

Manganese Health Research

Program: Recent published literature

January 2002- May 2006

June 2006

The Institute of Environment and Health (IEH) was established at Cranfield University in November 2005. The research and consultancy activities of the Institute are principally funded through specific grants, contracts and awards by UK Government Departments and Agencies.

This document is a report by the Institute of Environment and Health for the Manganese Health Research Program (MHRP)

Prepared by Lini Ashdown & Phil Holmes

©Institute of Environment and Health, 2006

Institute of Environment and Health
Cranfield University
Silsoe
Bedfordshire
MK45 4DT
UK
www.silsoe.cranfield.ac.uk

Introduction

This report presents bibliographic details of recent literature addressing a number of research areas that are considered of direct relevance to the health effects of Manganese (Mn), and include:

Section 1 - EXPOSURE MEASUREMENT AND MODELLING: Papers relating to the measurements or modelling of environmental and occupational Mn exposure, the development of biomarkers of exposure or effect.

Section 2 - HEALTH EFFECTS: Papers on the influence of Mn on health, disease and dysfunction.

Section 3 - MECHANISM: Papers on the physiological, biochemical and cellular mechanisms underlying the toxic effects of Mn.

Section 4 - HUMAN SUSCEPTIBILITY: Papers relating to assessment of the influence of genetic and epigenetic factors on human susceptibility to the effects of Mn.

Section 5 - TREATMENT AND IMAGING: Papers on the development and implementation of new medical approaches to the treatment of excessive Mn exposure.

Section 6 - MISCELLANEOUS: Other papers considered of interest or potential relevance to the study of the health effects of Mn.

The papers presented herein were identified using a series of structured searches of the following on-line databases: Medline, Toxline, Biological Sciences and Proquest Health. The paper abstracts were reviewed and categorised by an experience Scientist to confirm their relevance before inclusion in this report.

The papers presented were identified as being first published between **January 2002** and **May 2006**. Future reports will present the literature published during subsequent 3-monthly (quarterly) intervals.

1. EXPOSURE MEASUREMENT AND MODELLING

Anonymous (2005) Manganese Inhaled from the Shower: A Public Health Threat? *Journal of Environmental Health*, 68(4), 51

Agha, F., Sadaruddin, A. & Khatoon, N. (2005) Effect of environmental lead pollution on blood lead levels in traffic police constables in Islamabad, Pakistan. *JPMA*, 55(10), 410-413

Anetor, J.I., Adelaja, O. & Adekunle, A.O. (2003) Serum micronutrient levels, nucleic acid metabolism and antioxidant defences in pregnant Nigerians: implications for fetal and maternal health. *African Journal of Medicine and Medical Sciences*, 32(3), 257-262

Aschner, M., Erikson, K.M. & Dorman, D.C. (2005) Manganese dosimetry: species differences and implications for neurotoxicity. *Critical Reviews in Toxicology*, 35(1), 1

Audrey, S., Takser, L. & Andre, M., et al. (2002) A comparative study of manganese and lead levels in human umbilical cords and maternal blood from two urban centers exposed to different gasoline additives. *Science of the Total Environment*, 290(1-3), 157-164

Bergomi, M., Vinceti, M. & Nacci, G., et al. (2002) Environmental exposure to trace elements and risk of amyotrophic lateral sclerosis: a population-based case-control study. *Environmental Research*, 89(2), 116-123

Bhuie, A.K., Ogunseitan, O.A., White, R.R., Sain, M. & Roy, D.N. (2005) Modeling the environmental fate of manganese from methylcyclopentadienyl manganese tricarbonyl in urban landscapes. *Science of the Total Environment*, 339(1-3), 167-178

Bolté, S.é, Normandin, L., Kennedy, G. & Zayed, J. (2004) Human exposure to respirable manganese in outdoor and indoor air in urban and rural areas. *Journal of Toxicology and Environmental Health, Part A.*, 67(6), 459-467

Charles, L.E., Burchfiel, C.M. & Fekedulegn, D., et al. (2006) Occupational exposures and movement abnormalities among Japanese-American men: the Honolulu-Asia Aging Study. *Neuroepidemiology*, 26(3), 130-9

Chillrud, S.N., Epstein, D. & Ross, J.M., et al. (2004) Elevated airborne exposures of teenagers to manganese, chromium, and iron from steel dust and New York City's subway system. *Environmental Science & Technology*, 38(3), 732-737

Chillrud, S.N., Grass, D. & Ross, J.M., et al. (2005) Steel dust in the New York City subway system as a source of manganese, chromium, and iron exposures for transit workers. *Journal of Urban Health*, 82(1), 33-42

Clewell, H.J., Lawrence, G.A., Calne, D.B. & Crump, K.S. (2003) Determination of an occupational exposure guideline for manganese using the benchmark method. *Risk Analysis*, 23(5), 1031-1046

Delgado, I.F. & Paumgarten, F.J.R. (2004) [Pesticide use and poisoning among farmers from the county of Paty do Alferes, Rio de Janeiro, Brazil]. *Cadernos De Saude Publica*, 20(1), 180-6

Ellingsen, D.G., Haug, E., Gaarder, P.I., Bast-Pettersen, R. & Thomassen, Y. (2003) Endocrine and immunologic markers in manganese alloy production workers. *Scandinavian Journal of Work, Environment & Health*, 29(3), 230-238

