



Spores in Milk and Milk Products

Amandeep Dhillon

Director Quality-Michigan Milk Producers Association

U.S Industry continues to invest to control spores

- Recognition: spores are on everyone's radars
- Multi-faceted approach to control spores by dairy industry
 - Equipment choice: add, modify, new construction
 - Plant and Piping layout
 - Practices/Processing

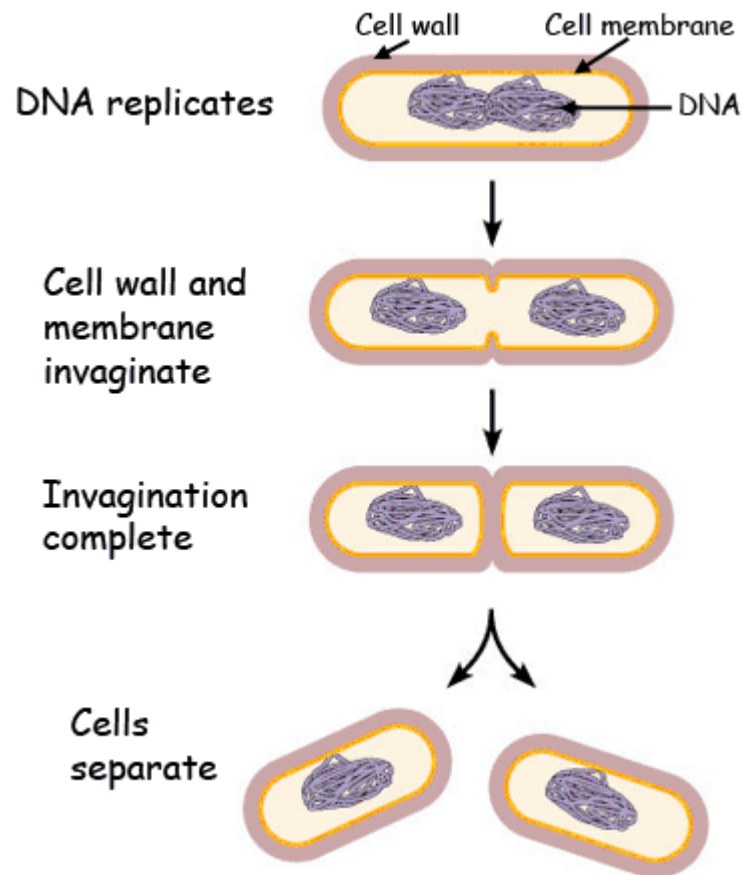


Why invest in quality improvements

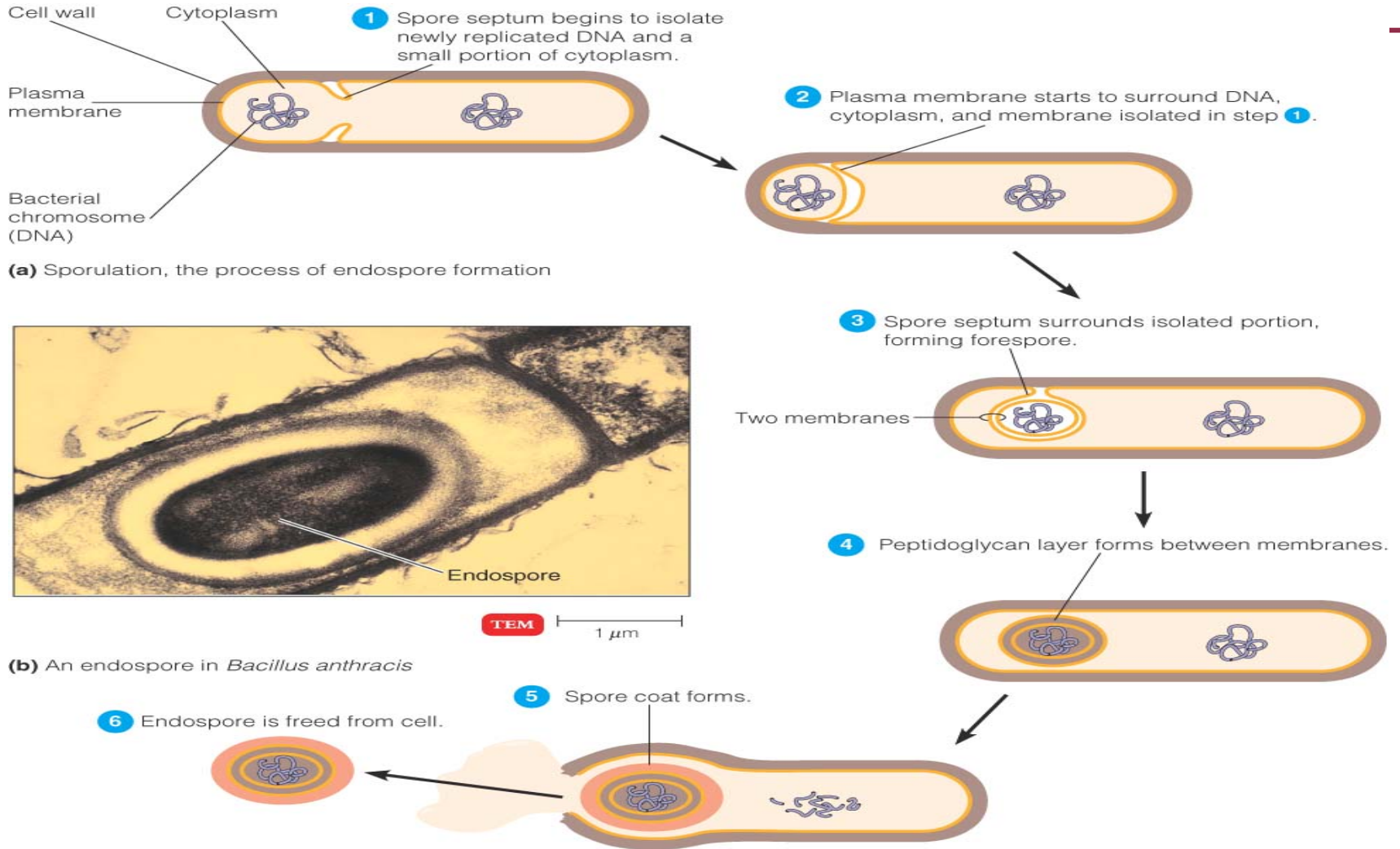
- Spores remain viable in the product and can impact shelf-life, quality and safety
- Low spore powder is needed in infant formula and UHT products
- End-users are requiring more stringent controls on quality and food safety
- Specifications are set considering the final process's ability to grow and/or remove spores
- U.S suppliers able to meet the high quality will gain a competitive advantage



