

# Human relationship with mercury

Effects of Dietary Methylmercury  
on Human Health



環境省  
国立水俣病総合研究センター  
NIMD National Institute for Minamata Disease

# Type of Mercury

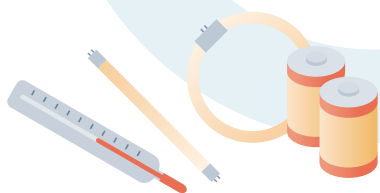
Mercury has been used in our lives in various applications. Mercury is roughly divided into 3 chemical forms: **metallic mercury**, **inorganic mercury** (inorganic mercury compounds), and **organic mercury**. **Methylmercury is the only organic mercury that is generated in the natural environment.**

\*Mercurochrome, a disinfectant, and mercury-based pesticides are also produced from man-made organic mercury, but mercury-based pesticides are no longer used.

**In natural, mercury is transformed as shown by the arrow.**

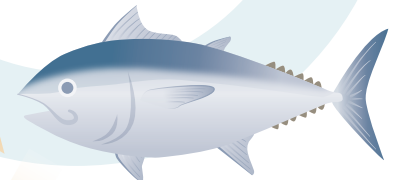
## Metallic mercury $\text{Hg}^0$

Metallic mercury is an easily vaporized liquid. It has been used for thermometers and fluorescent lamps. It has properties of dissolving gold and silver, and has also been used in dental amalgam (silver teeth using mercury), and artisanal and small-scale gold mining.



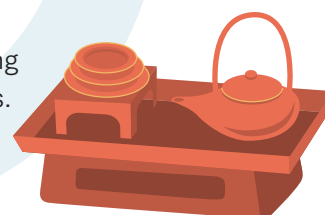
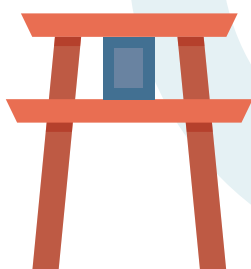
## Methyl mercury $\text{CH}_3\text{Hg}^+$

Methylmercury is produced little by little in the natural environment and accumulates in fishes, shellfishes, etc. It is the most toxic, and caused Minamata disease when it was discharged from a chemical factory in a large amount in the past.



## Inorganic mercury $\text{Hg}^{2+}$

Inorganic mercury compounds include mercuric oxide and mercuric sulfide. Among them, mercuric sulfide has been used since ancient times as a germicide. It also has been used as cinnabar pigment for painting of lacquers and shrine gates.