- Finley, J.W., Penland, J.G., Pettit, R.E. & Davis, C.D. (2003) Dietary manganese intake and type of lipid do not affect clinical or neuropsychological measures in healthy young women. *The Journal of Nutrition*, 133(9), 2849-2856
- Frisbie, S.H., Ortega, R., Maynard, D.M. & Sarkar, B. (2002) The concentrations of arsenic and other toxic elements in Bangladesh's drinking water. *Environmental Health Perspectives*, 110(11), 1147-1153
- Goldhaber, S.B. (2003) Trace element risk assessment: essentiality vs. toxicity. *Regulatory Toxicology and Pharmacology : RTP*, 38(2), 232-242
- Gulson, B., Mizon, K. & Taylor, A., et al. (2006) Changes in manganese and lead in the environment and young children associated with the introduction of methylcyclopentadienyl manganese tricarbonyl in gasoline--preliminary results. *Environmental Research*, 100(1), 100-114
- Han, S.G., Kim, Y., Kashon, M.L., Pack, D.L., Castranova, V. & Vallyathan, V. (2005) Correlates of oxidative stress and free-radical activity in serum from asymptomatic shipyard welders. *American Journal of Respiratory and Critical Care Medicine*, 172(12), 1541
- Hasan, M.Y., Kosanovic, M., Fahim, M.A., Adem, A. & Petroianu, G. (2004) Trace metal profiles in hair samples from children in urban and rural regions of the United Arab Emirates. *Veterinary and Human Toxicology*, 46(3), 119-121
- Herrero Hernandez, E., Discalzi, G., Dassi, P., Jarre, L. & Pira, E. (2003) Manganese intoxication: the cause of an inexplicable epileptic syndrome in a 3 year old child. *Neurotoxicology*, 24(4-5), 633-639
- Itokawa, Y. (2004) [Manganese]. *Nippon Rinsho (Japanese Journal of Clinical Medicine)*, 62 Suppl 12308-310
- Keiloun, M., Yang, F. & Chau, Y.K., et al. (2002) Exposure of Gas Station Attendants to Methylcyclopentadienyl Manganese Tricarbonyl (MMT) Used in Gasoline. *Water, Air, & Soil Pollution*, 141(1-4), 155-163
- Kiebertz, K. & Kurlan, R. (2005) Welding and Parkinson disease: is there a bond? *Neurology*, 64(12), 2001-2003
- Kilic, E., Saraymen, R., Demiroglu, A. & Ok, E. (2004) Chromium and Manganese Levels in the Scalp Hair of Normals and Patients with Breast Cancer. *Biological Trace Element Research*, 102(1-3), 19-26
- Kim, J.Y., Hauser, R., Wand, M.P., Herrick, R.F., Amarasiriwardena, C.J. & Christiani, D.C. (2003) The association of expired nitric oxide with occupational particulate metal exposure. *Environmental Research*, 93(2), 158-166
- Kim, J.Y., Mukherjee, S., Ngo, L.C. & Christiani, D.C. (2004) Urinary 8-hydroxy-2'-deoxyguanosine as a biomarker of oxidative DNA damage in workers exposed to fine particulates. *Environmental Health Perspectives*, 112(6), 666-671
- Kuhnlein, H.V., Receveur, O., Soueida, R. & Egeland, G.M. (2004) Arctic indigenous peoples experience the nutrition transition with changing dietary patterns and obesity. *The Journal of Nutrition*, 134(6), 1447-1453

- Leblanc, J., Guérin, T., Noël, L., Calamassi-Tran, G., Volatier, J. & Verger, P. (2005) Dietary exposure estimates of 18 elements from the 1st French Total Diet Study. *Food Additives and Contaminants*, 22(7), 624-641
- Leotsinidis, M., Alexopoulos, A. & Kostopoulou-Farri, E. (2005) Toxic and essential trace elements in human milk from Greek lactating women: association with dietary habits and other factors. *Chemosphere*, 61(2), 238-247
- Lewis, S.M., Mayhugh, M.A. & Freni, S.C., et al. (2003) Assessment of antioxidant nutrient intake of a population of southern US African-American and Caucasian women of various ages when compared to dietary reference intakes. *The Journal of Nutrition, Health & Aging*, 7(2), 121-128
- Li, G.J., Zhang, L., Lu, L., Wu, P. & Zheng, W. (2004) Occupational exposure to welding fume among welders: alterations of manganese, iron, zinc, copper, and lead in body fluids and the oxidative stress status. *Journal of Occupational and Environmental Medicine*, 46(3), 241-248
- Machemer, S.D. (2004/1/15) Characterization of airborne and bulk particulate from iron and steel manufacturing facilities. *Environmental Science & Technology*, 38(2), 381-389
- Magari, S.R., Schwartz, J., Williams, P.L., Hauser, R., Smith, T.J. & Christiani, D.C. (2002) The association of particulate air metal concentrations with heart rate variability. *Environmental Health Perspectives*, 110(9), 875-880
- Merkur'eva, L.I. & Riabova, O.I. (2003) [Diagnostic and prognostic value of serum manganese levels for chronic manganese intoxication in electric welders]. *Meditsina Truda i Promyshlennaia Ekologiya*, (8), 41-43
- Mielke, H.W., Gonzales, C.R., Powell, E., Shah, A. & Mielke, P.W. (2002) Natural and anthropogenic processes that concentrate Mn in rural and urban environments of the lower Mississippi River delta. *Environmental Research*, 90(2), 157-168
- Miki, F., Sakai, T., Wariishi, M. & Kaji, M. (2002) Measurement of zinc, copper, manganese, and iron concentrations in hair of pituitary dwarfism patients using flameless atomic absorption spectrophotometry. *Biological Trace Element Research*, 85(2), 127-136
- Nadal, M., Bocio, A., Schuhmacher, M. & Domingo, J.L. (2005) Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: levels in hair of school children. *Biological Trace Element Research*, 104(3), 203-13
- Newson, R.B., Shaheen, S.O., Henderson, A.J., Emmett, P.M., Sherriff, A. & Calder, P.C. (2004) Umbilical cord and maternal blood red cell fatty acids and early childhood wheezing and eczema. *The Journal of Allergy and Clinical Immunology*, 114(3), 531-537
- Noël, L., Leblanc, J.C. & Guérin, T. (2003) Determination of several elements in duplicate meals from catering establishments using closed vessel microwave digestion with inductively coupled plasma mass spectrometry detection: estimation of daily dietary intake. *Food Additives and Contaminants*, 20(1), 44-56
- Powers, K.M., Smith-Weller, T., Franklin, G.M., Longstreth, W.T., Swanson, P.D. & Checkoway, H. (2003) Parkinson's disease risks associated with dietary iron, manganese, and other nutrient intakes. *Neurology*, 60(11), 1761-1766

