REFERENCES

Aikawa, J. K. (1971) The relationship of magnesium to disease in domestic animals and in humans. In *Trace Elements in Human Health and Disease* (ed. A. S. Prasad), pp. 47-73. Academic Press, New York.

Airey, D. (1984) Pollution indicators, fish consumption and the accumulation of mercury in human hair. *Marine Pollution Bulletin,* **15**: 337-340.

Alexander, P. and Earland, C. (1950) Structure of wool fibres: Isolation of an α and β protein in wool. *Nature*, **166**: 396-397.

Anderson, I. (1994) Villagers sue mine over 'ruined river'. *New Scientist*, 14 May. pp. 4

Australian Department of Health. (1975) Heavy metal contaminants in seafoods. Cadmium and Zinc. Australian Government Publishing Service, Canberra.

Baden, H. P., Goldsmith, L. A. and Fleming, B. (1973) A comparative study of the physicochemical properties of human keratinized tissues. *Biochimica et Biophysica Acta,* **322**: 269-278.

Baden, H. P., Lee. L. D. and Kubilus, J. (1975) A genetic electrophoretic variant of human hair α polypeptide. *American Journal of Human Genetics,* **27**: 472-477.

Baden, H. P. (1976) Genetic basis for structural protein changes in hair. In *Biology and Disease of the Hair* (eds. T. Kobori and W. Montagna), pp.129-139. University Park Press, Tokyo.

Bagehi, K. N. and Ganguly, H. D. (1941) Mineral constituents of human hair. *Annals of Biochemistry and Experimental Medicine,* **1**: 83.

Bate, L. C. and Dyer, F. F. (1965) Trace elements in human hair. *Nucleonics*, **23**: 74-81.

Bate, L. C. (1966) Adsorption and elution of trace elements on human hair. *International Journal of Applied Radiation and Isotopes*, **17**: 417-423.

Baumslag, N. and Petering, H. G. (1976) Trace metal studies in bushman hair. *Archives of Environmental Health*, **31**: 254-257.

Bernstein, I. A. (1983) The Proteins of Keratohyalin. In *Biochemistry and Physiology of the Skin* (ed. L. A. Goldsmith), 1st edn, p. 170, Oxford University Press, Oxford.

Bose A. K. and Chakravorty, M. D. (1964) Manganese concentration in hair. *Indian Journal of Medical Reseach*, :110-114.

Bordier, C. and Crettol-Jarvinen, A. (1979) Peptide mapping of heterogenous protein samples. *Journal of Biological Chemistry,* **254**: 2565-2567.

Bowen, H. J. M. (1972) Determination of trace elements in hair samples from normal and protein-deficient children by activation analysis. *The Science of the Total Environment,* **1**: 75-79.

Bou-Olayan, A-H. and Al-Yakoob, S. N. (1994) Mercury in human hair: a study of residents in Kuwait. *Journal of Environmental Science Health,* **A29**: 1541-1551.

Bradfield, R. B. Hambidge, K. M. (1980) Problems with hair zinc as an indicator of body zinc status. *The Lancet,* **1**: 363.

Bradford, M. M. (1976) A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry,* **72**: 248-254

Briggs, M. H., Briggs, M and Wakatama, A. (1972) Trace elements in human hair. *Experientia,* **28**: 406-7.

Brush, A. H. (1974) Feather keratin-analysis of subunit heterogeneity. *Comparative Biochemistry and Physiology*, **48B**: 661-670.

Budowle, B and Acton, R. T. (1981) A technique for the detection of variable electrophoretic patterns of hair proteins. *Electrophoresis,* **2**: 333-334.

Burk, R. F. (1973a) ^{75}Se-binding by rat plasma proteins after injection of $^{75}Se\ O_3^{2-}$. *US-Army Medical Research and Nutrition Laboratory Report* 334.

Burns, C. and Currie, B. (1995) The efficacy of chelation therapy and factors influencing mortality in lead intoxicated petrol sniffers. *Australian and New Zealand Journal of Medicine*, **25**: 197-203.

Carvalho, F. M., Silvny-Neto, A. M., Melo, A. M. C., Chaves, M. E. C., Brandao, A. M. and Tavares T. M. (1989) Cadmium in hair of children living near a lead smelter in Brazil. *The Science of the Total Environment,* **84**: 119-128.

Chapman, R. E. (1976) Electron microscopic and histochemical features of the formation of the orthocortex and paracortex in wool. In: Ziegler, K (ed) 5th Int Wool Text Res Conf 1975, Vol. II, pp. 152-161. German Wool Textile Research Institute, Aachen.

Chapman, J. F. and Dale, L. S. (1978) A simple apparatus for the spectrometric determination of mercury by the cold vapour-atomic absorption technique. *Analytica Chimica Acta,* **101**: 203-206.

Chapman, J. F. and Dale, L. S. (1982) The use of alkaline permanganate in the preparation of biological materials for the determination of mercury by atomic absorption spectrometry. *Analytica Chimica Acta,* **134**: 379-382.

Chattopadhyay, A., Roberts, T. M. and Jervis, R. E. (1977) Scalp hair as a monitor of community exposure to lead. *Archives of Environmental Health*, **32**: 226-236.

Chuang, L. S. and Emery J. F. (1978) Hair as an indicator of environmental exposure in Hong Kong. *Journal of Radioanalytical Chemistry,* **45**: 169-180.

Chuttani, H. K., Gupta, P. S., Gulati, S. and Gupta, D. W. (1965) Acute copper sulphate poisoning. *American Journal of Medicine*, **39**: 849-854.

Clanet, P., DeAntonio, S. M., Katz, S. A.and Scheiner, D. M. (1982) Effects of some cosmetics on copper and zinc concentrations in human scalp hair. *Clinical Chemistry,* **28**: 2450-2451.

Cleveland, D. W., Ficher, S. G., Kirschner, M. W. and Laemmli, U. K. (1977) Peptide mapping by limited proteolysis by sodium dodecyl sulfate and analysis by gel electrophoresis. *Journal of Biological Chemistry*, **252/3**: 1102-1106.

Cohen, E. and Elvehjem, C. A. (1934) The relation of iron and copper to the cytochrome oxidase content of animal tissue. *Journal of Biological Chemistry,* **244**: 5785-5789.

Corridan, J. P. (1974) Head hair samples as indicators of environmental pollution. *Environmental Research,* **8**: 12-16.

Cotzias, G. C., Papavosilou, P. S. and Miller, S. T. (1964) Manganese in melanin. *Nature*, **201**: 1228-1229.

Cousins, R. J., Barber, A. K. and Trout, J. R. (1973) Cadmium toxicity in growing swine. *Journal of Nutrition*, **103**: 964-972.

Cousins, D. and Nievwenhuysen, J. (1984) Manganese mining on Groote Eylandt. In Aboriginals and the Mining Industry. Case studies of the Australian experience. Committee for Economic Development of Australia. Allen and Unwin, Sydney.

Couzy, F., Kastenmayer, P., Mansourian, R., Guinchard, S. and Munoz-Box, R. (1993) Zinc absorption in healthy elderly humans and the effect of diet. *American Journal of Clinical Nutrition,* **58**: 690-694.

Creason, J. P., Hinners, T. A., Burngasner, J. E. and Pinkerton, C. (1975) Trace elements in hair as related to exposure in metropolitan, New York. *Clinical Chemistry*, **21**: 603-

Crewther, W. G., Gillespie, J. M., Harrap, B. S. and Inglis, A. S. (1966) Low-sulphur proteins from α-keratins. *Biopolymers*, **4**: 905-916.