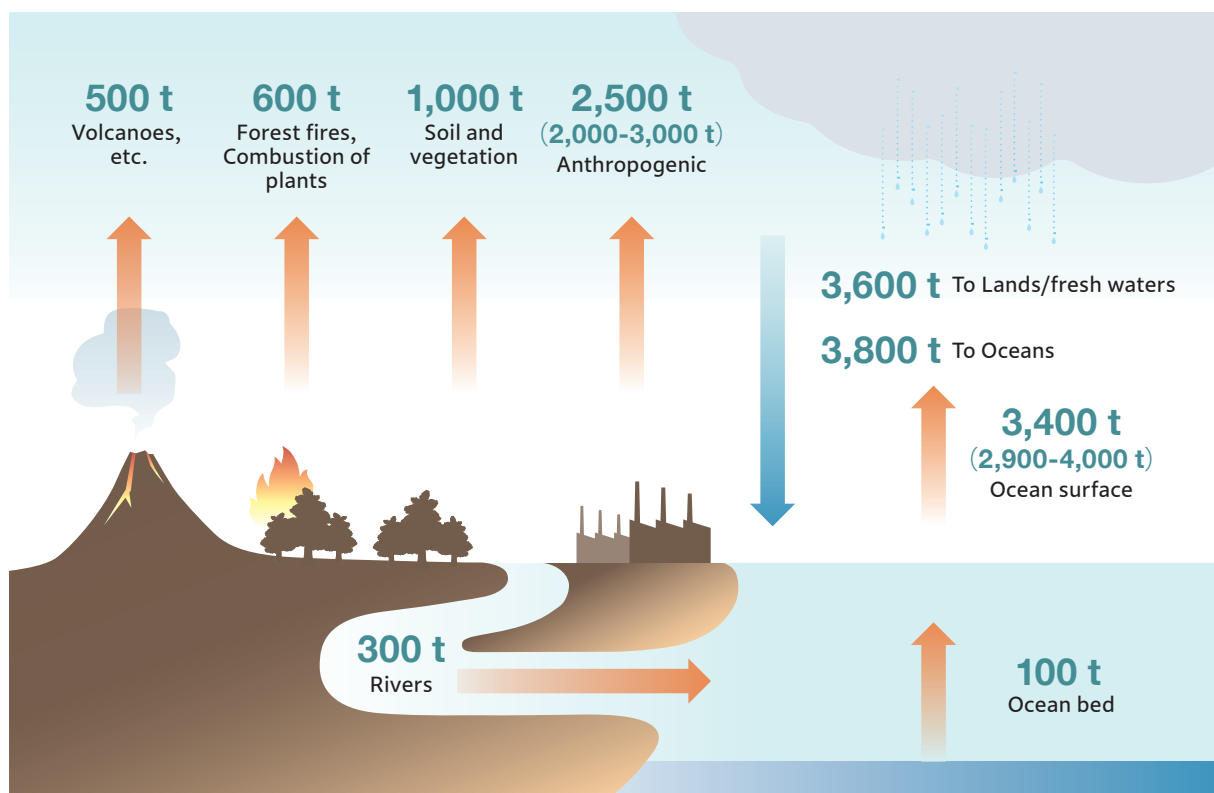


# Mercury in the Natural Environment

Since the birth of the earth, mercury has been coming out from the earth's crust to the surface by volcanic eruption, etc. Recently, **the amount of human emission of mercury has been increased** due to industrial activities such as artisanal and small-scale gold mining, coal combustion by thermal power generation, etc., cement production, and production of metals. Mercury circulates between the atmosphere, oceans, fresh waters, and soils, and exists mainly in 3 chemical forms: metallic mercury, inorganic mercury, and methylmercury. Inorganic mercury is the most abundant among them.

## ● Circulation of mercury in the natural environment

(Annual estimated amount)



\*UNEP, Global Mercury Assessment 2018

## The Minamata Convention on Mercury

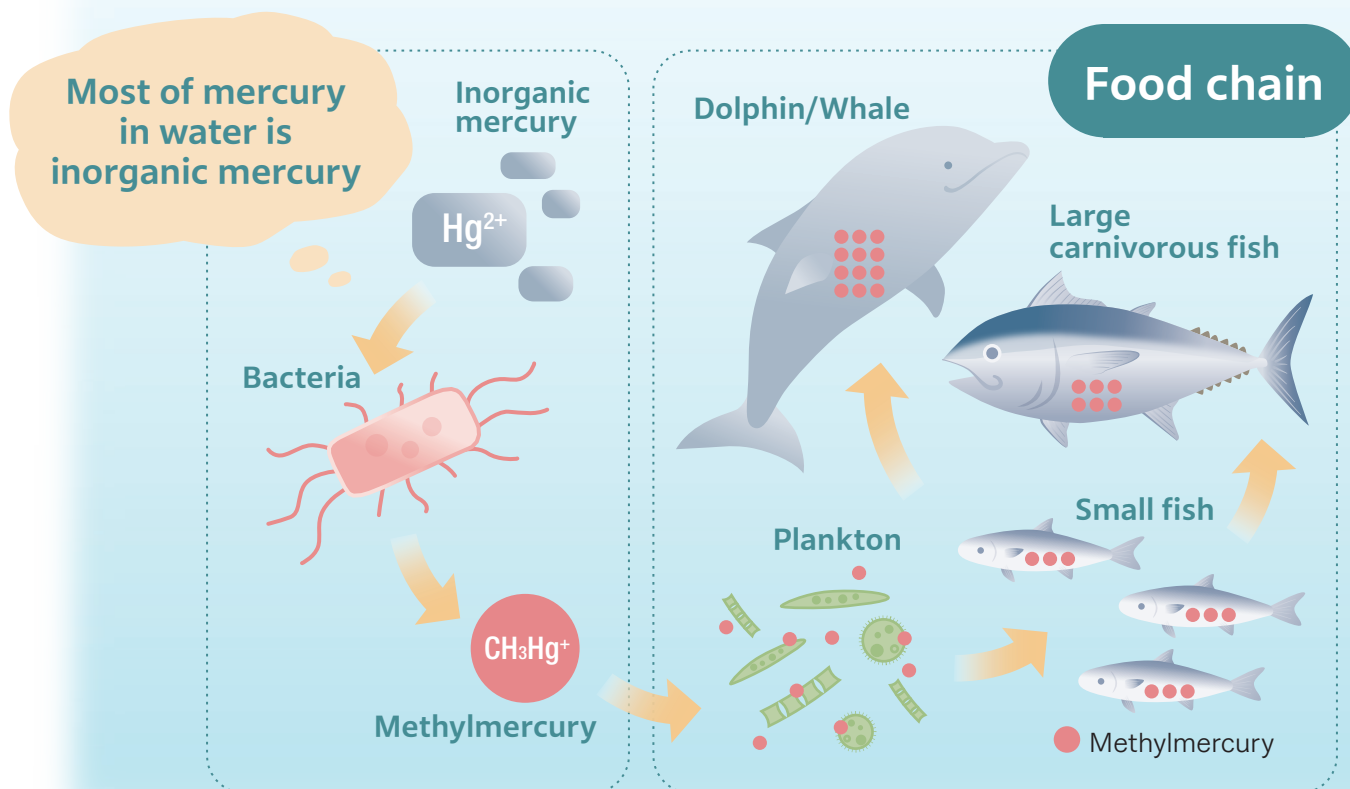
The Minamata Convention on Mercury was adopted in Kumamoto City and Minamata City in 2013, and went into effect on August 16, 2017. The objective of the convention is to reduce the artificial release of mercury from products using mercury, factories, and mines into the environment to prevent environmental pollution and health hazards caused by mercury. This convention also claims to reduce the supply, use, and release of mercury and to limit its international trade.

