# Hygiene and sanitation during food production and transportation

BY

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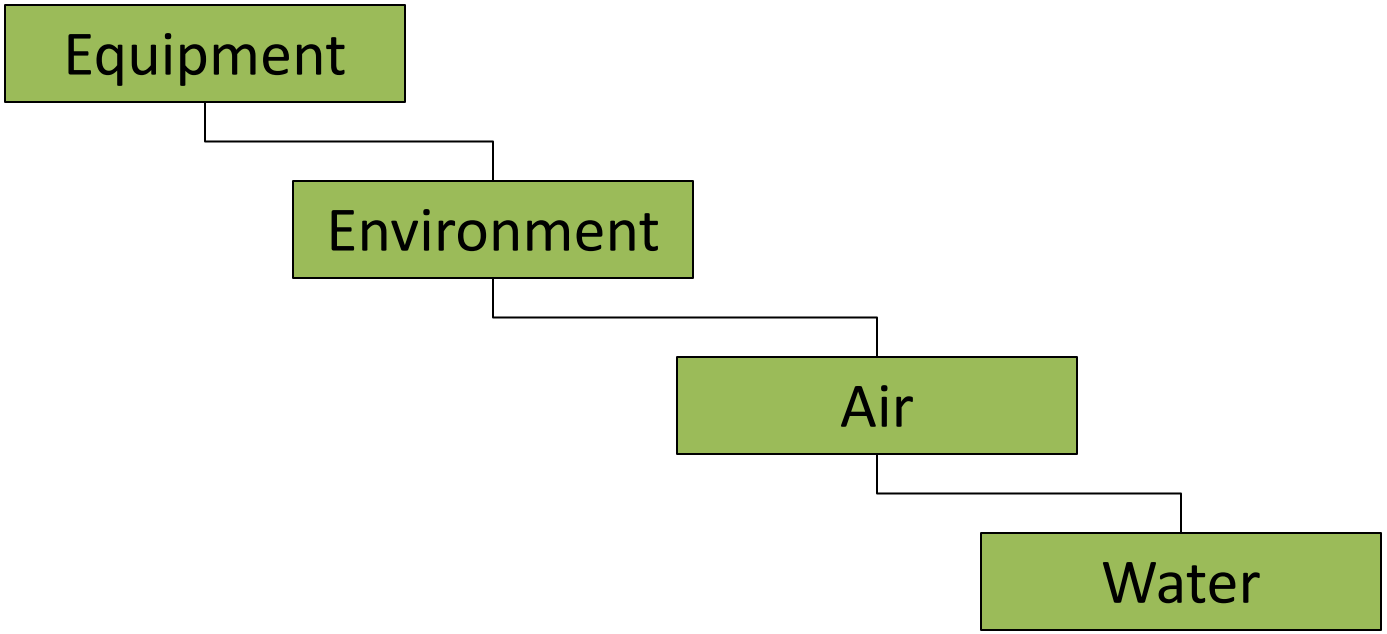
**Lecture 3 & 4**


HACCP
Sanitation Control Procedures
Good Manufacturing Practices

# Sanitation



# Training is Key to the Success of Sanitation

- Important to get staff involved
- Training must be focused and practical
- Records of training and incentives provided.
- Staff involved in developing plan, implementation, monitoring and verification.

# The roots of hygiene

- **Hygeia the goddess of health (greeks)**
- **Hippocrates (460-377 B.C.)**, the most famous doctor in ancient Greece, was titled as Father of Medicine
- For at least a century strychnine was the best remedy the profession had for palsy and paralysis. It was used to kill rats, cats and dogs
- In the mid of the 19 century two persons lay the foundation of modern hygiene. It was the Hungarian physician Semmelweis and the British surgeon Lister. Both introduced hygienic methods which still appear to be essential in modern society
- Ignác Fülöp Semmelweis (1818 - 1865) was a Hungarian physician who demonstrated that puerperal fever[1] (also known as "childbed fever") was contagious and that serious form of septicemia contracted by a woman during childbirth or abortion (usually attributable to unsanitary conditions); formerly widespread but now uncommon. Its incidence could be drastically reduced by enforcing appropriate hand-washing behavior by medical care-givers

# “operation successful but patient died” – WHY?

Joseph Lister (1827-1912)
Introduced the antiseptic surgery

in 1865, Louis Pasteur suggested that decay in wounds was caused by living organisms in the air.

