	6 mo.	" "
Soil, dung and pasture land summer and autumn	2-6 mo.	" "
12 guinea pigs kept outdoors, grazed on infected grass, grass infected 4x one mo. apart	Inoc. 12,000,000 org./sq. ft. of grass; 2 died of pneumonia, 8 out of 10 infected with tuberculosis	Maddock 1934
12 guinea pigs in shed and fed on cut infected grass, 2 oz./pig/day	6 out of 12 contracted tuberculosis	" "
Garden soil & canal liquid <del>manure</del> exposed to noon sun	123 d.	Musehold 1900
Garden soil left & canal liquid manure exposed to weather conditions	148 d.	" "
Garden soil & canal liquid manure exposed to all weather and noon sun	66 d.	" "
<u>M. tuberculosis (bovine)</u>		
Pure culture mixed with cow manure exposed 2" layer in pasture in sunshine	Alive and virulent for 2 mo.	Briscoe 1912
shade	Longer time	" "
garden soil	>213 d. <230 d.	" "
Soil in South of Eng., summer	49 d.	Maddock 1933
Pasture land	Survive well	Williams 1930
<u>M. tuberculosis (avian)</u>		
Toluol sterilized soil	3 mo.	Rhines 1935
Unster. soil	>33 d.	" "
Barn yards	12 mo.	Schalk 1928
<u>M. tuberculosis (cont'd)</u>		
Soil & sewage if properly treated is free of org.		Pramer 1950

TABLE

310

## THE SURVIVAL OF PROTOZOA AND METAZOA IN SOIL

Factor(s)	Survival	Reference
<b>CLAY</b>		
<u>Ascaris lumbricoides</u> Eggs, clay summer temp. on surface in shade in S.W. Va.	2 mo.	Otto 1929
On surface in sun in S.W. Va., summer temp.	Recov. $\frac{1}{4}$ eggs isolated still alive, 160 d.	" "
Soil, sun	71% motile, 21 d.	Brown 1927
" shade	85% " " "	" "
<u>Necator americanus</u> Clay & humus, R.H. 41.4%, tin sleeve containers	Recov. 6%, 9 d.	Payne 1922
<b>LOAM</b>		
<u>Ascaris lumbricoides</u> Human ascaris eggs, sum- mer temp., on surface in shade in S.W. Va.	2 mo.	Otto 1929
On surface in sun, S.W. Va., summer temp.	Recov. $\frac{1}{4}$ eggs, 160 d.	" "
Soil, shade	89.3% motile, 21 d.	Brown 1927
" sun	54% " " "	" "
<u>Necator americanus</u> 5-8 d. old cult. larva, moist clay loam	Inoc. 1,100, Recov. 18, 26 d.	Augustine 1922
5-8 d. old cult. larva, moist clay loam sod	Inoc. 392, Recov. 5, 26 d.	" "
5-8 d. old cult. larva, moist red clay loam	Inoc. 500, Recov. 9, 26 d.	" "
<b>SAND</b>		
<u>Ascaris lumbricoides</u> Human eggs, on surface in shade in S.W. Va., sum- mer temp.	2 mo.	Otto 1929
On surface in sun, S.W. Va., summer temp.	Recov. $\frac{1}{4}$ eggs isolated still alive, 160 d.	" "
Soil, sun	Recov. 0, 21 d.	Brown 1927
" shade	90.8% motile embryos, 35 d.	" "
<u>Necator americanus</u> 5-8 d. old cult., moist sand	Inoc. 498 larva, Recov. 91, 15 d.	Augustine 1922
<u>Trichuris trichiura</u> Soil, shade	74% motile, 35 d.	Brown 1927
<b>GENERAL</b>		
<u>Ascaris lumbricoides</u> Veg. on soils manured with human feces	Found	Heeger 1949
Eggs buried in ground with thin layer, winter	150-180 d.	Yoshida 1920
<u>Endamoeba histolytica</u> Cysts in soil & feces, R.T., & 14C for 4 hr.	8 d.	Beaver 1949
Cysts in soil & feces & water, R.T. 1 hr.	6 d.	" "

Factor(s)	Survival	Reference
<b>GENERAL (cont'd)</b>		
<u>Endamoeba histolytica</u>		
Cysts in soil, feces & water, 14C 12 hr.	4 d.	Beaver 1949
Veg. fertilized by feces	A factor in spread of dysentery as part played by handlers	Winfield 1939
<u>Necator americanus</u>		
Larva in moist soil, outside temp., incubated 6-7 d., left in shade	Few existed at end of 7-9 wk.	Augustine 1923
Larva in moist soil, incubated 6-7 d., outside temp., mod. shade	Almost complete dying out at 5½ wk.	" "
Larva in moist soil, incubated 6-7 d., outside temp., direct sun	1 seen at end of 1 wk.	" "
Dry soil, dense shade	Recov. 0, > 1 mo.	" "
" " mod. shade	Recov. 0, 10 d.	" "
" " direct sun	" " 5 d.	" "
" " 16C	Inoc. 345, Recov. 0, 17½ wk.	" "
" " 20-31C	Inoc. 335, Recov. 0, 7wk	" "
" " 27C	" 341, " " 11 wk.	" "
" " 40C	Recov. 0, 1 wk.	" "
" " 35C	" " 3 "	" "
" " 16C	" " 14 wk.	" "
" " 27C	" " 11 wk.	" "
Soil, favorable conditions	6-12 wk.	Payne 1922
" 35C	3 wk.	" "
" 27C	> 9 wk.	" "
" 15C	10-12 wk.	" "
" 0C	1 wk.	" "
" direct sun	5 d.	" "
"	42-84 d.	Yoshida 1920
Larva in soil and feces, direct sun, no veg.	Inoc. 150, Recov. 0, 6 wk.	Augustine 1923
Larva in soil and feces, direct sun with veg.	Inoc. 4,208, Recov. 32, 6 wk.	" "
Larva in soil and feces, direct sun with veg.	Inoc. 8,160, " 0, 9 wk.	" "
Larva in soil and feces, bright shade, no veg.	Inoc. 98,160, Recov. 16,044; 5½ wk.	" "
Larva in soil and feces, bright shade, no veg.	Inoc. 105,600, Recov. 0, 10 wk. & 2 d.	" "
Larva in soil and feces, light shade, with veg.	Inoc. 30,960, Recov. 12,240; 6 wk.	" "
Larva in soil and feces, light shade, with veg.	Inoc. 36,592, Recov. 60, 9½ wk.	" "
Larva in soil and feces, dense shade, no veg.	Inoc. 9,680; Recov. 2420, 5 wk. & 3 d.	" "

TABLE 510 (CONT'D)

## THE SURVIVAL OF PROTOZOA AND METAZOA IN SOIL

Factor(s)	Survival	Reference
<b>GENERAL (cont'd)</b>		
<u>Necator americanus</u>		
Larva in soil and feces, dense shade, no veg.	Inoc. 48,168; Recov. 0, 9 wk.	Augustine 1923
Larva in soil and feces, dense shade, with veg.	Inoc. 190,120; Recov. 104,360; 5 wk. & 5 d.	" "
Larva in soil and feces, dense shade, with veg.	Inoc. 99,680; Recov. 540, 9 wk. & 2 d.	" "
Soil and feces dil. with water in spring	99% reduc., 8-12 wk.	Cort 1925
Soil and feces dil. with water, summer, 70F	99% reduc., 4-6 wk.	" "
Soil and feces dil. with urine, summer	99% reduc., 2-3 wk.	" "
<u>Eimeria tenella</u>		
Oocysts of E. tenella in soil, direct sunlight	< 1 yr.	Farr 1949
Oocysts of E. tenella in soil, part shade	" " "	" "
Oocysts in soil, deep shade	" " "	" "
Addition of 10% CaO to contaminated soil	Org. still present 12 wk.	Patterson 1933
<u>Eimeria maxima</u>		
Oocysts in soil, direct sun	< 1 yr.	Farr 1949
Oocysts in soil, part shade	" " "	" "
Oocysts in soil, deep shade	" " "	" "
<u>Eimeria acervulina</u>		
Oocysts in soil	86 wk.	" "
<u>Gastrointestinal Nematodes of sheep</u>		
Pasture soil, temp. warm and moist	Good survival	Kates 1950
Pasture soil, cold weather	Highly resistance	" "
Pasture soil, drought and high temp.	Low "	" "
Pasture soil, free living stages, drought high & low temp.	Most resistant to complex climatic conditions	" "
Pasture soil, larva of most common parasites	3-3.5 mo.	" "
1 gm. of field soil	Numerous	Waksman 1927
<u>Toxocara canis</u>		
Soil under snow	Winter mo.	Owen 1930

Factor(s)	Survival	Reference
<b>CLAY</b>		
<u>S. typhosa</u>		
Clay, rainy season	6 wk.	Beard 1937
" dry "	3 "	" "
" "	15 d.	Levy 1903
<b>HUMUS AND GRAVEL</b>		
<u>S. typhosa</u>		
Humus and gravel, RT.	Inoc. 24 hr. bouillon cult., 9-16 mo.	Rullmann 1901
<b>LOAM</b>		
<u>S. typhosa</u>		
Loam	49 d.	Beard 1940
" , rain	120 d.	" "
Sandy loam with raw sewage	Recov. 0, 5 d.	Mallmann 1951
Clayloam	" " 12 d.	" "
<b>MUD</b>		
<u>S. typhosa</u>		
Mud at bottom of aquarium	2 mo.	Hoffmann 1926
Tidal mud	5 wk.	Savage 1905
<u>S. typhimurium</u>		
Mud in infected water, outside temp.	Demonstrable 22 d.	Bartos 1947
<b>PEAT</b>		
<u>S. typhosa</u>		
Stock cult. and dry peat, at 51F. max. 56F and min. 37F	>13 d.	Firth 1902
<u>S. spp.</u>		
Peat, pH 3-4	Low survival	Beard 1940
Peat	24 hr.	Dempster 1894
" , dry or wet or moist	20-30 d.	Hanne 1932
Pure peat	24 hr.	Martin 1898
Peat with sewage, 52-78F	11 d.	Firth 1902
<b>SAND</b>		
<u>S. typhosa</u>		
Fine sand with dil. raw sewage, 33F-54F	Inoc. stock cult., 6 d.	Firth 1902
Fine sand with dil. raw sewage, 55F-75F	" enteric stool cult. 13 d.	" "
Sand	4-7 d.	Beard 1940
Dry sand, 53-83F	>25 d.	Firth 1902
Fine sand, moist	>12 d.	" "
White sand	70 d.	Dempster 1894
Sand with sewage	Recov. 1.336, 33 d.	Mallmann 1951
Ster. sand	55 d.	Murillo 1919
Filtered sand	82 d.	Osler 1901
Ster. sand, filtered, 1400 air dried after 36 hr. 4 min. water susp'n	Viable 82 d.	Uffelmann 1894
<b>GENERAL</b>		
<u>S. typhosa</u>		
Soil, freezing temp	<12 mo.	Beard 1940

TABLE 54 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<b>S. typhosa</b>		
Soil moistened with sewage, 33.2-83F	Inoc. Stock cult., 74 d.	Firth 1902
Soil around drain moistened with sewage, 14.3-58.8F	" " " 65 d.	" "
Soil around leaking drain moistened with sewage, 40-81F	" Stool cult., 53 d.	" "
Soil with sewage kept in a closed box, 19.6-59.2F	" " " 45 d.	" "
Stool of carrier mixed with garden soil	< 7 d.	Horrocks 1911
Ster. feces, infected soil R.T.	Inoc, 1 cc 24 hr. bouillon cult., Viable 1 yr.	Rullmann 1901
Unster. feces, infected soil, R.T.	Inoc. 1cc 24 hr. bouillon cult., Viable 100d.	" "
Soil	50% in 48 hr.	Beard 1940
Moist soil, freezing temp.	24 mo.	" "
" " " and refreezing	99% reduc. in 18 mo.	" "
Moist soil with rain added, 16.2-57F	55 d.	Firth 1902
Soil and rain, 14.8-54.3F	44 d.	" "
" " " 34-62F	32 d.	" "
Surface soil, 122 hr. sunshine	22 d.	" "
Soil	5 1/2 mo.	Grancher 1889
Garden earth	10-21 d.	Dempster 1894
Natural soil	3 mo.	Karlinski 1889
Soil, dry	12-30 d.	Kligler 1921
" wet	40-90 d.	" "
Unster. soil	42-74 d.	Mair 1908
Ster. " "	9 d.	" "
Natural soil	Small no. 70-80 d.	" "
" " "	Large " 20 d.	" "
Soil enclosed by grass & moisture added	84 d.	" "
Garden soil	>36 d.	Murillo 1919
Soil, freezing temp.	Decreases viability	Robertson 1898
" " , unster.	Low temp, moisture, inc. viability	Rudolfs 1950
" " "	>100 d.	Rullmann 1901
Polluted soil, ster.	>16 mo.	" "
Garden earth	21 d.	Osler 1901
Ster. soil	Inoc. broth cult., 216 d.	Rullmann 1901
Soil filtrate, dark	Inoc. 7000/ml., Recov. 1100/ml., 5 d.	Ruys 1941
Dry soil	>2 wk.	Sedgwick 1902
Natural soil	21 d.	Smith 1903
Dry soil	8 d.	Tanner 1944
Moist soil	>60 d.	" "

TABLE 511 (CONT'D)

## THE SURVIVAL OF SALMONELLA SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>GENERAL</b>		
<u>S. typhosa</u>		
Ster. garden soil, 140C, air dried after wetting with susp'n of typhosa	Viable 21 d.	Uffelmann 1894
Upper soil layers	6 mo.	McFarland
Soil natural or ster.	Short time	Smith 1904
" with carrier urine, allowed to dry at lab. temp.	Inoc. 12000/gm, Recov. 330/gm, 7 d.	Horrocks 1911
Humus from garden soil with carrier urine, exposed to weather without rain	Inoc. 1600/gm, Recov. 280/gm, 10 d.	" "
Soil	Found on veg in soil	Melick 1917
<u>S. paratyphi A &amp; B</u>		
Dry soil	8 d.	Tanner 1944
Moist soil	> 60 d.	" "
<u>S. enteritidis</u>		
Soil	Short time	Smith 1904
<u>S. pullorum</u>		
Soil, pH 7.0	> 64 d.	Sanyal 1941
<u>S. gallinarum</u>		
Soil, pH 6.2-6.4	1 wk.	Sanyal 1941
" " 6.7-7.0	40-70 d.	" "
<u>S. spp.</u>		
Tomatoes grown on fertilized soil	< 7 d.	Falk 1949
Soil and feces (enteric stool) 38-79F	53 d.	Firth 1902
Damp soil with raw sewage	35 d.	" "
Moss	404 d.	Martin 1898
Ster. soil	Death more rapid	" "
Dry soil	Inoc. agar & 3 drops feces susp'n, Viable 28 d.	Pfuhl 1902
Wet garden earth, 1 $\frac{1}{2}$ -21C	Inoc. agar and feces, viable 3 mo.	" "
Soil from 1 summer to another	Sunlight kills org. on surf. < 1/10 inch deep still alive	Robertson 1898
Tomatoes growing in field fecal matter applied	7 d.	Rudolfs 1951

TABLE

## THE SURVIVAL OF SHIGELLA SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>SAND</b>		
<u>S. dysenteriae</u>		
Sand, heated room	Viable 12 d.	Pfuhl 1902
<b>GENERAL</b>		
<u>S. dysenteriae</u>		
Feces and earth, 1.5-15C	>101 d.	Hampil 1932
Earth and water, 5-6C	Growth inhibited	Hampil 1932
Dry soil	12-30 d.	Kligler 1921
Wet "	40-90 d.	" "
Wet garden earth, 1½-21C	Viable 101 d.	Pfuhl 1902
Feces applied to tomatoes growing in field	7 d.	Rudolfs 1951
Garden soil	6-49 d.	Vincent 1917
Soil	6-15 d.	Zinsser 1939
Rich garden soil	No survival time	Felsen 1945
<u>S. paradysenteriae (Flexner)</u>		
Series of trenches at 1, 2, 3, 4, 5, & 6 ft. levels	Inoc. 25 cc. 10 day broth cult., < 1 yr.	" "
Rich garden soil	No survival time	" "



TABLE 513

## THE SURVIVAL OF STREPTOCOCCUS SPECIES IN SOIL

Factor(s)	Survival	Reference
<b>LOAM</b>		
<u>S. faecalis</u> Loam	Recov. 6.4 logs/100gm., 0 wk.	Mallmann 1951
"	Recov. 0.7 " " " 11 wk.	" "
<u>S. spp.</u> Loam (Isabella)	Inoc. 5.9 logs/100gm., Recov. 0.8 logs/100 gm., 9 wk.	" "
" (Fox Sandy)	Inoc. 5.2 logs/100 gm., Recov. 2 logs/100 gm., 5 wk.	" "
" (Brookston clay)	Inoc. 5.6 logs/100 gm., Recov. 0.8 logs/100 gm., 7 wk.	" "
Muck	Inoc. 5.9 logs/100 gm., Recov. 0.6 logs/100 gm., 11 wk.	" "
Dried Miami sandy loam, 1 treatment raw sewage & S. typhosa	Inoc. 5.5 logs/100gm., Recov. 3.7 logs/100gm., 26 d.	" "
Dried Brookston clay loam, 1 treatment raw sewage & S. typhosa	Inoc. 5.7 logs/100 gm., Recov. 2.9 logs/100gm, 33 d.	" "
Dried muck, 1 treatment raw sewage & S. typhosa	Inoc. 7.0 logs/100 gm., Recov. 1.4 lgos/100gm., 40 d.	" "
<b>SAND</b>		
<u>S. pyogenes</u> Sand	53 d.	Laurell 1949
<u>S. spp.</u> 10 gm. of sand	Inoc. 2cc. broth cult., 66 d.	Bryan 1934
" " " "	Inoc. 2cc. nutrient susp. 66 d.	" "
Oshtemo sand	Inoc. 4.6 logs/100 gm., 5 wk.-0.9 " " "	Mallmann 1951
Dried Oshtemo sand, 1 treatment of sewage & S. typhosa	Inoc. 5.0 logs/100 gm., Recov. 1.3 logs/100 gm., 33 d.	" "
<b>GENERAL</b>		
<u>S. faecalis</u> Soil	Found	Winter 1946
<u>S. pyogenes</u> Soil, R. T.	53 d.	Laurell 1949
<u>S. spp.</u> Soil fertilized with chicken manure, 72C	Inoc. $10^{-2}$ , Recov. $10^{-1}$ dil/g., 21 d.	Ostrolenk 1947
Soil fertilized with chicken manure, R.T.	Inoc. $10^{-5}$ , Recov. $10^{-2}$ dil/g., 160 d.	" "

TABLE 513 (CONT'D)

## THE SURVIVAL OF STREPTOCOCCUS SPECIES IN SOIL

Factor(s)	Survival	Reference	
GENERAL (cont'd)			
<u>S. spp.</u>			
10 gm. soil	Inoc. 2cc. broth cult., 12 d.	Bryan	1934
10 gm. soil	Inoc. 2cc. nutrient free susp'n, 10 d.	"	"
Unster. soil, R.T.	Inoc. $10^{-1}$ , Recov. 1 gm, 109 d.	Ostrolenk	1947
Unster. " ice box	Inoc. $10^{-1}$ , Recov. $10^{-2}$ , 123 d.	"	"
Soil with pecans artif. infect.	Inoc. $10^{-4}$ , Recov. $10^{-1}$ , 160 d.	"	"

TABLE S 14

THE SURVIVAL OF VIRUSES IN SOIL

Factor(s)	Survival	Reference
<b>SAND</b>		
<u>Foot &amp; mouth virus</u>		
Sand, 62F, R.H. 52%	14 d.	Burbury 1928
<b>GENERAL</b>		
<u>Newcastle virus</u>		
Soil, 37C, pH 5.2	Inoc. 1 ml., 25 d.	Olesuik 1951
" 20-30C, pH 4.9	" " " 71 d.	" "
" 11-36C, pH 4.9	" " " 172 d.	" "
" 3-6C, pH 4.9	" " " 235 d.	" "
" -26C, " "	" " " 538 d.	" "
Soil in chicken pens	1 mo.	Levine 1950
<u>Bacteriophage</u>		
S. typhosa phage in soil	Present	Pasricha 1941
3 ft. deep		

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
.	none
-	minus

THE PERSISTENCE (SURVIVAL) OF ORGANISMS ON SURFACES

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TABLE Lu

## THE SURVIVAL OF BACILLUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>B. megatherium</u> Evidence of transport of spores during dust storm	-----	Soule 1934
<b>FABRIC</b>		
<u>B. anthracis</u> Silk threads, spores	> 20 hrs.	Ficker 1898
" " " non-spores.	Dead in few hrs.	
Dry sterile canvas, room temp., diffuse sunlight, dry atm., spores.	> 10-22 1/2 yrs.	Graham 1941
Dry sterile canvas in envelopes, spores.	Much > 34 yrs.	" "
Wool, 80 C., mat'l shaken with sev. vol. st. salt sol.	30 minutes	Mackie 1934
Diseased cow blood dried on gauze, diffuse sunlight, spores.	40 years	McCulloch 1945
<u>B. spp. (aerobic)</u> Burlap strips, 200-280 F. 5-9 min., spores.	Yielded growth	Jungherr 1950
<b>GLASS</b>		
<u>B. anthracis</u> Glass rod, 37 C., Flamed with 95% alc., 10 sec., 3 day old agar culture; 6 day old bowl, cult.:	Viable 2 days 33 days	Mayser 1925
Porcelain dish, 12 cm. dia., 37 C., burned with alcohol 1 min, 3 day agar culture.	None recovered	" "
Porcelain saucer, 37 C., burned with alc., 6 day culture.	None recovered	" "
Shaving mug.	Two years	Vincent 1922
Glass slides, blood, slowly dried in moist air at R.T., stored in dry air at R.T..	Survived 60-90 das.	Minett 1950
Glass slide, dried, 56 C. 100 C., and 80 C..	Few days	Thurn 1914
<b>PAPER</b>		
<u>B. anthracis</u> Paper-slips, spores, sunlight.	8 hrs.	Weinzirl 1914
<u>B. subtilus</u> Paper-slips, sterile in petri plates, sunlight, spores.	8 hrs.	" "
<b>GENERAL</b>		
<u>B. anthracis</u> Match head, 37 C., spores 95% alc. 3 da. cult.	Viable 2 das.	Mayser 1925

TABLE 41 (CONT'D) THE SURVIVAL OF BACILLUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>GENERAL (CONT'D)</b>		
Spores, R.T., dry-diffuse daylight.	50% germinated in a few mos.; large no. of remaining 50% capable of germination for 10 years; All dead in 23 yrs.	Smith 1930
Shaving brushes, 80 C. Brass wire, 5 cm., heated 37 C., flamed 95% alc., 3 day old agar culture.	30 minutes Viable 9 days.	Mackie 1934 Mayser 1925
Shaving brushes	7.3% contained virulent anthrax bacilli	Symmers 1921
<b><u>B. subtilis</u></b>		
Catgut sutures, alcohol, toluol.	>17 days	Hite 1938
Metal, bullet lodged in flesh of soldier	>2 mos.	Pulvertaft 1929
Few viable one present on and use of high pressure	surfaces after cleaning steam.	Peabody 1951
Hand telephones,	93.79% organisms	Smeall 1937
Tele phones with separate receiver and transmitter	92.59%	" "



TABLE 42

THE SURVIVAL OF BRUCELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>B. melitensis</u> Dry dust of Malta Dry sterile dust Dust Favorable conditions	20-28 days 20 days 44 days 6 weeks	Horrocks 1906 " " Kennedy 1905 Bang 1897
<b>FABRICS</b>		
<u>B. abortus</u> Burlap bag, dried in Burlap sacking, dried in, unheated cellar	5 days 30 days	Cameron 1932 " "
<u>B. melitensis</u> Cloth, dried on	17 days	Kennedy 1905
<u>B. suis</u> Sacking	4 weeks	Anon. 1933
<u>B. spp.</u> Wool, washed with water over 55 C., dried at 75- 80 C. or heated 30 min. at 105-111 C.	-----	Cherkasskii 1938
<b>GLASS</b>		
<u>B. abortus</u> Glass, dried on	Survival several days	Cameron 1932