# Intake of Methylmercury from Seafood

A tiny amount of inorganic mercury is dissolved in natural waters such as the oceans and lakes. A part of inorganic mercury transforms to methylmercury by microbial action in water.

In the ecosystem, methylmercury **accumulates in organisms such as fish and shellfish via the food chain**. This means that large carnivorous fish and deep marine fish, as well as carnivorous marine mammals such as dolphins, have higher levels of methylmercury concentration, compared to small herbivorous or omnivorous organisms.

**The consumption of seafood allows the methylmercury to enter the body, even though it is trace amounts.** The amount of methylmercury in the body varies depending on how individuals eat fish (type and amount). However, in countries such as Japan, where people eat more seafood than in Western countries, they tend to ingest relatively large amounts of methylmercury. Also, cooking, such as grilling, simmering, and frying, does not remove the methylmercury in seafood.

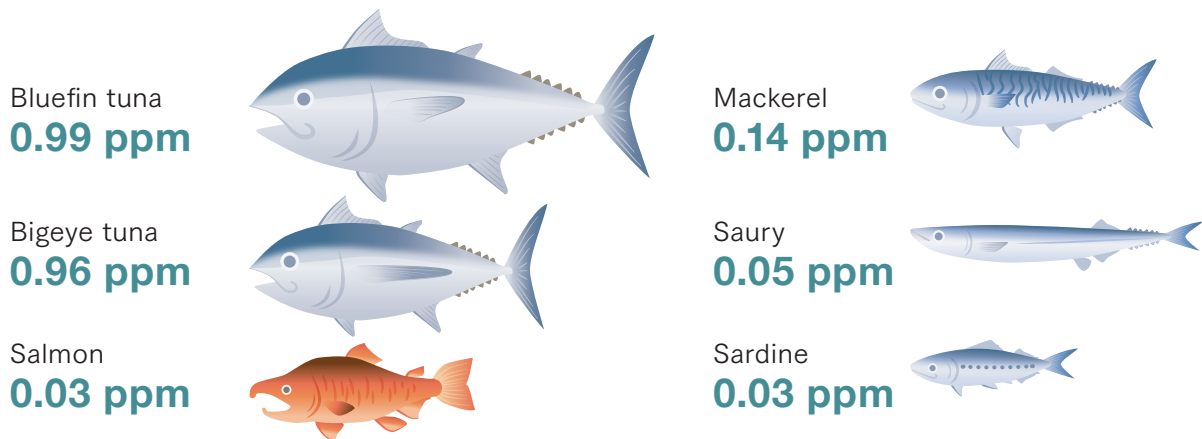


The food chain stands for the relationship of 'Eating – Eaten' in natural. Here, small fish eat plankton, and large carnivorous fish, dolphins, etc. eat small fish.