# Hygiene and Sanitation basic guidelines

Knowledge of proper hygiene and sanitation before and after the food process is necessary

- 1. Water
  - Cleanliness of the food, equipment, dining area and surrounding area.
- 2. Clean Surroundings
  - Pests, insects, rats, flies and cockroaches (carry bacteria, that may cause disease)
  - Cleanliness, orderliness and maintenance of pest control in kitchen and dining area.
  - Pesticide spray (keep equipment and utensils safely covered during spray)
- 3. Sanitation head
  - One person in charge of maintaining the sanitation of the kitchen and dining area
- 4. Proper food handling and storage
  - Avoid spoilage and wastage
  - Determine the shelf life (e.g. fish =2-3 days, leafy veg. should be cooked on the day bought, meat should be kept in big cuts)
- 5. Waste disposal
  - Segregate wet and dry garbage.
- 6. Cleanliness, Orderliness and health workers in the food service
  - Give specific responsibilities to all workers
  - Health workers-regular medical checkups to avoid communicable disease
- 7. Uniform or clothes of the workers
  - Proper, Clean and neat clothes

# Some famous episodes

Bilmar Foods 1998

Frankfurters

- *Listeria monocytogenes*

  80 Cases 21 deaths (6 stillbirths)

  Recall: 17m kg of Product

  Direct loss: $76m

  Loss sales: $200m

  Litigation: $5m

- Deli meats
  - *Listeria monocytogenes*
  - 14m kg recall
  - 46 cases 10 deaths (3 stillbirths)
  - >$100m loss

John Tudor & Sons 2005

- Deli meats
  - *Escherichia coli O157*
  - >150 cases
  - 1 death

# Sanitation is important

- 35% of food-borne illness cases attributed to poor sanitation
- 19% - Poor personnel hygiene
- 16% - contaminated equipment/environment

# Provincial food inspection agencies

- In Pakistan

- Municipal Level
  - Sanitary environment
  - Potable water
  - Environmental and health issues affecting the food industry
  - Retail stores

# REGULATIONS

## Food & Drugs Acts 1985 US

**7.** No person shall manufacture, prepare, preserve, package or store for sale any food under unsanitary conditions.

**What about Pakistan???**

- Pakistan Pure Food Laws (PFL) devised in 1963 forms the basis of the entire existing trade-related food quality and safety legislative framework----- covers 104 food items
  - It sets the regulations addressing the usage of preservatives, antioxidants, colorants, flavorants and other food additives.
- The Contonment Pure Food Act of 1966 applied food safety regulations on contonment areas
- Pakistan hotels and restaurants act of 1976 makes it obligatory for hotels, restaurants and caterers all over Pakistan to control and regulate their rates and standards of services.
- PSQCA (Pakistan Standards and Quality Control Authority Act)—1996 is not generally classified as a food law

# Code of Practice

- Guidelines to meet the regulatory requirements of the Food & Drugs Act
  - Codex Alimentarius Commission
  - Sanitary and Phyto- sanitary (international)
  - Standards

- Sanitary facilities
- Air quality
- Water quality
- Facility Construction
- Sanitation procedures
- Hygiene and Health requirements
- Training

# Facilities

- Drains

  Sufficient number and construction
- Floor slopes uniformly to the drain
- Walls
  - Hard
  - Smooth
  - Constructed to enable cleaning
- Food contact Surfaces

  Non- absorbent

  Free from pitting, crevices and loose scale

  Capable of withstanding repeated cleaning.

# Cold Stores

- Reduce the risk of condensation
- Relative humidity
- Air flow

Sanitation Program

An effective sanitation program for equipment and premises is in place to prevent contamination of food.

