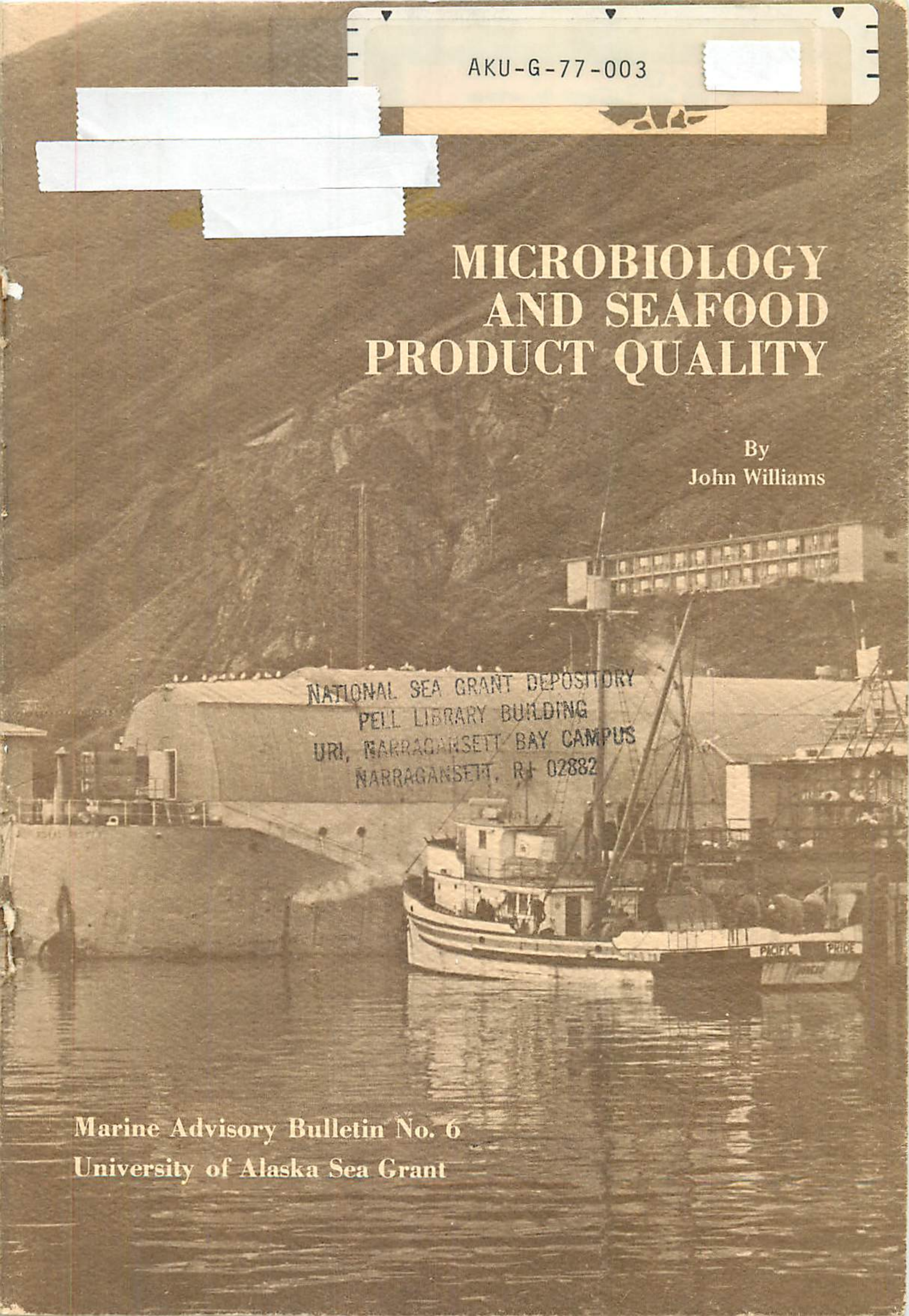
# MICROBIOLOGY AND SEAFOOD PRODUCT QUALITY

By
John Williams



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# MICROBIOLOGY AND SEAFOOD PRODUCT QUALITY

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Marine Advisory Program

## UNIVERSITY OF ALASKA
## SEA GRANT PROGRAM

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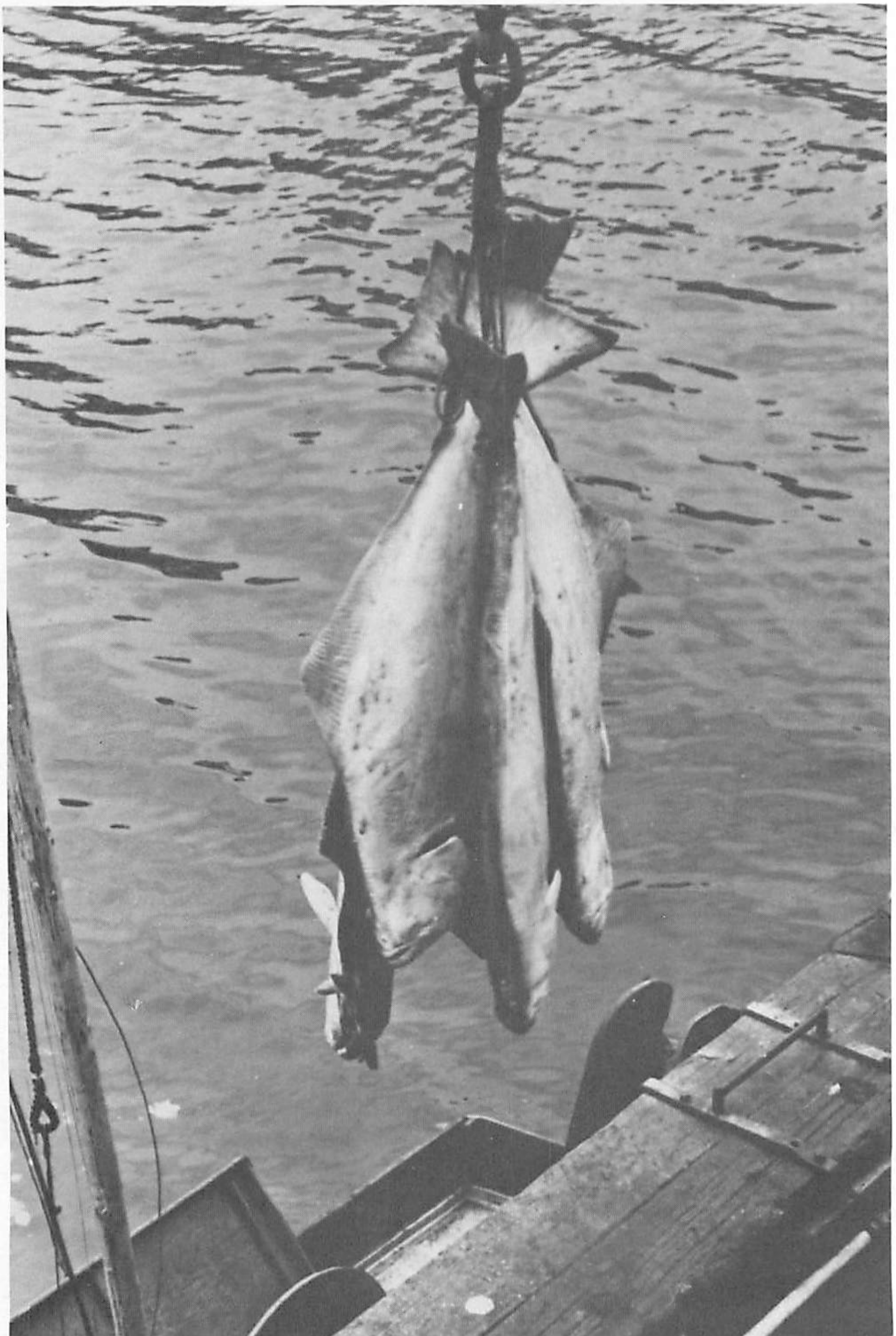
*Cover photo:*

