Spores in Milk and Milk Products

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U.S Industry continues to invest to control spores

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

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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

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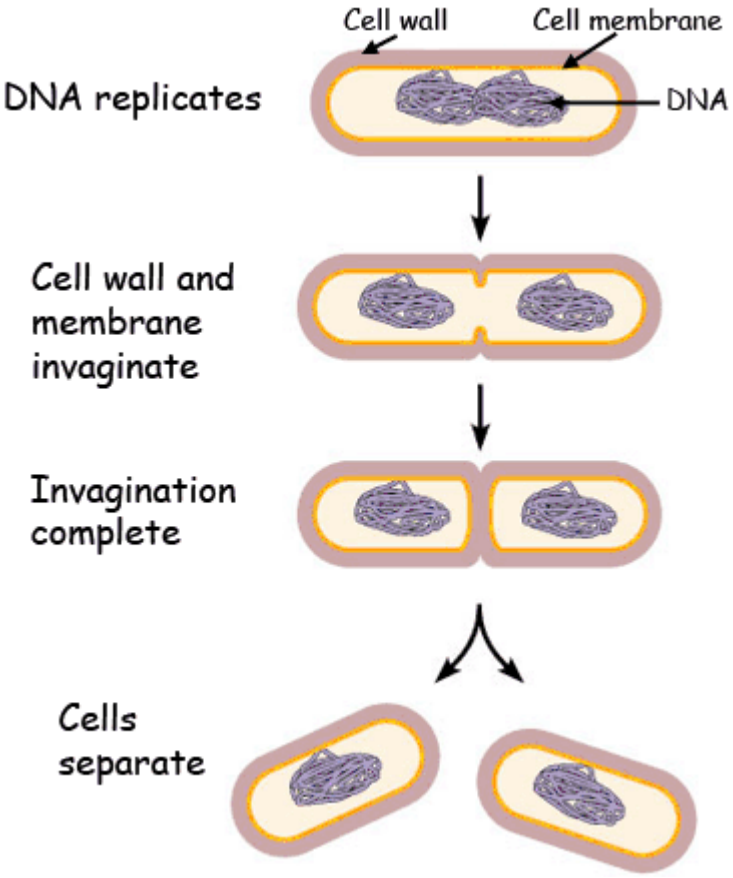
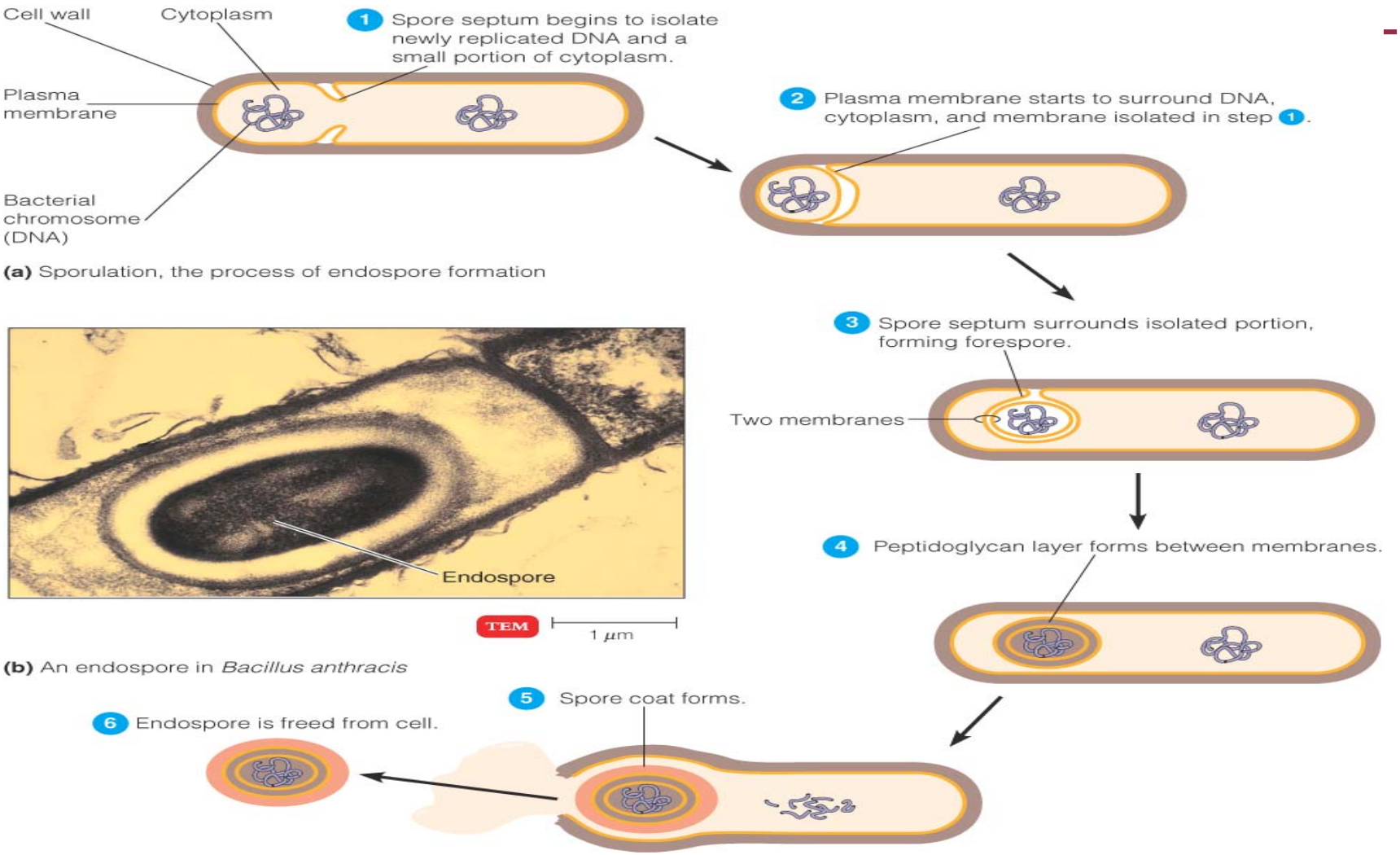
How bacteria multiply



