Diesel Particulate In the Body

How Oregon's Unfiltered Commercial Trucks affect Human Health

Our immune system is designed to protect our bodies from threats, whether internal or external, such as cold germs, cancer cells, or air pollution. Airborne particulate matter is the most dangerous category of air pollution in the Portland area. Our immune system recognizes particulate matter as a foreign invader and instigates a defensive response. When the immune response is sustained, excessive, and unchecked, it may adversely affect our organs, including the lungs, heart, and brain.

While diesel powered vehicles are only 6% of Oregon vehicles on the road, they emit 60 - 70% of all particulate emissions from all on-road vehicles combined. In the Portland area, 3/4 of commercial trucks do not have a diesel particulate filter and cause the majority of airborne diesel particulate. In contrast, by 2015 virtually all California trucks had filters that remove 90% of diesel particulate emissions. The State of California reported that currently diesel particulate is still "responsible for about 70% of California's estimated known cancer risk attributable to toxic air contaminants."

DEQ reported in 2015 that diesel exhaust causes lung and bladder cancer, certain heart attacks and other blood clotting diseases, coronary artery disease, malignant childhood brain tumors, decreased cognitive functioning, increased incidence of Lou Gehrig's disease (ALS), acute bronchitis, and asthma. A study by Bishop et al. found diesel particulate causes dementia and Alzheimer's disease. Immediate symptoms include eye and throat irriation, coughing and phlegm, swollen airway, bronchial irritation, nausea, headache, lightheadedness, and fatigue.

Particulate Matter Defined

Particles larger than ten micrometers in diameter tend to be trapped in the nose, mouth or throat and can be coughed or sneezed out.

PM10, which is particulate matter that is ten micrometers or smaller, can be inhaled deep into the lungs and is associated with lung problems. The primary sources of PM10 are

> "road and agricultural dust, tire wear emissions, products of wood combustion, construction and demolition works, and mining operations."

PM 2.5 are particles 2.5 microns or smaller and are more dangerous than larger particles.

> "PM 2.5 particles commonly originate from oil refineries, metal processing facilities, tailpipe and brake emissions, residential fuel combustion, power plants, and wild fires." PM 2.5 and smaller can be deposited in lung tissue and can cross the thin lung membrane into the bloodstream.

Ultrafine particulate (UFP) is 0.1 micrometers and smaller in diameter. Due to the small size and aerodynamic properties of UFP, it is of greatest concern to our health. Diesel particulate is primarily UFP.

Research experiments on simulated air pollution found that PM 2.5, which includes UFP, accumulates in various organs, such as the liver, spleen, kidneys, heart, and brain. It can even cross the placenta and infiltrate the fetus.

Entering the Bloodstream

For air pollution, "the lungs are the portal of entry" into the body where it may enter the bloodstream.

> "All of the blood that leaves the lungs goes through the heart, where it's then pumped out to the rest of the body ... This triggers the immune system, causing inflammation."

It is hypothesized that the small size of PM 2.5 allows it to cross the single cell layer of the lung alveoli and traverse the thin lung capillary wall, thereby accessing the bloodstream. Another hypothesis is that PM 2.5 passes into the lymphatic circulation and from there enters the bloodstream.

Peripheral Inflammation

Lung cells, such as alveolar epithelial cells and alveolar macrophages, are the first line of defense against toxins. When tissues come in contact with PM 2.5 it activates the innate immune system, resulting in local inflammation. Lung epithelial cells secrete proteins which alert the immune system to the invader. When particulate matter accumulates in lung tissue, immune cells and inflammation molecules increase to excess in the circulation. This results in peripheral inflammation, which is inflammation not including the brain.

Blood-Brain Barrier

In general, the blood-brain barrier prevents toxins, chemicals, medicines, etc. in the bloodstream, or peripheral circulation, from reaching the brain. Less than two percent of the smallest molecules such as oxygen, water molecules, and hydrophobic molecules cross the blood-brain barrier. Glucose, the primary energy source of the brain, uses a molecular key to cross via active transport.