TABLE Su 3

## THE SURVIVAL OF CLOSTRIDIUM SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>FABRIC</b>		
<u>Cl. tetani</u> Bandages, 200 C., heated in hot air oven	Recovered 0, 1 hr.	Murray 1949
Silk strips spores dried on, light, room temp.	Still viable, 3 1/2 mos.	Tizzoni 1891
<u>Cl. welchii</u> Cotton-wool swabs, 16- 20 C., plain dry	5-20 col. at 24 hrs.	Rubbo 1951
plain moist	5-20 col. at 8 hrs.	
serum dry	20-50 col. at 24 hrs.	
serum moist	20-50 col. at 24 hrs.	
<b>GENERAL</b>		
<u>Cl. tetani</u> Stored in rubber-capped test tube in cupboards, rusty metal, room temp., Tetanus spores	18 years  Remain viable at the site of inoculation for as long as 6 months	Semple 1911  " "
Talcum powder, 20 lbs. in autoclave	Survived	Sevitt 1949
<u>Cl. sporogenes</u> Catgut sutures, exposure to both alcohol and toluol	> 17 days	Hite 1938

TABLE 4

THE SURVIVAL OF COLIFORM SPECIES ON SURFACES

Factor (s)	Survival	Reference
<b>FABRICS</b>		
<u>Escherichia coli</u> Cotton-woolweb, 16-28 C., plain, dry plain, moist serum, dry serum, moist	No growth 8 hrs. 50-200 col. at 24 hrs. 20-50 col. at 48 hrs. 50-200 col. at 48 hrs.	Rubbo 1951 " " " " " "
<u>E. coli</u> (with Hem. strep. <u>Sarc. flava</u> , and <u>S. aureus</u> ) Blankets (47), sucked from, on E.N.T. ward.	14,400-7,344,000 per cu. ft. air.	Rountree 1946
<u>Klebsiella pneumoniae</u> Cotton-woolweb, 16-28 C., plain, dry plain, moist serum, dry serum, moist	No growth 8 hrs. 50-200 col. at 24 hrs. 20-50 col. at 48 hrs. 50-200 col. at 48 hrs.	Rubbo 1951 " " " " " "
<b>GLASS</b>		
<u>E. coli</u> Glass cover slips, air- dried, dark, vacuum, dried at -195 C..	Recovered 0 in 4 days	Shattock 1912
Ozone to sterilize the air in small room, temp. 15- 16, humidity 60, cultures exposed and dried on pieces of glass for 9 hrs	No killing or inhibi- tion of the bacteria was obtained	Galli 1914
Ground glass Glass, sunlight Glass, 37 C., Inoc. at 30 sec. 107,000	Killed in 10 min. 2 minutes Recovered 0 at 15 min.	Rebell 1950 Weinzirl 1907 Bryan 1933
<u>E. coli communis</u> Dessicator, 16-18 C., Room Temperature Moist chamber	60 days 32.5 days 98 days	Buckley 1906 " " " "
<b>PAPER</b>		
<u>E. coli</u> Filter paper, dipped in culture, dried over sul- furic acid; dried in vacuum;	Recov. 0, 1, 10 and 25 col. in 17 hrs.	Walliczek 1894 " " " "
dried in air. Filter paper, dried from peptone salt, 24 hr. cult	Recov. 28, 45, 78, and >1,000 col. in 45 min. 0 recovered in 18 hrs. <28 hrs.	" " " " Chick 1900
Filter paper, stool dried on, dark	45 days	Dold & Ketterer 1944
Filter paper, watery stool Paper, 28 C., dried Paper, sunlight	143 days 77 days Longer if in clumps 2-10 minutes	" " Kusuma 1925 Weinzirl 1907

TABLE 4 (CONT'D) THE SURVIVAL OF COLIFORM SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>PAPER (CONT'D)</b>		
<u>E. coli</u> Filter paper, moist, Inoc. 251,000 at 30 sec.	149,000 in 15 minutes	Bryan 1933
<u>E. coli communis</u> Paper, dessicator, 16-18 C. Paper, room temperature Moist chambers, paper	21 days 7.5 days 47.5 days	Buckley 1906
<u>Colon-aerogenes spp.</u> Filter paper, 24 hr. agar cult., dry incubator at 37 C. Paper infected with milk cultures	31 days 96 days	Hastings 1923 " "
<u>General</u> Coliform group destroyed in drying process of paper production		Appling 1945
<b>PLASTER</b>		
<u>E. coli communis</u> Dessicator 16-18 C. Room temperature Moist chamber	84.5 days 84 days 168 days	Buckley 1906
<b>UTENSILS</b>		
<u>Colon-aerogenes spp.</u> Kitchen utensils, 91-100 C. Kitchen utensils, 41-60 C. colony count at 48 hrs. Kitchen utensils, 61-80 C. colony count at 48 hrs.	Effective in destroying colon-aerogenes group 41 colonies 19 colonies	Sellers 1944 " "
<b>WOOD</b>		
<u>E. coli</u> Stumps, feces on, blizzard, inoc. 532,000/gm.; Spring, Inoc. 11,800/gm.; Warm season, Winter, pure cult., inoc. 323,000/gm. 307,000/gm Spring, pure culture	0 recovered in 18 days 0 recovered, 153 days 172 days 0 recovered, 22 days 0 recovered, 9 days 228 days	Tonney 1931 " " " " "
<u>E. coli communis</u> Dessicator, 16-18 C. Cotton wood Lime wood Pine wood Room temperature Cotton wood Lime wood Pine wood Moist chamber Cotton wood Lime wood Pine wood	49 days 86 days 22 days 64 days 80 days 14 days 53 days 168 days 78 days	Buckley 1906 " "

TABLE 4 (CONT'D) THE SURVIVAL OF COLIFORM SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>WOOD (CONT'D)</b>		
<u>Aerobacter aerogenes</u>		
Stumps, pure culture on,	0 recovered, 22 days	Tonney 1931
Winter, inoc. 708,000/gm.	0 recovered, 9 days	" "
456,000/gm.	228 days	" "
Spring, pure culture		
<b>GENERAL</b>		
<u>E. coli</u>		
Ultra-violet, low humidity	Bactericidal action is greatest.	Elford 1942
Ultra-violet, 45% R.H.	Almost 10 times as lethal as at 90% R.H.	" "
Doorknob, brass	Recov. positive, 12 hrs	Frank 1943
Doorknob, white bronze	Recov. 0, 24 hrs.	" "
Stuffing boxes of pumps,	Recov. positive, 48 hrs.	" "
lub. grease	Abundance of growth	Frantsev 1935
Water filter, after water	24-36 hrs.	Gage 1903
stopped	4-6 days	" "
Continuous filter	-----	Tenaka 1931
Action of metal salts,		
gold colloids, ferric		
chloride, silver nitrate,		
zinc chloride and others		
at varying dilutions		

TABLE 45

## THE SURVIVAL OF CORYNEBACTERIUM SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>C. diphtheriae</u> Brick dust, 37 C., bacilli culture, air dried, dried with sulfuric acid	Kept full virulence during drying up period until death. 5184 col., 12 days 1728 col., 12 days	Germano 1897 " "
<u>C. diphtheriae gravis</u> Present in dust Dust, recov. with unimpaired toxicity Sawdust, mitis, gravis, and intermedius recov. with unimpaired toxicity Occurrence in air and dust	175 days 175 days <1 day -----	Laurell 1949 Ouchterlony 1949 " " Trevelyan 1898
<b>FABRICS</b>		
<u>C. diphtheriae</u> Silk, dried on, R.T. Silk, dried on, dark. Cloth, old dried out cult. Silk thread, -23 1/2 to 12 1/2 C., 2-4 da. old culture. Strain I; Control, R.T., Strain I. Silk thread, strain II; control Silk thread, strain III; control Cloth, <u>gravis</u> strain, R.T. dried  Linen-- <u>mitis</u> ; cotton-- <u>gravis</u> and <u>inter.</u> ; wool-- <u>gravis</u> and <u>inter.</u> Dry towelling Cotton-wool swab, 16-22 C. <u>gravis</u> , plain dry plain moist serum dry serum moist Cotton swab, sterile, 37 C. 1 loop 24 hr. cult, with sterile horse serum; without horse serum; Cotton plugs (40), R.T., in dark, placed on horse serum agar Linen Cotton Wool Occurrence on clothes.	3-14 weeks Still alive 189 days 3-3 1/2 mos. Recovered no growth in 68 days No growth 74 days No growth 61 days No growth 86 days No growth 61 days No growth 86 days Recovered mostly with unimpaired toxicity > 145 days Recovered mostly with unimpaired toxicity > 98 days Alive at end of 48 hrs. 5-20 col. at 4 <sup>h</sup> hrs. 5-20 col. at 8 hrs. 50-200 col. at 4 <sup>h</sup> hrs. 50-200 col. at 48 hrs. Still alive at 24 hrs. Most dead at 1 hr. 7 plugs were negative 33 plugs positive in 24 hrs. 15 days 15 days 25 days -----	Abel 1893 " " Abel 1895 " " " " Ouchterlony 1949 " " Pease 1930 Rubbo 1951 " " Van Reim- 1924 sdiijk " " " Lomry 1929 " " Trevelyan 1898

TABLE 45 (CONT'D) THE SURVIVAL OF CORYNEBACTERIUM SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>GLASS</b>		
<u>C. diphtheriae</u> Dessicator 16-18 C., Room temperature, Moist chambers .	68 days 24 days 51.5 days	Buckley 1906
Petri dishes, empty, sterile R.T.	24-48 hrs.	Kirstein 1902
Glass, dried, virulent strain 1 billion/cc, 37 C.	37 days	Ross 1945
Glass, <u>intermedius</u> strain	Recovered mostly with unimpaired toxicity > 98 days	Ouchterlony 1949
Slides, sterile, 37 C.	3 days	Teague 1913
Glass, sunlight	2 min.	Weinzirl 1907
<b>PAPER</b>		
<u>C. diphtheriae</u> Dessicator 16-18 C., room temperature., moist chambers	21 days 6 days 15 days	Buckley 1906 " "
Paper, <u>gravis</u> strain	Recovered mostly with unimpaired toxicity 159 days	Ouchterlony 1949
Paper, sunlight	Longer if in clumps, 2-10 minutes	Weinzirl 1907
<b>PLASTER</b>		
<u>C. diphtheriae</u> Dessicator 16-18 C. Room temperature Moist chambers	73 days 37.5 days 75 days	Buckley 1906
<b>UTENSILS</b>		
<u>C. diphtheriae</u> Metallic blades, 60-80 F.	86 days	Ecklund 1932
<b>WOOD</b>		
<u>C. diphtheriae</u> Oak Beech Resins	8 days 8 days 8 days	Lomry 1929
Dessication, 16-18 C. Cotton wood Lime wood Pine wood	88.5 days 77 days 20 days	Buckley 1906
Room temperature Cotton wood Lime wood Pine wood	24 days 41 days 8.5 days	" "
Moist chamber Cotton wood Lime wood Pine wood	17.5 days 75 days 7 days	" "
<b>GENERAL</b>		
<u>C. spp.</u> Hand telephones Telephone with separate receiver & transmitter	14.58 % diphtheroids 11.10 % diphtheroids	Smeall 1937 " "

TABLE Lu 6THE SURVIVAL OF DIPLOCOCCUS  
PNEUMONIAE ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
Dried cultures mixed with sterile dust; at 0 C.	2 days 8 days	Germano 1897
<b>FABRICS</b>		
Type I (smooth Dried rabbit blood on gauze, dark 40 F., ice box, dark	2 mos. 9 mos.	Stillman 1940
Type I (rough Gauze, 80 F., daylight Gauze, 80 F., dark Gauze, 40 F., dark	Viable 10 mos. Viable 15 mos. 9 mos.	" "
Type II (smooth Gauze, rabbit blood dried, 80 F., daylight and dark 40 F., in icebox, dark	2 mos. 12 mos.	" "
Type II (rough Gauze, 80 F., daylight dark Gauze, icebox, 40 F., dark Dry towelling, including turkish towel	9 mos. 13 mos. 8 mos. Alive at end of 24 hrs.	Pease 1930
Type III (smooth Gauze, daylight, 80 F. Gauze, dark, 80 F. Gauze, 40 F. icebox, dark	5 mos. 11 mos. 12 mos.	Stillman 1940
Type III (rough Gauze, 80 F., daylight Gauze, 80 F., dark Gauze, icebox, 40 F., dark	7 mos. 9 mos. 9 mos.	" "
Type III Cotton wool swab, plain dry plain, moist serum, dry serum, moist	5-20 col. at 8 hrs. 5-20 col. at 8 hrs. 5-20 col. at 48 hrs. 20-50 col. at 24 hrs.	Rubbo 1951
Pneumococci life slightly longer on cloth than on non-absorbing surfaces		Wood 1905
<b>GLASS</b>		
Type I (smooth Glass, dried rabbit blood, 80 F., daylight 40 F., icebox, dark	1 mo. 12 mos.	Stillman 1940
Type I (rough Glass, 80 F., daylight dark Glass, 40 F., dark	Viable 10 mos. " 11 mos. " 15 mos.	" "
Type II (smooth Glass, dried rabbit blood, 80 F., daylight and dark 40 F., dark	2 mos. 12 mos.	



TABLE Sub (CONT'D) THE SURVIVAL OF DIPLOCOCCUS PNEUMONIAE ON SURFACES

Factor(s)	Survival	Reference
GLASS		
Type II(rough Glass, 80 F., daylight dark 40 F., dark	3 mos. 9 mos. 9 mos.	Stillman 1940
Type III(smooth Glass, dried rabbit blood, 80 F., daylight 80 F., dark 40 F., dark	5 mos. 7 mos. 13 mos.	Stillman 1940
Type III(rough 80 F., daylight 80 F., dark 40 F., dark	0 mos. 1 mo. 7 mos.	" "
Diplococcus--at this age no known difference between meningococci and pneumo- cocci. Dried rabbit blood on watch glass	>45 days	Foa 1888

TABLE Lu 7THE SURVIVAL OF MICROCOCCUS  
SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS</b>		
<u>M. pyogenes</u>		
Burlap strips	14 days--test negative	Jungherr 1950
Garments, dried on, liquid air	Several mos., no change in resistance	Paul 1907
<u>M. pyogenes var. aureus</u>		
Cotton-wool swab, plain dry;	20-50 cols. at 48 hrs.	Rubbo 1951
plain, moist;	20-50 cols. at 24 hrs.	
serum, dry;	50-200 cols. at 48 hrs.	
serum, moist.	50-200 cols. at 48 hrs.	
Handkerchief, nasal secretions, dried	>1 mo.	Duguid 1948
Handkerchief, sterile, dark, R.T., single nose blow	1 mo.	" "
Handkerchiefs, disinfected with various % of various disinfectants, inoc. with org., remained overnight at 70 F., cultured	3.0% to 39 % survivors	Dumbell 1949
Cotton squares, treated as above, wider range of conc. of disinfectants	0.2% to 100% survivors	" "
Blankets(47), ENT ward, hemolytic strep., <u>Sarc. flava</u> , <u>E.coli</u> , <u>Staph aur.</u>	14,400-7,344,000/cu.ft. of air.	Rountree 1946
<u>M. pyogenes var. albus</u>		
Woolen serge, aqueous susp. 0.44 ppm. zone, R.H. 70%, 20 C, exposed 90 min.	54% killed	Elford 1942
Woolen serge, serum broth, 0.5ppm. zone, R.H. 70%, 21 C., exposed 30 min.	Nil	" "
<b>GLASS</b>		
<u>M. pyogenes var. aureus</u>		
Glass, dessicator, 16-18 C.	90 days	Buckley 1906
Glass, room air	53 days	
Glass, moist chamber	74 days	
Petri dishes, empty, steril R.T..	8-10 days	Kirstein 1902
Glass cover slips, dried at -195 C., kept in vacuum	4-15 weeks	Shattock 1912
Glass cover slips, air dried	16-22 days, dead on 40	" "
Glass slides, dried	Few days	Thurn 1914
Glass, 37 C., innoc. 225,000.	Recovered 97,000, 15 min	Bryan 1933

TABLE 2

## THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>GLASS (CONT'D)</b>		
<u>M. pyogenes var. aureus</u> Sterile dishes, put into machine with soiled dishes		Ward 1937
0.3% calgonite		
% sterile after wash	10 %	" "
% sterile after 1st rinse	15 %	" "
% sterile after 2nd rinse	32 %	" "
Average no. of bacteria/dish remaining contaminated after wash	14	" "
after 1st rinse	4	" "
after 2nd rinse	6	" "
Max. no. of bact./dish remaining contaminated wash	14	" "
1st rinse	4	" "
2nd rinse	6	" "
Soiled dishes, % sterile after wash in machine	10%	" "
after 1st rinse	16-30 %	" "
after 2nd rinse	12-28 %	" "
Glass, 20 and 9-12 C., inoc. 300,000/0.1cc in a 24 hr. cult., dark	Recovered almost 100% in 48 hrs.	Lehmann 1931
<u>M. pyogenes var. albus</u> Glass, aqueous susp'n, 0.44 ppm ozone, R.H. 70%, 20 C., exposed 90 min.	> 99% killed	Elford 1942
Glass, serum broth R.H. 70%, 0.5ppm ozone, 21 C., exposed 30 min.	Nil	" "
Glass, etc. exposed to ozone, 15-16 C., R.H. 60%, dried for 5, 6, 9 hrs.	No killing or inhibition of the bacteria was obtained	Galli-Valerio 1914
<u>M. pyogenes (Gen'l)</u> Slides, sterile, 37 C., innoc. innumerable cols.	Recovered 41 col., in 7 days	Teague 1913
Glass, direct sunlight	60-90-minutes	Weinzirl 1907
Glass, direct sunlight	10 min.	Weinzirl 1907
<b>PAPER</b>		
<u>M. pyogenes var. aureus</u> Paper, dessicator, 16-18C	66 days	Buckley 1906
Paper, room air	70 days	" "
Paper, moist chamber	51 days	" "
Filter paper, test org.	Survived longer on skin than on filter paper	Hellot 1948
Paper, surface, agar plates, inoc. 1800; inoc. 900.	Recovered 400, 3 min. Recovered 46, 3 min.	Norton 1932 " "
Filter paper, moist, 37 C., inoc. 173,000	Recovered 170,000 15 min.	Bryan 1933

TABLE Lu 2 (CONT'D)

## THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>PAPER (CONT'D)</b>		
<u>M. pyogenes var. albus</u> Filter paper, aqueous susp'n, 0.44 ppm ozone, R.H. 70%, 20 C., exposed 90 min.	80% killed	Elford 1943
Filter paper, serum broth 0.5 ppm ozone, R.H. 70%, 21 C., exposed 30 min	Nil	" "
<u>M. pyogenes</u> Paper, sunlight	71 hrs.	Weinzirl 1907
<b>PLASTER</b>		
<u>M. pyogenes var. albus</u> Plaster, desiccator, 16- 18 C., room air, moist chamber.	100 days 100 days 38 days	Buckley 1906
<b>RUBBER</b>		
<u>M. pyogenes var. aureus</u> Rubber sheet, susp'n con- taining 2568 org., ex- posed 7 minutes.	807 washed off	Burtenshaw 1938
Rubber sheet, susp'n of 2568 org., exposed 90 minutes.	247 washed off	" "
Rubber sheet, susp'n of 3459.2 org., exposed 6 minutes.	923.6 washed off	" "
Rubber sheet, susp'n of 3459.2 org., exposed 92 min.	192.4 washed off	" "
<b>UTENSILS</b>		
<u>M. pyogenes var. aureus</u> Glazed porcelain dishes, cold water without serum	34 colonies--1 hr. 198 " " --3 hrs. 29,000 colonies--5 hrs.	Blumenberg 1927
With serum	514 colonies--1 hr. 3,500 col.--3 hrs. 100,000 col.--5 hrs.	" "
Unglazed chinaware, 37 C., rinsed in warm flowing water, with serum	1300 cols. --1 hr. 25,000 cols.--3 hrs. >1 Million cols.--5 hrs.	" "
without serum	51 cols.--1 hr. 640 cols.--3 hr. >300,000 cols.--5 hrs.	" "
Glazed china, without serum	6 cols.--1 hr. 44 cols.--3 hr. 5000 cols.--5 hrs.	" "

TABLE Lu 7 (CONT'D)

## THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>UTENSILS (CONT'D)</b>		
<u>M. pyogenes var. aureus</u> Glazed china, rinsed with warm flowing water, 37 C. with serum	78 cols.-- 1 hr. 820 cols.-- 3 hrs. 38,000 cols.-- 5 hrs.	Blumenberg 1937
Glazed china, rinsed in warm flowing 2% soda sol'n, without serum; with serum	2 cols.-- 1 hr. 12 cols.-- 3 hrs. 311 cols.-- 5 hrs. 13 cols.-- 1 hr. 90 cols.-- 3 hrs. 1640 cols.-- 5 hrs.	" "
Unglazed china, rinsed in warm flowing 2% soda sol't, 37 C. with serum	1090 cols.-- 1 hr. 3200 cols.-- 3 hrs. 7,300,000 cols.-- 5 hrs.	" "
without serum	10 cols.-- 1 hr. 176 cols.-- 3 hrs. 16,600 cols.-- 5 hrs.	" "
Knife blade, 60-80 F. Food utensils, large collection, washed	12 wks. & 2 das. (86 da)	Ecklund 1932
	3-12 % recovery	Hutchinson 1947
<b>WOOD</b>		
<u>M. pyogenes var. aureus</u> Dessicator, 16-18 C. lime wood pine wood cotton wood	126 days 64 days 130 days	Buckley 1906
Room air lime wood pine wood cotton wood	126 days 39 days 122 days	" "
Moist chamber lime wood pine wood cotton wood	100 days 35 days 38 days	" "
<b>GENERAL</b>		
<u>M. pyogenes var. aureus</u> Tinfoil, susp'n containing 2568 orgs. exposed 11 min; Same susp'n at 100 min. Tinfoil, susp'n containing 3459.2 orgs., exposed 8 min. Same susp'n at 96 min. Smooth surfaces, ultra-violet, 2,000-2,950 Å units	973.4 washed off 194.7 washed off  1011.2 washed off 316 <del>washed off</del> Effect reduced counts	Burtenshaw 1938  " "
Hand telephone Telephone with separate receiver and transmitter	4.17 % 3.7%	Smeall 1937 " "

TABLE 27 (CONT'D)

## THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
GENERAL (CONT'D)			
<u>M. pyogenes</u> , var. <u>aureus</u> Action of metal salts, gold colloids, silver nitrate, zinc chloride and others in varying dilutions.		Tanaka	1931
<u>M. pyogenes</u> var. <u>albus</u> Hand telephones	35.42 %	Smeall	1937
Telephones with separate receiver and transmitter.	11.10 %	"	"
<u>M. pyogenes</u> Doorknob, brass	Recov. positive 24 hrs.	Frank	1943
Door knob, white, bronze	Recov. negative 38 hrs.	"	"
<u>M. spp.</u> (chromogenic cocci) Hand telephones	62.50 %	Smeall	1937
Telephones with separate receiver & transmitter	11.10 %		

