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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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C	The Persistence (Survival) of Organisms in CULTURE.
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P	The Effects of PRESSURE on the Persistence (Survival) of Organisms.
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A1	The Persistence (Survival) of Organisms in AIR.
B1	The Persistence (Survival) of Organisms in the BODY AND BODY MATERIALS.
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) of Organisms.
R1	The Effects of RADIATION on the Persistence (Survival) of Organisms.
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Su1	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.

LIST OF TABLES ON PERSISTENCE (SURVIVAL) OF BRUCELLA SPECIES

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.
F 2	The Persistence (Survival) of Organisms in FOOD.
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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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 COLIFORM ORGANISMS *

A 5 — The Persistence (Survival) of Organisms in AIR.

B 6 — The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.

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) 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 5 — The Persistence (Survival) of Organisms in WATER.

*Coliform includes Escherichia, Aerobacter and Paracolobactrum species.

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A 4 The Persistence (Survival) of Organisms in AIR.

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.

Streptococcus

A 12 The Persistence (Survival) of Organisms in AIR.

B 16 The Persistence (Survival of Organisms in the BODY and BODY MATERIALS.

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 FUNGI, YEASTS AND MOLDS

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B 8 The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.

C 26 The Persistence (Survival) of Organisms in CULTURE.

F 14 The Persistence (Survival) of Organisms in FOOD.

I 8 The Persistence (Survival) of Organisms in INSECTS.

P 1 The Effects of PRESSURE on the Persistence (Survival) of Organisms.

R 18 The Effects of RADIATION on the Persistence (Survival) of Organisms.

S 6 The Persistence(Survival) of Organisms in SOIL.

Su 18 The Persistence (Survival) of Organisms on SURFACES.

W 20 The Persistence (Survival) of Organisms in WATER.

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A 9	The Persistence (Survival) of Organisms in AIR.
B 7	The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
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 MYCOBACTIUM SPECIES (INCLUDING MYCOBACTIUM TUBERCULOSIS)

A 7	The Persistence (Survival) of Organisms in AIR.
B 9	The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
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) of Organisms.
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.

LIST OF TABLES ON PERSISTENCE (SURVIVAL) OF PASTEURELLA SPECIES

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

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B	13	The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.
C	16	The Persistence (Survival) of Orgnisms 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.

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A 10 — The Persistence (Survival) of Organisms in AIR.

B 14 — The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.

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) of Organisms.

R 13 — The Effects of RADIATION on the Persistence (Survival) of Organisms.

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.

LIST OF TABLES ON THE PERSISTENCE (SURVIVAL) OF SHIGELLA SPECIES

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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 STAPHYLOCOCCUS (MICROCOCCUS) SPECIES

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 VIBRIO SPECIES

B 17 The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS.

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

A	9	The Persistence (Survival) of Organisms in AIR
A	13	" " " " "
B	18	The Persistence (Survival) of Organisms in the BODY and BODY MATERIALS
C	3	The Persistence (Survival) of Organisms in Culture.
C	25	" " " " "
F	13	The Persistence (Survival of Organisms in FOOD
I	20	The Persistence (Survival of Organisms in Insects.
P	1	The effects of Pressure on the Persistence (Survival) of Organisms.
R	3	The Effects of RADIATION on the Persistence (Survival) of Organisms.
R	17	" " " "
S	14	The Persistence (Survival) of Organisms in SOIL
Su	17	The Persistence (Survival) of Organisms on SURFACES
W	2	The Persistence (Survival) of Organisms in WATER
W	19	" " " " "

LIST OF TABLES ON SURVIVAL OF ORGANISMS (GENERAL)*

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A 6	" " " " "
A 9	" " " " "
B4	The Persistence (Survival) of Organisms in the Body and Body Materials.
B 19	" " " " "
C 7	The Persistence (Survival) of Organisms in CULTURE
C 10	" " " " "
C 11	" " " " "
C 13	" " " " "
C 19	" " " " "
F 6	The Persistence (Survival) of Organisms in FOOD
F 7	" " " " "
I 6	The Persistence (Survival of Organisms in Insects
I 9	" " " " "
I 11	" " " " "
P 1	The Effects of PRESSURE on the Persistence (Survival) of Organisms.
R 2	The Effects of RADIATION on the Persistence (Survival) of Organisms.
R 8	" " " " "
R 10	" " " " "
R 12	" " " " "
S 5	The Persistence (Survival) of Organisms in SOIL.
S 7	" " " " "
S 8	" " " " "
Su 5	The Persistence (Survival) of Organisms on SURFACES
Su 8	" " " " "
Su 9	" " " " "
Su 11	" " " " "
Su 14	" " " " "
W 9	The Persistence (Survival) of Organisms in WATER
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 evidenceditself 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 Medicus

   Original 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.

ACKNOWLEDGMENT

This report was made possible, to a great extent, through funds made available on contract DA-18-064-CML-463 from P. D. Division, Biological Laboratories, Chemical Corps, Camp Detrick, Frederick, Maryland, and through the interest of Drs. Charles Phillips and Saul Kaye.

The literature survey was carried out in the Department of Bacteriology and Parasitology of the University of Texas Medical Branch, Galveston, Texas, where the facilities of the Medical Library were utilized to a great extent. Some foreign and obscure journals were obtained by microfilm through the Army Medical Library, Washington, D. C.

Most of the work was done on a part-time basis by personnel of the University of Texas, who were responsible for the searching, reading, tabulating and writing-up of the material. These workers were:

Wilbur White	Martha Jordan
William Dillen	Norman Halbrooks
Jacqueline Terrill	Mary Faubion
Meredith Holladay	Elise R. Stein
Pat Riddle	Jean Cobb
Beatrice D. Engley	Louis DeVito
Elfe Thomas	Maxine Munn

Frank B. Engley Jr.
Responsible Investigator

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% many 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 how 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 then 3 weeks. 5[illegible]% RH more effective in destroying virus then 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 [illegible] 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 uretheal 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 inquinale - 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 tc 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 strins 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.

Schistasoma - 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, surcrose 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. Cetrifuging 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 - Survied 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

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 HYMENOLEPIASIS.
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. Ornithodorus 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, Rhipecephalus 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

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 pertenue 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 6000atm. 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 mu-or 2000-3000 Å units); (2) X-rays (0.005-1 mu); (3) γ rays (short x-rays); (4) β rays, or cathode rays or high velocity electrons; (5) α 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 amcunt of radioactive lethal doses involved necessary for killing vegetative cells and spores of different organisms at between 4-200 r x 10^3. Ultraviolet energy expended approaches 1-50 ergs x $10^3/cm^2$. 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 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 erg/m^2 at 2537 Å 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 erg/m^2 per second at 2537 Å (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 Å where it was most active. Other strains were less resistant. Usual destruction time is in a few minutes. Rate de-

pends 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 ½ longer than those exposed to light.

Hemophilus - Were very susceptible to UV.

Klebsiella - Almost completely destroyed after 3 monutes 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 flourescent 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^2 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 2800-2540 Å killed the cells quickly. Some 168 erg/mm^2 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^2 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 Parvobacterioceae) 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

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 11½ 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 air-borne 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

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 hankerchiefs) 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 ½-¼ 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 gonorrheae 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

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) Poliomyelitis 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 mansoni, Aleurisma castellanii, 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	
EXPERIMENTAL			
B. anthracis			
Spores, dist. water, 25C. Direct sun, strong wind.	Inoc. 8,000 Colonies. Recov. 0, 2 h.	Kruse	1893
Ozone, 4 h., 37 C.	No effect	Ransome	1901
Sunlight with air	24 h.	Roux	1887
" without air.	>83 h.	"	
Steam under pressure, autoclave, 15 lbs.	30 min.	Smyth	1927
B. subtilis			
Spores, spray drying.	Show small mortality	Bullock	1943
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 occupied space can be made bacteria free.		DallaValle	1944
Exposed to U.V.	Innumerable colonies 1 min., 42, 3 min.	Hart	1939
Suspended in air	62,225 (±72%) ergs/cm^2 necessary for sterilization of air.	Sharp	1940
Broth sprayed in air	2.6 bacteria/ft.^{3} air after 5 d.	Wells	1934
Dist water sprayed in air.	10 bact./10 ft.^{3} air after 7 d.	"	
Infection depends more on than on settling rate.	viability of organism	"	
OUTDOOR			
B. anthracis			
Dry air, 200 F.	24 h.	Smyth	1921
B. megatherium			
Dust	Evidence of transport during storm	Soule	1934

TABLE 4 2 THE SURVIVAL OF BRUCELLA SPECIES IN AIR

Factor(s)	Survival	Reference	
EXPERIMENTAL			
B. melitensis			
Dust contaminated with urine.	30 d.	Chief	1944
Dust.	44 d.	Kennedy	1905
Ozone 4 h., 22 C.	No effect	Ransome	1901
OUTDOOR			
B. melitensis			
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.	"	
B. spp.			
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 43 THE SURVIVAL OF CLOSTRIDIUM, CORYNEBACTERIUM, LACTOBACILLUS, NEISSERIA & VIBRIO SPECIES IN AIR.

Factor(s)	Survival	Reference
EXPERIMENTAL		
C. diphtheriae		
Ozone, 4 h., 37 C.	Growth resumed after 8 d. incub.	Ransome 1901
Air	2 d.	Wells 1936
C. xerose		
Maleic & phthalic anhydrides are more active than their corresponding acids. The effective vapor concentration is 25% saturation for chemical disinfection of air.		White 1944
Lactobacillus acidophilus		
Those which became suspended in the air from liquid media either by natural or artificial means settle out rapidly in 5-10 min.		DuBuy 1947
Bacterial population somewhat reduced by radiation but not consistently.		DuBuy 1948
Vibrio cholera		
Water spray, cocoon thread.	Recov. 0, 1½ h.	Kirstein 1900
" " silk threads	Recov. 0, 72-108 h.	"
In Calcutta	Death rate increases with temperature	Ray 1950
INDOOR		
Corynebacterium diphtheriae		
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 & 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 " " "	
Dust, dried, R.T.	175 d.	Ouchterlony 1949
Dust	Long periods	Pressman 1937
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.	"
Neisseria meningitidis		
Can be carried at night from a carrier to his neighbor unless bed space is > 5 feet.		Eagleton 1919
OUTDOOR		
Clostridium welchii		
Only sporulating forms survive when influenced by oxygen under pressure or atmospheric air conditions		Ernst 1900
Corynebacterium diphtheriae		
Air, drying.	Surv. long time in dust.	Ernst 1900
V. cholera	Coldest month of year, dries out.	Rogers 1944

TABLE A 4 THE SURVIVAL OF DIPLOCOCCUS SPECIES IN AIR

Factor(s)	Survival	Reference
EXPERIMENTAL		
D. pneumoniae		
Daylight, in simulated room environment	42 min.	Buchbinder 1942
Dark, simulated room environment.	12 h.	"
Spraying into atmosphere saliva or 0.5% saline rate at 50% R.H. At R.H. survival was prolonged.	from large susp. of broth, produced high mortality above or below this the	Dunklin 1948
When saline free liquid death rate at intermediate R.H. 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.	used, the sharp peak in disappeared.	Dunklin 1948
INDOOR		
D. pneumoniae		
Organisms susp. in fresh atomized saliva	Recov. 95.3 immed. after spraying.	
	Recov. 329 after 75 min.	Robertson 1942
Outside body	Brief duration	Robertson 1947
22 D., R.H. 50-80%	Within 10 min. all the pneumo. had disappeared from air at 50% R.H.	" 1948
Floor dust, Types I & II	>1 mo.	Stillman 1917
Air	48 h.	Wells 1935

TABLE A 5

THE SURVIVAL OF ESCHERICHIA COLI IN THE AIR

Factor(s)	Survival	Reference	
EXPERIMENTAL			
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^2 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
OUTDOORS			
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
ALTITUDE		
Bacteria & mold spores.	Found at 70,000 Ft.	Armstrong 1936
Nutrient agar, 22 C., pH 7.2, 5,700 ft. above surface	103 colonies. Numerous bacteria carried along with dust into atmosphere are not killed by light, heat & dryness of desert air.	Brown 1930
Higher bacterial counts in clouds.		Dillon 1929
Lower count bacteria in clouds due to loss of electrostatic charge that caused dislodging of particles which adhered to plane		Durham 1941
Bacteria, moist film, ozone	More easily killed than when in dry state.	Ilford. 1942
Bacteria sprayed into air, RH 66%, ozone, .15 ppm, 21 C., 15 min.	>99% killed	"
Ozone co c. in excess of 1 ppm. in an atmosphere of 60-70% R.H. required to produce good sterilization.		"
Ten times as many germs in [illegible] days as on foggy days.		LeGuyon 1931
Subnormal sunshine & precipitation caused responsible for survival of infectious agents in air.		
High cooling power due to strong winds reduced resistance of people		Meissner 1940
Decreasing number of bacteria proceeding from basement to 4th floor.		Parvis 1948
Chance association with dust particles increases survival of air borne organisms.		Personnel of Navy Res. 1943
4 cases described bitten by insect native to S. America in Mojave desert.		Schlotthauer 1940
Study of # of organisms found in upper atmosphere ranging from 28 to 280		Timmon 1949
Agar plates at 19,000 to 28,000 ft. produced no organisms.		Walker 1935
EXPERIMENTAL		
Rats, G.P. & rabbits exposed 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		Bourdillon 1948

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
EXPERIMENTAL, CONT.		
Air from sneezing	100,000 bacteria remain in air over 1 min. 16,000 still in air over 30 min.	Bourdillon 1942
Air with hypochlorite spray, 65 F., R.H. 66%	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.	"
Apparatus for determination of penetration of particulate air borne material through nose described. Particles greater than 5 micra are filtered out.		Boyland 1947
In general, moving hot air is more effective in sterilizing of plane polished surface than still hot air of same temperature		Breinl 1935
Size of aggregates of micellae increased with concentration of saline, with increase time in sedimentation chamber.		Dautrebande 1948
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.		Duguid 1946
Bacteria carried in handkerchief after 2 days use liberated on mild manual shaking. Recov. 14,720		Dumbell 1948
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.		Dunklin 1948
50% solution calcium chloride spread on floor will prevent dust 4-6 weeks.		Galambos 1942
Technic outlined for determining particle size distribution of viable air borne bacteria		Goldberg 1950
Means of sampling bacterial aerosols		" 1951
Wave length of 2537 Å highly efficient in inactivating many disease agents.		1946 Hollaender
Factors which influence efficacy of glycol vapors: 1) RH.H. 30-50% 2) Greater below 72 F. than above. 3) More effective with dirt & dust than alone.		Harbuger 1945
The physiological & biological concepts for bactericidal irradiation of air have been fairly well-established by various investigators.		Hart 1944
Relatively low intensity U.V. of 2537 Å will interfere with cellular division & readily inactivate many disease agents which are not protected by other substances.		Hollaender 1942

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference
EXPERIMENTAL, CONT.		
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, dedreasing 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 may be important mode of	spread within group. of dust borne pathogens	Lemon 1948
Construction of apparatus of respiratory infections.	for experimental study	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, dondensation upon surfaces, adsorption by surfaces.	
The disappearance of the vapors from the air appromated a logarythmic 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 bod 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 46 THE SURVIVAL OF MICROORGANISMS IN AIR

Factor(s)	Survival	Reference	
EXPERIMENTAL, CONT.			
One gram of propylene glycol aerosol in 2,000,000 of air effected complete atmosphere containing as of air.	sterilization of an many as 500,000 bact./l.	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 90F.		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 clycol 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%.		Rentschler	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
EXPERIMENTAL, CONT.		
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
INDOOR		
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. Preceeding freezing with liquid air makes gram negative bacteria more strongly suscept. 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.		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.		Wilimon 1948

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR

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

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR (ADDENDUM)

Factor(s)	Survival	Reference	
ALTITUDE			
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
EXPERIMENTAL			
Erwinia amylovora			
R.H. close to 0.	Viable & infectious after 1 yr.	Rosen	1936
Hemophilus pertussis			
Air	1 h.	Wells	1936
Malleomyces mallei			
Ozone 4 h, 37 C.	Growth resumed after 8 d. incubation.	Ransome	1901
Micrococcus candidus			
Aerosols, air, after atomization.	Resistant to shock. Same vitality in aerosol as in suspension.	Ferry	1951
Proteus vulgaris			
Exposed to U.V.	61 col. 1 min.; 2 col. 3 min.	Hart	1939
Pseudomonas pyocyaneus			
Exposed to U.V.	Innum. col. 1 min.; 38 col. 3 min.	"	
Ozone 4 h.	60 sec.	Ransome	1901
Pseudomonas aeruginosa			
Suspension in air.	16,00(± 4.7%) ergs/cm^2 necessary for sterilizing air	Sharp	1940
Sprayed into air	< 1 d.	Wells	1934
Air	<1 d.	"	1936
Sarcina lutea			
Swabbed on tongue, nasal mucosa & tonsil crypts.	Usually impossible to recover.	Bloomfield	1919
Sarcina spp.			
Air, R.T., R.H. 70-72%, Triethylene glycol vaperized with hot air.	82% killed, 24 h.	Gruen	1949
Serratia marcescens			
Suspension in spray reduced to dust, R.T.	Disappeared at rate of 1.5-0.17 mm/sed. 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	
EXPERIMENTAL, CONT.			
Serratia marcescens			
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^2 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
INDOOR			
Proteus morgani			
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.		Jarrett	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 # bactoria found during greatest activity.		Lemon	1944

TABLE 46 THE SURVIVAL OF MICROORGANISMS IN AIR (ADDENDUM)

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

TABLE 42 THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS IN AIR

Factor(s)	Survival	Reference	
EXPERIMENTAL			
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.	Fluge	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 dan 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
INDOOR			
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 42 THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS IN AIR

Factor(s)	Survival	Reference	
INDOOR (CONT)			
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	2-2⅓ mos.	Sawizky	1891
Dust, room, hospital & home	Long periods	Thomas	1941
OUTDOOR			
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

TABLE 48

THE SURVIVAL OF PASTEURELLA SPECIES IN THE AIR

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

TABLE: A-9 THE SURVIVAL OF PROTOZOA, METAZOA, BACTERIOPHAGE AND RICKETTSSIAE SPECIES IN AIR.

Factor(s)	Survival	Reference
EXPERIMENTAL		
Bacteriophage		
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
Rickettssiae spp.		
Dyer Nine Mile, Henzerling str.½ saline susp. yolk sac.	30 min.	Ransom 1951
INDOOR		
Rickettssiae, typhus		
May be transmitted by air.		Lofflor 1942
OUTDOOR		
Entamoeba histolytica, cystic		
Air dried	Recov. 0	Kuenen 1913
C. burneti		
Air of goatery	Known infection in herd contaminates air considerably.	Lennette 1951

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

Factor(s)	Survival	Reference	
EXPERIMENTAL			
S. typhosa			
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
S. dysenteriae (Hiss Y)			
Air	8-24 hrs.	Wells	1936
S. paratyphosa			
Air	8-24 hrs.	Wells	1936
S. pullorum			
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 cumulative.		DeOme	1944
INDOOR			
S. pullorum			
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 dispersed with bacteria may have a marked protective action			
OUTDOOR			
S. typhosa			
Direct rays of sun	4-10 hrs.	Osler	1901
S. enteriditis			
Open air, broth plate	Recov. on 5 occasions.	Hewlwtt	1905

TABLE A // THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN AIR

Factor(s)	Survival	Reference	
EXPERIMENTAL			
S. albus			
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%	Lethal for organisms.		
R.H. on either side of "	Prolongs survival	Dunklin	1948
Sprayed in aerosol. Safe in R.H. 60-90% 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.V. LIGHT	26,200 ergs/sq.cm. sufficient to kill all suspended bacteria present with exposure of 1.06 sec.	Sharp	1938
Suspended in air	23,300 (±5.1%) ergs/cm^2 necessary for steril. air.	Sharp	1940
S. aureus			
Dried in nasal secretion in handkerchief.	Lg. # surv. > 1 mo.	Duguid	1948
Suspended in air	26,500 (±5.7%) ergs/cm^2 necessary for sterilizing air.	Sharp	1940
Sprayed into air	3 d.	Wells	1934
S. citreus			
Exposed to U.V.	102 col., 1 min, 6 col. 3 min.	Hart	1939
S. pyogenes			
Greater numbers released in dust than by sneezing. 50% reduction when wearing surgical gown.		Duguid	1948
S. spp.			
Killed rapidly at 70-90% R.H. with sprayed HClO. Bactericidal effect reduced in atmosphere of extremely low carbon dioxide content (0.001%) compared with behavior in N_2. Organisms in finely dispersed mixture killed more rapidly than those in heterogenously sprayed particles.		Elford	1945
Wounds cross infected	18 of 28 surgical wounds.	Rountree	1947
INDOOR			
S. albus			
Air during & after cleaning.	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 A11 THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN AIR

Factor(s)	Survival	Reference	
INDOOR (CONT.)			
S. aureus			
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
S. spp.			
R.H. 5-80%	Maximum humidity effect between 60 & 70%	Robertson	1949
OUTDOOR			
S. aureus			
Conc. calcium chloride, R.H. 35-40%	Least growth with minimum humidity.	Kopeloff	1922

TABLE A12 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE AIR

Factor(s)	Survival	Reference
ALTITUDE		
S. spp.		
Sprayed with 5 ml. of 1% hypochlorite sol'n.	95% killed; 5% recov.	Andrews 1940
Oiled blanket, plates exposed 5 min. during and after beating	170 colonies	
Unoiled blanket, plates exposed 5 min. during and after beating	1030 colonies	" "
EXPERIMENTAL		
S. pyogenes(Group A)		
Exposed to daylight in simulated room envirn.	252 min.	Buchbinder 1942
Dark, simulated room envirn.	65 hrs.	" "
Sprayed in air, settle on filter paper, daylight.	6 hrs.	Buchbinder 1941
S. pyogenes(Group B)		
Exposed to daylight in simulated room envirn.	66 min.	Buchbinder 1942
Dark, simulated room envirn.	132 hrs.	
Sheep blood agar, 18 hrs, 37C., dark room, susp'n in air.	Remain viable in dust of room at least 2 wks.; some impairment of virulence	Buchbinder 1941
Exposed to ultra-violet, 1 min.	98 colonies	Hart 1939
3 min.	12 colonies	
Air and triethylene glycol, CO2, 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 broth culture were more sensitive under dry condit.		" "
S. pyogenes(Group C)		
Sprayed into air, RH 50%,	Rapidly lethal	Dunklin 1948
Sprayed into air, RH above or below 50%	Increases survival	" "
Propylene glycol vapor conc. 0.2mg/l, RH 42%, 1 cu. ft. immediately after spraying,	4166 colonies	Bigg 1944
15 min. after spraying	3120 "	
30 min. after spraying	1760 "	
60 min. " "	442 "	" "
Sprayed in aerosol. Ozone in safely tolerated conc (0.04ppm) in RH of 160-90% exerted a disinfectant action.		Elford 1942

TABLE A12 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE AIR

Factor(s)	Survival	Reference	
EXPERIMENTAL(cont'd)			
S. pyogenes(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
S. pyogenes			
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 property 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
S. viridans			
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
S.salivarius			
Sprayed in aerosol. Ozone (0.04ppm.) in RH of 160-90% exerted a disinfectant reaction.	in safely tolerated conc	Elford	1942
S. zoocepidemicus			
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 airborne route than by direct nasal route.		Shechmeister	1950
S. spp.			
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 a t least 2 wks in dust of room with some impairment of virulence		Buchbinder	1941

TABLE 4-12 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE AIR

Factor(s)	Survival	Reference
INDOORS		
S. pyogenes		
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
Unoiled 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 occurence 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 4/2 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE AIR

Factor(s)	Survival	Reference	
INDOORS(cont'd)			
S. pyogenes			
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.		Loosli	1948
Air and dust in hospital wards	From w ar wound infections	Miles	1940
Air in barracks during heavy activity	40/10 cu. ft. of air	Miller	1948
Air in barracks during moderate activity	2/10 cu. ft. of air		
On floor, petri dish, dark	20% alive, 14 das.	Phelps	1939
diffuse light	<1% alive, <7 das		
Sprayed culture	Practically all settled in 48 hrs.		
Air, single noseblow by carriers.	Millions recovered	Hamburger	1946
Air, coughing by carriers.	Relatively few recov.		
Sneezing by carriers	Very few recovered.		
Triethylene glycol, RH 40-50%, bed making	88.6-54% reduction	Hamburger	1945
Air, hospital wards, glycol vapor	Diminution of bacteria of 32-75% during periods of glycolization	Hamburger	1945
Air after shaking cloth	Persisted over 15 min.	Duguid	1948
S. pyogenes(Group C)			
Ultra violet	In low conc. of air, UV markedly reduced bacteria	Henle	1942
Freshly atomized	Not killed as fast as those in low humidity. floating for 5 hrs.	Robertson	1951
RH 15-20%, floating in in air for 5 hrs.	Killed twice as fast as those exposed after atmmization		

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

Factor(s)	Survival	Reference
INDOORS(cont'd)		
S. pyogenes (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
S. salivarius		
Vapors of lactic acid, mandelic acid & triethanolamine, RH 70%, 15-21 C.	Gave good kills of org in sprayed saliva	Lovelock 1944
S. spp.		
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
Ist hour after cleaning	Found in air; not found after 2 hrs.	Furtherer 1946
Air drying	Many mos.	Ernst 1900
OUTDOORS		
S. pyogenes		
Air after shaking clothes	Persisted over 15 min.	Duguid 1948
S. spp.		
Air, drying	Many mos.	Ernst 1900

TABLE A 13 THE SURVIVAL OF VIRUSES IN AIR

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

TABLE A/3 THE SURVIVAL OF VIRUSES IN AIR

Factor(s)	Survival	Reference
INDOOR, CONT.		
Influenza		
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 32-65% 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.		Sheckmeister 1950
R.H. 32-65% (A)	High aerosol recovery	"
" 60%	Minimum " "	"
OUTDOOR		
Foot & mouth		
Normal atmospheric cond.	1 wk.	Burbury 1928
Related epidemiologically to distribution in dust.		Ostertag 1943

TABLE 4-13 THE SURVIVAL OF VIRUSES IN AIR

Factor(s)	Survival	Reference
OUTDOOR, CONT.		
Infectious jaundice		
Dust borne dried excreta carries causative organisms. Less common in towns than rural districts.		Anderson 1947
Influenza		
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%, 1cc. glycol vapor	< 24 h.	Post 1945
Dry	36 h.	"
Smallpox		
Epidemic in India		
Humidity rise	Lower incidence of disease	
Low absolute humidity favors disease.		Rogers 1928
R.H. low absolute	Seasonal rises in incidence	" 1948
GENERAL		
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 blendor 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 4/12 THE SURVIVAL OF YEASTS, MOLDS & FUNGI IN AIR

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

TABLE 4/2 THE SURVIVAL OF YEASTS, MOLDS, & FUNGI IN AIR

Factor(s)	Survival	Reference
ALTITUDE		
General, cont.		
Four species isolated from Antartica where mean temp. is -20 C.		McLean 1918
EXPERIMENTAL		
Aspergillus		
Exposed to U.V.	10 min. Immum. col., 20 min., 0 col.	Hart 1939
Geotrichum		
Exposed to U.V.	3 min., Immum. col., 10 min., 0 col.	"
Monilia		
Exposed to U.V.	1 min., 200 col., 5 min., 0 col.	"
Mucor		
Exposed to U.V.	1 min., Immum. col., 5 min. 25, 10 min., 0 col.	"
Penicillium		
Exposed to U.V.	10 min., Immum. col., 20 min., 0 col.	"
Pink yeast		
Water spray	Visible 10-14 d.	Kirstein 1903
Saccharomyces albicans		
Ozone, 4 h.	60 sec.	Ransome 1901
INDOOR		
Fungi paralleled bacteria except more abundant in textile room with high R.H.		Matuse 1935
OUTDOOR		
Coccidioides		
Chlamydospores in dust. Infection rates highest in dry seasons & dusty conditions. Rate of infection diminished by dust control. Southern climates have highest inf. rate.	Easily transported in air.	Dickson 1938
		Smith 1946
Molds		
Spores in sea air	Long periods of time	Zobell 1942
Puccinia malvaccarum		
Moist atmosphere, 1 C.	50 d.	Cohen 1946
Phytomonas malvacera		
Wind-blown rain	Important factor in dissemination	Faulwetter 1917
Sporotrichosis		
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
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 THE BODY (AND BODY MATERIALS)

TABLE #	TABLE OF CONTENTS	PAGES
B1	Bacillus anthracis	1
B2	Borrelia, Leptospira, Spirillum, Treponema species	3
B3	Brucella species	1
B4	Clostridium, Corynebacterium, Hemophilus, Lactobacillus, Malleomyces, Microbacterium, Proteus, Pseudomonas, Serratia and Erysipelothrix	3
B5	Diplococcus species	1
B6	Escherichia coli, Aerobacter and Paracolobactrum	2
B7	Metazoa and Protozoa	3
B8	Molds, Yeasts and Fungi	1
B9	Mycobacterium species	5
B10	Micrococcus species	2
B11	Neisseria species	1
B12	Pasteurella species	1
B13	Rickettsiae species	1
B14	Salmonella species	3
B15	Shigella species	2
B16	Streptococcus species	2
B17	Vibrio species	1
B18	Viruses	5
B19	General bacteria	1

THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN THE BODY

(AND BODY MATERIALS)

TABLE #	TABLE OF CONTENTS (CONT'D)	PAGES
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TABLE B1 THE SURVIVAL OF BACILLUS ANTHRACIS IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
BLOOD			
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.	"	
FECES			
G.P. feces	Spores in 7 of 19	Stein	1947
SKIN			
100% inhibited by normal human	skin	Hill	1933
URINE			
Urine of G.P.	Vegetative forms in 19 of 28 cases	Stein	1947
TISSUE, GENERAL			
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	
BLOOD			
B. recurrentis			
Defibrinated, refrigerated sheeps blood	195 d.	Beck	1937
Infected blood, Inoc. into physiol. saline with boiled egg white At ice box temp.	Still viable 3-4 wks. " " 4 d.	Krantz	1925
Rat blood, -48 C.	Remained infective for mice 27 mos.	Lofgren	1945
Iced 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.	"	
L. icterohemorrhagica			
Blood, defibrinated, R.T., light of day, 45 C.	Still infective 7 d. " " 15 min.	Uhlenhuth	1916
S. minus			
Frozen	1 yrs.	Turner	1939
S. rubrum			
Sterile rabbit blood susp.	at least 5 yrs.	Frobisher	1947
T. pallidum			
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, -70 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.	"	
FECES			
Borrelia spp.			
Feces	4 wks.	Gowen	1945
L. icterohemorrhagica			
Feces	24 h.	Noguchi	1918
Urine, Body temp.	wks. or mos.	Sawers	1938
URINE			
L. icterohemorrhagica			
R.T.	Still infectious 2 d.	Uhlenhuth	1916

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

Factor(s)	Survival	Reference	
TISSUES, GENERAL			
B. duttoni			
Mouse tissue, -78 C.	1 mo.	Oag	1939
Frozen rabbit testes, -78C.	1 yr.	Turner	1939
L. icterohemorrhagica			
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, -78C.	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.	"	
Treponema pallidum			
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	3 hrs.	"	
41 C.	2 hrs.	"	
41.5 C.	1 hr.	"	
Dead bodies of cong. syphilitic children, refrig.	24-36 h.	Hoffman	1926
Rabbit testes dried in vacuo from frozen state	nil.	Hampp	1951
Corpse of cong. syphilitic child	5 d.	Koch	1911
Corpse of " " child, dried & incub 37C.	Recov. 0 72 hrs.	Kratzeisen	1923
Liver & sterilized gall.	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 B2 THE SURVIVAL OF BORRELIA, LEPTOSPIRA, SPIRILLUM AND TREPONEMA SPECIES IN THE BODY (CON'T). (AND BODY MATERIALS)

Factor(s)	Survival	Reference
TISSUES, GENERAL, CON'T.		
Treponema pallidum		
Frozen exudates	13 mos.	Shmuntoff 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.T.		
Dried in vacuum	68 hrs. to 4 d.	Zurhelle 1927
T. pertenue		
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 39 THE SURVIVAL OF BRUCELLA SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
BLOOD			
B. abortus			
Sterile rabbit blood susp	At least 5 yrs.	Frobisher	1947
B. bronchiseptica			
Sterile rabbit blood susp	9 yrs.	"	
Broth culture, 0 C.	43 d.	Hampil	1932
B. melitensis			
Sterile rabbit blood susp.	3 mos.	Frobisher	1947
Normal skin of G.P. more vulnerable to B. melitensis entry than digestive tract.		Hardy	1929
B. spp.			
Citrated 4C. from convalescing patient.	6 mos.	Spink	1950
B. suis			
Sterile rabbit blood susp.	3 mos.	Frobisher	1947
FECES			
B. abortus			
Isolated from patient's stool in 10% CO_2, aerobically and anaerobically.	Surviving in 16th month of infection.	Amoss	1929
B. melitensis			
Dry, sterile manured soil	72 d.	Horrocks	1906
moist, sterile " "	7 d.	"	
" unsterile " "	20 d.	"	
B. suis			
Feces, sterile, dark.	100 d.	Anonymous	1933
" " "	100 d.	Cameron	1933
SKIN			
B. melitensis			
34% inhibited on normal human skin	--	Hill	1933
URINE			
B. melitensis			
Favorable conditions	6 d.	Bang	1894
Urine contam. with dust.	30 d.	Chief	1944
TISSUES, GENERAL			
B. abortus			
Uterus of cow, F.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
B. melitensis			
Uterus, F.P.	6 d.	Bang	1897
Colon at autopsy	More prevalent in cold wet season than dry & hot.	Eyre	1908
B. suis			
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 & ERYSIPELOTHRIX IN THE BODY. ~~(AND BODY MATERIALS)~~

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

TABLE R4 THE SURVIVAL OF CLOSTRIDIUM, CORYNEBACTERIUM, HEMOPHILUS, LACTOBACILLUS, MALLEOMYCES, MICROBACTERIUM, PROTEUS, PSEUDOMONAS, SERRATIA & ERYSIPELOTHRIX IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
SKIN (CONT.)			
Serratia marcescens			
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.	At least 5 yrs.	Erobisher	1947
Survived longer on skin than on filter paper		Hellat	1948
16.1% inhibited on normal skin		Hill	1933
Palmar surface, clean hand	Inoc. 1,200, Recov. 0 after 2 min.	Norton	1932
Washed hide	Inoc. 520, Recov 0., after 20 min.	"	
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
URINE			
Malleomyces pseudomallei			
26-27 C., culture	16 d.	Fletcher	1928
TISSUES, GENERAL			
Clostridium botulinum			
Intestinal tract, 22 C.	4 mos.	Burke	1919
Cl. sporogenes			
War wounds.	5 yrs.	Anonymous	1923
Cl. tertius			
War wounds.	5 yrs.	"	
Cl. tetani			
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, LACTOBACILLUS, MALLEOMYCES, MICROBACTERIUM, PROTEUS, PSEUDOMONAS, SERRATIA & ERYSIPELOTHRIX IN THE BODY. (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
TISSUES, GENERAL (CONT.)			
Cl. tetani			
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
Corynebacterium diphtheriae			
Small dried pieces	9 wks.	Abel	1893
Inoc. on membrane	4 mos.	"	
Throat of boy after attack	Virulent 6 mos.	Macgreggor	1898
Erysipelothrix rhusiopathiae			
Dried, dark	1 mo.	Hall	1917
Sunlight	10 12 d.	"	
Salted or pickled meat	3 4 mos.	"	
Carcass of buried animals	mos.	Losana	1896
Erysipelothrix spp.			
18-20 C., carcass	mos	Hettche	1933
Serratia marcescens			
Mouth, 28 S.	16 h.	Teague	1912

TABLE B5

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

Factor(s)	Survival	Reference	
BLOOD			
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 6 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. "	"	"
SPUTUM			
37C., with dust, air dried	Recov. 0 in 25 days	Germano	1897
37C, dried	4mos.	Guarnieri	1888
Dried in test tubes, 80F., diffuse daylight, TypeIII	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	25 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		
GENERAL			
32-35 C. Abdominal cavity	4-5 days	Foa	1888

TABLE 86 THE SURVIVAL OF ESCHERICHIA COLI, AEROBACTER AND PARACOLOBACTRUM IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
BLOOD			
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 stationery.	"	"
FECES			
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.	>54 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, -8 F to -30 F., exposed to open air.	>100 days	Lu-Ti-Huan	1930
Fecal emulsion, dilute, diffuse sunlight	3 days	Mc Naught	1910
inside window	11 days		
test tube, direct sunlight	19 hrs.		
Feces, saline susp'n., 37 C.	63 mos	Parr	1937
Feces, saline susp'n., ice-box temp.	599 days		
Feces, 37 C.	1 yr. 8 mos.		
Feces 40 C.	2 yrs.		
Feces, -11 C.	2-3 mos.	"	"
Feces, ice-box temp.	359 days		
Feces, animal, 61 F., inoc.1-3 mos.52 F.	Recovered 3-10 in 4 wks.	Savage	1917
Feces, on stump, blizzard inoc. 512,000/gm.;	Recovered none, 18 das.	Tonney	1931
on stump, spring, inoc. 11,800/ gm.;	Recovered none, 153 das.		
on stump, warm season;	172 days		
pure cult, stump, winter, inoc. 323,000/ gm.	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	
SKIN			
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
URINE			
Exposed to open air, -8 F to -30 F.	>100 days	Lu-Ti-Huan	1930
GENERAL			
Stomach-absence of free HCl.	Coliforms found in abundance	Lohr	1927
Isolated from frozen shrimp other coliform organism.	more frequently than any	Holmes	1949
FECES			
Aerobacter aerogenes			
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
SKIN			
Aerobacter aerogenes			
5% inhibited on normal human skin		Hill	1933
BLOOD			
Paracolobactrum aerogenes			
Sterile rabbit blood susp.	3-9 yrs.	Frobisher	1947

TABLE B7

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

Factor(s)	Survival	Reference	
BLOOD			
Anaplasmosis (Bartonella bovis)			
Dried blood	< 3 das	Dypstra	1948
Blood submitted to heating and chilling over period of 6 das.	0		
Plasmodium vivax			
-50 to -70 C.	10-15 das	Saunders	1947
Tryponosoma equiperdum			
Bats kept at low temp.			
10 C to 3-4 C.	Do not develop	Kalabuchov	1935
33 C. to 37 C.	Develop in blood in short time		
FECES			
Entamoeba histolytica			
Feces 37 C.	2-4 hrs.	Gurevitch	1947
Feces, 25-30 C.	5-8 hrs.		
Feces, 6-8 C.	8-10 hrs.		
Infected feces, 27-30C.	9 das.	Kuenen	1913
37 C.	3 das.		
Infected feces, with Ice salt mixture, freezing. inoc. 50 cysts	Recov. 13 dead thereafter hrs.		
Stool emulsion, R.T., allowed to dry on fingers	10 min.	Spector	1934
Dried feces	Instant death	Wenyan	1917
Very dilute feces	> 1 mo.		
Feces with free Cl2 in water, 1:10,000	No effect in several hrs.		
0 C., 16 hr. cult.	9 das.	York	1926
16-20 C.	7 das.		
0 C. washed & conc. cysts	17 das.		
16-20 C., washed & conc. suspension.	10 das.		
Human feces, cult. tube	14 das.	Dobell	1936
R.T. 4 hrs., and 14 C. for 14 hrs.	2 das.	Beaver	1949
Soil plus stool plus water R.T., 1 hr	6 das.		
14C. 12 hrs.	4 das.		
28-34 C.	8 and 4 days.	"	"
Feces	3 das.	Rudolfs	1951
Entamoeba coli			
Human feces, 1-2C., culture cysts	4 1/2 mos.	Dobell	1936
Stool emulsion, R.T., allowed to dry on fingers	More resistant than E. histolytica	Spector	1934
Entamoeba coli marcorcarum			
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	
FECES (CONT'D)			
Hookworm			
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.		
Necator americanus			
45 C.	2 hrs.	Nicholls	1939
Ascaris lumbricoides			
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 > 7 1/2 hrs.		
Pig feces, sunlight, 130F	5-30% disintegrated in >7 1/2 hrs.	"	"
Human and pig feces, lying shade	Recov. 0, 2 wks.		
Human feces moist with constant temp. 40-50C.	38% ova disintegrated in 14 das.	"	"
Pig feces, moist with constant temp. 40-50 C.	40% ova disintegrated in 14 das.	"	"
45 C. compost	3 mos.	Nicholls	1939
54-55 C.	3-5 min.	Nolf	1932
Fecal susp'n of eggs	All degenerate in 27-35 das.	Rudolfs	1951
Trichuris trichuris			
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 d as.		
-9 C., 4 das incubation	Recovered 40%, 8 das.		
Sand in shade, human	74% motile, 35 das.	Brown	1927
Eggs of T. trichiura, as well as N. americanus, A. lumbricoides, T. saginata, S. haematobium, pass thru cockroach unharmed.		Macfie	1922

TABLE 57 (CONT'D) THE SURVIVAL OF METAZOA AND PROTOZOA IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
URINE			
A. lumbricoides			
Human urine	No survival	Yoshida	1920
Trichomonas vaginalis			
Urine, 20C., inoc. with vaginal secretion	Few alive in 20 hrs.	Jirovec	1948
GENERAL			
T. vaginalis			
Vaginal discharge	Recov. 2-4% in 6 hrs.	Kessel	1950
Vaginal discharge, R.T., Paraffin sealed cover-slips.	>5 das.	Kirby	1943
Pus, dry	3 hrs.	Swift.	1937
E. histolytica			
Cysts drying on human hand	5 min.	Spector	1934
Cysts pass through cockroach	unharmed	Macfie	1922
T. batrachorum			
In Riana pipiens, R.T., distilled water, and gastric mucin	6 yrs & 11 mos.	Wenrich	1949
T. wenyani			
In white rats, R.T., with distilled water and gastric mucin.	4 yrs.	"	"
In amphiuma, R.T., with gastric mucin	4 yrs.(T. prowazeki)	"	"
T. augusta			
In Rana pipiens, R.T., with water & gastric mucin.	2 yrs.	"	"
T. hominis			
In man, 32-34 C., in water and gastric mucin.	3 yrs.	"	"
T. species			
From Crotelus horridus	2 yrs.	"	"
Trivitus parva			
From Triturus viridescens	4 yrs.	"	"
Monocercomonoides			
From Lipulid larvae	4 yrs.	"	"
T. spp.			
From Japanese beetle larvae.	4 yrs.	"	"
Trichinella spiralis			
G.p., rat muscle, pork,			
pork sausage, -35 C.	2 Hrs.	Blair	1934
-17.8C.	53 hrs.		
Tr. spp.(larvae)			
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
SKIN		
M. oudouini		
Hair	420 d	Farley 1921
Hair in well stoppered bottles	125 d	Robinson 1948
Trichophyton interdigitale		
Scrapings from toes	300 d	Mitchell 1922
SPUTUM		
Coccidioides immitis		
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	
BLOOD			
M. tuberculosis			
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.			
FECES			
M. tuberculosis			
Feces, R.T., dark, summer	1 day	Abe	1949
fall	3 days		
winter	9 days		
Feces, 8 C,	Still virulent, 3 1/2 mo	Gärtner	1898
Dung	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.	Stenhause	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.		
M. paratuberculosis			
Infected feces, atmospheric conditions	246 days	Lovell	1944
PUS			
M. tuberculosis			
Pus, room temp., dark	Viable 4 mos.	Abe	1949
Pus, R.T., in half dark	Viable 3 mos.		
SKIN			
M. tuberculosis			
Human tubercle bacillus in reed capsule placed under skin of cattle	7 years	Heymans	1927