*"Cannery Row" –*

*Kodiak's busy harbor front.*

*(Courtesy of the Arctic Environmental Information and Data Center)*

*Sketches by*
*Ann C. Schell*


Mac's Photo

## INTRODUCTION

Each year, millions of pounds of fish and shellfish are landed at Alaskan ports where they are purchased from the fishermen and processed. The fish are caught by seines, gillnets, pots, traps, longlines, trolls, and trawls. Whatever method a fisherman chooses to use will have some effect on the quality of his catch. Every fisherman must be aware of the steps he needs to take to insure that his catch will be of the best quality.

What is quality? It is the word that describes how acceptable his catch will be to consumers. If it is firm, of good aroma, and not contaminated with any unnatural substances, it is probably of high quality.

Once the fish is brought to the tender or to the dock, it is then the job of seafood processors to evaluate the fisherman's catch and to process it in a manner that will insure quality and safety. Agencies, such as the Food and Drug Administration, regulate processing operations to insure that a safe, wholesome product is produced by every processor. The final word on product quality, however, remains with the management of each company.

*Giant halibut – a part of Alaska's rich harvest from the sea – are hoisted to the dock. These specimens measure more than five feet long and weigh over 100 pounds.*

## CHEMICAL AND PHYSICAL QUALITY

The microbiological aspect of seafood is one of the major factors of product quality, and will be discussed in the following pages. Although very important, it is not the only thing that determines quality. Other aspects include the chemical breakdown processes that take place in the product.

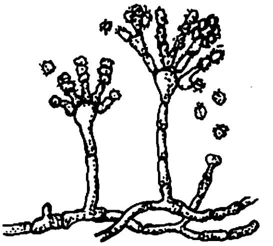
Every food, whether from animal or plant, begins to decompose the instant it dies. The rate of that decomposition is determined by such factors as temperature, exposure to sunlight, subjection to oxygen, and the presence or absence of substances which may either slow down or speed up decomposition. These factors will have varying effects depending on the species and the point in the life cycle when the product is harvested. In the case of animal foods, a very complex factor affecting the chemical aspects of quality is a phenomenon called *rigor mortis:* the stiffening of muscles after death. Eventually this stiffening or contraction ceases, and the muscle returns to a softer state. This process of rigor mortis dramatically determines the rate of chemical breakdown of the flesh. Until rigor mortis is complete and the flesh has become soft, all decomposition processes are greatly inhibited, and the flesh does not suffer any great loss of quality. Hence, efforts to slow down the onset of rigor mortis and to lengthen the rigor mortis period once it has begun will extend the time of high quality. With seafood, this can most easily be accomplished by keeping the catch cool and out of sunlight.

Quality can also be affected simply by the physical handling of the catch. Walking on deckloads of product, piling fish to excessive depths in the hold, and bruising during unloading operations causes loss of quality. Keeping it free of paint flakes, grease, pieces of wood, mud, rubber, and cloth increases its quality.

## WHAT IS MICROBIOLOGY?

Looking at the various parts of the word gives a clue as to the meaning. *Micro* means small. *Biology* means the study of life and life processes. Thus, *microbiology* is the study of very small life forms, generally seen only with the aid of a microscope. Microorganisms are everywhere — in us, on us, and in the air around us. When discussing microbiology of foods, the organisms which are of concern are bacteria, yeasts, and molds. Of these three, bacteria are by far the major concern of seafood processors, but mention should be made of the other two, since they can be troublesome.

## WHAT ARE MOLDS?

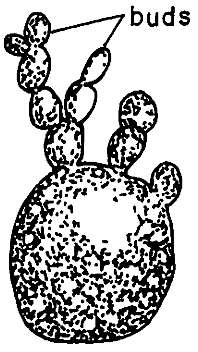


Mold fruiting body

Molds are one of the few microorganisms you can see without a microscope. The green or black growth on bread and oranges is mold. The mildew that forms on many surfaces in moist climates is another type of mold. The greenish-blue which appears on bleu cheese is a mold, intentionally grown on the cheese to give it its characteristic bleu cheese flavor.

Molds can grow almost anywhere. In fact, they are found in all climates, all continents, and all oceans. They are multicellular life forms which reproduce either by releasing seed-like spores, or branching from a base to form a new body.

The growth of mold in a fish plant indicates improper cleaning procedures. If surfaces are not cleaned of all food particles and kept dry, mold will result. Consequently, the presence of mold in an Alaskan fish plant tells the processor that he is not doing an adequate job of cleaning his plant. In fact, he is probably doing a very poor job, since mold is easily prevented with basic housekeeping procedures.




YEAST

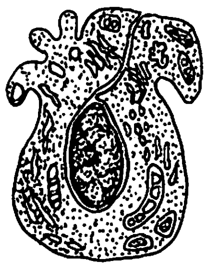
## WHAT ARE YEASTS?

Yeasts are very much like molds except that they are single celled organisms which appear alone or in clusters. Yeasts are commonly used in the food industry for such things as fermenting fruits, grapes, and cereals to make various alcoholic beverages. They are necessary to leaven bread, and are grown commercially to extract vitamins and food supplements. Yeasts reproduce commonly by budding, but also form spores.

