Body Burden of Toxicants

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Definition:

The total amount of chemicals/toxicants that are stored in the body at a given point in time is called the **body burden.**

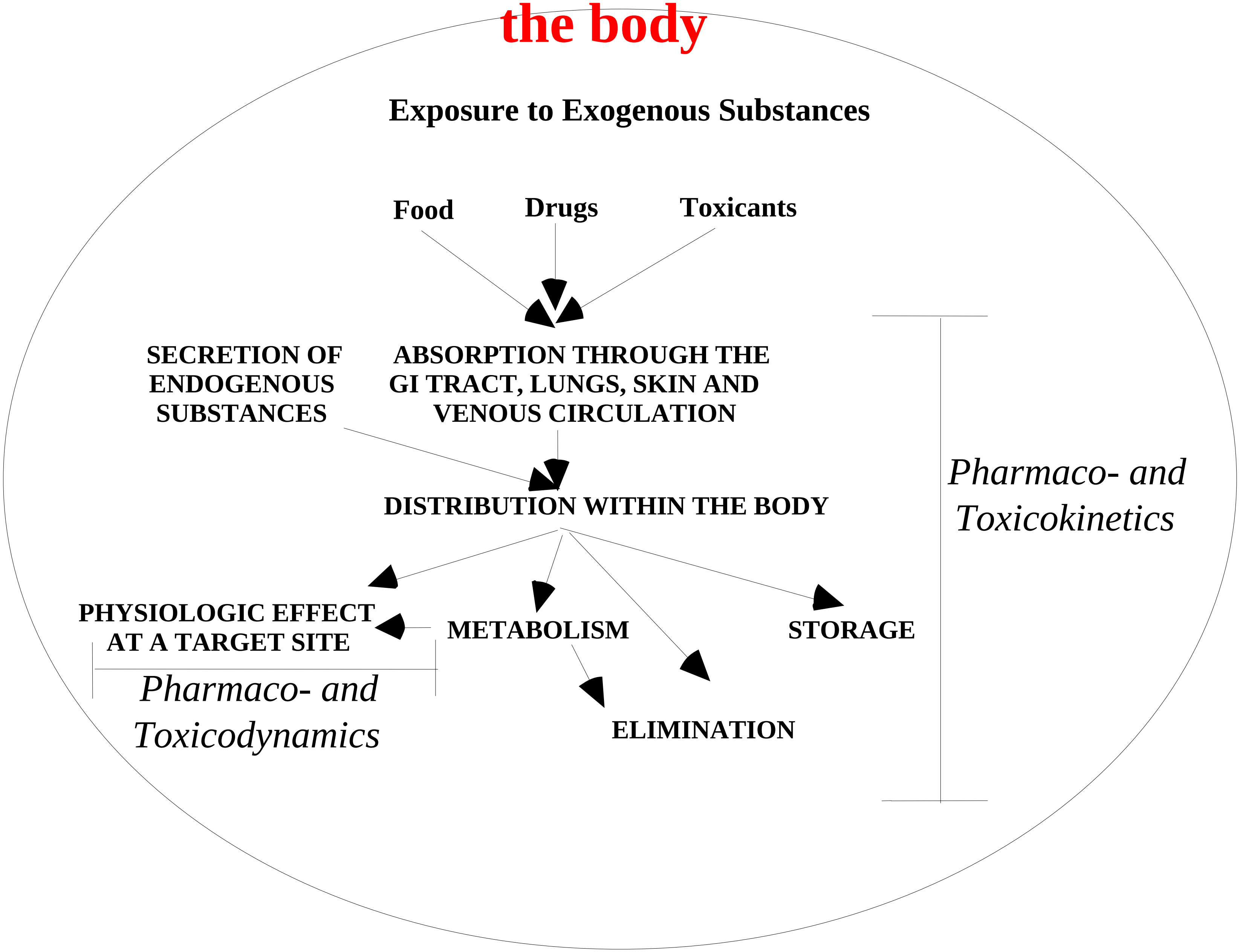
When the body's detoxification system is insufficient to remove the toxic chemicals from the body, then the toxicants will not be excreted, but instead will be stored in different components of the body viz. fat, semen, breast milk, muscles, bones, brain, liver and other organs thus leading to **body burden**.

