



Interfacing Food & Medicine



Interfacing Food and Medicine

Can the Gut Microbiome Control the Brain?

Dr Gerard Clarke

Department of Psychiatry and Neurobehavioural Science
and APC Microbiome Ireland
University College Cork

Ostrava January 31st 2018



Ah, on what little things
does happiness depend.

Oscar Wilde

quote fancy

OSCAR WILDE
THE NIGHTINGALE
AND THE ROSE

Illustrated by Freire Wright and
Michael Foreman



Gut Feelings

➤ Brain-Gut-Microbiome Axis

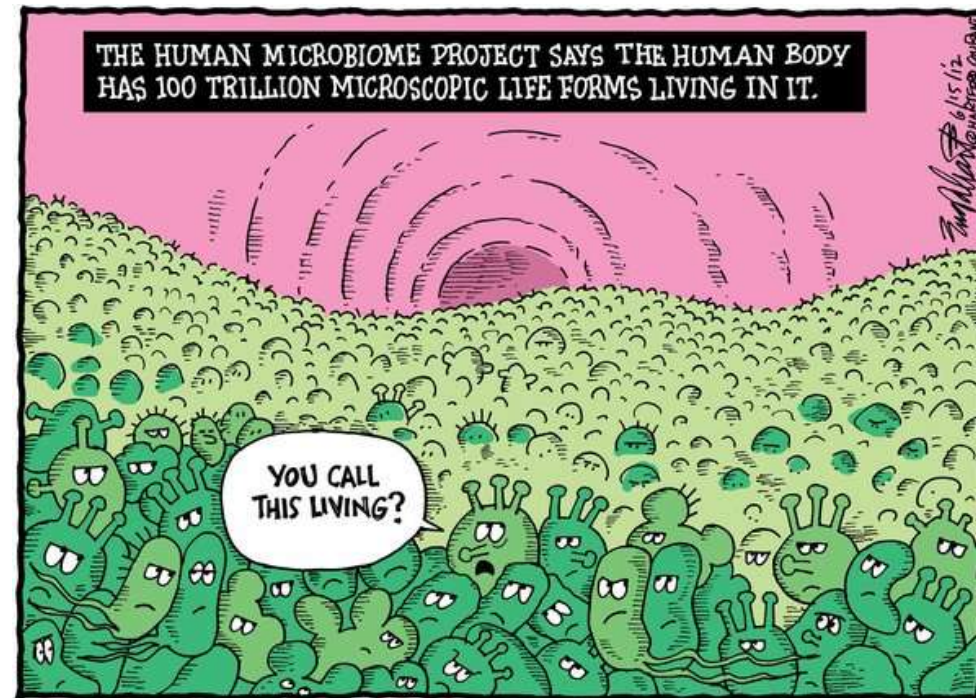
➤ Health and Disease

➤ ‘Mind altering microbes’

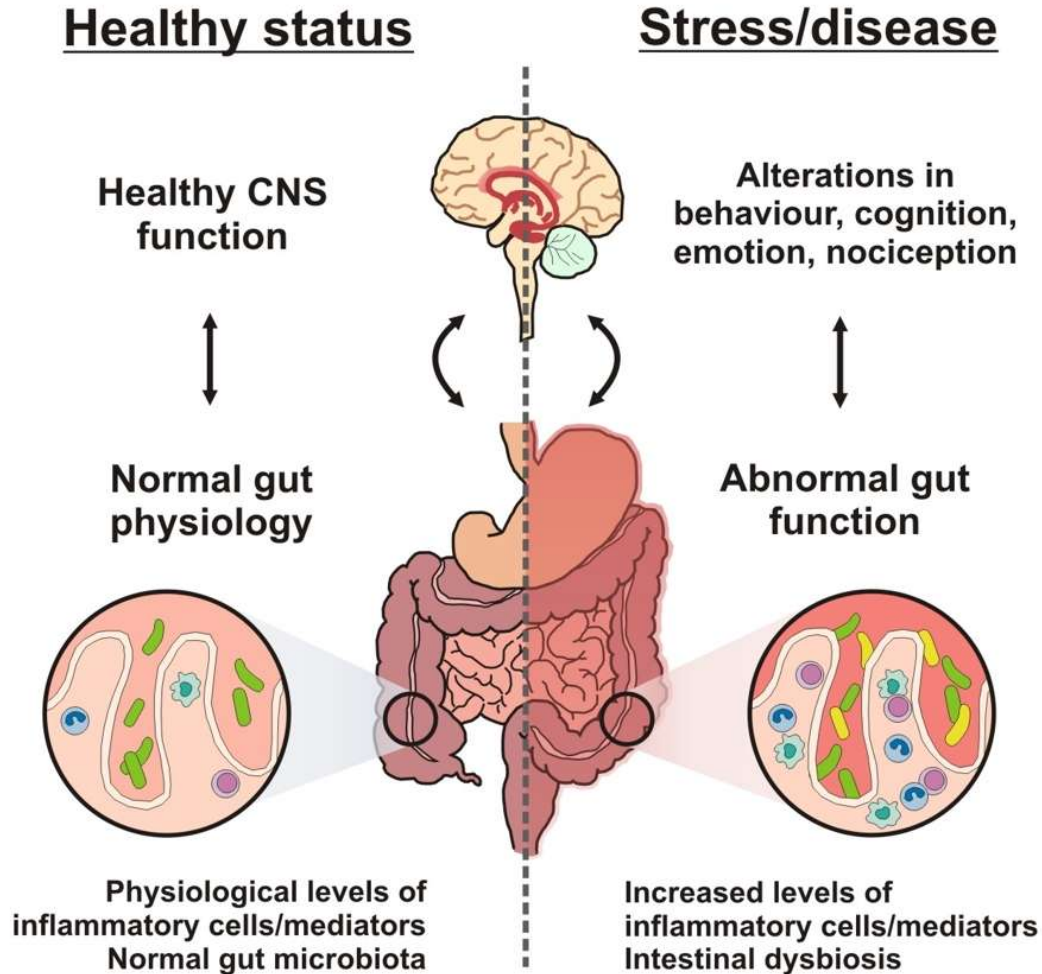
➤ Anxiety, Depression,
Stress and Cognition

➤ Tryptophan availability and metabolism

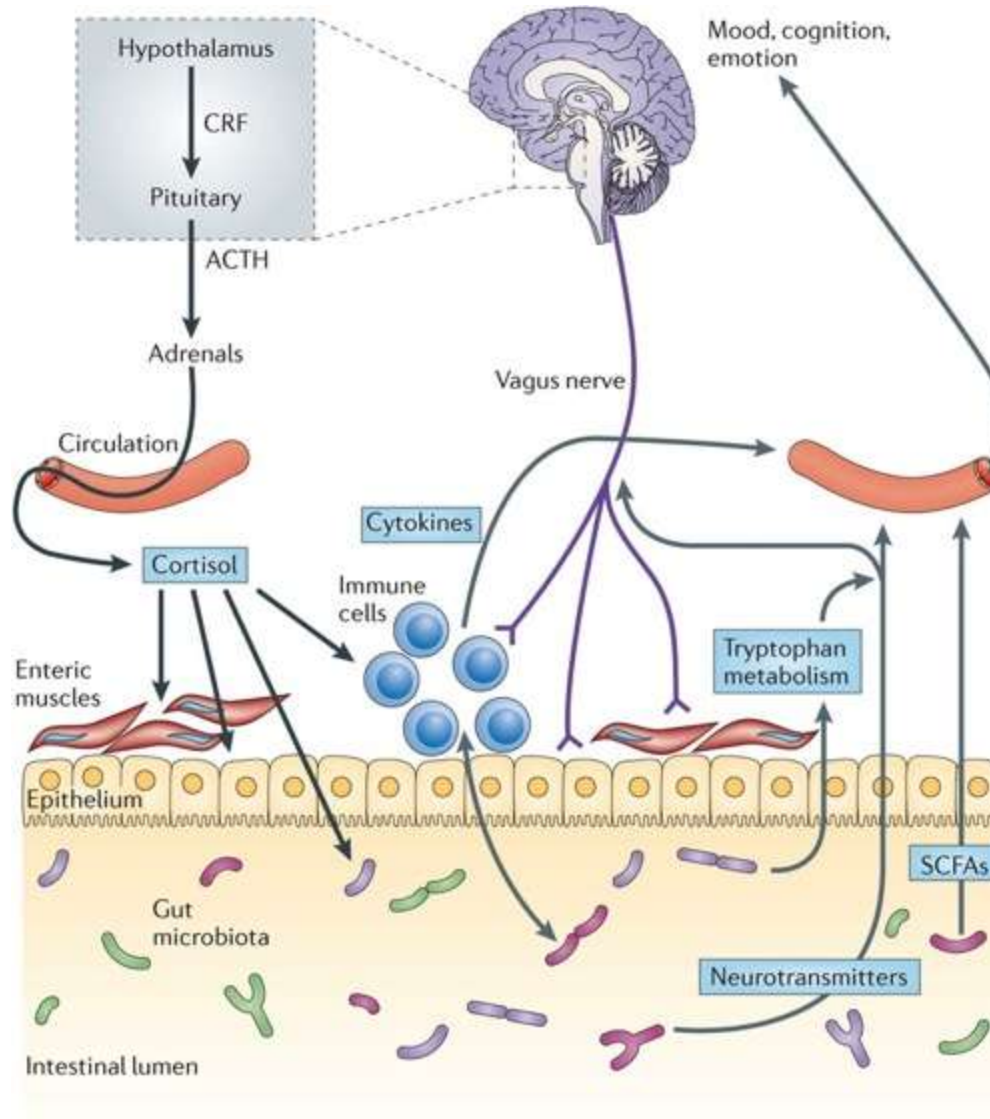
➤ Translational implications and opportunities for intervention?



Brain-Gut-Microbiome Axis



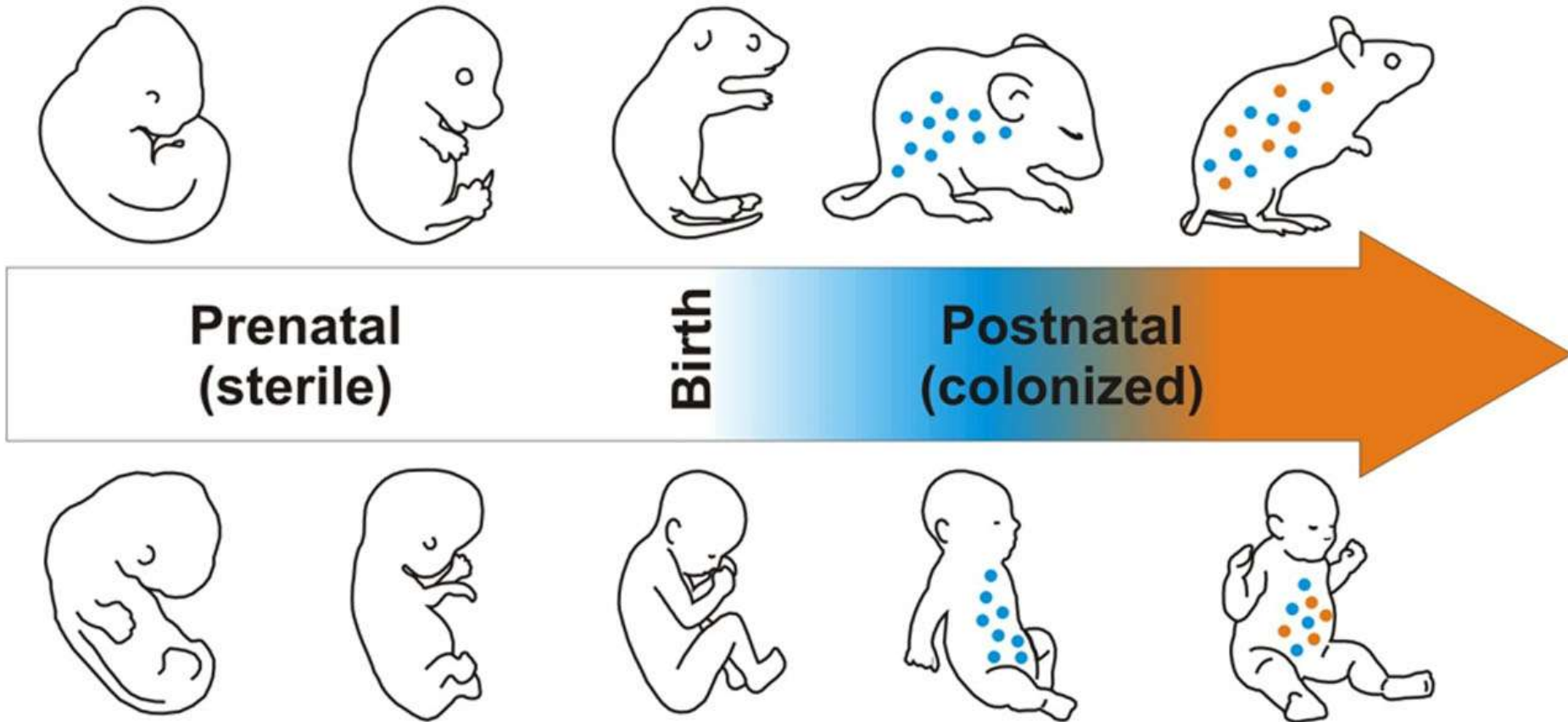
Signalling Along the Brain-Gut-Microbiota axis



Nature Reviews | Neuroscience

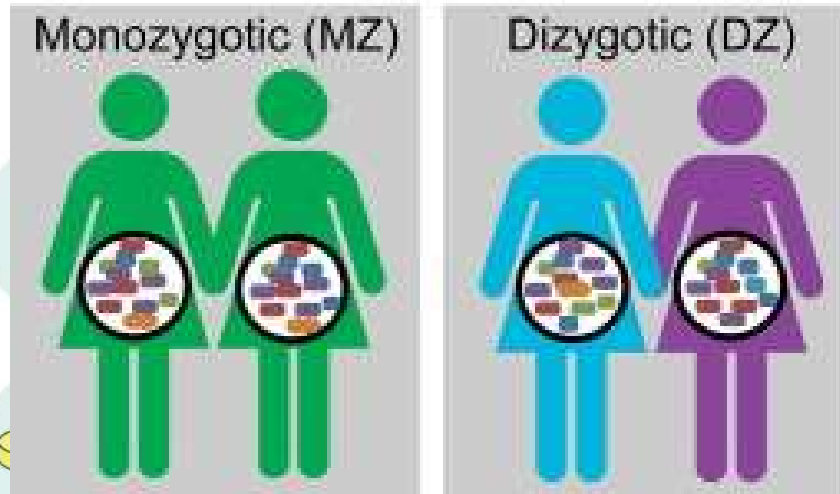
Cryan and Dinan, Nat Rev Neurosci Oct 2012

Where do we get our microbiota from?