TABLE 14

## THE SURVIVAL OF MICROORGANISMS ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>Proteus morgani</u> Dust	2-12 d.	Hoare 1943
<b>FABRICS</b>		
<u>Proteus vulgaris</u> Cotton-wool swab, 16-22C, plain, dry	No growth at 8 hr. 50-200 col. at 24 hr.	Rubbo 1951 " "
moist	20-50 col. at 48 hr.	" "
Cotton-wool swab, 16-22C, serum, dry	50-200 col. at 48 hr.	" "
moist		
<u>Hemophilus pertussis</u> Cotton-wool swab, 16-22C, plain, dry	No growth at 8 hr.	" "
moist	" " " " "	" "
Cotton-wool swab, 16-22C, serum, dry	20-50 col. at 24 hr.	" "
moist	20-50 " " " "	" "
<u>Proteus morgani</u> Blanket	>81 d.	Hoare 1943
<u>Rickettsia</u> <u>Coxiella burnetii</u> Soiled laundry from Q fever lab.	Infection evident on laundry workers hand- ling prior to launder- ing	Oliphant 1949
<u>Treponema pallidum</u> Cloth, 21.5-25C, diffuse light	11½ hr.	Zinsser 1914
<u>Vibrio comma</u> Dried on silk threads in air, temp of desiccator	30 d.	Berckholz 1889
Thread	7 mo.	Ficker 1898
Ster. moist linen strips, R.T.	Still viable 5 wk.	Gamaleia 1893
Dry linen strips	Recov. O, 17 hr.	" "
Dried on silk threads in desiccator	3-4 d.	Kitasato 1889
Cotton-wool swab, 16-22C, plain, dry	No growth at 8 hr.	Rubbo 1951
moist	" " " " "	" "
Cotton-wool swab, 16-22C, serum, dry	" " " " "	" "
moist	5-20 col. at 24 hr.	" "
Clothing especially linen	Several days even weeks	T. & W. 1946
<b>GLASS</b>		
<u>Pseudomonas aeruginosa</u> Glass, 24 hr. peptone, 1% water culture, vacu- um dried	7 mo. & 7 d.	Shottoch 1912
Glass, sunlight	2 min.	Weinzirl 1907

TABLE Lu8 (CONT'D) THE SURVIVAL OF MICROORGANISMS ON SURFACES

Factor(s)	Survival	Reference
<b>GLASS (cont'd)</b>		
<u>Sarcina aurantiaca</u> Glass (direct and under glass) sunlight	25-60 min.	Weinzirl 1907
<u>Treponema pallidum</u> Glass slides allowed to dry	4½ hr.	Zinsser 1914
<u>Vibrio comma</u> Vibrio dried on cover slip Ster. slides, 37C,	3 hr. Inoc. innumerable, Recov. O, 2 min.	Kitasato 1889 Teague 1913
Glass slides dried " " , 56, 100, & 80C	Few days 30 min.	Thurn 1914 " "
Glass sunlight	2 min.	Weinzirl 1907
<b>PAPER</b>		
<u>Bacterium linens</u> Ster. filter paper, dried, R.T.	Inoc. soaked in 48 hr. cult. in peptone, still gave active org. when placed in peptone 90 d.	Albert 1944
<u>Proteus morgani</u> Filter paper	11-20 d.	Hoare 1943
<u>Vibrio comma</u> Banknotes touched by fingers infected with cholera stool	4 hr.	Jettmar 1927
<b>WOOD</b>		
<u>Trichomonas vaginalis</u> Enamel surface of a small wooden block	< 7 hr.	Kessel 1950
<b>GENERAL</b>		
<u>Alcaligenes faecalis</u> Hand telephones	4.17% of org. present	Smeall 1937
<u>Rickettsia typhi</u> In a vacuum with CaCl <sub>2</sub> for 48 hr. Paper, R.T.	100 d. still viable Still viable at 21 d.	Blanc 1940 " "
<u>Trichomonas vaginalis</u> Natural conditions	Long enough to permit transfer to another	Kessel 1950
Vaginal discharge	Recov. 2-4%, 6 hr.	" "
<u>Vibrio comma</u> Inside earthen pot Outside " "	2 d. 4-8 d.	Arguelles 1927 " "



TABLE Lu 9

## THE SURVIVAL OF MICROORGANISMS ON SURFACES (GENERAL)

Factor(s)	Survival	Reference
<b>DUST</b>		
Air during dust storm	High ct. of mold, bacteria, & dust particles	Proctor 1935
<b>FABRICS</b>		
Oiled blankets	90-95% fewer than control	Dingle 1946
Egypt cotton parachute material, dry over nite 70F, dust free room, shaking for 30 sec.	Recov. 14,720	Dumbell 1948
Mechanical shaking 30sec.	Recov. 60,300	" "
Violent shaking	" 136,000	" "
Turkish towel	24 hr.	Pease 1930
10 blankets untreated and in use for 4 mo.	Near 6,200,000/gm. of blanket	Rountree 1947
Blankets	6 mo.	Shechmeister 1947
Org. were killed more rapidly on glass surfaces than woolen <del>sage</del> , filter paper, or blood agar		Elford 1945
<b>GLASS</b>		
Drying in tubes	.5 hr.	Buckley 1907
" " desiccator	" "	" "
" " R.T.	1.75-hr.	" "
" " Moist chamber	8 d.	" "
Cover slips, dried	1 mo.	Sternberg 1950
Glass, 12 specimens	>1 million	MacNabb 1938
<b>METAL</b>		
Surfaces of Fe, Zn, Cu, brass, limewash, lead paint & too were bactericidal		Minett 1950
Polio virus-partial inactivation		McKhann 1948
<b>PAPER</b>		
Spore bearing bacteria survive drying process of paper.		Appling 1945
Drying in tubes	1.5 hr.	Buckley 1907
" " desiccator, 16-18 degrees C	1.75 hr.	" "
Drying in R.T.	5 hr.	" "
Moist chamber	5 d.	" "
<b>WOOD</b>		
Drying in tubes:		
cotton wood	.25 hr.	Buckley 1907
lime wood	1.5 hr.	" "
pine wood	1.5 hr.	" "
Drying in desiccator:		
cotton wood	7.5 hr.	" "
lime wood	" "	" "
pine wood	1.5 hr.	" "
Drying R.T.:		
cotton wood	9 hr.	" "
lime wood	8 hr.	" "
pine wood	7.5 hr.	" "
Drying moist chamber:		
cotton wood	14.5 d.	" "
lime wood	19 d.	" "
pine wood	1 d.	" "

TABLE 249 (CONT'D) THE SURVIVAL OF MICROORGANISMS ON SURFACES (GENERAL)

Factor(s)	Survival	Reference
<b>GENERAL</b>		
Bact. found in bricks 1,005 Ster. of plane polished surfaces	400 yr. old.	Lipman 1934
Sterilization of plane polished surfaces by air at 50 miles/min. at 300-600 mi./min.	Slightly longer time for sterilization Effect pronounced	Breinl 1935 " "
Sterilization of polished surfaces by still air at 100-120C, 600 mi./min.	50-60 min. 10-15 min. for killing	" "
Ozone in excess of 1p.p.m., R.H. 60-80%	Good sterilization	Elford 1942
Survive well in temp. colder than CO <sub>2</sub> frozen	that of liquid O <sub>2</sub> , -183C	Lujet 1938
Survival temp. ranging from to that of liquid helium,	-269C.	" "
Drying on tubes	0.5 hr.	Buckley 1907
" in desiccator	3 hr.	" "
Drying in moist chamber	7 d.	" "
Drinking utensils, 51 specimens examined: 12 greater than 1 million, 5 greater than 1 thousand to 1 million, 17 greater than 1	to 1 thousand.	MacNabb 1938

TABLE *LXIV*THE SURVIVAL OF MYCOBACTERIUM  
TUBERCULOSIS ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
Dust, infected, diffuse daylight	5 days	Soparker 1917
Dust, infected, direct sunlight	2 hrs.	" "
Dust, infected	8 days	Kirstein 1905
Street dust, infected	3-8 days	" "
Sterile dust, mixed with T.B., direct sunlight	5 hrs	Sweany 1919
Film of dust, south room	5 days	" "
Film of dust, north room	7 days	" "
<b>FABRICS</b>		
Garments worn by tubercular patients, dust and scrapings	Unable to infect g.p.	Jacobs 1944
Linen or woolen cloth, with sputum, sunlight	24-30 hrs	Migneco 1895
Handkerchief, sputum, dried in sun	18 hrs	" "
Carpet, sputum	Infective 39 days	Twitchell 1906
Handkerchief or blanket exposed to direct sunlight	Lesions resulted after 70. but not after 110 days Infective after 1 hr. but not after 7 hrs.	" "
On threads of clothing	5-10 days	Kirstein 1905
<b>GLASS</b>		
Glass, sputum dried in thin smears	4 mos.	Sormani 1886
<b>PAPER</b>		
Books, handled by tubercular patients	Unable to demonstrate viable tubercle bacilli	Jacobs 1944
Sheets of paper coughed on, stored in bell jar,	>50 % infective, 2 days infection for g.p., no infection 31 days	" "
Paper, sunlight, known type	2-10 mins.	Weinzirl 1907
Paper, under glass, No. 101 tubercle culture	1 1/2 hr.	" "
Paper, and moisture under glass, No. 101 culture	1/2 hr.	" "
Paper, No. 101 culture	15-20 min.	" "
Paper and moisture under glass, No. 110 culture	1/2 hr.	" "
Paper under glass, No. 110	< 10 min	" "
Paper, moisture, sunlight, No. 101	25-30 min	" "
Paper, sunlight, No. 101	25 min.	" "
Paper, sunlight, No. 101, under colorless glass	5 min.	" "
under red glass	10-20 min.	" "
under green glass	30 min.	" "
under blue glass	5-10 min.	" "

TABLE *Surv* (CONT'D) THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS ON SURFACES

Factor(s)	Survival	Reference
<p>PAPER (CONT'D)</p> <p>Paper, infected, dried 24 hrs., exposed to little air</p> <p>Books, sputum.</p>	<p>&gt; 35 days</p> <p>2 wks. to 3 1/2 mos.</p>	<p>Ransom</p> <p>Smith 1942</p>
<p>GENERAL</p> <p>Thin smears of human, bovine and avian types, sunlight</p> <p>Dessication in a dark, well-ventilated place--human and bovine.</p> <p>Exposed to direct sunlight in India.</p> <p>Dessicated in darkness.</p> <p>Decomposing sputum.</p> <p>Exposed to electric light, bovine t.b.,</p> <p>Bovine t.b. from deer lung, direct sunlight, diffuse light.</p> <p>Hypochlorite disinfection and compounds had weak tuberculocidal power.</p> <p>Braille books</p>	<p>Killed in 1-4 min.</p> <p>Killed human within 4 days; killed bovine within 8 days.</p> <p>Alive---6 das.</p> <p>Dead---8 das.</p> <p>Live virulent bacilli for 309 days.</p> <p>20-26 days</p> <p>74 days alive, dead in 100 days.</p> <p>10-12 hrs.</p> <p>30 days</p> <p>3 mos.</p>	<p>Briscoe 1912</p> <p>" "</p> <p>Soparkar 1917</p> <p>" "</p> <p>" "</p> <p>Klarman 1951</p> <p>Chaikin 1926</p>

TABLE July

THE SURVIVAL OF NEISSERIA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS</b>		
<u>N. gonorrhoeae</u>		
Cotton plug in closed tube under water	0 recovered, 24 hrs.	Lorentz 1924
Cotton plug in open tube	0 recovered, 30 min.	" "
Cotton plug in incubator, 40 C.	0 recovered, 10 min.	" "
Cotton plug in sun (summer)	0 recovered, 5 min.	" "
Cotton plug, R.T.	0 recovered, 5 min.	" "
<u>N. meningitidis</u> , 16-22 C.		
plain dry;	No growth at 8 hrs.	Rubbo 1951
Plain moist;	No growth at 8 hrs.	" "
serum dry;	No growth at 8 hrs.	" "
serum moist.	No growth at 8 hrs.	" "
<u>N. intracellularis</u>		
Cotton fabrics	7 days, survival shortened at 37 C, & prolonged at 6-10 C.	Miller 1944
<u>N. gonorrhoeae</u> , 16-22 C.		
plain, dry	No growth at 8 hrs.	Rubbo 1951
plain, moist	No growth at 8 hrs.	" "
serum, dry	No growth at 8 hrs.	" "
serum, moist	No growth at 8 hrs.	" "
Cotton fabrics exposed to direct sunlight in dried films	Few hrs.	Miller 1944
Cotton gauze, exposed to diffuse daylight, passing thru window pane, & pyrex petri dish	30 hrs.	" "
Fabric	1 hr. still alive, 2 hrs. dead	Weiss 1921
<b>GLASS</b>		
<u>N. meningitidis</u>		
Glass beads, dark, dried, R.T.	10 days, visible light is germicidal.	Miller 1944
Surface glass, direct sunlight, in dried films	Few hours	Miller 1944
Glass beads, diffuse daylight, passing thru window pane & pyrex petri dish	30 hrs.	" "
Glass, drying on Garnets and glass, dried, in dark	72 hrs.	Elser 1909
diffuse daylight	24 hrs.	Flügge 1905
10 hrs.	10 hrs.	" "
Glass, dried, R.T.	24 hrs.	Kutscher 1906
Watch glass, dried rabbit blood	>45 days	Foa 1888

TABLE *Sub II* (CONT'D) THE SURVIVAL OF NEISSERIA SPECIES ON SURFACES

Factor(s)	Survival	Reference
<p>GLASS (CONT'D)</p> <p><u>N. gonorrhoeas</u> Glass covered in sun</p>	<p>2 strains stopped growing after 3 hrs.; 5 hrs. no growth</p>	<p>Lorentz 1924</p>
<p>WOOD</p> <p><u>N. meningitidis</u> Wood exposed to direct sunlight in dried films Wood, room temperature</p>	<p>Few hrs. 8 days</p>	<p>Miller 1921 " "</p>
<p>GENERAL</p> <p><u>N. meningitidis</u> Human secretions, drying in, Metal 15 strains, R.T., 25-26 C., dark, diffuse daylight, direct sun ice box, 6-8 C. Meningococci might remain alive for years if dried rapidly under freezing temperatures and kept frozen</p>	<p>Several days 1 hr still alive, 2 hrs. dead 9 strains survived 2 wks. 6 for 4 wks. 0 survived for 5 wks. 1 wk. 8-9 hrs. None survived a week alive for years if dried temperatures and kept</p>	<p>Jungeblut 1935 Weiss 1922 Elser 1929 " " Elser 1939</p>

TABLE 5THE SURVIVAL OF PASTEURELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS</b>		
<u>P. pestis</u>		
Silk cloth, protected from light	0 recovered, 1-21 days	Gladin 1898
Handkerchief	0 recovered, 14 days	" "
Coarse linen	0 recovered, 12-76 days	" "
On silk cloth in sun	0 recovered, 6½ hrs.	" "
On linen in sun	0 recovered, 18½ hrs.	" "
<b>GLASS</b>		
<u>P. pestis</u>		
Cover glass, dried bubonic pus, 28-30C, inoc into bouillon	No growth, 4 days	Abel 1897
Cover glass, pure cult., dried, 29-31C	No growth, 4½ days	" "
Desiccator, dess. temp. Dried in lighted room, 16-20C	No growth, 3 hrs. No growth, 3 hrs.	" "
Cover glass, pus & cult., room temperature	Still viable 6-9 days	" "
Cover glass, finely divided, dried in sun, 30C	No growth, 1 hr.	" "
Cover glass, dried Desiccator, 16-18C	No growth, 1 hr. 3.5 hrs.	" "
Glass, room temperature	2.3 days	Buckley 1906
Glass, moist chamber	13.5 days	" "
Cover glass, 14-24C protected from light	None recovered, 1-9 d.	Gladin 1898
Cover glass, dried by sun	None recovered, 1¼ hrs.	" "
Test tube, sun, 40-44C	Still alive, 5½ hrs.	" "
Cover slip, R.T., bubo juice, dried exposed to sun	< 4 days 3-4 hrs.	Kitasato 1894
Slide, dried, Giemsa stain, inoc. 1:1,000	Viable 2 hrs.	Tinker 1930
Slide, reagents used for hemoglobin determination	Kill organism in 45 min.	" "
<u>P. spp.</u>		
Glass tube, blood allowed to putrify	100 days	Ostertag 1908
<b>PAPER</b>		
<u>P. pestis</u>		
Desiccator 16-18C	5 days	Buckley 1906
Room temperature	3.6 days	" "
Moist chamber	8.3 days	" "
Filter paper, dried, 14-24C, protected from light	None recovered, 1-20 d	Gladin 1898
<u>P. tularensis</u>		
Filter paper, feces on, 20C, dried unexposed to direct light	20 days	Francis 1922

TABLE 412 (CONT'D)THE SURVIVAL OF PASTEURELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>PLASTER</b>		
<u>P. pestis</u> Dessicator, 16-18 C. Room temperature Moist chamber	9.5 days 5 days 11 days	Buckley 1906
<b>WOOD</b>		
<u>P. pestis</u> Dessicator, 16-18 C. Cotton wood Lime wood Pine wood Room temperature Cotton wood Lime wood Pine wood Moist chamber Cotton wood Lime wood Pine wood	22 days 6.5 days 3.5 days 11 days 2 days ----- 36.3 days 2.6 days 1 hour	Buckley 1906 " "
<b>GENERAL</b>		
<u>P. pestis</u> Frozen daily, -20 C.. Dried, 37 C.. Protected from sun, 37 C.. Protected from sun, R.T..	40 days Most were dead, 3 das. 2-3 mos. 260 days	Gladin 1898 "



TABLE Lu 13THE SURVIVAL OF SALMONELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>S. typhosa</u> Dried soil (dust), stock culture, avg. temp. 52 F., Max. temp. 57 F., Min. temp. 49 F.	>22 days	Firth 1902
Dried soil, stool cult., avg. temp. 51 F., max. temp. 55 F., min. temp. 48 F.	>30 days	" "
Dust, stool cult., avg. temp. 53 F., max. 55 F., min. 4 F.	>20 days	" "
Street dust.	30 days	Osler 1901
Sweeping, bedroom, sterile R.T., dried after 16 hrs. & wetted with inoc. of bacterial water susp'n, 12 mm. layer.	36 days	Uffelmann 1894
Street sweepings, sterile	32 days	
Sweepings, kitchen refuse	30 days	Kister 1928
Ashes, contaminated	130 days	
<u>S. typhimurium</u> Dust	3 weeks	Browne 1949
<u>S. paratyphi</u> Sweepings, kitchen refuse.	50 days	Kister 1928
Ashes, contaminated.	130 days	" "
<b>FABRICS</b>		
<u>S. typhosa</u> Soiled washing, R.T., dark Linen, dried on	4 days 98 days	Dold 1944
White drill cloth, temp. 105 F., exposed to sun, inoc. 240,000	2 hrs.	Hewlett 1909
White drill cloth, 92 F., dark	76 days	" "
White drill cloth, soaked in urine with org., in dark, inoc. 240,000	10 days	" "
Turkish towels	Alive at end of 48 hrs.	Pease 1930
Cotton-wool swab, 16-22 C. plain, dry	No growth at 8 hrs.	Rubbo 1951
plain, moist	5-20 col. at 24 hrs.	
serum, dry	5-20 col. at 24 hrs.	
serum, moist	20-50 col. at 48 hrs.	" "
Dried on linen	98 days	Dold 1943
Linen	150 days	Lomry 1929
Cotton	150 days	" "
Wool	100 days	" "
Linen	60-70 days	Osler 1901
Linen, suspn.	Viable 97 days	Pfuhl 1902
Linen, sterile, 1:3 dil't	90 days	Uffelmann 1894
Buckskin, sterile	100 days	

TABLE 13 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS</b>		
<u>S. enteritidis</u> Dried on linen	39 days	Dold 1944
<u>S. paratyphi B</u> Dried on linen	191 days	" "
Turkish towels	Alive at end of 48 hrs.	Pease 1930
<u>S. paratyphi</u> Dried on linen	191 days	Dold 1943
Linen	150 days	Lomry 1929
Cotton	150 days	" "
Wool	70 days	" "
<u>S. pullorum</u> burlap strips, soaked in cult., exposed to U.-V. 200-215F. for 5 min. 95-180 F. for 4 min. 205-270 F. for 5-7 min.	No inactivation Was not isolated after 5 min exposure Readily recovered Not recovered	Jungherr 1950
<u>S. sp. (Type Oranienburg)</u> Cotton wick of water de- vise	15 days	Olson 1950
<b>GLASS</b>		
<u>S. typhosa</u> Desiccator, 16-18 C. Room temperature Moist chamber Petri dishes, empty, R.T., sterile	44.5 days 12 days 38.5 days 24 hrs.	Buckley 1906 Kirstein 1902
Glass rod, sterile, 37 C. flamed with 95% alc. for 5 sec., 24 hr. agar cult.	Viable 2 days	Mayser 1925
Porcelain saucer, 37 C., 1 eating, spoon of alc. 1 min. 24 hr. cult.	None recovered, 3 days	" "
Glass cover slips, vacuum dried at -195 C; air dried, dark	None recovered, 4 days	Shattock 1912
Sterile slides, 37 C., inoc. innumerable cols. Dishes washed with 0.3% Calgonite, 1/2 sterile, sterile dishes soiled dishes	None recovered, 60 hrs. 70-90% approx. 4-10%	Teague 1913 Ward 1939
Glass, sunlight Self sterilizing ability of skin against <u>S. typhosa</u> similar phenomenon on glass rods.	5 min.	Weinzirl 1907 Dold 1919
<u>S. sp. (Type Oranienburg)</u> Glass, few drops broth culture.	34 days	Olson 1950

TABLE *Sub* (CONT'D)THE SURVIVAL OF SALMONELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>PAPER</b>		
<u>S. typhosa</u> Dessicator, 16-18 C..	13 days	Buckley 1906
Room temperature	5.3 days	
Moist chamber	10.5 days	
Paper slips, in vapor of 35 gms. plus/1000 ft <sup>3</sup>	Recovered none, 1 hr.	Hewlett 1939
Filter paper, stool dried on, R.T.	>55 days	Dold & Ketterer 1944
Filter paper, thin watery stool	>137 days	
Filter paper, dried	1-2 wks	Joe 1950
Paper, surface, inoc. 56	Recovered none, 3 min.	Norton 1932
Paper, surface, inoc. 1,500	Recovered none, 3 min.	" "
Paper, sunlight	2-10 min., longer if in clusters	Weinzirl 1907
<u>S. paratyphi</u> Dried on filter paper, dark, R.T.	Pure cult. of org. >8 mo.	Dold & Ketterer 1944
Filter paper, dried on	421 days	Dold 1947
Filter paper, stool, dried,	1-2 wks.	Joe 1950
Paper, sunlight	2-10 mins., longer if in clumps	Weinzirl 1907
<b>PLASTER</b>		
<u>S. typhosa</u> Dessicator, 16-18 C.	83 days	Buckley 1906
Room temperature	91 days	
Moist chamber	101 days	
<b>WOOD</b>		
<u>S. typhosa</u> Dessicator, 16-18 C.		
cotton wood	50 days	Buckley 1906
lime wood	89 days	
pine wood	38.5 days	
Room temperature		
cotton wood	64 days	" "
lime wood	91 days	
pine wood	9 days	
Moist chamber		
cotton wood	59 days	" "
lime wood	119 days	
pine wood	12 days	
Wooden bowl, 20cm dia., 37 C., 1 eating spoon of Alc., 1 min. flaming, bouillon culture	Viable 2 days	Mayser 1925
Oak	80 days	Lomry 1929
Beech	80 days	
Resins	80 days	
Wood	32 days	Oslar 1901
On bench	Recov. 17.0%, 23 days	Stamp 1947

TABLE 13 (CONT'D)THE SURVIVAL OF SALMONELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>WOOD (CONT'D)</b>		
<u>S. typhosa</u> Pine or fir-wood plank, incubator temp., water sus'p in a thin layer, 1:3 firs to water	32 days, decreasing by degrees	Uffelmann 1894
<u>S. paratyphi</u> Oak	80 days	Lomry 1929
Beech	80 days	" "
Resins	80 days	" "
On bench	Recov. 17.0%, 23 days	Stamp 1947
<b>GENERAL</b>		
<u>S. typhosa</u> Bread, on surface after baking	30 hrs.	Alves 1935
Rye bread, on crust of, in well-ventilated room, at R.T.	4 1/2-6 mos. (longer survival at lower temp. -5 to -25 C.	Bachman 1943
Water filter after water stopped	2-3 hrs.	Gage 1903
In continuous water filter	2 days	" "
Iron	20 days	Lomry 1929
Copper	20 days	" "
Tin	30 days	" "
<u>S. paratyphi</u> On crust of rye bread, in well-ventilated room at R.T., emulsion with <u>S.</u> <u>typhosa</u>	4 1/2 - 6 mos., longer survival at lower temp. -5 to -25 C.	Bachman 1943
Iron	30 days	Lomry 1929
Copper	20 days	" "
Tin	40 days	" "
<u>S. enteritidis</u> Smooth surface, ultra- violet rays, 2,000- 2,950 Å units	Effect reduced counts	Cathcart 1942