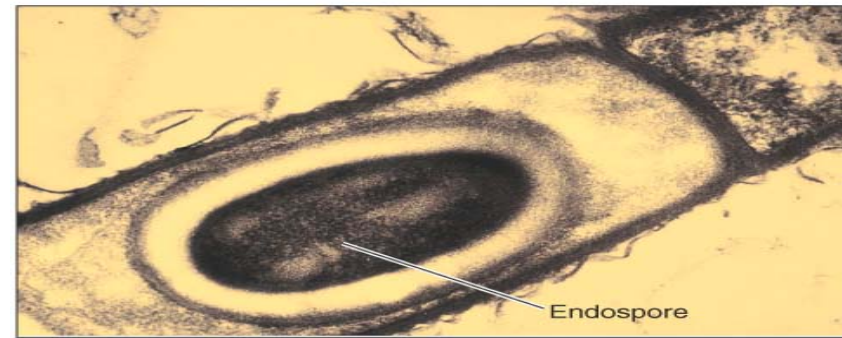
How bacteria multiply



Sporulation Process



(a) Sporulation, the process of endospore formation



(b) An endospore in *Bacillus anthracis*



Spore heat resistance due to structure

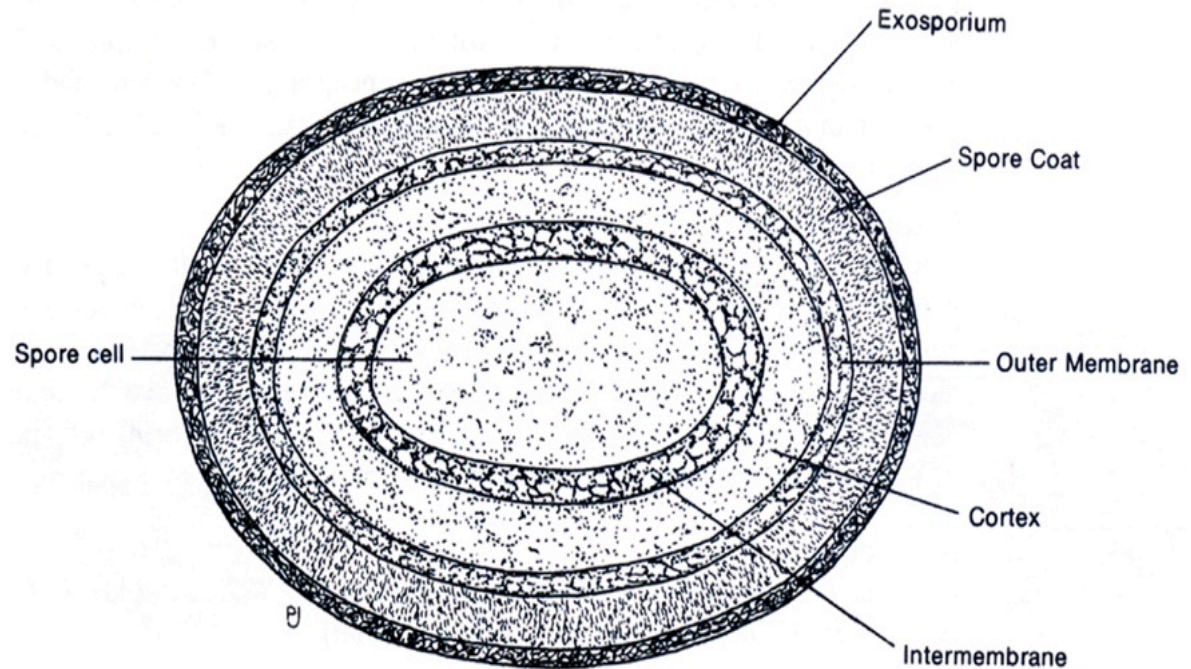
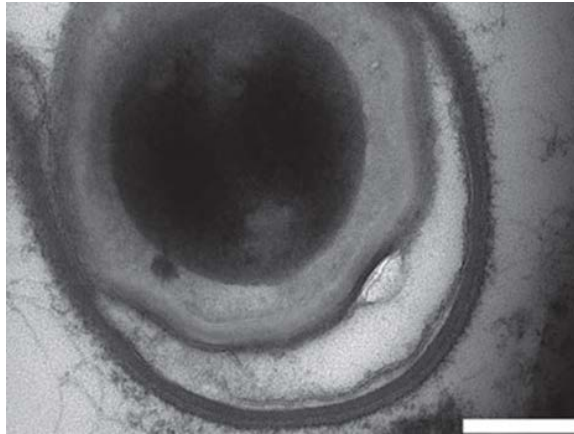


Fig. 8.1. Endospore

- Exosporium - A thin delicate covering made of protein
- Spore coats - Composed of layers of spore specific proteins
- Cortex - Composed of loosely linked peptidoglycan and contains dipicolinic acid (DPA), which is particular to all bacterial endospores



