

## Understanding ME/CFS through the systemic actions of the bioenergetics mediator hydrogen sulfide

List of comparative citations as referenced in IACFS/ME poster, October 2016

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Key Word	ME/CFS Finding	H2S Finding
<b>Metabolic Hypo-function</b>	<b>Metabolism in chronic fatigue syndrome.</b> Armstrong CW, McGregor NR, Butt HL, Gooley PR., Adv Clin Chem. 2014;66:121-72.	<b>Hypothesis: chronic fatigue syndrome is caused by dysregulation of hydrogen sulfide metabolism.</b> Lemle MD., Med Hypotheses. 2009 Jan;72(1):108-9. doi: 10.1016/j.mehy.2008.08.003. Epub 2008 Sep 16. PMID: 18799269
<b>Lipid peroxidation</b>	<b>Antioxidant status and lipoprotein peroxidation in chronic fatigue syndrome.</b> Manuel y Keenoy B, Moorkens G, Vertommen J, De Leeuw I., Life Sci. 2001 Mar 16;68(17):2037-49	<b>Hydrogen sulfide decreases the plasma lipid peroxidation induced by homocysteine and its thiolactone.</b> Olas B1, Kontek B., Mol Cell Biochem. 2015 Jun;404(1-2):39-43. doi: 10.1007/s11010-015-2364-8. Epub 2015 Feb 21.
<b>Mitochondria</b>	<b>Mitochondrial dysfunction and the pathophysiology of Myalgic Encephalomyelitis/Chronic Fatigue Syndrome (ME/CFS).</b> Booth NE, Myhill S, McLaren-Howard J., Int J Clin Exp Med. 2012;5(3):208-20. Epub 2012 Jun 15. PMID: 22837795	<b>Regulation of mitochondrial bioenergetic function by hydrogen sulfide. Part I. Biochemical and physiological mechanisms.</b> Szabo C, Ransy C, Módis K, Andriamihaja M, Murghes B, Coletta C, Olah G, Yanagi K, Bouillaud F., Br J Pharmacol. 2014 Apr;171(8):2099-122. doi: 10.1111/bph.12369. Review. PMID: 23991830  <b>Regulation of mitochondrial bioenergetic function by hydrogen sulfide. Part II. Pathophysiological and therapeutic aspects.</b> Módis K, Bos EM, Calzia E, van Goor H, Coletta C, Papapetropoulos A, Hellmich MR, Radermacher P, Bouillaud F, Szabo C., Br J Pharmacol. 2014 Apr;171(8):2123-46. doi: 10.1111/bph.12368. Review. PMID: 23991749
<b>ATP synthase</b>	<b>Bottom-up proteomics suggests an association between differential expression of mitochondrial proteins and chronic fatigue syndrome.</b> Ciregia F, Kollipara L, Giusti L, Zahedi RP, Giacomelli C, Mazzoni MR, Giannaccini G, Scarpellini P, Urbani A, Sickmann A, Lucacchini A, Bazzichi L., Transl Psychiatry. 2016 Sep 27;6(9):e904. doi: 10.1038/tp.2016.184. PMID: 27676445	<b>S-Sulfhydration of ATP synthase by hydrogen sulfide stimulates mitochondrial bioenergetics.</b> Módis K, Ju Y, Ahmad A, Untereiner AA, Altaany Z, Wu L, Szabo C, Wang R., Pharmacol Res. 2016 Aug 20;113(Pt A):116-124. doi: 10.1016/j.phrs.2016.08.023. PMID: 27553984
<b>Carnitine</b>	<b>Brain regions involved in fatigue sensation: reduced acetylcarnitine uptake into the brain.</b> Kuratsune H1, Yamaguti K, Lindh G, Evengård B, Hagberg G, Matsumura K, Iwase M, Onoe H, Takahashi M, Machii T, Kanakura Y, Kitani T, Långström B, Watanabe Y., Neuroimage. 2002 Nov;17(3):1256-65. Neuropsychobiology. 1995;32(3):132-8.	<b>The mitochondrial carnitine/acylcarnitine carrier is regulated by hydrogen sulfide via interaction with C136 and C155.</b> Giangregorio N, Tonazzi A, Console L, Lorusso I, De Palma A, Indiveri C., Biochim Biophys Acta. 2016 Jan;1860(1 Pt A):20-7. doi: 10.1016/j.bbagen.2015.10.005. Epub 2015 Oct 14. PMID: 2645900
<b>Soluble guanylyl cyclase</b>	<b>Activators or stimulators of soluble guanylate cyclase for use in treating chronic fatigue syndrome.</b> Fluge O, Mella O. US Patent US20160256460 A1, Publication date Sep 8, 2016	<b>Regulation of soluble guanylyl cyclase redox state by hydrogen sulfide.</b> Zhou Z, Martin E, Sharina I, Esposito I, Szabo C, Bucci M, Cirino G, Papapetropoulos A., Pharmacol Res. 2016 Sep;111:556-62. doi: 10.1016/j.phrs.2016.06.029. Epub 2016 Jul 1.
<b>Glutathione</b>	<b>Increased ventricular lactate in chronic fatigue syndrome. III. Relationships to cortical glutathione and clinical symptoms implicate oxidative stress in disorder pathophysiology.</b> Shungu DC, Weiduschat N, Murrrough JW, Mao X, Pillemer S, Dyke JP, Medow MS, Natelson BH, Stewart JM, Mathew SJ., NMR Biomed. 2012 Sep;25(9):1073-87. doi: 10.1002/nbm.2772. Epub 2012 Jan 27. PMID: 22281935	<b>Hydrogen sulfide increases glutathione production and suppresses oxidative stress in mitochondria.</b> Kimura Y, Goto Y, Kimura H., Antioxid Redox Signal. 2010 Jan;12(1):1-13. doi: 10.1089/ars.2008.2282. PMID: 19852698
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<b>Neuroinflammation</b>	<b>Neuroinflammation in Patients with Chronic Fatigue Syndrome/Myalgic Encephalomyelitis: An <sup>11</sup>C-(R)-PK11195 PET Study.</b> Nakatomi Y, Mizuno K, Ishii A, Wada Y, Tanaka M, Tazawa S, Onoe K, Fukuda S, Kawabe J, Takahashi K, Kataoka Y, Shiomi S, Yamaguti K, Inaba M, Kuratsune H, Watanabe Y, J Nucl Med. 2014 Jun;55(6):945-50. doi: 10.2967/jnumed.113.131045. Epub 2014 Mar 24.	<b>Hydrogen Sulfide and Neuroinflammation.</b> Kida K, Ichinose F., Handb Exp Pharmacol. 2015;230:181-9. doi: 10.1007/978-3-319-18144-8_9.