Human Genetics Shape the Gut Microbiome

Julia K. Goodrich,^{1,2} Jillian L. Waters,^{1,2} Angela C. Poole,^{1,2} Jessica L. Sutter,^{1,2} Omry Koren,^{1,2,7} Ran Blekhman,^{1,8} Michelle Beaumont,³ William Van Treuren,⁴ Rob Knight,^{4,5,6} Jordana T. Bell,³ Timothy D. Spector,³ Andrew G. Clark,¹ and Ruth E. Ley^{1,2,*}

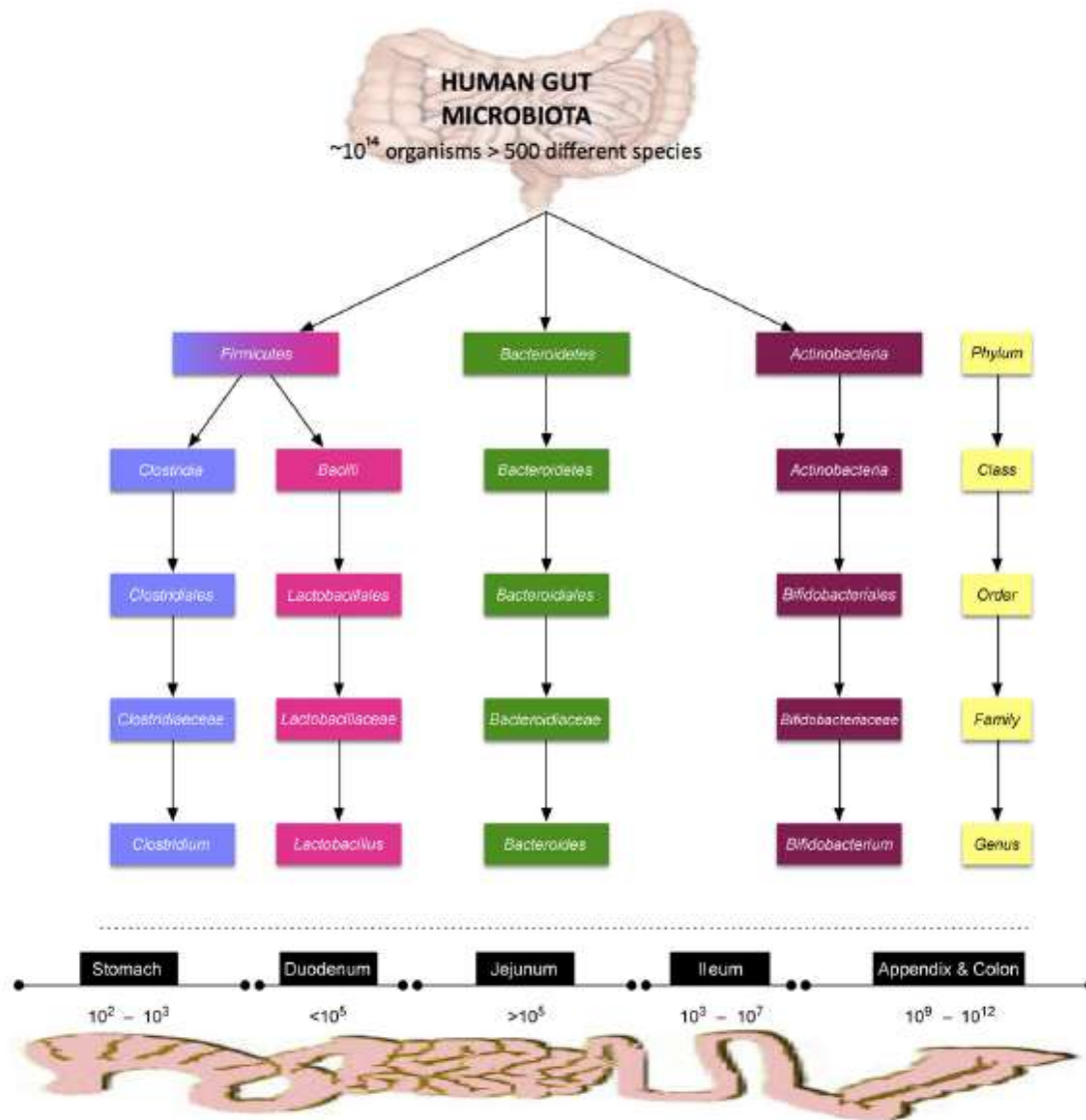
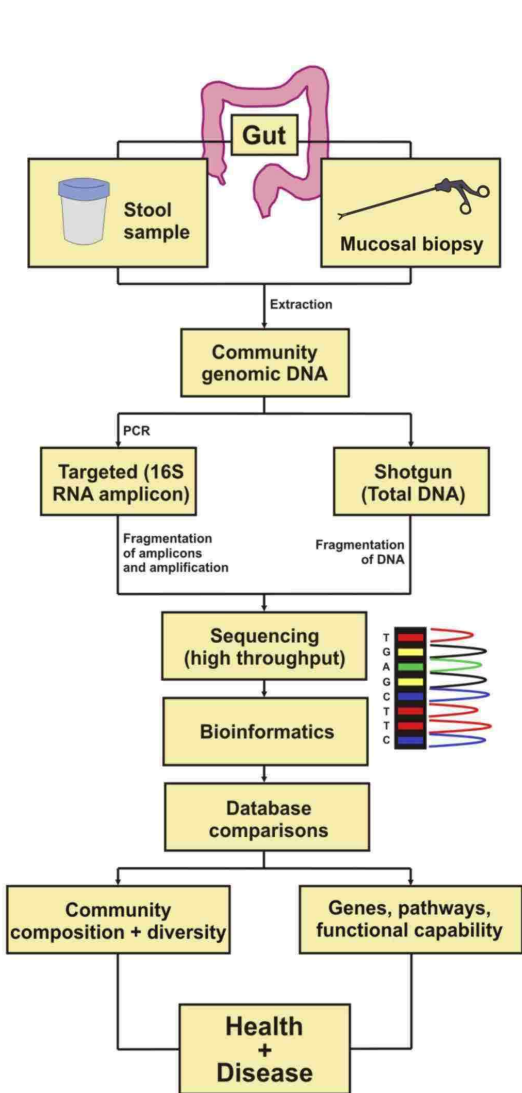


MZ twins have a more similar microbiota than DZ twins

Figure 1 | Factors that can influence the composition and function of the human gut microbiota.

It's a gut feeling: How the gut microbiota affects the state of mind

Adam D. Farmer, Holly A. Randall and Qasim Aziz

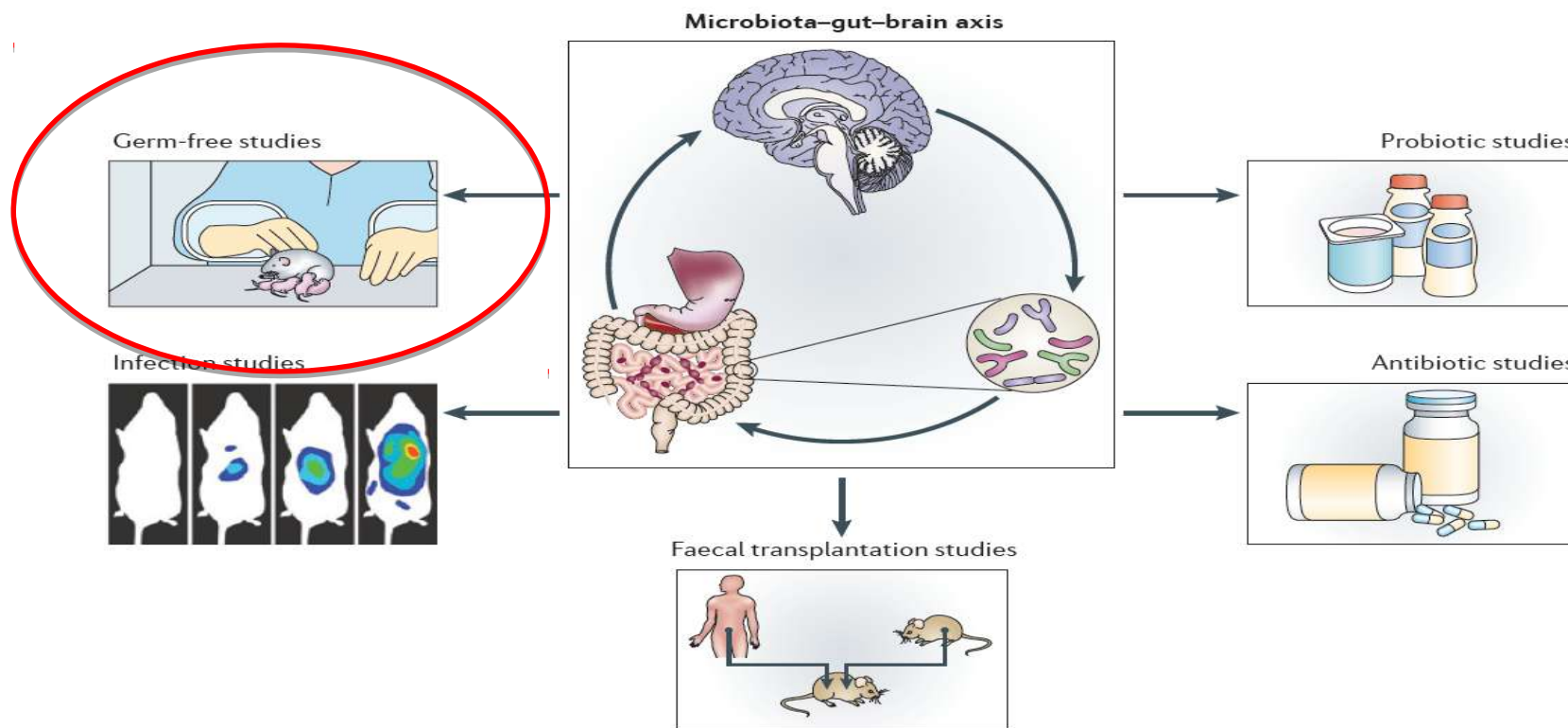


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Mind-altering microorganisms: the impact of the gut microbiota on brain and behaviour

John F. Cryan^{1,2} and Timothy G. Dinan^{1,3}

Abstract | Recent years have witnessed the rise of the gut microbiota as a major topic of research interest in biology. Studies are revealing how variations and changes in the



Germ-Free Living?



Conventional



Germ-free



Germ-free colonised



Figure 2. Reyniers's isolator; (1) technician, (2) electrical outlet, (3) air outlet, (4) mobile truck, (5) entrance/exit autoclave, (6) viewing port.

Source: J. A. Reyniers, P. C. Trexler, and R. F. Ervin, "Rearing Germ-Free Albino Rats," *LOBUND Rep.* 1 (1946): 1-84, 5. © University of Notre Dame.

Reprinted with permission.

Kirk, R, *Bulletin of the History of Medicine*, 2012

... REYNIER'S ISOLATOR, BORN TODAY AT A news conference. "He said that we had all these tubes and I'm getting tired. Why don't we just pull out all of these tubes and let me go home," Shearer said. The end came just over two weeks after the joyous moment when David stepped out of his bubble for the first time, kissing his mother and felt the loving warmth of a human touch. "When David died, everybody in the hospital felt it. There were tears all around. All of the family cried. A lot of the nurses cried and even some tough police officers cried," said Houston police officer Bradley L. Mills. His family, whose last name has never been released to protect their privacy, left an hour later without comment. "They seemed limp and exhausted," Mills said. David left the two-room enclosure Feb. 7 because it was the only way doctors could treat flu-like symptoms attributed to an experimental bone marrow transplant he received in October from his 13-year-old sister. David, who had talked of getting out of his bubble since the age of 3 and once

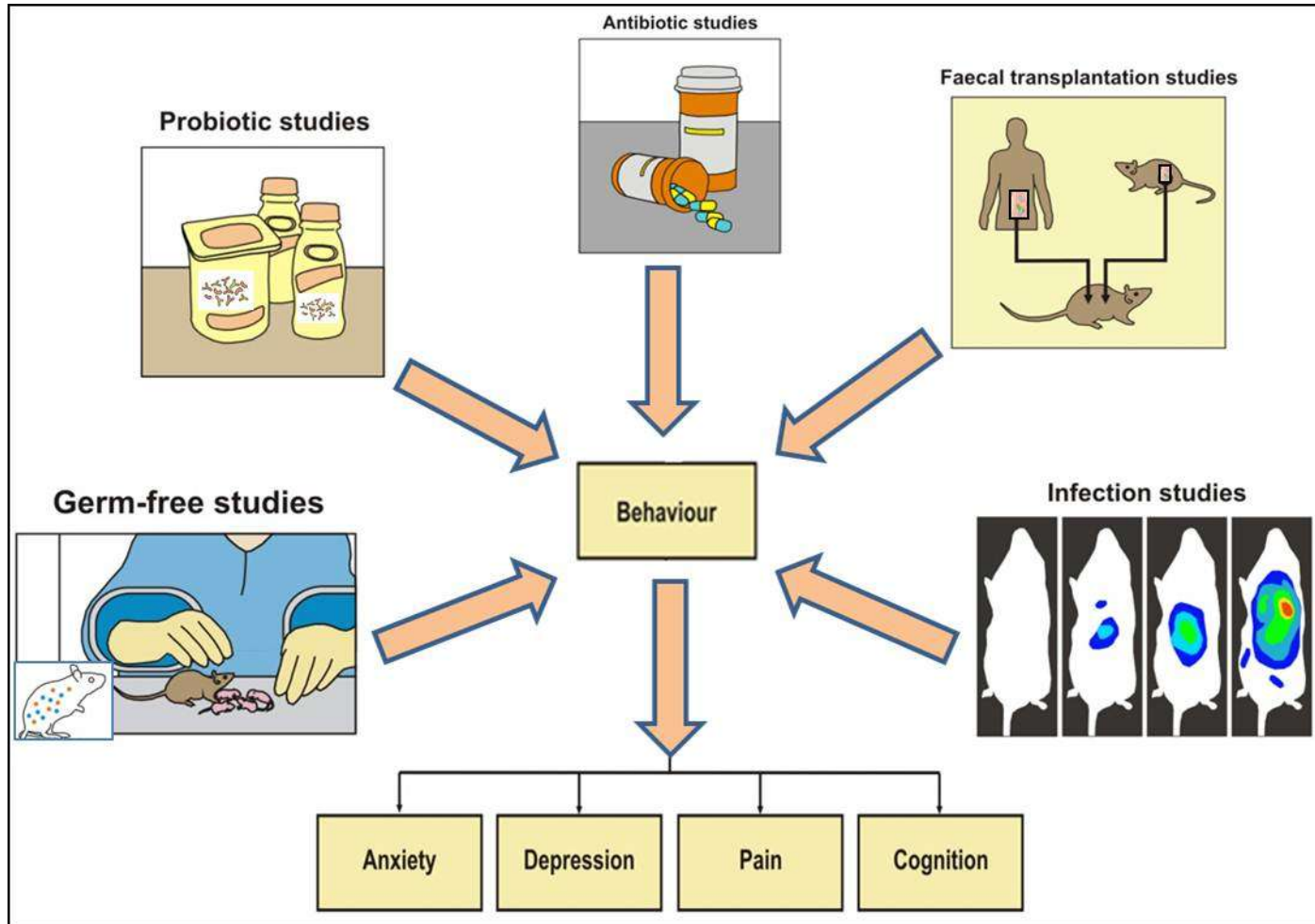
■ weeks after the joyous moment when David stepped out of his bubble for the first time, kissed his mother and felt the loving warmth of a human touch. He was delivered by Caesarean section under extremely sterile conditions on Sept. 21, 1971, and put into a sterile incubator — the first of a series of plastic homes that grew as he did. Everything he touched — his clothes, food, toys and books — was sterilized and passed through an airtight into the bubble. David initially spent most of his time at the hospital, then shared time at home after a bubble was built there, along with one for the family's station wagon. By 1991, he was spending all but two weeks a year at home. A sixth-grader at the time of his death, he attended school by telephone. He consistently got high grades, and tests showed he was brighter than average.

