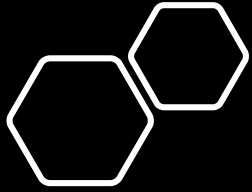


Persoonallisuuden piirteet bakteereissani

Anna Aatsinki, LT,
tutkijatohtori
FinnBrain-tutkimus,
Turun Yliopisto

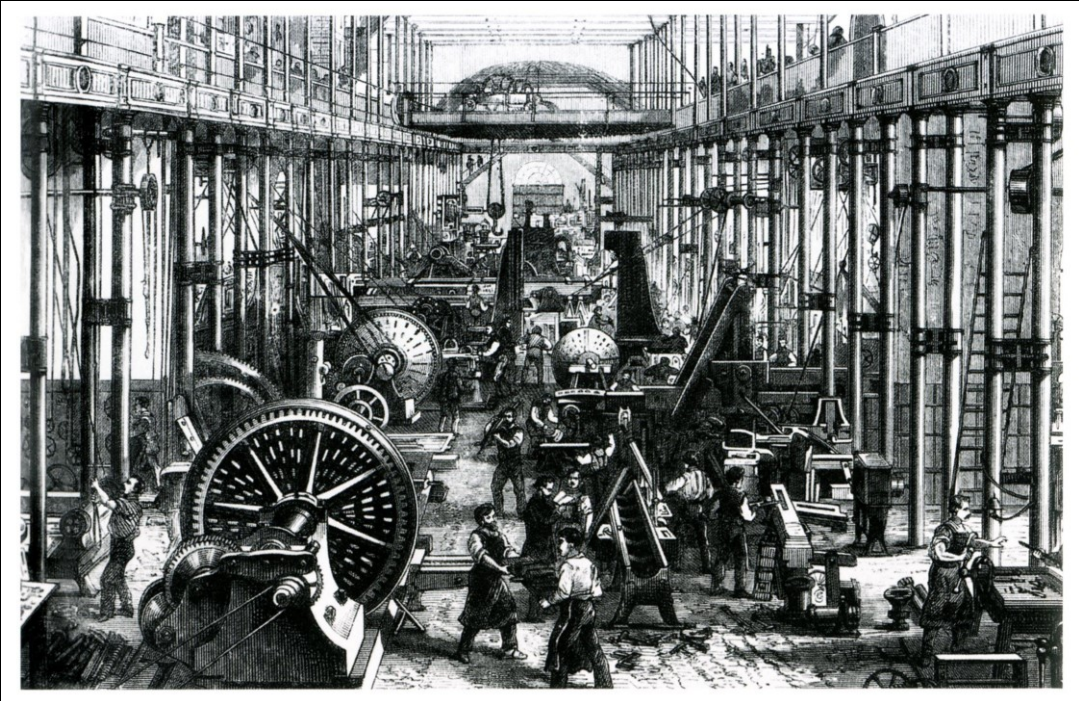


Esityksen sisältö

- Suoli-aivoakselin historiaa
- Suoli-aivo – akseli eläimillä ja sen mekanismit
- Havaintoja ihmisillä
- Esimerkkejä “interventioista”



Historian havinaa



March 12, 1898

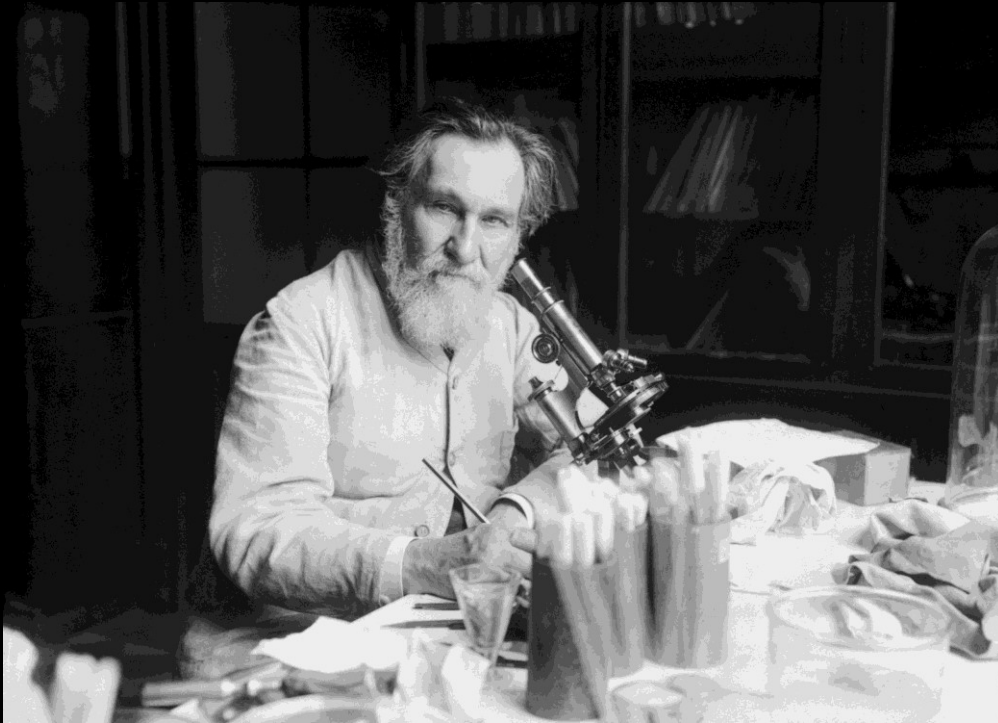
AUTO-INTOXICATION IN ITS RELATIONS TO THE DISEASES OF THE NERVOUS SYSTEM.

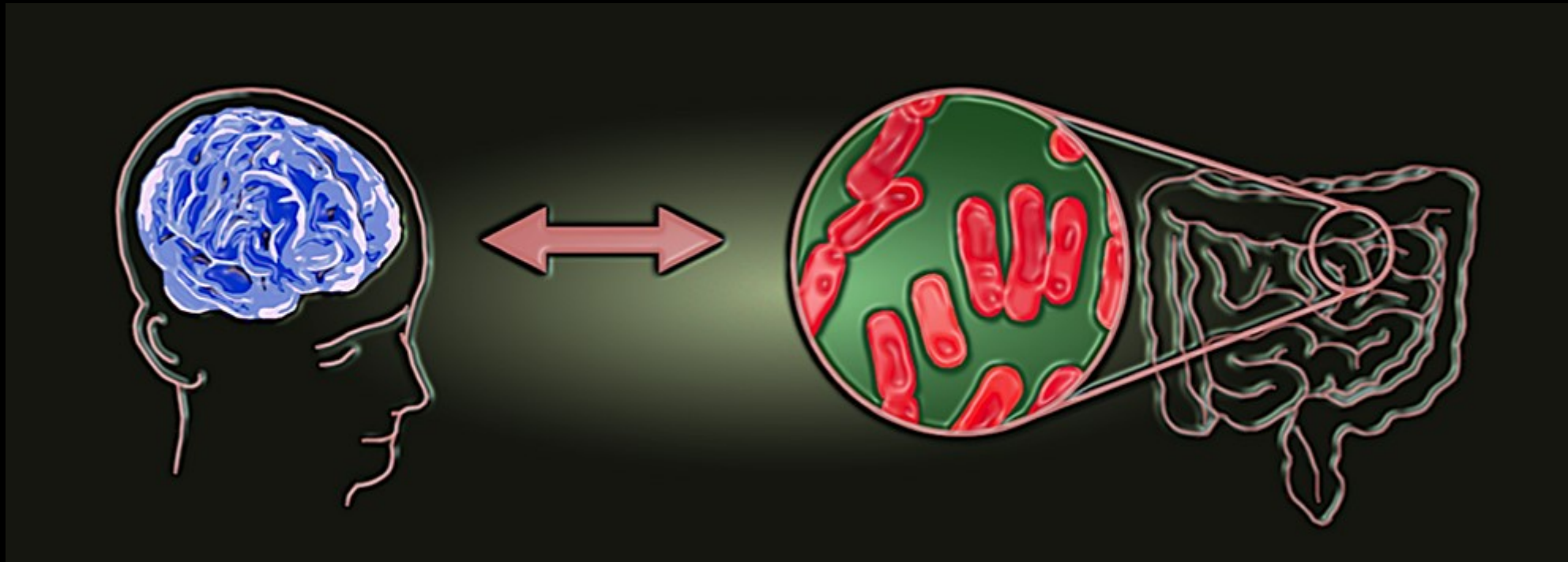
DANIEL R. BROWER, M.A., M.D.

[» Author Affiliations](#)

JAMA. 1898;XXX(11):575-577. doi:10.1001/jama.1898.72440630001001

Historian havinaa





Original Articles | [Published: February 1986](#)

Variations of brain histamine levels in germ-free and nephrectomized rats

[Linda R. Hegstrand](#) & [R. Jean Hine](#)

[Neurochemical Research](#) 11, 185–191 (1986) | [Cite this article](#)

