

## Module 02 - lecture 01

# Microbiological hazards

# Microorganisms are very small



YOGHURT

World population is  
**5.5 BILLION**  
i.e. 5 500 000 000

1 cup  
of yoghurt contains  
**22 X** this number!  
i.e. **120 000 000 000**  
separate living  
organisms.

# Microorganisms classified by their significance

- ◆ **Pathogenic organisms**
- ◆ **Spoilage organisms**
- ◆ **Useful organisms**

# Dangerous microorganisms

## *Foodborne diseases*

- ◆ **Bacteria**
- ◆ **Moulds**
- ◆ **Viruses**
- ◆ **Parasites**

# Major bacteria causing foodborne disease

*Aeromonas* spp.

*Bacillus cereus*

*Brucella* spp.

*Campylobacter jejuni*

*Clostridium botulinum*

*Clostridium perfringens*

*Escherichia coli*

*Listeria monocytogenes*

*Mycobacterium bovis*

*Salmonella* spp.

*Shigella* spp.

*Staphylococcus aureus*

*Vibrio cholerae*

*Vibrio parahaemolyticus*

*Vibrio vulnificus*

*Yersinia enterocolitica*

# Spoilage microorganisms

- **Bacteria**
- **Yeasts**
- **Moulds**

# Food products made with useful microorganisms

- ◆ **Fermented meats**
- ◆ **Yoghurt**
- ◆ **Cheese**
- ◆ **Beer**
- ◆ **Leavened bread**
- ◆ **Soy sauce**
- ◆ **Fermented soybean (tofu)**

# Useful microorganisms

## ***Lactic acid bacteria (LAB)***

These ferment carbohydrates into organic acids which inhibit

- ◆ ***Salmonella***
- ◆ ***Staphylococcus***
- ◆ ***Listeria***
- ◆ ***Clostridium***
- ◆ ***E. coli***

***LAB are found in***

- ◆ **Plants**
- ◆ **Soil**
- ◆ **Animals**
- ◆ **Human gut**



# Major viruses causing foodborne disease

- ◆ **Hepatitis A and E viruses**
- ◆ **Small round structured viruses  
(e.g. Norwalk agent)**
- ◆ **Rotavirus**
- ◆ **Polio virus**

