

Διερευνώντας τα Αίτια που μπορεί να προκαλέσουν Ποιοτικά προβλήματα στην παραγωγή Τροφίμων (Route Cause Analysis) και η σημασία της επίβλεψης του Περιβάλλοντος παραγωγής (Environmental Monitoring).

18 Ιουνίου 2024 | Βασίλης Αρβανιτίδης

A FAMILY HISTORY
SERVING MEDICINE &
PUBLIC HEALTH WORLDWIDE



FOLLOWING PASTEUR'S FOOTSTEPS SINCE 1897



MARCEL MÉRIEUX

Student of Louis Pasteur
Founder of Institut Mérieux in 1897



CHARLES MÉRIEUX

Took up the reins
of Institut Mérieux in 1937



ALAIN MÉRIEUX

Founder of bioMérieux
in 1963



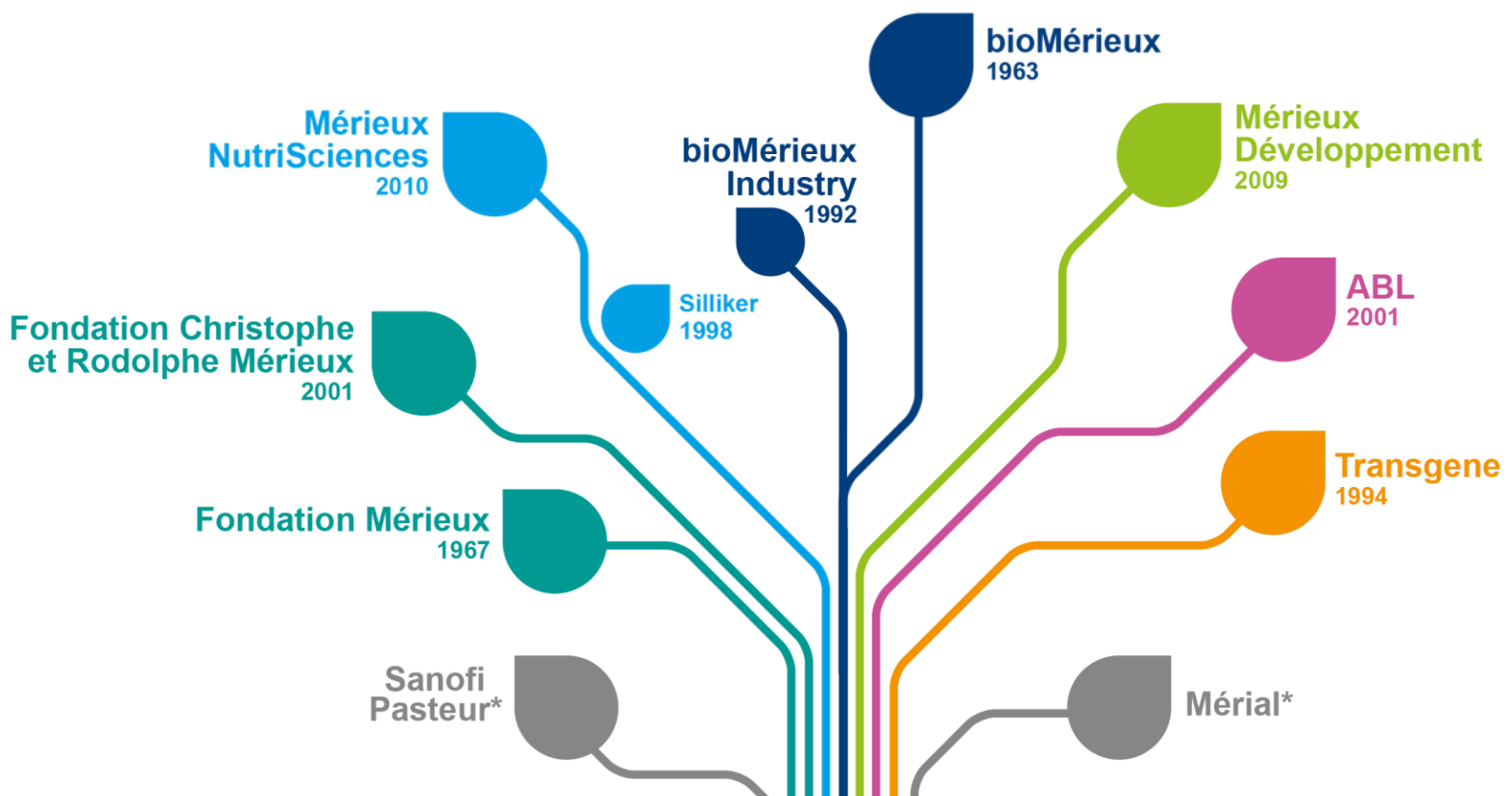
ALEXANDRE MÉRIEUX

Executive Chairman

FOUR GENERATIONS

of one family committed to global public health

INSTITUT MÉRIEUX: SERVING PUBLIC HEALTH FOR OVER A CENTURY



INSTITUT MERIEUX

1897

** Companies which are no longer part of the Institut Mérieux since 1994 and were created by the Mérieux family.*

FACTS AND FIGURES

60 YEARS
OF EXPERTISE IN *IN VITRO*
DIAGNOSTICS

30+ YEARS
OF EXPERTISE IN
INDUSTRIAL
MICROBIOLOGY CONTROL



€3.675

BILLION IN SALES
IN 2023



More than **90%**
INTERNATIONAL SALES
(outside of France)



≈ 14,000

TEAM MEMBERS
WORLDWIDE

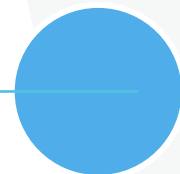
OUR INTERNATIONAL PRESENCE



Americas

BIOINDUSTRIAL SITES:
Brazil, United States

R&D CENTERS:
Brazil, United States



WE ARE LOCATED IN
46 COUNTRIES
and serve more than 160 countries
through a large distribution network



Asia Pacific

BIOINDUSTRIAL SITES:
Australia, China, India

R&D CENTERS:
China, India



Europe, Middle East and Africa

BIOINDUSTRIAL SITES:
France, Germany, Italy, Spain

R&D CENTERS:
Belgium, France, Germany, Italy

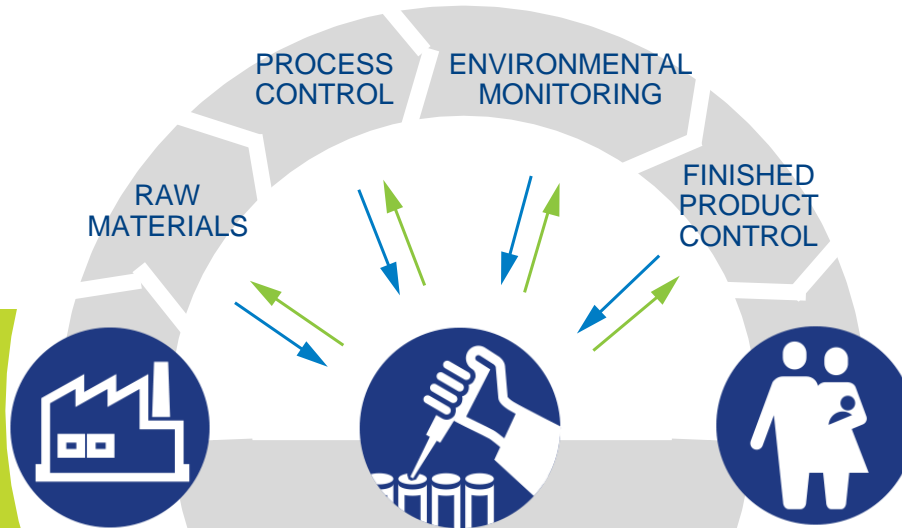
INDUSTRIAL MICROBIOLOGICAL CONTROL

Food Safety & Quality,
Pharmaceutical & Healthcare industries

CLINICAL
APPLICATIONS

INDUSTRIAL
APPLICATIONS

MANUFACTURING



CONSUMERS

Market Intelligence, Quality Control, Innovative instruments,
Reagents, IT solutions, Data Science, Services



SAMPLES

RESULTS

FOOD INDUSTRY CHALLENGES



FOOD INDUSTRY CHALLENGES

FOOD SAFETY-PATHOGEN RISK



OUTBREAK-BRAND IMAGE RISK



BIOMÉRIEUX

THE CONSUMER



NEW PRODUCTS-NEW RISKS



RESSOURCES-ENERGY-PROFITABILITY



FOOD QUALITY-SPOILAGE RISK

1/3 OF THE WORLD'S FOOD IS WASTED.

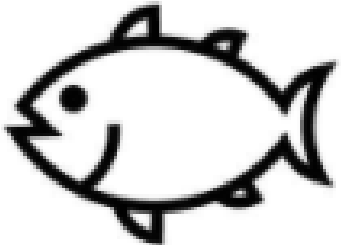
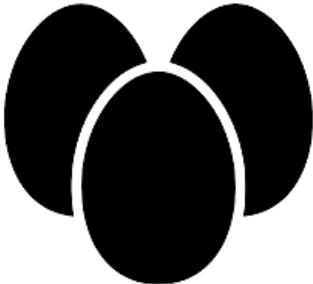
Help raise awareness on #WFD18 and win your own Zero Waste Toolkit!

World Food Day
#FoodWasteHero
 CHALLENGE

- 1 Share a photo of your food waste hero on Facebook and explain the reason for your choice in the caption.
- 2 Include the hashtags #FoodWasteHero and #WFD18 and mention @eatfood so we can find you! Don't forget to set your post to public before pushing the send button.

eat Food

ANIMAL PROTEIN GENERAL OVERVIEW & TRENDS 2028



Poultry

Beef

Fish & Seafood

PRODUCTIVITY & SUPPLY CHAIN RISK

THE BIG FOCUS

PRECISION FARM, SMART FARM, SMART TESTING, SPEED PROCESS, DATA DECISION TOOLS

THE BIG TRENDS



IMPACTING CHALLENGE

ESG RISK PROFILE

FOOD SAFETY

ACCESS MARKET

ANIMAL HEALTH

DATA INTEGRATION AND PREDICTIONS TOOLS

ANIMAL PROTEIN KEY CHALLENGES & TRENDS



- Need for Speed
- RT Screening_ Productivity
- BioData Risk Tool to predict and decision



- BioSecurity Data to anticipate Risk
- Integrated & Smart Animal Health
- Welfare Markers



- Access Market Needs
- Risk Profile to Investors
- Impacting Productivity

The Meat industry will be more and more upstream data driven and automatized and special care and focus will be dedicated to critical areas.

Mitigation across the whole production chain.




Data will become gradually more processable requiring **tool predictions** to translate them into actionable insights for proper **risk**


OUR OFFER? THE ECOSYSTEM

OUR AUGMENTED PORTFOLIO FROM SAMPLES TO ACTIONABLE INSIGHTS


KEY SEGMENTS




BEVERAGES



DAIRY
& PlantBased















ANIMAL PROTEIN
and alternatives




PROCESSED FOOD
& Nutraceuticals

INNOVATION HIGHLIGHTS


From Test Results...
... to Actionable Insights

 <p>SAMPLE & MEDIA PREPARATION <i>Optimized preparation and enrichment</i></p>	 <p>TEMPO® <i>Automated quality indicator enumeration</i></p>	 <p>VIDAS® KUBE <i>Automated pathogen detection</i></p>	 <p>GENE-UP® TYPER <i>Rapid typing for pathogens</i></p>	 <p>CONNECT-UP™ <i>Lab data management</i></p>	 <p>DATA SERVICES <i>On EM & data analytics</i></p>
 <p>BIOBALL® <i>Standardized strains</i></p>	 <p>CHEMUNEX® D-COUNT® <i>Ultra rapid microbiology testing</i></p>	 <p>GENE-UP® <i>Automated PCR pathogen detection</i></p>	 <p>Pathogen/Spoiler Mapping <i>Root Cause Analysis</i></p>	 <p>ENVIROMAP <i>Environmental Monitoring Digitalization Visibility</i></p>	 <p>GENE-UP® XPRO Program <i>Custom Assay</i></p>
SAMPLE PREPARATION	ENUMERATION	DETECTION	IDENTIFICATION INVESTIGATION	DIGITAL & DATA ANALYSIS	ANTICIPATION PREVENTION


