# Biomonitoring: Frequently Asked Questions

## What is biomonitoring?

Biomonitoring is the measurement of specific substances in the human body, usually through the analysis of blood, urine, breast milk and tissue samples. Typically, biomonitoring studies rely on informed volunteers to provide samples of fluid or tissue at a single point in time. Samples are then analyzed to measure trace concentrations of a predetermined set of naturally occurring and/or manmade substances that may be present. The detection of a substance simply indicates that an exposure may have taken place prior to obtaining the sample.

## How do chemical substances enter our bodies?

The human body is made of thousands of chemical substances, many of which – vitamins, nutrients, proteins and hormones – are essential to life. While some of these chemicals are generated within our bodies, others are absorbed through eating, drinking, breathing and skin contact.

Throughout our lives, humans and other organisms are continually exposed to substances in our environments, both naturally occurring (from air, water and soil or produced by plants, animals and natural events, such as forest fires and volcanoes) and manmade (pharmaceuticals, soaps, disinfectants, etc.)

Although scientists have long understood that our bodies absorb substances from our environments, today's technology allows researchers to detect and measure extraordinarily low levels in human samples

## Exactly what is measured in a biomonitoring study?

Biomonitoring researchers analyze samples of human fluids and tissues to study the physical evidence of an exposure to a particular substance. Evidence may include (1) trace concentrations of the substance itself, (2) the presence of metabolites, or chemicals formed as the original substance is broken down and processed for elimination, and (3) indications that an exposure has had some measurable change on a cellular or other biological process, such as increased enzyme levels.

## Why are biomonitoring data important?

Before biomonitoring technology was developed, scientists could only roughly estimate the potential for human exposure using measurements of substances detected in air, water, soil and food. Today, biomonitoring studies can verify that an exposure has taken place.

## What do biomonitoring data tell us about human exposure?

Biomonitoring measures concentrations of substances in a body fluid or tissue at a specific point in time. In the vast majority of instances, these data allow scientists to verify that an environmental exposure occurred at some point prior to obtaining a sample.

However, the human body, through normal metabolic processes, produces certain substances, which *also* exist in the environment. A few better-known examples include formaldehyde and acetone. In such instances, the detection of a substance in body tissues or fluids is not necessarily an indication of an environmental exposure.

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### What do biomonitoring data tell us about *levels* of exposure?

Biomonitoring data can only *quantify* exposure if the relationship between the amount of a substance with which a person comes into contact and concentrations of that substance (or its metabolites) in the human body can be established. Converting biomonitoring data into meaningful estimates of exposure requires additional studies of exposure, such as the contact between an individual and a concentration of a substance over a defined period of time as well as the interaction of that substance within the body (e.g. absorption, distribution, metabolism and excretion).

### What are the limitations of biomonitoring data?

While biomonitoring data can confirm the occurrence of an exposure, they do not provide information about:

- The source(s) of an exposure: *Was the person exposed through diet, air, medical treatment, pollution, etc.?*

- How long a substance has been in the body: *Was it a single large exposure, multiple smaller exposures or a combination? Did the exposure(s) occur recently or back in time?*

- What effect, if any, a substance may have on human health: *What are the potential health effects? Are they positive or negative? At what levels or concentrations would you expect to see changes in health?*

### How do biomonitoring data help scientists evaluate risks to human health?

Assessing risk is an extremely complex scientific process that requires input from multiple areas of expertise. There are four major components of a scientific risk assessment:

- Hazard Identification: A description of the potential health effects associated with a particular substance.

- **Exposure Assessment: Estimations of the quantity of a substance that has come into contact with the body over a defined period of time. This includes measurements or estimations of the intensity, frequency and duration of exposure to a substance.**

- Dose-Response Assessment: A determination of the relationship between a dose of a substance and a specific biological response.

- Risk Characterization: The integration of all previous components to estimate the incidence of health effects due to exposure under a defined set of conditions.

By confirming that an exposure has occurred, biomonitoring data take some of the guesswork out of the Exposure Assessment phase of a scientific risk evaluation. But in addition to biomonitoring data, an Exposure Assessment often includes information about the most likely route of exposure (e.g., air, food, water, skin), the concentrations of substances in these media, and how our bodies absorb, metabolize, and excrete these substances.

Although biomonitoring studies alone do not constitute a complete picture of risk, they are a very important contributor to the scientific risk assessment process.