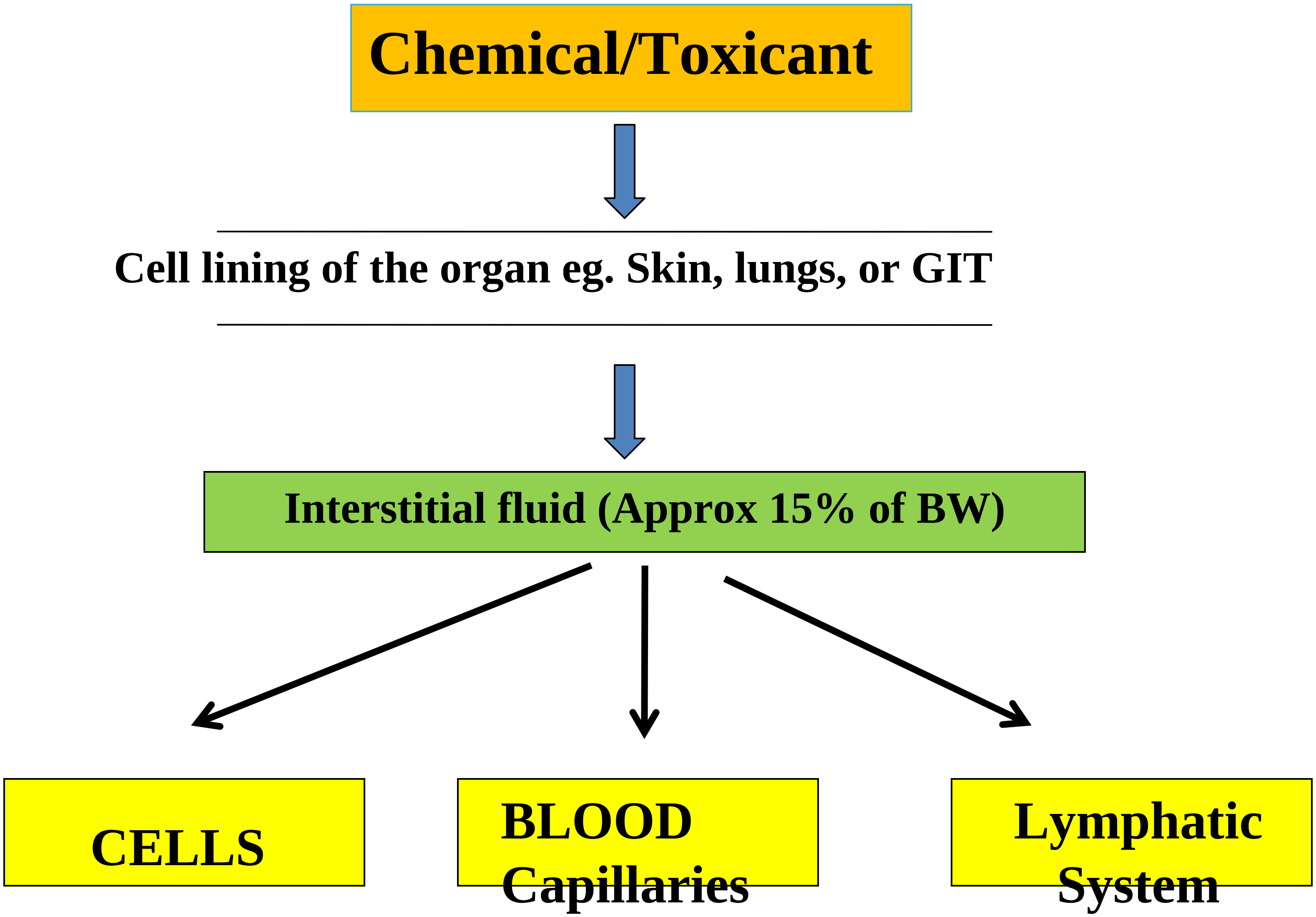
It is reported that everyone alive today is contaminated with at least 700 toxic chemicals in their bodies. It doesn’t matter whether the person is occupationally exposed or not, where he lives, just being on this planet, every body is contaminated.

