

Know Your Microbes

Know Your Microbes

- Introduction to food microbiology
- Factors affecting microbial growth
 - Temperature
 - Time
 - pH
 - Water activity (A_w)
 - Nutrient availability
 - Atmosphere
- Hurdle technology
- Foodborne pathogens

Food Microbiology

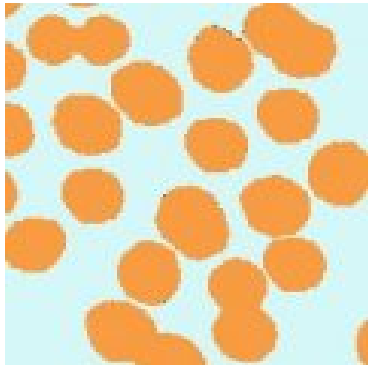
- **The study of microorganisms that are too small to be seen with the naked eye**
 - **Bacteria**
 - **Fungi**
 - **Viruses**
 - **Protozoa**
 - **Algae**



Food Microbiology

- **Shape and size - bacteria**

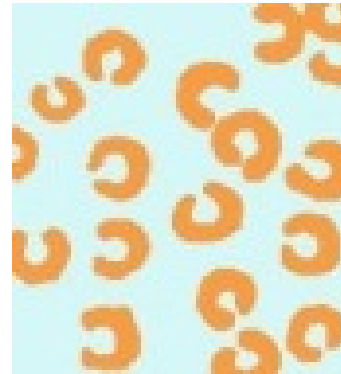
– 4 basic forms



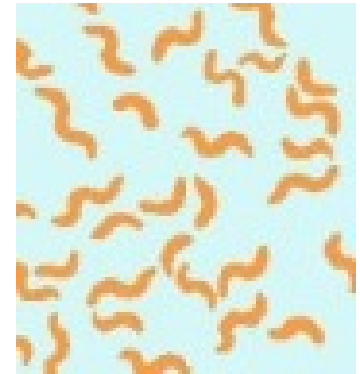
Cocci



Rods



Commas



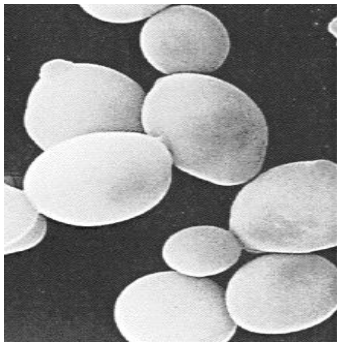
Spirals

Size 1–4 μm

(1 μm = 1/1000 mm)