Yeasts, like molds, are easily removed from food equipment by proper cleaning. Their presence indicates improper cleaning procedures. There is no health hazard associated with yeast growth in seafood, but yeast presence suggests that conditions may allow for the growth of other microorganisms which might be more harmful.

## WHAT ARE BACTERIA?

Bacterial cell



⊢0.0001"⊣

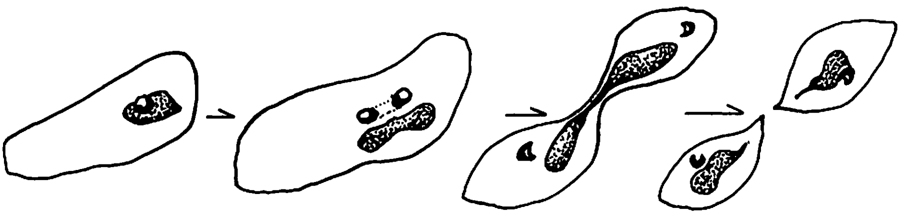
Bacteria are single cell life forms, complete within one cell and the surrounding cell wall. Ten thousand bacteria, placed side by side, would make a string 1 inch long, and 1/10,000 inch wide. Hundreds of thousands of bacteria could fit on the head of a pin. Obviously, bacteria are only seen individually under a microscope. Scientists have found ways of counting bacteria with the naked eye, which will be discussed later.

It is interesting that the biggest nuisance in one case is the savior of all life on earth in another. Without bacteria to decay all dead life forms, the earth would soon be a trash heap of trees, plants, and animals which eventually would tie up all the necessary chemicals to continue new life.

Ninety-nine percent of the bacterial types are harmless to man. In fact, the digestion of food in our small intestine is due in great part to the bacteria which live and multiply there. The other one percent of the bacteria are "pathogenic," meaning disease causing. Less than one-half of that one percent of pathogens use food as a carrier to spread disease from one victim to another.

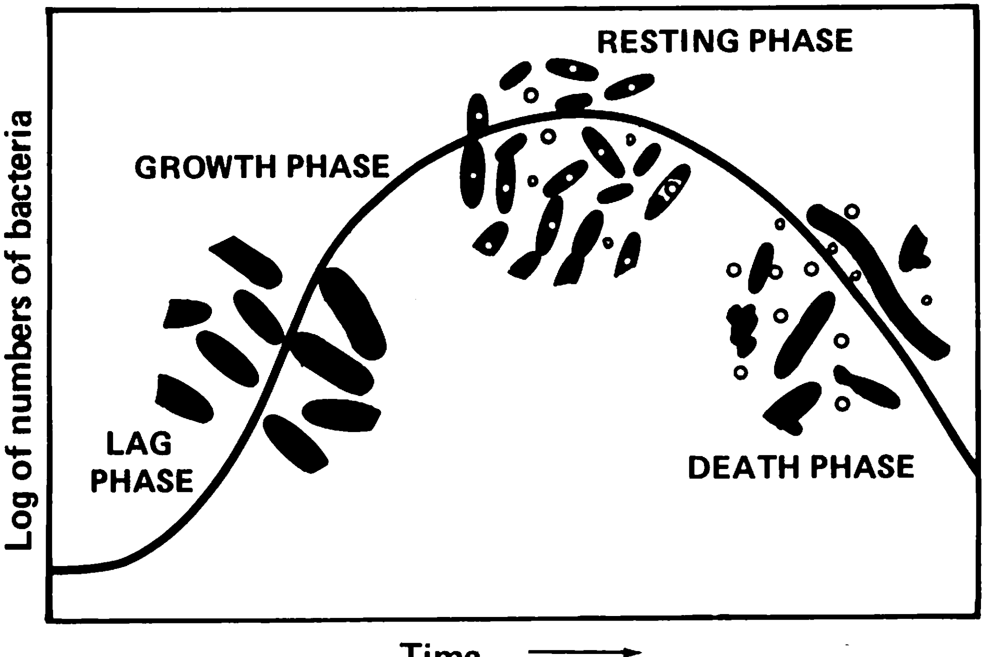
## HOW DO BACTERIA GROW?

Most of us are familiar with the concept of growth meaning getting bigger and/or older. Not so for bacteria, which "grow" by dividing. That is, one cell becomes two cells, and those two cells divide to become four separate and complete cells. This process is called *binary fission,* which means two breaking apart. This splitting or binary fission begins with a cell enlarging and elongating, then constricting at the middle. The constriction eventually separates the single cell into two cells. The cell wall forms around each new cell with its entire complement of genetic material, energy producing bodies, digestive parts, etc.

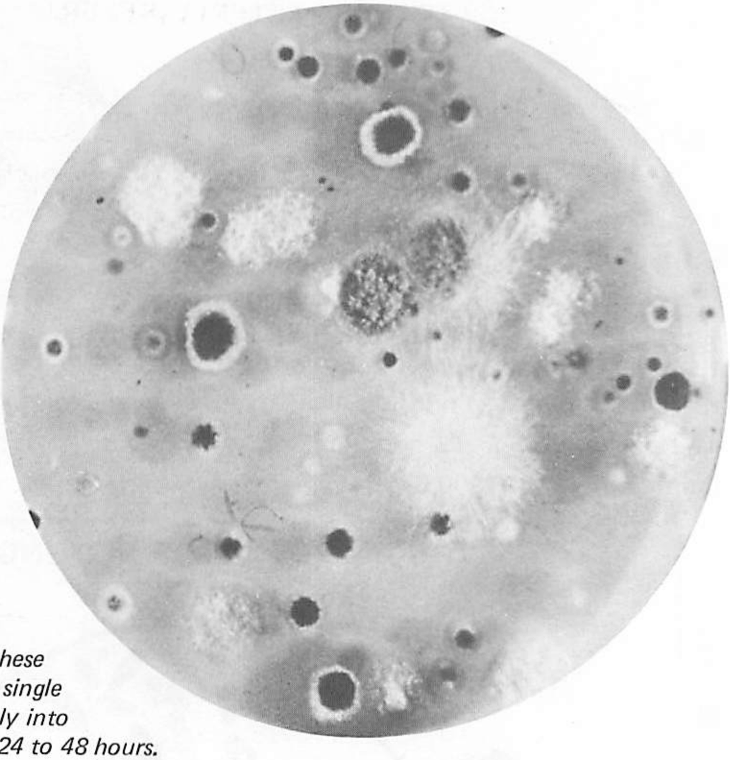


Binary fission

This process of growth by dividing is very rapid if all the conditions are right. Under ideal conditions, bacteria can divide every 20 to 30 minutes. That means that in 12 hours one bacterium could multiply to the fantastic number of 17,000,000,000!