Endospore germination



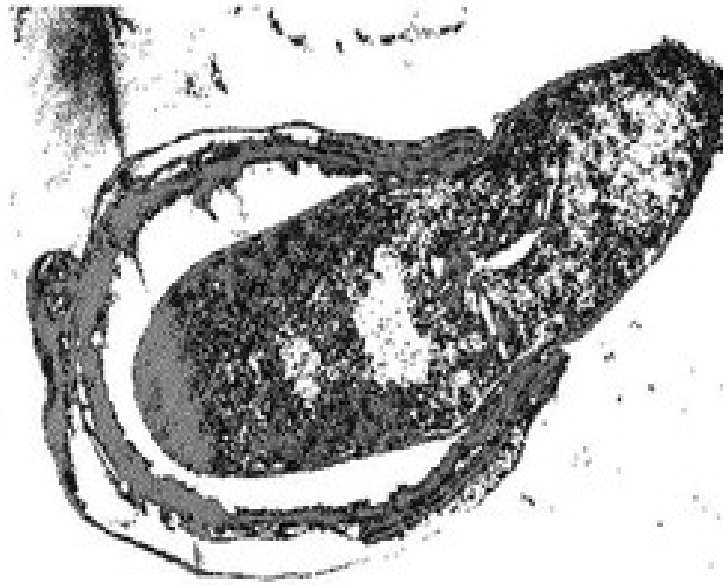
Spore



- Activation
- Germination
- Outgrowth



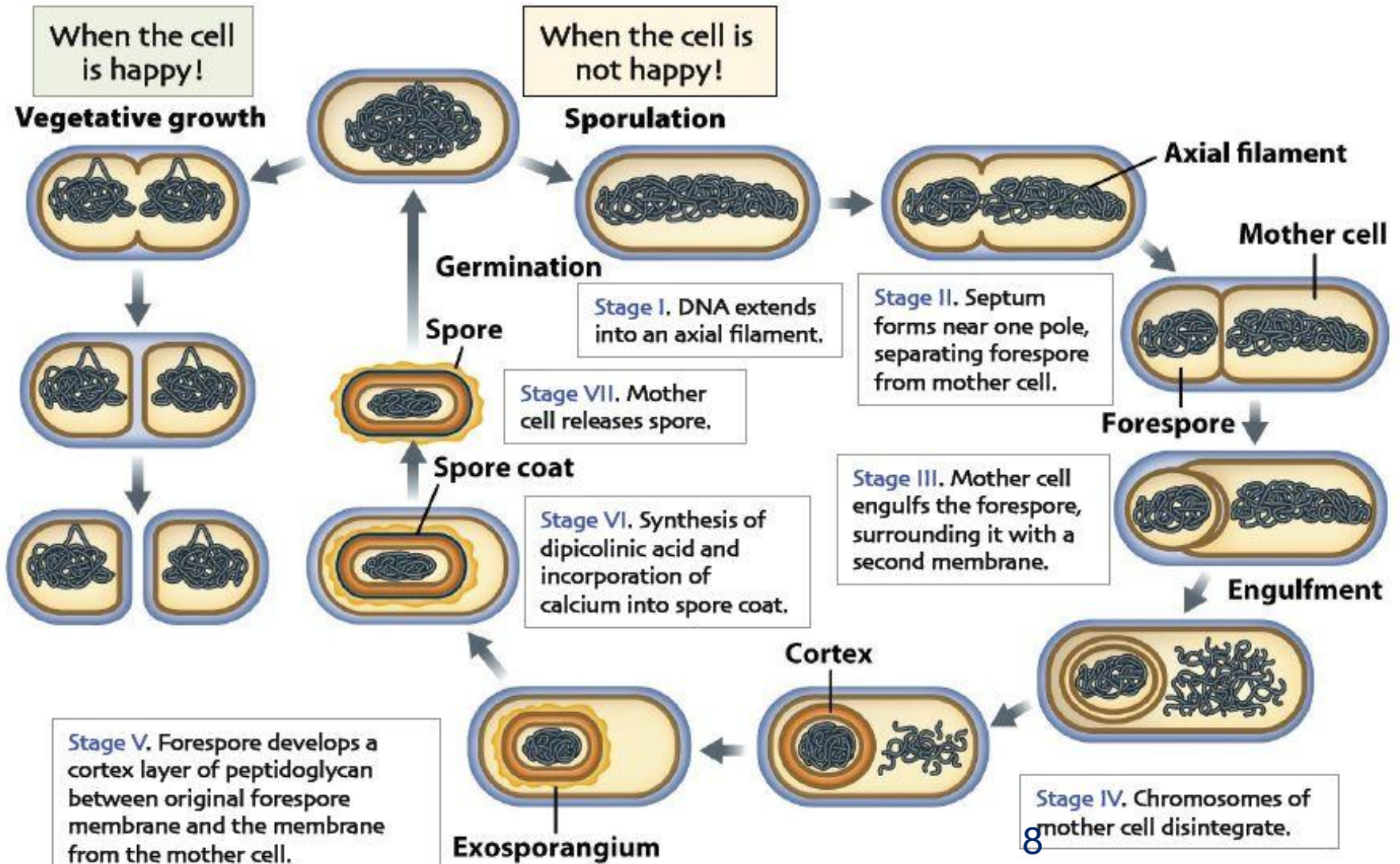
Vegetative form



- DNA repair during germination

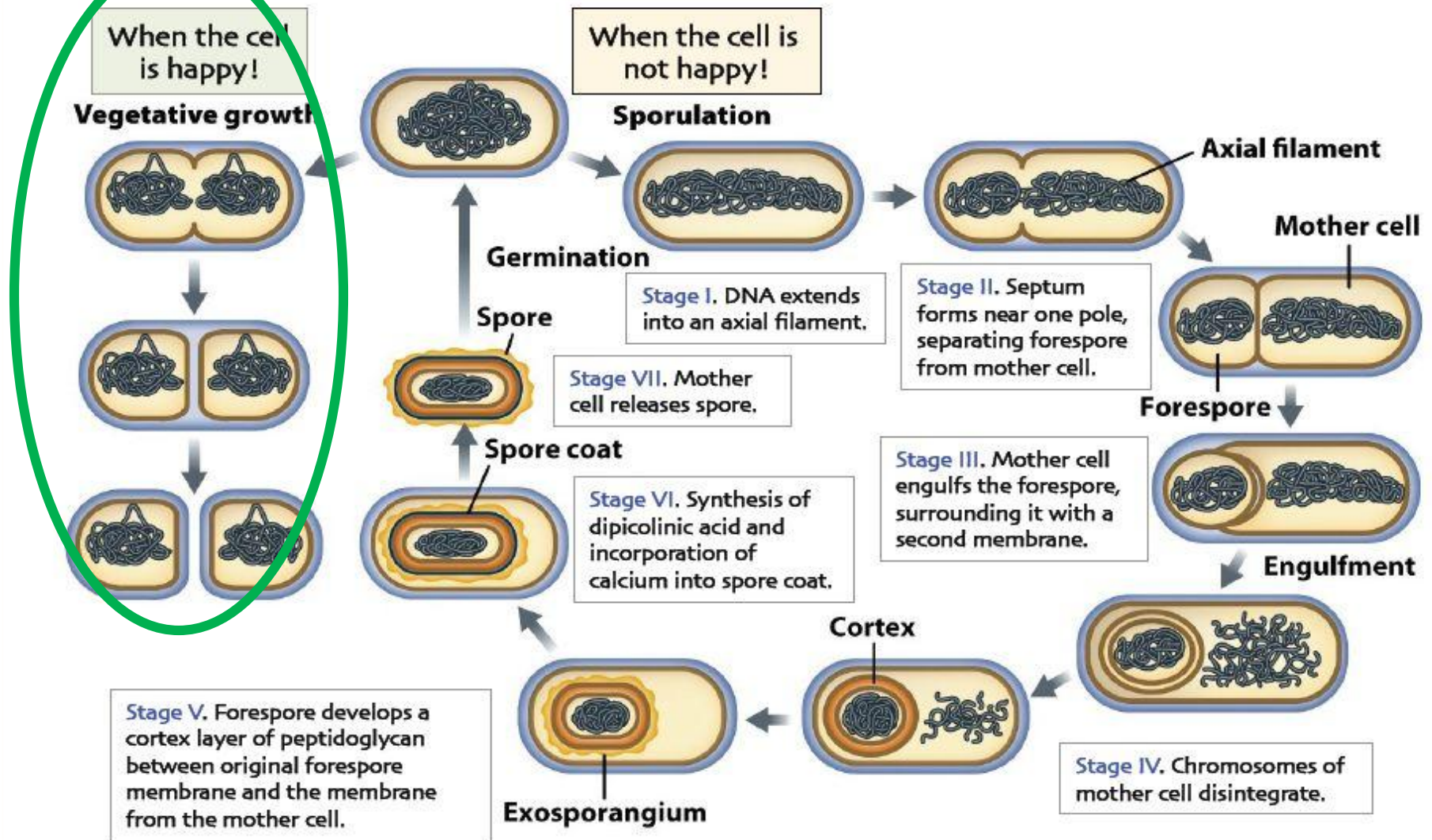
Bacterial endospore: Sporulation & Germination

Sporulation: Upon starvation, **vegetative cell** differentiates into **endospore** through a complex, genetically directed sporulation process (more than 200 genes involved).