TABLE B7 (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
SPUTUM			
M. tuberculosis			
Sputum, R.T., dark	Viable 4 mos.	Abe	1949
Sputum, half dark	Viable 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 sunlight, 12-14 C, R.H.50%,			
afternoon	9 min, recovery 12/	Albini	1940
noon	1-4 min.		
diluted 1:2(5:00 PM.)	1 min., recovery 3 /		
diluted 1:25	----------		
Sputum, exposed to sunlight, 7-9C., R.H. 40%			
afternoon	1 min., recovery 3 /	"	"
diluted 1:2	4 min., recovery /		
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 exposed 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	
SPUTUM(CONT'D)			
M. tuberculosis			
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 distence 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
Dessicated 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.	Twichell	1905
	Produce no lesion in 188 das.		
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	
SPUTUM			
M. tuberculosis			
Out of doors, winter mos. open bottles	Lesion in 110 das, no lesion in 132 das.	Twichell	1905
Handerchief	Lesion in 70 das, no lesion in 110 das	"	"
Woolen blanket	Lesion in 70 das, no lesion in 110 das.		
Wood	Lesion in 70 das, no lesion in 110 des,	"	"
In thermostat	Lesion in 33 das., no lesion in 70 das.		
Dry light place, sand	Lesion 30 das., no lesion 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	Infective 39 days		
20 C., dark	4 mos.	Vidal	1934
2 C.	12 mos.		
Dried	Several weeks	Villemin	1869
M. paratuberculosis			
Electric light	74-100 days	Soparkar	1917
Direct sunlight	10-12 hrs.		
Diffuse light	30 days		
Diffuse daylight	6-8 days	"	"
URINE			
M. tuberculosis			
Room temperature, dark; in half dark	Viable 4 mos. Viable 3 mos.	Abe	1949
2-3 C.	Viable [illegible]		
60 C.	Recovered 0 in 1.5 hrs.	Nasta	1930
Refrigerator	Recovered 0 in 30 days		
Inject into peritoneum of g.p.	Lose power in 30-40 das.	"	"
GENERAL			
M. tuberculosis			
Dried or broken up organic matter	Still virulent at 43 & 38 das. respectively	Cadeac	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 soap	Larson	1922

TABLE 89 (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
GENERAL(CONT'D)			
M. tuberculosis			
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	4 mos.	Stillman	1938
summer	2 mos.		
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
M. paratuberculosis			
Intestinal scrapings mixed with river water, outdoor temp.	Recovered in 163 das.	Lovell	1944
B.C.G.			
Spleen of g.p.	53 days	Gernz-Rieux	1950
Axillary lymph nodes	175 days		

TABLE B10

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

Factor(s)	Survival	Reference	
BLOOD			
M. spp.			
Sterile rabbit blood suspn	24 strains viable 9 yrs. 15 strains viable 19 yrs	Frobisher	1947
FECES			
M. pyogenes var. aureus			
Feces, sunlight with heat	Bactericidal effect not marked	Lehmann	1931
SKIN			
M. pyogenes var. aureus			
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;	32 % recov. in 30 min.		
arm down	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 sterilizing action	"	"
Nail beds and areas surrounding nail beds	Less effective at sterilizing than normal areas	"	"
Keratotic areas	No more effective at removing *M. aureus* than normal areas	"	"
Moist areas	Depression of steriliz ing power	"	"
Denuded epithelium	Not as effective in removing Staph. as intact areas.	"	"
Previous exposure to U.V.	Does not enhance destructive power against Staph.	"	"
Skin of persons with furunculosis	Remain longer than in skin of others	"	"
Psoriatic lesions, bared of scales	Free themselves of Staph faster than lesions with scales.	"	"
Survived longer on skin than on filter paper		Hellot	1948
17.2% inhibited on normal skin		Hill	1933

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

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

TABLE B 11

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

Factor(s)	Survival	Reference	
BLOOD			
N. gonorrhoeae			
Sterile serum sealed with layer of paraffin	16 mos.	Ungerman	1918
Sterile serum sealed with layer of paraffin	7-8 weeks		
N. meningitidis			
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
N. spp.			
Sterile rabbit blood susp	Neisseria--6 wks-3 mos.	Frobischer	1947
URINE			
N. gonorrhoeae			
Male with urethritis	---------	Charles	----
20-26C, pH 5-8.5	Two colonies survived 48 hrs.	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
GENERAL			
N. gonorrhoeae			
Urethral secretion, -5 to 2 C., pH 7.4-7.6, grown on ascitic agar;	1 hr. some reduction	Hamptman	1930
plus 12 C, pH 7.4	8 hrs. some reduction		
plus 22 C, pH 7.4	12 hrs. some reduction		
Urethra, body conditions	<3 yrs	Keyes	1911
Fresh pus, 22-23 C.	Still viable 24 hrs.	Schofield	1927
Cases successfully treated & operated on.	No survival times	Cohn	1946
N. meningitidis			
Dried human secretions	Several days	Jungleblut	1935

TABLE B12

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

Factor(s)	Survival	Reference	
BLOOD			
P. pestis			
Blood allowed to putrefy in test tube	100 das.	Ostertag	1908
P. of hemorrhagic septicemia			
Physiological serum	5 mos.	Jacotot	1926
FECES			
P. of swine plague			
Swine feces, 8 C.	Recov. 0 in 4-5 das	Gartner	1898
P. spp.			
Sterile feces	Still alive 2 wks-4 mos.	Gladin	1898
SPUTUM			
P. pestis			
Droplets	--------	Teague	1912
URINE			
P. pestis			
Sterile, R.T.	Still alive 3 mos.	Gladin	1898
GENERAL			
P. pestis			
Spleen of infected g.p., -15 C.	Virulent 14 mos., slightly vir. 2 yrs. 7 mos., dead 3 yrs. 5 mos.	Francis	1932
R.H. $\geq$37%, temp.$>$40 F.	Restricted to areas with these factors	Nonr	1951
Corpses of *C. pygmaeus*	Viable 23rd day after death	Novikova	1934
Frozen cadavers in Manchuria	Viable 3 mos. after death	Strong	1942
Cadavers with putrid spleen	4 days	"	"
Cadavers after burial	3-30 das.		
Glycerine in spleen, -15C.	Viable 7 yrs.	Frances	1932
P. tularensis			
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 B12 THE SURVIVAL OF RICKETTSIAE IN THE BODY (AND BODY MATERIALS)

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

TABLE P/4 THE SURVIVAL OF SALMONELLA SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
BLOOD			
Sterile rabbit blood susp.	1 yrs.	Frobisher	1947
FECES			
S. enteriditis			
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.	"	"
S. paratyphi			
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.	"	"
S. paratyphi B			
Fluid stool, R.T., dark.	115 d.	Dold,	1944
Fluid stool, R.T.	115 d.	"	1943
S. schottmülleri			
Fluid stool, R.T., dark	18 d.	Dold	1944
Stool dried on paper, R.T.	>8 mos.	"	"
Fluid stool, dark	20 d.	"	"
S. species			
Not found in feces of cockroaches		Macfie	1922
Rat feces, R.T.	148 d.	Welch	1941
S. typhimurium			
Original feces	74 d.	Dold	1947
Dried "	421 d.	"	"
SKIN			
S. enteriditis			
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.	Krueger	1942
Dirty or fatty skin	Several hrs.	Singer	1929
S. Paratyphi			
Dirty or fatty skin	Several hrs.	"	"
S. typhimurium			
Turkey skin, frozen	13 mos!	Browne	1949
TISSUE, GENERAL			
S. typhimurium			
Chicken tissue, 93-96 C.	Inoc. 3.15×10^9/gm.	Husseman	1951
after broiling	Recov. .18% in 42 min.		
after roasting	Inoc. 9.36×10^9/gm.		
	Recov. 0.1% in 140 min.	"	"

TABLE 84 THE SURVIVAL OF SALMONELLA TYPHOSA IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
BLOOD			
Normal goat serum, dried	Death rate logarithmic in response to conc. of surviving organisms.	Chic...	1912
Sterile rabbit blood susp.	7 yrs.	Frobi...	1947
Sterile " " "	1 str. viable 18 yrs.	"	"
Blood & peritoneal fluid, R.T., air excluded	Virulence preserved >10 yr.	Puntoni	1924
FECES			
Freezing	Several minutes	Beard	1940
Fluid stool, R.T., dark	4 d.	Dold	1944
Fluid Stool, dark	4 d.	"	1943
Stool dried on filter paper, R.T.	> 55 d.	"	1944
Stool, thin, watery, dark, RT.	3 d.	"	"
" " ", dried on filter paper, R.T.	> 137 d.	"	"
Feces in a latrine	30 d.	Galv...no	1908
Feces in a cask	25 d.	"	
Feces in earth of latrine, buried 10 d.	40 d.	"	
Feces in sand	5-20 d.	"	
Feces in loam	5-15 d.	"	
Feces in gravel	10-20 d.	"	
After being 10 days in latrine the organisms were no longer virulent.		"	
8 C.	Recov. 0 in 5 d.	Gartner	1899
3 C.	Recov. 0 in 10 d.	"	
Tap water with stool	Inoc. 100,000/cc water Recov. 200/cc water in 2d.	Horrocks	1911
R.T.	52 d.	Jordan	1906
Feces in latrine, winter	5 mos.	Levy	1903
-8 ti -30 F., exposed to open air	40-50 d.	Lu-ti-huan	1930
Not found in feces of cockroach		Macfie	1918
12-17 C,	Viable after 4-12 d.	Schiller	1930
Liquid manure	4 d.	"	
Liquid manure, 13-22 C.	9 d.	"	
" " below 12 C.	8 d.	"	
" " above 13 C.	8 d.	"	
Feces & urine, 16-20 C.	Viable 7 d.	"	
8 day cult., below 12C.	Viable 7 D.	"	
10 day cult., below 12 C.	Viable 9 d.	"	
13 day dult., below 12 C.	" 27 d.	"	
15 d. cult., 12-22 C.	Viable 9 d.	"	
5 d. cult., below 12 C.	" 14 d.	"	
" over 18 C.	Viable 8 d.	"	
21 d. cult., below 12 C.	Viable 13 d.	"	
Liquid manure 12-17 C. 6 d. cult.	" 4 d.	"	
Liquid manure, 10 d. cult.	" 4 d.	"	
" " 13 d. cult.	" 7 d.	"	

TABLE B14 THE SURVIVAL OF SALMONELLA TYPHOSA IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
FECES, CONT.			
Fresh feces, 17-22 C. weakly acid.	Viable 115 d.	Uffelman	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 116 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.	"	
SKIN			
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
URINE			
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 glucose	14 wks.	Zeller	1948
TISSUE, GENERAL			
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
FECES		
S. ambigua		
Desert temp., in open box with flies	297 h.	Stewart 1944
S. dysenteriae		
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.		" 1943
(Ruhr bacillus), Fluid stool	8.2 d.	" 1944
" " Dried stool	27.2 d.	"
" " Fluid, R.T., dark.	10 d.	"
" " Dried in dark.	1 mo.	"
" " Fluid, dark, R.T.	28 d.	"
Feces, 1.5-19 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.	"
S. paradysenteriae		
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.	"
S. sonnei		
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
URINE		
S. dysenteriae		
Urine, warm, indoor, -8 to -30 F., Exposed to open air.	40-50 d.	Lu 1933
	55 d.	Lu-ti-huan 1930
TISSUES, GENERAL		
S. dysenteriae		
Filtered human gastric juice, pH 4.5	Germicidal for Sonne-Duval strain of S. dysenteriae	Felsen 1939

TABLE B/b THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
BLOOD		
S. fecalis		
Sterile rabbit blood susp.	7-19 yrs.	Frobisher 1947
S. hemolyticus		
R.T., liquid paraffin, arachis oil	8 wks.	
	4 wks.	Coulthard 1951
Refrig., liquid paraffin, arachis oil	4 wks.	
	> 37 wks.	"
Saliva, R.H., 40-55%	Mortality rates smaller than pneumococcus.	Dunklin 1948
Sterile rabbit blood susp.	Alive 18 yrs. (Beta)	Frobisher 1947
" " "	" 9 yrs. (Alpha)	"
S. liquefaciens	7-19 yrs.	"
Sterile rabbit blood susp.		
S. spp.		
Horse serum, 55 C.	--	Belin 1933
37 C. for 3 hrs., defibrinated. Sprayed from chamber.	Increased from 600 org. per unit to 50,000/unit in 1-7 days.	Buchbinder 1941
SKIN		
S. pyogenes		
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 4 min.	" 48 " .22	"
Right palm, " 4 min.	" 48 " 0	"
Exposed to long chain fatty acids.	Lethal	Burtenshaw 1945
S. hemolyticus		
Normal skin of hand, R.T. From broth culture.	Recov. 30 million, 3 min.	Colebrook 1930
	" 1.7 " 1 h.	"
	" 7,000 2 h.	"
Hands of normal person	Group A isolated from hands of 7 out of 181.	
	Non-hemolytic on nearly all of hands.	"
Skin of hands.	6% viable, 1 h.	Krueger 1942
Washed hide	Inoc. 1400, Recov. 400 30 min.	Norton 1932
Surface, washed hide	Inoc. 1,000, Recov. 75, 30 min.	"
Wounds	Alpha strep. found in 3 of 82 wounds.	

TABLE B16 (CONT.) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference
SKIN (CONT.)		
S. pneumoniae		
Exposed to long chain fatty acids	Lethal	Burtenshaw 1945
S. viridans		
Exposed to long chain fatty acids.	Lethal	"
SPUTUM		
S. hemolyticus (Beta)		
Dried, 37 C.	Viable at 150 d.	Germano 1897
Saliva	In 20% no strep. demonstrable. 80% same strep. as in throat culture.	Hamburger 1944
TISSUE, GENERAL		
S. hemolyticus (Beta)		
Dried membrane, 37 C.	Viable after 3 mos.	Germano 1897
Nasal secretion	Recoverable after last normal hand washing.	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.	½ yr.	Jettman 1927
S. spp.		
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
BLOOD		
V. comma		
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 3 wks.	"
FECES		
V. comma		
Flies in contact with mat'l. rich in organisms.	Found in feces	Alessandri -
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., Exposed 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.	"
URINE		
V. comma		
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	
BLOOD			
Hoof & Mouth virus			
-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_2O_5 in vacuo	2 1/2 hrs.		
Dried lymph 122 C., dried with P_2O_5 in vacuo	3 min.	"	"
Dried lymph of g.p., 52 C in P_2O_5	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
Herpes			
U.V. radiation, fresh normal rabbit serum	10 min.	Gunderson	1932
Normal rabbit serum	40 min.	McKinley	1926
Mexican typhus			
Blood and tissue, 5 C.	79 das.	Macchiavello	1937
Yellow Fever virus			
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
Rift Valley Fever			
Blood, refrigerator	62 days	Smithburn	1949
Blood, refrigerator(stored, fluid)	2 yrs.		
Serum, refrigerator	1048 das.	"	"
FECES			
Hoof & Mouth virus			
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
Infective Jaundice			
Dust borne, dried	31 das.	Anderson	1947
Newcastle virus			
Dried chicken feces, pH 6.3 and 6.8		Olesiuk	1951
Psittacosis			
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	
FECES (CONT'D)			
Polio virus			
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 activated sludge and chlorination		Krumbiegel	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	"	"
SKIN			
Influenza virus			
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
Vaccinia virus			
Light reduced 1/2	Pustule up to 8 hr.	Herzberg	1933
SPUTUM			
Virus spp. R.T.	Recovery positive, 92das	Arloing	1927
GENERAL			
Hoof & Mouth virus			
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, -10to -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 thawed at R.T.	4 mos.	Henderson	1948
Kinderpest virus			
Live rabbits & storage	7 das.	Haddow	1947

TABLE B/8.1(CONT'D) THE SURVIVAL OF VIRUSES IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	Reference	
GENERAL(CONT'D)			
Polio virus			
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
Rabies			
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.		
Herpes virus			
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
Yellow Fever virus			
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
Influenza virus			
Palmar skin	Recov. 20 in 10 min.	Anon.	1943
Mouse brain susp'n in N rabbit serum, -20to -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
Newcastle Disease virus			
Skin, eviscerated carcass, 34 F., exp. infected	96 das	Asplin	1949
Bone marrow	134 das		
Unplucked carcasses, skin;	160 das		
bone marrow	196 das	"	"
Fowlpox virus			
Dried material from lesions	2 yrs.	Loewenthal	1906

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

Factor(s)	Survival	Reference	
GENERAL (CONT'D)			
Polio virus			
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
Rabies			
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.		
Herpes virus			
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
Yellow Fever virus			
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
Influenza virus			
Palmar skin	Recov. 0 in 10 min.	Anon.	1943
Mouse brain susp'n in N rabbit serum, -20to -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
Newcastle Disease virus			
Skin, eviscerated carcass, 34 F., exp. infected	96 das	Asplin	1949
Bone marrow	134 das		
Unplucked carcasses, skin;	160 das		
bone marrow	196 das	"	"
Fowlpox virus			
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	
GENERAL(CONT'D)			
Vaccinia virus			
Mouse brain, 4 C., Dried over CaCl2 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 apparatue, 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	"	"
Neurotropic viruses -20 to -30 C.	9 mos.	Olitsky	1949
Encephalitides			
Brain tissue, 50% glycerin	1 yr.	Hull	1947
Dried	Lose virulence		
Frozen	>3 mos.		
pH below 5.5	Lose viability		
pH 9.2	Viability returns	"	"
Mouse brain susp'n in N rabbit serum -20to -30C (Jap.B encephalitis)	<6 mos	Olitsky	1949
Mouse brain emulsion in plain broth, -78C.	6 mos.	Turner	1938
Meningo-meningitis			
Frozen rabbit testes,-78C	3 yrs.	Turner	1939
Lympho-granuloma inguinale			
Frozen rabbit testes,-78C.	10 mos.		
Smallpox virus(Variola)			
Dry crusts, 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	
GENERAL(CONT'D)			
Pneumoenteritis virus			
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.	"	"
Virus spp.			
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 B9 THE SURVIVAL OF GENERAL BACTERIA IN THE BODY (AND BODY MATERIALS)

Factor(s)	Survival	REFERENCE	
Gastric juice	Organisms recovered 5½ hrs. after feeding dogs 500 cc. alk. milk with organisms.	Arnold	1926
Sweat. Freshly secreted. May	have mild antiseptic	Bergeim	1943
value due to acid pH imparted	by lactic acid.		
Tissue surfaces in contact with bacteria as respiratory and	environment rich in		
strong inhibitory effect on	digestive tract have		
lacking on tissue surfaces of	bacteria which is		
as pleura, pericardium, peri	the body cavities such		
important role since it cont	toneum. Saliva plays		
tive to cold, soluble in wat	ains inhibators sensi-		
alcohol, chloroform, and ace	er and precipitated by		
	tone.	Dold	1947
4 days since bath. Skin scrapings.	Deltoid area: aerobic 70 organisms. Anaerobic 37 "		
7 days since bath. Skin scrapings.	Scapular area: aerobic, 47 organisms. anaerobic, 10 "	Evans	1950
Saliva sprayed in air	36 hrs.	Lukriech	1947
Hands & arms.	Inoc. 4,580,000, Recov. 1,000,000 after scrubbing 14 min.	Price	1938
Sores on man & beast, 110-120 F			
Sun on sores.	Organisms destroyed.	Sternberg	1894

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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 CULTURE

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THE PERSISTENCE (SURVIVAL) OF ORGANISMS IN CULTURE

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TABLE 9/ THE SURVIVAL OF BACILLUS ANTHRACIS IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
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
LIQUID			
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_2, -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. 10^9	114 d.	Velu	1931
" " dil. 10^8	1072 d.	"	"
" " dil. 10^7	1072 d.	"	"
" " dil. 10^6	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
SOLID			
Plate cultures	30 hrs.	Arloing	1885
Spores, bouillon, test tube	2 hrs.	"	"
Agar & gelatin plates, exposed to sunlight	1⅛ hrs. (July, Mar., Aug.) 2⅛ hrs. (Nov.) 4⅛ hrs. (winter)	Dieudonne	1894
Agar plates, R.T.	2-3 wks.	Jones	1942
Agar, 37C	18½ hrs.	Launder	1932
Nutrient agar tubes, ozonized air thru tube	No change at 8 d.	Ransome	1901

TABLE C 1 THE SURVIVAL OF BACILLUS ANTHRACIS IN CULTURE

Factor(s)	Survival	Reference	
SOLID, (cont'd)			
Agar, incub. temp.	Viable 24 hrs.	Sanfelice	1893
Agar cult. 2-3 days old.	5% incapable of germinating 7 hrs.	Swann	1924
Agar cult. 8 mos. old, kept over fused $CaCl_2$	7 hrs.	"	"
Gelatin agar, 180C, sunlight for 6 d.	2-6 hrs.	Ward	1892
GENERAL			
80C. (Str. R1009)	Inoc. 234, Recov. 200 after 2 hrs. expos. to alkali	Jones	1942
Best time & temp for heating suspected infected with anthrax	industrial material 5 min @ 65C.	"	"
Continuous freezing at -60 to -70C, blood susp.	Organisms destroyed in 90-124 d.	Stein	1947
18 hr. serum broth cult. -5 to-10C.	Viable for G.P. after 10 yrs, 8 mos.	"	"
Boiling	10 min.	Topley	1936

TABLE C 7, THE SURVIVAL OF BACILLUS SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
B. spp.			
Dried	4-5 yrs.	Proom	1949
LIQUID			
B. cereus			
Broth, before centrifug.	100% survive	Winslow	19?
" 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% "	"	
½ Locke-Ringers, before centrifuge	100% "	"	
" " after cen.	3% "	"	
1 hr. later	1% "	"	
[illegible]	8-16 min.	Davis	1948
" "	Inocs. 100 million spores, Recov. 0,16 min.	"	
Gentian violet, HgCl,	Resistant to action	"	
Streptomycin	" "	"	
98.5 F.	12 min. (heat resist)	"	
B. megatherium			
Bouillon cult. direct sunlight on paper slips.	Spores, 6 h.	Weinzirl	1914
Preisz-Nocard bacillus			
Semim in flask, light	11 mos.	Urbain	1930
" " dark	13 mos.	"	
B. radicicola			
Solution	242 d.	Alicante	1926
B. radiobacter			
Solution	10 min	"	
B. subtilis			
High press., 17,600, R.T.	45 min.	Basset	1932
Alcohol & toluol	6 mos.	Hite	1938
Bouillon cult., sunlight	Bact. 8.5 h., spores 5h.	Weinzirl	1914
B. vulgatus			
Bouillon cult., sunlight	5 h.	"	
SOLID			
B. alcaligenes			
Agar, Exp. to UV 30 min.	Acquired slight germicidal properties.	Tanner	1930
B. fluorescens putridus			
Agar & gelatin plates exp. to sunlight	2½ hrs.	Dieudonne	1894
B. megatherium			
Agar covered with sterile 10% cane sugar, 10 C.	8 mos.	Keith	1913
Agar, Exp. to UV, 30 min.	Acquired slight germicidal properties	Tanner	1930

TABLE C 2. THE SURVIVAL OF BACILLUS SPECIES IN CULTURE

Factor(s)	Survival	Reference	
SOLID			
B. proteus			
Nutrient agar, 0-5C	No growth	Haines	1934
B. Subtilis			
Agar cov. with sterile cane sugar, -10C	8 mos.	Keith	1913
Agar, exp. to UV, 30 min.	Acquired slight germicidal prop.	Tanner	1926
GENERAL			
B. megatherium			
-5 to -15C	Resisted better than higher temp.	Campbell	1932
	>272 d.	Enl	1921
B. mesentericus			
Broth, -13 to -15C	>80 wks.	Tanner	1928
Salt soln., -13 to -15C	>80 wks.	"	"
B. subtilis			
Broth, -13 to -15C	>80 wks.	"	"
Salt soln., -13 to-15C	>80 wks.	"	"
B. globigii, B. thermoacidurans, B. subtilis	Amino acids & growth factors had little if any effect on sporulation. Heat resistant spores were enveloped. Resistance to phenol and iodine paralleled heat resistance.	Williams	1948
B. brevis, B. subtilis, B. megatherium, B. globigii, B. cereus	Species of aerobic spore forming bacilli that produce spores of unequal 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
B. mycoides			
Bouillon cult., direct sun on paper slips.	Bacteria 4 hrs., spores 5 hrs.	Gabrieli	1914
Bacterium linens			
Litmus milk, 20C	Inoc. 1,2,000,000/ml. 1/1., 17 d.	Albert	1914
" " R.T.	4 mos.	"	"

TABLE 3 THE SURVIVAL OF BACTERIOPHAGE IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
Typhoid, phage			
32% NaCl dehydrated in Raust-Heim apparat.	Viable 26 yrs.	Marcuse	1949
Phage, general			
Dried in vacuo	3½ yrs.	Campbell	1941
Dried	More resistant to heat	Vedder	193[illegible]
DRIED, LYOPHILIZED			
E. coli and staphylococci			
-78 C. and thawed 20X	Did not lose activity	Sanderson	1945
[illegible] thawing	16% failed to survive	"	
10th "	86% " "		
[illegible] "	99% " "	"	
Dysentery phage			
Addition of 1% gelatin with lyophilized dest[illegible] lytic activity of dysentery phage. Raw egg whites protected phage for inactivating effect of glycogen. 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 lyophilization. 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 dessication. No particular pH favors lytic activity. Addition of cysteine, ascorbic acid & removal of O_2 prior to lyophil. failed to effect stability.		Schade	1944
GENERAL			
Staphylococcus phage			
.01 1% methylene blue, indirect sunlight	5 min.	Clifton	1931
E. coli phage			
2-5 C. (R1)	11 yrs.	Raketen	1947
" (R1 & R2)	7-17 yrs.	"	
Dysentery phage			
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.	No constant protection for phage	Schade	1944
pH 3.3-4.3. 48 hrs, 18C.	Survives	Sierakowski	1930
Less resistant to same pH at 37 C. in acid med.			
pH 10-9.55, 24 h, 18 C.	Survives	"	
More resistant to same pH levels at 37 C.			
More resistant to pH than corresponding organism.		"	

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

Factor(s)	Survival	Reference	
DRIED, LYOPHILIZED			
Borrelia			
-78C (duttoni	1 yr.	Turner	1939
Blood drawn early in disease regains motility better than blood drawn late. (novyi)		Lofgren	1945
-78C. (novyi)	1 yr.	Turner	1939
Rat blood, -12 to -20C (recurrentis)	Infectivity reduced 6 wks.	"	"
Warming from -78C to 0C. over 2-6 hrs. period (swellengrebel)	Kills most of organisms	"	"
-78C (tickmouse)	1 yr.	"	"
Dried from frozen state (vincenti)	192 hrs.	Hampp	1947
Lyophil. vaccine has greater stability than regular liquid vaccine.		Verwey	1950
Leptospira icterohemorrhagiae			
Rabbit testes in infusion broth, -78C	10 mos.	Turner	1939
20% tissue susp. in infusion broth, -78C	Actively motile 10 mos.	"	"
Spirillum minus			
Mouse blood & peritoneal fluid, -78C	Viable for mice, 1 yr.	Turner	1939
LIQUID			
Leptospira icterohemorrhagiae			
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 C 5 THE SURVIVAL OF BRUCELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
Brucella, species			
Dried	4-5 yrs.	Proom	194?
LIQUID			
Brucella abortus			
Broth, 15-20 F., dry	400 d.	Feldman	1935
Saline, 62 C.	all dead 1 min.	Seelemann	1938
Brucella melitensis			
Broth	15 d.	Bellelli	1928
Brucella suis			
Aerated broth cult. with dextrose & ascorbic acid. 20-25 C.	2 mos.	Elberg	1947
Brucella, species			
Soln. buffered to pH 7.2	4-5 wks.	Zobell	1932
SOLID			
Brucella melitensis			
Nutrient gel, 22 C.	No change 8 d.	Ransome	1901
GENERAL			
Brucella abortus			
Incub. 30 d. @ 37 D.	Smooth replaced by Smooth X at end of 30 d.	Goodlow	1951
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.		Hutton	1951
2-5 C.	Innoc. 25 b/cc. Recov. 20.2 b/cc, 100 d.	Verwey	1950
Optimum pH 7-7.4		Zobell	1932
Brucella melitensis			
Stored 37 C.	17.3% survival 4 yrs.	Stamp	1947
Brucella, species			
Sunlight and drying	Lowers incidence of disease	Polding	1947

TABLE C6 THE SURVIVAL OF CLOSTRIDIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference
DRIED, GENERAL		
Cl. novyi	4-5 yrs.	Proom, 1949
Cl. perfringens	3-4 yrs.	" "
Cl. septicum	3-4 yrs.	" "
Cl. spp.	4-5 yrs.	" "
DRIED, LYOPHILIZED		
Cl. botulinum		
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
LIQUID		
Cl. tetani		
Glycerine under high pressure. (13,500 atm)	20% active 45 min.	Basset 1932
Cl. botulinum		
Uninocculated dextrose broth exposed to O_2 for 1 hr.	Recov. 32-81%	Dack 1929
" pH 6.8	Recov. 0-57%	" "
Unbuffered salt soln.	Recov. 0-37%	" "
Subcult. in beef heart 100C with 4% peptone	Recov. in 1½-2½ hrs.	Sommer 1930
Above plus PO_4	Recov. in 4 hrs.	" "
Casein digest	Heat resist. 4½ hrs. Most resistant in 4-8 day cultures.	" "
10C refrig. foods	Growth only after 27 d.	Tanner 1940
5C "	No growth up to 108 d.	" "
Glucose, beef infusion broth, heated in water bath 70-73C	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
Cl. tetani		
Grown in dextrose bouillon 3 mos.	Viable 2⅔ mos.	Wesbrook 1896
SOLID		
Cl. tetani		
Sealed agar tubes	38 yrs.	Boventer 1947
Agar, 37C	20-25 d.	San Felice 1893
GENERAL		
Cl. botulinum		
>5F	140 d.	Campbell 1932
100C, moist, 5 hrs., pH 6.8-7.0	Spores destroyed	Tanner 1923
105C, " 2 " "	" "	" "

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., "	"	"	
	Young spores more resis.		
16 C.	14 mos.	"	1931
" in fruits and veg.	>2 yrs.	"	
Direct sunlight, cotton plugged tubes	24-40 h.	Thom	1919
Diffuse light, "	2mos.	"	
100 C.	1 h.	"	
100 C. pH 7.5	Killed 5 h.	Weiss	1921
105 C. "	40 min.	"	
120 C. "	6 min.	"	
	Decrease in thermal resistance as spores age. H ion decreases resistance of spores to heat.		
Cl. fragilis			
37 C.	24-30 h.	Repaci	1910
Regrig.	1 mo	"	
Cl. moniliformis			
37 C.	4 wks.	"	
R.T.	2⅓ mos.	"	
Cl. perfringens			
37 C.	3 d.	"	
Refrig.	1 mo.	"	
Cl. tethoide			
37 C.	6 d.	"	
R.T.	6 wks.	"	

TABLE 67 THE SURVIVAL OF CORYNEBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
C. diphtheria			
Dried	4-5 yrs	Proom	1949
C. Magnusson-Holth			
Dried, dark	6 wks.	Ottosen	1945
Daylight	2-4 wks.	"	
C. pyogenes	4-5 yrs.	Proom	1949
C. spp.			
Dried	4-5 yrs.	"	
LIQUID			
C. diphtheria			
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.	Kasansky	1899
Bouillon susp. from diph. memb., R.T.	Innoc. 100,000 col., recov. 6, 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 7d	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. 0, 5 min.	Philibert	1926
Pure culture swabs, dark	60 d. Pathogenic 40 h. following isolation. Pathogenic 50 hrs. following dessic. with light.	Schofield	1916
Liquid air in glass	Recov. 35% in 2 hrs.	White	1901
C. Magnusson-Holth			
.5% formaldehyde	Killed in 3 h.	Ottosen	1945
C. pyogenes			
Pure culture	30 d.	Kirstein,	1902

TABLE (?) The SURVIVAL OF CORYNEBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference	
SOLID			
C. diphtheria			
Gelatine	18 mos. still alive	Abel	1893
Gelatine in dark	331 d.	"	
Agar cult.	7 mos.	"	
Agar cult in dark, R.T.	Still viable 171-172 d.	"	
Loefflers, -23.5 C., old cult., 24 d.	Viable 86 d.	Abel	1895
Loefflers, 23.5 C., old cult. 24 d.	Viable 86 d.	"	
"	Str. 2, no growth 86 d.	"	
"	Str. 3, 2 colonies viable 86 d.	"	
Glycerine agar tubes 37 C., ozonized air aspirated thru tube	No change at end of 8d.	Ransome	190
GENERAL			
C. diphtheria			
Incubator, dried, R.T.	7 mos.	Abel	1893
ERYSIPELOTHRIX RHUSIOPATHIAE			
DRIED			
Dried	4-5 yrs.	Proom	1949
Stored at 37 C.	2.6% survived 4 yrs.	Stamp	1947

TABLE C 8 THE SURVIVAL OF DIPLOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
D. pneumoniae			
Dried and formalized with modified gastric mucin	9 weeks, agglutinated 4 weeks, capsules disintegrated	Bourn	1947
Dried	7-8 yrs.	Lal Kalra	1948
38 C.	6-8 yrs.	Patella	1932
Loss than 17 C.	4-5 yrs.	Proom	1949
DRIED, LYOPHILIZED			
D. pneumoniae			
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
LIQUID			
D. pneumoniae			
Broth, saliva or 0.5% saline susp. RH 50%	high mortality	Dunklin	1948
Physiol. saline, R.T., abs. drying in vacuo.	Innoc. on blodd 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, ico box, hermetically sealed	several mos.	Yourevitch	1930
SOLID			
D. pneumoniae			
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
GENERAL			
D. pneumoniae			
37 C.	> 132 d.	Lal	1931
Change in pH from 7.80 to 4.47 from 13 h. to 1h.	Progressive increase in death rate	Lord	1932
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
DRIED, GENERAL		
Dried in desiccator	>10 d.	McManus 1910
Dried	4 1/2 yrs.	[illegible] 1[illegible]
Vacuum dried, 295 C.	4 d.	[illegible] 1912
Air dried, dark	4 d	"
DRIED, LYOPHIL		
Susp. in broth, -185 C.	Innoc. 180,000,000	Rivers, T. 1927
Frozen and thawed 22 times	Recov. 40 000	
LIQUID		
Saline susp. 6-11 C., RH 70-85%, CO_2 5-4%	[illegible]	Arai 1931
1% glucose or lactose in 1/2% Witte peptone + 1/2% di potassium in dist. water	Innoc. 100,000,000 after 24 hrs, recov 0.5 d.	Burling 1918
Dextrose bouillon. Freezing vacuum dessic., freeze 47 h. Culture age 48 hrs.	3 by d.	" 1[illegible]
Above with culture age 24 h. freezing 24 h	57 d.	"
Bouillon culture 5 C	Innoc. 2,200,000,000/cc. Recov. 190,000,000/cc in 62h.	Bolberg 1932
	Innoc. 15,000,000/cc Recov. 1500/cc, 1 3/4 h	
	Innoc. 14,500,000/cc Recov. 7,000/cc, 2 1/4 h.	
Glucose soln -6 C.	90% dead	Hilliard 1918
Glucose, tap water, 10 C	4 hrs.	"
Glucose soln -0.5 C	3 Hrs.	"
" -2.5 C	3 Hrs	"
" 6 C	3 hrs.	"
	Rapid destruction of 90% or more when frozen in tap water for 3 hrs.	
M/15 PO_4 buffer 2 C., irrad. O_2 tension lowered	Showed 1/3 sensitivity when oxygen tension lowered by saturating with N_2 or CO_2. Protect. given by adding glucose or addition of cysteine	Hollaender 1951
Sterile buffer soln 15.5 C.	KI 80%, 10 min.	Horwood 1950
"	80%, 15 min.	"
With ultra sonicator	99%, 40 min	"
1% agar soln., 4-8 C.	6 h.	Jolle 1895
2% " " "	4 h.	"
9% " " 28 & 30 C.	30 min	"
6% " " "	3 h.	"
3% " " "	6 h.	"
1% " " "	24 h	"

TABLE 69 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
LIQUID (Cont.)		
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 in 6	"
	+ 12 min	
.85% NaCl, -252 C	3 h	Kadisch 1931
NaCl soln	Still recoverable 6 wks	Karaffa 1912
5-42% C.P. glycerine, 20 C	Large % alive 6 mos.	Keith, 19..3
susp. in water		
Cultures, R.T., dark in	358 d.	MacConkey 1905
Inverted Pastoms dish		
-185 C Liquid air	No impired vitality 20%	MacFayden 1899
Broth emulsion with star		
milk, liquid air	No impaired vitality 7 d	MacFayden 1900
Quill tubes, liquid air		"
Liquid H_2, -252 C, s. [illegible]	10 h	"
Lactose peptone water	5-16 d	Oshii 1920
Serum, 37 C.	30 d	Panisset 1925
Sensit with met. violet	Recov. 0, 2 h	Philibert 1926
Saline, -78 C, Freeze in	21.2%	Proom 1949
CO2 ice.		
Broth " " "	52%	"
Broth, R.T.	43.3%	"
Saline, -78 C.	64.6 %	"
Ringers soln, pH 2	Recov 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	"
CaCl2 soln 1.45 M, pH 2	" 0% 4 H.	"
" pH 6	" "	"
" " 8	" "	"
" "11	" "	"
Balanced salt soln may be distinctly favorable to bact viab in water at optimum react while distinctly unfav in slightly more alk soln. Acid soln kills rapidly. Neutral pH favors 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, 1931
$CaCl_2$ soln	Buffering capac. partial abolished in all solns which were non toxic at favorable pH.	"
NaCl and $CaCl_2$	Showed no material inc. in buffering capac over that of the soln cont $CaCl_2$ alone	"
NaCl soln	Still recoverable 6 wks	Stadler 19[illegible]
Broth, 13 to 15 C	Recov 1% 8 wks	Tanner 19[illegible]
Salt soln "	" 1% 12 16 wks	"
10% sucrose susp, 195 C	Inoc 6,000,000/ml 48.6% reduct, $2\frac{1}{2}$ h.	Weiser 1946
" denitrified "	Inoc 6,000,000/ml 50 1% reduct, $2\frac{1}{2}$ h	"
" crystallized "	Inoc 10,000,000/ml 3[illegible].0% reduct 2 h.	"
Peptone buffer mix 195 C pH 7.0, susp 20 h cult	Death slow and difficult to detect, 10 h	Weiser, 1945
Broth, before centrifug	100% survival	Winslow 1927
" after "	70% "	"
" 1 h after "	10% "	"
Broth cult mixed with sea sand, 69 C, RH 90%	8 h	Winslow 1911
Above with RH 72%	10 h	"
Above, temp 70C, RH 60%	7 h	"
Above, temp. 69C, RH 90%	8 h	"

TABLE C 4 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference	
SOLID			
Raw milk on 1% lactose agar & added to litmus milk, incub. 15 d. @ 20 C.	Fermentation time lengthened	Allen	1923
Agar & gelatin plates, exposed to sunlight Nov.	1½ H. (March, July, Aug) 2½ h (Nov.) 4½ h. (Winter)	Dieudonné	1894
Salt media	91 d.	Frank	1940
Nutrient agar. R.T. stored in dark	Many viable cells 1¼ yrs	Sears	1946
Agar exposed to U.V. 30 min.	Acquired slight germicidal power	Tanner	1935
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	1916
CaCl, 0.00145 M	Recov. 152% 24 h	Winslow	1923
NaCl 0.0145 M	Innoc. 100%. Recov 140% 24 h	"	
Gelatin 20 C., 1% acid add to phenolphthalein	11 mos.	Worth	1919
GENERAL			
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 Temp	Innoc. 1,467,000, Recov. 120,000, 38 hrs.	Elliker	1938
" 58 C.	Innoc. 1,674,000, Recov. 570,000, 37 h.	"	
" 50.5 C.	Innoc. 1,510,000, Recov. 407,000, 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. (1½-3 yrs. old) 10C following pasteurization 45 C	95% reduction in 1 h. due to temp. change	Hegarty	1940
Susp. E. coli, hem. strep., & acid fast saprophytes heated various lengths of time. Inc. in counts greatest in plates heated longest. Greatest inc. in E. coli and strep. in 48 h.		Isaacs	1930
Grown in culture	1,562 d.	Lal,	1925
Desiccated	Death proceeds logarythmically	Heller	1941
In fluid state	Viable for longer periods than when dessic.	"	

TABLE C 4 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference	
GENERAL			
Dist. water, saline, salicin, tryptophane, glucose, xylose, sucrose	% reduction in dessic. microorganisms changes from 83.8% to 8.0% in 1 d. With similar cpds. in fluid control, the % reduct. changed from 33% to 6.0%	Heller	1941
Variation of resistance in relation to age of cult.	Ratio drops in 2 hrs. then climbs and reaches maximum of 1 at 8 hrs.	Regnier	1938
60 C.	30 min.	Ruska	1941
100 C., broth, dist. water, dried on collodion film.	Viable 1 h.	Ruska	"
62 C., watery medium	1 h.	"	
5-7 C.	24 h.	"	
Liquid air, -183 C.	-	"	
-78 C., thawed 20 times	Did not lose activity	Sanderson	1925
45 C., changes suddenly to 10 C.	95% reduction, 1 h. Not affected when changes in temp. take place gradually	Sherman	1934
Young cells, 1 C.	Inoc. 8,600,000, Recov. 0, 42 d.	"	1942
Mature cells, 1 C.	Inoc. 650,000,000, Recov. 10,400,000, >62 d.	"	
Stored at 37 C.	12% survive 4 yrs.	Stamp	1947
8 C. rise in temp. at a given conc. NaOH	K inc. by 35-109%	Watkins	1932
Double conc. of NaOH	Increases K 10 times	"	
Lime treatment, pH 9-9.5	>540 min.	Wattle	1943
" " " 9.5-10.0	>600 "	"	
" " " 10.0-10.5	>600 min.	"	
" " " 10.5-11	>600 "	"	
" " " 11-11.5	>300 "	"	
Rate of storage death at the higher freezing temp. is very rapid & is much greater at the temps. above -30 C. than -30 C. & 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. & -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.			