Crewther, W. G. (1976) Primary structure and chemical properties of wool. In : Ziegler, K (ed) 5th Int Wool Text Res Conf 1975, Vol. I., pp. 1-101. German Wool Research Institute, Aachen.

Cromwell, P. F. and Abadie, B. R. (1989) Hair mineral analysis: Biochemical imbalances and violent criminal behavior. *Psychological Reports,* **64**: 259-266.

Czerniejewski, C. P., Shank, C. W., Bechtel, W. G. and Bradley, W. B. (1964) The minerals of wheat, flour and bread. *Cereal Chem*istry, **41**: 65-72.

Danks, D. M., Campbel, P. E., Walker-Smith, J., Stevens, B. J., Gillespie, J. M., Blomfield, J. and Turner, B. (1972) Menkes' kinky-hair syndrome. *The Lancet*, 1100-1102.

Darskus, R. L. (1972) Electrophoretic and chromatographic characterization of sulphur-rich proteins from wool. *Journal of Chromatography,* **69**: 341-348.

Darskus, R. L. and Gillespie, J. M. (1971) Breed and species differences in the hair proteins of four genera of Caprini. *Australian Journal of Biological Science*, **24**: 515-524.

Day, T. H. (1972) Interspecific variation in the hair proteins. *Comparative Biochemistry and Physiology,* **43B**: 361-367.

Deeming, S. B. and Charles, W. W. (1978) Hair analysis of trace minerals in human subjects as influenced by age, sex and contraceptive drugs. *American Journal of Clinical Nutrition,* **31**: 1175-1180.

Dissanayake, C. B., Senaratne, A. and Weerasooria, V. R. (1984) Environmental significance of trace elements in human hair—a case study from Sri Lanka. *International Journal of Environmental Studies,* **23**: 41-48.

Dormandy, T. L. (1986) Trace element analysis of hair. *British Medical Journal,* **293**: 975-976.

Downes, A. M., Sharry, L. F. and Rogers, G. E. (1963) Separate synthesis of fibrillar and matrix proteins in the formation of keratin. *Nature,* **199**: 1059-1061.

Drews, L. M., Keis, C. and Fox, H. M. (1979) Effect of dietary fiber on copper, zinc and magnesium utilization by adolescent boys. *American Journal of Clinical Nutrition*, **32**: 1893-97.

Durfor, C. N. and Becker, E. (1962) Public water supplies of the 100 largest cities in the United States. U. S. Government Printing Office, Washington, D. C. Geological Survey Water Supply Paper 1812.

Eads, E. A. and Lambdin, C. E. (1973) A survey of trace metals in human hair. *Environmental Research,* **6**: 247-252.

Eltayeb, M. A. H. and Van Grieken, R. E. (1990) Iron, copper, zinc and lead in hair from Sudanese population of different age groups. *The Science of the Total Environment,* **95**: 157-165.

Emerson, T. and Waldman, S. (1992) The shameful truth about lead poisoning. *Reader's Digest* (Feburary). pp. 125-130.

Eminians, J., Reinhold, J. G., Georage, A., Kfoury, G. A., AmirHakimi, G. H., Sharif, H. and Ziai, M. (1967) Zinc nutrition of children in far province of Iran. *American Journal of Clinical Nutrition*, **20**: 734-742.

Erten, J., Arcasoy, A., Cavdar, A. O. and Cin, S. (1978) Hair zinc levels in healthy and malnourished children. *American Journal of Clinical Nutrition,* **31**: 1172-1174.

Fernandez-Madrid, F., Prasad, A. S. and and Oberleas, D. (1976): In Trace elements in human health and disease (ed. Prasad, A. S) Vol. 1, Zinc and copper. Academic Press, New York.

Fett, M. J., Mira, M., Smith, J., Alperstein, G., Causer, J., Brokenshire, T., Gulson, B. and Cannata, S. (1992) Community prevalence survey of childern's blood lead levels and environmental lead contamination in inner Sydney. *The Medical Journal of Australia*, **157**: 441-445.

Fishbein, D. H., Harbin, H. and Thatcher, R. W. (1985) Mutidimensional study of clinical risk factors in violent adolescents. *Paper presented at the 37th Annual Meeting of the American Society of Criminology, San Diego, CA.*

Fletcher, D. J. (1992) Hair analysis: Proven and problematic applications. *Hair Analysis,* **72/5**:79-88.

Folin, M., Contiero, E. and Vaselli, G. M. (1991) Trace element determination in humans: The use of blood and hair. *Biological Trace Element Research,* **31**: 147-158.

Forshufvud, S., Smith, H. and Wassen, A. (1961) Arsenic content of Napolean I's hair probably taken immediately after his death. *Nature,* **192**: 103-105.

Fraser, R. D. B., MacRae, T. P. and Rogers, G. E. (1972) *Keratins. Their Composition, Structure and Biosynthesis*. Thomas, Springfield, USA.

Frenkel., M. J., Gillespie, J. M. and Reis, P. J. (1974) Factors Influencing the biosynthesis of the tyrosine-rich proteins of wool. *Australian Journal of Biological Science*, **28**: 331-338.

Friberg, L. (1949) Proteinuria and emphysema among workers exposed to cadmium and nickel dust in a storage battery plant. *Proceedings of International Congress of Indian Medicine, 9th 1948*. pp. 641-644.

Friberg, L. (1949) Proteinuria and emphysema among workers exposed to cadmium and nickel dust in a storage battery plant. *Proceedings of International Congress of Indian Medicine, 9th 1948*. pp. 641-644.

Friberg, L. (1950) Health hazards in the manufacture of alkaline accumulators with special reference to chronic cadmium poisoning. *Acta Medica Scandinavica, 138*, supplement, **240**, p. 124.

Fulkerson, W., Goeller, H. E., Gailar, J. S., and Copenhaver, E. D. (1973) Eds., Cadmium, the dissipated element, Oak Ridge National Laboratory ORNL NSF-EP-21, USA.

Gentile, P., Trentalange, M. J. and Coleman, M. (1981) The relationship of hair zinc concentrations to height, weight, age and sex in the normal population. *Pediatric Research,* **15**: 123-127.

Gerhard, M. (1987) Electrophoretic variability in human head hair: Polyacrylamide gel electrophoresis of hair proteins in the presence of sodium dodecyl sulfate and urea. *Electrophoresis,* **8**: 153-157.

Gershoff, S. N., McGandy, R. B., Nondsauta, A., Pisolyabutra, U. and Tantiwongse, P. (1977) Nutrition studies in Thailand III. Trace minerals in human and rat hair. *The American Journal of Clinical Nutrition,* **30**: 868-872.

Gibson, R. S. (1980) Hair as a biopsy material for the assessment of trace element status in infancy. *Journal of Human Nutrition,* **34** : 405-416.

Gillespie, J. M. (1959) A high- sulphur protein from wool. In *Sulfur in Proteins* (eds. R. Benesch and R. E. Benesch), pp. 51-54. Academic Press, New York.

Gillespie, J. M. (1965) The high-sulphur proteins of normal and aberrant keratins. In *Biology of the Skin and Hair Growth* (eds. A. G. Lyne and B. F. Short), pp. 377-398. Angus and Robertson, Sydney.

Gillespie, J. M. (1968) The dietary regulation of the synthesis of hair keratin. In *Symposium on Fibrous Proteins Australia 1967* (ed. W. G. Crewther), pp. 362-363. Butterworths, Australia.