"It was necessary to take the calculated risk," hospital spokesman Gayl McNutt said. But in January, David became ill for the first time in his life, developing diarrhea and vomiting. After leaving the bubble, he developed a bleeding ulcer and began receiving blood transfusions. Other internal bleeding occurred and could not be found or stopped. Doctors said Feb. 13 that test showed David had graft-vs-host disease, a condition in which the transplanted material attacks the body. The boy's death was his most important contribution to medicine, Shearer said. David apparently died of a proliferation of a type of lymphocyte — an "at normal growth" of B-cells — not from graft vs. host disease as had been believed, Shearer said. That discovery, made after Shearer performed an autopsy, is "an unusual finding and of great medical significance," he said. The funeral was scheduled for Saturday morning, David's family requested that it be private, the hospital said.

ston

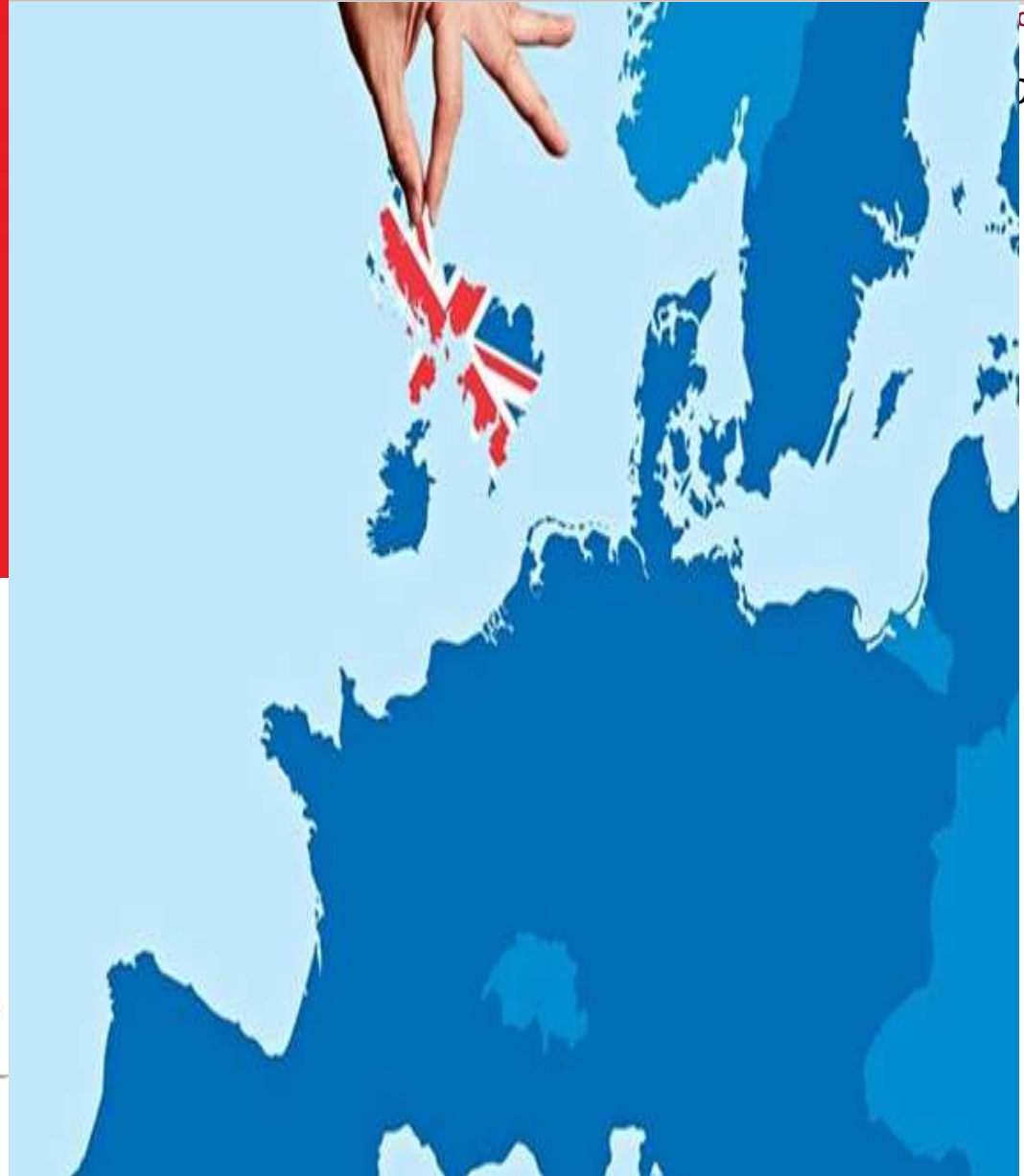
of the outside world when National Aeronautics Administration engineer died in the yard of his home, weeping as he held adults with a water... w the suit, and no nev... ted. id's parents asked fo... w transplant from his... e, using a new proce... ed the use of marrow... rfect tissue match. Da... ie idea eagerly, signe... himself. ve been impossible t... eedure without his coo... rer said.

Microbiota, Brain and Behaviour



Clarke et al., Encyclopedia Metagenomics 2013

Stressors



c.ie
on to



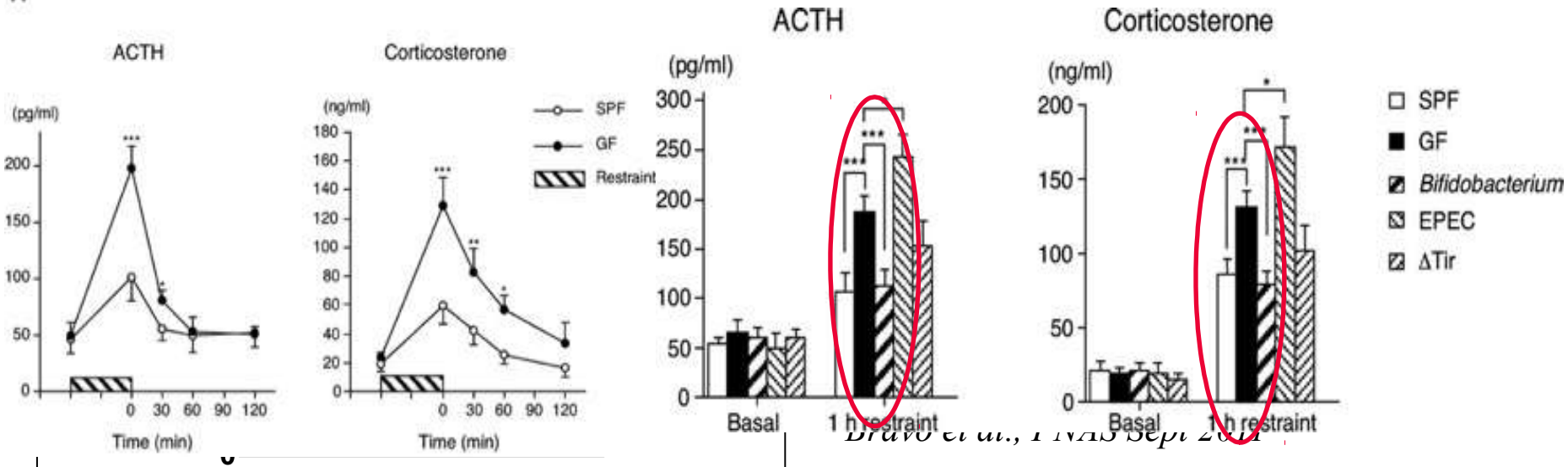
J Physiol 558.1 (2004) pp 263–275

Postnatal microbial colonization programs the hypothalamic–pituitary–adrenal system for stress response in mice

Nobuyuki Sudo^{1,2}, Yoichi Chida¹, Yuji Aiba^{3,4}, Junko Sonoda¹, Naomi Oyama¹, Xiao-Nian Yu¹, Chiharu Kubo¹ and Yasuhiro Koga³

¹Department of Psychosomatic Medicine and ²Department of Health Care Administration & Management, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan, ³Department of Infectious Diseases, Tokai University School of Medicine, Isehara, Kanagawa, Japan and ⁴Wakamoto Pharmaceutical Co. Ltd, Oki-machi, Kanagawa, Japan

A



Dravo et al., 11/13/05 Sep 2004

Microbiota Determines Amygdala Volume

Research Report

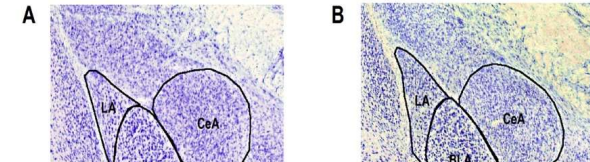
Adult microbiota-deficient mice have distinct dendritic morphological changes: differential effects in the amygdala and hippocampus

Pauline Luczynski¹, Seán O. Whelan³,
Colette O'Sullivan³, Gerard Clarke^{1,2},
Fergus Shanahan¹, and John F. Cryan¹

Issue

SEARCH
In this issue
Advanced > Saved Searches >

Brain, Behavior, and Immunity 50 (2015) 209–220



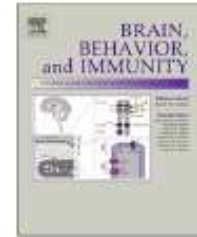
DOI: 10.1016/j.bbi.2015.08.001
This article reserves



Contents lists available at ScienceDirect

Brain, Behavior, and Immunity

journal homepage: www.elsevier.com/locate/ybrbi



Microbes & neurodevelopment – Absence of microbiota during early life increases activity-related transcriptional pathways in the amygdala



Roman M. Stilling^{a,b,*}, Feargal J. Ryan^{a,c,1}, Alan E. Hoban^{a,b,1}, Fergus Shanahan^a, Gerard Clarke^{a,d},
Marcus J. Claesson^{a,c}, Timothy G. Dinan^{a,d}, John F. Cryan^{a,b,*}



CC = Conventionally Colonised
GF = Germ Free

ORIGINAL ARTICLE
The microbion
AE Hoban^{1,2}, RM Stilling^{1,2}, G M

Volume 40 No. 1 January 2018 · ISSN 0265-9247

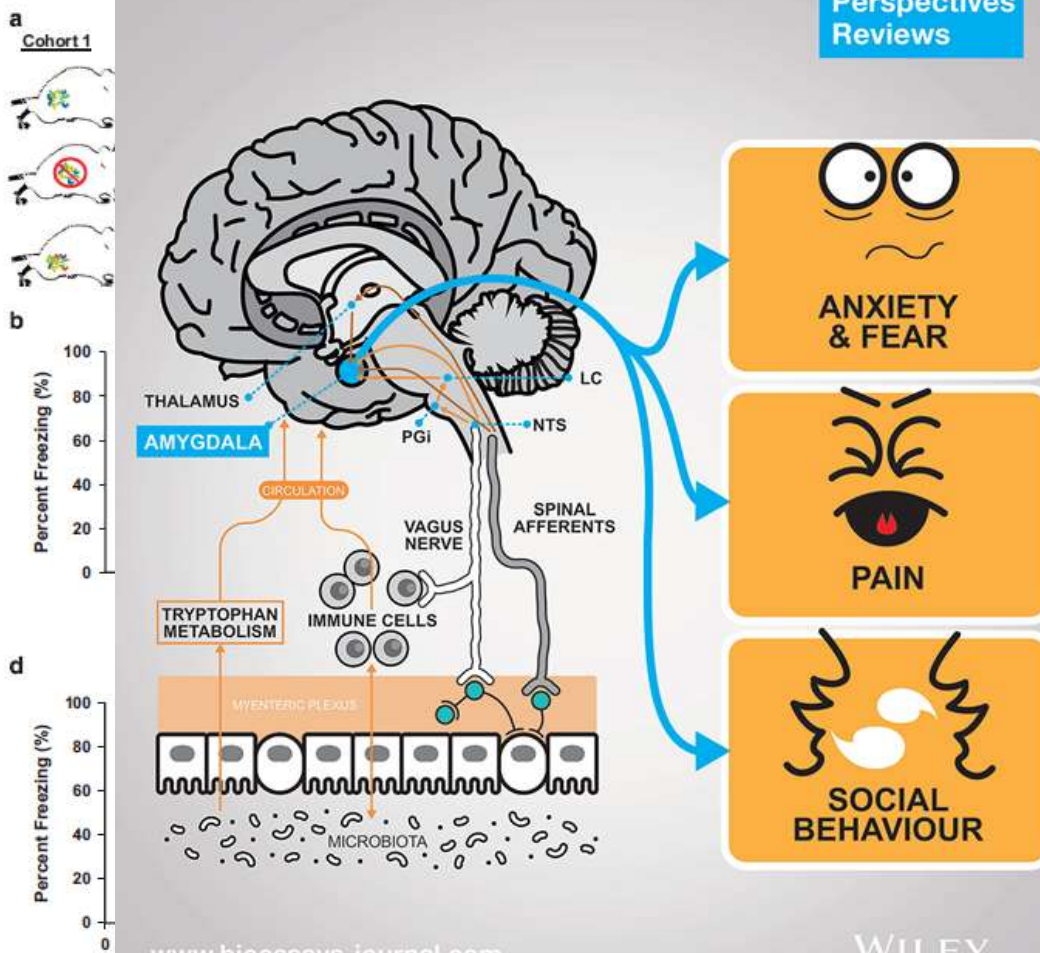
BioEssays

1/18

Ideas that Push the Boundaries

Hypotheses
Perspectives
Reviews

3



Anatomical correlates of abnormal fear and anxiety can be localised to the amygdala in germ-free animals using cued fear conditioning

Correspondence

Ebere S. Ogbonnaya
Gerard Clarke
Fergus Shanahan
Timothy G. Dinan
John F. Cryan
Olivia F. O’Leary

