Death Decoded: Exploring the Crossroads of Cellular Death and Forensic Microbiome Research

Dr. Sheree J. Finley, Ph.D.

Speaker Objectives:

- Compare and contrast mechanisms of cellular death.
- Analyze the connection between cellular death and the human postmortem microbiome.
- Demonstrate knowledge of the recent findings in forensic microbiome research.

DEATH DECODED:

EXPLORING THE CROSSROADS OF CELLULAR DEATH AND FORENSIC MICROBIOME RESEARCH

SHEREE FINLEY, PH.D.

2025 ROBERT & JEAN ADAMS MEDICAL & CLINICAL LABORATORY SCIENCES SYMPOSIUM

JAVAN THANATOS LAB

Outline

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Presentation

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Introduction

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Introduction

Sheree J. Finley, Ph.D.

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Soil microbiome & forensic …

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Complexity of human death: its physiological, transcriptomic, and microbiological implications GT Javan, K Singh, SJ Finley, RL Green, CK Sen Frontiers in Microbiology 14, 1345633	6	2024
Life and death: new perspectives and applications in forensic science, volume II GT Javan, ME Benbow, SJ Finley, JJ Parrott Frontiers in Ecology and Evolution 11, 1305083		2023
COVID-19 and brain-heart-lung microbial fingerprints in Italian cadavers GT Javan, SJ Finley, M Moretti, SD Visonà, MP Mezzari, RL Green Frontiers in Molecular Biosciences 10, 1196328	1	2023
Cadaver Microbial Signatures of the Submandibular Glands and Thyroid for Forensic Investigations S Finley, M Moretti, S Visonà, G Javan Cadaver Microbial Signatures of the Submandibular Glands and Thyroid for …		2023
Correlation between postmortem microbial signatures and substance abuse disorders GT Javan, T Wells, J Allen, S Visona, M Moretti, C Tipton, L Scott, … Plos one 17 (9), e0274401	9	2022
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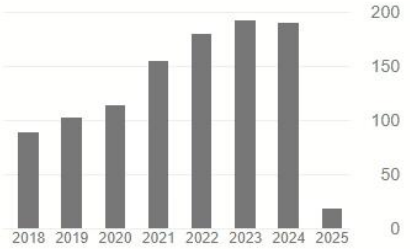

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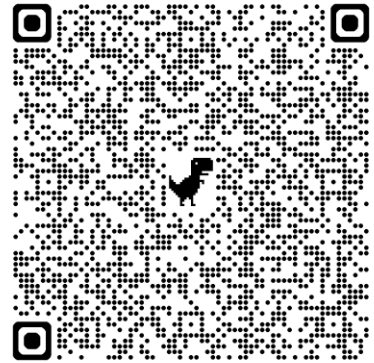
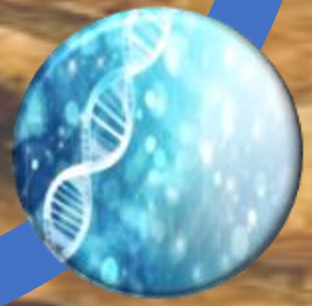


Objectives

Compare and contrast mechanisms of cellular death

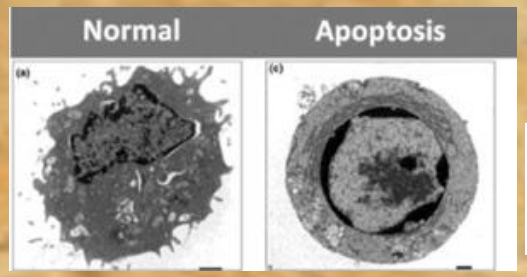
Analyze the connection between cellular death and the human postmortem microbiome

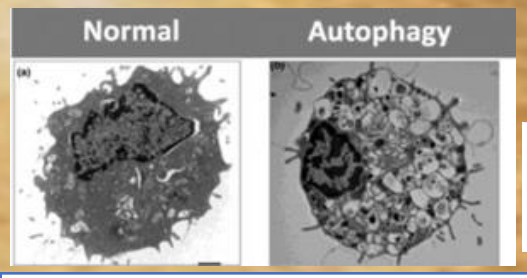


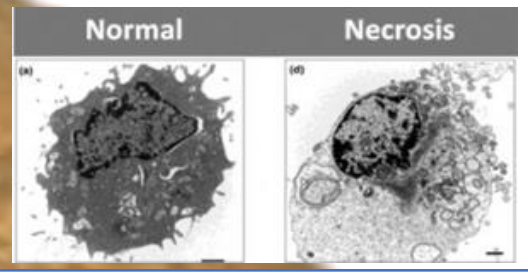
Demonstrate knowledge of the recent findings in forensic microbiome research

Cellular Death

For a cell, the suffix "-osis" spells trouble







Parameter	Apoptosis	Autosis (Autophagy)	Necrosis
Plasma membrane	Preserved, blebbing	Rupture in late phase	Rupture in early stage
Nucleus	Compaction, nuclear fragmentation (karyorrhexis)	Ballooning of perinuclear space (autosis)	Dilation of nuclear membrane
Chromatin	Condensation	Minor/mild condensation	Minor/mild condensation
Mitochondria	Loss of membrane potential	Mild dilation	Swelling
Cytoplasm	Shrinkage	Vacuolization with numerous autophagosomes and autolysosomes	Influx of extracellular fluid
Other	Cell shrinkage (pyknosis), cell rounding, detachment from surface	Health effects?	Cell and organelles swell, leakage of proteosomes and lysosomes

