Mercury Exposures and Health Effects in Small Scale Mining

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MERCURY IN THE ENVIRONMENT

- Increasingly recognized as a *global pollutant* (UNEP, WHO)
- Major environmental risk to *children's health* (EPA, WHO, CEC)
- Critical effect - *Developmental neurotoxicity* (WHO, US NAS)
- *Fish consumption* major route of human exposure to methyl mercury (MeHg)
- Importance of airborne Hg exposures?
- *Mercury exposures continue in workplaces*
  - *Thermometers, flow/pressure devices, fluorescent bulbs, switches, pesticides … garimpagem*

RESEARCH SUPPORT

- US EPA
- PAN AMERICAN HEALTH ORGANIZATION
- GORGAS MEMORIAL FOUNDATION
- US ARMY - WRAIMR
- CNPq – BRASIL
- NIH – FOGARTY, NIEHS
- HEINZ FOUNDATION

GOALS OF THIS PRESENTATION

- HOW ARE POPULATIONS EXPOSED TO MERCURY FROM SMALL SCALE MINING?
- WHAT ARE THE HEALTH RISKS OF MERCURY EXPOSURES AMONG THESE POPULATIONS?
- WHAT ARE THE INTERACTIONS BETWEEN MERCURY AND INFECTIOUS DISEASE?

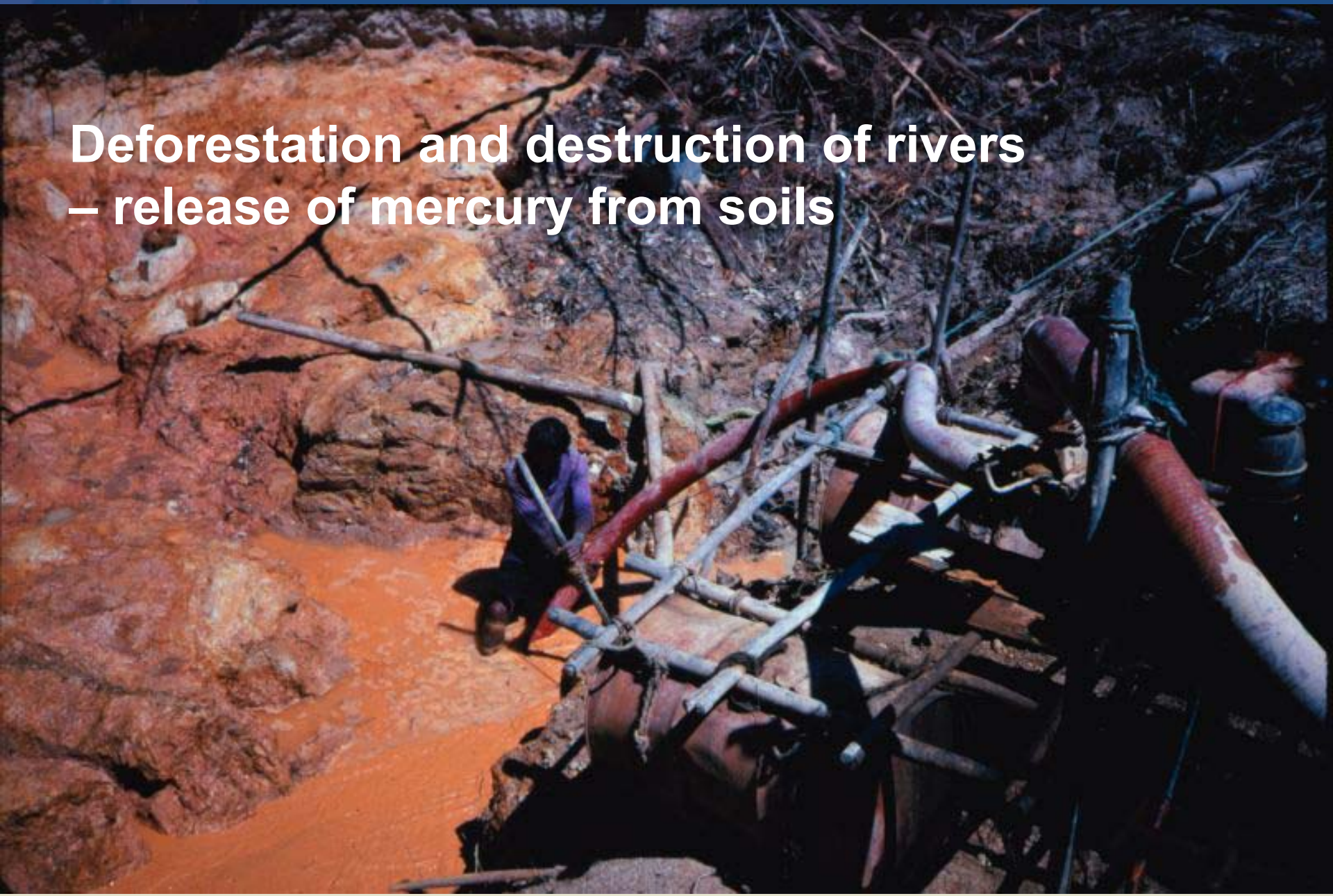
HOW ARE POPULATIONS EXPOSED TO MERCURY IN SMALL SCALE MINING?

