Todar's Online Textbook of Bacteriology

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Control of Microbial Growth (page 1)

(This chapter has 6 pages)

Introduction

In the 19th century, surgery was risky and dangerous, and patients undergoing even the most routine operations were at very high risk of infection. This was so because surgery was not performed under aseptic conditions. The operating room, the surgeon's hands, and the surgical instruments were laden with microbes, which caused high levels of infection and mortality.

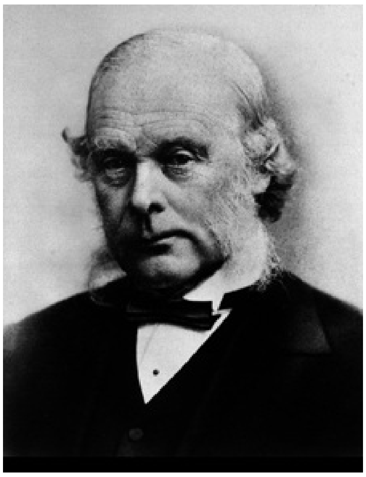
Surgeons in the mid-1800s often operated wearing their street clothes, without washing their hands. They frequently used ordinary sewing thread to suture wounds, and stuck the needles in the lapels of their frock coats in between patients. Surgical dressings were often made up of surplus cotton or jute from the floors of cotton mills. It was against this background that French scientist Louis Pasteur demonstrated that invisible microbes caused disease.

Louis Pasteur

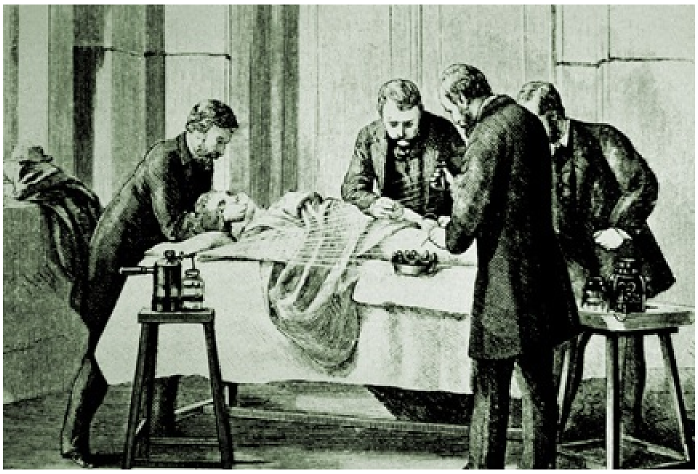
Pasteur's work influenced the English surgeon Joseph Lister, who applied Pasteur's germ theory of disease to surgery, thus founding modern antiseptic surgery. To disinfect, Lister used a solution of carbolic acid (phenol), which was sprayed around the operating room by a handheld sprayer.

Web Review of Todar's Online Textbook of Bacteriology. *"The Good, the Bad, and the Deadly"*

Tag words: bacterial growth, antibiotic, chemotherapeutic agent, disinfectant, antiseptic, preservative, control of growth, sterilization, pasteurization.



Joseph Lister



19th Century surgery using Lister's carbolic acid sprayer.

It was clear that Lister's techniques were effective in increasing the rates of surviving surgery, but his theories were controversial because many 19th century surgeons were unwilling to accept something they could not see. Also, perhaps another reason that surgeons were slow to pick up on Lister's methods was the fact that during surgery they were required to breathe an irritating aerosol of phenol.

Control of Microbial Growth

The control of microbial growth is necessary in many practical situations, and significant advances in agriculture, medicine, and food science have been made through study of this area of microbiology.

"Control of microbial growth", as used here, means to inhibit or prevent growth of microorganisms. This control is affected in two basic ways: (1) by killing microorganisms or (2) by inhibiting the growth of microorganisms. Control of growth usually involves the use of physical or chemical agents which either kill or prevent the growth of microorganisms. Agents which kill cells are called **cidal** agents; agents which inhibit the growth of cells (without killing them) are referred to as **static** agents. Thus, the term **bactericidal** refers to killing bacteria, and **bacteriostatic** refers to inhibiting the growth of bacterial cells. A **bactericide** kills bacteria, a **fungicide** kills fungi, and so on.

In microbiology, **sterilization** refers to the complete destruction or elimination of all viable organisms in or on a substance being sterilized. There are no degrees of sterilization: an object or substance is either sterile or not. Sterilization procedures involve the use of heat, radiation or chemicals, or physical removal of cells.