Cellular Death

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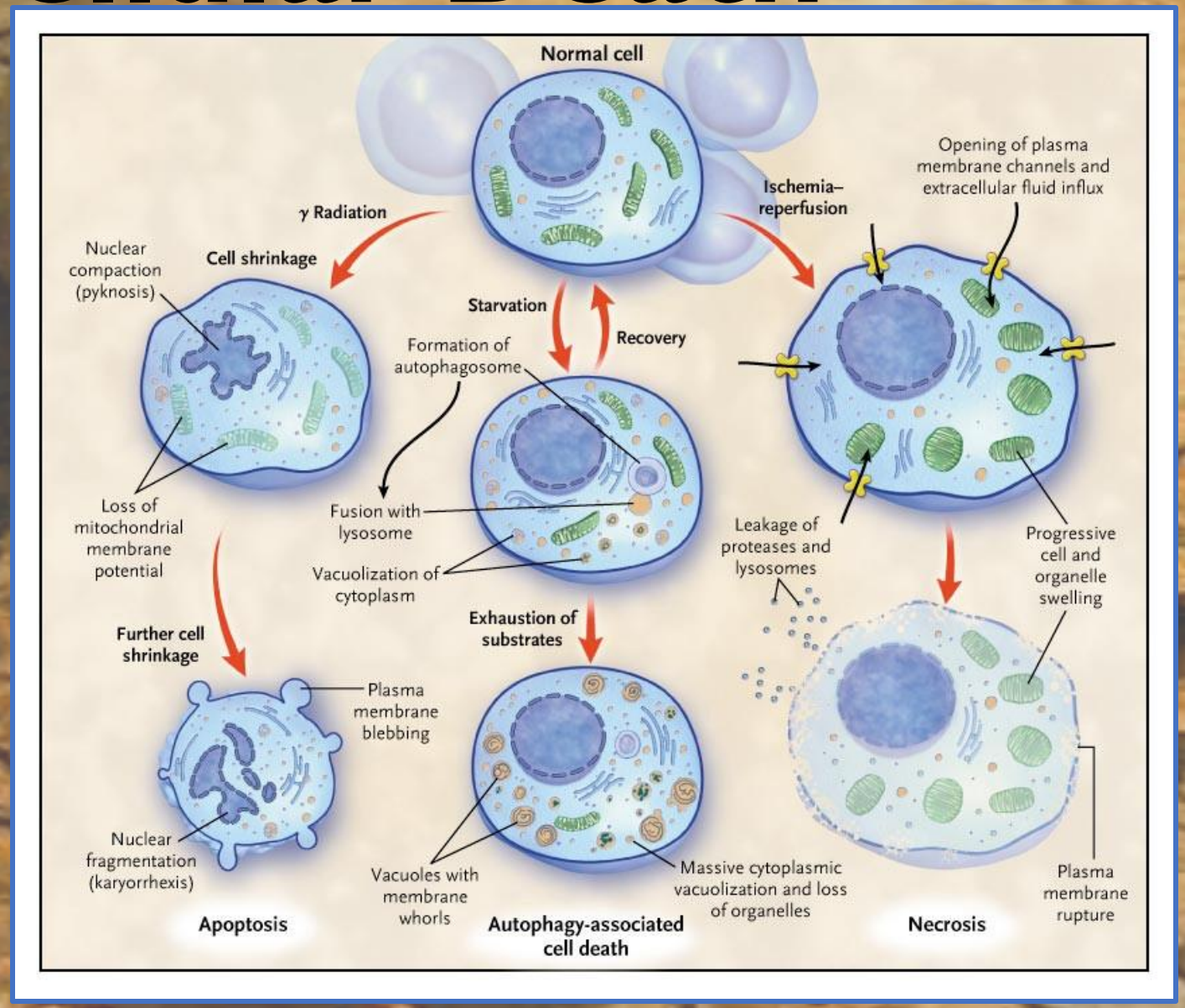

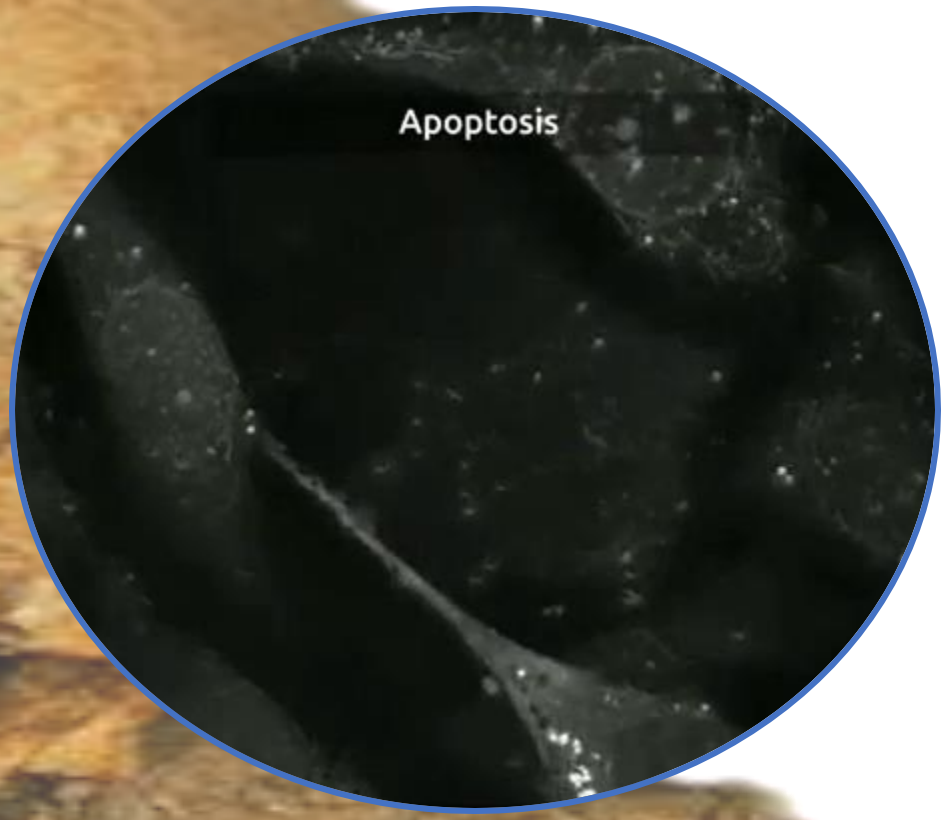

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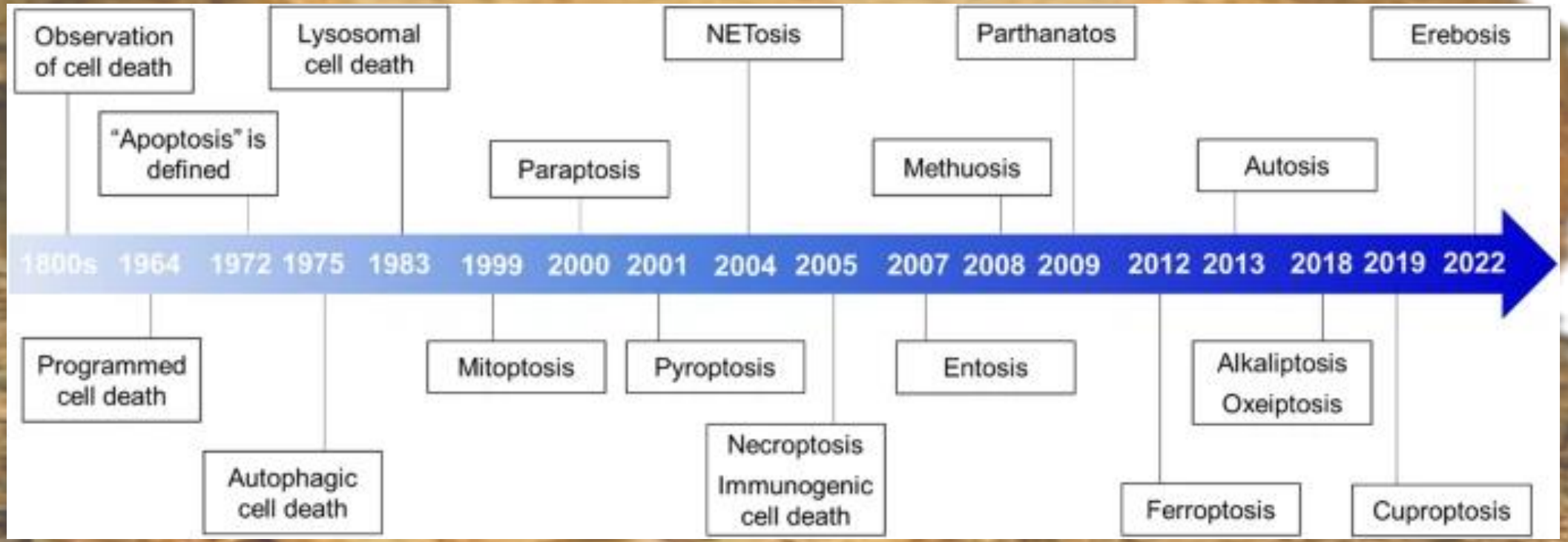