- DELIBERATE USES OF MERCURY IN GOLD EXTRACTION
- COINCIDENTAL RELEASES OF MERCURY FROM SOILS DURING MINING
- ECOSYSTEM CONTAMINATION AND EXPOSUSRES VIA DIET

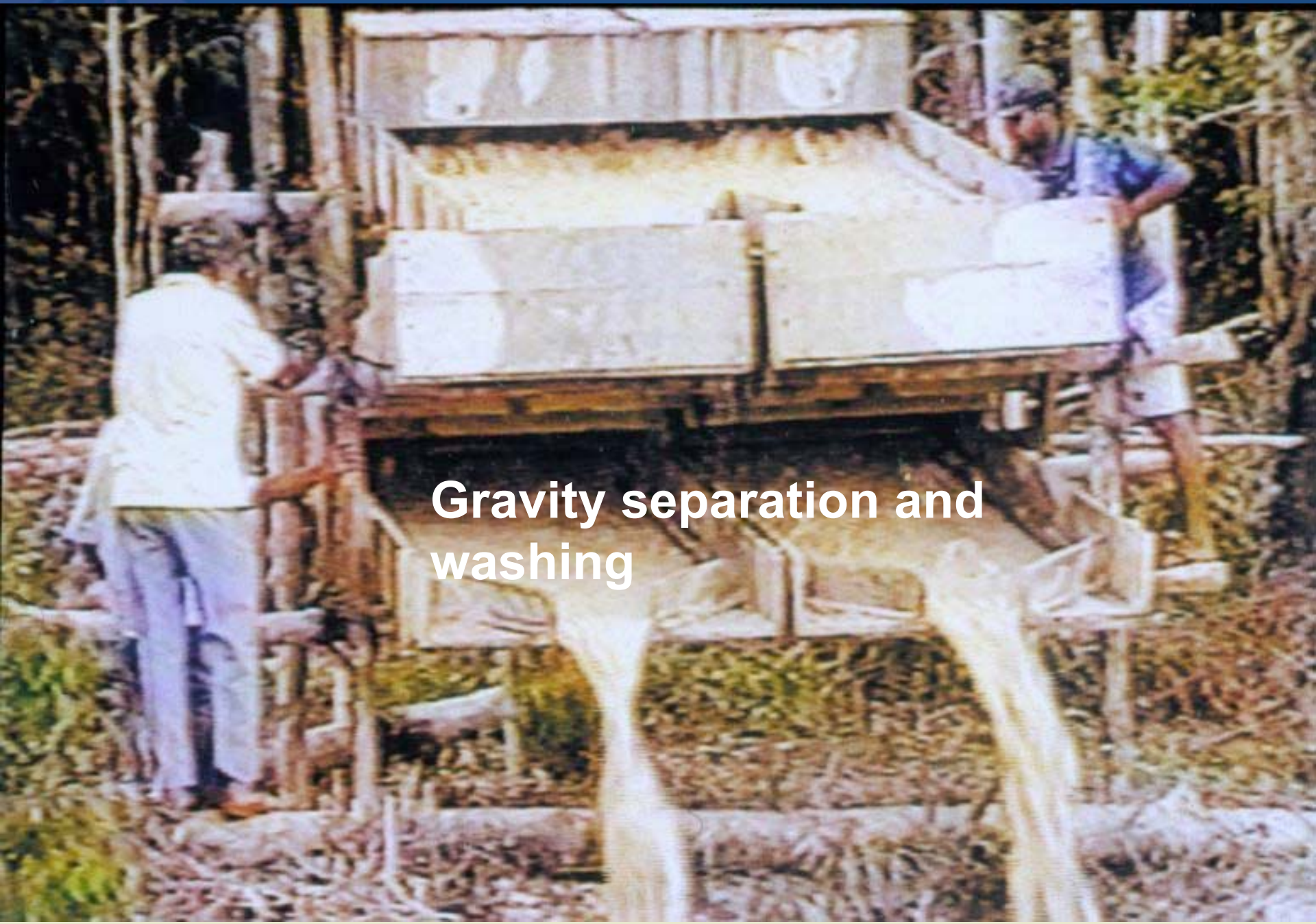
Small scale (Artisanal) mining:

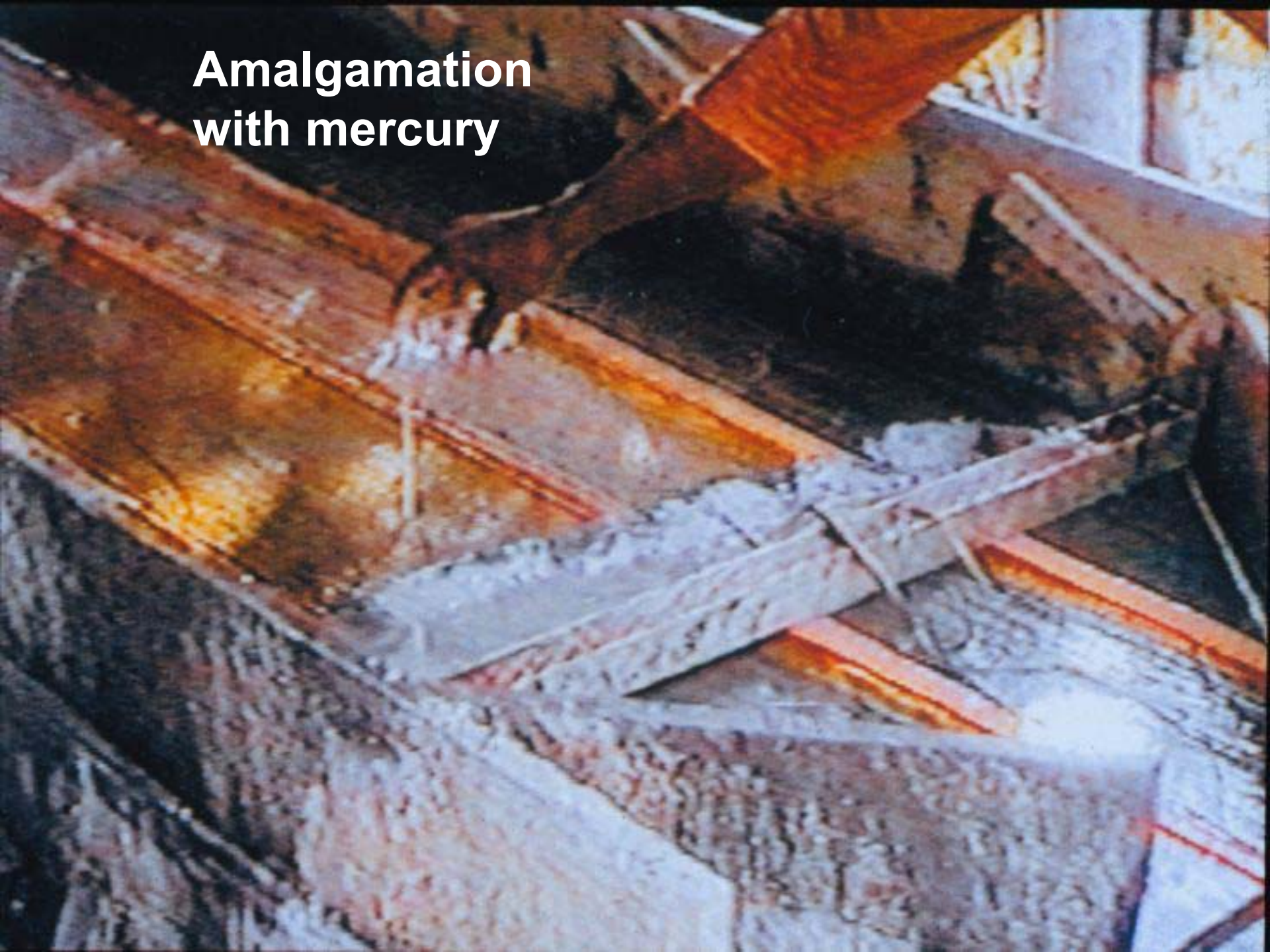
- World wide activity
  - Unregulated, illegal, unclear data
- *Women and children are involved*
- Hazardous conditions – injuries, crime
- Toxic chemicals
- Regional, national, transboundary impacts

