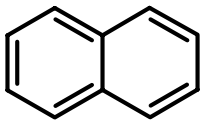
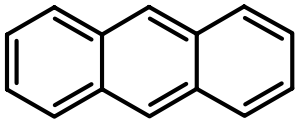
Dr. Kevin Smith **Polycyclic Aromatic Hydrocarbons** (PAHs)

WHAT ARE PAHs?

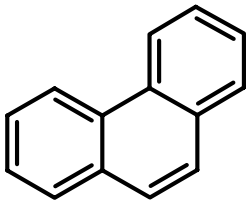
Polycyclic aromatic hydrocarbons or (PAHs) are a class of very stable organic molecules made up of only carbon and hydrogen. Consider these as "fused benzene ring" structures ---- a variety of representative PAHs can be seen below. These molecules are planar, with each carbon having three neighboring atoms much like graphite (pencil lead).



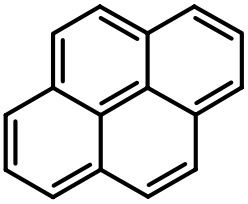
naphthalene



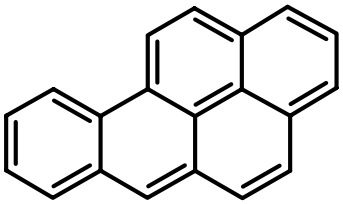
anthracene



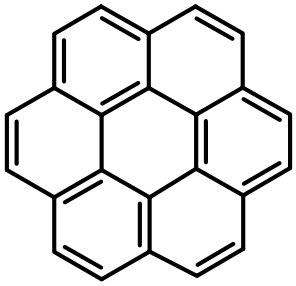
phenanthrene



pyrene



benzo[a]pyrene



coronene

HOW CAN I BE EXPOSED TO PAHs?

PAHs are found throughout our environment in the air, water, and soil, and can persist in the environment for months or years. PAHs occur naturally in coal, crude oil, gasoline, coal-tar pitch, creosote, and asphalt. When coal is converted to natural gas, PAHs can be released. PAHs are also produced during the incomplete combustion of fossil fuels, garbage, or other organic substances. The less efficient the burning process, the more PAHs are given off. Forest fires and volcanoes produce PAHs naturally. Levels of PAHs in urban air may be 10 times greater than those found in rural areas. You may be exposed to PAHs in soil near hazardous waste sites or near areas where coal, wood, gasoline or other products have been burned.

Thus, PAHs are found in polluted air but they can also be found in cooking oil fumes, tobacco smoke, smoked foods, and foods cooked at high temperature. Some, such as pyrene and benzo[a]pyrene, are found in charcoal broiled meats such as hamburgers.

HOW CAN PAHs AFFECT MY HEALTH?

The health effects that can be caused by exposure to PAHs depend on many factors including:

- how much has entered your body
- how long you have been exposed to PAHs
- how your body responds to PAHs.

Short-term health effects

It is not clear that PAHs cause short-term health effects. Other compounds resulting from incomplete combustion which are commonly found with PAHs may be the cause of short-term symptoms such as eye irritation, nausea, vomiting, diarrhea, and confusion.

Long-term health effects

Long-term health effects of exposure to PAHs may include cataracts, kidney and liver damage, and jaundice. Repeated skin contact to the PAH naphthalene can result in redness and inflammation of the skin. Breathing or swallowing large amounts of naphthalene can cause the breakdown of red blood cells.

Long-term exposure to low levels of some PAHs have caused cancer in laboratory animals with pyrene and benzo(a)pyrene being the most carcinogenic. Studies of workers exposed to mixtures of PAHs and other compounds have noted an increased risk of skin, lung, bladder, and gastrointestinal cancers. However, the information provided by these studies is limited because these workers were exposed to other potential cancer-causing chemicals besides just PAHs. Animal studies have shown adverse reproductive and developmental effects from PAH exposure also but these effects have generally not been seen in humans.

HOW CAN I REDUCE MY EXPOSURE TO PAHs?