TABLE *Lu 14* THE SURVIVAL OF SERRATIA MARCESCENS ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS</b>		
Serge, woolen, aqueous susp' 21ppm. ozone, R.H. 68%, temp. 20.5 C. exposed 30 minutes exposed 60 minutes exposed 90 minutes	----- ----- -----	Elford 1942
Serge, woolen, aqueous susp. .06 ppm. ozone, R.H. 89%, 21 C., exposed 45 min.	95% killed	" "
<b>GLASS</b>		
Glass, aqueous susp'n, R.H. 68%, 20.5 C., 21ppm ozone exposed 30 min. exposed 60 min. exposed 90 min.	>99% killed on surface >99% killed on surface >99% killed " "	Elford 1942
Glass, aqueous susp'n, R.H. 89%, 21C., .06 ppm ozone, exposed 45 minutes.	-----killed	
Petri dishes, empty, sterile room temperature	24 hrs.	Kirstein 1902
Slides, sterile, 37C., innoc. innumerable colonies	None recovered, 28 hrs.	Teague 1913
Glass slides, 37 C., innoc. 1,900	Recovered 3, 40 min.	Norton 1931
Glass, sunlight	2 minutes	Weinzirl 1907
Glass, 37 C., innoc. 110,000 at 30 sec.	Recovered none, 10 min.	Bryan 1933
<b>PAPER</b>		
Aqueous susp'n, 21 ppm. Oz- one, R.H. 68%, 20.5 C., exposed 30 min. exposed 60 min. exposed 90 min.	98% killed 99% killed >99% killed	Elford 1942
Aqueous susp'n, 0.06 ppm. ozone, R.H. 89%, 21 C., exposed 45 min.	98% killed	" "
Filter paper, surface, innoc. 150	Recovered none, 20 min.	Norton 1931
Filter paper, moist, innoc. 960	Recovered none, 30 min.	
Filter paper, innoc. 4,000	Recovered 40, 30 min.	" "
Filter paper, surface of, innoc. 1,000	Recovered 6, 30 min.	" "
Filter paper, moist, innoc. 320	Recovered 1,000 at 30 minutes	" "
Filter paper, innoc., 3,500	Recovered 310 at 30 min	" "
Paper, surface, innoc. 230, colonies on agar plates	Recovered none at 2 min	Norton 1932
Paper, sunlight	2-10 minutes	Weinzirl 1907
Filter paper, moist, innoc. 500,000, 37C.	Recovered 141,000 at 15 minutes	Bryan 1933

TABLE LVTHE SURVIVAL OF SHIGELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>S. dysenteriae</u> Dust	10 days	Kister 1928
<b>FABRICS</b>		
<u>S. dysenteriae</u> Hemp	Several days	Lentz (?)
Clothes	24 days	
Leinwand	17 days	
Clothes, dried on R.T., dark, 37 C.	150 days 11 days	Winter 1912
R.T., diffuse daylight	20 days	
Sheep's wool, R.T.	106 days	Karlinski 1907
Cloth, 17-20 C.	4-9 days	Frost 1905
Cloth, 38 C.	Only 1/2- 1/4 survive of those at 17-20 C. (Shiga more frail than Flexner)	
Dried on linen	30 days	Dold 1943
Linen, scraps, feces on, diffuse light, R.T.	79 days	Karlinski 1907
dried in sun	1/2 hr.	
on bed straw, 15-21 C.	38 days	
Cloth, dried	None recovered, 22 days	Pfuhl 1902
Soiled washing, R.T., dark dried on linen	30 days	Dold 1944
<u>S. paradysenteriae</u> (Flexner) Cotton-wool swab, inoc. 7,200 cols. plain, dry	0 at 8 hrs.	Rubbo 1951
plain, moist	5-20 cols. at 24 hrs.	
serum, dry	5-20 cols. at 24 hrs.	" "
serum, moist	20-50 cols. at 48 hrs.	" "
Dried on linen, <u>S. sonnei</u> than Flexner strain	survive 2-3 times longer	Dold 1943
<u>S. spp.</u> Dried on linen, R.T., dark	5-46 days	Roelcke 1938
Linen, dried on, R.T., dark	5-46 days	Vaillard 1903
Linen, alc. ether, chloro form, 37 C.	Few hours	
Linen, desiccation	20-25 days	" "
<u>S. sonnei</u> Dried on linen, <u>S. sonnei</u> longer than Flexner strain	survives 2-3 times	Dold 1943
<b>PAPER</b>		
<u>S. dysenteriae</u> Paper, 17-20 C.	4-9 days	Frost 1905
Paper, 38 C., will live 1/2-1/4 surv. of those at 17-20 C.--Shiga more frail than Flexner.		
Filter paper, dried with Flexner	113 days	Dold 1947
Filter paper, dried, stool	1-2 wks.	Joe 1950

TABLE Surv (CONT'D)THE SURVIVAL OF SHIGELLA SPECIES  
ON SURFACES

Factor(s)	Survival	Reference
<b>PAPER (CONT'D)</b>		
<u>S. paradysenteriae</u> Filter paper, dried	270 days	Dold 1947
<u>S. spp.</u> Paper sunlight	5 min	Weinzirl 1907
<b>WOOD</b>		
<u>S. dysenteriae</u> Wood, 17-20 C Wood, at 38 C., org. will live only 1/2-1/4 surv. of those at 17-20 C.. Shiga more frail than Flexner	4-9 days	Frost 1905
<b>GENERAL</b>		
<u>S. dysenteriae</u> Bread, surface of after baking	30 hrs.	Alves 1935
Crust of rye bread in well-ventilated room at R.T., with strains of <u>Flexner</u> and <u>Sonnei</u>	45 days	Bachmann 1943
Same as above only at lower temperature -5 to -25 C.	2 mos.	" "
<u>S. paradysenteriae (Flexner)</u> Bread, surface, after baking	30 hrs.	Alves 1935
Crust of rye bread, in well ventilated room at R.T., with Shiga and <u>sonnei</u> . At lower temps. -5 to -25 C.	45 days	Bachmann 1943
	2 mos.	Bachmann 1943
<u>S. sonnei</u> Crust of rye bread, in well ventilated room at room temp., with Flexner strains and <u>dysenteriae</u>	45 days	" "
At lower temp -5 to -25C.	Longer than 2 mos.	" "

TABLE Sub 6

THE SURVIVAL OF STREPTOCOCCUS  
SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>S. pyogenes (group A)</u>		
Dry sweeping, 38 samples	73.8% (10,000-1 mill.) 26.2% (150-10,000)	Hamburger 1944
Dry sweeping of scarlet fever ward, 47 samples	4.3%--0 63.9% (1,000-10,000) 29.7% (10,000- 1 mill.) 2.1% (over 1 million)	" "
Sweeping of compound, 49 samples	52% (0) 42% (150-10,000) 6% (10,000- 1 million)	" "
Dust, strain 1, R.T.	44 days	Laurell 1949
Floor dust, type 3	Many recovered, 4 days	Lemon 1944
Dust, description of tonsillitis in person who swept out cubicle previously occupied by puerperal sepsis case.	25 days	White 1936
Floor dust, 4 strains of Group A recovered--three different methods--sweeping, vacuum cleaner and blowing.	20%-67% recovered	Williams 1949
<b>FABRICS</b>		
<u>S. pyogenes (group A)</u>		
Cotton wool swab, strept. throat, 17-19 C., inoc. 150 colonies, plain swab serum swab	21 colonies at 48 hrs. 27 colonies at 48 hrs.	Rubbo 1951
Absorbent wool, plain, swabs, 17-22 C., inoc. > 200 cols., Plain dry Plain moist	20-50 cols. at 48 hrs. 5-20 cols. at 8 hrs.	" "
Non-absorbent wool, 17-22 C., inoc > 200 cols. plain dry plain moist	50-200 cols. 48 hrs. 20-50 cols. 48 hrs.	" "
Absorbent wool, serum, dry	50-200 cols. 48 hrs.	" "
Absorb. wool, serum, moist	50-200 cols. 48 hrs.	" "
Cotton-wool swab., 16-22 C. plain, dry plain, moist serum, dry serum, moist	5-20 cols. at 48 hrs. 5-20 cols. at 8 hrs. 50-200 cols. at 48 hrs. 50-200 cols. at 48 hrs.	" "
Bedding, type 3	Many recovered, 4 days	Lemon 1944
Blankets	Survive > 4 months	Robertson 1944 1947
Blankets, glycol vapor	70% reduction	" "
Blankets, oiled, 2% mineral oil emulsion	90% reduction	" "
Blanket, oiled, exposed 5 min. after & during heating	170 colonies	Andrewes 1940



TABLE Lu 16 (CONT D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS (CONT'D)</b>		
<u>S. pyogenes</u> (group A)		
Blanket, unoiled	1030 colonies	Andrewes 1940
Blankets oiled	26 out of 307 cultures were positive	Dingle 1946
Blankets, unoiled, (441)	160 positive, 50% of these were Group A and remainder largely group C & B	" "
Cotton, R.T., strains 1, 2, 3, dried	> 53 days	Laurell 1949
Linen, R.T., strains 1, 2, 3, 4, dried	> 53 days	" "
Wool, R.T., strains 1, 3, 4, dried	> 53 days	" "
Blanket, 70-85 F., R.H. 25-30%. 10 blankets pos. at beginning.	Only 1 positive, 7 mos.	Loosli 1948
Overcoat, wool blouses & towels, envir. temp.	At least 4 days	" "
Toweling, dry	Alive at end of 48 hrs.	Pease 1930
Blankets, sucked from, no. 47, ENT ward, along with <u>M. aureus</u> , <u>E. coli</u> & others	14,400-7,344,000/cu.ft. of air.	Rountree 1946
Oiling of blankets, bed linen, & garments	Reduces no. of bacteria in air during bed making; 91-98% below those in control ward	Cruickshank 1947
Rate lower in oiled ward	18.6% versus 73.3%.	" "
In air, floor dust, & bed clothings of hospital wards		Hamburger 1944
<u>S. pyogenes</u> (Group B)		
Blankets, beaten, strep. plate count. 0 hour	2000/ plate	Van den Ende 1940
24 hrs.	701/ plate	
10 days	294/plate	
4 weeks	98/plate	
very slight reduction in virulence in	virulence in 4 weeks	" "
<u>S. pyogenes</u> (Group C)		
Blankets, 2 ft. above floor, 10min. after beating	426/plate	" "
<u>S. viridans</u>		
Cotton-wool swab, 16-22 C., plain, dry	5-20 cols. at 48 hrs.	Rubbo 1951
plain, moist	20-50 cols. at 24 hrs.	
serum, dry	50-200 cols. at 48 hrs.	
serum, moist	50-200 cols. at 48 hrs.	" "

TABLE Sub B (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>FABRICS (CONT'D)</b>		
<u>S. spp.</u>		
Serge, sprayed, medicinal paraffin, mechanically beaten, 1st 2 min.; during 5 min. period, 12 to 17 min. after beating	Recovered 1300 Recovered 900	Van den Ende 1941
Woolen blanket, beaten, during 1st 2 min.; during 5 min. period, 12-17 min. after beating	Recovered 4000 Recovered 2500	" "
Wool blanket, dry strep. during 1st 2 min.; during 5 min. period, 12-17 min. after beating	Recovered 490 Recovered 11	" "
Cotton sheet, dry strep. during 1st 2 min.; during 5 min. period 12-17 min. after beating	Recovered 508 Recovered 24	" "
Cotton, sprayed strept. during 1st 2 min.; during 5 min. period 12-17 min. after beating.	Recovered 1320 Recovered 232	" "
Blankets, clothing	"month or more"	Pulvertaft 1947
Blankets, application of crude liquid paraffin before sweeping floors, greatly reduces contamination at 5 ft. level and 2 ft. level.		Van den Ende 1940
<b>GLASS</b>		
<u>S. pyogenes</u>		
Sterile dishes	50-90%	Wood 1939
Soiled dishes	6-20%	
Petri dishes, org. in. on floor, dark, diffuse light	20% alive, 14 days <1% alive, <7 days	Phelps 1939
Glass.		
Susp'n Cont.      Exp. time in min.		Burtenshaw 1938
339.2              105	10.2 washed off	
583.2              10	35.2 " "	
720                85	6.2 " "	
852                6	54.4 " "	" "
1270               5	45 " "	
1542.4            84	23.3 " "	
1971.2            3	132.2 " "	
2329.6            4	14.6 " "	
2880               6	328.6 " "	
<u>S. viridans</u>		
Ground glass, deposited & allowed to dry. Discrete colonies when surfaces are embedded in a nut. agar medium.	Also used to determine effect of atmos. Hum. on survival of bacteria on glass surfaces.	Annear 1951

TABLE Sub (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>GLASS (CONT'D)</b>		
<u>S. salivarius</u>		
Glass, serum broth, R.H. 65%, 0.21ppm. ozone, 20C. exposed 90 min.,	97% killed	Elford 1942
Glass, serum broth, R.H. 82%, 18C., exposed 75min.	>99% killed	" "
Glass, serum, 0.12ppm. ozone, R.H. 84%, 20 C., exposed 60 min..	>99% killed	" "
Glass, serum, 0.18 ppm. ozone, R.H. 80%, 20 C., exposed 90 min	>99% killed	" "
<b>PAPER</b>		
<u>S. salivarius</u>		
Paper, serum broth, R.H. 65%, 20C. 0.ppm. ozone, exposed 90 min.	48% killed	Elford 1942
Paper, serum, R.H. 82%, 18 C., 0.21ppm. ozone, exposed 75 min.	99% killed	" "
Paper, serum, 0.12ppm. ozone, R.H. 84%, 20C. exposed 60 min.	85% killed	" "
Paper, serum, 0.18 ppm. ozone, R.H. 80%, 20C., exposed 90 min.	54% killed	" "
<u>S. pyogenes</u>		
Paper, R.T., strain 1, dry	44 days	Laurell 1949
<b>RUBBER</b>		
<u>S. pyogenes (hemolyticus)</u>		
Rubber apron, Susp'n cont.      Exp. time in min.	No. washed off	Burtenshaw 1938
339.2                      105	2.1	
583.2                      9	12.0	
720                        85	7.1	
852                        6	35.3	
1270.4                    4	9.6	
1542.4                    80	.4	
1971.2                    4	4.8	
2329.6                    5	6.1	" "
2880                        5	295.7	" "
* Rubber condom, Susp'n cont.      Exp. time in min.	No. washed off	" "
339.2                      105	5.3	
583.2                      10	18.2	
720                        85	27.0	" "
852                        6	38.2	
1270.4                    4	65.0	

TABLE Sub 16. (CONT'D)

## THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference
<b>RUBBER (cont'd)</b>		
<u>S. pyogenes</u> Rubber condom, Susp'n cont. Exp time in min.	No. washed off	Burtenshaw 1938
1542.4 78	40.2	
1971.2 4	93.6	" "
2329.6 5	175.7	
2880 5	360.1	
<b>UTENSILS</b>		
<u>S. faecalis</u> Utensils	High %	Hutchinson 1947
<u>S. viridans</u> Utensils	High %	" "
<b>GENERAL</b>		
<u>S. pyogenes</u> Mouthpiece of telephone	4-11 days	Coulter 1937
Metal from bullet lodged in flesh of soldier	> 2 mos.	Pulvertaft 1929
<u>S. salivarius</u> Hand telephone	72.92%	Smeall 1937
Telephone with separate receiver and trans- mitter	11.10%	" "
<u>S. mitis</u> Hand telephone	68.75%	" "
Telephone with separate receiver and trans- mitter	3.70%	
<u>S. non-hemolyticus</u> Hand telephone	2.10%	" "
Telephone with separate receiver and trans- mitter	3.70%	
<u>S. equine</u> Hand telephone	12.50%	" "
<u>S. ignavus</u> Hand telephone	8.33%	
<u>S. faecalis</u> Hand telephone	2.10%	" "

TABLE *412*

## THE SURVIVAL OF VIRUSES ON SURFACES

Factor(s)	Survival	Reference
<b>DUST</b>		
<u>Foot &amp; Mouth disease</u> Stable dust, 62 F., 52% R.H.	11 days	Burbury 1928
<u>Influenzae virus</u> Dust, drying, inoc. $1 \times 10^4$	Recovered none, 3 wks.	Edwards 1941
Dust, soaked virus susp'n, R.T., dried	Between 1%-10% recover- ed in 1 wk.	Krueger 1942
Dust, ...	Long periods	Pulvertaft 1947
<b>FABRICS</b>		
<u>Influenzae virus</u> Sheet, dried, 22C.	> 3 days	Edwards 1941
Sheet, dried, 37C.	< 24 hrs.	
Sheet, dark, dried	1 wk.	
Sheet, light, dried	< 3 days	" "
Sheet, 22 C., inoc. 0.1cc	Recovered none, 7 days	" "
Sheet, 37 C., inoc. 0.1cc	Recovered none, 24 hrs.	" "
Sheet, treated with in- fected saliva.	1 month	" "
Blanket, dried, inoc. 5% susp'n.	> 5 hrs.	" "
Blanket, sterile, ord. atmos. conditions	Survives drying	Krueger 1942
Sheeting, merge, soaked with virus susp'n., dried	Between 1%-10% recover- ed in 1 wk.	" "
R.T. Fabric	Survived for many days	Robertson 1945
<u>Newcastle virus</u> Burlap strips, 4, 22, & 36 C., treated with org- anic mercurial cpds.	Survived for over 50 days	Jungherr 1950
Cotton cloth, inoc. 0.2ml. of 1:10 dilution, 37 C.	16 days	Olesuik 1951
20-30 C.	52 days	
11-36 C.	145 days	
3-6 C.	193 days	
-26 C.	538 days	
Burlap, inoc. 0.5ml. 37 C.	14 days	" "
20-30 C.	16 days	
11-36 C.	108 days	
3-6 C.	123 days	
-26 C.	538 days	
<b>GLASS</b>		
<u>Foot &amp; Mouth virus</u> Glass, dried on, R.T., kept chem. dry	2 years	Burbury 1928
Glass, dried on, 62 F., 52% humidity	10 days	
Glass slides, dried on, exposed to August sun.	1 hr.	Topley 1946

TABLE 17

## THE SURVIVAL OF VIRUSES ON SURFACES

Factor(s)	Survival	Reference
<b>GLASS (CONT'D)</b>		
<u>Influenzae virus</u> Glass, dried on surface, R.T.	Still positive 40 min. after drying	Anon. 1943
Glass, dried	$1 \times 10^6$ was reduced to $< 1 \times 10^2$ in 6 weeks	Edwards 1941
Glass, dried, 0.1cc inoc. Glass, 22 C.	Recovered none > 4 weeks	" "
Glass, 37 C. Glass slides soaked with virus suspn., dried, kept at R.T.	< 1 week Between 1% - 10% recov. in 1 wk.	Krueger 1942
<u>Newcastle disease virus</u> Glass, refrig. temp.	Active many months	Asplin 1949
<u>Smallpox virus</u> Diluted vesicle fl. dried on glass slides, dark daylight	84 days 35 days	Downie 1947
<u>Filterable virus</u> Film on glass slide	Retain virulence 15 mos.	Burnet 1906
<b>PAPER</b>		
<u>Foot &amp; Mouth virus</u> Paper, 62 F., 52% R.H.	2 days	Burbury 1928
<u>Newcastle disease virus</u> Filter paper, exposed to dry cond., 98 F. Paper, refrig. temp. Filter paper, inoc. 0.2ml. 37 C. 20-30 C. 11-36 C. 3-6 C. -26 C.	Inactive after 12 hrs. Active many months 28 days 25-49 days 129 days 157 days 538 days	Asplin 1949 Olesuik 1951
<b>RUBBER</b>		
<u>Influenzae virus</u> Rubber, R.T.	40 min. after drying still positive	Anon. 1943
<b>GENERAL</b>		
<u>Foot &amp; Mouth virus</u> Temp. 3.5 & 5.5 C., if kept moist R.T., dried rapidly in a vacuum On infected premises	6 months 105 days 345 days	Traum 1934 " "
<u>Tobacco mosaic virus</u> Cured tobacco leaves	31 years	Valleoy 1927
<u>Small pox virus</u> Crusts	" many years"	Pulvertaft 1947
<u>Swine-fever virus</u> Bricks autoclaved, dried Hay, autoclaved, dried Virus destroyed in 15 min. and hypochlorite, 1.66 % available chlorine.	3 days 3 days by 5% soln. pure phenol	Slavin 1930 Slavin 1938

TABLE 417 (CONT'D). THE SURVIVAL OF VIRUSES ON SURFACES

Factor(s)	Survival	Reference
GENERAL (CONT'D)		
<u>Influenzae virus (Melbourne)</u>		
Talc, dried with, original titer $10^{-3}$	Recovered none, 22 days	Parker 1944
Mucin in air, dried with, original titer $10^{-4}$	Recovery positive in 45 days	

THE SURVIVAL OF YEAST, MOLDS  
AND FUNGI ON SURFACES

Factor(s)	Survival	Reference
<p>DUST</p> <p><u>Molds</u> Dust in air during dust storm</p>	<p>Dust counts yielded unusually high counts</p>	<p>Proctor 1935</p>
<p>FABRICS</p> <p><u>Trichophyton interdigitale</u> Woolen jersey</p> <p><u>Trichophyton gypseum</u> Cotton string and linen</p> <p><u>Microsporon audouini</u> Cotton string</p> <p><u>Microsporon lanosum</u> Cotton string</p> <p><u>Fungi spores</u> Clothing, spores carried</p>	<p>2 months</p> <p>Several months, at least 102-346 days</p> <p>At least 78-276 days</p> <p>At least 102-235 days</p> <p>-----</p>	<p>Gould 1931</p> <p>Shaw 1944</p> <p>Smith 1943</p>
<p>PAPER</p> <p><u>Trichophyton gypseum</u> Filter paper</p> <p><u>Molds</u> Cardboard strips, spores ultra-violet light</p> <p><u>Yeasts</u> Whatman # 50 paper, water susp'n. sprayed, 15 min. exposure to short waves</p>	<p>Several months, at least 102-346 days</p> <p>None entirely killed</p> <p>50 % killed</p>	<p>Shaw 1944</p> <p>Appling 1941</p> <p>Lion 1949</p>
<p>GENERAL</p> <p><u>Microsporon audouini</u> Hair planted on Sabouraud</p> <p><u>Fungi</u> Hand tele phone</p> <p><u>Molds</u> Hand tele phones Telephones with separate receiver and transmitter</p> <p><u>Yeast</u> Hand telephones Telephones with separate receiver and transmitter</p>	<p>420 days</p> <p>5.75 % organism</p> <p>20.83% organisms</p> <p>11.10% organisms</p> <p>47.92%</p> <p>11.10%</p>	<p>Farley 1921</p> <p>Smeall 1937</p> <p>Smeall 1937</p> <p>Smeall 1937</p> <p>" "</p>



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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Ig.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
app.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
>	greater than
<	less than
+	present; plus
0	none
-	minus

THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN WATER

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TABLE W1

## THE SURVIVAL OF BACILLUS SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Bacillus anthracis</u>		
Tap, 20C	6 d.	Bolton 1886
" 35C	55 hr.	" "
Lake	12 yr.	Anon. 1921
Well	36 hr.	Emmerich 1889
Water, laboratory condition	18.5 yr.	Hastings 1923
Raw	5 mo.	" "
Tap, 11-13C	3 d.	Hochstetter 1887
" 18-20C	Spores 15 1/2 d.	" "
Water	72 hr.	Karlinski 1889
Tap, R.T., in spleen	3 1/2 yr.	Konradi 1904
" " " culture	> 264 d.	" "
" " " spores on silk thread	> 816 d.	" "
Tap, body temp., in spleen	3 yr.	" "
" " " " cult.	264 d.	" "
" " " spores on silk thread	144 d.	" "
Ster., R. T., in spleen	3 1/2 yr.	" "
" " " " cult.	> 264 d.	" "
" " " spores on silk thread	> 816 d.	" "
Ster., body temp., in spleen	1 yr.	" "
Ster., body temp., in cult.	> 264 d.	" "
Ster., " " spores on silk thread	144 d.	" "
Well, tap, 10 1/2 C	Inoc. 1050-1180, 3 d.	Kraus 1887
Ster. muddy, stored in bottles in pond on plains	> 2 yr.	Minett 1950
Lake	12 yr.	Morris 1921
Stagnant pools	Viable	Naik 1938
River, 30-35, 7-10C	Recov. 34,800, 2 d.	Wolffhugel 1886
Filtered river, 35, 7 10C	Recov. 4 immediately	" "
<u>Bacillus yellow sp.</u>		
Tap	208 d.	Hochstetter 1887
<b>DISTILLED WATER</b>		
<u>Bacillus anthracis</u>		
Dist. and filtered well, 20C-35C	90 d.	Bolton 1886
Ster. dist.	30 mo.	Hastings 1923
Dist.	Spores 15 1/2 d.	Hochstetter 1887
Dist., R.T., in cult.	> 264 d.	Konradi 1904
" " " spleen	3 1/2 yr.	" "
" body temp., in cult.	264 d.	" "
Dist., " " " spleen	3 1/2 yr.	" "

TABLE W1

THE SURVIVAL OF BACILLUS SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Bacillus anthracis</u>		
Tap, 20C	6 d.	Bolton 1886
" 35C	55 hr.	" "
Lake	12 yr.	Anon. 1921
Well	36 hr.	Emmerich 1889
Water, laboratory condition	18.5 yr.	Hastings 1923
Raw	5 mo.	" "
Tap, 11-13C	3 d.	Hochstetter 1887
" 18-20C	Spores 154 d.	" "
Water	72 hr.	Karlinaki 1889
Tap, R.T., in spleen	3½ yr.	Konradi 1904
" " " culture	> 264 d.	" "
" " " spores on silk thread	> 816 d.	" "
Tap, body temp., in spleen	3 yr.	" "
" " " " cult.	264 d.	" "
" " " spores on silk thread	144 d.	" "
Ster., R. T., in spleen	3½ yr.	" "
" " " " cult.	> 264 d.	" "
" " " spores on silk thread	> 816 d.	" "
Ster., body temp, in spleen	1 yr.	" "
Ster., body temp., in cult.	> 264 d.	" "
Ster., " " spores on silk thread	144 d.	" "
Well, tap, 10½C	Inoc. 1050-1180, 3 d.	Kraus 1887
Ster. muddy, stored in bottles in pond on plains	> 2 yr.	Minett 1950
Lake	12 yr.	Morris 1921
Stagnant pools	Viable	Naik 1938
River, 30-35, 7-10C	Recov. 34,800, 2 d.	Wolffhugel 1886
Filtered river, 35, 7-10C	Recov. 4 immediately	" "
<u>Bacillus yellow sp.</u>		
Tap	208 d.	Hochstetter 1887
<b>DISTILLED WATER</b>		
<u>Bacillus anthracis</u>		
Dist. and filtered well, 20C-35C	90 d.	Bolton 1886
Ster. dist.	30 mo.	Hastings 1923
Dist.	Spores 154 d.	Hochstetter 1887
Dist., R.T., in cult.	> 264 d.	Konradi 1904
" " " spleen	3½ yr.	" "
" " body temp., in cult.	264 d.	" "
Dist., " " " spleen	3½ yr.	" "



TABLE u (CONT'D) THE SURVIVAL OF BACILLUS SPECIES IN WATER

Factor(s)	Survival	Reference
<b>DISTILLED WATER</b>		
<u>Bacillus anthracis</u>		
Dist., R.T., spores on silk thread	>816 d.	Konradi 1904
Dist., body temp., spores on silk thread	>144 d.	" "
Dist., 25C, direct sun, strong wind	Inoc. 8000 coln., 2 hr.	Kruse 1897
Dist.	Up to 80 d.	Panisset 1925
"	20 mo.	Sirena 1894
Ster. dist., 15-20C	131 d.	Strauss 1889
Dist.	90 d.	T. & W. 1946
<u>Bacillus cereus</u>		
Dist., pH 6	Inoc. 100%, 2% in 120min	Winslow 1927
" " 7	" " 40% " " "	" "
" " 8	" " 23% " " "	" "
" " 9	" " 49% " " "	" "
" centrifuging, pH 6	" 12,000,000/cc; Recov. 9,000/cc; 60	" "
" " " 7	Inoc. 17,000,000/cc; Recov. 3,000/cc; 60	" "
" " " 8	Inoc. 242,000,000/cc; Recov. 12800/cc; 60	" "
" " " 9	Inoc. 271,000,000/cc; Recov. 10200/cc; 60	" "
<u>Bacillus megatherium</u>		
Dist., pH 6	Inoc. 100%; 61% in 90min	" "
" " 7	" " 132% " " "	" "
" " 8	" " 71% " " "	" "
" " 9	" " 82% " " "	" "
<u>Bacillus spp.</u>		
Dist., 10-17C	12d.	Hochstetter 1887
Dist.	Relatively short	Zobell 1932
Redist., R.T.	4-5 wk.	" "
<b>ICE</b>		
<u>Bacillus mesentericus</u>		
Ice	Present	Haines 1937
<b>SALINE SOLUTIONS</b>		
<b>SEA</b>		
<u>Bacillus anthracis</u>		
Sea, bouillon	Inoc. exclusively, 5 d.	De Giaxa 1889
" agar	" very few, 1 d.	" " "
"	20 mo.	Sirena 1894
Ster. sea, bouillon	Inoc. 1052, 36 d.	De Giaxa 1889
<b>SEWAGE</b>		
<u>Bacillus anthracis</u>		
Sewage, R.T.	Inoc. 10,000/cc; 19 d.	Gillissen 1950
Mud of sewage, R.T.	" " " 5 wk.	" "
Sedimentation pond	" " " > 10 d.	" "
Sewage	16 mo.	Sirena 1894
<b>OTHERS</b>		
<u>Bacillus anthracis</u>		
Seltzer, 11-13C and 18-20C	1 hr. and spores 154 d.	Hochstetter 1887

TABLE W

THE SURVIVAL OF BRUCELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<p><b>NATURAL WATERS</b>  <u>Brucella melitensis</u>                      Water favorable condition                      Ster. tap  <u>Brucella abortus</u>                      Pasture water  <u>Brucella suis</u>                      Tap</p>	<p>10 wk.                      20 d.                      &gt; 8 d. &lt; 30 d.                      77 d.</p>	<p>Bang 1897                      Kenndy 1905                      Christiansen 1950                      Bryan 1934</p>
<p><b>SALINE SOLUTIONS</b>  <b>PHYSIOLOGICAL</b>  <u>Brucella spp.</u>                      Salt soln.</p>	<p>in 0.25% than 0.85%                      Above pH 8 and below                      pH 6.6 shorter viability</p>	<p>Zobell 1932</p>

TABLE W3

## THE SURVIVAL OF BACTERIOPHAGE IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>E. coli phage</u> Tap, pH 7.5, 45-75C	Death rate of first order	Chang 1950
Water, pH 5.2, alkaline	Present	Marginesu 1929
<u>S. typhosa phage</u> Water, pH 5.2, alkaline	Not present	" "
Rivers of cities	More in summer mo.	DeAssumpeao 1943
<u>S. paratyphi phage</u> Rivers of cities	" " " "	" "
<u>Sh. dysenteriae phage</u> Water, pH 5.2, alkaline	Not present	Marginesu 1929
<u>Micrococcus phage</u> Water, pH 5.2, alkaline	Present	" "
<u>Vibrios phage</u> Water	Disappearance of Vibrios	D'Herelle 1926
<b>DISTILLED WATER</b>		
<u>Virus T<sub>2</sub> phage</u> Dist., daylight	3% after 72 hr. of irradiation	Latarjet 1951
" white hot bulb	0% after 65 hr. " "	" "
<b>SALINE SOLUTIONS</b>		
<b>SEA</b>		
<u>S. typhosa phage</u> Sea	Recov. 10% in 7 d.	Guelin 1948
<u>S. paradysenteriae phage</u> Sea	Recov. 9% in 30 d.	" "
<u>E. coli phage</u> Sea	" " " " "	" "
<u>General phage</u> Sea	Longer than bacteria	" "
<b>SALINE SOLUTIONS</b>		
<b>PHYSIOLOGICAL</b>		
<u>S. typhosa phage</u> Saline	4% in 3 d.	Guelin 1948
<u>Sh. paradysenteriae phage</u> Saline	2% in 2 d.	" "
<u>E. coli phage</u> Saline	1% in 2 d.	" "
<b>SEWAGE</b>		
<u>General phage</u> Sewage	Varies seasonally	Beckwith 1930

TABLE W4

THE SURVIVAL OF CLOSTRIDIUM SPECIES IN WATER

Factor(s)	Survival	Reference
<p>ICE  <u>Clostridium botulinum</u>                      Ice, -16C</p>	<p>14 mo.</p>	<p>Tanner 1931</p>
<p>SEWAGE  <u>Clostridium perfringens and</u>                      Activated sludge</p>	<p><u>sporogenes</u>                      After being pressed and                      heated was present</p>	<p>Greer 1926</p>

TABLE 147

## THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Escherichia coli</u>		
Polluted, 20C	Recov. 827; 72 hr.	Albert 1917
" " 37C	" 384; " "	" "
Well, outside temp.	Inoc. 1-301 of infected water, 55 d.	Bartos 1947
" " " , with S. typhimurium	6 d.	" "
Well, outside temp., " S. typhosa	30 d.	" "
Well, outside temp., " Sh. spp.	30 d.	" "
Well, R.T., pH 7.8-8.2	Inoc. 6.3-9.8 million 55 d.	" "
Water, full radition iron ore, under glass cooled	5-30 min.	Bazzoni 1914
Tap 22C	>200 d.	Bigger 1934
River, 35-4C	>6 d. and 3 d. resp.	Bogolyubov 1946
Water plus sunlight	Inoc. 100,000, 1 hr.	Buchner 1892
River coliform in tap	>70 d.	Burke 1931
River	Not given	Butterfield 1928
Water plus ultraviolet rays	Few sec.	Bujwid -
Water plus chloramine	Am't of chloramine and length of exposure effect survival	Butterfield 1946
Spring	Longer than has been reported	Catalano 1947
Water	At constant pH and rise in temp. E. coli dies faster than S. typhosa	Cohen 1922
Water, 25 Kg, press. of carbon dioxide	>5 d.	Colin 1915
Water, R. T., 6-10C	Erratic fluctions in cts.	Cox 1949
River, weaklight	Inoc. 72,000,000; 46 d.	Arloing 1931
" daylight	" " " "	" "
" natural	" " 87 d.	" "
" filtered	" " " "	" "
" " and heat- ed to 120C	" " " "	" "
Iced and not iced water for shipment	Little importance	Ellison 1928
River	Isolated every test period	Ford 1912
Well	Grows in pump grease for contamination	Frantsev 1935
Unster., cold 8C	Prolongs, 84 d.	Hale 1910
" hot 37C	Curtails, 8-10 d.	" "
Water	Death increases with temp.	Hinds 1932
Surface	Rarly occur on long storage	Holwerda 1928

TABLE lv (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>Escherichia coli</u>		
Well, R. T.	31 d.	Horrocks 1903
River, R.T.	2 mo.	" "
Ster. river	2-3 mo.	" "
River, winter	After 10 hr. 80%	Hoskins 1935
" summer	" " " 67.3%	" "
River, cold	Prolongs	Houston 1911
" hot	Curtails	" "
Tap, 20C	Dies rapidly	" 1912
Ship tanks, 27C, purified 10x	Inoc. 100cc, 25 d.	Jones 1936
Tank not cleaned for 7 mo. 19C	" 4cc, 54 d.	" "
Tank uncleaned for 15 mo.	" 1000cc, 15 d.	" "
Steam ster. lake, R.T., dark	Inoc. 1925, 262 d.	Jordan 1895
Water	Not given	Kister 1930
Tap	61 d.	Kusama 1925
Natural plus chlorine	Pathogenes found on occasion	Levine 1947
Ster., 10-15C, diffuse sun	13 d.	McNaught 1910
" 12-15C, inside window	>15 d.	" "
Ag treated water	0 at 30 min.	Mallmann 1937
Water, 12C	Recov. 1236, 1 d.	Maccolin 1946
" "	" 756, 6 d.	" "
" 17C	" 989, 14 d.	" "
" "	" 1248, 14 d.	" "
Well, R.T., 0.35-0.65% Cl, traces of nitrate and nitrite	2-5 mo.	Mazzeo 1940
Water	2-3 wk.	Ministry of Health 1934
"	Low conc. of Cl stimulate growth	Nordgren 1939
Commercial spring, 20C	Inoc. 99,750,000; Recov. <10; 45 d.	Obst 1919
Ster. river, 18C, dark	Inoc. 27,000/cc; Recov. 4,900/cc; 73 d.	Platt 1935
" " " diffuse	Inoc. 27,000/cc; Recov. 0; 52 d.	" "
" " 37C, dark	Inoc. 27,000/cc; Recov. 0; 30 d.	" "
" " 0-2C	Inoc. 27,000/cc; Recov. 3,900/cc; 73 d.	" "
" " dark, 18C, with E. coli and A. aerogenes	Inoc. 57,000/cc; Recov. 9,700/cc; 73 d.	" "
Ster. river, diffuse, 18C, with E. coli and A. aerogenes	Inoc. 57,000/cc; Recov. 420,000/cc; 73 d.	" "

TABLE W7 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>Escherichia coli</u>		
Ster. river, dark, 37C, with E. coli and A. aerogenes	Inoc. 57,000/cc; Recov. 0; 30 d.	Platt 1935
Raw river, 0-20	Inoc. normal river flora Recov. 0; >29 d.	" "
" " dark, 18C	Inoc. normal river flora Recov. 0; >1 <5 d.	" "
" " diffuse light, 18C	Inoc. normal river flora Recov. 0; >1 <5 d.	" "
Raw river, incubator, 37C	Inoc. normal river flora Recov. 0; >1 <5 d.	" "
" " dark, 18C	Inoc. >10,000; Recov. 0, >1 <5 d.	" "
" " 0-20	Inoc. >10,000; Recov. 0, >5 <9	" "
" " diffuse, 18C	Inoc. >10,000; Recov. 0, >5 <9	" "
" " incubator, 37C	Inoc. >10,000; Recov. 0, >5 <9	" "
Stored river in open masonry tank during monsoon and hot weather	>4 mo.	Raghavachari 1939
Tap, litmus lactose	48 d.	Rector 1917
" dextrose liver	64 d.	" "
Bottle of water, litmus lactose	25 d.	" "
Bottle of water, dextrose liver	36 d.	" "
River, 26C, tank not cleaned for 7 mo.	Recov. present in 1000cc, 54 d.	Royds 1936
River, 28C, tank not cleaned for 15 mo.	Recov. " " 300cc, 14 d.	" "
River, 28C, tank cement washed	Recov. present in 12.5cc, 0 d.	" "
River, 27C Tank emptied without cleaning	Recov. present in 100cc, 7 d.	" "
Streams, cold	Prolongs	Ruediger 1911
" hot	Curtails	" "
Raw, ultraviolet	Inoc. 1500, 15 sec.	Schwarz 1911
Stagnant	Dies rapidly in summer	Stundl 1941
Water, 13-17C	Increase	Taylor 1947
Water, dark, stored	>20 yr.	Teissier 1919
Deep well, 22C, on agar	Inoc. 84/cc, Recov. 3500, 24 hr.	Thresh 1910
" " 0C " "	Inoc. 84/cc, Recov. 18/cc, 24 hr.	" "
" " 22C, on gel.	Inoc. 23/cc, Recov. 1.700 /cc, 24 hr.	" "
" " 0C, " "	Inoc. 127/cc, Recov. 86/cc, 24 hr.	" "

TABLE 10 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>Escherichia coli</u>		
Water, after centerifuging 1 hr. later	280 d. 131 d.	Winslow 1927 "
Water, 37C, pH 4	Recov. 1%, 9 hr.	" 1923
" " " 5	" 82%, 9 hr.	" "
" " " 6	" 106%, 9 hr.	" "
" " " 7	" 54%, 9 hr.	" "
" " " 7.5	" 35%, " "	" "
" " " 8	" 12%, " "	" "
Boiled or steamed hard water, capsulated non-excretal	2-3½ yr.	Wood 1943
Boiled or steamed hard water, noncapsulated excretal	5 wk.	" "
River	45 d.	Webster 1934
"	34 d.	" "
<b>DISTILLED WATER</b>		
<u>Escherichia coli</u>		
Distilled	31½ mo.	Ballantyne 1930
" " 0-8C	16 mo.	" "
" full radition with Hg, under glass cooled	30-5 min.	Bazzoni 1914
Distilled water with talc. 37C	220 d.	Bigger 1941
Distilled water with talc. 22C	335 d.	" "
Distilled water with K <sub>2</sub> MnO <sub>4</sub> and KOH	72 hr.	Burke 1936
Double dist.	Longer than has been reported	Catalano 1947
Dist.	51 d.	Gramarossa 1927
" gelose	2 d.	Duhot 1933
" bouillon	75 d.	" "
"	4-7 d., K value 0.175 33.0% reduct/d.	Heller 1941
"	69 d.	Kusama 1925
"	Died more rapidly with increase in temp.	Levine 1921
" 37C	Up to 74 d.	Panisset 1925
" litmus lactose	48 d.	Rector 1917
" dextrose liver	57 d.	" "
" pH 2	Recov. 1%, 4 hr.	Shaughnessy 1925
" " 6	" 115%, 4 hr.	" "
" " 8	" 120%, " "	" "
" " 11	" 4%, 4 hr.	" "
" " 6-6.9	Most favorable zone	" 1924
Ster. Dist., 37C, agar 3 d.	50 d.	Slater 1893
Dist.	Greater than in suppose	Tanner 1944



TABLE W (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>DISTILLED WATER (cont'd)</b>		
<u>Escherichia coli</u> Dist., 60-142C,	Inoc. 16-20 hr. cult. in 6 cc water, 1 hr.	Tinti 1923
"	74 d.	Webster 1934
" pH 6	Inoc. 84% at 1 hr., Recov. 77 at 24 hr.	Winslow 1923
"	93.7% recov., 24 hr.	Zobell 1937
<b>ICE</b>		
<u>Escherichia coli</u>		
Ice, clear and core	Fewer alive in clear	Christomanos 1898
Ice	3-5 d.	Fraenkel -
Ice, -20C	Inoc. 0.1cc suspn., 163d	Haines 1937
" -2C	" " " 11 d.	" "
" -6C	93-99% death	Hilliard 1918
Glucose in tap, -10C	50% death, 3 hr.	" "
Tap, -20C	3 wk.	Keith 1913
Water, -20C	Many mo., metabolism and the protection offered by the medium effect	" "
Dist, -21 to -78C	Inoc. 10,000-100000/ml., more resistant to freezing than thawing	Lund -
Water, -8 to -30C	30 d.	Lu-Ti-Huan 1930
Dist., -10C, pH 6.5	Inoc. 15.20m/cc, 68.5% killed 1 wk.	McFarlane 1941
" -20C, pH 6.5	Inoc. 15.20m/cc, 34% killed 1 wk.	" "
" -10C, pH 5	Inoc. 2,310,000; 99.9% killed 32 wk.	" "
" -20C, " "	Inoc. 2,310,000; " killed 32 wk.	" "
" -10C, " 3.6	Inoc. 1.5-2.5m/cc; " killed 1 wk.	" "
" -20C, " "	Inoc. 1.5-2.5m/cc; " killed 1 wk.	" "
" -16, -40, and -79C	Long time	Tanner 1931
<b>SALINE SOLUTION</b>		
<b>SEA</b>		
<u>Escherichia coli</u> River and sea	Bacteriophage effect survival	Arloing 1925
Sea, filtered	Inoc. 500,000/cc; >35 d.	Beard 1935
" unfiltered	" 1,200/cc; >35 d.	" "
" infected by ducks	Present	Bidwell 1950
"	2 d.	Gohar 1948
" Seitz filtered	4 d.	" "
" " " "	39 d.	" "
autoclaved		
Sea, " Seitz filtered, pulp disc	10 d.	" "
Sea, Seitz filt, 60C	5 d.	" "
" " " 100C	27d.	" "

TABLE W (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>SALINE SOLUTION</b>		
<b>SEA</b>		
<u>Escherichia coli</u>		
Sea, autoclaved	5 d.	Guelin 1948
" not autoclaved	5 d.	" "
" 20C	Dies rapidly	Houston 1912
Ster. sea, 22C	Inoc. gelatine lactose, Recov. < 100, 80 d.	Violle 1942
Sea	Could not be isolated	Zobell 1941
Salt lake	Sewage bact. Recov. 4.8% 24 hr.	" 1937
<b>PHYSIOLOGICAL</b>		
<u>Escherichia coli</u>		
85% NaCl, 37C	13 1/2 mo.	Ballantyne 1930
" R.T.	31 1/2 mo.	" "
Physiological soln., full radition, under glass and cooled	5 min.	Bazzoni 1914
Saline	32 d.	Cramarossa 1927
" , cultured in gelose	7 d.	Duhot 1933
Saline, bouillon	> 90 d.	" "
"	K value 0.085, 17.7% reduction 1 d.	Heller 1941
NaCl, 1.45M soln., pH 2	Recov. 2%, 4 hr.	Shaughnessy 1925
" " " " 6	" 65%, 4 hr.	" "
" " " " 8	" 0%, 4 hr.	" "
" " " " 11	" " " "	" "
" 0.145M " " 2	" " " "	" "
" " " " 6	" 88%, 4 hr.	" "
" " " " 8	" 112%, 4 hr.	" "
" " " " 11	" 0%, 4 hr.	" "
" 0.0145M " " 2	" .1%, 4 hr.	" "
" " " " 6	" 91%, " "	" "
" " " " 8	" 60%, " "	" "
" " " " 11	" 0%, 4 hr.	" "
<b>SEWAGE</b>		
<u>Escherichia coli</u>		
Sewage	Cts. higher in summer than in winter	Allen 1949
" plus cloroben in streams	50-90% killed Found 12 mi. below out- let, on sunny days 2.9 mi.	Brown 1947 " 1916
Sewage	Milt. on storage at high temp.	Butterfield 1933
" , aerated 62 hr. and irrigation	Inoc. 1:300, 6 hr.	Carlson 1943
water	Not given	Chapman 1935
Sewage	Not sufficient to cause disease	Crawford 1940
Sewage ordinary	53-65 d.	Firth 1902

TABLE W (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>SEWAGE</b>		
<u>Escherichia coli</u>		
Crude sewage	12 d.	Firth 1902
Sewage with phosphate buffer	> 4 d.	Heukelekian 1933
River plus 45% sewage	After 46 hr. 60%	Hoskins 1935
Sewage held in parchment bag in running water	Inoc. 190 T, Recov. 30/cc	
Ster. water and feces, 200	7 d.	Rogers 1918
	Inoc. 4,700,000/cc at 31 d., Recov. 38,750/cc	"
	278 d.	
Feces and natural water	2 d.	Savage 1917
Sewage, winter	> 26 d.	Shimomura 1935
" summer	> 7 d.	"
<b>NATURAL WATERS</b>		
<u>Escherichia intermedium</u>		
River	45 d.	Webster 1934
"	34 d.	"
Water, 37C, pH 4	Recov. 1%, 9 hr.	Winslow 1923
" " " 5	" 82%, 9 hr.	"
" " " 6	" 106%, 9 hr.	"
" " " 7	" 54%, " "	"
" " " 7.5	" 35%, " "	"
" " " 8.0	" 12%, " "	"
<u>Aerobacter aerogenes</u>		
Well	> 1 yr.	Caldwell 1933
River, Ster., ice chest 0-2C	Inoc. 30,000/cc; Recov. 0, 21 d.	Platt 1935
River, ster., dark, 18C	Inoc. 30,000/cc; 4,900.cc; 73 d.	"
River, ster., diffuse light, 18C	Inoc. 30,000/cc; 420,000/cc; 73 d.	"
River, ster., incubator, 37C	Inoc. 30,000/cc; 0, 1 d.	"
Raw river, ice chest, 0-2C	Inoc. normal river, Recov. 0, >29 d.	"
Raw river, dark, 18C	Inoc. normal river, Recov. 0, >9 <14 d.	"
Raw river, diffuse light, 18C	Inoc. normal river, Recov. 0, >1 <5 d.	"
Raw river, incubator, 37C	Inoc. normal river, Recov. 0, >5 <9 d.	"
Ster. river, ice chest, 0-2C, plus E. coli	Inoc. 57,000/cc; Recov. 4,900/cc, 73 d.	"
Ster. river, dark, 18C, plus E. coli	Inoc. 57,000/cc; Recov. 9,700/cc; 73 d.	"
Ster. river, diffuse light, 18C, plus E. coli	Inoc. 57,000/cc; Recov. 420,000/cc; 73 d.	"
Ster. river, incubator, 37C, plus E. coli	Inoc. 57,000/cc; Recov. 0, 30 d.	"
Water before contamination 37-22C	Recov. 23-30, 1 d. and 35-51, 56 d.	Gray 1932