Gold mining on the Rio Tapajos, Brazil


Deforestation and destruction of rivers
– release of mercury from soils


Hydraulic excavation


Gravity separation and
washing


Amalgamation
with mercury

CHILD LABOR IN ARTISANAL MINING

BURNING AMALGAM

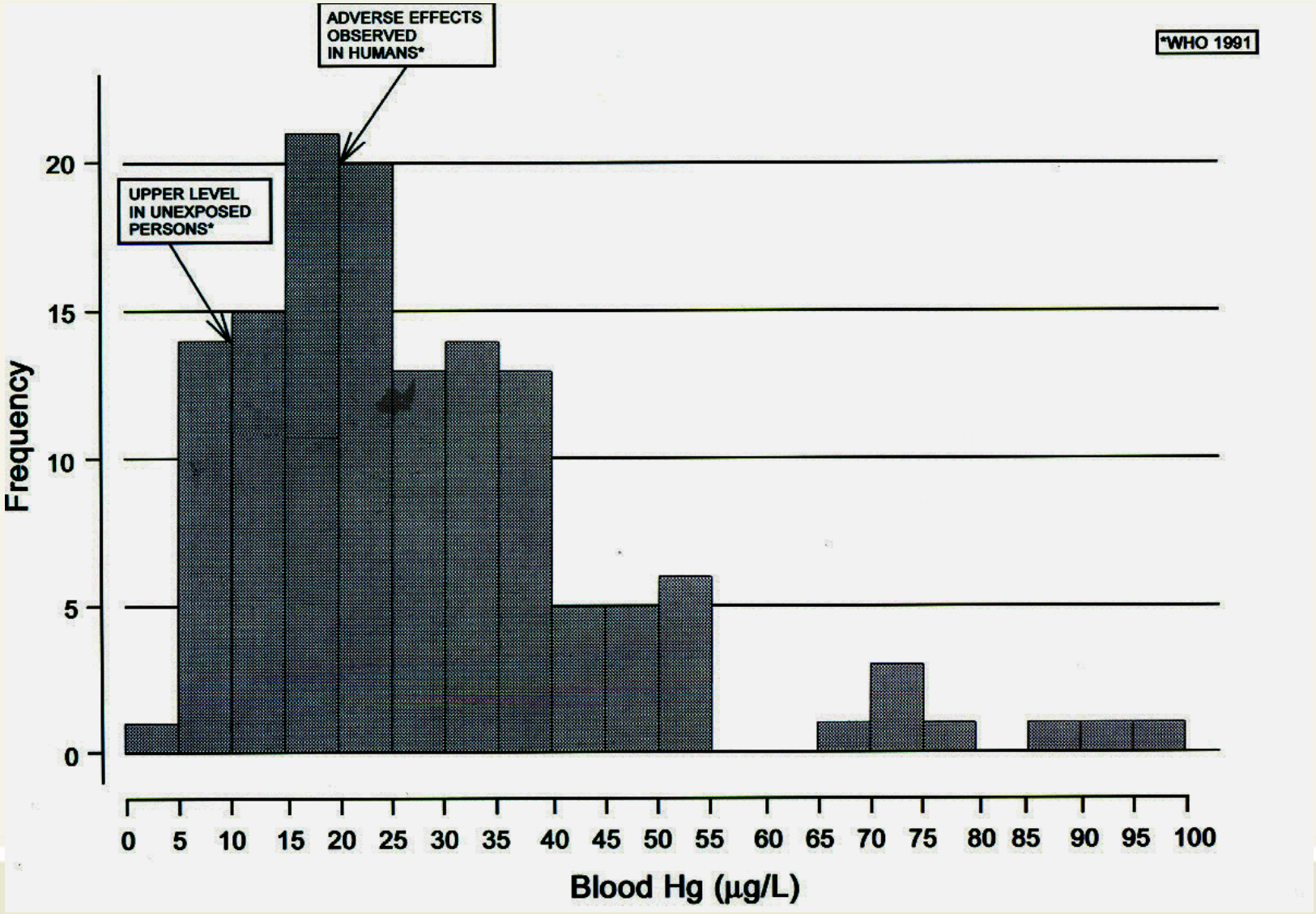
GARIMPAGEM IN USA: 1849 "GOLD RUSH" – contamination remains 2005

