Mucosal Simulator of the Human Intestinal Microbial Ecosystem

Commonly used acronym: *M-SHIME*

Created on: 03-03-2025 - Last modified on: 04-03-2025

Contact person

Tom Van de Wiele

Organisation

Name of the organisation Ghent University (UGent)

Department Center for Microbial Ecology and Technology

Country Belgium

Geographical Area Flemish Region

SCOPE OF THE METHOD

The Method relates to	Human health
The Method is situated in	Basic Research, Education and training, Translational - Applied Research
Type of method	In vitro - Ex vivo

DESCRIPTION

Method keywords

dynamic gut simulator

mucus covered microcosms

mucosal microenvironment

mucosal microbiome

fecal microbiota

Scientific area keywords

host-microbiome interaction
human health
human diseases
inflammatory bowel disease

Method description

The M-SHIME is a dynamic model for the human digestive tract that mimics the different compartments - stomach, small intestine and colon - while also incorporating a cross-sectional simulation mimicking both the luminal as the mucosal microenvironment of the human gut. The mucosal environment in particular is simulated with mucus-coated microcosms (carriers with high specific surface area) to facilitate colonisation of the mucosal microbiota. Compared to regular SHIME systems, the M-SHIME model allows to accurately study the colonisation of the endogenous mucosal microbiome, study different colonisation behaviour according to health status, and assess the engraftment potential of probiotic strains or live biotherapeutics. The M-SHIME is inoculated with fecal microbiota from an individual human donor. Mimicking the mucosal conditions enables adaptation of the microbiota to the mucosal environment thus yielding a microbial community that reflects the *in vivo* situation in terms of composition and functionality. Pooling of fecal microbiota samples is strongly disadvised. The method is a 1 donor per experiment setup. This also allows maintaining the unique features of an individual's microbiome in order to study interindividual differences in mucosal colonisation and microbial behaviour.

Lab equipment

BSL2 lab required as M-SHIME inoculum is derived from human fecal slurry.

Method status

History of use
Internally validated
Published in peer reviewed journal

PROS, CONS & FUTURE POTENTIAL

Advantages

- Specific study of gut mucosa-associated microbiota that are difficult to access through invasive *in vivo* sampling procedures (tissue brushes, biopsies…),
- Multi-parametric model,
- Longitudinal model that allows time-resolved analyses,
- Responsive model that allows treatments that are impossible to carry out *in vivo*,
- Absence of host tissue allows to solely address responsiveness of the mucosal microbiota to determinants/stressors of interest (e.g. antibiotics, drugs…).

Challenges

Absence of host tissue means absence of epithelial barrier or immune response.

Modifications

- Incorporation of different mucin types for more delicate enteropathogen studies,
- Incorporation of more immune related components (Ig, AMP…).

Future & Other applications

Enteropathogen studies, Human nutrition, Chronic gut inflammation, Pharmacokinetics, Toxicokinetics…

REFERENCES, ASSOCIATED DOCUMENTS AND OTHER INFORMATION

References

Van den Abbeele, Pieter, Clara Belzer, Margot Goossens, Michiel Kleerebezem, Willem M De Vos, Olivier Thas, Rosemarie De Weirdt, Frederiek-Maarten Kerckhof, and Tom Van de Wiele. 2013. “Butyrate-Producing Clostridium Cluster XIVa Species Specifically Colonize Mucins in an in Vitro Gut Model.” ISME JOURNAL 7 (5): 949–961. doi:10.1038/ismej.2012.158.

De Weirdt, Rosemarie, Els Coenen, Bruno Vlaeminck, Veerle Fievez, Pieter Van den Abbeele, and Tom Van de Wiele. 2013. “A Simulated Mucus Layer Protects Lactobacillus Reuteri from the Inhibitory Effects of Linoleic Acid.” BENEFICIAL MICROBES 4 (4): 299–312. doi:10.3920/BM2013.0017.

Van den Abbeele, Pieter, Massimo Marzorati, Melanie Derde, Rosemarie De Weirdt, Joan Vermeiren, Sam Possemiers, and Tom Van de Wiele. 2016. “Arabinoxylans, Inulin and Lactobacillus Reuteri 1063 Repress the Adherent-Invasive Escherichia Coli from Mucus in a Musosa-Comprising Gut Model.” NPJ BIOFILMS AND MICROBIOMES 2. doi:10.1038/npjbiofilms.2016.16.

Chassaing, Benoit, Tom Van de Wiele, Jana De Bodt, Massimo Marzorati, and Andrew T. Gewirtz. 2017. “Dietary Emulsifiers Directly Alter Human Microbiota Composition and Gene Expression Ex Vivo Potentiating Intestinal Inflammation.” GUT 66 (8): 1414–1427. doi:10.1136/gutjnl-2016-313099.

Geirnaert, Annelies, Marta Calatayud Arroyo, Charlotte Grootaert, Debby Laukens, Sarah Devriese, Guy Smagghe, Martine De Vos, Nico Boon, and Tom Van de Wiele. 2017. “Butyrate-Producing Bacteria Supplemented in Vitro to Crohn’s Disease Patient Microbiota Increased Butyrate Production and Enhanced Intestinal Epithelial Barrier Integrity.” SCIENTIFIC REPORTS 7. doi:10.1038/s41598-017-11734-8.

Van Herreweghen, Florence, Kim De Paepe, Hugo Roume, Frederiek-Maarten Kerckhof, and Tom Van de Wiele. 2018. “Mucin Degradation Niche as a Driver of Microbiome Composition and Akkermansia Muciniphila Abundance in a Dynamic Gut Model Is Donor Independent.” FEMS MICROBIOLOGY ECOLOGY 94 (12). doi:10.1093/femsec/fiy186.