Food Microbiology

- **Fungi**
 - Many different forms



Yeast cells

Size 6-8 μm



Mould Colony

0.2 – 2 cm

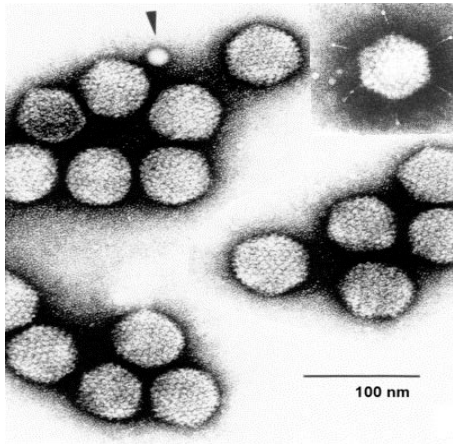


Mushroom

1 cm – 0.5 m

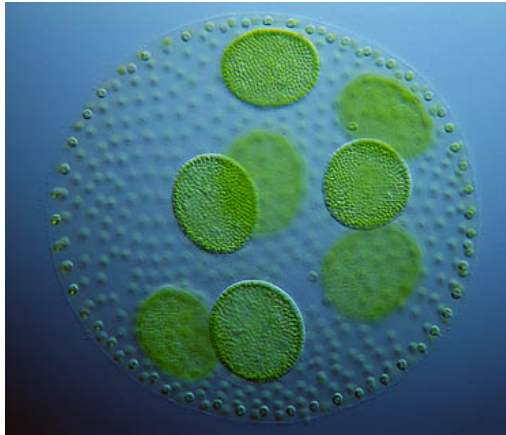
Food Microbiology

Viruses



0.1 μm

Algae



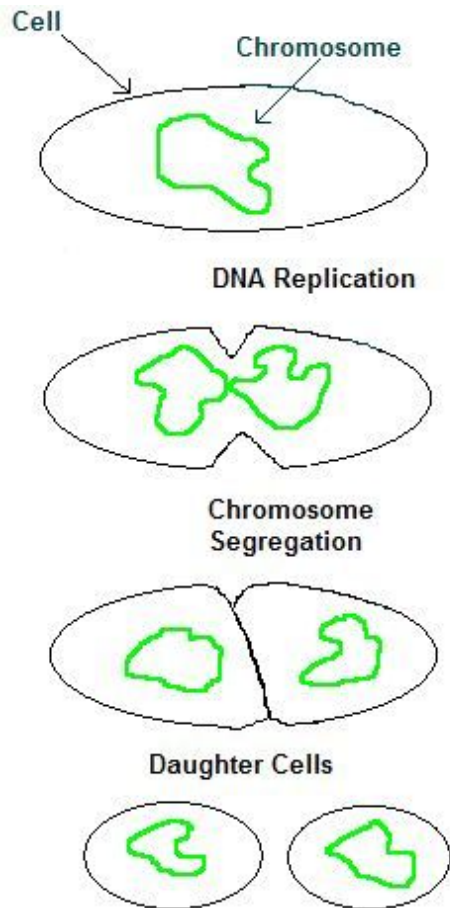
1 mm

Protozoa



50 μm

How Bacteria Grow – Binary Fission

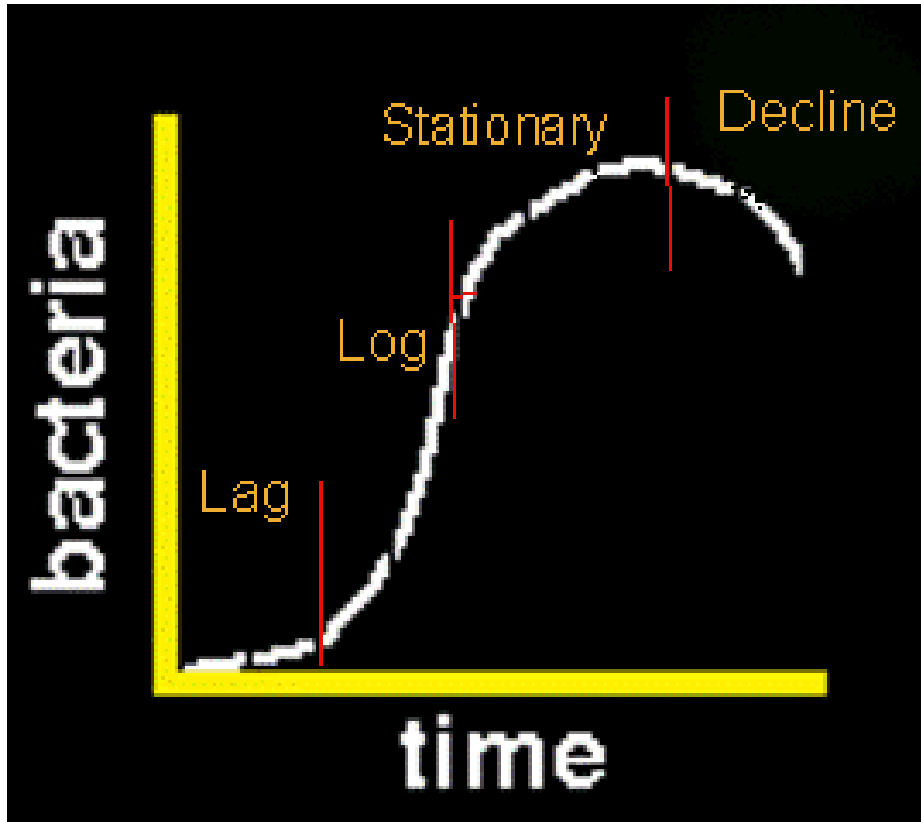


- Cell divides under appropriate conditions
- DNA replicates into 2 identical strands
- Cell starts to lay down material along the cell midpoint
- Cell wall develops isolating DNA
- Cell splits into two