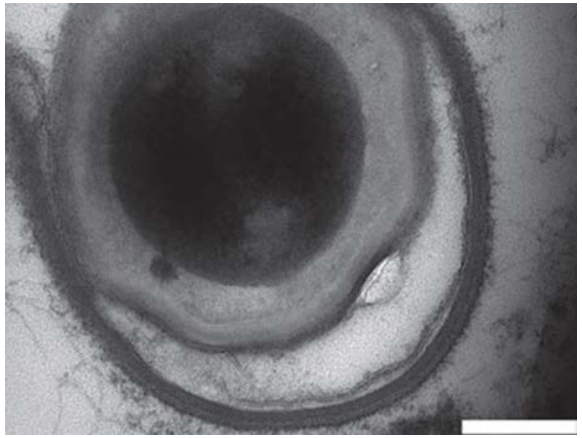
Source: http://www.ncl.ac.uk/dental/oralbiol/oralenv/tutorials/bacterial_growth.htm

Sporulation Process



Source: http://classes.midlandstech.edu/carterp/Courses/bio225/chap04/04-21_Sporulation_1.jpg

Spore heat resistance due to structure



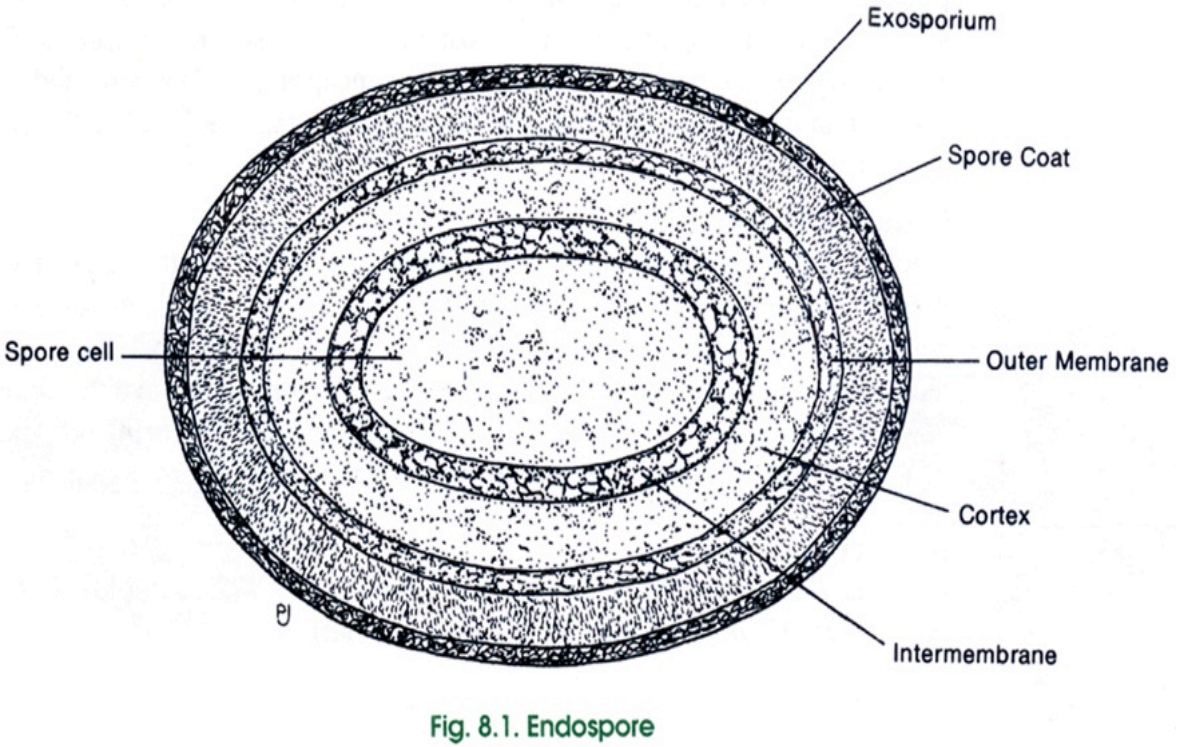


Fig. 8.1. Endospore

- 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

Source: Jimenez, 2013 U.S. Dairy Industry Spore Seminar

