

# Historical overview of Food Safety

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# Food Safety

Assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use



Which fields in Food Microbiology  
contribute significant to Food Safety

World Health Day was celebrated on 7 April 2015, with  
WHO highlighting the challenges and opportunities  
associated with food safety under the slogan

'From farm to plate, make food safe'

# Why .....

Over 200 diseases transmitted through food and water containing **harmful bacteria**, parasites, viruses, chemical substances, result in (estimated) two million deaths every



photo Beawiharta/Reuters

# Microbiology started with:



Antonie van Leeuwenhoek

- animalcules (small animals)
- first microbiologist
- never wrote a book
- letters to the Royal Society in London
- draper shop; interest in
  - lens making (hobby)

# One of his microscopes ...



He investigated as much as possible:  
muscle fibers, spermatozoa, algae,  
blood flow, pepper ....



fig: A  D


fig: B 


fig: E 


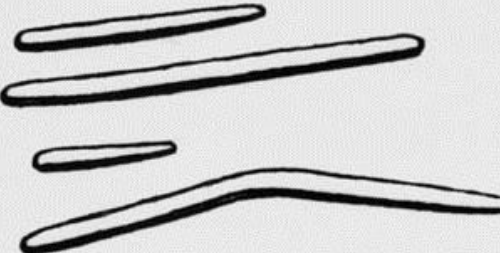
fig: G. 

fig: F 

# Fields in microbiology

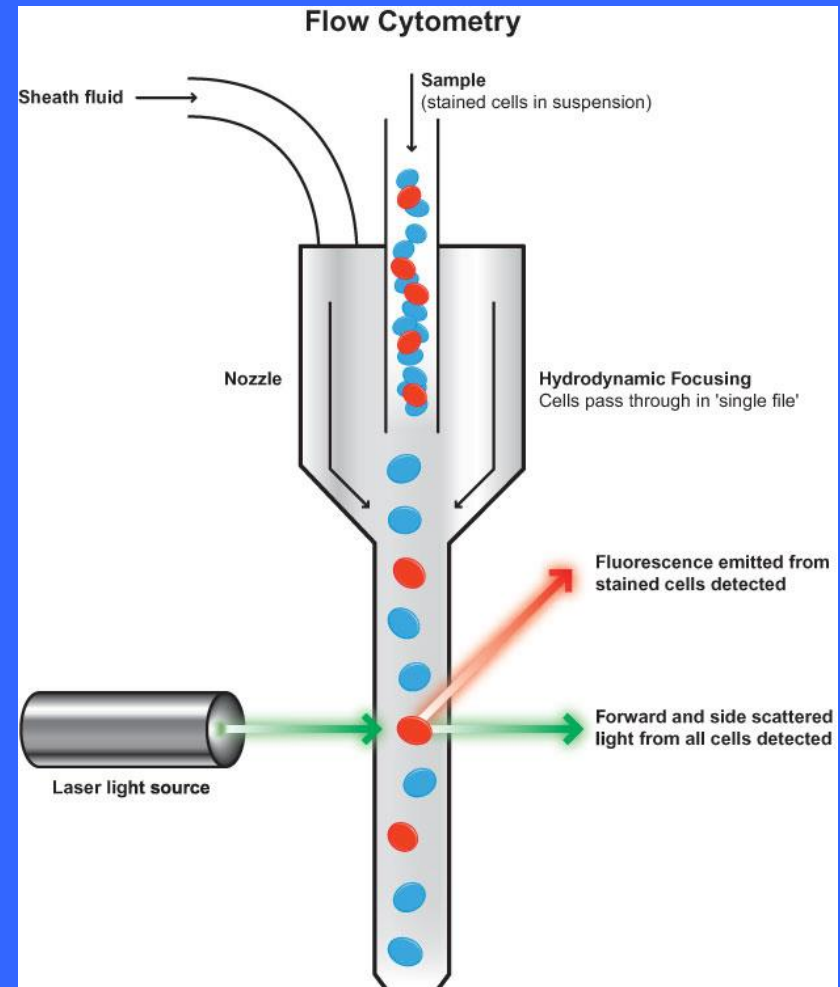
- Methods to detect and identify microorganisms
- (spoilage organisms and foodborne pathogens)  
microscopy, plating, DNA-based methods ...
- Ecophysiology of mo in foods/environment  
growth, survival, inactivation, stress response
- Functional mo  
fermentation, probiotics
- Risk analysis and modelling  
risk assessment
- Hygiene in the production chain  
GMP, HACCP



# Methods to detect and identify microorganisms

## Microscopy

- AvL microscope,
- staining of microorganisms
- phase contrast microscopy
- DEFT
- electron microscopy
- Flowcytometer
- Bactoscan (raw milk)  
(up to 200 samples/h)

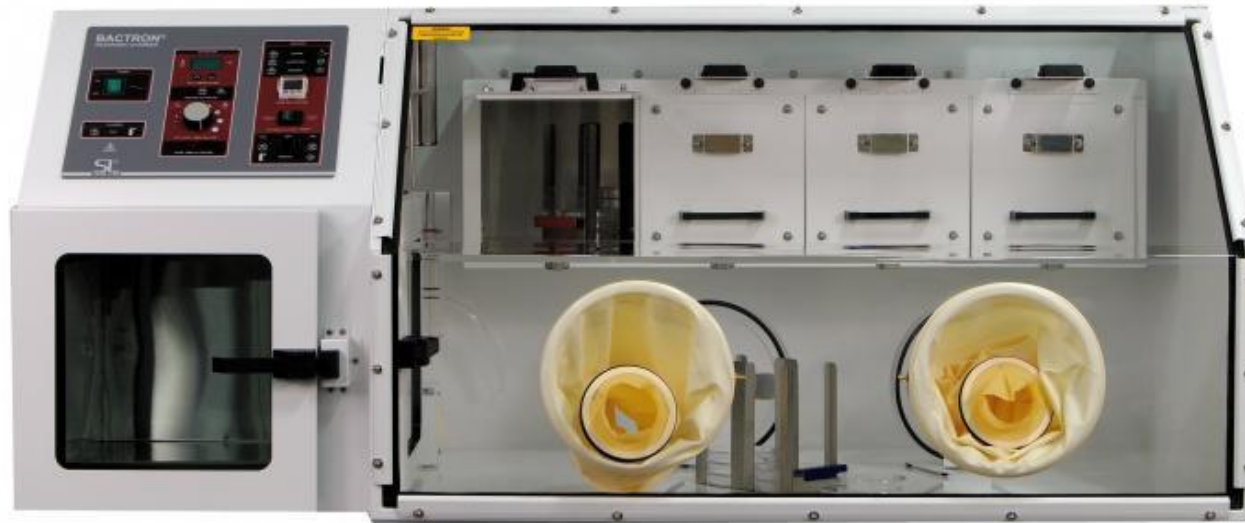




# Methods to detect and identify microorganisms

## Growing microorganisms

- (micro)anaerobic incubation



# Methods to detect and identify microorganisms

## Growing microorganisms

- nutrient media

Bloedserum uit rundbloed, aseptisch verkregen, goed geschikt voor diphterie.

Gal, goed geschikt voor typhus- en colibacteriën.

Urine, bevat tot 3 % carbamide.

Carbamideoplossing (Söhngen 1909) voor ureumbacteriën :  
30 ureum, 0.5  $K_2HPO_4$ , 10 calciumcitraat  $Ca_3(C_6H_5O_7)_2 \cdot 4H_2O$ ,  
1000 leidingwater ; pH op 7.2.

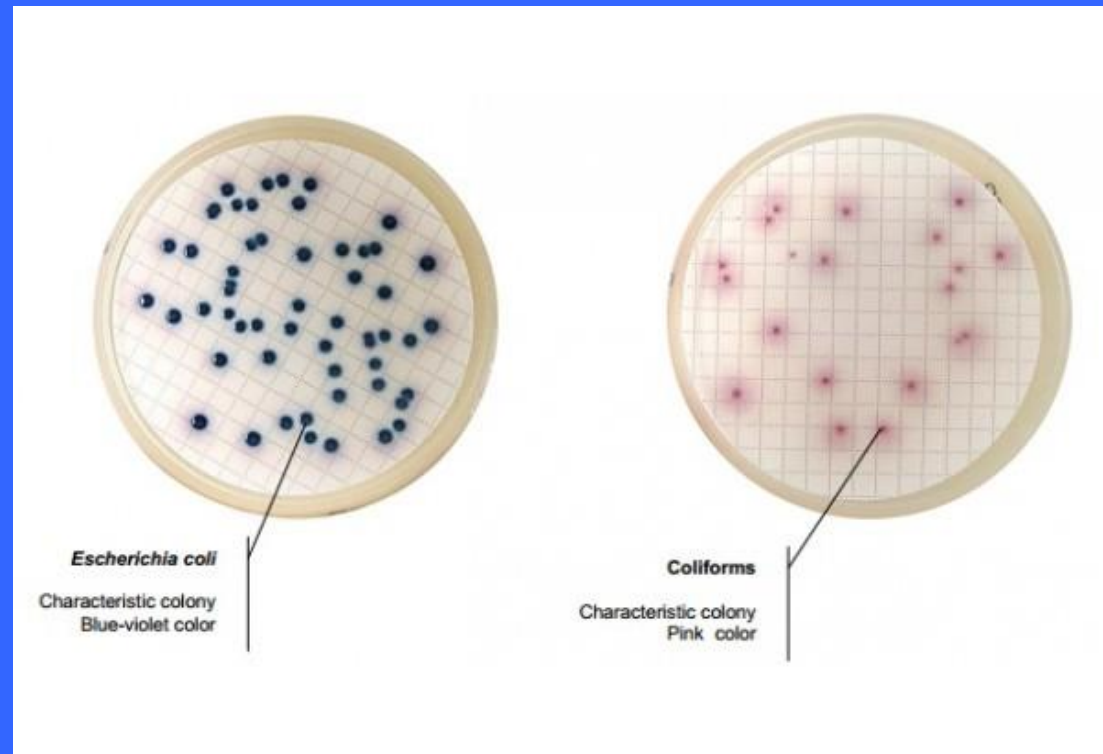
Aardappel en brood met vleeschnat of met melk vochtig gemaakt ; steriliseeren op 120° C.

Oplossing Pasteur : 2  $K_2HPO_4$ , 0.2  $Ca_3(PO_4)_2$ , 0.2  $MgSO_4 \cdot 7H_2O$ , 10 ammoniumtartraat, 100 suiker, 1000 water ; driemaal op 100° C. verwarmen.

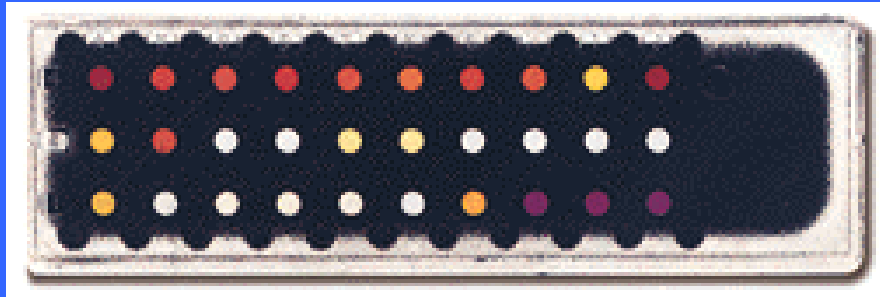
# Methods to detect and identify microorganisms

## Growing microorganisms

- intelligent media
- chromogenic media
- testing of culture media, ISO 11133
- Immunology
- ATP, TEMPO
- PCR, qPCR
- Impedance  
(Bactometer, Malthus)



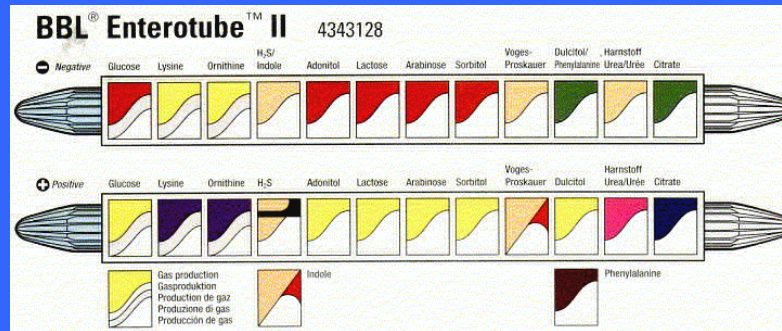
# Methods to identify microorganisms



BD-Crystal



numbers of tubes



Enterotube

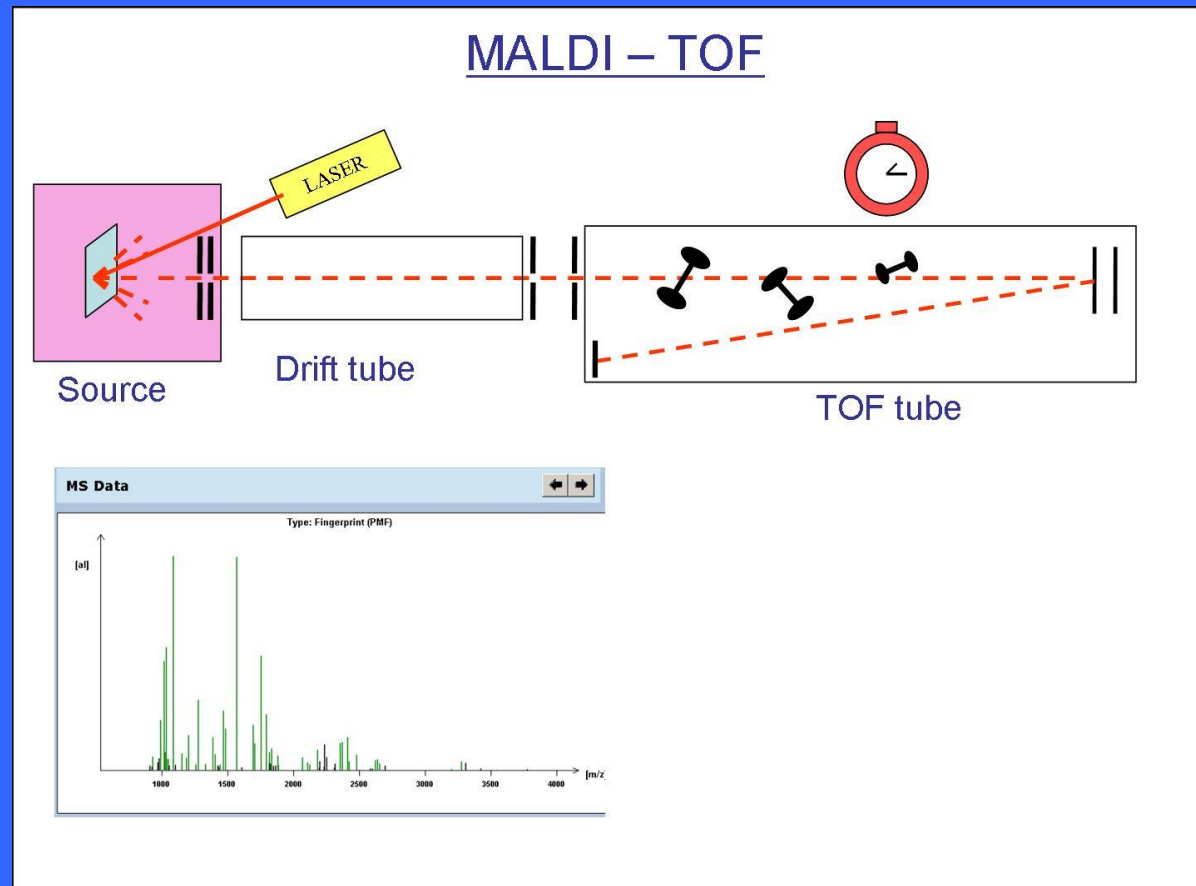


API

# Methods to identify microorganisms

## Other methods

- immunology
- sequencing
- Maldi tof



# Shakespeare: the seven ages of man

**“ALL THE WORLD’S A STAGE, AND ALL THE MEN  
AND WOMEN MERELY PLAYERS: THEY HAVE  
THEIR EXITS AND THEIR ENTRANCES; AND ONE  
MAN IN HIS TIME PLAYS MANY PARTS, HIS  
ACTS BEING SEVEN AGES.”**