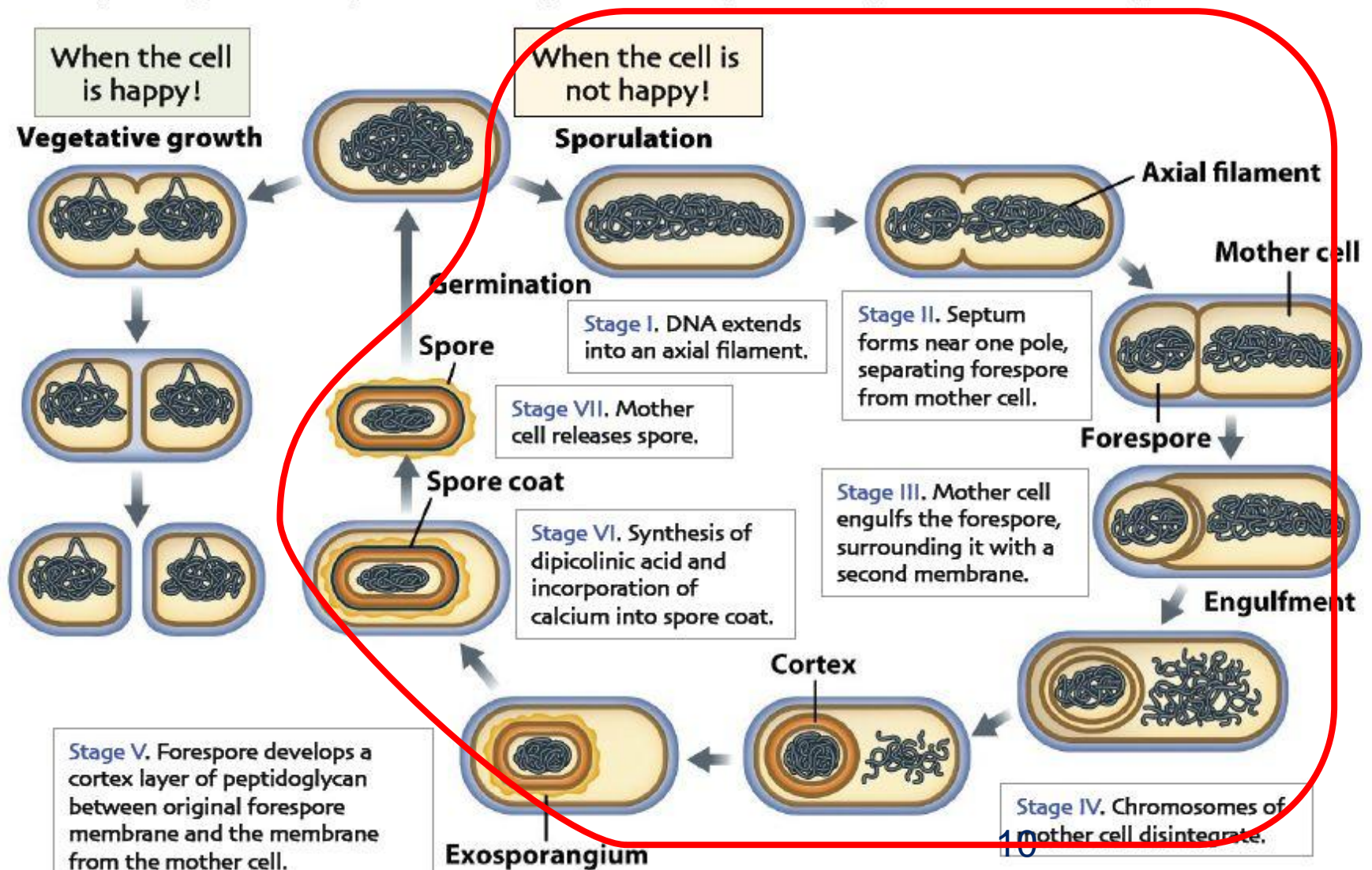
Bacterial endospore: Sporulation & Germination

Sporulation: Upon starvation, **vegetative cell** differentiates into **endospore** through