OUR FOOD SCIENCE EXPERTISE




MICROBIOLOGY




MOLECULAR BIOLOGY



GENOMICS



TECHNOLOGY

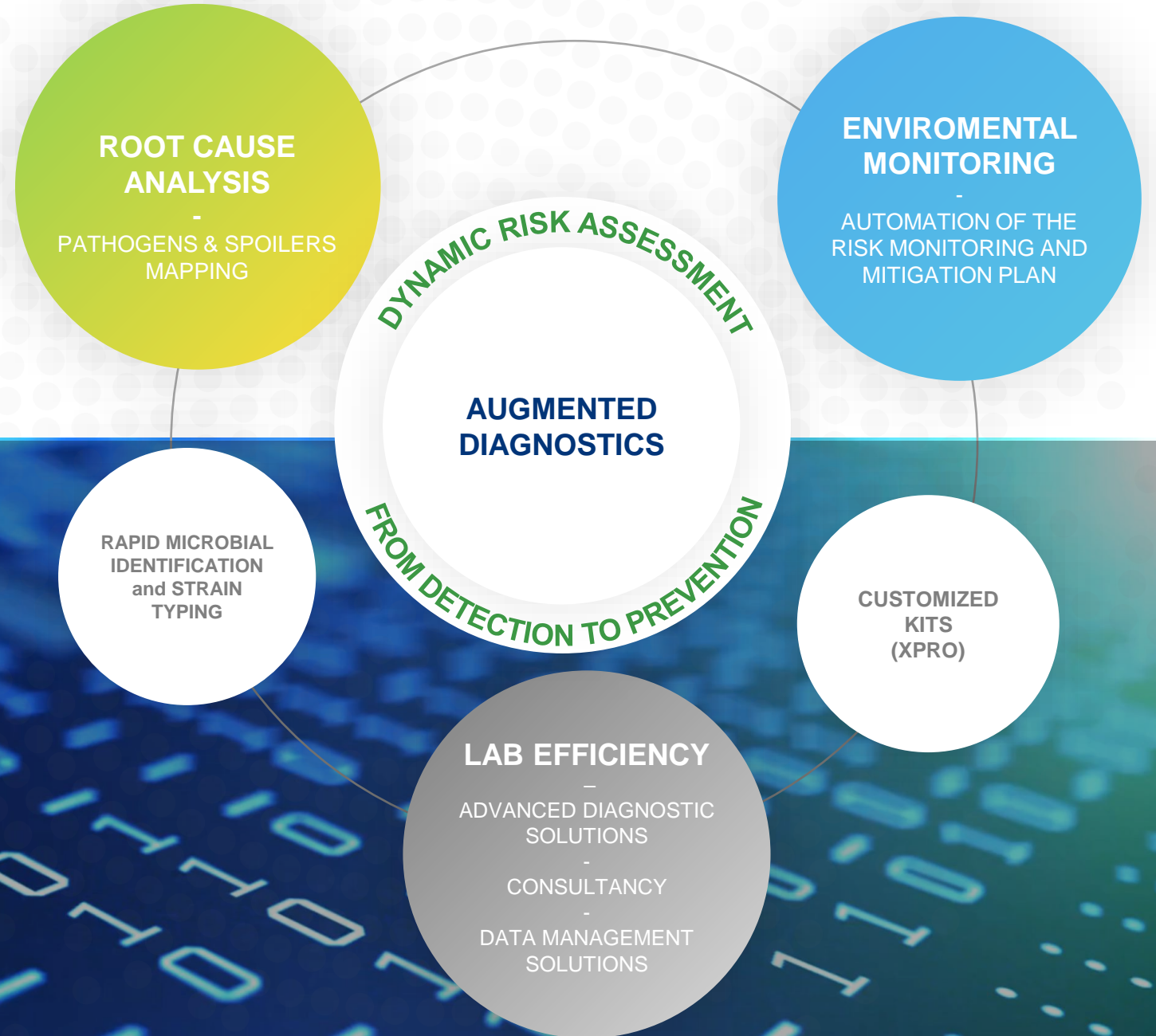


DATA SCIENCE



INTRODUCING AUGMENTED DIAGNOSTICS

PEACE OF MIND TODAY
PIONEERING TOMORROW



100% CUSTOMIZED APPROACH ACCORDING TO NEEDS



ROUTE CAUSE ANALYSIS



PATHOGEN ISSUE



CLUEDO

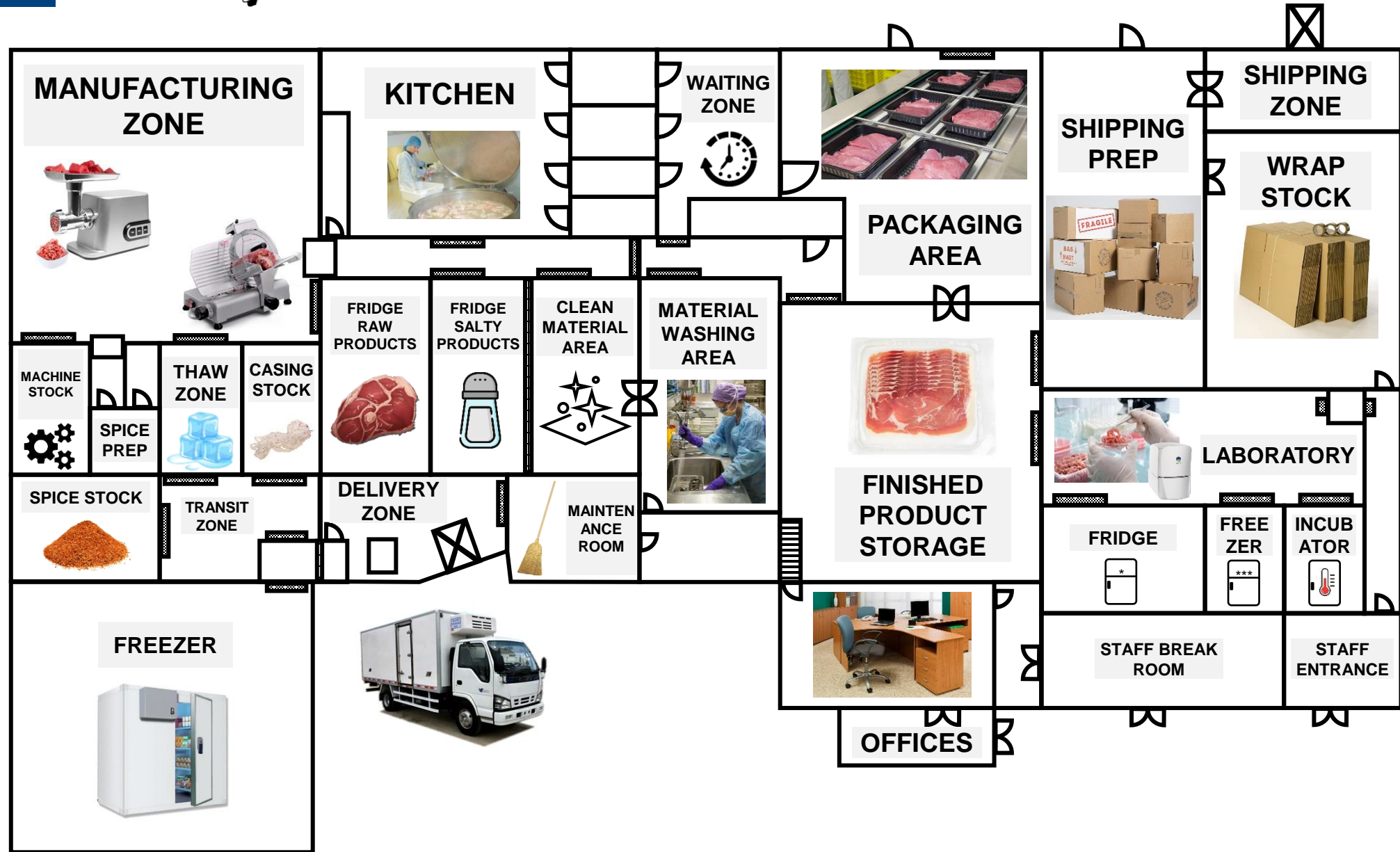


BACTERIO



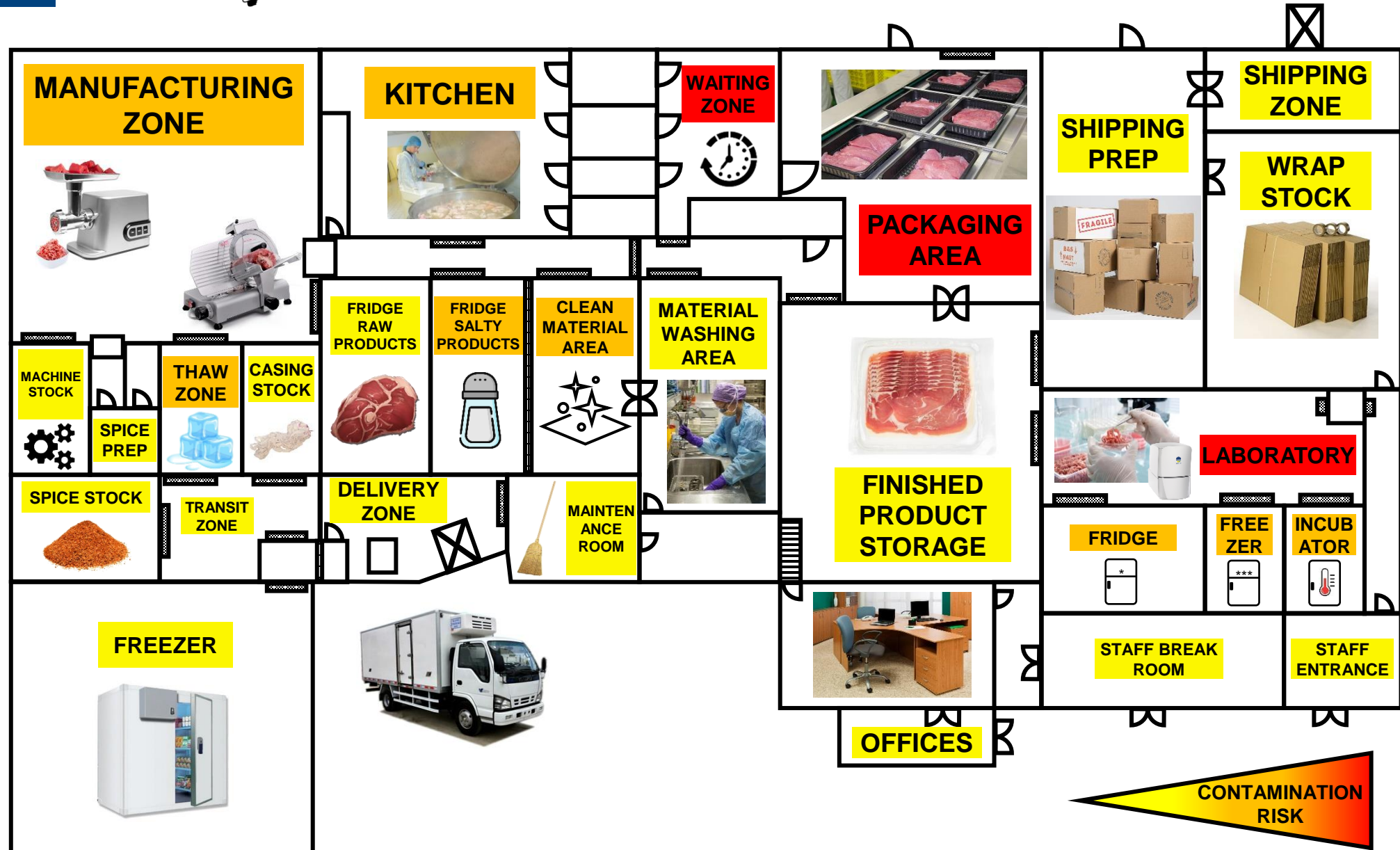
CLUEDO BACTERIO

In search of lost pathogen



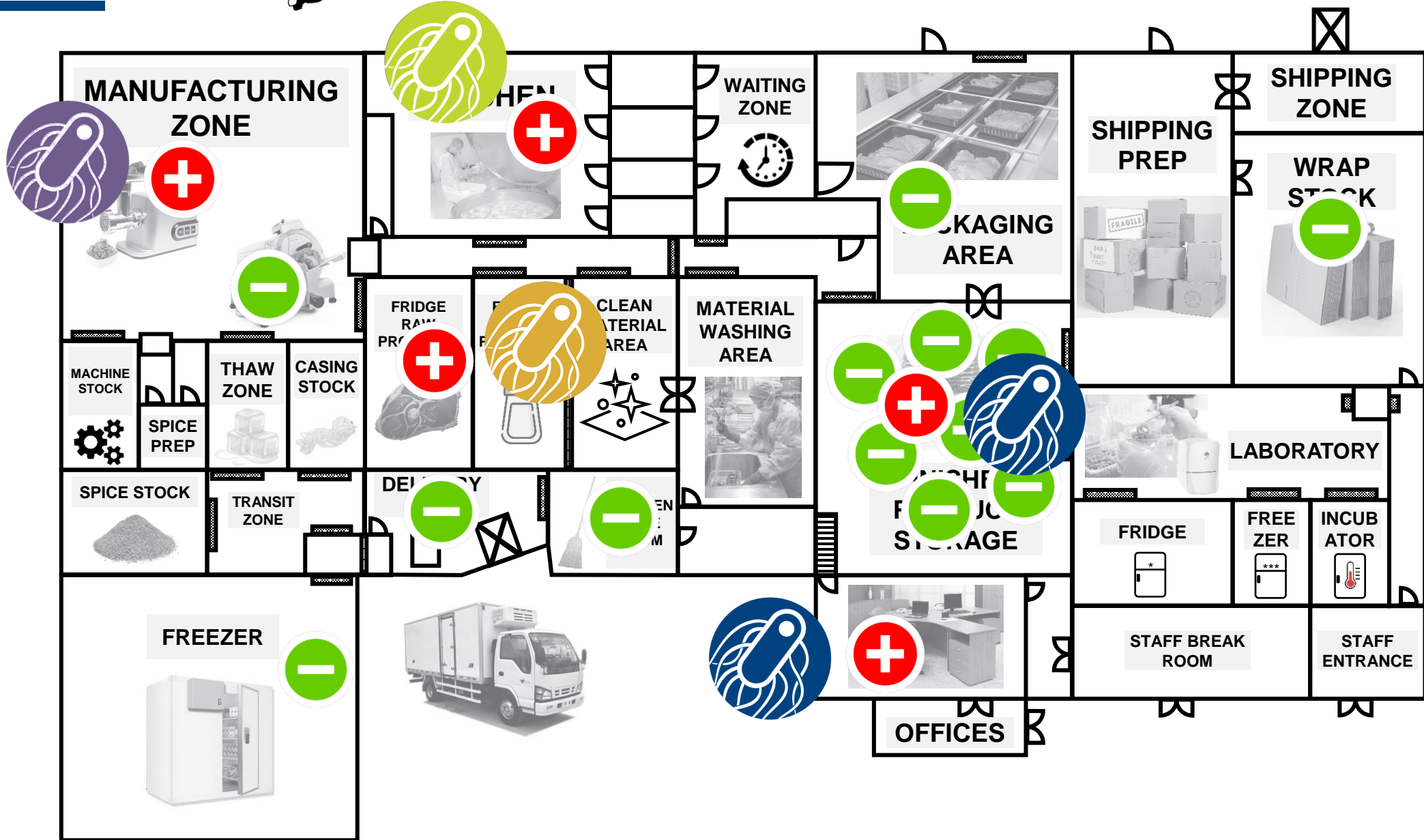
CLUEDO BACTERIO

In search of lost pathogen

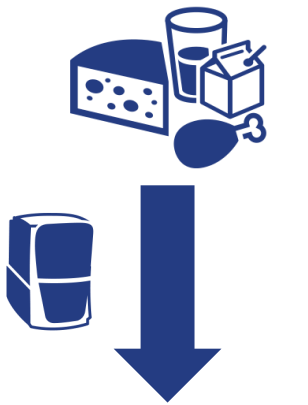


CLUEDO BACTERIO

In search of lost pathogen



A PATHOGEN COMES WITH MANY QUESTIONS



Negative

Positive



Product release



Product destruction



Have I seen this strain before?



Is it a persistent strain/biofilm in my factory?
Where?

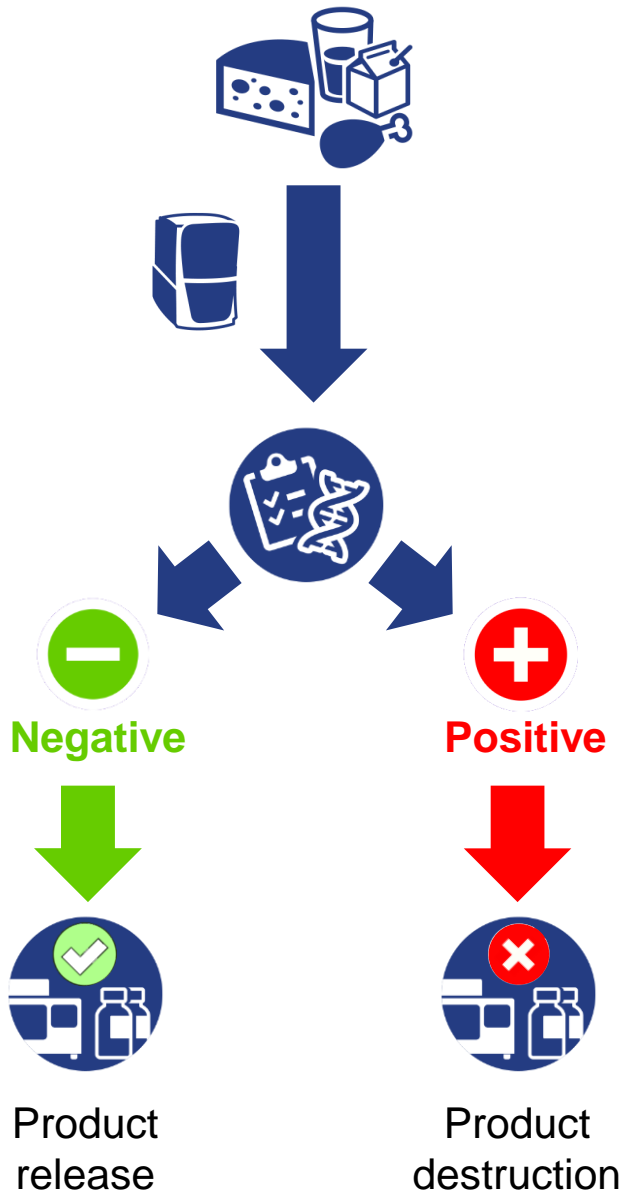


Is this a true contamination or a lab cross-contamination?



Can I link it to a raw material supplier?