85 Accesses | 21 Citations | 3 Altmetric | [Metrics](#)

ARTICLES

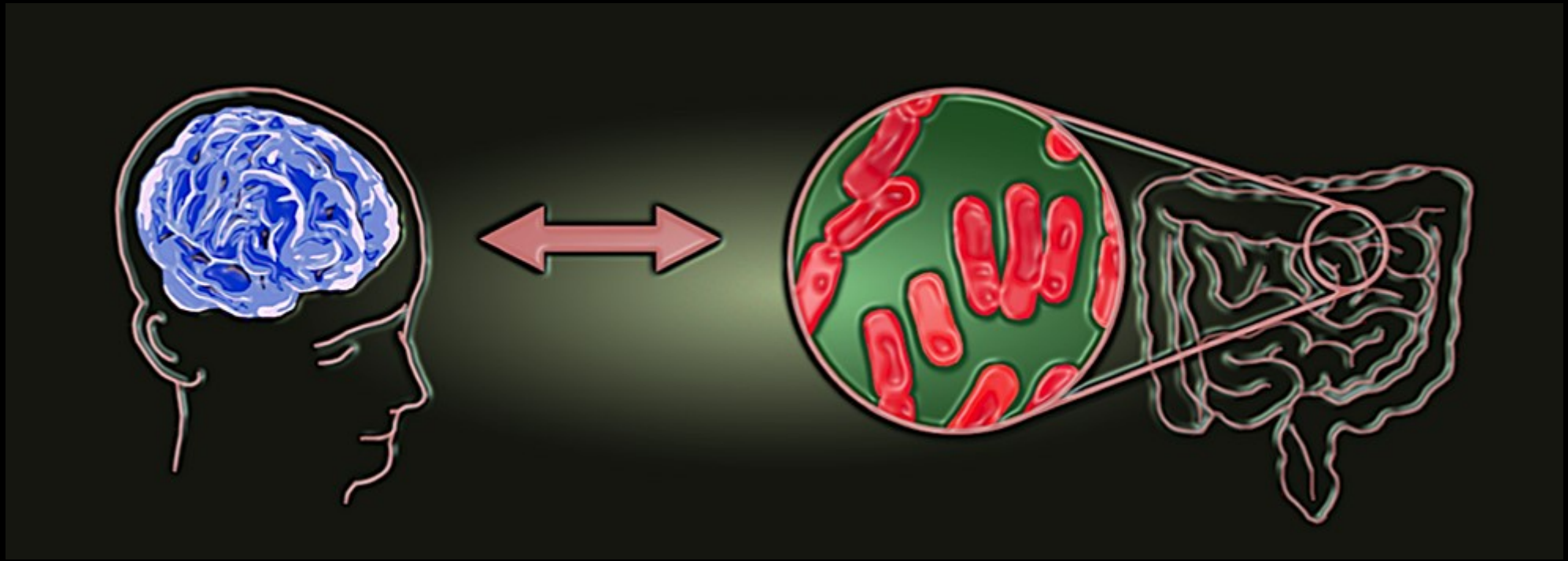
BIOLOGICAL FREUDIANISM

Lasting Effects of Early Environmental Influences

René Dubos, Ph.D. (M.D. Hon.), Dwayne Savage, Ph.D., and Russell Schaedler, M.D.

The Rockefeller University, New York

PEDIATRICS, Vol. 38, No. 5, November 1966



Microbiota-Gut-Brain axis

=

Bidirectional communication between gut microbiota and central nervous system



Havaintoja
eläinmalleissa

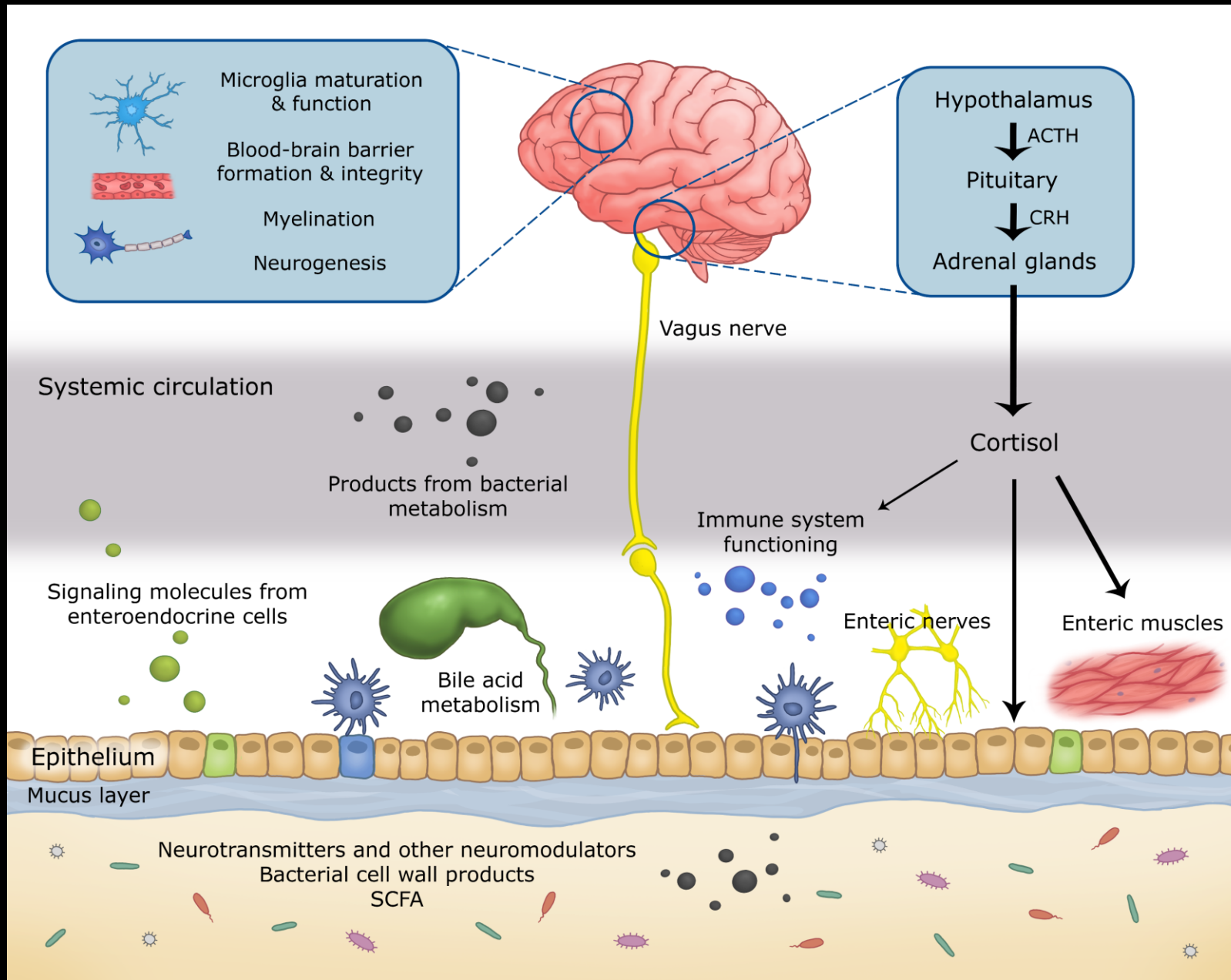
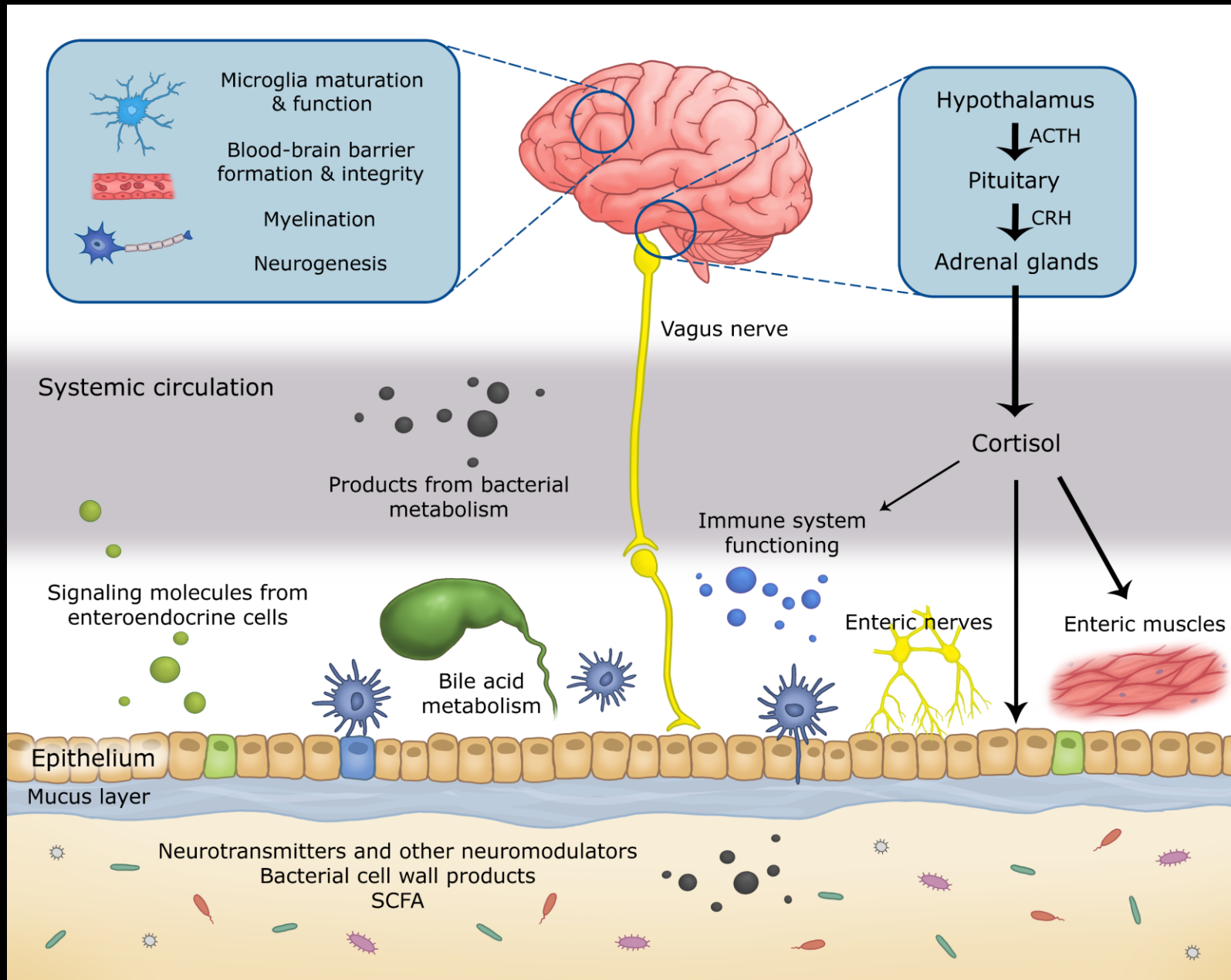