Endospore germination

Spore

- Activation
- Germination
- Outgrowth

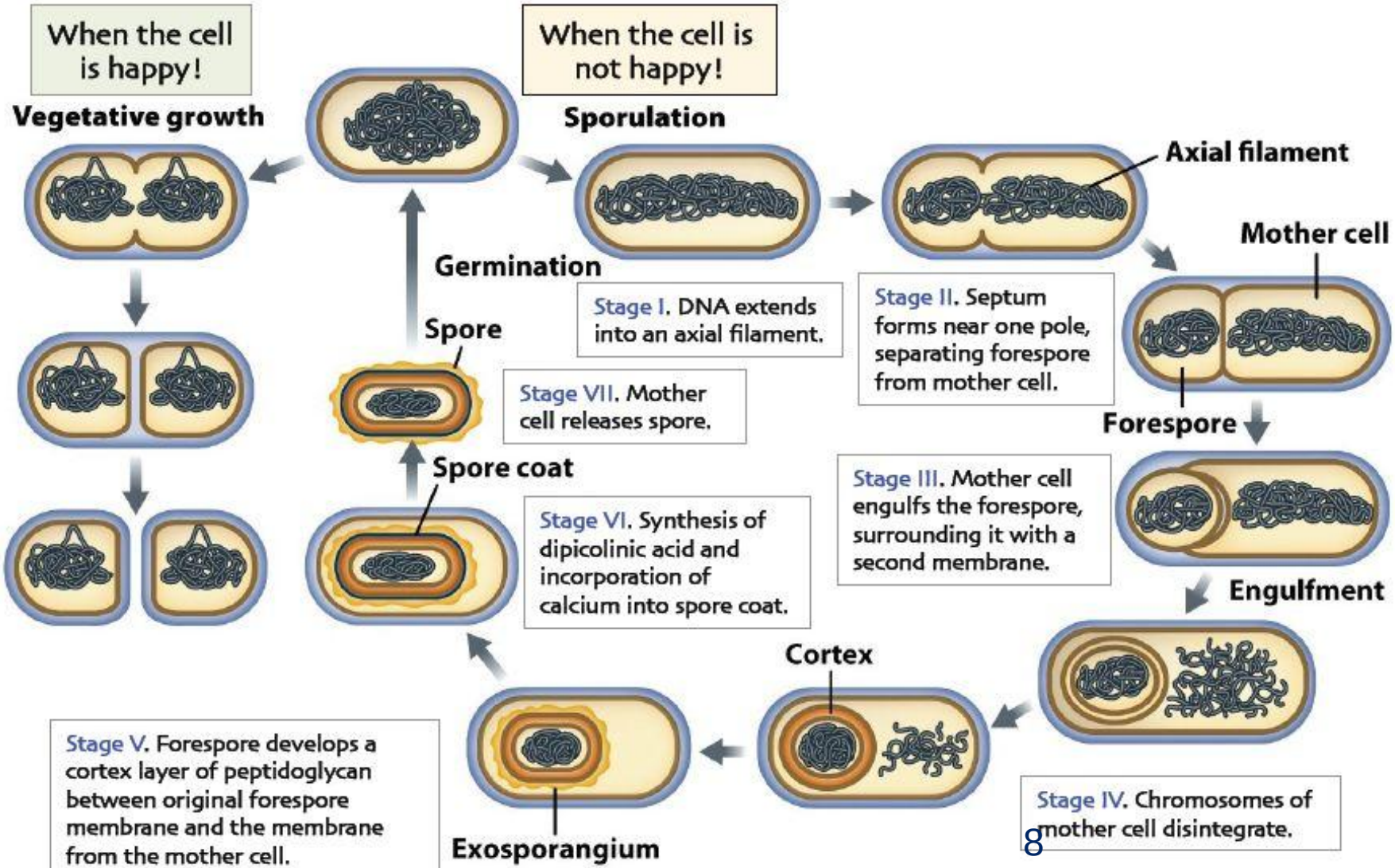
Vegetative form

- DNA repair during germination

Source: http://o.quizlet.com/i/bHf9KSy7NZfvG1cyLmsBdw.jpg

Bacterial endospore: Sporulation & Germination

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



Source: http://classconnection.s3.amazonaws.com/388/flashcards/265388/jpg/capture1316392540497.jpg