**WILLIAM SHAKESPEARE**

© Lifehack Quotes



Sculpture

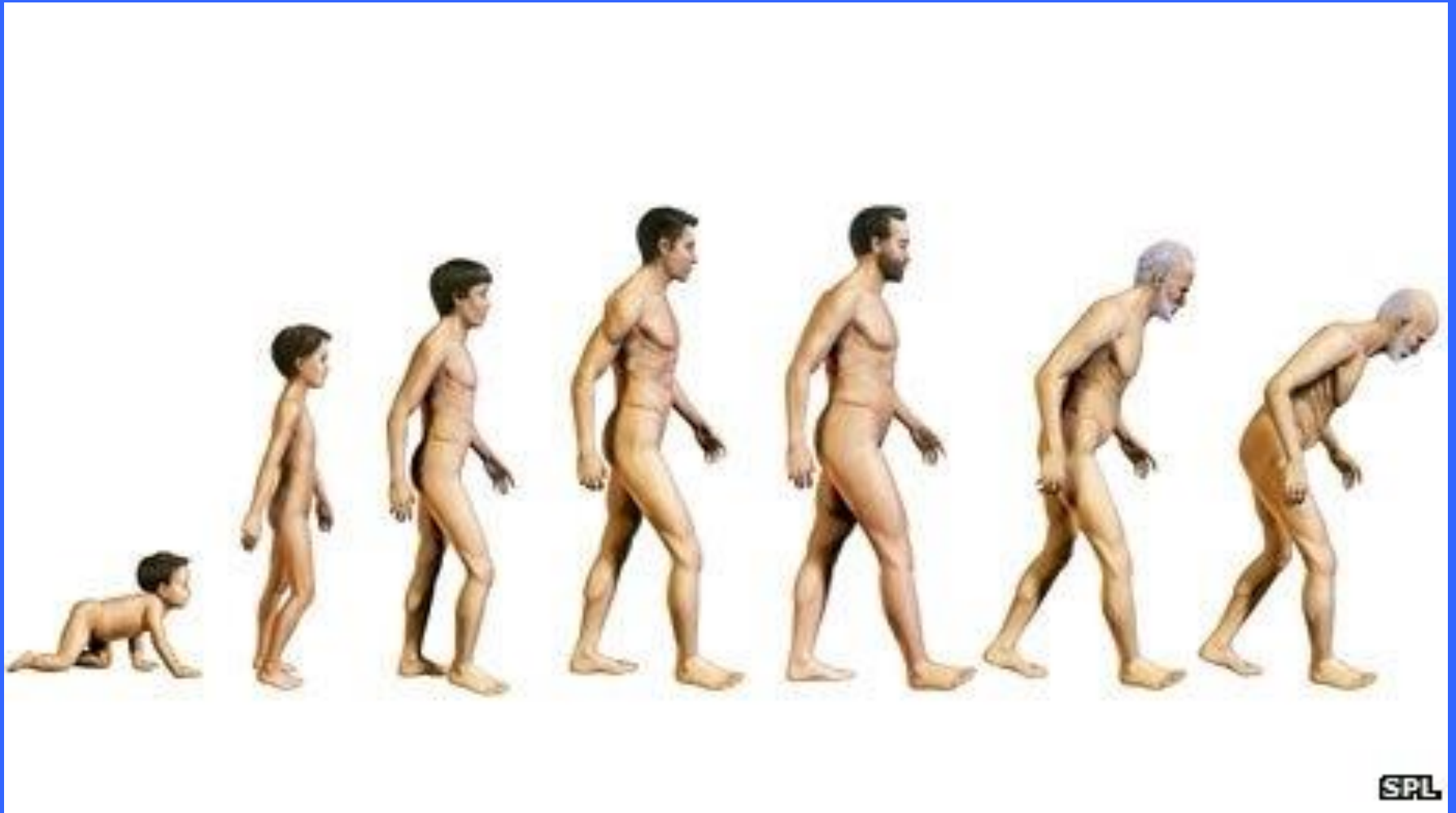
*seven ages of man*

London

by Lonpicman



more or less the same ...



# The seven ages of man ...

- infancy: helpless baby, knows little
- whining schoolboy: goes to school, not confident yet
- the lover: sentimental, trying to express his feelings
- the soldier: hot headed, making reputation
- the justice: acquired wisdom
- old age: loses his firmness and assertiveness
- incapacity: dependent on others, unable to interact

# Looking back to microscopy ...

infancy, whining schoolboy, the lover, the soldier

all fields: AvL, phase contrast, DEFT, Bactoscan, FC, EM

the justice

phase contrast, Bactoscan, FC, EM

old age

DEFT

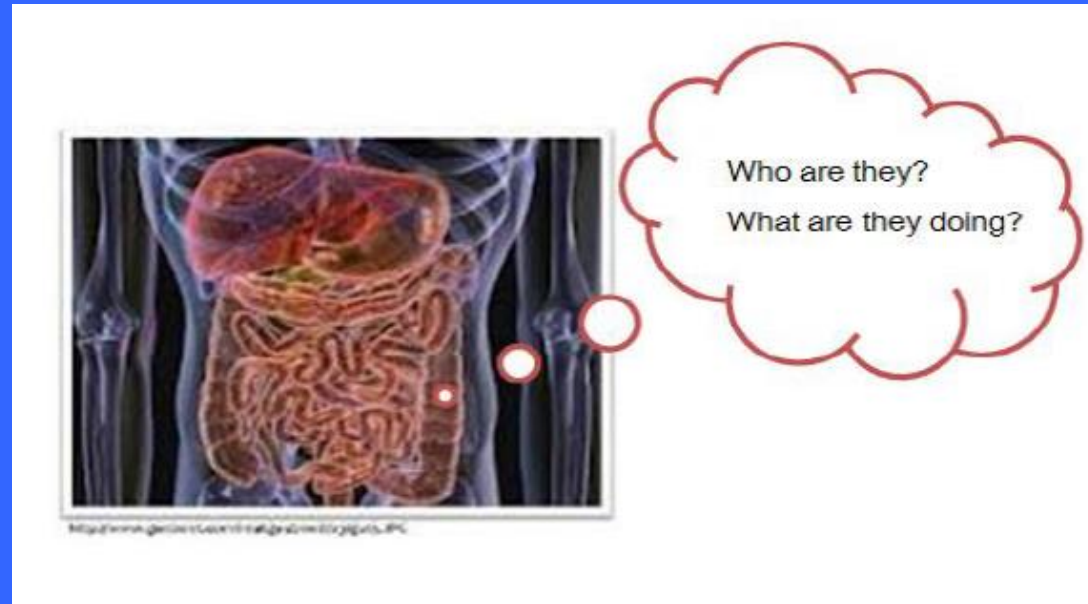
incapacity

DEFT

# Ecophysiology of mo in foods/environment

As soon as growth of mo was possible, a lot of questions arose:

- why is this mo there?
- which factors involved?
- how to investigate?
- possible to change factors to control the growth of mo?



# Ecophysiology of mo in foods/environment

it started with intrinsic factors

- structure
- water activity
- pH
- preservatives
- etcetera



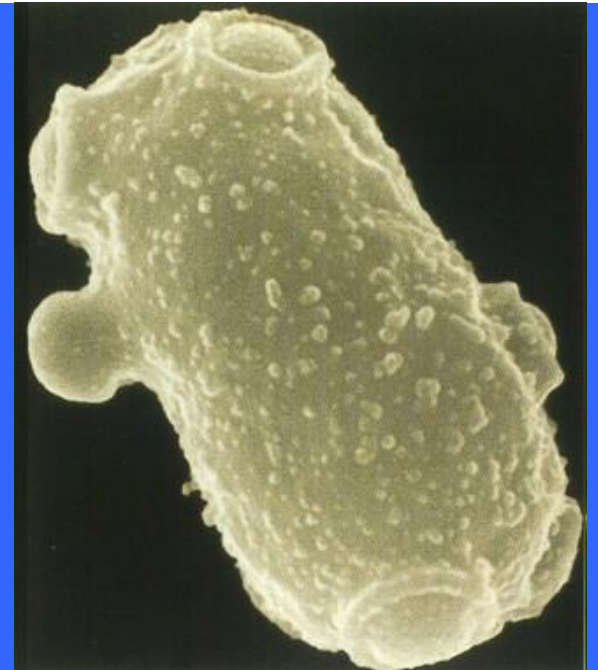
# Ecophysiology of mo in foods/environment

## extrinsic factors

- modified atmosphere packaging
- relative humidity
- storage temperature

## process factors

- temperature
- ultra high pressure
- pulsed electric fields



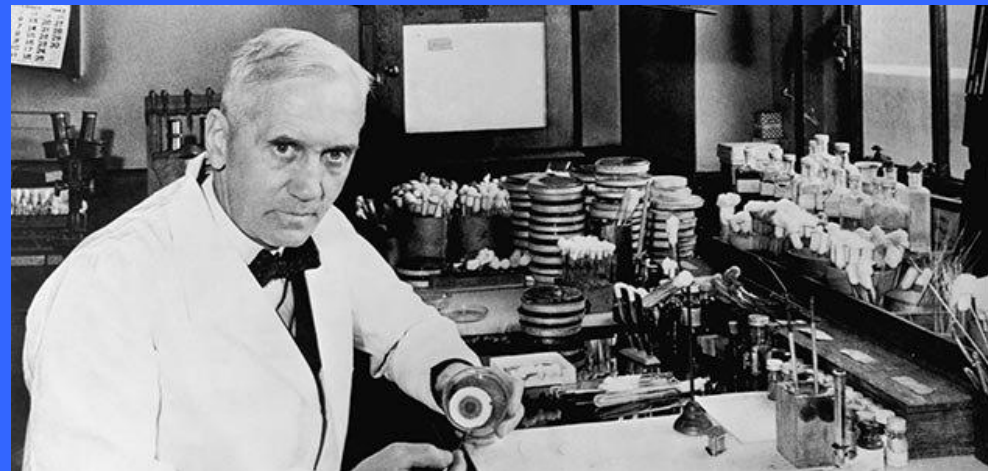
# Ecophysiology of mo in foods/environment

## implicit factors

- synergism ... working together  
starch ... amylase ... sugars ...  
growth other mo  
yoghurt fermentation



- antagonism ... preventing  
growth of other mo  
*Penicillium* ... antibiotics ...  
Fleming



possibilities for preservation ... (antibiotics '60-'70)!



# Ecophysiology of mo in foods/environment

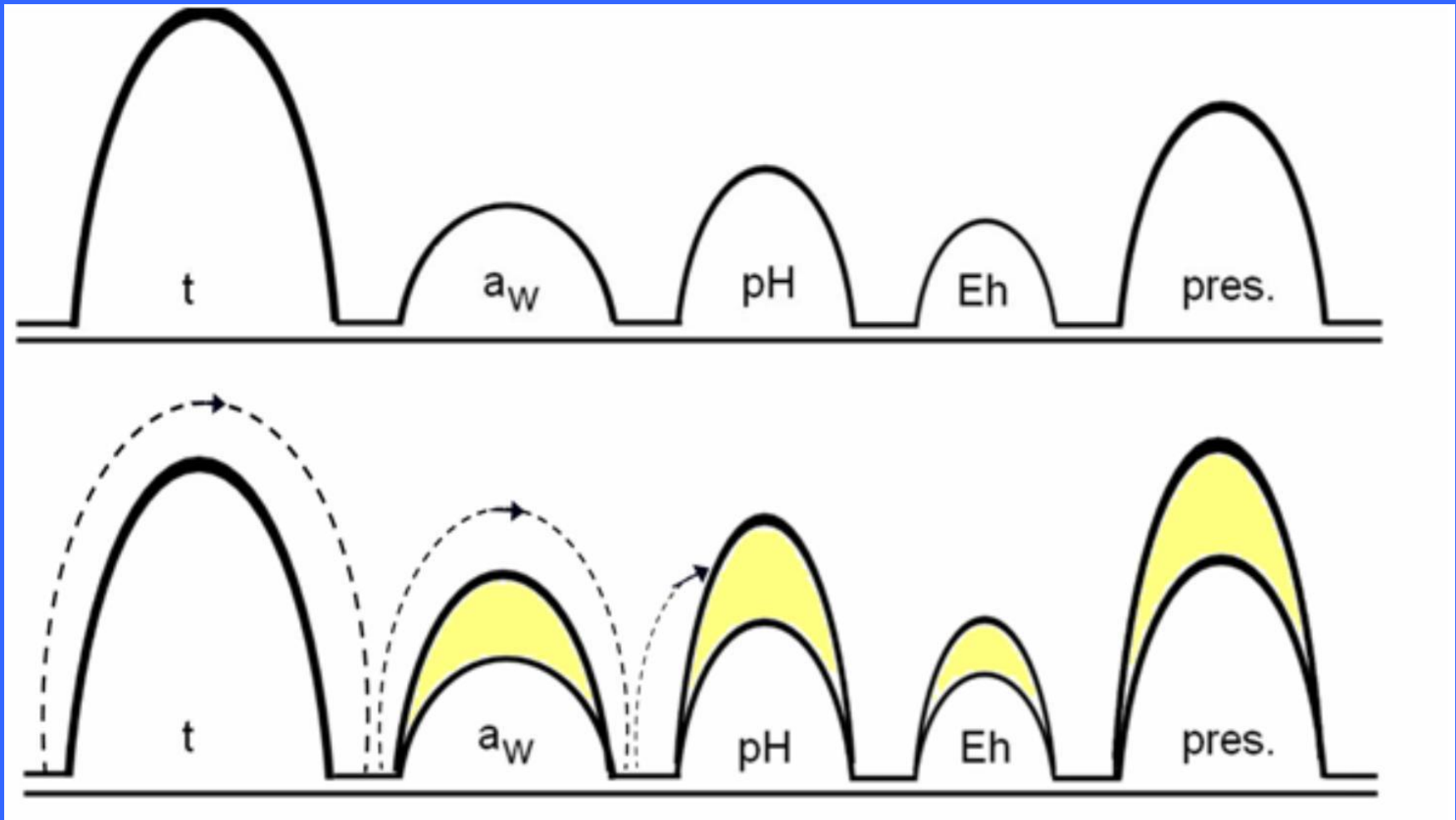
With the growing knowledge preservation of food products was possible