Each processor ‘should’ have and implement a written SSOP or similar document that is specific to each location

# Sanitation plans

- Provide a schedule for sanitation procedures
- Provide a foundation to support a routine monitoring program
- Encourage prior planning to ensure that corrections are taken when necessary
- Identify trends and prevent recurrent problems
- Ensure that everyone, from management to production workers, understands sanitation
- Provide a consistent training tool for employees
- Lead to improved sanitation practices and conditions in the plant.

# Sanitation Performance Standards (SPS)

- Standards based on The Food Code.
- Address the conditions within the facility
- Used in conjunction with SSOP's

## Plans

- Provide a schedule for sanitation procedures
- Provide a foundation to support a routine monitoring program
- Encourage prior planning to ensure that corrections are taken when necessary
- Identify trends and prevent recurrent problems

# Sanitation Monitoring Program

"Each processor 'shall' monitor the conditions and practices during processing with sufficient frequency to ensure, at a minimum, conformance with these conditions and practices specified in the [GMP] that are appropriate to the plant and food being processed."

- Ensure that everyone, from management to production workers, understands sanitation
- Provide a consistent training tool for employees
- Lead to improved sanitation practices and conditions in the plant.

# Sanitation Testing

- Monitoring: Elements of the sanitation program are being performed correctly (e.g sanitizer concentration, contact time).
- Verification: Long term effectiveness of the sanitation plan (e.g. microbiological testing).

**Why Monitor Sanitation Control Procedures**

" . . . to develop a culture throughout the food industry in which processors assume an operative role in controlling sanitation in their plants."

# Sanitation Monitoring Forms

1. Specific sanitation conditions or practices to be monitored
2. Space to record observations and measurements at the prescribed frequency
3. Space to document any necessary corrections.

# Monitoring

- Detergent
- Contact time
- Sanitizer concentration
- Excess

  Increased costs; Corrosion

  Insufficient

  Low efficacy; Generation of tolerant mutants

Visual inspection in good light
Protein residue tests

ATP bioluminescence
- Indirect measure of viable cells
- Automated logging

BioTrace
BioControl

# Sanitation Verification

- Low risk areas
  - Product contact surfaces
  - 24- 48h to obtain results

Contact plates, Swab samples and Sticky tape

Total Aerobic Count

Spoilage microflora

Fecal indicators

# Microbiological Criteria

- No specific criteria
- Trend analysis

Meat Processing Lines

- Total Aerobic Counts <10 cfu/$cm^2$
- Enterobactereaceae <1 cfu/$cm^2$

# Sanitation Control Procedure (SCP)

- Sanitation part of pre-requisite programs
- Can also be incorporated into HACCP plan
- Maintain sanitary conditions usually related to the entire processing facility or an area

# SCP vs CCP'S

| Hazard | Control | Program |
|---|---|---|
| Pathogen survival | Time and temperature for smoking fish | CCP |
| Contamination with pathogens | Wash hands before touching product | Sanitation |
| Contamination with pathogens | Clean and sanitize food contact surfaces | Sanitation |

# Training is Key to the Success of Sanitation

- Important to get staff involved
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- verification.

# Five Steps of Cleaning and Sanitizing

1. Dry- clean
2. Pre- rinse
3. Apply detergent
4. Post- rinse
5. Sanitize

# Physically removing soils

- Brushes - proper stiffness
- Pads - proper cutting properties
- Pressure spray - moderate pressure

**Pads, brushes and brooms should be dedicated to tasks for which they are designed**

- Optimizes cleaning effectiveness
- Minimizes cross- contamination between areas of the plant

# Pre rinse

- Rinse until visually free of soils.
- Use lowest effective pressure to minimize aerosols and condensation.
- Lower pressure reduces risk of cross contamination and machine damage.