- Riabova, O.I., Davydova, N.I. & Kalashnikova, A.A. (2004) Diagnostic and prognostic value of determining serum levels of cytokines and antibodies to basic myeloprotein in chronic manganese intoxication. *Meditcina Truda i Promyshlennaia Ekologiya*, (12), 10-13
- Röllin, H., Mathee, A., Levin, J., Theodorou, P. & Wewers, F. (2005) Blood manganese concentrations among first-grade schoolchildren in two South African cities. *Environmental Research*, 97(1), 93-99
- Schuhmacher, M., Domingo, J.L., Agramunt, M.C., Bocio, A. & Müller, L. (2002) Biological monitoring of metals and organic substances in hazardous-waste incineration workers. *International Archives of Occupational and Environmental Health*, 75(7), 500-6
- Schutte, A.E., Van Rooyen, J.M., Huisman, H.W., Kruger, H.S., Malan, N.T. & De Ridder, J.H. (2003) Dietary markers of hypertension associated with pulse pressure and arterial compliance in black South African children: the THUSA Bana Study. *Cardiovascular Journal of South Africa*, 14(2), 81-89
- Shamberger, R.J. (2002) Validity of hair mineral testing. *Biological Trace Element Research*, 87(1-3), 1-28
- Shamberger, R.J. (2003) Calcium, magnesium, and other elements in the red blood cells and hair of normals and patients with premenstrual syndrome. *Biological Trace Element Research*, 94(2), 123-129
- Smargiassi, A., Takser, L. & Masse, A., et al. (2002) A comparative study of manganese and lead levels in human umbilical cords and maternal blood from two urban centers exposed to different gasoline additives. *Science of the Total Environment*, 290(1-3), 157-164
- Takser, L., Lafond, J., Bouchard, M., St-Amour, G. & Mergler, D. (2004) Manganese levels during pregnancy and at birth: relation to environmental factors and smoking in a Southwest Quebec population. *Environmental Research*, 95(2), 119-125
- Tereshchenko, I.V., Goldyreva, T.P. & Bronnikov, V.I. (2004) [Trace elements and endemic goiter]. *Klinicheskaya Meditsina*, 82(1), 62-68
- Thibault, C., Kennedy, G., Gareau, L. & Zayed, J. (2002) Preliminary assessment of atmospheric methylcyclopentadienyl manganese tricarbonyl and particulate manganese in selected urban sites. *Journal of Toxicology and Environmental Health Part A*, 65(7), 503-511
- Torra, M., Rodamilans, M. & Corbella, J. (2002) Biological monitoring of environmental exposure to manganese in blood samples from residents of the city of Barcelona, Spain. *Science of the Total Environment*, 289(1-3), 237-241
- Torrente, M., Colomina, M.T. & Domingo, J.L. (2005) Metal concentrations in hair and cognitive assessment in an adolescent population. *Biological Trace Element Research*, 104(3), 215-221
- Uz, E., Sahin, S., Hepsen, I.F., Var, A., Sogut, S. & Akyol, O. (2003) The relationship between serum trace element changes and visual function in heavy smokers. *Acta Ophthalmologica Scandinavica*, 81(2), 161-164
- Vigeh, M., Yokoyama, K. & Ramezanzadeh, F., et al. (2006) Lead and other trace metals in preeclampsia: a case-control study in Tehran, Iran. *Environmental Research*, 100(2), 268-75

Wasserman, G.A., Liu, X. & Parvez, F. (2006) Water Manganese Exposure and Children's Intellectual Function in Araihasar, Bangladesh. *Environmental Health Perspectives*, 114(1), 124

Wasserman, G.A., Liu, X. & Parvez, F., et al. (2004) Water arsenic exposure and children's intellectual function in Araihasar, Bangladesh. *Environmental Health Perspectives*, 112(13), 1329-1333

Woolf, A., Wright, R., Amarasiriwardena, C. & Bellinger, D. (2002) A child with chronic manganese exposure from drinking water. *Environmental Health Perspectives*, 110(6), 613-616

Zayed, J., Guessous, A., Lambert, J., Carrier, G. & Philippe, S. (2003) Estimation of annual Mn emissions from MMT source in the Canadian environment and the Mn pollution index in each province. *Science of the Total Environment*, 312(1-3), 147-154

2. HEALTH EFFECTS

Antonini, J.M., Taylor, M.D., Zimmer, A.T. & Roberts, J.R. (2004) Pulmonary responses to welding fumes: role of metal constituents. *Journal of Toxicology and Environmental Health. Part A.*, 67(3), 233-249

Aschner, M., Erikson, K.M. & Dorman, D.C. (2005) Manganese dosimetry: species differences and implications for neurotoxicity. *Critical Reviews in Toxicology*, 35(1), 1

Bast-Pettersen, R. & Ellingsen, D.G. (2005) The Kløve-Matthews static steadiness test compared with the DPD TREMOR. Comparison of a fine motor control task with measures of tremor in smokers and manganese-exposed workers. *Neurotoxicology*, 26(3), 331-342

Bergomi, M., Vinceti, M. & Nacci, G., et al. (2002) Environmental exposure to trace elements and risk of amyotrophic lateral sclerosis: a population-based case-control study. *Environmental Research*, 89(2), 116-123

Beuter, A., Lambert, G. & MacGibbon, B. (2004) Quantifying postural tremor in workers exposed to low levels of manganese. *Journal of Neuroscience Methods*, 139(2), 247-255

Boev, V.M., Burdakov, V.V., Fel'dman, A.G., Kolosova, N.I., Kazistova, T.M. & Raimov, A.G. (2002) [Ecological aspects of myasthenia gravis in the Orenburg region]. *Gigiena i.Sanitariia*, (5), 44-47

Boojar, M.M.A. & Goodarzi, F. (2002) A longitudinal follow-up of pulmonary function and respiratory symptoms in workers exposed to manganese. *Journal of Occupational and Environmental Medicine*, 44(3), 282-290

Boojar, M.M.A., Goodarzi, F. & Basedaghat, M.A. (2002) Long-term follow-up of workplace and well water manganese effects on iron status indexes in manganese miners. *Archives of Environmental Health.*, 57(6), 519-528