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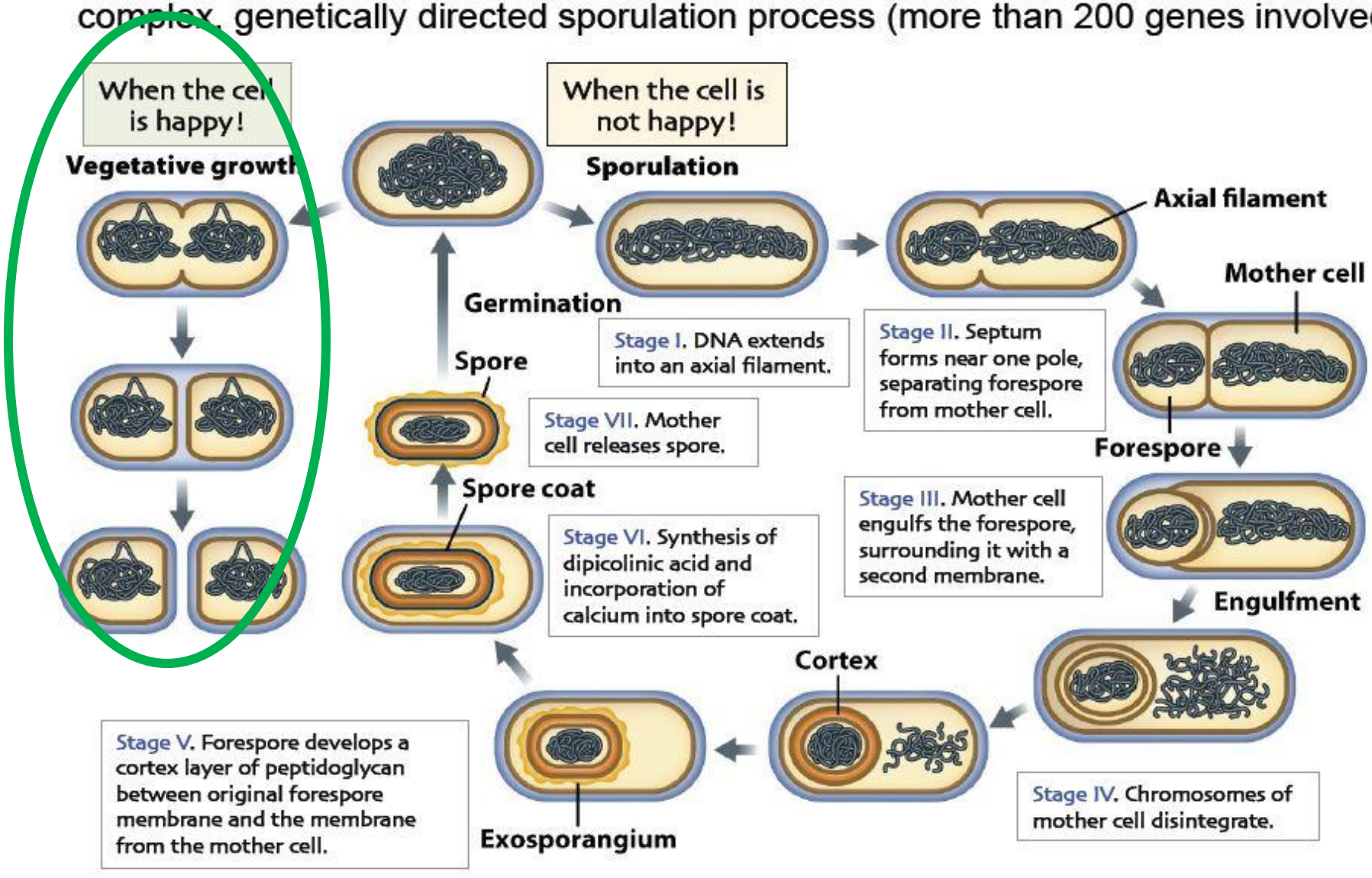