Image: Heidi Huhtanen



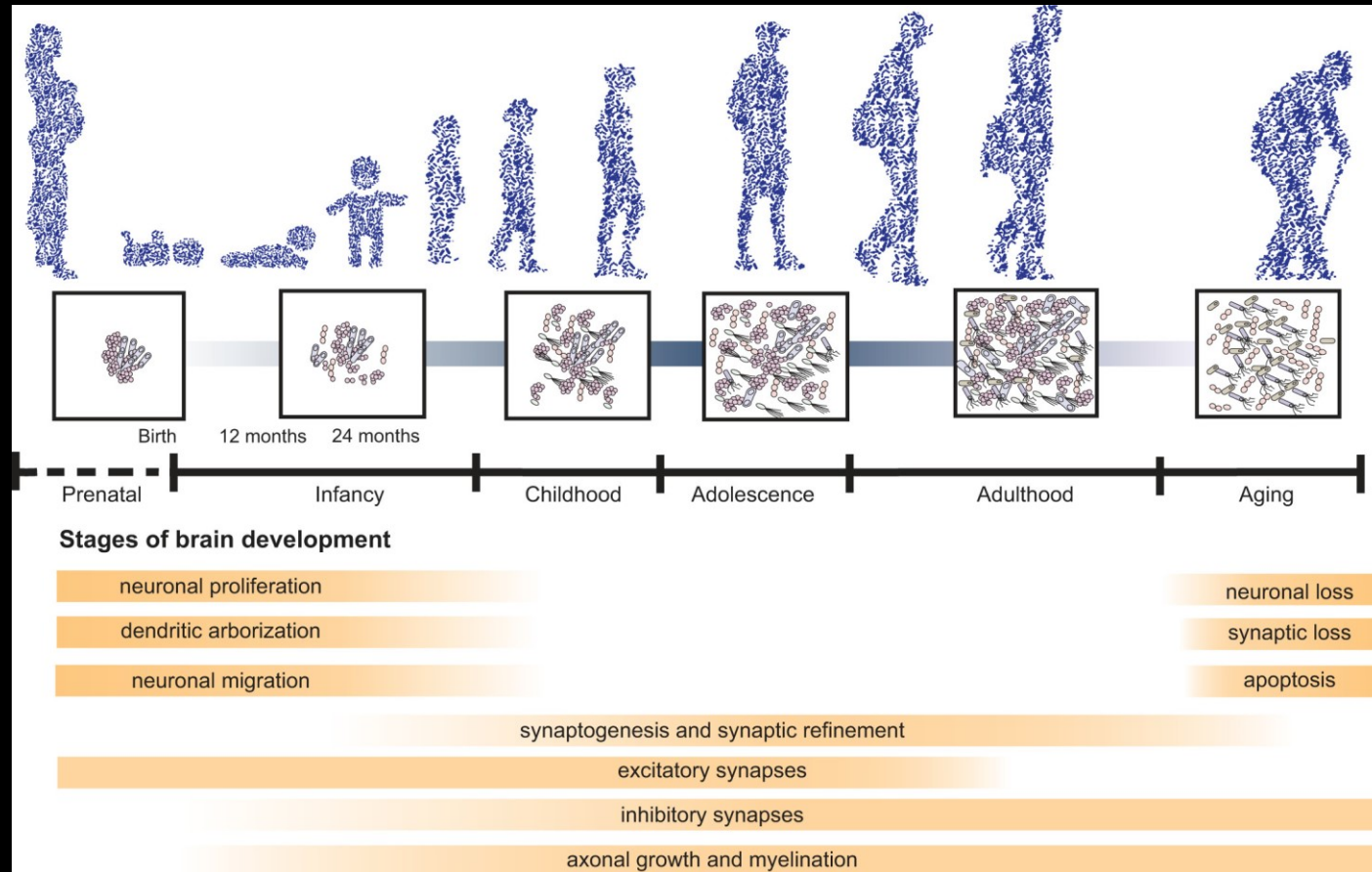
Phenotypes affected:

- Social behavior
- Cognition
- Fear regulation
- Stress-responsivity
- bidirectional relationship
- Food intake and appetite

Cryan et al. 2019

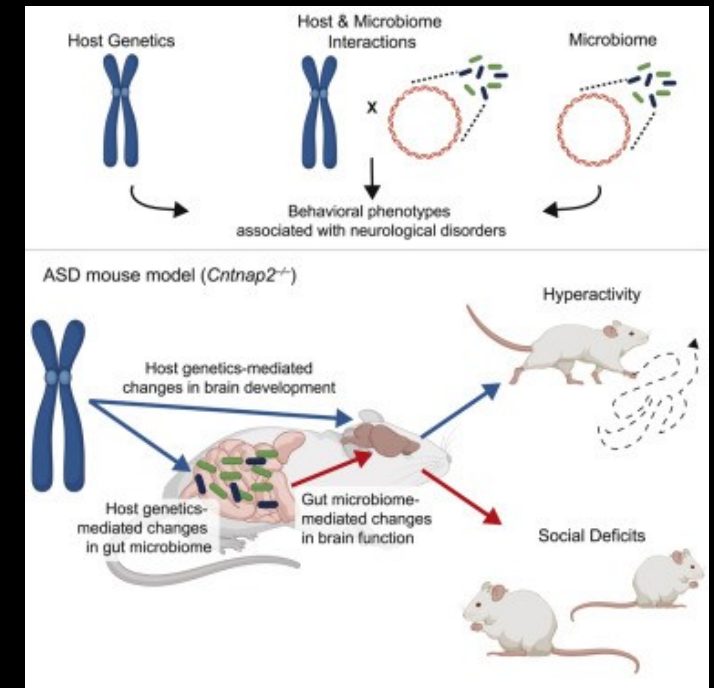
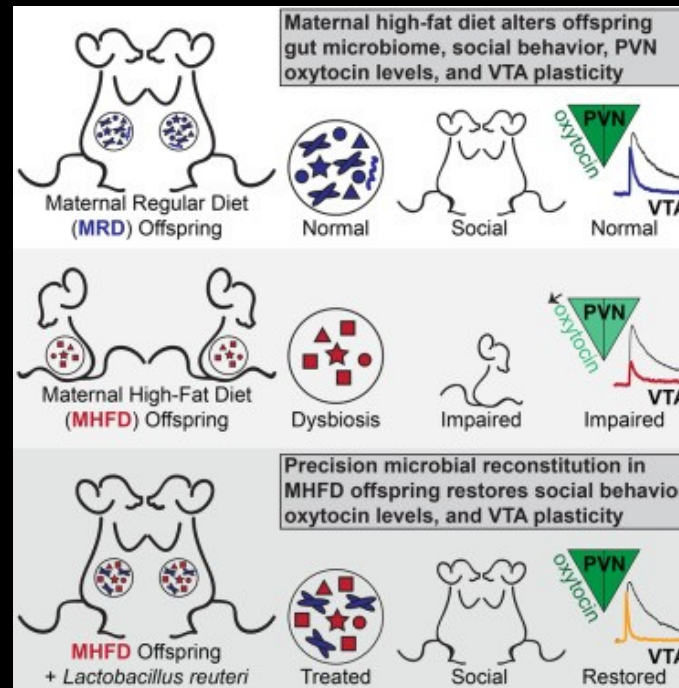
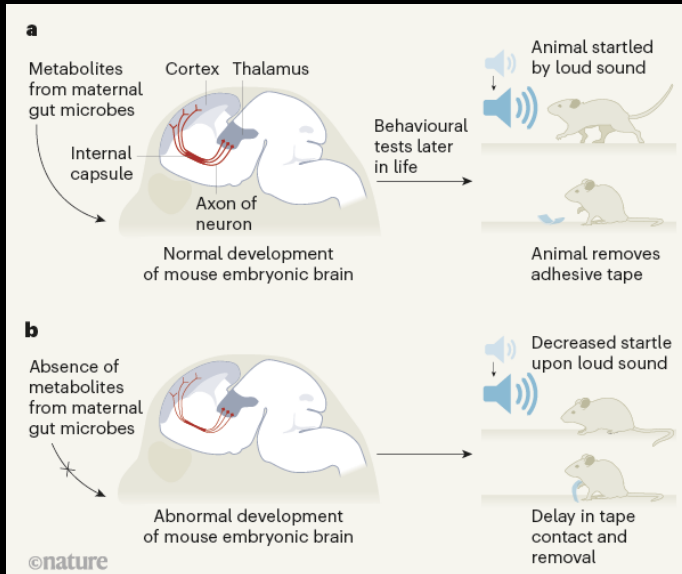
doi:10.1152/physrev.00018.2018

Mikrobisto elämänkaaren aikana



DOI: (10.1152/physrev.00018.2018)

Varhainen mikrobisto ja sosiaaliset aivot



→ Varhainen kontakti mikrobeihin tai niiden aineenvaihduntatuotteisiin ohjelmoi käyttäytymisen kehitystä yhdessä perimän kanssa


Ref: Vuong, 2020, Nature; Meckel, Kiraly, 2020, Nature; Buffington et al. 2016, Cell; Buffington et al., Cell, 2021; Garcias, 2016 eLife

Varhainen mikrobisto ja kehitys

ARTICLE IN PRESS

Biological
Psychiatry

Gut microbiome and brain functional connectivity in infants—a preliminary study focusing on the amygdala

Wei Gao^{1,2}  · Andrew P. Salzwedel¹ · Alexander L. Carlson³ · Kai Xia⁴ · M. Andrea Azcarate-Peril^{5,6} · Martin A. Styner^{4,7} · Amanda L. Thompson^{8,9} · Xiujuan Geng¹⁰ · Barbara D. Goldman^{11,12} · John H. Gilmore⁴ · Rebecca C. Knickmeyer^{4,13,14}

Received: 22 September 2018 / Accepted: 21 December 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2019

Archival Report

Infant Gut Microbiome Associated With Cognitive Development

Alexander L. Carlson, Kai Xia, M. Andrea Azcarate-Peril, Barbara D. Goldman, Mihye Ahn, Martin A. Styner, Amanda L. Thompson, Xiujuan Geng, John H. Gilmore, and Rebecca C. Knickmeyer

JAMA
Network | **Open**[™]



Original Investigation | Pediatrics

Association of the Infant Gut Microbiome With Early Childhood Neurodevelopmental Outcomes An Ancillary Study to the VDAART Randomized Clinical Trial

Joanne E. Sordillo, ScD; Susan Korrick, MD; Nancy Laranjo, BA; Vincent Carey, PhD; George M. Weinstock, PhD; Diane R. Gold, MD; George O'Connor, MD; Megan Sandel, MD; Leonard B. Bacharier, MD; Avraham Beigelman, MD; Robert Zeiger, MD, PhD; Augusto A. Litonjua, MD; Scott T. Weiss, MD