**In association with this process, methylmercury is bioconcentrated.**

# Seafood Types and Methylmercury

The methylmercury concentration in fish and shellfish varies greatly among species. Other than large carnivorous fish such as bluefin tuna, bigeye tuna, southern bluefin tuna, and swordfish, the methylmercury concentration tends to be high in red bream and hilgendorf saucord. In addition, it is even higher in toothed whales such as bottlenose dolphin. **Be careful not to overeat these fishes and shellfishes, etc. during pregnancy.** On the other hand, the mercury concentration in canned tuna is not so high, despite medium-sized yellowfin and white tuna, and small tuna being used as ingredients. Seafood, however, also contains many great nutrients. A balanced diet, including seafood, etc., is very important for the promotion of our health and the growth of fetuses.



## ● Seafood Commonly consumed in Japan and Their Mean Mercury Concentrations

| Fish species                       | Mercury concentration (ppm) | Fish species                  | Mercury concentration (ppm) |
|------------------------------------|-----------------------------|-------------------------------|-----------------------------|
| Mackerel                           | 0.14                        | Octopus                       | 0.03                        |
| Salmon                             | 0.03                        | Flatfish                      | 0.04                        |
| Horse mackerel                     | 0.05                        | Hard clam and Littleneck clam | 0.01                        |
| Saury                              | 0.05                        | Bonito                        | 0.15                        |
| Squid                              | 0.04                        | Yellowtail                    | 0.15                        |
| Tuna(all species including marlin) | 0.68                        | Sea bream                     | 0.10                        |
| Canned tuna (fish flake, etc.)     | 0.14                        | Eel                           | 0.06                        |
| Shrimp                             | 0.03                        | Crab                          | 0.10                        |
| Sardine                            | 0.03                        | Sweetfish                     | 0.06                        |

The table was based on the ranking of **“Fishes and Shellfishes commonly consumed”** in the national survey conducted by National Institute for Minamata Disease. Fishes and shellfishes that are not included in the table but have a high total mercury concentration include red bream (0.65 ppm) and hilgendorf saucord (0.36 ppm). In addition, the methylmercury concentration in bottlenose dolphin is 6.6 ppm.