Borská, L., Fiala, Z., Smejkalová, J. & Tejral, J. (2003) Health risk of occupational exposure in welding processes I. Genotoxic risk. *Acta Medica (Hradec Kralove)*, 46(1), 25-29

Burkhard, P.R., Delavelle, J., Du Pasquier, R. & Spahr, L. (2003) Chronic parkinsonism associated with cirrhosis: a distinct subset of acquired hepatocerebral degeneration. *Archives of Neurology*, 60(4), 521-528

Butterworth, R.F. (2003) Hepatic encephalopathy. *Alcohol Research & Health*, 27(3), 240-246

Cerhan, J.R., Saag, K.G., Merlino, L.A., Mikuls, T.R. & Criswell, L.A. (2003) Antioxidant micronutrients and risk of rheumatoid arthritis in a cohort of older women. *American Journal of Epidemiology*, 157(4), 345-354

Charles, L.E., Burchfiel, C.M. & Fekedulegn, D., et al. (2006) Occupational exposures and movement abnormalities among Japanese-American men: the Honolulu-Asia Aging Study. *Neuroepidemiology*, 26(3), 130-9

Chetri, K. & Choudhuri, G. (2003) Role of trace elements in hepatic encephalopathy: zinc and manganese. *Indian Journal of Gastroenterology*, 22 Suppl 2, S28-30

- Clewell, H.J., Lawrence, G.A., Calne, D.B. & Crump, K.S. (2003) Determination of an occupational exposure guideline for manganese using the benchmark method. *Risk Analysis*, 23(5), 1031-1046
- Crossgrove, J. & Zheng, W. (2004) Manganese toxicity upon overexposure. *NMR in Biomedicine*, 17(8), 544-553
- Crump, K.S. & Clewell, H.J. (2004) The effects of manganese in air. *Science*, 303(5655), 169-73
- Delgado, I.F. & Paumgarten, F.J.R. (2004) [Pesticide use and poisoning among farmers from the county of Paty do Alferes, Rio de Janeiro, Brazil]. *Cadernos De Saude Publica*, 20(1), 180-6
- Dobson, A.W., Erikson, K.M. & Aschner, M. (2004) Manganese neurotoxicity. *Annals of the New York Academy of Sciences*, 1012115-128
- Dressler, J., Schulz, K., Klemm, M., Schüttig, R., Beuthin, A. & Felscher, D. (2002) Lethal manganese-cadmium intoxication. A case report. *Archives of Toxicology*, 76(8), 449-51
- Ellingsen, D.G., Haug, E., Ulvik, R.J. & Thomassen, Y. (2003) Iron status in manganese alloy production workers. *Journal of Applied Toxicology*, 23(4), 239-247
- Finley, B.L. & Santamaria, A.B. (2005) Current evidence and research needs regarding the risk of manganese-induced neurological effects in welders. *Neurotoxicology*, 26(2), 285-289
- Finley, J.W. (2004) Does environmental exposure to manganese pose a health risk to healthy adults? *Nutrition Reviews*, 62(4), 148-153
- Finley, J.W., Penland, J.G., Pettit, R.E. & Davis, C.D. (2003) Dietary manganese intake and type of lipid do not affect clinical or neuropsychological measures in healthy young women. *The Journal of Nutrition*, 133(9), 2849-2856
- Fored, C.M., Fryzek, J.P. & Brandt, L., et al. (2006) Parkinson's disease and other basal ganglia or movement disorders in a large nationwide cohort of Swedish welders. *Occupational and Environmental Medicine*, 63(2), 135-140
- Goldhaber, S.B. (2003) Trace element risk assessment: essentiality vs. toxicity. *Regulatory Toxicology and Pharmacology : RTP*, 38(2), 232-242
- Gorell, J.M., Peterson, E.L., Rybicki, B.A. & Johnson, C.C. (2004) Multiple risk factors for Parkinson's disease. *Journal of the Neurological Sciences*, 217(2), 169-174
- Herrero Hernandez, E., Discalzi, G., Dassi, P., Jarre, L. & Pira, E. (2003) Manganese intoxication: the cause of an inexplicable epileptic syndrome in a 3 year old child. *Neurotoxicology*, 24(4-5), 633-639
- Itokawa, Y. (2004) [Manganese]. *Nippon Rinsho (Japanese Journal of Clinical Medicine)*, 62 Suppl 12308-310
- Jafari, A.J. & Assari, M.J. (2004) Respiratory effects from work-related exposure to welding fumes in Hamadan, Iran. *Archives of Environmental Health*, 59(3), 116-120
- Jankovic, J. (2005) Searching for a relationship between manganese and welding and Parkinson's disease. *Neurology*, 64(12), 2021-2028