*BACTERIAL GROWTH/DEATH CURVE: This curve demonstrates the rate of bacterial growth. Initially, a lag phase exists, when bacterial numbers are small and a significant period of time is required to greatly increase that number. This lag phase is followed by a "log growth phase." "Log" refers to an exponential rate of increase. Each unit increase up the vertical axis represents a ten-fold increase in cell numbers. The log growth phase is followed by a resting phase, when growth rate equals death rate. As less and less food is available, or higher levels of bacterial toxins (poisons) are produced during cell growth, the death rate increases to a "log death rate."*



*Bacterial colonies are grown in dishes containing food dissolved in water and a gelling agent. Under these ideal conditions, tiny single bacterium can multiply into visible masses within 24 to 48 hours.*

Fortunately, ideal conditions for bacterial growth do not remain constant for long periods of time. Most often, bacteria growing in ideal conditions soon consume all the available food, which then stops growth. In other cases, the bacteria are prevented from further growth because of the waste products they form as they digest food. Just as humans consume food and water and cast off wastes, so do bacteria. These wastes often reach concentrations high enough to poison the bacteria and thus stop growth.

Scientists often grow bacteria in order to study them. One of the most common ways to accomplish this is by mixing a powdered food and water with a compound similar to gelatin called *agar*. The food mixture is poured into a shallow glass dish called a *petri dish*. The dish is covered and the agar allowed to gel. Then a sample containing bacteria is smeared on the gelled surface and the dish is placed in a warming cabinet called an *incubator*, which keeps it at an optimum temperature for bacterial growth. Under these ideal conditions for growing, each bacterium rapidly multiplies so many times that the massive number of cells can easily be seen. This mass is called a *colony*. By counting each colony, the initial number of bacteria contained in the sample which was smeared on the dish can be determined.

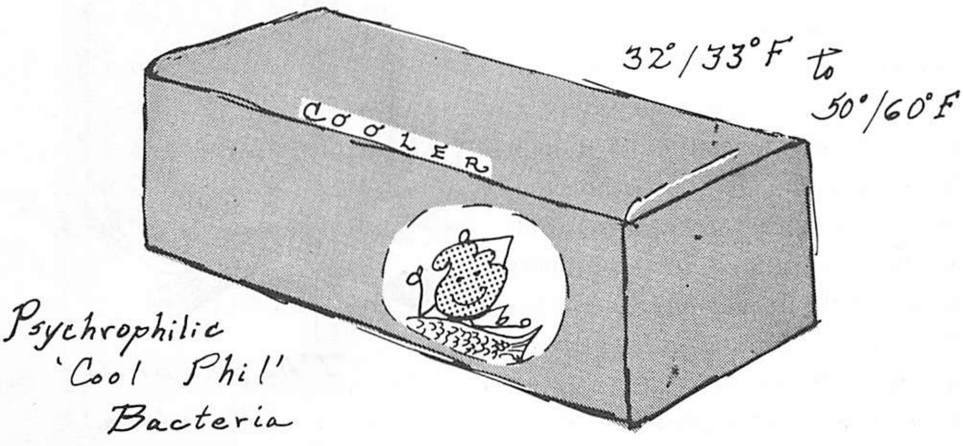
## HOW DO BACTERIA DIFFER?

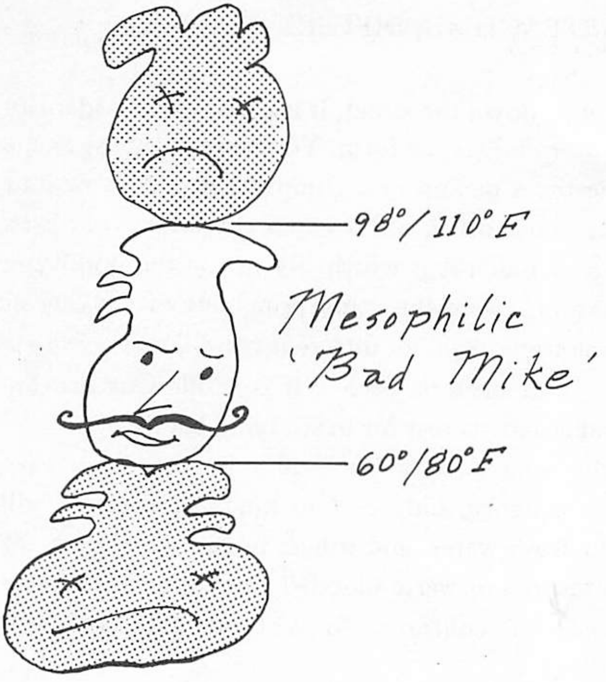
When you see a car traveling down the street, it is often easy to identify that vehicle by looking at its *morphology*, or form. You can tell by the shape whether it is foreign or domestic, a pickup or a compact, two door or fcur door, two wheel drive or four wheel drive, and if you really know your cars, what year it was made and how much it is worth. By lifting the hood you can discover further information. Using the same principles of looking at morphology and by testing the bacteria under different conditions, scientists can often determine what sort of bacteria each cell is. Following are the most common differences that scientists test for in studying bacteria:

**1. Origin** — Knowing the source of a bacterium is sometimes very helpful in identifying it. For instance, only certain kinds of bacteria will grow in sea water, others in fresh water, and others in soil. One group of bacteria grows only in the intestines of warm-blooded animals and are called *fecal coliforms.* The presence of coliforms in seafood indicates poor sanitation and improper handling.

**2. Growth Temperature** — Scientists have divided bacteria into three classes as determined by the temperature they prefer for optimum growth conditions. These three classes are:

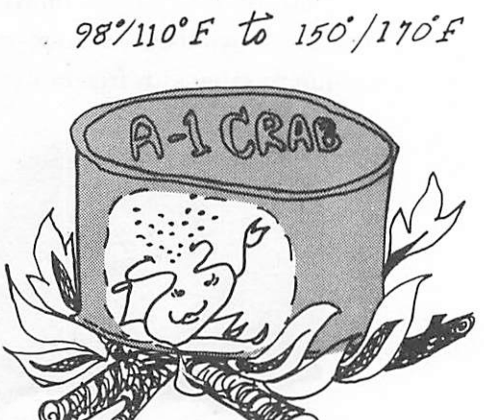
(a) *Psychrophilic bacteria* – *Psychro* means cold; *philic* means loving. Thus, these kinds are named cold-loving bacteria. They will grow in temperatures varying from refrigerator temperatures (32° to 33° F) up to 50° or 60°F. (The limits vary according to different authors.) These are obviously of concern in refrigerated products, since they continue to grow at refrigerator temperatures.