One of the greatest sources of exposure to PAHs is breathing these compounds in tobacco smoke. Smokers can lower their own exposure and the exposure of their families by stopping smoking. People could also reduce their use of wood burning stoves and fireplaces. Additional steps to lower exposure to PAHs include:

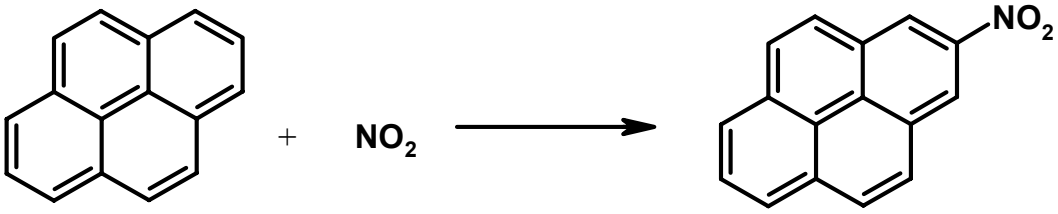
- decreasing consumption of smoked and charbroiled foods
- decreasing the use of coal-tar-based cosmetics and shampoos
- substituting cedar shavings or aromatic herbs for mothballs, moth flakes, and deodorant cakes
- avoiding skin contact by wearing protective clothing, such as long-sleeve shirts, long pants, and gloves, if you are handling creosote-treated wood products
- avoiding exposure to dust and fumes by wearing an appropriate respirator when working with products containing PAHs.

WHAT ABOUT NITRATED PAHs

Nitrated polycyclic aromatic hydrocarbons (NPAHs) belong among highly dangerous mutagenic compounds which are associated with the increasing occurrence of cancer diseases. The interest in these substances has grown after 1978 when it was discovered that NPAHs could be formed in polluted air by reactions of polycyclic aromatic hydrocarbons with nitrogen oxides (NO_2, commonly produced during combustion in air). Some of NPAHs are directly emitted to the atmosphere by diesel and petrol engines. Nitrated polycyclic aromatic hydrocarbons are responsible for a high proportion of the "direct-acting" mutagenicity of air and diesel particulate extracts, when tested in the Ames' bioassay. Great effort have been made to detect NPAHs in different kinds of environmental samples. Attention was also being paid to the analysis of another highly mutagenic derivatives, which can be formed during metabolic transformations.

ORIGIN AND OCCURRENCE OF NITRATED PAHs

Nitrated polycyclic aromatic hydrocarbons have been found in air, diesel and petrol engine exhausts, in carbon black, exhaust from waste incineration plants, in sediments, cigarete smoke and some foodstuffs. Diesel engine exhaust belongs to the most important sources of NPAHs in the air. More than 50 different NPAHs have been identified in diesel exhaust samples. The most abundant substance is 1-nitropyrene, although we can find anthracene and phenanthrene nitroderivatives in these samples as well. A typical representatives of a NPAHs, 2-nitropyrene, formed exclusively by atmospheric reactions is shown below.



pyrene 2-nitropyrene

BIOLOGICAL ACTIVITIES OF NPAHs

When analyzed in the Ame's assays, many of NPAHs have been found to be mutagenic even in the absence of exogenous metabolic activation. Some of them, such as dinitropyrenes, are among the most potent mutagens ever tested. NPAHs can enter the body by inhalation, absorption through the skin and through the intestinal tract. They are probably reduced by reductase enzymes in the liver to form methaemoglobin - inducing substances, *e.g.* nitroso derivatives and N-hydroxylamines. However, these intermediates are further reduced to the corresponding amino aromatic compounds, which are excreted in urine in free form or after acetylation. The cellular reduction of NPAHs is catalysed by NADPH-cytochrome P450 reductases. In addition, C-hydroxylation of the aromatic ring system can occur and further metabolic derivatives of the NPAHs can be formed by N-N dimerization of the reduced intermediates. The toxic effects of various nitroaromatic compounds are attributed to the formation of free radicals as a result of enzyme activity. The most important reactions are with the cellular macromolecules, especially with proteins and nucleic acids. These reactions may explain the mutagenic and carcinogenic effects of NPAHs.