

pain), and central and peripheral nervous system disorders. Chronic (long-term) inhalation exposure to inorganic arsenic in humans is associated with irritation of the skin and mucous membranes. Human data suggest a relationship between inhalation exposure of women working at or living near metal smelters and an increased risk of reproductive effects, such as spontaneous abortions. Inorganic arsenic exposure in humans by the inhalation route has been shown to be strongly associated with lung cancer, while ingestion of inorganic arsenic in humans has been linked to a form of skin cancer and also to bladder, liver, and lung cancer. We have classified inorganic arsenic as a Group A, human carcinogen.

5. Beryllium

Acute (short-term) inhalation exposure to high levels of beryllium has been observed to cause inflammation of the lungs or acute pneumonitis (reddening and swelling of the lungs) in humans; after exposure ends, these symptoms may be reversible. Chronic (long-term) inhalation exposure of humans to beryllium has been reported to cause chronic beryllium disease (berylliosis), in which granulomatous (noncancerous) lesions develop in the lung. Inhalation exposure to beryllium has been demonstrated to cause lung cancer in rats and monkeys. Human studies are limited, but suggest a causal relationship between beryllium exposure and an increased risk of lung cancer. Oral exposure to beryllium was found to cause stomach lesions in dogs, but effects on humans are not well-described. We have classified beryllium as a Group B1, probable human carcinogen, when inhaled; data are inadequate to determine whether beryllium is carcinogenic when ingested.

6. Cadmium

The acute (short-term) effects of cadmium inhalation in humans consist mainly of effects on the lung, such as pulmonary irritation. Chronic (long-term) inhalation or oral exposure to cadmium leads to a build-up of cadmium in the kidneys that can cause kidney disease. Cadmium has been shown to be a developmental toxicant in animals, resulting in fetal malformations and other effects, but no conclusive evidence exists in humans. An association between cadmium inhalation exposure and an increased risk of lung cancer has been reported from human studies, but these studies are inconclusive due to confounding factors. Animal studies have

demonstrated an increase in lung cancer from long-term inhalation exposure to cadmium. We have classified cadmium as a Group B1, probable human carcinogen when inhaled; data are inadequate to determine whether cadmium is carcinogenic when ingested.

7. Chromium

Chromium may be emitted in two forms, trivalent chromium (chromium III) or hexavalent chromium (chromium VI). The respiratory tract is the major target organ for chromium VI toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing have been reported from acute exposure to chromium VI, while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Limited human studies suggest that chromium VI inhalation exposure may be associated with complications during pregnancy and childbirth, while animal studies have not reported reproductive effects from inhalation exposure to chromium VI. Human and animal studies have clearly established that inhaled chromium VI is a carcinogen, resulting in an increased risk of lung cancer. We have classified chromium VI as a Group A, human carcinogen by the inhalation exposure route. Oral exposure of humans to chromium VI has been reported to cause sores in the mouth, gastrointestinal effects, and elevated white blood cell counts. Animal studies of oral chromium VI exposure have reported testicular degeneration and fetal damage in mice and rats. Chromium IV is also a potent contact sensitizer, producing allergic dermatitis in previously-exposed humans. Data are inadequate to determine if chromium VI is carcinogenic by oral exposure.

Chromium III is much less toxic than chromium VI. The respiratory tract is also the major target organ for chromium III toxicity, similar to chromium VI. Chromium III is an essential element in humans, with a daily oral intake of 50 to 200 micrograms per day ($\mu\text{g/d}$) recommended for an adult. Data on adverse effects of high oral exposures of chromium III are not available for humans, but a study with mice suggests possible damage to the male reproductive tract. We have not classified chromium III for carcinogenicity.

8. Cobalt

Acute (short-term) exposure to high levels of cobalt by inhalation in humans and animals results in respiratory effects such as a significant decrease in ventilatory function, congestion, edema, and hemorrhage of the lung. Respiratory effects are also the major effects noted from chronic (long-term) exposure to cobalt by inhalation, with respiratory irritation, wheezing, asthma, pneumonia, and fibrosis noted. Cardiac effects, congestion of the liver, kidneys, and conjunctiva, and immunological effects have also been associated with cobalt inhalation in humans. Cobalt is an essential element in humans, as a constituent of vitamin B12, but excessive oral intake has been reported to damage the heart, and to cause gastrointestinal effects and contact dermatitis. Human and animal studies are inconclusive with respect to potential carcinogenicity of cobalt. We have not classified cobalt for carcinogenicity.

9. Mercury

Mercury exists in three forms: Elemental mercury, inorganic mercury compounds (primarily mercuric chloride), and organic mercury compounds (primarily methylmercury). Each form exhibits different health effects. Brick, structural clay products, and clay ceramics manufacturing may release elemental or inorganic mercury, but not methylmercury. However, elemental and inorganic mercury are deposited on surface water, where they are converted to methylmercury, an important food contaminant.

Acute (short-term) exposure to high levels of elemental mercury in humans results in central nervous system (CNS) effects such as tremors, mood changes, and slowed sensory and motor nerve function. High inhalation exposures can also cause kidney damage and effects on the gastrointestinal tract and respiratory system. Chronic (long-term) inhalation exposure to elemental mercury in humans also affects the CNS, with effects such as increased excitability, irritability, excessive shyness, and tremors. Data on toxic effects of oral exposure to elemental mercury are sparse. We have not classified elemental mercury for carcinogenicity.

Acute exposure to inorganic mercury by the oral route may result in effects such as nausea, vomiting, and severe abdominal pain. The major effect from chronic exposure, either oral or inhalation, to inorganic mercury is kidney damage. Reproductive and developmental animal studies have reported effects such as alterations in