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Review of the effects of Asphalt fume emission (VOCs and PAHs) in vitro, in vivo and human studies

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Background

Asphalt/bitumen is a dark or brown petroleum-like substance obtained as a byproduct of petroleum distillation or natural deposits. Asphalt contains hydrogen and carbon molecules with small amounts of nitrogen, sulfur, and oxygen. Asphalt is abundantly available around human operations including road paving and roofing sites. However, their emissions and fumes (specifically volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs)) have been found to have adverse effects on health. Asphalt fumes are a class 2A carcinogen and exposure can increase the risk of lung cancer, asthma, headache, fatigue, and other cardiovascular diseases as shown in Figure 1.

To have a better understanding of how asphalt impacts the health system, it is critical to review previous in vitro, in vivo, and human scientific literature that discussed asphalt fume exposure and its effect on the health system.

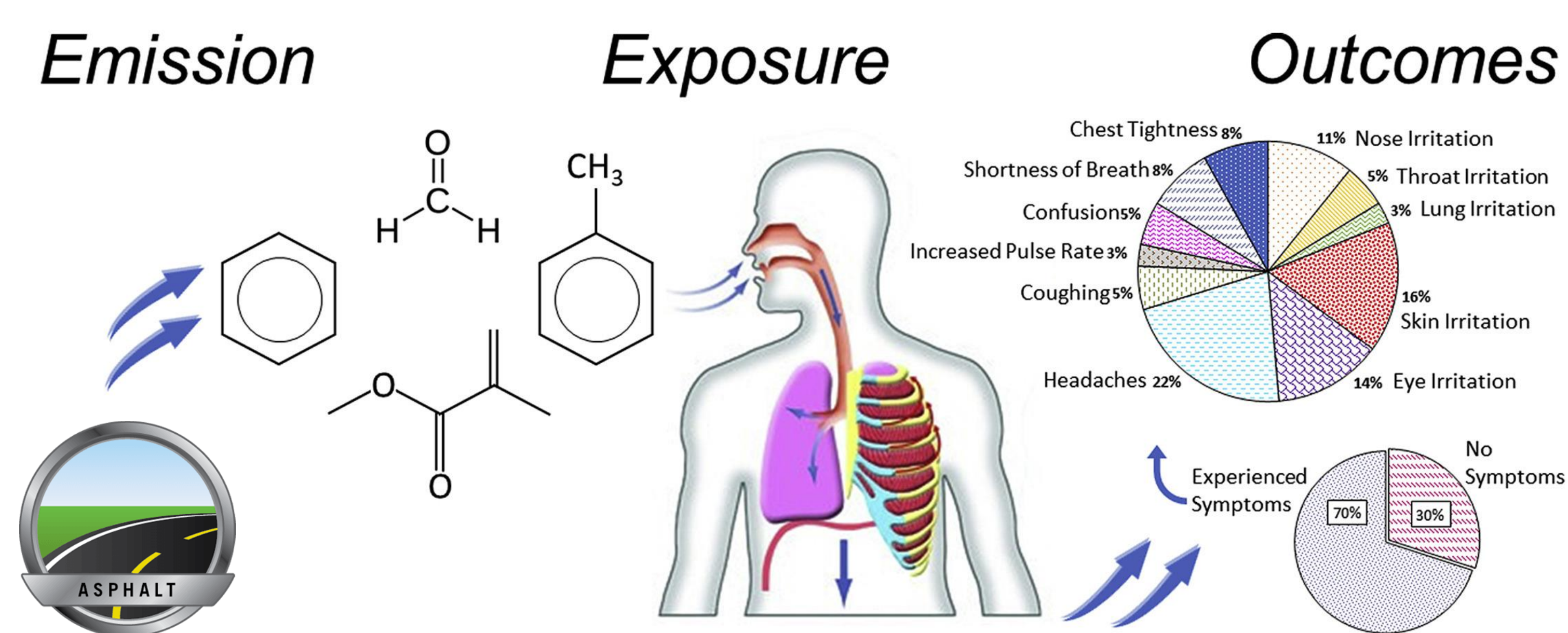


Figure 1. basic design that shows how Asphalt fume affect the lung Retrieved from (Lamplugh, 2019)