Research paper

Maternal prenatal gut microbiota composition predicts child behaviour

Samantha L. Dawson^{a, b}, Martin O'Hely^{a, b}, Felice N. Jacka^{a, b, h}, Anne-Louise Ponsonby^{c, d}, Christos Symeonides^{b, d}, Amy Loughman^a, Fiona Collier^{a, b, f}, Margarita Moreno-Betancur^{b, d}, Peter Sly^{b, g}, David Burgner^{b, d, e}, Mimi L.K. Tang^{b, d, e}, Richard Saffery^{b, d}, Sarath Ranganathan^{b, d, e}, Michael A. Conlonⁱ, Leonard C Harrison^{d, j}, Susanne Brix^k, Karsten Kristiansen^l, Peter Vuillermin^{a, b, f, g, i, j, k, l}, the BIS Investigator Group

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ISSN: 1528-3542

<https://doi.org/10.1037/emo00009>

Research paper

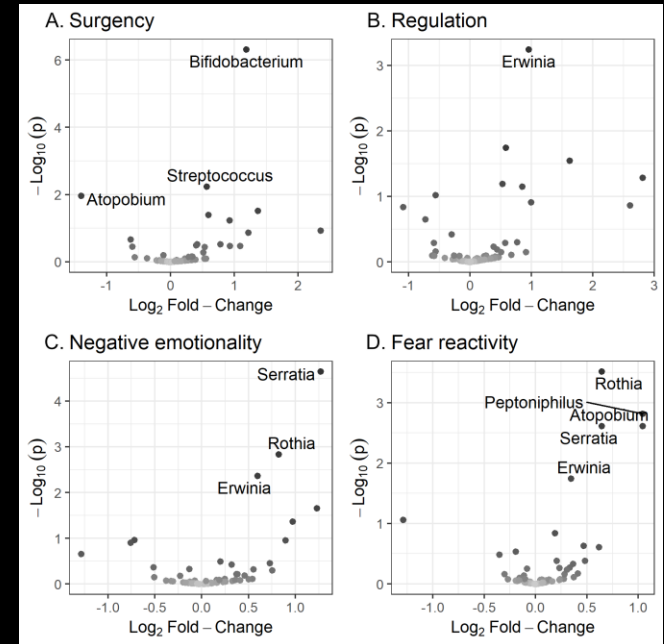
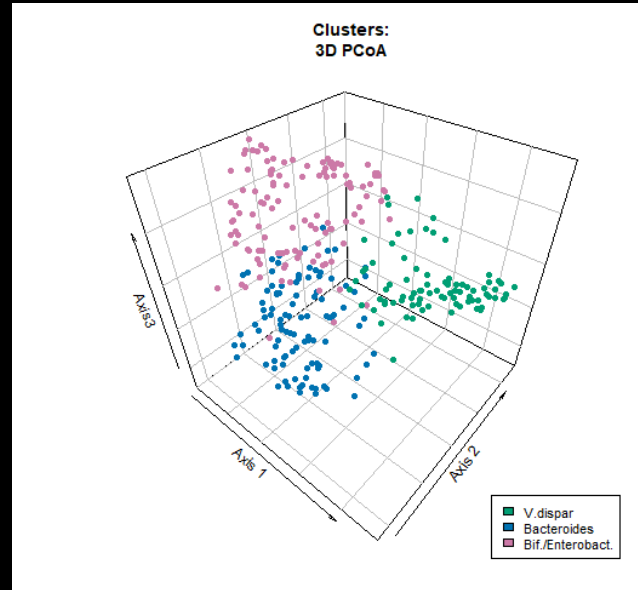
Gut microbiota composition during infancy and subsequent behavioural outcomes

Amy Loughman^a, Anne-Louise Ponsonby^{b, h}, Martin O'Hely^{a, b}, Christos Symeonides^{b, d, e}, Fiona Collier^{a, b, c}, Mimi L.K. Tang^{b, d, e}, John Carlin^{b, d}, Sarath Ranganathan^{b, d, e}, Katrina Allen^{b, d, e}, Angela Pezic^b, Richard Saffery^{b, d}, Felice Jacka^{a, b}, Leonard C. Harrison^{d, f}, Peter D. Sly^{b, g}, Peter Vuillermin^{a, b, c, *}, the BIS Investigator Group

Infant Fecal Microbiota Composition and Attention to Emotional Faces

Anna-Katariina Aatsinki¹, Eeva-Leena Kataja^{1, 2}, Eveliina Munukka³, Leo Lahti⁴, Anniina Keskitalo^{1, 5}, Riikka Korja^{2, 1}, Saara Nolvi^{6, 1, 7}, Tuomo Häikiö², Saija Tarro¹, Hasse Karlsson^{1, 8, 9, 10}, and Linnea Karlsson^{1, 8, 9, 11}

Varhainen mikrobisto ja temperamentti



Infant behavioral questionnaire revised (Rothbart et al. 1981) at 6 mo, n=301

Aatsinki et al., Brain, Behavior, and Immunity, 2019

Temperament and gut microbiota

Gut microbiota composition is associated with newborn functional brain connectivity and behavioral temperament

Caroline M. Kelsey^{a,b,c,*}, Stephanie Prescott^{d,e}, John A. McCulloch^d, Giorgio Trinchieri^d, Tara L. Valladares^a, Caitlin Dreisbach^{f,g}, Jeanne Alhusen^f, Tobias Grossmann^{a,h,*}

Gut microbiome composition is associated with temperament during early childhood

Lisa M. Christian^{a,b,c,d}, Jeffrey D. Galley^{b,e}, Erinn M. Hade^f, Sarah Schoppe-Sullivan^g, Claire Kamp Dush^g, Michael T. Bailey^{b,e}

Gut microbiota composition is associated with temperament traits in infants

Anna-Katariina Aatsinki^a, Leo Lahti^b, Henna-Maria Uusitupa^a, Eveliina Munukka^{c,d}, Anniina Keskitalo^{d,e}, Saara Nolvi^a, Siobhain O'Mahony^f, Sami Pietilä^g, Laura L. Elo^g, Erkki Eerola^e, Hasse Karlsson^{a,h}, Linnea Karlsson^{a,i}



Association between Gut Microbiota and Infant's Temperament in the First Year of Life in a Chinese Birth Cohort



by Ying Wang^{1,†}, Xiaoli Chen^{1,†}, Yun Yu¹, Yanqun Liu^{1,*}, Qing Zhang^{1,*} and Jinbing Bai²

Development of the infant gut microbiome predicts temperament across the first year of life

Molly Fox^{1,2}, S. Melanie Lee^{2,3}, Kyle S. Wiley^{1,2}, Venu Lagishetty^{3,4,5}, Curt A. Sandman⁶, Jonathan P. Jacobs^{3,4,5} and Laura M. Glynn⁷



OPEN ACCESS | Research Article | 21 January 2020


Gut Feelings Begin in Childhood: the Gut Metagenome Correlates with Early Environment, Caregiving, and Behavior

Authors: Jessica E. Flannery, Keaton Stagaman, Adam R. Burns, Roxana J. Hickey, Leslie E. Roos, Ryan J. Giuliano, Phillip A. Fisher, and Thomas J. Sharpton | AUTHORS INFO & AFFILIATIONS




- Positive emotionality
 - Bifidobacterium + positive emotionality (Fox 2021)
 - Klebsiella – positive emotionality (Fox 2021)
 - Lachnospiraceae + positive emotionality (Fox 2021)
 - Bacteroides fragilis – impulsivity (Flannery 2020)
- Self-regulation
 - Bifidobacterium + Soothability (Wang 2020)
 - Hungatella + Cuddliness (Wang 2020)
 - Bifidobacterium adolescentis – inhibitory control (Flannery 2020)
 - Bacteroides fragilis + inhibitory control (Flannery 2020)
 - Eubacterium siraeum + impulsivity (Flannery 2020)
- Negative emotionality
 - Ruminococcus + negative emotionality (Fox 2021)
 - Lactobacillus – negative emotionality (Fox 2021)
 - Parabacteroides distasonis + fear (Flannery 2020)
 - Bilophila + fear (Flannery 2020)
 - Bacteroides fragilis – sadness (Flannery 2020)
- Impulsivity + tryptophan metabolism (Flannery 2020)
- Fear + melatonin biosynthesis (Flannery 2020)

Aikuisilla





Brain, Behavior, and Immunity
Volume 69, March 2018, Pages 374-385




Full-length Article

Correlation between gut microbiota and personality in adults: A cross-sectional study

Han-Na Kim ^a, Yeojun Yun ^a, Seungcho Ryu ^{b, c}, Yoosoo Chang ^{b, c}, Min-Jung Kwon ^{b, d}, Juhee Cho ^{b, e, g}, Hocheol Shin ^{b, f}, Hyung-Lae Kim ^a  


- Neuroottisuus pos. yhteydessä Gammaproteobakteerien pitoisuuteen



Contents lists available at [ScienceDirect](#)

Human Microbiome Journal


journal homepage: www.sciencedirect.com/journal/human-microbiome-journal



Original Article

Gut microbiome composition and diversity are related to human personality traits

Katerina V.-A. Johnson



University of Oxford, Department of Experimental Psychology, New Radcliffe Building, Radcliffe Observatory Quarter, Oxford OX2 6GG, United Kingdom