However, some researchers were too enthusiastic i.e. bacteriocines, extracts from herbs

soldier, stage 4



# Ecophysiology of mo: combining factors = hurdle technology (Leistner 2000), wisdom



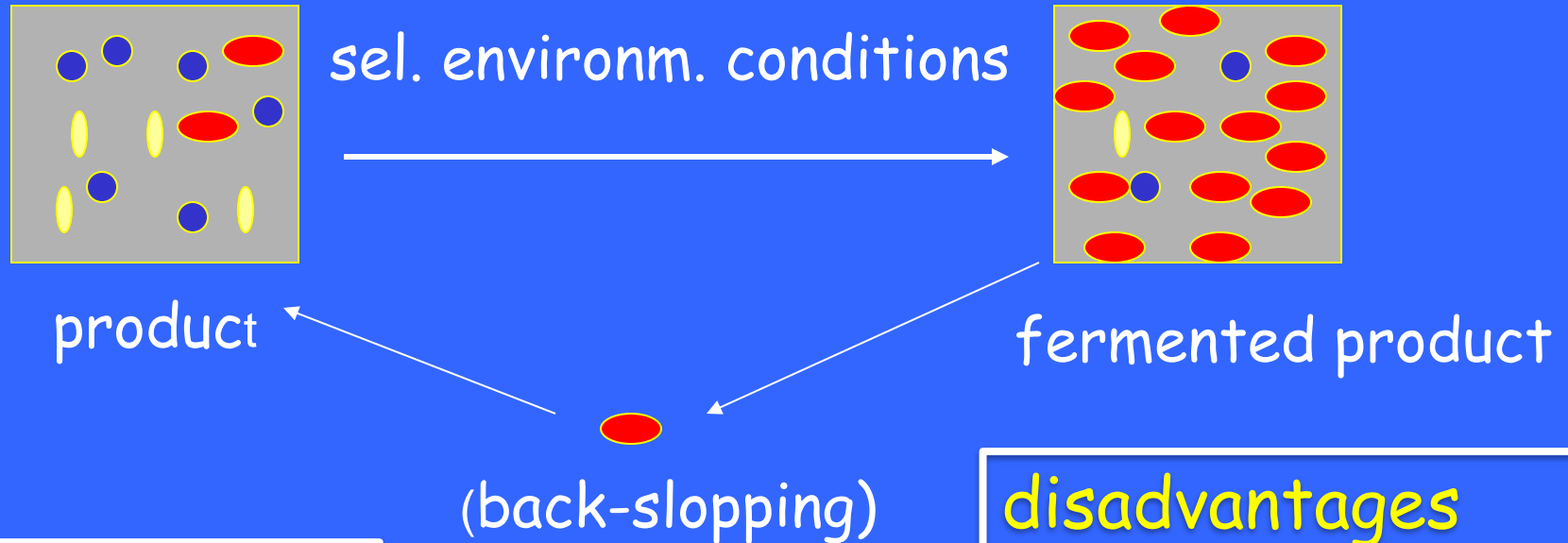
# Fermentation

Fermentation: The chemical breakdown of a substance by bacteria, yeasts, or other mo (or its enzymes)

- just a small step from the previous slide
- some people call an unknown fermented product **spoiled**



# Natural fermentation



## advantages

simple

low cost

more tasty?

## disadvantages

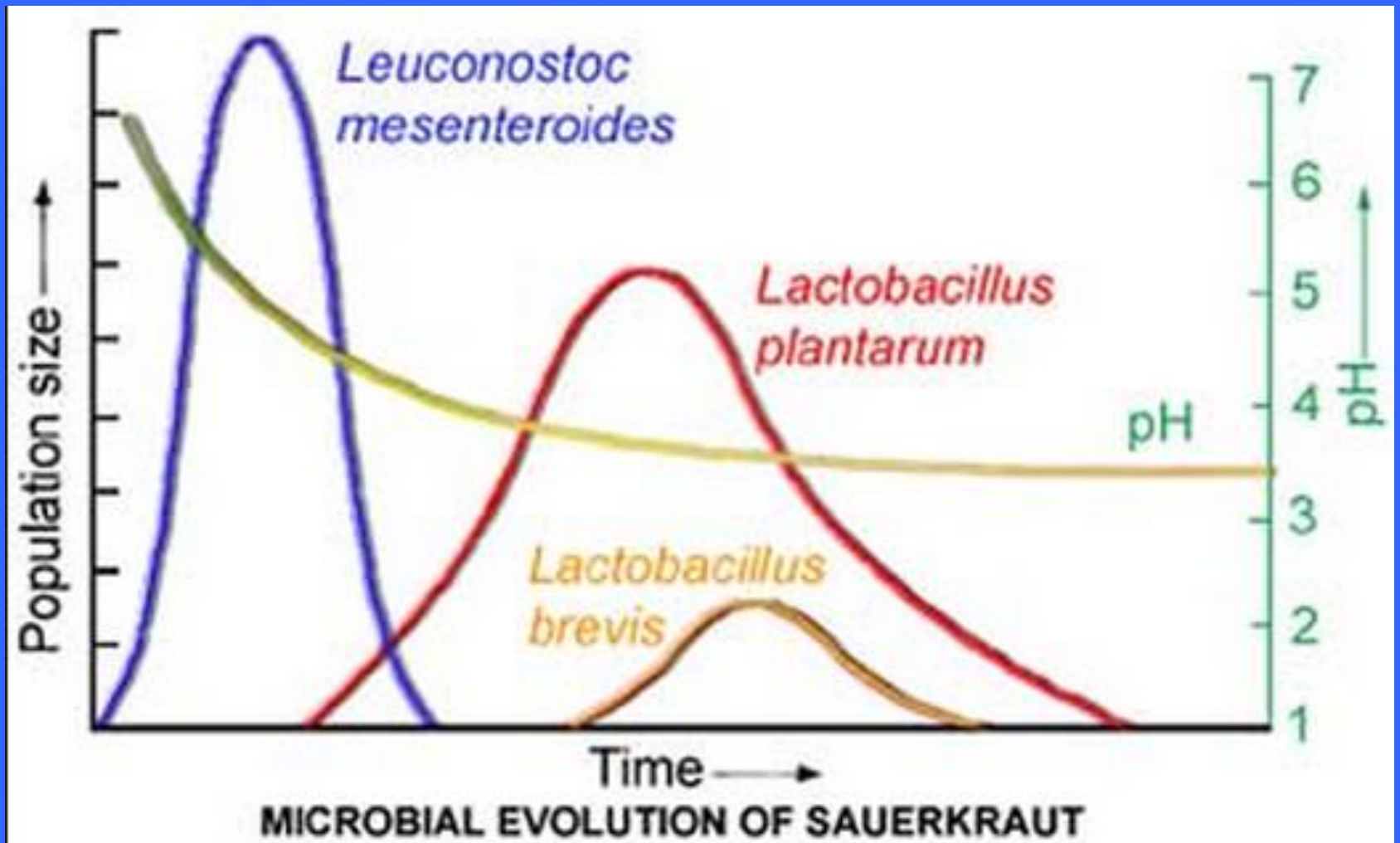
sometimes slow start

less predictable

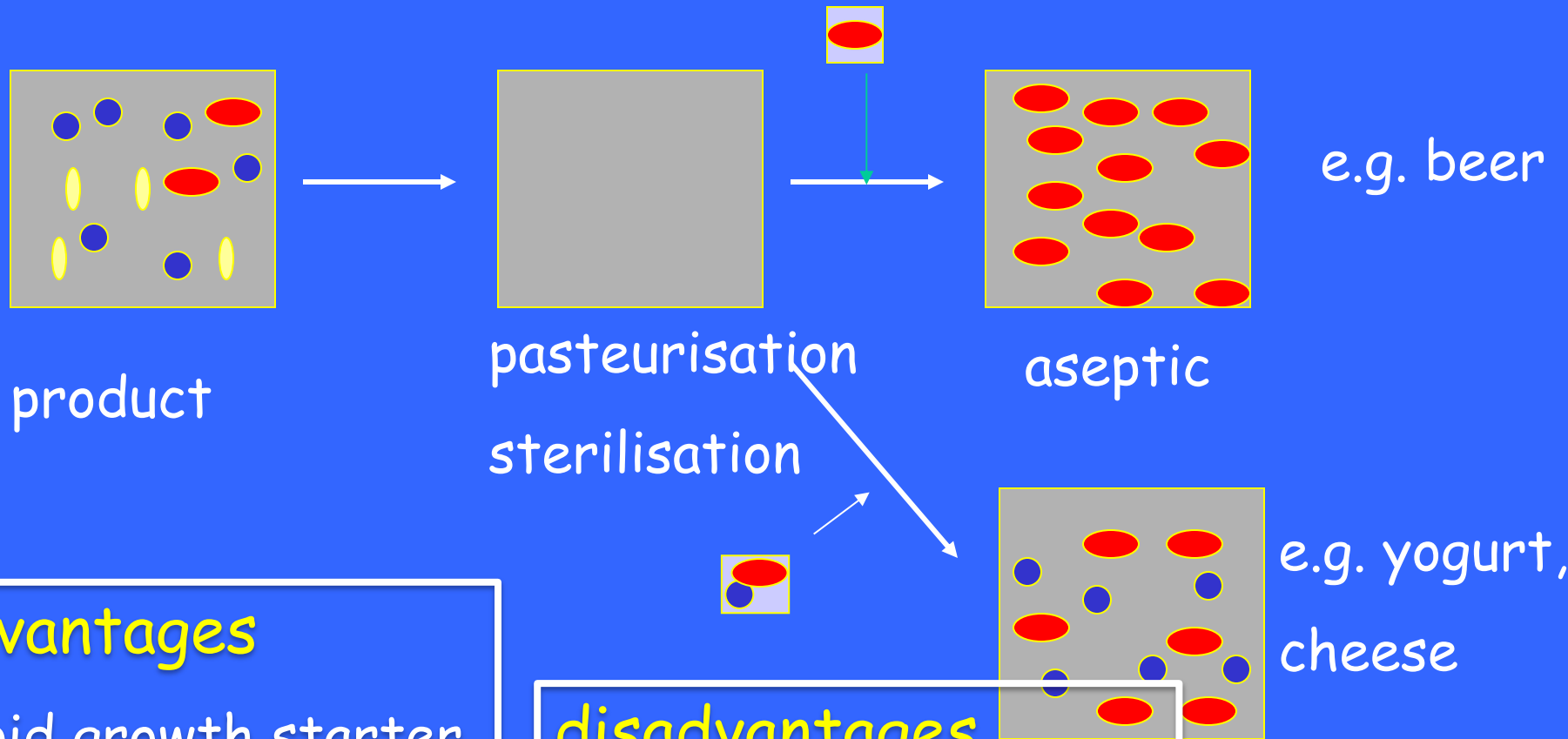
> chance failure

> chance pathogens

# Fermentation



# Fermentation with selected starters



## advantages

- rapid growth starter
- predictable
- constant quality

## disadvantages

- > expensive
- > sensible for phages

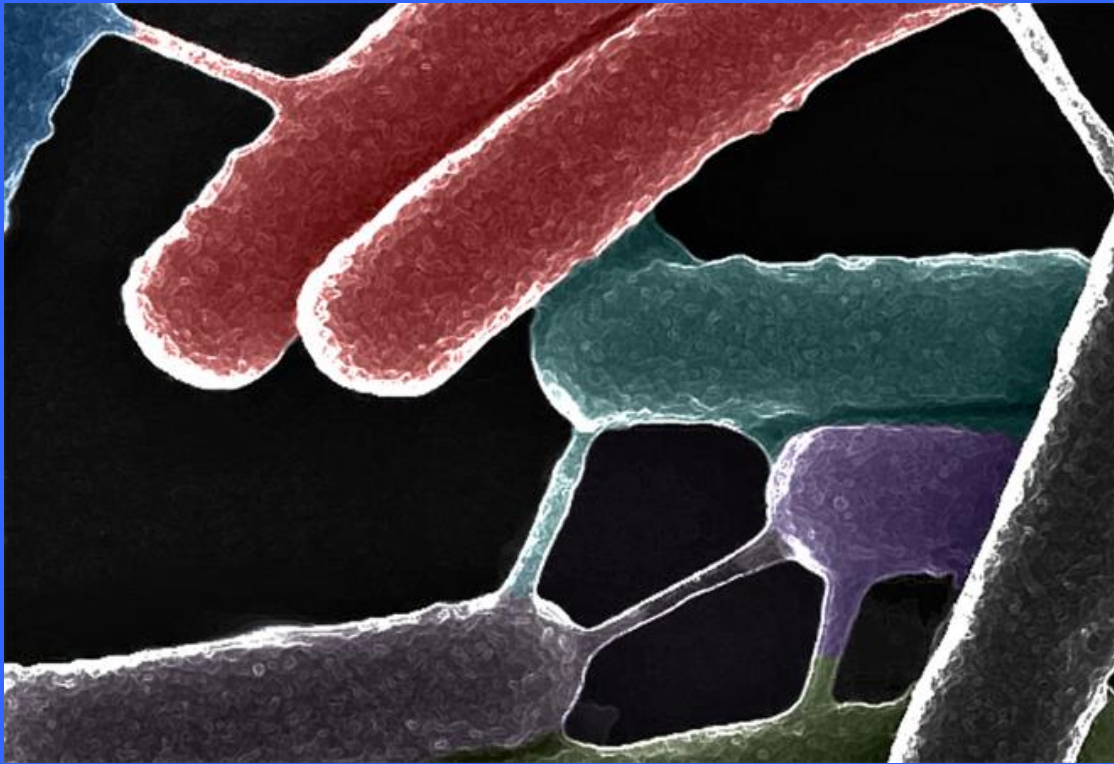
# Probiotics: definition

- Living microbial food supplement,  
stimulating health by improving microbial balance  
human intestine
- Minimal  $>10^8 - 10^9$  cfu necessary
- Addition to normal diet
- Active in small intestine (competition)