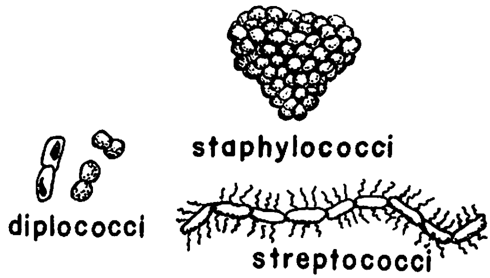

(b) *Mesophilic bacteria* — *Meso* means **middle.** Hence, these bacteria grow at middle range temperatures. The extremes of the temperatures necessary for growth of this class are 60° to 80° as a minimum, and 98° to 100°F maximum. All of the pathogens are in this group.

(c) *Thermophilic bacteria* — These are **heat-loving** bacteria, and grow from 98° to 110°F up through 150° — or even 170°F. These types most often present problems in canned food products because of another characteristic they have — that of spore formation. Although these bacteria are not pathogenic, they have been the cause of food spoilage in canned food products which are not adequately cooled after retorting or were held at too high a temperature during warehousing or shipping.



3. **Cell Shape** — Bacteria generally can be partially classified by determining the shape of their individual cells under a microscope. The most commonly seen shapes are *coccus* (round), *bacillus* (rod-like), and *spirilla* (spiraled). Some bacteria are intermediate between the first two, and are called *cocco-bacilli.*

BACTERIAL MORPHOLOGY (cell shapes)



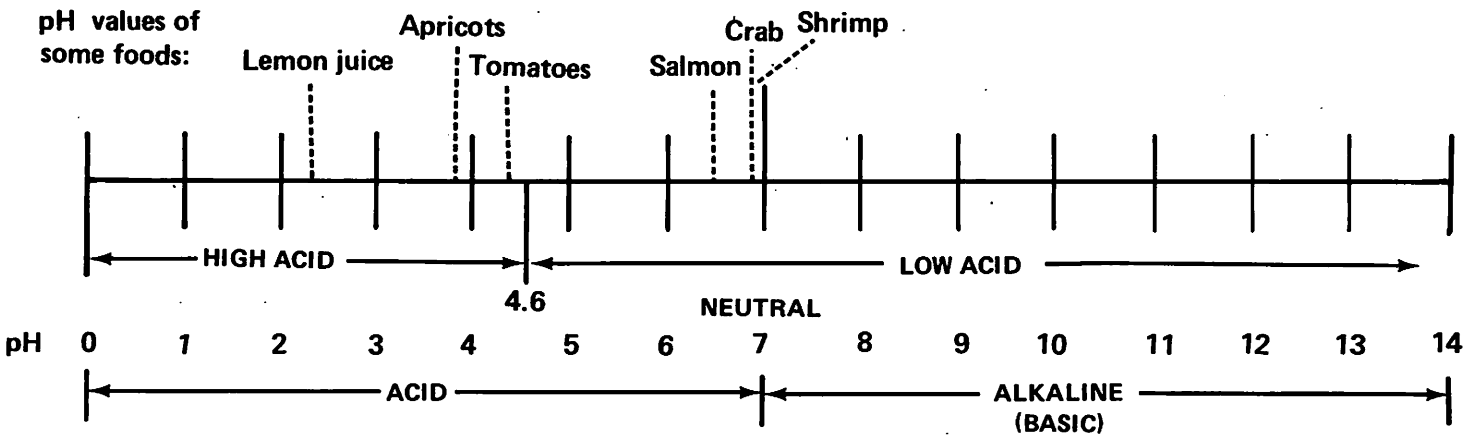

4. **Cell Clusters** — Even though each bacterial cell is equipped to exist independent of all other bacteria, different types of bacteria often remain in characteristic clumps or clusters. The commonly seen clusters are: *diplococci* (two coccus cells together), *streptococci* (coccus cells in long chains), and *staphylococci* (cells in clusters like a bunch of grapes). Bacillus cells may appear in pairs or chains.

5. **Oxygen Requirements** — Some bacteria require oxygen for growth, just as animal life does. These are *aerobic* bacteria. Other bacteria are poisoned by oxygen, and grow only in the absence of oxygen. These are *anaerobes*.

Anaerobic conditions are found in such places as deep in the soil, deep in sea water, and most importantly, inside of vacuum packed cans or plastic films. Other bacteria grow either in the presence or absence of oxygen, and are called *facultative anaerobes.*


Aerobic 'Al' needs oxygen.

## THE pH SCALE




*On the pH scale, values from 0 to 7 are acid, 7 is neutral, and values from 7 to 14 are basic. The most acidic is pH 0; the most basic is pH 14.*

*As you move up the scale from pH 0 towards pH 7, an increase of 1 unit (for example, pH 2 to pH 3) represents a 10-fold dilution of acidity. Hence, pH 5 is 10 times more acidic than pH 6, and 10 times less acidic than pH 4.*

*As you move down the scale from pH 14 towards pH 7, every decrease in number represents a 10 fold decrease in basicity. pH 10 is 10 times more basic than pH 9, and 10 times less basic than pH 11.*

*pH 7 is the pH of pure distilled water. At pH 7, there is a perfect balance of all acidic and basic ions in the solution.*

6. **pH Requirement** – pH is a method of measuring the degree of acidity or alkalinity (basicity) of a substance. The pH is very important in determining the suitability of a food for bacterial growth. Acid is added to some foods in order to lower the pH and thus prevent the growth of particular types of spoilage organisms. (Acid added to canned shrimp is used, not for this purpose, but mainly to stabilize color.)

On the pH scale, 0-7 is acid, 7 is neutral, and 7-14 is alkaline. If the pH is *low*, the food is a *high acid* food. If the pH is relatively *high*, the food is a *low acid* food. Seafoods are usually low acid foods. The pH which determines the separation of high acid (low pH) and low acid (high pH) foods is pH 4.6. This number is chosen because a pH higher than 4.6 is required for growth of the organism which causes botulism; any food with a pH lower than 4.6 is not a suitable food for the growth of this organism.