Bacterial Fission



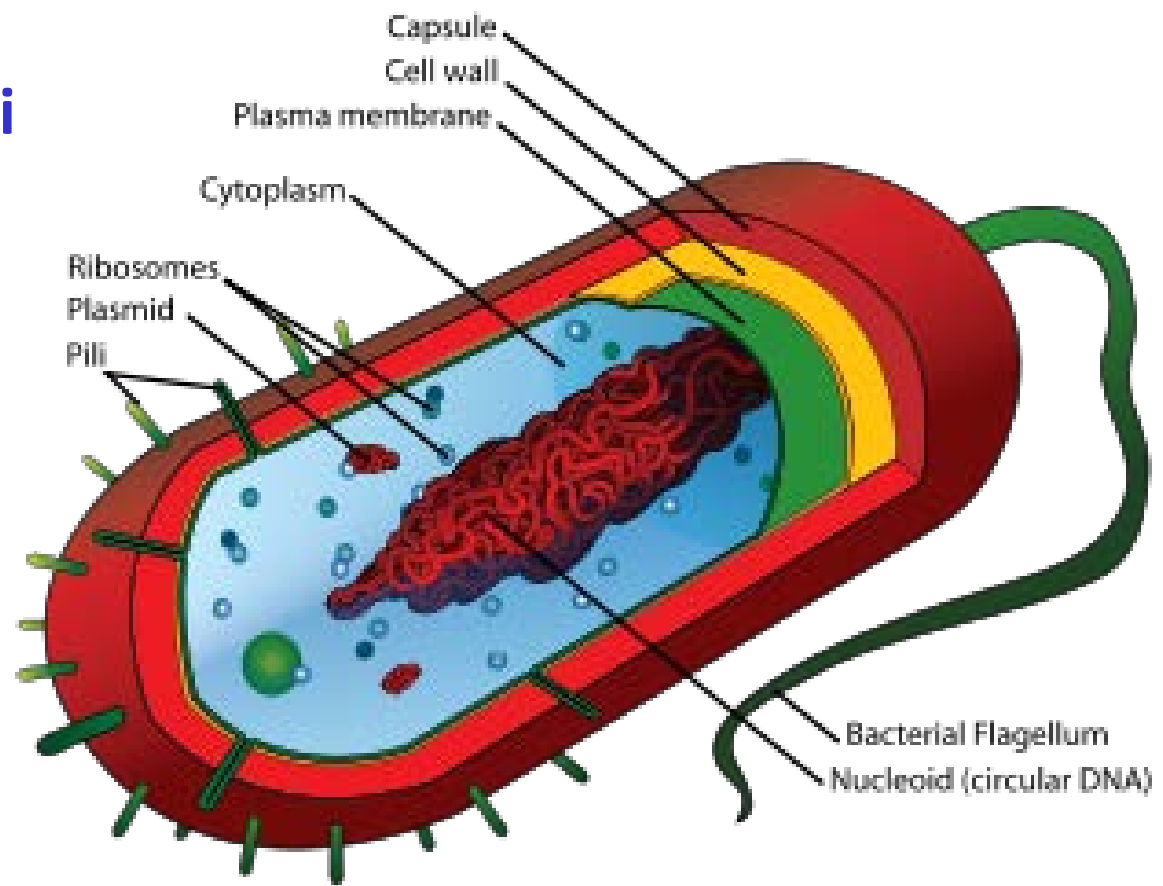
Bacteria Growth Phases



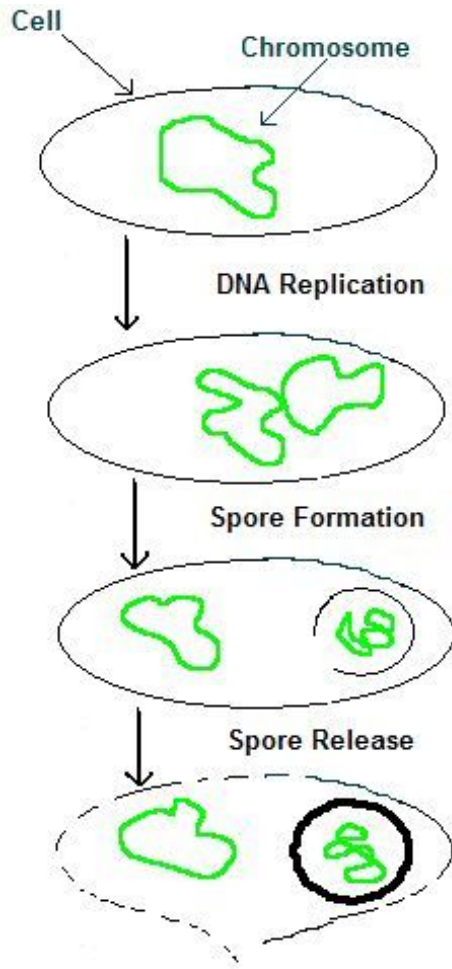
- **Lag phase**
 - adaptation time
- **Log phase**
 - exponential growth phase
- **Stationary phase**
 - tailing off of growth
 - nutrients decrease
 - metabolites/waste products increase
- **Decline phase**
 - slow decline and death