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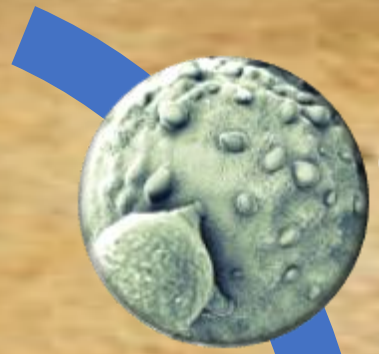

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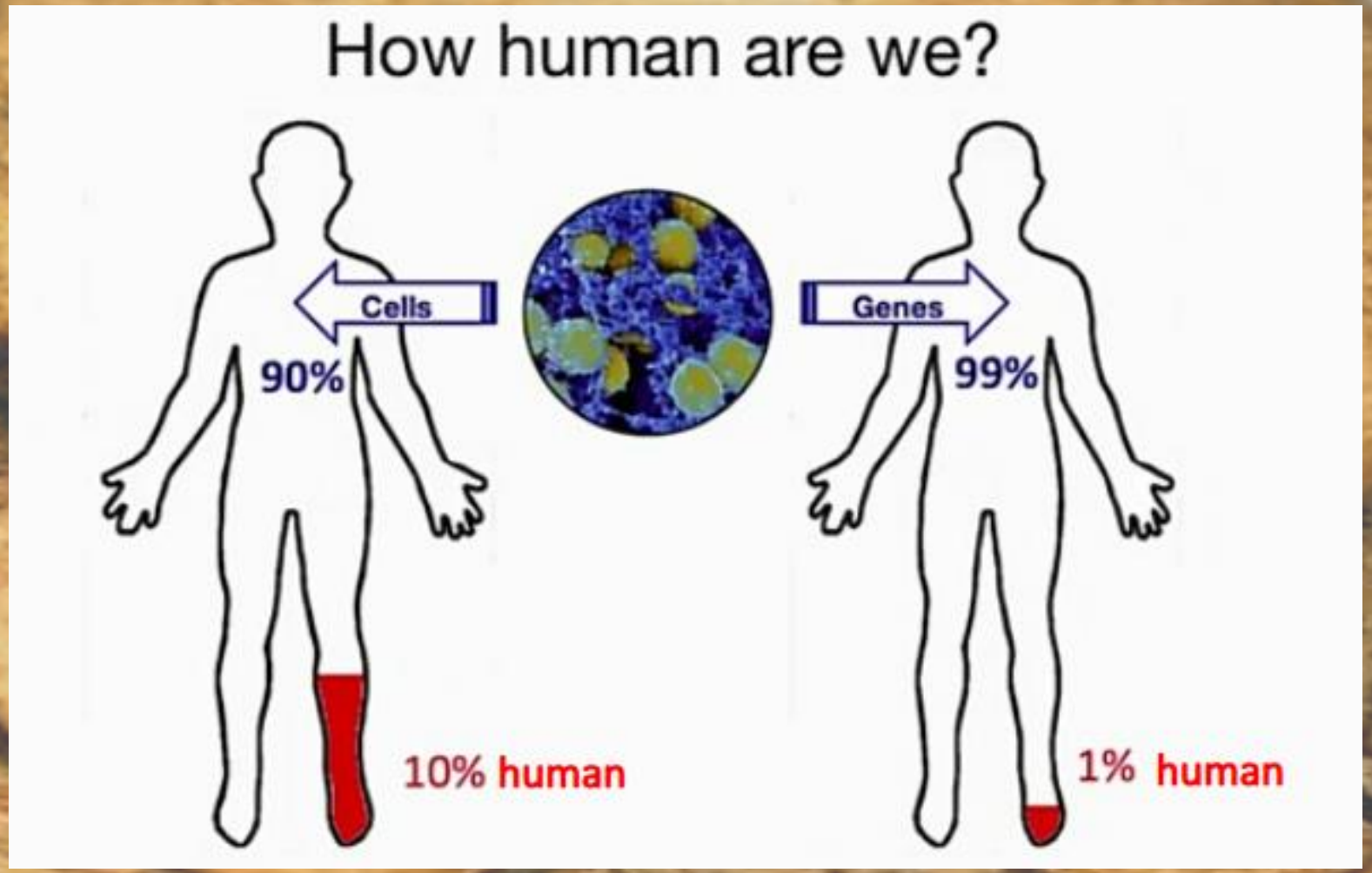
Analyze the connection between cellular death and the human postmortem microbiome

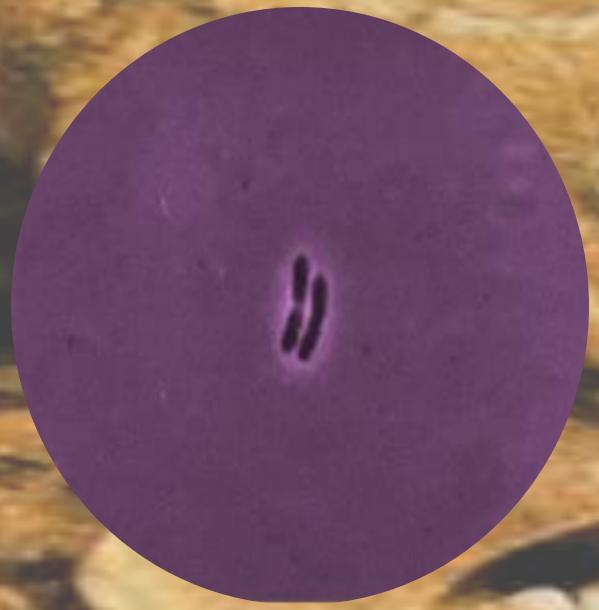
Demonstrate knowledge of the recent findings in forensic microbiome research

Connections

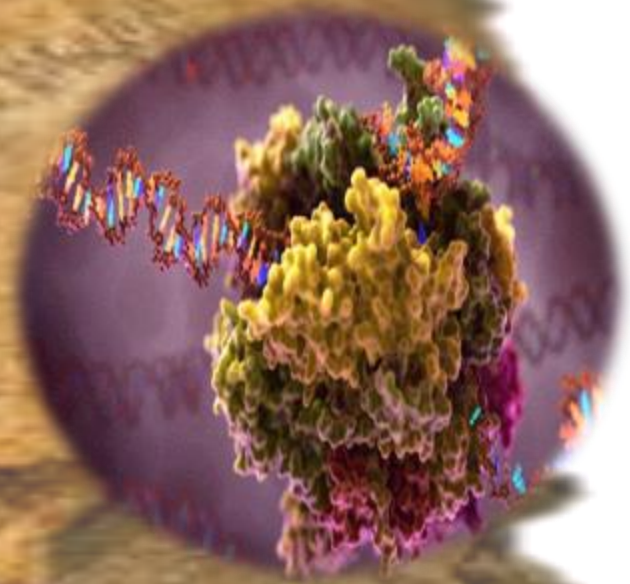


Connections

Bifurcated Research Approach



Thanatomicrobiome



Thanatotranscriptome

Connections

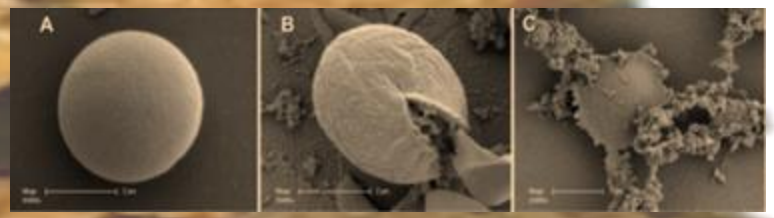
Death is a universal phenomenon!