Gillespie, J. M. and Inglis, A. S. (1965) High-sulphur proteins as a major cause of variation in sulphur content between α-keratins. *Nature,* **207**: 1293-1294.

Gillespie, J. M. (1972a) Proteins rich in glycine and tyrosine from keratins. *Comparative Biochemistry and Physiology,* **41B**: 723-734.

Gillespie, J. M and Frenkel, M. J. (1974) The diversity of keratins. *Comparative Biochemistry and Physiology,* **47B**: 339-346.

Gillespie, J. M. and Marshall, R. C. (1977) Proteins of the hard keratins of Echidna, Hedgehog, Rabbit, Ox and Man. *Australian Journal of Biological Science,* **30**: 401-409.

Gillespie, J. M. and Marshall, R. C. (1981) The proteins of normal and aberrant hair keratins. In *Hair Research* (eds. C. E. Orfanos, W. Montagna and G. Suttgen), pp. 76-83. Springer, New York.

Gillespie., J. M., Frenkel, M. J.and Reis, P. J. (1980) Changes in the matrix proteins of wool and mouse hair following the administration of depilatory compounds. *Australian Journal of Biological Science*, **33**: 125-136.

Gillespie, J. M., Marshall, R. C., Moore, G. P. M., Panaretto, B. A. and Robertson, D. M. (1982) Changes in the proteins of wool following treatment of sheep with epidermal growth factor. *Journal of Investigative Dermatology*, **79**: 197-200.

Gillespie, J. M. (1983) The structural proteins of hair: Isolation, characterisation and regulation of biosynthesis. In *Biochemistry and Physiology of the Skin* (ed. L. A. Goldsmith), 1st edn. p. 475-510. Oxford University Press, Oxford.

Gillespie, J. M. (1991) The structural proteins of hair: Isolation, characterisation and regulation of biosynthesis. In *Physiology, Biochemistry and Molecular Biology of the Skin,* 2nd. edn, Vol. 1, (ed. L. A. Goldsmith), pp. 625-659. Oxford University Press, Oxford.

Gold, R. J. M. and Kachra, Z. (1974) Molecular defect in hydrotic ectodermal dysplasia. In *Proc.First Human Hair Symp. Atlanta 1973* (ed. A. C Brown), pp. 260-276. Medcom, New York.

Gonzalez, M. J., Rico, M. C., Hernandez, L. M. and Baluja,G. (1985) Mercury in human hair: A study of residents in Madrid, Spain. *Archives of Environmental Health*, **40**: 225-228.

Gordon, G. F. (1985) Sex and age related differences in trace element concentrations in hair. *The Science of the Total Environment,* **42**: 133-147.

Gordus, A. (1973) Factors affecting the trace-metal content of human hair. *Journal of Radioanalytical Chemistry,* **15**: 229-243.

Gormican, A. (1970). Inorganic elements in foods used in hospital menus. *Journal of American Dietetic Association*, **56**: 397-403.

Grandjean, P. (1983) Monitoring of environmental exposure to toxic metals. In *Chemical Toxicology and Clinical Chemistry of Metals* (eds. S. S. Brown and J. Savory) London: Academic Press, 1983: 99-112.

Gross, S. B., Yeager, D. W. and Middendorf, M. N. (1976) Cadmium in liver, kidney and hair of humans, fetal through old age. *Journal of Toxicology and Environmental Health,* **2**: 153.167.

Gunn, S. A., Gould, T. C., Anderson, W. A. *et al.,* (1961) Zinc protects against cadmium injury to rat testis. *Archives of Pathology*, **71**: 274-281.

Halsted, J. A., Ronaghy, H. A., Abadi, P., Haghshenass, M., Amirhakemi, G. H., Barakat, R. M. and Reinhold, J. G. (1972) Zinc deficiency in man. *American Journal of Medicine*, **53**: 277-284.

Hambidge, K. M. and Baum, J. D. (1972) Hair chromium concentrations of human newborn and changes during infancy. *The American Journal of Clinical Nutrition,* **25**: 376-379.

Hambidge, K. M., Franklin, M. L. and Jacobs, M. A. (1972) Changes in hair chromium concentrations with increasing distances from hair roots. *The American Journal of Clinical Nutrition,* **25**: 380-383.

Hambidge, K. K., Hambidge C., Jacob, M. Baum, J. D. (1972) Low levels of zinc in hair anorexia, poor growth and hypogeusia in children. *Pediatric Research*, **6**: 868-874.

Hambidge, K. K., Hambidge C., Jacob, M. Baum, J. D. (1972) Low levels of zinc in hair anorexia, poor growth and hypogeusia in children. *Pediatric Research*, **6**: 868-874.

Hambidge, K. M., Franklin, M. L. and Jacob, M. A. (1972) Hair chromium concentration: effects of sample washing and external environment. *The American Journal of Clinical Nutrition*, **25**: 384.

Hambidge, K. M. (1973) Increase in hair copper concentration with increasing distance from the scalp. *The American Journal of Clinical Nutrition,* **26**: 1212-1215.

Hambidge, K. M. (1974) Chromium nutrition in man. *The American Journal of Clinical Nutrition*, **27**: 505-514.

Hamilton, D. L. and Valberg, L. S. (1974) Relationship between cadmium and iron absorption. *American Journal of Physiology*, **227**: 1033-1037.

Hammer, D. I., Finklea, J. F., Hendricks, R. H. and Shy, C. M. (1971) Hair trace metal levels and environmental exposure. *American Journal of Epidemiology,* **93**: 84-92.

Happey, F. and Johnson, A. G. (1962) Some electron microscope observations on hardening in the human hair follicle. *Journal of Ultrastructure Research*, **7**: 316-327.

Harrap, B. S. and Woods, E. F. (1967) Species differences in the proteins of feathers. *Comparative Biochemistry and Physiology*, **20**: 449-460.

Harrison, W. W., Yurachek, J. P. and Benson, C. A. (1969) The determination of trace elements in human hair by atomic absorption spectrometry. *Clinical Chemica Acta*, **23**: 83-91.

Hart, E. B., Steenbock, H., Waddell, J. and Elvehjem, C. A. (1928) Iron in nutrition. VII. Copper as a supplement to iron for heamoglobin building in the rat. *Journal of Biological Chemistry,* **77**:, 797-812.

Hecker, L. H., Allen, H. E., Dinman, B. D. and Neel, J. V. (1974) Heavy metal levels in acculturated and unacculturated populations. *Archives of Environmental Health,* **29**: 181-185.

Helsby, C. A. (1976) Determination of mercury in finger nails and body hair. *Analytica Chimica Acta*, **82**: 427-430.

Hemphill, V. P. D. (ed) (1972) Trace substances in environmental health. University of Missouri Press. Columbus, USA.

Higgs, D. J., Morris,V. C. and Levander, O. A. (1972) Effect of cooking on selenium content of foods. *Journal of Agricultural Food Chemistry*, **20**:678-680.

Hilderbrand, D C. and White, D. H. (1974) Trace element analysis in hair: An evaluation. *Clinical Chemistry*, **20/2**: 148-151.

Holzbecher J. and Ryan, D. E. (1982) Some observations on the interpretation of hair analysis data. *Clinical Biochemistry.*, **15**: 80-82.

Hopps, H. C. (1977) The biological bases for using hair and nail for analyses of trace elements. The *Science of the Total Environment.* **7**: 71-87.

Horlick. G, Tan, S. H., Vaugham, M. A. and Shao, Y. (1987) Inductively coupled Plasma-Mass Spectrometry, Radiation Chemistry: Principles and Applications. (eds. A. Farhat and M. A. J. Rogers) VCH Publishers, New York.