TABLE C 4 THE SURVIVAL OF ESCHERICHIA COLI IN CULTURE

Factor(s)	Survival	Reference
GENERAL		
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/0 THE SURVIVAL OF MICROORGANISMS IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
Alcaligenes, spp.			
Dried	4-5 yrs.	Proom	1949
Aerobacter, spp.			
Dried	4-5 yrs.	"	
Hemophilus			
Dried (spp.)	4-5 yrs.	"	
" (pertussis)	"	"	
Klebsiella			
Drying	months	Loewenberg	1874
Dried	4-5 yrs.	Proom	1949
Lactobacillus			
Dried (spp.)	3-4 yrs.	Proom	1949
" 30-37 C. (bulgaricus)	Became inactive in short time	Rogers	1914
Proteus spp			
Dried	4-5 yrs.	Proom	1949
Pseudomonas			
Dried(spp)	4-5 yrs.	"	
Dried in vacuo(pyocyaneus)	Still alive 4 mos.	Shattock	1911
DRIED, LYOPHILIZED			
Lactobacillus bulgaricus			
10 cc. milk. Freeze dry in vacuo, 3-4 hrs.	90-110%	Rogers	1914
Pseudomonas aeruginosa			
Frozen, -24 C., thawed repeatedly at 25 C.	35.6% mortality 1st freezing.	Stille	1943
LIQUID			
Aerobacter aerogenes			
Peptone and water susp. spray dried	Recov. 1%	Bullock	1947
Freeze dried, peptone & water susp.	Recov 10%	"	
Flavobacterium spp.			
5 to 15 F.	Recov. 0, 77 d.	Campbell	1932
Hemophilus influenza			
Blood broth, 15 C.	2½ h.	Onorato	1902
" " 20 C.	1½ h.	"	
Klebsiella			
Serum, 37 C.(Friedlanders)	43 d.	Panisset	1925
Lactobacillus			
Broth emulsion with unster. milk, liquid air, (acidophilus)	7 d.	MacFayden	1900
Liquid H_2, -252 C.	10 h.	"	
NaCl susp., -10 to -80 C. (acidophilus)	Undiminished count	Mejlbo	1941
.85% NaCl (acidophilus)	Decreased little in 3 d.	Zeug	1920
Milk & lactose, 40-43 C. (bulgaricus)	Innoc. 1 X 10^9/ml. Recov. 100 X 10^9/gm.	Rogers	1914

TABLE C1/0 THE SURVIVAL OF MICROORGANISMS IN CULTURE

Factor(s)	Survival	Reference	
LIQUID			
Lactobacillus casei			
Nutrient broth	Rapid freezing caused less injury than slow freezing	Lund	-
Proteus vulgaris			
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_2, -252 C.	10 h.	"	
Pseudomonas pyocyaneus			
24 h. peptone water cult., vacuum dried	7 mos. & 7 d.	Shattock	1912
24 h. peptone water cult., air dried	4-6 d.	"	
SOLID			
Achromobacter, spp.			
Nutrient agar, 0 C.	Rapid growth, 5 d.	Haines	1934
Aerobacter spp.			
24 h. agar cult. in dist. water on filter paper in dry incubator, 37 C.	Alive 31 d.	Hastings	-
Above with milk cult.	Alive 96 d.	"	
Dry corn starch, R.T.	3½ yrs.	"	
Azotobacter chroococcum			
Dextrine agar, dried	10 yrs.	Omeliansky	1926
Hemophilus pertussis			
Agar, 20 C.	8 mos.	Worth	1919
Lactobacillus bulgaricus	>657 d.	Lal	1921
Malleomyces mallei			
Glycerine agar tubes, 37 C. ozonized air aspir. thru tubes.	No change at end of 10 d.	Ransome	1901
Proteus vulgaris			
Agar, 10% sterile cane sugar soln., -10 C.	8 mos.	Keith	1913
Pseudomonas			
Agar, covered with 10T sterile cane sugar, -10 C. (fluorescens)	8 mos.	"	
Agar, full radiation of Hg. arc. (pyocyaneus)	1 h. at 5 cm. 15 min. at 8 cm.	Fazzoni	1914
Nutrient agar, 0 C. (spp.)	Rapid growth, 5 d.	Haines	1934
GENERAL			
Aerobacter aerogenes			
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.	"	
Erwinia amylonora			
Exudate, 16 C., RH 0-45%	22 d.	Rosen	1938

TABLE C 10 THE SURVIVAL OF MICROORGANISMS IN CULTURE

Factor(s)	Survival	Reference	
GENERAL			
Erwinia			
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
Hemophilus influenza			
Blood agar slope, 37 C.	>132 d.	Lal	1921
Physiol. NaCl soln., R.T. sealed tubes. Absolute drying over sulfuric acid in vacuo	Viable for mos.	Otten	1930
Klebsiella			
Stock lab. cult., R.T., sealed tubes.	12-13 yrs.	Ahuja	1935
Malleomyces mallei			
Vacuum, 1-4 C.	25 mos.	Velu	1942
Proteus spp.			
Stock lab. cult., R.T. sealed.	19 yrs.	Ahuja	1935
14-30 C.	103 d.	Hilliard	1918
(P. morgagnii)	1,562 d.	Lal	1925
None given	"	"	
Pseudomonas			
(Aeruginosa) Freezing 50 h. cult. age 24 h.	17 d.	Hammer	1911
(Pyocyaneous) Excluded from light	3 mos.	Shattock	1911
Excess lime, pH 9.5-10	>420 min.	Wattle	1943
" " " 10-10.5	>300 min.	"	
" " " 10.5-11	>240 min.	"	
" " " 11-11.5	>120 min.	"	

TABLE C // THE SURVIVAL OF MICROORGANISMS IN CULTURE (GENERAL)

Factor(s)	Survival	Reference
LIQUID		
Broth or dist. water, -16C.	Shorter than in sea water.	Hess 1934
-185 C.	No impairment of vitality, 20 h.	MacFayden 1899
Horse serum, vacuum over phosphorus pentoxide.	83% viable 14 yrs.	Rhodes 1950
SOLID		
Nutrient agar, 22 C., pH 7.2	103 colonies	Brown 1930
Nutrient agar slants, 37 C. or 30 C. with 572-25,320 R. X-ray.	Order of decreasing resistance: Staph. aureus, E. coli, A. aerogenes, S. marcescens, P. aeruginosa, P. fluorescens.	Fram 1950
Greatest in resistance observed with readily absorbed cations.		Harris 1949
Petroff medium, bottles evacuated, left in ice box.	11 mos. (acid fast)	Harris 1933
GENERAL		
Spring temp	< 40 d.	Duclaux 1885
Summer temp.	< 20 d.	"
Dried organisms more resistant to high temp.		Flosdorf 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.		Imshenetskii 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_2. 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 011 THE SURVIVAL OF MICROORGANISMS IN CULTURE (GENERAL)

Factor(s)	Survival	Reference	
GENERAL			
23 cultures enteric bacteria preserved on nutrient agar. unchanged 11-37 yrs.	from suspected food Original character	Pergola	1950
Death during storage is a function of storage temp. Moisture presence most important factor contributing to loss of viability. Presence of O_2 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 slants held at 16 F. for 1	3 yrs. at 15 F. Agar yr.	Smart	1935
7-10 C. below optimal temp.	Maximum tolerance observed.	Van Eseltine	1949
High temp. resulted in spores phosphate	of increasing resistance in peptone water with added salts of magnesium	Williams	1929
Sodium favors viability but Calcium opposite effect of Pb & Hg, though toxic, stimulate viability in high dilution.	toxic in high conc. sodium in low conc.	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	
DRIED, GENERAL			
M. tuberculosis			
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
LIQUID			
M. tuberculosis			
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 coln. 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/2 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference	
LIQUID, CONT.			
M. tuberculosis			
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 multiplicat. in culture & produced TB in animals	"	
Stored daily for 21 hrs. in CO_2 bath	All animals showed TB in spleen following infection	"	
Culture stored 6 yrs.	Inj. into rabbits (4cc) All died 3-4 wks.	"	
-3 C. in PO_4 soln.	[illegible] show any effect [illegible] wk. old chidks. Lost pathogen. after 1h. R.T.	"	
200 X alternate freezing in liquid N_2(-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 retain	"	
Glycerine agar cult. 38 C. glass sealed, incub. (bovine)	Loss of infect., 2 mos.	Potter	1942
Hohn, Lowenstein, Petragnani deprived of O_2, stored in dark. 2-5 wks. (human)	Non-viable 1 mo.	"	
.85% NaCl	800 d. does not infect guinea pig	Pugrani	1929
Glycerine agar tubes with ozonized air, 37 C.	No change in 10 D.	Ransome	1901

TABLE C/2 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference	
LIQUID, CONT.			
M. tuberculosis			
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
SOLID			
M. tuberculosis			
Glycerol agar, 37.5 C.	4-8 mos. (max. 16 mos)	Cooper	1923
Glycerol "	Dead in 6 yrs (*M. phlei* dead in 4 yrs)	Gloyne	1920
Petroffs medium in bottle evac., left in ice box 11 mos.	(Human) 11 mos.	Harris	1933
	(Bovine) 11 mos.	"	
	(Avian) 11 mos.	"	
Agar, pH 6.6	Grew well	Isaacs	1930
	Heating decreases # of survivors able to grow during lag phase. Unless 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.	"	
GENERAL			
M. tuberculosis			
40-50 F.	7-19 mos. Bovine more resistant than human	Cooper	1923
37 C. incub. in glycerol broth	12 yrs, 42% human viab.		
	" 44% bovine viab.	"	
-9.4 to -19.9 C.	Viable 1st 24 h.	Homma	1927
-1.0 to -8.0 C.	Viable 2nd 24 h.	"	
-7.0 to -14.3 C.	Viable 3rd 24 h.	"	
-17.3 to -29.2 C.	Viable 4th 24 h.	"	
-10.6 to -23.9 C.	" 5th "	"	
-13.4 to -26 C.	" 1st 24 h.	"	
-11.5 to -24.3 C.	" 2nd 24 h.	"	
-8.7 to -17.4 C.	" 3rd 24 h.	"	
Below 0 C.	623.5 h.	"	
Above 0 C.	216.5 h	"	
Mixed with quinine	Requires 25 min. exp. to U.V.	Mayer	1924
Deprived of O_2 and H_2O for 24 hos.	Survive as viable pathogens	Potter	1935
Dark, no O_2 R.T., Dessic.	(Str. P4) 2 yrs	Potter	1937
Dark, 37C., H_2 Dessic.	(Str. P7) 1 yr	"	

TABLE 6/2 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN CULTURE

Factor(s)	Survival	Reference	
GENERAL, CONT.			
M. tuberculosis			
Deprival of O_2 kills tubercle bacilli. Rapid dessication favors survival. Avian bacilli at body temp. survive for more than 1 yr. with only trace of O_2 and H_2O 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.	Snope	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
BCG, DRIED, LYOPHILIZED			
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 Deinse	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.	"	
BCG, LIQUID			
Lowensteins egg medium, 1:10 dil., 2-4 C.	2 yrs.	Birkhaug	1951

TABLE C 13 THE SURVIVAL OF NEISSERIA SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
N. intracellularis			
Dried on garnets and glass in dark	24 h.	Flugge	1905
Diffuse daylight	10 h.	"	
Dark	25 h.	"	
Dried	4-5 yrs.	Proom	1949
N. gonorrhea			
Dried	4-5 yrs.	"	
N. species			
Dried	4-5 yrs.	"	
Drying	Little resistance	Rhodes	1950
DRIED, LYOPHILIZED			
N. intracellularis			
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, [illegible], >89, >41 d.	"	
2cc broth	>2 mos.	Swift	1921
N. gohorrhea			
Dried in frozen state	18 yrs.	Elser	1935
LIQUID			
N. intracellularis			
Bouillon, diffuse light, dried, ascitic agar, 37C.	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.	Ungerman	1918

TABLE C 13 THE SURVIVAL OF NEISSERIA SPECIES IN CULTURE

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

TABLE C /3 THE SURVIVAL OF NEISSERIA SPECIES IN CULTURE

Factor(s)	Survival	Reference	
SOLID, CONT.			
N. intracellularis			
Glucose agar slant, -15C.	No loss of viab. 8 mos.	Pabst	1935
Gelatin 37 C., 1% acid added to phenolphthalein	>7 mos.	Worth	1919
N. gonorrheae			
Gelatin 37 C., 1% acid added to phenolphthalein	>8 mos.	"	
GENERAL			
N. intracellularis			
Various nutritive substances alter the survival period		Foa	1887
37 C.	> 86 d.	Lal	1921
Survival shortened at 37 C. and prolonged in ice box, 6-10 C.		Miller	1944
-	4 d.	Murray	1929
-5 C.	5 d	Pabst	1935
Icebox, 0-5 C.	48 h.	Von Albrecht	
" 65 C.	½ h.	"	1901
" 80 C.	Few min.	"	
" 100 C.	Immediate	"	
Stoppered with gutta percha, 19-21 C.	4-5 d.	"	
Dried and stoppered with gutta percha, incub. temp.	185 d.	"	
N. gohorrheae			
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/4 THE SURVIVAL OF PASTEURELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference
DRIED, GENERAL		
Pasteurella pestis		
37 C.	Most dead in 3 d.	Gladin 1898
Bubo juice, R.T., exposed to sun, dried.	3-4 h.	Kitasato 1894
Bubo juice, R.T., dried on coverslip	< 4 d.	"
Dried	Viable 2 h	Tinker 1930
P. tularensis		
Susp. in mixt. of beef infusion, cystine & rabbit blood, dried, sealed	4 yrs.	Miller 1946
P. species		
Dried	4-5 yrs.	Proom 1949
LIQUID		
P. multocida		
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
P. pestis		
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.	5⅔ 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 Hammorek 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 44 THE SURVIVAL OF PASTEURELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference	
SOLID			
P. pestis			
Gelatine, 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., innoc. 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.	5½ hrs.	"	
Agar cult., -1.8 C.	1st subcult. still viable 4 mos.	Kasansky	1899
" - 31 C.	2nd and 3rd subcult. 5-5½ hrs.	"	
GENERAL			
P. pestis			
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
P. pleurisepticus			
Physiol. NaCl, R.T., abs. dried over H_2SO_4 in vacuo.	Viable for months.	Otten	1930
P. pseudotuberculosis			
Sealed and viable.	Viable for a number of yrs.	Merlin	1938
P. species			
Physiol. NaCl, R.T., Abs. dried over H_2SO_4 in vacuo.	Innoc. into blood or serum, viable mos.	Otten	1930
P. tularensis			
Eggs, freezing	Recov. 1%, 3 mos.	Downs,	1947
Factors leading to population changes. 1) Type & comp. of med., 2) initial pH, 3) Inoculum size, 4) One or more factors present in old cult. filtrates		Eigelbach	1951

TABLE C 15 THE SURVIVAL OF PROTOZOA AND METAZOA IN CULTURE

Factor(s)	Survival	Reference
LIQUID		
E. histolytica		
Ringers' fluid & solid rice starch, body temp.	3 wks.	Dobell 1926
Dist. H_2O, 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.	"
Plasmodium gallinaceum		
Susp. saline extract, R.T. in washed chicken rbc.	Little loss of infectivity 72 hrs.	Whitman 1948
Trypanosoma cruzi		
N.N. medium, R.T.	>6 yr.	Packchanian 1943
Trichomona vaginalis		
R.T.	8 d.	Mohr 1937
Bact. free in serum, Ringers soln. over liver infusion agar slants, 37C.	4-6 d.	Trussell 1947
Cysteine, peptone broth, liver, maltose, R.T.	13 d.	"
SOLID		
S. mansoni		
Horse serum	14-18 d.	Ross 1950
Serum ultra filtrate	10-12 d.	"
100% N_2	5 d.	"
L. donovani		
Blood agar, R.T.	4 mos.	Packchanian 1943
T. americanum		
Blood agar, R.T.	4 mos.	"
T. avium		
Blood agar, R.T.	3 mos.	"
T. duttoni		
Blood agar, R.T.	4 mos.	"
T. lewisii		
Blood agar, R.T.	4 mos.	"
T. malophagium		
Blood agar, R.T.	4 mos.	"
T. rotatorium		
Blood agar, R.T.	4 mos.	"
T. vaginalis		
Semi-dry state	6 hrs.	Vazques-Calet 1936
GENERAL		
E. histolytica		
Powdered starch, R.T.	10 d.	Walker 1913

TABLE C 15 THE SURVIVAL OF PROTOZOA AND METAZOA IN CULTURE

Factor (s)	Survival	Reference
GENERAL, CONT.		
T. vaginalis		
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
Trypanosoma equiperdium		
-20 C.	3 1/4 hrs.	De Jong 1922
-145 C.	45 min.	"
-191 C.	31 d.	"
Trypanosoma evansi		
-20 C.	1¼ hrs.	"
-191 C.	9 min.	"
Ascaris lumbricoides		
-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 C 16 THE SURVIVAL OF RICKETTSSIAE IN CULTURE

Factor(s)	Survival	Reference
DRYING, LYOPHILIZED		
R. tsutsugamushi		
Soln. 0.2 M. sucrose plus buffer salts	Superior to skim milk medium	Jackson 1951
LIQUID		
Coxiella burneti (Dyer, nine mile and Henzerling str.)		
Saline susp. yolk sac. 60C.	30 min.	Ransom 1951
" " " 50 C.	15 min.	"
R. mooseri, & prowazeki		
Yolk sac material, -72C., .05 glutamate, pH close to 7, basal salt soln., high in K ions, .1 to 1% serum albumin.	Survival favored by these.	Bovarnick 1950
Tissue cult., in serum		
with Tyrodes, 37 % -20C	Several mos.	Nigg 1935
" " 20 % -40C	Week or two	"
R. prowazeki		
Sterile skim milk, 26-28C.	24 h.	Anderson 1944
Broth, 26-28 C.	6 h. (Breine str.)	"
20% normal yolk sac, 26-28 C.	50% mortality, 6 hrs. (Bogota epidemic Str.)	"
Tyrodes soln. 26-28 C	6h.	".
Tyrodes, G.P. serum, 26-28 C.	6 h.	"
56 C.	30 min	Rivers 1948
Blood spec 2-4 C.	1 or more h.	"
" " 37 C	few hrs.	"
Dessicated, R.T.	Few hrs.	"
G.P blood, R.T.	few hrs.	"
Carbon tet. or benzene, CS_2, 25% NH_3, ether, cresol, ethylene Cl_2, tetramine	Viable >1 h.	Schlote 1948
Physiol. saline with tap water	<7 min.	
	Affects viability deleteriously.	Topping, 1940
R. species		
Aqueous susp.	40 hrs.	Latarjet 1951
Chick embryo dil. 1/10 N. saline, 50 C.	1 wk.	Payzin 1947
Chick embryo dil. with Tyrodes & horse serum.	Not viable after 20 d.	"
Chick memb., -14 C., with carbon snow in presence of P_2O_5, sealed under H_2	13 d.	"
R. rickettsi		
Pure glycerol, -10 C.	10 mos.	Spencer 1924
Rocky Mtn. Spotted Fever		
Dessicated, R.T.	few hrs.	Rivers 1948
Guinea pig blood, R.T.	1 wk.	"

TABLE 6/6 THE SURVIVAL OF RICKETTSSIAE IN CULTURE

Factor(s)	Survival	Reference
LIQUID		
Rocky Mtn. Spotted Fever		
G.P. blood, cold room	2 wks.	Rivers 1948
G. P. blood, brain & spleen, -7 C.	1 yr.	"
Typhus		
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.	"
GENERAL		
R. burneti		
-70 C.	Long time	Rivers 1948
Infection spread by means of air borne droplets		Commen. on Resp. Dis. 1946
R. prowazeki		
Dry heat, 39 C.-41 C.	1 h	Schlote 1948
Scrub typhus		
-70 C.	long time	Rivers 1948
Typhus		
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	
DRIED, GENERAL			
S. Paratyphi			
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_2O_5 at 100-300 mm Hg. Stored in vacuo, R.T.	>4 yr. survival	"	
S. Species			
Dried	4-5 yrs.	"	
DRIED, LYOPHILIZED			
S. choleraesuis			
Broth culture	10 yrs.	Schoening	1949
LIQUID			
S. choleraesieus			
Glucose-peptone water	7 d.	Oshii	1920
S. enteriditis			1912
NaCl soln.	4⅓ wks.	Karaffa-Korbutt	
S. hiss	1,283 d.	Lal	1925
Glucose peptone water	5-7 d.	Oshii	1920
NaCl soln.	Recov. 0, 4⅓ wks.	Stadler	1899
S. morbificans			
NaCl soln.	3 wks.	Karaffa-Korbutt	1912
NaCl soln.	Recov. 0, 3 wks.	Stadler	1899
S. paratyphi A			
Tryptic digest	3,259 d.	Lal	1925
Bouillon, 63 C.	Viable 1-4 min.	Orskov	1925
Saline, 0.9%, 62 C.	< 5 min.	"	
Lactose peptone water	3-5 d.	Oshii	1920
NaCl soln, R.T., dried in vacuo	Viable mos.	Otten	1930
S. paratyphi B.			
Muttan, agar	3.259 d.	Lal	1925
Bouillon 63 C.	4 min	Orskov	1925
Lactose-peptone water	3-6 d.	Oshii	1920
NaCl soln. R.T., dried in vacuo	Viable mos.	Otten	1930
S. schottmulleri			
Broth & water, frozen	17 d.	Thomas	1925
S. species			
Bouillon cult., in glass capillaries	>1 yr.	Wesselinoff	1949
S. typhimurium			
Bouillon & beer wort, exposed to U.V. 10-15 min.	1-15 sec.	Gilles	1935
SOLID			
S. enteriditis			
transmitted by rat fleas		Eskey	1949

TABLE C/2 THE SURVIVAL OF SALMONELLA SPECIES IN CULTURE

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

TABLE C/8 THE SURVIVAL OF SALMONELLA TYPHOSA IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
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.	"	
DRIED, LYOPHILIZED			
Standardized susp., -192 C.	10 d.	Turner	-
LIQUID			
.85% NaCl, freezing	> 6 d.	Bolten	1918
Bouillon culture, continuous freezing @ -20 to -16C	Survived 4½ mos.	Brehme	1901
Watery susp. of fresh cult. placed on petri dish in sunlight.	Innoc. 100. 95-99% reduct. in 10-15 min.		
	100% reduct. ½-4 hrs.	Clark	1903
1% soap soln, 4-8 C.	12 h.	Jolles	1895
6% " " "	15 min.	"	
1% " " 18 C.	24 h.	"	
6% " " "	30 min.	"	
5% " " "	1 h.	"	
3% " " "	12 h.	"	
Bouillon susp., R.T., Fall on Petri dishes	24 h.	Kirstein	1902
Tryptic digest	3,838 d.	Lal	1925
-185 C., liquid air	No impaired vitality		
	20 h.	MacFayden	1899
Broth emulsion with liquid air.	No impaired vitality, 7 d.	MacFayden	1900
Sealed tubes, liquid air.	6 mos.	"	
Liquid H_2, -252 C.	10 h.	"	
Beef-peptone agar in sun	10 min. to 1 h.	Minck	1896
Bouillon, 63 C.	Viable 1-2 min	Orskov	1925
Lactose peptone water	3-5 d.	Oshii	1920
Thick susp., R.T., dried in vacuo over H_2SO_4	Innoc. to blood or serum agar, 2-5% survived 24-48 h.	Otten	1930
NaCl soln., R.T., dried in vacuo	Innoc. to blood or serum agar. Viable mos.	Otten	1930
Bouillon, neutral pH	82 d.	Remy	1900
Peptonized beef bouillon freezing, -17.8 C.	Recov. 1/45, 2 h.	Smith	1905
" -190 C. in liquid air.	Recov. 2/60, 2 h.	"	
Peptonized beef bouillon, frozen	99.5% killed 2 h.	"	
-17.8 C.	.5% recov. 2 h.	"	
Huntoon broth, frozen	13 d.	Thomas	1925
Susp. in agglut. immune serum	No effect on surv. time.	Tinti	1923
Emulsion 24 hr. bouillon cult. in salt soln. heated at 80 c. for 10 min.	2-8 hrs. (6X as much needed to kill spores.		
Liquid air in glass		Weinzirl	1914
	Recov 25% 2 h.	White	1901

TABLE (1 /4 THE SURVIVAL OF SALMONELLA TYPHOSA IN CULTURE

Factor(s)	Survival	Reference	
SOLID			
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
GENERAL			
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.	22wks.	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 C/9 THE SURVIVAL OF SERRATIA SPECIES IN CULTURE

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

TABLE C 20 THE SURVIVAL OF SHIGELLA SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED GENERAL			
S. spp.			
Dried	4-5 yrs.	Proom	1949
Dessicated	20-25 d.	Vaillard	1903
LIQUID			
S. dysenteriae			
Bouillon	920 d.	Lal	1921
Mutton, agar slope	1,562 d.	Lal	1925
Thick susp., dried in vacuo over H_2SO_4, 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_2.	25%	Proom	1949
Broth, -78 C.	96.5%	"	
Broth, R.T.	32.2%	"	
Saline, -78 C.	42.3%	"	
S. paradysenteriae (Flexner)			
Bouillon	>1,044	Lal	1921
Mutton, agar slope	1,562 d.	Lal	1925
S. paradysenteriae (His Y)			
Mutton, agar slope	1,562 d.	Lal	1925
S. pseudodysentery			
Physiol saline, R.T.	-	Otten	1930
S. spp.			
Alcohol, other, chloroform, 37 C.	few hrs.	Vaillard	1903
SOLID			
S. dysenteriae			
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
S. Paradysenteriae (Flexner)			
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.	"	
S. sonnei			
Crust of rye bread, R.T.	Overgrown with spores of bacillus	"	
GENERAL			
S. dysenteriae			
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
GENERAL, CONT.		
S. dysenteriae		
-	10 d.	Kister 1928
Dark, R.T.	920 d.	Lal 1925
Stored 37 C.	4.5% survived 4 yrs.	Stamp 1947
Excess lime pH 9.5-10	>300 min	Wattie 1943
" " pH 10-10.5	>300 min.	"
" " " 10.5-11	180 min.	"
" " " 11-11.5	75 min.	"
S. equuli		
Cult., R.T., pH 7.4, Stored in dark.	3-4 mos.	McCollum 1951
S. ambigua(Schmitz)		
Cult. in bouillon, strong sunlight	< 40 min.	Bamberger 1936
S. kruse		
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.	"
S. paradysenteriae(Flexner)		
Bouillon, strong sun.	<60 min.	"
R.T., dark	1,049 d.	Lal 1925

TABLE C 2 / THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference	
GENERAL			
S. albus			
Stock lab cult., sealed, R.T.	11-12 yrs.	Ahuja	1935
-	523 d.	Lal	1921
Material obtained from sputum, antrum, nose, skin, throat, urine, uterus & put in broth & adjusted with HCl and NaOH. Of 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
S. aureus			
-	524 d. (Bombay str.)	Lal	1921
"	> 692 d.	"	
Dark, R.T.	657 d.	Lal	1925
Matl. obtained from boil, abseess, 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
S. citreus			
-	523 d.	Lal	1921
S. spp.			
Dessication	30 yrs.	Fasquelle	1950
60-100 C., in broth & dist. water, dried on collodion	cell membrane separated	Ruska	1941
Very resistant to drying.		Rhodes	1950
MICROCOCCUS SPECIES			
GENERAL			
M. melitensis			
-	523 d.	Lal	1921
M. neoformans			
-	523 d.	"	
M. pyogenes			
Sensitive to .85% NaCl		Zeiss	1920
SOLID			
M. aurococcus			
Agar covered with sterile 10% cane sugar soln. & holding at 10 C.	8 mos.	Keith	1913
M. candicans			
Nutrient gel, 22 C.	No change, 8 d.	Ransome	1901
M. catarrhalis			
2 0 C.	3 mos.	Worth	1919

TABLE C 2 / THE SURVIVAL OF STAPHYLOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED. GENERAL			
S. aureus			
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.	"	
S. spp.			
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
LIQUID			
S. albus			
.85% NaCl, -252 C.	50 h.	Kadisch	1931
S. aureus			
Saline susp., 6-11 C., R.H. 70-85%, CO_2 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	$2\frac{1}{2}$-$3\frac{1}{2}$ yrs.	Belin	1933
Dextrose, bouillon cult., freezing, 48 h., vacuum dessicated	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_2, -252 C.	10 h.	"	
Physiol. NaCl soln., R.T. Dried in vacuo over H_2SO_4.	Viable for mos.	Otten	1930
Serum, 37 C.	Up to 11 d.	Panisset	1925
Met. violet	Recov. 0, 1 min.	Philibert	1926
Saline, -78 C., Freeze in CO_2 ice.	100%	Proom	1949
Broth, freeze in CO_2	100%	"	
37 C.	Viable 2 yrs.	Rhodes	1950
SOLID			
S. spp.			
Nutrient agar, below 10C.	No growth	Haines	1934

TABLE 122 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, GENERAL			
S. species			
Dried	7 yrs.	Lal	1948
Dried	4-5 yrs.	Iroom	1949
Dried	2/3 of original, 97 d.	Stark	1931
DRIED, LYOPHILIZED			
S. hemolyticus			
Dried 12 h.	51 mos.	Swift	1921
Frozen and dried	many yrs.	Swift	1937
LIQUID			
S. hemolyticus			
Citrate, gelatin, R.T.,	>3 d.	Meleney	1924
Lockes gelatin, 37 C.	>12 h.	"	
Bacteria indifferent to osmotic pressure. Bivalent & univalent salts antagonize each other at certain levels		"	
Susp. in broth or saliva in dry air.	Highly suscept. to triethylene glycol vapor after 5 h. dessicat.	Robertson	1951
" " " low R.H.	Slower rate of killing	"	
Veal infusion broth, 22C	at least 60 d. (alpha)	Surgalla	[illegible]
" " " 37 C	At least 30 d. "	"	
S. spp.			
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	Rhoads	1929
S. salivarius			
Serum broth, 17 C., RH 77% Ozone .6-.4PPM	> 99% killed	Elford	1942
GENERAL			
S. agalactise			
"	mos.	Watts	1941
RH 0	3 yrs.		
RH 75%	8 wks.	"	1945
RH 55%	26 wks.	"	
RH 25 %	156 wks.	"	
RH 10%	156 wks.	"	
S. aureus			
Stored at 37 C.	-	Stamp	1947
S. fecalis			
Stock lab. cult., sealed test tube, R.T.	11-12 yrs.	Ahuja	1935
S. hemolyticus			
Capillary tubes, -17 to -18C.	2 wks.	Citovicz	1928

TABLE C 22 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN CULTURE

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

TABLE (23 THE SURVIVAL OF TREPONEMA SPECIES IN CULTURE

Factor(s)	Survival	Reference
DRIED, GENERAL		
T. pallidum		
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.	"
DRIED, LYOPHILIZED		
T. pallidum		
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.	"
T. pertenue		
Rabbit testes in infusion broth, -78 C.	3 yrs.	Turner 1939
-78 C.	1 yr.	"
LIQUID		
T. hispanicum		
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
T. pallidum		
Saline susp. 45 C.	Killed 7-10 min.	Bronfenbrenner 1913
10% rabbit serum, -10 C.	> 15 d.	Kindle 1934
½ inactive dog serum, ½ physiol salt soln., 20.4-3.65 abs.	4 h.	Jahnel 1938
Above at 1.7 abs.	2½ h.	"
Serum exudate from chancre R. T.	121 d.	Lacy 1921
Saline susp. rabbit testes, R.T.	58 d.	"
Brewers fluid, thioglycollate below 37 C. incub. with rabbit testes	Improved survival	Nelson 1948
Expos. to 5% CO_2 with isotonic PO_4 buffer, pH 7.0	Prolonged survival	"

TABLE C23 THE SURVIVAL OF TREPONEMA SPECIES IN CULTURE

Factor(s)	Survival	Reference	
LIQUID, CONT.			
T. pallidum			
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
SOLID			
T. spp.			
Deep tubes of agar anaerobically under paraffin oil at R.T. and 37 C. in dark was not satisfactory.		Rosebury	1950
GENERAL			
T. pallidum			
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_4 buffer, glutathione, cysteine, vitamins & $NaHCO_3$, 30 C., under 5% CO_2-95% N_2	8-10 d.	Nelson	1948
Culture of rabbit testes	10 d.	Perry	1948
Stored in solid CO_2	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.	"	
T. pertenue			
60 C.	15 min.	Marchoux	1938
37 C.	2 h.	Miyao	1930
0 C.	< 15 min.	"	
T. spp.			
Temp ranging from that of liquid O_2 to that of liquid He	Survived	Luyet	1938

TABLE C 2 4 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

Factor(s)	Survival	Reference
DRIED, GENERAL		
V. comma		
Peptone, water cult. dried in vacuo over P_2O_5. R.T. Sealed glass tubes.	4 yrs.	Campbell-Renton 1942
(Schillong 653)	Orig. count, 9×10^6 After 4 yrs., 240	"
(Rangoon R)	Orig. count, 6×10^6 After 4 yrs., 50	"
(Schillong 1077)	Orig. count, 9×10^6 After 4 yrs., 50	
(Schillong 610 R)	Orig. count, 125×10^7 After 4 yrs., 0	"
Dried	4-5 yrs.	Proom 1949
V. foetus		
Dried	3-4 yrs.	"
LIQUID		
V. comma		
Sterile sat. soln. $NaCl$ in water	< 1 d.	Arguelles 1927
Fish extract, sterile	125 d.	"
Bouillon cult. with	57 d.	Brehme 1901
Cont. freeze -10 to -16C.		
Bouillon, -8 to -18 C.	Perished in 5 d.	"
Peptone, water dult., R.T. Dried in vacuo, sealed tubes over P_2O_5	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 $Ca(NO_3)_2$	Normal forms.	"
0.3 gms NaCl & 0.1 g. $Ca(NO_3)_2$.	Invol. & Normal forms.	"
Meat infusion	4-5 wks.	Hesse 1889
Ham broth	4-5 wks.	"
Bouillon susp. R.T.,	10 h.	Kirstein 1902
Bouillon cult.,106 D. old. 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	
LIQUID			
V. comma			
-	>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 unster. milk, liquid air.	No " " 7 d.	"	
Liquid H_2, -252 C.	10 h.	"	
Thick susp. R.T., dried in vacuo over H_2SO_4	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 dult., 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. Recov. 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, Recov 0, 1 mo.	"	
Bouillon, -60 C.	Innoc. 40,000/cc, Recov. 0, 40 d.	"	
1to 25% saline	Survived 3 d.	"	
20% NaCl, -70 C.	Innoc. 390,000/cc, Recov. 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.	"	
SOLID			
V. comma			
10 cc. agar, 38 C., 0.46 gm. NaCl	Many involu. forms.	Eisler	1909

TABLE 127 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

Factor(s)	Survival	Reference	
SOLID, CONT.			
V. comma			
10 cc. agar, 38 C., plus			
.46 gm. NaCl & .05 $Ca(NO_3)_2$	Dispersed invol. forms.	Eisler	1909
.4 gm. NaCl & .1 Gm. $Ca(NO_3)_2$	Normal	"	
0.1 gm. LiCl	Many invol. forms.	"	
0.1 g. LiCl & .05 g. $Ca(NO_3)_2$	Many normal, some invol.	"	
.05 g. $Mg(NO_3)_2$	Invol. & normal	"	
.05 g. $Mg(NO_3)_2$ & 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 incubator.			
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 incubl			
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 2 4 THE SURVIVAL OF VIBRIO SPECIES IN CULTURE

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

TABLE (225) THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference
DRIED, GENERAL		
Allantoid		
Dried & ppt. at 4 C.	6 mo..	Fasquelle 1950
Aphteuse		
Dried & left at 37 C.	2 yrs.	"
Herpes febrilis		
Ice box dried in vacuum over H_2SO_4 with reduced press., -5 C., Recov. in Lockes soln.	>1 yr.	Hawkins 1929
Herpetique		
Dried & left at 37 C.	2 mo.	Rasquelle 1950
Hoof & Mouth		
Dried with 0.5 g. P_2O_5 at 70 C. in vacuo	2½ hrs.	Sichert-Modrow 1930
Lymph, 122 C., dried with 0.5 g. P_2O_5 in vacuo.	3 min.	"
Dried lymph of G.P., 52 C. in atm. of P_2O_5.	Still infectious, 14 h.	"
" " " R.T.	10 d.	"
Influenza (Melbourne str.)		
Dried talc	30 min.	Parker 1944
Polio,(Aycock str.)		
Heat 30 min. at 50 C.	Remained infective	Shaughnessy 1930
" " 52.5 C.	Non-infective	"
Smallpox		
37 C., dried	80 d.	Hornibrook 1951
4-6 C., dried	24 h.	"
Tobacco mosaic		
Dessicated	many yrs.	Stakman 1942
Vaccinia (testicular str.)		
Dried, 4 C.	12-18 mos.	Noguchi 1918
Dried	229 d.	Paschen 1908
DRIED, LYOPHILIZED		
Foot & mouth		
Dried in vacuo & refrig.	93 d.	Lepine 1937
Herpes		
0.5 fresh brain emuls. with Lockes soln.	4 wks.	Rivers 1927
Influenza		
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
Laryngotracheitis (fowl)		
Lyophil. & stored 4 C.	3 yrs.	Hoffstadt 1946
Lymphogranuloma inguinale		
Infusion broth, rabbit testes, -78 C.	10 mos.	Turner 1939
Lymphocytic choriomeningitis		
Frozen, dried, 5 C.	378 d.	Wooley 1939

TABLE C 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference	
DRIED, LYOPHILIZED (cont'd)			
Meningopneumonitis			
Infusion broth, rabbit testes, -78C	3 yrs.	Turner	1939
St. Louis encephalitis			
Frozen, dried, 5C	833 d.	Wooley	1939
Vaccinia			
Frozen, dried	mos.	"	"
Lockes soln., -185C			
Frozen & thawed 22X	No reaction, rabbit skin	Rivers	1927
Lyophil apparatus appears to be useful also in maintaining the viability of virus strains without continuous animal passage. (10 mos.)		Flosdorf	1935
LIQUID			
Coxsackie			
Susp., 53-55C	30 min.	Robinson	1950
" pH 2.3-9.4	1 d.	"	"
" pH 4.8	7 d.	"	"
Enteritis			
PO_4 buffer, pH 7	<20 d.	Gallo	1948
1/1,000 dil.	Killed 75% of mice	"	"
1/10,000 dil.	" 25% " "	"	"
1/100,000 dil.	None killed	"	"
Equine encephalitis			
Acidic saline with agitation, bubbling, gases & shaking, pH 6.4	Rapidly inactivated	McLimans	1947
Foot & mouth			
GP blood 37C, citrated	4.9 d.	Brooksby	1948
" " " defibrinate	2.1 d.	"	"
M/45 buff. PO_4 soln., 0C	Inoc. dil. 1/100,000		
pH 7.6, purified	Recov. dil. 1/100, 97 d.	Galloway	1936
pH 7.6, unpurified	Inoc. dil. 1/100,000		
	Recov. dil. 1/1,000, 126 d.	"	"
Saline, 37C	24 hrs.	Lepine	1937
50% glycerine	174 d.	"	"
GP lymph., pH 7.5 in PO_4 buffer.	Still infectious, 2 yrs.		
	20 d.	Sichert-Modrow	1930
Ammonia brine, repeated freezing	Did not destroy, 124 d.	Stockman	1926
Fresh GP lymph, 2-7C	Retained virulence 190 d.	"	"
Herpes			
20% susp. of infected rabbit brain in buff. physiol. saline, 37C	100 hrs.	Boak	1940
" " " 41.5C	70-80 hrs. (Frank str.)	"	"
" " " "	30 hrs. (Go str.)	"	"
Fresh normal rabbit serum with UV radiation	10 min.	Gundersen	1932
Tissue cult., 40.2C	Did not survive	Thompson	1942

TABLE 225 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference	
LIQUID, (CONT.)			
Influenza			
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 M. oleic acid.	90 min.	"	
50% glycerine	3-4 wks.	Wilson	1919
Japanese B. encephalitis			
Mouse brain susp. with rabbit serum, -20 to -30 C.	6 mos.	Olitsky	1949
Lymphogranuloma inguinale			
Aqueous susp.	40 hrs.	Latarjet	1951
Measles			
50% glycerine	3 mos.	VanRooyen	1940
Mumps			
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.	"	
Myxoma			
Tissue cult., 42.2 C.	Did not survive	Thompson	1942
Neurotropic			
Mouse brain susp. with rabbit serum, -20 to -30C.	9 mos.	Olitsky	1949
Newcastle			
50% glycerine, R.T., pH 7.6	95 d.	Prier	1950
" " " 5C, "	353 d.	Prier	1950

Factor(s)	Survival	Reference	
LIQUID,(CONT.)			
Noguchi Str. (Vaccinia)			
Tissue cult., 45.1 C.	<4 d.	Thompson	1942
Poliomyelitis			
Glycerol	6 yrs.	Flexner	1917
Spinal cord in 50% glycerol, 4 C.	>25 mos.	"	1914
Glycerol (M.A. str.)	>11 mos.	"	
0.5% phenol	>14 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.	Viable 59 d.	Romer	1910
1st passage.	14-31 d.	"	
50% glycerol, 3rd pass.	Some mos.	Wilson	1919
50% glycerine			
Psittacosis			
Beef saline	29 d.	Rivers	1948
Rabies			
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.	Gryez	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.	"	
Streptobacillus virus			
Bouillon, 100 C., 48 h. cult., 1-100 dil. (Str. # 1776)	No growth	Bingel	1947
Vaccinia			
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	
LIQUID, CONT.			
Vaccinia			
Chorion & 1 drop calf lymph, Refrig. temp.			
(Str. 3, Breslau)	2 yrs.	Haagen	1939
(Str. 4, Dresden)	"	"	
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
Variola			
Saline soln., 35 C.	30 min.	Gordon	1925
Yellow fever			
Physiol. saline	Better than dist. water.	Bauer	1940
Aqueous susp.	10 d.	Latarjet	1951
Glycerol	8 mos.	Rivers	1948
SOLID			
Foot & mouth			
Congealed state	162 d.	Lepine	1937
Vaccinia			
Levinthal, blood agar, -13 C.	Recov. 11% after 4 yrs., 58.3% after 10 yrs.	Schartner	1939
GENERAL			
Colorado tick fever			
Ice compartment	3½ yrs.	Rivers	1948
Cow pox			
Culture, -70 C.	< 108 h.	Pictet	1884
" -130 C.	< 20 h.	"	
Dengue			
Stegomya, 22 C.	Up to 85 d.	Blanc	1929
" 16.5 C.	" "	"	
" 22.5 C.	Up to 174 d.	"	
Encephalitis			
40 C., pH 8.4 (St. Louis)	Still visble 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 8 days following blood meal	Hammon	1949

TABLE C 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference	
GENERAL			
Encephalitis			
-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.	"	
Fowl plague			
pH 6-99	Range of stability	Pyl	1938
Foot & mouth			
Guinea pig vesicle fluid, R.T.	3-6 mos.	Anonymous	-
Herpes simplex			
-70 C.	> 1 yr.	Rivers	1948
Influenza			
10% normal horse serum, shaken 24 h. (PR8 Str.)	Hold titer better than 0.2% bovine albumin	Dick	1949
10% normal monkey serum, shaken 24 h. (French neurotropic)	Hold 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)	2-3 mos.	Rivers	1948
R.T.	6 wks	Scherp	1938
0-40 C.	1 wk.	"	
Inclusion conjunctivitis			
Refrigerated	Sev. days	Rivers	1948
Looping ill			
Mouse brain, 80 C.	30 sec.	"	
" " 60 C.	2 min.	"	
" " [illegible]	10 min	"	
Lymphogranuloma [illegible]			
37 C.	2-4 d.	"	
56 C.	10 min.	"	
70 " 20 C.	> 1 yr.	"	

TABLE C 25 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference	
GENERAL			
Mumps			
-70 C.	10-mos.	Rivers	1948
Measles			
-72 to -35 C.	4 wks.	Rivers	1948
Freezing	25 hrs.	Van Rooyen	1940
Newcastle			
pH 5.5-7.5	-	Elford	1948
Incub. 37 C., undil. amniotic fluid	Viable 126 d.	Olesiuk	1951
Papilloma			
Neutral to pH 4.2	Least loss of activity.	Beard	1938
weakly alkaline	Gradual loss of activ.	"	
On acid side of pH 7 the high until at pH between suddenly. At pH 10.1 to observed. (Shope virus)	virus activity remains 2.9 & 3.3 it is lost 10.2 immediate inactiv.	Wyckoff	1937
Poliomyelitis			
More effective when suspended in low pH.	(Armstrong mouse adapted)	Hammon	1941
Infective after heating at 55-58 C.	-	Howitt	1930
Emulsion of hemoceles of flies & cockroaches	Produced paralysis in mice in 12 & 15 d. respectively.	Hurlbut	1950
<38.5 C., 2800-3100 Å	Complete destruction 1-30 min.	Jungleblut	1937
Berkefeld filter, 38 C.	7 d.	Landsteiner	1910
35 C.	2 hrs.	Leiner	1910
37 C.	21 d.	Levaditi	1913
-70 to -20 C.	No loss in infectivity 12 mos.	Melnick	1946
With E. histolytica	Settles out	Young	1949
50 C.	3 min.	Shaughnessy	1930
Pseudolymphocytic chorio meningitis			
Mouse brain, 56 C.	30 min.	Rivers	1948
Psittacosis			
Broth, 40 C.	Several wks.	Rivers	1948
-70 C.	>2 yrs.	"	
Rabies			
Fats & lipids extracted from dessicated rabies vaccine with various solvents and injected into mice fail to give protection or provoke evidence of toxic response when given subdurally or intraperitonally. 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
Rift valley fever virus			
Light, met. blue	40 min.	Rivers	1948
Rinderpest virus			
Leucocytes & spleen 4 C., Dried & ppt. with acetone.	>2 mos.	Das	1949

TABLE 125 THE SURVIVAL OF VIRUSES IN CULTURE

Factor(s)	Survival	Reference	
GENERAL, CONT.			
Rinderpest virus			
Leucocytes & spleen 40 C.	>4 mos.	Das	1949
Dried over $CaCl_2$ in vacuo.			
" " " " 37 C.	15 d.	"	
Semlike forest virus			
60 C.	1 h.	Rivers	1948
Trachoma			
Refrigerate	1 wk.	Julianelle	1942
Vaccinia			
Ottens d., light, 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_2 or CO_2, 18 C.	Destroyed virus complete.	"	
Sonic vibrations	>15 min. partial inact.	Rivers	1937
Yellow fever			
10% N. monkey serum shaken 24 h.	Held titer better than 0.2% bovine alb. dil.	Dick	1949
Dessicated, frozen	many yrs.	Rivers	1948
Cold virus filtrates,			
-76 C., dry ice	2 yrs.	Andrews	1949
-10 C.	27 d.	"	
4 C.	3 d.	"	

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

Factor(s)	Survival	Reference	
DRIED, GENERAL			
Actinomyces			
Dessicated (wentii)	>1 yr.	Wehmer	1897
" (niger)	3 yrs.	"	
" (oryzae)	>4 yrs.	"	
Dried (spp.)	405 yrs.	Proom	1949
Brewers yeast			
Dried with plaster paris	10 mos.	Pasteur	1876
Saccharomyces pastorianus			
Diffuse light	< 3 yrs.	Kayser	1889
Yeast, spp.			
More resistant in dry state than in moist.		Kayser	1889
DRIED, LYOPHILIZED			
Ascomycetes			
Culture suspended in normal horse serum, quick frozen, dried in high vacuum & sealed quickly	0.2% survival rate in 3 mos.	Atkin	1949
Saccharomyces cerevisiae			
Bouillon & beerwort, exp 10-15 min. to U.V.	More time req. for gelatinized media	Gilles	1935
Frozen at -24 C. & thawed as 25 C.	28% killed	Stille	1943
Yeasts, spp.			
Lyophillized in vacuo	1 yr.	Dopter	1949
Lyophilized	2 yrs.	Wickerham	1946
LIQUID			
Aspergillus			
Nutrient media, -6 to -11C.	4 d.	Bartetzko	1910
1% glucose, -12 C.	2 h.	"	
Epidermophytes			
.85% NaCl, -20 to -30 C.	34 d.	Kadisch	1931
Saccharomyces			
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.	"	
Yeasts, spp.			
10% sucrose	Of 25 strs., 15 retained viability 10¼ yrs., 9 dead in 8¼ yrs.	Meissner	1911
Nutrient broth & fruit juices, -23.3 C.	3 yrs.	Tanner	1934

TABLE C26 THE SURVIVAL OF YEASTS, MOLDS AND FUNGI IN CULTURE.