The heart stops

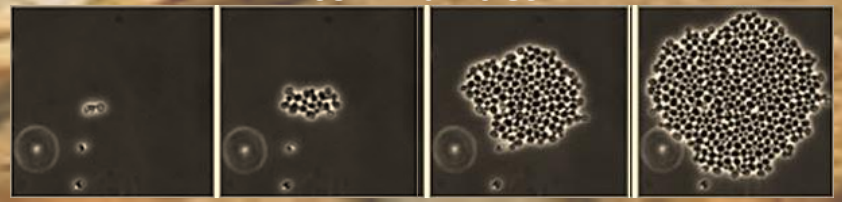
Hypoxia activates intracellular factors

Necrosis begins

Cellular components are released



Massive proliferation of microbial communities



Connections

Warning: Graphic Pictures

Connections

Connections

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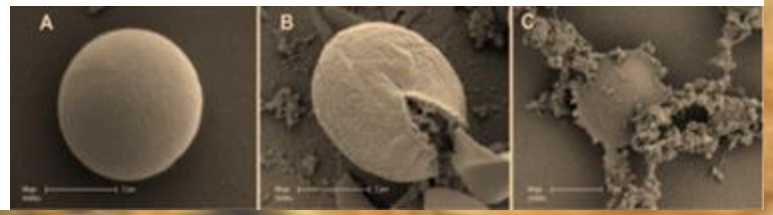
When a person dies, **cellular death** occurs in stages:

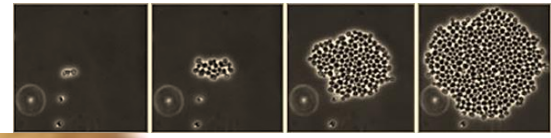
- **Primary necrosis**
- **Autolysis**
- **Tissue breakdown**



2. Microbial Proliferation and the Postmortem Microbiome

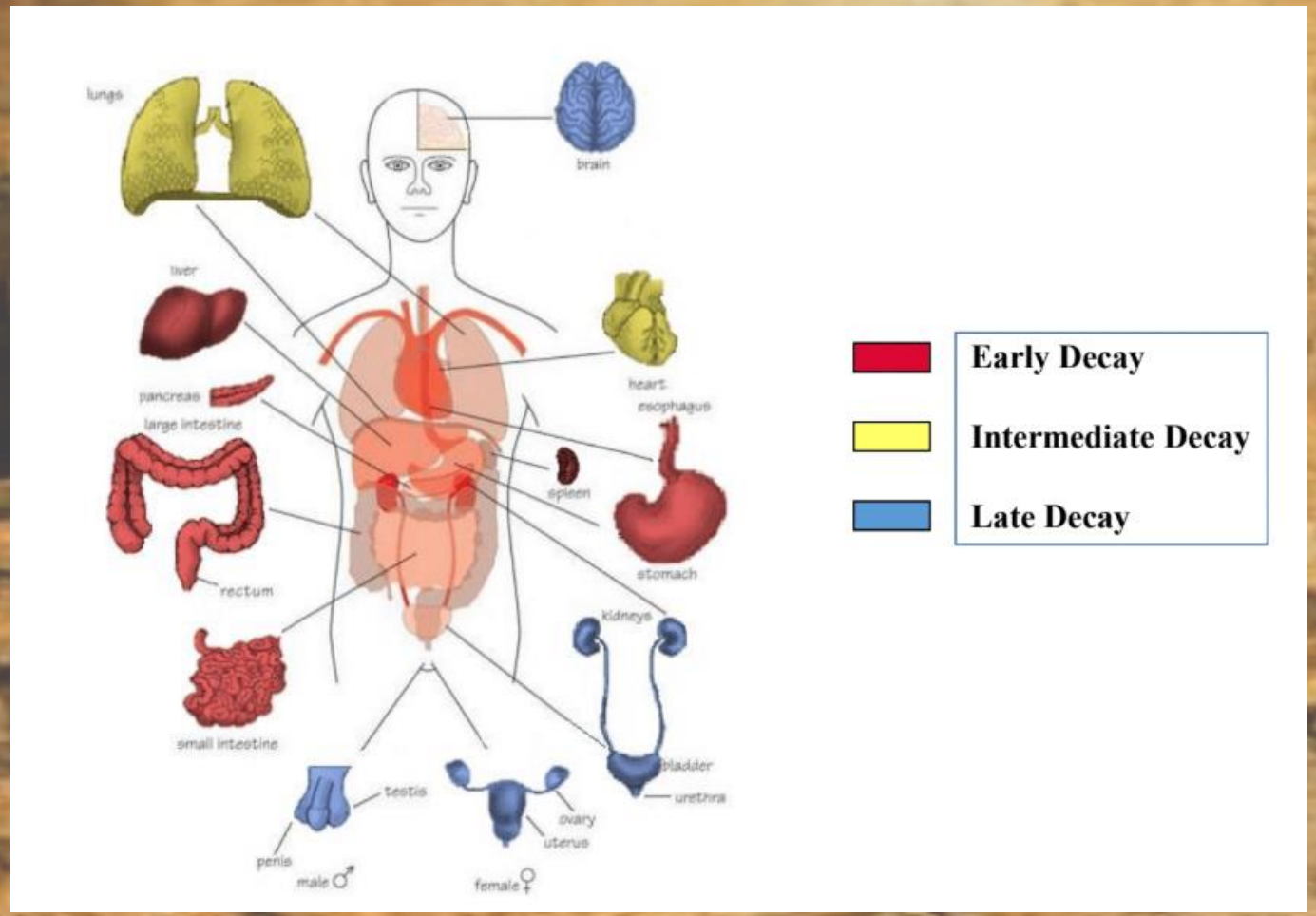
As cells break down, they release nutrients (e.g., amino acids, fatty acids) that support microbial growth. This leads to:

- **Shifts in microbial composition**
- **Translocation of microbes**



3. The "Thanatomicrobiome" – *Thantos*- Greek for death

Connections



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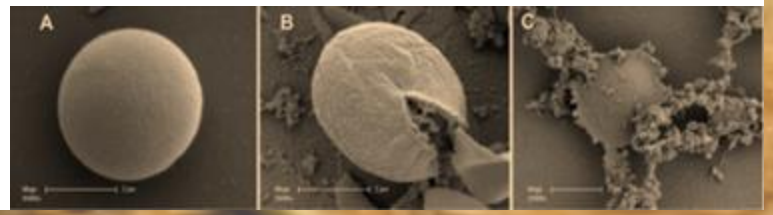

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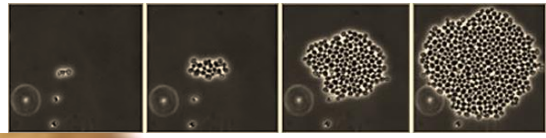

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Connections

frontiers in Microbiology

ORIGINAL RESEARCH
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Cadaver Thanatomicrobiome Signatures: The Ubiquitous Nature of *Clostridium* Species in Human Decomposition

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Human thanatomicrobiome studies have established that an abundant number of putrefactive bacteria within internal organs of decaying bodies are obligate anaerobes, *Clostridium* spp. These microorganisms have been implicated as etiological agents in potentially life-threatening infections; notwithstanding, the scale and trajectory of these microbes after death have not been elucidated. We performed phylogenetic surveys of thanatomicrobiome signatures of cadavers' internal organs to compare the microbial diversity between the 16S rRNA gene V4 hypervariable region and V3-4 conjoined regions from livers and spleens of 45 cadavers undergoing forensic microbiological studies. Phylogenetic analyses of 16S rRNA gene sequences revealed that the V4 region had a significantly higher mean Chao1 richness within the total microbiome data. Permutational multivariate analysis of variance statistical tests, based on unweighted UniFrac distances, demonstrated that taxa compositions were significantly different between V4 and V3-4 hypervariable regions ($p < 0.001$). Of note, we present the first study, using the largest cohort of criminal cases to date, that two hypervariable regions show discriminatory power for human postmortem microbial diversity. In conclusion, here we propose the impact of hypervariable region selection for the 16S rRNA gene in differentiating thanatomicrobiomic profiles to provide empirical data to explain a unique concept, the Postmortem Clostridium Effect.