A PATHOGEN COMES WITH MANY QUESTIONS



GENE-UP TYPER Project



Whole Genome Sequencing (WGS) (e.g. Pathogen Mapping)



MALDI-ToF (e.g. VITEK® MS)



Serotyping



PFGE



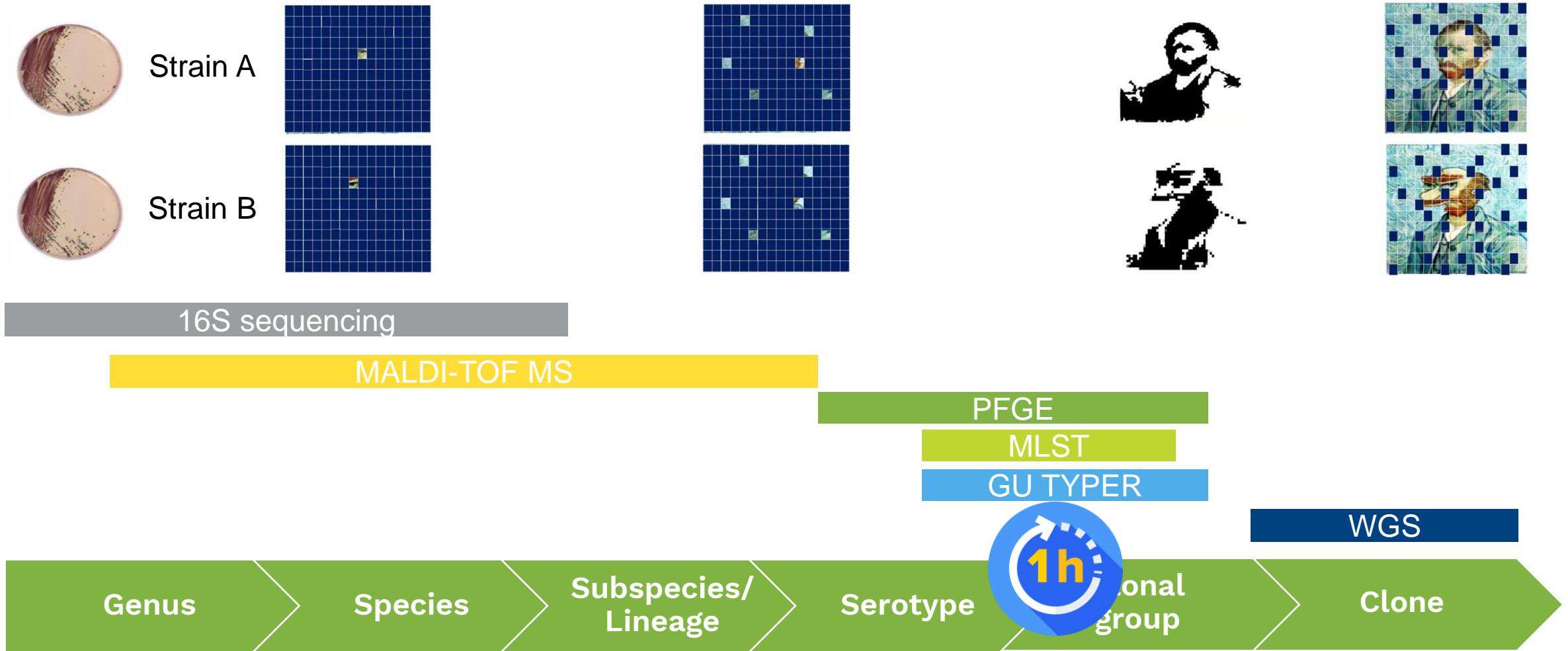
Discriminatory power

Time-to-result

Cost

Complexity

STRAIN TYPING IS PATTERN RECOGNITION



For ex: *Listeria*

Listeria monocytogenes

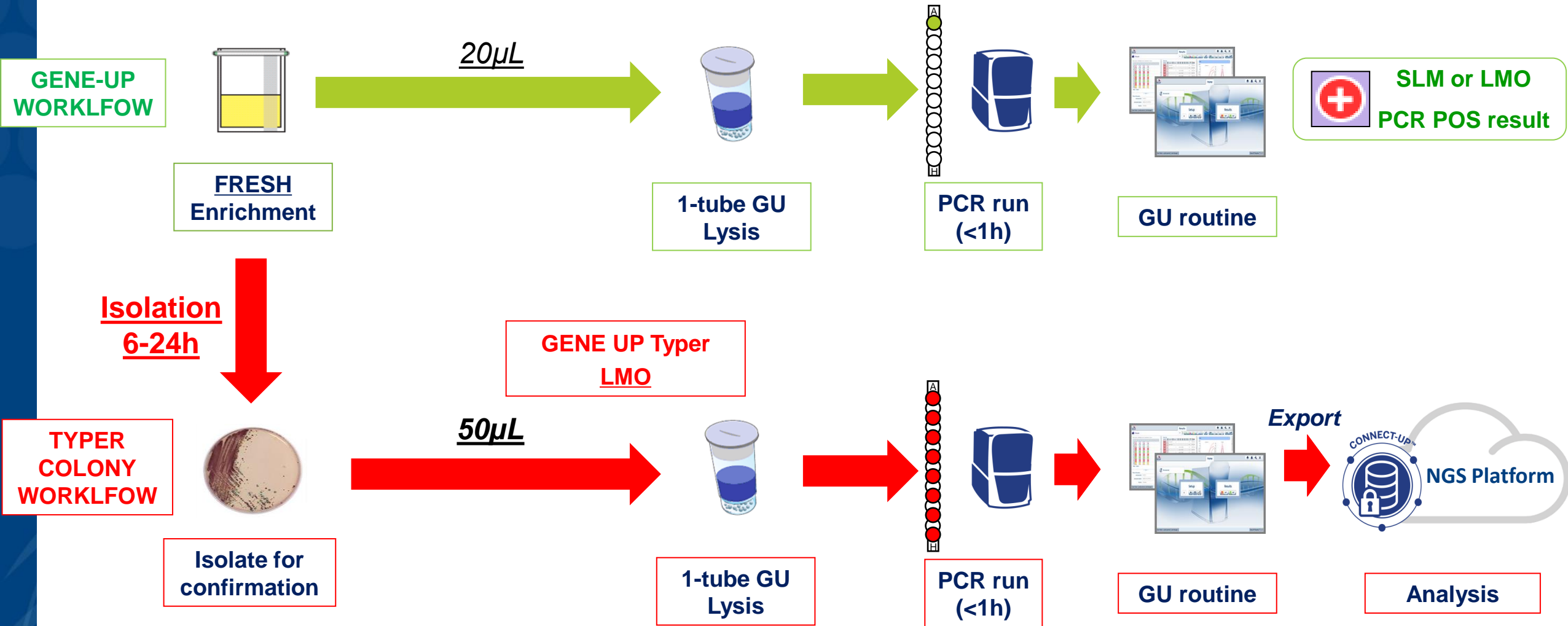
Lineage
I

Serotype
1/2b

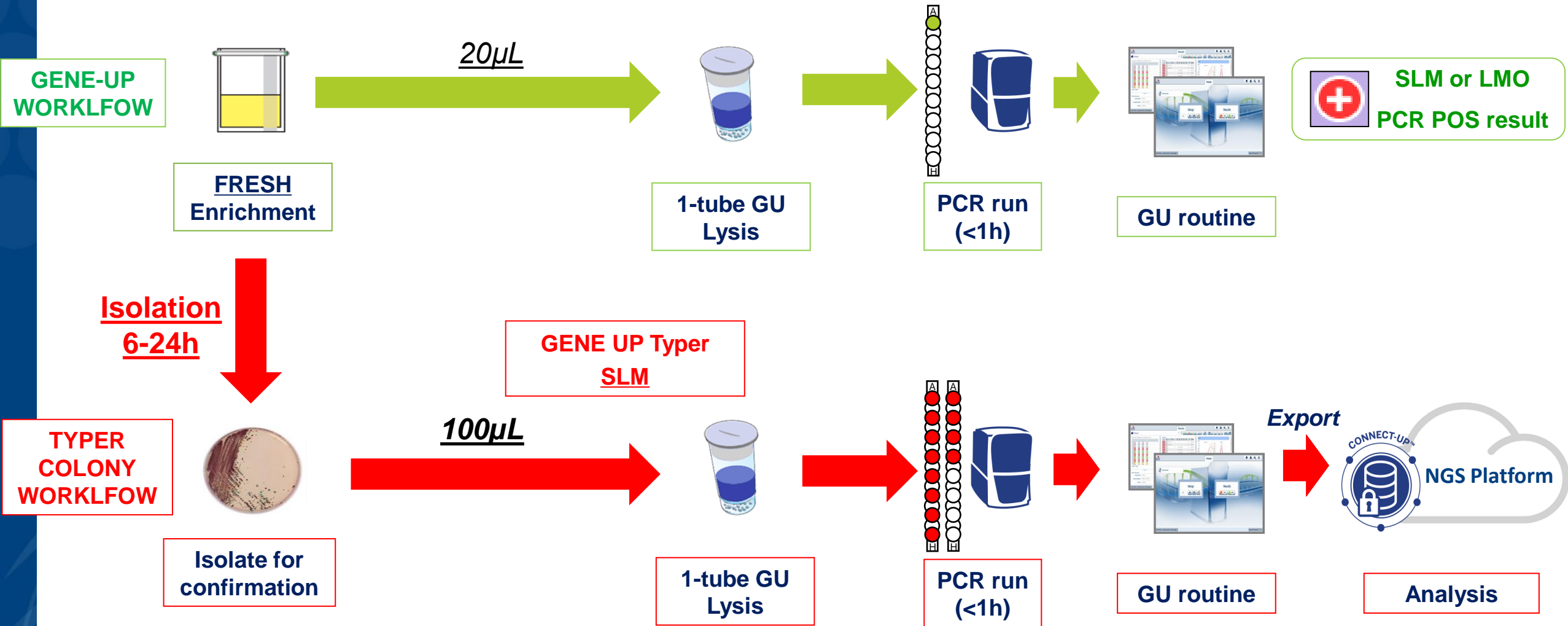
ST87

GENE UP TYPER

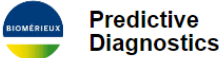
GENE-UP TYPER WORKFLOW – AS SIMPLE AS IT CAN BE



GENE-UP TYPER WORKFLOW – AS SIMPLE AS IT CAN BE



GENE-UP TYPER WEB APPLICATION: SAMPLES

 **Predictive Diagnostics**

Samples

Clusters

Notifications

JD

Search

Upload

Some samples have improperly formatted dates, please correct them.

SampleID	Source	Sampling Date	Sampling Point	Product	Site	Upload	Cluster
<input type="checkbox"/> Demosample_1		Not specified				06/21/2023	Unique
<input type="checkbox"/> Demosample_43	→ Finished product	04/13/2023	Ripening	Cheese	A	06/12/2023	L11G50
<input type="checkbox"/> Demosample_54	→ Environment	03/07/2023	Moulding		A	06/12/2023	Unique
<input type="checkbox"/> Demosample_44	→ Finished product	04/14/2023	Packing	Cheese	A	06/12/2023	L11G50
<input type="checkbox"/> Demosample_56	Raw material	02/07/2023	Storage tank		A	06/12/2023	Undetermined
<input type="checkbox"/> Demosample_51	Finished product	03/11/2023	Packing	Cheese	A	06/09/2023	L11G368
<input type="checkbox"/> Demosample_labstrain_dairy		Not specified				06/09/2023	L11G62
<input type="checkbox"/> Demosample_36	→ Environment	04/07/2023	Curd cutting		A	06/09/2023	L11G50
<input type="checkbox"/> Demosample_35	→ Raw material	04/13/2023	Storage tank		B	06/09/2023	L11G50
<input type="checkbox"/> Demosample_50	Finished product	03/11/2023	Ripening	Cheese	A	06/09/2023	L11G368
<input type="checkbox"/> Demosample_46	Environment	03/09/2023	Curd cutting		A	06/09/2023	L11G368
<input type="checkbox"/> Demosample_52	Environment	02/02/2023	Curd stirring		B	06/09/2023	Unique
<input type="checkbox"/> Demosample_45	Environment	03/07/2023	Curd cutting		A	06/09/2023	L11G368
<input type="checkbox"/> Demosample_40	→ Environment	04/09/2023	Moulding		A	06/09/2023	L11G50

BIOMÉRIE

1 2

GENE-UP TYPERWEB APPLICATION: CLUSTERS



Predictive Diagnostics



Samples



Clusters



Notifications

Search

JD

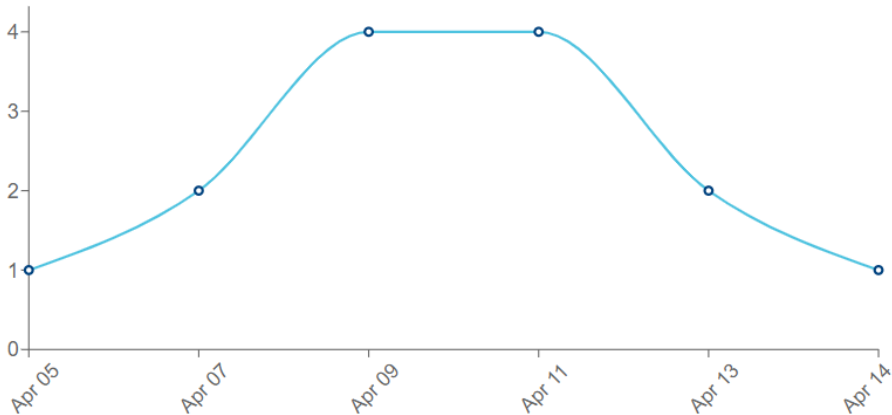
Cluster: L11G50

Seen for the first time: 04/05/2023 Seen for the last time: 04/14/2023 Number of samples: 14

A cluster is based on the genetic relatedness of a sample with others.



Evolution of the cluster



Distribution of *Listeria* samples



Sample Identifier	Source	Sampling Date	Sampling Point	Product	Site	Upload
Demosample_44	Finished product	04/14/2023	Packing	Cheese	A	06/12/2023
Demosample_35	Raw material	04/13/2023	Storage tank		B	06/09/2023
Demosample_43	Finished product	04/13/2023	Ripening	Cheese	A	06/12/2023
Demosample_41	Finished product	04/11/2023	Ripening	Cheese	A	06/09/2023
Demosample_39	Environment	04/11/2023	Curd cutting		A	06/09/2023

CASE STUDY - FROM INSIGHT TO ACTION

Augmented Diagnostics with GENE-UP® TYPER for root cause analysis of *Listeria monocytogenes* in the production of raw milk products.

BACKGROUND

A dairy product producer needed to assess the quality of milk upon arrival to make rapid decisions

Listeria monocytogenes is the key contaminant of concern in raw milk. Testing the presence of this contaminant is crucial to the decision of the production team. Raw-milk based products have a higher value than pasteurized milk based products. As such, they were looking for a **rapid and reliable diagnostics tool**.

In some cases, *L. monocytogenes* was also found in final products after the milk had been cleared for production.

On top of this, the company wanted to have in house typing capability to **identify the origin** to **root cause analysis**.

How do we obtain rapid reliable results in house?

Are there different strains contaminating the raw milk?

Are the final products' contaminants coming from raw milk, from other raw materials or even from the environment?

RESULTS

GENE-UP® TYPER is rapid decision making tool based on easy, fast and reliable insight and identification of the source of contamination.

- Production environment risk**
Better discrimination of raw milk suppliers thanks to a simple **in-house tracking of related strains**, without waiting for external lab results.
- Extended environment assessment**
Faster understanding on whether the contamination is **resident or transient** led to an improved environmental control and **root cause analysis**.
- The Value**
Thanks to fast typing results, the company was able to optimize their raw milk cheese production, **generating hundreds of thousands of euros**.

METHOD

bioMérieux provided a 2 in 1 solution for routine detection and typing.

While GENE-UP® granted conduction of in house routine testing, they were particularly interested in a tool allowing **root cause analysis** and understanding past contaminations. Within the Augmented Diagnostics approach, the quality team expressed interest in GENE-UP-TYPER®.

Based on selected genetic markers of the pathogen, **GENE-UP® TYPER predicts the strain's genome using an underlying reference genome database**. The solutions allows for higher resolution information **24 hours after positive detection or 1 hour from a colony**, more efficient root cause analysis through strain clustering

CONCLUSION

GENE-UP® TYPER is a component in an advanced solutions system called Augmented Diagnostics

- By partnering with bioMérieux, the company was rapidly able to identify contaminated milk tanks to produce higher value raw milk based products.
- GENE-UP® TYPER use resulted in better root cause analysis.
- GENE-UP® TYPER allowed the company to provide consumer with safe and high quality products with a tracability based on typing.

biomerieux.com
Learn more about our Augmented Diagnostics Approach.

PATHOGEN MAPPING

PATHOGEN MAPPING FROM BIO-INFORMATICS TO ACTIONABLE INSIGHTS



**Which strain(s) is it?
True contamination or lab cross
contamination?**



**Persistent strain/biofilm in my
factory?**



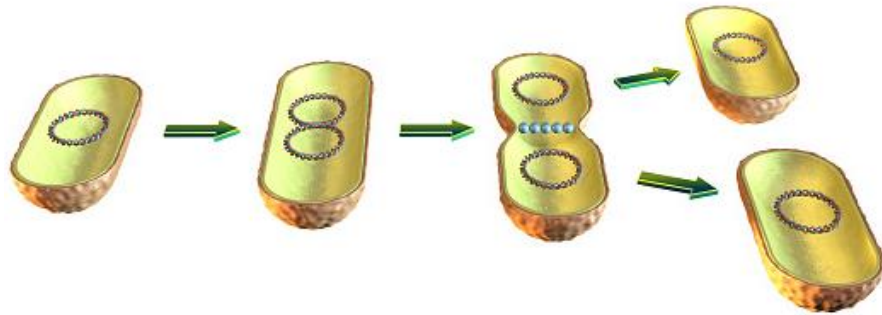
Biocide resistance issues?



**Supplier raw material
introducing pathogen?**

GET TO KNOW YOUR STRAINS :

Strain mutation in environment



- Microbes grow by dividing
- For each division DNA is copied
- Mistakes (changes) are made during this copying, at a fairly stable rate
- The **number of changes** therefore gives an idea on **how long and how well** a particular microbe has been growing

→ **Few differences** → **persistent strain, it's found a niche in the environment**

→ **Many differences** → **unrelated** microbes

Biocide Resistance



- Genes presence or absence in a Microbe helps know its resistance to stress :
 - Thermal
 - Biocides
 - Metallic etc.