7. **Moisture Requirement** — All bacteria require water for growth, but some need more than others. Generally, if a food has less than 25 to 30 percent water, it will not support the growth of pathogenic bacteria.

Some chemicals, when added to a food, tie up a portion of the water by physical attraction. Two common examples of chemicals exhibiting this characteristic are salt and alcohol. Drying, brining, salting, and fermenting are very old food preservation methods which affect water availability.

8. **Spore Formation** – Some kinds of bacteria produce spores. These differ from yeast and mold spores in that they are formed within the bacterial cell and are released at time of death. Bacterial spores are formed in times of environmental stress. Spores are dormant life stages which contain all the necessities for changing back into vegetative bacterial cells when environmental conditions permit. These spores are the most death-resistant life forms known. They withstand extreme temperatures, both very hot and very cold. Because spores are so heat resistant, they are difficult to destroy during canning of foods. Bactericides, which are compounds that easily kill bacteria, have much less effect on spores.

Thermophilic bacteria produce spores. Since thermophiles are not a health hazard, destroying their spores is not necessary during thermal processing. However, since the spores can return to vegetative bacterial forms, it is necessary to keep the finished cans at ambient temperatures so the thermophilic spores will not have ideal temperature conditions.

*Clostridium botulinum*, the bacterium that causes botulism, is also a spore former, but not thermophilic. It is very important to kill all spores of this organism when canning food. In fact, retorting times and temperatures are scientifically determined to kill these spores.

9. **Miscellaneous**— Many other techniques are used by scientists to classify bacteria. These include their susceptibility to inhibitory chemicals (such as salt, chlorine, acids, etc.), the structure of their cell walls, the color or shape of bacterial colonies, the production of gas during growth in certain conditions, the abilities to change the color of dyes while growing, the presence or absence of *flagella* (hair-like structures which are processed by some bacteria for mobility), and many others.

## WHAT FACTORS CAN BE CONTROLLED IN ORDER TO KILL OR INHIBIT BACTERIAL GROWTH?

The previous section discusses some characteristics that distinguish one kind of bacteria from others and examples of bacteria which might be found in different situations. This section will discuss some factors which seafood processors can control or alter, and the effect these changes may have on bacteria.

As was mentioned earlier, the moment any plant or animal dies, natural decomposition processes begin immediately. This decomposition includes both natural chemical breakdown resulting from changes within the food, and the natural growth of bacteria which rapidly hastens the process. Man's effort to prevent this decomposition, or at least to slow it down, are efforts to prevent naturally occurring processes. To accomplish this, conditions are altered to less favorable conditions. This concept is the basis of food processing and food preservation. Following are six most easily altered factors which influence the rate of bacterial decomposition of food:

1. **Food**— One of the first requirements for bacterial growth is something to grow on — a food source. Good housekeeping in a seafood plant requires the removal of food particles from all machinery and interior surfaces. This is accomplished with detergents, water, and muscle. Once all the food has been removed, it is then wise to spray the surfaces with chlorinated water to kill any bacteria which would otherwise remain dormant on the surfaces — waiting for their next meal and chance to multiply. Cleanup is thus a two-step operation. First, food particles must be removed with detergents, and second, remaining bacteria must be killed with a chlorinated water wash-down.

2. **Temperature** — The previous section discussed three classifications of bacteria based upon the temperature ranges within which each class could grow. With this knowledge, we can change the temperature to some level which will either kill bacteria or reduce their growth rate.

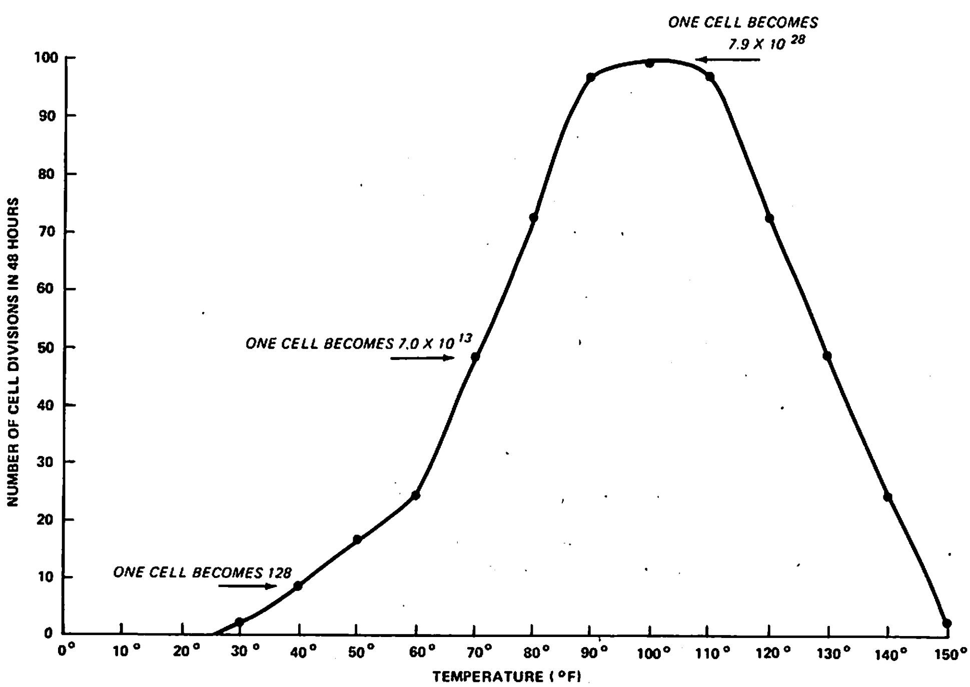
(a) Freezing of food prevents bacteria from growing. Frozen foods held at 0° F at all times during storage will not allow for bacterial growth. Freezing does not kill bacteria at a very fast rate; it only prevents them from growing.

(b) Refrigeration and icing of seafood will dramatically slow both chemical decomposition and bacterial growth. Temperatures for refrigeration should be close to 32° F for maximum effect.

(c) Boiling a food is a good method of killing bacteria. Bacteria will not grow at temperatures above 170° F. Any time a seafood is being boiled or blanched, the water should always be hotter than 140°, and preferrably hotter than 170°.

(d) In the last section, the resistance to heat and cold of bacterial spores was discussed. In the canning industry, it is vitally important to kill all spores of the organism *Clostridium botulinum*. Because of the

BACTERIAL GROWTH RATES AT DIFFERENT TEMPERATURES



spore's high heat resistance, it is most common to use high temperature steam under pressure to destroy it. Scientists have tested standard products in commercial cans of all low-acid foods to determine the minimum conditions of temperature and time to kill *Clostridium* spores. Those guidelines should be followed without exception as the minimum requirements for retorting seafood products.