Biological
Psychiatry

Adult Hippocampal Neurogenesis Is Regulated by

least significant difference post hoc test for group-wise

RESEARCH ARTICLE

BLOOD-BRAIN BARRIER

The gut microbiota influences blood-brain barrier permeability in mice

Viorica Braniste,^{1*†} Maha Al-Asmakh,^{1*} Czeslawa Kowal,^{2*} Farhana Anuar,¹ Afrouz Abbaspour,¹ Miklós Tóth,³ Agata Korecka,¹ Nadja Bakocevic,⁴ Ng Lai Guan,⁴ Parag Kundu,⁵ Balázs Gulyás,^{3,5} Christer Halldin,^{3,5} Kjell Hultenby,⁶ Harriet Nilsson,⁷ Hans Hebert,⁷ Bruce T. Volpe,⁸

Be

NATURE NEUROSCIENCE ADVANCE ONLINE PUBLICATION

1

Host microbiota constantly control maturation and function of microglia in the CNS

Daniel Erny^{1,12}, Anna Lena Hrabě de Angelis^{1,12}, Diego Jaitin², Peter Wieghofer^{1,3}, Ori Staszewski¹, Eyal David², Hadas Keren-Shaul², Tanel Mahlakoi⁴, Kristin Jakobshagen⁵, Thorsten Buch⁶, Vera Schwierzeck⁷, Olaf Utermöhlen⁵, Eunyoung Chun⁸, Wendy S Garrett⁸, Kathy D McCoy⁹, Andreas Diefenbach⁷, Peter Staeheli⁴, Bärbel Stecher¹⁰, Ido Amit² & Marco Prinz^{1,11}

Neuroanatomy and Physiology of Brain Dysfunction in Sepsis

Aurelien Mazeraud^{a,b,c}, Quentin Pascal, DVM^a,
 Franck Verdonk^{a,b}, Nicholas Heming, MD, PhD^c,
 Fabrice Chrétien, MD, PhD^{a,b,d}, Tarek Sharshar, MD, PhD^{a,c,e,*}

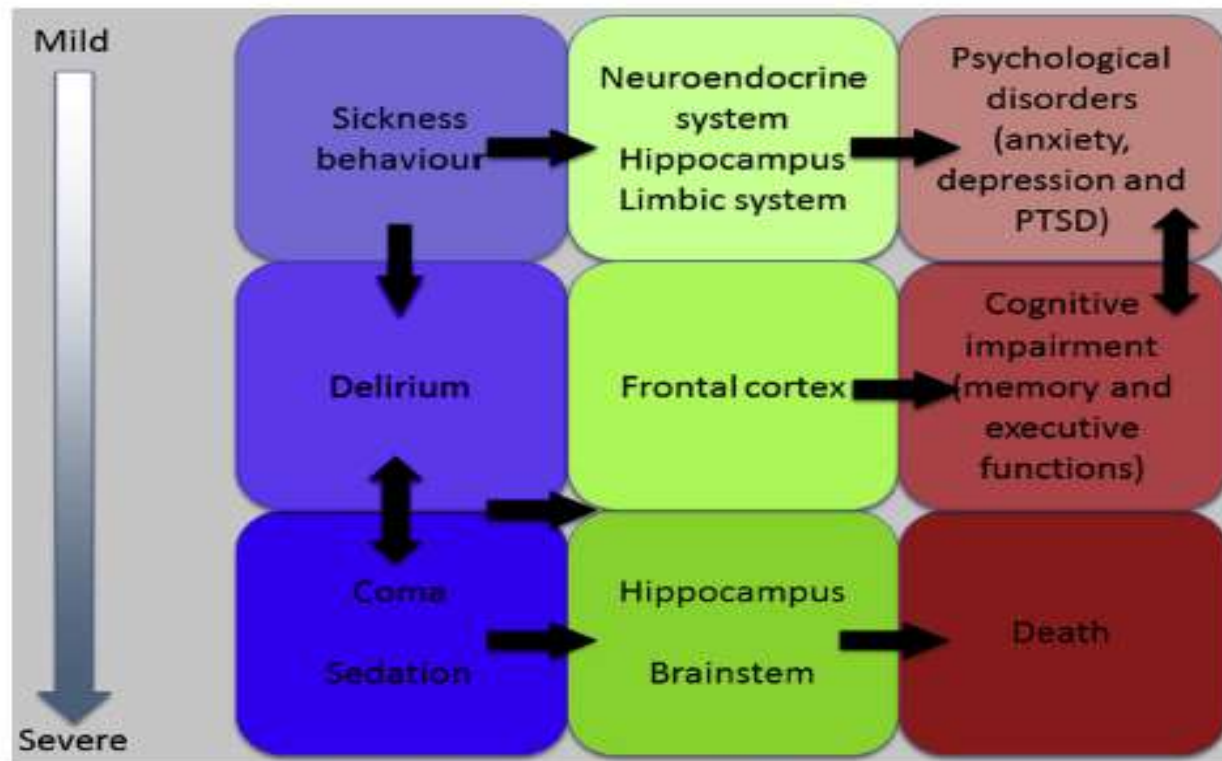


Fig. 1. Schematic representation of pathophysiologic processes during sepsis-associated encephalopathy (SAE). PTSD, posttraumatic stress disorder.



Review

Serotonin, tryptophan metabolism and the brain-gut-microbiome axis



S.M. O'Mahony^{a,b,1}, G. Clarke^{a,c,*}, Y.E. Borre^a, T.G. Dinan^{a,c}, J.F. Cryan^{a,b}

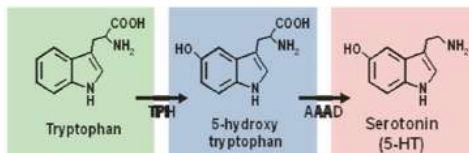
Behavioural Effects

- Visceral pain
- Emotion
- Stress response
- Appetite
- Addiction
- Sexuality



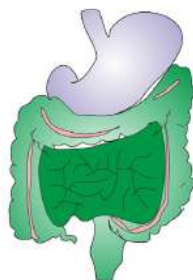
CNS Effects

- Motor control
- Circadian rhythm
- Cerebellar regulation
- Body temperature
- CNS vascular tone



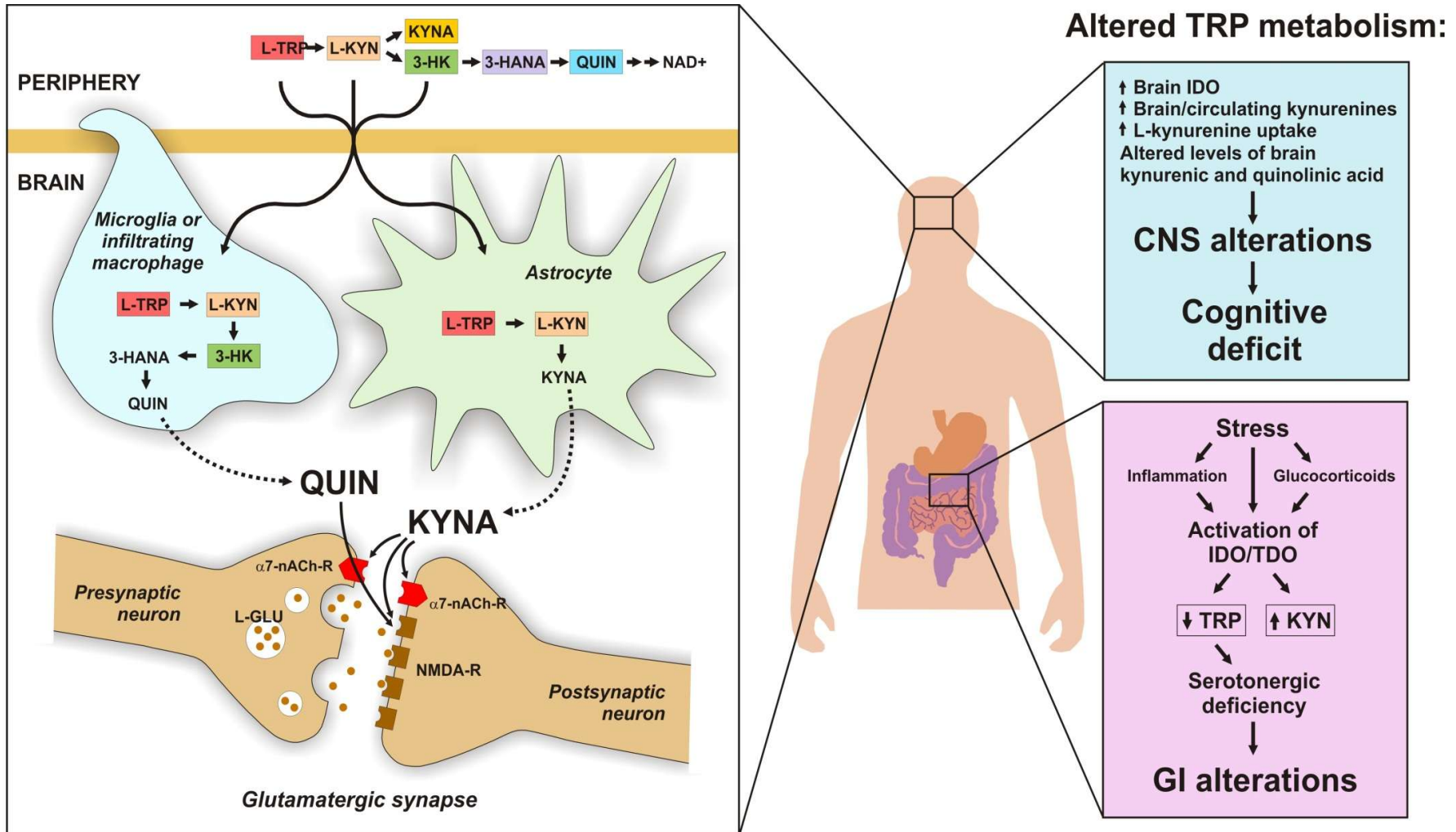
GI Effects

- Gastric secretion
- Gastrointestinal motility
- Intestinal secretions
- Colonic tone
- Pancreatic secretion



"Of course you feel great. These things are loaded with antidepressants."

The Kynurenine Pathway



REVIEW

METABOLISM

Kynurenines: Tryptophan's metabolites in exercise, inflammation, and

OPEN ACCESS Freely available online

June 2011 | Volume 6 | Issue 6 | e21185



An Observational Cohort Study of the Kynurenine to Tryptophan Ratio in Sepsis: Association with Impaired Immune and Microvascular Function

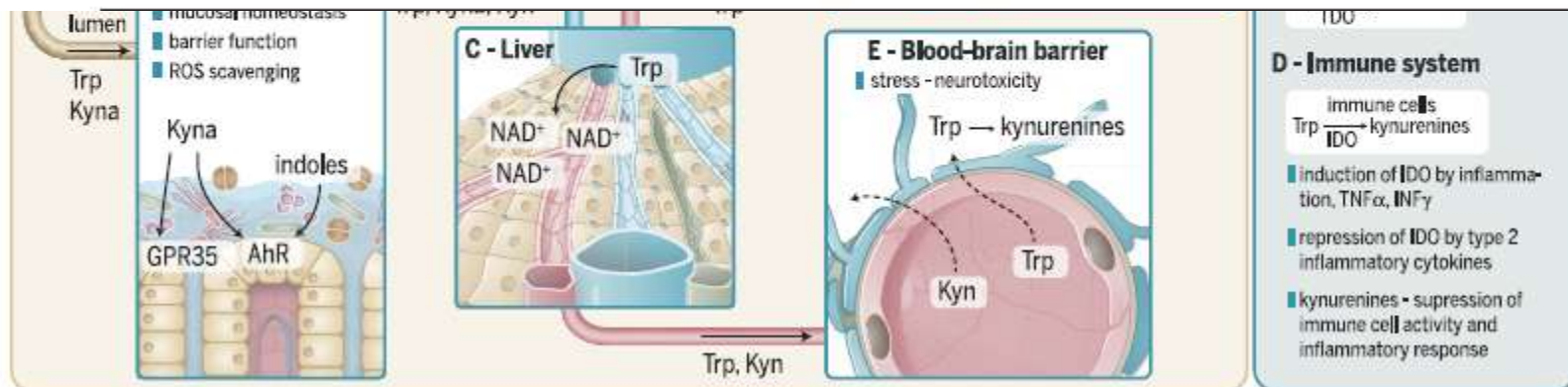
 Christabelle J. Darcy^{1,3}, Joshua S. Davis^{1,2,3}, Tonia Woodberry¹, Yvette R. McNeil¹, Dianne P. Stephens³, Tsin W. Yeo^{1,2}, Nicholas M. Anstey^{1,2*}
¹ Global Health Division, Menzies School of Health Research and Charles Darwin University, Darwin, Northern Territory, Australia, ² Division of Medicine, Royal Darwin Hospital, Darwin, Northern Territory, Australia, ³ Intensive Care Unit, Royal Darwin Hospital, Darwin, Northern Territory, Australia


Fig. 3. Activity, uptake, and conversion of tryptophan and its metabolites in peripheral tissues during unchallenged conditions. 5-HT, 5-hydroxy

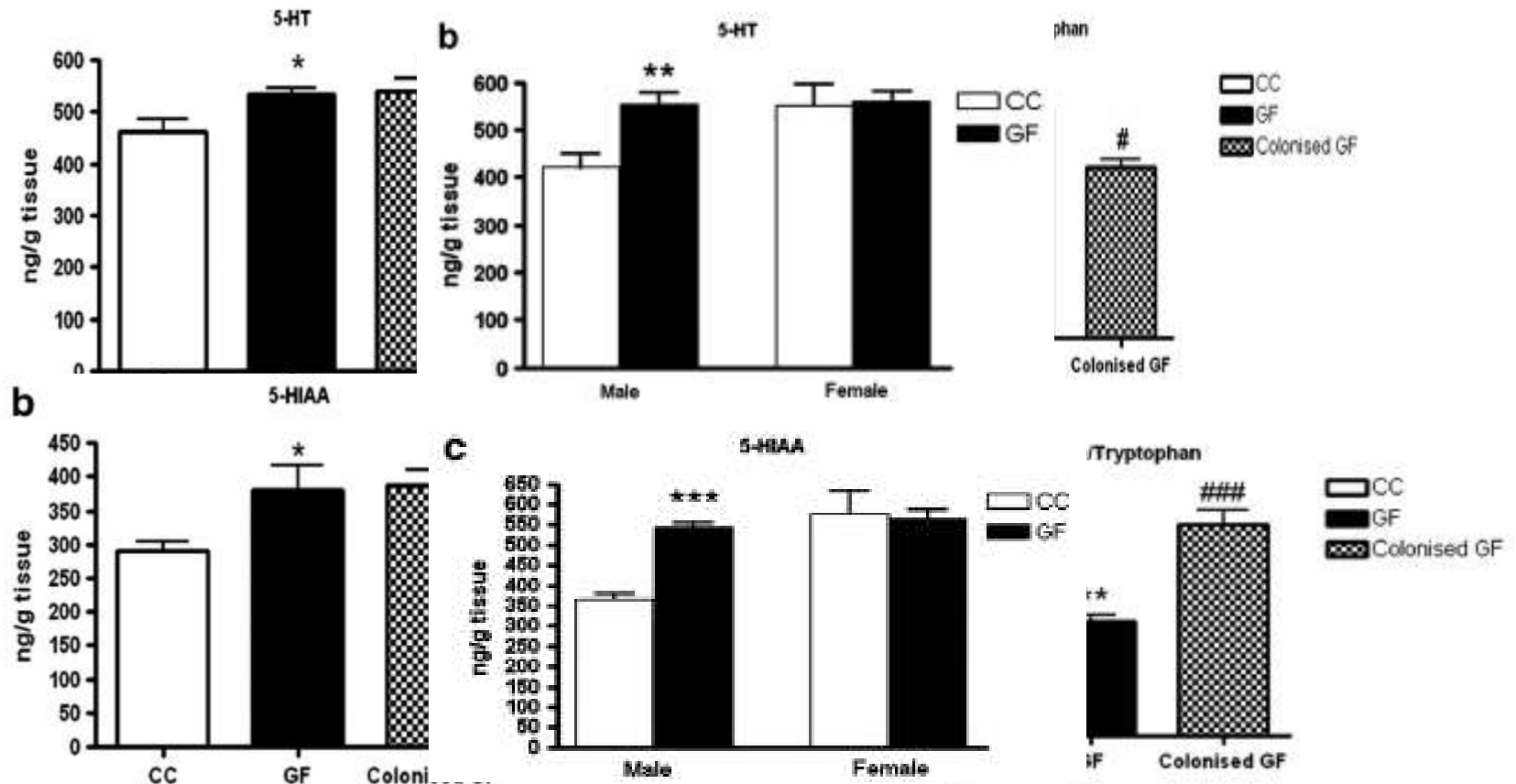


ORIGINAL ARTICLE

The microbiome-gut-brain axis during early life regulates the hippocampal serotonergic system in a sex-dependent manner