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

PLATE C26 THE SURVIVAL OF YEASTS, MOLDS AND FUNGI IN CULTURE

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

TABLE #	TABLE OF CONTENTS	PAGES
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F4	Escherichia coli, Paracolobactrum and Aerobacter	2
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F6	Microorganisms	2
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F12	Vibrio species	4
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	Abbreviations	1

TABLE F1 THE SURVIVAL OF BACILLUS SPECIES IN FOOD

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

TABLE F2 THE SURVIVAL OF BRUCELLA SPECIES IN FOOD

Factor(s)	Survival	Reference	
MILK			
Br. abortus			
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, 22-24	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
Br. melitensis			
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	"	"
Br. suis			
Milk, 62C, open coil pasteurizer	4 min.	Murray	1932
Milk foam in outlet, 63C	30 "	"	"
DAIRY PRODUCTS			
Br. abortus			
Butter, 8C	81-32 d.	Carpenter	1928
" 46F	142 d.	"	"
Cheese	60 d.	Daklberg	1946
Butter, 8C	Inoc:artifical;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
Br. melitensis			
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 F2 (cont'd) THE SURVIVAL OF BRUCELLA SPECIES IN FOOD

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

TABLE E3 THE SURVIVAL OF CLOSTRIDIUM SPECIES IN FOOD

Factor(s)	Survival	Reference	
DAIRY			
Cl. (spp.)			
Cheese	Most common	Fabian	1947
MEAT			
Cl. botulinum			
Cooked meat and fish	Spores present	Editorial	1926
Canned salmon, beef, sardines, clam juice, duck	" "	"	"
Cl. sporogenes			
Putrid meat, 50C	No growth in 9 d.	Haines	1944
Spore forming anaerobes			
Roast beef, canned in 1824	3 strains viable	Wilson	1938
Tripe, canned 1880	Not found	"	"
Cl. (spp.)			
Salted fish	---	T & W	1946
Cooked meat and fish	---	"	"
VEGETABLE			
Cl. tetani			
Various vegetables	Present	Dubovsky	1922
Cl. botulinum			
Home canned string beans, corn, asparagus, spinach, pinento, 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	1932
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 "	"	"
Spore forming anaerobes			
Carrots, canned 1885	Not found	Wilson	1938
Cl. (spp.)			
Cans of spinach	Inoc:800,000;50% of the org. died in 18 hr.	Koser	1921

TABLE E3 (cont'd) THE SURVIVAL OF CLOSTRIDIUM SPECIES IN FOOD

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

TABLE E4 THE SURVIVAL OF ESCHERICHIA COLI IN FOOD
ALSO PARACOLOBACTRUM & AEROBACTER

Factor(s)	Survival	Reference	
MILK			
E. coli			
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, pH4.6	24 hr.	"	"
Skim milk or cream, 20C	Well	Robinton	1945
DAIRY PRODUCTS			
E. coli			
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 acidity and prompt salting	Check growth	Palladina	1935
Butter, 14F	8 wk.	Rice	1938
" 60F	Did not mult. but survived long	"	"
EGGS			
E. coli			
Frozen eggs	Recov. 50% colonies examined 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.	"	"
MEAT			
E. coli			
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.	" "	"
VEGETABLES			
E. coli			
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
FRUITS			
E. coli			
Fruits	In 90% of samples	Maurgia	-
Fruit in cold water	Recov. 100%, few min.	Spaini	1944

TABLE E4 (CONT'D) THE SURVIVAL OF ESCHERICHIA COLI IN FOOD
ALSO PARACOLOBACTRUM & AEROBACTER

Factor(s)	Survival	Reference	
FRUITS (cont'd)			
E. coli			
Fruit in boiling water	Recov. 70%, few min.	Spaini	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.	"	"
BEVERAGES			
E. coli			
Beer	Contained many, from water to dilute beer	Buttiaux	1949
MILK			
A. aerogenes			
Milk, pH 4.2	Growth checked	Palladina	1935
" 5% NaCl, pH 4.6	24 hr.	"	"
DAIRY PRODUCTS			
A. aerogenes			
Butter, 14F	8 wk.	Rice	1938
Salted butter, 60F	Did not mult. but survived long	"	"
EGGS			
P. sp.			
Turkey and chicken egg albumin, incubated	Slight effect on bacteria	Gregory	1948
VEGETABLES			
A. aerogenes			
Cantaloupes, -4F	>1 yr.	Burton	1949
BEVERAGES			
A. sp.			
Beer	Contained 1000/ml	Buttiaux	1949

TABLE E5 THE SURVIVAL OF MICROCOCCUS SPECIES IN FOOD

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

TABLE 55 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES IN FOOD

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

TABLE E6 THE SURVIVAL OF MICROORGANISMS IN FOOD

Factor(s)	Survival	Reference	
MILK			
Corynebacterium diphtheriae			
Cream, frozen	>4 d.	Bolten	1918
Milk	Present	Trevelyan	1898
Lactobacillus casei			
Milk, -21 to -78C	Inoc. 100,000/ml., more resistant to freezing than thawing	Lund	-
Lactobacillus acidophilus			
Milk, 116C	15 min.	Morrison	1930
Rickettsia spp.			
Ster. skim milk, 26-28C	Inoc. 0.5ml. of $2x10^{-1}$ cotton rat liver, 24 hr.	Anderson	1944
Raw milk	Not given	Huebner	1948
Rickettsia			
Coxiella burneti			
Milk, R.T.	7 d.	Babudieri	1950
" 37C, air dried stored	30 d.	"	"
DAIRY PRODUCTS			
Achromobacter delmarvae			
Butter	239 d.	Berry	1927
" and margarine, rapid develop. of acid and prompt salting	Growth checked	Palladina	1935
Bacterium linens			
Cheddar cheese, 10C, pH 5.13	4 mo.	Albert	1944
Corynebacterium diphtheriae			
Butter	1 mo.	Minn.St.Bd.of Health	1911
Rickettsia			
Coxiella burneti			
Cheese made with infected milk	46 d.	Babudieri	1950
Butter, below freezing	41 d.	Jellison	1948
Lactobacillus sp.			
Butter	275-462 D.	Tanner	1944
MEAT			
Corynebacterium diphtheriae			
Sausage, 85C for 70 min.	24 hr.	Mueller-Claus	1938
Animal parasites			
Trichinella spiralis			
Pork, -15C	24-36 hr.	Tanner	1944
Trichina larvae			
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	
CEREAL			
Pasteurella tularensis			
Grain	Present	Ayres	1948
" contaminated with urine or feces of infected mice	"	Zeiss	1943
VEGETABLES			
Lactobacillus cucumeris			
Peas, 15F	>2 yr.	Berry	1933
Lactobacillus spp.			
Veg., -10C	2 yr.	"	"
Peas, -10C	2 yr.	Weiser	1951
Pseudomonas aeruginosa			
Plants	Recov. many, 69 d.	Russell	1893
Bacteria and parasites			
Veg., from irrigation water	Found	Wright	1950
FRUIT			
Proteus vulgaris			
Cherry juice, -17.8C and -40C	<4 wk.	Wallace	1933
GENERAL			
Pasteurella tularensis			
Food stuff	Present	Schuller	1943
Food, contaminated with urine or feces of infected mice	"	Zeiss	1943

TABLE E7 THE SURVIVAL OF MICROORGANISMS IN FOOD (GENERAL)

Factor(s)	Survival	Reference
MILK		
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
DAIRY PRODUCTS		
Margarine	42% had plate cts. of 100/ml. or less	Foltz 1951
Ice cream	Lower in winter mo.	Tanner 1944
EGGS		
Powdered egg, 60C	99% reduct. 1 d., decrease proportional to increase in temp.	Gibbons 1943
Egg whites, frozen	Low cts.	Vergo 1928
" yolks, "	" "	" "
" whites, R. T.	High cts.	" "
" yolks, " "	" "	" "
" , 0F	Greater destruction of bacteria than at lower temp.	Winter 1947
MEAT		
Chicken-a-la-King	In ¼ 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 destrictive 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	
MEAT (cont'd)			
Fish (haddocks), -12C	Start 47, Recov. 560, 7 wk.	Prescott	1932
" " -18C	Start 47, Recov. 75	"	"
VEGETABLES			
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 pathogenes and other pathogenes reduce survival	Rudolfs	1950
FRUITS			
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 present even after 3rd. washing	Hoder	1928
Blackberries		"	"
Currants		"	"
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	
FRUITS (cont'd)			
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
CEREAL			
Soy beans, alfalfa	Viable 6-9 mo.	Fellers	1919
Pop corn, unpopped	Contained 100,000/g.	Breazeale	1951
" " popped	" 10/g.		
GENERAL			
Frozen foods	Fats and sugar soln. protect and acids destroy	James	1933
Food, -25.2C	>10 hr.	Tanner	1944
Food, pH 2	Practically all destroied	Virtanen	1940

TABLE 18 THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS IN FOOD

Factor(s)	Survival	Reference	
MILK			
Human			
Milk	10 d.	Heim	1889
Sour milk	4 wk.	Honda	1938
Milk, 58C, pH 6.7, 6.3, 6.0	30 min.	Katrandjieff	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
Bovine			
Sour milk	10 d.	Honda	1938
Sour milk, 200cc., R. T.	Inoc. 1 loop cult., viable 20 d.	Kliewe	1937
DAIRY PRODUCTS			
Human			
Butter, 15-22C	30 d.	Heim	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	6½ yr.	Wallace	1938
" "	30 mo.	"	1933
Butter from t.b. milk, pasteurized at 55, 60, and 70C	Survived pasteurization	Cookson	1926
Bovine			
Ice cream	6½ yr.	Wallace	1938
" "	30 mo.	"	1933
Avium			
Ice cream	4½ yr.	"	1938
" "	30 mo.	"	1933

TABLE E9 THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference	
MILK			
S. paratyphi A			
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
S.paratyphi B			
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
S. paratyphi			
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
S. enteritidis			
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	
MILK (cont'd)			
S. typhimurium			
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
S. typhosa			
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 1 mo.	Bolley	1898
" " 2 " "	Inoc:15cc+5cc; 5 d.	"	"
" skim milk	" 100cc+ cc cult;5d.	"	"
Sweet milk	" " + 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 Eq (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference	
MILK (cont'd)			
S. typhosa			
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	20 d.	Washburn	1908
" , pH 4.9-5.1	63 d. plus	Wilson	1945

TABLE E9 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference	
DAIRY PRODUCTS			
S. paratyphi A			
Butter	117 d.	Berry	1927
S. paratyphi B			
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
S. paratyphi types			
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
S. sp. (Type Newport)			
Butter, contamined by cooling water	Present ---	Eriksson	1941
S. enteritidis			
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
S.typhimurium			
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. +	"	"
S. choleraesuis			
Butter	49 d.	Berry	1927
S. typhosa			
Buttermilk, strongly acid	Inoc. 1 loop cult, 10 d.	Bruck	1903
" 22C	" 2 " 24 hr. cult 3 d.	Fraenkel	1898
" 37C	Inoc. 2 loop 24 hr. cult 24 hr.	"	"
" pH 3.5-4.4	2-3 d.	Marsh	1918

TABLE E9 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference	
DAIRY PRODUCTS (cont'd)			
S. typhosa			
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.	Bhat	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, artifically 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 E9 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference	
DAIRY PRODUCTS (cont'd)			
S. typhosa			
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.	"	"
EGGS			
S. typhimurium			
Defrosted whole egg; -1, -9, and -18C	11 mo. +	Hartsell	1950
S. typhosa			
Defrosted whole egg	" " "	"	"
S. sp. (Type Oranienburg)			
Defrosted whole egg; -1, -9, and -18C	" " "	"	"
S. spp.			
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
S. pullorum			
Raw egg	Inoc. feces, present	Mitchell	1946
MEAT			
S. paratyphi B			
Chicken chow mein, -25.5C	Inoc. 230×10^5/gm, Recov. 19×10^5/gm, 270 d.	Gunderson	1948
S. paratyphi types			
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
MEAT (cont'd)		
S. paratyphi types		
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% " "	" "
S. enteritidis		
Corned beef	Inoc. 30-5000/gm, Recov. $30x10^6$, = 60 d.	Surgella 1945
S. typhimurium		
Chicken chow mein,-25.5C	Inoc. $167x10^5$/gm, Recov. $34x10^5$/gm, 270 d.	Gunderson 1948
S. anatum		
Chicken chow mein,-25.5C	Inoc. $100x10^5$/gm, Recov. $4.2x10^5$/gm, 270 d.	" "
S. gallinarum		
Chicken chow mein,-25.5C	Inoc. $68,5x10^5$/gm, Recov. $4.8x10^5$/gm, 270 d.	" "
S. sp. (Type Newington)		
Chicken chow mein,25.5C	Inoc. $75.5x10^5$/gm, Recov. $2.2x10^5$/gm, 270 d.	" "
S. typhosa		
Souse meat	3 mo.	Duff 1942
Salt fish blocks, 5-6C	22 d.	Frank 1941
Chicken chow mein,-25.5C	Inoc. $12,8x10^5$/gm, Recov. $4.8x10^5$/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, sterib sea water, wet	Inoc. 2,250,000; Recov. 105; 3 d.	" "
Oysters, sterile sea water, dry	Inoc. 2,250000; 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 Eg (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN FOOD

Factor(s)	Survival	Reference
MEAT (cont'd)		
S. typhosa		
Sausage, 35C	24 hr.	Maurel 1910
Tuna, -3 to 22.5C	Inoc. 3371 g, Recov. 0, 39 d.	Tetsumoto 1930
Mackeral, -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.	" "
Mackeral, 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
SAUCES		
S. spp.		
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, 015% acid	144 hr.	" "

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

Factor(s)	Survival	Reference	
CEREAL			
S. sp.			
Crust of rye bread, R.T.	6 mo.	Bachmann	1943
S. typhosa			
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
VEGETABLES			
S. enteritidis			
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.	"	"
S. typhimurium			
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
S. pullorum			
Green veg., R.T.	4-8 wk.	Felsenfield	1945
Onions	Not considerable time	"	"
S. sp. (Type Oranienburg)			
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
S. sp. (Type Montevided)			
Green veg., refrigerator	5-10 wk.	Felsenfield	1945
" " R.T.	2-7 wk.	"	"
S. typhosa			
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. 33.4×10^6; Recov. 0.124×10^6; 12 wk.	Hartsell	1951

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

Factor(s)	Survival	Reference	
VEGETABLES (cont'd)			
S. typhosa			
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.	Ommyoji	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.	"	"
FRUITS			
S. paratyphi B			
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.	"	"
S. paratyphi types			
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
S. enteritidis			
Tomatoes, 20C and 6-9C	7 d.	Koser	1922
S. typhimurium			
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.	"	"
S. typhosa			
Sliced sweetened strawberries, -18C	Inoc. 500/gm., 6 mo.	McCleskey	1941
Uncut sweet strawberries	14 mo.	"	"
Pears, ➖ 80C, water	➖ 1 min.	Ommyoji	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
BEVERAGES			
S. typhosa			
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
BEVERAGES (cont'd)		
S. typhosa		
Beer, 4.86% alcohol, 1.79% acid	4 d.	SerpaSantos 1939
Wines	1 hr.	" "
S. spp.		
Beer, 22-37C, with paratyphoid	1-3 d.	Humpesch 1949
Beer, natural with paratyphoid	5-10 wk.	" "
Carbon dioxide drinks	Effect of CO_2 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.	" "
GENERAL		
S. sp.		
Anaerobic sludge used for fertilizer	7 d.	Wolman 1924

TABLE E10 THE SURVIVAL OF SHIGELLA SPECIES IN FOOD

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

TABLE F/b (CONT'D) THE SURVIVAL OF SHIGELLA SPECIES IN FOOD

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

TABLE E11 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN FOOD

Factor(s)	Survival	Reference	
MILK			
Streptococcus cremoris			
Sterilized milk, 30C	2 d.	Mattick	1946
Streptococcus fecalis			
Milk, 62.8 and 37C	Young cells more resistant than mature	Stark	1929
Streptococcus spp.			
Milk, 110C	Recov. 4 hr.	Belin	1933
Milk, ice box	17 d.	Berry	1927
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.	"	"
DAIRY PRODUCTS			
Streptococcus pyogenes			
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	"	"
Streptococcus fecalis			
Cheddar cheese, 50F	Inoc, 300/ml, Recov. 11x 10^6 /ml, 180 d.	Kosikowsky	1948
" " 60F	Inoc; 300/ml, Recov. 13x 10^6/ml, 180 d.	"	"
Streptococcus spp.			
Butter, from infected cow, salted	6 mo.	Bryan	1944
Butter, from infected cow, unsalted	6 mo.	"	"

TABLE E11 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN FOOD

Factor(s)	Survival	Reference
DAIRY PRODUCTS (cont'd)		
Streptococcus spp.		
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.	" "
EGGS		
Streptococcus spp.		
Egg white, 50C	Recov. 6, 4 hr.	Belin 1933
MEAT		
Streptococcus pyogenes		
Sausage, 4 d. drying	13 d.	Mueller-Claus 1938
Lobster meat	May remain alive in salad a considerable time	Scamman 1927
Streptococcus viridans		
Potted meat	Inoc. 30-5000/gm. meat, Recov. 30×10^8 org, 60d.	Surgella 1945
VEGETABLES		
Streptococcus fecalis		
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
MILK		
Vibrio comma		
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.	" "
DAIRY PRODUCTS		
Vibrio comma		
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
EGGS		
Vibrio comma		
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.	" "
MEAT		
Vibrio comma		
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 F12 (CONT'D) THE SURVIVAL OF VIBRIO SPECIES IN FOOD

Factor(s)	Survival	Reference
MEAT (cont'd)		
Vibrio comma		
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.	" "
Mackeral 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 mackeral, " "	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.	" "
Mackeral, 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.	" "
" (yamatoni), 19-34.5 C	Inoc. 0.1cc, Recov. 0, 20 d.	" "

TABLE E12 (CONT'D) THE SURVIVAL OF VIBRIO SPECIES IN FOOD

Factor(s)	Survival	Reference	
MEAT (cont'd)			
Vibrio comma			
Bointo (yamatoni), 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- 34.5 C	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, 19-34.5 C	Inoc. 0.1cc, Recov. 0, 25 d.	"	"
Scallop, " "	Inoc. 0.1cc, Recov. 0, 22 d.	"	"
Beef yamatoni, 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	8 d. - 2 wk.	Tohyama	1925
Oysters and clams, 0-5C	40 d.	"	"
Fish meat, 80C	2 min.	"	"
" " 70C	3 min.	"	"
" " 60C	7.5 min.	"	"
" " hottest day	7-10 d.	"	"
" " 3-8C	2 wk.	"	"
SAUCES			
Vibrio comma			
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.	"	"
CEREAL			
Vibrio comma			
Soy bean milk	8-15 hr.	Genevray	1938
VEGETABLES			
Vibrio comma			
Potatoes	4-5 wk.	Hesse	1889
Veg.	Well	Lal	1926
FRUITS			
Vibrio comma			
Watermelon, pH 4.7	4 d.	Bharucha	1938

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

Factor(s)	Survival	Reference
FRUITS (cont'd)		
Vibrio comma		
Watermelon	Inoc. artificial, 6 d.	Bharucha 1938
Grapes	4 d.	Dobrosklonsky 1911
Berries (inside)	24 hr.	" "
Grape stems	12 d.	" "
Grapes (inside)	24 hr.	" "
Fresh lime, pH 4.4	30 min.	Panja 1945
GENERAL		
Vibrio comma		
Human food	6 d.	Vasquet-Colet 1924
Vibrio sp.		
Skim milk, frozen, dried at 100m. press.	681 d.	Stockton 1950

TABLE E.3 THE SURVIVAL OF VIRUS IN FOOD

Factor(s)	Survival	Reference	
MILK			
Polio virus			
Milk	Polio virus can stand more heat in milk than water	Lawson	1947
Foot and mouth disease virus			
Milk	Present ---	Jansen	1942
DAIRY PRODUCTS			
Polio virus			
Butter, ice box	91 d.	Kling	1931
EGGS			
Newcastle disease virus			
Eggs, 36C, incubator	up to 126 d.	Olesiuk	1951
" R.T., 20-30C	" " 235 d.	"	"
" hen house, 36C	255 d.	"	"
" ice bow, 3-6C	538 d.	"	"
Foul-pox virus			
Chicken eggs, in dry state	Active at 3593 d.	Beaudette	1948
Duck eggs, " " "	" " 1928 d.	"	"
Pigeon-pox virus			
Chicken eggs, " " "	" " 3605 d.	"	"
Duck eggs, " " "	" " 1099 d.	"	"
Jap. B encephalitis virus			
Eggs, 4C	6 hr.	Morgan	1946
MEAT			
Foot and mouth disease virus			
Beef, -20C, thawed in buff. phosphate soln. at 37C	4 mo.	Henderson	1948
Beef, -4C	24 hr.	"	"
CEREAL			
Foot and mouth disease virus			
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
N. d. virus			
Mash, pH 5.5, 37C	56 d.	Olesiuk	1951
" " " 20-30C	94 d.	"	"
" " " 11-36C	172 d.	"	"
" " " 3-6C and -26C	>538 d.	"	"
FRUITS			
Polio virus			
Unwashed fruits and veg.	Present ---	Gebhart	1946

TABLE F14 THE SURVIVAL OF YEAST AND MOLD IN FOOD

Factor(s)	Survival	Reference	
MILK			
Yeast			
Milk, -21 to -78C	Inoc. 100,000/ml., more resistant to freezing than thawing	Lund	-
DAIRY PRODUCTS			
Mold			
Margarine	Viable 42%	Foltz	1951
Yeast			
Margarine	" 46%	"	"
VEGETABLES			
Mold			
Veg., frozen	90% killed	Magoon	1932
" below freezing	16 mo.	Tanner	1931
Yeast			
Veg., frozen	90% killed	Magoon	1932
FRUITS			
Mold			
Fruit juices, -23.3C	3 yr.	Tanner	1934
Good oranges, 17.8C	Inoc. 10,900/cc, Recov. 2,600/cc, 7 mo.	Wolford	1948
Soft rotten oranges, 17,8C	Inoc. 26,500,000/cc, Recov. 990,000/cc,8 mo	"	"
Strawberries, -9.4C, sealed tins	3 yr.	Smart	1934
Yeast			
Good oranges, 17.8C	Inoc. 10,900/cc, Recov. 2,600/cc, 7 mo.	Wolford	1948
Soft rotten oranges, 17.8C	Inoc. 26,500,000/cc, Recov. 990,000/cc,8 mo	"	"
Grape juice, freezing	18 wk.	Tanner	1944
Strawberries, -9.4C, sealed tins	3 yr.	Smart	1934
BEVERAGES			
Yeast			
Beer, freezing	Cells remain active	Melsens	1870
Beer,	15 yr.	Tanner	1944
GENERAL			
Yeast			
Food, -9.4C	3-15 mo.	Smart	1936
Syrup, very dry condition isolated from acid syrup	Several wk.	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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I2	Borrelia species	2
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I4	Clostridium species	1
I5	Coliform organisms (Escherichia, Paracolobactrum and Aerobacter)	2
I6	Corynebacterium species	1
I7	Diplococcus and Streptococcus species	1
I8	Fungi, Yeasts and Molds	1
I9	Malleomyces mallei	1
I10	Micrococcus species	2
I11	Microorganisms	2
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I13	Pasteurella species	3
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TABLE 1 THE SURVIVAL OF BACILLUS SPECIES IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
B. anthracis			
Stomach			
13-17C	exptl; 48-96 hr.		
37C	" 24-48 hr.		
Feces	" 1st 24 hr. after		
of bedbugs	feeding	Nuttall	1899
Feces	present		
of Dermestes vulpinus		Proust	1894
BEETLES			
B. anthracis			
Intestinal tract	present		
of Blaps mucronata			
Tentyria sp.			
Pimelia bifurcata			
" sardea		Cao	1898
Surface	present		
Feces	"		
of Ptinus sp.			
Attagenus pellio			
Anthrenus museorum		Matheson	1950
COCKROACHES			
B. anthracis			
Intestinal tract	present		
of Blatta orientalis		Cao	1898
Feces	present		
of Blatta orientalis		Kuster	1902
B. subtilis			
Feces	present		
of Blaberus cranifer		Wedberg	1949
B. cereus			
in Blaberus cranifer	present	Wedberg	1949
FLIES			
B. anthracis			
Stomach	present; transmitted		
Intestines	" "		
of flies		Bollinger	1874
Intestinal tract	survived through life		
of Musca domestica	cycle and 9 d after		
Calliphora vomitoria	maturity		
Lucilia caesar			
Sarcophaga carnaria		Cao	1906
in Calliphora erythroceph-	survived through life		
ala	cycle and 15 d after		
Lucilia caesar	maturity	Matheson	1950
in Tabanus striatus	exptl; present; trans-		
	mitted	Mitzmain	1914
Gut	present; transmitted		
Feces	" "		
of flies		Schuberg	1912

TABLE 2 / (CONT'D) THE SURVIVAL OF BACILLUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
FLIES (cont'd)		
B. anthracis (cont'd)		
in Musca domestica	exptl; present; transmitted	
Calliphora erythrocephala		
Feces	exptl; present; not transmitted; 72 hr.	Sen 1944
of Stomoxys calcitrans		
B. cereus		
Feces	present	
of Musca domestica		Hawley 1951
B. megatherium		
Feces	present	
of Musca domestica		Hawley 1951
TICKS		
B. anthracis		
in Argas persicus	present; transmitted indefinitely	Delpy 1937
Intestines	at least 100 d	
Feces		
of Argas persicus		Hindle 1925
Intestines	24 hr.	
of Boophilus decoloratus		Martinaglia 1932

TABLE 2 THE SURVIVAL OF BORRELIA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
B. recurrentis			
in Cimex lectularis	exptl; present; not able to transmit by bite	Francis	1938
in Cimex lectularis	exptl; present; not able to transmit by bite	Rosenholz	1927
LICE			
B. recurrentis			
Tissues of Pediculus corporis	life of louse(19 d or more)	Chung	1936
in monkey louse - Pedicinus longiceps	exptl; present; not able to transmit	Francis	1938
Gut, ovaries, testis and malpighian tubules of Pediculus capitis and corporis	present	Mackie	1907
in lice	exptl; present; 18 d	Wolman	1945
B. persica			
Tissues of Pediculus corporis	present; transmitted	Adler	1942
REDUVIIDS			
B. duttonii			
Intestinal tract of Triatoma infestans	exptl; present; 6 d	Liem	1941
TICKS			
B. recurrentis			
in Ornithodoros turicata	present; transmitted	Burroughs	1944
Starved 5 yr. after an infective meal	exptl; 5 yr.; transmitted		
1 meal in 6½ yr. in Ornithodoros turicata	exptl; 6½ yr.; transmitted	Francis	1938
in Ornithodoros tholozani	present; transmitted	Gambles	1948
in " papillipes	" "	Pavlovskii	1945
in " tholozani	" "	Pavlovskii	1946
in " papillipes	exptl; 134 d; transmitted		
" tartakovskyi		Sofiev	1946
in " moubata	present; transmitted		
" savignyi			
" talaje			
" rudis			
" turicata			
" hermsi			
" parkeri			
" erraticus			
" tholozani			
" tartakovskyi			
" nerensis		Steinhaus	1947
in " turicata	present; transmitted	Weller	1930
in " turicata	present; transmitted	Wisseman	1945

TABLE 2 (CONT'D) THE SURVIVAL OF BORRELIA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
TICKS(cont'd)			
B. duttonii			
in Ornithodoros moubata	present; transmitted	Dutton	1905
in " "	present	Ross	1904
B. duttonii var. crocidurae			
in Ornithodoros erraticus	present; transmitted	Boiron	1949
B. hispanica			
in Ornithodoros erraticus	present; transmitted	Boiron	1948
in Rhipicephalus sanguineus	exptl; present	Seargent	1938
B. anserina			
in Argas persicus			
" reflexus			
Ornithodoros moubata	Present; transmitted	Steinhaus	1947
B. theileri			
in Margaropus decoloratus			
Rhipicephalus evertsi	present; transmitted	Steinhaus	1947

TABLE 3 THE SURVIVAL OF BRUCELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
BEDBUGS		
Brucella spp.		
Feces of bedbugs	>3 mos.; not transmitted by bite	Tovar 1947
COCKROACHES		
B. abortus		
Intestinal tract of Periplaneta americana	24 hrs.	Ruhland 1941
FLEAS		
Brucella spp.		
Feces of fleas	present; not transmitted by bite	Tovar 1947
FLIES		
B. abortus		
in flies	24 hrs.	Patton 1931
Intestinal tract	>96 hrs.	Ruhland 1941
TICKS		
Brucella spp.		
Feces of ticks	>3 mos.; transmitted by bite and transmitted to eggs and larvae	Tovar 1947

TABLE 24 THE SURVIVAL CLOSTRIDIUM SPECIES IN INSECTS

Factor(s)	Survival	Reference
BEETLES		
C. tetani		
Feces of Blaps mucronata, Tentyria sp., Pimelia bifurcata, " sardea	present	Cao 1906
C. chauvoei		
Feces of Blaps mucronata, Tentyria sp., Pimelia bifurcata, " sardea	present	Cao 1898
C. sporogenes		
Feces of Blaps mucronata, Tentyria sp., Pimelia bifurcata, " sardea	present	Cao 1898
COCKROACHES		
C. tetani		
Feces of Blatta orientalis	present	Cao 1906
C. sporogenes		
Feces of Blatta orientalis	present	Cao 1898
C. chauvoei		
Feces of Blatta orientalis	present	Cao 1898

TABLE 15 THE SURVIVAL OF COLIFORM ORGANISMS IN INSECTS (ESCHERICHIA, PARACOLOBACTRUM & AEROBACTER)

Factor(s)	Survival	Reference	
BEETLES			
E. coli			
Feces of Blaps mucronata, Tentyria sp., Pimelia bifurcata, " sardea	present	Cao	1898
COCKROACHES			
E. coli			
Feces of Blatta orientalis	present	Cao	1898
Legs and feces of Blatta orientalis	present	Longfellow	1913
Intestinal tract of Blattella germanica	present	Steinhaus	1941
E. coli var. communior			
Feces of Blaberus cranifer	present	Wedberg	1949
E. freundii			
Feces of Blaberus cranifer	present	Wedberg	1949
E. spp.			
Hindgut of Periplaneta americana	present; transmitted	Bitter	1949
Paracolobactrum sp.			
Hindgut of Periplaneta americana	present; transmitted	Bitter	1949
Feces of Blaberus cranifer	present	Wedberg	1949
A. aerogenes			
Feces of Blaberus cranifer	present	Wedberg	1949
in cockroaches	present	Morrell	1911
A. cloacae			
in cockroaches	present	Morrell	1911
A. spp.			
Hindgut of Periplaneta americana	present; transmitted	Bitter	1949
FLIES			
E. coli			
Feces of Musca domestica, Calliphora vomitoria, Lucilia caesar, Sarcophaga carnaria	present	Cao	1898
Intestines of Musca domestica	present	Cox	1912
Body	Inoc; fed a suspension of 12,000-48,000 organisms. Recov: multiplied in body		
Feces of flies	present	Hawley	1948

TABLE 2 5 (CONT'D) THE SURVIVAL OF COLIFORM ORGANISMS IN INSECTS (ESCHERICHIA, PARACOLOBACTRUM & AEROBACTER)

Factor(s)	Survival	Reference	
FLIES (cont'd)			
E. coli (cont'd)			
Feces of Musca domestica	Inoc: 12,000-900,000 bacteria Recov: 1st d - 10-10,000 6th d - 1-200,000,000	Hawley	1951
Intestines of Musca domestica	present	Nicoll	1911
Intestines of Musca domestica	present	Scott	1917
Intestines of Musca domestica	present	Torrey	1912
E. coli var. communior			
Intestines of Musca domestica	present	Torrey	1912
Intestines of Musca domestica	present	Scott	1917
E. coli var. acidilactici			
Intestines of Musca domestica	present	Torrey	1912
Intestines of Musca domestica	present	Cox	1912
E. coli var. neopolitana			
Intestines of Musca domestica	present	Cox	1912
E. coli var. mutabilis			
Intestines of Musca domestica	present	Nicoll	1911
A. aerogenes			
External	Sanitary areas of city: 21,000-100,000/fly Unsanitary areas of city: 800,000-500,000,000/fly		
Internal of Musca domestica	Sanitary areas of city: 100-[illegible],000/fly Unsanitary areas of city: 10,000-333,000,000/fly	Cox	1912
[illegible] of Musca domestica	present	Hawley	1951
Intestines of Musca domestica	present	Nicoll	1911
Intestinal tract of Musca domestica	present	Torrey	1912
Colon group			
Internally and externally of Musca domestica	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
BEETLES		
C. pseudodiphthericum		
Intestinal tract	present	
Tentyria sp.		
Blaps mucronata		
Pimelia bifurcata		
" sardea		Cao 1898
COCKROACHES		
C. pseudodiphthericum		
Intestinal tract of Blatta orientalis	present	Cao 1898
C. diphtheriae		
Legs and feces of Blata orientalis	present	Longfellow 1913
FLIES		
C. diphtheriae		
Legs and wings	exptl; few hrs.	
Intestines	" > 24 hrs.	
Feces	" 51 hrs.	
of Musca domestica		
Calliphora erythrocephala		Graham-Smith 1910
Intestinal tract of flies	exptl; 24 hrs.	Graham-Smith 1913

TABLE 17 THE SURVIVAL OF DIPLOCOCCUS & STREPTOCOCCUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
COCKROACHES		
Diplococcus pneumoniae		
Legs and feces of Blatta orientalis	present	Longfellow 1913
Streptococcus faecalis		
Alimentary tract of Blattella germanica	present	Steinhaus 1941
FLEAS		
Diplococcus pneumoniae		
Intestinal tract of fleas	present	Pinto 1930
FLIES		
Streptococcus faecalis		
Intestinal tract of Musca domestica	present	Cox 1912
Intestinal tract of Musca domestica	present	Scott 1917
Intestinal tract of Musca domestica	present	Torrey 1912
Streptococcus equinus		
Intestinal tract of Musca domestica	present	Torrey 1912
Streptococcus sp.		
in flies	present	Schuberg 1914
Streptococcus pyogenes		
in Musca domestica	present	Scott 1917
Externally of flies	present	Shooter 1944
Streptococcus agalactiae		
in Musca domestica	present	Ewing 1942
in " "	present	Saunders 1904
LICE		
Diplococcus pneumoniae		
Feces Pediculus capitis	24 hrs.	Pierce 1921
REDUV[illegible]		
Streptococcus faecalis		
in Triatoma infestans	present; transmitted	Brecher 1944

TABLE 9 8 THE SURVIVAL OF FUNGI, YEASTS & MOLDS IN INSECTS

Factor(s)	Survival	Reference
COCKROACHES		
Rhizopus nigricans		
Penicillium spp.		
Saccharomyces cerevisiae		
Actinomyces spp.		
Molds		
Yeasts		
Feces	[illegible]	
of Blaberus cranifer		Wedberg 1949
Torula rosea (yeast)		
Feces	exptl;	
of Blaberus cranifer	Inoc: massive doses Recov: present 6 d	Wedberg 1949
Torula sp.		
in Periplaneta americana	present; transmitted	Owen 1948

TABLE 19 THE SURVIVAL OF MALLEOMYCES MALLEI IN INSECTS

Factor(s)	Survival	Reference
BEETLES		
M. mallei		
Feces	present	
of Blaps mucronata		
Tentyria sp.		
Pimelia bifurcata		
" gardea		Cao 1898
COCKROACHES		
M. mallei		
Feces	present	
of Blatta orientalis		Cao 1898
FLEAS		
M. pseudomallei		
Body	50 d; transmitted	
Feces	present; transmitted	
of Xenopsylla cheopis		Blanc 1941
in rat fleas	exptl; present; transmitted	Blanc 1942
MOSQUITOES		
M. pseudomallei		
in Aedes egypti	exptl; present; transmitted	Blanc 1942

TABLE 9/0 THE SURVIVAL OF MICROCOCCUS SPECIES IN INSECTS

Factor(s)	Survival	Reference	
BEETLES			
M. albus			
Intestinal tract of Melolontha vulgaris	present	Cao	1906
M. aureus			
Intestinal tract of Melolontha vulgaris	present	Cao	1906
M. citreus			
Intestinal tract of Melolontha vulgaris	present	Cao	1906
COCKROACHES			
M. albus			
in Blattella germanica	present	Herms	1939
in Blaberus cranifer	present	Wedberg	1949
M. aureus			
Antennae, feet and stomach of Blattella germanica	present	Herms	1939
Legs and feces of Blatta orientalis	present	Longfellow	1913
Feces of Blaberus cranifer	present	Wedberg	1949
M. citreus			
Legs and feces of Blatta orientalis	present	Longfellow	1913
FLIES			
M. albus			
External of flies	present	Scott	1917
External of flies	present	Torrey	1912
in tabanid flies	present	Joly	1898
M. aureus			
Feces of Musca domestica	present	Celli	1888
Feces of Musca domestica	present	Hawley	1951
in tabanid flies	present	Joly	1898
Feet of flies	present	Scott	1917
M. aureus, 611			
Gut	8 d		
Feces	3-5 d	Moorehead	1946
M. citreus			
Body and feces of flies	survived through life cycle and 9 d after maturity	Scott	1917
M. spp.			
in Musca domestica	present	Cox	1912
Sarcina lutea			
Feces of Musca domestica	present	Hawley	1951
LICE			
M. pemphigicontagiosa			
in Pediculus capitis	present; transmitted	Dewevre	1892