Intervention paikka: probiootit

Intervention paikka: probiootit

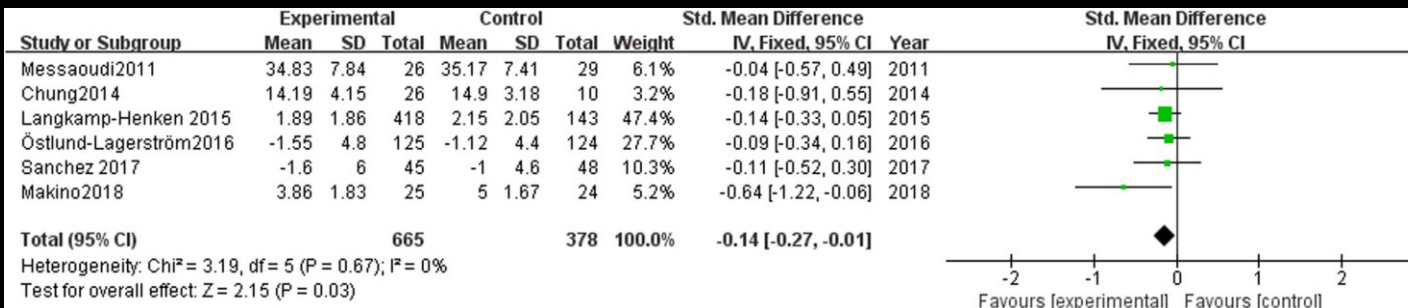
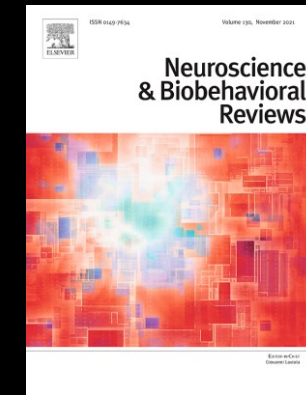
Brain and Behavior

Open Access

REVIEW | Open Access |

Efficacy of probiotics on stress in healthy volunteers: A systematic review and meta-analysis based on randomized controlled trials

Ning Zhang, Yanan Zhang, Menglin Li, Weiguang Wang, Zhenzhu Liu, Chongcheng Xi, Xunying Huang, Jintao Liu, Junwei Huang, Dong Tian, Jie Mu, Xing Liao , Shuangqing Zhai



Review article

The effect of probiotics on cognitive function across the human lifespan: A systematic review

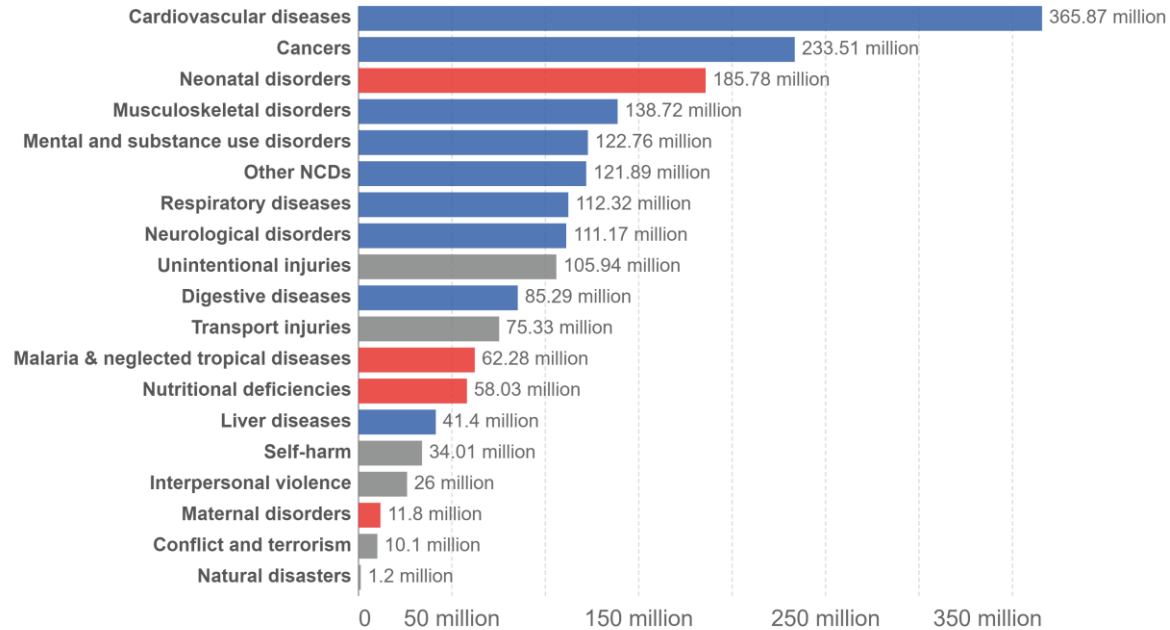
Jessica Eastwood ^a, Gemma Walton ^b, Saskia Van Hemert ^c, Claire Williams ^a, Daniel Lamport ^a

Muuttuva tautitaakka

Burden of disease by cause, World, 2017

Total disease burden, measured in Disability-Adjusted Life Years (DALYs) by sub-category of disease or injury. DALYs measure the total burden of disease – both from years of life lost due to premature death and years lived with a disability. One DALY equals one lost year of healthy life.

Our World in Data



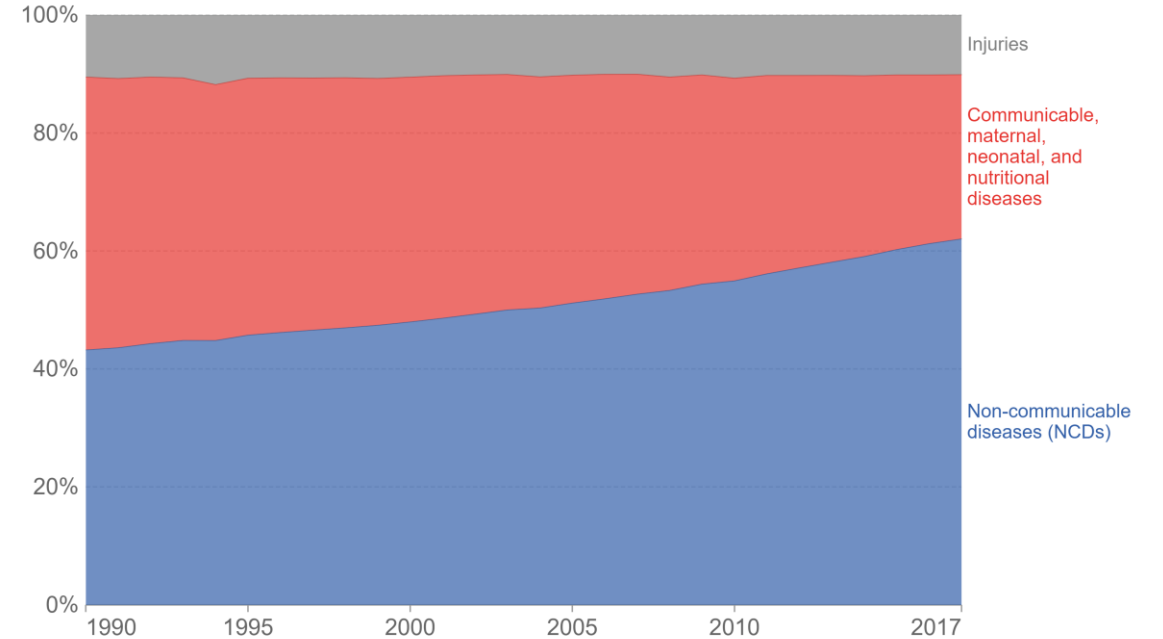
Source: IHME, Global Burden of Disease

OurWorldInData.org/burden-of-disease • CC BY

Total disease burden by cause, World, 1990 to 2017

Total disease burden measured as Disability-Adjusted Life Years (DALYs) per year. DALYs measure the total burden of disease – both from years of life lost due to premature death and years lived with a disability. One DALY equals one lost year of healthy life.

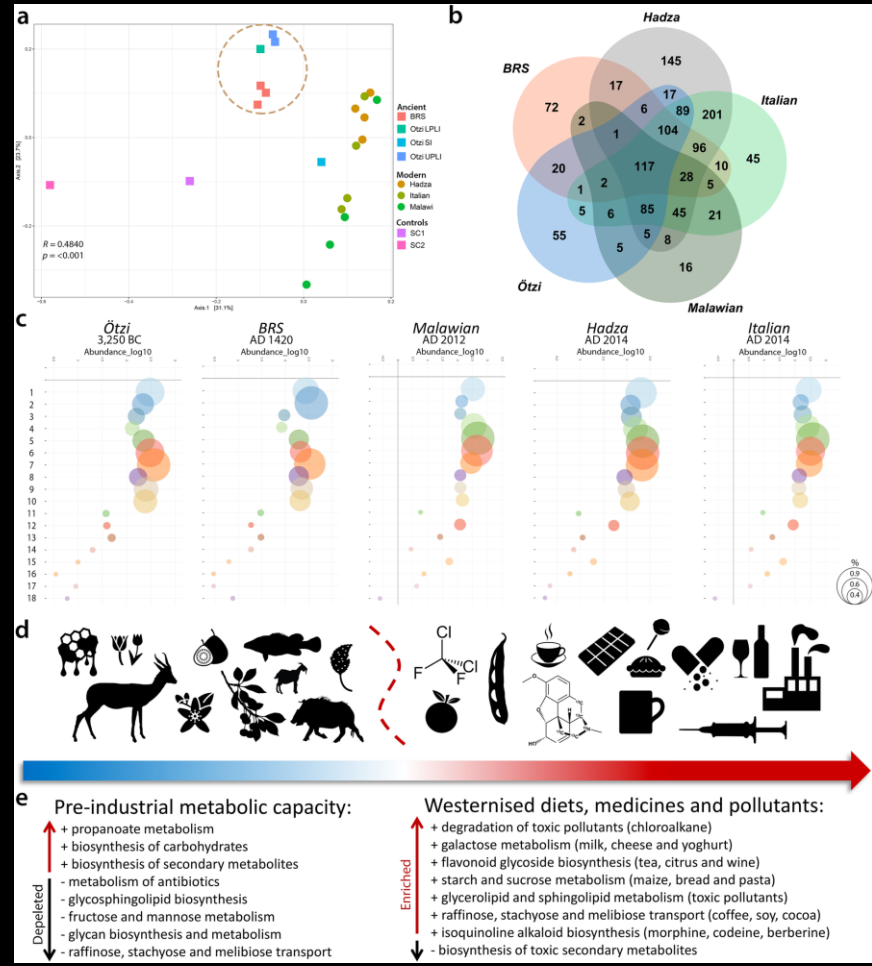
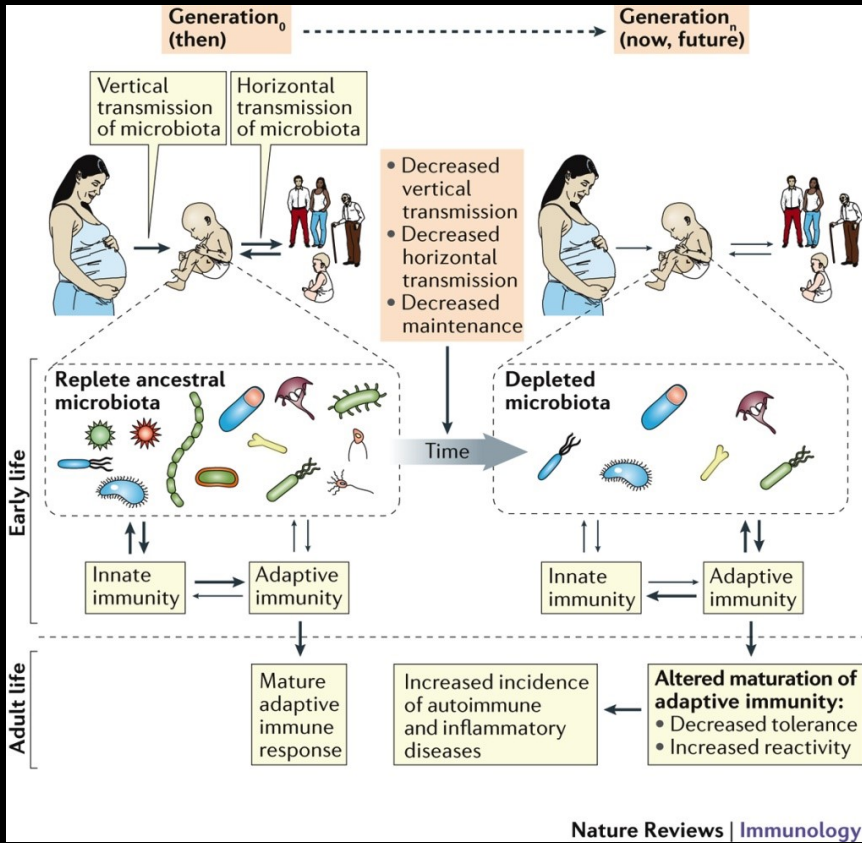
Our World in Data