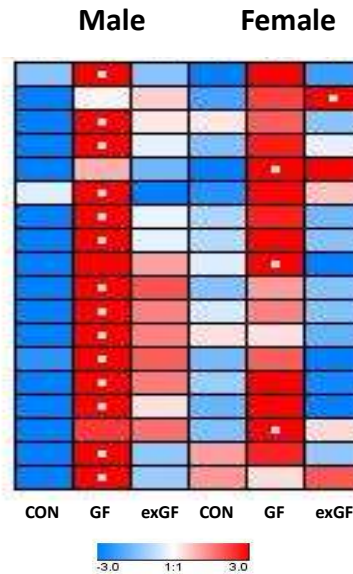
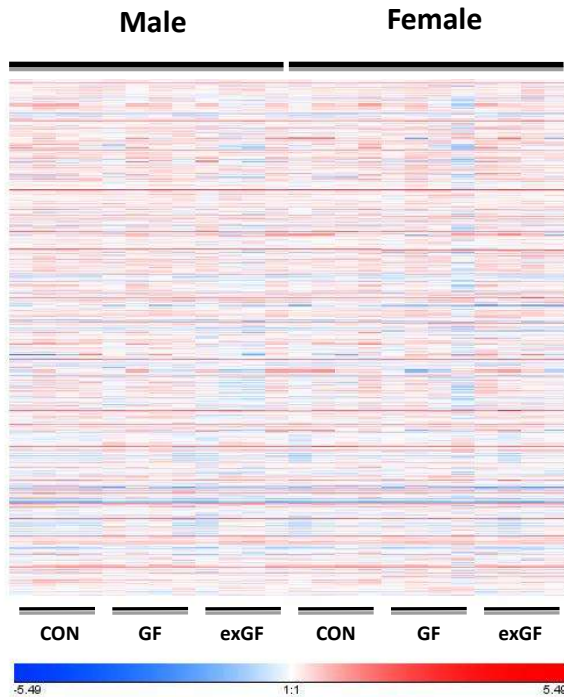
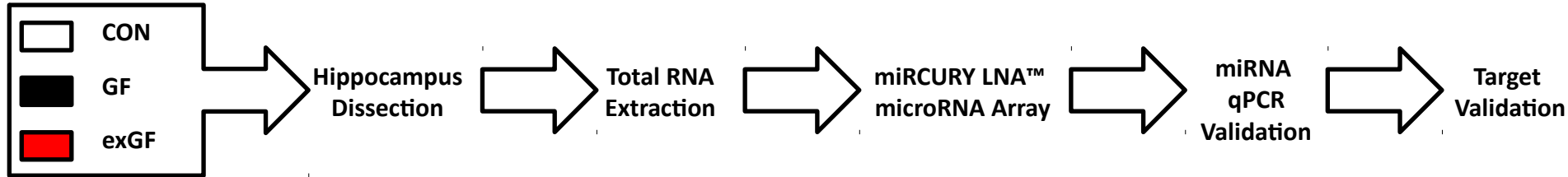
G Clarke^{1,2}, S Grenham¹, P Scully¹, P Fitzgerald¹, RD Moloney¹, F Shanahan^{1,3}, TG Dinan^{1,2} and JF Cryan^{1,4}

a

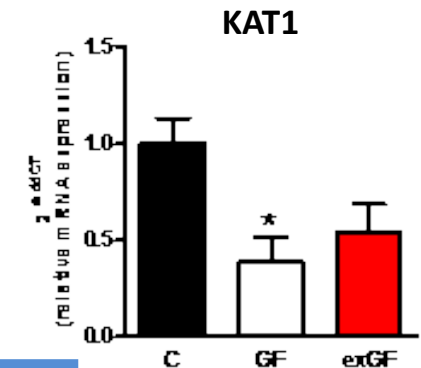
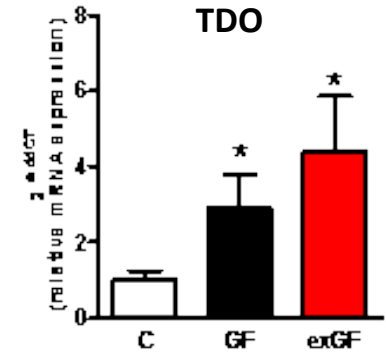




Transcriptional Regulation of Kynurenine Pathway Metabolism in Hippocampus



mmu-miR-137-5p
mmu-miR-152-3p
mmu-miR-294-5p
mmu-miR-3103-5p
mmu-miR-342-3p
mmu-miR-370-3p
mmu-miR-3961
mmu-miR-468f-3p
mmu-miR-467g
mmu-miR-5125
mmu-miR-5616-5p
mmu-miR-5624-3p
mmu-miR-5624-5p
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mmu-miR-669c-5p
mmu-miR-691
mmu-miR-709



OPEN

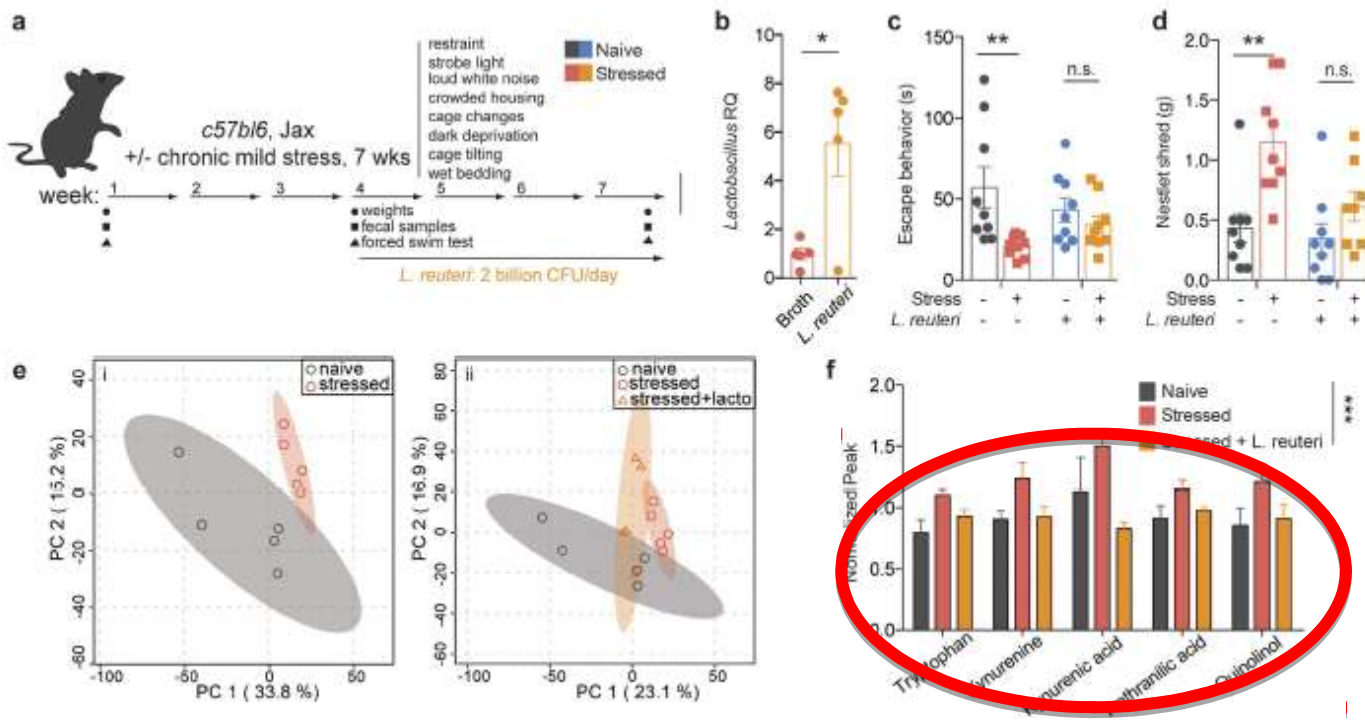
Microbiota alteration is associated with the development of stress-induced despair behavior

Received: 11 October 2016

Accepted: 31 January 2017

Published: 07 March 2017

Ioana A. Marin^{1,2,3}, Jennifer E. Goertz^{1,2}, Tiantian Ren⁴, Stephen S. Rich⁵, Suna Onengut-Gumuscu⁵, Emily Farber⁵, Martin Wu⁴, Christopher C. Overall^{1,2}, Jonathan Kipnis^{1,2,3,*} & Alban Gaultier^{1,2,3,*}



Restoring
intestinal
Lactobacillus
levels
normalized
stress-
induced
behavior and
suppressed
kynurenine
production

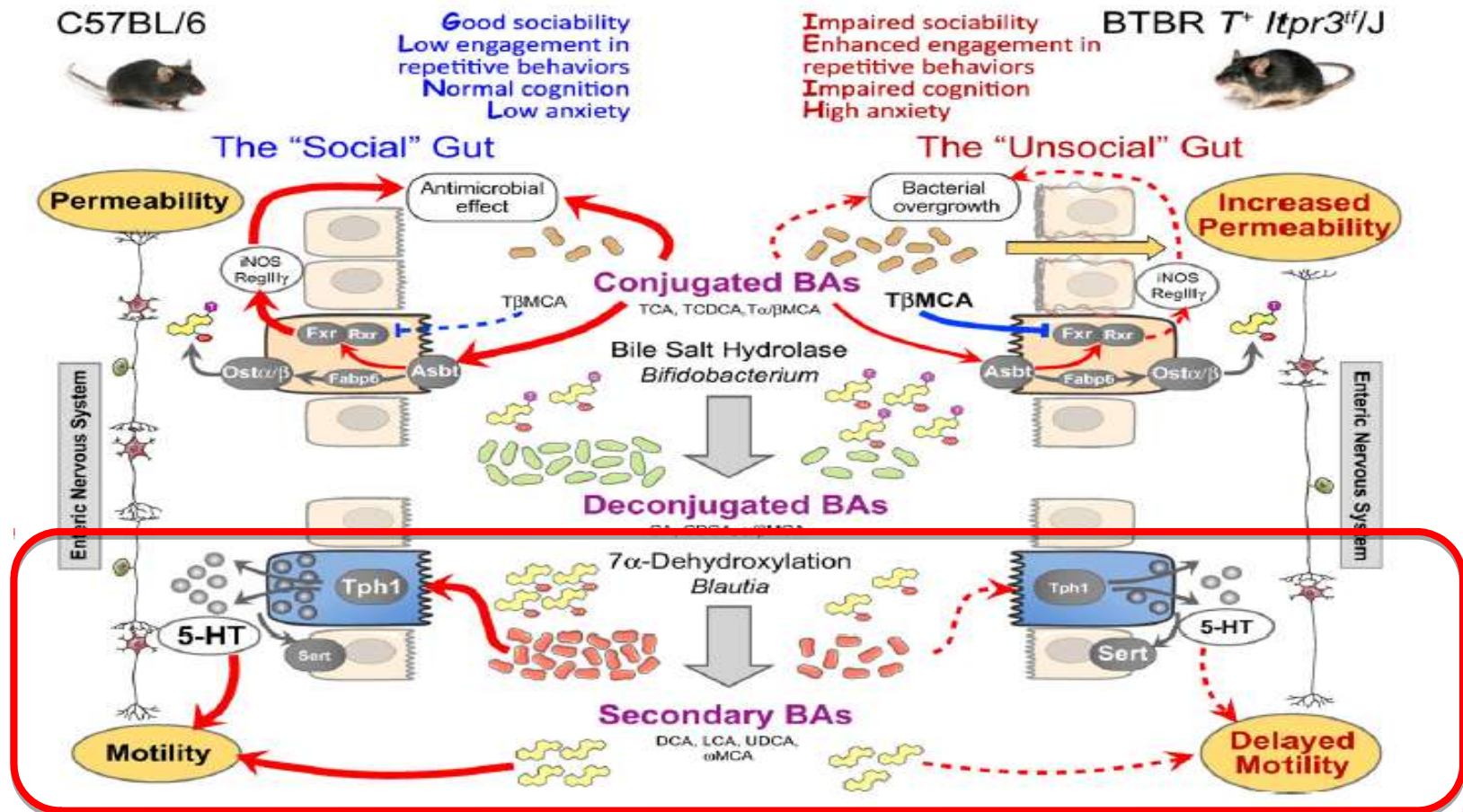
Figure 3. Treatment with probiotic *L. reuteri* ameliorates the escape behavior induced by chronic stress.