Methods

We used three literature sources (Google Scholar, PubMed and Web of Science) to gather in vitro, animal in vivo, and human studies about asphalt/bitumen exposure and their effects on lungs, as well as focusing on biomarker measurements, such as interleukin-8 (IL-8) concentration in blood and 1-hydroxypyrene (1-OHP) in urine samples. The search term ("asphalt" OR "bitumen") AND "health" yielded 207,000 hits, 454 hits, and 931 hits from Google Scholar, PubMed and Web of Science, respectively. Focusing on the PubMed and Web of Science hits, 267 duplicates were found, leaving 987 papers. After removing studies that were not directly related to human health (e.g. environmental impacts), there were around 630 papers.

After screening for relevance, the number of papers reviewed are shown in Figure 2.

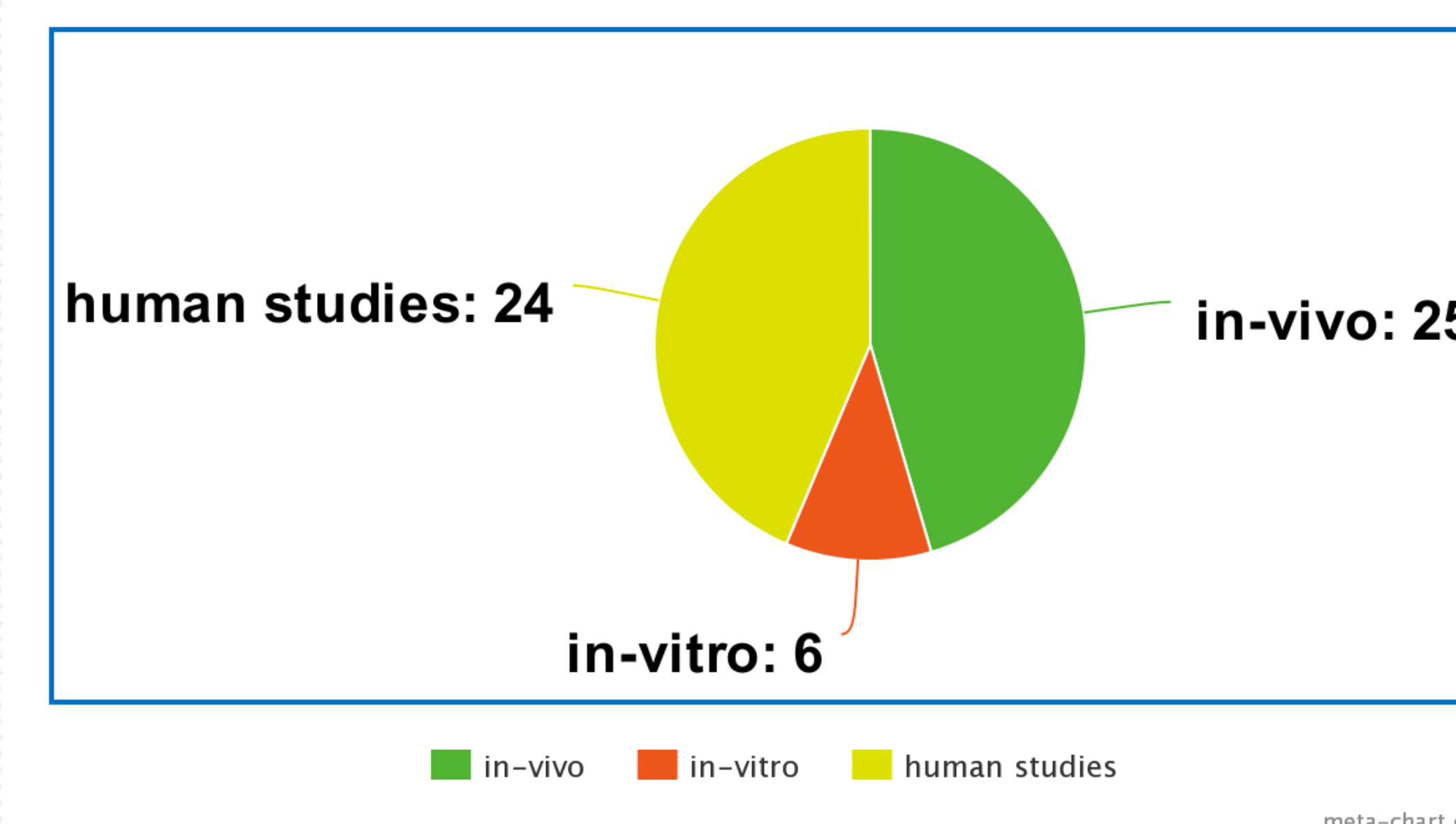


Figure 2. Pie graph that shows the number of studies reviewed for biomarkers and health effects.

Results

After reviewing the in-vitro, animal in-vivo and human studies literature papers, we narrowed our focus to two biomarkers (Interleukin 8 and 1-hydroxypyrene).

Interleukin 8 (IL-8) is a chemoattractant cytokine produced by a variety of cells, including blood cells. It is mostly used to assess chronic inflammation. A high level of IL-8 is associated with a variety of chronic inflammatory conditions, including heart disease, diabetes, cancer, and bowel diseases.

