# Uranium

CAS No. 7440-61-1

### General Information

Uranium is a silver-white, extremely dense, and weakly radioactive metal. It is typically extracted from ores containing less than 1% natural uranium. Natural uranium is a mixture of three isotopes: $^{238}$U (99.2739%), $^{235}$U (0.7204%), and $^{234}$U (0.0057%). It usually occurs as an inorganic compound with oxygen, chlorine, or other elements. Uranium has many commercial uses, including its use in nuclear weapons, nuclear fuel, in some ceramics, and as an aid in electron microscopy and photography. Depleted uranium (DU) refers to uranium in which the proportion of $^{235}$U and $^{234}$U isotopes have been reduced, compared with the proportion in natural uranium. DU is used in the production of armor-piercing projectiles.

Human exposure to uranium occurs primarily in the workplace by inhaling dust and other small particles. Exposure to insoluble uranium oxides and uranium metal via inhalation results in retention of these forms of uranium in the lungs and other tissues with little excretion in the urine. Soluble forms of uranium salts are poorly absorbed in the gastrointestinal tract, but these small amounts can be reflected in urinary measurements. Some uranium can be absorbed from food and water, especially in areas where large amounts of uranium occur naturally. Soluble uranium compounds may exhibit some dermal absorption. Exposure to DU can occur after internal contact with DU-containing shrapnel or dust.

After absorption, soluble uranium is predominantly distributed to the kidneys and the bones. Approximately 50% of uranium is eliminated in the urine within the first

### Table 30. Uranium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2002.

| | Survey years | Geometric mean (95% conf. interval) | Selected percentiles (95% confidence interval) | | | | Sample size |
|---|---|---|---|---|---|---|---|
| | | | 50th | 75th | 90th | 95th | |
| **Total, age 6 and older** | 99-00 | **.008** (.007-.009) | **.007** (.006-.007) | **.013** (.010-.016) | **.026** (.021-.038) | **.046** (.036-.054) | 2464 |
| | 01-02 | **.009** (.007-.010) | **.008** (.006-.009) | **.014** (.011-.016) | **.029** (.022-.037) | **.046** (.034-.062) | 2690 |
| **Age group** | | | | | | | |
| 6-11 years | 99-00 | **.009** (.007-.011) | **.007** (.005-.007) | **.013** (.009-.019) | **.032** (.018-.048) | **.046** (.033-.066) | 340 |
| | 01-02 | **.008** (.007-.010) | **.008** (.006-.010) | **.014** (.010-.020) | **.025** (.020-.036) | **.037** (.025-.049) | 368 |
| 12-19 years | 99-00 | **.009** (.008-.011) | **.009** (.008-.010) | **.014** (.012-.018) | **.025** (.020-.043) | **.043** (.028-.072) | 719 |
| | 01-02 | **.010** (.008-.012) | **.009** (.008-.012) | **.017** (.012-.023) | **.030** (.021-.042) | **.041** (.027-.088) | 762 |
| 20 years and older | 99-00 | **.008** (.006-.009) | **.007** (.005-.008) | **.012** (.009-.016) | **.026** (.021-.038) | **.045** (.035-.054) | 1405 |
| | 01-02 | **.009** (.007-.010) | **.007** (.006-.009) | **.014** (.011-.016) | **.030** (.022-.039) | **.046** (.034-.059) | 1560 |
| **Gender** | | | | | | | |
| Males | 99-00 | **.009** (.008-.011) | **.007** (.007-.010) | **.015** (.012-.020) | **.036** (.024-.046) | **.053** (.040-.067) | 1227 |
| | 01-02 | **.009** (.008-.011) | **.008** (.007-.010) | **.014** (.012-.019) | **.033** (.023-.043) | **.046** (.035-.065) | 1335 |
| Females | 99-00 | **.007** (.006-.008) | **.006** (.005-.007) | **.011** (.009-.014) | **.023** (.016-.032) | **.035** (.026-.050) | 1237 |
| | 01-02 | **.008** (.007-.010) | **.008** (.006-.009) | **.013** (.011-.016) | **.027** (.018-.037) | **.040** (.029-.062) | 1355 |
| **Race/ethnicity** | | | | | | | |
| Mexican Americans | 99-00 | **.017** (.012-.023) | **.015** (.011-.021) | **.032** (.019-.053) | **.059** (.040-.127) | **.113** (.054-.279) | 883 |
| | 01-02 | **.013** (.010-.016) | **.011** (.009-.015) | **.022** (.016-.027) | **.039** (.031-.054) | **.054** (.045-.067) | 683 |
| Non-Hispanic blacks | 99-00 | **.009** (.007-.011) | **.007** (.006-.010) | **.013** (.010-.019) | **.028** (.018-.045) | **.049** (.030-.067) | 568 |
| | 01-02 | **.008** (.007-.009) | **.007** (.007-.009) | **.012** (.010-.013) | **.020** (.017-.027) | **.030** (.023-.037) | 667 |
| Non-Hispanic whites | 99-00 | **.007** (.006-.009) | **.007** (.005-.007) | **.012** (.008-.014) | **.023** (.016-.033) | **.041** (.027-.051) | 822 |
| | 01-02 | **.008** (.007-.009) | **.006** (.006-.008) | **.012** (.010-.014) | **.026** (.018-.034) | **.036** (.028-.049) | 1132 |