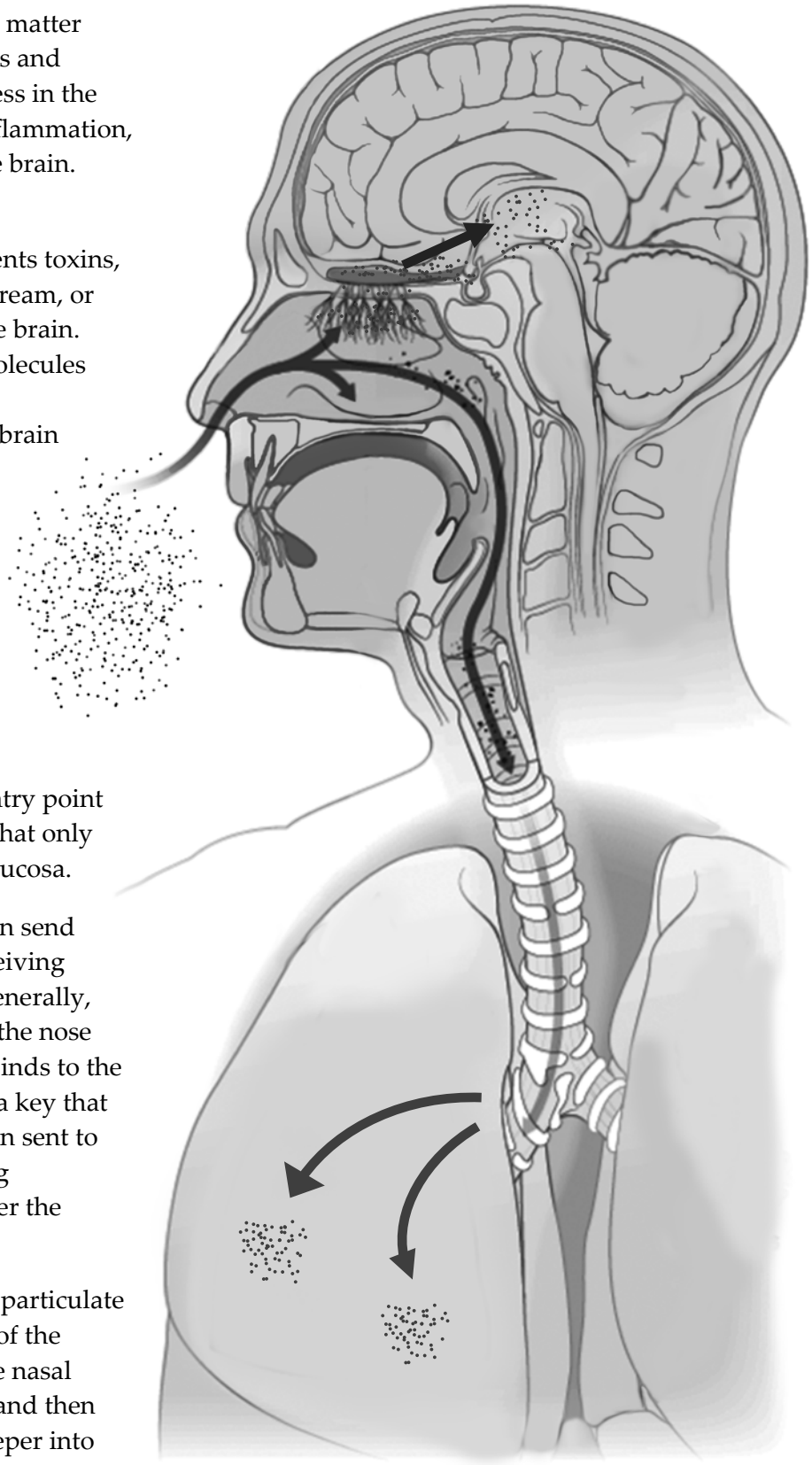
Current research suggests that PM 2.5 crosses the blood-brain barrier after peripheral inflammation and oxidative stress occurs.