Bacterial Cell Structures

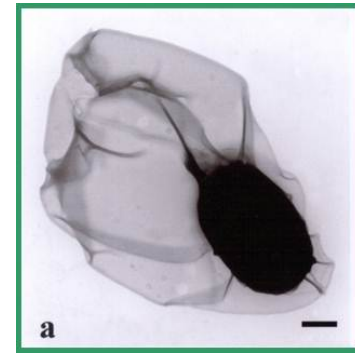
- Loop of DNA
- Flagella and/or pili
- Cell wall
- Cell membrane
- Cell capsule



Spore Formation



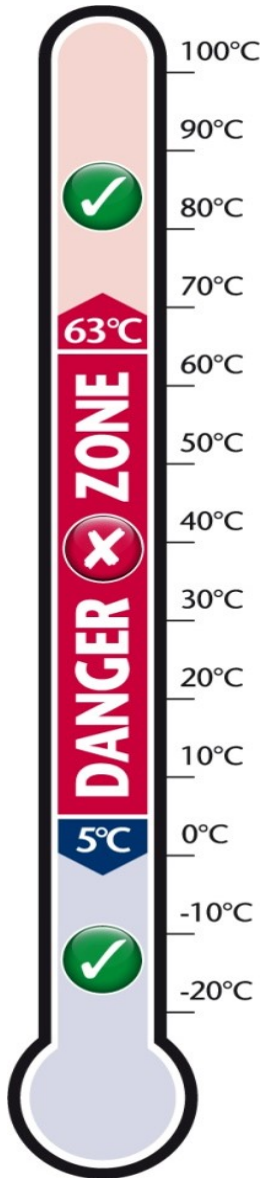
- Response to adverse conditions
- DNA replicates
- Spore coat laid down around DNA
- Cell bursts open releasing spore



Factors Affecting Microorganism Growth

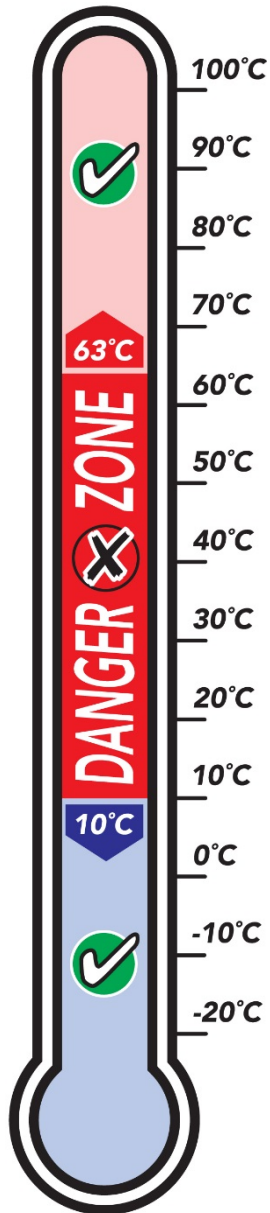
- **Temperature**
- **Time**
- **pH**
- **Water activity (A_w)**
- **Nutrient availability**
- **Atmosphere**
- **Antimicrobials**

Temperature



- Cells die rapidly above 65°C
- 5-63°C bacteria grow actively
 - “DANGER ZONE”
- Optimal growth range:
 - most foodborne pathogenic bacteria: 25–40°C
 - yeasts: 20–30°C
- Growth slows as temperature drops below 8°C

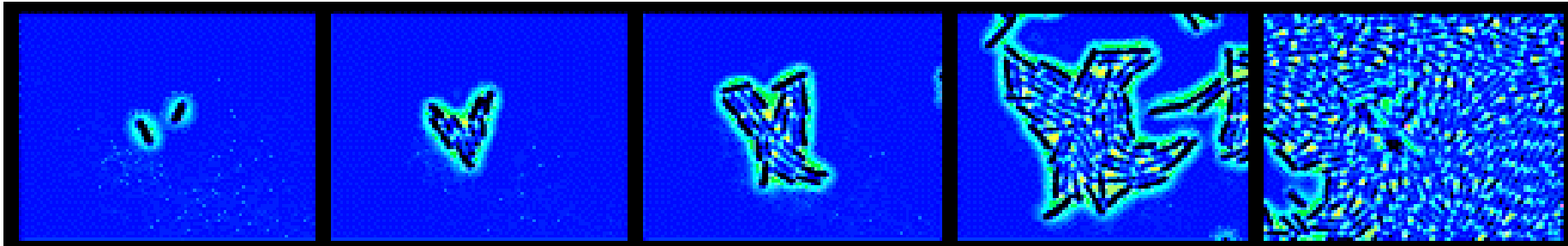
Classifying Re: Temperature



- Foodborne pathogens' optimum growth temperatures usually close to host body temperatures, e.g.
 - Humans 37°C
 - Birds 42°C
 - Heat-loving - Thermophile: 30-55°C
 - Cold-loving - Psychrophile: 0-35°C
 - Others - Mesophiles: 10-45°C