Stimulation immune system is a rather vague claim

# Probiotics

Some scientists call it 'magic bacteria',



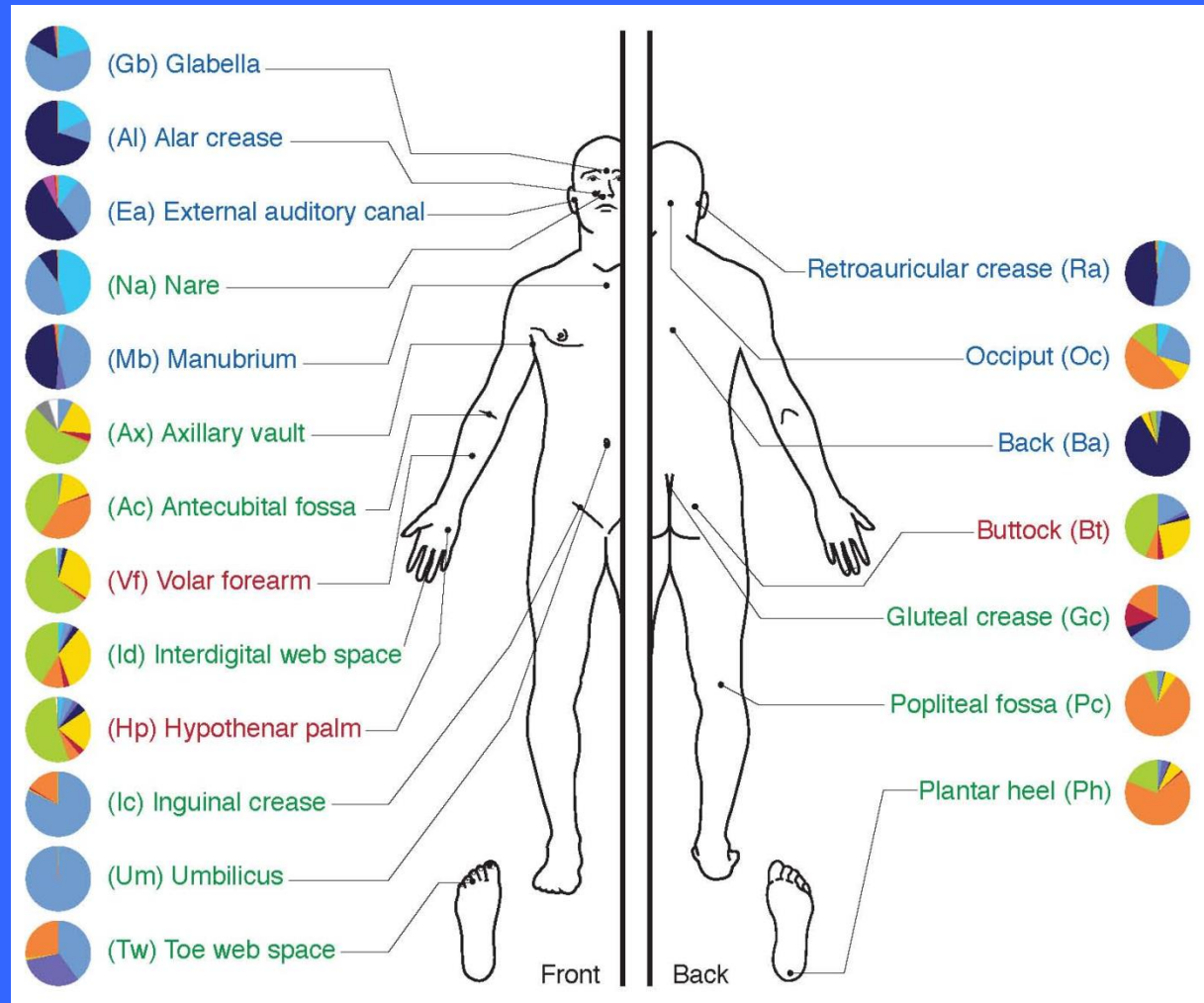
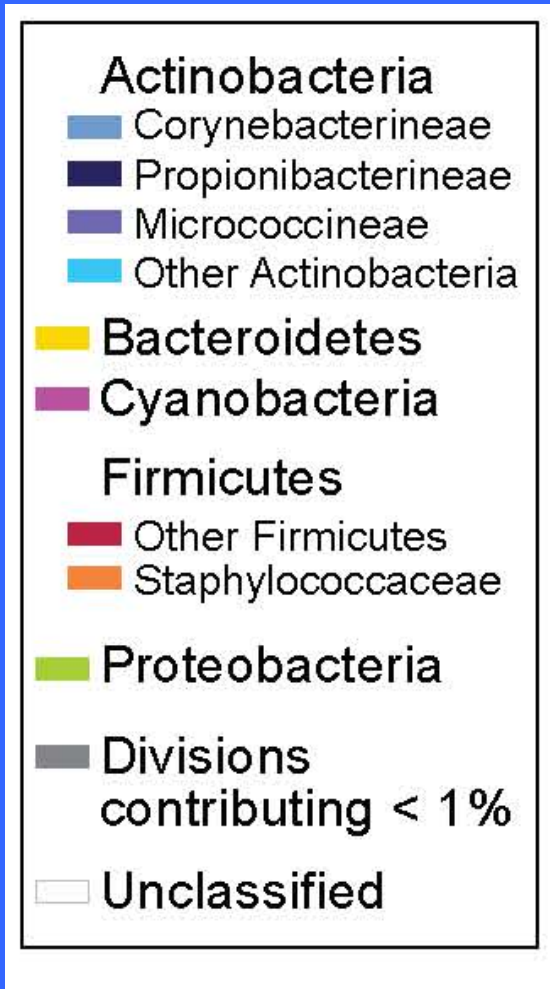
At Danone and Yakult the cash registers jingle



# Fermentation and probiotics

- Natural fermentation in the first three stages of age: infancy, schoolboy, lover
- Fermentation with selected starters acquired wisdom
- Probiotics still in the stages infancy - soldier

# Not fermentation ... but microbiota accumulation of mo



A **microbiota** is 'the ecological community of commensal, symbiotic and pathogenic mo that literally share our body space'.

Joshua Lederberg coined the term, emphasizing the importance of mo inhabiting the human body in health and disease.



# Microbiotica

Many researchers think the human microbiome has potentially overwhelming impact on human health

It may have a role in auto-immune diseases like diabetes, rheumatoid arthritis, muscular dystrophy, multiple sclerosis, fibromyalgia, and perhaps some cancers.

Furthermore, obesity, schizophrenia, depression, and other neuro-chemical imbalances.

Be careful: Researchers always say: it may also ...

Still many speculations: stage 4, the soldier

# Back to the ecophysiology of mo

The group of mo consist of:

useful

annoying, and

dangerous mo



# The Bible for food microbiologists

Han Joosten, WUR ex Nestlé

Micro-Facts: Peter Wareing,  
Felicity Stuart and Rhea  
Fernandes, 7<sup>th</sup> ed. 2010

The working companion  
for food microbiologists



# Some foodborne pathogens

1880	<i>Staphylococcus aureus</i>
1892	<i>Clostridium botulinum</i>
1897	<i>Cl. perfringens</i>
1900	<i>Salmonella</i> , named in honour of DE Salmon
'-50	<i>Bacillus cereus</i> , <i>Vibrio parahaemolyticus</i>
1977	<i>Campylobacter</i>
1980	<i>Cronobacter</i>
1982	STEC
'-80	<i>Listeria monocytogenes</i>

AB-resistant mo

# Food Safety: control of pathogens in food products

With the hurdles:  $A_w$ , pH, preservatives, low or high temperature, UHP, PEF, irradiation, (natural) antimicrobial systems ...

Some of the methods are quite effective

Demand for  
mild preservation





# Survival strategies for pathogens

Microbiological **stress respons** and minimal processing

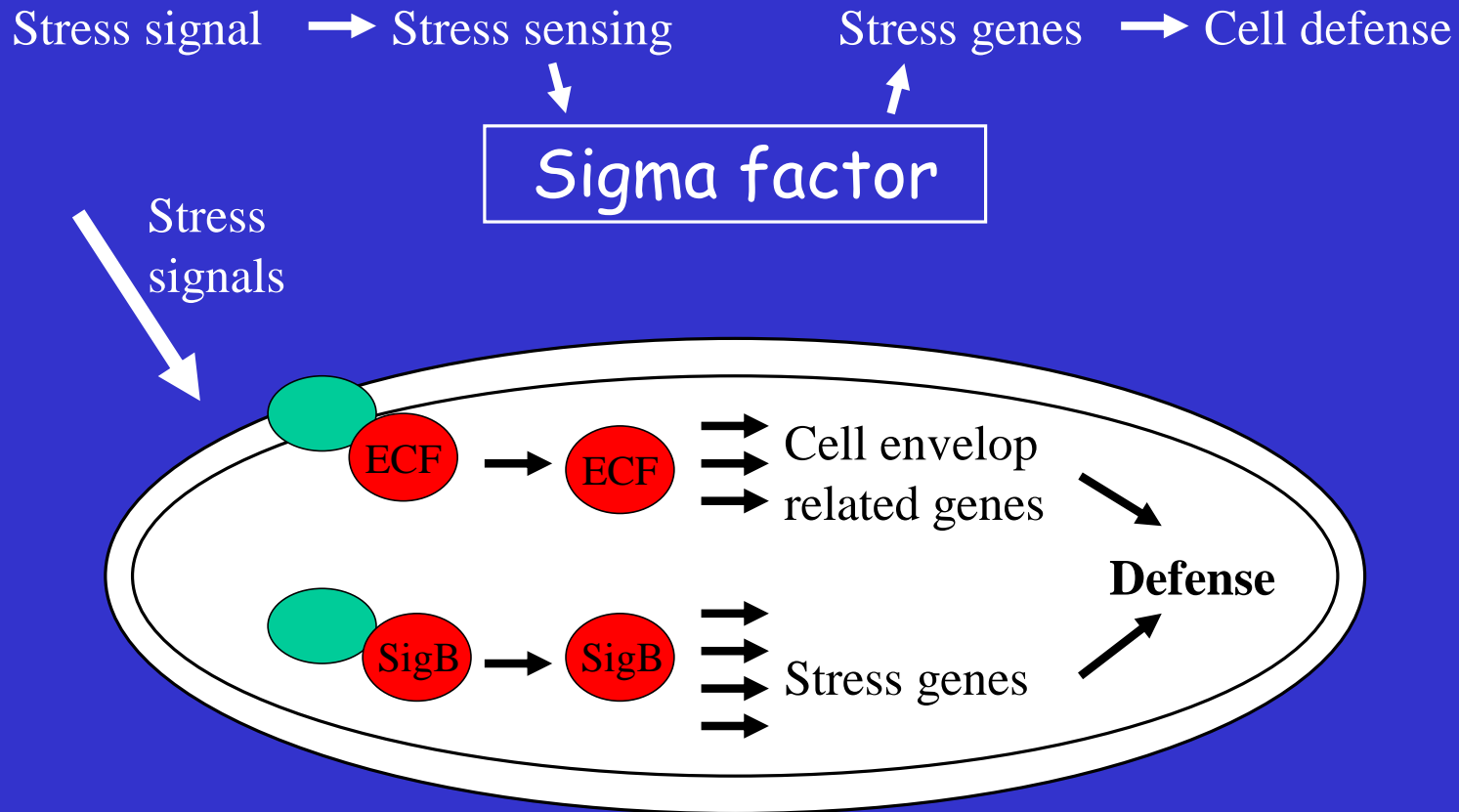
Consumers **ask** for mild processed products

New methods for control food safety: UHP, PEF, ultrasound, combinations of preservatives, bacteriocins, essential oils ...

**Stress response: acquired wisdom, stage 5**

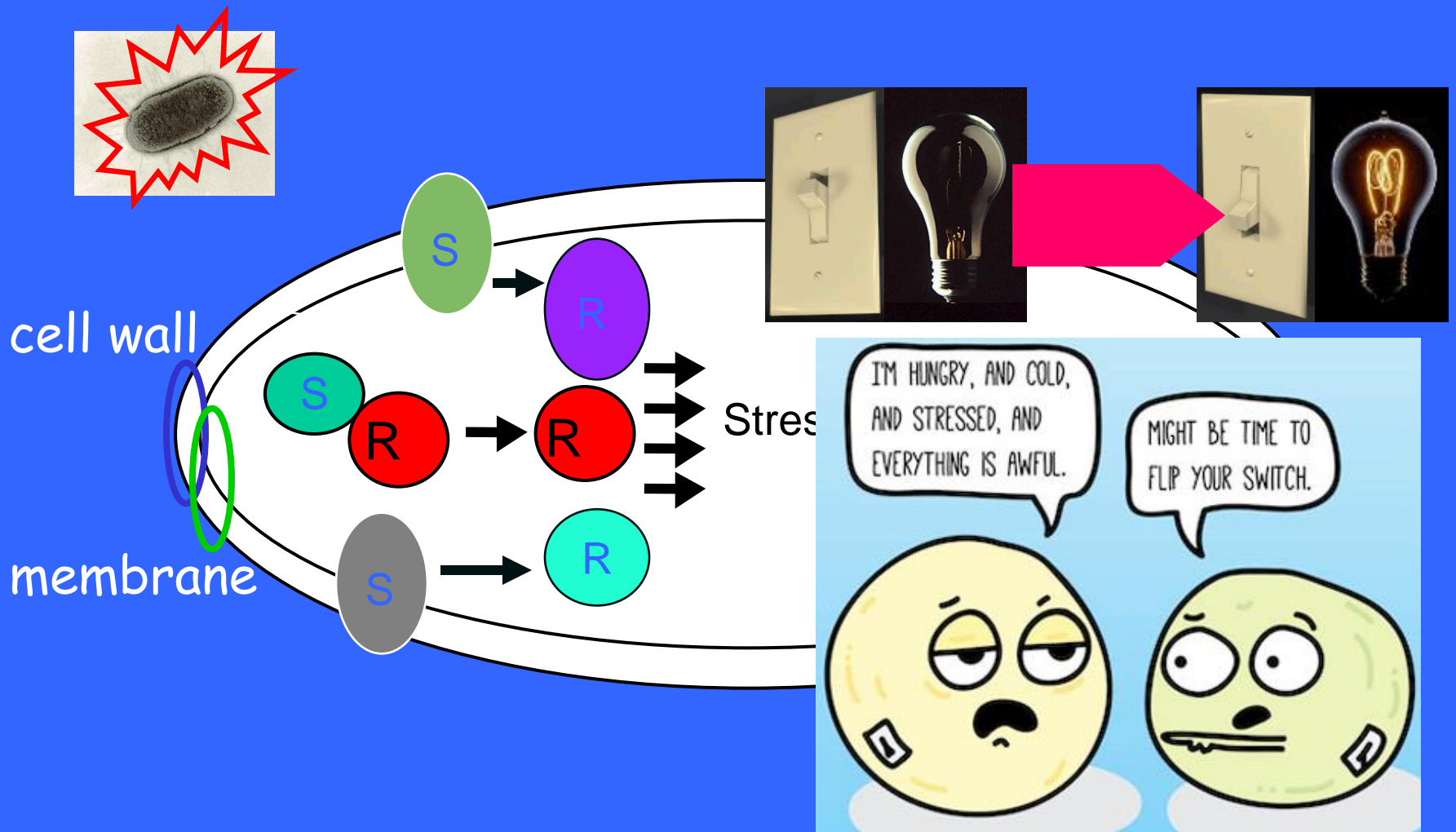
# Important factors for surviving stress

