I. Mercury Toxic Mechanism

A. General Mechanism: Mercury is a metabolic poison, basically affecting function rather than structure. It can affect virtually any tissue in the body. Mercury exerts its toxic effect once it complexes with the ligands within the body.

   a. "Heavy metals, which, of course, cannot be metabolized, persist in the body and exert their toxic effects by combining with one or more reactive groups (ligands) essential for normal physiologic functions."
   b. "The primary mode of action of both kinds of mercury compounds may be interference with membrane permeability and enzyme reactions by binding of mercury to sulphydryl groups, but distribution of the organic and inorganic forms may differ."

2. Pathogenic Mechanisms of Mercury from Chang, LW. Experimental and Clinical Neurotoxicology, Mercury: Chap. 35: 508-526, Williams & Wilkins, Baltimore, 1980:
   b. Anabolic Disturbances-- e.g. Changes in RNA and protein synthesis.
   c. Enzyme System Disruption-- e.g. Glycolytic pathway and mitochondrial respiration.
   d. Destruction and in situ Denaturation of Cellular Proteins
   e. Breakdown of Biological Membranes

B. Ligand
   1. An organic molecule that donates the necessary electrons to form coordinate covalent bonds with metallic ions.
   2. An ion or molecule that reacts to form a complex with another molecule.

C. Mercury Affinities
   1. Selenium: Has the strongest affinity for mercury.
      a. If mercury is bound to selenium before it enters the body, as is the case in most is in fish and seafood, it will be less toxic since the mercury will not easily leave the selenium to attach to body ligands.
      • From the National Academy of Sciences, An assessment of Mercury in the Environment, Washington, D.C., 1978: “Fish with higher levels of methylmercury also contain even higher levels of selenium. The protective effect of dietary selenium against mercury toxicity is confirmed. (23 studies cited) Methylmercury in tuna and other fish is less toxic than methylmercury ingested under other circumstances.”
      b. However, if mercury attaches to selenium AFTER it has entered the body, it might be more difficult to remove from the body as most mercury chelators are sulphydryls.
2. Sulfhydryl (thiol): The sulfur-hydrogen (-SH) combination. A highly reactive group that is characteristic of mercaptans and is present in many biologically active compounds (various proteins, enzymes, enzyme inhibitors, cell membranes).
   - Mercaptan (ML: "Mercurium Captins" = "Seizing Mercury"). Any compound containing the -SH group bound to carbon. Analogous to the alcohols and phenols but containing sulfur in place of oxygen.

3. Phosphoryl
4. Carboxyl
5. Amide
6. Amine

D. Proteins as Targets of Mercury
1. Protein: Any of numerous naturally occurring extremely complex combinations of amino acids which are the essential constituents of all living cells.
2. Contain: Carbon, hydrogen, oxygen, nitrogen, and usually sulfur; occasionally other elements (phosphorus, iron).
3. Form: Cell membranes, enzymes, hormones, antibodies, hemoglobin, energy production systems.
4. Key Amino Acids—
   a. Methionine: Contains sulfur (S)
   b. Cysteine: Contains sulfhydryl (-SH)
   c. Cystine: Contains disulfide (S-S). Formed by the oxidation (loss of hydrogen) of 2 cysteine-SHs.