Keywords: thanatomicrobiome, *Clostridium*, 16S rRNA gene, V4 hypervariable regions, V3-4 hypervariable regions, Postmortem Clostridium Effect

- ***Clostridium's* very fast growth rate.**

C. perfringens has the most rapid doubling time of approximately 7.4 minutes at optimal temperatures.

- **The bacteria's proteolytic functions.**

Clostridium spp. have collagenases that digest vertebrate collagen which allows access to gut epithelial layers and transmigration to other tissues such as liver and spleen.

- ***Clostridium* spp's anaerobic nature.**

Corpses lack oxygen which facilitates anaerobic bacteria to rapidly grow in the nutrient-rich host.

Connections

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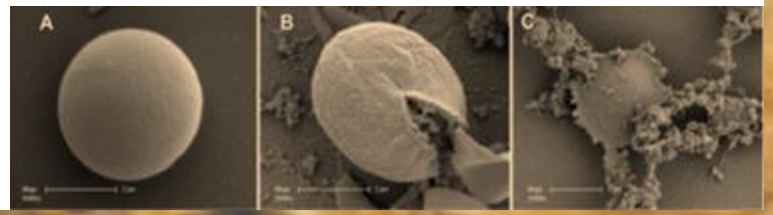

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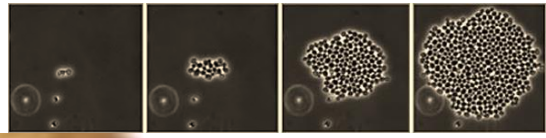


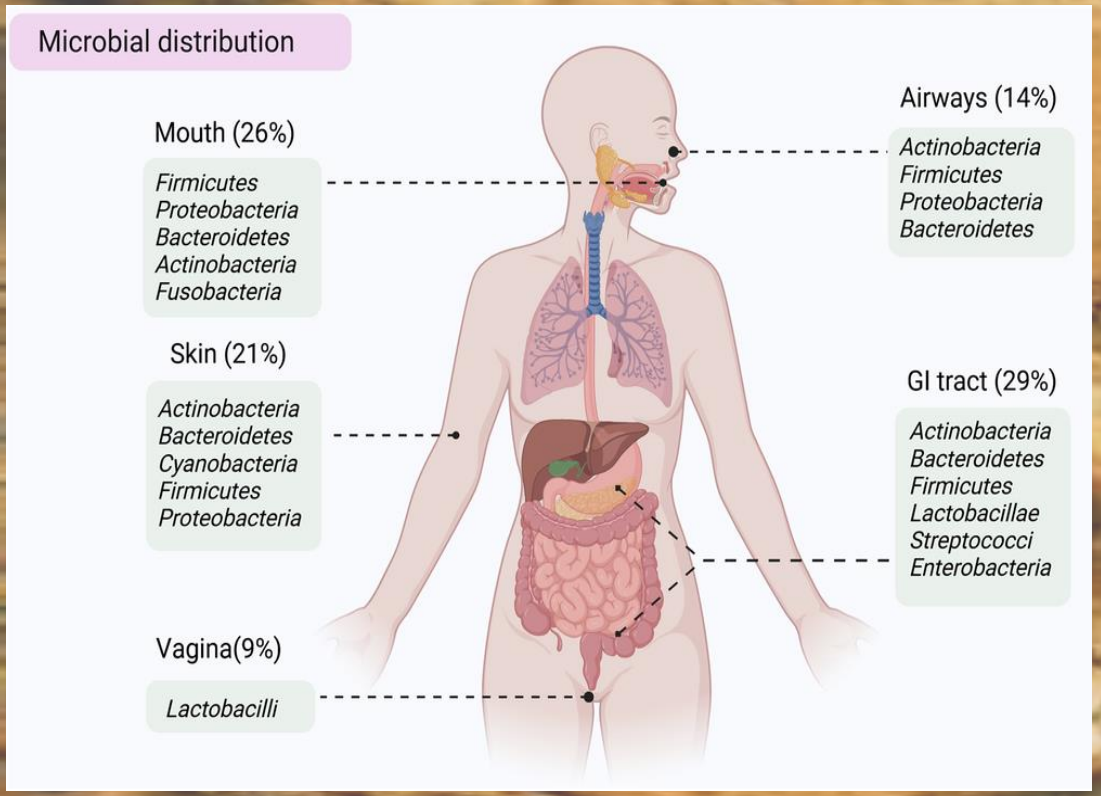
3. The "Thanatomicrobiome" – *Thantos*- Greek for death

The postmortem microbiome, also called the **thanatomicrobiome**, consists of microbial communities that dominate the body after death. Its composition is influenced by:

- **Host factors**
- **Environmental conditions**
- **Time since death**

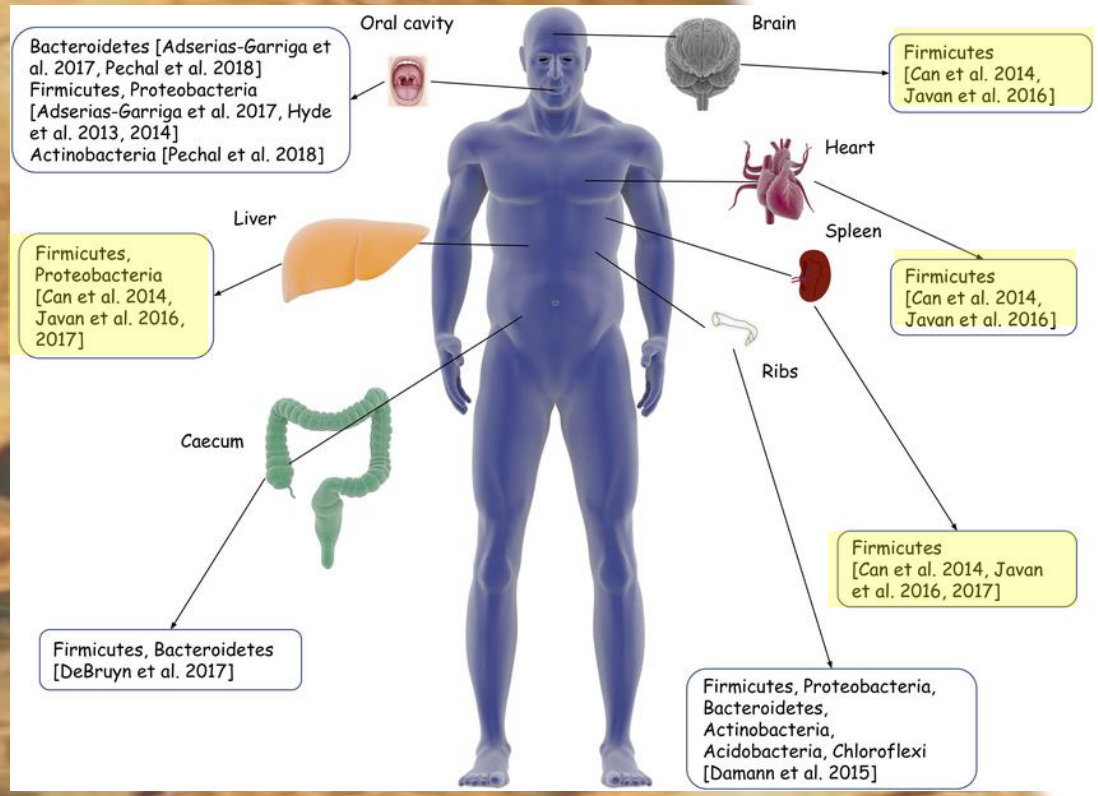
Connections

Human Microbiome



Vs.

