The effects of metals as endocrine disruptors

TABLE 1. Effects of Metals on Endocrine System

Metals	Effects	References
Cadmium	Alterations of the secretory patterns of pituitary hormones	Lafuente et al., 2003
	Stimulation of progesterone synthesis (low doses)	Powlin et al., 1997; Massanyi et al., 2000
	Inhibition of progesterone synthesis (high doses)	Paksy et al., 1997; Piasek and Laskey, 1999; Jolibois et al., 1999a; 1999b; Kawai et al., 2002
	Estrogenic effect	Garcia-Morales et al., 1994
	Increase in early delivery	Nishijo et al., 2002
	Lower birth weight	Frery et al., 1993; Nishijo et al., 2002
	Early onset of puberty	Johnson et al., 2003
Mercury	Stimulation of progesterone synthesis	Mondal et al., 1997
	Reduction in plasma levels of testosterone and 17-beta-estradiol	Drevnick and Sandheinrich, 2003; Vachhrajani and Chowdhury, 1990; Ng and Liu, 1990
	Reduction in sperm motility and sperm count	Chowdhury et al., 1989
	Increase in plasma levels of T4, TSH, estrone, and estradiol	Barregård et al., 1994; Ellingsen et al., 2000; Agusa et al., 2007; Abdelouahab et al., 2008
Arsenic	Increase in GR-, MR-, PR-, AR-, RAR-, and TR-mediated transcription (low doses)	Bodwell et al., 2004; Bodwell et al., 2006; Davey et al., 2008
	Inhibition of GR-, MR-, PR-, AR-, RAR-, and TR-mediated transcription (high doses)	Kaltreider et al., 2001; Bodwell et al., 2004; Davey et al., 2008
	Inhibition of ER-mediated transcription	Davey et al., 2007
	Estrogenic effect	Jana et al., 2006
	Inhibition of spermatogenesis	Sarkar et al., 2003; Pant et al., 2004; Jana et al., 2006
Lead	Alterations of affinity of estrogen and luteinizing hormone receptors	Wide, 1980; Wiebe and Barr, 1988; Wiebe et al., 1988
	Action at multiple sites on the hypothalamus–pituitary–gonadal axis	Ronis et al., 1996; Srivastava et al., 2004
	Reduction in serum levels of IGF-1, LH, testosterone and estradiol	Ronis et al., 1996; Dearth et al., 2002; Srivastava et al., 2004;
	Alterations of onset of puberty	Iavicoli et al., 2004; 2006
	Morphological and functional alterations of sperm	Sokol and Berman, 1991; Kempinas et al., 1994; Wadi and Ahmad, 1999; Gennart et al. 1999; Bonde et al., 2002; Kasperczyk et al., 2008
	Inhibition of GH synthesis	Huseman et al., 1992; Ronis et al., 1996
Manganese	Increase in serum levels of LH, FSH and testosterone	Pine et al., 2005; Lee et al., 2006
	Stimulation of spermatogenesis	Lee et al., 2006
	Stimulation in the secretion of LH and LHRH	Prestifilippo et al., 2007; Lee et al., 2007
	Early onset of puberty	Pine et al., 2005
Zinc	Stimulation of spermatogenesis	Fuse et al., 1999; Chia et al., 2000; Ali et al., 2005; Yuyan et al., 2007

TABLE 2. Mechanisms of Action of Metals as Endocrine Disruptors

Metals	Mechanisms of action	References
Cadmium	Bond with estrogen receptors	Garcia-Morales et al., 1994;
	Inhibition of transcription of the LDL-R	Jolibois et al., 1999b;
	Inhibition of $P450_{scc}$	Kawai et al., 2002
Mercury	Induction of 3 beta-hydroxysteroid dehydrogenase	Mondal et al., 1997
	Inhibition of the type I iodothyronine deiodinase	Barregård et al., 1994
Arsenic	Stimulation or inhibition of nuclear transcription activity mediated by several hormone receptors	Kaltreider et al., 2001
	Bond with estrogen receptors	Jana et al., 2006
Lead	Reduction of the expression of the steroidogenic acute regulatory protein (StAR)	Srivastava et al., 2004
	Inhibition of LH secretion	Srivastava et al., 2004; Ronis et al., 1996
	Increased lipid peroxidation in seminal plasma	Kapserczyk et al., 2008
	Increased ROS production	Hsu et al., 1998
Manganese	Activation of the soluble guanylyl cyclase (sGC) and of cGMP-PKG system	Prestifilippo et al., 2007; Lee et al., 2007
Zinc	Membrane-stabilizing activity	Aitken and Clarkson, 1987
	Antioxidant activity	
	Inhibition of DNAase	

Ivo Iavicoli , Luca Fontana & Antonio Bergamaschi (2009) The Effects of Metals as Endocrine Disruptors, Journal of Toxicology and Environmental Health, Part B: Critical Reviews, 12:3, 206-223, DOI: 10.1080/10937400902902062