3. **Oxygen** — The last section defined aerobes as bacteria which require oxygen for growth, and anaerobes as bacteria which grow only in the absence of oxygen. By removing oxygen from around a food (by vacuum packing in an oxygen-impermeable plastic wrap or in a can or jar), the growth of all aerobes is prohibited. By so doing, though, the processor has set up ideal conditions for the growth of anaerobes.

(a) Thermophilic bacteria produce spores and are anaerobic. They do not cause sickness or disease, but can decompose food under the right conditions. The spores of these anaerobes will not invariably be killed during retorting. To prevent these spores from converting to vegetative cells and growing, it is important to cool cans to ambient temperatures after retorting and to warehouse all cans in cool, dry storage areas.

(b) *Clostridium botulinum* is also an anaerobe, and produces a deadly poison when it grows in a food product. It is important never to allow this anaerobe or its spores to survive during thermal processing.

(c) In cold-storage operations it is common practice to glaze fish. This does a good job of preventing oxygen contact with the product. This is not done for purposes of bacterial growth control, but instead, to prevent freezer burn (dehydration of the frozen flesh).

4. **pH** — High acid and low acid foods are discussed in the last section. These two terms are based upon the pH conditions which will or will not allow *Clostridium botulinum* to grow. Low acid foods (having a pH higher than 4.6) can allow this organism to produce its toxin if other conditions are permitting (temperature, moisture, etc.). All foods with a pH higher than 4.6, which includes all fresh seafood, must be treated as potential carriers of *Clostridium botulinum* organisms and be treated in such a manner as to not allow for their growth.

Processors of some food products are able to add acid to the food without seriously affecting the quality of the product. If enough acid can be added to lower the pH below 4.6, then the concerns about botulism are greatly diminished. Unfortunately, this technique is not feasible for the Alaska seafood products presently being processed because of the bad effect it would have on texture and flavor.

5. **Water Availability** — Drying, salting, and brining will tie up or remove enough water from a food to prevent the growth of many bacteria. A scientific measurement of available water is called *water activity* and is symbolized as $A_W$. Pure distilled water has an $A_W$ value of 1.00. Any food product with an $A_W$ value of less than 0.85 will not allow *Clostridium botulinum* to grow.

6. **Presence of Inhibitory or Lethal Substances** — Chlorine and iodine solutions kill bacteria and are safe to use around food products. Chlorinated water and iodine hand-dips are invaluable tools in controlling bacterial growth in food processing plants.

A number of other substances will also prevent bacterial growth and are safe to use in foods. Jams and jellies are free from bacterial growth because of a high concentration of sugar which inhibits bacterial growth. Many other specially designed preservatives, called food additives, are used by food processors to control bacterial growth.

## RULES OF THUMB

1. Under ideal conditions bacteria can multiply very rapidly. Careful and frequent cleaning of machinery, aprons, gloves, and utensils removes particles that serve as a bacterial food source.

Cool, chlorinated water, sprayed on machinery and equipment after cleansing, will kill most remaining bacteria. The consistent and frequent attention paid to reducing bacterial numbers gives seafood processors a built-in safety factor. The chart on the following page illustrates this.

2. The feces of warm-blooded animals, such as dogs, cats, and man, is an excellent source of pathogens. Fecal coliforms are not pathogenic, but are found only in feces. Thus, the presence of fecal coliforms in a seafood product indicates the possible presence of pathogens, and in addition identifies the source of contamination. Dogs and cats should never be allowed in seafood plants. If coliform organisms are found in seafood products, the processor must suspect that some employees are not following the sanitation guidelines required in every Alaska seafood plant. Every trip to the toilet must be followed by hand washing and a hand dip before the employee returns to his job.

## BACTERIAL GROWTH UNDER VARYING HOUSEKEEPING PRACTICES

| | Bacterial numbers per unit area of food equipment | | | |
|---|---|---|---|---|
| BACTERIAL LOAD → | Time: 0 hour Start of morning operations. Bacterial load | Time: 2 hours (4 bacterial growth cycles) | Bacterial load after 2-hour washdown | Time: 4 hours (8 bacterial growth cycles) |
| **PLANT A**<br>Practices good housekeeping<br>Washdown every 2 hours<br>Thorough cleaning at end of shift | 50/unit | 400/unit | 50/unit | 400/unit |
| **PLANT B**<br>Practices some housekeeping<br>Washdown every 4 hours<br>Thorough cleaning at end of shift | 50/unit | 400/unit | No washdown | 6,400/unit |
| **PLANT C**<br>Practices poor housekeeping<br>Washdown every 4 hours<br>Improper cleaning at end of shift | 1,000/unit | 16,000/unit | No washdown | 256,000/unit |

3. Even though only one percent of all bacterial types are pathogens, other bacteria can and do grow in food. These are called spoilage organisms. If spoilage organism growth is allowed to continue unchecked, the food will not be suitable for consumption because of objectionable flavor, odor, and texture.

4. Spore forming bacteria are the hardest to kill with heat or chemicals, since their spores are so resistant to environmental stresses. Thermophilic anaerobes will grow in canned foods if their spores are not destroyed by the heat process. The rate of their growth will depend on the warehouse temperatures of the canned products.

5. Freezing temperatures kill bacteria at a very slow rate. This should never be considered an adequate method of killing bacteria. Bacterial numbers should be very small on any product that is to be frozen. Once it is thawed and ready for preparation, most of the bacteria that were present when the product was frozen will begin to grow.

6. *CLOSTRIDIUM BOTULINUM*, THE ORGANISM WHICH CAUSES BOTULISM, IS A SPORE FORMING, ANAEROBIC, MESOPHILIC, TOXIN (POISON) PRODUCING PATHOGEN. THE TOXIN PRODUCED BY THE BACTERIUM IS ONE OF THE DEADLIEST SUBSTANCES KNOWN TO MAN. Following are the critical points to be controlled in every seafood canning operation to prevent the possibility of improper processing:

- Keep the level of contamination of the raw product at a minimum. Proper handling before retorting will insure that the bacterial load on the raw product is at a minimum. The fewer "bugs" present, the less likely one deadly one will survive the heat process. Keep it clean, keep it cool, and keep it moving.
- Good seams are a must. If the seams are not within the specifications as stated by the can supplier, there is a chance the seams will not isolate the contents of the can from the outside environment. Thermal processing is wasted effort if any speck of bacteria-laden dirt or moisture can enter through a faulty seam after processing.
- Be sure every lot of cans entering the retort has an internal temperature greater than the "initial temperature" specified for the cook being used. The initial temperature minimums for every cook are stated in Bulletin 26-L of the National Canners Association.
- Every retort must be properly designed, as specified in Part 128-b of the Food and Drug Administration canning regulations.