TABLE 8/6 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES IN INSECTS

Factor(s)	Survival	Reference
LICE (cont'd)		
M. spp.		
in Pediculus capitis	present	Pierce 1921
MOSQUITOES		
M. aureus		
Gut		
of Aedes egypti	at least 24 hr.; not after 7 d	St. John 1930
TICKS		
M. aureus		
in Argas reflexus	present	Galli-Valerio 1907

TABLE 9 11 THE SURVIVAL OF MICROORGANISMS IN INSECTS

Factor(s)	Survival	Reference	
BEETLES			
Klebsiella pneumoniae			
Feces	present		
of Blaps mucronata			
Tentyria sp.			
Pimelia bifurcata			
" sardea		Cao	1898
COCKROACHES			
Klebsiella pneumoniae			
Feces	present		
of Blatta orientalis		Cao	1898
Proteus vulgaris			
Hindgut	present; transmitted		
of Periplaneta americana		Bitter	1949
Legs and feces	present		
of Blatta orientalis		Longfellow	1913
Feces	present		
of Blaberus cranifer		Wedberg	1949
Proteus morganii			
Proteus mirabilis			
Proteus rettgeri			
Hindgut	present; transmitted		
of Periplaneta americana		Bitter	1949
Pseudomonas aeruginosa			
Hindgut	present; transmitted		
of Periplaneta americana		Bitter	1949
Feces	present		
of Blaberus cranifer		Wedberg	1949
Serratia marcescens			
Feces	exptl; duration of life		
of Blaberus cranifer	of roach	Wedberg	1949
FLIES			
Neisseria gonorrhoeae			
Feet	3 hrs.		
of flies		Matheson	1950
Neisseria meningitidis(intracellularis)			
in flies	present	MacGregor	1917
Proteus vulgaris			
Feces	present		
of Mucsa domestica			
Calliphora vomitoria			
Lucilia caesar			
Sarcophaga carnaria		Cao	1906
in Musca domestica	present	Scott	1917
Proteus morganii			
Feces	present		
of Musca domestica		Hawley	1951
in Musca domestica	present	Morgan	1909
Intestines	present		
of Musca domestica		Nicoll	1911
in Musca domestica	present	Cox	1912

TABLE 9 // (CONT'D) THE SURVIVAL OF MICROORGANISMS IN INSECTS

Factor	Survival	Reference
FLIES (cont'd)		
Pseudomonas aeruginosa		
Intestinal tract of Musca domestica	survives through metamorphosis; transmitted	Bacot 1911
Feces of Musca domestica	present; survived through the life cycle	
Calliphora vomitoria		
Lucilia caesar		
Sarcophaga carnaria		Cao 1898
Gut of Stomoxys calcitrans	present	Duncan 1926
Intestinal tract of flies	present; survives through metamorphosis	Ledingham 1911
Pseudomonas sp.		
Feces of Musca domestica	present	Hawley 1951
Serratia marcescens		
Crop	exptl; large numbers recovered; 4-5 d	
Intestines of Musca domestica	exptl; present; up to 18 d	Graham-Smith 1913
Pupae of Musca domestica	1 d	Ledingham 1911

TABLE 2/2 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN INSECTS

Factor(s)	Survival	Reference
BEDBUGS		
M. leprae		
Intestinal tract of Cimex lectularis	present	Long 1911
Proboscis	5 d	
Intestinal tract	16 d	
Feces of bedbugs	present	Matheson 1950
BEETLES		
M. tuberculosis		
Intestinal tract of Tentyria sp. Blaps mucronata Pimelia bifurcata " sardea	present	Cao 1898
COCKROACHES		
M. tuberculosis		
Intestinal tract of Blatta orientalis	present	Cao 1898
Feces of Blatta orientalis	present	[illegible]uster 1902
Feces of [illegible]eriplaneta americana	present	Macfie 1922
Feces of Periplaneta americana	2-5 d; transmitted	Riley 1932
Feces of cockroaches	present	Tejira 1926
M. leprae		
Feces of Periplaneta americana	present	Macfie 1922
Gut	exptl; multiplied	
Feces - dried of cockroaches	" 169 d	Moiser 1945
Intestines of cockroaches	present	Riley 1932
in cockroaches	present	Tejira 1926
FLEAS		
M. leprae		
Stomach of fleas	present	Munoz-Rivas 1946
FLIES		
M. tuberculosis		
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
FLIES (CONT'D)		
M. leprae		
Intestinal tract and feces of Musca domestica	several days	
Sarcophaga palliner-vis		
Sarcophaga barbata		
Volencelle obesa		
Lucilia sp.		Currie 1910
in Stomoxys calcitrans		
Musca domestica	present	Honeij 1914
LICE		
M. leprae		
in Pediculus capitis	present	McCoy 1912
MOSQUITOES		
M. leprae		
in Aedes egypti	present	Riley 1938
Gut of Aedes egypti	at least 24 hr., not after 7 d	St. John 1930

TABLE 9 13 THE SURVIVAL OF PASTEURELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
P. tularensis			
in Cimex lectularis	136 d	Bozhenko	1935
Excrement of Cimex lectularis	exptl; infective; present	Davis	1943
in Cimex lectularis	present	Francis	1927
in " "	exptl; present; transmitted	Francis	1922
in bedbugs	present	Kamil	1936
FLEAS			
P. pestis			
Alimentary tract of fleas	greatly multiplied; transmitted	Bacot	1914
Live	21 d; transmitted		
Dead	5 d; "		
Excreta of Pulex irritans	5 d; "	Blanc	1941
in Xenopsylla cheopis Nosophyllus fasciatus Orchopeassexdentatus sexdentatus Opisodasys nesiotus Megabothris abantis Malareus telchinom Diamanus montanus Echidnophaga gallinacea	present, transmitted	Burroughs	1947
Alimentary tract	present		
Feces of fleas	present in very small numbers	Douglas	1943
Feces- dried of fleas	4 wk.; exptl.; transmitted	Eskey	1938
Feces-dried, 66F. of fleas	5 wk.; exptl.; transmitted	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 Hoplopsyllus anomalus	present; transmitted	Meyer	1949
in fleas	exptl; present; survive through hibernation	Prince	1947
in fleas 50F., RH - saturated	present; favorable conditions for survival		
>80F., RH- dry	present; adverse conditions for survival	Topley	1932

TABLE 2-13 (CONT'D) THE SURVIVAL OF PASTEURELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
FLEAS(cont'd)			
P. tularensis			
in Spilopsyllus cuniculi	present; transmitted	Green	1938
Tissues	present		
of fleas		McCoy	1911
in Ctenocephalus pallex			
" orientalis	present; transmitted	Volferz	1934
in Cediopsylla simplex	" "	Waller	1940
FLIES			
F. tularensis			
in Chrysops discalis	present; transmitted	Francis	1921
in horse-fly, stable-fly and rainfly	present	Olsofiev	1936
LICE			
P. tularensis			
in lice	present; transmitted	Davis	1935
in Haemodipus ventricosus	" "	Francis	1922
in Polyplex serratus	" "	Francis	1922
MITES			
P. tularensis			
in Bdellonyssus bacoti	exptl; present, transmitted	Hopla	1951
in Gamasidae	present, transmitted	Volferz	1934
MOSQUITOES			
P. tularensis			
Feces	present		
of Culex apicalis		Bozhenko	1936
in Aedes cinereus	present	Olin	1942
in mosquitoes	present	Olsofiev	1936
Intestines and feces	present; transmitted		
of Aedes nearticus			
" vexans			
" dorsalis			
" stimulans			
" caradensis			
Theobaldi indicens			
Culex tarsalis		Philip	1932
TICKS			
P. pestis			
in Hyalomma volgense			
P. schulze			
E. schlottke	present; transmitted	Borzenkov	1933
in Argas persicus	" "	Foddeeva	1932
Tissues	" "		
of ticks		Lien-teh	1936
Tissues	" "		
of ticks		Matheson	1950
P. tularensis			
Tissues	Present; transmitted		
of ticks		Davis	1940
Tissues	exptl; not transmitted during feeding		
Ornithodoros turicata	674 d		
" parkeri	701 d	Davis	1940

TABLE 2/3 (CONT'D) THE SURVIVAL OF PASTEURELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
TICKS (cont'd)			
P. tularensis (cont'd)			
in Ixodes ricinus	present	Davis	1937
" californicus	present; transmitted		
Feces of Dermacentor andersoni	" "	Francis	1927
in ticks	" "	Matheson	1950
in Dermacentor variabilis	" "	Green	1931
in Ornithodoros lahorensis	" "	Kamil	1938
in Dermacentor occidentalis	survived life cycle stage to stage and generation to generation survival	Parker	1929
in Dermacentor andersoni		Parker	1924
in Dermacentor variabilis		Philip	1934

TABLE 2 / 44 THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
Trypanosoma cruzi in Cimex pilosellus	exptl; present; transmitted	Wood	1951
COCKROACHES			
Endamoeba histolytica			
Hindgut and feces of Periplaneta americana	exptl; cysts present for 72 hr.	Frye	1936
Feces of Periplaneta americana	cysts present	Macfie	1922
Giardia lamblia			
in Periplaneta americana	cysts present	Macfie	1922
Colonic contents of cockroaches	exptl; 12 d	Youn[illegible]	1937
Anclyostoma duodenale			
" ceylanicum			
Necator americanus			
Ascaris lumbricoides			
Trichuris trichura			
Taenia saginata			
Schistosoma haemotobium			
Feces of Periplaneta americana	eggs present	Macfie	1922
FLIES			
Chilomastix mesnili			
Feces of Musca domestica	cysts present	Root	1921
Endamoeba histolytica			
Intestinal contents of Chrysomyia megacephala, Lucilia sericata, Sarcophaga spp.	cysts present	Chang	1943
in Musca domestica	cysts present	Frye	1932
in flies	" "	Harris	1946
Dejecta	trophozoites present		
"	cysts recovered 154-258 minutes; exptl.		
of Musca domestica, Lucilia pallescens, Cochliomyia macellaria, Phormia regina, Sarcophaga miserio		Pipkin	1943
	exptl; troph. / cysts		
Crop	40 min. / 210 min.		
Midgut	30 " / 240 "		
External surface	/ 4 "		
Rectum	/ 210 "		
Vomit drop	17 " / 64 "		
Faecal drop	/ 254 "		
of flies		Pipki[illegible]	1949
Feces of Musca domestica	exptl; cysts present	Root	1921
Feces of Musca domestica	" " "	Roubaud	1918
Feces of Musca domestica	" " "	Sieyro	1942

TABLE 914 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference	
FLIES (cont'd)			
Endamoeba histolytica (cont'd)			
Feces and intestinal tract	cysts present		
" " " " of Musca domestica	exptl; cysts present; 2-3 d	Matheson	1950
Endamoeba coli			
in Musca domestica	cysts present	Frye	1932
Feces of Musca domestica	exptl; cysts present	Root	1921
Feces of Musca domestica	" " "	Roubaud	1918
Feces and intestinal tract	cysts present		
" " " " of Musca domestica	exptl; cysts present, 2-3 d	Matheson	1950
Endolimax nana			
in Musca domestica	cysts present	Frye	1932
Giardia lamblia			
Feces of Musca domestica	cysts present	Root	1921
Feces of Musca domestica	cysts present	Roubaud	1918
Feces and intestinal tract	cysts present		
" " " " of Musca domestica	exptl; cysts present, 2-3 d	Matheson	1950
in flies	cysts present	Frye	1932
Leishmania braziliensis			
in Phlebotomus lutzi			
" " intermedius	present, transmitted	Steinhaus	1947
Leishmania donovani			
in Phlebotomus argentipes	exptl; present; transmitted	Napier	1933
Gut of Phlebotomus argentipe	present	Matheson	1950
Gut of Phlebotomus major var. chinensis	present		
Phlebotomus sergenti		Patton	1927
in Phlebotomus argentipes	exptl; present; transmitted	Matheson	1950
in Phlebotomus argentipes	exptl; present; transmitted	Smith	1936
in Phlebotomus argentipes " perniciosus major longicuspis major var. chinensis	present; transmitted	Steinhaus	1947
in Phlebotomus argentipes	exptl; present; transmitted	Swanimath	1942
Gut of Phlebotomus spp.	present	Young	1927

TABLE 2 / K (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
FLIES (cont'd)		
Leishmania tropica		
in Phlebotomus papatasii	present; transmitted	Adler 1941
in " sergenti	" "	Adler 1939
in " papatasii		
" sergenti	" "	Adler 1948
in " papatasii		
" sergenti	" "	Steinhaus 1947
Trypanosoma rhodesiense		
in Glossina brevipalpis		
" morsitans	present; transmitted	Matheson 1950
in Glossina morsitans	" "	Bagshawe 1912
in " "		
" swynnertoni	present; transmitted	Steinhaus 1947
in " palpalis		
" brevipalpis	exptl; present; transmitted	Steinhaus 1947
Trypanosoma gambiense		
Proboscis	<48 hrs; transmitted	
of Glossina palpalis		Bruce 1903
in Glossina palpalis	present; transmitted	Castellani 1903
in " "	" "	Kleine 1909
in " "	multiplied; duration of life; transmitted	Robertson 1912
in Glossina tachinoides	present; transmitted	Steinhaus 1947
in " morsitans		
" fusca		
" pallidipes		
" submorsitans	exptl; present; transmitted	Steinhaus 1947
Trypanosoma brucei		
in Glossina morsitans	present; transmitted	Kleine 1909
Ascaris lumbricoides		
Intestinal tract	ova present	
of Chrysomyia megacephala		
Lucilia sericata		
Sarcophaga spp.		Chang 1943
Externally	exptl; eggs present	
of Musca domestica		
Lucilia pallescens		
Cochliomyia macellaria "		
Phormia regina		
Sarcophaga miserio		Pipkin 1943
Enterobius vermicularis		
Externally	exptl; eggs present	
of Musca domestica		
Lucilia pallescens		
Cochliomyia macellaria		
Phormia regina		
Sarcophaga miserio		Pipkin 1943

TABLE 2/4 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
FLIES (cont'd)		
Hookworms - spp. not given		
Intestinal contents	ova present	
of Chrysomyia megacephala		
Lucilia sericata		
Sarcophaga spp.		Chang 1943
Hookworm - Necator americanus		
Externally	exptl; eggs present	
of Musca domestica		
Lucilia pallescens		
Cochliomyia macellaria		
Phormia regina		
Sarcophaga miserio		Pipkin 1943
Trichuris trichura		
Intestinal contents	ova present	
of Chrysomyia megacephala		
Lucilia sericata		
Sarcophaga spp.		Chang 1943
Externally	exptl; eggs present	
of Musca domestica		
Lucilia pallescens		
Cochliomyia macellaria		
Phormia regina		
Sarcophaga miserio		Pipkin 1943
LICE		
Trypanosoma duttoni		
in Pediculus corporis	present; transmitted	Heisch 1949
MOSQUITOES		
Plasmodium flaciparum		
in Anopheles albimanus	present; transmitted	Eyles 1949
Over 68F, opt. 86F	" "	
RH - near 70%		
in mosquitoes		Gill 1938
in Anopheles quadrimaculatus		
Anopheles albimanus	exptl; present; transmitted	Jeffery 1950
35F	24 hrs.	
in Anopheles quadrimaculatus		King 1917
Over 68F, opt. 86F		
RH at least 70%	present; transmitted	
in mosquitoes		Matheson 1950
Plasmodium malarie		
in Anopheles maculipennis	exptl; present; transmitted	Young 1947

TABLE 2/4 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference
MOSQUITOES (cont'd)		
Plasmodium vivax		
in Anopheles quadrimaculatus	exptl; present; transmitted	Eyles 1948
Mean temp. between 60.8-68F; RH - not below 70% in mosquitoes	present; transmitted	Gill 1938
in Anopheles maculipennis	infective for nearly 6 mos.	James 1927
4-6C	infective for 2½ yrs.	
in Anopheles maculipennis		Matheson 1950
30F	2 d	
31F	4 d	
46F	17 d	
in Anopheles quadrimaculatus		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 Anopheles maculipennis freeborni		
Anopheles maculipennis occidentalis		
Anopheles punctipennis	exptl; present; transmitted	Moore 1945
in Anopheles barberi	exptl; present; transmitted	Stratman-Thomas 1936
in Anopheles quadrimaculatus	exptl; present; transmitted	Watson 1945
in Anopheles quadrimaculatus	exptl; present; transmitted	Young 1952
in Anopheles quadrimaculatus		
Anopheles maculipennis freeborni	exptl; present; transmitted	Young 1945
Plasmodium spp.		
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_2O	68-92 d	
in Anopheles punctipennis		Mayne 1922

TABLE 4/4 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference	
MOSQUITOES (cont'd)			
Plasmodium spp. (cont'd)			
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
Trypanosoma gambiense			
in Mansonia uniformis	exptl; present; transmitted	Steinhaus	1947
Wuchereria bancrofti			
in Culex quinquefasciatus			
" annulirostris	exptl; present; transmitted	Cobrera	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
Wuchereria malayi			
in subgroup Mansonioides spp.			
Anopheles byrcanus	present; transmitted	Carter	1948
Filaria sanguinis hominis			
in Culex fatigans	present	Ross	1898
REDUVIIDS			
Leishmania donovani			
in Triatoma spp.	exptl; no multiplication; 1 d	Packchanian	1948
Leishmania tropica			
in Triatoma spp.	exptl; no multiplication; 1 d	Packchanian	1948
Trypanosoma cruzi			
Feces of Rhodnius prolixus	present; transmitted	Brumpt	1912
in Triatoma megista	" "	Chagas	1909
in " sanguisuga	" "	Elkins	1951
in Rhodnius prolixus			
" pictipes	" "	Floch	1947
in Triatoma protracta	" "	Kofoid	1933

TABLE 94 (CONT'D) THE SURVIVAL OF PROTOZOA & METAZOA IN INSECTS

Factor(s)	Survival	Reference	
REDUVIIDS (cont'd)			
Trypanosoma cruzi (cont'd)			
in Triatoma megista			
" infestans			
" sordida			
" dimidiata			
" heidemanni			
" gerstaeckeri			
" sanguisuga			
" chazasi			
" geniculata			
" hegneri			
" vitticeps			
" longipes			
" rubida			
Rhodnius prolixus			
" pictipes			
Eratyrus cuspidatus	present; transmitted	Steinhaus	1947
in Triatoma gerstaeckeri			
" lecturiaris			
" protracta			
" sanguisuga			
" nectomae			
" rubida	present; transmitted	Sullivan	1949
in Triatoma protracta	" "	Wood	1934
in Triatoma protracta			
" rubida			
" longipes			
dead for 15 days	present; transmitted	Wood	1942
in Triatoma heidemanni	" "	Wood	1943
in Triatoma protracta	" "	Wood	1950
Trypanosoma gambiense			
in Triatoma spp.	exptl; present; 4-6 d	Packchanian	1948
Trypanosoma brucei			
in Triatoma spp.	exptl; present; 4-6 d	Packchanian	1948
Trypanosoma duttonii			
in Triatoma gerstaeckeri	exptl; no multiplication; 2-3 d	Packchanian	1948
TICKS			
Babesia bigemina			
in Boophilus annulatus	present; transmitted	Dennis	1931
in " "	" "	Dennis	1932
in " "	" "	Smith	1893
Babesia bovis			
in Ixodes ricinus	present; transmitted	Steinhaus	1947
Leishmania donovani			
Gut of ticks	exptl; 25 d; transmitted	Feng	1949
Trypanosoma cruzi			
in Ornithodoros furcosus			
" parkeri			
" amblus	present; many wks. or mos.	Steinhaus	1947

TABLE 2/2 THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
R. typhi			
in Cimex lectularis	exptl; not transmitted; 10 d	Castaneda	1930
R. rickettsi			
in Cimex lectularis			
" rotundatus	exptl; 24 hrs.; present	Steinhaus	1947
R. prowazeki			
Coelomic cavity of bedbugs	present; harbors but does not transmit	Nauck	1941
FLEAS			
R. typhi			
in Echidnophaga gallinacea	exptl; present; transmitted	Olicata	1942
in " "	present; transmitted	Brigham	1941
Tissues of fleas	at least 52 d; transmitted	Dyer	1932
in Xenopsylla cheopis	present	Dyer	1951
in Ctenocephalus felis	present; transmitted	Irons	1944
in Xenopsylla cheopis Ceratophyllus anisus	present; transmitted	Liu	1944
Feces of Xenopsylla cheopis	<96 hrs.; transmitted	Rickard	1951
in Xenopsylla cheopis	present; transmitted	Savoor	1948
in fleas	exptl; present	Weyer	1949
R. prowazeki			
in Xenopsylla cheopis	exptl; present	Dyer	1934
in fleas	" "	Weyer	1949
LICE			
R. typhi			
in Pediculus corporis	present; transmitted	Liu	1944
in Polyplax spinulosus	" "	Mooser	1931
in Pediculus corporis	exptl; present; transmitted	Mooser	1930
in Pediculus corporis	exptl; present; 10 d	Snyder	1949
R. prowazeki			
Excreta - dry, room temp.	11-12 d	Arkwright	1923
in Pediculus capitis			
" corporis	present; transmitted	Atkin	1922
in Pediculinus albidus	exptl; present; transmitted	Blanc	1945
in Pediculus corporis	exptl; present; transmitted	Cabasso	1947
Gut			
>32C	exptl; present; transmitted		
23C	exptl; did not survive		
of lice		DaRocha	1916
in lice	exptl; present	Mariani	1940
in Pediculus capitis			
" corporis	exptl; present; transmitted	Nicolle	1909

TABLE 215 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
LICE (cont'd)			
R. prowazeki (cont'd)			
Feces - room temp.	60 d		
of Pediculus capitis			
" corporis		Nuttall	1917
in Pediculus vestimenti	present; transmitted	Ricketts	1910
Feces			
RH - high RH hastened disappearance of rickettsia in feces	8-9 d (guinea pig test) 19-147 d (louse test)		
of lice		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
R. wolhynica			
lice	exptl; present		
dried feces	" " 2½yrs.	Weyer	1948
R. quintana			
Gut and feces	present; transmitted		
of Pediculus corporis		Hindle	1921
in Pediculus corporis	present; 4 mos.	Steinhaus	1947
Stomach lumen	present		
of lice		Toepfer	1916
MITES			
R. typhi			
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
R. tsutsugamushi			
in mites	present; transmitted	Kawamura	1931
in mites	" "	Kitashima	1918
in Trombicula fletcheri			
" walchi	" "	Kohls	1945
in " deliensis			
larvae	exptl; present; transmitted	Krishman	1949
in Trombicula deliensis	present; transmitted	Krishman	1949
in " "			
hatched eggs	present; transmitted	Mackie	1946
in mites	" "	Miyajima	1917
in mites	present	Philip	1945
in Trombicula akamushi			
" deliensis	present; transmitted	Steinhaus	1947
in mites	" "	Tanaka	1899
in Euschongastia indica	" "	Traub	1950

TABLE 2/5 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference
MITES (cont'd)		
R. akari		
in Allodermanyssus sanguineus	present	Huebner 1946
in Liponyssus bacoti	exptl; present; transmitted	Philip 1948
in "	exptl; present; transmitted	Phillip 1948
TICKS		
R. typhi		
in Ornithodoros moubata	exptl; present	Weyer 1948
in Dermacentor andersoni		
Otocenter nitens		
Amblyomma sp.	exptl; present; 12 d	Zinsser 1931
R. rickettsi		
in Rhipicephalus sanguineus	present; transmitted	Anigstein 1943
in Dermacentor andersoni	" "	Davis 1939
in " variabilis	present; transovarian transmission	Dyer 1931
in " andersoni		
" variabilis		
Haemaphysalis leporis-palustris		
Amblyomma americanum	present; transmitted	Parker - Unpublished expt.
in Dermacentor occidentalis		
Rhipicephalus sanguisuga	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 Otocentor nitens		
Dermacentor andersoni		
Ornithodoros parkeri		
" rudis		
" turicata	present; transmitted	Patino-Camargo 1941
All tissues of Dermacentor andersoni	present; transmitted	Steinhaus 1947
in ticks	present; transmitted	Badger 1932
in Amblyomma cajennense	" "	Bustamente 1946
in Rhipicephalus sanguineus	" "	Bustamente 1946
in Rhipicephalus sanguineus	present	Mariotte 1944
in Ornithodoros furcosus	exptl; 345 d	Mazzotti 1946

TABLE 2/5 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
TICKS (cont'd)			
R. rickettsi (cont'd)			
in Haemaphysalis leporis-palustris	present; transmitted	Parker	1923
in Haemaphysalis leporis-palustris	present; transmitted	Parker	1951
in Dermacentor andersoni	" "	Ricketts	1906
RMSF-like rickettsia			
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
R. prowazeki			
in Ornithodoros moubata	exptl; present; 262 d	Weyer	1948
R. wolhynica			
in Ornithodoros moubata	exptl; present; 69 d	Weyer	1948
R. conori			
in Rhipicephalus sanguineus	>18 mos.; transmitted	Brumpt	1932
Nearly all tissues in Rhipicephalus sanguineus	present	Hass	1936
in Ornithodoros moubata	exptl; >36 d	Parker	1942
in Rhipicephalus sanguineus	survives through life cycle	Steinhaus	1947
Bullis fever rickettsia			
in Amblyomma americanum	present	Pollard	1946
Coxiella burneti			
in Hymlomma mauritanicum	present; transmitted	Blanc	1949
in " savignyi	" "	Blanc	1946
in Dermacenter occidentalis Amblyomma americanum	" "	Cox	1940
in Dermacentor andersoni	" "	Davis	1939
Tissues and feces of Rhipicephalus sanguineus	exptl; present; transmitted	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 / 5 (CONT'D) THE SURVIVAL OF RICKETTSIA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
TICKS (cont'd)			
Coxiella burneti (cont'd)			
in Dermacentor andersoni	present	Matheson	1950
in Haemephysalis leachi	present; transmitted	Giroud	1950
in Ornithodoros moubata	4 mos.	Jadin	1950
in Otobius megnini	present	Jellison	1948
in Dermacentor andersoni	present; transmitted	Parker	1938
in Hyalomma savignyi	present	Parker	1939
in Amblyomma americanum	present	Parker	1943
in Phipicephalus sanguineus	present	Parker	1949
Feces - dried of ticks	viable in storage as long as 586 d	Philip	1948
in Haemaphysalis humerosa	present; transmitted	Smith	1940

TABLE 4.16 THE SURVIVAL OF SALMONELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
S. paratyphi			
Stomach of Cimex lectularis	exptl; 2-3 wks.; not transmitted	Caspari	1939
COCKROACHES			
S. typhosa			
Body and feet of Periplaneta orientalis	present; transmitted	Antonelli	1930
Feces of cockroaches	present	Riley	1932
S. typhimurium			
Intestinal tract Appendages of Periplaneta americana	present	Beck	1943
Feces	Inoc: 4-10 million exptl; 11 d		
Alimentary canal of cockroaches	" 7 d	Janssen	1952
Feces of Blaberus cranifer	exptl; Inoc: massive doses 12 d	Wedberg	1949
S. paratyphi B in Periplaneta americana	present; transmitted	Bitter	1949
S. oranienburg			
in Periplaneta americana	present; transmitted	Bitter	1949
Feces of Periplaneta americana	Inoc: 100 million 10 d		
Feces of Blattella germanica	Inoc: 100 million 12 d		
Tissues	Inoc: 100 million; 42 d		
Feces of Blatta orientalis	" " " 20 d	Olson	1950
S. bredeney			
Hindgut of Periplaneta americana	present; transmitted	Bitter	1949
S. bovis-morbificans			
Appendages Intestinal tract of cockroaches	present	Mackerras	1948
S. spp.			
Intestinal tract Appendages	18-42 d	Mackerras	1948
FLEAS			
S. enteritidis			
Body and feces of Xenopsylla cheopis	exptl; present; transmitted	Eskey	1949
Body	exptl; 96 hr.; transmitted		
Feces of Pulex irritans Ctenocephalus canis	exptl; <24 hr.; transmitted	Varela	1946

TABLE 2/6 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
FLEAS (cont'd)		
S. choleraesuis		
in Pulex irritans	present; transmitted	Messerlin 1942
FLIES		
S. typhosa		
in flies	present	Bahr 1914
in flies	"	Bertarelle 1910
Feces	"	
of Musca domestica		Celli 1888
in flies	"	Cochrane 1912
Legs	exptl; present	
Feces	" greater trans-	
of flies	mission than legs; 16d	Faichnie 1909
Intestinal tract	multiplied	
of flies		Faichnie 1929
in Musca domestica	exptl; 23 d; transmitted	Matheson 1950
Intestinal tract	5-23 d	
of flies		Fickler 1903
Intestinal tract	present	
of flies		Graham-Smith 1909
Intestinal tract	exptl; present	
of flies		Graham-Smith 1913
Externally	exptl; 11 d	
Intestinal tract	" 15 d	
Internally -		
killed with DDT	" 7 d	
" " fly paper	" 10 d	
of Musca domestica		Gross 1951
Intestinal tract	present	
of Musca domestica		Hamilton 1903
in Musca domestica	present	Howard 1911
In or on body	23 d	
of Musca domestica		Jordan 1908
in flies	present	Klein 1908
in Musca domestica	"	Ledingham 1911
in flies	"	Manson-Bahr 1919
in flies	"	Veeder 1898
S. paratyphi B		
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 Musca domestica		Hawley 1948
Feces	Inoc: 18,000-6,300,000	
of Musca domestica	bacteria	
	Recov: 1st d - 10-200,000,000	
	6th d - 200,000,000	Hawley 1951
Intestines	at least 11 d	
of Musca domestica		Nicoll 1911

TABLE 2/6 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
FLIES (cont'd)		
S. paratyphi		
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
S. enteritidis		
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
S. cholerae-suis		
in Musca domestica	present	Scott 1917
S. spp.		
Feces of Musca domestica	present	Hawley 1951
LICE		
S. typhosa		
in Pediculus capitis		
" corporis	present; transmitted	Abe 1907
S. enteritidis		
in lice	present	Huang 1937
MOSQUITOES		
S. paratyphi		
Intestines of Culex pipiens	3-4 wks.	Felsenfeld 1947
S. enteritidis		
in Aedes egypti	exptl; 1 hr.	Varela 1950
TICKS		
S. enteritidis		
Feces of Dermacentor andersoni	35 d	Parker 1943
in Dermacentor andersoni	present	Reitler 1946

TABLE 4/7 THE SURVIVAL OF SHIGELLA SPECIES IN INSECTS

Factor(s)	Survival	Reference
ANTS		
S. paradysenteriae		
Feet of ants	at least 24 hrs.	Griffitts 1942
FLIES		
S. dysenteriae		
Internal and external of Chrysomyia megacephala	5-6 d	Chow 1940
in flies	present	Dudgeon 1919
Body	Inoc: fed a suspension of 12,000-48,000 organisms Recov: multiplied in body	
Feces of Musca domestica	present	Hawley 1948
Feces of Musca domestica	Inoc: 12,000-6,300,000 bacteria Recov: 1st d - 10-200,000,000 6th d - 200,000,000	Hawley 1951
Bowel of flies	5 d	Manson-Bahr 1920
Feces of flies	11 d	Stewart 1944
S. paradysenteriae		
in flies	present	Graham-Smith 1909
in flies	"	Kuhns 1944
S. paradysenteriae (Flexner)		
in flies	273 hrs.	Stewart 1944
S. ambigua (S. dysenteriae-Schmitz)		
in flies	present; 297 hrs.	Stewart 1944
S. spp.		
Intestinal tract of flies	present	Fickler 1903
Intestinal tract of flies	present	Graham-Smith 1909
Intestinal tract of Musca domestica	present	Hamilton 1903
Intestinal tract of Musca domestica	present	Ledingham 1911
Intestinal tract of Musca domestica	present	Nicoll 1911

TABLE 2/8 THE SURVIVAL OF SPIROCHETES IN INSECTS

Factor(s)	Survival	Reference
FLIES		
Treponema pertenue		
in Hippelates pallipes	present; transmitted	Kumm 1936
in Musca domestica		
Hippelates pallipes		
" flavipes	present; transmitted	Steinhaus 1947
REDUVIIDS		
Leptospira icterohaemorrhagicae		
Intestinal tract of Triatoma infestans	exptl; present; 6 d	Liem 1941

TABLE 2 19 THE SURVIVAL OF VIBRIO SPECIES IN INSECTS

Factor(s)	Survival	Reference
COCKROACHES		
Vibrio comma		
Feces	79 hrs.	
of Periplaneta americana		Barber 1914
in Periplaneta americana	present	Toda 1923
FLIES		
Vibrio comma		
Feet, wings, body and feces	present; transmitted	
of flies		Alessandrini
in flies	present	Cattani 1886
in flies	exptl; present	Faichnie 1909
Intestinal tract	exptl; 48 hrs.	
Feces	" 30 hrs.	
of Musca domestica		Graham-Smith 1913
in Musca domestica	present	Hamilton 1903
in Musca domestica	present	Ledingham 1911
in flies	present	Macrae 1895
Feces	present	
of Eristalis tenax Calliphora vomitoria		Maddox 1885
in Musca domestica	present	Nicoll 1911
in flies	present	Simmonds 1892

TABLE 9.20 THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference	
BEDBUGS			
Yellow fever virus			
in Cimex lectularis	2 d	Kumm	1932
Lymphocytic choriomeningitis virus			
22-25C	exptl; present; 10 min.		
in Cimex lecutlaris	to 85 d	Milzer	1942
COCKROACHES			
Poliomyelitis virus			
Intestinal tract	present; 24 hrs.		
of cockroaches		Hsiang	1952
Tissues - 30C	exptl; 15 d		
of cockroaches		Hurlbut	1949
Hemocoele	exptl; 15 d; transmitted		
of cockroaches		Hurlbut	1950
Poliomyelitis viruses - GDVII, C group A and human polio virus			
Body	exptl; present		
Feces	" killing amounts		
of Periplaneta americana	excreted for 7-15 d		
human polio virus			
in Periplaneta americana			
Supella supellactilium			
Blattella germanica	natural vectors for Brunhilde, Minnesota and Mahoney strains	Syverton	1952
Lymphocytic choriomeningitis virus			
in Blattella germanica	present	Steinhaus	1944
Coxsackie virus			
Feces	exptl; 15 d; transmitted		
of cockroaches		Fischer	1951
Mouse encephalitis virus			
Feces	exptl; present; trans-		
of cockroaches	mitted; 7 d	Syverton	1950
FLIES			
Poliomyelitis virus			
Lansing strain	exptl; 2 d		
Theiler strain	" 12 d		
	only when adult itself acquires virus by		
in Musca domestica	feeding	Bang	1943
Surface and alimentary tract	exptl; at least 48 hrs.		
of flies		Flexner	1911
Surface and alimentary tract	exptl; at least 48 hrs.		
of flies		Howard	1912
Tissues			
30C	exptl; 12 d		
of Musca domestica		Hurlbut	1949

TABLE 2 2d (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference	
FLIES (cont'd)			
Poliomyelitis virus (cont'd)			
Hemocoele of flies	exptl; 12 d; transmitted	Hurlbut	1950
in Phormia regina Phaencia sericata Musca domestica Sarcophaga spp. Cynomyopsis cadaverina	present	Melnick	1949
Gut	exptl; 2 wks.		
Feces	" 3 wks.		
of Phormia regina		Melnick	1941
in Muscidae Calliphoridae	may harbor virus in nature	Paul	1941
Abdomen, feces, vomit (Lansing strain)	exptl; 2 d		
of Musca domestica		Rendtorff	1943
in Muscidae Calliphoridae	may harbor virus in nature	Sabin	1942
in Muscidae Calliphoridae	may harbor virus in nature	Tomey	1941
in Muscidae Calliphoridae	may harbor virus in nature	Trask	1943
LICE			
Eastern equine encephalitis virus			
in Eomenacanthus stramineus	present	Howitt	1948
MITES			
St. Louis encephalitis virus			
in Dermanyssus gallinae	exptl; present; transmitted	Smith	1941
in Dermanyssus gallinae	present; transmitted	Smith	1944
in Dermanyssus gallinae	" "	Smith	1945
Eastern equine encephalitis virus			
in Dermanyssus gallinae	present	Howitt	1948
Western equine encephalitis virus			
in Dermanyssus americanus	present	Miles	1951
in Liponyssus sylvarium	"	Reeves	1947
in Dermanyssus gallinae	"	Sulkin	1945
MOSQUITOES			
Yellow fever virus			
in Haemagogus capricorni	exptl; present; transmitted	Bates	1944
in " "	present; transmitted	Bushell	1944
in " "	" "	Bugher	1944
In Culex fatigans	exptl; 39 d; transmitted	Davis	1933

TABLE 22 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference	
MOSQUITOES (cont'd)			
Yellow fever virus (cont'd)			
Most tissues of mosquitoes	Inoc: titer of 1 billion lethal doses/cc Recov: Immediately after - 1-2 million lethal doses 2 wks - 1% of inoc.		
	exptl; 2 wks.	Davis	1933
in Aedes africanus	present; transmitted	Haddow	1948
in Aedes egypti	" "	Hargett	1944
in Aedes egypti	duration of life of mosquito (which may be over 200 d)	Herms	1950
in Aedes egypti	present; transmitted	Reed	1900
in mosquitoes 30C for 14 d, 1.1-4.4C thereafter	exptl; present; 32 d	Ross	1950
in Haemagogus capricorni	present; transmitted	Shannon	1938
in Aedes africanus	" "	Smithburn	1949
Nearly all tissues of approx. 20 spp.	through life of mosquito	Steinhaus	1947
in Aedes egypti			
killed with ether	4 hrs.		
" " tobacco smoke	20 hrs.		
" " KCN	45.5 hrs.		
" " Chloroform	½-1 hrs.		
starved	17.5 hrs.		
in Haemagogus equinus			
" spegazzinii	present	Waddell	1945
in Haemagogus capricorni	exptl; present	Waddell	1948
in " equinus	" "	Waddell	1947
in Aedes egypti	multiplied	Whitman	1937
Dengue fever virus			
in mosquitoes	present; transmitted	Ashburn	1907
Temp. below 18C	lose infectivity		
" above "	regain "		
in mosquitoes	174 d; transmitted	Blanc	1929
in Aedes egypti	present; transmitted	Chandler	1923
in mosquitoes	" "	Matheson	1950
in Aedes egypti	duration of life of mosquito (which may be over 200 d)	Herms	1950
in Aedes scutellaris	exptl; present; transmitted	Mackerras	1946
in Aedes egypti	present; virulence may lessen with serial passage; lives longer in live than dead tissues	Simmons	1931

TABLE 120 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference	
MOSQUITOES (cont'd)			
St. Louis encephalitis virus			
in Culex tarsalis			
" pipiens			
" coronator			
" quinquefasciatus			
Aedes lateralis			
" taeniorhynchus			
" vexans			
"			
Theobaldia incidens	exptl; present; transmitted	Hammon	1943
Culiseta inornata			
in Aedes dorsalis	present; transmitted	Hammon	1947
in Culex tarsalis	" "	Hammon	1943
in Culex pipiens			
" quinquefasciatus			
Anopheles punctipennis			
" quadrimaculatus			
Aedes egypti			
" triseriatus			
" vexans	exptl; present; transmitted	Smith	1941
in Culex tarsalis			
" pipiens			
Culiseta inornata	present; transmitted	Steinhaus	1947
Poliomyelitis virus			
in Culex pellens			
Aedes aloopictus	3 wks.	Paul	1947
Eastern equine encephalitis virus			
in Culiseta melanura	present; transmitted	Chamberlain	1951
in Aedes vexans			
" sollicitans			
" cantator			
" atropalpus			
" triseriatus	exptl; present	Matheson	1950
in Mansonia perturbans	present	Howitt	1949
in Aedes egypti	at least 36 d; transmitted	Kelser	1933
in Aedes egypti			
" sollicitans	1,000-10,000 fold increase; 63 d	Merrill	1934
All tissues of Aedes egypti	present for duration of life but able to transmit only approx. 2 mos	Merrill	1935
in Aedes albopictus			
" sollicitans			
" dorsalis			
" lateralis			
" geniculatus			
" vexans	present; transmitted	Steinhaus	1947

TABLE 220 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference	
MOSQUITOES (cont'd)			
Western equine encephalitis virus			
in Aedes dorsalis	present; transmitted	Hammon	1947
Culex tarsalis	" "	Hammon	1945
in " "	" "	Hammon	1943
in " "	" "	Kelser	1938
in Aedes taeniorhynchus			
in Culex coronator			
Theobaldia incidens	exptl; present; transmitted	Steinhaus	1947
in Culex tarsalis			
" pipiens			
Culiseta inornata	present; transmitted	Steinhaus	1947
in Aedes dorslais	" "	Thompson	1951
Japanese B encephalitis virus			
in Culex tritaeniorhynchus			
" pipiens var. pallens	exptl; present; transmitted	Hammon	1949
in Culex tritaeniorhynchus	present	Hammon	1949
in Aedes chemnlpoensis	exptl; 15 d; transmitted.		
Culex pipiens var. pallens	exptl; 15 d; not transmitted.	Huang	1951
Temp. of 8-12C.	91 d		
in Culex quinquefasciatus		Hurlbut	1949
in mosquitoes	exptl; multiplied-max. titer recovered; 17d	Hurlbut	1951
in Culex quinquefasciatus			
" annulirostris	exptl; present	Hurlbut	1948
Lymphocytic choriomeningitis virus			
in Aedes egypti	exptl; present; transmitted	Coggeshall	1939
Temp. of 26-34 C.	exptl; present		
Temp. of 37C, 25C, or lower	exptl; not present		
in Culex pipiens			
" albopictus		Milzer	1942
Encephalomyocarditis virus (Mengo encephalomyelitis virus)			
in Taeniorhynchus fuscopennatus			
Taeniorhynchus spp.	present	Dick	1948
Venequelan equine encephalitis virus			
in Aedes taeniorhynchus			
Anopheles neomaculipalpis			
Mansonia titillans	present; transmitted	Matheson	1950

TABLE 2-20 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference	
MOSQUITOES (cont'd)			
Venezuelan equine encephalitis virus (cont'd)			
in Aedes geniculatus			
" aegypti,			
" albopictus	exptl; present; transmitted	Roubaud	1941
Neurotropic virus group			
in Aedes spp.			
Psorophora spp.	present; transmitted	Laemmert	1947
in mosquitoes	present	Roca-Garcia	1944
Rift Valley fever virus			
in Eretmapodites spp.			
Aedes spp.	present; transmitted	Smithburn	1948
REDUVIIDS			
Yellow fever virus			
in Triatoma megista	exptl; 1 wk; not transmitted by bite	Davis	1933
Western equine encephalitis virus			
in Triatoma sanguisuga	present; transmitted	Kitselman	1940
Venezuelan equine encephalitis virus			
in Triatoma infestans	exptl; present; not transmitted; 17 d	Lepine	1941
TICKS			
Yellow fever virus			
in Amblyomma cajennense	15 d; not trans. by bite		
Argas persicus	6 d; " " " "		
Rhipicephalus sanguineus	23 d; " " " "		
Boophilus microphilus	10 d; " " " "		
	exptl.	Davis	1933
Eastern equine encephalitis virus			
in Dermacentor andersoni	exptl; present; transmitted	Syverton	1941
Russian spring and summer encephalitis virus			
in Ixodes persulcatus	present; transmitted	Chumakov	1939
in " "	" "	Chumakov	1940
in Ornithodoros moubata	exptl; 40 d	Parker	1942
All organs	present		
gut	25 d		
of Ixodes persulcatus		Pavlovskii	1940
St. Louis encephalitis virus			
in Dermacentor variabilis	exptl; present; transmitted	Blattner	1941
Temp of 12.5C	exptl; 10 mos.; trans-		
in Dermacentor variabilis	mitted	Blattner	1944