a complex, genetically directed sporulation process (more than 200 genes involved).



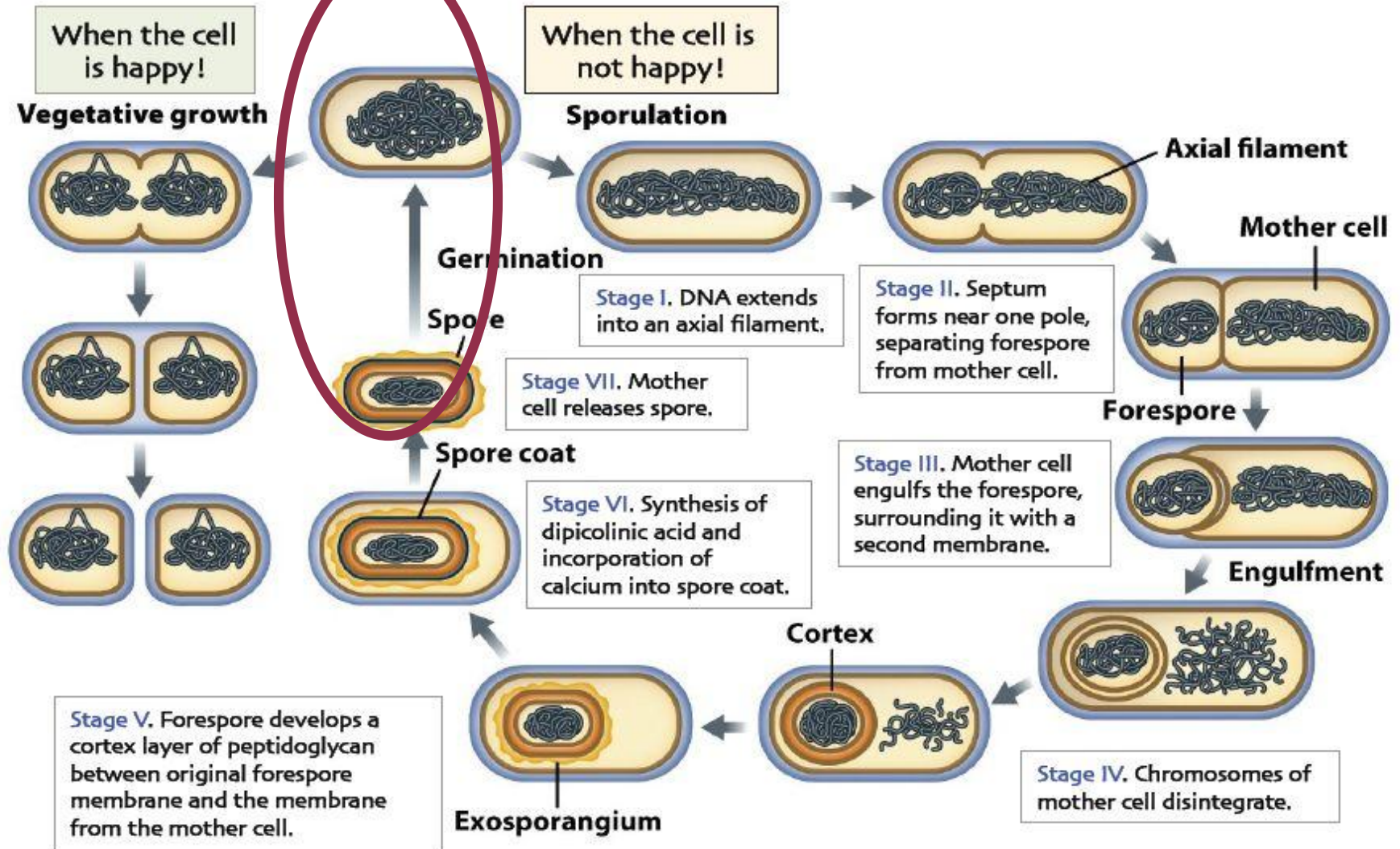
Bacterial endospore: Sporulation & Germination

