



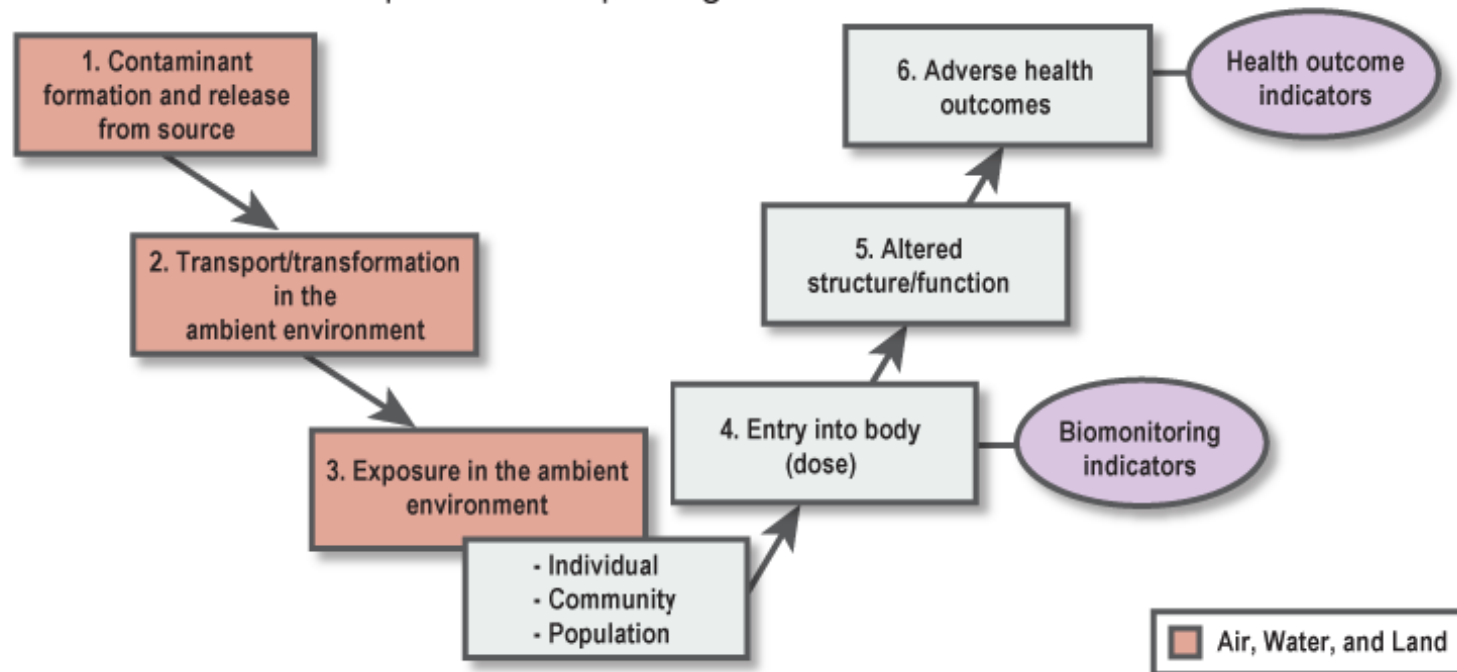
The Challenge of Moving from the Measurement of Particulate Matter to Evaluating Individual Exposure