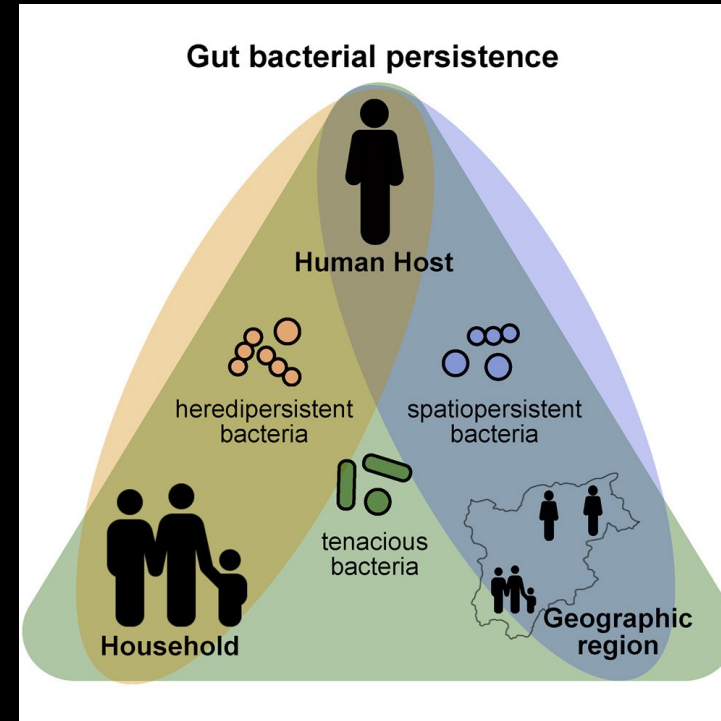
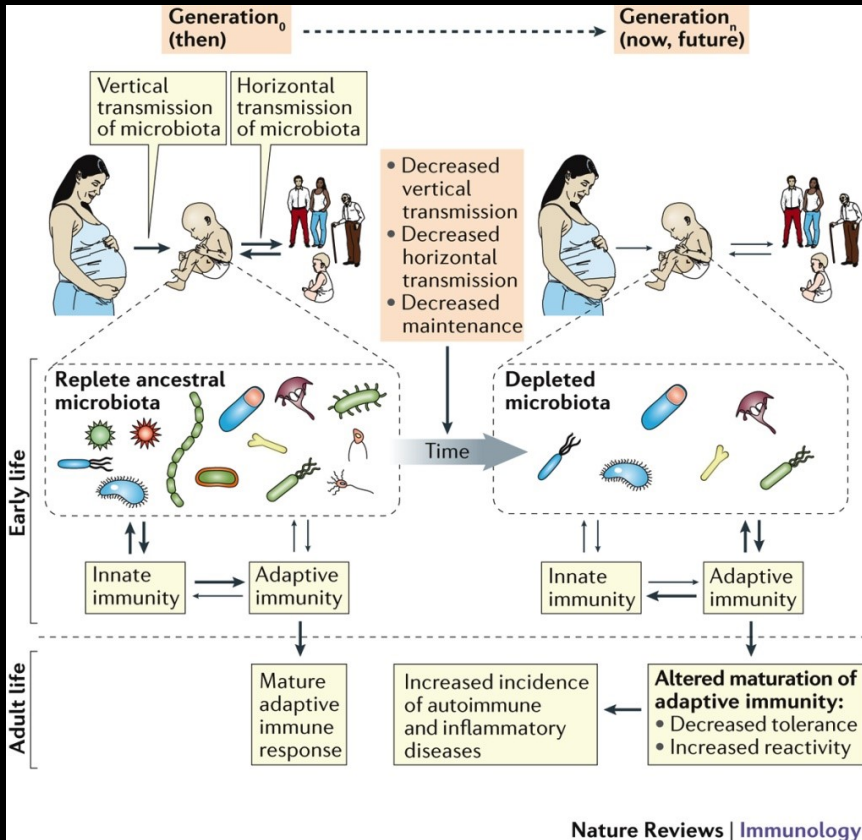
Source: IHME, Global Burden of Disease

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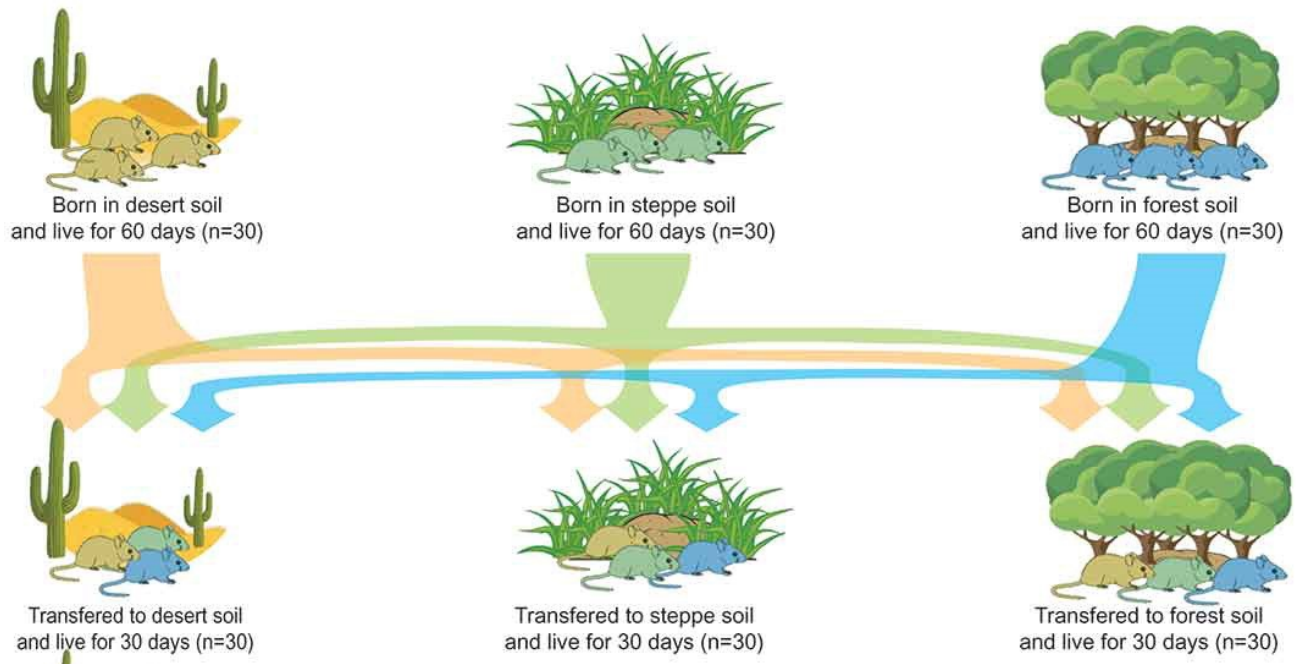
Muuttuva mikrobisto