TABLE W5 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>Aerobacter aerogenes</u>		
Water, 10C	Prevalent	Taylor 1947
Tap, diffuse light	Inoc. 46%, Recov. 71%, 60 d.	Winslow 1918
Water plus E. coli	98-99% reduction 10 d. A. aerogenes decreased more rapidly	" "
Tap plus E. coli, diffuse light, and dark, R.T.	E. coli died more rapid	" "
<u>Aerobacter cloacae</u>		
River	Constant	Ford 1912
<u>Aerobacter spp.</u>		
Water, 12C	Recov. 1804, 1 d.	Maccolini 1946
" "	" 7800, 6 d.	" "
" 17C	" Innumerable	" "
" "	" "	" "
<b>DISTILLED WATER</b>		
<u>Escherichia intermedium</u>		
Dist.	59 d.	Webster 1934
"	62 d.	" "
<b>SEWAGE</b>		
<u>Aerobacter aerogenes</u>		
Crude sewage and effluent	About the same as E. coli	Atkinson 1934
Ster. water plus feces, 20C	Inoc. 4,700,000 at 31 d. Recov. 38,750/cc; 278d	Rogers 1918

TABLE 26

## THE SURVIVAL OF LEPTOSPIRA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATER</b>		
<u>L. icterohaemorrhagiae</u>		
Pit water	Months	Buchanan 1927
Water, 5-32C	3-9 d.	Chang 1948
Ster. tap, pH 7.0-7.1, 26C	30-32 d.	" "
" " " " " 5-6C	16-18 d.	" "
Tap with bact., neutral pH	4 wk.	" "
River, pH 7.1-7.0	5-6 d.	" "
Tap with 1% serum, 25-27C, pH 7.2-7.3	> 3 mo.	" "
River	48 hr.	Noguchi 1918
Stagnant, 25-32C, pH 7.6	Inoc. 1cc. active cult., 55 d.	Sawyer 1928
" " " " "	Inoc. 1cc. active cult., 55 d.	" "
" " " " "	Inoc. 1 cc. " "	" "
	115 d.	
<b>DISTILLED WATER</b>		
<u>L. icterohaemorrhagiae</u>		
Dist.	7 d.	Noguchi 1918
<b>SALINE SOLUTION</b>		
<b>SEA</b>		
<u>L. icterohaemorrhagiae</u>		
Sea	18-20 hr.	Chang 1948
<b>SEWAGE</b>		
<u>L. icterohaemorrhagiae</u>		
Sewage	7-8 d.	Chang 1948
Polluted water	More in summer and fall	Gardner 1946
Feces and tap, 25-32C	Inoc. 0.5cc. active cult., 55 d.	Sawyer 1928

TABLE u7

THE SURVIVAL OF METAZOA AND PROTOZOA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Endamoeba histolytica</u>		
Water, R.T. for 4 hr.	2 d.	Beaver 1949
" 14C, for 4 hr.	" "	" "
" R.T. for 1 hr.	4 d.	" "
" 14C for 12 hr.	" "	" "
" 28-340C	" "	" "
Chlorinated water	Not all of cysts die	Becker 1946
Water, R.T.	10 min.	Bolduc 1935
" ultraviolet rays	Short time	Chamberlain -
" 45C	Inoc. 1,100; 105 min.	Chang 1950
" 47C	" " 32 "	" "
" 49C	" " 8 "	" "
" 50C	" " 2 "	" "
" R.T.	5 wk.	Dobell 1919
Drinking water	Can be transmitted	Hegner 1934
Water, pH 6.5-6.7, 45-54.5C	> 2 hr. 1 min.	Jones 1948
Water, 7cm. deep, sun 360	50% left in 2 hr.	Kuenen 1913
"	Inoc. 50 cysts; Recov. 47; 9 d.	" "
Slow running water	15 d.	Penfold 1916
<u>Trichomonas vaginalis</u>		
Water	35-45 min.	Jerovic 1948
<u>Ancylostoma duodenale</u>		
Water, 60F	18 mo.	Nicoll 1917
<u>Ancylostoma sp.</u>		
Water, by lab window	12 mo.	Loebker 1906
<u>Necator americanus</u>		
Water, 60F	18 mo.	Nicoll 1917
<b>DISTILLED WATER</b>		
<u>Endamoeba histolytica</u>		
Dist., 12-22C	153 d.	Boeck 1921
" tap, R.T.	14 d.	Dobell 1926
<u>Endamoeba coli</u>		
Dist., 12-22C	244 d.	Boeck 1921
<u>Giardia intestinalis</u>		
Dist., 12-22C	32-66 d.	" "
<u>Chilomastix mesnili</u>		
Dist., 12-22C	187 d.	" "
<b>SEWAGE</b>		
<u>Endamoeba histolytica</u>		
Sludge, 103C	Inoc. 500,000; 48 hr.	Cram 1943
Dilute feces	> 1 mo.	Wenyon 1917
<u>Ascaris lumbricoides</u>		
Sludge, 103C	Egg lives 3 min.	Cram 1943
" "	" " 151 d.	" "
"	62 d.	Wright 1942
<u>Acylostoma sp.</u>		
Sludge, 103C	5 d.	Cram 1943
<u>Taenia saginata</u>		
Sludge, digestion, 75-85F	Inoc. 600,000; 6 mo.	Newton 1949
<u>Trichuris trichiura</u>		
Sludge	22 d.	Wright 1942

TABLE W1 (CONT'D) THE SURVIVAL OF METAZOA AND PROTOZOA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Paramecium</u>		
Sewage	Die in few days.	Purdy 1918
<u>General</u>		
Sewage	Protozoa and bacteria rapid increase in protozoa, decrease in bacteria	" "

TABLE W8

THE SURVIVAL OF MICROCOCCUS ~~SP.~~ IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Micrococcus aurantiacus</u> Tap, 10-17C	22 d.	Hochstetter 1887
<u>Micrococcus spp.</u> Tap, 20C	2-4 d.	Bolton 1886
Impure filtered, 20C	4-6 d.	" "
Tap, 35C	2-4 d.	" "
Impure filtered, 35C	2-4 d.	" "
Unfiltered well, 20C	4-6 d.	" "
" " 35C	4-6 d.	" "
Tap, R.T., in cult.	508 d.	Konradi 1904
" " in pus	545 d.	" "
" body temp., in cult.	438 d.	" "
" " " pus	511 d.	" "
Ster., R.T., in cult.	30 d.	" "
" " " pus	" "	" "
" body temp., in cult.	30 d.	" "
" " " pus	" "	" "
Swimming pool plus Cl	30 min.	Ritter 1948
Ster. tap without Cl	7 hr.	" "
Ster. soda water, 37 C	Inoc. agar cult. 48 hr. old; 12 d.	Slater 1893
Water	10-20 d.	Veissfeiler 1935
<b>DISTILLED WATER</b>		
<u>Micrococcus pyogenes var. aureus (Staph. aureus)</u> Dist.	32 d.	Cramarossa 1922
<u>Micrococcus pyogenes var. albus</u> Dist.	48 d.	" "
<u>Micrococcus spp.</u> Distilled tap and well, 20C	20-30 d.	Bolton 1886
Distilled " " " 35C	5-10 d.	" "
Distilled, 20C	2-4 d.	" "
" 35C	2-4 d.	" "
Dist. R.T., in cult.	30 d.	Konradi 1904
" " " pus	" "	" "
" body temp., in cult.	438 d.	" "
" " " pus	469 d.	" "
Ster. dist., 15-20C	21 d.	Strauss 1889
Dist., 60-142C	Inoc. 16-20 hr. cult. in 6 cc. water; 1 hr.	Tinti 1923
<u>Micrococcus aurantiacus</u> Dist., 10-17C	22 d.	Hochstetter 1887
<b>ICE</b>		
<u>Micrococcus pyogenes var. aureus (Staph. aureus)</u> Water, alternate freezing and thawing	Inoc. 111,782/cc; 96 hr.	Prudden 1887
Contaminated, 14-30F	Recov. 49,280/cc; 66 d.	" "
Dist., -20 to -78C	Inoc. 10,000-100,000/ml. More resistant to freezing	Lund "



TABLE W8

## THE SURVIVAL OF MICROCOCCUS SPECIES IN WATER

Factor(s)	Survival	Reference
<b>SALINE SOLUTIONS</b>		
<b>SEA</b>		
<u>Micrococcus pyogenes var. aureus</u> (Staph. aureus)	Inoc. 3/4, 36 d.	De Giava 1889
Sea, bouillon	" almost exclusively	" " "
" agar	9 d.	" " "
Ster. sea, bouillon	Inoc. rich growth, 36 d,	" " "
<b>PHYSIOLOGICAL</b>		
<u>Micrococcus pyogenes var. aureus</u> (Staph. aureus)		
Saline	29 d.	Cramarossa 1927
<u>Micrococcus pyogenes var. albus</u>		
Saline	23 d.	" "
<b>OTHERS</b>		
<u>Micrococcus aurantiacus</u>		
Seltzer, 10-17C	16 d.	Hochstetter 1887

TABLE W9

## THE SURVIVAL OF MICROORGANISMS IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Alcaligenes faecalis</u> River	Constant	Ford 1912
<u>Corynebacterium diphtheriae</u> Ster. R.T.	3 d.	Lomry 1929
" 37C	30 hr.	" "
<u>Neisseria gonorrhoeae</u> Ster. tap, 37C	22 min.	Bengtson 1925
<u>Bacterium phosphorescens</u> Fresh	1 wk.	Korinek 1926
<b>DISTILLED WATER</b>		
<u>Alcaligenes faecalis</u> Dist.	18 d.	Cramarossa 1927
<u>Neisseria gonorrhoea</u> Ster. dist., 37C	22 min.	Bengtson 1925
Dist., 18-22C	Inoc. 24 hr. cult., Re- cov. 60.4%, 6 hr.	Pieper 1930
" " "	Inoc. 48 hr. cult., Recov. 70%, 6 hr.	" "
<b>ICE</b>		
<u>Lactobacillus casei</u> Dist., -21 to -78C	10,000-100,000/ml, more resistant to freezing than thawing	Lund -
<u>Neisseria gonorrhoea</u> Ice	9-15 d.	Hampil 1932
<b>SALINE SOLUTIONS</b>		
<b>PHYSIOLOGICAL</b>		
<u>Alcaligenes faecalis</u> Saline	21 d.	Cramarossa 1927
<u>Neisseria gonorrhoea</u> Physiological NaCl, R.T.	Inoc. 24 hr. agar cult. Recov. 79.2%, 6 hr.	Pieper 1930
" " "	Inoc. 48 hr. agar cult. Recov. 57.9%, 6 hr.	" "
<b>SEWAGE</b>		
<u>Bacterium salmonicida</u> Domestic sewage	15 d.	Duff 1940
Sewage after removal of original sewage	13-67 d.	" "
<b>NATURAL WATERS</b>		
<u>Erysipelothrix spp.</u> Drinking water	4-5 d.	Hettche 1937
<b>SALINE SOLUTIONS</b>		
<b>SEA</b>		
<u>Erysipelothrix sp.</u> Sea ster.	1 wk.	Hettche 1937

TABLE

W10

THE SURVIVAL OF MICROORGANISMS IN WATER  
(Klebsiella, Serratia, Proteus, & Pseudomona)

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Serratia marcescens</u>		
Impure well, 20C	310 d.	Bolton 1886
Water, spring	Present	Mazurczak 1945
Tap, 10-17C	109-98 d.	Hochstetter 1887
Raw with ultraviolet	Inoc. 250,000/cc; 15 sec.	Schwarz 1911
Water plus potato juice with peptone, diffuse light	48 hr.	Symon 1947
<u>Proteus sp.</u>		
River	Found	Ford 1912
<u>Pseudomonas pyocyanea</u>		
Water, Hg and Fe ore radiation, under glass, cooled	1 min. at 8 cm.	Bazzoni 1914
All kinds of water	Flourished	Frankland 1886
<u>Pseudomonas spp.</u>		
Tap, 12-17C	14 d.	Hochstetter 1887
Aerated, 22C	Inoc. 4 d. old gel. cult. 16 d.	Slater 1893
<b>DISTILLED WATER</b>		
<u>Klebsiella pneumoniae</u>		
Distilled	31½ mo.	Ballantyne 1930
"	Up to 76 d.	Panisset 1925
Ster. dist., 15-20C	8 d.	Strauss 1889
<u>Serratia marcescens</u>		
Dist., 20C	48 d.	Bolton 1886
" 35C	14 d.	" "
" 10-17C	7 d. - 5 d.	" "
"	36 d.	Cramarossa 1922
<u>Pseudomonas pyocyanea</u>		
Dist., 37C	30 3/4 mo.	Ballantyne 1930
"	31½ mo.	" "
" 0-8C	25 mo.	" "
"	85 d.	Cramarossa 1922
<u>Pseudomonas spp.</u>		
Dist., 12-17C	14 d.	Hochstetter 1887
" plus Cu 1/10m.	2 hr.	T. & W. 1932
<b>ICE</b>		
<u>Serratia marcescens</u>		
Water, -10 to -1C	Continous freezing 51 d.	Hilliard 1918
Contaminated, 14-30F	Recov. 6,300/cc, 51 d.	Prudden 1887
Water, -10 to -1.1C	51 d.	Frankland 1894
<u>Proteus vulgaris</u>		
Ice, 14-30F	103 d.	Hilliard 1918
Contaminated water, 14- 30F	Inoc. 8,320/cc; Recov. 0, 51 d.	Prudden 1887
Water, -10 to -1.1C	51 d.	Frankland 1894
<u>Pseudomonas pyocyanea</u>		
Ice, -5, -20, -70C	80%	Haines 1937
<u>Pseudomonas fluorescens</u>		
Contaminated, 14-30F	Inoc. innimerable, Recov. 85,008/cc; > 7 d.	Prudden 1887

TABLE W 10 (CONT'D) THE SURVIVAL OF MICROORGANISMS IN WATER  
 (Klebsiella, Serratia, Proteus, & Pseudomona)

Factor(s)	Survival	Reference
<b>SALINE SOLUTIONS</b>		
<b>PHYSIOLOGICAL</b>		
<u>Klebsiella pneumoniae</u>		
85% NaCl	3½ mo.	Ballantyne 1930
<u>Proteus sp.</u>		
Saline	40 d.	Cramarossa 1927
<u>Pseudomonas pyocyanea</u>		
85% NaCl, 37C	30 3/4 mo.	Ballantyne 1930
" " R.T.	31¼ mo.	" "
Saline	85 d.	Cramarossa 1927
<b>SEWAGE</b>		
<u>Pseudomonas sp.</u>		
Ster. sewage, R.T.	7½ mo.	Rochaix 1930
<b>OTHERS</b>		
<u>Serratia marcescens</u>		
Seltzer, 10-17C	6-10 d.	Hochstetter 1887
<u>Pseudomonas sp.</u>		
Seltzer, 12-17C	11 d.	" "

TABLE W11

THE SURVIVAL OF MYCOBACTERIUM SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Mycobacterium tuberculosis</u> Washings from children's hands, R.T.	0	Augustine 1929
Water	> 21 d.	Bartel 1908
Running water	441 d.	Briscoe 1912
Water, winter	120 d.	Cadeac 1888
Tap	> 1 yr.	Caussimon 1933
Ster. river, 8-12C	15 d.	Chantemesse 1888
Unster. " 15-20C	62 d.	" "
River plus boiled sputum	Nothing	Gaustad 1947
Well and tap, 10 1/2 C	Inoc. 57,960-56,000; 6 d.	Kraus 1887
Water	Still virulent 3-3 1/2 mo.	Loesener 1896
Water susp'n., 37C,	Inoc. 4-6 wk. serum cult.	Moriya 1909
" " ice box	1-4 d. Inoc. 4-6 wk. serum "	" "
Canal, diffuse light, R.T. mixed with sputum	52-142 d. 6 1/2 mo.	Musehold 1900
Canal, dark	" "	" "
" " diffuse light all weather	4 1/2 "	" "
<u>Myc. tuberculosis (avium)</u> Stream	Inoc. 48,000/cc; Recov. 940/cc; 73 d.	Rhines 1935
<u>Myc. paratuberculosis</u> Intestinal scrapings with river, outdoor temp.	Recov. 163 d.	Lovell 1944
<b>DISTILLED WATER</b>		
<u>Myc. tuberculosis</u> Dist.	16 mo.	Ballantyne 1930
" "	31 1/2 mo.	" "
" " 0-8C	21 3/4 mo.	" "
Water dist.	> 38 d.	Bartel 1908
Dist., 37C	< 10 d.	Davies 1939
" "	Inoc. 4-6 wk. serum cult.	Moriya 1909
" " Ice box	2-9 d. Inoc. 4-6 wk. serum cult.	" "
Ster. dist., 15-20C	7-152 d. 115 d.	Strauss 1889
<u>Myc. paratuberculosis</u> Dist., pond, tap, and mud	Recov. 9 mo.	Lovell 1944
<b>ICE</b>		
<u>Myc. tuberculosis</u> Dist. ice, dark	> 12 wk.	Gloyne 1928
Ice	12 wk.	" "
<b>SALINE SOLUTIONS</b>		
<b>PHYSIOLOGICAL</b>		
<u>Myc. tuberculosis</u> 85% NaCl, 37C	13 1/2 mo.	Ballantyne 1930
Isotonic NaCl 0.9%	> 88 d.	Bartel 1908

TABLE WII (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN WATER

Factor(s)	Survival	Reference
<b>SALINE SOLUTIONS</b>		
<b>PHYSIOLOGICAL</b>		
<u>Myc. tuberculosis</u>		
0.9% saline	< 4 d.	Davies 1939
Saline, R.T., dark	> 3½ mo. < 5 mo.	Dudgeon 1914
0.8% NaCl, ice box	Inoc. 4-6 wk. serum cult.	
" " 37C	21 d.	Moriya 1909
" " ice box	Inoc. 4-6 wk. " "	" "
	98 d.	" "
	Inoc. 4-6 wk. " "	" "
	152 d.	" "
<b>SEWAGE</b>		
<u>Myc. tuberculosis</u>		
Sewage	Not given	Cummins 1929
" contaminated river	" "	Dudgeon 1914
Waste water, summer, dark	4 mo.	Honkanen 1947
" " winter, "	5 mo.	" "
" " " light	4 mo.	" "
Waste water from abattoir	Present	Jepsen 1940
Sewage, environmental	"	Jessen 1910
Canal liquid manure	6½ mo.	Musehold 1900
at R.T., diffuse light		
Canal liquid manure, all weather	6½ mo.	" "
Canal liquid " R.T. dark	105 d.	" "
Canal liquid manure and garden soil, exposed to noon sun	4 mo.	" "
Canal liquid manure and garden soil, all weather	148 d.	" "
Canal liquid manure, all weather and noon sun	60 d.	" "
Sewage, 50C	Inoc. 830,000/ml, Recov. 840,000/ml, 1 hr.	Pramer 1950
" 37C	Inoc. 27, Recov. 35 coln. 35 d.	" "
Polluted water, R.T., dark	3 mo.	Rhines 1935
Sewage	93 d.	Tanner 1944
<u>Myc. avium</u>		
Sewage	Inoc. 49,000/cc, Recov. 400/cc, 73 d.	Rhines 1935

TABLE 1 <sup>2</sup>

FACTORS AFFECTING SURVIVAL OF ORGANISMS IN WATERS

Factors(s)	Survival	Reference
<b>NATURAL WATERS</b>		
Deionized water more frequently regenerated the fever organisms		Eisman 1949
The action of the ultraviolet rays on bacteria is affected by the minerals in water		Gutfeld 1928
Drinking fountain drains had a count of 42,000/ml bacteria, inlets had 6,000/ml, outlets 7,000/ml.		Hitchens 1943
Terrestrial and fresh water bacteria tolerate changes in salinity and osmotic pressure better than marine.		Korinek 1926
When coliform group is not found others may be present. Reasons why coliform group should not be used as indicators for sanitation.		Levine 1947
(1) Out breaks of enteric diseases associated with treated waters that had been found potable by coliform index.		
(2) Antagonistic effects of some strains of Shigella against coliforms.		
(3) Greater resistance of some viruses, Salmonella, Shigella, and E.berthella to chlorination than are some of coliform groups.		
(4) Viruses of poliomyelitis and hepatitis in feces transmission of latter by water and typhus fever by ingestion.		
(5) Role of the non-lactose fermenting bacteria of the genera Salmonella, Shigella and possibly Proteus as inciters of enteric disease.		
The presence of coli aerogenes strain in chlorinated water in summer due to clumps of bacteria or protection of the organisms by some constituent of the water.		Levine 1939
Bacteria found in softeners usually slow down growing. Coliform found when city water supply neg.		Mallmann -
Spore-bearing bacteria exposed to ultraviolet are killed as readily as others.		Schwarz 1911
Colon-typhoid group destroyed in high pH, limiting value 9.5.		Scott 1924
Bacteria in lake water found in greatest numbers in autumn and winter.		Taylor 1949
Stored bacteria in glass containers increase at high temp. and repressed at low.		" "
Bacteria count reduced by mechanical dishwashers.		Ward 1939
Water 50cm deep in cylinders exposed to sun.		T. & W. 1946
Italian sun:		
Surface, Inoc. 4900, Recov. 0, 6 hr.		
Middle, " 4510 " 2 " "		
Bottom " 6781 " 8 " "		
Darkened cylinder:		
Surface, Inoc. 4900 " 7261, 6 hr.		
Middle " 4510 " 9051, " "		
Bottom " 6781 " 12591, " "		
<b>ICE</b> Dist., -16C	Shorter than sea water	Hess 1934

TABLE WV (CONT'D) FACTORS AFFECTING SURVIVAL OF ORGANISMS IN WATERS

Factor(s)	Survival	Reference
<b>ICE (cont'd)</b>		
Dust laden snow	4,370,000/g. deposit all but one spore former	Lochhead 1938
Clear ice contains fewer microbial forms and less soluble mineral matter than ice containing air bubbles.		Mc Farlane 1940
Snow and bubbly ice contain a greater number of bacteria than transparent ice from some block. Greater reduction shortly after.		Prudden 1887
The viability of typhoid is much stronger than V. cholerae. V. Cholerae dies after 10x repeated freezing.		Tohyama 1930
Snow: Achromobacter, Flavobacterium, and Micrococcus present.		Darling 1941
<b>SALINE SOLUTIONS</b>		
In Atlantic during May and June close to Portugal the number of bacteria increased and increased at night in surf and decreased in morning.		Bertel 1912
Sea water at -16C bacteria live longer than in broth or distilled water.		Hess 1934
400% sea water	Lethal	Johnson 1938
15% " "	No destruction of bact.	
300% - 350% sea water	Slow destruction of bact.	
Bacteria in stored sea water followed a population curve. Curve not affected by surface of water exposed but by volume of storage container.	showed increase variation	Lloyd 1937
Bacteria at surf 25/cc, 25 meters depth 420/cc due to killing action of sunlight.		Schmidt-Nielson 1901
Bacteria of Salmonella group probably due to protozoa. Below 20C protozoa have no effect.	quickly die in sea	Stryszak 1949
Relatively no bacteria in sea with plankton.		Velankar 1950
Fresh sea, 18-20C, Inoc. 2.5cc, Recov. 63.4, 56 d.		Waksman 1937
Heated sea, 18-20C, " " 215, " "		" "
Artificial salt, 18-20C, Inoc. 2.5cc, Recov. 205, 56 d		" "
Berkefield filtered, Inoc. none, Recov. >1000, 14 d		" "
Bacteria does not survive long in sea.		Zobell 1936
Polluted sea found E. coli, Eberthella, (S. typhosa), V. cholerae, Salmonella and other enteric bacteria.		" 1942
Marine bacteria are much more thermosensitive than are terrestrial bacteria.		" "
Bacteria in sea water and mud at 30C	25% killed in 10 min.	" 1940
Bacteria in sea " " mud at 40C	80% " " " "	" "
Sea - gram-neg. bacteria predominate in microflora.		" 1934
Terrestrial spp. in sea water at 30C growth retarded by 4500 lb. p.s.i. Deep sea more resistant than surface.		" 1949
Sea water, direct sun, depth of 10 mm.	Inoc. 163/cc, Recov. 126/cc, 2 hr.	" 1935