Various chemicals move through the body at different rates.

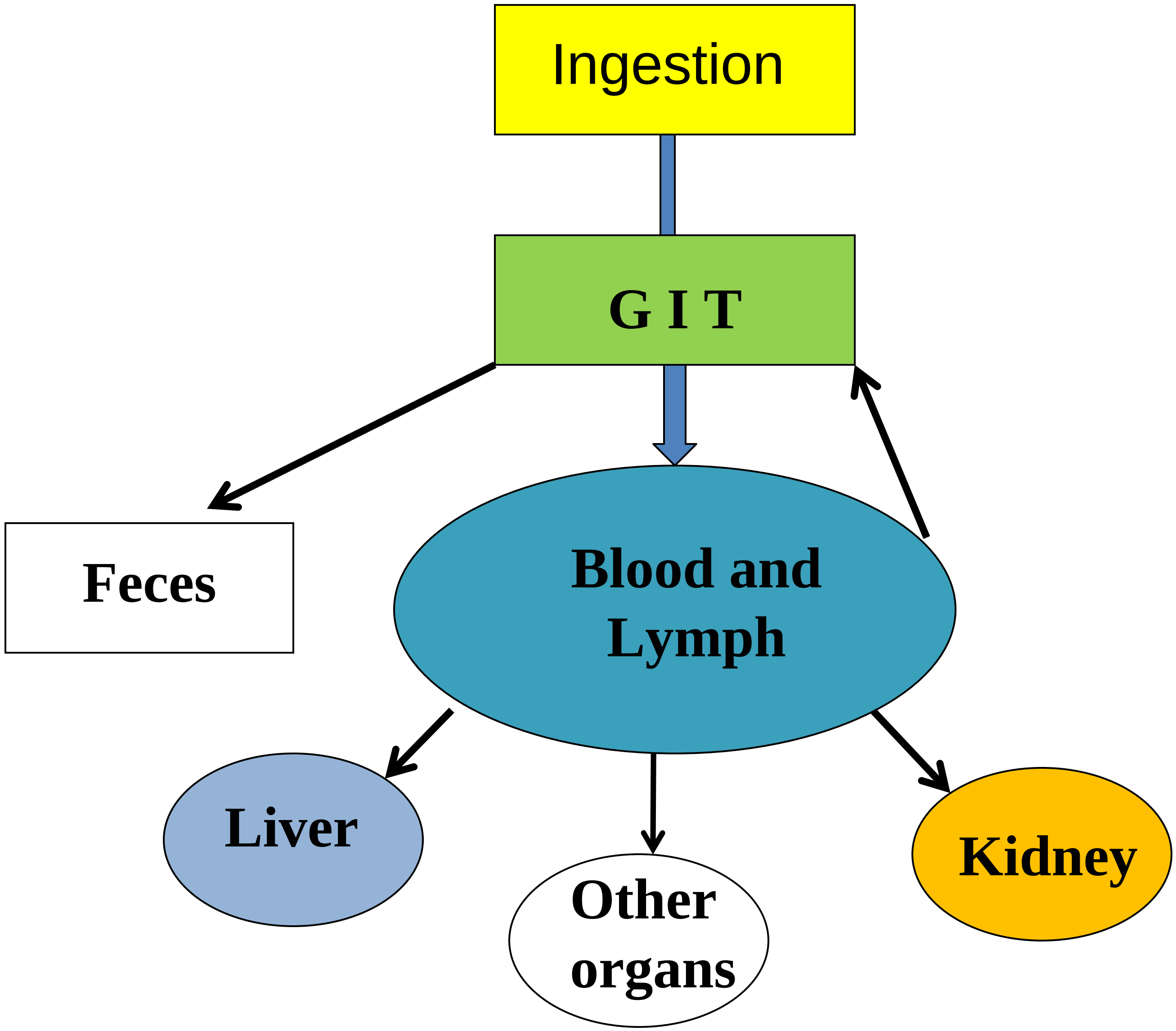
The removal of chemicals from the body depends on the efficiency of body’s detoxification system and the amount of toxic chemicals the person is exposed to.