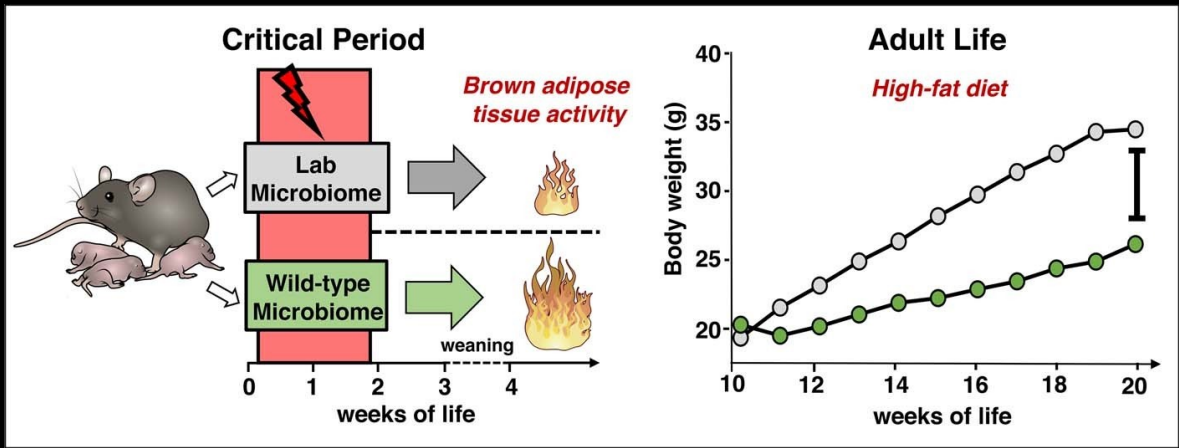
Muuttuva mikrobisto



a



b



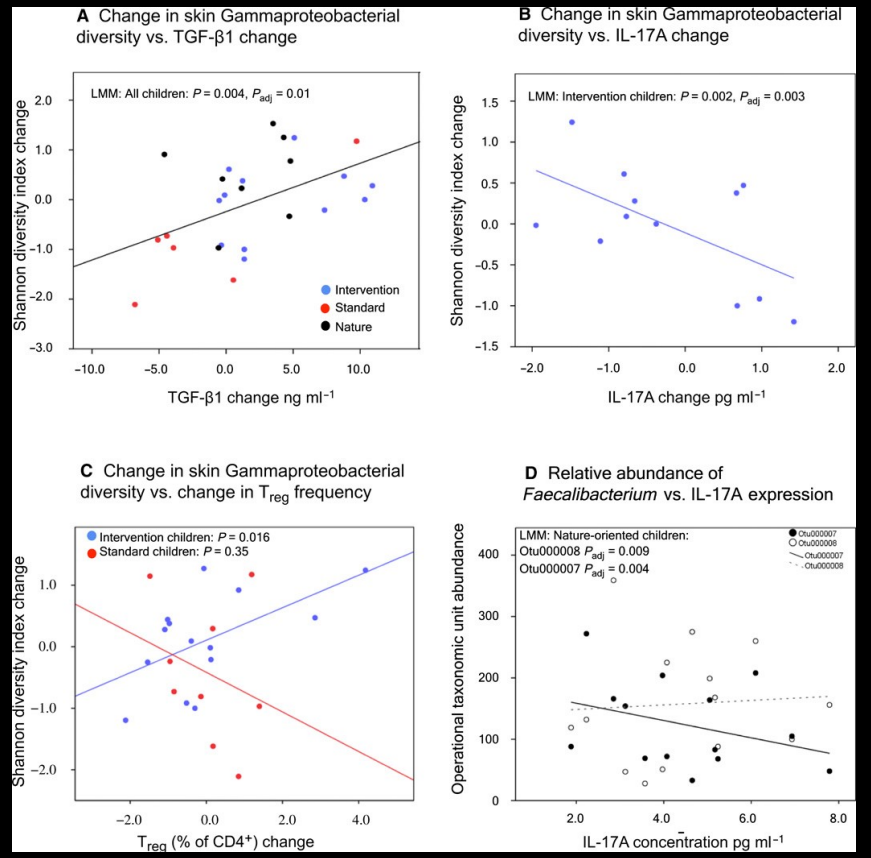
Liu et al. 2021 Gut Microbes; ROSLUND et al. 2020, Sci Adv; Hild et al. 2021 Nat Metabolism.

Impact of outdoor nature-related activities on gut microbiota, fecal serotonin, and perceived stress in preschool children: the Play&Grow randomized controlled trial

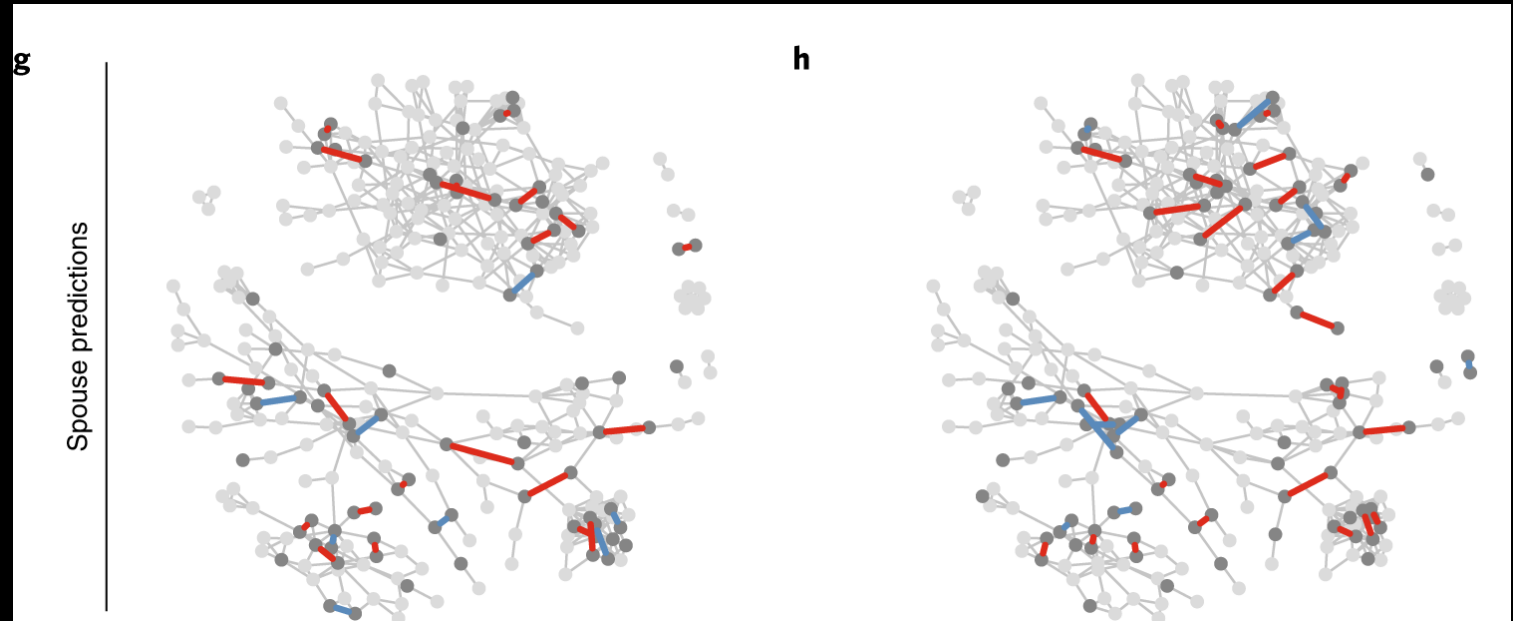
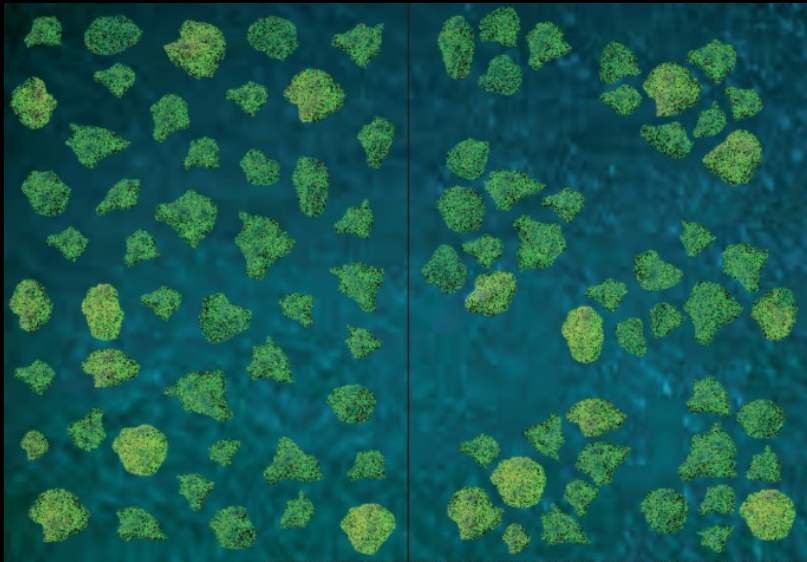
Tanja Sobko, Suisha Liang, Will H. G. Cheng & Hein M. Tun

[Scientific Reports](#) 10, Article number: 21993 (2020) | [Cite this article](#)

3111 Accesses | 16 Altmetric | [Metrics](#)



Sosiaaliset verkostot ja mikrobisto



Perspective | [Published: 22 June 2020](#)

Microbial transmission in animal social networks and the social microbiome

[Amar Sarkar](#) , [Siobhán Harty](#), [Katerina V.-A. Johnson](#), [Andrew H. Moeller](#), [Elizabeth A. Archie](#), [Laura D. Schell](#), [Rachel N. Carmody](#), [Timothy H. Clutton-Brock](#), [Robin I. M. Dunbar](#) & [Philip W. J. Burnet](#)

[Nature Ecology & Evolution](#) **4**, 1020–1035 (2020) | [Cite this article](#)