TABLE 20 (CONT'D) THE SURVIVAL OF VIRUSES IN INSECTS

Factor(s)	Survival	Reference
TICKS (cont'd)		
Colorado tick fever virus		
in Dermacentor andersoni	present; transmitted	Florio 1948
in " variabilis	exptl; present; transmitted	Florio 1950
in " andersoni	present; transmitted	Florio 1950
Lymphocytic choriomeningitis virus		
in Dermacentor andersoni	present; transmitted	Humphreys 1944
Feces of Dermacentor andersoni	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
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 EFFECT OF PRESSURE ON THE PERSISTENCE (SURVIVAL) OF ORGANISMS

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TABLE P

THE EFFECT OF PRESSURE ON THE SURVIVAL OF MICROORGANISMS

Factor(s)	Survival	Reference	
Escherichia coli			
5,000 atm. hydrostatic pressure	45 min.	Basset	1937
10,000 bolts in an evaccuated 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	"	"
Aerobacter aerogenes			
85-100 thousand lb./sq. in.	4-5 min.	Hite	1914
50-65 " " " "	10 min.	"	"
30-45 " " " "	1 hr.	"	"
Salmonella typhosa			
5,000 atm. hydrostatic pressure	45 min.	Basset	1937
10,000 volts in an evaccuated tube	1 hr.	Dognon	1930
40-45 thousand lb./sq. in.	Killed	Hite	1914
Salmonella paratyphi A & B			
10,000 volts in an evaccuated tube	1 hr.	Dognon	1930
Salmonella typhimurium			
High tension, low pressure ultraviolet lamp in test tube of liquid cult.	5 min.	Gilles	1935

TABLE Pr (CONT'D) THE EFFECT OF PRESSURE ON THE SURVIVAL OF MICROORGANISMS

Factor(s)	Survival	Reference	
S. typhosa bacteriophage			
4500 atm. of pressure	Resists	Basset	1937
Bacillus subtilis bacteriophage			
4500 atm.	Resists	"	"
Bacillus megatherium bacteriophage			
4500 atm.	Resists	"	"
Rabies virus			
4000 atm	30 min.	"	"
Herpes virus			
7000 atm.	" "	"	"
Yellow fever virus			
3000 atm.	" "	"	"
Foot-and-mouth virus			
3000 atm.	" "	"	"
Encephalomyelitis virus			
<6500 atm.	" "	"	"
Smallpox virus			
4500 atm.	45 min.	Waeser	1937
Mold			
10,000 volts in an evacuated tube	1 hr.	Dognon	1930
Yeast			
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.	"	"
Bacteria general			
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 IV (CONT'D) THE EFFECT OF PRESSURE ON THE SURVIVAL OF MICROORGANISMS

Factor(s)	Survival	Reference	
Streptococcus faecalis			
10,000 volts in an evacuated tube	1 hr.	Dognon	1930
Streptococcus cremoris			
85-100 thousand lb./sq. in.	4-5 min.	Hite	1914
50-65 " " " "	10 min.	"	"
30-45 " " " "	1 hr.	"	"
Micrococcus aureus			
Liquid, 3000 atm. pressure, ordinary temp.	Recov. ≠, 45 min.	Basset	1932
Liquid, 6000 atm. " ordinary temp.	" 0, time not given	"	"
Micrococcus spp.			
5000 atm. hydrostatic pressure	45 min.	"	"
10,000 volts in an evacuated tube	1 hr.	Dognon	1930
Mycobacterium tuberculosis			
Liquid, 3000 atm., ordinary temp.	Recov. ≠, 45 min.	Basset	1932
Liquid, 6000 atm., " temp.	" 0, time not given	"	"
Pasteurella sp.			
> 2000 atm.	30 min.	Basset	1937
Bacillus subtilis			
Liquid at 17,600 atm., ordinary temp.	Recov. ≠, 45 min.	Basset	1932
20,000 atm. hydrostatic pressure	> 45 min.	"	1937
Bacillus anthracis			
10,000 volts in an evacuated tube	1 hr.	Dognon	1930
Proteus vulgaris			
10,000 volts in an evacuated tube	1 hr.	"	"
Serratia marcescens			
Liquid, 3000 atm., ordinary temp.	Recov. ≠, 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.	"	"
Corynebacterium diphtheriae			
40-45 thousand lb/sq. in.	Killed	"	"
Diplococcus pneumoniae			
5000 atm. hydrostatic pressure	45 min.	Basset	1937
Micrococcus bacteriophage			
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
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 EFFECT OF RADIATION ON THE PERSISTENCE (SURVIVAL) OF ORGANISMS

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TABLE R1 THE EFFECT OF RADIATION ON BACILLUS SPECIES

Factor(s)	Survival	Reference
ULTRAVIOLET		
B. anthracis		
Uv.	Killed	Phelps 1939
Uv. 452 erg/mm^2 at 2537A°	Reduc. 90%	Sharp 1939
Uv.	Chief factor in sunlight and artifical light	Ward 1894
B. subtilis		
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^2	Kil[illegible]	" 1944
Uv.	"	Phelps 1939
Uv. 62000 erg/cm^2	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
B. megatherium		
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
B. sp.		
Uv. 2537 A°	Kills	Lea 1940
LIGHT		
B. anthracis		
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 " " no air	>83 hr.	" "
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
B. subtilis		
Sunlight	8 hr.	Weinzirl 1914
B. megatherium		
Sunlight	" "	" "

TABLE R1 (CONT'D) THE EFFECT OF RADIATION ON BACILLUS SPECIES

Factor(s)	Survival	Reference	
ULTRASONIC			
B. anthracis			
Saline, ultrasounds frequency 320 kc.	Inoc. 3.5×10^9, Reduc. 97.5%, 45 min.	Grabar	1945
B. megatherium			
Ultrasounds frequency 320 kc.	Inoc. 4.4×10^8, Reduc. 99.7%, 45 min.	"	
OTHER RADIATION			
B. anthracis			
10,000 v. in evacuated tube	1 h.	Dognon	1930
B. subtilis			
High voltage cathode rays	1 sec.	Porter	1947

TABLE R2) THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference	
ULTRAVIOLET			
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 mm.	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	Ishmenetskii	1946
Uv. 2537 A°, with room lights on, in air.	Respiratory org. recov. 0.5%, 2 hr.	Knowles	1950
Uv. partial radiation	Not given	Lidwell	1946
" absorption	Bactericidal	"	
" open agar plate	15 min.	Miller	1948
" 20 microwatts/sq. cm. 2537 A°, in air.	Recov. adequate disinfection, 250-500 sec.	Mudd	1944
Uv. 30 microwatts/sq. cm. 2537 A°, in air	Recov. same, 167-334 sec.	"	
Water contaminated with clay and turf, Uv.	Not so easily ster. as clear water	Ohlon-Plom	
Uv. rays	The bactericidal effect not due to action of HNO_2, O_3 or water but to direct action of rays on protoplasm	"	
" "	Older resting cells more resistant than younger cells in cell division	Oster	1934
" "	Reduc. 80%, 0.2 sec.	Perkins	1929
" "	Larger forms more resistant		
" " on air	Bactericidal	Rentschler	1940
" " "	1/10 as resistant in air as in agar. More resistant at high R.H.; Less resistant if first exposed to heat.	"	1941
Low press. Hg. discharge in Uv. transmitting glass	35% killed/4 tantalum units.	"	1942

TABLE R2 (CONT'D) THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference
ULTRAVIOLET		
Low press. Hg discharge in quartz	36.0% killed/4 tantalun 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
LIGHT		
Sunlight in cities	Important in destruction	Clement 1886
Long continued, strong, direct sunlight	Bactericidal	DeLarequette 1918

TABLE R21 (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	Meader 1926
" , waves shorter than 3100 A°	Lethal	" "
Subnormal sunshine and ppt.	Long survival of infect-agents in air	Meissner 1940
Sunlight	Not given	Rossi 1924
Sun on pathogenes	" "	Granchor 1889
Sunlight on sea bact.	Recov. 26 bact./cc at surf, 420/cc at 25 meters depth	Schmidt-Nielson 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 Spore-formers less resistant	Gastaldi 1949
Roentgen rays	Incidental morphological	Rozhin-Kokhanii 1948

TABLE R2 (CONT'D) THE EFFECT OF RADIATION ON BACTERIA (GENERAL)

Factor(s)	Survival	Reference	
ULTRASONIC			
Sonic energy	Proteins interfer with germicidal action	Beckwith	1936
Ultrasonic waves	Death of cell	Kvasnikov	1941
" vibrations	Disintergration	Loiseleur	1945
OTHER RADIATION			
Electric energy	Not given	Sugiyama	1951
Continous current at 260-320 milliamperes on bouillon, 98.5C	10 min.	Zeit	1901
Continous current 48 milliamperes, 37C	2-3 hr.	"	"
Continous current 100 " amperes,	75 min.	"	"
Photosensitivity	Gram-neg. less susceptible than gram - posit.	Porter	1947
Heat on thermophilie bact.	No effect	Arrhenius	1927

TABLE R3 THE EFFECT OF RADIATION ON BACTERIOPHAGE

Factor(s)	Survival	Reference	
ULTRAVIOLET			
E. coli phage			
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
Sh. dysenteriae phage			
Uv. 6 or 1.5 erg/sq. mm. per sec. and 2537 A°	Inactivated, larger phage more sensitive	Latarjet	1945
LIGHT			
Micrococcus phage			
Indirect sunlight on 0.01 -0.1% M.B.	5 min.	Clifton	1931
Sunlight 1:100,000 methylene blue	Greatest inactivation	Porter	1947
Virus +2 phage			
Daylight bulb	Recov. 3%, 70 hr.	Latarjet	1951
ULTRASONIC			
E. coli phage			
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.	"	"
OTHER RADIATION			
General phage			
Radium 7-8 microcuries	3 d. contact	Bruynoghe	1925

TABLE R4 THE EFFECT OF RADIATION ON BRUCELLA SPECIES

Factor(s)	Survival	Reference	
LIGHT			
B. melitensis			
Tropical sunlight, 44 C.	Inoc. 1 loop 24 h. cult., Recov. 0, 45 min.	Ukil	1927
B. sup.			
Sunlight & dryness	Lower incidence of disease	Polding	1947
ULTRASONIC			
B. melitensis			
2641 kc.	Cell in smooth phase yielded cells in rough phase in 3 h.	Rucci	1949

TABLE R5 THE EFFECT OF RADIATION ON DIPLOCOCCUS PNEUMONIAE

Factor(s)	Survival	Reference	
ULTRAVIOLET			
Uvs	Less susceptible than other org. studied	Wells	1945
LIGHT			
Sunlight	Larger strains more resistant	Colowey	1942
Tropical sunlight, 55C	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 R6

THE EFFECT OF RADIATION ON ESCHERICHIA COLI AND AEROBACTER AEROGENES

Factor(s)	Effect	References	
ULTRAVIOLET			
E. coli			
Phys. split sec., ultra-violet lamp (160v, 6-8 amps) dist. of 50cm	More resistant when sensitized with own immune serums	Akzyama	1935
U.v. rays, 15 units	40 sec.	Baker	1933
" at 3500 A°	1 hr	Bayne-Jones	1923
"	Shorter time	Brooks	1933
" 295-6 mm.	150-300 min.	Brownlee	1917
Wave lengths 2800, 2650-2700 & 2540 A°	Kills	Bruger	1928
0.01 watt/sq. ft.	Kills 100%, 1 min.	Bustolph	1943
Agar-broth cult., pH 7.4 60 kv.	24 hr.	Cavalli	1929
Wave lengths less than 2800 A°	Lethal effect	Coblentz	1924
U.V. 2540 A°	Killing	Ehrismann	1929
" , 45% R.H.	More lethal than at high humidity	Elford	1942
"	Inoc. Immeasurable, Recov. 8 3 min	Neet	1939
" 24,000 erg/cm²	Kills	"	1934
" 200 erg/mm²	"	Ercolk	1936
" 3500-4900 A°	Not given	Hollaender	1943
" without molecular oxygen	Photoreactivation	Johnson	1950
U.v., 200 erg.	Recov. 50%	Luterjek	1943
" rays of 2537 A°	Kills	Lea	1940
" " " " "	Develops resistivity	Luckiesh	1942
"	" "	Hollaender	1943
" dist. of 17 cm	20 min.	Nobeko	1928
" in raw water	Inoc. 1500/cc, Recov. Practically 0 10 sec.	Schwarz	1911
" 245 erg/mm² at 2537A°	Reduc. 90%	Sharp	1939
" 24000 erg/cm²	Lethal	"	1940
"	Older strains less resistant than younger	Stenstrom	1931
"	30 min.	Tanner	1930
" in broth and air	Recov. 1, 30 min	Watts	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%	Wasley	1940
"	Relatively resistant	Witkin	1947
"	The shorter the wave length 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	
ULTRAVIOLET			
A. aerogenes			
U.v.	Destroys the ability to grow on ammonia	Peacocke	1948
LIGHT			
E. coli			
Watery susp'n of fresh cult. placed on petri dishes in sunlight	Inoc. 1 cc., Reduc. 96%, 10-15 min.	Clark	1903
			1939
Stored water, sunlight	4-5 wk.	Raghavachari	
Diffuse light on polluted water	Inoc. pure cult., death rate was higher in polluted water	Smit	1931
Sunlight 49 C., in urine	Inoc. pure cult., 1 loop 24 h., Recov. 0, 3 h.	Ukil	1927
" 45 C., in feces	Inoc. 1 loop 24 h. cult. Recov. 0, 3 h.	"	
Broth and air in dark	Recov. 3/10 sq. ft., 120 min.	Wells	1935
" " " light	Recov. 0, 120 min.	"	
X-RAY			
E. coli			
X-ray	Younger die quicker	Cavalli	1948
" 2000,2200 roentgen	37% survival	Fram	1950
Susp'n irradiated with 250 kv. x-rays at 40,000 r/hr.	Only 1/3 sensitivity when oxygen was reduced by saturation with N_2, CO_2, etc.	Hollaender	1951
X-ray	Relatively resistant	Witkin	1947
A. aerogenes			
X-ray 14,000 Roentgens	37% survival	Fram	1950
ULTRASONIC			
E. coli			
Ster. buffer soln., 15.5 C. crystal ultrasonorator used.	Inoc. 6,000;66,000; 628,000 & 6,000,000/ml. Recov. 99%, 40 min.	Horwood	1950
Ultrasonic or standard phosphate buffer	Inoc. $1x10^6$/cc. Reduc. 99.9%, 15 min.	Whitney	1951
OTHER RADIATION			
E. coli			
2300 v. of electrons	Recov. 50%	Dieckmann	1950
10,000 v. in evacuated tube	1 h.	Dognon	1930
Neon light sensitized with methyl violet	No results in 2 hr.	Philibert	1926
Cult. of bouillon with radium	0 multiplication, 48 h.	Bruynoghe	1925

TABLE R7 THE EFFECT OF RADIATION ON MICROCOCCUS SPECIES

Factor(s)	Survival	Reference
ULTRAVIOLET		
M. aureus		
Uv. at 3500A°	1 hr.	Bayne-Jones 1923
"	Shorter time	Brooks 1942
Wave lengths of 2800, 2650, 2700 and 25 40 A°	Kills	Burger 1928
Uv. rays 2000-2950 A°	Reduc. ct.	Cathcart 1942
" " 2660 A°	Bactericidal action	Gates 1929
"	"	Hart 1937-41
" 26000 erg/cm^2	Killed	" 1944
"	"	Laurens 1938
"	Survived	Phelps 1939
" 260 erg/mm^2 at 2537A°	Reduc. 90%	Sharp 1939
" 26000 erg/cm^2	Lethal	" 1940
"	More susceptible than Bacillus veget. and influenza virus	Wells 1945
M. albus		
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^2	Killed	" 1944
Uv. 26200 erg/sq. cm.	1.06 sec.	Sharp 1938
Uv. 23000 erg/cm^2	Lethal	" 1940
Uv. 184 " /mm^2 at 2537A°	Reduc. 90%	" 1939
Uv. at 2x10^4 ergs	Killed	Wells 1931
Uv. at 5x10^6 " /mm. Hg in vacuum	"	" "
Uv.	More susceptible than Bacillus veget. and influenza virus, Diplococcus, Serratia, S. aureus	" 1945
M. luteus		
Uv.	Not given	Boston 1950
M. citreus		
Wave lengths of 2800, 2650, 2700 & 2540A°	Kills	Burger 1928
Uv.	Inoc. 160, Recov. 6, 3 min.	Hart 1939
M. roseus		
Uv.	30 min.	Tanner 1930
M. epidermis		
Uv.	" "	" "
M. spp.		
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	
LIGHT			
M. aureus			
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.	Ukil	1927
M. spp.			
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
X-RAY			
M. aureus			
X-ray 3600-4400	37% survival	Fram	1950
ULTRASONIC			
M. aureus			
Ringer soln., ultrasound frequency 320 kilocycle	Inoc. 40.2×10^9, Reduc. 90.4%, 45 min.	Grabar	1945
[illegible]ER RADIATION			
M. albus			
Low velocity electrons	Killed	Wells	1931
M. spp.			
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	
ULTRAVIOLET			
Alcaligenes melitensis			
Uv. 15 units	40 sec.	Baker	1926
Alcaligenes sp.			
Uv. 15 units	30 min.	Tanner	1930
Corynebacterium diphtheriae			
Uv. on agar	Reduc. marked, 5 min.	Bedford	1927
Uv. 337 erg/mm^2 at 2537 A°	Reduc. 90%	Sharp	1939
Uv.	More susceptible than Bacillus, Serratia, Staph, Diplococcus, influenza virus	Wells	1945
Corynebacterium pseudodiphtheriticum			
Uv. on agar	Reduc. slight, 5 min.	Bedford	1927
Hemophilus influenzae			
Uv.	Shorter time	Brooks	1942
Klebsiella pneumoniae			
Uv.	Inoc. innumerable, Recov 19, 3 min.	Hart	1939
Lactobacillus acidophilus			
Uv.	Reduced	Du Buy	1948
Proteus vulgaris			
Uv.	Inoc. innumerable, Recov. 2, 3 min.	Hart	1939
Uv.	Older strains less resistant	Stenstrom	1931
Serratia marcescens			
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^2	"	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^2 at 2537 A°	Reduc. 90%	Sharp	1939
Uv. 20,000 erg/cm^2	Lethal	"	1940
Uv. 135 cm. away	Recov. 0, 25 min.	Strebel	1901
Uv.	More susceptible than Bacillus, Staph., Dilococcus, influenza virus	Wells	1945
LIGHT			
Azotobacter sp.			
Soil in sun	Destroys	Dhar	1939
Corynebacterium diphtheriae			
Neon light sensitized with methyl violet	Recov. 0, 5 min.	Philibert	1926

TABLE R8 (CONT'D) THE EFFECT OF RADIATION ON MICROORGANISMS

Factor(s)	Survival	Reference
LIGHT (cont'd)		
Corynebacterium diphtheriae		
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
Corynebacterium spp.		
Drying in dark	6 wk.	Uttosen 1945
" daylight	4 wk.	"
Leptospira icterohemorrhagica		
Light, R.T.	7 d.	T & W. 19[illegible]
Pasteurella pestis		
Tropical sunlight, 40 C.	Inoc. 1 loop 24 hr. cult., Recov. 0, 5 min.	Ukil 1[illegible]
Proteus spp.		
Neon light	Not destroyed after 30 min.	Philibert 1926
Treponema pallidum		
On cloth, 21.5-25 C., diffuse light	11½ h.	Zinsser 1[illegible]
X-RAY		
Serratia marcescens		
X-ray 1200-1300 roentgens	37% survival	Foam 1950
OTHER RADIATION		
Proteus vulgaris		
10,000 v. in evacuated tube	Not destroyed after 30 min.	Philibert 1926
Serratia marcescens		
10,000 v. in evacuated tube.	1 h.	Dognon 1930

TABLE R4 THE EFFECT OF RADIATION ON MYCOBACTERIUM TUBERCULOSIS

Factor(s)	Survival	Reference	
ULTRAVIOLET			
Saline, uv. 7620-2300 A°	Inoc. 15cc.m of susp'n, Recov. 0, 10 min.	Eidenow	1927
Saline, uv. 5720-2800 A°	Inoc. 15cc.m. of susp'n, Recov. 0, 30 min.	"	"
Uv.	Death slower at low temp than high, pH has no effect	Howze	1926
Guinea pigs infected 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.	Meyer	1924
Quartz-Hg vapor as above plus quinine	25 min.	"	"
LIGHT			
Mixed sputum in sunlight	Inoc. into guinea pigs, 2-72 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	Meyer	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.	Soparkar	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, " " lung	6-8 d.	"	"
Sunlight, 53C	Inoc. 1 loop 24 hr. cult. Recov. 0, 30 min.	Ukil	1927
"	Recov. 0, 20 min.	Weinzirl	1907
X-RAY			
X-ray on agar	64 hr.	Minck	1896
ULTRASONIC			
Saline, ultrasound frequency 320 kilocycles	Inoc. 3.8×10^9, Reduc. 75%, 75 min.	Graber	1945

TABLE R10 THE EFFECT OF RADIATION ON NEISSERIA SPECIES

Factor(s)	Survival	Reference
ULTRAVIOLET		
N. catarrhalis		
Wave lengths of 2800, 2650, 2700, & 2540 A°	Kills	Burger 1928
LIGHT		
N. meningitidis		
24 h. cult., direct sunlight, 10AM-6PM, 35-37 C.	2 h.	1904 Beltencourt
24 h. cult. direct sun 12 noon-evening	"	"
24 h. cult., immersed in water bath; 50 C.	3 min.	"
55 C.	1 min.	"
60, 70, 80 C.	1 min.	"
100 C.	30 sec.	"
24 h. bouillon cult. 0-7 C.	>1 mo.	"
Direct sunlight, dried in films on surface of glass, wood, cotton	Few hrs.	Miller 1944
Diffuse daylight passing 2 layers of gauze	30 h.	"
Diffuse daylight thru cotton towelling & wood	6-7 d.	"
Glass beads, R.T., dark	10 d.	"
Wood " " "	8 d.	"
Cotton " " "	7 d.	"

TABLE R11 THE EFFECT OF RADIATION ON PROTOZOA AND METAZOA

Factor(s)	Survival	Reference
ULTRAVIOLET		
Amoebae		
Short exposure to uv.	Killed	Chamberlain
Paramecium		
Uv.	Killed	Tang, 1937
LIGHT		
Nemator americanus		
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%, 1⅓ mo.	" "
Alternating moist and drying soil	Recov. 0, 8 wk.	" "
Drying soil, dense shade	" " >1 mo.	" "
" " moderate "	" " 10 d.	" "
" " direct sun	" " 5 d.	" "
Feces, strong sun	>2 hr.	Nicoll 1917

TABLE R12 THE EFFECT OF RADIATION ON PSEUDOMONAS SPECIES

Factor(s)	Survival	Reference	
ULTRAVIOLET			
P. aeruginosa			
Full radiation of Hg arc at 8cm. on agar cult.	15 min.	Rozenti	1914
In water, full radiation of Hg arc, 8cm.	Recov. 0, 1 min.	"	"
In water, full radiation of iron arc, 8 cm.	" " " "	"	"
Uv.	Inoc. innumerable. Recov. 38, 3 min.	Hart	1939
Uv. 16000 erg/cm²	Kills	"	1944
Uv.	Survived	Phelps	1939
Dosages of uv. which are ordinary lethal	"	Sharp	1940
Uv. 16000 erg/cm²	Lethal	"	"
P. fluorescens			
Uv.	Not given	Boston	1950
Uv.	More resistant than non-fluorescens, convert short wave lengths into long	Burge	1915
P. sp.			
Uv.	Shorter time	Brooks	1942
LIGHT			
P. aeruginosa			
Tropical sunlight, 44C	Inoc. 1 loop 24 hr. cult. Recov. 0, 1½ hr.	Ukil	1927
Neon light	Not destroyed after 30 min.	Philibert	1926
X-RAY			
P. aeruginosa			
X-ray 1000-1200 roentgens	37% survival	Fram	1950
P. fluorescens			
X-ray 1000-1100 "	" "	"	"
GAMMA RADIATION			
P. aeruginosa			
Cult. of bouillon, petri	2 milliwatts, 45 hr.	Bruynoghe	1925

TABLE R13 THE EFFECT OF RADIATION ON SALMONELLA SPECIES

Factor(s)	Survival	Reference	
ULTRAVIOLET			
S. typhosa			
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
Uv. rays, 15 units	40 sec.	Baker	1926
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
Fluid, pH 2, Uv.	2 sec.	Browning	1917
Wave lengths of 2800, 2650 2700 & 2540 A°	Kills	Burger	1928
Uv.	Inoc. 200 cc. emulsion, Recov. 0, 5 min.	Gilles	1935
Uv. 2100-2800 A°	Very sensitive	Newcomer	1917
Fe sparks, 1990-2005 A°	Recov. 4100, 10 min.	"	
" " 2250-2270 "	" 6500, "	"	
" " 2485-2510 "	" 0 "	"	
" " 2645-2675 "	" 100 "	"	
" " 2845-2885 "	" 700 "	"	
" " 2945-2985 "	" 4500 "	"	
Uv. 214 erg/mm² at 2537 A°	Reduc. 90%	Sharp	1939
Cu sparks, 2130-2140 A°	Recov. 5722, 10 min.	Newcomer	1917
" " 2205-2225 "	" 30 "	"	
" " 1990-2105 "	" 1 "	"	
S. paratyphi A & B			
Uv. ray, 15 units	40 sec.	Baker	1926
S. enteritidis			
Uv. rays 2000-2950 A°	Reduced count.	Cathcart	1942
S. typhimurium			
Uv.	Th shorter the wave the more lethal	Wyckoff	1932
LIGHT			
S. typhosa			
Thin layer of water, sun	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.	Miles	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	
LIGHT (Cont'd).			
S. typhosa			
Direct rays of sun	4-10 h.	Osler	1901
Sunlight, 40 C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 20 min.	Ukil	1927
Neon light	Not destroyed after 30 min.	Philibert	1926
S. paratyphi A			
Sunlight, 42 C.	Inoc. 1 loop of 24 hr. cult., Recov. 0, 30 min.	Ukil	1927
S. paratyphi B			
Sunlight, 48 C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 1 h.	"	
Neon light	Not destroyed after 30 min.	Philibert	1926
S. enter. tidis			
Tropical sunlight, 49 C.	Inoc. 1 loop 24 hr. cult. Recov. 0, 3 h.	Ukil	1927
X-RAY			
S. typhosa			
Bouillon cult., 40 C.	Inoc. 1 loop, Recov. no difference in #, 3 h.	Minck	1896
OTHER RADIATION			
S. typhosa			
Irradiation	0 multiplication	Bruynoghe	1925
10,000 v. in evacuated tube	1 h.	Dognon	1930
S. paratyphi A & B			
10,000 v. in evacuated tube	1 h.	"	
S. typhosa			
Cult. of bouillon, radium	0 multiplication, 48 h.	Bruynoghe	1925

TABLE R14 THE EFFECT OF RADIATION ON SHIGELLA SPECIES

Factor(s)	Survival	Reference	
ULTRAVIOLET			
S. dysenteriae			
Wave lengths 2800, 2650, 2700 & 2540 A°	Kills	Burger	1928
S. paradysenteriae			
Uv. 168 erg/mm² at 2537 A°	Reduc. 90%	Sharp	1939
LIGHT			
S. dysenteriae			
Strong sunlight, cultured in bouillon	< 30 min.	Bamberger	1936
Sealed cult. sunlight	920 d.	Lal	1923
" " direct sunlight & 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.	Ukil	1927
S. paradysenteriae (Flexner)			
Strong sunlight, cultured in bouillon	< 60 min.	Bamberger	1936
Sealed cult., sunlight	1045 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
S. paradysenteriae (Sonne)			
Strong sunlight, cultured in bouillon	< 30 min.	Bamberger	1936
S. ambigua			
Strong sunlight, cultured in bouillon	< 40 min.	"	
ULTRASONIC			
S. dysenteriae			
Isotonic PO_4, pH 7.3, ultrasound frequency 680 kilocycles	Inoc. 120.8×10^8, Reduc. 88%, 30 min.	Grabar	1945
S. paradysenteriae			
Ringer liquid, ultrasound 320 kilocycles	Inoc. 6.2×10^8, Reduc. 98%, 30 min.	"	
OTHER RADIATION			
S. dysenteriae			
Neon light	Not destroyed after 30 min.	Philibert	1926

TABLE R5 THE EFFECT OF RADIATION ON STREPTOCOCCUS SPECIES

Factor(s)	Survival	Reference	
ULTRAVIOLET			
S. pyogenes			
Uv.	Shortened time	Brooks	1942
"	Inoc. innumerable, Recov. 12, 3 min.	Hart	1939
Uv. 216 erg/mm^2 at 2537 Å.	Reduc. 90%	Sharp	1939
S. viridens			
Uv.	Less susceptible than Bacillus spores and t.b.	Wells	1945
S. hemolyticus			
Uv.	Less susceptible than Bacillus spores, t.b., & S. viridans	"	
S. salivarius			
Uv. 200 erg/mm^2 at 2537 Å	Reduc. 99%	Sharp	1939
S. spp.			
Phys. salt soln., Uv. 1 amp (100 v., 6-8 amps) at distance of 50 cm.	More resistant when sensitized with immune serum	Akiyama	1935
Uv.	1946-44.4% present, 1945 -1.9%	Alcreas	1950
Uv., 1 cu. ft. of air	Recov. 0	Henle	1942
Uv. irradiation of upper air	Kills	Jarrett	1948
LIGHT			
S. pyogenes			
Sunlight	Recov. 50%, 40 min.	Buchbinder	1941
Daylight	6 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.	"	
S. spp.			
Visible light	Kills	Buchbinder	1941
Sunlight	Recov. 50%, 5 min.	"	
"	Larger strains more resistant to daylight	Selwyn	1942
Tropical sunlight on agar 42° C.	Inoc. 1 loop 24 h. cult. Recov. 0, 15 min.	Uhl	1927
Sputum, tropical sunlight 50° C.	Inoc. 1 loop 24 h. cult. Recov. 0, 30 min.	"	
Neon light sensitive to methyl violet	Recov. 0, 30 min.	Philibert	1926
OTHER RADIATION			
S. faecalis			
10,000 v, an attenuated tube.	1 h.	Wagner	1950

TABLE R16 THE EFFECT OF RADIATION ON VIBRIO CHOLERAE

Factor(s)	Survival	Reference	
ULTRAVIOLET			
Uv.	Reduc. complete, 5 min.	Bedford	1927
Uv. in raw water	Inoc. 1500/cc, Recov. practically 0, 15 sec.	Schwarz	1911
LIGHT			
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.	Yasukawa	1933
Exposed polarized light, 24C	Inoc 1 in 100,000 dil'n, Recov. 121 colonies, 13-30 hr.	Lal	1926
OTHER RADIATION			
Cult. of bouillon, radium	0 multiplication, 48 hr.	Bruynoghe	1925

TABLE R17 THE EFFECT OF RADIATION ON VIRUSES

Factor(s)	Survival	Reference	
ULTRAVIOLET			
Polio virus			
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% suspn., 75 min. (did not infect animals)	Toomey	1937
Influenza virus			
Uv.	Not given	Hollaender	1944
"	More resistant than E. coli	"	
"	Killed	Wells	1935
"	Sensitive	"	1941
"	More susceptible than Bacillus vaget.	"	1945
Vaccine virus			
Short wave Uv.	40 min.	Barkad	1932
Uv. 480 ergs at 2537 Å	Kills	Rivers	1928
Herpes virus			
Cornea, 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 amps.	Recov. 0, 40 min.	McKinley	1935
Encephalomyelitis virus			
Uv. from alpine sun lamp 1 ft. away of 4.5 amps.	" "	"	
Uv.	Not given	Taylor	1941
Tobacco mosaic virus			
Uv. 3100-2652 Å	Inactivation	Duggar	1934
African horse-sickness virus	"		
Uv.	"	Polson	1950
Measles, chicken-pox, mumps			
Uv.	Sensitive	Wells	1941
Virus general			
Uv. 2537 Å.	Sensitivity similar to bacteria	Hollaender	1943
Uv.	Correlation between inactivation dose & size	Lea	1947
LIGHT			
Polio virus			
Direct sunlight	30 min.	Carlson	1942
Sunlight	Rapidly killed	Flexner	1916
Vaccinia virus			
Thiazine, acridine & chloxanthine dyes & light energy	< 5 min.	Herzberg	1933
Foot & mouth virus			
Dried & exposed to noon August sun.	1 h.	Sedson	1927

TABLE R17 (CONT'D) THE EFFECT OF RADIATION ON VIRUSES

Factor(s)	Survival	Reference
LIGHT (cont'd)		
Foot & mouth virus		
Dried & exposed to winter light	>1 h.	Bedson 1927
ULTRASONIC		
Polio virus		
Sonic vibration	Not affected	Scherp 1936
OTHER RADIATION		
Polio virus		
High speed electrons	Inacti ated	D ck 195[illegible]

TABLE R18 THE EFFECT OF RADIATION ON YEASTS, MOLDS, & FUNGI

Factor(s)	Survival	Reference	
ULTRAVIOLET			
Yeasts			
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
Molds			
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
Fungi			
Uv.	Lethal action, pigmentation is a defense	Chavarria	1924
" 2650 Å	Increased resistance with age	Dimond	1941
Uv. in petri dishes at 25 cm.	1-10 min.	Fever	1920
Uv.	Inoc. innumerable, Recov. 0, 20 min.	Hart	1939
Uv. 3,000 Å	Kills	Hollaender	1943
LIGHT			
Fungi			
Sunlight	Not given	Ward	1894
"	8 h.	Weinzirl	1914
ULTRASONIC			
Yeasts			
Ringer soln., ultrasound frequency 680 Kilocycle	Inoc. 1.3×10^9, Reduc. 85%, 30 min.	Grabar	1945
OTHER RADIATION			
Molds			
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
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 SOIL

TABLE #	TABLE OF CONTENTS	PAGES
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TABLE 5/ THE SURVIVAL OF BACILLUS SPECIES IN SOIL

Factor(s)	Survival	Reference	
MUD			
B. subtilis			
Black mud, dark, moist	Recov. 0, >80 d.	Rubentschik	1936
B. cereus var. mycoides			
Black mud dark, moist	Recov. 0, " "	"	"
GENERAL			
B. anthracis			
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.	"	"
B. subtilis			
Soil 400 meters deep, 30C	Inoc. Bouillon & 27% watt extract with 2% agar, recov. growth, 1-8 d.	Lieske	1929
B. spp.			
B. cereus, megatherium, and mycoides 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	
SAND			
B. suis			
Sand	120 d.	Bryan	1934
GENERAL			
B. abortus			
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.	"	"
B. melitensis			
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.	"	"
B. suis			
Soil	46 d.	Bryan	1934
B. sp.			
Soil in pastures where animals excrete large amounts of org.	Poor survival	Christiansen	1950

TABLE 53 THE SURVIVAL OF CLOSTRIDIUM SPECIES IN SOIL

Factor(s)	Survival	Reference	
LOAM			
C. botulinum			
Soil from counties in Md. where veg. grow	A, B, & C strains isolated	Damon	1926
C. tetani			
Sandy loam - corn	Isolated	"	"
SAND			
C. botulinum			
Veg. grown in sandy soil in counties of Md.	Isolated	Damon	1926
GENERAL			
C. botulinum			
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
C. tetani			
Soil	More or less permanent habitat	"	"
"	Found	Dubovsky	1922
Soil of school ground	"	Ishihara	1933
C. perfringens (welchii)			
Soil	More or less permanent habitat	Sanyal	1941
C. tetani (cont'd)			
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	
LOAM			
Escherichia coli			
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.	"	"
MUD			
E. coli			
Mud with infected water outside temp.	Demonstrable 45 d.	Bartos	1947
Tidal mud	3 mo.	Savage	1905
SAND			
E. coli			
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.	"	"
GENERAL			
E. coli			
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, persistant 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, sterilized with dry heat	Isolated 17 mo. later	Fellow	1923

TABLE 54 (CONT'D) THE SURVIVAL OF COLIFORM IN SOIL

Factor(s)	Survival	Reference	
GENERAL (cont'd)			
E. coli			
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 gm., 66 d.	Ostrolenk	1947
Soil with pecans, R.T., artifical infection	Inoc. 10^{-7}, Recov. 10^{-6}, 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.	"	"
Aerobacter aerogenes			
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 54 (CONT'D) THE SURVIVAL OF COLIFORM IN SOIL

Factor(s)	Survival	Reference	
GENERAL			
Enteric bacteria			
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
SAND		
Fine sand, 37C with cult. dried in air	Recov. 0, 30 d.	Germano 1897
Fine sand, 37C, with cult. dried over H_2SO_4	" " 50 d.	" "
Sand	175 d.	Laurell 1949
"	>98 d., Recov. mostly with unimpaired toxicity	Ouchterlony 1949
GENERAL		
Soil at 37C, dried in air	Recov. 0, 25 d.	Germano 1897
" " " " over H_2SO_4	" " 35 d.	" "
Soil	208 d.	Laurell 1949
Soil	>98 d., recov. mostly with unimpaired toxicity	Ouchterlony 1949
Soil drained	May be killed	Sharp 1896

TABLE 56 THE SURVIVAL OF FUNGI, YEASTS AND MOLDS IN SOIL

Factor(s)	Survival	Reference	
PEAT			
Actinomyces			
Strongly acid peat soil	Fewest occured	Jensen	1930
GENERAL			
Malleomyces mallei			
Pasture	Unsafe for at least 1 yr.	Lovell	1944
Actinomyces			
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
Actinomyces bovis			
Soil	More or less permanent habitat	Sanyal	1941
Fungi general			
Soil in autumn	Higher than spring	Eggleton	1934
1 gm. field soil	Contains 10T-20M fungi	Waksman	1927
Yeasts general			
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	"	"
Mold general			
Soil, -2 to -14C	Activity was unaffected	Demoussy	1929
Fungi general (cont'd)			
Seed-bed soil	Disinfected by solar energy	Grushevoi	1940

TABLE 5/ THE SURVIVAL OF MICROORGANISMS IN SOIL

Factor(s)	Survival	Reference	
CLAY			
Agrobacterium tumefaciens			
Clay	539 d.	Patel	1929
LOAM			
Agrobacterium tumefaciens			
Loam	587 d.	Patel	1929
MUD			
Pasteurella tularensis			
Mud naturally contaminated and stored in cold	12 wk.	Parker	1943
Uncontaminated mud	" "	Steinhaus	1945
PEAT			
Vibrio comma			
Independent of amount of moisture	24-26 hr.	Dempster	1894
SAND			
Diplococcus pneumoniae			
Dried cult. mixed with sand and veg. oil	2 d.	Germano	1897
Agrobacterium tumefaciens			
Sand	669 d.	Patel	1929
Vibrio comma			
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, moisture allowed to evap.	3-8 d.	"	"
White crystal sand, moisture 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.	"	"
VOLCANIC ASH			
Diplococcus pneumoniae			
Dried cult. and mixed with volcanic ash, kept moist	6 d.	Germano	1897
GENERAL			
Leptospira icterohaemorrhagiae			
Polluted soil	3 d.	Noguchi	1918
Leptospira sp.			
Wet ground from mines	months	Buchanan	1927
Pseudomonas fluorescens			
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	
GENERAL			
Leptospira grippo-typhosa			
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
Vibrio comma			
Garden earth	4 d.	Dempster	1894
Moist garden earth	> 33 d.	"	"
Excess moist garden earth	> 68 d.	"	"
Soil, no moisture	1-2 d.	"	"
Azotobacter spp.			
Soil, dark	10X nos. in soil in sun	Dhar	1939
Acid soils	< 24 hr.	Katznelson	1940
Lime and soil	Survived	"	"
Lime and dextrose and soil	Multiplied	"	"
Pure cult. in ster. soil	Multiplied upto 40 d. then dec. Still dec. at 85 d.	"	"
Indiam & Malayan soil, pH 3.6-3	Capable of growing but limit on acid side	Waksman	1940
Soil	Present	Vandecavege	1934
Soils most frequently fertilized with manure	Showed largest no. of azotobacter	Kanivets	1938

TABLE 58 THE SURVIVAL OF MICROORGANISMS IN SOIL (GENERAL)

Factor(s)	Survival	Reference	
GENERAL			
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 5x (CONT'D) THE SURVIVAL OF MICROORGANISMS IN SOIL (GENERAL)

Factor(s)	Survival	Reference	
GENERAL (cont'd)			
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 estuars" near Odessa stored since 1901 in sealed tube with CO_2 or H_2	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_2 in soil result of activity of soil microbes. Definite correlation between seasonal changes in soil microbes and CO_2 production. CO_2 content of lower layer of the atmosphere beneath the forest is influenced by soil respiration.		Feher	1938

TABLE 24 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN SOIL

Factor(s)	Survival	Reference	
GENERAL			
M. tuberculosis			
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 manure 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.	"	"
M. tuberculosis (bovine)			
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
M. tuberculosis (avian)			
Toluol sterilized soil	3 mo.	Rhines	1935
Unster. soil	>33 d.	"	"
Barn yards	12 mo.	Schalk	1928
M. tuberculosis (cont'd)			
Soil & sewage if properly	treated is free of org.	Pramer	1950

TABLE 5.10 THE SURVIVAL OF PROTOZOA AND METAZOA IN SOIL

Factor(s)	Survival	Reference	
CLAY			
Ascaris lumbricoides			
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. ¼ eggs isolated still alive, 160 d.	"	"
Soil, sun	71% motile, 21 d.	Brown	1927
" shade	85% " " "	"	"
Necator americanus			
Clay & humus, R.H. 41.4%, tin sleeve containers	Recov. 6%, 9 d.	Payne	1922
LOAM			
Ascaris lumbricoides			
Human ascaris eggs, summer temp., on surface in shade in S.W. Va.	2 mo.	Otto	1929
On surface in sun, S.W. Va., summer temp.	Recov. ¼ eggs, 160 d.	"	"
Soil, shade	89.3% motile, 21 d.	Brown	1927
" sun	54% " " "	"	"
Necator americanus			
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.	"	"
SAND			
Ascaris lumbricoides			
Human eggs, on surface in shade in S.W. Va., summer temp.	2 mo.	Otto	1929
On surface in sun, S.W. Va., summer temp.	Recov. ¼ eggs isolated still alive, 160 d.	"	"
Soil, sun	Recov. 0, 21 d.	Brown	1927
" shade	90.8% motile embryos, 35 d.	"	"
Necator americanus			
5-8 d. old cult., moist sand	Inoc. 198 larva, Recov. 91, 15 d.	Augustine	1922
Trichuris trichiura			
Soil, shade	74% motile, 35 d.	Brown	1927
GENERAL			
Ascaris lumbricoides			
Veg. on soils manured with human feces	Found	Heeger	1949
Eggs buried in ground with thin layer, winter	150-180 d.	Yoshida	1920
Endamoeba histolytica			
Cysts in soil & feces, R.T., & 4C for 4 hr.	8 d.	Beaver	1949
Cysts in soil & feces & water, R.T. 1 hr.	6 d.	"	"