# Some toxigenic moulds causing foodborne disease

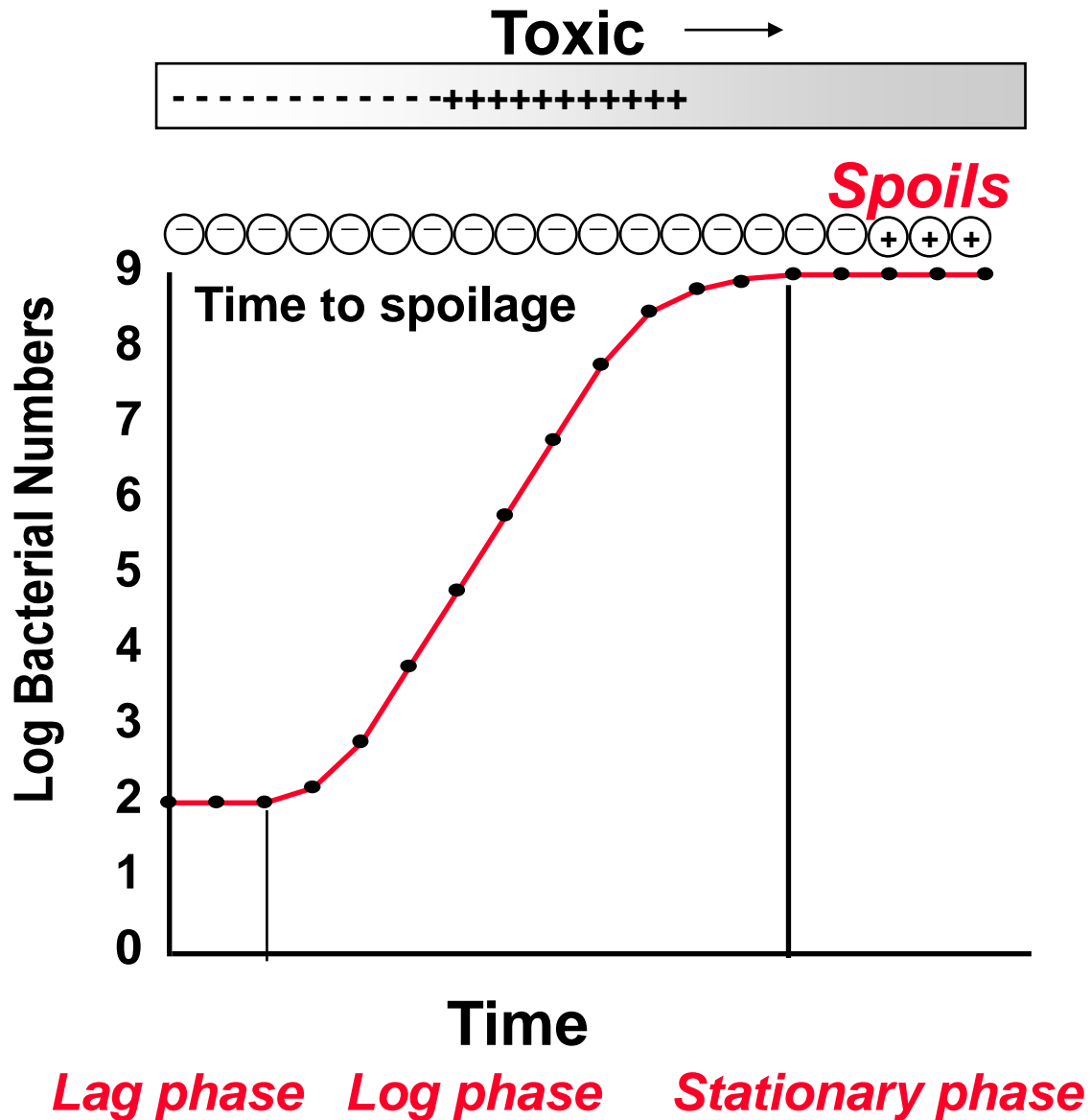
- *Aspergillus* spp.
- *Fusarium* spp.
- *Penicillium* spp.

( *Main sources - fruits, nuts and grains* )

# Major parasites causing foodborne disease

- ◆ *Anisakis*
- ◆ *Ascaris*
- ◆ *Clonorchis sinensis*
- ◆ *Cryptosporidium*
- ◆ *Cyclospora cayetanensis*
- ◆ *Diphyllobothrium*
- ◆ *Echinococcus*
- ◆ *Entamoeba histolytica*
- ◆ *Fasciola hepatica*
- ◆ *Giardia*
- ◆ *Opisthorchis felinus*
- ◆ *Opisthorchis viverrini*
- ◆ *Sarcosporidium*
- ◆ *Taenia*
- ◆ *Toxoplasma*
- ◆ *Trichinella*

# Bacterial growth curve



# Infectious foodborne bacteria

## ***INFECTION***

**Invasion of and multiplication  
within the body by**

***Salmonella***

***Campylobacter***

***E. coli* (certain strains)**

***V. parahaemolyticus***

***V. cholerae***

***Y. enterocolitica***

***A. hydrophila***

***L. monocytogenes***

# Salmonellosis

## ➤ *Main symptoms*

- Diarrhoea
- Fever
- Abdominal cramps
- Vomiting

## ➤ *Persons at high risk*

- Young
- Old
- Pregnant women
- Immunocompromised
- Underlying disease states

## ➤ *Fatality rate*

- < 1%

## ➤ *Incubation period*

- usually 12 - 36 hours

# ***Salmonella***

***2200 different serotypes***

**200 of which cause foodborne disease in Europe in any one year**

**70% cases caused by *S. enteritidis* and *S. typhimurium***

**Serotypes split into subtypes called *phage-types* (PT)**

# Raw food materials likely to be contaminated by *Salmonella*

- ◆ Poultry
- ◆ Meat
- ◆ Milk
- ◆ Eggs
- ◆ Vegetables
- ◆ Shellfish
- ◆ Spices and herbs
- ◆ Untreated water