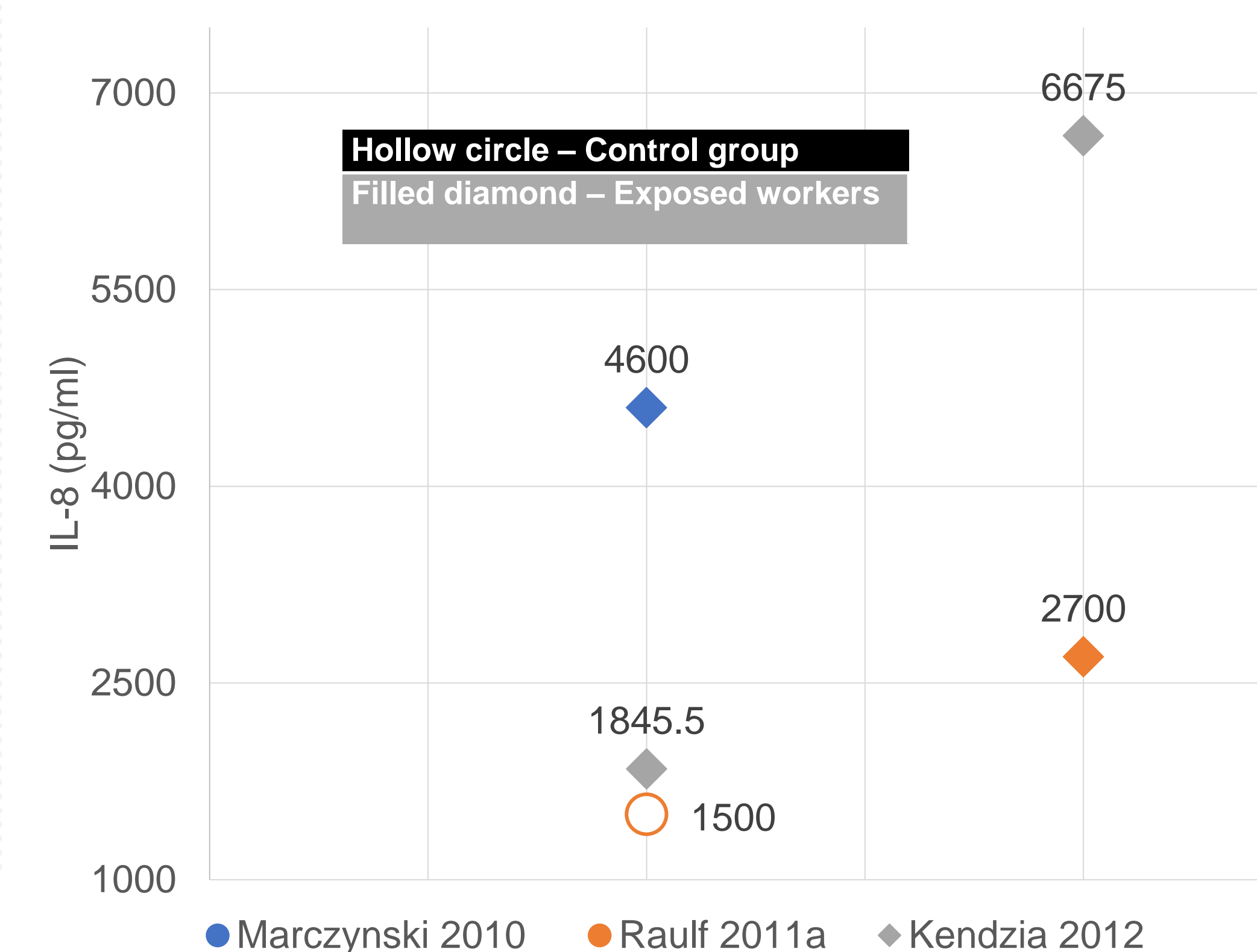


Figure 3. IL-8 (pg/ml) values from different studies.

According to the results represented in Figure 3. The concentration of IL-8 exposed asphalt workers is 3.5 times that of the control group (Kendzia, 2012), and in the (Raulf, 2011a) study, the concentration of the control group was approximately half that of the exposed Asphalt workers. The significant disparity in the number of exposed Asphalt workers between the three studies was related to a variety of factors, including (1) the type of Asphalt used (roofing or road paving), (2) personal diet, and (3) the studies did not indicate whether or not the worker was a smoker.

As for 1-hydroxypyrene (1-OHP), 1-OHP is one of the biomarkers used to detect the presence of PAHs in urine samples. There are numerous factors that contribute to the increase in the value of 1-OHP not just exposure to Asphalt/bitumen, including tobacco use and working in the oil & gas industry. As for what the 1-OHP number indicates, high 1-OHP values correlate to high worker/human exposure to pyrene containing compounds because 1-OHP is a metabolite of pyrene.

Based on the results shown in Figure 4. Each study that compared non-exposed control groups to Asphalt workers demonstrated a clear effect of exposure to Asphalt/bitumen, as the mean 1-OHP (ng/g of creatinine (crn)) value for exposed workers ranged from 2 to 11 times that of the control group (Peash,2011, Yilmaz,2016, Cavallo,2006). According to the results above, asphalt exposure had a significant effect on the 1-OHP value in urine samples, implying that asphalt exposure may be as detrimental as tobacco use in terms of 1-OHP levels.