- Josephs, K.A., Ahlskog, J.E. & Klos, K.J., et al. (2005) Neurologic manifestations in welders with pallidal MRI T1 hyperintensity. *Neurology*, 64(12), 2033-9
- Kessler, K.R., Wunderlich, G., Hefter, H. & Seitz, R.J. (2003) Secondary progressive chronic manganism associated with markedly decreased striatal D2 receptor density. *Movement Disorders*, 18(2), 217-218
- Klos, K.J., Ahlskog, J.E., Josephs, K.A., Fealey, R.D., Cowl, C.T. & Kumar, N. (2005) Neurologic spectrum of chronic liver failure and basal ganglia T1 hyperintensity on magnetic resonance imaging: probable manganese neurotoxicity. *Archives of Neurology*, 62(9), 1385-1390
- Krantz, A. & Dorevitch, S. (2004) Metal exposure and common chronic diseases: a guide for the clinician. *Disease-a-Month (DM)*, 50(5), 220-262
- Lacal Peña, J.M., Noguero Iriarte, P., Biedma Alvarez, D. & Mangas Rojas, A. (2005) [Metallic fumes fever. With regard to a case related to manganese]. *Revista Clinica Espanola*, 205(3), 145-146
- Lees-Haley, P.R., Greiffenstein, M.F., Larrabee, G.J. & Manning, E.L. (2004) Methodological problems in the neuropsychological assessment of effects of exposure to welding fumes and manganese. *The Clinical Neuropsychologist*, 18(3), 449-464
- Levy, B.S. & Nassetta, W.J. (2003) Neurologic effects of manganese in humans: a review. *International Journal of Occupational and Environmental Health*, 9(2), 153-163
- Li, G.J., Zhang, L., Lu, L., Wu, P. & Zheng, W. (2004) Occupational exposure to welding fume among welders: alterations of manganese, iron, zinc, copper, and lead in body fluids and the oxidative stress status. *Journal of Occupational and Environmental Medicine*, 46(3), 241-248
- Louis, E.D., Applegate, L.M., Factor-Litvak, P., Parides, M.K. & Andrews, L. (2004) Essential tremor: occupational exposures to manganese and organic solvents. *Neurology*, 63(11), 2162-2164
- Lynam, D.R., Pfeifer, G.D. & Roper, J.M. (2002) Summary of health testing of manganese exhaust products from use of methylcyclopentadienyl manganese tricarbonyl (MMT) in gasoline. *7th International Highway and Urban Pollution Symposium*, 20-23 May 2002
- Magari, S.R., Schwartz, J., Williams, P.L., Hauser, R., Smith, T.J. & Christiani, D.C. (2002) The association of particulate air metal concentrations with heart rate variability. *Environmental Health Perspectives*, 110(9), 875-880
- Matsuoka, M. & Igisu, H. (2004) [Neuropsychiatric disorders induced by exposure to metals]. *Nippon Rinsho (Japanese Journal of Clinical Medicine)*, 62 Suppl503-506
- McMillan, G. (2005) Is electric arc welding linked to manganism or Parkinson's disease? *Toxicol. Rev.*, 24(4), 237-257
- Meo, S.A. & Al-Khlaiwi, T. (2003) Health hazards of welding fumes. *Saudi Medical Journal*, 24(11), 1176-1182
- Mullen, K.D. (2003) Newer aspects of hepatic encephalopathy. *Indian Journal of Gastroenterology*, 22 Suppl 2S17-20

- Myers, J.E., teWaterNaude, J. & Fourie, M., et al. (2003) Nervous system effects of occupational manganese exposure on South African manganese mineworkers. *Neurotoxicology*, 24(4-5), 649-656
- Newson, R.B., Shaheen, S.O., Henderson, A.J., Emmett, P.M., Sherriff, A. & Calder, P.C. (2004) Umbilical cord and maternal blood red cell fatty acids and early childhood wheezing and eczema. *The Journal of Allergy and Clinical Immunology*, 114(3), 531-537
- Nishida, Y. (2003) Elucidation of endemic neurodegenerative diseases--a commentary. *Zeitschrift Fur Naturforschung C (Journal of Biosciences)*, 58(9-10), 752-758
- Obama, R., Tachikawa, H., Yoshii, F., Takeoka, T. & Shinohara, Y. (2002) [A case of idiopathic portal hypertension (IPH) with hypermanganemia presenting as spastic gait]. *Rinsho Shinkeigaku (Clinical Neurology)*, 42(9), 885-888
- Olanow, C.W. (2004) Manganese-induced parkinsonism and Parkinson's disease. *Annals of the New York Academy of Sciences*, 1012209-223
- Ono, K., Komai, K. & Yamada, M. (2002) Myoclonic involuntary movement associated with chronic manganese poisoning. *Journal of the Neurological Sciences*, 199(1-2), 93-96
- Park, J., Yoo, C. & Sim, C.S., et al. (2005) Occupations and Parkinson's disease: a multi-center case-control study in South Korea. *Neurotoxicology*, 26(1), 99-105
- Park, J., Yoo, C. & Sim, C.S., et al. (2004) Occupations and Parkinson's disease: a case-control study in South Korea. *Industrial Health*, 42(3), 352-358
- Polizzi, S., Pira, E. & Ferrara, M., et al. (2002) Neurotoxic effects of aluminium among foundry workers and Alzheimer's disease. *Neurotoxicology*, 23(6), 761-774
- Powers, K.M., Smith-Weller, T., Franklin, G.M., Longstreth, W.T., Swanson, P.D. & Checkoway, H. (2003) Parkinson's disease risks associated with dietary iron, manganese, and other nutrient intakes. *Neurology*, 60(11), 1761-1766
- Racette, B.A., Antenor, J.A. & McGee-Minnich, L., et al. (2005) [18F]FDOPA PET and clinical features in parkinsonism due to manganism. *Movement Disorders*, 20(4), 492-496
- Riabova, O.I. (2003) [Features of somatic diseases in electric welders with chronic manganese intoxication]. *Meditsina Truda i Promyshlennaia Ekologiya*, (8), 38-41
- Sadek, A.H., Rauch, R. & Schulz, P.E. (2003) Parkinsonism due to manganism in a welder. *International Journal of Toxicology*, 22(5), 393-401
- Sassine, M.P., Mergler, D., Bowler, R. & Hudnell, H.K. (2002) Manganese accentuates adverse mental health effects associated with alcohol use disorders. *Biological Psychiatry*, 51(11), 909-921
- Schutte, A.E., Van Rooyen, J.M., Huisman, H.W., Kruger, H.S., Malan, N.T. & De Ridder, J.H. (2003) Dietary markers of hypertension associated with pulse pressure and arterial compliance in black South African children: the THUSA Bana Study. *Cardiovascular Journal of South Africa*, 14(2), 81-89
- Steenkamp, V., Stewart, M.J., Curowska, E. & Zuckerman, M. (2002) A severe case of multiple metal poisoning in a child treated with a traditional medicine. *Forensic Science International*, 128(3), 123-126