II. Relative Toxicity of Mercury Forms
A. Toxicity of Mercury and its Compounds
1. This includes
   a. Methyl and ethyl organic salts
   b. Mercury vapor
   c. Inorganic salts and other organic compounds.
   [d. Liquid mercury, by ingestion was not included by the MAC Committee—
    the International Committee to Determine Maximum Allowable Concentrations (MAC) for Mercury. Archives of Environmental Health, Volume 19, December 1969.]
2. Since 1969, a growing number of scientists have believed that mercury vapor is at least as toxic as methyl and ethyl organic salts.
B. Absorption Rates: The relative toxicity of the various forms of mercury is determined more by its "absorption rate" in humans than by a basic difference of action within the body. The extent of the toxic effect is dependent upon the ease with which the form enters the body and attaches to or enters body tissues or fluids.
1. Absorption rates, for humans, of some mercury forms are:
   a. Ingested metallic mercury = less than 0.01%
   b. Ingested mercuric nitrate = less than 25%
   c. Ingested inorganic mercury compounds = 0-25%
   d. Inhaled mercury vapor = 74-100% (average 80%)
   e. Ingested methyl mercury (organic) = 95-100%
   [Source: USEPA, Health Effects Assessment for Mercury, EPA/540/1-86-042, Sept 1984.]
2. From the figures in II.B.1 above, it can be readily seen that exposure to inhaled mercury vapor and ingested methyl mercury are the biggest risks. Both of these mercury forms are lipid (fat) soluble, thereby allowing ready penetration of cell membranes for access to the body and its cells.

C. Biological Half-Times (Half-Life) of Mercury in Humans

1. The half-time is the time required for half the amount of a substance (as a drug or radioactive tracer) in or introduced into a living system to be eliminated by natural processes.
2. Half-times of mercury in human whole body
   a. Mercury vapor = 35-90 days
   b. Inorganic mercury salts = 40 days
   c. Methyl mercury = 70 days
3. Note that the half-time of mercury varies considerably for different tissues, such as blood. [Source: Goyer, RA. Cassarett & Doull's Toxicology, Chap. 19, page 606, Macmillan Pub. Co., 1986]

III. Dental Amalgam as a Source of Mercury in Humans

A. Amount of Mercury in Dental Amalgam

2. Note that 12 grains= 780 milligrams (65 milligrams/grain).
3. In 1984, the U.S. Environmental Protection Agency (EPA) had a Maximum Annual Intake Standard of 7.3 milligrams of non-organic mercury per year (much lower now). Therefore, ONE average sized amalgam filling contains enough mercury to exceed the U.S. EPA old human intake standard for over 100 YEARS, given exposure to all of the mercury in the one amalgam filling. Obviously, this does not happen as the amalgam breaks down when enough mercury exits the filling. The point is, there is more than enough mercury in even one amalgam to present a cause for concern.

B. The Stability of Dental Amalgam

1. Dental amalgam contains at least four metals (Hg, Ag, Cu, Sn, plus others). These metals combine to form a random mixture of alloys, called "phases." Each alloy is separate and unique, and therefore has a different electrical potential than the others.
2. Amalgam is continuously bathed in electrolytes (saliva, tissue fluids, liquids).
3. Dissimilar metals in electrolytes always become batteries, which generate electrical currents by the movement of metal ions! Therefore, it is impossible for dental amalgam to be stable in the oral environment. Further, the fact that dental amalgams become miniature batteries has been scientifically documented in the dental literature since 1878. [Sources: Chase, HS (DDS & MD). Some Observations and Experiments Connected With Oral Electricity, J Dental Science, 12:18-23, 1878-1879. Schriever, W; Diamond, L.E. Electromotive Forces and Electric Currents Caused by Metallic Dental Fillings. J Dental Research, 31(2):205-228, 1952.]
C. Patient Inhalation of Mercury Vapor from Dental Amalgams: Early Published Research

1. By 1984, research published in valid journals had demonstrated that patient exposure to mercury released from amalgam dental fillings approached or exceeded current adult standards, even with no stimulation of the fillings. Since then, numerous studies have demonstrated continuous patient exposure to amalgam mercury under different circumstances. Even the American Dental Association and the National Institute of Dental Research, in 1984, formally acknowledged this continuous mercury exposure.