Human Postmortem Microbiome



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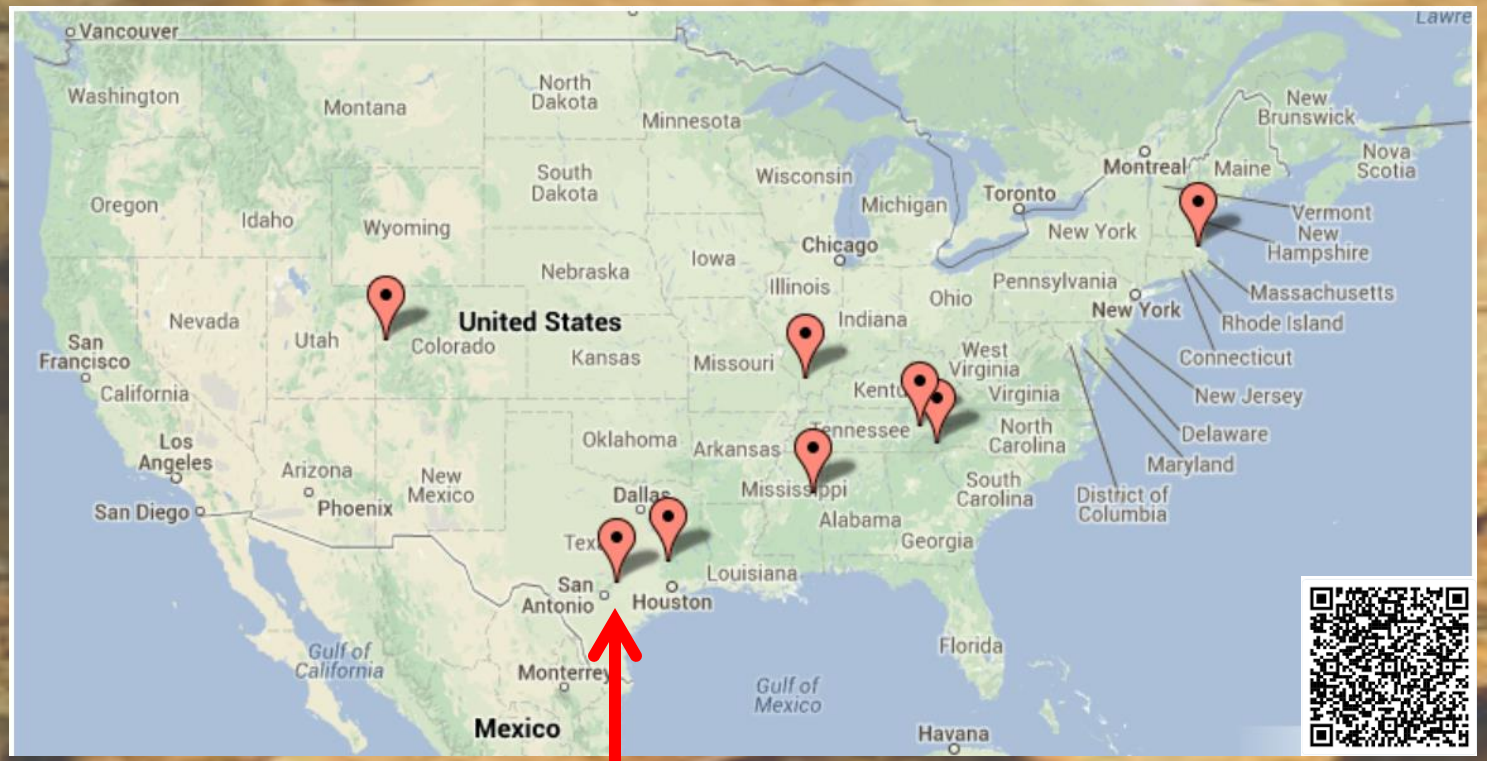


The Dirty World of Body Farm Microbes
Published on Forensic Magazine (http://www.forensicmag.com)

The Dirty World of Body Farm Microbes

Dr. Gulnaz Javan

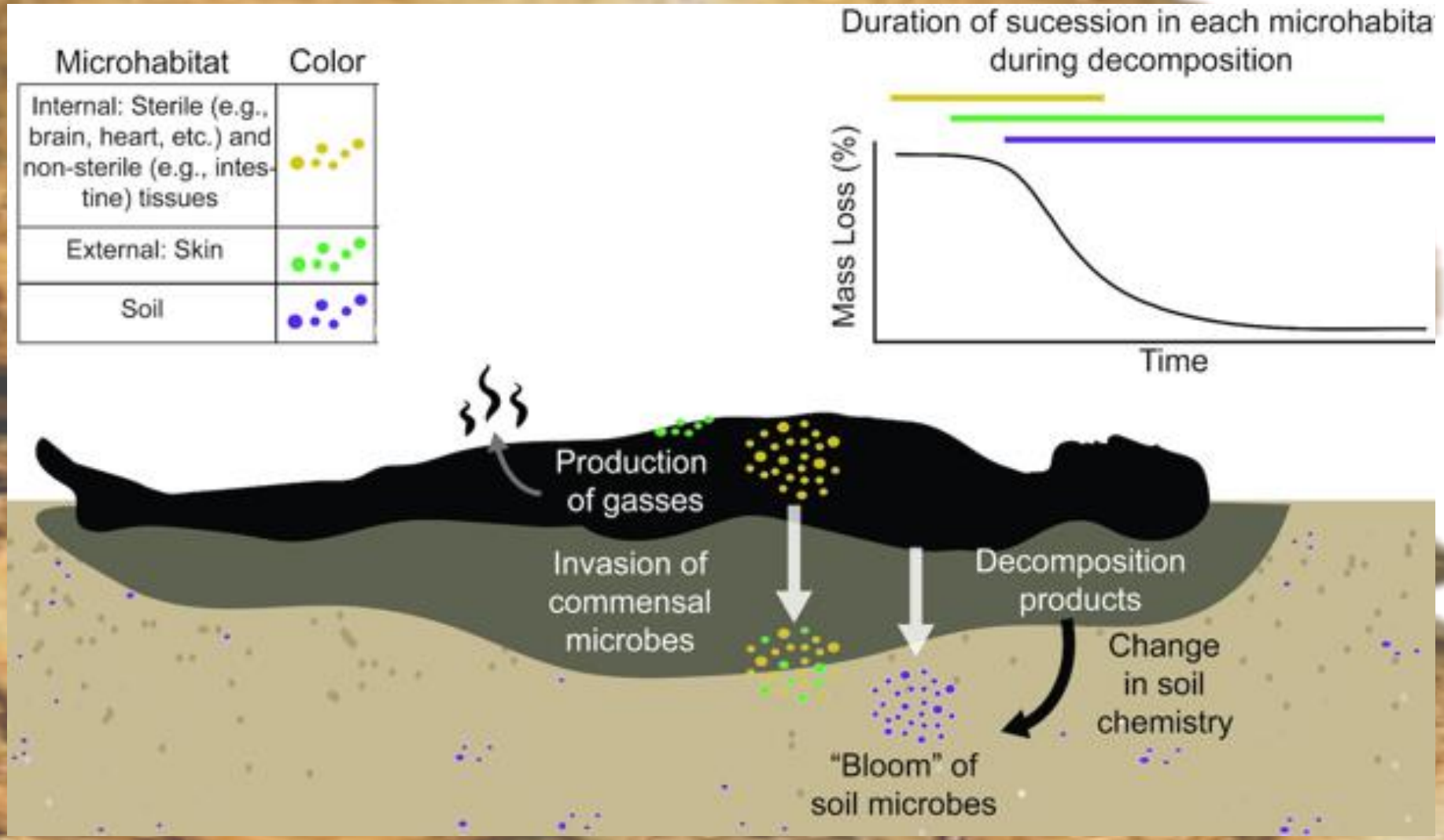
Dirt is full of life, microbial life. Although dirt seems to be an inert, lifeless material, one gram of soil may contain up to eight billion living bacterial cells. Grave soil found next to dead and decomposing human bodies is teeming with many microbial secrets that have yet to be uncovered.