- Tereshchenko, I.V., Goldyreva, T.P. & Bronnikov, V.I. (2004) [Trace elements and endemic goiter]. *Klinicheskaiia Meditsina*, 82(1), 62-68
- Thiel, R.J. & Fowkes, S.W. (2004) Down syndrome and epilepsy: a nutritional connection? *Medical Hypotheses*, 62(1), 35-44
- Torrente, M., Colomina, M.T. & Domingo, J.L. (2005) Metal concentrations in hair and cognitive assessment in an adolescent population. *Biological Trace Element Research*, 104(3), 215-221
- Uz, E., Sahin, S., Hepsen, I.F., Var, A., Sogut, S. & Akyol, O. (2003) The relationship between serum trace element changes and visual function in heavy smokers. *Acta Ophthalmologica Scandinavica*, 81(2), 161-164
- Vigeh, M., Yokoyama, K. & Ramezanzadeh, F., et al. (2006) Lead and other trace metals in preclampsia: a case-control study in Tehran, Iran. *Environmental Research*, 100(2), 268-75
- Wasserman, G.A., Liu, X. & Parvez, F. (2006) Water Manganese Exposure and Children's Intellectual Function in Araihasar, Bangladesh. *Environmental Health Perspectives*, 114(1), 124
- Wasserman, G.A., Liu, X. & Parvez, F., et al. (2004) Water arsenic exposure and children's intellectual function in Araihasar, Bangladesh. *Environmental Health Perspectives*, 112(13), 1329-1333
- Wójcik, A., Brzeski, Z., Sobańska, E., Kargul, M. & Borzecki, A. (2004) Hazard estimation for the chosen work stands in metallurgical industry. *Annales Universitatis Mariae Curie-Skłodowska Sectio D: Medicina*, 59(2), 416-420
- Woolf, A., Wright, R., Amarasiriwardena, C. & Bellinger, D. (2002) A child with chronic manganese exposure from drinking water. *Environmental Health Perspectives*, 110(6), 613-616

3. MECHANISM

Altindag, Z.Z., Baydar, T., Engin, A.B. & Sahin, G. (2003) Effects of the metals on dihydropteridine reductase activity. *Toxicology in Vitro*, 17(5-6), 533-537

Anantharam, V., Kitazawa, M., Latchoumycandane, C., Kanthasamy, A. & Kanthasamy, A.G. (2004) Blockade of PKC δ Proteolytic Activation by Loss of Function Mutants Rescues Mesencephalic Dopaminergic Neurons from Methylcyclopentadienyl Manganese Tricarbonyl (MMT)-Induced Apoptotic Cell Death. *Annals of the New York Academy of Sciences*, 1035271-289

Anantharam, V., Kitazawa, M., Wagner, J., Kaul, S. & Kanthasamy, A.G. (2002) Caspase-3-Dependent Proteolytic Cleavage of Protein Kinase C delta Is Essential for Oxidative Stress-Mediated Dopaminergic Cell Death after Exposure to Methylcyclopentadienyl Manganese Tricarbonyl. *Journal of Neuroscience*, 22(5), 1738-1751

Bannon, D.I., Abounader, R., Lees, P.S.J. & Bressler, J.P. (2003) Effect of DMT1 knockdown on iron, cadmium, and lead uptake in Caco-2 cells. *American Journal of Physiology - Cell Physiology*, 284(1), C44-50

Bouchard, M., Mergler, D., Baldwin, M., Sassine, M., Bowler, R. & MacGibbon, B. (2003) Blood manganese and alcohol consumption interact on mood states among manganese alloy production workers. *Neurotoxicology*, 24(4-5), 641-647

Butterworth, R.F. (2003) Pathogenesis of hepatic encephalopathy: update on molecular mechanisms. *Indian Journal of Gastroenterology*, 22 Suppl 2S11-6

Chebassier, N., El Houssein, O., Viegas, I. & Dreno, B. (2004/8) In vitro induction of matrix metalloproteinase-2 and matrix metalloproteinase-9 expression in keratinocytes by boron and manganese. *Experimental Dermatology*, 13(8), 484-490

Dalfó, E., Portero-Otín, M., Ayala, V., Martínez, A., Pamplona, R. & Ferrer, I. (2005) Evidence of oxidative stress in the neocortex in incidental Lewy body disease. *Journal of Neuropathology and Experimental Neurology*, 64(9), 816-830

Desoize, B. (2003) Metals and metal compounds in carcinogenesis. *In Vivo*, 17(6), 529-539

Erikson, K.M., Suber, R.L. & Aschner, M. (2002) Glutamate/Aspartate Transporter (GLAST), Taurine Transporter and Metallothionein mRNA Levels are Differentially Altered in Astrocytes Exposed to Manganese Chloride, Manganese Phosphate or Manganese Sulfate. *Neurotoxicology*, 23(3), 281-288

Evseeva, T.I., Geras'kin, S.A. & Shuktomova, I.I. (2003) Genotoxicity and toxicity assay of water sampled from a radium production industry storage cell territory by means of Allium-test. *Journal of Environmental Radioactivity*, 68(3), 235-248

Felix, K., Manna, S.K., Wise, K., Barr, J. & Ramesh, G.T. (2005) Low levels of arsenite activates nuclear factor-kappaB and activator protein-1 in immortalized mesencephalic cells. *Journal of Biochemical and Molecular Toxicology*, 19(2), 67-77

Fitsanakis, V.A. & Aschner, M. (2005) The importance of glutamate, glycine, and gamma-aminobutyric acid transport and regulation in manganese, mercury and lead neurotoxicity. *Toxicology and Applied Pharmacology*, 204(3), 343-354