## Central role for sigma factors ( $\sigma^B$ and ECF) in stress response

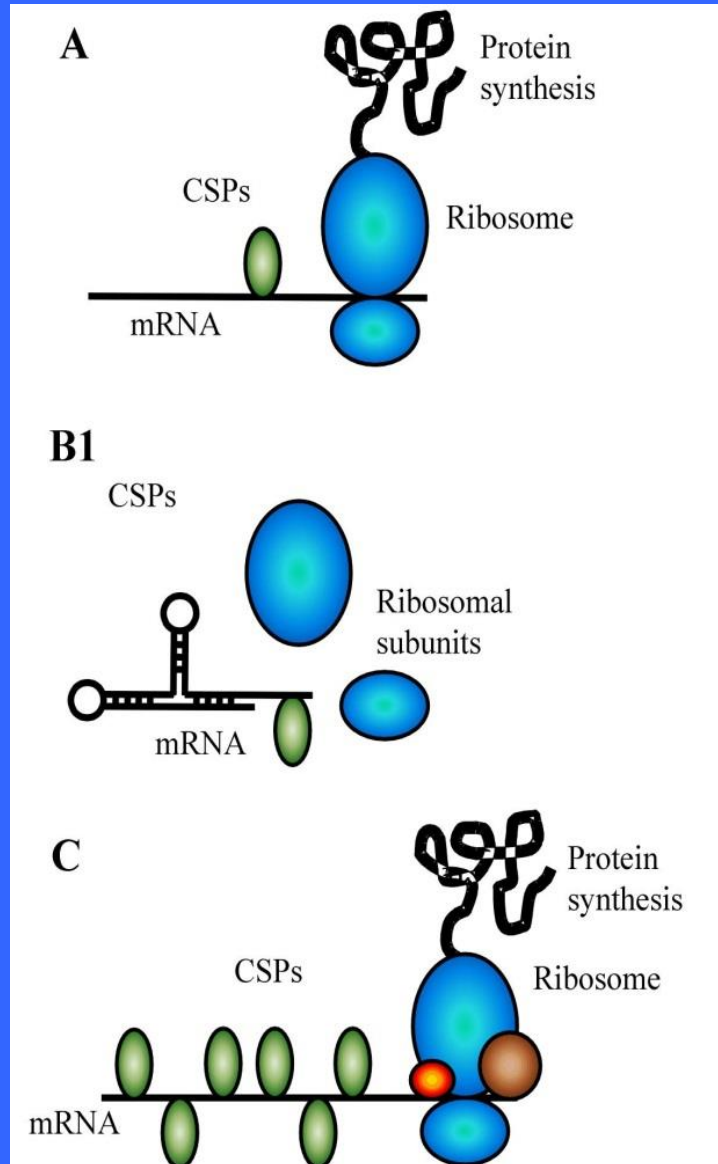


# Activation stress response

Activ. sensors > activ. regulators > activ. genes > activ. defense



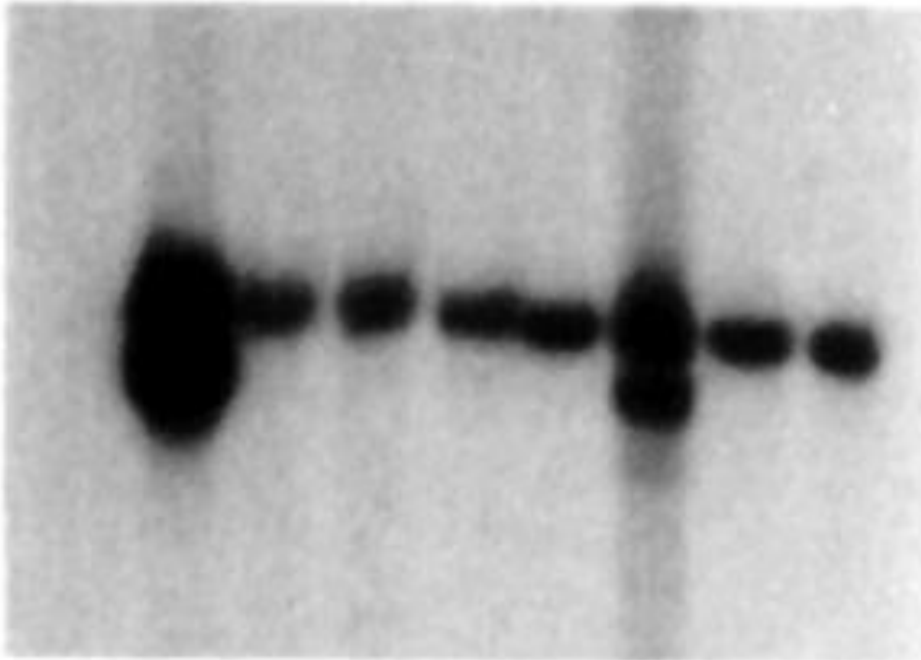
# Cold shock proteins in survival of stress



# Stress-induced expression of Sigma factor B

*sigB* mRNA concentrations increase during stress

**1 2 3 4 5 6 7 8 9**



1. mid-exp. phase

2. 4% NaCl

3. 2% ethanol

4. 1 mM EDTA

5. 0.15% H<sub>2</sub>O<sub>2</sub>

6. pH 5.3

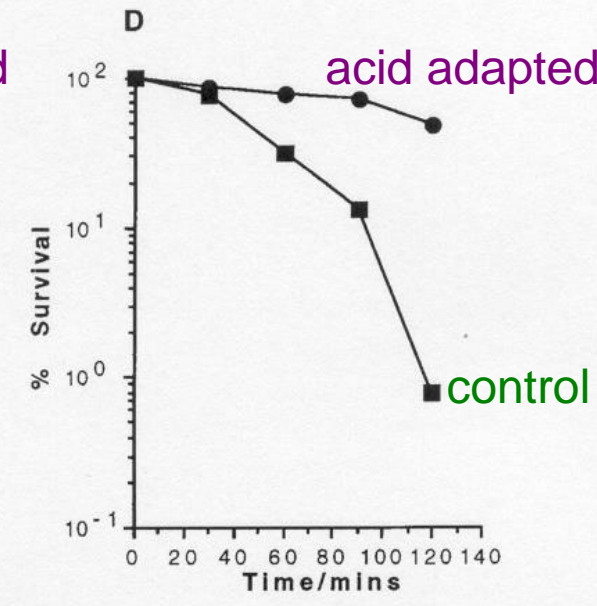
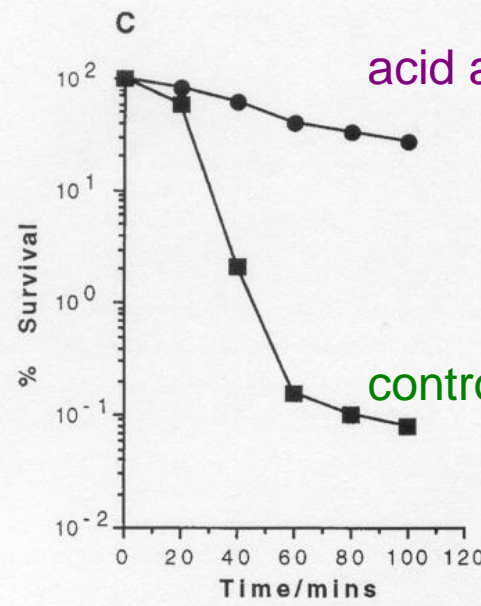
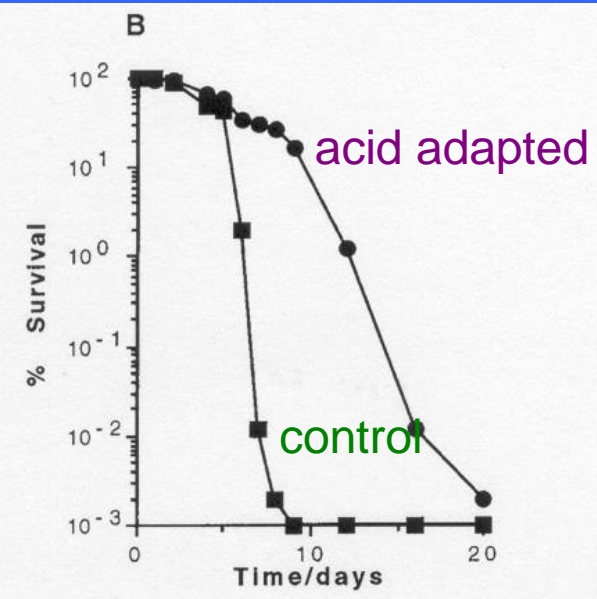
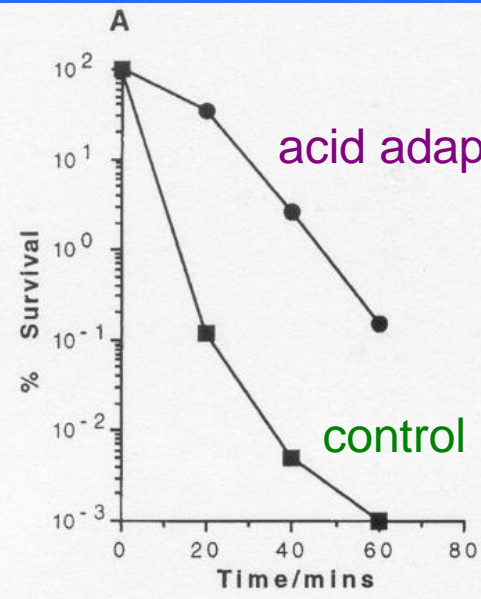
7. 48°C

8. 4°C

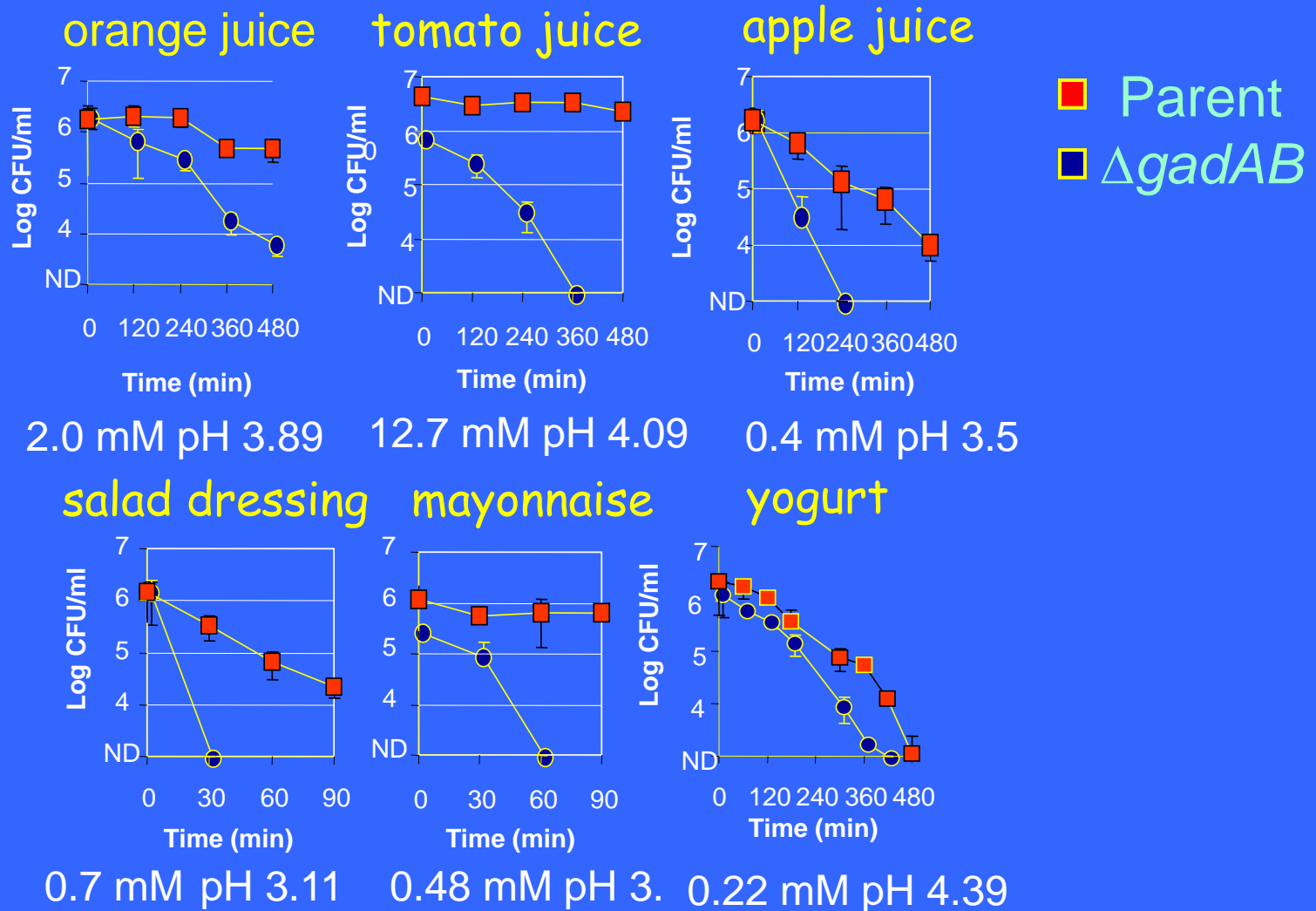
9. stat. phase

Better survival of acid-adapted *Lm* in comparison with control strains

- exposure to:
- A, Heat (52° C)
- B, NaCl (2.5 M)
- C, H<sub>2</sub>O<sub>2</sub>
- D, Ethanol (15%)