Research Paper

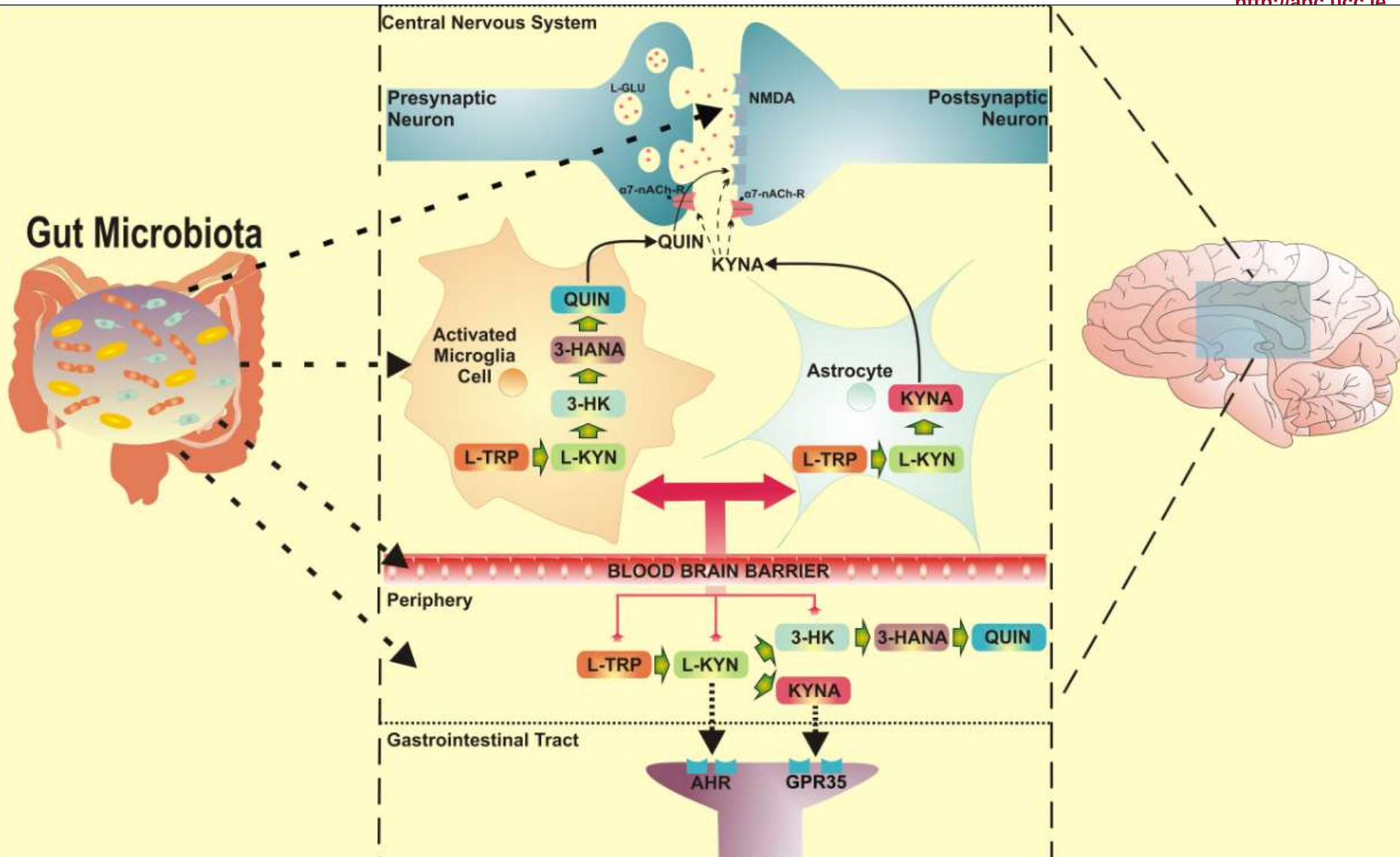
Microbiota-related Changes in Bile Acid & Tryptophan Metabolism are Associated with Gastrointestinal Dysfunction in a Mouse Model of Autism



Anna V. Golubeva^a, Susan A. Joyce^{a,b,1}, Gerard Moloney^{c,1}, Aurelijus Burokas^{a,1}, Eoin Sherwin^a, Silvia Arboleya^{a,d}, Ian Flynn^c, Dmitry Khochanskiy^e, Angela Moya-Pérez^a, Veronica Peterson^a, Kieran Rea^a, Kiera Murphy^d, Olga Makarova^{e,f}, Sergey Buravkov^{e,f}, Niall P. Hyland^{a,g}, Catherine Stanton^{a,d,h}, Gerard Clarke^{a,h}, Cormac G.M. Gahan^{a,i}, Timothy G. Dinan^{a,h}, John F. Cryan^{a,c,*}



Summary



Behind the Curve!

BBC

Stalin 'used secret laboratory to analyse Mao's excrement'

By Steven Rosenberg
BBC News

🕒 28 January 2016 | Asia

"For example, if they detected high levels of amino acid Tryptophan," he explained, "they concluded that person was calm and approachable."



Mao Zedong (L) and Josef Stalin (R) were the two most powerful leaders in the communist world at the time (two photos have been merged together to create this image)

ARTICLE IN PRESS

Annals of Epidemiology xxx (2016) 1–7



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Annals of Epidemiology

journal homepage: www.annalsofepidemiology.org



Review article

Brain-gut-microbiota axis: challenges for translation in psychiatry

John R. Kelly MD^{a,b}, Gerard Clarke PhD^{a,b}, John F. Cryan PhD^{a,c}, Timothy G. Dinan MD, PhD^{a,b,*}

^aAlimentary Pharmabiotic Centre, APC Microbiome Institute, University College Cork, Cork, Ireland

^bDepartment of Psychiatry and Neurobehavioural Science, University College Cork, Cork, Ireland

^cDepartment of Anatomy and Neuroscience, University College Cork, Cork, Ireland

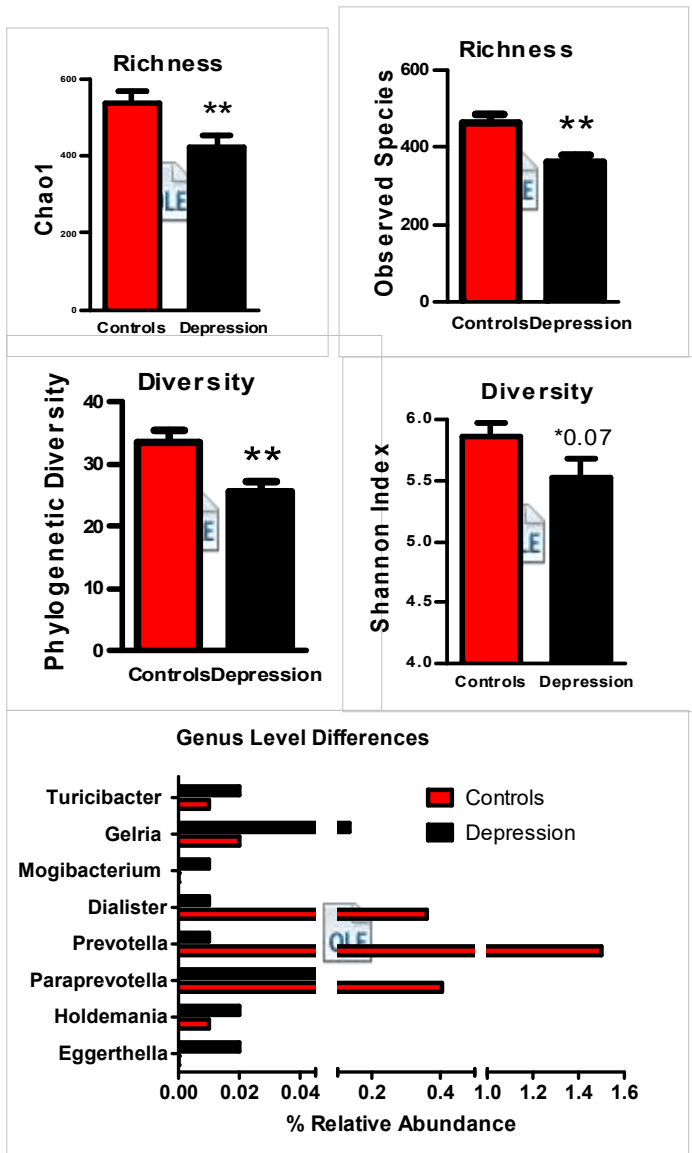
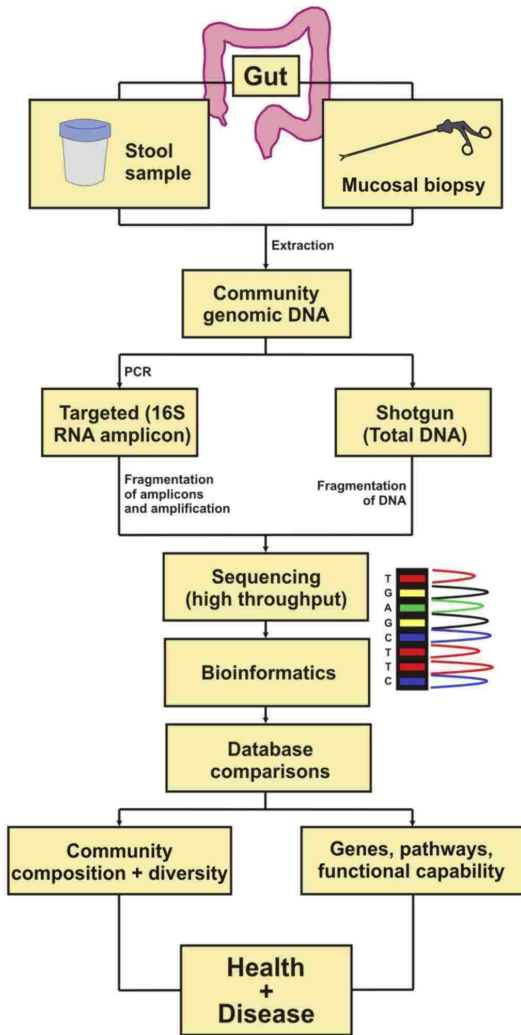
Cryan et al., Trends in Pharmacol. Sci. 2002

How to recognize the moods of an Irish setter

Gary Larson



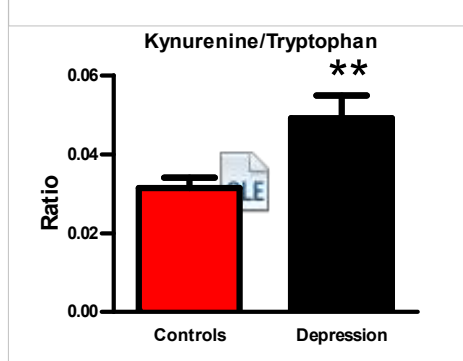
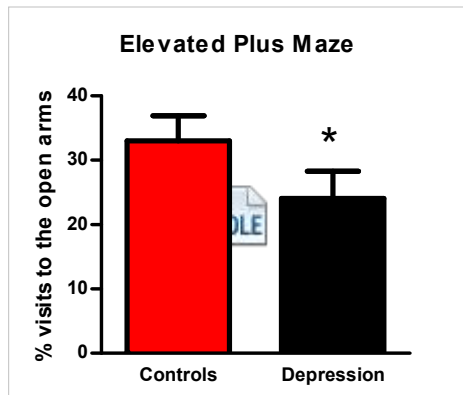
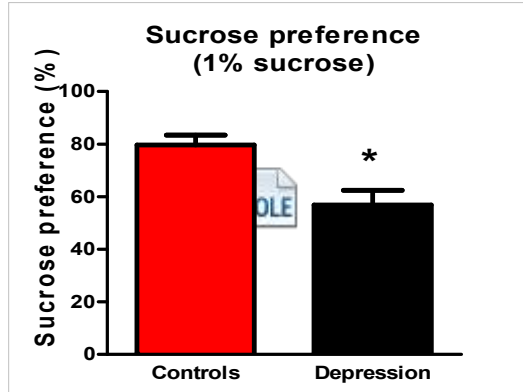
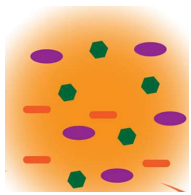
Altered Microbiota in Depression



Reduced microbial diversity in depression

Prevotella, a genus of Gram-negative bacteria, is reduced in depression

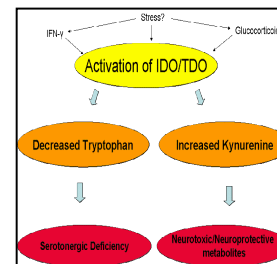
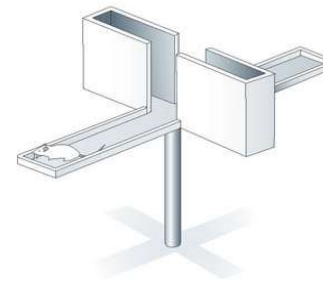
Transfer of Depressive Phenotype



Anhedonia-like behaviours transferred via gut microbiota

Anxiety-like behaviours transferred via gut microbiota

Tryptophan metabolism Profile transferred via gut microbiota



Drugging the gut microbiome

Why is my hangover so bad? | Life and style | The Guardian



Ostravar
ZALOŽENO 1897
NAŠE REČ JIŽ 115 LET

WCHITNÁVĚSTĚ ZOPROVĚDNĚ. PĚKILJEMĚ!

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Food & drink

Why is my hangover so bad?

It's not just the booze giving you a hangover – it's the microbes in your stomach



An artist's impression of human intestinal microbes. Photograph: Science Photo Library

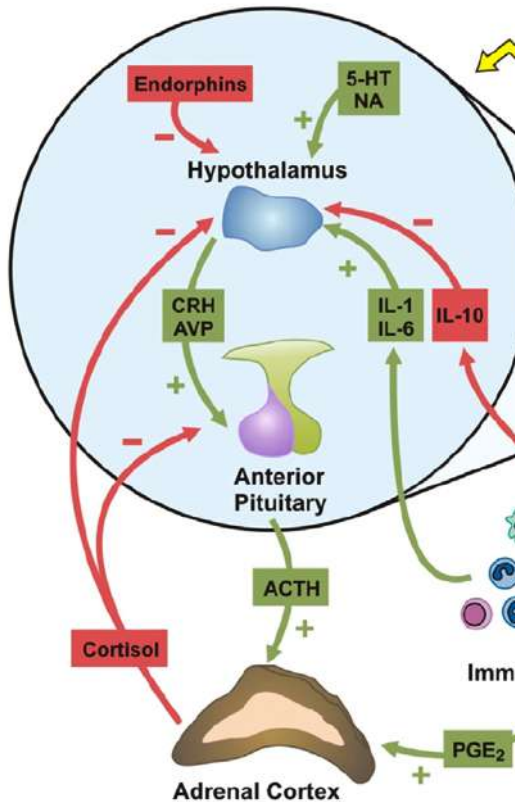
Cleveland Clinic	Small-molecule inhibitors
Cipac Therapeutics	FMT encapsulation or re
Enterome BioScience (Paris)	EP-8018 small-molecule adhesion
FMT, fecal microbiota transplantation; UTI, urinary tract infection;	

REVIEW

Psychobiotics:

Timothy G. Dinan, Catherine

Here, we define a psychobiotic as suffering from psychiatric illness. As such as gamma-aminobutyric acid and psychobiotics possess antidepressant systems. So far, psychobiotics have syndrome, where positive benefits emerging of benefits in alleviating inflammatory actions of certain psych scale placebo-controlled studies are



"Up-to-the-minute research and practical advice on the gut-brain axis—perhaps the most exciting area of science today."
—BOB KNIGHT, author of *Follow Your Gut*

