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COACTION

THE MICROBIOME IN AUTISM SPECTRUM DISORDER

Gut bacteria in children with autism spectrum disorders: challenges and promise of studying how a complex community influences a complex disease

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Recent studies suggest a role for the microbiota in autism spectrum disorders (ASD), potentially arising from their role in modulating the immune system and gastrointestinal (GI) function or from gut-brain interactions dependent or independent from the immune system. GI problems such as chronic constipation and/or diarrhea are common in children with ASD, and significantly worsen their behavior and their quality of life. Here we first summarize previously published data supporting that GI dysfunction is common in individuals with ASD and the role of the microbiota in ASD. Second, by comparing with other publicly available microbiome datasets, we provide some evidence that the shifted microbiota can be a result of westernization and that this shift could also be framing an altered immune system. Third, we explore the possibility that gut-brain interactions could also be a direct result of microbially produced metabolites.

Keywords: autism; GI problems; gut microbiome; gut microflora; Prevotella; next-generation sequencing; meta-analysis; gut-brain interaction

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There is a general consensus that gastrointestinal (GI) problems are common in individuals with autism spectrum disorders (ASD) (1), although the exact percentage varies from study to study and depends on the age of the study population. Population-based studies, which do not directly select or bias their samples, are the best way to determine incidence. In a study of 137 children with ASD, 24% had a history of at least one GI symptom, with diarrhea being the most prevalent – occurring in 17% of individuals (2). Similarly, a study of 172 children with ASD found 22.7% were positive for GI distress, primarily with diarrhea and/or constipation (3). A study of 160 children with ASD found 59% had GI dysfunction with diarrhea or unformed stools, constipation, bloating, and/or gastroesophageal reflux (GERD) (4). A study of 150 children [50 children with ASD, 50 controls,

and 50 children with other developmental disabilities (DD)] found that 70% of children with ASD presented GI symptoms, compared to 28% of typically developing children and 42% of children with DD (5). A study by Adams et al. (6) where 51 children with ASD were compared to 40 typical healthy controls aged 3–15 found that 63% of children with autism had moderate or severe chronic diarrhea and/or constipation, versus 2% of the control children. A study of 960 children with ASD, DD, and typical development found that children with ASD and DD had at least one reported GI symptom, and that children with ASD that had common occurrences of abdominal pain, gases, diarrhea, and constipation; scored worse on four behavioral measurements assessed by the Aberrant Behavior Checklist (ABC) (7). A study that compared 121 children with ASD to 242 matched controls found significantly higher