24 hours after exposure. Following exposure to soluble uranium salts, the initial half-life of uranium is considered to be about 15 days (Bhattacharyya et al., 1992), representing distribution and excretion, with a much slower elimination from bone. After inhalation exposure of insoluble uranium, the half-life for disappearance from the lung is several years (Durakovic et al., 2003).

Health effects from uranium exposure occur from chemical toxicity. Radiation risks from exposure to natural uranium are very low. Nephrotoxicity, the primary toxic effect attributed to chronic uranium exposure in people, manifests as tubular damage and appears reversible with decreasing exposure. Workplace air standards for external exposure to soluble and insoluble uranium compounds have been established by OSHA and ACGIH. Although older evaluations suggested the carcinogenicity of uranium among smokers, the U.S. EPA has withdrawn its classification for carcinogenicity; IARC and NTP have no ratings.

Information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at http://www.epa.gov/iris and from ATSDR's Toxicological Profiles at http://www.atsdr.cdc.gov/toxprofiles.

### Interpreting Levels of Urinary Uranium Reported in the Tables

Urine uranium levels were measured in a subsample of NHANES participants aged 6 years old and older. Participants were selected within the specified age range to be a representative sample of the U.S. population. The analytical method measures only levels of the $^{238}U$ isotope and not levels of the $^{235}U$ isotope ($^{235}U$ is higher in enriched uranium used as nuclear fuel). More than 99% of naturally occurring uranium is $^{238}U$.

A previous nonrandom subsample from NHANES III (n = 499) showed concentrations that are essentially similar to those in this *Report* (Ting et al., 1999). Dang et

## Table 31. Uranium (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2002.

| | Survey years | Geometric mean (95% conf. interval) | Selected percentiles (95% confidence interval) | | | | Sample size |
|---|---|---|---|---|---|---|---|
| | | | 50th | 75th | 90th | 95th | |
| **Total, age 6 and older** | 99-00 | **.007** (.006-.009) | **.007** (.006-.009) | **.013** (.010-.016) | **.024** (.019-.030) | **.034** (.027-.053) | 2464 |
| | 01-02 | **.008** (.007-.010) | **.007** (.006-.009) | **.014** (.011-.018) | **.026** (.020-.033) | **.040** (.028-.054) | 2689 |
| **Age group** | | | | | | | |
| 6-11 years | 99-00 | **.009** (.007-.012) | **.008** (.006-.010) | **.015** (.010-.024) | **.030** (.016-.044) | **.037** (.030-.077) | 340 |
| | 01-02 | **.010** (.008-.011) | **.010** (.008-.012) | **.015** (.013-.019) | **.027** (.018-.032) | **.033** (.027-.048) | 368 |
| 12-19 years | 99-00 | **.007** (.006-.008) | **.006** (.005-.008) | **.010** (.009-.014) | **.020** (.014-.030) | **.030** (.019-.074) | 719 |
| | 01-02 | **.007** (.006-.008) | **.007** (.006-.008) | **.012** (.009-.016) | **.020** (.014-.026) | **.026** (.020-.042) | 762 |
| 20 years and older | 99-00 | **.007** (.006-.009) | **.007** (.005-.008) | **.013** (.010-.016) | **.024** (.019-.029) | **.034** (.025-.051) | 1405 |
| | 01-02 | **.008** (.007-.010) | **.007** (.006-.009) | **.014** (.011-.019) | **.027** (.020-.039) | **.043** (.030-.063) | 1559 |
| **Gender** | | | | | | | |
| Males | 99-00 | **.007** (.006-.009) | **.006** (.005-.008) | **.011** (.009-.015) | **.021** (.017-.028) | **.035** (.024-.056) | 1227 |
| | 01-02 | **.007** (.006-.008) | **.007** (.006-.008) | **.012** (.010-.015) | **.022** (.018-.028) | **.033** (.025-.047) | 1334 |
| Females | 99-00 | **.008** (.007-.010) | **.007** (.006-.009) | **.013** (.010-.017) | **.024** (.019-.033) | **.034** (.027-.054) | 1237 |
| | 01-02 | **.009** (.008-.011) | **.009** (.007-.011) | **.016** (.012-.021) | **.029** (.021-.042) | **.045** (.031-.067) | 1355 |
| **Race/ethnicity** | | | | | | | |
| Mexican Americans | 99-00 | **.015** (.011-.022) | **.015** (.011-.020) | **.028** (.016-.058) | **.059** (.027-.146) | **.100** (.042-.270) | 883 |
| | 01-02 | **.012** (.010-.016) | **.012** (.009-.016) | **.021** (.015-.028) | **.033** (.024-.053) | **.049** (.033-.077) | 682 |
| Non-Hispanic blacks | 99-00 | **.006** (.004-.007) | **.005** (.004-.006) | **.008** (.006-.013) | **.017** (.011-.028) | **.028** (.018-.048) | 568 |
| | 01-02 | **.005** (.005-.006) | **.005** (.005-.006) | **.008** (.007-.010) | **.013** (.011-.014) | **.017** (.014-.029) | 667 |
| Non-Hispanic whites | 99-00 | **.007** (.006-.009) | **.007** (.006-.009) | **.012** (.010-.015) | **.021** (.017-.027) | **.030** (.024-.050) | 822 |
| | 01-02 | **.008** (.007-.009) | **.007** (.006-.009) | **.013** (.011-.016) | **.025** (.018-.032) | **.034** (.025-.051) | 1132 |