## Types of Detergents

- General Purpose (GP)
- Alkaline
- Chlorinated (chlorinated alkaline)
- Acid
- Enzyme

## Detergent application methods

- Soak tanks
- Foam
- Automated systems
  - CIP (clean- in- place)
  - parts washers
- Manual (pails)

# 5th Step !

**Sanitizing follows proper cleaning**

1. Dry- clean
2. Pre- rinse
3. Detergent application
4. Post- rinse
5. Sanitizing

**Step 6 ?: Rinse**

**Pros**: Remove residues and reduces the generation mutants

**Cons**: No residual anti- microbial activity

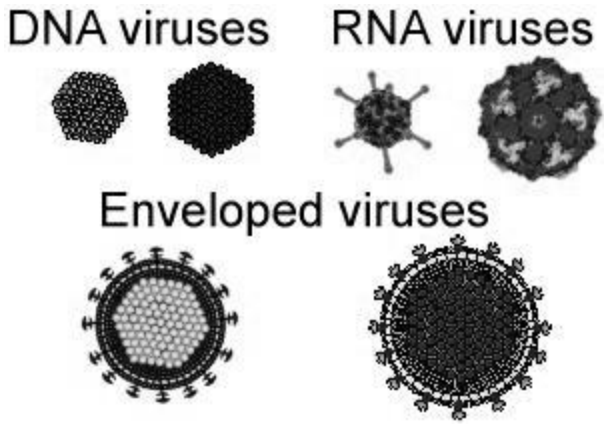
# Chemical Sanitation

- Effectiveness Based on:
  - Exposure Time
- More microorganisms - Longer exposure time
- Colonies die in logarithmic pattern
- Different types of organisms die at different rates
  - Temperature
- Generally, the hotter the temperature, the more effective the chemical sanitizer

# Effectiveness of Chemical Sanitizers

- Concentration
  – Follow label
  – More not necessarily better
- pH
  – Differs depending of Type of Sanitizer
- Cleanliness
  – Soil can react with sanitizers and neutralize them
- Water Hardness
- – Calcium and Magnesium in hard water neutralize Quats
- – Can add chelating agent
- Bacterial Attachment
- Attachment to surfaces make bacteria more resistant to sanitizers

Viruses




Endospore

Outer spore coat: Physical barrier

Cortex, SASP: Glassy structure to protect DNA

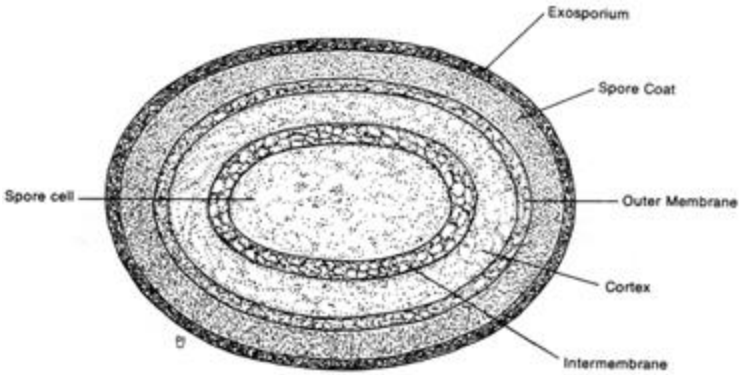
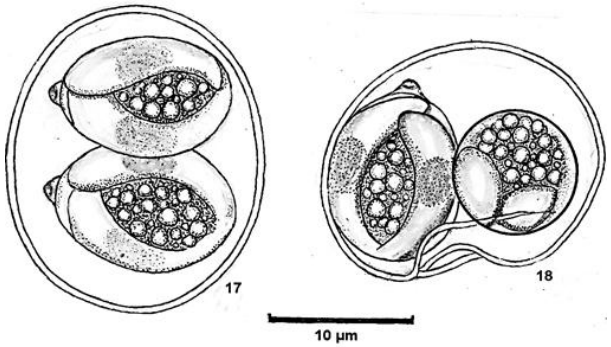