Factor(s)	Survival	Reference	
GENERAL (cont'd)			
Endamoeba histolytica			
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
Necator americanus			
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 210 (CONT'D) THE SURVIVAL OF PROTOZOA AND METAZOA IN SOIL

Factor(s)	Survival	Reference	
GENERAL (cont'd)			
Necator americanus			
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, donse 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.	"	"
Eimeria tenella			
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
Eimeria maxima			
Oocysts in soil, direct sun	< 1 yr.	Farr	1949
Oocysts in soil, part shade	" " "	"	"
Oocysts in soil, deep shade	" " "	"	"
Eimeria acervulina			
Oocysts in soil	86 wk.	"	"
Gastrointestinal Nematodes of sheep			
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 conditio	"	"
Pasture soil, larva of most common parasites	3-3.5 mo.	"	"
1 gm. of field soil	Numerous	Waksman	1927
Toxocara canis			
Soil under snow	Winter mo.	Owen	1930

TABLE 5 11 THE SURVIVAL OF SALMONELLA SPECIES IN SOIL

Factor(s)	Survival	Reference	
CLAY			
S. typhosa			
Clay, rainy season	6 wk.	Beard	1937
" dry "	3 "	"	"
"	15 d.	Levy	1903
HUMUS AND GRAVEL			
S. typhosa			
Humus and gravel, RT.	Inoc. 24 hr. bouillon cult., 9-16 mo.	Rullmann	1901
LOAM			
S. typhosa			
Loam	49 d.	Beard	1940
" , rain	120 d.	"	"
Sandy loam with raw sewage	Recov. 0, 5 d.	Mallmann	1951
Clayloam	" " 12 d.	"	"
MUD			
S. typhosa			
Mud at bottom of aquarium	2 mo.	Hoffmann	1926
Tidal mud	5 wk.	Savage	1905
S. typhimurium			
Mud in infected water, outside temp.	Demonstrable 22 d.	Bartos	1947
PEAT			
S. typhosa			
Stock cult. and dry peat, at 51F. max. 56F and min. 37F	>13 d.	Firth	1902
S. spp.			
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
SAND			
S. typhosa			
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, 53-86F	>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
GENERAL			
S. typhosa			
Soil, freezing temp	<12 mo.	Beard	1940

TABLE 5 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN SOIL

Factor(s)	Survival	Reference	
GENERAL			
S. typhosa			
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	5½ 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	
GENERAL			
S. typhosa			
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
S. paratyphi A & B			
Dry soil	8 d.	Tanner	1944
Moist soil	> 60 d.	"	"
S. enteritidis			
Soil	Short time	Smith	1904
S. pullorum			
Soil, pH 7.0	> 64 d.	Sanyal	1941
S. gallinarum			
Soil, pH 6.2-6.4	1 wk.	Sanyal	1941
" " 6.7-7.0	40-70 d.	"	"
S. spp.			
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, 1½-21C	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 24 THE SURVIVAL OF SHIGELLA SPECIES IN SOIL

Factor(s)	Survival	Reference	
SAND			
S. dysenteriae			
Sand, heated room	Viable 12 d.	Pfuhl	1902
GENERAL			
S. dysenteriae			
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
S. paradysenteriae (Flexner)			
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 213 THE SURVIVAL OF STREPTOCOCCUS SPECIES IN SOIL

Factor(s)	Survival	Refernece	
LOAM			
S. faecalis			
Loam	Recov. 6.4 logs/100gm., 0 wk.	Mallmann	1951
"	Recov. 0.7 " " " 11 wk.	"	"
S. spp.			
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.	"	"
SAND			
S. pyogenes			
Sand	53 d.	Laurell	1949
S. spp.			
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/loo gm. 33 d.	"	"
GENERAL			
S. faecalis			
Soil	Found	Winter	1946
S. pyogenes			
Soil, R. T.	53 d.	Laurell	1949
S. spp.			
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 5 13 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES IN SOIL

Factor(s)	Survival	Reference	
GENERAL (cont'd)			
S. spp.			
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	
SAND			
Foot & mouth virus			
Sand, 62F, R.H. 52%	14 d.	Burbury	1928
GENERAL			
Newcastle virus			
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
Bacteriophage			
S. typhosa phage in soil 3 ft. deep	Present	Pasricha	1941

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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 ON SURFACES

TABLE #	TABLE OF CONTENTS	PAGES
Su 1	Bacillus species	2
Su 2	Brucella species	1
Su 3	Clostridium species	1
Su 4	Coliform species	3
Su 5	Corynebacterium species	2
Su6	Diplococcus pneumoniae	2
Su 7	Micrococcus species	5
Su 8	Microorganisms	2
Su 9	Microorganisms (General)	2
Su 10	Mycobacterium tuberculosis	2
Su 11	Neisseria species	2
Su 12	Pasteurella species	2
Su 13	Salmonella species	4
Su 14	Serratia marcescens	1
Su 15	Shigella species	2
Su 16	Streptococcus species	5
Su 17	Viruses	3
Su 18	Yeasts, molds, fungi	1
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	Authors appearing in references but not in tables.	1
	Abbreviations	1

TABLE 44 THE SURVIVAL OF BACILLUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
DUST			
B. megatherium			
Evidence of transport of spores during dust storm	----------	Soule	1934
FABRIC			
B. anthracis			
Silk threads, spores	>20 hrs.		
" " , non-spores.	Dead in few hrs.	Ficker	1898
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
B. spp.(aerobic)			
Burlap strips, 200-280 F. 5-9 min., spores.	Yielded growth	Jungherr	1950
GLASS			
B. anthracis			
Glass rod, 37 C., Flamed with 95% alc., 10 sec.,		Mayser	1925
3 day old agar culture;	Viable 2 days		
6 day old bowl, cult..	33 days		
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
PAPER			
B. anthracis			
Paper-slips, spores, sunlight.	8 hrs.	Weinzirl	1914
B. subtilus			
Paper-slips, sterile in petri plates, sunlight, spores.	8 hrs.	"	"
GENERAL			
B. anthracis			
Match head, 37 C., spores 95% alc. 3 da. cult.	Viable 2 das.	Mayser	1925

TABLE 141 (CONT'D) THE SURVIVAL OF BACILLUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
GENERAL (CONT'D)			
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..	30 minutes	Mackie	1934
Brass wire, 5 cm., heated 37 C., flamed 95% alc., 3 day old agar culture.	Viable 9 days.	Mayser	1925
Shaving brushes	7.3% contained virulent anthrax bacilli	Symmers	1921
B. subtilus			
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
Telephones with separate receiver and transmitter	92.59%	"	"

TABLE 442 THE SURVIVAL OF BRUCELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
DUST			
B. melitensis			
Dry dust of Malta	20-28 days	Horrocks	1906
Dry sterile dust	20 days	"	"
Dust	44 days	Kennedy	1905
Favorable conditions	6 weeks	Bang	1897
FABRICS			
B. abortus			
Burlap bag, dried in	5 days	Cameron	1932
Burlap sacking, dried in, unheated cellar	30 days	"	"
B. melitensis			
Cloth, dried on	17 days	Kennedy	1905
B. suis			
Sacking	4 weeks	Anon.	1933
B. spp.			
Wool, washed with water over 55 C., dried at 75-80 C. or heated 30 min. at 105-111 C..	----------	Cherkasskii	1938
GLASS			
B. abortus			
Glass, dried on	Survival several days	Cameron	1932

TABLE 4u 3 THE SURVIVAL OF CLOSTRIDIUM SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRIC			
Cl. tetani			
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
Cl. welchii			
Cotton-wool swabs, 16-22 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.		
GENERAL			
Cl. tetani			
Stored in rubber-capped test tube in cupboards, rusty metal, room temp.,	18 years	Semple	1911
Tetanus spores	Remain viable at the site of inoculation for as long as 6 months	"	"
Talcum powder, 20 lbs. in autoclave	Survived	Sevitt	1949
Cl. sporogenes			
Catgut sutures, exposure to both alcohol and toluol	>17 days	Hite	1938

TABLE 44 THE SURVIVAL OF COLIFORM SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS			
Escherichia coli			
Cotton-woolswab, 16-28 C.,			
plain, dry	No growth 8 hrs.	Rubbo	1951
plain, moist	50-200 col. at 24 hrs.	"	"
serum, dry	20-50 col. at 48 hrs.	"	"
serum, moist	50-200 col. at 48 hrs.	"	"
E. coli (with Hem. strep. *Sarc. flava*, and *S. aureus*)			
Blankets(47), sucked from, on E.N.T. ward.	14,400-7,344,000 per cu. ft. air.	Rountree	1946
Klebsiella pneumoniae			
Cotton-woolswab, 16-28 C.,			
plain, dry	No growth 8 hrs.	Rubbo	1951
plain, moist	50-200 col. at 24 hrs.	"	"
serum, dry	20-50 col at 48 hrs.	"	"
serum, moist	50-200 col. at 48 hrs.	"	"
GLASS			
E. coli			
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 inhibition of the bacteria was obtained	Galli	1914
Ground glass	Killed in 10 min.	Rebell	1950
Glass, sunlight	2 minutes	Weinzirl	1907
Glass, 37 C., Inoc. at 30 sec. 107,000	Recovered 0 at 15 min.	Bryan	1933
E. coli communis			
Dessicator, 16-18 C.,	60 days	Buckley	1906
Room Temperature	32.5 days	"	"
Moist chamber	98 days	"	"
PAPER			
E. coli			
Filter paper, dipped in culture, dried over sulfuric acid;	Recov. 0,1,10 and 25 col. in 17 hrs.	Walliczek	1894
dried in vacuum;	Recov. 28, 45, 78, and >1,000 col. in 45 min.	"	"
dried in air.	0 recovered in 18 hrs.	"	"
Filter paper, dried from peptone salt, 24 hr. cult	<28 hrs.	Chick	1900
Filter paper, stool dried on, dark	45 days	Dold & Ketterer	1944
Filter paper, watery stool	143 days	"	"
Paper, 28 C., dried	77 days	Kusama	1925
Paper, sunlight	Longer if in clumps 2-10 minutes	Weinzirl	1907

TABLE IV (CONT'D) THE SURVIVAL OF COLIFORM SPECIES ON SURFACES

Factor(s)	Survival	Reference	
PAPER(CONT'D)			
E. coli			
Filter paper, moist, Inoc. 251,000 at 30 sec.	149,000 in 15 minutes	Bryan	1933
E. coli communis			
Paper, dessicator, 16-18 C.	21 days	Buckley	1906
Paper, room temperature	7.5 days		
Moist chambers, paper	47.5 days		
Colon- aerogenes spp.			
Filter paper, 24 hr. agar cult., dry incubator at 37 C..	31 days	Hastings	1923
Paper infected with milk cultures	96 days	"	"
General			
Coliform group destroyed in drying process of paper production		Appling	1945
PLASTER			
E. coli communis			
Dessicator 16-18 C..	84.5 days	Buckley	1906
Room temperature	84 days		
Moist chamber	168 days		
UTENSILS			
Colon-aerogenes spp.			
Kitchen utensils, 91-100 C;	Effective in destroying colon-aerogenes group	Sellers	1944
Kitchen utensils, 41-60 C. colony count at 48 hrs.	41 colonies	"	"
Kitchen utensils, 61-80 C. colony count at 48 hrs.	19 colonies	"	"
WOOD			
E. coli			
Stumps, feces on, blizzard, inoc. 532,000/gm.;	0 recovered in 18 days	Tonney	1931
Spring, Inoc. 11,800/gm.;	0 recovered, 153 days	"	"
Warm season,	172 days		
Winter, pure cult., inoc. 323,000/ gm.	0 recovered, 22 days	"	"
307,000/ gm	0 recovered, 9 days	"	"
Spring, pure culture	228 days	"	"
E. coli communis			
Dessicator, 16-18 C.			
Cotton wood	49 days	Buckley	1906
Lime wood	86 days		
Pine wood	22 days		
Room temperature			
Cotton wood	64 days	"	"
Lime wood	80 days		
Pine wood	14 days		
Moist chamber			
Cotton wood	53 days	"	"
Lime wood	168 days		
Pine wood	78 days		

TABLE Lu 4 (CONT'D) THE SURVIVAL OF COLIFORM SPECIES ON SURFACES

Factor(s)	Survival	Reference	
WOOD(CONT'D)			
Aerobacter aerogenes			
Stumps, pure culture on,			
Winter, inoc. 708,000/gm.	0 recovered, 22 days	Tonney	1931
456,000/gm.	0 recovered, 9 days	"	"
Spring, pure culture	228 days	"	"
GENERAL			
E. coli			
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 Recov. 0, 24 hrs.	Frank	1943
Doorknob, white bronze	Recov. positive, 48 hrs.	"	"
Stuffing boxes of pumps, lub. grease	Abundance of growth	Frantsev	1935
Water filter, after water stopped	24-36 hrs.	Gage	1903
Continous filter	4-6 days	"	"
Action of metal salts, gold colloids, ferric chloride, silver nitrate, zinc chloride and others at varying dilutions	----------	Tanaka	1931

TABLE 45 THE SURVIVAL OF CORYNEBACTERIUM SPECIES ON SURFACES

Factor(s)	Survival	Reference
DUST		
C. diphtheriae		
Brick dust, 37 C., bacilli culture,	Kept full virulence during drying up period until death.	Germano 1897
air dried,	5184 col., 12 days	" "
dried with sulfuric acid	1728 col., 12 days	
C. diphtheriae gravis		
Present in dust	175 days	Laurell 1949
Dust, recov. with unimpaired toxicity	175 days	Ouchterlony 1949
Sawdust, mitis, gravis, and intermedius recov. with unimpaired toxicity	<1 day	" "
Occurrence in air and dust	----------	Trevelyan 1898
FABRICS		
C. diphtheriae		
Silk, dried on, R.T.	3-14 weeks	Abel 1893
Silk, dried on, dark.	Still alive 189 days	" "
Cloth, old dried out cult.	3-3 1/2 mos.	Abel 1895
Silk thread, -23 1/2 to 12 1/2 C., 2-4 da. old culture. Strain I;	Recovered no growth in 68 days	
Control, R.T., Strain I.	No growth 74 days	" "
Silk thread, strain II;	No growth 61 days	
control	No growth 86 days	
Silk thread, strain III;	No growth 61 days	
control	No growth 86 days	" "
Cloth, gravis strain, R.T. dried	Recovered mostly with unimpaired toxicity > 145 days	Ouchterlony 1949
Linen--mitis; cotton--gravis and inter.; wool--gravis and inter..	Recovered mostly with unimpaired toxicity > 98 days	" "
Dry towelling	Alive at end of 48 hrs.	Pease 1930
Cotton-wool swab, 16-22 C.		
gravis, plain dry	5-20 col. at 48 hrs.	Rubbo 1951
plain moist	5-20 col. at 8 hrs.	
serum dry	50-200 col. at 48 hrs.	" "
serum moist	50-200 col. at 48 hrs.	
Cotton swab, sterile, 37 C. 1 loop 24 hr. cult. with		
sterile horse serum;	Still alive at 24 hrs.	Van Reimsdijk 1924
without horse serum;	Most dead at 1 hr.	
Cotton plugs(40), R.T., in dark, placed on horse serum agar	7 plugs were negative 33 plugs positive in 24 hrs.	" " "
Linen	15 days	Lomry 1929
Cotton	15 days	
Wool	25 days	" "
Occurrence on clothes.	----------	Trevelyan 1898

TABLE 4a5 (CONT'D) THE SURVIVAL OF CORYNEBACTERIUM SPECIES ON SURFACES

Factor(s)	Survival	Reference
GLASS		
C. diphtheriae		
Dessicator 16-18 C.,	68 days	Buckley 1906
Room temperature,	24 days	
Moist chambers .	51.5 days	
Petri dishes, empty, sterile R.T.	24-48 hrs.	Kirstein 1902
Glass, dried, virulent strain 1billion/cc, 37 C.	37 days	Ross 1945
Glass, *intermedius* strain	Recovered mostly with unimpaired toxicity >98 days	Ouchterlony 1949
Slides, sterile, 37 C.	3 days	Teague 1913
Glass, sunlight	2 min.	Weinzirl [illegible]
PAPER		
C. diphtheriae		
Dessicator 16-18 C.,	21 days	Buckley 1906
room temperature.,	6 days	
moist chambers	15 days	" "
Paper, *gravis* strain	Recovered mostly with unimpaired toxicity 159 days	Ouchterlony 1949
Paper, sunlight	Longer if in clumps, 2-10 minutes	Weinzirl 1907
PLASTER		
C. diphtheriae		
Dessicator 16-18 C.	73 days	Buckley 1906
Room temperature	37.5 days	
Moist chambers	75 days	
UTENSILS		
C. diphtheriae		
[illegible] blade, 60-80 F.	86 days	Ecklund 1932
WOOD		
C. diphtheriae		
Oak	8 days	Lomry 1929
Beech	8 days	
Resins	8 days	
Dessication, 16-18 C.		Buckley 1906
Cotton wood	88.5 days	
Lime wood	77 days	
Pine wood	20 days	
Room temperature		
Cotton wood	24 days	" "
Lime wood	41 days	
Pine wood	8.5 days	
Moist chamber		
Cotton wood	17.5 days	" "
Lime wood	75 days	
Pine wood	7 days	
GENERAL		
C. spp.		
Hand telephones	14.58 % diphtheroids	Smeall 1937
Telephone with separate receiver & transmitter	11.10 % diphtheroids	" "

TABLE 46

THE SURVIVAL OF DIPLOCOCCUS PNEUMONIAE ON SURFACES

Factor(s)	Survival	Reference	
DUST			
Dried cultures mixed with sterile dust;		Germano	1897
at 0 C.	2 days		
	8 days		
FABRICS			
Type I(smooth			
Dried rabbit blood on gauze, dark		Stillman	1940
40 F., ice box, dark	2 mos.		
Typ I(rough	9 mos.		
Gauze, 80 F.,daylight	Viable 10 mos.	"	"
Gauze, 80 F., dark	Viable 15 mos.		
Gauze, 40 F., dark	9 mos.		
Type II(smooth			
Gauze, rabbit blood dried,			
80 F., daylight and dark	2 mos.	"	"
40 F., in icebox, dark	12 mos.		
Type II(rough			
Gauze, 80 F, daylight	9 mos.	"	"
dark	13 mos.		
Gauze, icebox, 40 F, dark	8 mos.		
Dry towelling, including turkish towel	Alive at end of 24 hrs.	Pease	1930
Type III(smooth			
Gauze, daylight, 80 F.	5 mos.	Stillman	1940
Gauze, dark, 80 F.	11 mos.		
Gauze, 40 F. icebox, dark	12 mos.		
Type III(rough			
Gauze, 80 F., daylight	7 mos.	"	"
Gauze, 80 F., dark	9 mos.		
Gauze, icebox, 40 F, dark	9 mos.		
Type III			
Cotton wool swab, plain			
dry	5-20 col. at 8 hrs.	Rubbo	1951
plain, moist	5-20 col. at 8 hrs.		
serum, dry	5-20 col. at 48 hrs.		
serum, moist	20-50 col. at 24 hrs.		
Pneumococci life slightly longer on cloth than on non-absorbing surfaces		Wood	1905
GLASS			
Type I(smooth			
Glass, dried rabbit blood,			
80 F,daylight	1 mo.	Stillman	1940
40 F, icebox, dark	12 mos.		
Type I(rough			
Glass, 80 F.,daylight	Viable 10 mos.	"	"
dark	" 11 mos.		
Glass, 40 F, dark	" 15 mos.		
Type II(smooth			
Glass, dried rabbit blood,			
80 F., daylight and dark	2 mos.		
40 F., dark	12 mos.		

TABLE 4u6 (CONT'D) THE SURVIVAL OF DIPLOCOCCUS PNEUMONIAE ON SURFACES

Factor(s)	Survival	Reference
GLASS		
Type II(rough		
Glass, 80 F., daylight	3 mos.	Stillman 1940
dark	9 mos.	
40 F., dark	9 mos.	
Type III(smooth		
Glass, dried rabbit blood,		
80 F., daylight	5 mos.	Stillman 1940
80 F., dark	7 mos.	
40 F., dark	13 mos.	
Type III(rough		
80 F., daylight	0 mos.	" "
80 F., dark	1 mo.	
40 F., dark	7 mos.	
Diplococcus--at this age no known difference between meningococci and pneumococci. Dried rabbit blood on watch glass	>45 days	Foé 1888

TABLE 4n7

THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS			
M. pyogenes			
Burlap strips	14 days--test negative	Jungherr	1950
Garments, dried on, liquid air	Several mos., no change in resistance	Paul	1907
M. pyogenes var. aureus			
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., *Sarc. flava*, *E.coli*, *Staph aur.*	14,400-7,344,000/cu.ft. of air.	Rountree	1946
M. pyogenes var. albus			
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	"	"
GLASS			
M. pyogenes var. aureus			
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 4w 2

THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
GLASS(CONT'D)			
M. pyogenes var. aureus			
Sterile dishes, put into machine with soiled dishs 0.3% calgonite		Ward	1937
% 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
M. pyogenes var. albus			
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, cult. 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
M. pyogenes(Gen'l)			
Slides, sterile, 37 C., innoc. innumberable cols.	Recovered 41 col., in 7 days	Teague	1913
Glass, direct sunlight	60-90-minutes	Weinzirl	1907
Glass, direct sunlight	10 min.	Weinzirl	1907
PAPER			
M. pyogenes var. aureus			
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;	Recovered 400, 3 min.	Norton	1932
inoc. 900.	Recovered 46 , 3 min.	"	"
Filter peper, moist, 37 C. inoc. 173,000	Recovered 170,000 15 min.	Bryan	1933

TABLE Xa 2 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
PAPER(CONT'D)			
M. pyogenes var. albus			
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	"	"
M. pyogenes			
Paper, sunlight	71 hrs.	Weinzirl	1907
PLASTER			
M. pyogenes var. aureus			
Plaster, dessicator, 16-18 C.;	100 days	Buckley	1906
room air,	100 days		
moist chamber.	38 days		
RUBBER			
M. pyogenes var. aureus			
Rubber sheet, susp'n containing 2568 org., exposed 7 minutes.	80% washed off	Burtenshaw	1938
Rubber sheet, susp'n of 2568 org., exposed 92 minutes.	84% washed off		
Rubber sheet, susp'n of 3459.2 org., exposed 6 minutes.	93.6 washed off	"	"
Rubber sheet, susp'n of 3459.2 org., exposed 92 min.	192.4 washed off	"	"
UTENSILS			
M. pyogenes var. aureus			
Glazed porcelain dishes, cold water without serum	34 colonies--1 hr. 198 " " --3 hrs. 29,000 colonies--5 hrs.	Blumenberg	1917
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 4u7 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
UTENSILS (CONT'D)			
M. pyogenes var. aureus			
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;	2 cols.---1 hr. 12 cols.--3 hrs. 311 cols.--5 hrs.	"	"
with serum	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.	12 wks. & 2 das. (86 da)	Ecklund	1932
Food utensils, large collection, washed	3-12 % recovery	Hutchinson	1947
WOOD			
M. pyogenes var. aureus			
Dessicator, 16-18 C.			
lime wood	126 days	Buckley	1906
pine wood	64 days		
cotton wood	130 days		
Room air			
lime wood	126 days	"	"
pine wood	39 days		
cotton wood	122 days		
Moist chamber			
lime wood	100 days	"	"
pine wood	35 days		
cotton wood	38 days		
GENERAL			
M. pyogenes, var. aureus			
Tinfoil, susp'n containing 2568 orgs. exposed 11 min;	973.4 washed off	Burtenshaw	1938
Same susp'n at 100 min.	194.7 washed off		
Tinfoil, susp'n containing 3459.2 orgs., exposed 8 min.	1011.2 washed off	"	"
Same susp'n at 96 min.	316 washed off		
Smooth surfaces, ultraviolet, 2,000-2,950 A units	Effect reduced counts	Cathcart	1942
Hand telephone	4.17 %	Smeall	1937
Telephone with separate receiver and transmitter	3.7%	"	"

TABLE 4a7 (CONT'D) THE SURVIVAL OF MICROCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	References	
GENERAL (CONT'D)			
M. pyogenes, var. aureus			
Action of metal salts, gold colloids, silver nitrate, zinc chloride and others in varying dilutions.	.....	Tanaka	1931
M. pyogenes var. albus			
Hand telephones	35.42 %	Smeall	1937
Telephones with separate receiver and transmitter.	11.10 %	"	"
M. pyogenes			
Doorknob, brass	Recov. positive 24 hrs. Recov. negative 38 hrs.	Frank	1943
Door knob, white, bronze	Recov. positive 72 hrs.	"	"
M. spp. (chromogenic cocci)			
Hand telephones	62.50 %	Smeall	1937
Telephones with separate receiver & transmitter	11.10 %		

TABLE 4a8 THE SURVIVAL OF MICROORGANISMS ON SURFACES

Factor(s)	Survival	Reference	
DUST			
Proteus morgani			
Dust	2-12 d.	Hoare	1943
FABRICS			
Proteus vulgaris			
Cotton-wool swab, 16-22C, plain, dry	No growth at 8 hr.	Rubbo	1951
moist	50-200 col. at 24 hr.	"	"
Cotton-wool swab, 16-22C, serum, dry	20-50 col. at 48 hr.	"	"
moist	50-200 col. at 48 hr.	"	"
Hemophilus pertussis			
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 " " " "	"	"
Proteus morgani			
Blanket	>81 d.	Hoare	1943
Rickettisa			
Coxiella burnetii			
Soiled laundry from Q fever lab.	Infection evident on laundry workers handling prior to laundering	Oliphant	1949
Treponema pallidum			
Cloth, 21.5-25C, diffuse light	11½ hr.	Zinsser	1914
Vibrio comma			
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. 0, 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
GLASS			
Pseudomonas aeruginosa			
Glass, 24 hr. peptone, 1% water culture, vacuum-dried	7 mo. & 7 d.	Shottoch	1912
Glass, sunlight	2 min.	Weinzirl	1907

TABLE Lu 8 (CONT'D) THE SURVIVAL OF MICROORGANISMS ON SURFACES

Factor(s)	Survival	Reference	
GLASS (cont'd)			
Sarcina aurantiaca			
Glass (direct and under glass) sunlight	25-60 min.	Weinzirl	1907
Treponema pallidum			
Glass slides allowed to dry	4½ hr.	Zinsser	1914
Vibrio comma			
Vibrio dried on cover slip	3 hr.	Kitasato	1889
Ster. slides, 37C,	Inoc. innumerable, Recov. 0, 2 min.	Teague	1913
Glass slides dried	Few days	Thurn	1914
" " , 56, 100, & 80C	30 min.	"	"
Glass sunlight	2 min.	Weinzirl	1907
PAPER			
Bacterium linens			
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
Proteus morgani			
Filter paper	11-20 d.	Hoare	1943
Vibrio comma			
Banknotes touched by fingers infected with cholera stool	4 hr.	Jettmar	1927
WOOD			
Trichomonas vaginalis			
Enamel surface of a small wooden block	< 7 hr.	Kessel	1950
GENERAL			
Alcaligenes faecalis			
Hand telephones	4.17% of org. present	Smeall	1937
Rickettsia typhi			
In a vacuum with $CaCl_3$ for 48 hr.	100 d. still viable	Blanc	1940
Paper, R.T.	Still viable at 21 d.	"	"
Trichomonas vaginalis			
Natural conditions	Long enought to permit transfer to another	Kessel	1950
Vaginal discharge	Recov. 2-4%, 6 hr.	"	"
Vibrio comma			
Inside earthen pot	2 d.	Arguelles	1927
Outside " "	4-8 d.	"	"

TABLE Su 9 THE SURVIVAL OF MICROORGANISMS ON SURFACES (GENERAL)

Factor(s)	Survival	Reference
DUST		
Air during dust storm	High ct. of mold, bacteria, & dust particles	Proctor 1935
FABRICS		
Oiled blankets	90-95% fewer than contrd	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 [illegible], filter paper, or blood agar		Elford 1945
GLASS		
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 millon	MacNabb 1938
METAL		
Surfaces of Fe, Zn, Cu, brass, limewash, lead paint & too were bactericidal		Minett 1950
Polio virus-partial inactivation		McKhann 1948
PAPER		
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.	" "
WOOD		
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 4u 9 (CONT'D) THE SURVIVAL OF MICROORGANISMS ON SURFACES (GENERAL)

Factor(s)	Survival	Reference	
GENERAL			
Bact. found in bricks 1,005	400 yr. old.	Lipman	1934
Ster. of plane polished surfaces			
Sterilization of plane polished surfaces by air at 50 miles/min.	Slightly longer time for sterilization	Breinl	1935
at 300-600 mi./min.	Effect pronounced	"	"
Sterilization of polished surfaces by still air	50-60 min.	"	"
at 100-120C, 600 mi./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_2 frozen	Lujet	1938
Survival temp. ranging from to that of liquid helium,	that of liquid O_2, -183C -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 millon, 5 greater than 1 thousand to 1 millon, 17 greater than 1 to 1 thousand.		MacNabb	1938

TABLE 4410

THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS ON SURFACES

Factor(s)	Survival	Reference	
DUST			
Dust, infected, diffuse daylight	5 days	Soparkar	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	"	"
FABRICS			
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	Lesions resulted after 70 but not after 110 da	"	"
exposed to direct sunlight	Infective after 1 hr. but not after 7 hrs.	"	"
On threads of clothing	5-10 days	Kirstein	1905
GLASS			
Glass, sputum dried in thin smears	4 mos.	Sormani	1886
PAPER			
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 das. 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 IV (CONT'D) THE SURVIVAL OF MYCOBACTERIUM TUBERCULOSIS ON SURFACES

Factor(s)	Survival	Reference	
PAPER(CONT'D)			
Paper, infected, dried 24 hrs., exposed to little air	>35 days	Ransom	
Books, sputum.	2 wks. to 3 1/2 mos.	Smith	1942
GENERAL			
Thin smears of human, bovine and avian types, sunlight	Killed in 1-4 min.	Briscoe	1912
Dessication in a dark, well-ventilated place--human and bovine.	Killed human within 4 days; killed bovine within 8 days.	"	"
Exposed to direct sunlight in India.	Alive---6 das. Dead---8 das.	Soparkar	1917
Dessiccated in darkness.	Live virulent bacilli for 309 days.	"	"
Decomposing sputum.	20-26 days		
Exposed to electric light, bovine t.b.,	74 days alive, dead in 100 days.	"	"
Bovine t.b. from deer lung, direct sunlight;	10-12 hrs.	"	"
diffuse light.	30 days		
Hypochlorite disinfection and quarternary ammonium compounds had weak tuberculocidal power.		Klarman	1951
Braille books	3 mos.	Chesin	1926

TABLE ~~4~~ 4a II

THE SURVIVAL OF NEISSERIA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS			
N. gonorrhoeae			
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.		
Cotton-wool swabs, also *N. meningitidis*, 16-22C.			
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.		
N. intracellularis			
Cotton fabrics	7 days, survival shortened at 37 C, & prolonged at 6-10 C.	Miller	1944
Cotton-wool swabs, also *N. gonorrhoeae*, 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
GLASS			
N. meningitidis			
Glass beads, dark, dried, R.T.	10 days, visible light is germicidal.	Miller	1944
Surface glass, direct sun light, in dried films	Few hours	Miller	1944
Glass beads, diffuse daylight, passing thru window pane & pyrex petri dish	30 hrs.	"	"
Glass, drying on	72 hrs.	Elser	1909
Garnets and glass, dried,			
in dark	24 hrs.	Flügge	1905
diffuse daylight	10 hrs.		
Glass, dried, R.T.	24 hrs.	Kutscher	1906
Watch glass, dried rabbit blood	>45 days	Foá	1888

TABLE Sull (CONT'D) THE SURVIVAL OF NEISSERIA SPECIES ON SURFACES

Factor(s)	Survival	Reference
GLASS (CONT'D)		
N. gonorrhoeae		
Glass covered in sun	2 strains stopped growing after 3 hrs.; 5 hrs. no growth	Lorentz [illegible]
WOOD		
N. meningitidis		
Wood exposed to direct sunlight in dried films	Few hrs.	Miller [illegible]
Wood, room temperature	8 days	" "
GENERAL		
N. meningitidis		
Human secretions, drying in,	Several days	Jungeblut [illegible]
Metal	1 hr still alive, 2 hrs. dead	Weiss [illegible]
15 strains, R.T., 25-26 C. dark,	9 strains survived 2 wks 6 for 4 wks.	Elser [illegible]
diffuse daylight,	0 survived for 5 wks.	" "
direct sun	1 wk.	
ice box, 6-8 C.	8-9 hrs.	
Meningococci might remain rapidly under freezing temperatures and kept frozen	None survived a week alive for years if dried	Elser [illegible]

TABLE 4y/2 THE SURVIVAL OF PASTEURELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS			
P. pestis			
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.	"	"
GLASS			
P. pestis			
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.	No growth, 3 hrs.		
Dried in lighted room, 16-20C	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	No growth, 1 hr.	"	"
Desiccator, 16-18C	3.5 hrs.	Buckley	1906
Glass, room temperature	2.3 days	"	"
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		Kitasato	1894
exposed to sun	< 4 days		
	3-4 hrs.		
Slide, dried, Giemsa stain, inoc. 1:1,000	Viable 2 hrs.	Tinker	1930
Slide, reagents used for hemoglobin determination	Kill organism in 45 min.	"	"
P. spp.			
Glass tube, blood allowed to putrify	100 days	Ostertag	1908
PAPER			
P. pestis			
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
P. tularense			
Filter paper, feces on, 20C, dried unexposed to direct light	20 days	Francis	1922

TABLE 4a12 (CONT'D) THE SURVIVAL OF PASTEURELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
BLASTER			
P. pestis			
Dessicator, 16-18 C.	9.5 days	Buckley	1906
Room temperature	5 days		
Moist chamber	11 days		
WOOD			
P. pestis			
Dessicator, 16-18 C.		Buckley	1906
Cotton wood	22 days		
Lime wood	6.5 days		
Pine wood	3.5 days		
Room temperature			
Cotton wood	11 days	"	"
Lime wood	2 days		
Pine wood	-------		
Moist chamber			
Cotton wood	36.3 days	"	"
Lime wood	2.6 days		
Pine wood	1 hour		
GENERAL			
P. pestis			
Frozen daily, -20 C..	40 days	Gladin	1898
Dried, 37 C..	Most were dead, 3 das.		
Protected from sun, 37 C..	2-3 mos.		
Protected from sun, R.T..	260 days	"	"

TABLE 4u13 THE SURVIVAL OF SALMONELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
DUST			
S. typhosa			
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		
S. typhimurium			
Dust	3 weeks	Browne	1949
S. paratyphi			
Sweepings, kitchen refuse.	50 days	Kister	1928
Ashes, contaminated.	130 days	"	"
FABRICS			
S. typhosa			
Soiled washing, R.T., dark	4 days	Dold	1944
Linen, dried on	98 days		
White drill cloth, temp. 105 F., exposed to sun, inoc. 240,000	2 hrs.	Hewlett	1909
White drill cloth, 98 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 4-13 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS			
S. enteritidis			
Dried on linen	39 days	Dold	1944
S. paratyphi B			
Dried on linen	191 days	"	"
Turkish towels	Alive at end of 48 hrs.	Pease	1930
S. paratyphi			
Dried on linen	191 days	Dold	1943
Linen	150 days	Lomry	1929
Cotton	150 days		
Wool	70 days	"	"
S. pullorum			
Burlap strips, soaked in cult., exposed to U.-V., 200-215F. for 5 min.	No inactivation Was not isolated after 5 min exposure	Jungherr	1950
95-180 F. for 4 min.	Readily recovered		
205-270 F. for 5-7 min.	Not recovered		
S. sp.(Type Oranienburg)			
Cotton wick of water device	15 days	Olson	1950
GLASS			
S. typhosa			
Dessicator, 16-18 C..	44.5 days	Buckley	1906
Room temperature	12 days		
Moist chamber	38.5 days		
Petri dishes, empty, R.T., sterile	24 hrs.	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, vaccum dried at -195 C; air dried , dark	None recovered, 4 days	Shattock	1912
Sterile slides, 37 C., inoc. innumerable cols.	None recovered,60 hrs.	Teague	1913
Dishes washed with 0.3% Calgonite, % sterile,			
sterile dishes	70-90% approx.	Ward	1939
soiled dishes	4-10%		
Glass, sunlight	5 min.	Weinzirl	1907
Self sterilizing ability of skin against S. typhosa similiar phenomenon on glass rods.		Dold	1919
S. sp.(Type Oranienburg)			
Glass, few drops broth culture.	34 days	Olson	1950

TABLE 4413 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
PAPER			
S. typhosa			
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^3	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
S. paratyphi			
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
PLASTER			
S. typhosa			
Dessicator, 16-18 C.	83 days	Buckley	1906
Room temperature	91 days		
Moist chamber	101 days		
WOOD			
S. typhosa			
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	Osler	1901
On bench	Recov. 17.0%, 23 days	Stamp	1947

TABLE 4413 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
WOOD (CONT'D)			
S. typhosa			
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
S. paratyphi			
Oak	80 days	Lomry	1929
Beech	80 days		
Resins	80 days	"	"
On bench	Recov. 17.0%, 23 days	Stamp	1947
GENERAL			
S. typhosa			
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	"	"
S. paratyphi			
On crust of rye bread, in well-ventilated room at R.T., emulsion with *S. typhosa*	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	"	"
S. enteriditis			
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	
FABRICS			
Serge, woolen, aqueous susp' 21ppm. ozone, R.H. 68%, temp. 20.5 C.		Elford	1942
exposed 30 minutes	----------		
exposed 60 minutes	----------		
exposed 90 minutes	----------		
Serge, woolen, aqueous susp. .06 ppm. ozone, R.H. 89%, 21 C., exposed 45 min.	95% killed	"	"
GLASS			
Glass, aqueous susp'n, R.H. 68%, 20.5 C., 21ppm ozone			
exposed 30 min.	>99% killed on surface	Elford	1942
exposed 60 min.	>99% killed on surface		
exposed 90 min.	>99% killed " "		
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
PAPER			
Aqueous susp'n, 21 ppm. Ozone, R.H. 68%, 20.5 C.,			
exposed 30 min.	98% killed	Elford	1942
exposed 60 min.	99% killed		
exposed 90 min.	>99% killed		
Aqueous susp'n, 0.06 ppm. ozone, R.H. 89%, 21 C., exposed 45 min.	98% killed	"	"
Filter paper, surface, inoc. 150	Recovered none, 20 min.	Norton	1931
Filter paper, moist, inoc. 960	Recovered none, 30 min.		
Filter paper, inoc. 4,000	Recovered 40, 30 min.	"	"
Filter paper, surface of, inoc. 1,000	Recovered 6, 30 min.		
Filter paper, moist, innoc. 320	Recovered 1,000 at 30 minutes	"	"
Filter paper, inoc., 3,500	Recovered 310 at 30 min	"	"
Paper, surface, inoc. 230, colonies on agar plates	Recovered none at 2 min	Norton	1932
Paper, sunlight	2-10 minutes	Weinzirl	1907
Filter paper, moist, inoc. 500,000, 37C.	Recovered 141,000 at 15 minutes	Bryan	1933

TABLE [illegible]

THE SURVIVAL OF SHIGELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
DUST			
S. dysenteriae			
Dust	10 days	Kister	1928
FABRICS			
S. dysenteriae			
Hemp	Several days	Lentz	(?)
Clothes	24 days		
Leinwand	17 days		
Clothes, dried on			
R.T., dark,	150 days	Winter	1912
37 C.	11 days		
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
S. paradysenteriae (Flexner)			
Cotton-wool swab, inoc. 7,200 cols.		Rubbo	1951
plain, dry	0 at 8 hrs.		
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, *S. sonnei* survive 2-3 times longer than Flexner strain		Dold	1943
S. spp.			
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, dessication	20-25 days	"	"
S. sonnei			
Dried on linen, *S. sonnei* survives 2-3 times longer than Flexner strain		Dold	1943
PAPER			
S. dysenteriae			
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 Survey (CONT'D) THE SURVIVAL OF SHIGELLA SPECIES ON SURFACES

Factor(s)	Survival	Reference	
PAPER(CONT'D)			
S. paradysenteriae			
Filter paper, dried	270 days	Dold	1947
S. spp.			
Paper sunlight	5 min	Weinzirl	1907
WOOD			
S. dysenteriae			
Wood, 17-20 C	4-9 days	Frost	1905
Wood, at 38 C., org. will live only 1/2-1/4 surv. of those at 17-20 C..Shiga more frail than Flexner			
GENERAL			
S. dysenteriae			
Bread, surface of after baking	30 hrs.	Alves	1935
Crust of rye bread in well- ventilated room at R.T., with strains of Flexner and Sonnei	45 days	Bachmann	1943
Same as above only at lower temperature -5to -25 C.	2 mos.	"	"
S. paradysenteriae (Flexner)			
Bread, surface, after baking	30 hrs.	Alves	1935
Crust of rye bread, in well ventilated room at R.T., with Shiga and sonnei, At lower temps.	45 days	Bachmann	1943
-5 to - 25 C.	2 mos.	Bachmann	1943
S. sonnei			
Crust of rye bread, in well ventilated room at room temp., with Flexner strains and dysenteriae	45 days	"	"
At lower temp -5 to -25C.	Longer than 2 mos.	"	"