Direct Access to the Brain

Research shows that the nose is a key entry point of particulate matter into brain despite that only 2-16% of inhaled air reaches the nasal mucosa.

Brain cells that process smell information send long extensions into the nose. These receiving ends are located in the nasal mucosa. Generally, the molecule creating a smell will enter the nose and pass through the mucosa. There it binds to the receiving end of the neuron, acting like a key that unlocks an electrical signal, which is then sent to the brain for further processing. Inhaling particulate matter may or may not trigger the sense of smell.

Unlike other molecules inhaled nasally, particulate matter is taken up by the receiving end of the nasal neurons and transported along the nasal nerve pathway, into the olfactory bulb, and then along the nasal processing pathway, deeper into the brain. One study showed a concentration gradient of particulate matter along the smell-processing pathway. The concentration was highest closer to the initial entry point at the olfactory bulb area and became less concentrated along the nasal processing pathway, deeper in the brain.



Neuroinflammation

When particulate matter directly contacts brain tissue it causes inflammation, vascular damage, and neurodegeneration. Even though these effects in the brain are dangerous, research suggests that peripheral inflammation caused by air pollution poses a greater threat to the brain. Particulate matter inhaled into the lungs triggers an inflammatory cascade response. This inflammatory cascade is hypothesized to degrade various physical defenses such as the olfactory, respiratory, and blood-brain barriers. As a result, indiscriminate access across a compromised blood-brain barrier increases neurodegeneration.

Peripheral inflammation has multiple ways of causing neurodegeneration. Immune cells and inflammatory molecules can cross the blood-brain barrier, kill neurons, and degrade glial cells. Glial cells make up one part of the blood-brain barrier and help with effective neuronal functioning.

Normal Immunity

Our immune system protects our health by identifying foreign invaders, such as cold germs, or defective cells, such as cancer cells. Immune signals activate the immune response to destroy or attempt to destroy the invader. If the immune response is not properly counterbalanced then oxidative stress can occur. According to many researchers, the worst effects of air pollution are inflammation and oxidative stress.

What is Oxidative Stress?

Various sizes of particulate matter have been documented to increase free radicals and induce immune dysfunction – this is called oxidative stress, which is associated with toxicity. Our cells consume oxygen, resulting in oxidation. Oxidation is a normal and essential consequence of our cells using oxygen to metabolize nutrients. During oxygen metabolism, electrons are removed one-by-one from the molecular oxygen we inhale, resulting in oxygen species that are more chemically reactive. These reactive oxygen species are called "free radicals" in popular culture.

There is a delicate balance between free radicals and antioxidant defenses within the body. When free radicals are not sufficiently counterbalanced by antioxidants, oxidative stress occurs and disease can result.

Chronic Inflammation

Excessive inflammation can exacerbate certain diseases such as cardiovascular diseases and increase the occurrence of asthma, allergies, and other immune-related diseases. Highly exposed individuals show indications of oxidative stress and neuroinflammation in post-mortem examinations. "Chronic inflammation can induce certain cancers, and solid tumors, in turn, can initiate and perpetuate local inflammatory processes that foster tumor growth and dissemination."

What You Can Do

Diesel particulate filters can remove 90% of trucks' diesel particulate before it becomes airborne. California banned all unfiltered trucks statewide; by 2015 virtually all California trucks had diesel particulate filters. Oregon can and should do this too. Because filters are not a perfect solution, and significant health risks associated with diesel remain, the long term solution is to require the use of electric trucks for short haul in-city delivery.

Portland Clean Air works to address industrial air pollution with the cooperation of 35 Portland Neighborhood Associations and over 3,000 individual Portland members. We welcome volunteerism and public participation.
Contact greg@portlandcleanair.org
go to PortlandCleanAir.org for more information.

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For a version of this report with complete citations go to portlandcleanair.org/files/dieselandhealth

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