- Every batch of cans must receive an adequate cook — that is — the proper application of the correct temperature for the minimally required period of time as stated in NCA Bulletin 26-L.
- Cooling water used to flood the retorts at the end of the cook should be sufficiently chlorinated to leave a one part per million (ppm) residual of chlorine at the end of the cooling period. The chlorination of the water is required to kill any bacteria which may be present in the water. During the cool-down stage, small droplets of water may enter the can through the seam as the process of cooling allows for the return of the vacuum inside the can. The Canned Salmon Control Plan, a voluntary agreement between members of the salmon industry and the Food and Drug Administration, requires 1 ppm chlorine residual at the completion of the cool-down process. It is so stated because some of the chlorine originally injected into the water will not be available to kill bacteria since it reacts with any organic matter in the water and with the iron retort.
- The cans should not be banged or bumped, since this may permanently deform the seam and break the seal. It is possible for a bump to instantly open a seam even a small amount — just long enough for a bacteria-laden droplet of water to be sucked through the seam into the can. Thus, finished cans should be kept free of moisture, in order to keep bacteria away from the seam and to prevent moisture from causing rust and corrosion on the can.

## FOOD POISONING

There are two types of bacterial food poisoning which are common throughout the United States and the world. Staph food poisoning involves the consumption of an amount of toxin which is produced by a *staphylococcus* organism. If quality control inspections reveal the presence of staph organisms in a seafood plant, the source is probably a worker with staph infected sores on the skin.

*Salmonella* food poisoning is not an intoxication, but is really an infection. Victims become ill from eating the salmonella organism itself in quantites large enough to produce the illness.

Both of the food poisonings above are common in the United States. Neither usually causes death, except in rare situations involving infants or elderly people. The toxin produced by the staphylococcus organism is not easily destroyed once it has been produced. Salmonella organisms can be readily killed by the application of sufficient heat.

## BOTULISM

Botulism is a much less common food poisoning but often results in death for its victims. *Clostridium botulinum* does not present any hazard until an oxygen-free environment is created. Hence, the canning industry is the center of greatest concern and must be constantly aware of the potential peril. Botulism cases resulting from the consumption of commercially canned low acid foods have been few in number. However, in situations where it has occurred, it has resulted in complete destruction of the company and has had severe effects on the whole industry.

## GLOSSARY

aerobe (ā'ĕr ōb) — a bacteria which lives and grows in contact with oxygen.

agar (ȧg' ȧr) — a gelatin-like substance used in the preparation of food for culturing bacteria.

anaerobe (ăn ā'ĕr ōb) — a bacteria which lives and grows only in the absence of oxygen.

bacteria, bacterium (bȧc•tē rē a) — single-celled microorganisms which grow by simple division. Some types can cause disease.

bacterial load — refers to the number of bacteria which exists in a food product or on surfaces, such as hands, clothes, or food equipment.

bactericide (bȧc'tē rĭ sīde) — an agent or substance which kills bacteria.

binary fission — *two breaking apart*, referring to the simple division growth of bacteria. One cell enlarges, elongates, and eventually separates to form two cells.

botulism (botch'ū•lis•um)— a disease caused by eating foods containing the toxin produced during the growth of the bacteria *Clostridium botulinum*.

chlorination (klō•ri•nā'shun) — adding chlorine to water for the purpose of killing bacteria.

*Clostridium botulinum* (klos•trĭ'de•um botch'ū līn•um) — the genus and species names of the anaerobic bacteria which causes botulism.

coliform (fecal coliform) (kō'lĭ form) — any of several species of bacteria which are associated with sewage and fecal sources. Although not pathogenic, their presence indicates the potential presence of sewage related pathogens.

colony — a very large number of bacterial cells growing from a single bacterium on prepared food medium — visible to the naked eye.

contamination — the presence of bacteria in a food or on food equipment. It may also refer to the presence of specific types of bacteria.

facultative anaerobe — any of the several types of bacteria which can grow in the presence or absence of oxygen.

fermentation — the process of yeast growing in a sugar source and converting the sugar to alcohol.

food infection — illness caused by an infection produced by invasion, growth, and damage to the host by pathogenic organisms carried in a food. Example is salmonella food poisoning.

food intoxication — illness caused by consuming food containing a toxin produced by certain bacteria as they grow. Examples of such are botulism and staph food poisoning.

food poisoning — a general term, meaning an illness caused by consuming food containing a poison; includes both food infection and food intoxication.

incubator — a controlled temperature cabinet used to grow bacteria at optimum temperatures.

mesophilic bacteria (mĕz · ō · fĭl′· ĭk) — bacterial types which grow at middle-range temperatures (60° to 110° F).

microorganism (mī·krō·or′găn·ĭz·um) — refers to any of the very small life forms, such as bacteria, yeasts, and molds. Many can be seen only with a microscope.

mold — types of microorganisms which generally appear as mildew or fuzzy growths, especially in damp environments.

pathogen (păth′ō·gĕn) — any microorganism which can cause disease.

petri dish — a shallow, round glass dish with a separate glass cover used to grow bacteria. A sterile dish is partially filled with a sterile food and inoculated with a sample containing bacteria.

psychrophilic bacteria (sī·krō·fĭl′ik) — bacterial types which grow at cold temperatures (32° to 60° F).

ptomaine poisoning (tō′ mān) — a misnomer. A common expression to describe food poisoning, but in reality only caused by consumption of greatly decomposed food.

spore — in yeasts and mold, a common means of reproduction. In bacterium, spores are formed internally within cells in response to environmental stress. Bacterial spores are resting life stages. They are the most death-resistant life forms known.

sterile — a term which means the complete absence of any life form capable of growing or reproducing.

thermophilic bacteria (thĕrm·ō·fĭl′ĭk) — bacterial types which grow at high temperatures (110° to 170° F). These bacteria are also spore formers.

vegetable cell — refers to actively growing bacterial cells, as opposed to spores, which are resting life forms.

yeast — a class of microorganism closely resembling molds. Yeasts ferment sugars to alcohol, and reproduce by budding, spores, simple division, and in some instances, by primitive sexual reproduction.