Life after Death

Scientists at Alabama State University (ASU) in Montgomery, Alabama, are spearheading efforts to uncover those secrets. Principle investigator, Dr. Gulnaz Javan, a forensic scientist who studies the human thanatomicrobiome (i.e., *thanatos*-, Greek for death), and a team of researchers have forged a partnership with a "body farm" at the Forensic Anthropology Center at Texas State (FACTS) outdoor Forensic Anthropology Research Facility (FARF) located on Texas State University's Freeman Ranch in San Marcos, Texas. The ultimate goal is to unlock the microbial secrets of the "dirty world" of body farm grave soil. Thanatomicrobiome is a relatively new term introduced at the 66th Annual American Academy of Forensic Science meeting by Dr. Javan in Seattle, Washington, on February 22, 2014. It involves the study of the relevant microorganisms associated with human decomposition residing and proliferating in the internal organs and blood. These studies encompass the identification and characterization of microbes extracted from a total of 400 specimens from 100 cadavers obtained from homicides, suicides, over-doses, and accidental death.

Forensic Anthropology Center at Texas State (FACTS) outdoor Forensic Anthropology Research Facility (FARF) Texas State University's Freeman Ranch

Connections



Objectives

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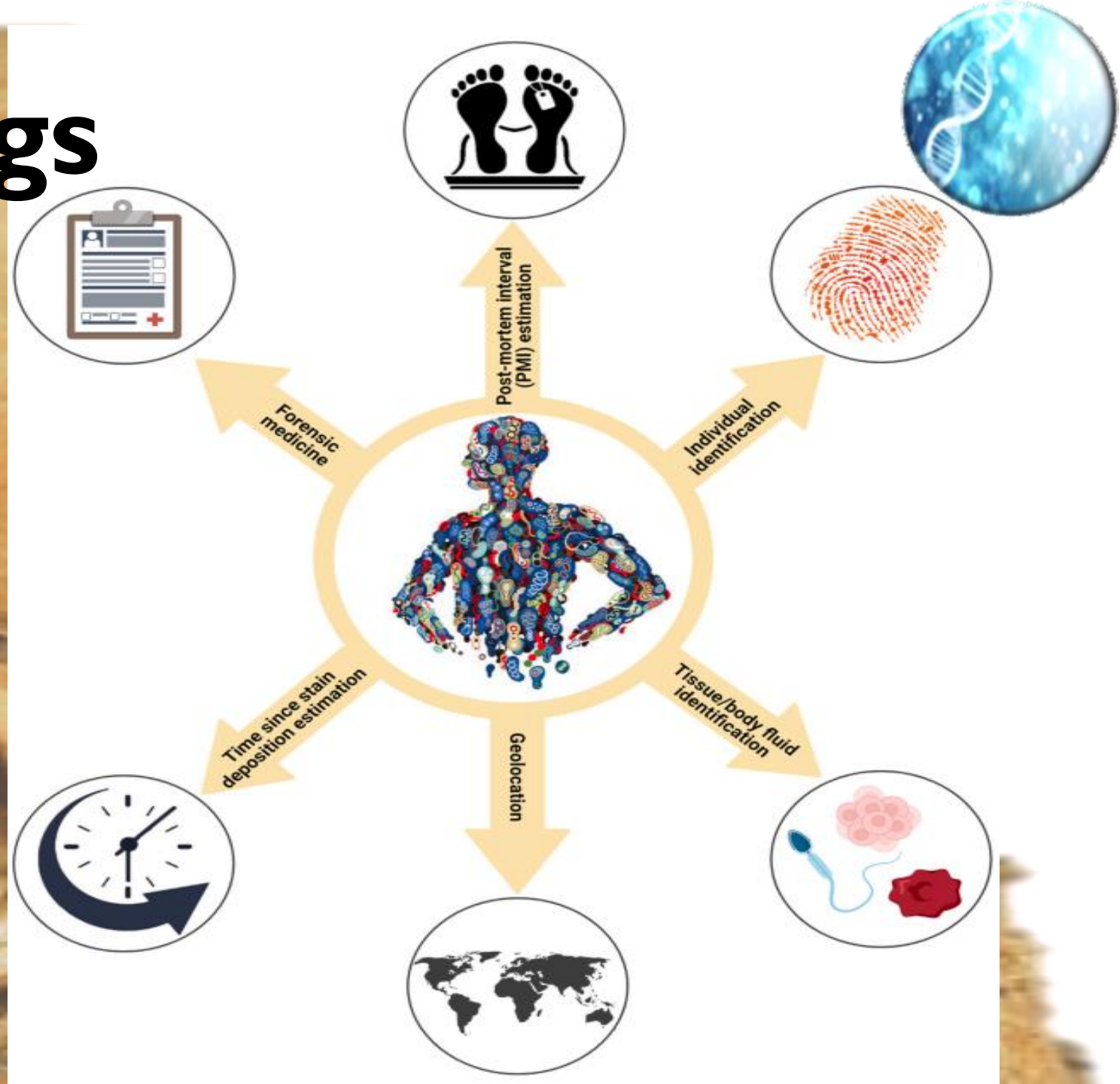
Recent Findings