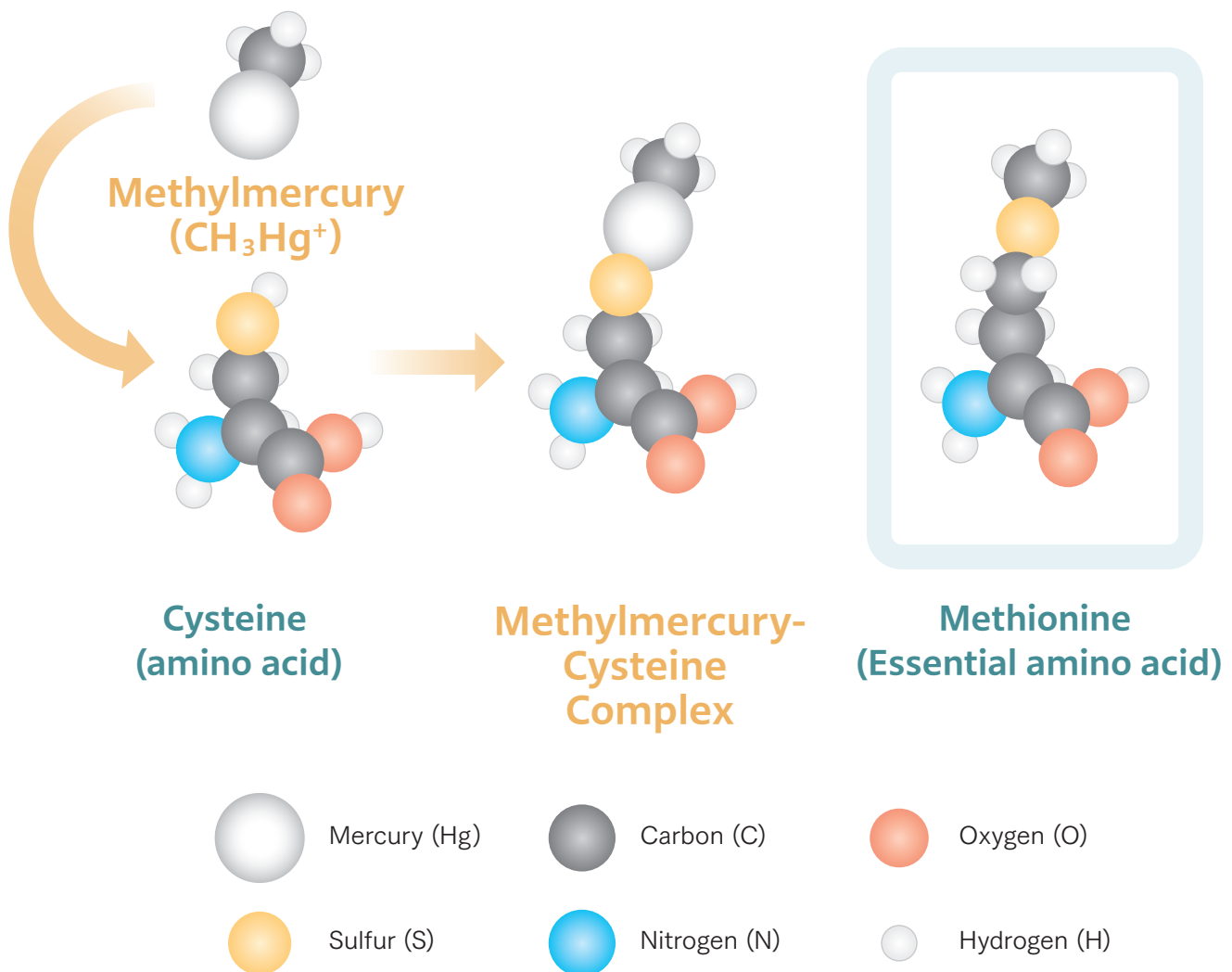
# Intake of Methylmercury into the Body

The ingested methylmercury is mainly absorbed from the intestinal tract into the body. Vaporized metallic mercury is absorbed from the lungs into the body, while inorganic mercury is poorly absorbed.

The protein that makes up our body consists of many amino acids, and one of them is cysteine. When methylmercury binds to this cysteine, it forms a complex which is similar structure to methionine, another amino acid. Methionine is a very essential amino acid, indispensable for brain function and fetal growth, and **methylmercury enters the brain and fetus in the same pathway as that of methionine.**

Hair and nails are also made of protein, and methylmercury is taken up in the hair and nails.

Unlike methylmercury, metallic or inorganic mercury does not have the property of being taken into hair.