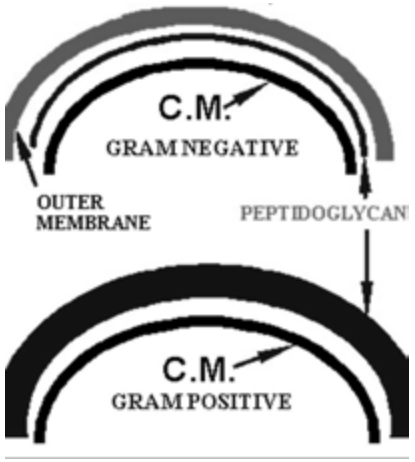

Fig. 8.1. Endospore

Protozoa

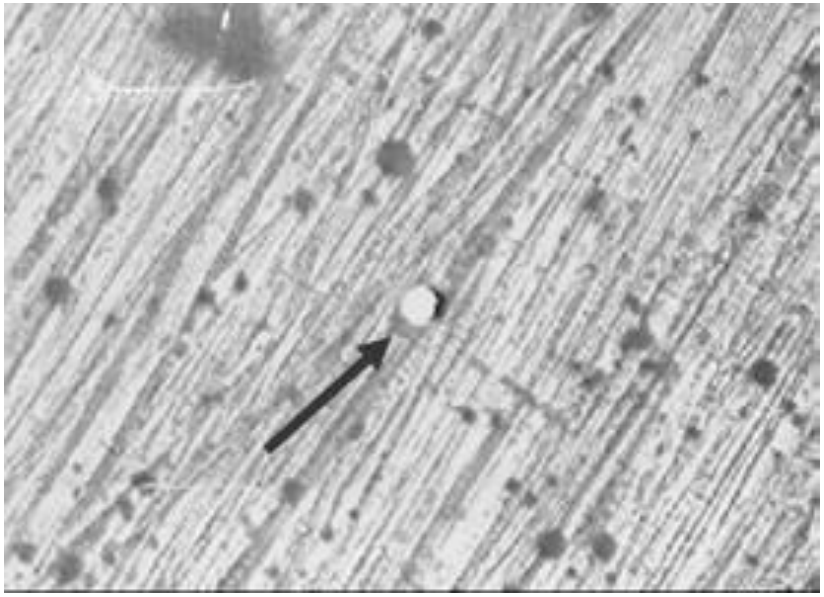


# Sanitizer Resistance

- Gram negative bacteria more tolerant to sanitizers
- Outer membrane forms physical barrier
- Less stable at alkali pH

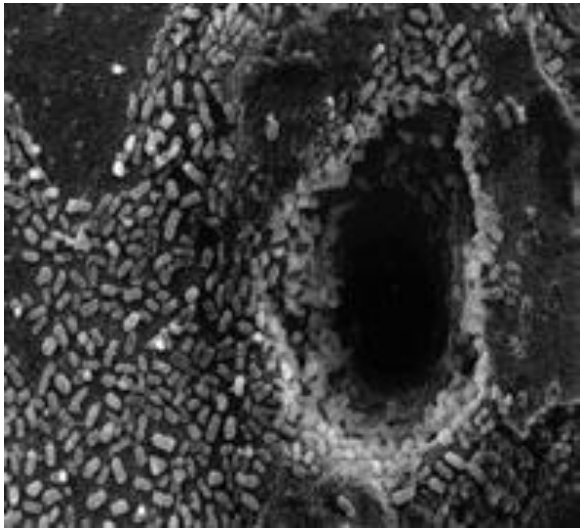


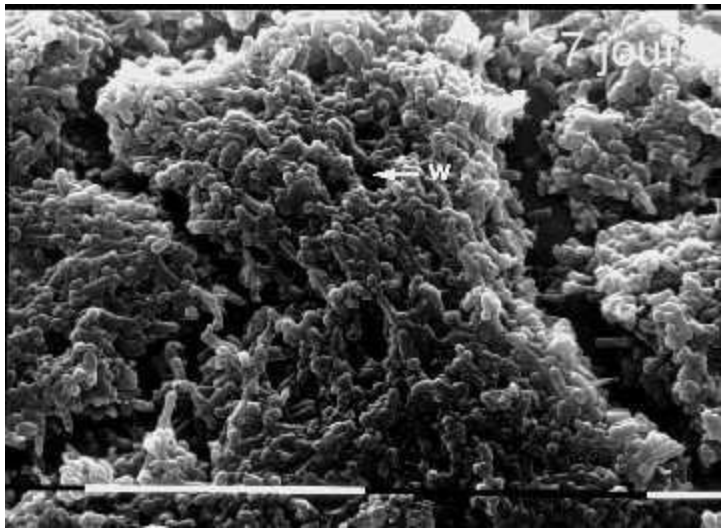
- Pitting Provides Sites for Bacterial Attachment