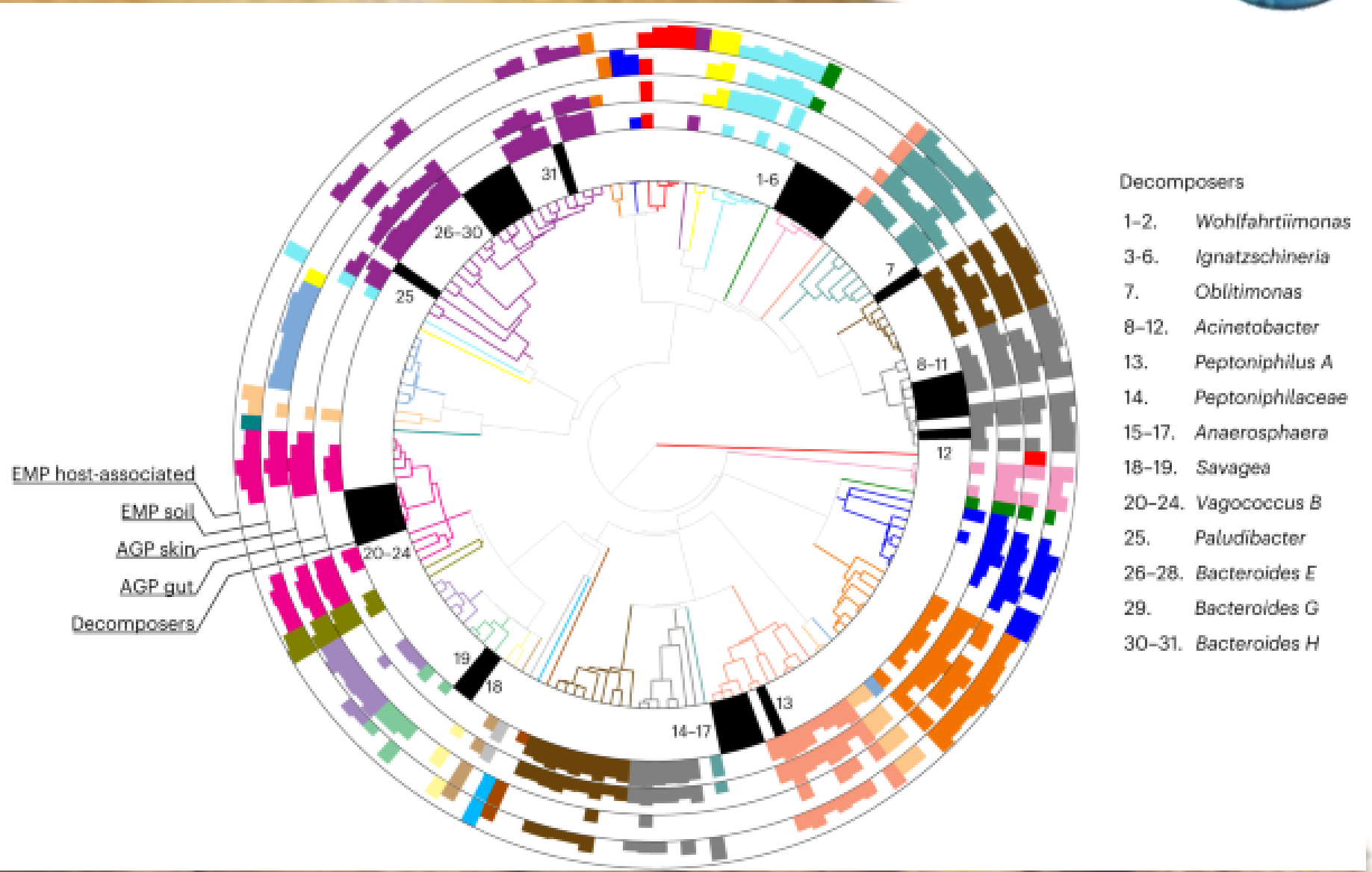


Recent Findings

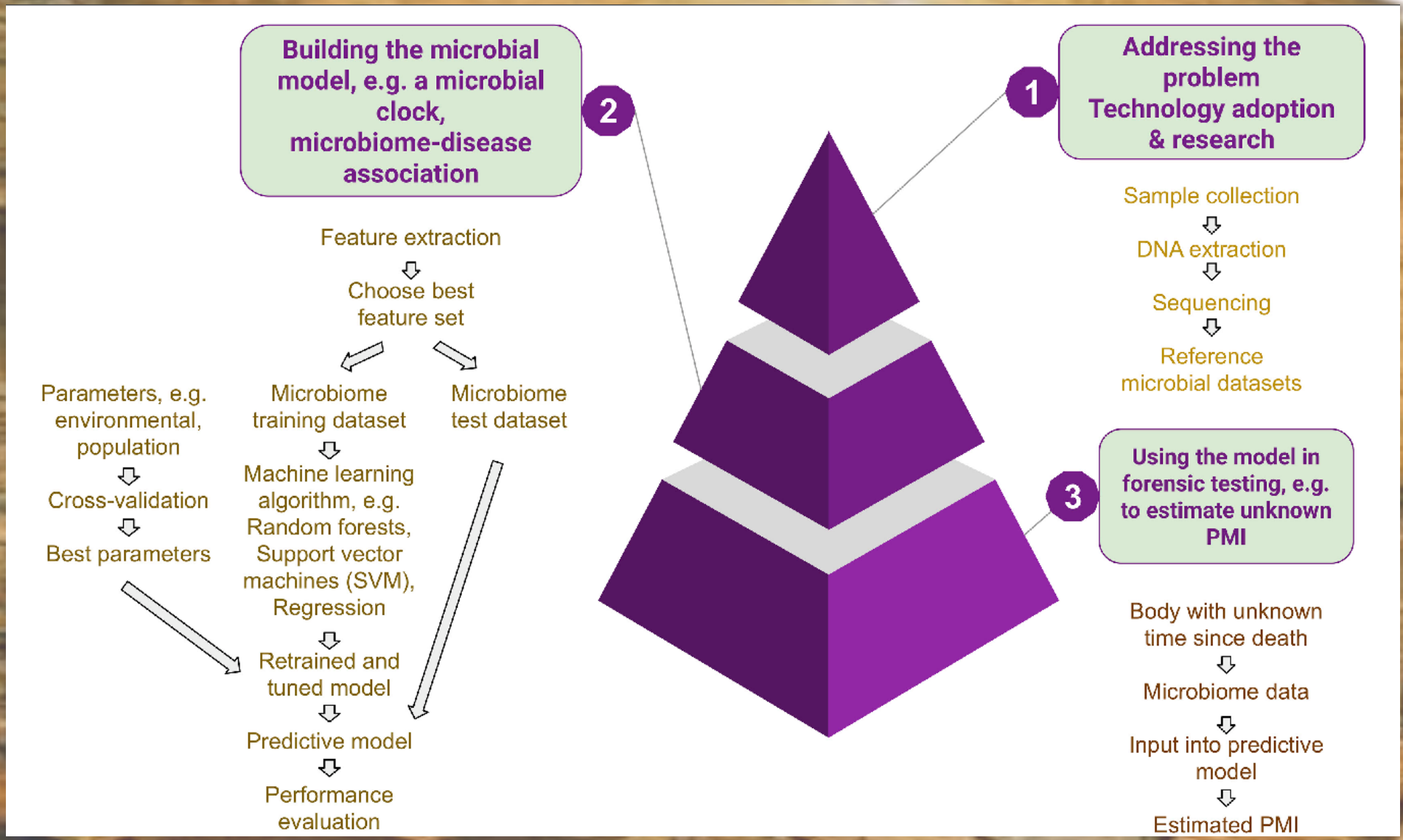
20 “specialist” decomposers were found associated with 36 terrestrial human cadavers.

Similar microbes arrived like clockwork at certain points throughout the 21-day observation period, regardless of outdoor variables.

“You never know if there will be fingerprints, or bloodstains or camera footage. But the microbes will always be there.”



Recent Findings



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QUESTIONS

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