The cycle of Exposure to toxicants and distribution in the body

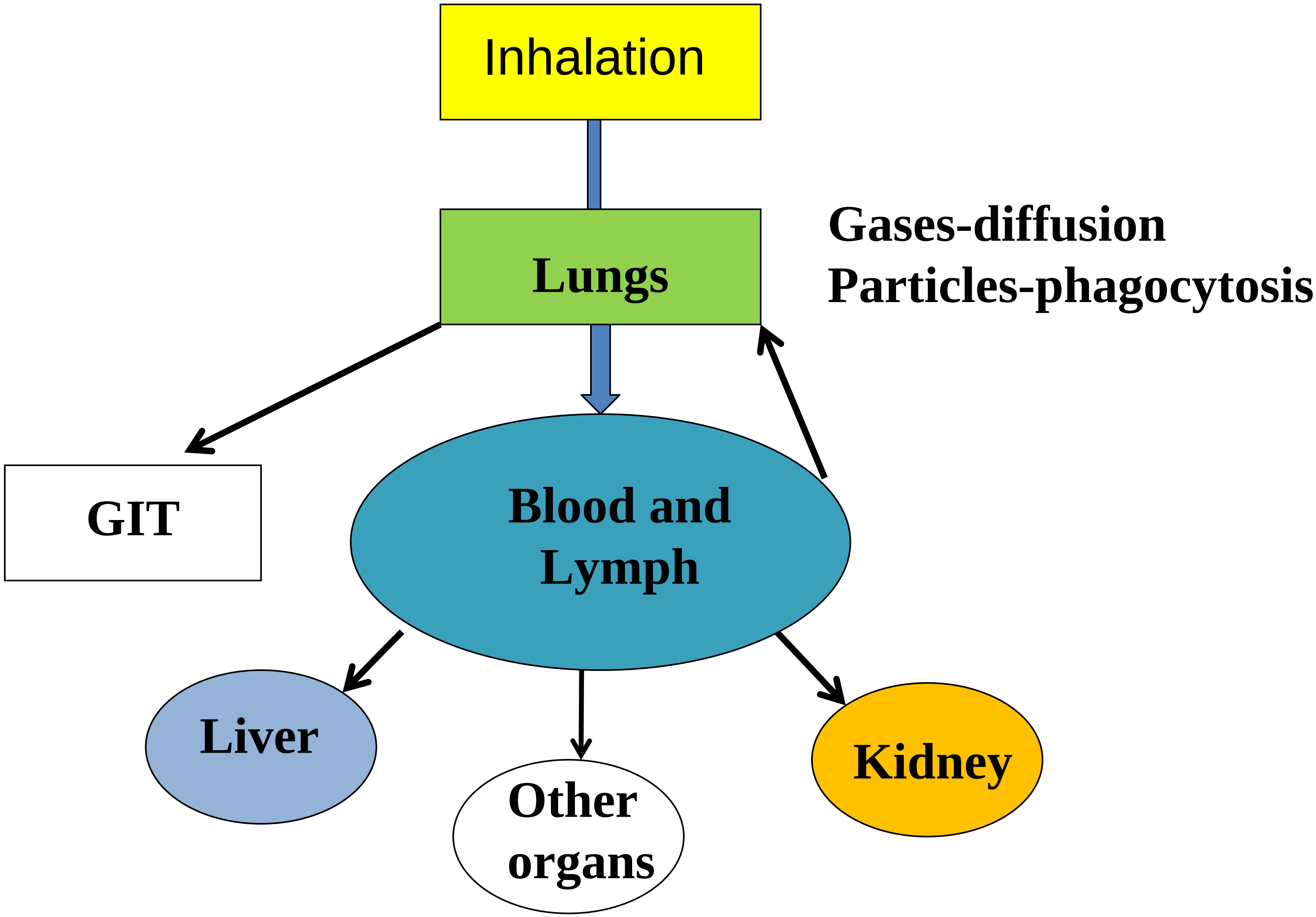




Route of distribution of a chemical after exposure



Absorption, distribution and excretion of a toxicant administered through oral route