Hrdy, D. and Baden, H. P. (1973) Biochemical variation of hair keratins in man and non-human primates. *American Journal of Physical Anthropology,* **39**: 19-24.

Hrdy, B. D., Baden, H. P., Lee, L.D., Kubilus, J and Ludwig, K.W. (1977) Frequency of an electrophoretic variant of hair α-keratin in human population. *American Journal of Human Genetics,* **29**: 98-100.

Hsu, J. M. (1976) In *Trace Elements in Human Health and Disease*, Vol. 1., Zinc and Copper (ed. A. S. Prasad), pp. 295-309, Academic Press, New York.

Jamett, A., Santander, M., Pena, L., Gras, N. and Munoz, L. (1991) Trace elements in the hair of workers of a copper mine and of children living in the vicinity. *Journal of Radioanalytical and Nuclear Chemistry Letters,* **155/6**: 383-389.

Japanese Expert Group. Epidemiology of mercury poisoning.: In Biogeochemistry of Mercury in the Environment (ed. J. O. Nriagu). Amsterdam: *Elsevier/North Holland Biomedical Press*, 1979: 359-

Japanese Expert Group. Epidemiology of mercury poisoning.: In Biogeochemistry of Mercury in the Environment (ed. J. O. Nriagu). Amsterdam: *Elsevier/North Holland Biomedical Press*, 1979: 359-

Jarret, A. and Spearman, R. I. C. (1964) Histochemistry of normal epidermal keratinization. In: *Histochemistry of the Skin-Psoriasis*. The English Universities Press, London.

Jervis, R. E., Tiefenbach, B. and Chattopadhyay, A. (1977) Scalp hair as a monitor of population exposure to environmental pollutants. *Journal of Radioanalitical Chemistry.*, **37**: 751-9.

Jones, L. N. (1976) Studies on microfibrils from α-keratin. *Biochemica Biophysics Acta*, **446**: 515-524.

Jones, G. L., Willy, D., Lumsden, B., Taufa, T. and Lourie, J. (1987) Trace metals in the hair of inhabitants of the Ok Tedi region, Papua New Guinea. *Environmental Pollution,* **48**: 101-115.

Kamakura, M. (1983) A study of the characteristics of trace elements in the hair of Japanese; interrelationships and ratios of trace elements in hair. *Keio Journal of Medicine,* **32**: 9-24.

Kaplin, I. J. and Whiteley, K. J. (1978) An electron microscopic study of fibril: matrix arrangement in high- and low-crimp wool fibres. *Australian Journal of Biological Science*, **31**: 231-240.

Keilim, D. and Mann, T. (1940) Zinc in carbonic anhydrase. *Nature*, **145**: 304.

Kemmerer, A. R., Elvehjem, C. A. and Hart, E. B. (1931) Studies on the relation of manganese to the nutrition of the mouse. *Journal of Biological Chemistry*, **92**: 623-630.

Kershaw, T. G., Dhahir, P. H., Clarkaon, T. W. (1980) The relationship between blood levels and dose of methylmercury in man. *Archives of Environmental Health,* **35**: 28-35.

Klevay, L. M. (1970) Hair as a biopsy material II. Assessment of copper nutriture. *The American Journal of Clinical Nutrition,* **23**: 1194-1202.

Klevay, L. M. (1973) Hair as a biopsy material III. Assessment of environmental lead exposure. *Archives of Environmental Health,* **26**: 169-172.

Klevay, L. M. (1978) Hair as a biopsy material : Progress and prospects. *Archives of International Medicine,* **138**: 1127-1128.

Knox, A. G. (1980) Feather protein as a source of avian taxonomic information. *Comparative Biochemistry and Physiology,* **65B**: 45-54.

Kopito, L. E., Byers, R. K. and Shwachman, H. (1967) Lead in hair of children with chronic lead poioning. *The New England Journal of Medicine,* **276**: 949-953.

Kopito, L. E. and Shwachman, H. (1975) Lead in human scalp hair : Some factors affecting its variability. *The Journal of Investigative Dermatology,* **64**: 342-348.

Kracke, K. R. (1982) Biochemical basis for behavioural disorders in children. *Journal of Orthomolecular Psychiatry,* **11**: 289-293.

Kyle, J. H. and Ghani, N. (1982) Elevated mercury levels in people from Lake Murray, Western Province. *Papua New Guinea Medical Journal,* **25**: 81-88.

Lau, H. K. Y. and Ashmead, H. (1975) Trace minerals in human hair by atomic absorption spectrphotometry—Recovery study. *Analytical Letters,* **8**: 815-824.

Labella, F. S., Dular, R., Lemon, P.,Vivan, S. and Queen, G. (1973) Prolectin secretion is specially inhibited by nickel. *Nature,* **245**: 330-332.

Laemmli, U. K. (1970) Cleavage of structural proteins during assembly of the head of bacteriophage T_4. *Nature,* **227**:680-685.

Lea, C. M. and Luttrell, V. A. S. (1965) Copper content in Kwashiorkor. *Nature,* **206**: 413.

Lee, L. D., Ludwig, K. and Baden, H. P. (1978) Matrix proteins of human hair as a tool for identification of individuals. *Forensic Science,* **11**: 115-121.

Leotsinidis, M. and Kondakis, X. (1990) Trace metals in scalp hair of Greek agricultural workers. *The Science of the Total Environment,* **95**: 189-195.

Lester, M. L., Thatcher, R. W. and Monroe-Lord, L. (1982) Refined carbohydrate intake, hair chromium levels and cognitive functioning in chldren. *Journal of Nutrition and Behaviour*, **1**: 1-14.

Lindley, H., Broad, A., Damaglou, A. P., Darskus, R. L., Elleman, T. C., Gillespie, J. M. and Moore, C. H. (1971) The high-sulphur protein fraction of keratins. *Applied Polymorphic Symposium.* No. **18**: 21-35.

Lourie, J. A. and Taufa, T. (1986) The Ok Tedi health and nutrition project, Papua New Guinea: Physique, growth and nutritional status of the Wopkaimin of the Star Mountains. *Annals of Human Biology,* **13**: 517-536.

Lynch, M. H., O'Guin, W. M., Hardy, C., Mak, L., and Sun, T-T. (1986) Acidic and basic hair/nail ("Hard") keratins: Their colocalization in upper cortical and cuticle cells of the human hair follicle and their relationship to "Soft" keratins. *The Journal of Cell Biology*, 103: 2593-2606.

MacDonald, I. and Warren, P. J. (1961) The copper content of the liver and hair of African children with Kwashiorkor. *British Journal of Nutrition*, **15**, 593.

McDonald, L. D., Gibson, R. S.and Miles, J. E. (1982) Changes in hair zinc and copper concentrations in breast-fed and bottle-fed infants six months. *Acta Paediaticar Scandinavica*, **71**: 785-89.

Malm, O., Pfeiffer, W. C., Souza, C. M. M. and Reuther, R. (1990) Mercury pollution due to gold mining in the Madeira River Basin, Brazil. *AMBIO*, **19**: 11-15

Marlowe, M., Moon, C., Errera, J. and Stellern, J. (1983) Hair mineral content as a predictor of mineral radiation. *Journal of Orthomolecular Psychiatry*, **12**: 26-33.

Marsh, D. O., Turner, M. D., Smith. J., Wun C, J. and Clarkson, T. W. Methylmercury (Me Hg) in human populatins eating large quantities of marine fish II. American Samoa, cannery workers and fishermen. *Proceedings of the First International Conference on Mercury* 1974: Vol II: 235-239.