Sporulation: Upon starvation, **vegetative cell** differentiates into **endospore** through a complex, genetically directed sporulation process (more than 200 genes involved).



Bacterial endospore: Sporulation & Germination

Sporulation: Upon starvation, **vegetative cell** differentiates into **endospore** through a complex, genetically directed sporulation process (more than 200 genes involved).



Describing spore-formers

Ability
to
survive
heat

Spore

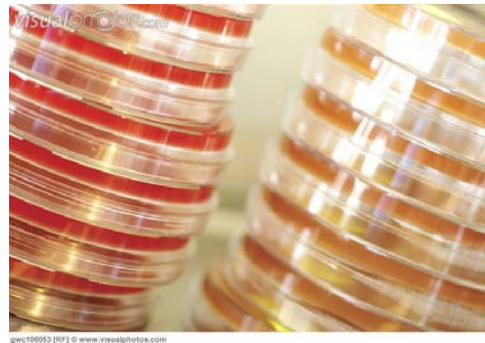
- Spore
80°C (176°F) for 12 min
- Heat resistant spores
100°C (212°F) for 30 min
- Highly heat resistant
>106°C (223°F) for 30 min



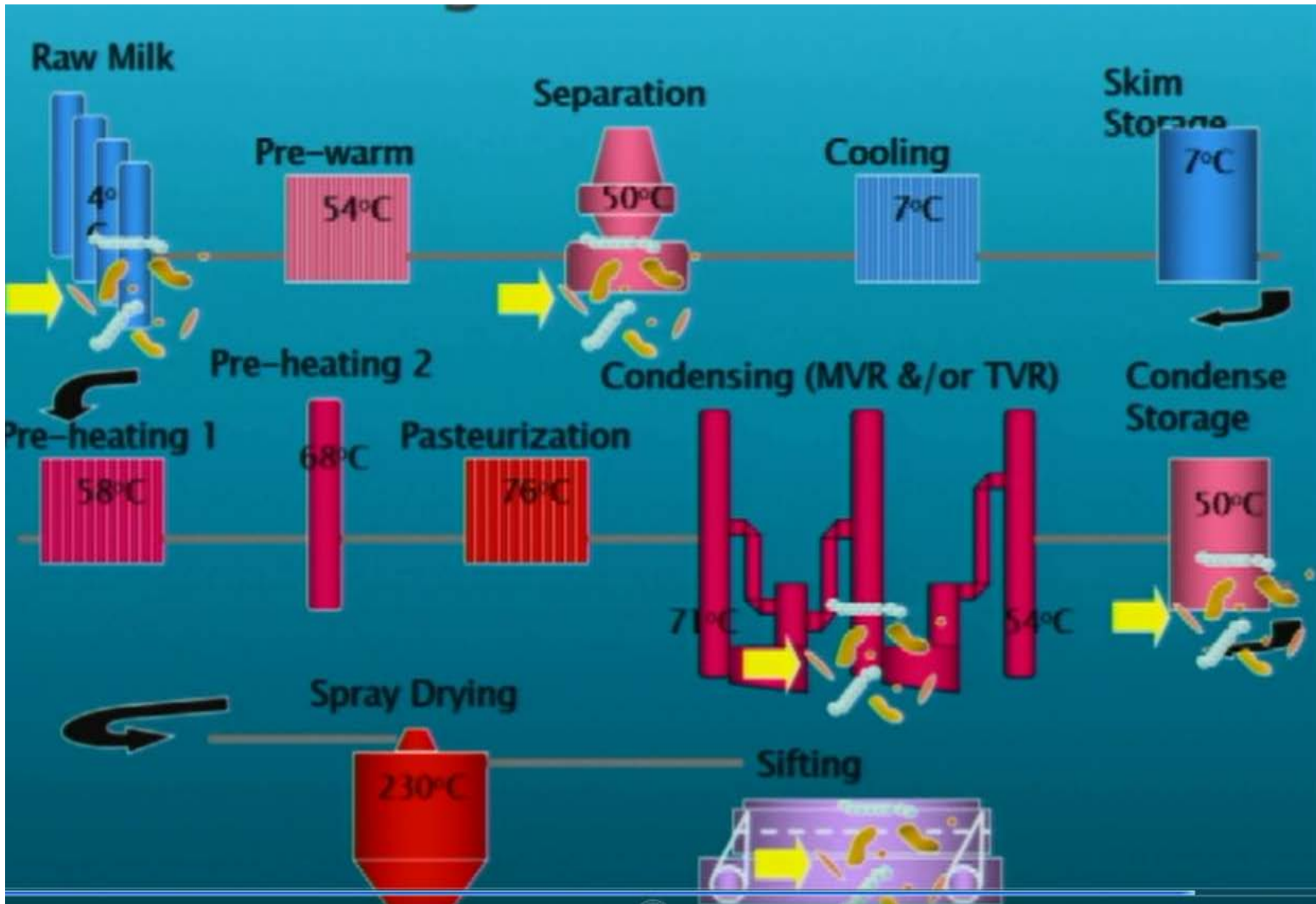
Ability
to
grow

Vegetative Cell

- Psychrotrophic
/psychrotolerant
- Mesophilic
- Thermophilic



Processing Plant



Spore control-Thermophilic

- Start with low-spore milk
- Keep the plant equipment design simple
- Minimize surface area-this will minimize biofilm and subsequent release of bacteria in product
- Minimize milk residence time at critical temperature permitting thermophilic spore growth(104F-158)

Spore-Formers Specification-Infant formula

Contaminant	Range of limit(CFU)
Mesophilic plate count	Threshold (m): <1,000 to<5000/g; Max(M): <5,000 to 10,000/g
Thermophilic plate count	Threshold:<2,500/g; Max:<5,000/g
Aerobic spore, mesophilic	<500 to<1,000/g