→ **Better know how to handle your contaminants**

PATHOGEN MAPPING : GET A CLEAR EXPLANATION !

Genomics results can be complex :

Salmonella isolates for sequencing

Salmonella Enteritidis	
Sample	Register number LVL
SAMPLE-01A-2303	23-015 ^A EECAE
SAMPLE-02B-2301	22-497
SAMPLE-04A-2304	21-489
AREA-45C-2212	22-894
SAMPLE-05D-2301	15-459

MLST (multilocus sequence typing):
Includes the analyse of seven genome-loci (housekeeping genes): *aroC*, *dnaN*, *hemD*, *hisD*, *purE*, *sucA* and *thrA*.

Salmonella Enteritidis		<i>aroC</i>	<i>dnaN</i>	<i>hemD</i>	<i>hisD</i>	<i>purE</i>	<i>sucA</i>	<i>thrA</i>	ST (sequence type) S. enterica MLST	Complex Type S. enterica cgMLST
SAMPLE-01A-2303		5	2	3	7	6	6	11	11	1702
SAMPLE-02B-2301		5	2	3	7	6	6	11	11	5327
SAMPLE-04A-2304		5	2	3	7	6	6	11	11	6508
AREA-45C-2212		5	2	3	7	6	6	11	11	6508
SAMPLE-05D-2301		5	2	3	7	6	6	11	11	216

Salmonella Typhimurium		<i>aroC</i>	<i>dnaN</i>	<i>hemD</i>	<i>hisD</i>	<i>purE</i>	<i>sucA</i>	<i>thrA</i>	ST (sequence type) S. enterica MLST	Complex Type S. enterica cgMLST
SAMPLE-025A-2307	21-5584									
AREA-044F-2211	25-1549									
SAMPLE-026T-2301	20-2854									
SAMPLE-152E-2302	23-2854									

Distance matrix:

	1	2	3	4	5	6	7	8	9
1. SAMPLE-01A-2303	0	206	239	205	205	2,501	2,501	2,501	2,501
2. SAMPLE-02B-2301	206	0	274	50	50	2,508	2,508	2,507	2,508
3. SAMPLE-04A-2304	239	274	0	270	270	2,507	2,507	2,506	2,507
4. AREA-45C-2212	205	50	270	0	0	2,507	2,507	2,506	2,507
5. SAMPLE-05D-2301	205	50	270	0	0	2,507	2,507	2,506	2,507
6. SAMPLE-025A-2307	2,501	2,508	2,507	2,507	2,507	0	0	5	0
7. AREA-044F-2211	2,501	2,508	2,507	2,507	2,507	0	0	5	0
8. SAMPLE-026T-2301	2,500	2,507	2,506	2,506	2,506	5	5	0	5
9. SAMPLE-152E-2302	2,501	2,508	2,507	2,507	2,507	0	0	5	0

Our bio-Informatic experts are here to make it clear :



Simplified report focusing on your main questions :

- What is this strain ?
- Have I seen this strain before ?
- Strain characteristics : Why is it here ?
- How can I get rid of it ?



Online meeting to present the results for each investigation

PATHOGEN MAPPING: OVERALL PROCESS

Sample collection

Product compatibility to be checked with the technical TEAM



Sample shipment

Final products can be shipped at their normal temperature: shelf stable products at ambient temp, cooled products with cooling blocks (4°C) and frozen products on dry ice.



Sequencing

Shallow shotgun sequencing is performed by bMx' sequencing provider.



Data analysis

Bioinformatics pipeline and result interpretation is performed by our Augmented Diagnostics TEAM



Report

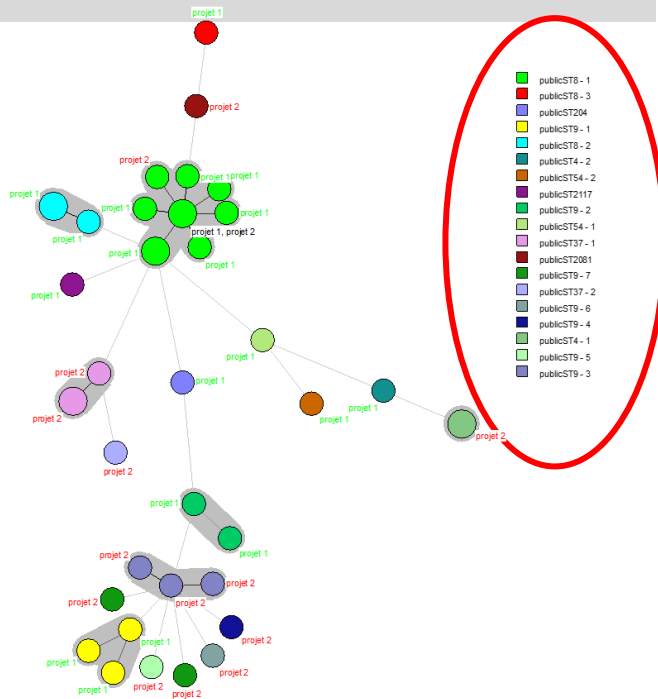
A report of the analysis is provided to the customer and will be discussed during the restitution meeting with our experts.



CASE STUDY: BEEF LEADER-LISTERIA

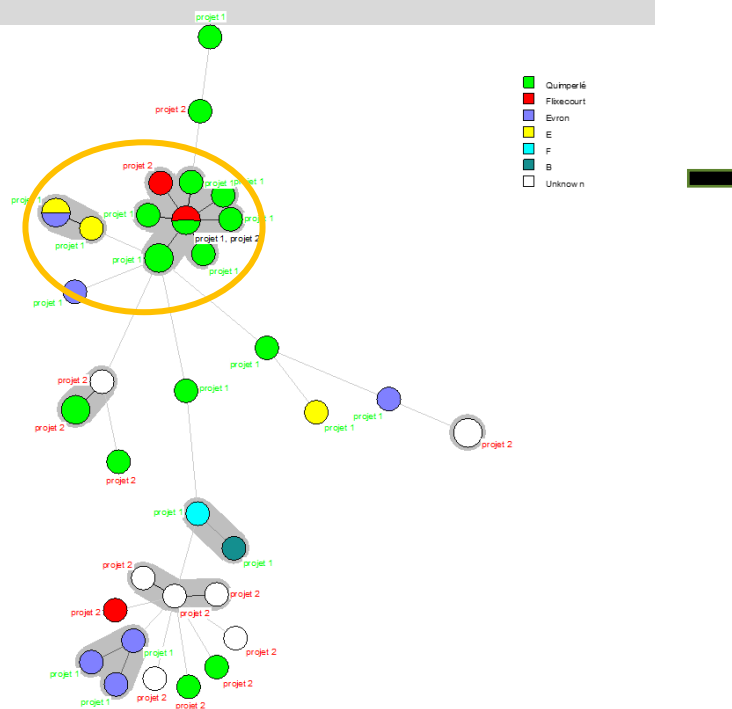
39 Listeria Positives

- Is it the same strain?
- Or something new every time?



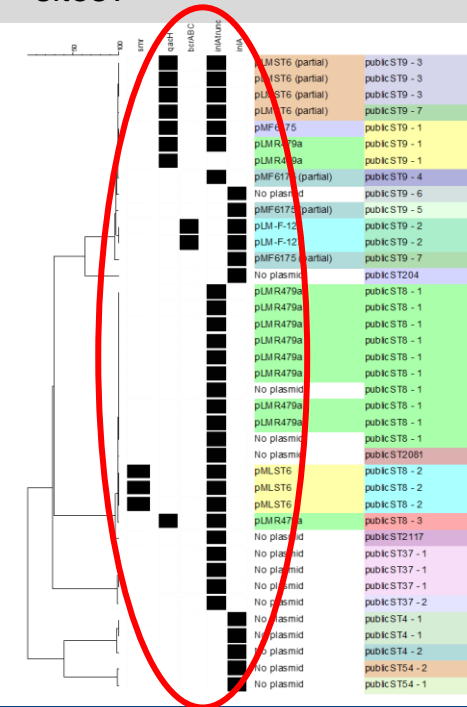
Found in Different Places

- Do we have contamination between sites?



Recurring Despite Mitigation

- Why do we find the same strain over time?
- Why is it spreading through different sites?

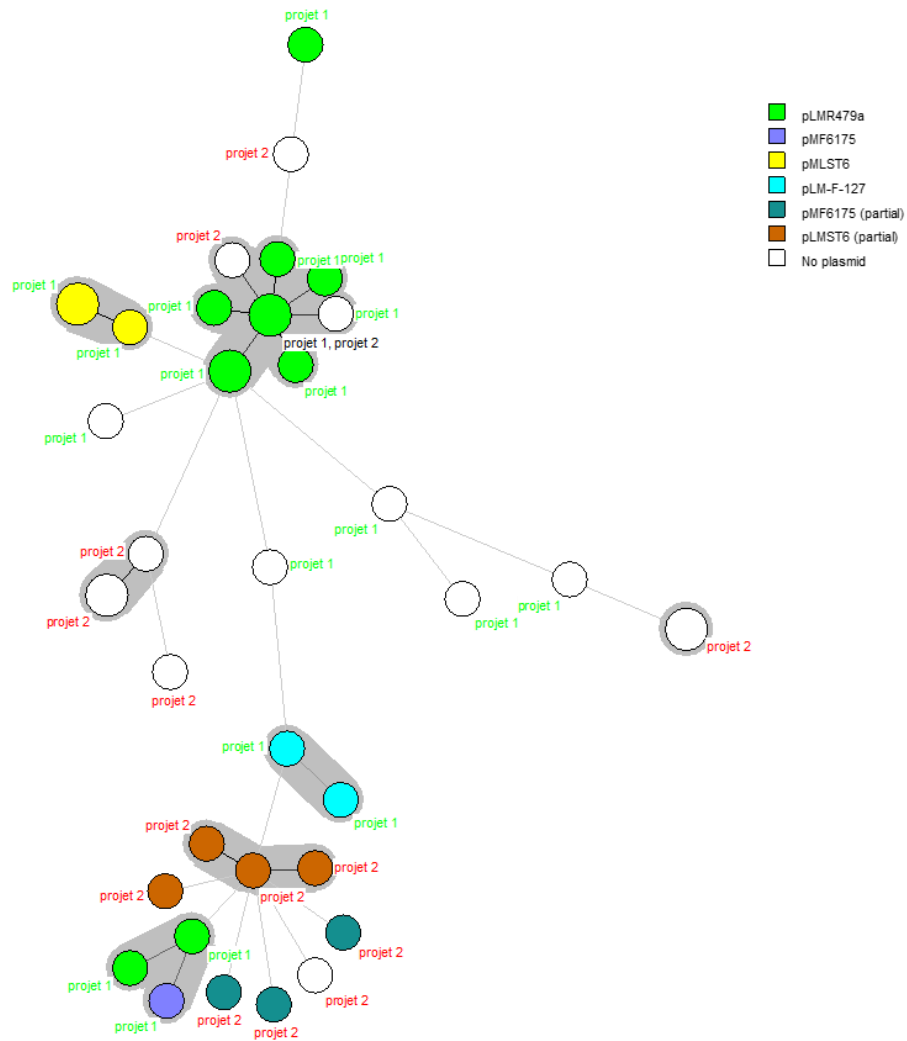


- The 39 isolates come from 19 strains
- 11 strains are transient (found one time in one place)
- Some strains are recurring, with a common source for some of them

- Site green and red are contaminated with the same strain
- Same for site purple and yellow

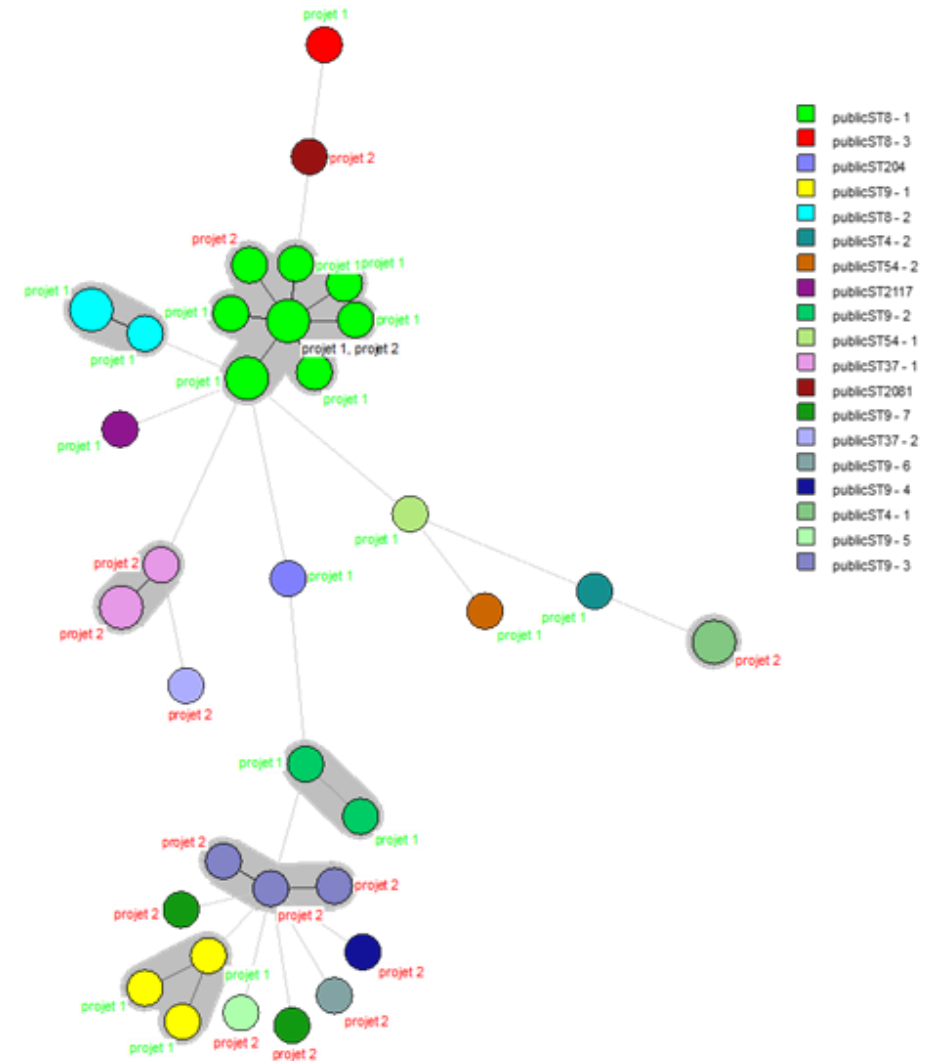
- Strain is resistant to multiple metals, classic for Listeria
- 3 different resistant gene to QAC are found, 2 in a Plasmid (smr, bcrABC)

CASE STUDY: BEEF LEADER-LISTERERIA



BIOCIDE RESISTANCE: Plasmid transmission

- How the resistance gene are spreading?
- Do we have contact between strains in the past?



- When we are facing plasmid transmission, strains are/were in the same place
- Plasmid pLMR479a is found in ST8-3, ST8-1 and ST9-1

CASE STUDY: BEEF LEADER-LISTERIA

- Pathogen Mapping demonstrated the contamination between Environment and Finish products, and the contamination cross sites. **Knowledge based has been built.**
- Gene-Up Typer gives a very precise information with high accuracy (same group as WGS) in a short time, and **is now fully adopted for investigation.**

Problem identified, understood and solved

ROOT CAUSE ANALYSIS : PATHOGEN INVESTIGATION

Routine analyses



Time is key



Insight needed to enable decision taking



POSITIVE RESULTS

CONTROL PLAN

STOP PRODUCTION



DECISION TO INVESTIGATE

LMO or SLM

GU TYPER



✓ WHAT

✓ WHERE

✓ WHAT TO DO

TAKE ACTION

Enough information to take 1st decision

CONTINUOUS IMPROVEMENT

Get a better understanding of your Pathogens

PATHOGEN MAPPING



Start today to build your strain Database for Tomorrow !



WGS



Expert support for root cause

GENE-UP Typer

Have I seen this *Listeria Mono* or *Salmonella** before ?

Clustering of pure bacterial pathogen isolates in raw materials, the product and factory environment.