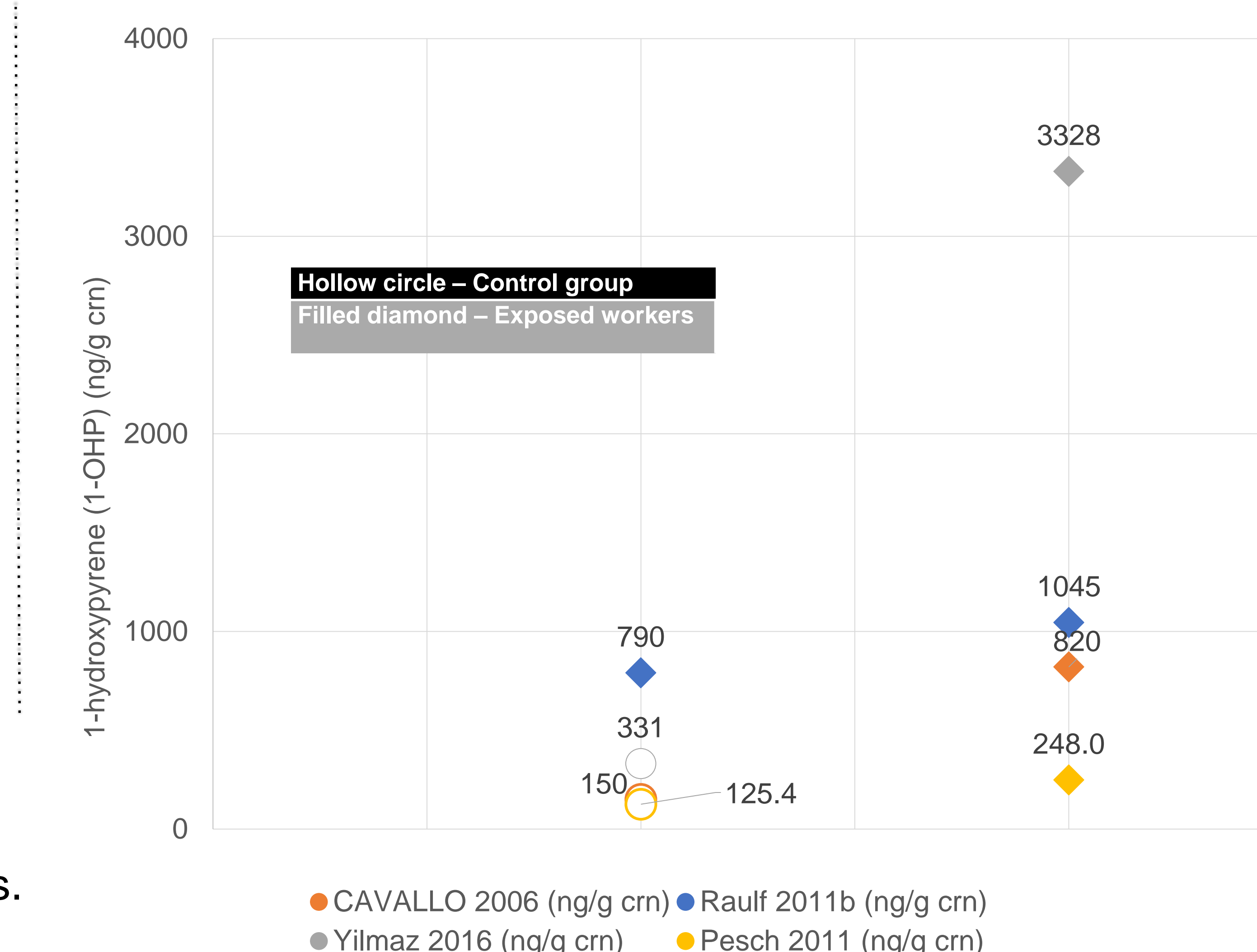


Figure 4. 1-OHP (ng/g crn) values from different studies.