THE PSYCHOBOTIC REVOLUTION

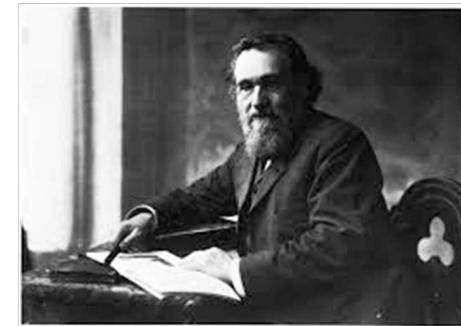
Mood, Food, and the New Science of the Gut-Brain Connection

SCOTT C. ANDERSON

with JOHN F. CRYAN, PH.D. & TED DINAN, M.D., PH.D.

opic

duces a health benefit in patients delivering neuroactive substances on in rodents suggests that certain ve, spinal cord, or neuroendocrine g in patients with irritable bowel *fidobacterium infantis*. Evidence is enefits may be related to the anti-al axis activity. Results from large



Elie Metchnikoff (1845-1916)
Nobel Prize 1908

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Brain, Behavior, and Immunity

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EBIOM-01190; No of Pages 7

EBioMedicine xxx (2017) xxx–xxx

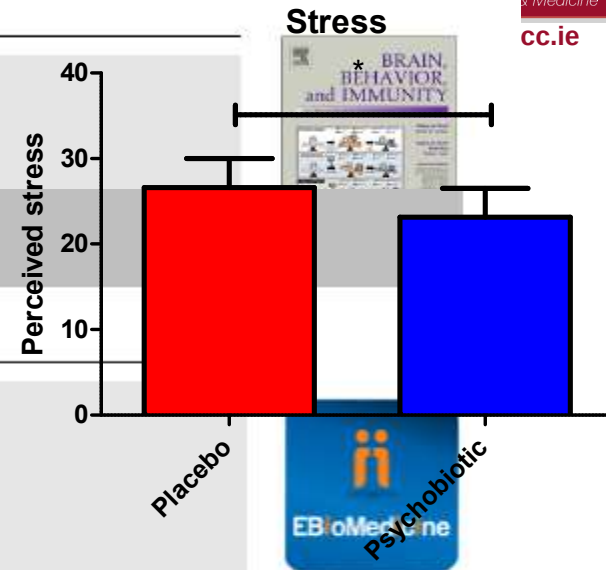
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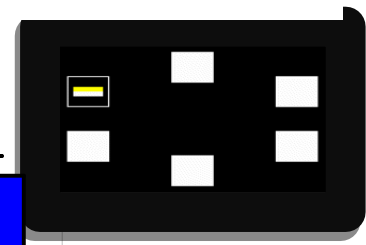
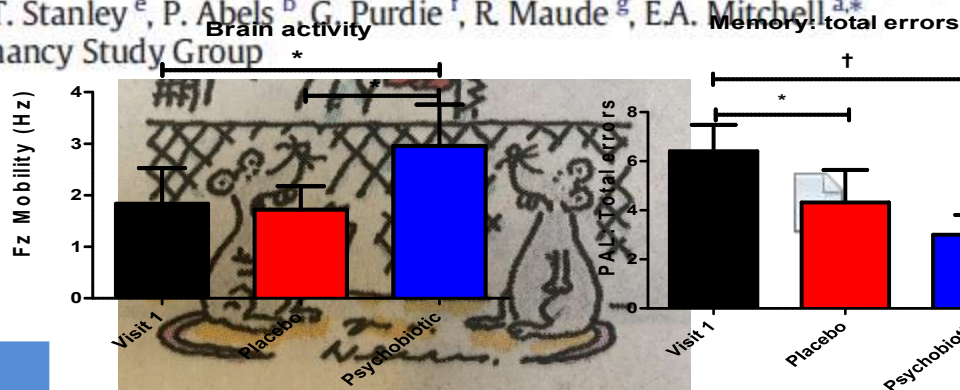
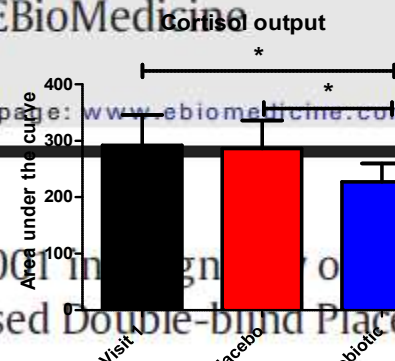
ELSEVIER



Research Paper

Effect of *Lactobacillus rhamnosus* HN001 in pregnancy on postpartum Symptoms of Depression and Anxiety: A Randomised Double-blind Placebo-controlled Trial

R.F. Slykerman^a, F. Hood^b, K. Wickens^b, J.M.D. Thompson^a, C. Barthow^b, R. Murphy^c, J. Kang^b, J. Rowden^a, P. Stone^d, J. Crane^b, T. Stanley^e, P. Abels^b, G. Purdie^f, R. Maude^g, E.A. Mitchell^{a,*}
the Probiotic in Pregnancy Study Group

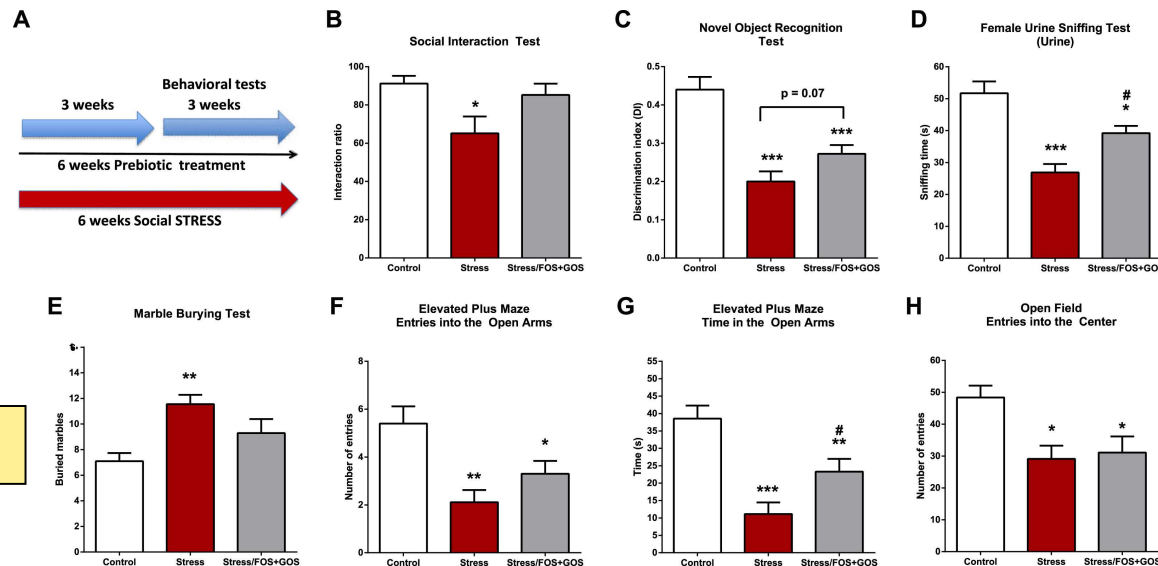


Archival Report

Targeting the Microbiota-Gut-Brain Axis: Prebiotics Have Anxiolytic and Antidepressant-like Effects and Reverse the Impact of Chronic Stress in Mice

Aurelijus Burokas, Silvia Arboleya, Rachel D. Moloney, Veronica L. Peterson, Kiera Murphy, Gerard Clarke, Catherine Stanton, Timothy G. Dinan, and John F. Cryan

Prebiotic reverses consequences of chronic stress



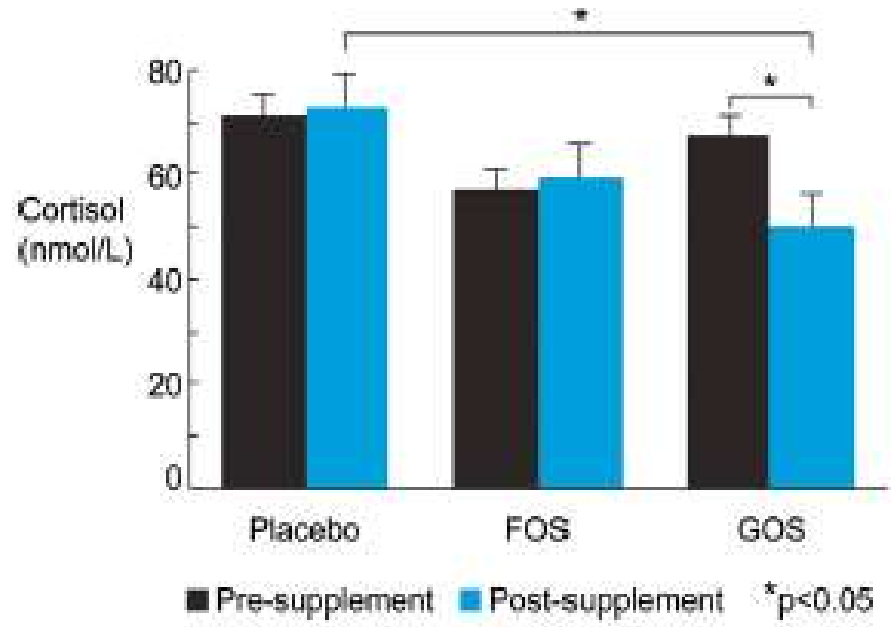
Social
behaviour and
cognition

Anxiety

ORIGINAL INVESTIGATION

Prebiotic intake reduces the waking cortisol response and alters emotional bias in healthy volunteers

Kristin Schmidt • Philip J. Cowen • Catherine J. Harmer •
George Tzortzis • Steven Errington • Philip W. J. Burnet



Feeding the microbiota-aut-brain axis:



Downloaded from <http://gut.bmj.com/> on September 29, 2017 - Published by group.bmj.com

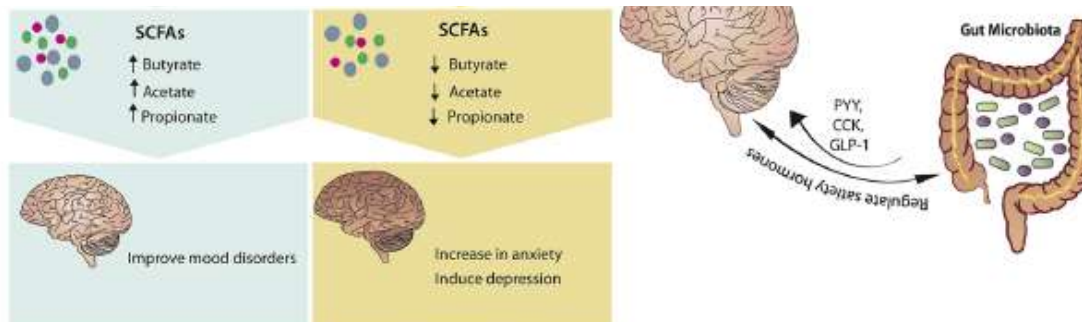
Gut Online First, published on September 26, 2017 as 10.1136/gutjnl-2017-314968

Gut microbiota

ORIGINAL ARTICLE

A randomised trial of the effect of omega-3 polyunsaturated fatty acid supplements on the human intestinal microbiota

Henry Watson,¹ Suparna Mitra,² Fiona C Croden,³ Morag Taylor,⁴ Henry M Wood,⁴ Sarah L Perry,¹ Jade A Spencer,⁵ Phil Quirke,⁴ Giles J Toogood,⁶ Clare L Lawton,³ Louise Dye,³ Paul M Loadman,⁵ Mark A Hull¹



RESEARCH ARTICLE

Open Access



A randomised controlled trial of dietary improvement for adults with major depression (the 'SMILES' trial)

Felice N. Jacka^{1,4,9,10,13*}, Adrienne O'Neil^{1,2,13}, Rachele Opie^{5,13}, Catherine Itsiopoulos⁵, Sue Cotton³, Mohammedreza Mohebbi¹, David Castle^{4,11}, Sarah Dash^{1,13}, Cathrine Mihalopoulos⁷, Mary Lou Chatterton⁷, Laima Brazionis^{5,6}, Olivia M. Dean^{1,4,12,13}, Allison M. Hodge⁸ and Michael Berk^{1,3,12,13}

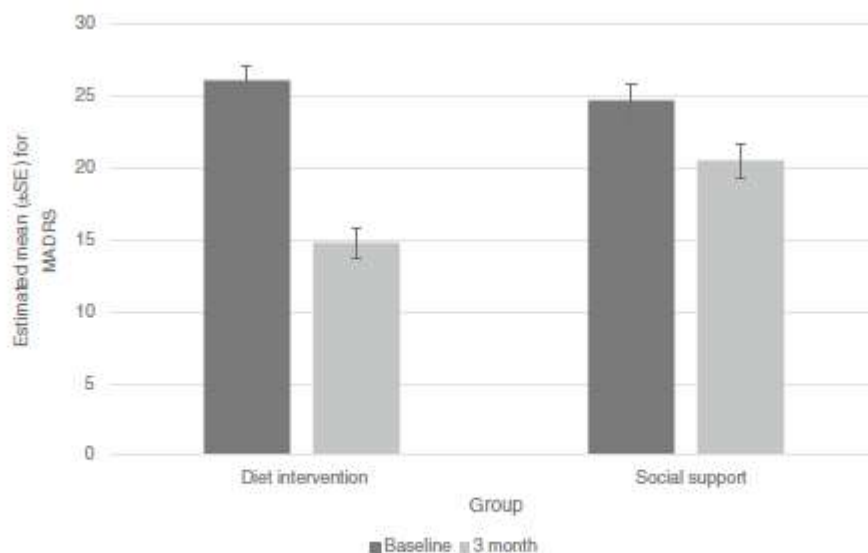


Fig. 2 MADRS scores for dietary support and social support control groups at baseline and endpoint. Effect size: Cohen's $d = -1.16$ (95% CI $-1.73, -0.59$). Baseline data $n = 67$; 12 week data $n = 56$