**Salmonella Enterica subsp. Enterica*

Other Pathogens

Feed the approach

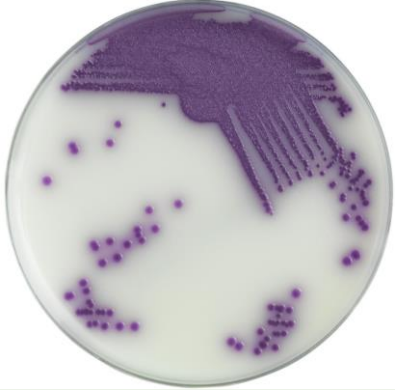
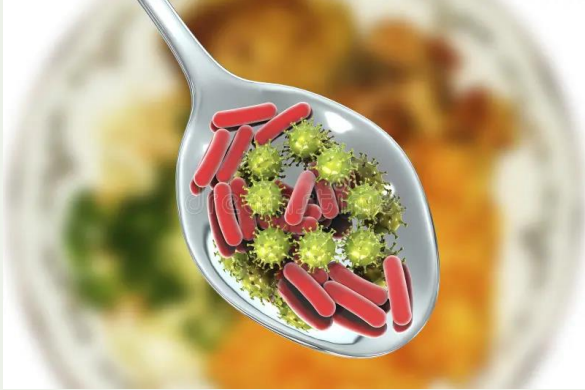
PATHOGEN MAPPING

Have I seen this pathogen isolates before ?

Root cause analysis of pure bacterial pathogen isolates in raw materials, the product and factory environment

SPOILER ISSUE

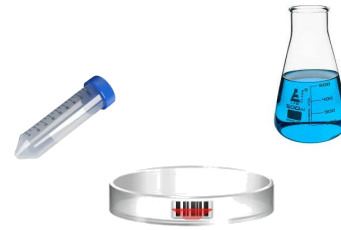
SPOILAGE MICROORGANISMS ARE NOT EASY

Spoiler Mapping When we know the spoilage	Meta-genomics When we don't know the spoilage
analysis of genomic DNA from an individual organism or cell	analysis of genomic DNA from a whole community
	
↓ Bacteria Yeast	↓ Bacteria (incl. phages) Viruses Fungi

- Metagenomics: the study of genetic material recovered directly from food samples, bypassing the need for isolation and lab cultivation of strains.

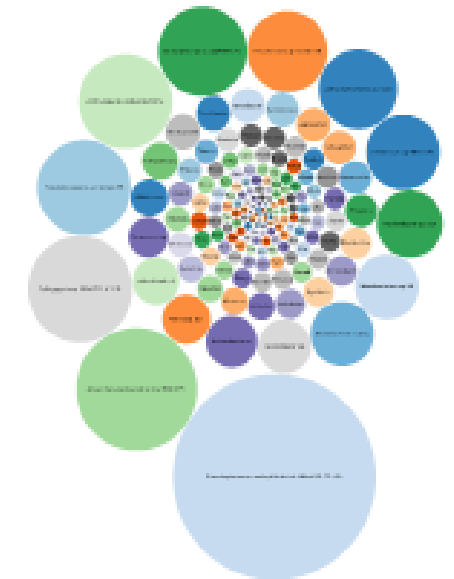
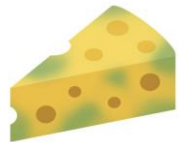
SPOILAGE DISCOVERY TO ID CAUSE OF SPOILAGE

- Many spoilers are non-culturable
- Enrichment bias



Traditional Enrichment & Plating

→ **Shallow Shotgun Metagenomics**
Whole microbiome, no bias



FROM BIO-INFORMATICS TO ACTIONABLE INSIGHTS :



What microorganisms are found in my sample?



What is their abundance ?



What are they doing ?



Who matters ?

MICROBIOME DISCOVERY REPORT(S)

A bunch of files

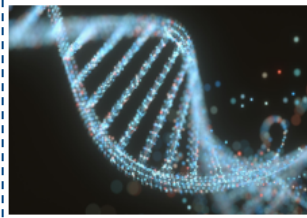
- 154122_abundance_table_with_FP_filter.xlsx
- A1_102433_FPcheck_S_bracken_report.txt
- A1_102433_G_bracken_report.txt
- A1_102433_kraken_report.txt
- A1_102433_kraken_report_bracken_species.txt
- A1_102433_log_minimizer_spread.png
- A1_102433_S_bracken_report.txt
- B1_102435_FPcheck_S_bracken_report.txt
- B1_102435_G_bracken_report.txt
- B1_102435_kraken_report.txt
- B1_102435_kraken_report_bracken_species.txt
- B1_102435_log_minimizer_spread.png
- B1_102435_S_bracken_report.txt

	A	B	C
1	name	relative abundance 33	relative abundance 35
2	Bacillus badius	0,27	
3	Cutibacterium modestum	0,04	0,03
4	Homo sapiens	0,37	0,31
5	Margalitia camelliae		0,20
6	Niallia circulans	35,25	36,10
7	Niallia nealsonii	0,62	0,59
8	Niallia taxi	0,43	0,37
9	Oceanobacillus massiliensis	0,15	
10	Peribacillus acanthi	0,16	0,18
11	Priestia veravalensis	0,18	
12	unclassified	52,39	51,02
13	false positives	10,16	11,21

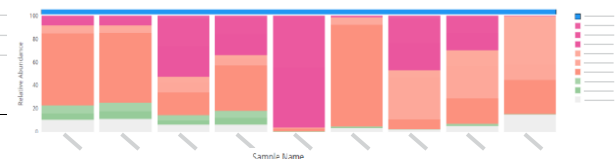
name	taxonomy_id	taxonomy_lvl	kraken_assigned_reads	added_reads	new_est_reads	fraction_total_reads
Homo sapiens	9606.0	S	9833.0	3166.0	12999.0	0.00777 0.37000771383109843 366279.0 128729.0
Cutibacterium modestum	2559073.0	S	1171.0	273.0	1444.0	0.00086 0.041102480096323266 56096.0 18973.0
Niallia circulans	1397.0	S	1117339.0	121076.0	1238415.0	0.74033 35.25064258205553
Niallia taxi	2499688.0	S	14437.0	723.0	15160.0	0.009059999999999999 0.4315191123686016 152021.0
Peribacillus acanthi	2171554.0	S	5206.0	353.0	5559.0	0.0033200000000000005 0.158233162642286
Niallia nealsonii	115979.0	S	21191.0	420.0	21611.0	0.01292 0.6151424496964281 154929.0
Bacillus badius	1455.0	S	7841.0	1543.0	9384.0	0.00561 0.2671091919833085 209358.0 1322.0 0.0063
Oceanobacillus massiliensis	1465765.0	S	4152.0	1053.0	5205.0	0.0031100000000000004 0.14804293558239426 36273.0
Priestia veravalensis	1414648.0	S	2852.0	3303.0	6155.0	0.0036799999999999997 0.1751978981945081
Cytobacillus kochii	859143.0	S	4604.0	297.0	4901.0	0.00293 0.1395036391634905 62556.0 578.0
Priestia megaterium	1404.0	S	3700.0	1501.0	5201.0	0.0031100000000000004 0.14804293558239426 36273.0
Enterococcus faecium	1352.0	S	3299.0	5554.0	8853.0	0.0052899999999999996 0.25199463732184896 159613.0
Neobacillus drementensis	220684.0	S	2077.0	570.0	2647.0	0.00158 0.07534505873612721 16217.0 448.0
Bacillus subtilis	1423.0	S	6944.0	12120.0	19064.0	0.0114 0.5426438230999354 207939.0 433.0
Bacillus cereus	1396.0	S	4698.0	9950.0	14648.0	0.0087599999999999999 0.4169453798136725 20204.0 365.0
Bacillus mediterraneensis	1805474.0	S	2908.0	126.0	3034.0	0.0018100000000000002 0.086360751116
Mesobacillus maritimus	1643336.0	S	3060.0	182.0	3242.0	0.0019399999999999999 0.09228132996695292



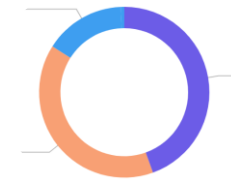
REPORT-METAGENOMICS



EXECUTIVE SUMMARY



ORGANISM	FEATURES	Growth T / pH
<i>Tepidiphilus thermophilus</i> (https://doi.org/10.1099/ijs.0.056424-0)	Gram-negative, monotrichous, non-sporulating, irregular rods. Grow aerobically and anaerobically only with nitrate. Nitrate is reduced to nitrite	30–60 °C, optimum at 50–55°C, pH 5.5–7.5
<i>Tepidiphilus succinatimandens</i> (former <i>Petrobacter succinatimandens</i>) (https://doi.org/10.1099/ijs.0.02732-0)	Gram-negative, aerobic and moderately thermophilic. Non-spore-forming straight rods, motile by means of a polar flagellum. They grow in the presence of oxygen or nitrate as terminal electron acceptor. Nitrate is reduced to nitrous oxide Growth medium DSMZ 979 (http://www.dsmz.de) PETROBACTER SUCCINATIMANDENS MEDIUM Media MediaDive (dsmz.de)	55°C, pH 6.9
<i>Tepidiphilus margaritifera</i> (https://doi.org/10.1099/ijs.0.025)	Type species of the genus <i>Tepidiphilus</i> . Gram-positive rods. Do not form endospores and are	25–61°C, optimum at 50°C, pH 6.8



- What microorganisms are found in my sample?
- What is their abundance?
- Who matters?
- What are they doing?

CASE STUDY: UHT MILK WITH CACAO



Ambient°C

**Blown
package+smell
& taste**



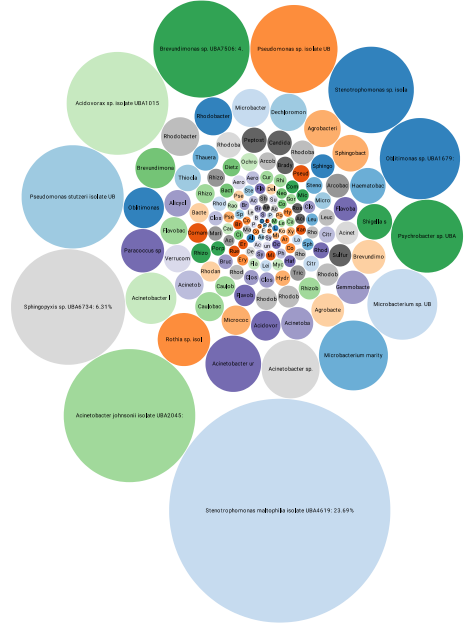
**Could Not ID
Spoilage**

Traditional Enrichment & Plating

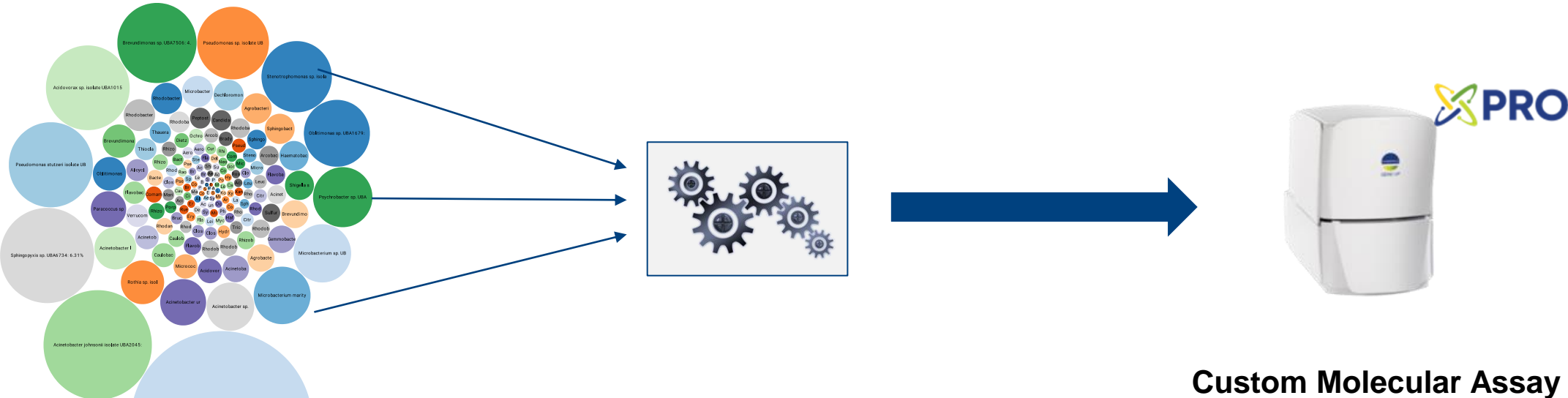
CASE STUDY: UHT MILK WITH CACAO



Thermophilic spore forming Bacteria: **Niallia**



XPRO: CUSTOM MOLECULAR ASSAY



Custom Molecular Assay

Possibility of creating customized kits according to customer needs. Development plan created collaboratively and financed by the client himself. Due to the XPRO project, around 10 new customized kits are currently developed every year.

COMPLETED xPRO PROJECTS

Innovation: GENE-UP NUTRAPLEX PRO for detection of *Salmonella*, *Staphylococcus*, and *E. coli* in nutraceutical products

Industry/Quality Impact: to run one test vs. 3 with one enrichment media driving down costs and improving lab efficiencies.

Herbalife Nutrition



Jackson Family Wines



Innovations: VINOBRETT, on-site detection of *Brettanomyces*, and BOTTLESAFE, onsite verification of final filtration

Industry/Quality Impact: Reduced time to result for *Brettanomyces* and common wine spoilage organisms to 4 hours from 2-10 days

Innovation: GENE-UP HRM for detection of heat-resistant molds.

Industry/Quality Impact: Reduces time to detect common HRM in 3 days vs. 15 days preventing shipping product at risk.

Ocean Spray



Mérieux NutriSciences



Innovation: Veriflow GFP, detection of GFP-tagged *Salmonella*, *Listeria*, and *E. coli* for use as a positive control

Industry/Quality Impact: Allows MXNS to detect cross-contamination events in < 2 hours vs. 24 hours

Innovations: BREWPAL for detection of hop-resistant pediococca and lactobacillus.

Industry/Quality Impact: Allows industry to detect common beer spoilage organisms in hours vs. days and to identify true spoiler from non-spoiler.

Victory Brewing



BODYARMOR

Body Armor

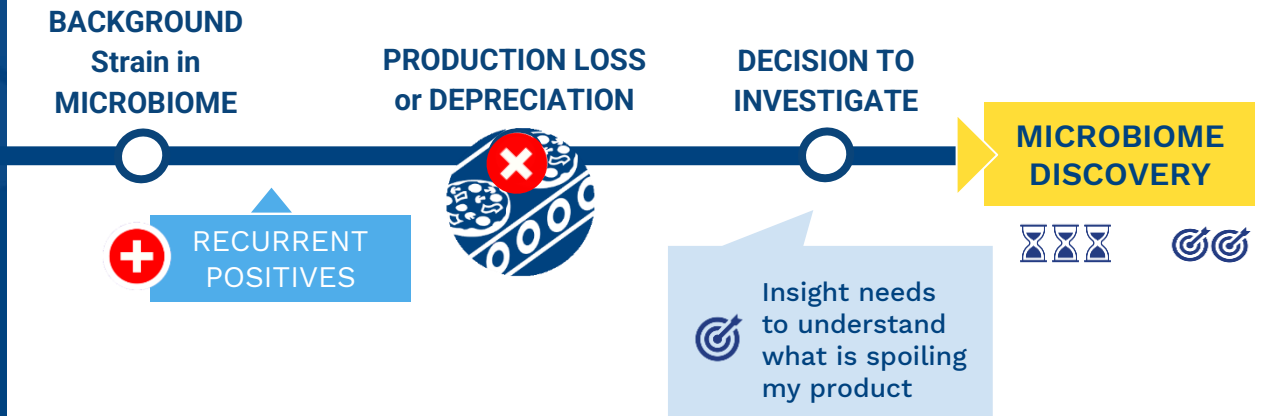
Innovations: Developed two assays (GENE-UP PRO BEVERAGE BACTERIA, GENE-UP PRO BEVERAGE YEAST) for detection of extremophilic organisms that survive in high-acid products and high-temp pasteurization.