2. Application of early published research measuring amount of mercury per breath:

Average inhalations/day of resting adult:
12 inhalations X 60 minutes X 24 hours = 17,280 inhalations/day

US Environmental Protection Agency (EPA) mercury intake standard for non-dietary, 154 lbs. adult in 1984:
20 micrograms (per day) X 1000 = 20,000 nanograms/day

Therefore, the amount of mercury/breath that would exceed EPA standards are
20,000 nanograms of mercury/day ÷ 17,280 inhalations/day =
1.16 nanograms/Hg breath/day

Calculation from Gay et al. Lancet, 1(8123):985-6, 1979:
Exhaled air/unstimulated amalgams=
1.42 nanograms/Hg breath/day

Calculation from Abraham et al., J Dental Research, 63(1):71-73, 1984:
Intra-oral air/unstimulated amalgam=
0.75 nanograms/Hg breath/day

IV. Estimates of Daily Intake of Amalgam Mercury in Non-Occupationally Exposed Humans

1. INTAKE AND ABSORPTION OF MERCURY PER DAY IN MICROGRAMS

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>Elemental Hg Vapor</th>
<th>Inorganic Hg Vapor</th>
<th>Methyl Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>0.030 (0.024)</td>
<td>0.002 (0.001)</td>
<td>0.008 (0.0064)</td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>0</td>
<td>0.600 (0.042)</td>
<td>2.4 (2.3)</td>
</tr>
<tr>
<td>Non-fish</td>
<td>0</td>
<td>3.6 (0.25)</td>
<td>0</td>
</tr>
<tr>
<td>Drinking Water</td>
<td>0</td>
<td>0.050 (0.0035)</td>
<td>0</td>
</tr>
<tr>
<td>Dental Amalgams</td>
<td>3.8-21 (3-17)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3.9-21 (3.1-17)</td>
<td>4.3 (0.3)</td>
<td>2.41 (2.31)</td>
</tr>
</tbody>
</table>

2. In non-occupationally exposed humans, the absorption of mercury from dental amalgams is 1.5-6.5 times the amount absorbed from all other sources combined, including fish!

B. Medical Experts/Journals vs. Dental "Experts"/Journal

1. On the daily intake of dental amalgam mercury, there is considerable difference between the conclusions of experts on mercury toxicology and those of dentists. One must question why the conclusions of the dentists were not validly peer-reviewed by mercury toxicologists and published in appropriate journals! Note that dentists do NOT receive education or training in mercury toxicology (unless they are IAOMT members).

2. SELECTED ESTIMATES OF MEAN DAILY AMALGAM MERCURY INTAKE

<table>
<thead>
<tr>
<th>Mercury (Micrograms/Day)</th>
<th>Authors</th>
<th>Reference</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental Sources:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.24</td>
<td>Mackert JR</td>
<td>J Dental Research</td>
<td>1987</td>
</tr>
<tr>
<td>1.7</td>
<td>Berglund A</td>
<td>J Dental Research</td>
<td>1990</td>
</tr>
<tr>
<td>3.0</td>
<td>Langworth et</td>
<td>Swedish Dental J</td>
<td>1988</td>
</tr>
</tbody>
</table>
### 3. EXTENSIVE COMPARISON OF ESTIMATES OF DAILY MERCURY EXPOSURE FROM DENTAL AMALGAM FILLINGS