# Thermal resistance of *Salmonella* in food

***Salmonella*** is heat - sensitive

Pasteurization is sufficient to kill

***Salmonella*** in high - moisture foods

Heating at 70°C for 2 min can achieve  
a 6 *log* reduction in numbers

# Campylobacteriosis

## ➤ *Main symptoms*

- Mild to severe diarrhoea
- Fever
- Nausea
- Abdominal cramps

## ➤ *Persons at risk*

- Babies and young people
- Debilitated people

## ➤ *Incubation usually 2-5 days*

# Survival of *Campylobacter*

*A very fragile organism, it does not survive well in food processing environments*

- ◆ **Heat - sensitive**
- ◆ **Sensitive to drying**
- ◆ **Survives freezing (several months in frozen meat and poultry)**
- ◆ **Survives better at chilled conditions rather than at ambient temperatures**

# Pathogenic *E. coli*

Enteropathogenic *E. coli* ( **EPEC** )

Enteroinvasive *E. coli* ( **EIEC** )

Enterotoxigenic *E. coli* ( **ETEC** )

Enterohaemorrhagic *E. coli* ( **EHEC** )

# Pathogenic *E. coli*

***EPEC*** Acute watery diarrhoea - young children particularly susceptible

***EIEC*** Dysentery - like syndrome

***ETEC*** Acute watery diarrhoea - often in travellers

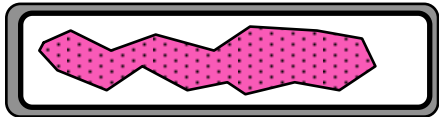
***EHEC*** Bloody diarrhoea syndrome

Incubation 8 - 44 hours depending on type

# Pathogenic *E. coli* associated with foodborne disease

<b>Type of <i>E. coli</i></b>	<b>Reservoir</b>	<b>Source of food contamination</b>	<b>Cause of FBD outbreaks</b>
<b><i>EPEC</i></b>	Man	Food handlers - sewage - environment	Rare
<b><i>EIEC</i></b>	Man	Food handlers - sewage	Soft cheese - water
<b><i>ETEC</i></b>	Man	Food handlers - sewage	Soft cheese - water
<b><i>EHEC</i></b>	Cattle	Cattle faeces - meat handling facilities Dairies	Under-cooked ground beef (hamburgers etc.) Unpast. milk

# Bacterial division



1



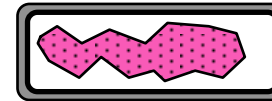
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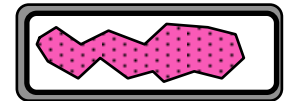
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4



5



# Infective dose

## *Host*

- ◆ **Age**
- ◆ **Immune status**
- ◆ **Gastric acidity - time of day**
- ◆ **Immuno - competence**
- ◆ **Nature of gut flora - carrier state**
- ◆ **Pregnancy**



# Infective dose

*Organism*

**Virulence of the strain**

**Vegetative cells or spores**

# Infective dose

## *Food*

- ◆ **Presence of fat**
- ◆ **Acidity**

# Host factors

Consequences of previous foodborne infections:

*Lasting immunity*

*Hepatitis A*

*Short-term immunity*

*Campylobacter*

*V. cholerae*

*No immunity*

*Salmonella (unless a carrier)*

# Minimum infective dose

- ◆ EPEC  $10^6$
- ◆ ETEC  $10^6$
- ◆ *Shigella*, EIEC 10 - 100
- ◆ EHEC 10
- ◆ *L. monocytogenes* high, but probably in risk groups  
c. 100/g of food
- ◆ *Salmonella* ( excluding *typhi* )  $10^6$  ( lower nos (i.e. 10-1000) may  
cause infection in fatty foods  
such as chocolate & cheese )
- ◆ *Campylobacter* ca. 500
- ◆ *Salmonella typhi* 10 - 100
- ◆ *V. cholerae*  $10^6$