Industry/Quality Impact: Reduced final micro clearance down from 5 days to 2 days and eliminated spoilage events not covered by conventional micro methods

xPRO Industry Projects

ROOT CAUSE ANALYSIS : SCENARIO 2 – MICROBIOME DISCOVERY

Investigation tools



MICROBIOME DISCOVERY

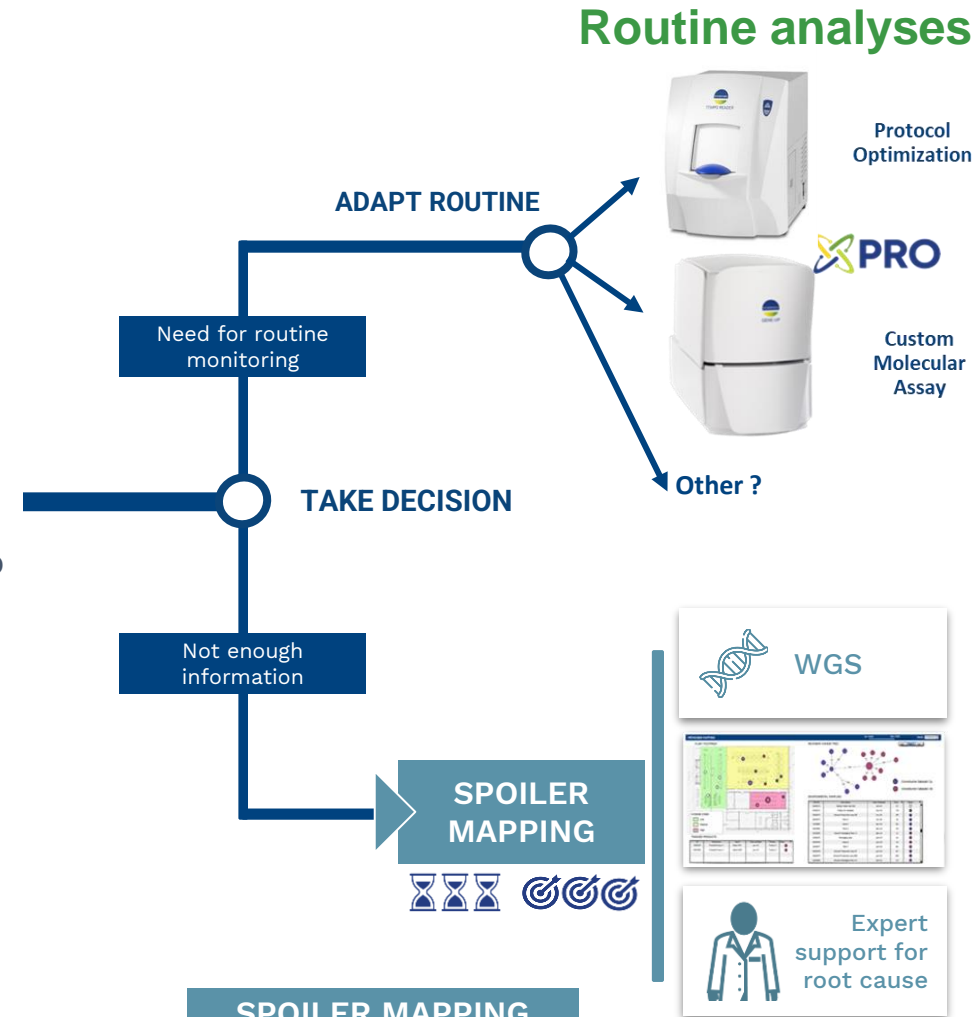
What is in my food sample?

Identification of pathogens / spoilers from a beverage, dairy or solid food sample* containing a **mixture of organisms**

* For water samples, please contact food.genomics@biomerieux.com to assess feasibility of such projects

BIOMÉRIEUX

- ✓ WHAT IS IT
- ✓ WHAT TO DO



SPOILER MAPPING

Have I seen this spoiler isolate before?

Root cause analysis of **pure bacterial and fungal* spoiler isolates** in raw materials, the product and factory environment

* Contact food.genomics@biomerieux.com to find out which fungal spoilers are supported

ROUTE CAUSE ANALYSIS SUMMARY

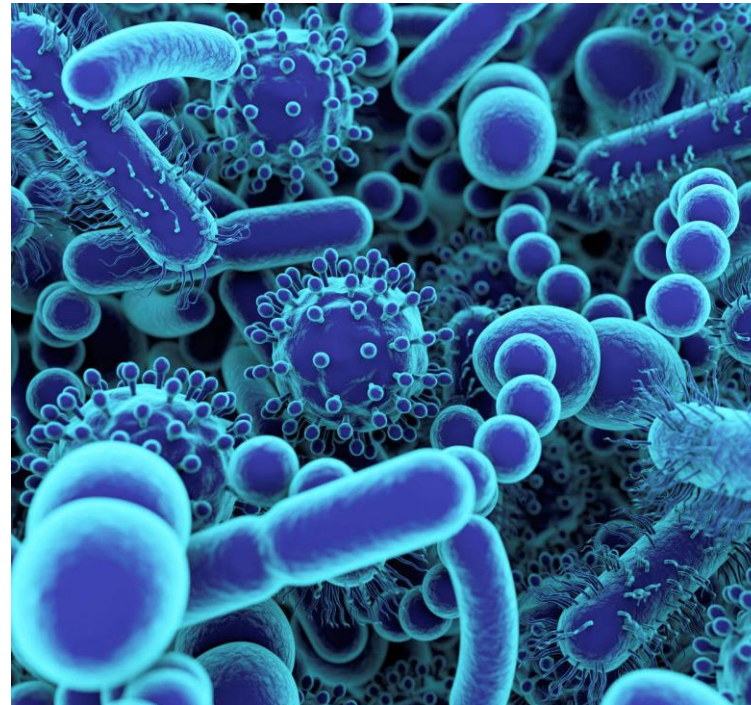
THE RIGHT GENOMIC TOOL FOR THE RIGHT INVESTIGATION :



PATHOGEN MAPPING

Have I seen this pathogen before?

Root cause analysis of bacterial pathogen isolates in raw materials, the product and factory environment

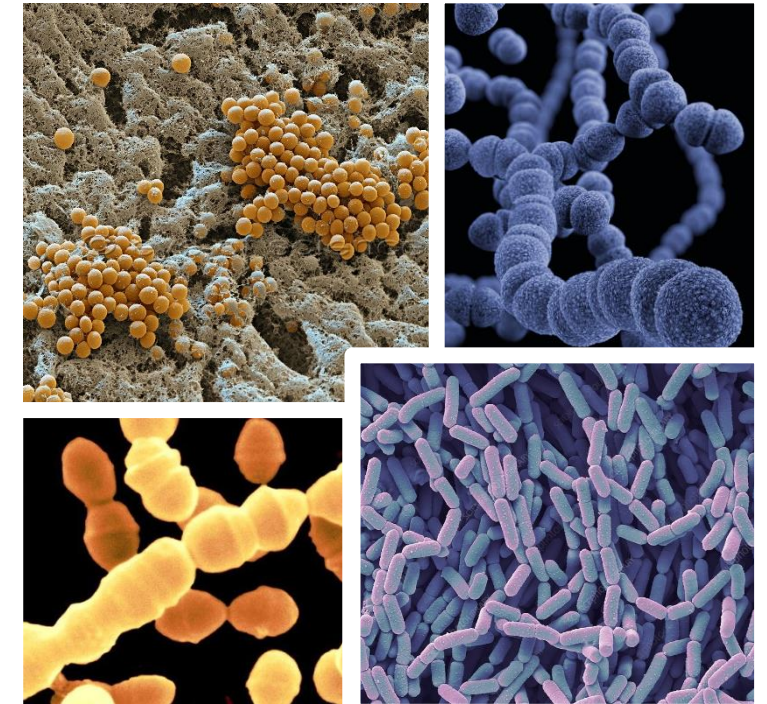


MICROBIOME DISCOVERY

What is in my sample?

Identification of pathogens / spoilers from a beverage, dairy or solid food **sample* containing a mixture of organisms**

* No service procedures are yet in place for water samples, please contact food.genomics@biomerieux.com to assess feasibility of such projects



SPOILER MAPPING

Have I seen this spoiler before?

Root cause analysis of bacterial and fungal* spoiler isolates in raw materials, the product and factory environment

* Contact food.genomics@biomerieux.com to find out which fungal spoilers are supported

ROOT CAUSE ANALYSIS SUMMARY

Vidas/GENE-UP : routine testing



Is there a pathogen? Which one is it?



Can I release my final product?



Is my environment & RM free of pathogens?
Can I start the production process without risk?

Pathogen Detection

GENE-UP Typer: Take fast decisions



True contamination or lab cross contamination?



Have I seen this strain before?



Identify potential sources of contamination ?

Pathogen Clustering

WGS: Root cause seeking investigation



Who/What is this strain(s)?



Persistent strain/biofilm in my factory?



Biocide resistance issues?

Pathogen Mapping

From discovery / detection.....to precision ID/mapping

Spoiler Detection

GENE-UP xPRO Assay: Customized Routine testing



Is my production batch at risk ?



Should I repurpose my product or raw material ?

Microbiome Discovery

Metagenomics : Understanding the Environment, product, or RM microbiome



What Microorganisms are living in my factory ?



Do I have some microbial background noise ?

Spoiler Mapping

WGS: Root cause seeking investigation



Have I seen this strain before?

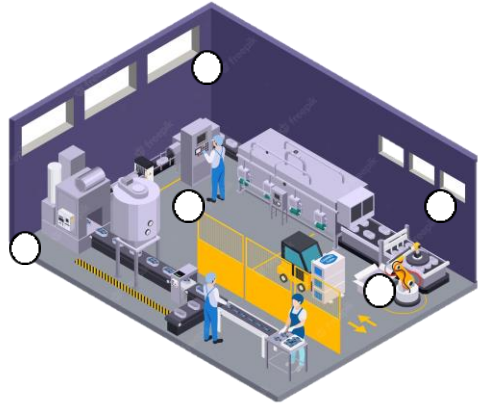


Is the spoiler resisting to cleaning treatments ?

ENVIRONMENTAL MONITORING

IMPROVE YOUR DAY TO DAY CONTROLS:

Production Environment



Finish Product



● *Listeria monocytogenes*



No positives in my environment, where is the contamination coming from ?



Is my Environmental Monitoring Program targeting the right locations ?



Where do I clean ?



IMPROVE YOUR ENVIRONMENTAL MONITORING PROGRAM :



EMP eLearning

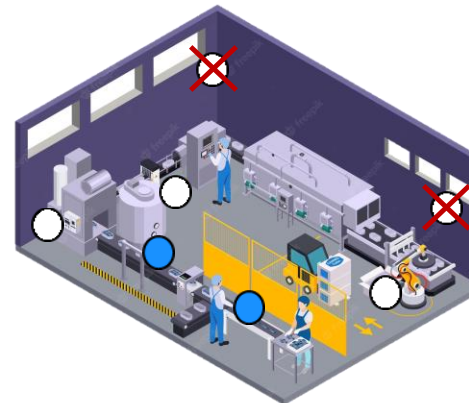


Expert services consultancy



Webinars

Production Environment



Finish Product



Remove low value locations

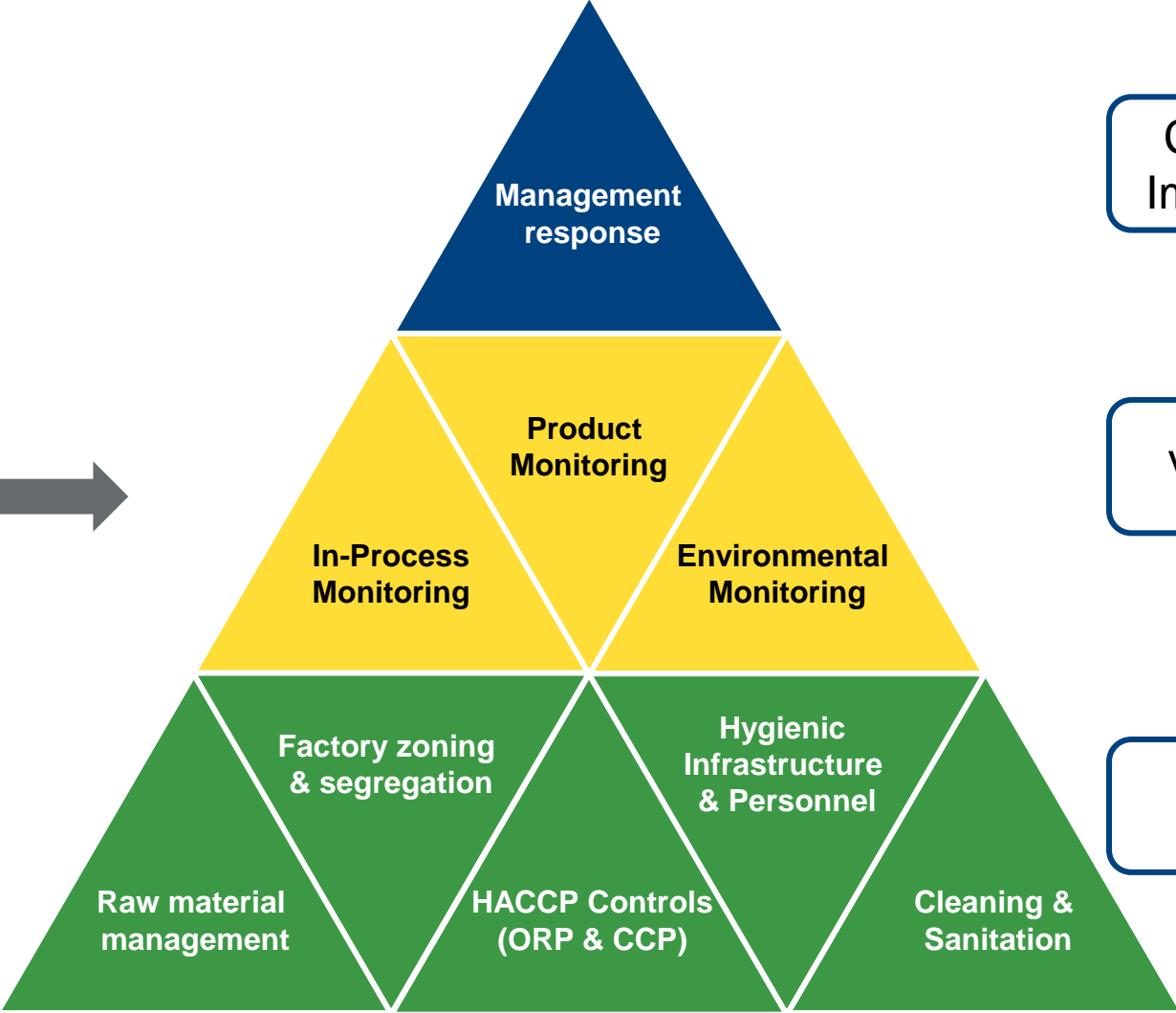


Stop only the production lines impacted



WHY ENVIRONMENTAL MONITORING?

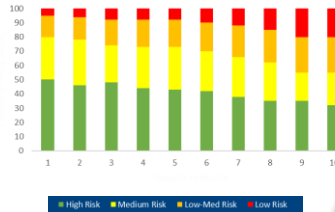
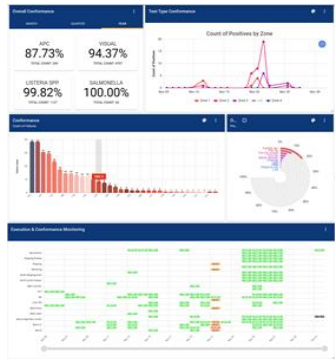
The purpose of **Environmental Monitoring** is to verify our food safety controls are working!