TABLE 4416

THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
DUST			
S. pyogenes (group A)			
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 pueperal 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
FABRICS			
S. pyogenes (group A)			
Cotton wool swab, strept. throat, 17-19 C., inoc. >50 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., 16-22C. 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 4/6 (CONT D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS(CONT'D)			
S. pyogenes(group A)			
Blanket, unoiled	1030 colonies	Andrewes	1940
Blankets oiled	26 out of 307cultures 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 M. aureus, E.coli & 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
S. pyogenes(Group B)			
Blankets, beaten, strep. plate count.0 hour	2000/ plate	Van den	1940
24 hrs.	701/ plate	Ende	
10 days	294/plate		
4 weeks	98/plate		
very slight reduction in	virulence in 4 weeks	"	"
S. pyogenes(Group C)			
Blankets, 2 ft. above floor, 10min. after beating	426/plate	"	"
S. viridans			
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 4a/6 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
FABRICS (CONT'D)			
S. spp.			
Serge, sprayed, medicinal paraffin, mechanically beaten, 1st 2 min.;	Recovered 1300	Van den Ende	1941
during 5 min. period, 12 to 17 min. after beating	Recovered 900		
Woolen blanket, beaten, during 1st 2 min.;	Recovered 4000	"	"
during 5 min. period, 12-17 min. after beating	Recovered 2500		
Wool blanket, dry strep. during 1st 2 min.;	Recovered 490	"	"
during 5 min. period, 12-17 min. after beating	Recovered 11		
Cotton sheet, dry strep. during 1st 2 min.;	Recovered 508	"	"
during 5 min. period 12-17 min. after beating	Recovered 24		
Cotton, sprayed strept. during 1st 2 min.;	Recovered 1320	"	"
during 5 min. period 12-17 min. after beating.	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
GLASS			
S. pyogenes			
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.		Burtenshaw	1938
Susp'n Cont. / Exp. time in min.			
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 " "		
S. viridans			
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 4416 (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)	Survival	Reference	
GLASS (CONT'D)			
S. salivarius			
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	"	"
PAPER			
S. salivarius			
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	"	"
S. pyogenes			
Paper, R.T., strain 1, dry	44 days	Laurell	1949
RUBBER			
S. pyogenes (hemolyticus)			
Rubber apron,		Burtenshaw	1938
Susp'n cont.	Exp. time in min.	No. washed off	
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 Su 6. (CONT'D) THE SURVIVAL OF STREPTOCOCCUS SPECIES ON SURFACES

Factor(s)		Survival	Reference
RUBBER (cont'd)			
S. pyogenes			
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	
UTENSILS			
S. faecalis			
Utensils		High %	Hutchinson 1947
S. viridans			
Utensils		High %	" "
GENERAL			
S. pyogenes			
Mouthpiece of telephone		4-11 days	Coulter 1937
Metal from bullet lodged in flesh of soldier		>2 mos.	Pulvertaft 1929
S. salivarius			
Hand telephone		72.92%	Smeall 1937
Telephone with separate receiver and transmitter		11.10%	" "
S. mitis			
Hand telephone		68.75%	" "
Telephone with separate receiver and transmitter		3.70%	
S. non-hemolyticus			
Hand telephone		2.10%	" "
Telephone with separate receiver and transmitter		3.70%	
S. equine			
Hand telephone		12.50%	" "
S. ignavus			
Hand telephone		8.33%	
S. faecalis			
Hand telephone		2.10%	" "

TABLE 4412 THE SURVIVAL OF VIRUSES ON SURFACES

Factor(s)	Survival	Reference	
DUST			
Foot & Mouth disease			
Stable dust, 62 F., 52% R.H.	11 days	Burbury	1928
Influenzae virus			
Dust, drying, inoc. $1X10^4$	Recovered none, 3 wks.	Edwards	1941
Dust, soaked virus susp'n, R.T., dried	Between 1%-10% recovered in 1 wk.	Krueger	1942
Dust,	Long periods	Pulvertaft	1947
FABRICS			
Influenzae virus			
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 infected saliva.	1 month		
Blanket, dried, inoc. 5% susp'n.	> 5 hrs.	"	"
Blanket, sterile, ord. atmos. conditions	Survives drying	Krueger	1942
Sheeting, serge, soaked with virus susp'n., dried R.T.	Between 1%-10% recovered in 1 wk.	"	"
Fabric	Survived for many days	Robertson	1945
Newcastle virus			
Burlap strips, 4, 22, & 36 C., treated with organic 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		
GLASS			
Foot & Mouth virus			
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 4a17 THE SURVIVAL OF VIRUSES ON SURFACES

Factor(s)	Survival	Reference	
GLASS(CONT'D)			
Influenzae virus			
Glass, dried on surface, R.T.	Still positive 40 min. after drying	Anon.	1943
Glass, dried	1x 10^6 was reduced to <1x10^2 in 6 weeks	Edwards	1941
Glass, dried, 0.1cc inoc.	Recovered none		
Glass, 22 C.	>4 weeks	"	"
Glass, 37 C.	<1 week		
Glass slides soaked with virus suspn., dried, kept at R.T.	Between 1% - 10% recov. in 1 wk.	Krueger	1942
Newcastle disease virus			
Glass, refrig. temp.	Active many months	Asplin	1949
Smallpox virus			
Diluted vesicle fl. dried on glass slides, dark	84 days	Downie	1947
daylight	35 days		
Filterable virus			
Film on glass slide	Retain virulence 15 mos.	Burnet	1906
PAPER			
Foot & Mouth virus			
Paper, 62 F., 52% R.H.	2 days.	Burbury	1928
Newcastle disease virus			
Filter paper, exposed to dry cond., 98 F.	Inactive after 12 hrs.	Asplin	1949
Paper, refrig. temp.	Active many months		
Filter paper, inoc. 0.2ml.			
37 C.	28 days	Olesuik	1951
20-30 C.	25-49 days		
11-36 C.	129 days		
3-6 C.	157 days		
-26 C.	538 days		
RUBBER			
Influenzae virus			
Rubber, R.T.	40 min. after drying still positive	Anon.	1943
GENERAL			
Foot & Mouth virus			
Temp. 3.5 & 5.5 C., if kept moist	6 months	Traum	1934
R.T., dried rapidly in a vacuum	105 days		
On infected premises	345 days	"	"
Tobacco mosaic virus			
Cured tobacco leaves	31 years	Valleoy	1927
Small pox virus			
Crusts	" many years"	Pulvertaft	1947
Swine-fever virus,			
Bricks autoclaved, dried	3 days	Slavin	1930
Hay, autoclaved, dried	3 days		
Virus destroyed in 15 min. by 5% soln. pure phenol and hypochlorite, 1.66 % available chlorine.		Slavin	1938

TABLE 4u17 (CONT'D). THE SURVIVAL OF VIRUSES ON SURFACES

Factor(s)	Survival	Reference
GENERAL(CONT'D)		
Influenzae virus(Melbourne)		
Talc, dried with, original titer 10^{-3}	Recovered none, 22 days	Parker 1944
Mucin in air, dried with, orginal titer 10^{-4}	Recovery positive in 45 days	

TABLE Lu 18 THE SURVIVAL OF YEAST, MOLDS AND FUNGI ON SURFACES

Factor(s)	Survival	Reference	
DUST			
Molds			
Dust in air during dust storm	Dust counts yielded unusually high counts	Proctor	1935
FABRICS			
Trichophyton interdigitale			
Woolen jersey	2 months	Gould	1931
Trichophyton gypseum			
Cotton string and linen	Several months, at least 102-346 days	Shaw	1944
Microsporon audouni			
Cotton string	At least 78-276 days		
Microsporon lanosum			
Cotton string	At least 102-235 days		
Fungi spores			
Clothing, spores carried	----------	Smith	1943
PAPER			
Trichophyton gypseum			
Filter paper	Several months, at least 102-346 days	Shaw	1944
Molds			
Cardboard strips, spores ultra-violet light	None entirely killed	Appling	1941
Yeasts			
Whatman # 50 paper, water susp'n. sprayed, 15 min. exposure to short waves	50 % killed	Lion	1949
GENERAL			
Microsporon audouini			
Hair planted on Sabouraud	420 days	Farley	1921
Fungi			
Hand tele phone	5.25 % organism	Smeall	1937
Molds			
Hand tele phones	20.83% organisms	Smeall	1937
Telephones with separate receiver and transmitter	11.10% organisms	Smeall	1937
Yeast			
Hand telephones	47.92%	"	"
Telephones with separate receiver and transmitter	11.10%		

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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 WATER

TABLE #	TABLE OF CONTENTS	PAGES
W1	Bacillus species	2
W2	Bacteriophage	1
W3	Brucella species	1
W4	Clostridium species	1
W5	Coliform bacteria	8
W6	Leptospira species	1
W7	Metazoa and Protozoa	2
W8	Micrococcus species	2
W9	Microorganisms	1
W10	Microorganisms (Klebsiella, Serratia, Proteus and Pseudomonas)	2
W11	Mycobacterium species	2
W12	Factors affecting survival of organisms	1
W13	Pasteurella species	1
W14	Rickettsiae species	1
W15	Salmonella species	10
W16	Shigella species	2
W17	Streptococcus species	1
W18	Vibrio comma	4
W19	Viruses	2
W20	Yeasts and Fungi	1
	References (1-391)	20
	References, Addendum (None)	0
	Authors appearing in references but not in tables	1
	Abbreviations	1

TABLE 6-1 THE SURVIVAL OF BACILLUS SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Bacillus anthracis			
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.	Karlinski	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	1936
River, 30-35, 7-10C	Recov. 34,800, 2 d.	Wolffhugel	1886
Filtered river, 35, 7 10C	Recov. 4 immediately	"	"
Bacillus yellow sp.			
Tap	208 d.	Hochstetter	1887
DISTILLED WATER			
Bacillus anthracis			
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.	"	"

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NATURAL WATERS			
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Raw	5 mo.	"	"
Tap, 11-13C	3 d.	Hochstetter	1887
" 18-20C	Spores 154 d.	"	"
Water	72 hr.	Karlinski	1889
Tap, R.T., in spleen	3½ yr.	Konradi	1904
" " " culture	> 264 d.	"	"
" " " spores on silk thread	> 816 d.	"	"
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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	"	"
Bacillus yellow sp.			
Tap	208 d.	Hochstetter	1887
DISTILLED WATER			
Bacillus anthracis			
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 41 (CONT'D) THE SURVIVAL OF BACILLUS SPECIES IN WATER

Factor(s)	Survival	Reference	
DISTILLED WATER			
Bacillus anthracis			
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
Bacillus cereus			
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 "	"	"
Bacillus megatherium			
Dist., pH 6	Inoc. 100%; 61% in 90min.	"	"
" " 7	" " 132% " " "	"	"
" " 8	" " 71% " " "	"	"
" " 9	" " 82% " " "	"	"
Bacillus spp.			
Dist., 10-17C	12d.	Hochstetter	1887
Dist.	Relatively short	Zobell	1932
Redist., R.T.	4-5 wk.	"	"
ICE			
Bacillus mesentericus			
Ice	Present	Haines	1937
SALINE SOLUTIONS			
SEA			
Bacillus anthracis			
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
SEWAGE			
Bacillus anthracis			
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
OTHERS			
Bacillus anthracis			
Seltzer, 11-13C and 18-20C	1 hr. and spores 154 d.	Hochstetter	1887

TABLE 42 THE SURVIVAL OF BRUCELLA SPECIES IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS		
Brucella melitensis		
Water favorable condition	10 wk.	Bang 1897
Ster. tap	20 d.	Kenndy 1905
Brucella abortus		
Pasture water	> 8 d. < 30 d.	Christiansen 1950
Brucella suis		
Tap	77 d.	Bryan 1934
SALINE SOLUTIONS		
PHYSIOLOGICAL		
Brucella spp.		
Salt soln.	in 0.25% than 0.85% Above pH 8 and below pH 6.6 shorter viability	Zobell 1932

TABLE W 3 THE SURVIVAL OF BACTERIOPHAGE IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
E. coli phage			
Tap, pH 7.5, 45-75C	Death rate of first order	Chang	1950
Water, pH 5.2, alkaline	Present	Marginesu	1929
S. typhosa phage			
Water, pH 5.2, alkaline	Not present	"	"
Rivers of cities	More in summer mo.	DeAssumpeao	1943
S. paratyphi phage			
Rivers of cities	" " " "	"	"
Sh. dysenteriae phage			
Water, pH 5.2, alkaline	Not present	Marginesu	1929
Micrococcus phage			
Water, pH 5.2, alkaline	Present	"	"
Vibrios phage			
Water	Disappearance of Vibrios	D'Herelle	1926
DISTILLED WATER			
Virus T_2 phage			
Dist., daylight	3% after 72 hr. of irration	Latarjet	1951
" white hot bulb	0% after 65 hr. " " ration	"	"
SALINE SOLUTIONS			
SEA			
S. typhosa phage			
Sea	Recov. 10% in 7 d.	Guelin	1948
S. paradysenteriae phage			
Sea	Recov. 9% in 30 d.	"	"
E. coli phage			
Sea	" " " " "	"	"
General phage			
Sea	Longer than bacteria	"	"
SALINE SOLUTIONS			
PHYSIOLOGICAL			
S. typhosa phage			
Saline	4% in 3 d.	Guelin	1948
Sh. paradysenteriae phage			
Saline	2% in 2 d.	"	"
E. coli phage			
Saline	1% in 2 d.	"	"
SEWAGE			
General phage			
Sewage	Varies seasonally	Beckwith	1930

TABLE W4

THE SURVIVAL OF CLOSTRIDIUM SPECIES IN WATER

Factor(s)	Survival	Reference
ICE		
Clostridium botulinum		
Ice, -16C	14 mo.	Tanner 1931
SEWAGE		
Clostridium perfringens and sporogenes		
Activated sludge	After being pressed and heated was present	Greer 1926

TABLE 1112 THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Escherichia coli			
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	Eratic fluctions in cts.	Cox	1949
River, weaklight	Inoc. 72,000,000; 46 d.	Arloing	1931
" daylight	" " " "	"	"
" natural	" " 87 d.	"	"
" filtered	" " " "	"	"
" " and heated 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 4w3 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS (cont'd)		
Escherichia coli		
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., 10-15 C, 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 1W2 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS (cont'd)		
Escherichia coli		
Ster. river, dark, 37C, with E. coli and A. aerogenes	Inoc. 57,000/cc; Recov. 0; 30 d.	Platt 1935
Raw river, 0-2C	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	Inod. >10,000; Recov. 0, >1 <5 d.	" "
" " 0-2C	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.	Raghavachavi 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, 22C Tank empied 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 442 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS (cont'd)		
Escherichia coli		
Water, after centerifuging	280 d.	Winslow 1927
1 hr. later	131 d.	" "
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.	" "
DISTILLED WATER		
Escherichia coli		
Distilled	31¼ 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_2MnO_4 and KOH	72 hr.	Burke 1936
Double dist.	Longer than has been reported	Catalano 1947
Dist.	51 d.	Cramarossa 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 sucrose	Tanner 1944

TABLE (12) (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference	
DISTILLED WATER (cont'd)			
Escherichia coli			
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
ICE			
Escherichia coli			
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., metabilism 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
SALINE SOLUTION			
SEA			
Escherichia coli			
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.	"	"
" " " autoclaved	39 d.	"	"
Sea, " " Seitz filtered, pulp disc	10 d.	"	"
Sea, Seitz filt, 60C	5 d.	"	"
" " " 100C	27d.	"	"

TABLE W1 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference
SALINE SOLUTION		
SEA		
Escherichia coli		
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
PHYSIOLOGICAL		
Escherichia coli		
85% NaCl, 37C	13½ mo.	Ballantyne 1930
" " R.T.	31½ 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.	" "
SEWAGE		
Escherichia coli		
Sewage	Cts. higher in summer than in winter	Allen 1949
" plus cloroben	50-90% killed	Brown 1947
" in streams	Found 12 mi. below outlet, on sunny days 2.9 mi.	" 1916
Sewage	Milt. on storage at high temp.	Butterfield 1933
", aerated 62 hr.	Inoc. 1:300, 6 hr.	Carlson 1943
" and irrigation water	Not given	Chapman 1935
Sewage	Not sufficient to cause disease	Crawford 1940
Sewage ordinary	53-65 d.	Firth 1902

TABLE 103 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference	
SEWAGE			
Escherichia coli			
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 7 d.	Rogers	1918
Ster. water and feces, 20C	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.	"	"
NATURAL WATERS			
Escherichia intermedium			
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%, " "	"	"
Aerobacter aerogenes			
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. 6,900/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 57 (CONT'D) THE SURVIVAL OF COLIFORM BACTERIA IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS (cont'd)			
Aerobacter aerogenes			
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	"	"
Aerobacter cloacae			
River	Constant	Ford	1912
Aerobacter spp.			
Water, 12C	Recov. 1804, 1 d.	Maccolini	1946
" "	" 7800, 6 d.	"	"
" 17C	" Innumerable	"	"
" "	" "	"	"
DISTILLED WATER			
Escherichia intermedium			
Dist.	59 d.	Webster	1934
"	62 d.	"	"
SEWAGE			
Aerobacter aerogenes			
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 a6 THE SURVIVAL OF LEPTOSPIRA SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATER			
L. icterohaemorrhagiae			
Pit water	Months	Buchannan	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.	"	"
DISTILLED WATER			
L. icterohaemorrhagiae			
Dist.	7 d.	Noguchi	1918
SALINE SOLUTION			
SEA			
L. icterohaemorrhagiae			
Sea	18-20 hr.	Chang	1948
SEWAGE			
L. icterohaemorrhagiae			
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 47 THE SURVIVAL OF METAZOA AND PROTOZOA IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Endamoeba histolytica			
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 36C	50% left in 2 hr.	Kuenen	1913
"	Inoc. 50 cysts; Recov. 47; 9 d.	"	"
Slow running water	15 d.	Penfold	1916
Trichomonas vaginalis			
Water	35-45 min.	Jerovic	1948
Ancylostoma duodenale			
Water, 60F	18 mo.	Nicoll	1917
Ancylostoma sp.			
Water, by lab window	12 mo.	Loebker	1906
Necator americanus			
Water, 60F	18 mo.	Nicoll	1917
DISTILLED WATER			
Endamoeba histolytica			
Dist., 12-22C	153 d.	Boeck	1921
" tap, R.T.	14 d.	Dobell	1926
Endamoeba coli			
Dist., 12-22C	244 d.	Boeck	1921
Giardia intestinalis			
Dist., 12-22C	32-66 d.	"	"
Chilomastix mesnili			
Dist., 12-22C	187 d.	"	"
SEWAGE			
Endamoeba histolytica			
Sludge, 103C	Inoc. 500,000; 48 hr.	Cram	1943
Dilute feces	>1 mo.	Wenyon	1917
Ascaris lumbricoides			
Sludge, 103C	Egg lives 3 min.	Cram	1943
" "	" " 151 d.	"	"
"	62 d.	Wright	1942
Acylostoma sp.			
Sludge, 103C	5 d.	Cram	1943
Taenia saginata			
Sludge, digestion, 75-85F	Inoc. 600,000; 6 mo.	Newton	1949
Trichuris trichiura			
Sludge	22 d.	Wright	1942

TABLE W1 (CONT'D) THE SURVIVAL OF METAZOA AND PROTOZOA IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS		
Paramecium		
Sewage	Die in few days.	Purdy 1918
General		
Sewage	Protozoa and bacteria rapid increase in protozoa, decrease in bacteria	" "

TABLE W8 THE SURVIVAL OF MICROCOCCUS [redacted] IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS		
Micrococcus aurantiacus		
Tap, 10-17C	22 d.	Hochstetter 1887
Micrococcus spp.		
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
DISTILLED WATER		
Micrococcus pyogenes var. aureus (Staph. aureus)		
Dist.	32 d.	Cramarossa 1922
Micrococcus pyogenes var. albus		
Dist.	48 d.	" "
Micrococcus spp.		
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
Micrococcus aurantiacus		
Dist., 10-17C	22 d.	Hochstetter 1887
ICE		
Micrococcus pyogenes var. aureus (Staph. aureus)		
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
SALINE SOLUTIONS		
SEA		
Micrococcus pyogenes var. aureus (Staph. aureus)		
Sea, bouillon	Inoc. 3/4, 36 d.	De Giaxa 1889
" agar	" almost exclusively 9 d.	" " "
Ster. sea, bouillon	Inoc. rich growth, 36 d,	" " "
PHYSIOLOGICAL		
Micrococcus pyogenes var. aureus (Staph. aureus)		
Saline	29 d.	Cramarossa 1927
Micrococcus pyogenes var. albus		
Saline	23 d.	" "
OTHERS		
Micrococcus aurantiacus		
Seltzer, 10-17C	16 d.	Hochstetter 1887

TABLE W9 THE SURVIVAL OF MICROORGANISMS IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Alcaligenes faecalis			
River	Constant	Ford	1912
Corynebacterium diphtheriae			
Ster. R.T.	3 d.	Lomry	1929
" 37C	30 hr.	"	"
Neisseria gonorrhoeae			
Ster. tap, 37C	22 min.	Bengtson	1925
Bacterium phosphorescens			
Fresh	1 wk.	Korinek	1926
DISTILLED WATER			
Alcaligenes faecalis			
Dist.	18 d.	Cramarossa	1927
Neisseria gonorrhea			
Ster. dist., 37C	22 min.	Bengtson	1925
Dist., 18-22C	Inoc. 24 hr. cult., Recov. 60.4%, 6 hr.	Pieper	1930
" " "	Inoc. 48 hr. cult., Recov. 70%, 6 hr.	"	"
ICE			
Lactobacillus casei			
Dist., -21 to -78C	10,000-100,000/ml, more resistant to freezing than thawing	Lund	-
Neisseria gonorrhea			
Ice	9-15 d.	Hampil	1932
SALINE SOLUTIONS			
PHYSIOLOGICAL			
Alcaligenes faecalis			
Saline	21 d.	Cramarossa	1927
Neisseria gonorrhea			
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.	"	"
SEWAGE			
Bacterium salmonicida			
Domestic sewage	15 d.	Duff	1940
Sewage after removal of original sewage	13-67 d.	"	"
NATURAL WATERS			
Erysipelothrix spp.			
Drinking water	4-5 d.	Hettche	1937
SALINE SOLUTIONS			
SEA			
Erysipelothrix sp.			
Sea ster.	1 wk.	Hettche	1937

TABLE W10

THE SURVIVAL OF MICROORGANISMS IN WATER
(Klebsiella, Serratia, Proteus, & Pseudomona)

Factor(s)	Survival	Reference	
NATURAL WATERS			
Serratia marcescens			
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
Proteus sp.			
River	Found	Ford	1912
Pseudomonas pyocyanea			
Water, Hg and Fe ore radition, under glass, cooled	1 min. at 8 cm.	Bazzoni	1914
All kinds of water	Flourished	Frankland	1886
Pseudomonas spp.			
Tap, 12-17C	14 d.	Hochstetter	1887
Aerated, 22C	Inoc. 4 d. old gel. cult. 16 d.	Slater	1893
DISTILLED WATER			
Klebsiella pneumoniae			
Distilled	31¼ mo.	Ballantyne	1930
"	Up to 76 d.	Panisset	1925
Ster. dist., 15-20C	8 d.	Strauss	1889
Serratia marcescens			
Dist., 20C	48 d.	Bolton	1886
" 35C	14 d.	"	"
" 10-17C	7 d. - 5 d.	"	"
"	36 d.	Cramarossa	1922
Pseudomonas pyocyanea			
Dist., 37C	30 3/4 mo.	Ballantyne	1930
"	31¼ mo.	"	"
" 0-8C	25 mo.	"	"
"	85 d.	Cramarossa	1922
Pseudomonas spp.			
Dist., 12-17C	14 d.	Hochstetter	1887
" plus Cu 1/10m.	2 hr.	T. & W.	1932
ICE			
Serratia marcescens			
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
Proteus vulgaris			
Ice, 14-30F	103 d.	Hilliard	1918
Contaminated water, 14-30F	Inoc. 8,320/cc; Recov. 0, 51 d.	Prudden	1887
Water, -1C to -1.1C	51 d.	Frankland	1894
Pseudomonas pycyanea			
Ice, -5, -20, -70C	80%	Haines	1937
Pseudomonas fluorescens			
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
SALINE SOLUTIONS		
PHYSIOLOGICAL		
Klebsiella pneumoniae		
85% NaCl	3⅛ mo.	Ballantyne 1930
Proteus sp.		
Saline	40 d.	Cramarossa 1927
Pseudomonas pyocyanea		
85% NaCl, 37C	30 3/4 mo.	Ballantyne 1930
" " R.T.	31¼ mo.	" "
Saline	85 d.	Cramarossa 1927
SEWAGE		
Pseudomonas sp.		
Ster. sewage, R.T.	7⅛ mo.	Rochaix 1930
OTHERS		
Serratia marcescens		
Seltzer, 10-17C	6-10 d.	Hochstetter 1887
Pseudomonas sp.		
Seltzer, 12-17C	11 d.	" "

TABLE W 11 THE SURVIVAL OF MYCOBACTERIUM SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Mycobacterium tuberculosis			
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, 10½C	Inoc. 57,960-56,000; 6 d.	Kraus	1887
Water	Still virulent 3-3½ mo.	Loesener	1896
Water susp'n., 37C,	Inoc. 4-6 wk. serum cult. 1-4 d.	Moriya	1909
" " ice box	Inoc. 4-6 wk. serum " 52-142 d.	"	"
Canal, diffuse light, R.T., mixed with sputum	6½ mo.	Musehold	1900
Canal, dark	" "	"	"
" diffuse light all weather	4½ "	"	"
Myc. tuberculosis (avium)			
Stream	Inoc. 48,000/cc; Recov. 940/cc; 73 d.	Rhines	1935
Myc. paratuberculosis			
Intestinal scrapings with river, outdoor temp.	Recov. 163 d.	Lovell	1944
DISTILLED WATER			
Myc. tuberculosis			
Dist.	16 mo.	Ballantyne	1930
"	31¾ 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. 2-9 d.	Moriya	1909
" Ice box	Inoc. 4-6 wk. serum cult, 7-152 d.	"	"
Ster. dist., 15-20C	115 d.	Strauss	1889
Myc. paratuberculosis			
Dist., pond, tap, and mud	Recov. 9 mo.	Lovell	1944
ICE			
Myc. tuberculosis			
Dist. ice, dark	>12 wk.	Gloyne	1928
Ice	12 wk.	"	"
SALINE SOLUTIONS			
PHYSIOLOGICAL			
Myc. tuberculosis			
85% NaCl, 37C	13½ mo.	Ballantyne	1930
Isotonic NaCl 0.9%	>88 d.	Bartel	1908

TABLE W11 (CONT'D) THE SURVIVAL OF MYCOBACTERIUM SPECIES IN WATER

Factor(s)	Survival	Reference	
SALINE SOLUTIONS			
PHYSIOLOGICAL			
Myc. tuberculosis			
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. 21 d.	Moriya	1909
" " 37C	Inoc. 4-6 wk. " " 98 d.	"	"
" " ice box	Inoc. 4-6 wk. " " 152 d.	"	"
SEWAGE			
Myc. tuberculosis			
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 at R.T., diffuse light	6½ mo.	Musehold	1900
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
Myc. avium			
Sewage	Inoc. 49,000/cc, Recov. 400/cc, 73 d.	Rhines	1935

TABLE 1&1 2 FACTORS AFFECTING SURVIVAL OF ORGANISMS IN WATERS

Factors(s)	Survival	Reference	
NATURAL WATERS			
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. (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 Eberthella to chlorination than are some of colon groups. (4) Viruses of poliomyelitis and hepatatis 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.		Levine	1947
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, Incc. 4900, Recov. 0, 6 hr. Middle, " 4510 " 2 " " Bottom " 6781 " 8 " " Darkened cylinder: Surface, Incc. 4900 " 7261, 6 hr. Middle " 4510 " 9051, " " Bottom " 6781 " 12591, " "			
ICE			
Dist., -16C	Shorter than sea water	Hess	1934

TABLE XIV (CONT'D) FACTORS AFFECTING SURVIVAL OF ORGANISMS IN WATERS

Factor(s)	Survival	Reference	
ICE (cont'd)			
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 reduction shortly after.	from some block. Greater	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
SALINE SOLUTIONS			
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.	quickly die in sea Below 20C protozoa have no effect.	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, " "		"	"
Artifical 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 terrestial 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 1112 (CONT'D) FACTORS AFFECTING SURVIVAL OF ORGANISMS IN WATERS

Factor(s)	Survival	Reference	
SALINE SOLUTIONS (cont'd)			
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
SEWAGE			
Bacteria in sewage high count 2-6 d., maintained 6-15 wk.		Purdy	1918
Saprophytes must play a big part in disappearance of organisms in sewage after testing survival with sterile sewage.		Rochaix	1930
Putrifaction bacteria attack E. coli.		"	1931

TABLE IV13 THE SURVIVAL OF PASTEURELLA SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Pasteurella tularensis			
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, 10-20C	" "	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
DISTILLED WATER			
Pasteurella multocida Dist., 14-18C	½ hr.	Hochstetter	1887
Pasteurella hemolytica Dist. 37C	2¼ hr.	Jacotot	1926
Pasteurella multocida Dist., 37C	Up to 4.5 hr.	Panisset	1925
OTHERS			
Pasteurella multocida Seltzer, 14-18C	½ hr.	Hochstetter	1887

TABLE W14 THE SURVIVAL OF RICKETTSIA SPECIES IN WATER

Factor(s)	Survival	Reference
NATURAL WATERS		
Rickettsia		
Coxiella burneti		
Water, R.T.	7 d.	Babudieri 1950
Rickettsia prowazekii		
Well	Present	Mazurczak 1945
DISTILLED WATER		
Rickettsia prowazekii		
Dist., 26-28C	<2 hr.	Anderson 1944
Tap and dist.	Deleterious effect on viability	Topping 1940
SALINE SOLUTIONS		
PHYSIOLOGICAL		
Rickettsia prowazekii		
Physiological saline	Deleterious effect on viability	Topping 1940

TABLE W15' THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
S. typhosa			
Tap	7 d.	Altoff	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. resptively	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	Curtails	"	"
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 1415 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS (cont'd)			
S. typhosa			
River	1 wk. gives 99% reduct.	Houston	1908
" cold	Proldngs	"	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	
NATURAL WATERS (cont'd)			
S. typhosa			
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 W/5 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS (cont'd)			
S. typhosa			
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 pathogenes 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.	"	"
S. paratyphi A			
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 IV.5 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS (cont'd)			
S. paratyphi A			
Tap	2 d.	Mouzet	1936
Boiled	10 d.	"	"
S. paratyphi B			
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.	"	"
S. paratyphi spp.			
Mineral	Inoc. 500 coli/1000cc 100paratyphoid/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.	"	"
S. typhimurium			
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 "	"	"
DISTILLED WATER			
S. typhosa			
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	
DISTILLED WATER (cont'd)			
S. typhosa			
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
" " " culture	490 d.	"	"
Distilled, body temp., in spleen	429 d.	"	"
Distilled, " " " culture	420 d.	"	"
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.	"	"
S. paratyphi A			
Distilled	5 d.	Aitoff	1935
" , incubator temp. pH 5.9-6.2	42 d.	"	"
Dist.	23 d.	Cramarossa	1922
"	5 d.	Mouzet	1936
S. paratyphi 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.	Mouzei	1936
Ster. dist.	8½ mo.	Tanner	1944
Dist., 60-142C,	Inoc. 16-20 hr. cult. & 6 cc. water, 1 hr.	Tinti	1923
ICE			
S. typhosa			
Ice	>8 mo.; 1% in 10 d.	Berry	1934

TABLE 1115 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference	
ICE (cont'd)			
S. typhosa			
Ice	22 wk.	Hampil	1932
" , 0 C	>7 mo.	Hutchings	1903
" of filtered river, <0C	Inoc. 2,000,000/cc; 1 d.	Jordan	1904
Water, feces, urine; -8 to -30C, exposed to air	40-50 d.	Lu-Ti-Huan	1930
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. 10,037,000; 14 d.	Ruedegir	1911
"	4 mo.	Park	1920
Contaminated water, 14-30F	Recov. 7,348/cc; 103 d.	Prudden	1887
Water, alternate freezing and thawing 5x	Inoc. 40,896/cc; 3 d.	"	"
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. 2,490/cc; 5 d.	Hilliard	1918
S. paratyphi spp.			
Ice	13 d.	Thomas	1925
S. paratyphi B			
Ice	17 d.	"	"
SALINE SOLUTION			
SEA			
S. typhosa			
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 Giaxa	1889
" agar	" almost " , 9 d.	"	"
Ster. sea, bouillon	Inoc. 11800, 9 d.	"	"
" " agar	" 4800, 10 d.	"	"
Sea	1 d.	Gohar	1948
" autoclaved, Seitz filtered	32 d.	"	"
Sea, Seitz filtered	2 d.	"	"
" " " , autoclaved, pulp disc	5 d.	"	"
Sea, Seitz filtered, 60-100C	3 d. at 60C & 30 d. -100C	"	"
Sea	10 d.	Herdman	1899
Sea (oysters)	Inoc. 160,000,000; Recov. 320; 4 d.	Klein	1905

TABLE 2115 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
SALINE SOLUTION (cont'd)		
SEA		
S. typhosa		
Non-contaminated sea	16 d.	Trawinski 1929
Contaminated sea	3 d.	" "
S. paratyphi A		
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.	" "
S. paratyphi B		
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.	" "
S. paratyphi sp.		
Sea non-contaminated,	16 d.	Trawinski 1929
" contaminated	" "	" "
S. entertidis		
Sea non-contaminated	23 d.	" "
" contaminated	5 d.	" "
S. typhimurium		
Sea non-contaminated	21 d.	" "
" contaminated	7 d.	" "
PHYSIOLOGICAL		
S. typhosa		
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
SALINE SOLUTION (cont'd)		
PHYSIOLOGICAL		
S. paratyphi A		
85% NaCl, 37C	13⅓ mo.	Ballantyne 1930
Saline	33 d.	Camarossa 1927
S. paratyphi B		
85% NaCl, 37 C	13⅓ mo.	Ballantyne 1930
Saline	73 d.	Camarossa 1927
S. paratyphi sp.		
85% NaCl, R. T.	25 ¾ mo.	Ballantyne 1930
S. entertidis		
85% NaCl, 37C	13⅓ mo.	Ballantyne 1930
SEWAGE		
S. typhosa		
Sewage and sludge	Inoc. 450,000/ml., 12 hr.	Bruns 1927
Septic tank	2-3 d.	Flu 1921
Raw, R.T., north light	Inoc. 6,500,000; 3 d.	Green 1938
" outside, lower than R.T., pH 7.2-7.8	Inoc. 5 m.; 27 d.	" "
Activated sludge, pH 6.8-7.6	Inoc. 37,500,000; >24 hr.	" "
Sewage in trickling filter	<⅓ hr.	" "
River plus urine of typhoid cases, dark	99.9% reduction 1 wk.	Houston 1911
Water and feces, 1.9C	Inoc. 5,800,000/cc; <1 d.	Jordan 1904
Sewage, 14.5-17C	" 12,000/cc; <1 d.	" "
Septic tank	5 d.	Kliger 1921
Sewage in river	Present	Lendon 1951
" of city	37 specimens out of 305	Messerschmidt 1951
Polluted	Disappeared more rapidly than in water or ice	Park 1920
Ster. sewage, R.T.	7⅓ mo.	Rochaix 1930
Activated sludge, aerated	Recov. 14%, 5⅓ hr.	Ruchhoft 1934
" " storage, 68-72F	" 0, 8-14 d.	" "
Activated sludge, storage, 50-60F	" 0, 83 d.	" "
Sewage	5 d.	Russell 1906
" , winter	26 d.	Shimomura 1935
" summer	7 d.	" "
Sewage, R.T.	Inoc. 1000/cc; neg. in 7 d.	Stewart 1933
Naturally infected sewage, R.T.	5 wk.	" "
Dried sludge, 14% moisture	Inoc. 7,500,000/ml; 180d.	Stokes 1945
Sludge anaerobic	45 d.	" "
Ster. sewage	3 mo. and 7 d.	Tanner 1944
Feces and water, 17-22.5C, weakly alkaline	Inoc. many; 96 hr.	Uffelman 1889
Feces and water, 9C, weakly alkaline	" " 24 hr.	" "

TABLE LVI5 (CONT'D) THE SURVIVAL OF SALMONELLA SPECIES IN WATER

Factor(s)	Survival	Reference
SEWAGE (cont'd)		
S. typhosa		
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
S. paratyphi A		
Ster. sewage, R.T.	7½ mo.	Rochaix 1930
S. paratyphi B		
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.	" "
S. paratyphi spp.		
Sewage of city	61 out of 305 specimens	Messerschmidt 1951
Sludge drying	Inoc. 25m/ml; 41 d.	Stokes 1945
S. entertidis		
Sewage of city	5 out of 305 specimens	Messerschmidt 1951
OTHERS		
S. typhosa		
Seltzer, 12-15 C	4 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	
NATURAL WATERS			
Sh. dysenteriae			
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.	"	"
Sh. paradysenteriae (Flexner)			
Tap	16 d.	Aitoff	1935
Boiled	22 d.	"	"
Tap	16 d.	Mouzet	1936
Boiled	22 d.	"	"
Water	38 d.	Stewart	1944
Sh. paradysenteriae (Sonne)			
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. residual Cl.	Found	Freen	1943
DISTILLED WATER			
Sh. dysenteriae			
Dist.	15 d.	Aitoff	1935
"	7-73 d.	Cramarossa	1927

TABLE 11B (CONT'D) THE SURVIVAL OF SHIGELLA SPECIES IN WATER

Factor(s)	Survival	Reference
DISTILLED WATER		
Sh. dysenteriae		
Dist.	18 d.	Kusama 1925
"	15 d.	Mouzet 1936
" , 60-142C,	Inoc. 16-20 hr. cult. in 6cc. water, 1 hr.	Tinti 1923
Sh. paradysenteriae (Flexner)		
Dist.	24 d.	Aitoff 1935
"	7-73 d.	Cramarossa 1927
"	24 d.	Mouzet 1936
ICE		
Sh. dysenteriae		
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
SALINE SOLUTIONS		
SEA		
Sh. dysenteriae		
Filtered sea	2-5 mo.	Felsen 1945
Contaminated and non-" sea	30 hr. and 12 hr.	Trawinski 1929
Sh. paradysenteriae spp.		
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.	" "
PHYSIOLOGICAL		
Sh. dysenteriae		
85% NaCl, 37C	13½ mo.	Ballantyne 1930
0.8% salt soln.	12-53 d.	Cramarossa 1927
Sh. paradysenteriae (Flexner)		
0.8% salt soln.	12-53 d.	Cramarossa 1927
Saline	35 d.	" "

TABLE LIII THE SURVIVAL OF STREPTOCOCCUS SPECIES IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
S. agalactiae			
Tap	66 d.	Bryan	1934
S. pyogenes			
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.	"	"
S. faecalis			
Swimming pool plus Cl	1 hr.	Ritter	1948
S. salivarius			
Swimming pool plus Cl	5 min.	"	"
S. enterococcus			
Tap without Cl	>12 hr.	"	"
S. spp.			
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.	"	"
DISTILLED WATER			
S. pyogenes			
Ster. dist., R.T., subdued light	3-87 d.	Livingston	1921
S. mitis			
Dist.	21 3/4 mo.	Ballantyne	1930
" , 0-8C	25 mo.	"	"
S. spp.			
Dist.	Not given	Gilcreas	1950
"	4-7 d., K value 0.736 81.6% reduction/day	Heller	1941
" , 37C	Upto 74 d.	Panisset	1925
Ster. dist., 15-20C	15 d.	Strauss	1889
SALINE SOLUTION			
PHYSIOLOGICAL			
S. mitis			
85% NaCl, 37C	13½ mo.	Ballantyne	1930
S. pyogenes			
Saline	12 d.	Livingston	1921
S. spp.			
Saline	K value 0.537, 70.9%/d.	Heller	1941
SEWAGE			
S. spp.			
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	
NATURAL WATERS			
Vibrio comma			
Tap	2 d.	Arguelles	1927
Ster. tap	6-10 d.	"	"
Water, 10 atm. carbon dioxide	<10 hr.	Colin	1915
Ster. spring	7 mo.	D'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.	"	"
" " recent "	" 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.	"	"
" " " " sealed	<72 hr.	"	"
Filtered	<48 hr.	"	"
Heated 55C for ½ hr.	<72 hr.	"	"
Open boiled and vapor from raw water at 80C for 15 min	<72 hr.	"	"

TABLE 118 (CONT'D) THE SURVIVAL OF VIBRIO COMMA IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS (cont'd)			
Vibrio comma			
Opened boiled plus vapor from raw water at 90C 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, 10⅔C	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, " clave, 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, uncone.	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	
NATURAL WATERS (cont'd)			
Vibrio comma			
Artifical 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
DISTILLED WATER			
Vibrio comma			
Ster. dist.	<1 d.	Argelles	1927
Dist.	29 d.	Camarossa	1922
" plus $CuSo_4$ 1/50M	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
ICE			
Vibrio comma			
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.	"	"
SALINE SOLUTION			
SEA			
Vibrio comma			
Sea	12 d.	Arguelles	1927
" , on bouillon, 37C	Inoc. 1,000; 4 d.	DeGiaxa	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.	"	"
" " " , autoclaved, pulp disc	5 d.	"	"
Sea, filt., ster. bact. suspn.	3 d.	"	"
Sea and sewage, 18C	24 hr.	"	"
Synthetic sea	26 d.	"	"

TABLE IV (CONT'D) THE SURVIVAL OF VIBRIO COMMA IN WATER

Factor(s)	Survival	Reference
SALINE SOLUTION		
SEA		
Vibrio comma		
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.	" "
PHYSIOLOGICAL		
Vibrio comma		
Sat. soln. of NaCl	Less than 1 d.	Arguelles 1927
Saline	36 d.	Cramarossa 1927
SEWAGE		
Vibrio comma		
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
OTHERS		
Vibrio comma		
Seltzer water, 18C	2½ hr.	Hochstetter 1887

TABLE 419 THE SURVIVAL OF VIRUS IN WATER

Factor(s)	Survival	Reference	
NATURAL WATERS			
Polio			
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, c 05 ppm. residual free Cl and .1-.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
Lymphocytic choriomeningitis			
Chlorinated drinking water, R.T.	7,3,4 d.	Zichis	1948
Western equine encephalitis			
Chlorinated drinking, R.T.	5,2,4 d.	"	"
St. Louis encephalitis			
Chlorinated drinking, R.T.	4,3,2 d.	"	"
DISTILLED WATER			
Yellow fever			
Dist., ice box	10 yr.	Bauer	1940
Polio			
Dist., pH 6.85-7.4, 0.05 ppm. residual free Cl	10 min.	Lensen	1949
Vaccinia virus			
Dist., 18-37C	60 d.	Noguchi	1918
SEWAGE			
Polio			
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 oro-nasopharyngeal secretion	Inactivated 30 min.	Faber	1951
Domestic sewage	Present	Maxcy	1949
Sewage of polio victims and carriers	Possibly hr.	"	1943

TABLE 119 (CONT'D) THE SURVIVAL OF VIRUS IN WATER

Factor(s)	Survival	Reference	
SEWAGE			
Polio			
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
NATURAL WATERS		
Aspergillus		
Tap, 12-17C	56 d.	Hochstetter 1887
DISTILLED WATER		
Aspergillus		
Dist., 12-17C	56 d.	Hochstetter 1887
Cladosporium mansoni		
Dist., R.T.	12 mo.	Castellani 1939
Aleurisma castellanii		
Dist., R.T.	" "	" "
Actinomyces sp.		
Dist., R.T.	" "	" "
Monilia sp.		
Dist., R.T.	" "	" "
Geotrichum sp.		
Dist., R.T.	" "	" "
Epidermophyton flaccosum		
Dist., R.T.	" "	" "
ICE		
Saccharomyces sp.		
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.	" "
OTHERS		
Aspergillus		
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
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

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