AIRBORNE MERCURY LEVELS in GARIMPOS in LATIN AMERICA - WHO guidance <0.01 mg/m^3

- Levels near amalgam burning in garimpos >100
- Levels in camps - 0.03-10
- Levels near gold shops in towns >20

Data from Drake, Cordier, Counter, Hacon, Camara, Malm, Hryhorczuk, et al

Hg EXPOSURES IN GOLD MINERS – Pará BRAZIL
Blood Hg LEVELS

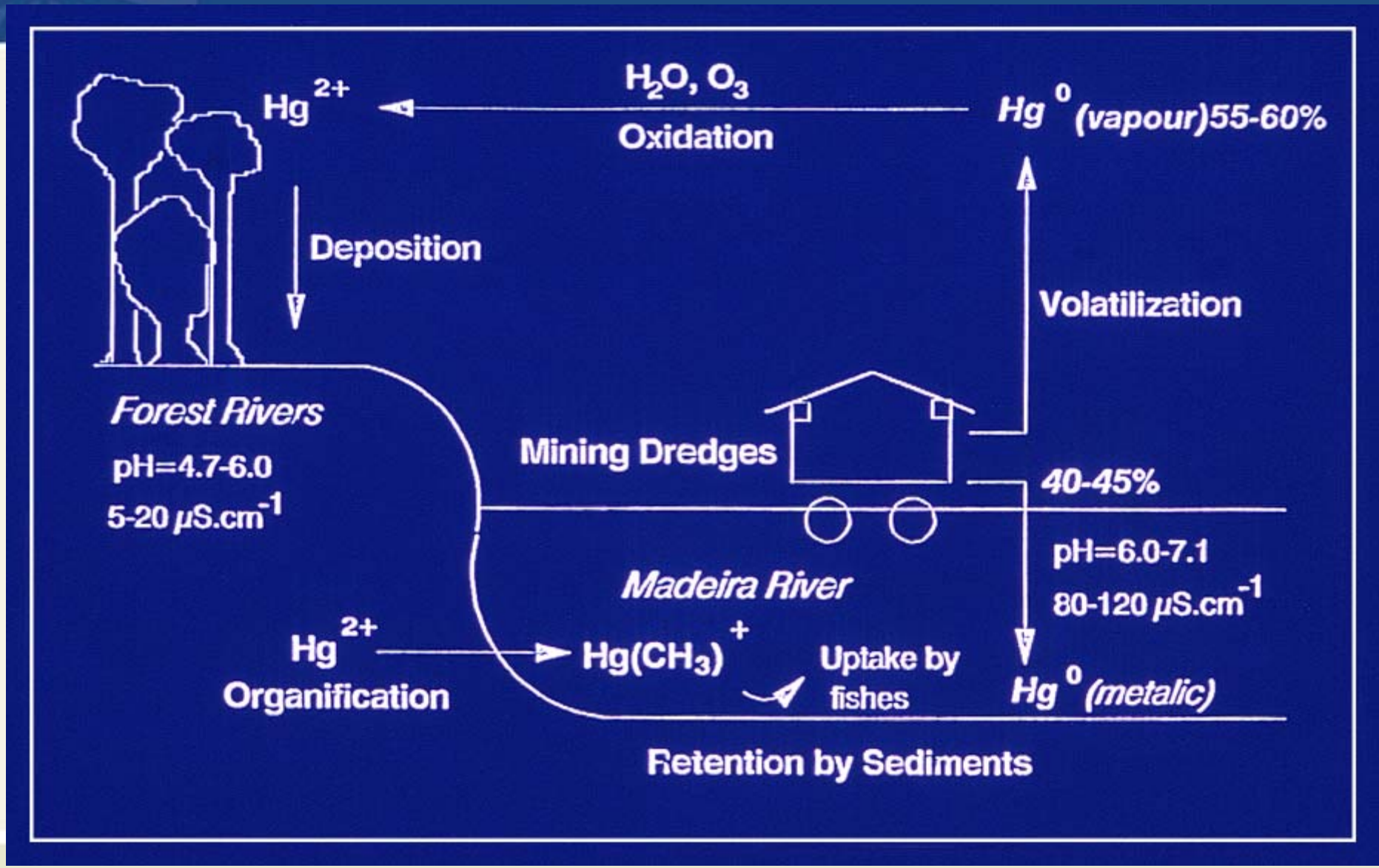


Health effects of mercury among miners and persons in mining camps

- Neurocognitive deficits
  - Tests of short term memory
  - Tests of fine motor function
- Neurophysiological dysfunction
  - Vision (evoked response)
  - Color sensivity
- Neuromotor signs and symptoms
  - Gait and balance
  - parasthesias