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<b>POTS</b>	<b>A matched case control study of orthostatic intolerance in children/adolescents with chronic fatigue syndrome.</b> Galland BC, Jackson PM, Sayers RM, Taylor BJ., <i>Pediatr Res.</i> 2008 Feb;63(2):196-202. PMID: 18091356	<b>Plasma hydrogen sulfide in differential diagnosis between vasovagal syncope and postural orthostatic tachycardia syndrome in children.</b> Zhang F1, Li X, Stella C, Chen L, Liao Y, Tang C, Jin H, Du J., <i>J Pediatr.</i> 2012 Feb;160(2):227-31. doi:
<b>Adrenergic Receptor</b>	<b>Gene expression alterations at baseline and following moderate exercise in patients with Chronic Fatigue Syndrome and Fibromyalgia Syndrome.</b> Light AR, Bateman L, Jo D, Hughen RW, Vanhaisma TA, White AT, Light KC., <i>J Intern Med.</i> 2012 Jan;271(1):64-81. doi: 10.1111/j.1365-2796.2011.02405.x. Epub 2011 Jul 13. PMID: 21615807	<b>Cystathione gamma lyase/Hydrogen Sulphide Pathway Up Regulation Enhances the Responsiveness of <math>\alpha</math>1A and <math>\alpha</math>1B-Adrenoreceptors in the Kidney of Rats with Left Ventricular Hypertrophy.</b> Ahmad A, Sattar MA, Azam M, Abdulla MH3, Khan SA, Hashmi F, Abdullah NA, Johns EJ., <i>PLoS One.</i> 2016 May 18;11(5):e0154995. doi: 10.1371/journal.pone.0154995.
<b>Vascular Endothelial Growth Factor</b>	<b>Reductions in circulating levels of IL-16, IL-7 and VEGF-A in myalgic encephalomyelitis/chronic fatigue syndrome.</b> Landi A, Broadhurst D, Vernon SD, Tyrrell DL, Houghton M., <i>Cytokine.</i> 2016 Feb;78:27-36. doi: 10.1016/j.cyto.2015.11.018. Epub 2015 Nov 28. PMID: 26615570	<b>Regulation and role of endogenously produced hydrogen sulfide in angiogenesis.</b> Katsouda A, Bibli SI, Pyriochou A, Szabo C, Papapetropoulos A., <i>Pharmacol Res.</i> 2016 Aug 26;113(Pt A):175-185. doi: 10.1016/j.phrs.2016.08.026. [Epub ahead of print]
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<b>Mast cell</b>	<b>Novel characterisation of mast cell phenotypes from peripheral blood mononuclear cells in chronic fatigue syndrome/myalgic encephalomyelitis patients.</b> Nguyen T, Johnston S, Chacko A, Gibson D, Cepon J, Smith P, Staines D, Marshall-Gradisnik S., <i>Asian Pac J Allergy Immunol.</i> 2016 Jun 30. doi: 10.12932/AP0711. [Epub ahead of print] PMID: 27362406	<b>The novel H2S donor 4-carboxy-phenyl isothiocyanate inhibits mast cell degranulation and renin release by decreasing intracellular calcium.</b> Marino A, Martelli A, Citi V, Fu M, Wang R, Calderone V, Levi R., <i>Br J Pharmacol.</i> 2016 Aug 22. doi: 10.1111/bph.13583. PMID: 27548075