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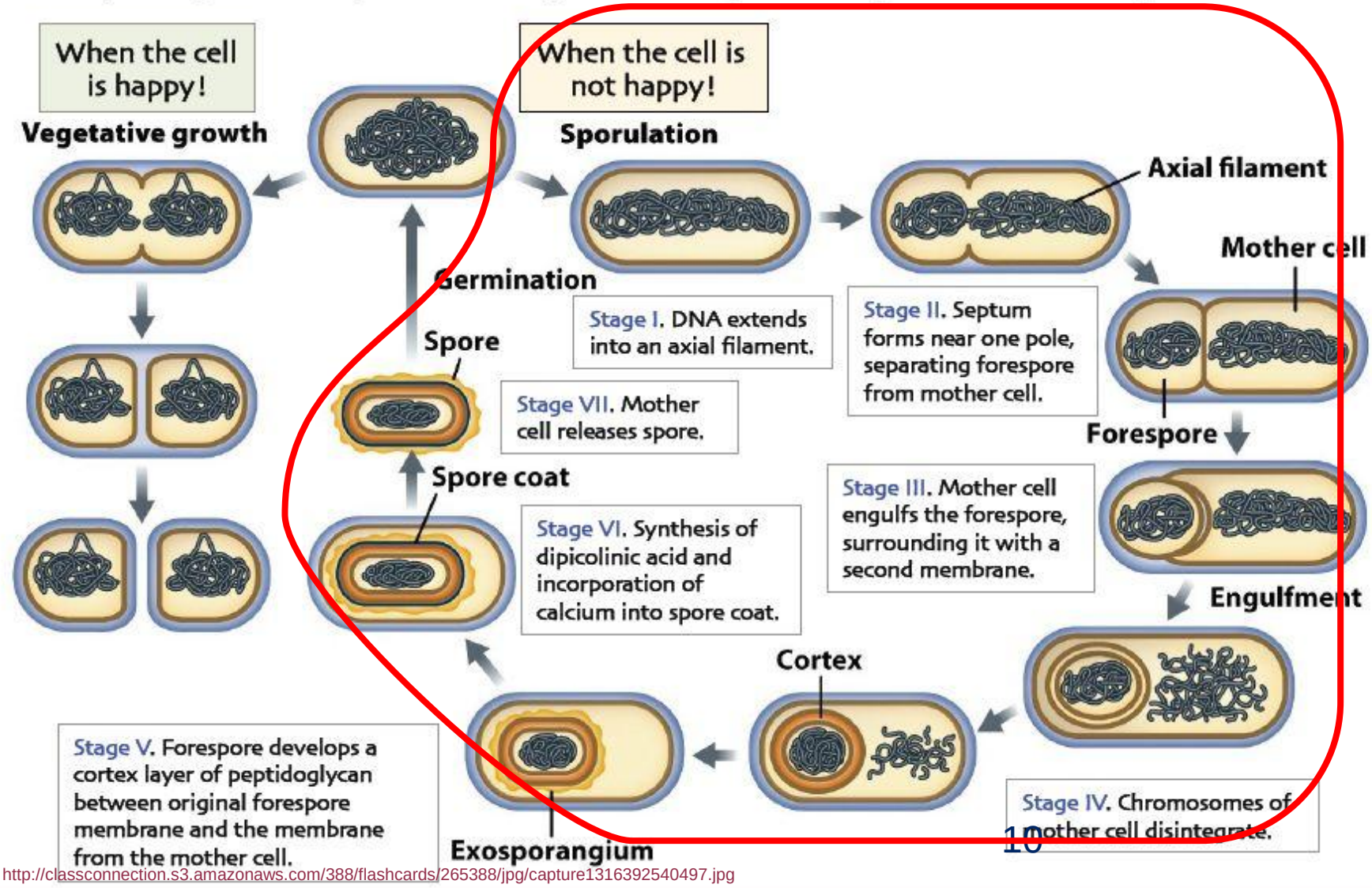