- HaMai, D. & Bondy, S.C. (2004) Oxidative basis of manganese neurotoxicity. *Annals of the New York Academy of Sciences*, 1012129-141
- Hirata, Y. (2002) Manganese-induced apoptosis in PC12 cells. *Neurotoxicology and Teratology*, 24(5), 639-653
- Huang, C., Weng, Y., Lu, C., Chu, N. & Yen, T. (2003) Dopamine transporter binding in chronic manganese intoxication. *Journal of Neurology*, 250(11), 1335
- Huang, W.-. & Lin, J.-. (2004) Acute Renal Failure Following Ingestion of Manganese-Containing Fertilizer. *Journal of Toxicology: Clinical Toxicology*, 42(3), 305-307
- Keller, J., Owens, C.T., Lai, J.C.K. & Devaud, L.L. (2005) The effects of 17beta-estradiol and ethanol on zinc- or manganese-induced toxicity in SK-N-SH cells. *Neurochemistry International*, 46(4), 293-303
- Kessler, K.R., Wunderlich, G., Hefter, H. & Seitz, R.J. (2003) Secondary progressive chronic manganism associated with markedly decreased striatal D2 receptor density. *Movement Disorders*, 18(2), 217-218
- Lu, W., Roos, P.H. & Mersch-Sundermann, V. (2005) Vinclozolin, a widely used fungicide, enhanced BaP-induced micronucleus formation in human derived hepatoma cells by increasing CYP1A1 expression. *Toxicology Letters*, 159(1), 83-88
- Luk, E., Jensen, L.T. & Culotta, V.C. (2003) The many highways for intracellular trafficking of metals. *Journal of Biological Inorganic Chemistry (JBIC)*., 8(8), 803-9
- Martelli, A. & Moulis, J. (2004) Zinc and cadmium specifically interfere with RNA-binding activity of human iron regulatory protein 1. *Journal of Inorganic Biochemistry*, 98(8), 1413-1420
- McKinney, A.M., Filice, R.W. & Teksam, M., et al. (2004) Diffusion abnormalities of the globi pallidi in manganese neurotoxicity. *Neuroradiology*, 46(4), 291-5
- Normandin, L. & Hazell, A.S. (2002) Manganese neurotoxicity: an update of pathophysiologic mechanisms. *Metabolic Brain Disease*, 17(4), 375-387
- Oommen, J., Steel, H.C., Theron, A.J. & Anderson, R. (2004) Investigation into the relationship between calyculin A-mediated potentiation of NADPH oxidase activity and inhibition of store-operated uptake of calcium by human neutrophils. *Biochemical Pharmacology*, 68(9), 1721-1728
- Osaba, L., Rey, M.J., Aguirre, A., Alonso, A. & Graf, U. (2002) Evaluation of genotoxicity of captan, maneb and zineb in the wing spot test of *Drosophila melanogaster*: role of nitrosation. *Mutation Research*, 518(1), 95-106
- Pascal, L.E. & Tessier, D.M. (2004) Cytotoxicity of chromium and manganese to lung epithelial cells in vitro. *Toxicology Letters*, 147(2), 143-151
- Pfeifer, G.D., Roper, J.M., Dorman, D. & Lynam, D.R. (2004) Health and environmental testing of manganese exhaust products from use of methylcyclopentadienyl manganese tricarbonyl in gasoline. *Science of the Total Environment*, 334-335397-408
- Pifl, C., Khorchide, M., Kattinger, A., Reither, H., Hardy, J. & Hornykiewicz, O. (2004) alpha-Synuclein selectively increases manganese-induced viability loss in SK-N-MC

neuroblastoma cells expressing the human dopamine transporter. *Neuroscience Letters*, 354(1), 34-37

Purdey, M. (2004) Elevated levels of ferrimagnetic metals in foodchains supporting the Guam cluster of neurodegeneration: do metal nucleated crystal contaminants [corrected] evoke magnetic fields that initiate the progressive pathogenesis of neurodegeneration? *Medical Hypotheses*, 63(5), 793-809

Rencuzogullari, E., Yavuz, A. & Topaktas, M. (2005) The genotoxic risk of underground coal miners from Turkey. *Mutation Research - Genetic Toxicology and Environmental Mutagenesis*, 588(2), 82-87

Roth, J.A. & Garrick, M.D. (2003) Iron interactions and other biological reactions mediating the physiological and toxic actions of manganese. *Biochemical Pharmacology*, 66(1), 1-13

Sisinno, C.L.S. (2003) [Non-inert industrial solid waste disposal in landfill dumps: evaluation of toxicity and implications for the environment and human health]. *Cadernos De Saude Publica*, 19(2), 369-74

Slikker, W., Andersen, M.E. & Bogdanffy, M.S., et al. (2004) Dose-dependent transitions in mechanisms of toxicity: case studies. *Toxicology and Applied Pharmacology*, 201(3), 226-294

Soldatovic, D., Matovic, V., Vujanovic, D., Guiet-Bara, A., Bara, M. & Durlach, J. (2002) Metal pollutants and bioelements: retrospective of interactions between magnesium and toxic metals. *Magnesium Research*, 15(1-2), 67-72

Sparks, D.L., Lochhead, J., Horstman, D., Wagoner, T. & Martin, T. (2002) Water quality has a pronounced effect on cholesterol-induced accumulation of Alzheimer amyloid beta (Abeta) in rabbit brain. *Journal of Alzheimer's Disease*, 4(6), 523-529

Takeda, A. (2004) [Essential trace metals and brain function]. *Yakugaku Zasshi (Journal of the Pharmaceutical Society of Japan)*, 124(9), 577-585

Takeda, A. (2004) [Function and toxicity of trace metals in the central nervous system]. *Clinical Calcium*, 14(8), 45-49

Takeda, A. (2003) Manganese action in brain function. *Brain Research Reviews*, 41(1), 79-87

Ursini, C.L., Perniconi, B. & Francesco, A.D., et al. (2005) Evaluation of genotoxic effects induced by exposure to antineoplastic drugs in lymphocytes and exfoliated buccal cells of oncology nurses and pharmacy employees. *Mutation Research - Genetic Toxicology and Environmental Mutagenesis*, 587(1-2), 45-51

Yang, R., Chen, J. & Hu, S. (2005) [Excitatory effect of low dose of manganese on spontaneous discharges of dorsal root ganglion neurons]. *Wei Sheng Yan Jiu (Journal of Hygiene Research)*,

Zatta, P., Lucchini, R., van Rensburg, S.J. & Taylor, A. (2003) The role of metals in neurodegenerative processes: aluminum, manganese, and zinc. *Brain Research Bulletin*, 62(1), 15-28

Zecca, L., Stroppolo, A. & Gatti, A., et al. (2004) The role of iron and copper molecules in the neuronal vulnerability of locus coeruleus and substantia nigra during aging. *Proceedings of the National Academy of Sciences of the United States of America*, 101(26), 9843-8

Zheng, W., Aschner, M. & Gherzi-Egea, J. (2003) Brain barrier systems: a new frontier in metal neurotoxicological research. *Toxicology and Applied Pharmacology*, 192(1), 1-11