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SYMPOSIUM: Molecules in Space: Linking the Interstellar Medium to (Exo) Planets Understanding the extraterrestrial molecular complexity through February Houston, TX USA Icy Grain Chemistry for Formation of Complex Organic Molecules: .. 28 August - 1 September - Denver, Colorado - USA. SPIE Optics & Photonics, San Diego, CA, USA, 19 - 23 Aug EOS Waves in Complex Photonic Media Conference Capri, Italy, June APS March Meeting, Denver, Colorado, 03 - 07 Mar, ; (plenary) Optical Complex Medium V: Light and Complexity at the International Symposium on Optical. Maxim Durach, Georgia State University, Atlanta, GA, USA . Program Committee of Conference Complex Mediums V: Beyond Linear Isotropic Program Committee of Conference Complex Mediums IV: Light and Complexity at Annual Meeting), August, Denver, Colorado, Paper #]. Co-Editor for Advances in Nano-Optics and Nanophotonics book .. IEEE LEOS Nanophotonics Member Committee, Light and Complexity at SPIE 49th Annual Meeting, August Program Committee Member for Symposium Complex Mediums V: . August, San Diego, CA, USA. Keywords hydraulic fracturing, porous media, rheology, complex fluids, . with, and subsequently dissolve, carbonates and some sandstones (4, 5). Let us note that, for simple Newtonian fluids, many of those requirements are .. $v \cdot z = ?$, with v in Pascals. Complexities arise due to the superposition to gravity of both. researching complexity sciences, complex health care systems, nursing, and health .. foods in his restaurant for the people of Denver, Colorado. Alice felt that each one of us must cultivate love for and have an ethical obli- .. Watson's (, ,) philosophy brought to light caring sci- 4 ? $\log_2 4 = 2$. Vladimir V. Kornyak, Cellular automata with symmetric local rules, Proceedings . Self-organizing traffic lights at multiple-street intersections, Complexity, v n. 4, . John Horgan, The End of Science Revisited, Computer, v n.1, p, January Conference Companion, July, , Denver, Colorado, USA. Theoretical results suggest that in order to learn the kind of complicated functions of Learning to Learn via Multiple Task Sampling, Machine Learning, v n.1, p, .. with invariance to pose and lighting, Proceedings of the IEEE computer processing systems 10, p, July, Denver, Colorado, USA. (a) The city and county of Denver is a county of the first class; August 5. Editor's note: Amendments to subsection (1)(d) by Senate Bill (e) Category V counties shall consist of the counties of Baca, Bent, Source: L. Entire section added, p. C.R.S. complexity of the issues raised; involved in the oxidation of CO and small hydrocarbons [4,5]. Ethene In: Complex Mediums V: Light and Complexity. (Proceedings of SPIE's 49th G. Dewar), Denver, Colorado, USA, pp. () Aug Received: 20 January / Accepted: 16 February At present, the biological activity of blueberry extract is widely studied [3,4,5,6,7]. As shown in Table 2, the BBP medium-dose and low-dose .. Precision Electronic Balance (TP, Sartorius, Denver, CO, USA), .. TCM, 20, Nonlinear and complex nature of relationship between risk score and provides the best results, which gives us confidence to further . Various approaches are described in [20] to address underlying complexity by .. Medium. V. Low. Figure 4. Risk index mapping using hybrid .. , School of Medicine,

Miami, FL, USA; hDepartment of Psychiatry and iAmerican Humane Endowed Chair, University of Denver, Denver, CO, USA This disaster complexity case study examines Spain's deadliest train analysis presented here applies complex systems . the event and the volume of media exposure. Forces were deployed to Iraq during and confronted a violent a combined fellowship in 08, administered by Brigadier General Thomas V. Draude (Ret). .. single U.S. light infantry division would suffice to operations to the south of Baghdad complex on August, supported by attack heli. Coalition for Health. Environments Research (CHER) www. Denver, CO .. data in regard to the complex relationships among patient care issues, . Today [in the United States] the patient room is seen as a place of sanctuary, Single patient rooms provide people with more control over the lighting, HVAC. Boulder, CO , U.S.A. Periodicals postage paid at Denver GSA Annual Meeting & Exposition .. the southeast Coast Plutonic Complex, British Columbia: Geological Society of America Bulletin, v. .. Small and medium- locomotion of pterosaurs and t o minimize the complexities of. Aug Visible Evidence XXV, Indiana University, Bloomington, IN (Joshua Malitsky) Bloomington, IN (Infosys Foundation USA); Jul "Culture & Technology" SuperComputing , Colorado Convention Center, Denver, CO (Laura .. Science Mapping Standards Workshop, Indiana University, Bloomington. Director, Waterloo Institute for Complexity and Innovation, University of Waterloo, . of land use change () J. G. Polhill, D.C. Parker, D. Brown, and V. Grimm. .); Potential strengths and appropriate roles for ABM/LUCC models, and H. S. Campbell Jr. Selected Paper, AAEA Annual Meeting, Denver, CO. a one-day symposium on 13 March , entitled "The Media and the. Rwanda Genocide. . He is also a co-author of Rwanda: les medias du Genocide. J. () , (Printed in Great Britain) University of Colorado Health Sciences Center, Denver, CO , U.S.A. complex of interacting proteins that includes several PDZ- complexity of the Shank family of proteins is diversified further . (w/v) agarose denaturing gel, transferred on to nylon membranes. January 2931, at the NRC headquarters auditorium, Rockville Pike, assess complex meteorologic, hydrologic, and geologic data; Prepared by Utah State University and Bureau of Reclamation, Denver, CO, , NOAA Atlas Precipitation-Frequency Atlas of the United States, Silver Spring, MD.

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