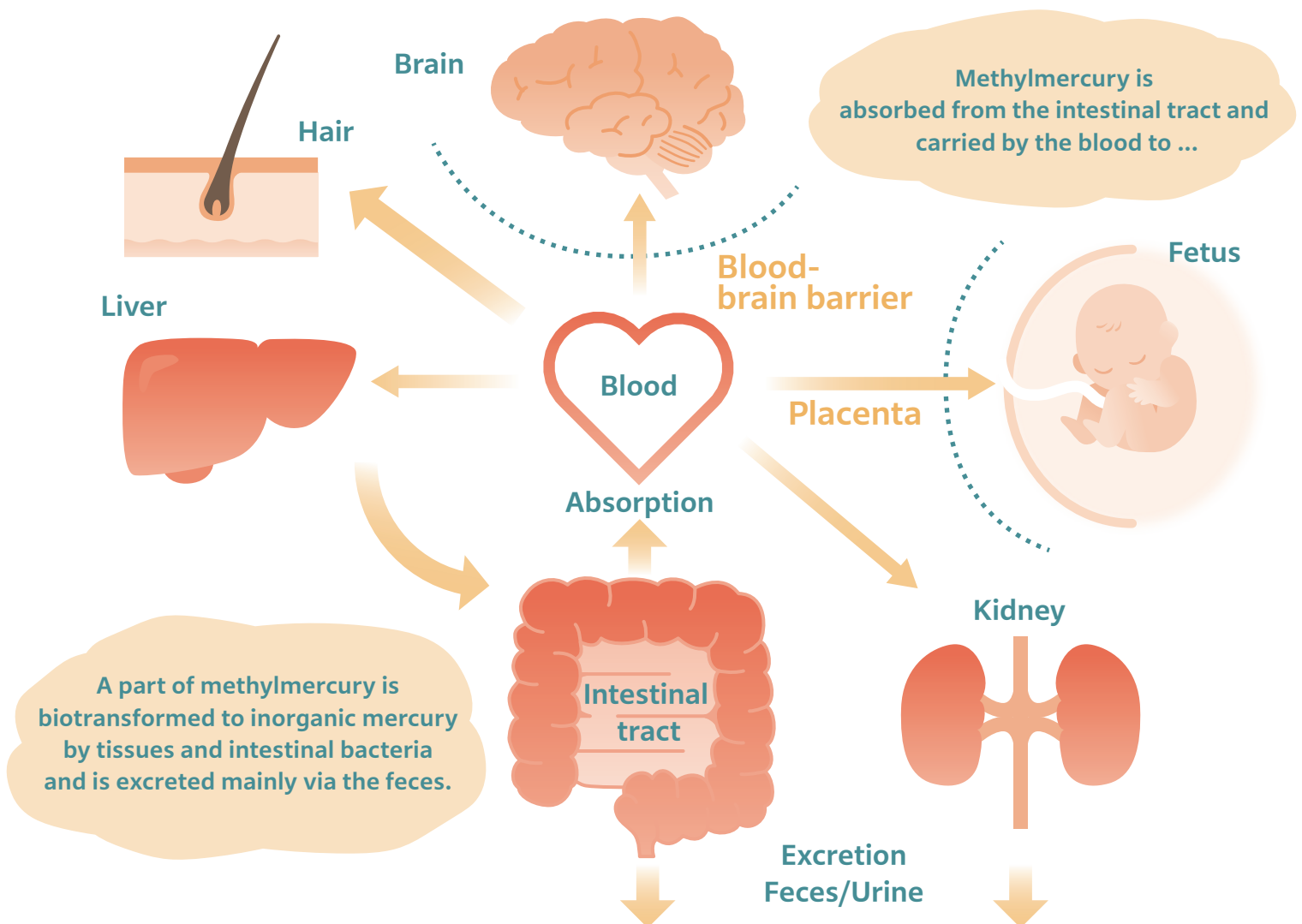


# Methylmercury in the Body

When methylmercury enters the body, it is absorbed mainly from the intestinal tract and accumulates particularly in the liver and kidneys. The brain and fetus are protected by the blood vessel barrier called the blood-brain barrier and the placenta, respectively, so that harmful substances absorbed from the outside of the body do not get into them, but methylmercury easily passes through them. The methylmercury concentration in the blood becomes higher in fetuses than in mothers.

Minamata disease is a serious methylmercury intoxication caused by eating large amounts of fish contaminated with high levels of methylmercury. Typical symptoms include sensory disturbance and cerebellar impairments, and the patients still suffers from residual disabilities.

On the other hand, methylmercury is constantly **excreted from the human body, mainly via feces, after degradation**. On average, 1 to 1.4% of methylmercury in the body is daily excreted from the body, and the mean time required to excrete half the amount in the body (biological half-time) is 50 to 70 days.



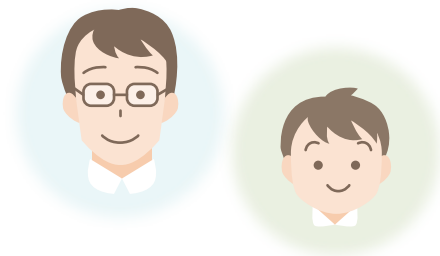
# Special Care for Pregnant Women

It is known that fetuses are particularly susceptible to the effects of methylmercury. **Intake of methylmercury during pregnancy may affect the growth of fetus**, and it is said that the effects of methylmercury are relatively likely to appear on language ability, and attention, etc. Note that since fish also contains nutrients such as polyunsaturated fatty acids (DHA and EPA) that promote the growth of babies and suppress the harmful effects of methylmercury, a balanced diet is important.