HOLE IN A HEAT-EXCHANGER PLATE

# Biofilm





# Antimicrobial Tests
# (Required for EPA Registration)

| Product | Required Organisms |
|---|---|
| General disinfectant | *Sal. cholerasuis* ATCC 10708<br>*Staph. aureus* ATCC 6538 |
| Hospital disinfectant | *S. cholerasuis* ATCC 10708<br>*S. aureus* ATCC 6538<br>*P. aeruginosa* ATCC 1542 |
| Sporicidal | *B. subtilis* ATOC 19659<br>*Cl. sporogenes* ATCC 3584 |

# Ideal Sanitizers

- Destroy vegetative microorganisms
- Work well in different environments
- Dissolve in water
- Inexpensive, easy to use, readily available
- Should not irritate skin
- Should not have offensive odor

# Types of Sanitizers

- Chlorine
- Chlorine dioxide
- Ozone
- Iodophores
- Quaternary ammonium compounds
- Trisodium phosphate
- Peroxyacetic acid

# Sanitizer concentration commonly used in food plants

| Sanitizer | Food contact surface | Non-food contact surfaces | Plant water |
|---|---|---|---|
| Chlorine | 100-200 ppm | 400 ppm | 3-10 ppm |
| Iodine | 25 ppm | 25 ppm | |
| Quats | 2000 ppm | 400-800 ppm | |
| Chlorine dioxide | 100-200 ppm | 100-200 ppm | 1-3 ppm |

## Chlorine

- Sodium or Calcium Hypochlorite
- Cheap
- Well established in the food industry
- Chlorous acid antimicrobial form
- pH dependent
- pH 6- 8 Chlorous acid
- pH < 6 Chlorine gas (toxic)
- Sequestered by organic material
- Carcinogenic chloramines can be produced.
- Unstable at high temperatures
- Corrosive
- Effective against vegetative cells, spores and
- fungi.
- Limited efficacy against viruses
- Can leave chlorine odor
- Mechanisms still unknown but primarily oxidation of proteins.

# Chlorine Dioxide ($ClO_2$)

- Powerful oxidizing agent (2.5 x greater than chlorine)
- Relatively stable in the presence of organics.
- Does not form chloroamines as a side reaction.
- Limited efficacy against viruses
- Unstable at temperatures > 30°C
- Used to decontaminate Post-Office affected by anthrax letters.

# Ozone

- Generated on site via passing air through high voltage fields.
- Powerful oxidizing agent.
- Poor solubility (max 6ppm in water)
- Negligible residues (used for treating bottled water)

# Iodine Compounds

**Iodophors**

– Iodine alcohol solutions and Aqueous iodine solutions

- Less germicidal than chlorine, but broader effective pH range (2-5)
- Low concentrations pass chambers test
- More effective on viruses than other sanitizers

**Iodine Compounds – Advantages**

- Less corrosive than Chlorine
- Stable when Concentrated
- Effective in hard water
- Can prevent mineral deposits
- Good Hand-dipping agent
- Amber color - Good indicator of active iodine

**Disadvantages of Iodine compounds**

- More expensive than Chlorine
- Off - flavors in Foods
- Vaporize at 50oC
- Stain and discolor equipment
- Not as effective as Chlorine in low temperature environments
- Foam formation (CIP)

# Ionic Compounds

- Trisodium Phosphate (TSP)
- Quaternary Ammonium Compounds (QAC's or QUAT's)
- Organic Acids

**TSP** inactivates bacteria by pH effect.

- 8% w/v TSP: pH 12
- Strips membranes from cells
- Gram positive bacteria more resistant than
- Gram negative

# QACs

- Non-corrosive
- Stable at high temperature
- Effective against yeast, molds and Gram positive bacteria.
- Less effective against Gram negative and viruses.
- Inactivated by surfactants
- Residual activity

**QACs : MODE OF ACTION**

1. Adsorption to bacterial cell surface
2. Diffusion through outer layers of cell
3. Binding to cytoplasmic membrane
4. Disruption of cytoplasmic membrane
5. Release of cell constituents ($K^+$, large mol. wt. materials)
6. Coagulation of cell contents and cell inactivation

Gram positive bacteria creates “potential problem of generating resistant mutants”.