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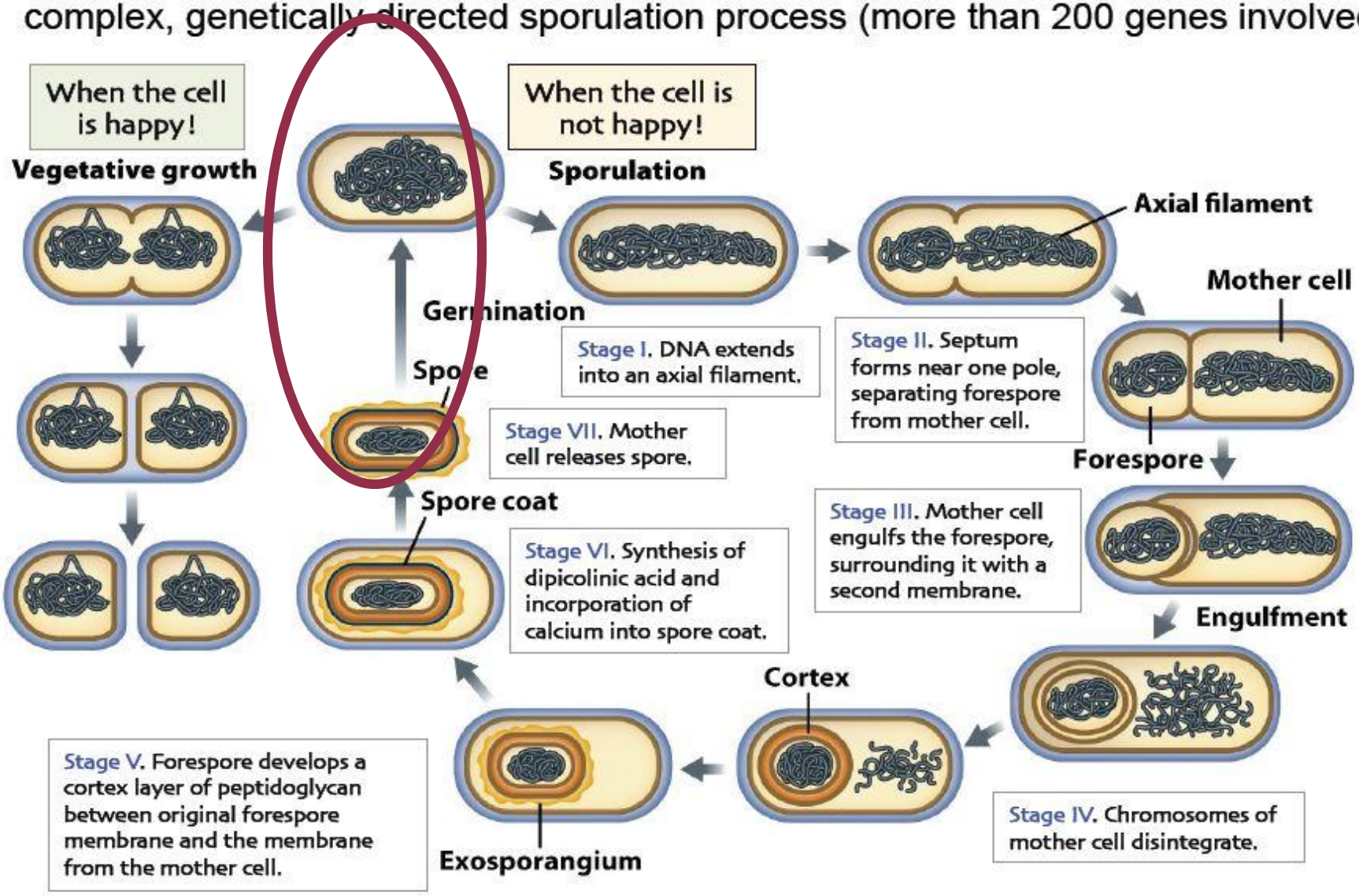