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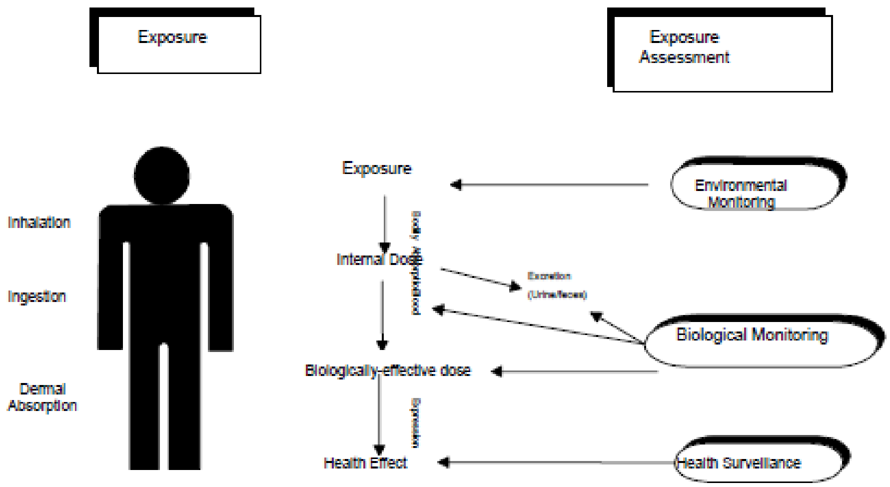
The following diagram illustrates the role of biomonitoring data in an Exposure Assessment.[1]




Adapted from Barr *et al.*, 1999

**What are some of the established uses for biomonitoring data?**

There are several important uses for this type of information. For instance, in 2001, the CDC began an ongoing human biomonitoring study to better understand background levels of substances in the general U.S. population. CDC publishes the results of this program in each edition of its *National Report on Human Exposure to Environmental Chemicals*. This research is helping CDC and other scientists to:

• Establish average exposure levels among Americans;

• Establish and compare biomonitoring data across subgroups by age, sex and ethnicity;

• Measure trends in exposure over time;

• Set priorities for additional research; and

• Verify the efficacy of selected pollution controls and other public health policy measures.

For example, by monitoring human levels of cotinine – a metabolite of nicotine – the CDC has been able to document reductions in exposure to environmental tobacco smoke in the general U.S. population, confirming that smoking controls have been effective in reducing exposure to nicotine.

As biomonitoring technology continues to advance, more information is being made available to help scientists and policy makers enhance public health.

[1] Barr, D.B. *et al*. 1999. Strategies for Biological Monitoring of Exposure for Contemporary-use Pesticides. *Toxicol Ind Health 1999 Jan-Mar; 15(1-2):168-79*

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**Should people be concerned when biomonitoring studies measure chemicals that have not been previously detected?**

As biomonitoring technology continues to progress, scientists are able to detect greater numbers of chemical substances and to measure them at smaller and smaller concentrations in the body. So the measurement and reporting of a particular chemical for the first time does *not* necessarily mean the chemical is new to our bodies or that our levels of exposure are increasing. Often it simply means that scientists have developed better analytical methods for studying human exposures.

Today, scientists are able to measure chemicals at trace concentrations as small as parts per million, parts per billion, and even parts per trillion.

CDC's *National Report on Human Exposure to Environmental Chemicals* typically reports measurements in units of micrograms per liter, often expressed as µg/L. One microgram equals one millionth of a gram. One microgram per liter of liquid equals a concentration of one part per billion (ppb).

**One microgram/liter (µg/L) equals one part per billion (ppb):**

- One drop of food dye in 16,000 gallons of water
- One ounce of sugar in 7,813,000 gallons of Kool-Aid
- One inch of 16,000 miles
- 1/32,000 of an inch of a 100-yard-long football field
- One second in 32 years
- One penny of $10,000,000

**What are some practical applications of biomonitoring data?**

In cases where supplemental information is available, scientists and policy makers have been able to draw meaningful conclusions that help protect public health. For example, research associating breath levels of alcohol with driving impairments has led to laws that have effectively reduced drunk-driving accidents. And research into the adverse effects on children of lead additives in gasoline has led to the elimination of such additives. In both these examples, the biomonitoring measurements can be interpreted with a high degree of scientific certainty because research has established the relationship among (1) external exposure (i.e., the concentration in the media at the point of contact), (2) the concentration in blood for lead (or breath for alcohol), (3) the internal dose (the concentration at a particular site) and (4) the response of the target tissue or cells to the internal dose.

As biomonitoring studies and supporting research continue to advance, the relationships between exposure assessment and risk analysis will grow stronger and more meaningful for larger numbers of substances.

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**Why are certain chemicals selected in biomonitoring studies, but not others?**

There are several factors that affect scientists' decisions regarding which chemicals to study. Some of the more obvious factors include scientific interest in a particular substance and the need to gauge the effectiveness of pollution controls or other public health measures, such as smoking restrictions. But there are other important factors to consider:

- Availability of biomonitoring methods. In many ways, biomonitoring involves the implementation of relatively new technologies. At present, the number of chemicals of interest to scientists far exceeds the number of chemicals for which biomonitoring technologies are currently available. But scientists are continually developing new methods to study chemicals. One chemical might be studied, while another chemical of equal or greater interest is not, simply because scientists have not yet developed an analytical technique for all chemicals.

- Cost. The equipment, sampling and laboratory analysis for well-designed, quality-controlled biomonitoring studies can be extremely costly. Based on the sampling and biomonitoring methods being deployed, specific chemicals are sometimes added to biomonitoring studies as a cost-effective way to leverage the research dollars of an existing study.

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