TABLE 112 (CONT'D) FACTORS AFFECTING SURVIVAL OF ORGANISMS IN WATERS

Factor(s)	Survival	Reference	
<b>SALINE SOLUTIONS (cont'd)</b>			
Sea water unexposed to sun	Inoc. 235/cc, Recov. 188/cc, 7 hr.	Zobell	1935
Sea water exposed to sun	Inoc. 246/cc, Recov. 198/cc, 7 hr.	Zobell	1935
<b>SEWAGE</b>			
Bacteria in sewage high count 6-15 wk.	2-6 d., maintained	Purdy	1918
Saprophytes must play a big part in disappearance of organisms in sewage after testing survival with sterile sewage.	part in disappearance after testing survival	Rochaix	1930
Putrifaction bacteria attack	E. coli.	"	1931

TABLE W13

## THE SURVIVAL OF PASTEURELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Pasteurella tularensis</u>		
Water contaminated by infected animals	Not given	Ayres 1948
Streams in Canada	" "	Bow 1944
Water	1 yr.	Brown 1944
Streams	Not given	Falk 1947
River, 10-200	" "	Glass 1948
Streams	Believed to be transmitted from mice to beavers	Jellison 1942
Water	Found over a period of 4 yr.	" 1950
Streams	48-72 hr.	Karpoff 1936
"	From bodies of infected animals	Lang 1947
"	Rats, mice are vectors	Maximov 1947
River	Contaminated by infected rabbits and infected man by fish fin	Miller 1939
Mountain streams	Guinea pig infected by inoc. from stream.	Parker -
River	Excreta of rats, mice, cats in drinking and washing water	Schuller 1943
Drinking water	Cl in larger doses than usual effective in killing tularemia	Steinhaus 1943
Contaminated cold	1 mo.	" 1945
Artificial contamination	11 wk.	" "
Streams	Contaminated by excreta of mice	Zeiss 1943
<b>DISTILLED WATER</b>		
<u>Pasteurella multocida</u>		
Dist., 14-18C	$\frac{1}{2}$ hr.	Hochstetter 1887
<u>Pasteurella hemolytica</u>		
Dist. 37C	$2\frac{1}{4}$ hr.	Jacotot 1926
<u>Pasteurella multocida</u>		
Dist., 37C	Up to 4.5 hr.	Panisset 1925
<b>OTHERS</b>		
<u>Pasteurella multocida</u>		
Seltzer, 14-18C	$\frac{1}{2}$ hr.	Hochstetter 1887

TABLE WL4

## THE SURVIVAL OF RICKETTSIA SPECIES IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS <u>Rickettsia</u> <u>Coxiella burneti</u> Water, R.T. <u>Rickettsia prowazekii</u> Well	7 d.  Present	Babudieri 1950  Mazurczak 1945
DISTILLED WATER <u>Rickettsia prowazekii</u> Dist., 26-28C Tap and dist.	<2 hr. Deleterious effect on viability	Anderson 1944 Topping 1940
SALINE SOLUTIONS PHYSIOLOGICAL <u>Rickettsia prowazekii</u> Physiological saline	Deleterious effect on viability	Topping 1940

TABLE W15

THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>S. typhosa</u>		
Tap	7 d.	Aitoff 1935
Boiled	30 d.	" "
Tap, filtered, incubator temp., pH 5.9-6.2	31 d.	" "
Tap, boiled, incubator temp., pH 5.9-6.2	69 d.	" "
Rain, filtered, incubator temp., pH 5.9-6.2	93 d.	" "
Rain, boiled, incubator temp., pH 5.9-6.2	86 d.	" "
Well, outside temp., with E. coli	40 d.	Bartos 1947
Well, .36cc, R.T., pH 7.6 to 7.8	Inoc. 630 million, 31 d.	" "
Well, .26cc, R.T., pH 7.2 to 7.4	" 2.6 " 10 d.	" "
Well, .43cc, R.T., pH 7.8 to 6.0	" 1.1 " 13 d.	" "
Well, R.T.	" 52.5 " 61 d.	" "
Well slime, R. T.	" " " 71 d.	" "
Tap, 20C	.7 d.	Bolton 1886
Tap, 35C	3 d.	" "
Filtered impure well, 20C	23 d.	" "
Unfiltered impure well	20-30 d.	" "
Filtered impure well, 35C	5-10 d.	" "
Water plus sunlight	1 hr. in thin layer	Clark 1902
" " "	5 hr. in bottles	" "
Water, pH 3.8-8.7	6 hr.-48 hr. respctively	Cohen 1922
Well with unfiltered surface, 37C	Passed through 10 cults.	Crone 1951
Surface, 37C	Subcultured 10 times	" "
Water, -10C to -1.1C	103 d.	Frankland 1894
Unster. river, 19-6C	34-40 d.	" "
" " " "	Inoc. 74,000/cc (typhoid)	" "
	69,000/cc (coli), 75 d.	" "
Steam ster. river	76 d.	" "
Water	> few days	Greer 1928
Unster. cold	Prolongs	Hale 1910
" heated	Curtaills	" "
Tap	4-5 wk.	Hesse 1889
Tap	4 wk.	Hewlett 1905
River	2 wk.	" "
Water	Death increases with temp.	Hinds 1932
Ster. tap	7 d.	Hochstetter 1887
Tap, 12-15C	7 d.	" "
Aquarium	36 d.	Hoffman 1926
Med. at bottom of aquarium	2 mo.	" "
Water	9 wk.	Houston -
River, R.T., dark	8 wk.	" 1908

TABLE LVII (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<b><u>S. typhosa</u></b>		
River	1 wk. gives 99% reduct.	Houston 1908
" cold	Prolongs	" 1911
" heated	Curtails	" "
" uncultivated	3 wk.	" 1912
" Cultivated	5 wk.	" "
" 0 C	Inoc. 103,328, 8 wk.	" 1913
" 5C	" " 6 wk.	" "
" 10C	" " 4 wk.	" "
" 18C	" " 3 "	" "
" 27C	" " 2 "	" "
" 37C	" " <2 wk.	" "
Water, 0 C	8 wk.	" 1914
" 18C	3 wk.	" "
" 37C	1 wk.	" "
Ster. tap, R.T., dark	Inoc. 2-3 needles loops >93 d.	Jordan 1895
Steam ster. lake, dark	Inoc. 6435, 93 d.	" "
Water	18 d.	" "
Lake, 9-16C (tap)	Inoc. 1,000,085/cc, 6 d.	" 1904
Lake, 1.9C	" 2,200,000/cc, 7 d.	" "
Ster. "	" 1,500,000/cc, >25 and <30 d.	" "
Ster. (porcelain filt.) 20C	Inoc. 500/cc, 5 d.	" "
Tap, 9-16C	" 540,000/cc, 6 d.	" "
Raw tap 1.5-2.5C	" 3,000,000/cc, 6 d.	" "
Ster. tap, 9-16C	1,000,000/cc, >15 d.	" "
Chicago tap, 20C	Inoc. 500/cc, 2 d.	" "
Filtered tap, 1-8C	" 1080/cc, 4 d.	" "
Raw river, 12-14C	" 2,000,000/cc, 3 d.	" "
Ster. river, 12-14C	" 1,500,000/cc, 2 d.	" "
Water	6 d.	Karlinski 1889
Tap, R.T., in spleen	499 d.	Konradi 1904
" body, in "	542 d.	" "
" R. T., in culture	490 d.	" "
" body, in "	420 d.	" "
Ster., R.T., in spleen	499 d.	" "
" " in culture	490 d.	" "
" body, in spleen	429 d.	" "
" " culture	30 d.	" "
Unster. tap and river	4-6 d.	Kyriasides 1931
Well	13-16 d.	" "
Ster. tap and river plus protozoa	2 d.	" "
Mineral, pH 6.9	Inoc, 28000/cc, 18000/cc after 8 d.	Lieb 1947
" pH 6.0	Inoc. 32000/cc, 120/cc after 8 d.	" "
" " 6.8	Inoc. 2,000,000/cc; Recov. 128,000/cc, 14d.	" "

TABLE W15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>S. typhosa</u>		
Mineral, pH 6.8	Inoc. 2,000,000/cc; Recov. 150,000/cc; 14d.	Lieb 1947
" pH 7.1	Inoc. 200,000-300,000/cc Recov. 4/cc; 1 mo.	" "
" pH 6.8	Inoc. 200,000-300,000/cc Recov. 200,000-300,000/cc; 14 d.	" "
Ster., R.T.	8 mo.	Lomry 1929
" 37C	8 d.	" "
Water or urine, outdoor temp.	20-40 d.	Lu 1933
Water or urine, indoors	Shorter time	" "
Tap	7 d.	Mouzet 1936
Boiled	30 d.	" "
Commercial spring, 20C	Inoc. 1,592,500; Recov. 340; 7 d.	Odst 1919
Ster.	Wks.	Osler 1901
Commercial spring, R.T.	Inoc. 1,383,000; " 520; 7 d.	Odst 1919
Water	77 d.	Park 1920
Well, 7-10C	Inoc. 2 mg. agar cult., 31 d.	Pfuhl 1902
Ice or cool water	40%-3 hr.; 98%-2 wk.	Prescott 1904
Ster.	2 mo.	" "
Unster.	3 d.-several wks.	" "
Streams, cold	Prolongs	Ruediger 1911
Streams, heated	Curtails	" "
Open river	Inoc. 7,200,000; Recov. 232,000; 72 hr.	" "
Lake	10 d.	Russell 1906
Water, 24C	<6 d.	Ruys 1897
" 6C	11 d.	" "
" 1-12C, dark	Inoc. 26,000; Recov. 15500; 3 d.	" "
" " " diffuse	Inoc. 26,000; Recov. 1, 3 d.	" "
" 4C, refrigerator	Inoc. 26,000; Recov. 3800; 3 d.	" "
Pond, 11-16C, light, surface of large vessel	Inoc. 45,000; 4 d.	" "
Pond, 11-16C, light, bottom, of large vessel	Inoc. " Recov. 4; 4 d.	" "
River, 6-10C, light, surface of large vessel	Inoc. 3500; Recov. 0, 4d.	" "
River, 6-10C, light, bottom, of large vessel	Inoc. " " 800; 4 d.	" "
Pond, dark, surface of small vessel	Inoc. 45000; Recov. 0, 4 d.	" "
Pond, dark, bottom of small vessel	Inoc. 45000; Recov. 160; 4 d.	" "

TABLE W15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>S. typhosa</u>		
River, dark, surface of small vessel	Inoc. 35000, Recov. 18, 4 d.	Ruys 1897
River, dark, bottom of small vessel	Inoc. 35000, Recov. 1650, 4 d.	" "
River, light, 7-12C	Inoc. 7000/ml, Recov. 0, 5 d.	" 1941
" dark, " "	Inoc. 7000/ml, " 31, 5 d.	" "
Bath water from 12 tons of bath water after 500 people bathed	Inoc. 30,000 to 300,000/cc. of water; survival not given	Tashiro 1932
Filtered, 20C	14 d.	Vacek 1933
Well, urine infected, 20C	>14 d., when other pathogens are added time decreases	" 1933
Water, summer	12 d.	Watanabe 1930
" winter	18 d.	" "
Tap, dark, 50-53F	Inoc. 1 drop cult., 21 d.	Wheeler 1907
" " 98-99F	" " " " 17 d.	" "
" Light, 68-72F	" " " " 15 d.	" "
" dark, " "	" " " " 43 d.	" "
Ster. tap, aerobic	2 mo.	Whipple 1906
" " anaerobic	4 d.	" "
Tap, 20C	Inoc. 1cc susp'n to 19cc water, Recov 6/cc, 47d.	" "
River	99% reduct., 1 wk.	" 1922
Water, 32C	Inoc. 100,000/ml; Recov. 3/ml; 5 wk.	" "
" 40C	Inoc. 100,000/ml; Recov. 3/ml; 4 wk.	" "
" 50C	Inoc. 100,000/ml; Recov. 3/ml; 3 wk.	" "
" 64.4C	Inoc. 100,000/ml; Recov. 3/ml; 2 wk.	" "
Tap, rain, swimming pool	7-10 d.	Wibaut 1927
Ground water, protozoa	4 wk.	" "
" "	>4 wk.	" "
River plus tap, 30-35C, 12-15C, 10-7C	10-32 d.	Wolffhugel 1886
Filtered river, 35C	Recov. 2800, 5 d.	" "
Well, 15-20C	Inoc. 5/500, Recov. 80, 1 d.	" "
<u>S. paratyphi A</u>		
Tap	2 d.	Aitoff 1935
Boiled	10 d.	" "
Tap, filtered, incubator temp., pH 5.9-6.2	50 d.	" "
Tap, boiled, incubator temp., pH 5.9-6.2	" "	" "
Rain filtered	86 d.	" "
" boiled	47 d.	" "

TABLE W15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>S. paratyphi A</u>		
Tap	2 d.	Mouzet 1936
Boiled	10 d.	" "
<u>S. paratyphi B</u>		
Tap	22 d.	Aitoff 1935
Boiled	42 plus d.	" "
Tap, filtered, incubator temp., pH 5.9-6.2	50 d.	" "
Tap, boiled, incubator temp., pH 5.9-6.2	47 d.	" "
Rain filtered	86 d.	" "
" boiled	50 d.	" "
Autoclaved buffered tap, 20C	Recov. 5x inoc.	Crone 1951
Surface, 37C	" 10x "	" "
Well, 37C	" 3x "	" "
Tap	24 d.	Mouzet 1936
Boiled	45 d.	" "
<u>S. paratyphi spp.</u>		
Mineral	Inoc. 500 coli/1000cc 100 paratyphoid/1000cc, 400 colonies/1000cc para sank to 6/1000cc	Lieb 1947
Water ster., R.T.	Up to 8 mo.	Lomry 1929
" " 37C	Up to 1 wk.	" "
Unster., with E. coli	Several hr.	" "
" with or without E. coli in dark	Plus after 1 mo.	" "
Ster., R.T.	>8 mo.	" "
" 37C	8 d.	" "
<u>S. typhimurium</u>		
Well, outside temp.	Survival not given	Bartos 1947
" " " , with E. coli	30 d.	" "
Well, R.T., pH 6.8-8.4	Inoc. 1103 million, Recov. 2, 12 d.	" "
0.26cc well, R.T., pH 7.8	Inoc. 7.3 million, Recov. 1, 8-10 d., none after 12 d.	" "
1.03cc well, R.T., pH 7.8	Inoc. 22.5 million, Recov. 20, 7 d., none after 8 d.	" "
Well, 37C	Recov. 3x inoc.	Crone 1951
Surface, 37C	" 10x "	" "
<b>DISTILLED WATER</b>		
<u>S. typhosa</u>		
Distilled	11 d.	Aitoff 1935
Tap distilled, incubator temp., pH 5.9-6.2	31 d.	" "
Distilled, 37C	3 wk.	Ballantyne 1930
"	14 mo.	" "



TABLE W15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>DISTILLED WATER (cont'd)</b>		
<b><u>S. typhosa</u></b>		
Distilled, 0-8C	22½ mo.	Ballantyne 1930
" R.T.	32 mo.	" "
" 20C	14 d.	Bolton 1886
" 35C	3 d.	" "
"	35 d.	Cramarossa 1927
Ster. distilled	5 d.	Hochstetter 1887
Distilled, 12-15C	½ hr.	" "
" R.T., in spleen	499 d.	Konradi 1904
" " "	490 d.	" "
culture		
Distilled, body temp., in spleen	429 d.	" "
Distilled, " " "	420 d.	" "
culture		
Distilled	3 mo.	McFarland -
"	11 d.	Mouzet 1936
"	3 wk.	Muir 1903
"	Up to 62 d.	Panisset 1925
Steam ster. dist., 37C	Inoc. 48 hr. agar cult. 50 d.	Slater 1893
Ster. dist., 15-20C	81 d.	Strauss 1889
" "	6 mo. and 23 d.	Tanner 1944
Dist., 20C	7 d.	Vacek 1932
" 10-12C, dark	Recov. 1, 17 d.	Wheeler 1906
" 37C, dark	" 2, 27 d.	" "
" 20-22C, light	" 2, 13 d.	" "
" 50-53F, dark	Inoc. 1 drop cult., 17 d.	" 1907
" 98-99F, "	" " " " 15 d.	" "
" 68-72F, light	" " " " 13 d.	" "
" " " " dark	" " " " 37 d.	" "
<b><u>S. paratyphi A</u></b>		
Distilled	5 d.	Aitoff 1935
" incubator temp.	42 d.	" "
pH 5.9-6.2		
Dist.	23 d.	Cramarossa 1922
"	5 d.	Mouzet 1936
<b><u>S. paratyphi B</u></b>		
Dist.	32 d.	Aitoff 1935
" incubator temp., pH 5.9-6.2	93 d.	" "
Dist.	25 mo.	Ballantyne 1930
" 0-8C	16 mo.	" "
"	73 d.	" "
"	32 d.	Mouzet 1936
Ster. dist.	8½ mo.	Tanner 1944
Dist., 60-142C,	Inoc. 16-20 hr. cult. & 6 cc. water, 1 hr.	Tinti 1923
<b>ICE</b>		
<b><u>S. typhosa</u></b>		
Ice	>8 mo.; 1% in 10 d.	Berry 1934

TABLE WIS (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>ICE (cont'd)</b>		
<u>S. typhosa</u>		
Ice	22 wk.	Hampill 1932
" , 0 C	>7 mo.	Hutchings 1903
" of filtered river, <0C	Inoc. 2,000,000/cc; 1 d.	Jordan 1904
Water, feces, urine; -8	40-50 d.	Lu-Ti-Huan 1930
to -30C, exposed to air		
Ster. dist., -5C	1 wk - 14%; 22 wk. - 0%	Park 1901
River, 0C	Recov. <1%, 2 mo.	" "
" 20-28F	" .004%, 16 wk.	" "
Ice	Inoc. 410,000,000; Recov.	Ruedegir 1911
"	10,037,000; 14 d.	
"	4 mo.	Park 1920
Contaminated water, 14-	Recov. 7,348/cc; 103 d.	Prudden 1887
30F		
Water, alternate freezing	Inoc. 40,896/cc; 3 d.	" "
and thawing 5x		
Ice	99.9% reduction, 8 d.	Tanner 1944
" in capsule	Agar: recov. 17, 24 hr.	Wheeler 1906
" " "	Broth: " 0, 2 d.	" "
" outside capsule	Agar: recov. 38, 2 d.	" "
" " "	Broth: " 0, 2 d.	" "
"	Inoc. 40,896/cc; Recov.	Hilliard 1918
	2,490/cc; 5 d.	
<u>S. paratyphi spp.</u>		
Ice	13 d.	Thomas 1925
<u>S. paratyphi B</u>		
Ice	17 d.	" "
<b>SALINE SOLUTION</b>		
<b>SEA</b>		
<u>S. typhosa</u>		
Sea, filtered	Inoc. 300,000,000/cc;	
"	32 d.	Beard 1935
" unfiltered	Inoc. 300,000,000/cc;	" "
"	28 d.	
" infected by ducks	Found	Bidwell 1950
" bouillon	Inoc. exclusively, 4 d.	De Giava 1889
" agar	" almost " , 9 d.	" "
Ster. sea, bouillon	Inoc. 11800, 9 d.	" "
" " agar	" 4800, 10 d.	" "
Sea	1 d.	Gohar 1948
" autoclaved, Seitz	32 d.	" "
filtered		
Sea, Seitz filtered	2 d.	" "
" " "	5 d.	" "
autoclaved, pulp disc		
Sea, Seitz filtered,	3 d. at 60C & 30 d. -100C	" "
60-100C		
Sea	10 d.	Herdman 1899
Sea (oysters)	Inoc. 160,000,000; Recov.	Klein 1905
	320; 4 d.	