Marshall, R. C., Frenkel, M. J. and Gillespie, J. M. (1977) High-sulphur proteins in mammalian keratins : A possible aid in classification. *Australian Journal of Zoology,* **25**: 121-32.

Marshall, R. C. and Gillespie, J. M. (1977) The keratin proteins of wool, horn and hoof from sheep. *Australian Journal of Biological Science*, **30**: 389-400.

Marshall, R. C. (1980) Genetic variation in the proteins of human nail. *Journal of Investigative Dermatology,* **75**: 264-269.

Marshall, R. C. (1981) Analysis of the proteins from single wool fibres by two-dimensional polyacrylamide gel electrophoresis. *Textile Research Journal*, **51**: 106-108.

Marshall, R. C. and Gillespie, J. M. (1982) Comparison of samples of human hair by two-dimensional electrophoresis. *Journal of the Forensic Science Society,* **22**: 377-385.

Marshall, R. C. (1983) Characterization of the proteins of human hair and nail by electrophoresis. *The Journal of Investigative Dermatology,* **80**: 519-524.

Marshall, R. C. (1985) Hair comparison by protein analysis. In *Proceedings of the International Symposium on Forensic Hair Comparison*, pp. 71-87. U.S. Government Printing Office, Washington, D.C.

Marshall, R. C., Gillespie, J. M. and Klement, V. (1985) Methods and future prospects for forensic identification of hairs by electrophoresis. *Journal of the Forensic Science Society,* **25**: 57-66.

Marshall, T. (1984) Detection of proteins on polyacrylamide gels using an improved silver stain. *Analytical Biochemistry,* **136**: 340-346.

Marshall, T., Paviour, S. M. and Williams, K. M. (1987) A simplified method for the electrophoretic analysis of hair proteins. *Journal of Biochemical and Biophysical Methods*, **14**: 53-58.

Matthews, A. D. (1983) Mercury content of commercially important fish of the Seychelles and hair mercury levels of a selected part of the population. *Environmental Research,* **30**: 305-312.

Maugh, T. H. (1978) Hair: A diagnostic tool to complement blood serum and urine. *Science,* **202**: 1271-1273.

Maxia, V., Meloni, S., Roller, M. A., Brandone, A., Patwardhan, V. N., Waslien, C. I and Said-El-Shami. (1972) Selenium and chromium assay in Egyptian foods and blood of Egyptian children by activation analysis. In " Nuclear Activation Techniques in the Life Science," IAEA-SM. **157/ 67**, pp. 527-550. IAEA, Vienna.

McClain, P. E., Wiley, E. R., Beecher, G. R. and Anthony, W. L. (1973) Influence of zinc defeciency on synthesis and cross-linking of rat-skin collagen. *Biochimica Biophysics Acta*, **304**: 457-465.

McKenzie, J. M. (1978) Alteration of the zinc and copper concentration of hair. *The American Journal of Clinical Nutrition,* **31**: 470-476.

McKenzie, J. M., Guthrie, B. E. and Prior, I. A. M. (1978) Zinc and copper status of Polynesian residents in the Tokelau Island. *The American Journal of Clinical Nutrition,* **31**: 422-428.

McKenzie, J. M. (1979) Contents of zinc in serum, urine, hair and toenails of New Zealand adults. *The American Journal of Clinical Nutrition,* **32**: 570-579.

Miyake, B. and Seta, S. (1987) Practical application of electrophoretic analysis of hair keratin to forensic hair comparison. *Canadian Journal of Forensic Science*, **20**: 245.

Miyake, B. and Seta, S. (1990) Hair protein polymorphism and its application to forensic science hair comparison. *Forensic Science Review*, **2**;25-36.

Montagna, W. (1962) The structure and function of skin, 2nd edn., Academic Press, New York.

Moon, J., Smith, T. J., Tamaro, S., Enarson, D., Fadl, S., Davision, A. J. and Weldon, L. (1986) Trace metals in scalp hair of children and adults in three Alberta Indian villages. *The Science of the Total Environment,* **54**: 107-125.

Morris, V. C. and Levander, O. A. (1970) Selenium content of food. *Journal of Nutrition,* **100**, 1383-1388.

Nagai, A., Komoriya, H., Bunai, Y., Yamada, S., Jiang, X. and Ohya, I. (1991) Effect of hair dyes and bleach on the hair protein patterns as revealed by isoelectric focusing. *Electrophoresis,* **12**: 451-453.

Nappe, C. and Kermici. (1989) Electrophoretic analysis of alkylated proteins of human hair from various ethnic groups. *Journal of Society and Cosmetics Chemistry*, **40**: 91-99.

Needleman, H. L., Gunnae, C., Leviton, A., Reed, R., Persie, H., Maher, C. and Barret, P. (1979) Deficits in psychologic and class room performance of children with elevated lead levels. *New England Journal of Medicine*, **300**: 689-695.

Nishiyama, K. and Nordberg, G. F. (1972) Adsorption and elution of cadmium on hair. *Archives of Environmental Health,* **25**: 92-96.

Nord, P. J. and Kadaba, M. P. and Sorenson, J. R. J. (1973) Mercury in human hair. *Archives of Environmental Health,* **27**: 40-44.

Obrusnik, I., Gislason, J., McMillan, D. K., D'Auria, J. and Pate, B. D. (1972) The variations of trace element concentrations in single human hairs. *Journal of Forensic Science*, **17**: 426.

O'Donnell, I. J. (1973) The complete amino acid sequence of a feather keratin from emu (*Dromaius novae-hollandiea*). *Australian Journal of Biological Science*, **26**: 415-37.

O'Donnell, I. J. and Thompson, E. O. P. (1964) Studies on reduced wool. IV. The isolation of a major component. *Australian Journal of Biological Science*, **17**: 973-87.

O'Donnell, I. J. and Inglis, A. S. (1974) Amino acid sequence of a feather keratin from Silver Gull (*Larus novae-hollandie*) and comparison with one from Emu (*Domaius-hollandiae*). *Australian Journal of Biological Science*, **27**, 369-82.

O'Fairchellaigh, C. (1984) Mineral development in Papua New Guinea: The Colonial Period, 1964-1972. In: Mining and Development. Foreign-financed mines in Australia, Ireland, Papua New Guinea and Zambia. Croom Helm, London and Sydney.

Ok Tedi Mining Limited. (1983) Environmental Monitoring Programme, six monthly report.

Olson, O. E., Novacek, E. J., Whitehead, E. I. and Palmer, I. S. (1970) Investigations on selenium in wheat. *Phytochemistry*, **9**: 1181-1188.

Orent, E. R. and McCollum, E. V. (1931) Effects of deprivation of managanese in the rat. *Journal of Biological Chemistry*, **92**: 651-678.

Orwin, D. F. G. (1979) The cytology and cytochemistry of the wool follicle. *International Review of Cytology*, **60**: 331-374.

Perkons, A. K. and Jervis, R. E. (1962) Application of radioactivation analysis in forensic investigations. *Journal of Forensic Science*, **7**: 449.

Perl, D. P. and Brody, A. R. (1980) Alzheimer's disease: X-ray spectrometric evidence of aluminium accumulation in neurofibrillary tangle-bearing neurons. *Science,* **208**: 297-299.

Petering, H. G., Yeager, D. W. and Witherup, S. O. (1971) Trace metal content of hair I. Zinc and copper content of human hair in relation to age and sex. *Archives of Environmental Health,* **23**: 202-207.