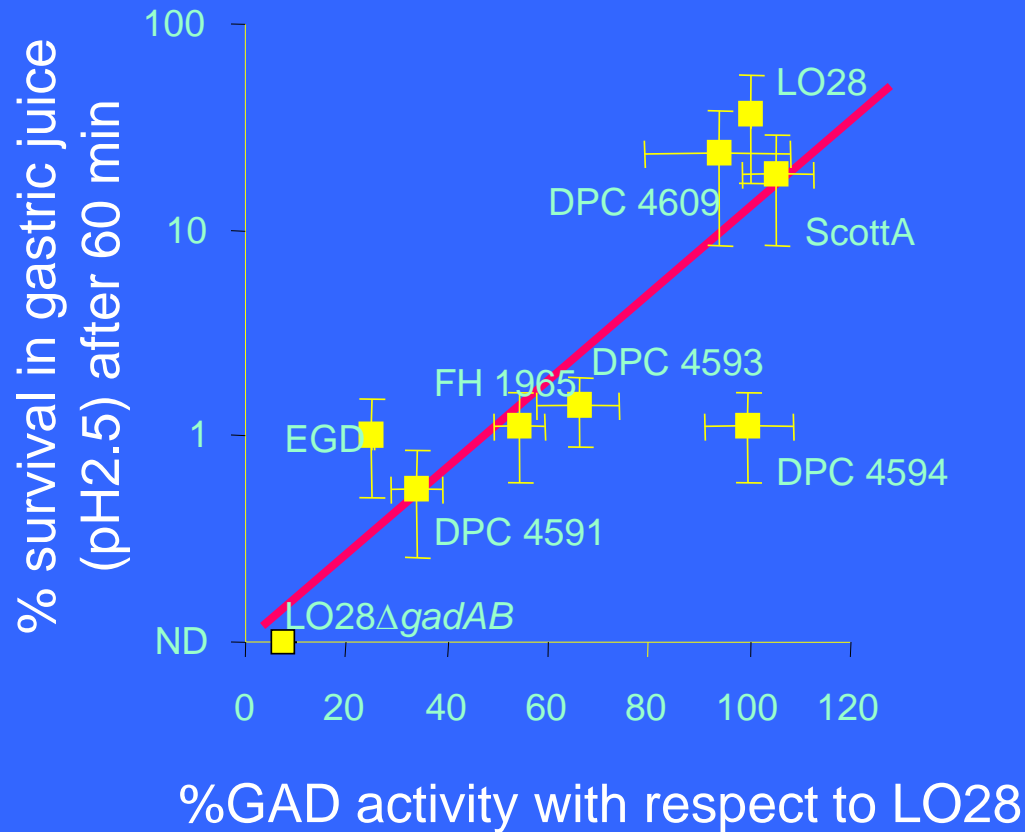


# *Lm* survival in acid products role glutamate decarboxylase (*GadAB*)



# Better survival for *Lm* in gastric juice?

Plotted: *GAD* activity vs. survival in gastric juice



no strain was more resistant than could be expected on the grounds of *GAD* activity

glutamate decarboxylase system important low pH survival



# Developments in Food Microbiology

- Microscopy: light, phase contrast, electron, FC
- Ecophysiology: growth, survival, inactivation, stress response
- Functional mo and probiotics
- Pathogens: DR, foodborne diseases, prevalence
- Risk analysis

# STRUCTURE OF RISK ANALYSIS



# Risk assessment: how to do?

A double fresh meal, with raw and semi-cooked ingredients mixed and MAP packaged, called **TV-dinner** in the USA

shelf life from 1-2 week  
heating in microwave  
by the consumer



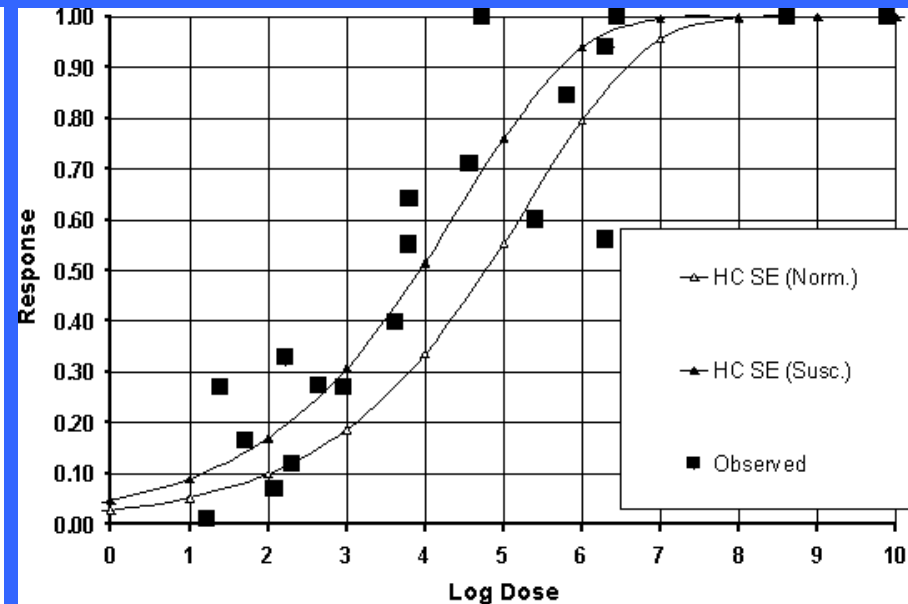
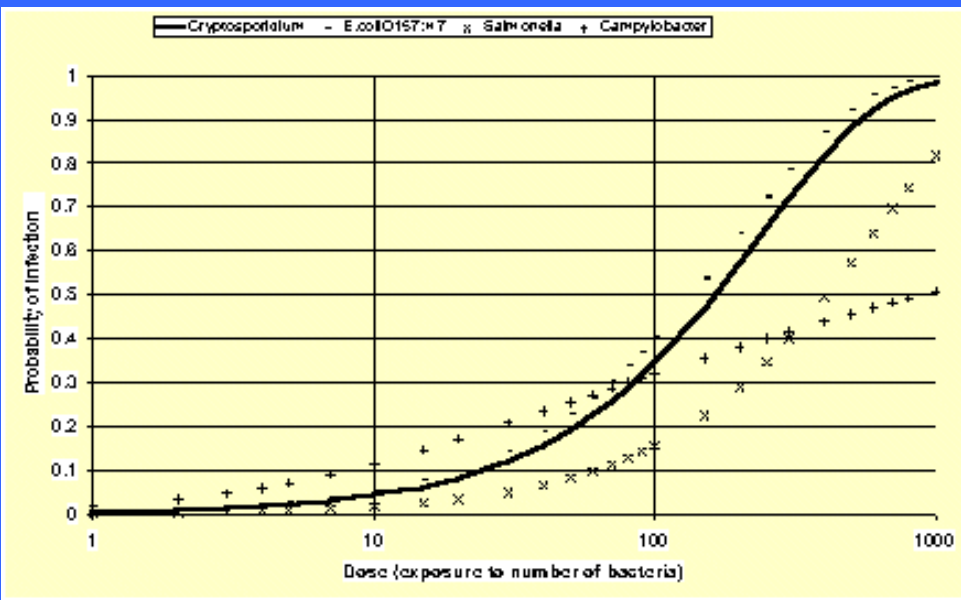
which foodborne pathogens should be inactivated?

# How great is the risk of mortality (NL)

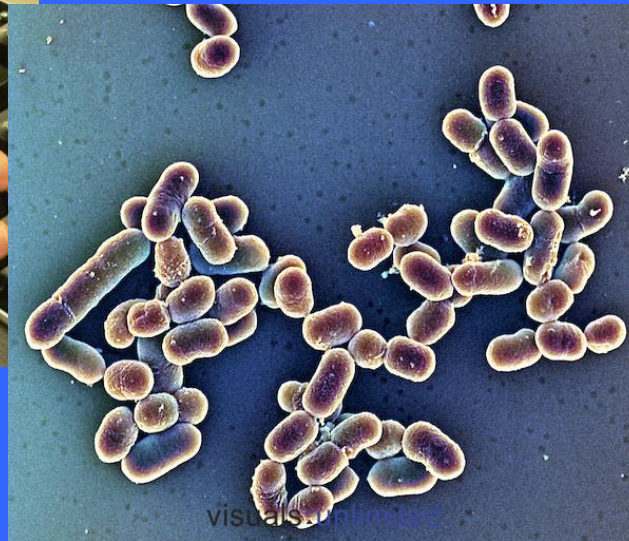
risk of mortality	N/10 <sup>6</sup>	cause of death
1 : 115	8.800	total # deaths
1 : 10.000	100	infectious diseases
1 : 10.000	100	suicide
1 : 15.000	75	traffic
1 : 55.000	16	food
1 : 200.000	6	drowning
1 : 20.000.000	0.05	lightning

# Important things to know of pathogens (1)

food borne infection or - intoxication; incidence; DR;  
incubation time; symptoms; duration; dead  
products involved; sources; environmental cycle;  
ecophysiology; control in food ... **stage 5**



# How to select relevant foodborne pathogens



List them all

Thereafter, use Risk Ranger to  
select the 3 most important

# Listed bacterial foodborne pathogens

Pathogen	Meat	Fish	Vegetables	Pasta/Rice
<i>Aeromonas</i>	=	=	=	
<i>B. cereus</i>	=	=	=	=
<i>C. botulinum</i>	=	=	=	
<i>C. perfringens</i>	=	=	=	
<i>Campylobacter</i>	=	=	=	
<i>E. coli</i>	=	=	=	?
<i>L. monocytogenes</i>	=	=	=	=
<i>Salmonella</i>	=	=	=	?
<i>S. aureus</i>	=	=	=	=
<i>Vibrio</i>	=	=	=	

# Risk Ranger to identify most important ones

download from:

<http://www.foodsafetycentre.com.au/docs/RiskRanger.xls>

- answers on 11 questions, result in a 'risk ranking'
- differences expressed on a log scale

just for your convenience, divided in a scale from 0-100

- mild:1:  $10^9$  people ill in 100 year
- severe: everybody dies after eating one meal
- 6 RR units: about a factor 10 difference



# Risk Ranger: example of a question

## B. PROBABILITY OF EXPOSURE TO FOOD

### 3 Frequency of Consumption

daily  
weekly  
monthly  
a few times per year  
OTHER

# Risk Ranger: a result

## RISK ESTIMATES

probability of illness per day per  
consumer of interest ( $P_{inf} \times P_{exp}$ )

1.42E-07

total predicted illnesses/annum  
in population of interest

2.54E+02

RISK RANKING ( 0 to 100)

46

# Some theory ...

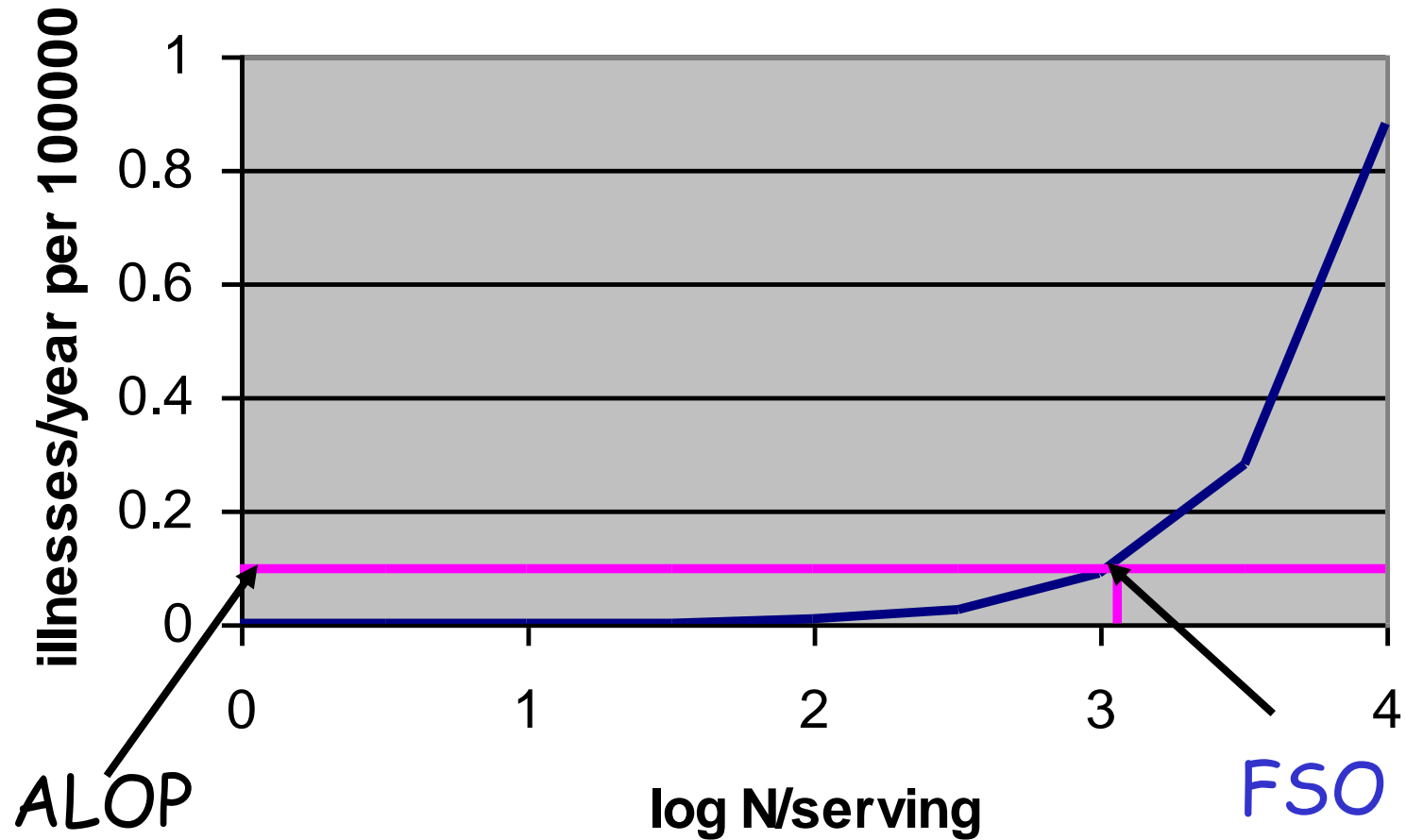
## FSO

Food Safety Objective  
(cfu/g, or presence of a pathogen (%))

based on **ALOP**

Appropriate Level Of Protection  
(# persons ill, in hospital, or death/year)