©

EMPOWER YOUR ENVIRONMENTAL MONITORING PROGRAM :

DATA MODELS & SERVICES



CONSULTING SERVICES

EMP TRAINING



Optimization

Strategy/
Planning

PATHOGEN MAPPING

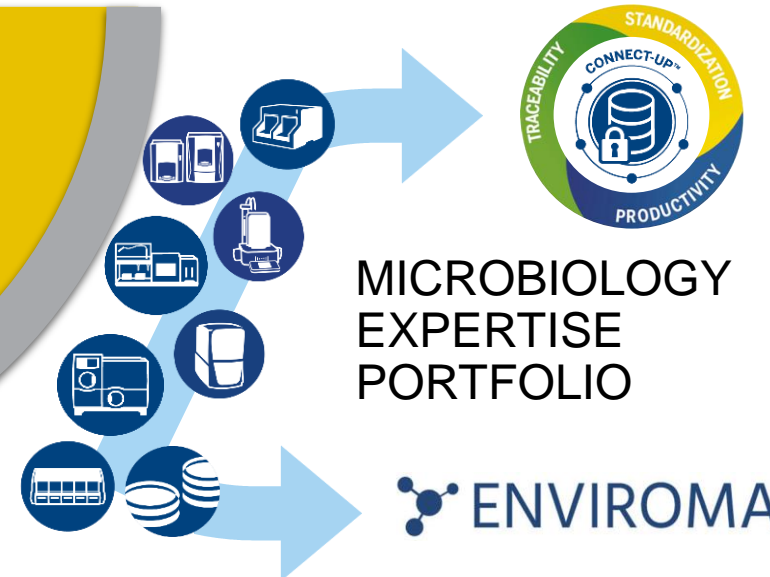
GENE-UP® TYPER

SPOILER MAPPING

SPOILER INVESTIGATION

Problem
Solving

Execution



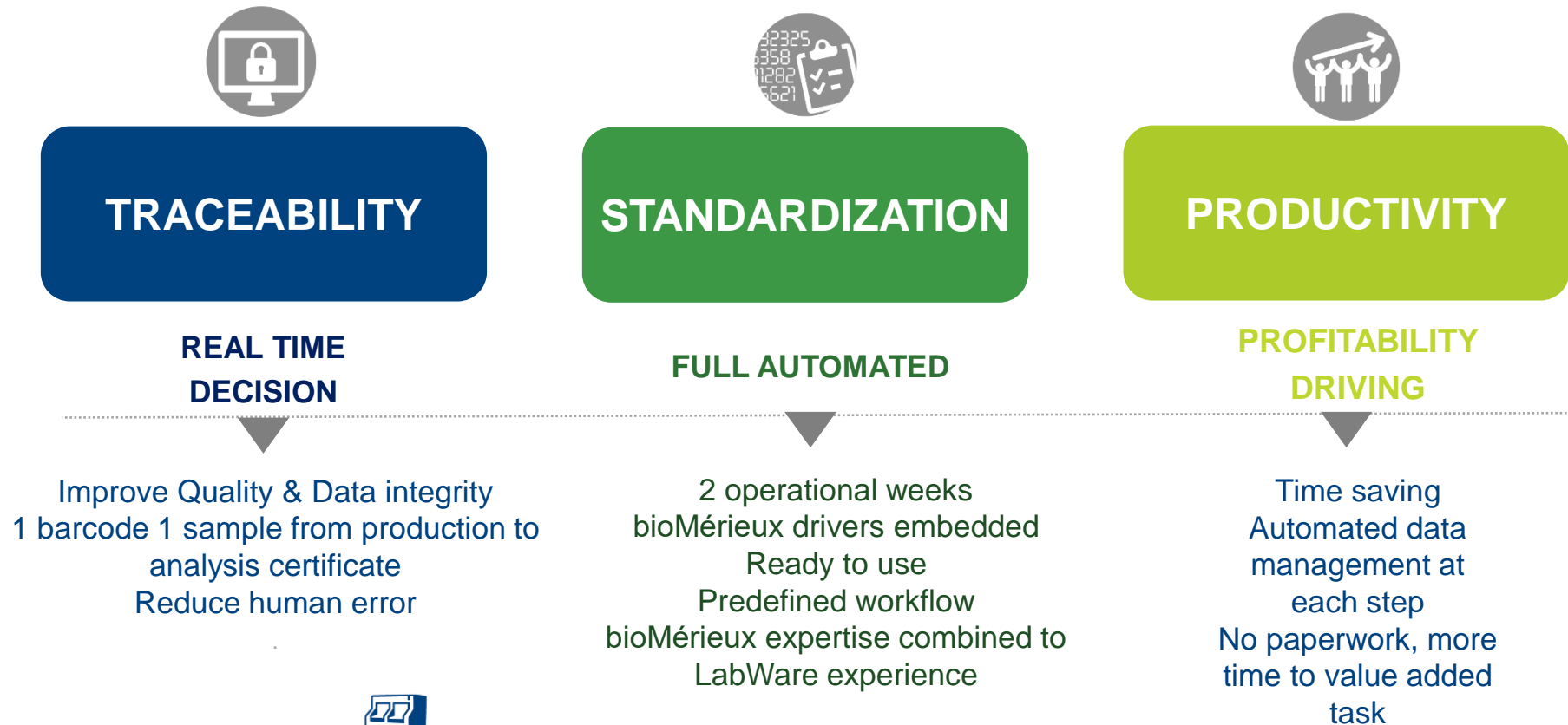
E-LEARNING ENVIRONMENTAL MONITORING FOR PATHOGENS

DIGITAL APPLICATIONS

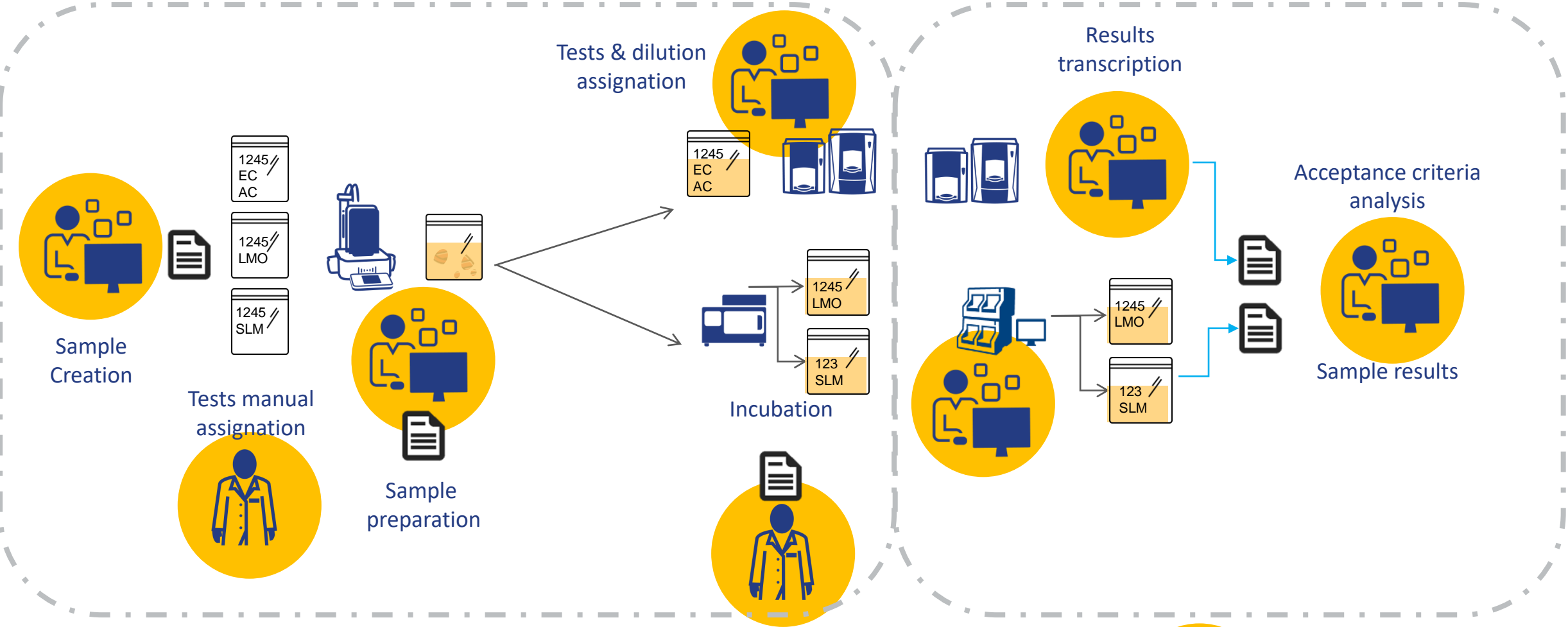
CONNECT-UP™

CONNECT UP

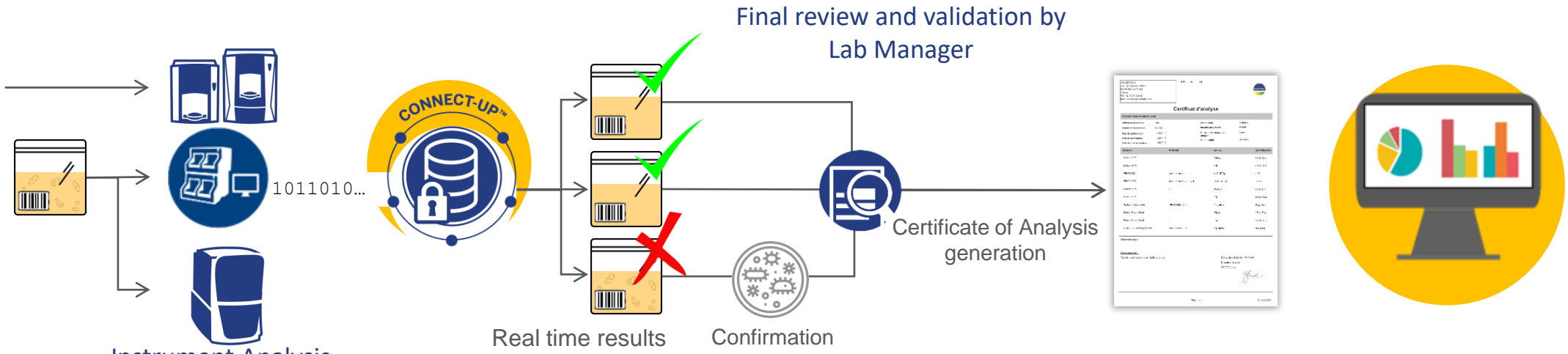
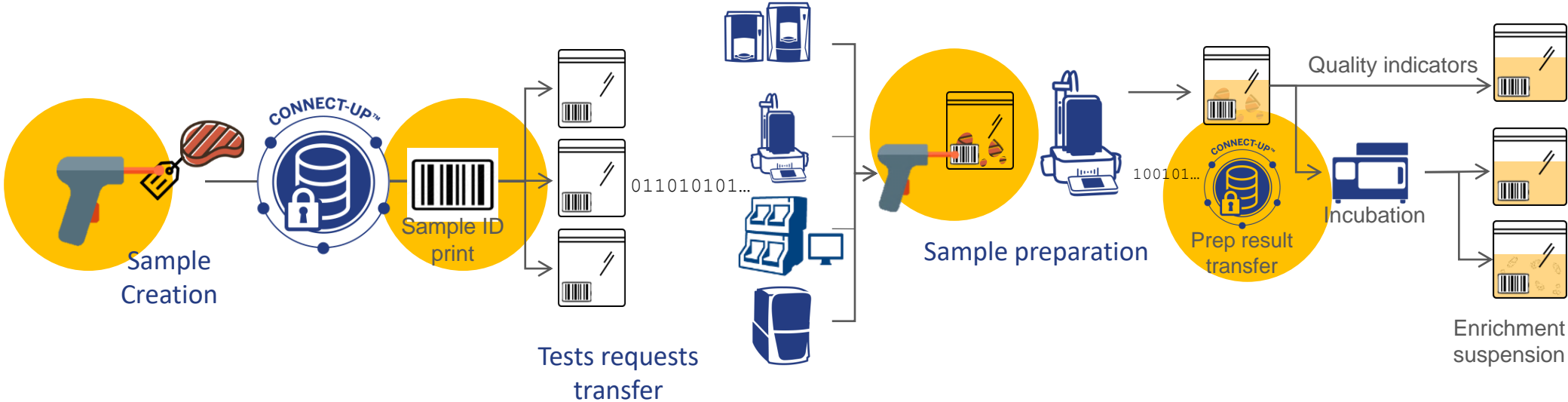
MAXIMIZE bioMérieux solutions EXPERIENCE



YOUR CURRENT DATA FLOW



CONNECT-UP™ DIGITAL DATA FLOW



FEATURES



Sample workflow

Sample prep to confirmation
Production sample registration.

Products

Products specifications
Predefine test assignment

Instruments

Connectivity
Calibrations, preventive maintenance and
service data

Inventory

Standards and reagents management.



Reporting

Certificate of Analysis
E-mail alerts
Electronic signature

Data visualization

Real time Product & Batch Trend
Lab management KPI

Conectivity

ERP Compatible
Server based

Security and Auditing

Data encryption | Auditing process,
Transaction logs | Controlled access

ENVIROMAP



A secure cloud-based system that allows you to automate environmental monitoring programs and assist with entire sampling life cycle:



Automated schedule



Automatic prescription of corrective actions



Results Mapping



Real time notifications



Executive Dashboard & Reporting



Tracing of activities



Management of Sanitations and Preop inspections

bioMérieux + Mérieux
Nutriscience partnership

Subscription model, monthly
fee

CONNECT-UP or Pathogen
mapping integration

AUTOMATE SCHEDULING

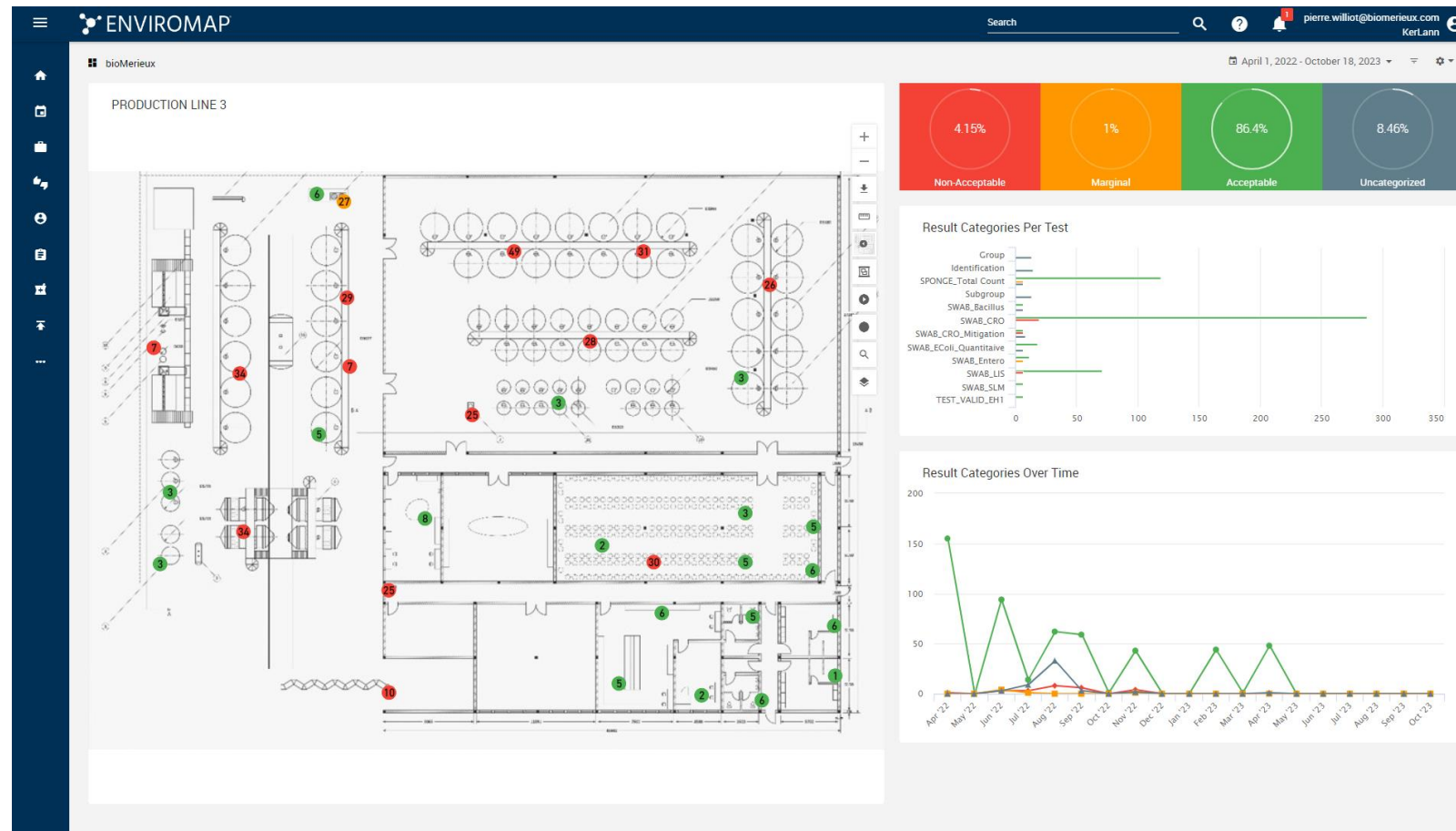
- Automated scheduling of sampling activities including the necessary randomization algorithm
- Color codes indicate the progress through the sampling lifecycle
- Plan and add automatically to your calendar re-test, investigation or actions in the event of a positive

The screenshot displays the ENVIROMAP software interface. At the top, there is a search bar and user information for William Melnychenko in Houston, TX. The main view is a calendar for April 2021, showing a grid of days with various sampling activities scheduled. The activities are color-coded: green for 'EMPC Processing', red for 'EMPC Warehouses', orange for 'ATP', and grey for 'SE'. A 'Corrective Action' is also visible on April 28th. The interface includes a sidebar with navigation icons and a top navigation bar with filters for 'All Types', 'All Plans', and 'All Statuses Selected'.