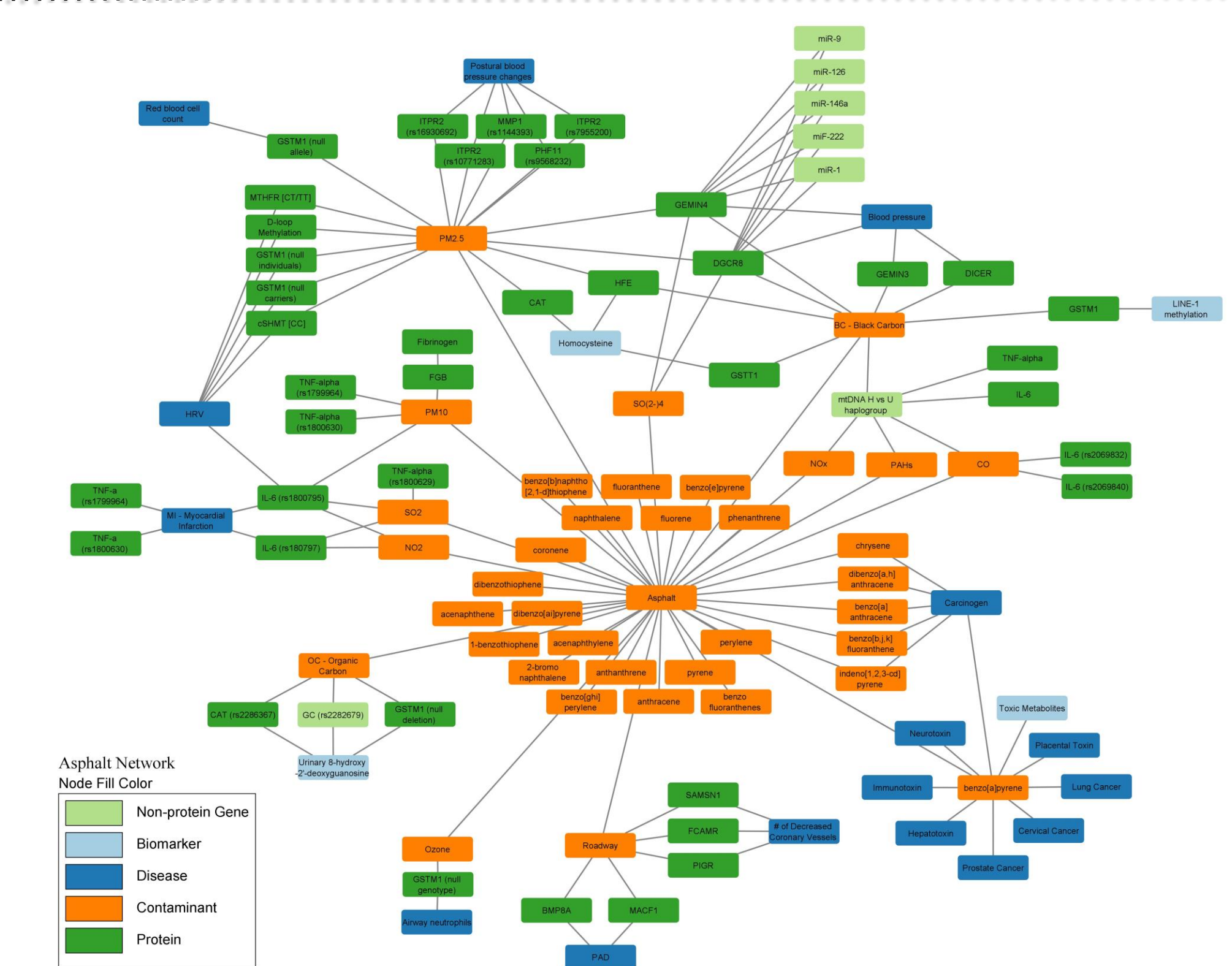


Figure 5. Interactions between asphalt/bitumen compounds and human body.

Conclusion/Recommendations

After a careful review of the available research from human studies, in-vivo animal studies, and in-vitro research, it was determined that existing research on the health effects of exposure to paving and roofing asphalts, as well as asphalt-based products, have focused on carcinogenicity and additional research is required to better understand the link to other health outcomes, such as asthma, fatigue, and obesity.

Due to a limited number of in-vitro, animal in-vivo, and human studies, it is difficult to determine

- whether exposure causes health problems such as lung disease, asthma, headaches, fatigue, and other cardiovascular disorders; and
- what specific compounds or chemicals (e.g. VOCs or PAHs) increase the risk of developing these health issues.

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