Petering, H. G., Yeager, D. W. and Witherup, S. O. (1973) Trace metal content of hairII. Cadmium and lead in human hair in relation to age and sex. *Archives of Environmental Health*, **27**: 327-330.

Phelps, R. W., Clarkson, T. W., Kershaw, T. G. and Wheatley, B. (1980) Interrelationships of blood and hair mercury concentrations in a North American population exposed to methylmercury. *Archives of Environmental Health,* **35**: 161-168.

Pihl, R. O. and Parkes, M. (1977) Hair element content in learning disabled children. *Science,* **198**: 204-206.

Pihl, R. O. and Ervin, F. (1990) Lead and cadmium levels in violent criminals. *Physiological Reports*, **66**: 839-844.

Pollitt, R. J. and Stonier, P. D. (1971) Proteins of normal hair and of cystine-deficient hair from mentally retarded siblings. *Biochemical Journal*, **122**: 433-444.

Pories, W. J., Henzel, J. H., Rob, C. G and Strain, W. H. (1967) Acceleration of wound healing in man with zinc sulphate given by mouth. *The Lancet,* **1**: 121-124.

Pories, W. J., Strain, W. H., Hsu, J. M. and Woosley, R. L. Clinical applications of zinc metabolism. Springfield: Charles C. Thomas, 1974.

Porter, J. and Fouweather, C. (1975) An appraisal of human head hair as forensic evidence. *Journal of Society and Cosmetics Chemistry,* **26**: 299-313.

Powell, G. W. Miller, W. J. Morton, J. D. and Clifton, C. M. (1964) Influence of dietary cadmium level and supplemental zinc on cadmium toxicity in the bovine. *Journal of Nutrition*, **84**: 205-214.

Prasad, A. S., Miale, A., Jr., Fraid, Z., Sandstead, H. H., Schulert, A. R., and Darby, W. J. (1963a) Biochemical studies on dwarfism, hypogonadism, and anemia. *Archives of Internal Medicine*, **111**: 407-428.

Prasad, A. S. (1966) Metabolism of zinc and its deficiency in human subjects. In Zinc Metabolism (ed. A. S. Prasad), pp.250-293. Thomas, Springfield USA.

Prasad, A. S. (1967) Federation Proceedings, **26**: 172.

Parsad, A. S. (1976) Trace elements in human health and disease. Academic Press, New York.

Price, V. H. (1979) Strukturanomalien des haarschaftes. In *Haar und Haarkrankheiten* (ed. C. E. Orfanos), pp. 387-446. Fisher Verlag, Stuttgart.

Price, V. H., Odom, R. B. Ward, W. H. and Jones, F. T. (1980) Trichothiodystrophy: sulfur-deficient brittle hair, a marker for a neuroectodermal symptom complex. *Archives of Dermatology*, **116**: 1375-1384.

Prizek, J. (1957) The destructive effect of cadmium ion on testicular tissue and its prevention by zinc. *Journal of Endocrinology*, **15**: 56-63.

Purser, D. B. (1979) in: *Physiological and Environmental Limitations to Wool Growth* (eds. J. L. Black and P. J. Reis), pp. 243-255, University of New England Publishing Unit, Armidale.

Ragan, H. A. (1977) Effects of iron deficency on the absorption and distribution of lead and cadmium in rats. *Journal of Laboratory and Clinical Medicine,* **90**: 700-706.

Reilly, C. and Harrison, F. (1979) Zinc, copper, iron and lead in scalp hair of students and non-student adults in Oxford. *Journal of Human Nutrition,* **33**: 248-252.

Ragan, H. A. (1977) Effects of iron deficency on the absorption and distribution of lead and cadmium in rats. *Journal of Laboratory and Clinical Medicine,* **90**: 700-706.

Reilly, C. and Harrison, F. (1979) Zinc, copper, iron and lead in scalp hair of students and non-student adults in Oxford. *Journal of Human Nutrition,* **33**: 248-252.

Reilly, C. and Harrison, F. (1983) Nutritional implications of levels of zinc, copper, iron and lead in hair of British and Australian children. *Proceedings of the Nutritional Society of Australia,* **8**: 209.

Reilly, C. (1983) Relation of hair zinc to age in children. *Proceedings of the Nutritional Society of Australia,* **8**: 210.

Reinhold, J. G., Kfoury, G. A., Ghalambor, M. A. and Bennet, J. C. (1966) Zinc and copper concentrations in hair of Iranian villagers. *The American Journal of Clinical Nutrition,* **18**: 294-300.

Reinhold, J. G., Kfoury, G. A., and Arslarian M. (1968) Relationship of zinc and calcium concentration in hair to zinc nutrition in rats. *Journal of Nutrition,* **96**: 519-524.

Reis, P. J. (1979) Effects of amino acids on the growth and properties of wool. In *Physiological and Environmental Limitations to Wool Growth* (eds. J. L. Black and P. J. Reis), pp. 223-242. The University of New England Publishing Unit, Armidale.

Reis, P. J. and Schinkel, P. G. (1964) The growth and composition of wool-IV. The isolation of a major component. *Australian Journal of Biological Science*, **17**:532-547.

Reis, P. J. and Downes, A. M. (1980) In: Wool Harvesting Research and Development. *Proccedings of 1st Conference, Melbourne, May, 1979 (*ed. P. R. W Hudson), pp. 257-268, Australian Wool Corporation, Melbourne.

Reynolds, L. F. and Price, M. J. (1979) Interim report on the mercury levels found in barramundi caught in Papuan Waters. Department of Primary Industry, Konedobu, Papua New Guinea 1974. Sorentino C. Mercury in marine and fresh water fish of Papua New Guinea. *Australian Journal of Marine and Fresh Water Research*, **30**: 617-623.

Ross, J., Gibson, R. S. and Sabry, J. H. (1986) A study of seasonal trace element intakes and hair trace element concentrations in selected households from the Wosera, Papua New Guinea. *Tropical and Geographical Medicine,* **38**:246-254.

Rush, P. M. and Seegers, H. J. (1990) OK Tedi Copper-Gold deposits. In: Geology of the Mineral Deposits of Australia and Papua New Guinea (ed. F. E. Hughes), pp. 1747-1754. The Australian Institute of Mining and Metallurgy; Melbourne.

Roth, S. and Hewlig, E. B. (1964) The cytology of the dermal pappilla, the bulb and the root sheaths of mouse hair. *Journal of Ultrastructure Research*, **11**, 33-51.

Said, H. M., Newsom, A. E., Feige, A. J., Laurens, S. L. and Mathews, R. A. (1986) Cysteine-rich proteins of human hair: Charaterization and structure as revealed by reversed-phase and size-exclusion high-performance liqiud chromatography. *Journal of Chromatography,* **381**: 41-52.

Said, H. M., Feige, A. J., Newsom, A. E., Laurens, S. L. and Mathews, R. A. (1987) The microfibrillar proteins of human hair: Separation by high-performance liquid chromatography and isolation of some proteins enriched in glycine and tyrosine. *Analytical Biochemistry,* **165**: 161-166.

Sandford, M. K., Van Gerven, D. P. and Meglen, R. R. (1983) Elemental hair analysis : New evidence on the etiology of Cribra Orbitalia in Sudanese Nubia. *Human Biology,* **55**: 831-844.

Sandstorm, B. and Cederblad, A. (1980) Zinc absorption from composite meals II. Influence of the main protein source. *American Journal of Clinical Nutrition,* **33**: 1778-1783.

Schimkat, M., Baur, M. P. and Henke, J. (1990) Inheritance of some electrophoretic phenotypes of human hair. *Human Genetics,* **85**: 311-314.