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<p><b>Mycoplasma</b></p>	<p><b>Mycoplasma blood infection in chronic fatigue and fibromyalgia syndromes.</b> Endresen GK., Rheumatol Int. 2003 Sep;23(5):211-5. Epub 2003 Jul 16. Review. PMID: 12879275</p>	<p><b>Hydrogen sulfide is a novel potential virulence factor of Mycoplasma pneumoniae: characterization of the unusual cysteine desulfurase/desulfhydrase HapE.</b> Großhennig S, Ischebeck T, Gibhardt J, Busse J, Feussner I, Stülke J., Mol Microbiol. 2016 Apr;100(1):42-54. doi: 10.1111/mmi.13300. Epub 2016 Feb 9. PMID: 26711628</p>
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<p><b>CD8+ T cells</b></p>	<p><b>Increased expression of activation antigens on CD8+ T lymphocytes in Myalgic Encephalomyelitis/chronic fatigue syndrome: inverse associations with lowered CD19+ expression and CD4+/CD8+ ratio, but no associations with (auto)immune, leaky gut, oxidative and nitrosative stress biomarkers.</b></p>	<p><b>Exogenous hydrogen sulfide induces functional inhibition and cell death of cytotoxic lymphocytes subsets.</b> Mirandola P, Gobbi G, Sponzilli I, Pambianco M, Malinverno C, Cacchioli A, De Panfilis G, Vitale M, J Cell Physiol. 2007 Dec;213(3):826-33.</p>
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