Absorption, distribution and excretion of a toxicant administered through inhalation route

Factors affecting the Body burden of a chemical

1. Absorption
2. Distribution
3. Biotransformation
4. Excretion

Absorption:

The rate of absorption determines the time of onset and the degree of toxicity. It mainly depends on the route of exposure viz. Intravenous> inhalation> oral> dermal

Volume of distribution

The plasma level of a chemical is important since it generally reflects the concentration of the toxicant at the site of action. The passive diffusion of the toxicant into or out of these body fluids is determined mainly by the toxicant's concentration gradient. The total volume of body fluids in which a toxicant is distributed is known as the apparent volume of distribution (VD), expressed in liters.

Volume of distribution (VD) is calculated by

VD = dose (mg) / plasma concentration (mg/L)

Body burden (mg) = plasma conc. (mg/L)/ VD (L)

Storage of toxicants

The primary sites for toxicant storage are adipose tissue, bone, liver and kidneys.

Lipid-soluble toxicants are often stored in adipose tissues

Lead and strontium may be substituted for Ca and deposited in bones

The liver is a storage site for some toxicants. It has a large blood flow and its hepatocytes contain proteins that bind to some chemicals, including toxicants.

As with the liver, the kidneys have a high blood flow, which preferentially exposes these organs to toxicants in high concentrations. Storage in the kidneys is associated primarily with the cells of the nephron .

Comparison of lead contents in human body during historical times Vs. today

An examination of lead in the bones of Peruvians buried 1600 years ago revealed that the bone lead levels in Peruvians was 1000 time lesser than the lead levels found in the bones of present day residents of the United Kingdom and the United States.

Biomonitoring:

Biomonitoring is the measurement of the **body burden** of toxic chemical compounds, elements, or their metabolites, in biological substances. Often, these measurements are done in blood and urine.

Since 2001, the National Center for Environmental Health (NCEH) at the Centers for Disease Control and Prevention (CDC) has started to assess U.S. population's exposure to environmental chemicals by Biomonitoring. The results also help scientists learn about the general population's exposure to certain chemicals.

The Fourth National Report on Human Exposure to Environmental Chemicals is the most comprehensive assessment to date of the exposure of the U.S. population to chemicals in our environment, with 212 chemicals measured in about 2400 people.

According to the report, some of chemicals found in the body of Americans are:

Polybrominated diphenyl ethers, Bisphenol A, perfluorooctanoic acid (PFOA) found in the serum of nearly all of the participants. These chemicals are used in the daily use products like fire retardants, polycarbonate bottles, non-stick coating on the utensils etc.

USEPA biopsies of human fat show the presence of:

Chemicals/toxicants	Sources
Polychlorinated biphenyls (PCBs)	carbonless copy paper, dyes, fluorescent light ballasts, inks, paints, pesticides, plastics
Styrene	styrofoam coffee cups and takeout food containers.
Dichlorobenzene	air fresheners, mothballs, and toilet-deodorizer blocks
Xylene	gasoline, paint varnish, shellac, rust preventatives, permanent markers and cigarette smoke
Dioxins	milk and dairy products, beef, fish, pork, poultry and eggs

Half-Life

Half-life (**$t_{1/2}$**) is the time required for a quantity to fall to half its value as measured at the beginning of the time period.

Half life for a chemical in the body describes how fast half of that particular chemical is cleared from the body by various means of elimination.

The **Half-life** is a measure of how rapidly a steady-state concentration will be achieved during constant rate dosing, and conversely how rapidly the concentration will fall after cessation of exposure.