Schroeder, H. A., Balassa, J. J. and Tipton I. H. (1962) Abnormal trace metal in man:chromium. *Journal of Chronic Diseases*,**15**: 941-964.

Schroeder, H. A., Balass, J. J. and Tipton, I. H. (1966) Essential trace elements in man: manganese. *Journal of Chronic Dieases*, **19**: 545-571.

Schroeder, H. A. (1967) Cadmium, chromium and cardiovascular disease. *Circulation*, **35**: 570.

Schroeder, H. A. (1968) The role of chromium in mammalian nutrition. *American Journal of Clinical Nutrition*, **21**: 230-244.

Schroeder, H. A. and Nason, A. P. (1969) Trace metals in human hair. *Journal of Investigative Dermatology*, **53**: 71-78,1969.

Schroeder, H. A., Nason, A. P. and Tipton, I. H. (1970) Chromium deficiency as a factor in atherosclerosis. *Journal of Chronic Diseases*,**23**: 123-142.

Schroeder, H. A. (1971) Losses of vitamin and trace minerals resulting from processing and preservation of foods. *American Journal of Clinical Nutrition*, **24**: 562-573.

Shimomura, S., Kimura, A., Nakagawa, H. and Takao, M. (1980) Mercury levels in human hair and sex factors. *Environmental Research,* **22**: 22-30.

Shimoshima, C., Nishioka, C., Takiyama, K., Yuge, O. and Katayama, Y. (1988) Influences of protein malnutrition on amino acid composition, trace metal elemenmts and tensile strength of rat hair. *Journal of Nutritional Science of Vitaminology,* **34**: 67-78.

Shrestha, K. K. and Schrauzer, G. N. (1989) Trace elements in hair: A study of residents in Darjeeling (India) and San Diego, California (USA). *The Science of the Total Environment,* **79**: 171-177.

Shrivastava, A. K. and Tandon, S. G. (1984) Studies on lead pollution: Atomic absorption spectrophotometric determination of lead in hair and teeth samples. *International Journal of Environmental and Analytical Chemistry,* **17**: 293-298.

Sian, L., Hambidge, K. M., Westcott, J. L., Miller, L. V. and Fennessey, P. V. (1993) Influence of a meal and incremental doses of zinc on changes in zinc absorption. *The American Journal of Clinical Nutrition,* **58**: 533-536.

Simonsen, H. B. (1976) Species identification of mamalian hair keratin. Thesis: Royal Veterinary and Agricutural University, Copenhagen.

Sorenson, J. R. J., Melby, E. G., Nord, P. J. and Petering, H. G. (1973) Interferences in the determination of metallic element in human hair: An evaluation of zinc, copper, lead and cadmium using atomic absorption spectrophotometry. *Archives of Environmental Health,* **27**: 36-39.

Sparrow, L. G. and Crewther, W. G. (1972) Further resolution of the low-sulphur S-carboxymethylkerateine fraction from wool by acrylamide gel electrophoresis. *Journal of the Textile Institute*, **63**, 619-621.

Steinners, E. (1975) Uptake of trace elements in human hair by anion exchange. *Internatiol Journal of Applied Radiation* and Isotopes, **26**: 595.

Stewart-Pinkham, S. M. (1989) The effect of ambient cadmium air pollution on the hair mineral content of children. *The Science of the Total Environment,* **78**: 289-296.

Strain, W. H., Steadman, L. T., Lankau, C. A jr., Berliner, W. P. and Pories, W. J. (1966) Analysis of zinc levels in hair for the diagnosis of zinc deficiency in man. *Journal of Laboratory and Clinical Medicine,* **68/2**: 244-249.

Suzuki, T. (1985) Mohatsu-Bunseki (Analysis of Hair). Yueki to Eiyo (Transfusion and Nutrition), 7-9.

Suzuki, T. and Hongo, T. (1984) Elemental contamination of Japanese women's hair from historical samples. *The Science of the Total Environment,* **39**:81-91.

Swedish Expert Group. Methylmercury in Fish: Nord Hygienisk Tidskrift 1971, supplement 4, Stockholm.

Tatcher, R. W., Lester, M. L., McMaster, R. and Horst, R. (1982) Effects of low levels of cadmium and lead on cognitive functioning in children. *Archives of Environmental Health*, **37**: 159-166.

Thatcher, R. W. and Lester, M. L. (1983) Anatomically related variartions in trace-metal concentrations in hair : A comment. *Clinical Chemistry,* **29/9**: 1691-1692.

Toepfer, E. W., Mertz, W., Roginski, E. E. and Polansky, M. M. (1973) Chromium in foods in relation to biological activity. *Journal of Agricultural Food Chemistry.*, **21**: 69-73.

Todd, W. R., Elvehjem, C. A. and Hart, E. B. (1934) Zinc in nutrition of the rat. *American Journal of Physiology*, **107**: 146-156.

Tsugane, S. and Kondo, H. (1987) The mercury content of hair of Japanese immigrants in various locations in South America. *The Science of the Total Environment,* **63**: 69-76.

Turner, M. D, Marsh D. O, Smith J, C., Inglis, J. B., Clarkson, T. W., Rubio,C. E., Chiriboga, J. and Chiribonga, C. C. (1980) Methylmercury in populations eating large quantities of marine fish. *Archives of Environmental Health*, **35**: 367-378.

Underwood, E. J. (1971) *Trace Elements in Human and Animal Nutrition,* 3rd edn. Academic Press, New York.

Underwood, E. J. (1977) *Trace Elements in Human and Animal Nutrition*, 4th edn. Academic Press, New York.

Valberg, L. S., Sorbie, J. and Hamilton, D. L. (1976) Gastrointestinal metabolism of cadmium in experimental iron deficiency. *American Journal of Physiology*, **231**: 462-467.

Valkovic , V. (1977) Trace elements in human hair. Garland Press, New York.

Vohra, P., Gray, G. A. and Kratzer, F. H. (1965) Phytic acid-metal complex. *Proceedings Society for Experimental Biology and Medicine*, **120**, 447-449.

Wagner, P. A., Krista, M. L., Bailey, L. B., Christakis, G. J., Jernigan, J. A., Araujo, P. E., Appledorf, H., Davis, C. G. and Dinning, J. S. (1980) Zinc status of elderly black Americans from urban low-income households. *American Journal of Clinical Nutrition,* **33**: 1771-1777.

Wahal, P. K., Mittal, V. P. and Bansal. O. P. (1965) Renal complications in acute copper sulphate poisoning. *Indian Practitioner*, **18**: 807-812.

Walravens, P. A. and Hambidge, K. M. (1978) Zinc nutrition and deficiency in pediatrics. In Zinc and Copper in Clinical Medicine (ed. K. M. Hambidge and B. L. Nichols), pp. 49-58. SP Medical and Scientific Books, London.

Warren, H. V. (1973) Water in relation to human disease. In: Environmental Medicine (eds. G. M. Howe and J. A. Lorraine), Heineman, London.

Wahal, P. K., Mittal, V. P. and Bansal. O. P. (1965) Renal complications in acute copper sulphate poisoning. *Indian Practitioner*, **18**: 807-812.

Walravens, P. A. and Hambidge, K. M. (1978) Zinc nutrition and deficiency in pediatrics. In Zinc and Copper in Clinical Medicine (ed. K. M. Hambidge and B. L. Nichols), pp. 49-58. SP Medical and Scientific Books, London.

Warren, H. V. (1973) Water in relation to human disease. In: Environmental Medicine (eds. G. M. Howe and J. A. Lorraine), Heineman, London.