SUN	MON	TUE	WED	THU	FRI	SAT
	28 8a EMPC Processing 8a Floor underneath bin...	29	30	31 8a Floor underneath bin...	1 8a ATP	2 8a Floor underneath bin...
	4 8a EMPC Processing	5 8a EMPC Warehouses	6 8a SE	7 8a ATP	8 8a Wall by row # going ...	9 8a Wall by row # going ...
	11 8a EMPC Processing	12 8a EMPC Warehouses 8a Wall by row # going ...	13	14	15 8a ATP	16 8a Wall by row # going ...
	18 8a EMPC Processing	19 8a EMPC Warehouses	20 8a SE	21 8a ATP	22	23
	25 8a EMPC Processing	26 8a EMPC Warehouses	27 2:40p Corrective Action...	28 8a ATP	29	30
	2 8a EMPC Processing	3 8a EMPC Warehouses	4 8a SE	5 8a ATP	6	7
						8

AUTOMATE RESULTS MAPPING

- We help you position your sites on your facility map.
- Multiple maps per facility & mapping points on equipment are supported.
- Risk levels, zones, and out of specification results are color coded.
- Photos can be added for each site



AUTOMATE COLLECTIONS

- Print collection list
- Print labels for traceability
- Update collection status and capture any required information
- Generate order to the lab (internal or external)
- View integrated results on the dashboard

The screenshot displays the ENVIROMAP software interface. The top navigation bar includes the ENVIROMAP logo, a user profile for 'mehdi.idir@mxns.com Chicago, IL', and a notification bell. The main content area is titled 'Weekly EMPC' and shows a collection plan for 'Weekly EMPC January 27, 2020 12:00 AM - 12:59 AM'. The interface includes a search bar, a list of collection items, and a sidebar with a calendar view. The collection items are:

- 1. Oven: Scheduled to be collected as part of Weekly EMPC. Sampling Point: Oven. Tests: EMPC, RISK LEVEL: ZONE 1, ATP, LISTERIA, SALMONELLA.
- 2. Any randomly chosen tool: Scheduled to be collected as part of Weekly EMPC. Sampling Point: Any randomly chosen tool. Tests: LOCATION: PRODUCTION, EMPC, RISK LEVEL: ZONE 3, ATP, LISTERIA, SALMONELLA.
- 3. Randomly chosen tank sampling spout: Scheduled to be collected as part of Weekly EMPC. Sampling Point: Randomly chosen tank sampling spout. Tests: LOCATION: MAINTENANCE, RISK LEVEL: ZONE 2, ATP, SALMONELLA.
- 4. Tote filler: Scheduled to be collected as part of Weekly EMPC.

The sidebar on the right shows a calendar view with a dropdown menu for 'Month View', 'Week View', and 'Day View'. The user is currently viewing the 'Month View'.

SANITATION MODULE - IMPLEMENTATION

Edit Sanitation Plan Schedule

Save Cancel Confirm Cancel Remove

Description: L1 sanitation

Assignee: Select

Task: Sanitation line 1

Sanitation Area: Line 1

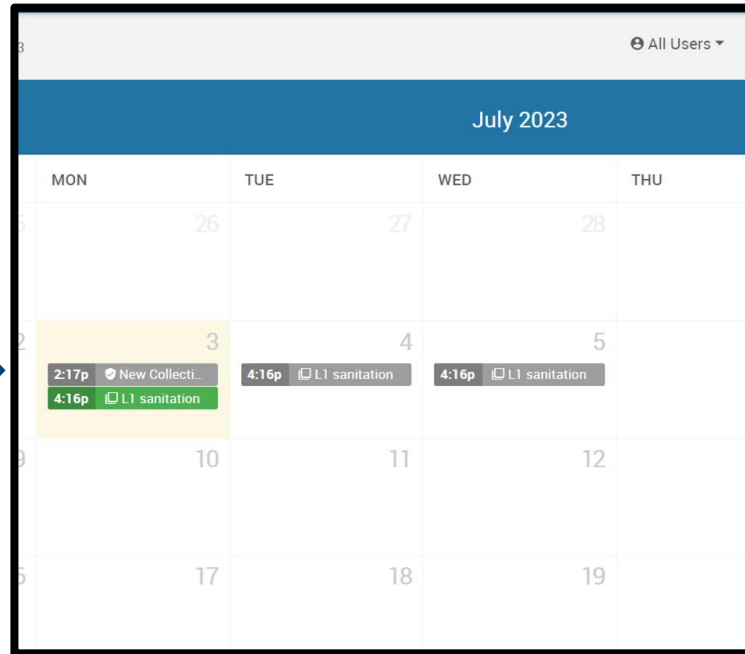
Start Date: July 3, 2023

Recur Every: 1 Week

Recur Time: At: 4:16 PM

End condition: Never Count Period End

Weeks to have scheduled at once: 12



Scheduled Tasks

Download Reset Filters

July 1, 2023 - July 31, 2023

Task	Closed Date	
Sanitation line 1	07/03/2023 4:17 PM	true
Sanitation line 1		
Sanitation line 1		

1 Set tasks & areas

- Create sanitation areas
- Associate verification samples
- Create different sanitation activities to reflect SOPs

2 Schedule sanitation

- Create sanitation plans made of different tasks
- Set frequencies and assign
- Visualize on calendar
- Add verification testing

3 Reporting

- Visualise sanitation compliance and effectiveness
- Track chemical effectiveness
- Download sanitation and verification details

AUTOMATE CORRECTIVE ACTIONS

- Record any Investigation or corrective action
- Visualize all mitigations associated to a positive
- Set mitigation plans
- Automatically trigger corrective action when criteria are met
- Print a full mitigation report

The screenshot displays the ENVIROMAP software interface. The main window is titled 'CAPA Reports' and shows a list of reports. The selected report is titled 'CAPA Report' and displays the following details:

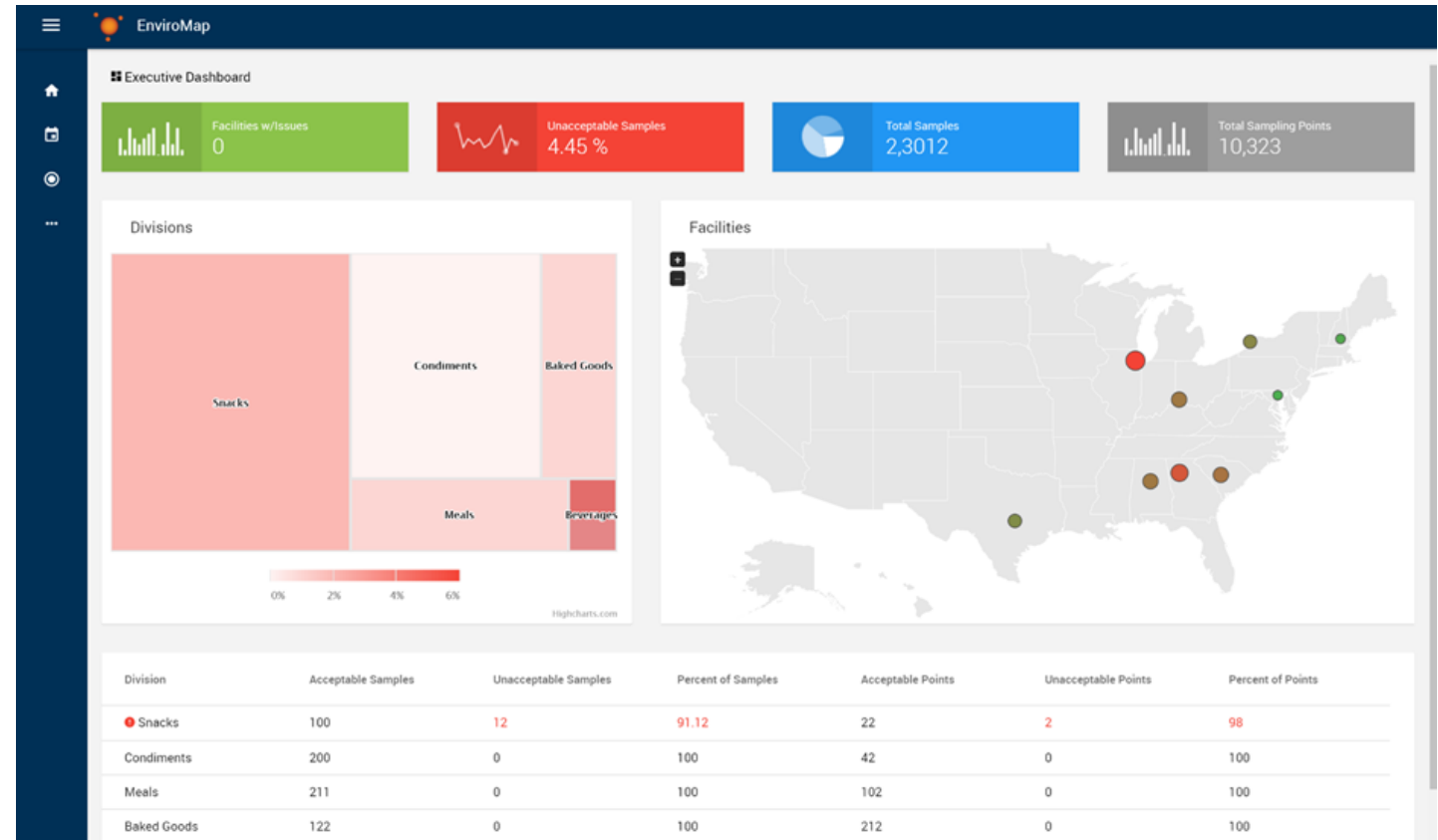
- Sample Id:** 5d444ae4-6b70-4e7b-94ec-58f6bdb021 cb
- Description:** C-Dock Floor
- Test:** Listeria
- Result:** Positive
- Reports:**

Closed Date	Sampling Point
07/20/2021 6:22 PM	C-Dock Floor
- Tasks:**

Date	Owner	Type
10/06/2021 8:33 AM	S	Root Cause Analysis C-Dock Floor
07/20/2021 7:00 AM		C-Dock Floor-1
07/27/2021 3:57 PM		C-Dock Floor-1
08/03/2021 12:00 AM		C-Dock Floor-2

CORPORATE DASHBOARD

- Corporate dashboard with access to all divisions & plants
- Visualize & compare performance among plants using EnviroMap.
- Drill inside data and navigate to a plant dashboard



AUDIT LOG

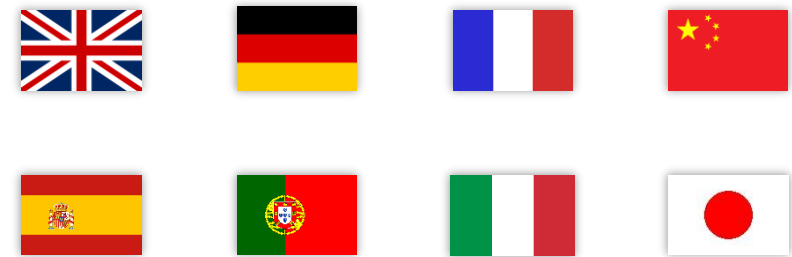
- User accountability the user knows that their actions are automatically recorded and tied to their unique identity.
- Reconstruction of events: when an investigation is warranted or triggered, the first step to remediate a problem is knowing the "when," the "how," and the "what" of the event.



ENVIROMAP GLOBAL REACH



AVAILABLE IN 8 LANGUAGES



+ 280 SITES
WORLDWIDE

GLOBAL SUPPORT

FOOD QUALITY & SAFETY
EXPERTISE

TESTIMONIALS AFTER 6 MONTHS :

MARS



Kellogg's

Mondelēz
International

SIGMA



dianapetfood

Optimization EMP
→ Decrease 16 % of
the monthly samples

More involvement from
technicians, more
ownership

Saving of 2 Hours/Day in
management and
oversight time

Optimization of chemicals
and cleaning procedures

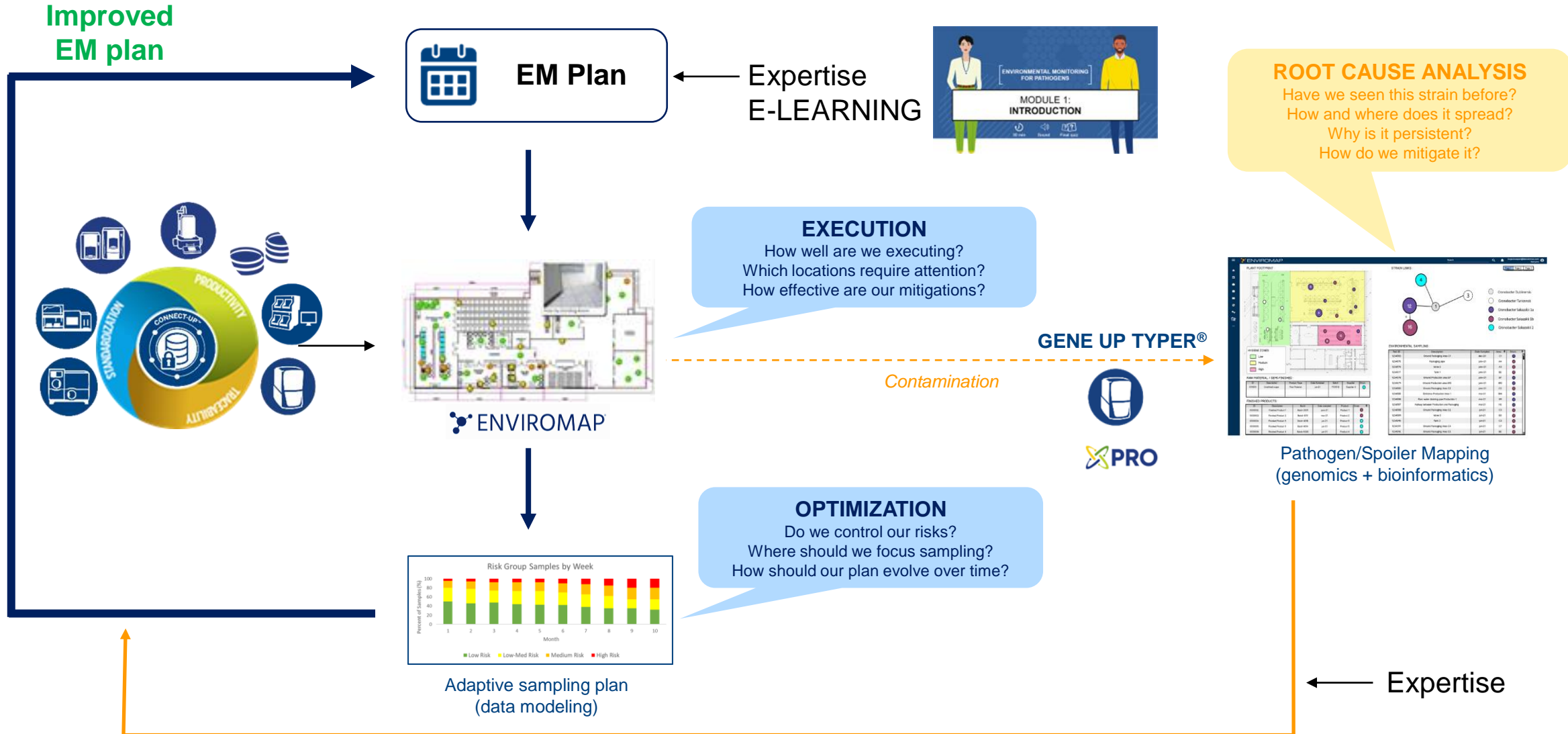
Reduce of production
losses → quicker time
to react

Audits are faster
and easier

ENVIRONMENTAL MONITORING SUMMARY

SUMMARY: HOW TO DYNAMICALLY MANAGE EM RISK

By leveraging digitalization and advanced analytical tools



YOUR TRUSTED PARTNER IN AUGMENTED DIAGNOSTICS



Smarter and more dynamic

RISK ASSESSMENT



Moving from Test results to

ACTIONABLE INSIGHTS



Safe products of the highest quality for

CONSUMERS

Augmented Diagnostics

A suite of solutions by bioMérieux based on Microbiology Expertise, Genomics, Bio-Informatics and Data Science



Reduce your factory's carbon footprint & your non-quality costs

Energy - Food waste

Toxic detergents - Water waste



Understand the past
Get clear root cause analysis

Optimize the present
Actionable insights

Anticipate the future
Take better & quicker decision

“ Move from results to better risk management through **insights**, and from risk detection to **anticipation & prevention**”



PIONEERING DIAGNOSTICS