Time

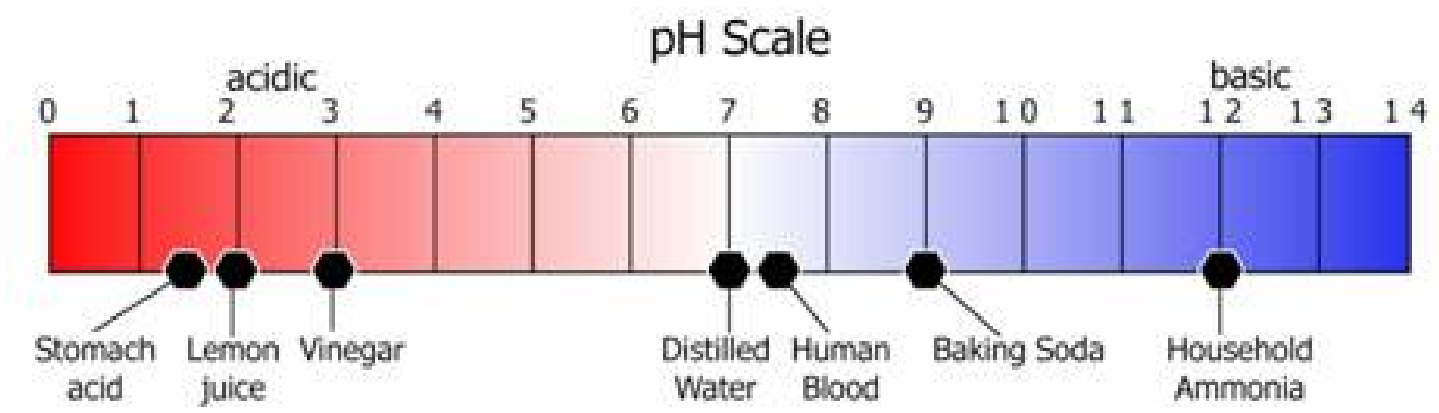
- Bacteria grow by binary fission - splitting and dividing of a single cell into two daughter cells



- Under ideal conditions *E. coli* doubles every 20 mins
- **One cell can increase to 4 million in 8 hours**
- Relates to shelf life in food supporting growth

pH

- Acid/alkaline concentration measured on a scale of 0-14



Growth ranges:

Bacterial pathogens: 4.0-9.0

Spoilage bacteria: 3.0-9.0

Yeasts: 2.0-8.0

Example chilled foods:

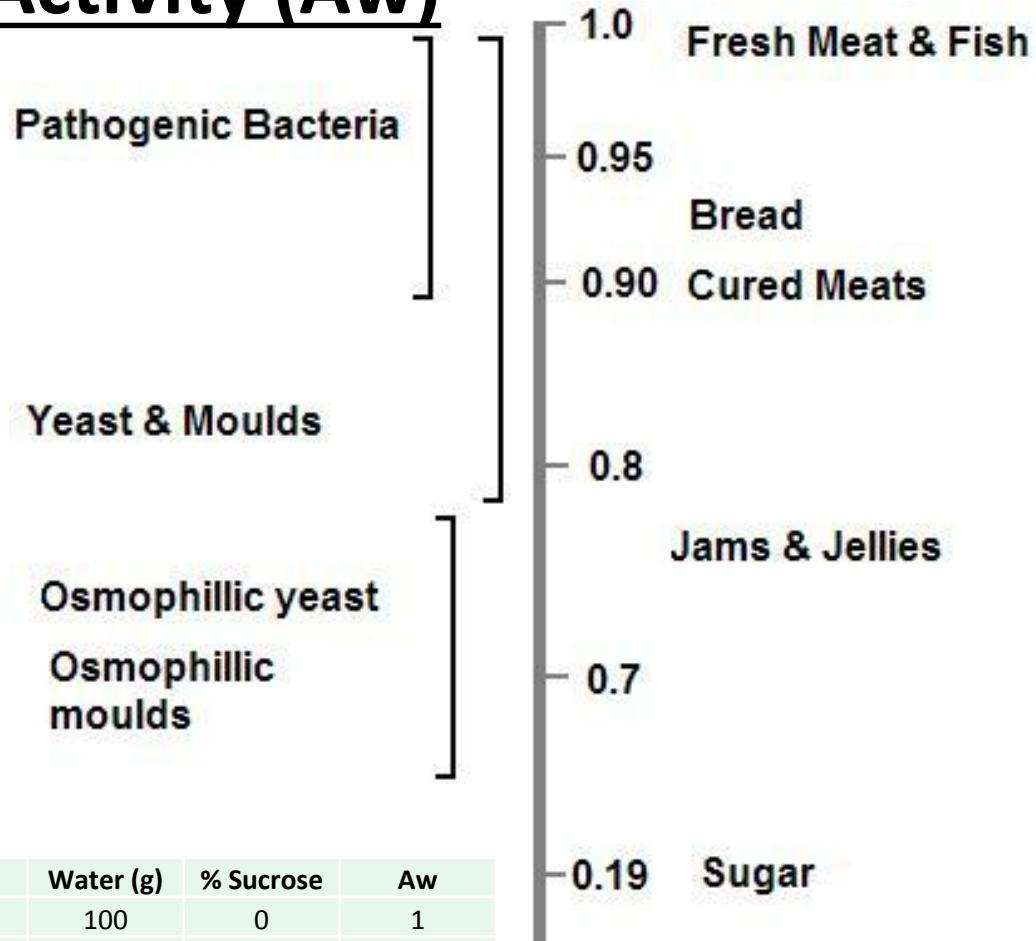
Cooked peeled prawns 6.6 to 7.7

Mashed potato 6.0

Gobi Aloo Sag 5.0

Water Activity (Aw)

- % of water available for microbial growth
- Limiting Aw can be effective to preserve foods
 - Raw meat ⇒ Bacon, biltong
 - Milk ⇒ Cheese
 - Grapes ⇒ Raisins
- Salt 6 times more effective in reducing Aw than sugar:



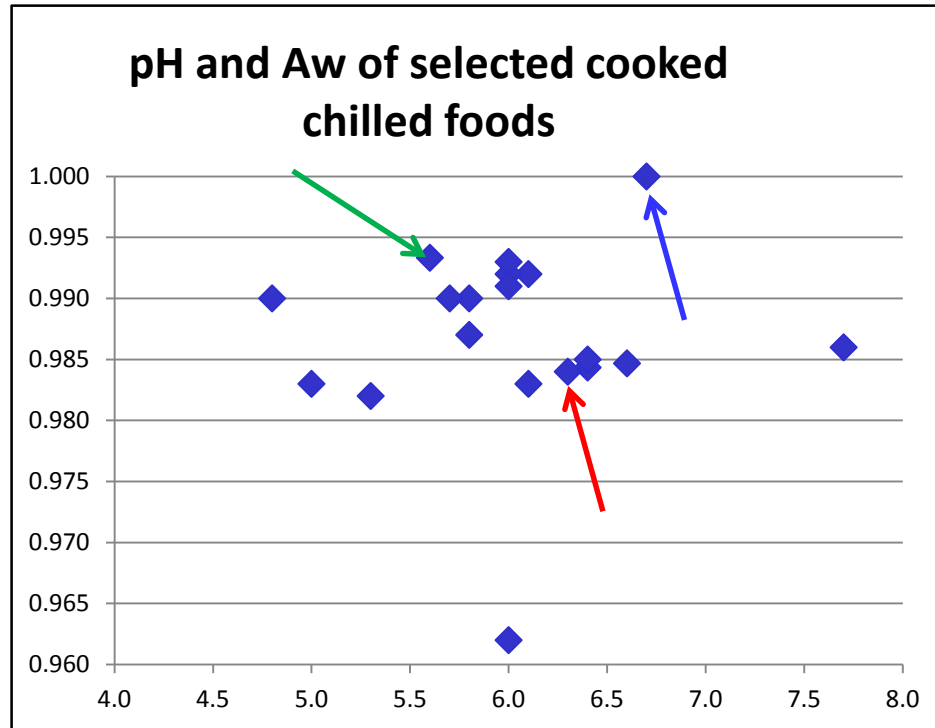
NaCl (g)	Water (g)	% NaCl	Aw
0.9	99.1	0.9	0.995
1.7	98.3	1.7	0.99
3.5	96.5	3.5	0.98
7	93	7	0.96
10	90	10	0.94
13	87	13	0.92
16	84	16	0.9
22	78	22	0.86

Sucrose (g)	Water (g)	% Sucrose	Aw
0	100	0	1
20	100	16.7	0.998
40	100	28.6	0.969
60	100	37.5	0.955
80	100	44.4	0.941
100	100	50	0.927
120	100	54.5	0.913
140	100	58.3	0.9
160	100	61.5	0.888
180	100	64.3	0.876
200	100	66.7	0.86

$$Aw = 1 - \%NaCl * (5.2471 + 0.12206 * \%NaCl) / 1000$$

(Resnik & Chirife, 1988)