# Toxigenic foodborne bacteria

## *Intoxication due to*

### **Toxin produced in the food**

- ◆ *Bacillus cereus*
- ◆ *Clostridium botulinum*
- ◆ *Escherichia coli* (ETEC)
- ◆ *Staphylococcus aureus*

# What is a toxin ?

**A poison found in some animals and plants and microorganisms**

**Botulinum toxin is formed when  
*C. botulinum* grows - it is a PROTEIN**

***Approximately 500g is enough to kill  
the human race !***

# Characteristics of FBD due to *C. botulinum*

<b>Characteristic</b>	<b>Proteolytic type</b>	<b>Non-proteolytic type</b>
<b>Onset</b>	<b>2h - 8 days</b>	<b>SAME</b>
<b>Duration</b>	<b>Days to several months</b>	
<b>Symptoms</b>	<b>Nausea Vomiting Visual disturbances, vertigo</b>	
<b>Toxic dose</b>	<b>0.005 - 0.1 <math>\mu</math>g</b>	<b>0.1 - 0.5 <math>\mu</math>g</b>

# Characteristics of FBD due to *S. aureus*

*Incubation period 1 - 6h*

*Main symptoms at 6 - 24h*

**Nausea**

**Vomiting**

**Diarrhoea**

**Abdominal pain**

***NO* Fever**

**Collapse and dehydration in severe cases**



# Characteristics of FBD due to *Bacillus cereus*

<b><i>Characteristic</i></b>	<b><i>Diarrhoeal Syndrome</i></b>	<b><i>Emetic Syndrome</i></b>
<b>Onset of symptoms</b>	<b>4 - 16 hours</b>	<b>1 - 14 hours</b>
<b>Duration of symptoms</b>	<b>12 - 24 hours</b>	<b>6 - 36 hours</b>
<b>Symptoms</b>	<b>Abdominal pain, watery diarrhoea</b>	<b>Nausea and vomiting</b>
<b>Number of bacteria in incriminated food</b>	<b><math>10^8</math> / g</b>	<b><math>10^8</math> / g</b>

# Minimum toxic doses of bacterial toxins

*Minimum toxic dose (cells / g)*

*S. aureus*

$10^6$

*C. botulinum*

$10^4 - 10^5$

*C. perfringens*

*B. cereus*

$10^7 - 10^8$



# Factors affecting growth of bacteria in food

- ◆ **Temperature**
- ◆ **Time**
- ◆ **pH**
- ◆ **Water activity ( $a_w$ )**
- ◆ **Oxygen tension**
- ◆ **Preservatives**
- ◆ **Microbial interactions**

# Temperature range for growth of pathogenic bacteria

## Temperature °C

	<i>Min.</i>	<i>Opt.</i>	<i>Max.</i>
<i>Salmonella</i>	5	35 - 37	47
<i>Campylobacter</i>	30	42	47
<i>E. coli</i>	10	37	48
<i>S. aureus</i>	6.5	37 - 40	48
<i>C. botulinum (proteolytic)</i>	10		50
<i>C. botulinum (non-proteolytic)</i>	3.3		25 - 37
<i>B. cereus</i>	4	30 - 35	48 - 50 <sup>1</sup> 43 <sup>2</sup>

<sup>1</sup> = Mesophilic

<sup>2</sup> = Psychrotrophic

# Temperature range for growth of toxigenic mould species

	<i>Min.</i>	<i>Opt.</i>	<i>Max.</i>
	°C	°C	°C
<i>Penicillium verrucosum</i>	0	20	31
<i>Aspergillus ochraceus</i>	8	28	37
<i>Aspergillus flavus</i>	10	32	42
(aflatoxin formation)	12	25	37
<i>Fusarium moniliforme</i>	3	25	37