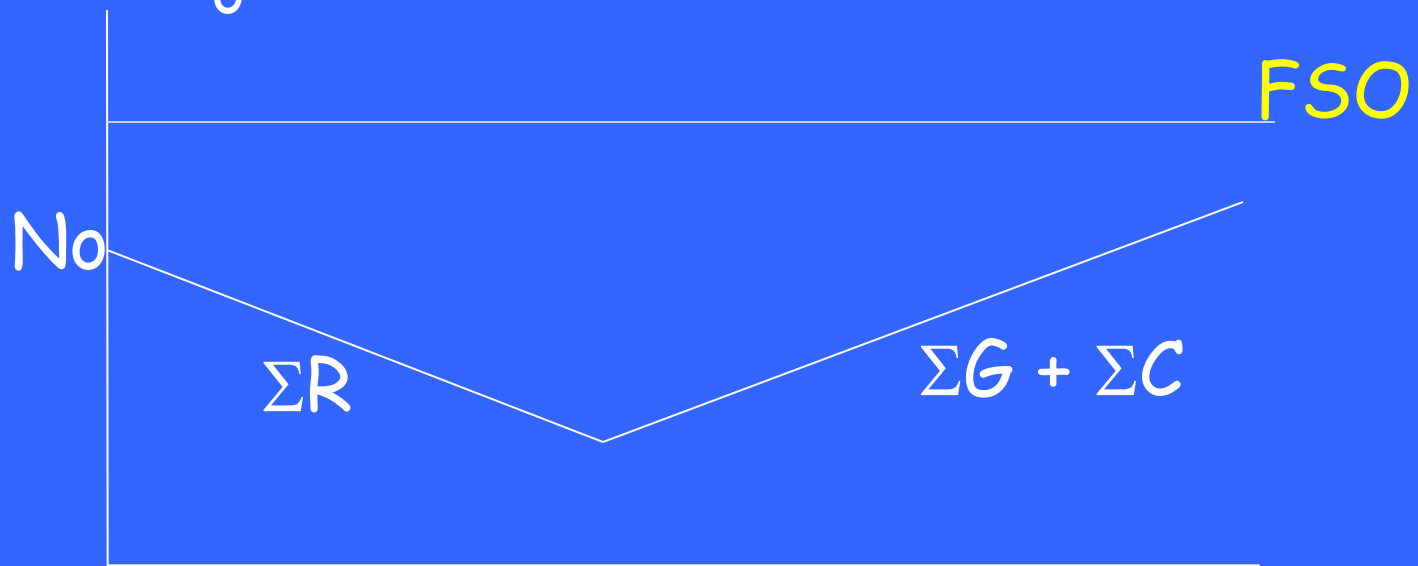
# FSO



based on dose/response and # of portions

# FSO (definition by ICMSF)

$$N_0 - \Sigma R + \Sigma G + \Sigma C < \text{FSO}$$



Food Safety Objective, formulated by the government

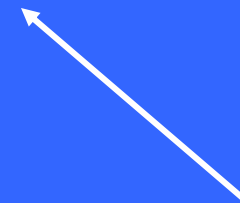
# FSO

$$N_0 - \Sigma R + \Sigma G + \Sigma C < \text{FSO}$$



## Industry

Microbiological research  
Quantitative microbiology



## Government

DR, Epidemiology,  
Consumption

# FSO

primary production

$$N_0 - \Sigma R + \Sigma G + \Sigma C < PO$$

performance objective

food industry

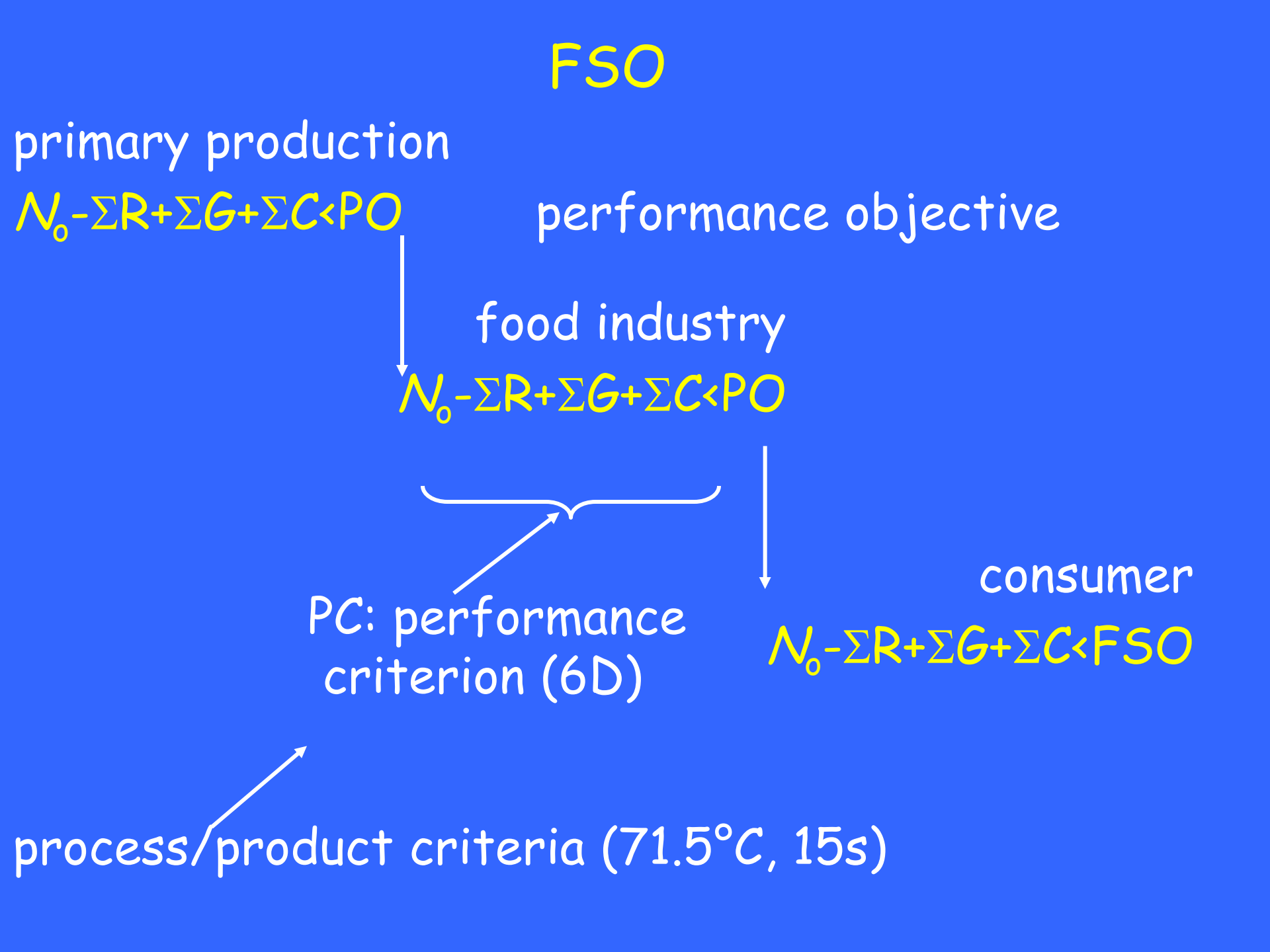
$$N_0 - \Sigma R + \Sigma G + \Sigma C < PO$$

PC: performance  
criterion (6D)

consumer

$$N_0 - \Sigma R + \Sigma G + \Sigma C < FSO$$

process/product criteria (71.5°C, 15s)



# Reminder

**ALOP** Appropriate Level of Protection  
illness, and †/year; DR, consumption

**FSO** Food Safety Objective  
cfu/g or prevalence (%)

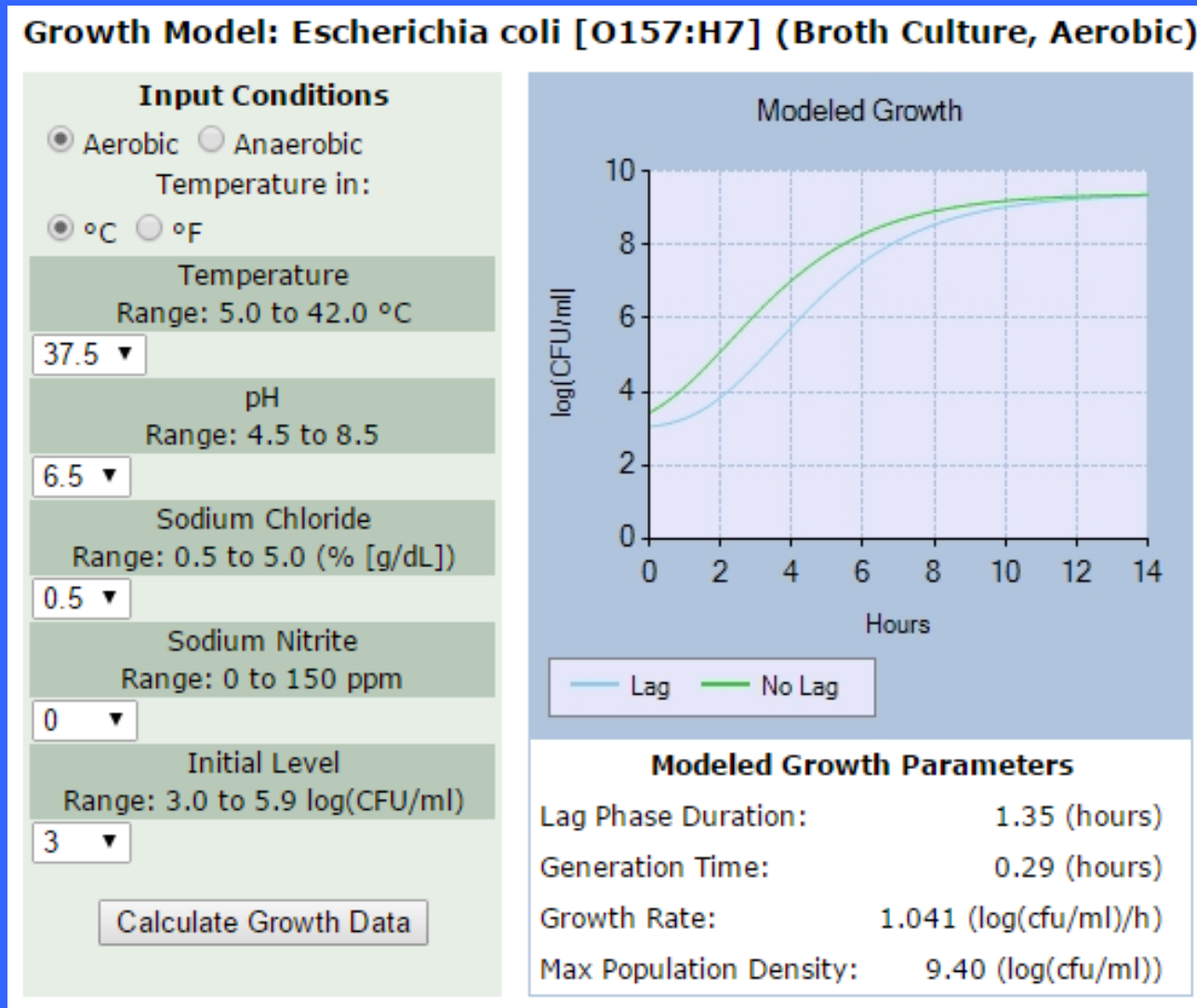
**PO** Performance Objective  
cfu/g or prevalence (%)

**PC** Performance Criterion  
>6D inactivatie, <3D growth

Process criterion: 15s 71.5°C and Product criterion: pH<4.6



Use a model to predict the growth of the three selected pathogens (Combase, PMP, or others, e.g. FSSP)

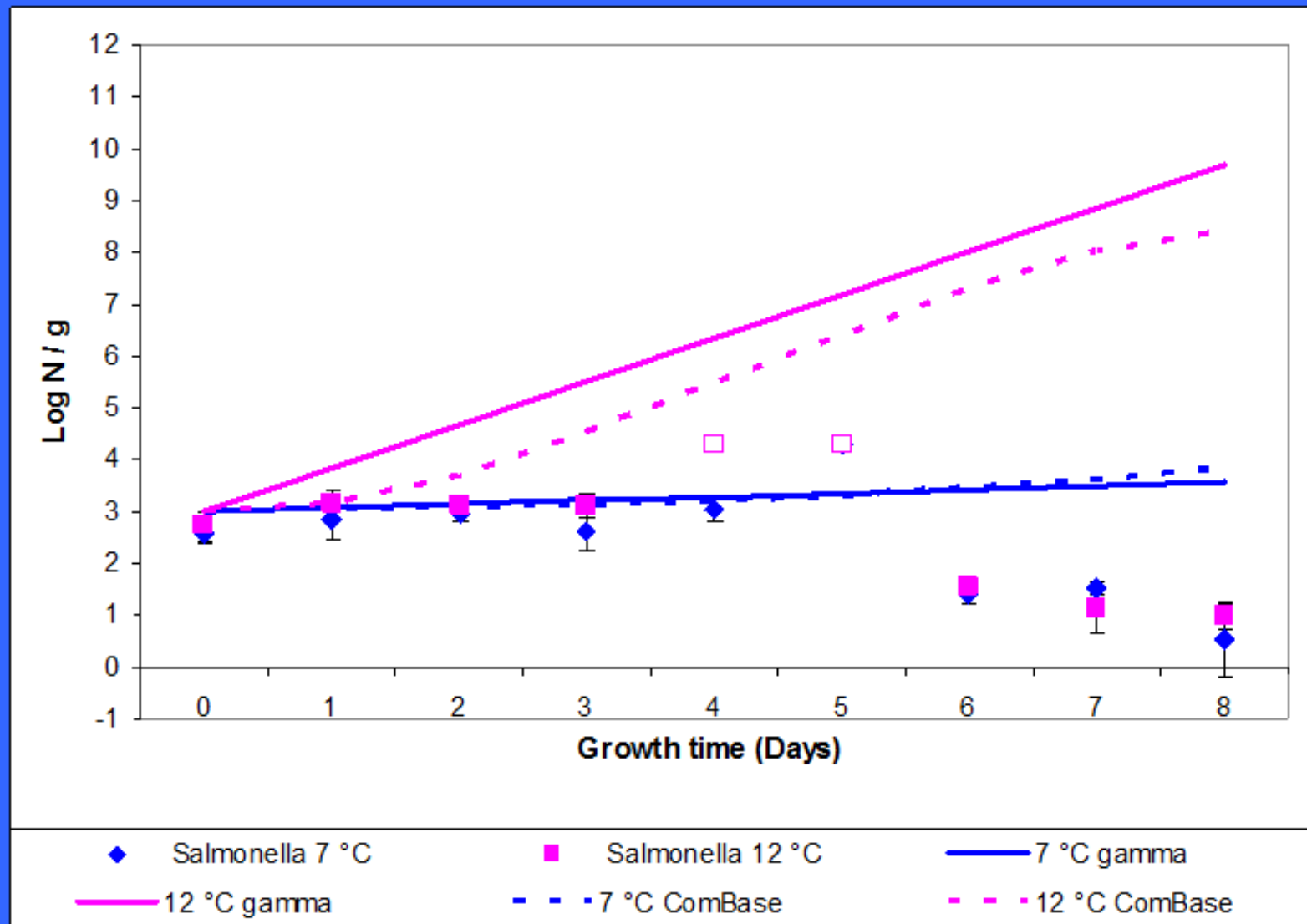


Thereafter, perform challenge tests

# A safe double fresh meal, you will get by combining the data obtained

foodborn pathogen	initial (LogN/g) raw materials	growth at retail and consumer	post process contam.	levels before heating (LogN/g)	inactivation microwave estimated	level at consumption (LogN/g)
<i>Listeria</i>	1	2	0	3	6	?
<i>Salmonella</i>	0	1	0	1	6	?
<i>Bacillus vegetative</i>	4	1	0	5	6	?