Waslien, C. I., Yacoub, N. Z. and Rizk, M. E. (1972) The diet of families with children having protein-calorie malnutrition. *Proceedings 6th Symposium on Nutritional Health in the Near East,* pp. 402-407.

Webb, M. (1972) Protection by zinc against cadmium toxicity. *Biochemical Pharmacology,* **21**: 2767-2771.

Weber, C. W., Nelson, G. W., Vasquez de Vaquera, M. and Pearson, B. P. (1990) Trace elements in the hair of healthy and malnourished children. *Journal of Tropical Pediatrics,* **36**: 230-234.

Weiss, D., Whitten, B. Leddy, D. (1972) Lead content of human hair (1871-1971). *Science*, **178**: 69-70.

Whiteley, K. J. and Kaplin, I. J. (1977) The comparative arrangement of microfibrils in ortho-, meso- and paracortical cells of merino wool fibres. *Journal of Textile Institute*, **68**: 384-386.

Wilhelm, M. and Ohnesorge, F. K. and Hotzel, D. (1990) Cadmium, copper, lead and zinc concentrations in human scalp and pubic hair. *The Science of the Total Environment,* **92**:199-206.

Wilhelm, M., Hafner, D., Lombeck, I. and Ohnesorge, F. K. (1991) Monitoring of cadmium, copper, lead and zinc status in young children using toenails: Comparison with scalp hair. *The Science of the Total Environment,* **103**: 199-207.

Witting, L. A. (1980) Vitamin E and lipid antioxidants in free-radical-initiated reactions. *In Free Radicals in Biology.* (ed. W. A. Pryor), pp. 295-319. Academic Press, New York.

Yamamura, Y. and Yamauchi, H. (1980) Arsenic metabolites in hair, blood and urine in workers exposed to arsenic trioxide. *Industrial Health,* **18**: 203-210.

Yu, J., Yu, D., Checla, D. M., Freedberg, I. M. and Bertolino, A. P. (1993) Human hair keratins. *Journal of Investigative Dermatology,* **101**: 56S-59S.

Yurachek, J. P., Clemena, G. G. and Harrison, W. W. (1969) Analysis of human hair by spark source mass spectrometry. *Analytical Chemistry,* **41**: 1666-1668.

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CHANGES IN THE HAIR HEAVY METAL LEVELS IN POPULATIONS NEAR THE OK TEDI MINE SITE, PAPUA NEW GUINEA.

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ABSTRACT:

It has long been known that mining activity can markedly change the level and distribution of certain heavy metals in the adjacent environment. This pollution can be quite widespread and long lasting and often has deleterious effects on the health of local populations.

In the present study scalp hair was used as the biopsy material because of its ease of collection and long history of use in connection. Hair was collected from all the local villages in the vicinity of the mine site, as well as from Papua New Guinean nationals from other provinces, and European expatriates who were employed by the mining company and who were resident in the area.

In addition hair was collected from eleven villages in the Central Highlands north west of the capital Port Moresby and remote from the mine site. In 1987 we published results detailing the baseline (i.e. pre-mining)levels of key metals, Iron (Fe), Copper (Cu), Zinc (Zn), Mercury (Hg), Cadmium (Cd) and Lead (Pb). Hairs from this survey were originally sampled in 1982.

In the baseline survey hair from local people showed a remarkably high iron content by comparison with previously studied populations. The extreme variations in hair iron levels were reflected in the differential distribution of levels according to location, age, and sex. Hair cadmium was also high in the population studies. Hair copper, lead, and mercury all appeared to be within 'normal' limits by comparison with urban western populations but were higher than the control PNG population.Hair Zinc was lower in both PNG populations by comparison with western populations.

Considerable changes were observed in both the 1987 and 1990 OK TEDI samples. An attempt has been made to reconcile these changes with the changing social, dietary and geophysical environment that has resulted from the impact of mining activity on the population.

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IMPROVED SEPARATION AND PARTIAL CHARACTERISATION OF S-CARBOXYMETHYLATED HUMAN HAIR PROTEINS.

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A highly reproducible, rapid procedure for the extraction, labelling and separation of human hair proteins by SDS-PAGE has been developed. Hair proteins were extracted in 8 M urea containing 0.2 M mercaptoethanol, followed by sonication. Extracts were neutralised with Tris and incubated with either labelled (^{14}C) or unlabelled iodoacetic acid to S-carboxymethylate cysteine groups. Proteins were separated on a 12.5% SDS polyacrylamide gels and gels stained with Coomassie brilliant blue or silver nitrate to reveal major protein bands. Gels were then treated with a fluorographic agent, dried and autoradiographed to reveal major sites of S-carboxymethylation. A given gel could be scanned by laser densitometry after Coomassie or silver stain to quantitate the protein content of each major protein zone. An autoradiogram of the same gel could then be scanned to quantitate the cysteine content of each major zone. In this way it was possible to rapidly and reproducibly partially characterise many different protein zones in different individual samples on one gel at the same time. By calculating the ratio of autoradiograph absorbance to Coomassie blue absorbance protein zones could be assigned to four different categories viz: very high cysteine (VHC) proteins, high cysteine (HC) proteins, low cysteine (LC) proteins and very low cysteine (VLC) proteins. The method described is reproducible, rapid and inexpensive enough to be suitable for mass screening. Overall the results were much more informative than previously reported one-dimensional separations[1] and indeed this technique may well be more suited to forensic and/or population investigations than the much more laborious and time consuming two-dimensional techniques.

1. Gerhard, M (1987) Electrophoretic variability in human head hair : Polyacrylamide gel electrophoresis of hair proteins in the presence of sodium dodecyl sulphate and urea. *Electrophoresis,* **8**: 153-157.

AN ELECTROPHORETIC COMPARISON OF HAIR AND FEATHER PROTEINS FROM VARIOUS SPECIES OF MAMMALS AND BIRDS.

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Hair S-carboxymethylated kerateines (SCMK's) constitute a heterogeneous mixture of covalently modified proteins, whose components are distinguishable as distinct classes of protein based on their content of a particular amino acid, cysteine, and their molecular weights[1]. Very harsh conditions are required to break disulphide bonds so that hair proteins may be disaggregated and dissolved. Since different species show differential solubilities, it is necessary to define conditions which, while they may not be optimal for all species at least provide a standard protocol suitable for comparative purposes. We have used an improved 1D SDS-PAGE (one-dimensional sodium dodecyl sulphate) separation to effect detailed electrophoretic comparison of the proteins that constitute hairs and feathers isolated from various representative samples of mammalian (both placental and marsupial) and avian species. The proteins from various species were S-carboxymethylated using labelled (^{14}C) iodoacetic acid and detected both by Coomassie stain and fluorography. Homologous proteins from mammalian species were compared with respect to their molecular weights and relative cysteine content using laser densitometry of gels both Coomassie stained and following fluorography. The relative cysteine content of each protein zone could be expressed as the ratio of the fluorograph absorbance to the Coomassie blue absorbance. Inter-specific comparison could then be made by normalising each ratio against the homologous human protein zone. These results may be quite useful forensically as an adjunct to fibre analysis since they yield much more information per analysis than previous procedures using the much more laborious 2D (two-dimensional) separation.

1. Gillespie, J. M. (1983) The structural proteins of hair: isolation, characterisation and regulation of biosynthesis. *In, Physiology, Biochemistry and Molecular Biology of the Skin,* 2nd. edn, Vol. 1, ed. L.A. Goldsmith, pp. 625-659. New York: Oxford University Press.