# Prevention of foodborne disease

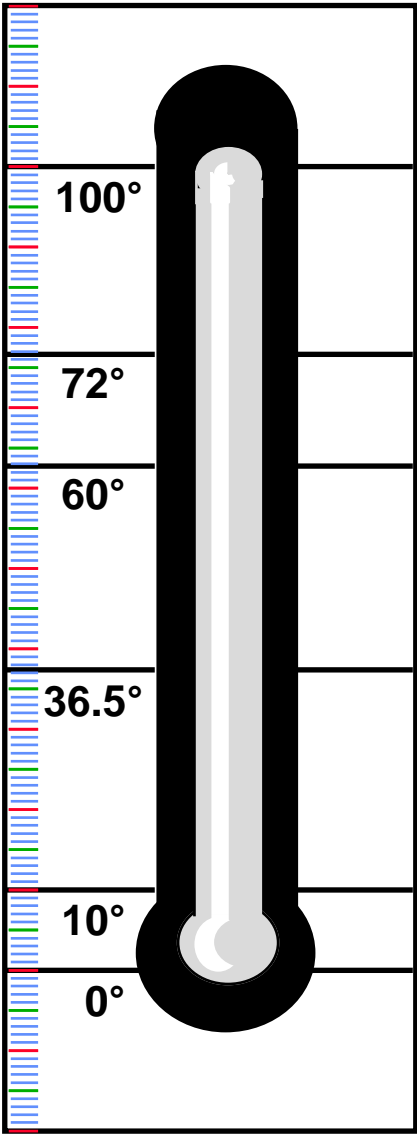
Boiling point

Pasteurizing temperature

Body temperature

Fridge

Freezer

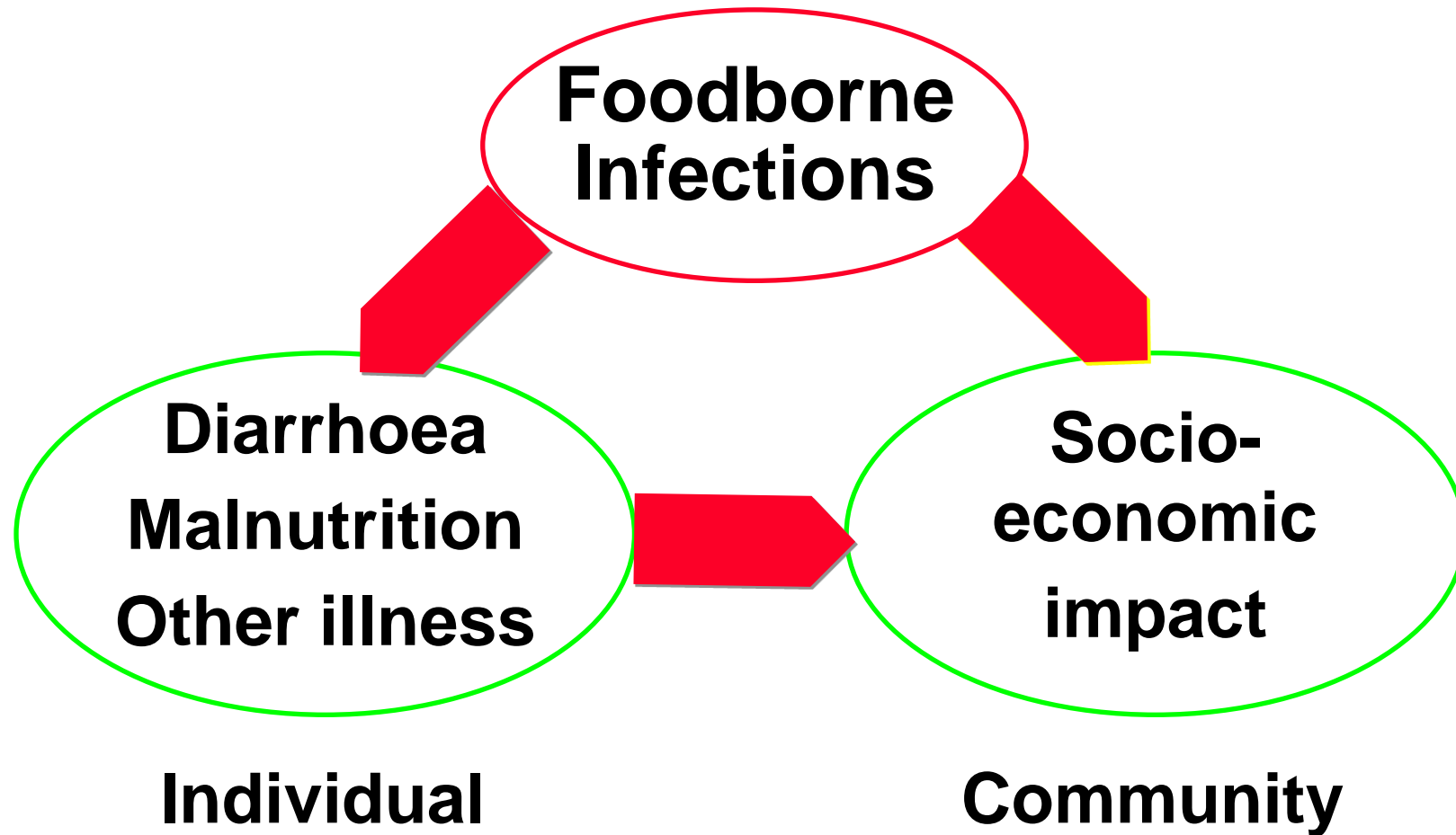


SAFETY

DANGER

SAFETY

# Consequences of foodborne infections



# Annual morbidity and mortality from diarrhoea

## *Estimates for global morbidity*

2.6 episodes / child / year	1980 - 1990	Bern et al (1992)
2.2 episodes / child / year	————→ 1982	Snyder and Merson (1982)

## *Estimates for global mortality*

3.3 million	1990	Bern et al. (1992)
4.6 million	1982	Snyder and Merson (1982)



# Places where food in outbreaks was mishandled

	<i>% Outbreaks</i>	
	<i>USA</i>	<i>Canada</i>
<b>Food service</b>	<b>34.0</b>	<b>32.6</b>
<b>Homes</b>	<b>14.7</b>	<b>14.6</b>
<b>Food processing</b>	<b>2.8</b>	<b>5.5</b>
<b>Retail food</b>	<b>-</b>	<b>4.1</b>
<b>Farms</b>	<b>-</b>	<b>0.2</b>
<b>Other</b>	<b>-</b>	<b>1.2</b>
<b>Unknown</b>	<b>48.5</b>	<b>41.8</b>

# Food handling faults in food service establishments in the USA

## *% Outbreaks*

<b>Inadequate cooling</b>	<b>64</b>
<b>Prepared too far in advance</b>	<b>39</b>
<b>Infected persons</b>	<b>34</b>
<b>Inadequate reheating</b>	<b>24</b>
<b>Inadequate hot storage</b>	<b>21</b>
<b>Inadequate cleaning</b>	<b>10</b>