Effects consistent with other occupational studies

The Downstream Story: Mercury in garimpagem → Methyl mercury in fish



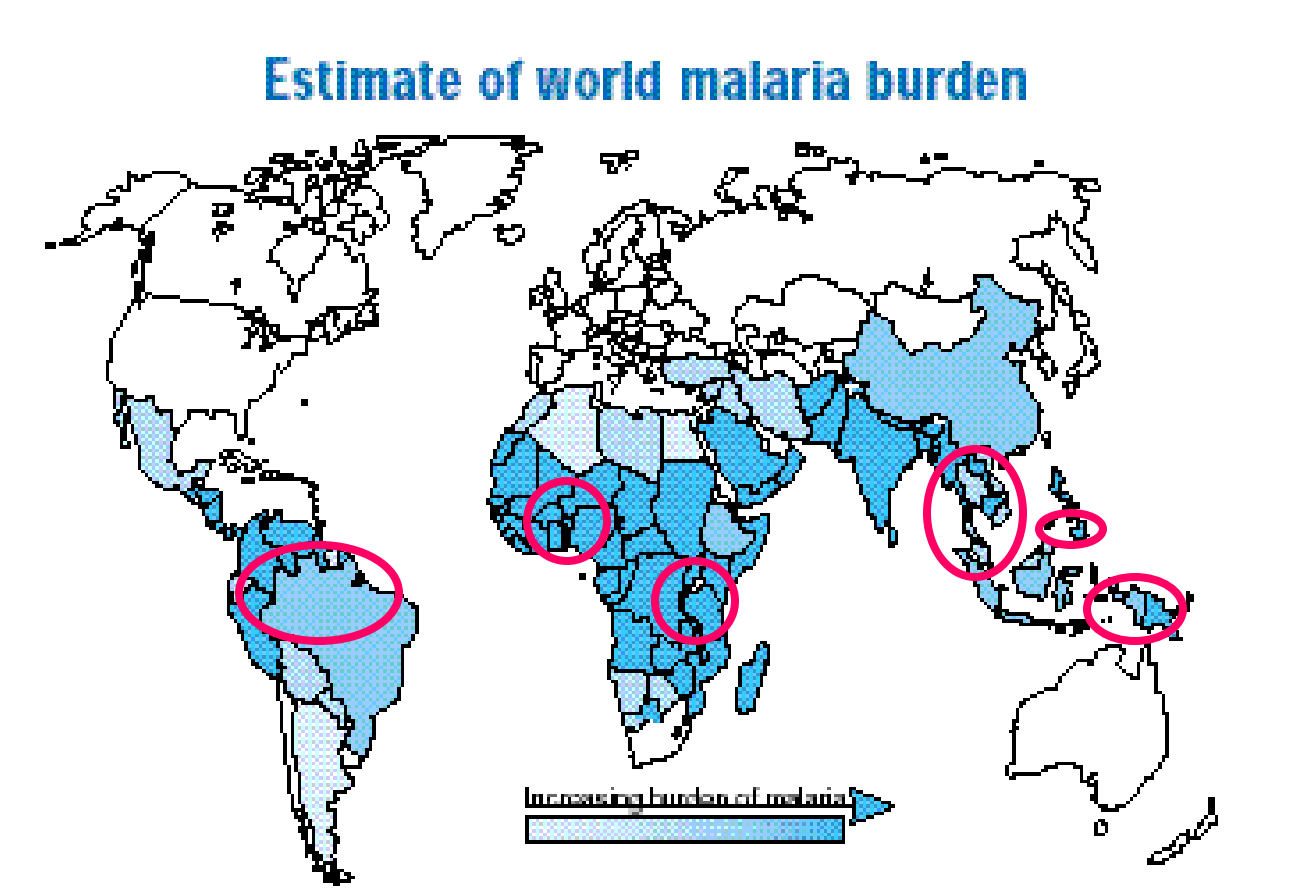
DOWNSTREAM MERCURY EXPOSURES

- Predominantly to methyl mercury
- Highly correlated with rates and types of fish consumption (Santos)
- Seasonal variation, related to fish consumption patterns (Mergler)
- Possible interactions with nutrition (Passos)
- Broad range of populations exposed
- Pregnant women also exposed
- Impacts reported on both adults and children