# Prediction and challenge test for the growth of *Salmonella* in a TV dinner



# Important things to know of mo in food

Control in food

- \* GMP, HACCP
- \* refrigeration, pasteurisation, sterilisation, etc.
- \* preservatives

and consumer education

# Control of food production

Prerequisite:  
Basics/common sense  
GMP, GHP, GLP

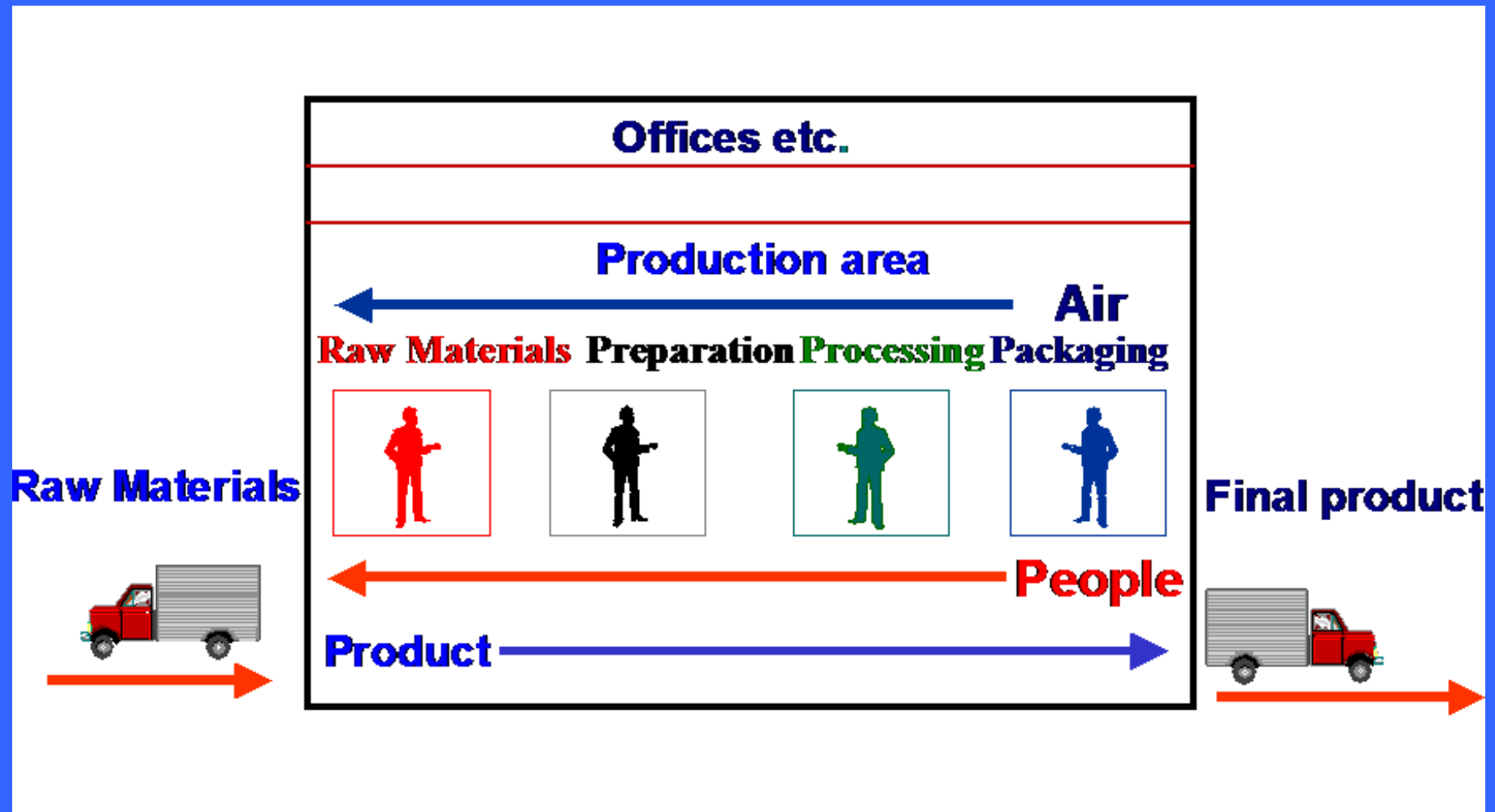
Training/long life learning  
prevent stupid errors

HACCP

QRA

Contributes to food safety, stage 5, wisdom

# Zoning: prevention of (cross) contamination



# Zoning

between areas to prevent (cross) contamination

also for internal traffic,

production apparatus

product flow

tools

workers



# Zoning: changing shoes?





# Zoning: corridor for visitors



# Sampling the environment

- \* When, what ... depends on type of factory  
know your basic level
- \* product spill, - scrape, dust, etc.



# Sampling the environment

A: environment close to the product

B: surrounding areas

C: remote places

# Sampling the environment

## Differentiation of samples

A: surfaces in contact with the product

B: surrounding areas

C: remote areas

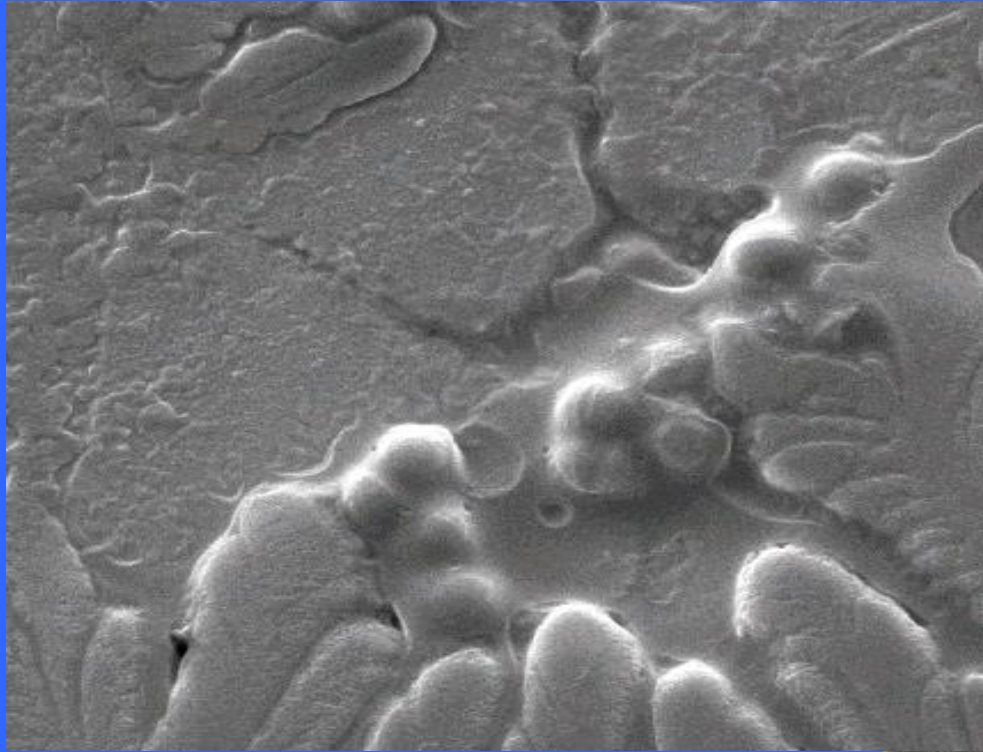
General hygiene: A 60%; B 40%

Pathogens: A 60%; B 30%; C 10%

# Transfer of mo using rodac plates

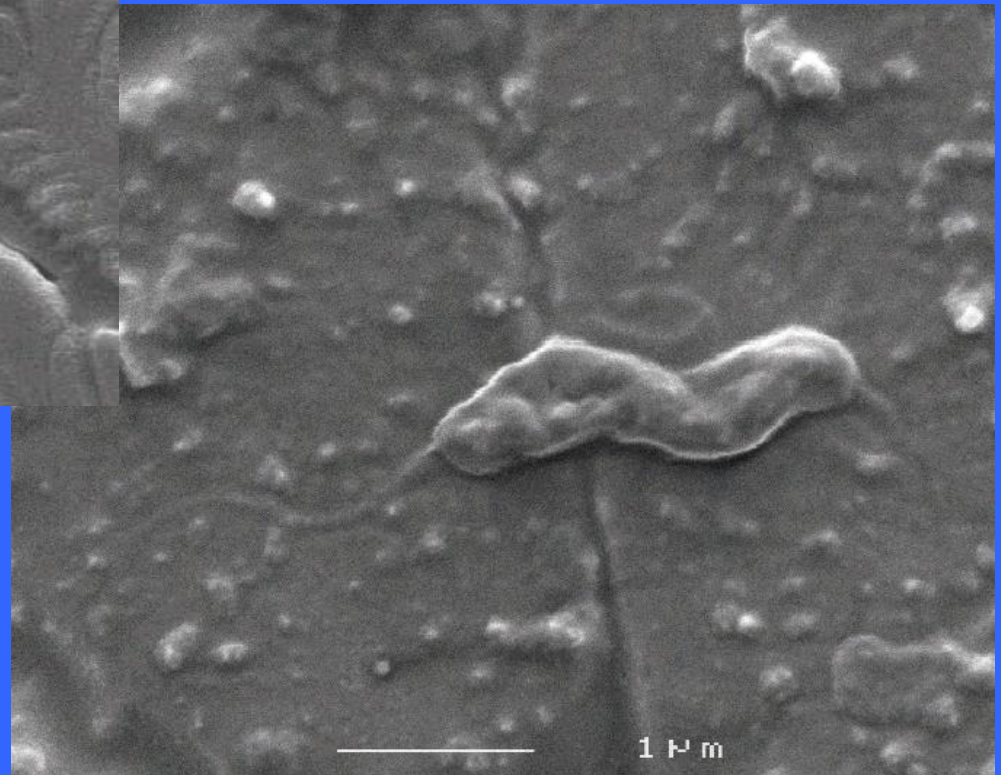
	N	Recovery (%)	
		1x	5x
<i>B. cereus</i>	50	18 ± 6	33 ± 11
<i>S. aureus</i>	10	46 ± 14	88 ± 26
<i>S. Ent.</i>	14	23 ± 6	42 ± 12
<i>C. jejuni</i>	10	7 ± 3	14 ± 7

Transfer determined by  
morphology/size of mo?



*Staph. aureus*

*Campylobacter*



# Transfer mo

depends on

contact time (10 sec)

pressure (500g)

device available at  
BioMérieux, VWR





Courtesy of AEW Delford and Charkman Group

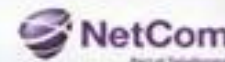




annonse



Med Trådløs Bedrift får kunden din alltid tak i rett person selv om du er Bestill på netcom.no eller ring 05051



TILBAKEKALLES: Hundrevis skal ha blitt syke etter å ha spist norsk røkelaks solgt i USA og Nederland. Saken har vakt oppmerksomhet verden over.

FRANK PERRY/SKJERMDUMP AFP/E24

# Gir gresk fabrikk skylden for salmonella i «norsk laks»



**SALMONELLA  
RECALL**

KEEP REFRIGERATED • GARDER AU RÉFRIGÉRATEUR

NET WT • POIDS NET 500 g • 2lbs

Best Before / Meilleur Avant  
2015 MA 04  
2513043

Product of / Produit du  
Canada

**SunRich.**   all-natural  
tous les naturels

**apple slices / tranches de pomme**

Produit au Canada / Produit au Canada  
Sun Rich Fresh Foods Inc., Brantford, ON N3S 1G2  
[WWW.SUN-RICH.COM](http://WWW.SUN-RICH.COM)

INGREDIENTS: FRUIT (APPLE, CACAO)  
ACIDULANT (ACIDIC), ACIDULANT  
(CITRIC ACID)  
INGREDIENTS: POMME (POMME), ACIDULANT  
(ACIDE CITRIQUE), ACIDE ACÉTIQUE  
(VINAIGRE)



**Nutrition Facts**  
**Valeur nutritive**

Serving Size 100 mg (100 g)  
Amount Per Serving 100 mg (100 g)

Total Fat / Matière grasse	0 g	0%
Cholesterol / Cholestérol	0 mg	0%
Sodium / Sodium	0 mg	0%
Total Crap / Sucres totaux	10 g	20%
Total Fat / Matière grasse	0 g	0%
Cholesterol / Cholestérol	0 mg	0%
Sodium / Sodium	0 mg	0%
Total Crap / Sucres totaux	10 g	20%
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Cholesterol / Cholestérol	0 mg	0%
Sodium / Sodium	0 mg	0%
Total Crap / Sucres totaux	10 g	20%

B2015MSIL00336  
2015\_SB376

# Conclusions for food producers

- \* Raw products, which are contaminated with pathogens will remain a hazard, even when the food is held at low temperatures (refrigerator or freezer)
- \* Heat treatment (temperature up to 70°C, or higher) will inactivate pathogens, usually not spores
- \* Most other methods only decrease mo in numbers
- \* Be aware of stress in mo
- \* Clean and disinfect thoroughly
- \* Be careful in case of a long shelf life

# Conclusions for consumers

For the safety of foods, which enter kitchens as raw agricultural commodities, including meat, poultry, seafood and vegetables, one cannot rely solely on animal health programs and sanitation

A certain knowledge is necessary to prepare food as safe as possible for family and guests