<b>Cross-contamination</b>	<b>10</b>

# Major factors contributing to foodborne illness

## *Contamination*

**Cross - contamination**  
**Unclean equipment**  
**Unsound / unwholesome food**  
**Chemical contamination**  
**Insects / rodents**  
**Infected handlers**

## *Survival*

**Inadequate cooking / reheating**

## *Growth*

**Insufficient cooling / hot holding**

# Nature of bacteria, moulds, viruses and parasites - key messages

- **Bacteria may be harmful or useful.**
- **Bacteria, yeasts and moulds can be used to preserve foods.**
- **Foodborne diseases are caused by bacteria, moulds, viruses, and parasites.**
- **Bacteria and moulds multiply on foods and may produce toxins.**
- **Viruses and parasites do not grow in food.**
- **Understanding the factors controlling growth of microorganisms allows us to control them in food.**

# Infectious pathogens - key messages

- **Most FBD are caused by infectious rather than toxigenic pathogens**
- **Globally most important are**
  - *Salmonella*
  - *Campylobacter*
  - *Shigella*
  - *E. coli*
- ***Infectious dose varies widely and depends on***
  - **Host**
  - **Organism**
  - **Food**
- ***Lasting immunity is rare***
  - **Preventive measures therefore essential**
  - **Vaccine available only for hepatitis A**