Toxicant	**Half-life in human body**
Elemental mercury	35-90 days
Lead	25 years
Arsenic (inorganic)	10 hrs
Cadmium	6-38 years
Poly chlorinated bi phenyls PCB-170 PCB-153 PCB-180	 15.5 years 14.4 years 11.5 years
Chloropyrifos	1 hr
Dieldrin	267 days
Endrin	20 hrs
Alpha-Endosulfan Beta-Endosulfan	35 days 150 days

Mercury

Sources:

Coal based thermal power plants, chlor-alkali plants and paper pulp industry, electrical and electronic industry, healthcare sector.

Exposure:

Mercury vapours (elemental form) through inhalation.
Organic mercury through food chain

Toxicity of mercury

- Compounds of mercury tend to be much more toxic than the element itself, and organic compounds of mercury are often extremely toxic.
- Dimethylmercury, for example, is a potent neurotoxin that is lethal in amounts of a fraction of a milliliter.
- Mercury damages the central nervous system, endocrine system, kidneys, and other organs, mouth, gums, and teeth.
- Exposure over long periods of time or heavy exposure to mercury vapor can result in brain damage and death. Mercury and its compounds are particularly toxic to fetuses and infants.

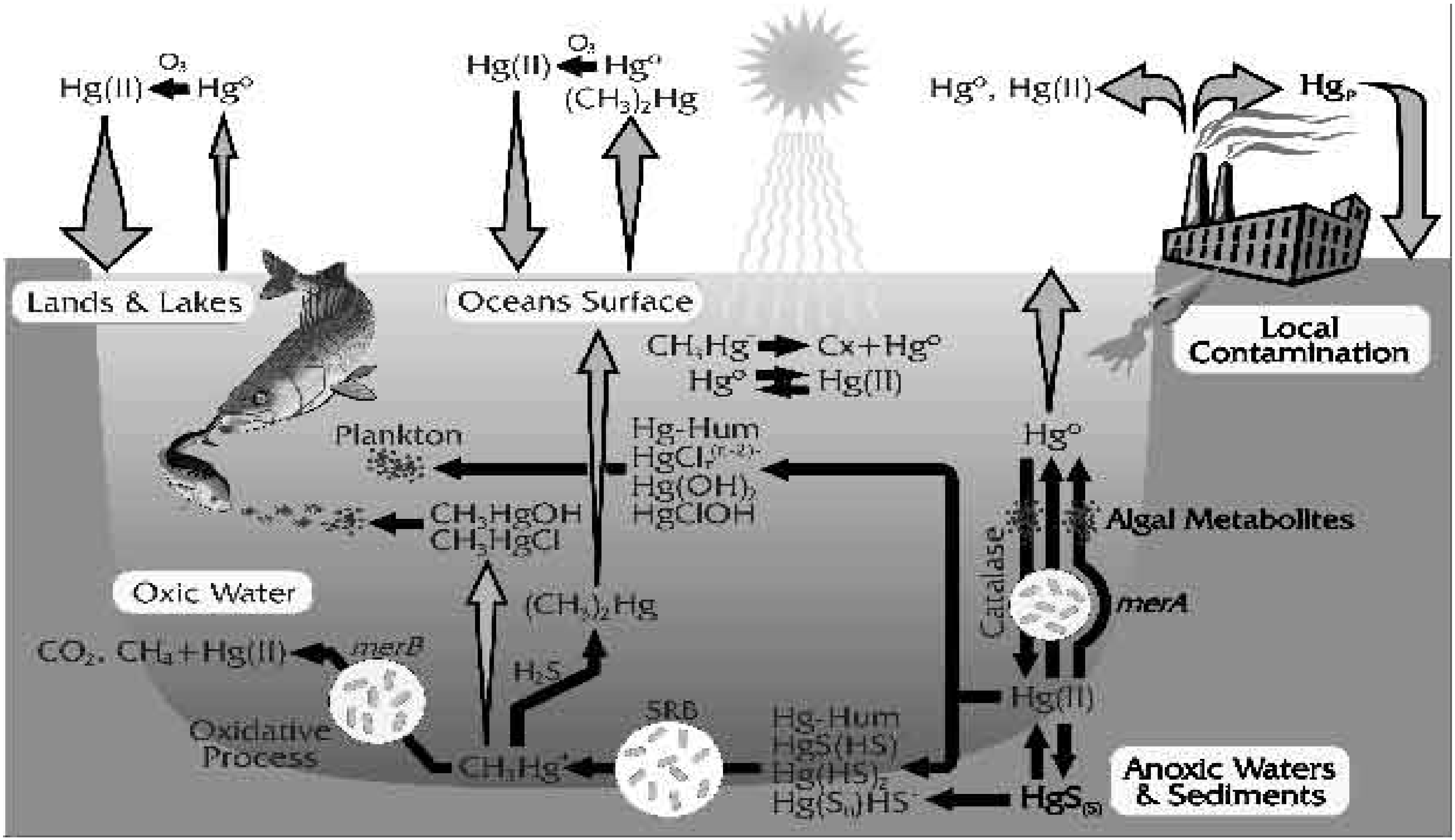
Some famous cases of Mercury poisoning

Minamata disease:

From 1932 to 1968 methyl mercury was released into the sea around the city of Minamata, Japan.

The toxin bioaccumulated in fish, which when eaten by the local population caused the largest case of mercury poisoning known as Minamata disease causing the death of over 1000 people and permanently disabled a great many more.

How Does the Hg Get Into the Fish?



Iraq Episode:

Another case of widespread mercury poisoning occurred in rural Iraq in 1971-1972, when grain treated with a methyl mercury-based fungicide was used by the rural population to make bread.

This resulted in the death of over 400 people.

Laboratory accident:

In December 1997, a chemistry professor, Karen Wetterhahn, at Dartmouth College was contaminated with dimethyl mercury when she spilled a drop on her latex glove. She revealed neurological symptoms, slipped into coma and died after a year even after chelation therapy.

Mercury contamination in Singrauli area:

IITR, Lucknow (formerly ITRC) undertook a study sponsored by NTPC in 1996-97 to monitor the mercury contamination in various compartments of the environment and found that:

- 66.3% of the subjects had mercury more than 5 ng/ml in blood as compared to 10.5% from control area.
- 47.9% subjects had more than 1 µg/g mercury in hair as compared to 24.5 % from control population.
- Only six samples of drinking water out of 40 samples collected from the region showed mercury more than the permissible limits (0.001 ppm)

- Out of 22 milk samples collected from the area, 19 showed mercury levels higher than the permissible levels of 3 μg/L.
- Some of the vegetable and fish samples from the area also showed higher mercury levels.
- Although many of the clinical symptoms were observed in the 1200 subjects from the area, none of them could be directly correlated to the mercury contamination.
- It was recommended that a more detailed study covering a larger population in the area is needed to get a in depth view on the problem.

Mercury contamination in Korba

In a Ministry of Environment & Forests sponsored study by IITR in 2007, following observations were made:

- Most of the 103 volunteers examined for their blood and urinary mercury levels showed higher levels than their control counterparts, but the levels were within the WHO permissible limits.
- Mercury levels in cereals and grains were also higher than those from the control area, but they were within the FDA permissible limits.
- Some of the water samples from the area had higher than the permissible limits of mercury.
- It was suggested that periodical monitoring of the environmental samples for mercury should be done considering the bioaccumulation property of the metal.

Cadmium

In 1940s and 50s cadmium mining in the Toyama Prefecture, Japan resulted in the release of this metal in the river. The rice fields were irrigated with water, rice absorbed heavy metals, especially the cadmium. The cadmium accumulated in the people eating contaminated rice.
Many people, specially post menopausal women, suffered from brittleness of the bones, anemia, kidney failure and ultimately died.

Factors altering the absorption of toxicants from GIT*

Cadmium	↓ **Zinc and copper**
Calcium	↓ **Cadmium**
Zinc	↓ **Copper**
Magnesium	↓ **Fluoride**
Milk	↑ **Lead**
Starvation	↑ **Dieldrin**
EDTA	↑ **Complex ions**

- Casarett & Doull's Toxicology (2001)


Thank You