Methods of Sterilization

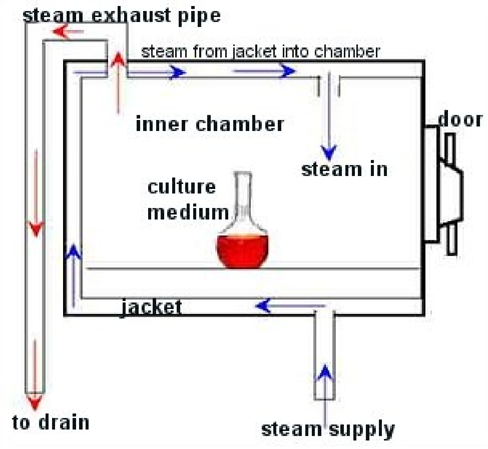
Heat: most important and widely used. For sterilization one must consider the type of heat, and most importantly, the **time of application** and **temperature** to ensure destruction of all microorganisms. Endospores of bacteria are considered the most thermoduric of all cells so their destruction guarantees sterility.

Incineration: burns organisms and physically destroys them. Used for needles, inoculating wires, glassware, etc. and objects not destroyed in the incineration process.

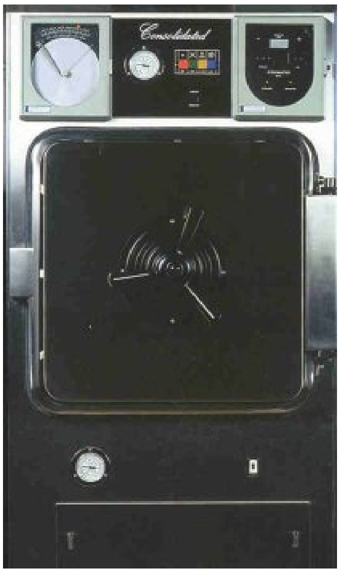
Boiling: 100^o for 30 minutes. Kills everything except some endospores. To kill endospores, and therefore **sterilize** a solution, very long (>6 hours) boiling, or **intermittent boiling** is required (See Table 1 below).

Autoclaving (steam under pressure or pressure cooker)
Autoclaving is the most effective and most efficient means of sterilization. All

autoclaves operate on a time/temperature relationship. These two variables are extremely important. Higher temperatures ensure more rapid killing. The usual standard temperature/pressure employed is 121ºC/15 psi for 15 minutes. Longer times are needed for larger loads, large volumes of liquid, and more dense materials. Autoclaving is ideal for sterilizing biohazardous waste, surgical dressings, glassware, many types of microbiologic media, liquids, and many other things. However, certain items, such as plastics and certain medical instruments (e.g. fiber-optic endoscopes), cannot withstand autoclaving and should be sterilized with chemical or gas sterilants. When proper conditions and time are employed, no living organisms will survive a trip through an autoclave.



Schematic diagram of a laboratory autoclave in use to sterilize microbiological culture medium. Sterilization of microbiological culture media is is often carried out with the autoclave. When microbiological media are prepared, they must be sterilized and rendered free of microbial contamination from air, glassware, hands, etc. The sterilization process is a 100% kill, and guarantees that the medium will stay sterile unless exposed to contaminants.



An autoclave for use in a laboratory or hospital setting.

Why is an autoclave such an effective sterilizer? The autoclave is a large pressure cooker; it operates by using steam under pressure as the sterilizing agent. High pressures enable steam to reach high temperatures, thus increasing its heat content and killing power. Most of the heating power of steam comes from its latent heat of vaporization. This is the amount of heat required to convert boiling water to steam. This amount of heat is large compared to that required to make water hot. For example, it takes 80 calories to make 1 liter of water boil, but 540 calories to convert that boiling water to steam. Therefore, steam at 100º C has almost seven times more heat than boiling water.

Moist heat is thought to kill microorganisms by causing denaturation of essential proteins. Death rate is directly proportional to the concentration of microorganisms at any given time. The time required to kill a known population of microorganisms in a specific suspension at a particular temperature is referred to as **thermal death time (TDT)**. Increasing the temperature decreases TDT, and lowering the temperature increases TDT. Processes conducted at high temperatures for short periods of time are preferred over lower temperatures for longer times.

Environmental conditions also influence TDT. Increased heat causes increased toxicity of metabolic products and toxins. TDT decreases with pronounced acidic or basic pHs. However, fats and oils slow heat penetration and increase TDT. It must be remembered that thermal death times are not precise values; they measure the effectiveness and rapidity of a sterilization process. Autoclaving 121ºC/15 psi for 15 minutes exceeds the thermal death time for most organisms except some extraordinary sporeformers.

Dry heat (hot air oven): basically the cooking oven. The rules of relating time and temperature apply, but dry heat is not as effective as moist heat (i.e., higher temperatures are needed for longer periods of time). For example 160^o/2hours or 170^o/1hour is necessary for sterilization. The dry heat oven is used for glassware, metal, and objects that won't melt.

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Next Page