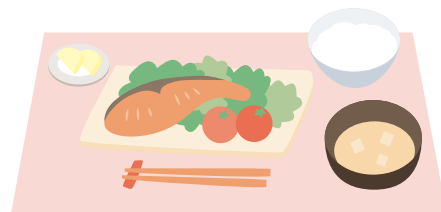
## Familiar Mercury and Health Effects

The preservative thimerosal (a type of organic mercury) contained in vaccines and the mercury in dental amalgam have been shown to have no association with autism. Dental amalgam hardly causes neurological symptoms or fetal effects. There is no genetic influence caused by mercury, and the mercury in a father's body does not affect the baby.

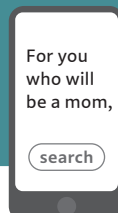


## Recommended Intake of Methylmercury

The safety standard (tolerable intake) for methylmercury is  $2.0 \mu\text{g}/\text{kg}$  body weight/week during pregnancy, and  $3.4 \mu\text{g}/\text{kg}$  body weight/week for the general population. According to the hair mercury survey conducted by National Institute for Minamata Disease, the mean intake in Japan is estimated to be **about  $1.6 \mu\text{g}/\text{kg}$  body weight/week**.



See the website of the Ministry of Health, Labour and Welfare for how to eat fish during pregnancy. Please search with **“For you who will be a mom,”** etc







## Would You Like to Measure the Mercury Concentration in Your Hair?

Do you know that your hair contains trace amounts of mercury? A part of methylmercury absorbed in the body is taken into the hair, and **the concentration of methylmercury in the body can therefore be estimated using hair.**

Why is methylmercury taken into hair? It is because the hair mainly composed of proteins, and methylmercury is taken up with other nutrients during the process of making these proteins. It is **more than 200 times more concentrated** compared to the concentration in blood.

As described above, methylmercury is concentrated in hair and easy to handle. Therefore, it is used as an index for methylmercury intake.

**Minamata Disease Archives accepts mercury analysis by hair sampling for visitors.**

---

If you wish, please contact the staff in the 1st floor office. We will inform you the measurement results by mail in approximately 1 to 2 months.



## Concentration of Mercury Taken into Hair (Hair Mercury Concentration)



The mercury in hair is derived from the methylmercury that has naturally accumulated in seafood, and its concentration varies from person to person depending on how the person eats seafood. It should be noted that methylmercury is constantly excreted from the human body and does not keep accumulating. Methylmercury levels in your body can be varied by changing your diet.

### ● Indication of Hair Mercury Concentration

**50 ppm** | A level at which neurological symptoms may be caused\*<sup>1</sup>  
Exceeding this level is rare\*<sup>3</sup>

**11 ppm** | A level at which would no appreciable adverse effect on the fetal development\*<sup>2</sup>  
Few participants exceed this level when limited to pregnant mothers\*<sup>3</sup>

**2.5 ppm** | Mean level for males (Japan)  
Mean of about 3,500 people in Japan\*<sup>3</sup>

**1.6 ppm** | Mean level for females (Japan)  
Mean of about 5,600 people in Japan\*<sup>3</sup>

No major effect on the health is observed at less than 50 ppm, except during pregnancy

\*Permed hair may show lower mercury concentration than the actual value

1 ppm is a unit representing 1/10,000 of 1%.

\*1) Maximum non-effect level in the general population (WHO, 1990)

\*2) Maximum non-effect level for effects on fetus (Food Safety Commission of Japan, 2005)

\*3) According to a survey conducted by National Institute for Minamata Disease

Unlike methylmercury, metallic or inorganic mercury  
**does not have the property to be taken into hair.**