*The National
Academies of* SCIENCES
ENGINEERING
MEDICINE

Kirsten Koehler
Associate Professor
Johns Hopkins University

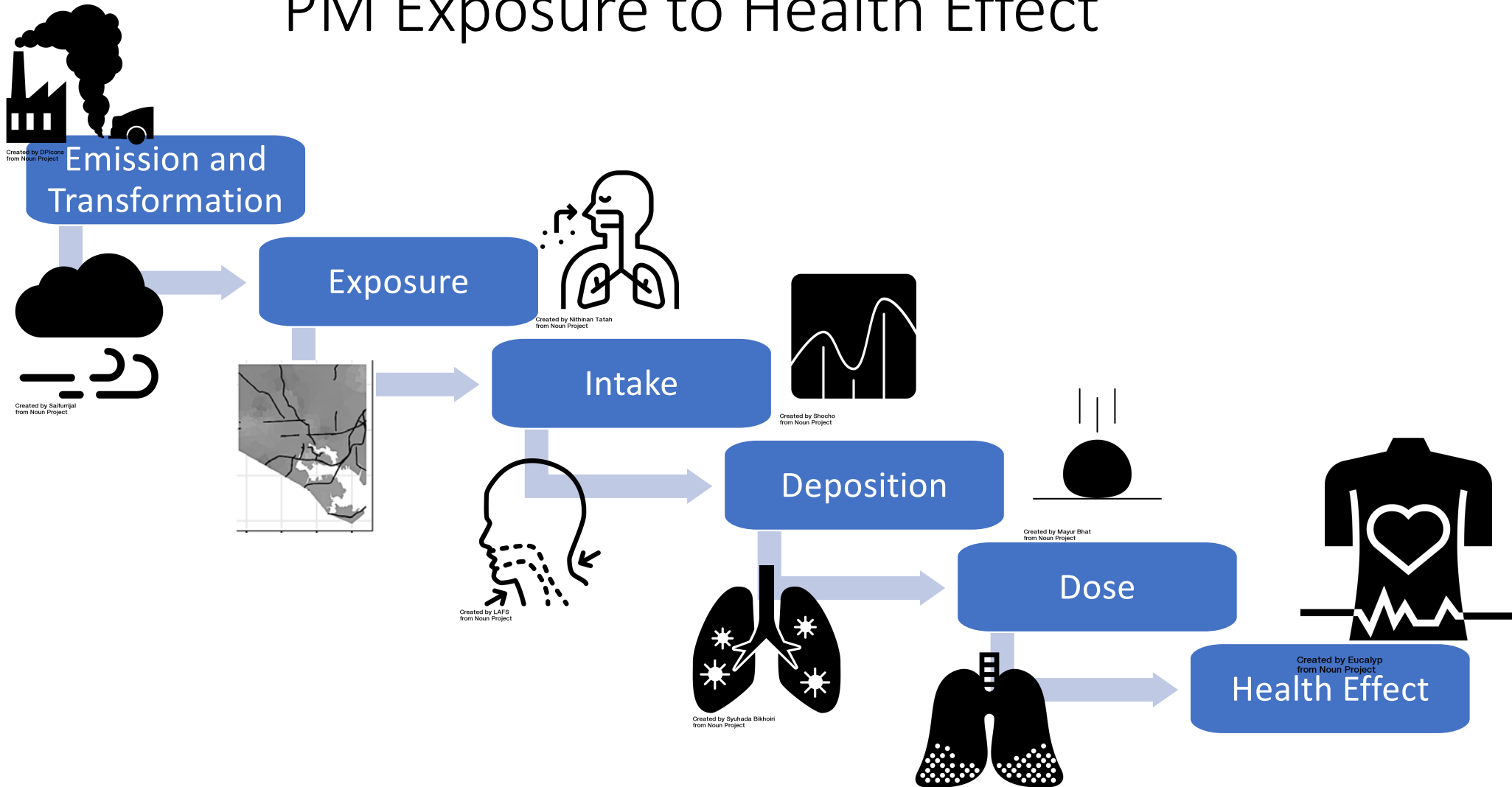
Environmental Health Paradigm

Exhibit 1. Environmental public health paradigm

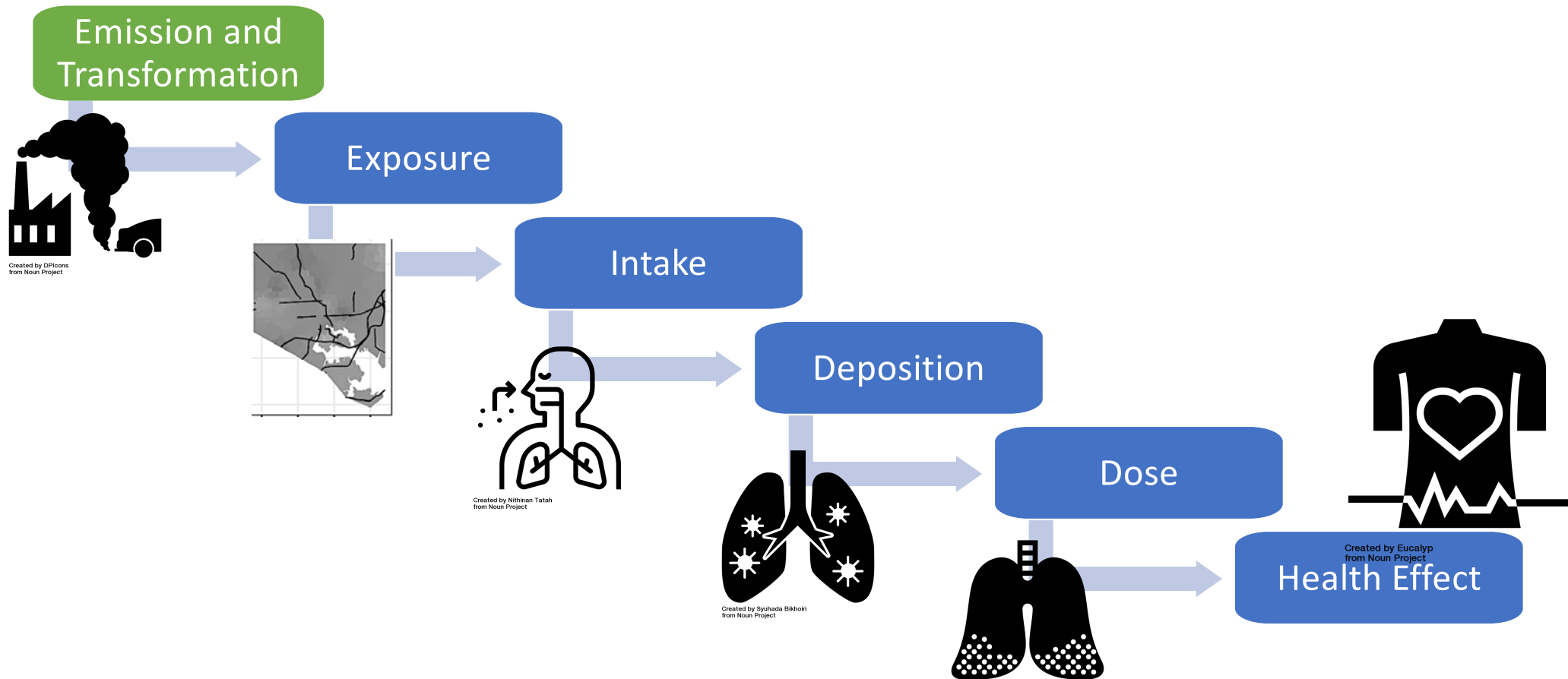


<https://www.epa.gov/report-environment/human-exposure-and-health>

PM Exposure to Health Effect



PM Exposure to Health Effect

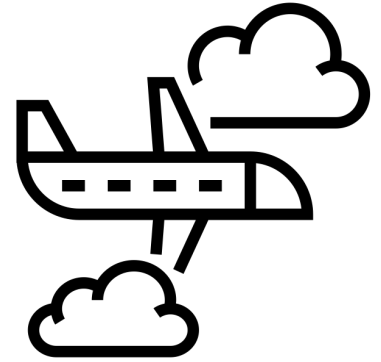


Regulation or Monitoring of Emissions

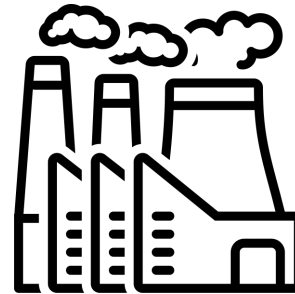
- In the U.S. emissions are regulated for some industries/sources.
- However, many factors can impact the relationship between emissions and ambient concentrations, even close to sources.