Lambrecht, Ellen, Els Van Coillie, Eva Van Meervenne, Nico Boon, Marc Heyndrickx, and Tom Van de Wiele. 2019. “Commensal E. Coli Rapidly Transfer Antibiotic Resistance Genes to Human Intestinal Microbiota in the Mucosal Simulator of the Human Intestinal Microbial Ecosystem (M-SHIME).” INTERNATIONAL JOURNAL OF FOOD MICROBIOLOGY 311. doi:10.1016/j.ijfoodmicro.2019.108357.

Rolhion, Nathalie, Benoit Chassaing, Marie-Anne Nahori, Jana De Bodt, Alexandra Moura, Marc Lecuit, Olivier Dussurget, Marion Berard, Massimo Marzorati, Hannah Fehlner-Peach, Dan R. Littman, Andrew T. Gewirtz, Tom Van de Wiele, and Pascale Cossart. 2019. “A Listeria Monocytogenes Bacteriocin Can Target the Commensal

Prevotella Copri and Modulate Intestinal Infection." CELL HOST & MICROBE 26 (5): 691–701. doi:10.1016/j.chom.2019.10.016.

Toe, Laéticia Céline, Frederiek-Maarten Kerckhof, Jana De Bodt, Fanny B. Morel, Jean-Bosco Ouedraogo, Patrick Kolsteren, and Tom Van de Wiele. 2020. "A Prebiotic-Enhanced Lipid-Based Nutrient Supplement (LNSp) Increases Bifidobacterium Relative Abundance and Enhances Short-Chain Fatty Acid Production in Simulated Colonic Microbiota from Undernourished Infants." FEMS MICROBIOLOGY ECOLOGY 96 (7). doi:10.1093/femsec/fiaa105.

Hernandez Sanabria, Emma, Evelien Heiremans, Marta Calatayud Arroyo, Ruben Props, Laurent Leclercq, Jan Snoeys, and Tom Van de Wiele. 2020. "Short-Term Supplementation of Celecoxib-Shifted Butyrate Production on a Simulated Model of the Gut Microbial Ecosystem and Ameliorated in Vitro Inflammation." NPJ BIOFILMS AND MICROBIOMES 6 (1). doi:10.1038/s41522-020-0119-0.

De Paepe, Kim, Joran Verspreet, Christophe M. Courtin, and Tom Van de Wiele. 2020. "Microbial Succession during Wheat Bran Fermentation and Colonisation by Human Faecal Microbiota as a Result of Niche Diversification."

Roussel, Charlène, Kim De Paepe, Wessam Galia, Jana De Bodt, Sandrine Chalancon, Francoise Leriche, Nathalie Ballet, Sylvain Denis, Monique Alric, Tom Van de Wiele, and Stephanie Blanquet-Diot. 2020. "Spatial and Temporal Modulation of Enterotoxigenic E. Coli H10407 Pathogenesis and Interplay with Microbiota in Human Gut Models." BMC BIOLOGY 18 (1). doi:10.1186/s12915-020-00860-x

Lambrecht, Ellen, Els Van Coillie, Nico Boon, Marc Heyndrickx, and Tom Van de Wiele. 2021. "Transfer of Antibiotic Resistance Plasmid from Commensal E. Coli towards Human Intestinal Microbiota in the M-SHIME ：Effect of E. Coli Dosis, Human Individual and Antibiotic Use."

Van Herreweghen, Florence, Kim De Paepe, Massimo Marzorati, and Tom Van de Wiele. 2021. "Mucin as a Functional Niche Is a More Important Driver of in Vitro Gut Microbiota Composition and Functionality than Akkermansia Muciniphila

Supplementation.” APPLIED AND ENVIRONMENTAL MICROBIOLOGY 87 (4). doi:10.1128/AEM.02647-20.

Van Herreweghen, Florence, Kim De Paepe, Massimo Marzorati, and Tom Van de Wiele. 2021. “Mucin as a Functional Niche Is a More Important Driver of in Vitro Gut Microbiota Composition and Functionality than Akkermansia Muciniphila Supplementation.” APPLIED AND ENVIRONMENTAL MICROBIOLOGY 87 (4). doi:10.1128/AEM.02647-20.

Roussel, Charlène, Kim De Paepe, Wessam Galia, Jana De Bodt, Sandrine Chalancon, Sylvain Denis, Francoise Leriche, Pascal Vandekerkove, Nathalie Ballet, Stephanie Blanquet-Diot, and Tom Van de Wiele. 2021. “Multi-Targeted Properties of the Probiotic Saccharomyces Cerevisiae CNCM I-3856 against Enterotoxigenic Escherichia Coli (ETEC) H10407 Pathogenesis across Human Gut Models.” GUT MICROBES 13 (1). doi:10.1080/19490976.2021.1953246.

Ouwerkerk, Janneke P., Hanne L. P. Tytgat, Janneke Elzinga, Jasper Koehorst, Pieter Van den Abbeele, Bernard Henrissat, Miguel Gueimonde, Patrice D. Cani, Tom Van de Wiele, Clara Belzer, and Willem M. de Vos. 2022. “Comparative Genomics and Physiology of Akkermansia Muciniphila Isolates from Human Intestine Reveal Specialized Mucosal Adaptation.” MICROORGANISMS 10 (8). doi:10.3390/microorganisms10081605.