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Describing spore-formers

Ability to survive heat

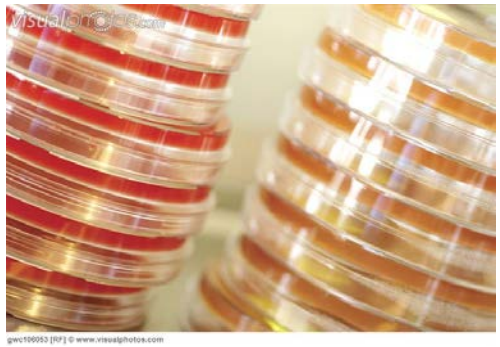
Spore

- 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



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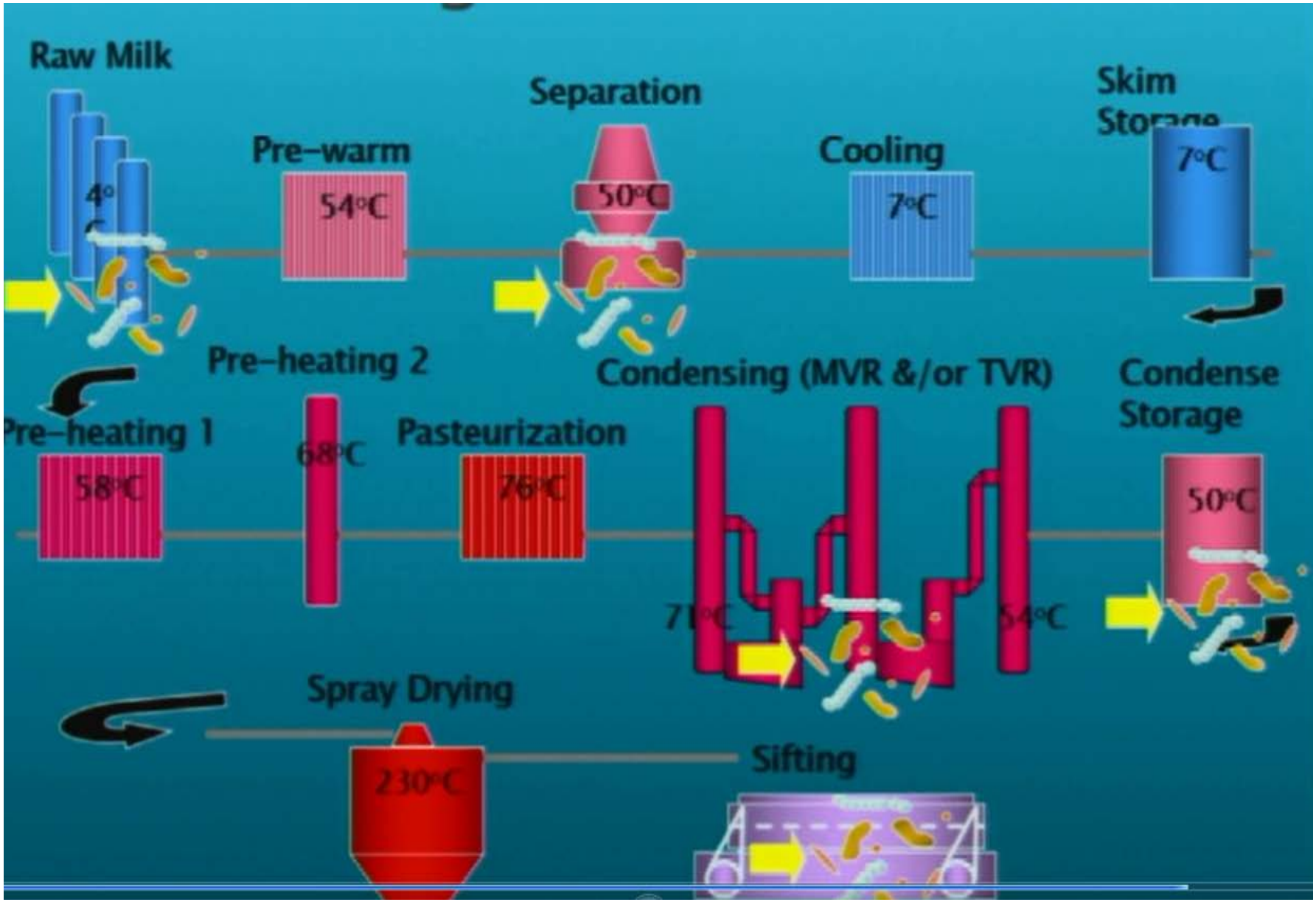
Processing Plant



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)

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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
Bacillus Cereus	Threshold:<50/g Max:<100/g
Clostridium perfringens	Threshold: negative/g Max: negative/0.1g
Sulfite reducing *clostria*	Threshold: <5 to<10/g Max: <10 to <25/g

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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
Thermoresistant Spores	<500/g

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Farm Management Practices Associated with Sporeformers

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

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Farm Management Practices and Spores

Cow Hygiene

Udder health

Milking Routine

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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
  - Ɣ-radiation

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Thank you and questions

Special thanks to Annie Bienvenue USDEC