Aerobic spore, thermophilic	<500 to <1,000/g
<i>Bacillus Cereus</i>	Threshold:<50/g Max:<100/g
<i>Clostridium perfringens</i>	Threshold: negative/g Max: negative/0.1g
Sulfite reducing <i>clostria</i>	Threshold: <5 to<10/g Max: <10 to <25/g

Spore-Formers Specification- Recombined & UHT

Contaminant	Range of limit(CFU)
Mesophilic plate count	<10,000/g
Thermophilic plate count	<5,000/g to 10,000/g
Aerobic spore, thermophilic	<500 to <2,000/g
<i>Thermoresistant Spores</i>	<500/g

Farm Management Practices Associated with Sporeformers

- Spores find their way into milk via
 - Environment
 - Silage, feed, manure
 - Milking Equipment
 - Hygiene
 - Handling/Storage

Farm Management Practices and Spores

SCORE 1
Clean, free from dirt

SCORE 2
Slightly dirty,
2-10% of the surface

SCORE 3
Moderately dirty,
10-30 % the surface

SCORE 4
Very dirty,
> 30% of the surface



Cow
Hygiene

Udder health

Milking
Routine



Conclusions

- Standard raw milk quality parameters reflect quality more than shelf-life
- Bacillus are predominant spore formers isolated from bulk tanks
- Spores are more resistant than vegetative cells to
 - High heat
 - High pressure
 - Freezing
 - UV Radiation
 - Chemical Compounds
 - Anti-microbial Compounds
 - γ -radiation



Thank you and questions

Special thanks to Annie Bienvenue USDEC