**PUBLISHED ESTIMATES OF Hg EXPOSURE IN ADULTS WITH DENTAL MERCURY FILLINGS**

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterson et al, 1985</td>
<td>1985</td>
</tr>
<tr>
<td>Mackert, 1987</td>
<td></td>
</tr>
<tr>
<td>Clarkson et al, 1988</td>
<td></td>
</tr>
<tr>
<td>Aronsson et al, 1989</td>
<td></td>
</tr>
<tr>
<td>Berglund, 1990</td>
<td></td>
</tr>
<tr>
<td>Vimy &amp; Lorscheider, 1990</td>
<td></td>
</tr>
<tr>
<td>Mackert, 1991</td>
<td></td>
</tr>
<tr>
<td>WHO, 1991</td>
<td></td>
</tr>
<tr>
<td>Olsson &amp; Berglund, 1992</td>
<td></td>
</tr>
<tr>
<td>CCEHRP, 1993</td>
<td></td>
</tr>
<tr>
<td>Weiner &amp; Nylander, 1995</td>
<td></td>
</tr>
<tr>
<td>Halbach, 1995A</td>
<td></td>
</tr>
<tr>
<td>Halbach, 1995B</td>
<td></td>
</tr>
<tr>
<td>Richardson &amp; Allan 1996A</td>
<td></td>
</tr>
<tr>
<td>Richardson &amp; Allan 1996B</td>
<td></td>
</tr>
<tr>
<td>Mackert &amp; Berglund, 1997</td>
<td></td>
</tr>
<tr>
<td>WHO, 2003</td>
<td></td>
</tr>
<tr>
<td>Richardson et al, 2011</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing published estimates of Hg exposure](image)

- **Mean**
- **CalEPA Hg RfC 0.38 ug/day**
- **USEPA Hg RfC 0.38 ug/day**
- **Estimated amalgam Hg dose ug/day**
V. The Comparative Toxicity of Mercury

A. Defenders of amalgam mercury are fond of saying that everything is potentially poisonous and "the dose makes the poison."

1. While this is true, they conveniently fail to point out the factor of "relative" or "comparative" toxicity. For example, given a fixed individual host factor of susceptibility or resistance, would that individual experience the same adverse effect from a given dose of sodium chloride (table salt) as from an equal dose of botulism toxin?

2. The amalgam mercury defenders (mostly dentists unfamiliar with mercury toxicology), while agreeing that patients are continuously exposed to mercury from their amalgams, steadfastly claim - without providing valid documentation - that the exposure is too small to cause harm. We must be aware of the findings of qualified mercury toxicologists, who have all concluded that no amount of human exposure to mercury vapor has been found to be harmless. In other words, there is no "toxic threshold" for human exposure to mercury vapor.

B. Selected research about levels of mercury and toxic effects

1. MAC Committee: Report of an International Committee: Maximum Allowable Concentrations (MAC) of Mercury Compounds, Arch Environ Health, 19, 902, Dec. 1969. "When numerical values for MAC values are considered, it is obvious that there exist little epidemiological data which provide scientifically satisfactory information about detailed dose-response relationships in man, even for a single mercury compound. " "Another factor that has not been possible to evaluate quantitatively is the risk of genetic or teratogenic effects of mercury compounds."

2. Friberg, L; Vestal, J. Mercury in the Environment: An Epidemiological and Toxicological Appraisal. CRC Press, Cleveland, OH, 1972. "Dose-response relationships are not known for most exposure situations." "It is not possible to state a lowest concentration which may give rise to some medical manifestations." "It is not possible to make a realistic estimation of the concentration to which the industrial concentrations given would correspond within the general population."

3. NIOSH: National Institute for Occupational Safety and Health. A Recommended Standard For Occupational Exposure to Inorganic Mercury. NITS No. PB222 223, 1973. "Because of the prevalence in the general population of non-specific signs and symptoms which can be associated with mercury, it is difficult, if not impossible, to establish a level at which no effects are observed."

4. USEPA: United States Environmental Protection Agency. Mercury Health Effects Update. E.IA. 600/8-84-0 19F, 1984. Mercury Vapor: "No threshold for these and other effects has been clearly established." (Page 2-7) "The dose-response relationship depicted in figure 65 does not exhibit a clear threshold." (Page 6-1) No threshold air concentration and concentration in urine or blood have been identified. A number of studies have raised the possibility of preclinical effects at air concentrations below 50 micrograms/cubic meter." (Page 6-21)


6. Sharma, RP; Obersteiner, EJ. Metals and Neurotoxic Effects: Cytotoxicity of Selected Metallic Compounds on Chick Ganglia Cultures. J Comparative Pathology, 91(2):23M4, Apr 1981. "Severely toxic (10-4M or less): Hg2+, Cd2-, As3-, and
Vendex-Sn2; Moderately toxic (10-4 to 10-6M): Tl3+, As6+, Se4+, and Cu2+; Slightly Toxic (10-3 or greater): Pb2+, As3+ (oxide), and Sn2+ (oxide).” Mercury, at 3.2 x 10-7M concentrations was the most toxic studied.