# Proxy acid compounds

- Low Foam
- Antimicrobial activity over broad temperatures
- Combine sanitizing and acid rinsing in one step
- Non-corrosive
- Tolerant to organic matter
- Effective against Biofilms

# Relative biocidal activity

| Strains | Compounds |
| --- | --- |
| Endospores<br>Mycobacterium<br>Non-enveloped viruses<br>Protozoa oocysts | Peroxyacids, glutaraldehyde, formaldehyde, chlorine dioxide, ethylene oxide |
| Mycobacterium<br>Non-enveloped viruses<br>Fungi | Phenolics, iodospors, hypochlorites |
| Vegetative cells<br>Enveloped viruses | Quaternary ammonium compounds, organic acids |

**Fresh Cut Produce**

- *Listeria monocytogenes*
- *Salmonella*
- *E. coli O157*
- Hepatitis A
- *Cyclospora*
- *Cryptosporidium*

**Ready-to-Eat**

- *Listeria monocytogenes*
- Raw materials
- Endemic: Drains, cold stores, difficult to clean areas

**Meat**

- *Salmonella*
- *Campylobacter*
- *E. coli O157*

**Environment vs Raw Material**

- Traditional view
- Post-process contamination
- *Listeria monocytogenes*

Raw material

- *Salmonella*
- *E. coli O157*

- Molecular Epidemiology
- Track and Trace Sources of microbial contamination.
- DNA typing of isolates taken from different
- sites.

# Molecular Typing of mutton, and Beef Chain

- Surfaces contaminated in the first 30 mins of processing
- Contamination derived from holding area and transporter
- Sanitizer resistance predicted by genetic lineage