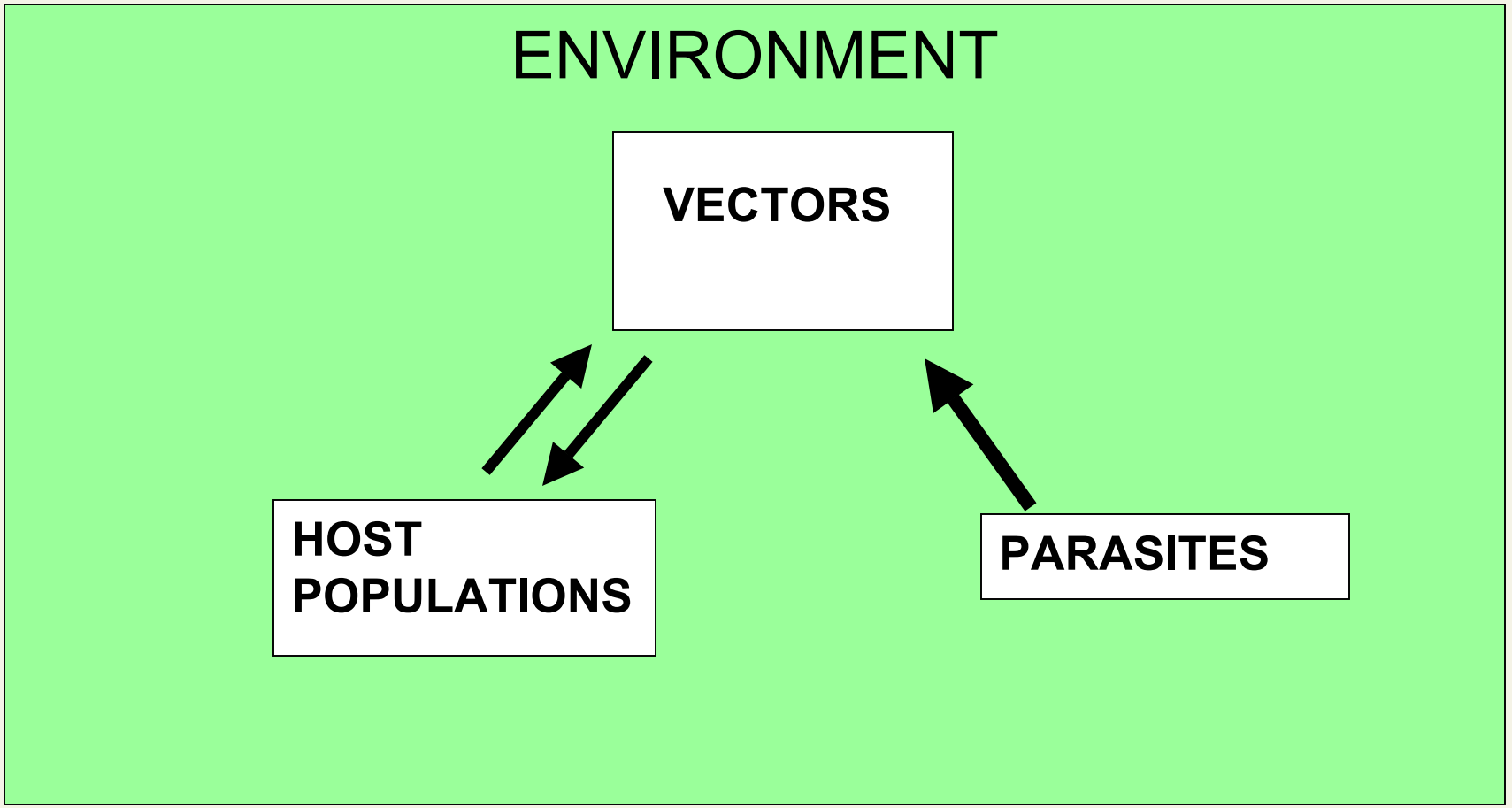
TOXIC EFFECTS OF MERCURY COMPOUNDS

- **NEUROTOXICITY**
  - Developmental effects
  - *But adults may be as sensitive (Yokoo et al 2003)*
- NEPHROTOXICITY
- DERMATOTOXICITY
- ***IMMUNOTOXICITY?***

MALARIA – WHO
GARIMPAGEM REGIONS – WORLD BANK



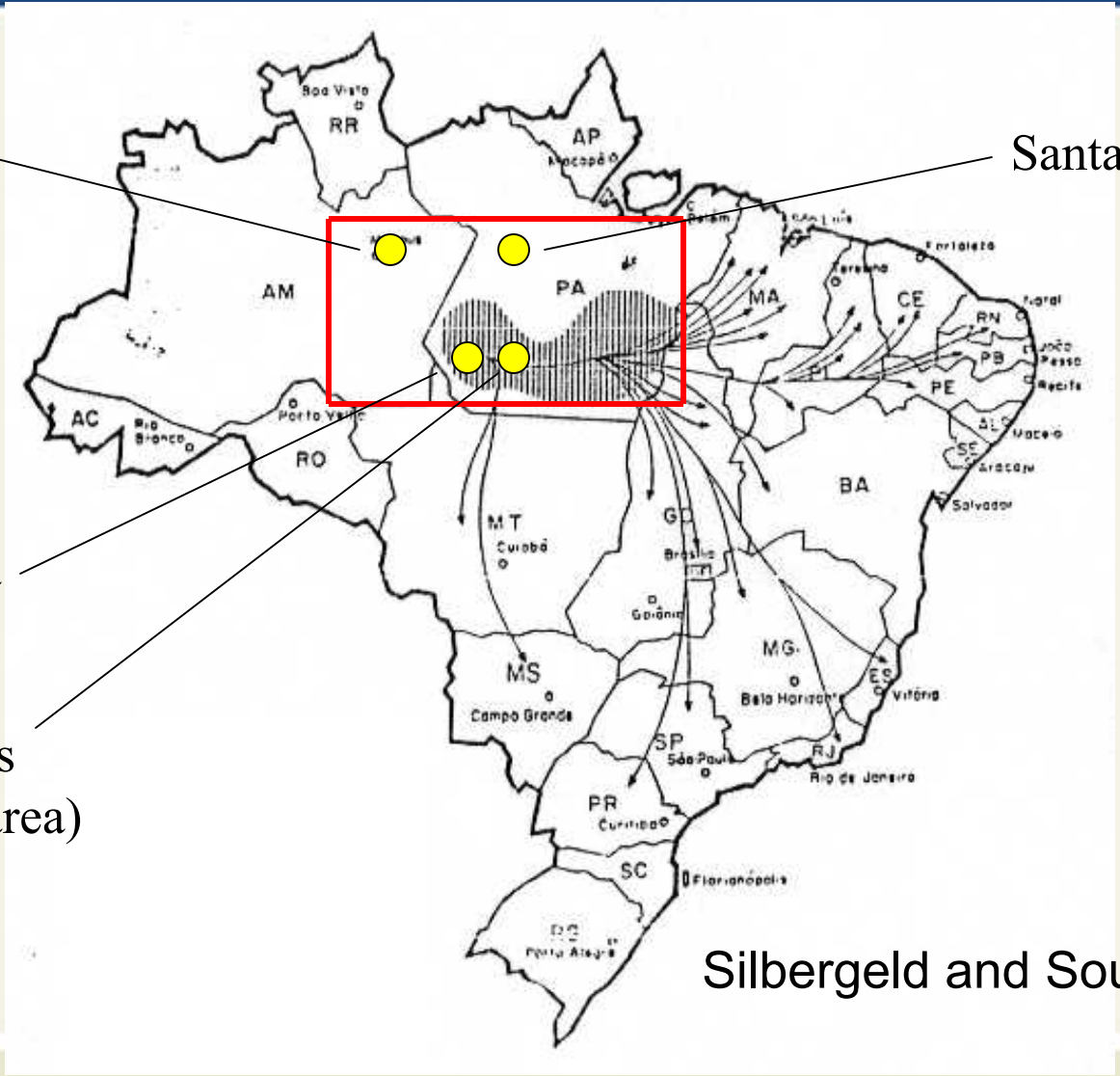
ECOLOGY and INFECTIOUS DISEASES



Gold mining on the Rio Tapajos, Brazil

GARIMPAGEM and VECTOR HABITATS - AMAZONIA

WHY STUDY MERCURY and MALARIA?