al. (1992), Karpas et al. (1996), and Galletti (2003) reported urinary levels for small groups of normal individuals in a range similar to those values seen in both the 1999-2000 and 2001-2002 subsamples. In addition, other studies have demonstrated urinary uranium concentrations that are consistent with levels documented in this *Report*, in that the reported levels were below their respective detection limits (Hamilton et al., 1994; Komaromy-Hiller et al., 2000; Byrne et al., 1991).

In one study, 105 people exposed to well water containing natural uranium in the range of 1.8 to 7770 μg/L (median 157 μg/L) had urinary levels of uranium as high as 9.55 μg/L (median 0.162 μg/L)(Orloff et al., 2003). Eighty-five percent of the levels were above the 95$^{th}$ percentile of the NHANES 1999-2000 subsample. In another study of people drinking well water with high natural uranium concentrations, the median urinary concentration was 0.078 μg/L (ranging up to 5.65 μg/L), and a subtle effect of uranium on calcium and phosphate fractional clearance was indicated (within the normal range of these measures), but without effects on other biochemical or traditional markers of renal function (Kurttio et al., 2002). The urinary uranium levels reported here for the NHANES 2001-2002 subsample are well below any of these aforementioned levels.

The U.S. Nuclear Regulatory Commission (U.S. NRC) has set an action level of 15 μg/L for uranium in urine to protect people who are occupationally exposed to uranium (U.S. NRC, 1978). Six workers in a depleted uranium program had concentrations of 0.110 to 45 μg/L (Ejnik et al., 2000). Several recent studies have investigated urinary uranium levels in veterans who served during the 1991 Gulf War. In one study, 17 soldiers with embedded shrapnel had a median urinary uranium concentration of 2.61 μg/g creatinine and 28 soldiers who may have been exposed to DU by inhalation, ingestion, or wound contamination, but in whom no shrapnel was embedded, had a mean urinary uranium concentration of 0.066 μg/g creatinine (Gwiazda et al., 2004). In a much larger study of a group of 446 Gulf War veterans who were concerned about past exposure to DU, the geometric mean urinary uranium concentration was 0.011 μg/L (McDiarmid, et al., 2004).

### Comparing Adjusted Geometric Means

Geometric mean levels of urinary uranium for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, log serum cotinine, and urinary creatinine (data not shown). In NHANES 2001-2002, adjusted geometric mean levels of urinary uranium in the group aged 6-11 years were higher than the groups aged 12-19 years. Mexican Americans had higher levels than either non-Hispanic blacks or non-Hispanic whites, and non-Hispanic whites had higher levels than non-Hispanic blacks. Females had slightly higher adjusted geometric mean levels of urinary uranium than males. It is unknown whether these differences associated with age, gender, or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

Finding a measurable amount of uranium in urine does not mean that the level of uranium causes an adverse health effect. Whether uranium at the levels reported here is cause for health concern is unknown; more research is needed. These urinary uranium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of uranium than are found in the general population. These data will also help scientists plan and conduct research about uranium exposure and health effects.

## Figure 13. Uranium (creatinine corrected)

Selected percentiles with 95% confidence intervals of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2002.