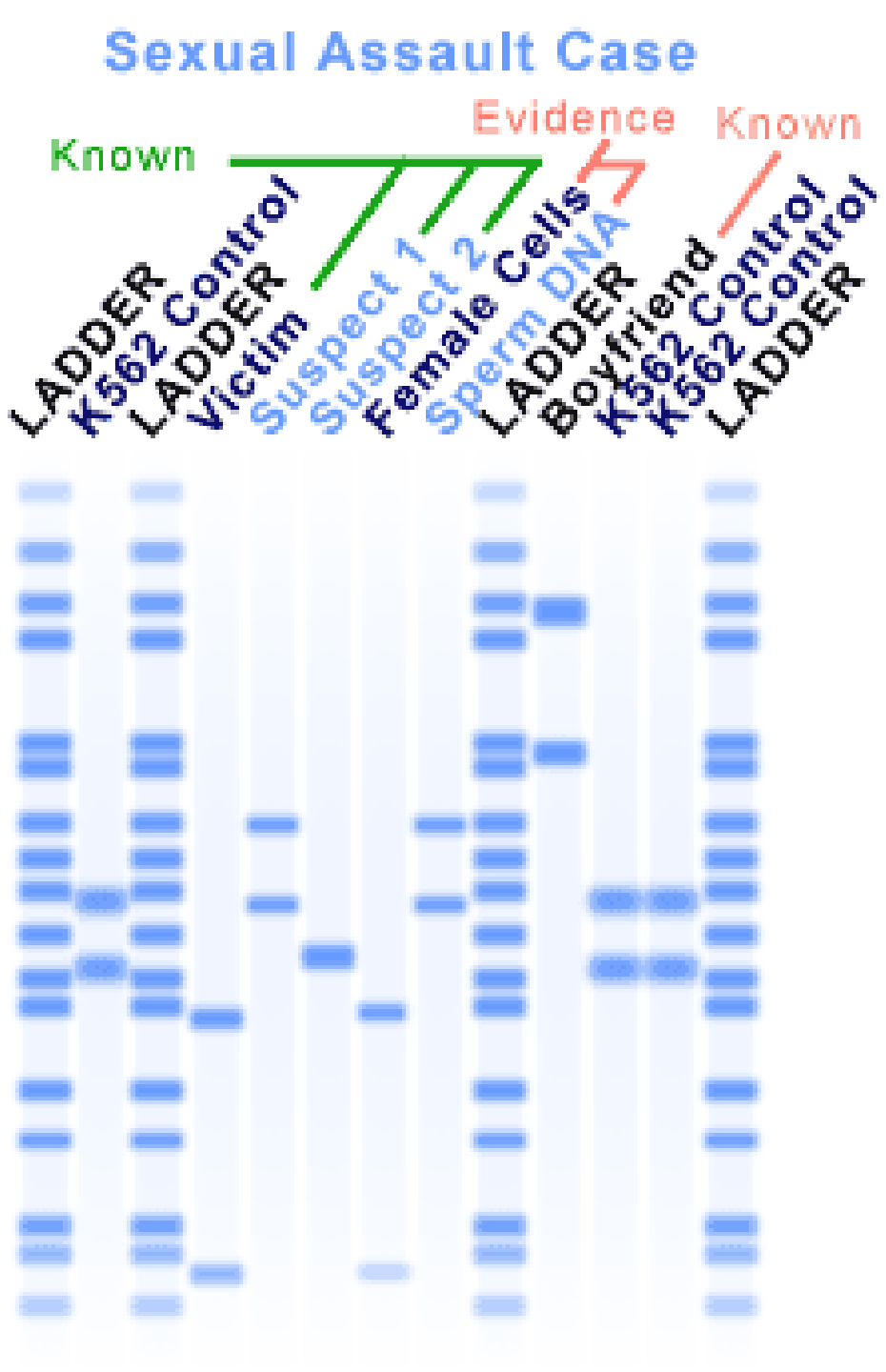
# Holding Area and Transporter

- Difficult to sanitize
- Short-lived benefits
- Increased sanitation decreases endemic populations

# Forensic Science


"I don't need to check anything with 'the boys in forensics', I know it was you."


"You've left DNA samples all over the place!"


Sexual Assault Case
Known
Evidence
Known
LADDER
K562 Control
LADDER
Victim
Suspect 1
Suspect 2
Female Cells
Sperm DNA
LADDER
Boyfriend
K562 Control
K562 Control
LADDER

# Food Handler

- *Salmonella*
- *E. coli O157*
- *Staphylococcus aureus*
- Enteric viruses (Norwalk, rotavirus)
- Hepatitis A

# Personal Hygiene and Identifying Unhealthy Personnel

- Supervisors
  – must identify unsanitary and unhealthy personnel
  – Observation is an effective means of identifying health risks
  – look for cuts/burns on fingers, hands, and arms; oozing sores, pimples, or boils; and significant coughing or sneezing
  – Workers not allowed around food if they are experiencing fever, vomiting, or diarrhea

# Hand washing

- most common source of contamination
  leading to illness is the fecal- oral- route
- contaminated after using the restroom
- bacteria and viral contamination transferred
  via contaminated food or utensils

# The effect of hand washing and the use of chlorinated lime on maternal death caused by puerperal fever

| Year/period | Maternal death rate in (%) | |
|---|---|---|
| | Medical students (clinic 1) | Mid wife students (clinic 2) |
| 1841-1846 | 9.92 | 3.38 |
| May 1847 | 12.42 | |
| ***Introduction of hand-wash*** | | |
| June 1847 | 2.38 | |
| July 1847 | 1.20 | |
| August 1847 | 1.89 | |
| ***Introduction of chlorinated lime hand-wash*** | | |
| October 1847 | 1.27 | 1.33 |
| March 1848 | 0 | 0 |
| August 1848 | 0 | 0 |

# Hand Washing Standards

- designated sink in the food preparation area for hand washing
- Hot and cold running water
  - – hot water must have a minimum temperature of 43$^{o}$C
  - – Liquid soap is preferred
  - – Fingernail brush
- Only disposable paper towels or air dryer are authorized for drying hands

# Hand washing by food handlers

- 52% supervisors could describe the hand washing procedure
- 48% of workers could demonstrate codecompliant hand washing

# The End Lectures 3 & 4