REVIEW

 OPEN ACCESS

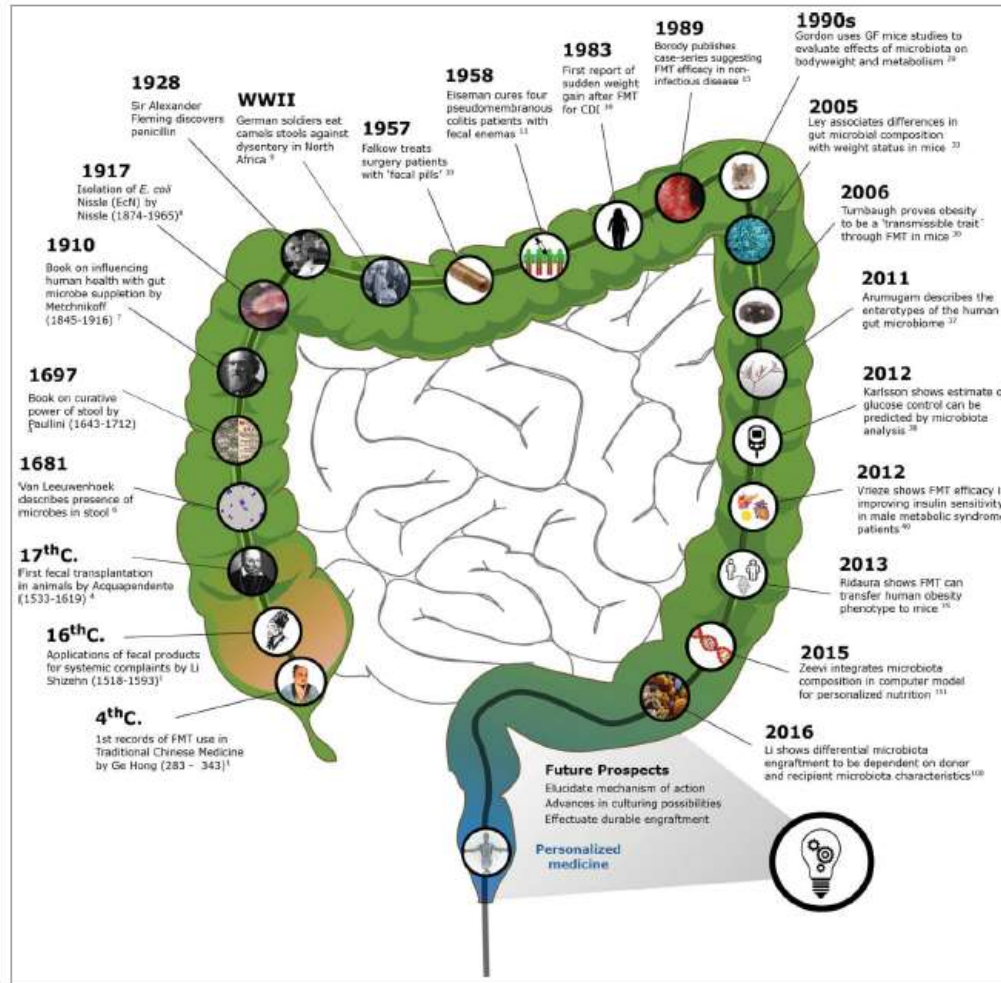
Fecal microbiota transplantation in metabolic syndrome: History, present and future

P. F. de Groot^a, M. N. Frissen^{ib}, N. C. de Clercq^a, and M. Nieuwdorp^{a,b,c,d}


Andrea Levy, *The Plair*

The New Ho
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By PAM BELLUCK OCT. 11, 2014



therapy

 Thursday, October 25, 2012

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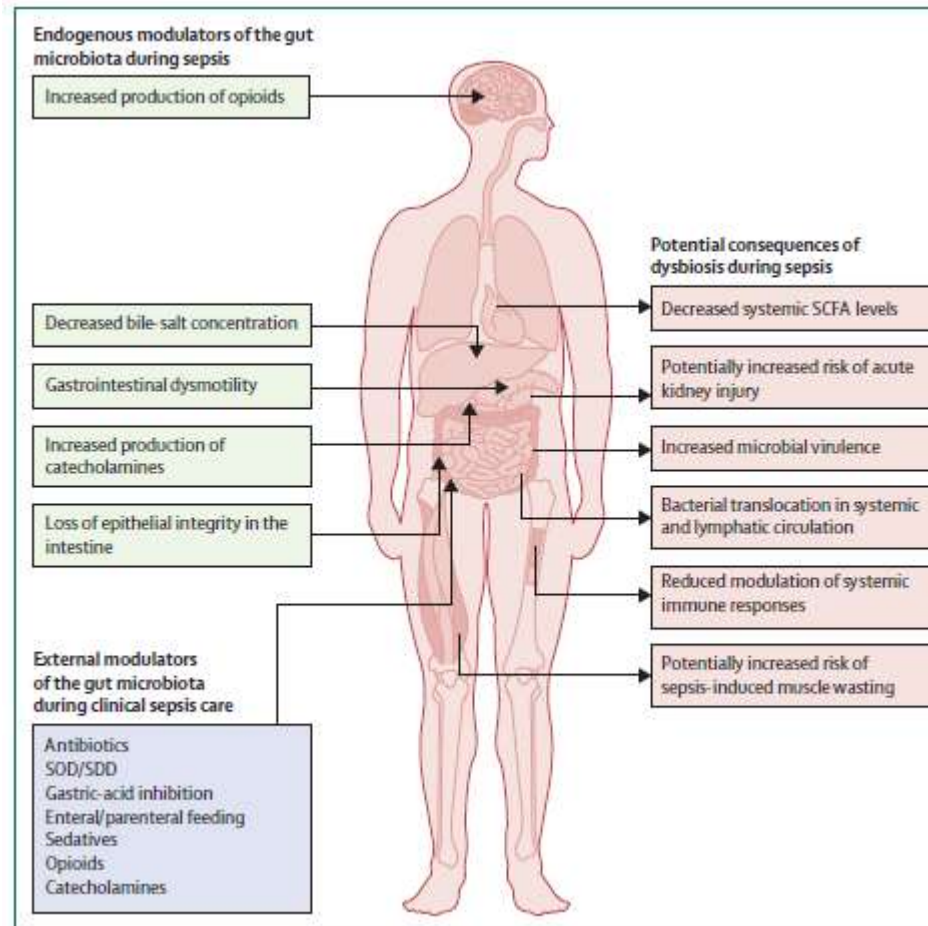
Environment | News Features | People

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ecal transplants?

The role of the gut microbiota in sepsis

Bastiaan W Haak, Wjoost Wiersinga



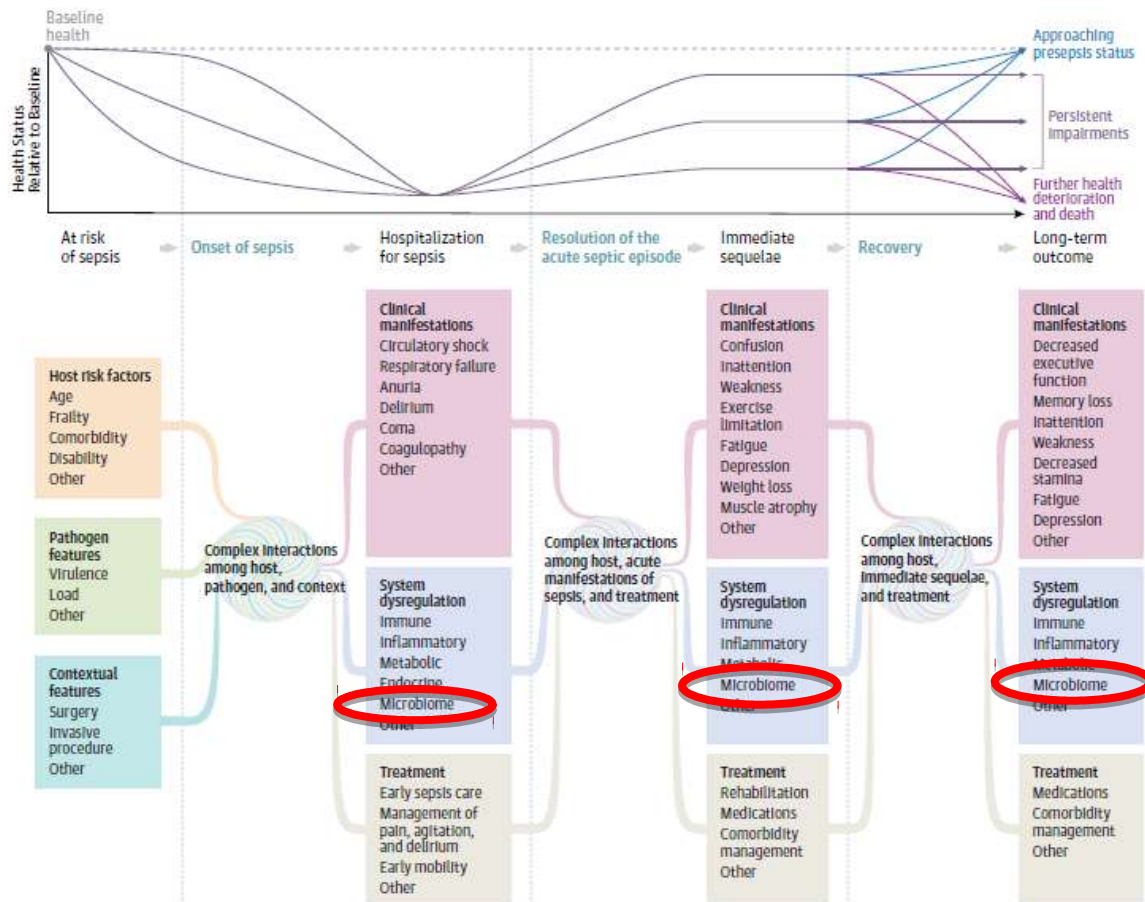
Enhancing Recovery From Sepsis A Review

Hallie C. Prescott, MD, MSc; Derek C. Angus, MD, MPH

Clinical Review & Education **Review**

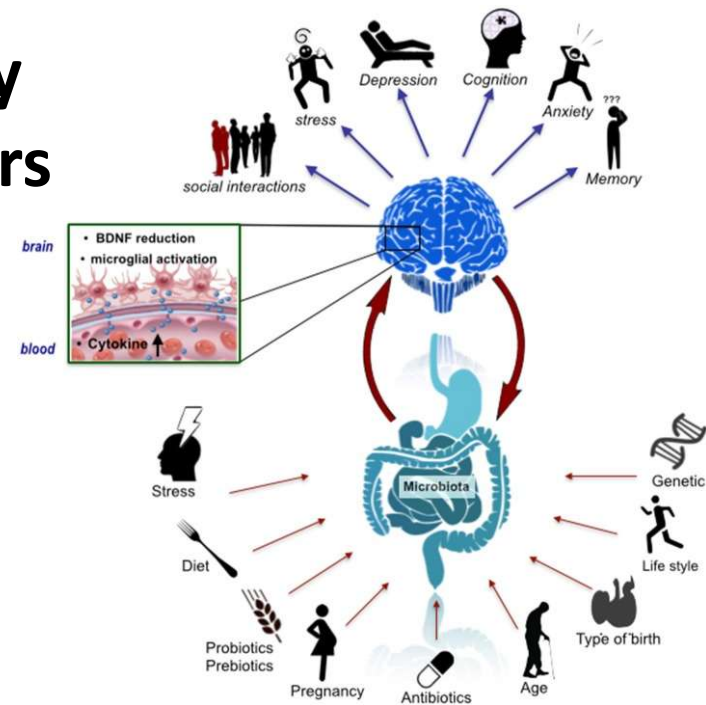
Sepsis Recovery: Recognition and Management of Long-term Sequelae

Figure 2. A Conceptual Model of the Potential Network of Factors and Interactions Important to Determining a Patient's Clinical Course and Long-term Outcome After Sepsis



Summary & Conclusions

- Gut microbiota is both stress-susceptible and can regulate stress response
- Regulates behaviours and physiology relevant to neuropsychiatric disorders
- Tryptophan availability/Kynurenine metabolism
- Translation to clinic?
- Microbial-based strategies for the treatment of stress-related disorders?



Kelly et al., *Frontiers Neuroscience* 2017

The **allium**

Science news you won't read nowhere else



Pope Francis To Award Sainthood To All Microbiome Researchers

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Vatican City - Pope Francis announced today that he was going to award automatic sainthood to all microbiome researchers worldwide for "Doing God's Work".

Acknowledgements



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Genes in irritable bowel syndrome



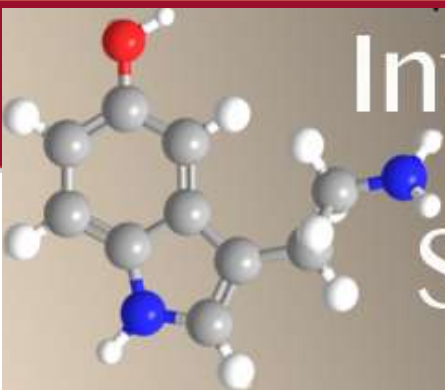
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International Society for Serotonin Research



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The 19th Meeting of the International Society
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Serotonin on the 'WILD ATLANTIC WAY'

University College Cork
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15th-19th July 2018

Plenary Lecturers

Patricia Gaspar
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Mark Geyer
(San Diego)

Kathryn Cunningham
(Texas)



Young Investigator Travel Award applications submission deadline is Friday December 15th 2017.

For application details contact Dr. Kelly Berg (berg@uthscsa.edu)
General registration and abstract submission open early 2018



Further details: <http://www.serotoninclub.org/>

List of Symposia

- Delineating the Neural Circuits Underlying Serotonin Modulation of Fear and Anxiety.
- 5-HT_{1F} Receptor Agonists, The New Kids On The Block for Antimigraine Treatment.
 - Serotonin Transport Proteins in Ecstasy; SERTS and OCTS in a Frenzy.
 - Lucky 7 (5-HT₇ Receptor): New Functions for a (relatively) New Colleague.
- Delving Deep into 5-HT Neurons: Probing Patterns and Regulation of 5-HT Transcriptomes and Translatomes.
 - Improving our Understanding of Serotonin in the Neurobiology of Psychosis.
 - Towards a Multiscale, Multispecies Perspective of Serotonergic Function.
 - Serotonin, Inflammation and Behaviour.
 - The Role of Serotonin in Synaptic Structure and Plasticity.
 - Multilevel Assembly of Serotonin Circuits and Its Impact on Emotional and Motivated Behaviors.
 - Serotonin Regulation of Dendritic Spines.
- Serotonin and Mental Illness: From Brain Development to Adult Dysfunction.
 - Feedback Control of Serotonin in Behavior and Antidepressant Response.
 - Serotonin and Autism Spectrum Disorder Hyperserotonemia and Beyond.

Special Session 1

Gut-Brain-Microbiome Axis

- Impact of Serotonin at the Microbial & Immune Interface on Gut-Brain Signalling.
 - Serotonin as a Modulator of the Gut-Brain-Microbiome Axis in Depression and other Mental Health Disorders.
- Serotonin Revisited – New Insights in Disturbed Functions in the Gastrointestinal Tract

Special Session 2

5-HT Receptor Signaling and Heteromerization

- Novel Functional Crosstalk and Heterodimerization of Serotonin Receptors in Mood and Social Behaviour.
 - Serotonin Receptor Complexes as Key Players in CNS Function.
- Three Crucial Factors that Underpin 5-HT_{2C} Function: Location, Location, Location.

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7th International Human Microbiome Consortium (IHMC) meeting 26th-28th June, Killarney, Ireland



For registration & further details go to: <http://apc.ucc.ie/ihmc-2018/>

IHMC 2018
7th International Human Microbiome Consortium meeting
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Thank you

g.clarke@ucc.ie

The Daily Mail, London Sept 2011