5070 Accesses | 22 Citations | 65 Altmetric | [Metrics](#)

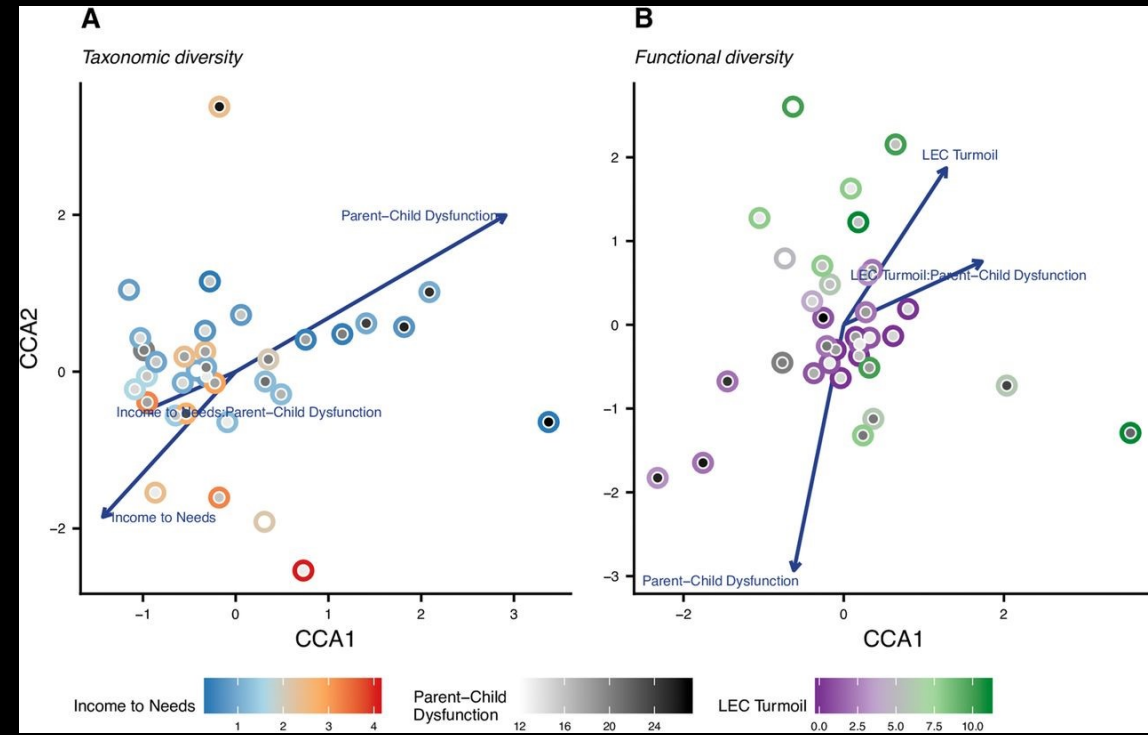
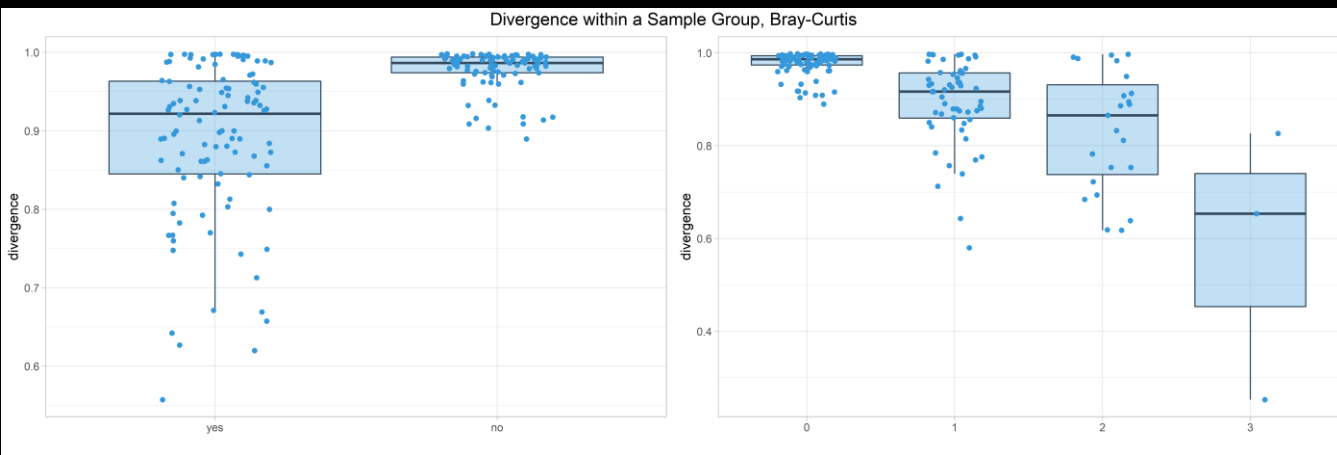
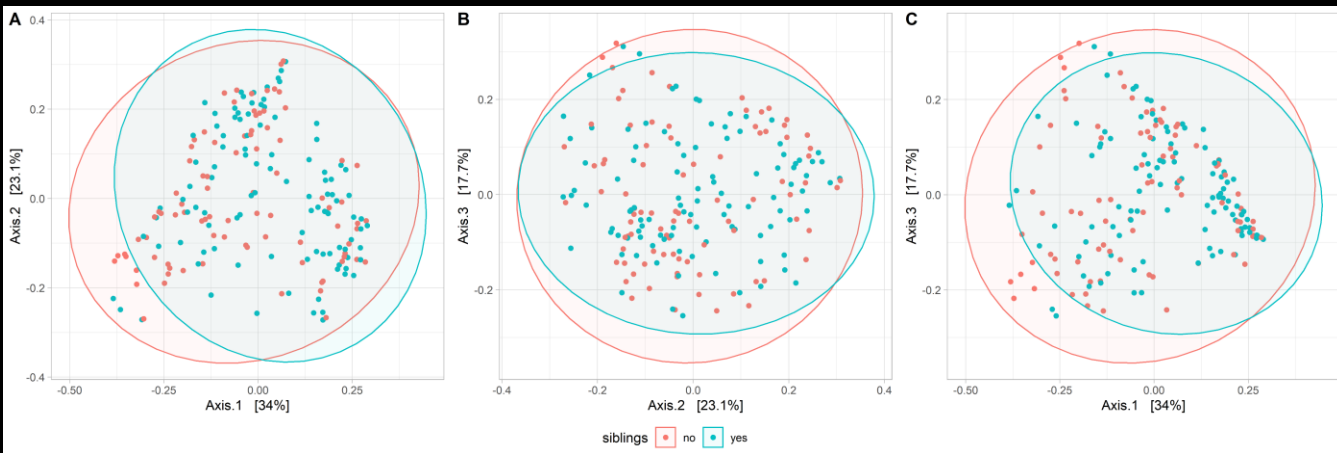
Letter | [Published: 25 March 2019](#)

Transmission of human-associated microbiota along family and social networks

[Ilana L. Brito](#) , [Thomas Gurry](#), [Shijie Zhao](#), [Katherine Huang](#), [Sarah K. Young](#), [Terrence P. Shea](#), [Waisea Naisilisili](#), [Aaron P. Jenkins](#), [Stacy D. Jupiter](#), [Dirk Gevers](#) & [Eric J. Alm](#) 

[Nature Microbiology](#) **4**, 964–971 (2019) | [Cite this article](#)

6870 Accesses | 52 Citations | 251 Altmetric | [Metrics](#)

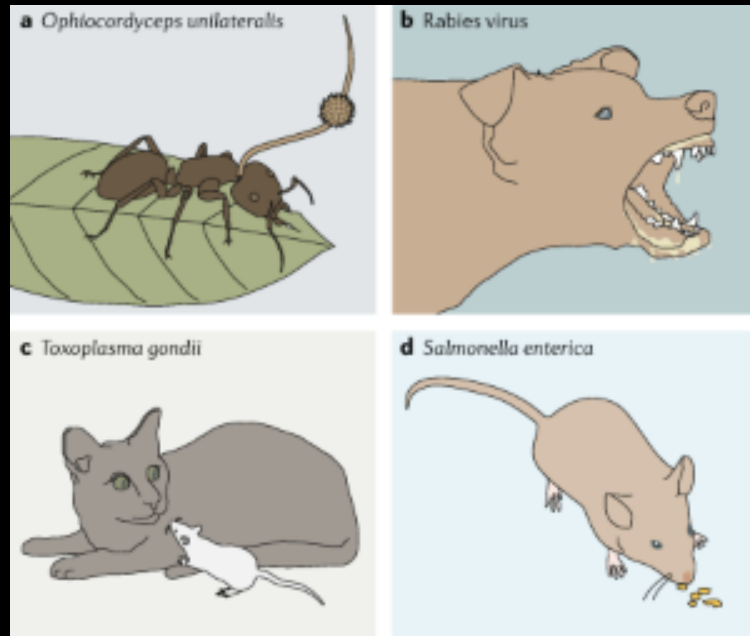


Infant saliva cortisol stress reactivity at 2.5 mo age, n=191, Keskitalo, Aatsinki et al. 2021 Stress

Gut Feelings Begin in Childhood: the Gut Metagenome Correlates with Early Environment, Caregiving, and Behavior

Jessica E. Flannery,^a Keaton Stagaman,^b Adam R. Burns,^c Roxana J. Hickey,^{d,e} Leslie E. Roos,^f Ryan J. Giuliano,^f Philip A. Fisher,^a Thomas J. Sharpton^{b,g}

Mikrobisto ja käyttäytyminen



Perspective | [Published: 24 April 2018](#)

OPINION

Why does the microbiome affect behaviour?

[Katerina V.-A. Johnson](#)  & [Kevin R. Foster](#) 

[Nature Reviews Microbiology](#) **16**, 647–655 (2018) | [Cite this article](#)

27k Accesses | **96** Citations | **709** Altmetric | [Metrics](#)

Take-home

- Mikrobisto voi olla yhteydessä käyttäytymiseen myös ihmisillä
 - välittyy mikrobiston aineenvaihduntatuotteiden, vagushermon toiminnan, immuunijärjestelmän kautta
 - Syntyy mikrobiston evoluution ja kiilailun sivutuotteena
- Varhainen mikrobisto voi olla yhteydessä sosioemotionaalisiin kehityskaariin
- Epäselvää minkä verran yksittäisillä bakteerikannoilla voi muuttaa käyttäytymistä aikuisilla
- Myös muista lähteistä tulevilla mikrobeilla voi olla vaikutusta suoliston ekosysteemiin ja sen isäntään kohdistuviin vaikutuksiin



Adj. Prof. Linnea Karlsson

Prof. Hasse Karlsson

Adj. Prof. Leo Lahti

Henna-Maria Kailanto, Eveliina Munukka, alumni

Saara Nolvi, Eeva-Leena Kataja, Anniina Keskitalo, post docs

Collaborators:

Teemu Kallonen, Turku Microbiome Biobank

Alex Dickens, Santosh Lamichhane, Turku Bioscience

Siobhain O'Mahony, University College Cork

Ana Joao Rodrigues, University of Minho

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Personal Funding:
Finnish Medical Foundation, Psychiatry Research Foundation, Maire Tapnonen foundation, Turku University Foundation, Signe and Ane Gyllenberg Foundation, Aivosäätiö, Instrumentarium Science Foundation, Finnish State Grants for Clinical Research, Emil Aaltonen Foundation