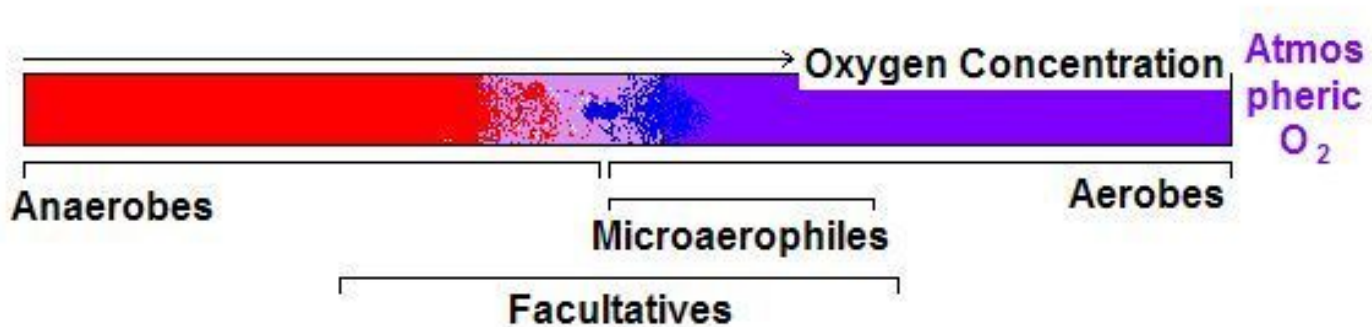
pH & Aw of Some UK Cooked Chilled Foods



Control (high pH/Aw)	pH 6.8, Aw 0.997
flame grilled chicken	pH 6.3, Aw 0.984
carbonara sauce	pH 5.8, Aw 0.990

Atmosphere

- Microbes are very adaptable
 - Can survive under many varied conditions



- Most are facultative, not obligate aerobes/anaerobes
 - Vacuum packing will not have any effect on Lm
 - Reduced oxygen packing encourages *Cl. botulinum* growth

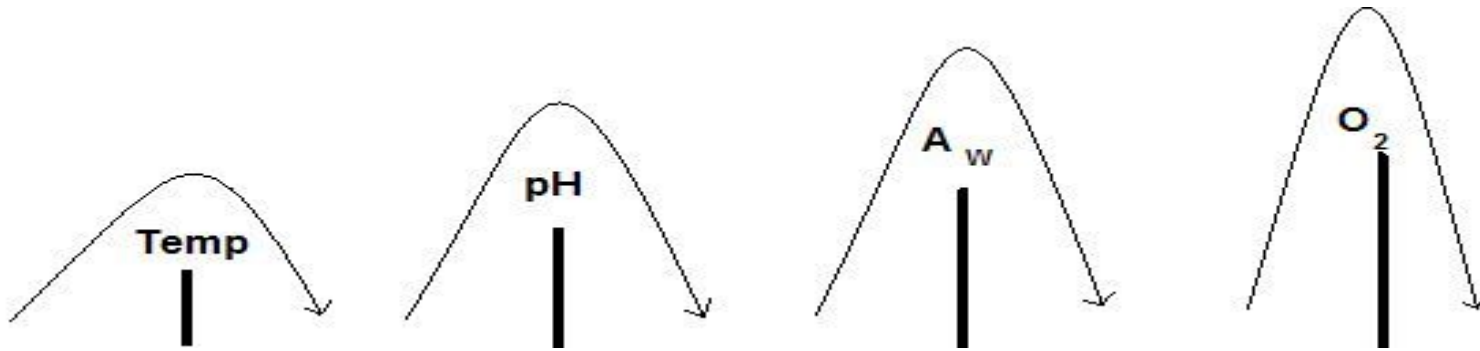
Atmosphere

- Control can be used to preserve food
- 3 main techniques of CAP, MAP & vac packing:
 - Controlled Atmosphere Packing:
 - extending fresh produce life
 - continuously controlled gas mix
 - Modified Atmosphere Packaging:
 - increased levels of O₂/CO₂ + buffer gas (usually N₂)
 - maintains appearance/colour of fresh meat and fish
 - relies on chilled storage
 - Vacuum Packing:
 - stops rancidity of fats, has some preservative effect BUT
 - promotes growth of anaerobes, e.g. *Clostridium botulinum*
 - has no effect on *Listeria monocytogenes*