Does mercury interact with malaria?

- Experimental studies:
  - Mouse models – P yoelii, P berghei
  - Infection (parasitemia), disease (mortality), immunity (Nussensweig model)
  - mechanisms
- Epidemiological studies:
  - Exposures to mercury
  - Prevalence, history of malaria
  - Biomarkers of mercury immune dysregulation

Mercury interacts with malaria in mice:

- Mercury pretreatment increases parasitemia in mice infected with *P yoelli*
- *Mercury blocks acquisition of immunity induced by irradiated P yoelli sporozoites*
- Mercury does NOT increase parasitemia after infection with blood stage malaria (*P yoelli*)
- Mercury does NOT inhibit early hepatic responses to malaria infection (*P yoelli*)

Note: these are some of the lowest dose effects of mercury in animal models!

Table 1. Effects of $HgC1_2$ on Peak Parasitemia in Balb C and C57B16 Mice

Strain		N	Peak (%)	Hg/Control
Balb C	♀C	10	5.6	
	♀Hg	10	10.7	191
	♂C	10	5.3	
	♂Hg	10	10.7	202
Balb C	♀C	10	16.5	
	♀Hg	5	51.6	313
	♂C	10	29.2	
	♂Hg	5	68.6	235
C57B16	♂C	6	10.3	
	♂Hg	6	26.0	260

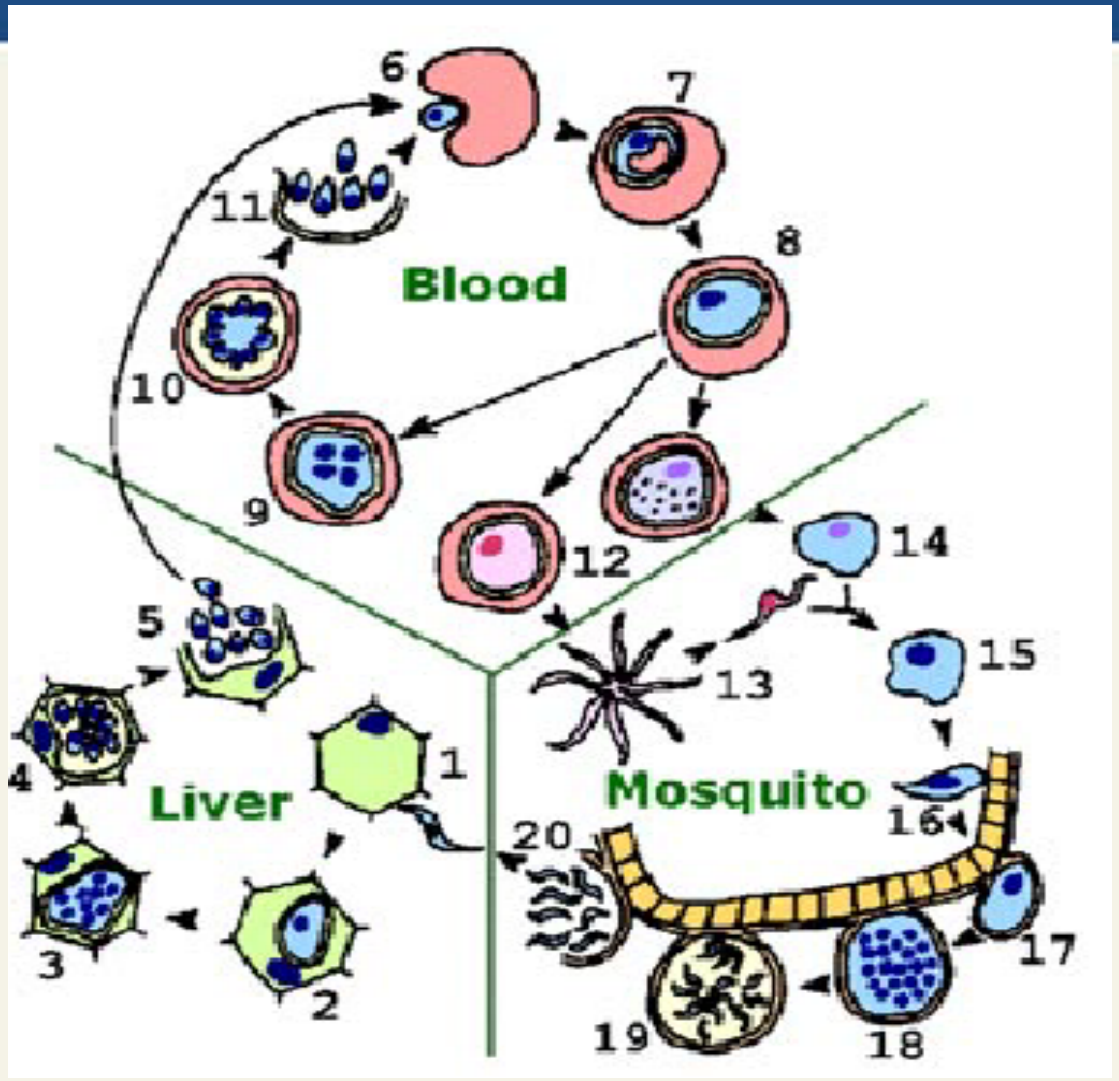
Peak parasitemia occurred between days 12-17 after infection; parasitemia was cleared by day 21 in most animals, with some delay in Hg mice.