4. HUMAN SUSCEPTIBILITY

Cheng, T., Chen, S. & Huang, C., et al. (2005) Breast cancer risk associated with genotype polymorphism of the catechol estrogen-metabolizing genes: a multigenic study on cancer susceptibility. *International Journal of Cancer*, 113(3), 345-353

Chubanov, V., Waldegger, S. & Mederos y Schnitzler, M., et al. (2004) Disruption of TRPM6/TRPM7 complex formation by a mutation in the TRPM6 gene causes hypomagnesemia with secondary hypocalcemia. *Proceedings of the National Academy of Sciences of the United States of America*, 101(9), 2894-9

Debarh, I., Rabelomanana, S., Penouil, F., Castaigne, F., Poisot, D. & Moore, N. (2002) [Human neurotoxicity of ethylene-bis-dithiocarbamates (EBDC)]. *Revue Neurologique*, 158(12 Pt 1), 1175-80

Gorell, J.M., Peterson, E.L., Rybicki, B.A. & Johnson, C.C. (2004) Multiple risk factors for Parkinson's disease. *Journal of the Neurological Sciences*, 217(2), 169-174

Purdey, M. (2004) The pathogenesis of Machado Joseph Disease: a high manganese/low magnesium initiated CAG expansion mutation in susceptible genotypes? *Journal of the American College of Nutrition*, 23(6), 715S-29S

Zheng, Y.X., Chan, P. & Pan, Z.F., et al. (2002) Polymorphism of metabolic genes and susceptibility to occupational chronic manganese. *Biomarkers: Biochemical Indicators of Exposure, Response, and Susceptibility to Chemicals*, 7(4), 337-346

5. TREATMENT AND IMAGING

Blanusa, M., Varnai, V.M., Piasek, M. & Kostial, K. (2005) Chelators as antidotes of metal toxicity: therapeutic and experimental aspects. *Current Medicinal Chemistry*, 12(23), 2771-2794

Butterworth, R.F. (2003) Role of circulating neurotoxins in the pathogenesis of hepatic encephalopathy: potential for improvement following their removal by liver assist devices. *Liver International*, 23 Suppl 35-9

Chu, N. (2004) Effect of levodopa treatment for parkinsonism in welders: a double-blind study. *Neurology*, 63(8), 1541; author reply 1541

Dietemann, J.-., Botelho, C. & Nogueira, T., et al. (2004) [Imaging in acute toxic encephalopathy.]. *Journal of Neuroradiology (Journal De Neuroradiologie)*, 31(4), 313-326

Gupta, R.K. & Dhiman, R.K. (2003) Magnetic resonance imaging and spectroscopy in hepatic encephalopathy. *Indian Journal of Gastroenterology*, 22 Suppl 2S45-9

Itokawa, Y. (2004) [Manganese]. *Nippon Rinsho (Japanese Journal of Clinical Medicine)*, 62 Suppl 12308-310

Kim, E., Kim, Y. & Cheong, H., et al. (2005) Pallidal index on MRI as a target organ dose of manganese: structural equation model analysis. *Neurotoxicology*, 26(3), 351-359

Kim, Y. (2004) High signal intensities on T1-weighted MRI as a biomarker of exposure to manganese. *Industrial Health*, 42(2), 111-115

Klos, K.J., Ahlskog, J.E., Josephs, K.A., Fealey, R.D., Cowl, C.T. & Kumar, N. (2005) Neurologic spectrum of chronic liver failure and basal ganglia T1 hyperintensity on magnetic resonance imaging: probable manganese neurotoxicity. *Archives of Neurology*, 62(9), 1385-1390

Koller, W.C., Lyons, K.E. & Truly, W. (2004) Effect of levodopa treatment for parkinsonism in welders: A double-blind study. *Neurology*, 62(5), 730-733

Krantz, A. & Dorevitch, S. (2004) Metal exposure and common chronic diseases: a guide for the clinician. *Disease-a-Month*, 50(5), 220-262

Laden, K., Zaklad, H., Simhon, E.D., Klein, J.Y., Cyjon, R.L. & Winchell, H.S. (2003) N,N',N''-tris(dihydroxyphosphorylmethyl)-1,4,7-triazacyclononane (Deofix) - a high-affinity, high-specificity chelator for first transition series metal cations with significant deodorant, antimicrobial, and antioxidant activity. *Journal of Cosmetic Science*, 54(3), 251-261

Merkur'eva, L.I. & Riabova, O.I. (2003) [Diagnostic and prognostic value of serum manganese levels for chronic manganese intoxication in electric welders]. *Meditsina Truda i Promyshlennaia Ekologiya*, (8), 41-43

Mozota Nunez, J.R., Mozota Nunez, M.L., Mozota Nunez, M., Vila Mendiburu, I., Bonaut Mendia, J.F. & Mozota Ortiz, J.R. (2003) Efficacy of the treatment of Meniere's disease with oligoelements. *Anales Otorrinolaringologicos Ibero-Americanos*, 30(6), 597-606

Riabova, O.I., Davydova, N.I. & Kalashnikova, A.A. (2004) Diagnostic and prognostic value of determining serum levels of cytokines and antibodies to basic myeloprotein in chronic manganese intoxication. *Meditsina Truda i Promyshlennaia Ekologiya*, (12), 10-13

6. MISCELLANEOUS

Beaupré, L.A., Salehi, F., Zayed, J., Plamondon, P. & L'Espérance, G. (2004) Physical and chemical characterization of mn phosphate/sulfate mixture used in an inhalation toxicology study. *Inhalation Toxicology*, 16(4), 231-244

Kaiser, J. (2003) Manganese: a high-octane dispute. *Science*, 300(5621), 926-928

Kaiser, J. (2003) State Court to rule on manganese fume claims. *Science*, 300(5621), 927

Takazawa, K., Ishikawa, N., Miyagawa, H., Yamamoto, T., Hariya, A. & Dohi, S. (2003) Metal allergy to stainless steel wire after coronary artery bypass grafting. *Journal of Artificial Organs*, 6(1), 71-72

Thompson, K.H. & Orvig, C. (2003) Boon and Bane of Metal Ions in Medicine. *Science*, 300(5621), 936-939