7. World Health Organization. Mercury in Health Care [policy paper]. Geneva, Switzerland: WHO; August 2005. "Recent studies suggest that mercury may have no threshold below which some adverse effects do not occur."

VI. Mercury Hypersensitivity (Allergy)


1. Hypersensitivity: A state of altered reactivity in which the body reacts with an exaggerated response to a foreign agent.

2. Immediate hypersensitivity: Antibody-mediated hypersensitivity characterized by lesions resulting from the release of histamine and other vasoactive substances. [Involves 8-cells.]

3. Delayed hypersensitivity: A slowly developing increase in cell-mediated immune response to a specific antigen. [Involves T-cells.]

4. Toxicity: The quality of being poisonous, especially the degree of virulence of a toxic microbe or of a poison.

5. Toxic: Pertaining to, due to, or of the nature of poison.

6. Poison: Any substance which, when ingested, inhaled or absorbed, or when applied to, injected into, or developed within the body, in relatively small amounts, by its chemical action may cause damage to structure or disturbance of function.

7. Sensitivity: A state of abnormal responsiveness to stimulation or of responding quickly and acutely.

8. Idiosyncrasy: An abnormal susceptibility to some drug, protein, or other agent which is peculiar to the individual.

B. The Incidence of Hypersensitivity (Allergy) to Mercury

1. While organized dentistry boldly proclaims that allergy to mercury is very rare (one in a million is frequently stated), no scientific evidence to support that claim has been offered.

2. To the contrary, considerable documentation exists contradicting that claim. A few examples are:

   a. Djerassi, E; Berova, N. The Possibilities of Allergic Reactions From Silver Amalgam Restorations, Intern Dental J, 19(4):481-8, 1969:

      o Study of 180 subjects with amalgam, 60 without.

        ▪ Subjects w/amalgam: 16.1% tested positive for allergy to amalgam and its components.

          ▪ 11.0% positive to mercury; 6% positive to copper; 3% positive to silver.

        ▪ Subjects w/o amalgam: 0.0% tested positive for allergy to amalgam and its components.

   b. North American Contact Dermatitis Group. Epidemiology of Contact Dermatitis in North America: 1972, Arch Dermatol,
108:537-40, 1973:

- 5% of population was allergic to ammoniated Hg
- 8% of population was allergic to thimerosal


- 1.4-16.5% reaction to mercury
- 1.1% allergic to amalgam
- 4.8-13.3% allergic to mercury chloride
- 1.2-22.6% allergic to thimerosal

VII. Dental Profession Positions on Mercury

A. Shafer, WG; Hine, MK; Levy, BM. A Textbook of Oral Pathology, WB Saunders, 1958: "A toxic reaction from absorption of mercury in dental amalgam has been reported on a number of occasions." (Chapter 10, page 444) [Note: "Toxic" not "allergic."]

B. National Institute of Dental Research/American Dental Association. Workshop: Biocompatibility of Metals in Dentistry, JADA, 109, 470, 1984: "Studies have demonstrated that patients are exposed to mercury vapor when amalgams are placed as a restoration, when existing amalgams are removed, and during chewing."

C. ADA. When Your Patients Ask About Mercury in Amalgam, JADA, 120:396, Apr 1990: "The strongest and most convincing support we have for the safety of dental amalgam is the fact that each year more than 100 million amalgam fillings are placed in the United States. And since amalgam has been used for more than 150 years, literally billions of amalgam fillings have been successfully used to restore decayed teeth." [Note: Anecdotal, not science!]