TABLE 15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>SALINE SOLUTION (cont'd)</b>		
<b>SEA</b>		
<u>S. typhosa</u>		
Non-contaminated sea	16 d.	Trawinski 1929
Contaminated sea	3 d.	" "
<u>S. paratyphi A</u>		
Sea, filtered Seitz	2 d.	Gohar 1948
"	1 d.	" "
" autoclaved, Seitz filtered	32 d.	" "
Sea, filtered, autoclaved and pulp disc	6 d.	" "
Sea, Seitz filtered and heated to 60C	4 d.	" "
Sea, Seitz filtered and heated to 100C	27 d.	" "
Sea, non-contaminated	18 d.	Trawinski 1929
" contaminated	6 d.	" "
<u>S. paratyphi B</u>		
Sea	12 d.	Trawinski 1929
" contaminated	" "	" "
"	2 d.	Gohar 1948
" Seitz filtered	3 d.	" "
" autoclaved	38 d.	" "
Sea, Seitz filtered, autoclaved and pulp disc	6 d.	" "
Sea, Seitz filtered, heated 60C	6 d.	" "
Sea, Seitz filtered, heated 100C	30 d.	" "
<u>S. paratyphi sp.</u>		
Sea non-contaminated,	16 d.	Trawinski 1929
" contaminated	" "	" "
<u>S. enteritidis</u>		
Sea non-contaminated	23 d.	" "
" contaminated	5 d.	" "
<u>S. typhimurium</u>		
Sea non-contaminated	21 d.	" "
" contaminated	7 d.	" "
<b>PHYSIOLOGICAL</b>		
<u>S. typhosa</u>		
85% NaCl	(1) 8 mo., (2) 5 mo.	Ballantyne 1930
" " , R. T.	32 mo.	" "
Physiological salt, full radiation of mercury, under glass, cooled	30 sec.	Bazzoni 1914
Saline	32 d.	Cramarossa 1927
Ster. salt soln., 1-8C	Inoc. 1,080/cc, >10 d.	Jordan 1904
" " " 20C	" 900/cc, 2 d.	" "

TABLE W15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>SALINE SOLUTION (cont'd)</b>		
<b>PHYSIOLOGICAL</b>		
<u>S. paratyphi A</u> 85% NaCl, 37C Saline	13½ mo. 33 d.	Ballantyne 1930 Camarossa 1927
<u>S. paratyphi B</u> 85% NaCl, 37 C Saline	13½ mo. 73 d.	Ballantyne 1930 Camarossa 1927
<u>S. paratyphi sp.</u> 85% NaCl, R. T.	25 ¾ mo.	Ballantyne 1930
<u>S. enteritidis</u> 85% NaCl, 37C	13½ mo.	Ballantyne 1930
<b>SEWAGE</b>		
<u>S. typhosa</u> Sewage and sludge Septic tank Raw, R.T., north light " outside, lower than R.T., pH 7.2-7.8 Activated sludge, pH 6.8- 7.6	Inoc. 450,000/ml., 12 hr. 2-3 d. Inoc. 6,500,000; 3 d. Inoc. 5 m.; 27 d. Inoc. 37,500,000; >24 hr.	Bruns 1927 Flu 1921 Green 1938 " " " "
Sewage in trickling filter River plus urine of typhoid cases, dark Water and feces, 1.9C Sewage, 14.5-17C Septic tank Sewage in river " of city	<¼ hr. 99.9% reduction 1 wk. Inoc. 5,800,000/cc; <1 d. " 12,000/cc; <1 d. 5 d. Present 37 specimens out of 305	" " Houston 1911 Jordan 1904 " " Kliger 1921 Lendon 1951 Messerschmidt 1951
Polluted	Disappeared more rapidly than in water or ice	Park 1920
Ster. sewage, R.T. Activated sludge, aerated " " storage, 68-72F Activated sludge, storage 50-60F	7½ mo. Recov. 14%, 5½ hr. " 0, 8-14 d. " 0, 83 d.	Rochaix 1930 Ruchhoff 1934 " " " "
Sewage " , winter " , summer	5 d. 26 d. 7 d.	Russell 1906 Shimomura 1935 " "
Sewage, R.T.	Inoc. 1000/cc; neg. in 7 d.	Stewart 1933
Naturally infected sewage R.T.	5 wk.	" "
Dried sludge, 14% moisture Sludge anaerobic Ster. sewage	Inoc. 7,500,000/ml; 180d. 45 d. 3 mo. and 7 d.	Stokes 1945 " " Tanner 1944
Feces and water, 17-22.5C, weakly alkaline	Inoc. many; 96 hr.	Uffelman 1889
Feces and water, 9C, weak- ly alkaline	" " 24 hr.	" "

TABLE LV15 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>SEWAGE (cont'd)</b>		
<u>S. typhosa</u>		
Polluted spring, 43C	2 d.	Watanabe 1930
" well, dark, 10-12C	Recov. 1; 37 d.	Wheeler 1907
Polluted well, " 37C	" " 17 "	" "
" " " 20-22C	" 50, 71 d.	" "
Polluted well, light, 20-22C	" 1, 15 d.	" "
Sewage (Belfast)	Isolated 10 out of 13x	Wilson 1931
" (Lisburn)	" 2x	" "
Tap exposed to elements and inoc. with feces	3 wk.	" 1912
Anaerobic sludge	7 d.	Wolman 1924
<u>S. paratyphi A</u>		
Ster. sewage, R.T.	7½ mo.	Rochaix 1930
<u>S. paratyphi B</u>		
Sewage, 37C	24 hr.	Hecker 1948
" 9.5-12C	3 d.	Jordan 1904
Activated sludge	50% reduction after 1 hr.	Pesch 1929
Ster. sewage, R.T.	7½ mo.	Rochaix 1930
" "	12 d.	Tanner 1944
Sewage (Belfast)	Isolated 2x	Wilson 1931
" , R.T., stored	3 wk.	" "
<u>S. paratyphi spp.</u>		
Sewage of city	61 out of 305 specimens	Messerschmidt 1951
Sludge drying	Inoc. 25m/ml; 41 d.	Stokes 1945
<u>S. enteritidis</u>		
Sewage of city	5 out of 305 specimens	Messerschmidt 1951
<b>OTHERS</b>		
<u>S. typhosa</u>		
Seltzer, 12-15 C	+ d.	Hochstetter 1887
" 7-10C	Inoc. a suspn. of agar cult., 15-27 d.	Pfuhl 1902

TABLE W16

## THE SURVIVAL OF SHIGELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Sh. dysenteriae</u>		
Tap	4 d.	Aitoff 1935
Boiled	11 d.	" "
Well, outside temp., with E. coli	30d.	Bartos 1947
Well, R.T., pH 7.2-7.8	Inoc. 2-12 million, 11-18 d.	" "
Water, ster.	24 d. after inoc.	Dudgeon 1919
River	Many hr.	" "
Ster. tap, R.T.	Inoc. 11 standard strain 6 mo.	Felsen 1945
Ster., 17-20C	Rarely more than a wk.	Frost 1905
Water and earth, winter	Failed to isolate growth	Hampil 1932
Raw lake	Inoc. 22,000/cc, 2 d.	Jordan 1904
Tap	" " " "	" "
Raw river	" 700,000/cc, 3 d.	" "
Heated well, R.T.	71 d.	Karlinski 1907
Unster., R.T.	42 d.	" "
Well, 10-12C	56 d.	" "
Tap	27 d.	Kusama 1925
Water or urine	40-50 d.	Lu-Ti-Huan 1933
Tap	4 d.	Mouzet 1936
Boiled	11 d.	" "
Spring, high in minerals or organic matter, 20C	Inoc. 6,550,000; 18 d.	Odst 1919
Spring, high in minerals or organic matter, R.T.	" 1,350,000; " "	" "
Well, 7-10C	Inoc. 2mg. agar cult., 9 d.	Pfuhl 1902
Well, R.T.	Inoc. 2mg. " " 5 d.	" "
Well, 37C, R.T., 3C	Longer at lower temp.	Steuer 1941
Ster.	30 d.	Tashira 1932
Water, 1-14C	10-13 d.	Vincent 1917
Impure, 22-28C	2-5 d.	" "
<u>Sh. paradysenteriae (Flexner)</u>		
Tap	16 d.	Aitoff 1935
Boiled	22 d.	" "
Tap	16 d.	Mouzet 1936
Boiled	22 d.	" "
Water	38 d.	Stewart 1944
<u>Sh. paradysenteriae (Sonne)</u>		
Well, outside temp., with E. coli	30 d.	Bartos 1947
Well, R.T., pH 7.2-7.8	Inoc. 12 million, 18 d.	" "
Tap, with 0.15 p.p.m. re- sidual Cl.	Found	Freen 1943
<b>DISTILLED WATER</b>		
<u>Sh. dysenteriae</u>		
Dist.	15 d.	Aitoff 1935
"	7-73 d.	Cramarossa 1927

TABLE WIB (CONT'D) THE SURVIVAL OF SHIGELLA SPECIES IN WATER

Factor(s)	Survival	Reference
<b>DISTILLED WATER</b>		
<u>Sh. dysenteriae</u>		
Dist.	18 d.	Kusama 1925
"	15 d.	Mouzet 1936
" , 60-142C,	Inoc. 16-20 hr. cult. in 6cc. water, 1 hr.	Tinti 1923
<u>Sh. paradysenteriae (Flexner)</u>		
Dist.	24 d.	Aitoff 1935
"	7-73 d.	Cramarossa 1927
"	24 d.	Mouzet 1936
<b>ICE</b>		
<u>Sh. dysenteriae</u>		
Ice from ster. water	2 mo.	Felsen 1945
Water, feces, urine; -8 to -30C	55 d.	Lu-Ti-Huan 1930
Ice	41-68 d.	Vincent 1917
<b>SALINE SOLUTIONS</b>		
<b>SEA</b>		
<u>Sh. dysenteriae</u>		
Filtered sea	2-5 mo.	Felsen 1945
Contaminated and non- " sea.	30 hr. and 12 hr.	Trawinski 1929
<u>Sh. paradysenteriae spp.</u>		
Sea	1 d.	Gohar 1948
" , Seitz filt.,	2 "	" "
" " " auto- claved	32 d.	" "
Sea, Seitz filt., auto- claved, pulp disc	4 d.	" "
Sea, Seitz filt. heated 60C	3 d.	" "
Sea, Seitz " " 100C	28 d.	" "
<b>PHYSIOLOGICAL</b>		
<u>Sh. dysenteriae</u>		
85% NaCl, 37C	13½ mo.	Ballantyne 1930
0.8% salt soln.	12-53 d.	Cramarossa 1927
<u>Sh. paradysenteriae (Flexner)</u>		
0.8% salt soln.	12-53 d.	Cramarossa 1927
Saline	35 d.	" "

TABLE W17

## THE SURVIVAL OF STREPTOCOCCUS SPECIES IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>S. agalactiae</u> Tap	66 d.	Bryan 1934
<u>S. pyogenes</u> Deep well	11 d.	Livingston 1921
Surface well	8 d.	" "
Lake	7 d.	" "
Street, autoclaved	6 d.	" "
River	" "	" "
Country roadside ditch	5 d.	" "
Street not ster.	4 d.	" "
Park lagoon	4 d.	" "
Tap	3 d.	" "
Chicago river	2 d.	" "
Water, 37.5C	Inoc. 10,000/cc; 6 d.	" "
" 27C	" " " 9 d.	" "
" 1C	" " " 15 d.	" "
<u>S. faecalis</u> Swimming pool plus Cl	1 hr.	Ritter 1948
<u>S. salivarius</u> Swimming pool plus Cl	5 min.	" "
<u>S. enterococcus</u> Tap without Cl	> 12 hr.	" "
<u>S. spp.</u> Water (phys)	3 hr.	Belin 1933
" " 50C	1 hr. 10 min.	" "
" " 44-45C	10.5 hr.	" "
" " 55C	1.5 hr.	" "
Open reservoirs	4 d.	Holwerda 1928
Covered reservoirs	8 d.	" "
<b>DISTILLED WATER</b>		
<u>S. pyogenes</u> Ster. dist., R.T., subdued light	3-87 d.	Livingston 1921
<u>S. mitis</u> Dist. " , 0-8C	21 3/4 mo. 25 mo.	Ballantyne 1930 "
<u>S. spp.</u> Dist. " , 37C	Not given 4-7 d., K value 0.736 81.6% reduction/day	Gilcreas 1950 Heller 1941
Ster. dist., 15-20C	Upto 74 d. 15 d.	Panisset 1925 Strauss 1889
<b>SALINE SOLUTION</b>		
<b>PHYSIOLOGICAL</b>		
<u>S. mitis</u> 85% NaCl, 37C	13 1/2 mo.	Ballantyne 1930
<u>S. pyogenes</u> Saline	12 d.	Livingston 1921
<u>S. spp.</u> Saline	K value 0.537, 70.9%/d.	Heller 1941
<b>SEWAGE</b>		
<u>S. spp.</u> Feces plus natural water	7 d.	Savage 1917
Polluted water	Twice that of typhoid & coli	Smit 1931



TABLE W18

THE SURVIVAL OF VIBRIO COMMA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Vibrio comma</u>		
Tap	2 d.	Arguelles 1927
Ster. tap	6-10 d.	" "
Water, 10 atm. carbon dioxide	<10 hr.	Colin 1915
Ster. spring	7 mo.	D <sup>r</sup> Herelle 1930
River, filtered	>1 yr.	" "
Tap	56-66 d.	" "
Ster. water	7-8 d.	" "
Water of aquarium	3 mo.	" "
Well	62 d.	" "
Raw water	1-24 d.	" "
Well	72 hr.	Emmerich 1889
Potable water, filtered river, deep well	3 wk.	Frankland 1886
Ster. tap	Inoc. 149,500; Recov. 0, 18 d.	Gelarie 1816
Native tap	Inoc. 149,500; Recov. 0, 3 d.	" "
Ster. bay	Inoc. 149,500; " " 154 d.	" "
Native bay	Inoc. 149,500; " " 21 d.	" "
Water	<5 wk.	Haffkine 1895
River, filtered	Inoc. 5,500; 3 hr.	Hankin 1896
" boiled	" 6,000; 49 hr.	" "
" both	" 7,000; 25 hr.	" "
Well, filtered	" 8,500; 49 hr.	" "
" boiled	" 7,500; " "	" "
River, filtered	" 4,200; 2 hr.	" "
Up river, filtered	Inoc. 1,200; 1-2 hr.	" "
Down stream	" 1,500; 1 hr.	" "
River, near old cadaver	Inoc. 1,250; 1-2 hr.	" "
" " regent "	" 2,000; 1-5 hr.	" "
Up stream, boiled	" 1,250; 48 hr.	" "
Well	" 1,200; 48 hr.	" "
Tap	4-5 wk.	Hesse 1889
"	391 d.	Hochstetter 1887
Raw river	99.9% 1 wk., 0 - >2 wk.	Houston 1909
River, lab conditions	99% in 3 d.	" 1910
"	8 d.	Kahn 1929
Well	12 d.	" "
River, boiled	3 d.	" "
Raw river	<24 hr.	" 1930
Boiled water, 5 min. open	<72 hr.	" "
" " " " seal-	<72 hr.	" "
ed		
Filtered	<48 hr.	" "
Heated 55C for 1/2 hr.	<72 hr.	" "
Open boiled and vapor from raw water at 80C for 15 min	<72 hr.	" "

TABLE 148 (CONT'D) THE SURVIVAL OF VIBRIO COMMA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<b>Vibrio comma</b>		
Opened boiled plus vapor from raw water at 90° for 15 min.	11 d.	Kahn 1930
Heated at 50C for 15 min.	< 24 hr.	" "
" " 80C " " "	< 120 hr.	" "
" " 90C " " "	< 96 hr.	" "
Water	72 hr.	Karlinski 1889
Spring	30 d.	Koch 1886
Well and tap, 10½C	Inoc. 10,100-8,700; Recov. 0, 24 hr.	Kraus 1887
Unster. tap and river	4-6 d.	Kyriasides 1931
Well	13-16 d.	" "
Ster. tap and river plus protozoa	2 d.	" "
Hill spring, untreated, raw	1 hr.	Lahiri 1939
Hill spring, autoclaved, raw	18 hr.	" "
Calcutta tap, untreated, raw	18 hr.	" "
Calcutta tap, untreated, filt.	2 d.	" "
Calcutta tap, autoclaved, raw	24 hr.	" "
Calcutta tap, " filtered	12 d.	" "
River, untreated, raw	18 hr.	" "
" " filtered	2 d.	" "
" autoclaved, raw	3 d.	" "
" " filt.	2 d.	" "
Dulhousie sq. tank, untreated, raw	48 hr.	" "
Dulhousie sq. tank, untreated, filt.	7 d.	" "
Dulhousie sq. tank, autoclaved, raw	3 d.	" "
Dulhousie sq. tank, " claved, filt.	15 d.	" "
Norheldanza & Vetudanza tank, untreated, raw	72 hr.	" "
Norheldanza & Vetudanza tank, untreated, filt.	7 d.	" "
Norheldanza & Vetudanza tank, autoclaved, raw	12 d.	" "
Norheldanza & vetudanza tank, autoclaved, filt.	18 d.	" "
Water or urine	2 d.	Lu-Ti-Huan 1933
River, unconc.	41 out of 66 samples	Panja 1947
" conc.	23 out of 66 samples	" "
Natural (Assam)	90.5-95% positive	Pandit 1938

TABLE LVII (CONT'D) THE SURVIVAL OF VIBRIO COMMA IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS (cont'd)</b>		
<u>Vibrio comma</u>		
Artificial water plus salt and organic matter for growth	> 3 wk.	Read 1939
Tap, 25C	56 d.	Schobel 1914
Ster., 25-27C	7 d.	" "
" soda water	Inoc. agar cult. 48 hr. 37C; 10 d.	Slater 1893
River and tap, 30-25, 12-15, 7-10C	15 d.	Wolffhugel 1886
River and tap and well	8 d.	Yasuhara 1926
<b>DISTILLED WATER</b>		
<u>Vibrio comma</u>		
Ster. dist.	< 1 d.	Argelles 1927
Dist.	29 d.	Camarossa 1922
" plus CuSO <sub>4</sub> 150M	1 hr.	Ficker 1898
"	Inoc. 4,500; 24 hr.	Hankin 1896
"	34 hr.	Hochstetter 1887
" river	< 24 hr.	Kahn 1929
Ster. dist., 15-20C	39 d.	Strauss 1889
" "	6 mo. & 23 d.	Tanner 1944
Dist.	Short	Wolffhugel 1886
<b>ICE</b>		
<u>Vibrio comma</u>		
Water, -8 to -30C	1 d.	Lu-Ti-Huan 1930
Ster. salt water, 0.5-0.7C	Recov. 0, 6-7 d.	Renk 1893
Ster. salt water, 0.5-0.7C	Inoc. 1,483,000/cc; Recov. 62,445.cc; 24 hr.	" "
<b>SALINE SOLUTION</b>		
<b>SEA</b>		
<u>Vibrio comma</u>		
Sea	12 d.	Arguelles 1927
" , on bouillon, 37C	Inoc. 1,000; 4 d.	DeGiava 1889
" " agar, 37C	" 8/10; 2 d.	" "
" ster., on bouillon, 37C	" exclusively, 5 d.	" "
Sea, ster., on agar, 37C	" very few, 1 d.	" "
Sea	4-122 d.	D'Herelle 1930
Bay, ster.	Inoc. 149,500; 154 d.	Gelarie 1916
" native	" 21 d.	" "
Sea, 18C, autoclaved	32 d.	Gohar 1948
" autoclaved and paper filt.	26 d.	" "
Sea, Seitz filt.	1 d.	" "
" " " , auto-claved, pulp disc	5 d.	" "
Sea, filt., ster. bact. suspn.	3 d.	" "
Sea and sewage, 18C	24 hr.	" "
Synthetic sea	26 d.	" "

TABLE W (CONT'D) THE SURVIVAL OF VIBRIO COMMA IN WATER

Factor(s)	Survival	Reference
<b>SALINE SOLUTION</b>		
<b>SEA</b>		
<u>Vibrio comma</u> Boiled sea	Lives longer than in RAW	Kiribazeuski 1934
Sea direct sun	8 hr.	Matsuda 1910
Ster. sea, 25-27C	106 d.	Schobel 1914
Sea,	5 d.	Tohyama 1925
" 20C	24 hr.	" "
Bay, 1-5C	11 d.	Yasuhara 1926
Sea and river	13 d.	" "
Sea, 30-18C	Inoc. 300,000/cc water, After 4 hr. decreased 99.8%, after 6 hr. slow increase	Yasukawa 1933
Sea, 36-20C	After 1 hr. decreased 86%, 2 hr. 91.7%; 6 hr. increased slow	" "
Surface	23 d.	" "
Center	22 d.	" "
Bottom	29 d.	" "
<b>PHYSIOLOGICAL</b>		
<u>Vibrio comma</u> Sat. soln. of NaCl	Less than 1 d.	Arguelles 1927
Saline	36 d.	Cramarossa 1927
<b>SEWAGE</b>		
<u>Vibrio comma</u> Sewage	24-48 hr.	D'Herelle 1930
Septic tank	24 hr.	Flu 1921
Sewage	Capable of enormous mult.	Frankland 1886
" , Seitz filtered, pH 6.5	23 d.	Gohar 1948
Sewage, autoclaved, pH 7.5	26-29 d.	" "
Sewer	6-7 d.	Koch 1886
Cesspool	< 24 hr.	" "
Ster. sewage	7½ mo.	Rochaix 1930
" "	3 mo. 7 d.	Tanner 1944
<b>OTHERS</b>		
<u>Vibrio comma</u> Seltzer water, 18C	2½ hr.	Hochstetter 1887

TABLE 49

THE SURVIVAL OF VIRUS IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Polio</u>		
Tap, ice box	100 d.	Carlson 1942
" direct sunlight	Inoc. 1:100 dil., 30-45 min.	" "
Water	None	Francis 1948
Tap, dark, R.T.	114 d.	Kling 1929
Susp'n of monkey cord added to water, R.T	1 mo	Landsteiner 1911
Natural water, pH 7.9 - 8.3, and 10-11.25, 0.05 ppm. residual free Cl and 0.1-0.15	10 mo.	Lensen 1949
Several lakes, 18-25.3C, pH 7.42-8.25, 0.05 ppm. residual Cl	Inoc. 0.25%, <10 min.	" "
River, 20-23C, pH 7.8-8.2, 0.05 ppm. free residual Cl, after 5 min. contact	Inoc. 0.25%, 10 min.	" "
Lime treated well, 21-26C, pH 8.0-10.5, traces of residual Cl after 5 min contact	Inoc. 0.25%, >1 hr. 0.5%, 1 hr.	" "
Creek water,	Infected by the cotton rat	Toomey 1945
<u>Lymphocytic choriomeningitis</u>		
Chlorinated drinking water, R.T.	7, 3, 4 d.	Zichis 1948
<u>Western equine encephalitis</u>		
Chlorinated drinking, R.T.	5, 2, 4 d.	" "
<u>St. Louis encephalitis</u>		
Chlorinated drinking, R.T.	4, 3, 2 d.	" "
<b>DISTILLED WATER</b>		
<u>Yellow fever</u>		
Dist., ice box	10 yr.	Bauer 1940
<u>Polio</u>		
Dist., pH 6.85-7.4, 0.05 ppm. residual free Cl	10 min.	Lensen 1949
<u>Vaccinia virus</u>		
Dist., 18-37C	60 d.	Noguchi 1918
<b>SEWAGE</b>		
<u>Polio</u>		
Sewage, 70F	Reg. at 5-14 d.	Evans 1946
Stool fresh	Present	Francis 1948
Sewage, 4C	2-3 mo.	Kling 1942
"	Activated sludge and chlorination effect	Krumbiegel 1944
Stool plus water and oronasopharyngeal secretion	Inactivated 30 min.	Faber 1951
Domestic sewage	Present	Maxey 1949
Sewage of polio victims and carriers	Possibly hr.	" 1943

TABLE W19 (CONT'D)

## THE SURVIVAL OF VIRUS IN WATER

Factor(s)	Survival	Reference
<b>SEWAGE</b> <b>Polio</b>		
Raw, hosp. (polio) sewage, residential sewage	Present in late summer and fall	Melnick 1947
Stool plus river, 4C, pH 7.98, dark	188 d.	Rhodes 1950
Activated sludge in am't as low as 1100 ppm.	Non-effective after 6 hr. aeration	Ridenour 1943
Sewage	Present when cases are reported	Trask 1942

TABLE W20

THE SURVIVAL OF YEASTS AND FUNGI IN WATER

Factor(s)	Survival	Reference
<b>NATURAL WATERS</b>		
<u>Aspergillus</u> Tap, 12-17C	56 d.	Hochstetter 1887
<b>DISTILLED WATER</b>		
<u>Aspergillus</u> Dist., 12-17C	56 d.	Hochstetter 1887
<u>Cladosporium mansonii</u> Dist., R.T.	12 mo.	Castellani 1939
<u>Aleurisma castellanii</u> Dist., R.T.	" "	" "
<u>Actinomyces sp.</u> Dist., R.T.	" "	" "
<u>Monilia sp.</u> Dist., R.T.	" "	" "
<u>Geotrichum sp.</u> Dist., R.T.	" "	" "
<u>Epidermophyton flaccosum</u> Dist., R.T.	" "	" "
<b>ICE</b>		
<u>Saccharomyces sp.</u> Dist., -21 to -78C	Inoc. 10,000-100,000/ml. More resistant to freezing than thawing	Lund -
" -10C, pH 6.5	Inoc. 550,000/cc; Recov. 68.2%; 28 wk.	McFarlane 1941
" -20C, " "	Inoc. 550,000/cc; 70.9%; 28 wk.	" "
" -10C, " 5	Inoc. 455,000/cc; 99.5%; 28 wk.	" "
" -20C, " "	Inoc. 455,000/cc; 80.7%; 28 wk.	" "
" -10C, " 3.7	Inoc. 500,000/cc; 99%; 15 wk.	" "
" -20C, " "	Inoc. 500,000/cc; 93.2%; 15 wk.	" "
<b>OTHERS</b>		
<u>Aspergillus</u> Seltzer, 12-17C	56 d.	Hochstetter 1887

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SUMMARY OF ABBREVIATIONS USED IN TABLES

alk.	alkaline
avg.	average
C.	Degrees centigrade
Col.	Colonies
conc.	concentration
cont'd, cont.	continued
ct.	count
cult.	culture
d., ds., das.	day or days
Desicc.	Desiccate
dil.	dilution
F.	Degrees fahrenheit
fl.	fluid
G.P.	Guinea pig
gel.	Gelatin
h., hrs.	hour or hours
inc.	increase
Inoc., Innoc.	Inoculate
irrad.	irradiated
Lg.	Large
max.	maximum
med.	medium
met.	methyl
min.	minute or minutes
mos.	months
mult.	multiplied
org.	organism
path.	pathogenic
physiol.	physiological
ppm.	parts per million
ppt.	precipitate
R.H.	Relative humidity
R.T.	Room temperature
Recov.	Recovered
refrig.	refrigeration
sec.	second
sensit.	sensitization
soln., sol'n	solution
spp.	species
str.	strain
susp., susp'n	suspension
T.B., tb	tuberculosis
temp.	temperature
U.V., U.v., UV	Ultra violet
wks.	weeks
X	times
yr., yrs.	year or years
	greater than
	less than
	present; plus
	none
	minus

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