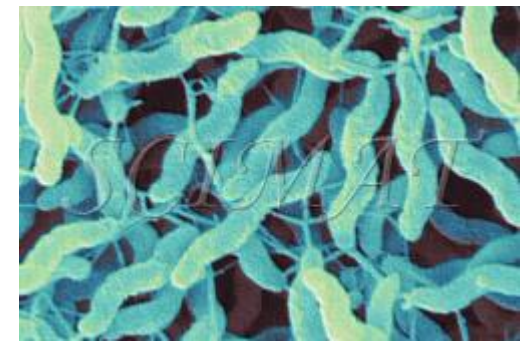
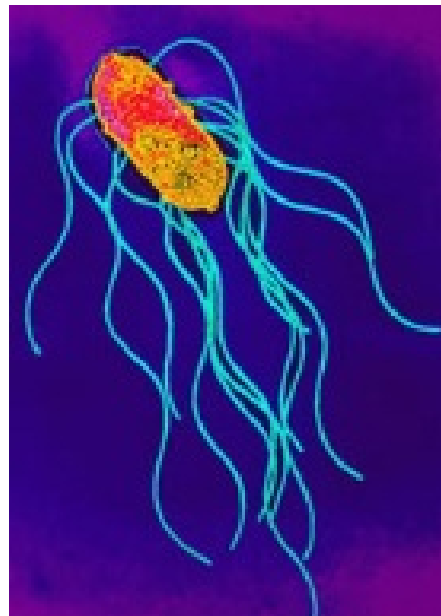
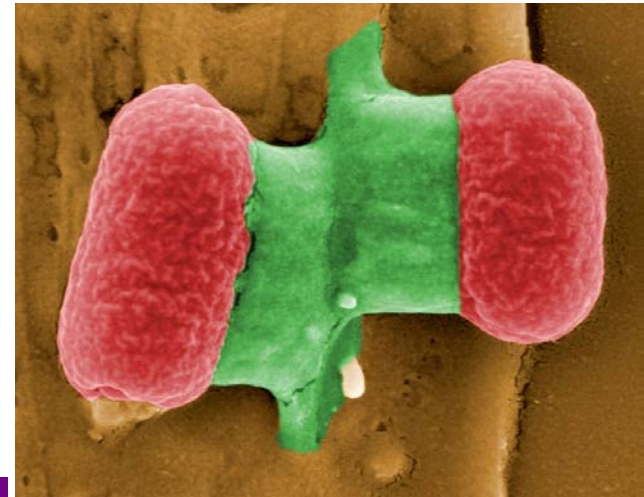
Hurdle Technology

- Understanding microbial growth/growth limits can be used to preserve food without using severe processes



- Each hurdle “costs” the microbe energy
- Combined hurdles, e.g. low pH, low A_w , low temperature can heighten the overall effect of one hurdle, e.g.
 - Sodium nitrite + salt to preserve cooked meats
 - MAP + chill

Foodborne Pathogens



Food Poisoning

- **2 types of food poisoning**

- Infections
- Intoxications

- **Toxins – two classes**

- Endotoxin released as the cell dies or begins sporulation
- Exotoxins produced as a by-product of growth

Infection

Salmonella

Campylobacter

Listeria monocytogenes

Vibrio parahaemolyticus

Clostridium perfringens

Escherichia coli

Viruses

Protozoa

Intoxication

Clostridium botulinum

Staphylococcus aureus

Bacillus cereus

Pathogen Growth Boundaries

Microorganism	Min temp (°C)	Min pH	Min Aw	Aerobic / anaerobic
L. monocytogenes	-0.4¹	4.3	0.92	Facultative
B. cereus	4	4.5	0.93 ¹	Facultative
Campylobacter jejuni	32	4.9	0.99	Microaerophilic
Cl. botulinum Mesophilic/proteolytic	10-12 ¹	4.6	0.93	Anaerobic
Cl. botulinum Psychrotrophic/non-proteolytic	3.3	5.0	0.97 (5% NaCl)	Anaerobic
Cl. perfringens	12 ¹	5.5-5.8 ¹	0.935 ¹	Anaerobic
E. coli O157:H7	6.5	4.5	0.95	Facultative
Salmonella	6	4.0	0.94	Facultative
Staphylococcus aureus	5.2	4.5	0.86	Facultative
V. parahaemolyticus	5	4.8	0.94	Facultative
Y. enterocolitica	-1.3 ¹	4.2	0.96	Facultative

¹ *Microorganisms in Foods. Vol. 5. Microbiological Specifications of Food Pathogens.* (1995), ICMSF, Blackie Academic & Professional
ACMSF Report on Verocytotoxin-Producing E coli (1995), HMSO, London, ISBN 0-11-321909-1.