Table 1. Effects of Mercury on Immunization by Irradiated *P yoelli* Sporozoites

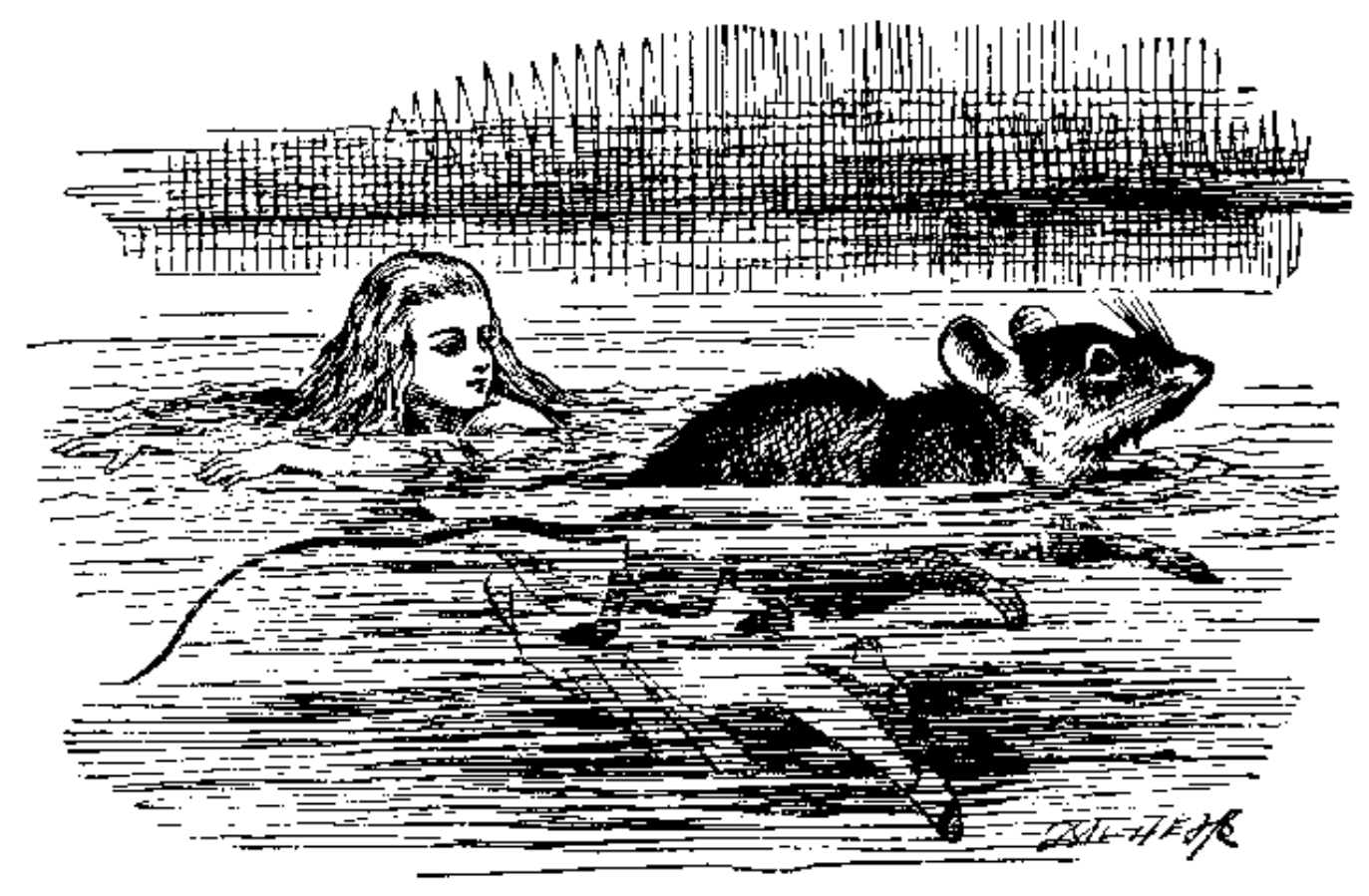
Treatment	Sex (n)	% Immunized[a]
1. Control	F (4)	60
Hg	F (4)	10
Control	M (4)	100
Hg	M (4)	0
2. Control	F (4)	100
Hg	F (4)	20
Control	M (4)	80
Hg	M (4)	0
3. Control	F (8)	75
Hg	F (8)	15

[a]Immunity was defined as parasitemia <1% after infection.

PLASMODIAL LIFE CYCLE



WHAT ARE THE MICE TELLING US?



EPIDEMIOLOGICAL EVIDENCE FOR MERCURY and MALARIA INTERACTIONS

- Studies in three communities – mining site (Rio Rato), fishing village (Jacareacanga), control village (Tabatinga)
- *Different mercury exposures, malaria risks*
- Mercury exposure related to malaria risk
- *Mercury exposure induces autoantibodies*
- *Mercury and malaria interact in autoimmunity*

STUDY SITE: PARA

www.pamp.ch/Gold/pp/pp_img/pan.jpg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Results: Jacareacanga

Fish consumption strongly associated with elevated mercury levels (ANOVA $p<0.001$)

- The odds of reporting a malaria history is 4.38 times greater among those who had ‘ever working with mercury’ vs. those who had never worked with mercury ($p = 0.057$), controlling for age, gender, SES, and time lived in village.

IMMUNOSUPPRESSIVE EFFECTS of MERCURY COMPOUNDS

Mercury increases severity of *several* infections in animal models:

- Coxsackie B3 virus – Ilback et al (1996); South et al (2002)
- Leishmaniasis – Kono et al (2002)

OTHER ISSUES

- Can mercury exposures interact with other infections? Viruses? Parasites?
- What are the effects of mercury exposure during development on immune function in infancy? Adulthood?
- Are there genetic determinants of mercury response in humans?
- *What are the consequences of mercury exposure for post-infection diseases (autoimmunity)?*

MINAMATA DISEASE – JAPAN