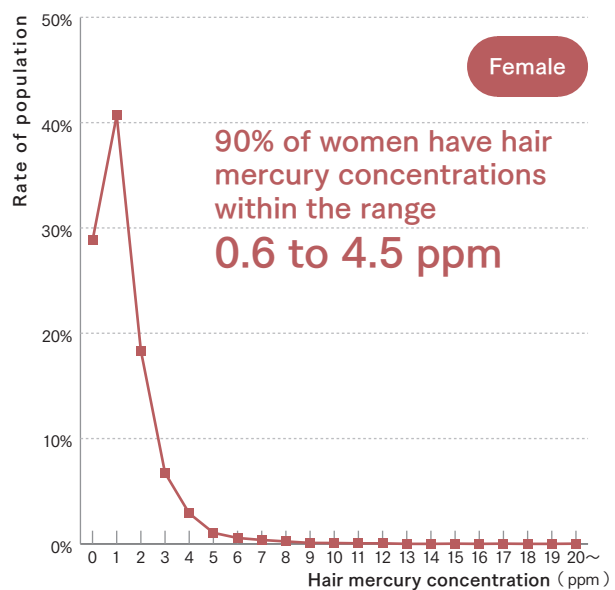
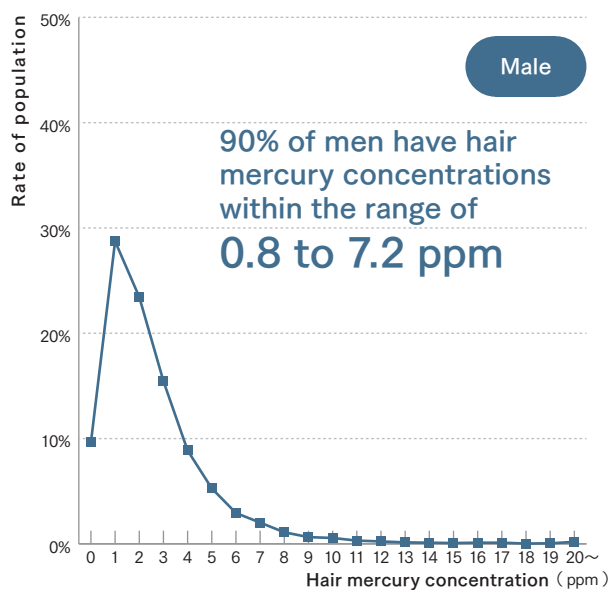


## There Is No Normal Value for Hair Mercury Concentration

The Hair mercury concentration **varies depending on how you eat seafood (type and amount)**.

Regional differences are also observed in hair mercury concentration. In general, areas with large tuna consumption such as Eastern Japan tend to show higher concentrations than in Western Japan. On the other hand, the coastal area does not necessarily show higher concentration than the inland area.

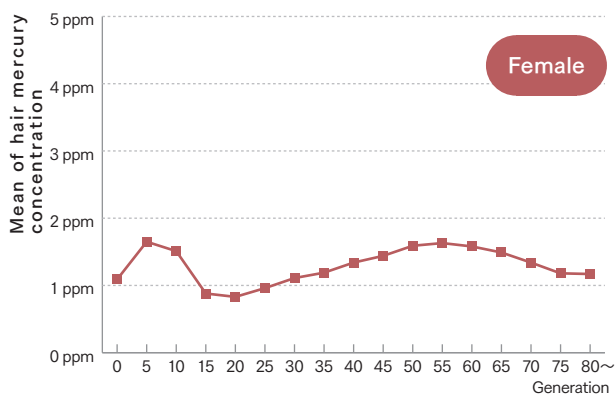
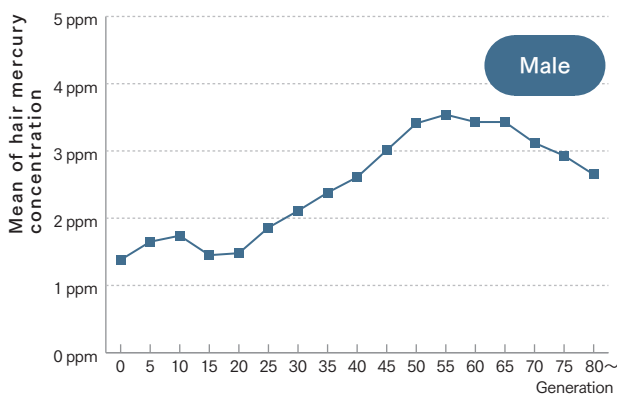
### ● Distribution of Hair Mercury Concentration



## Hair Mercury Concentration Varies by Age

The difference by age occurs because the way people eat seafood changes with age. Growing children may have high mercury concentration by eating a lot of seafood, but there usually is no need to worry about it.

### ● Mean of Hair Mercury Concentration (ppm)







環境省  
国立水俣病総合研究センター  
National Institute for Minamata Disease

4058-18 Hama, Minamata City, Kumamoto, 867-0008  
TEL 0966-63-3111