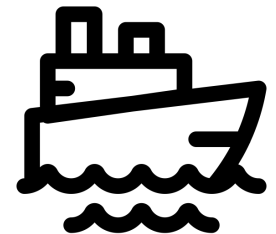
Created by LUTFI GANI AL ACHMAD
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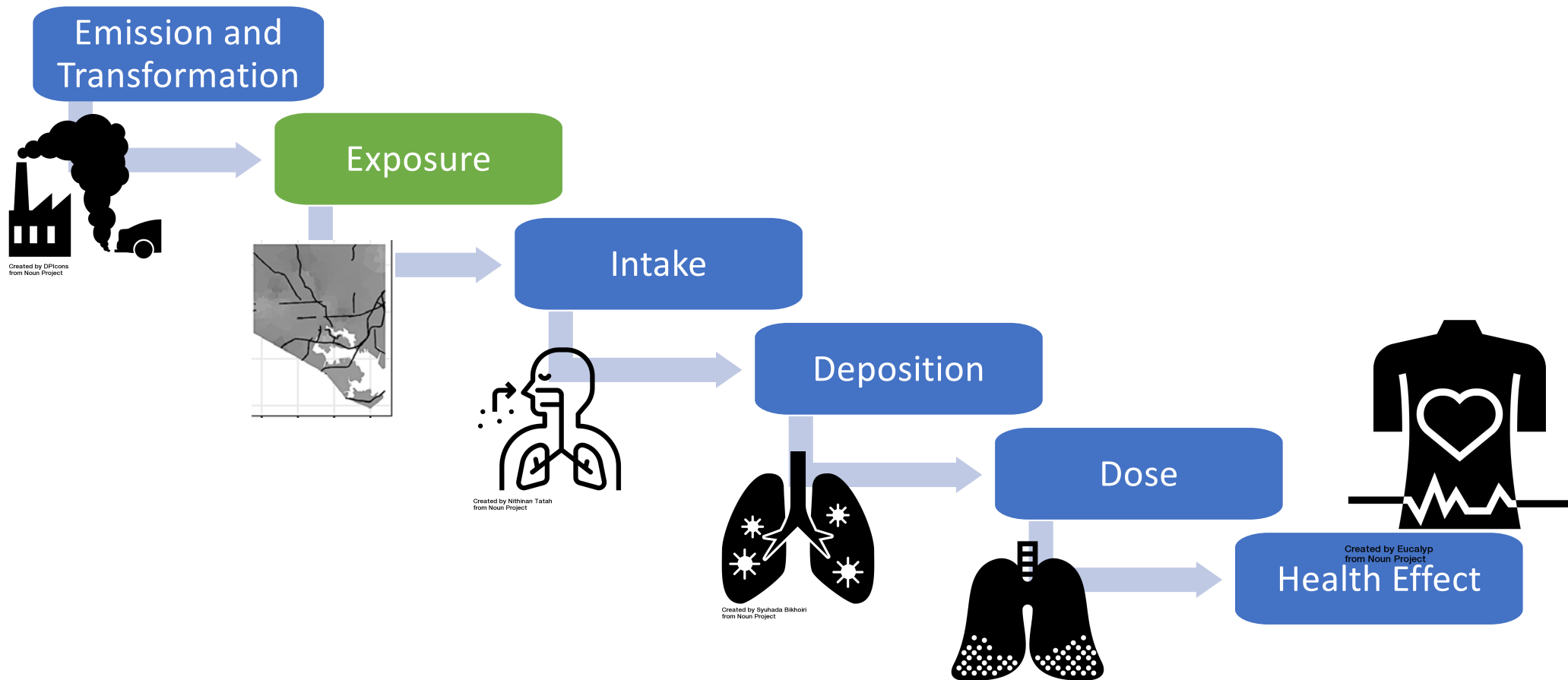


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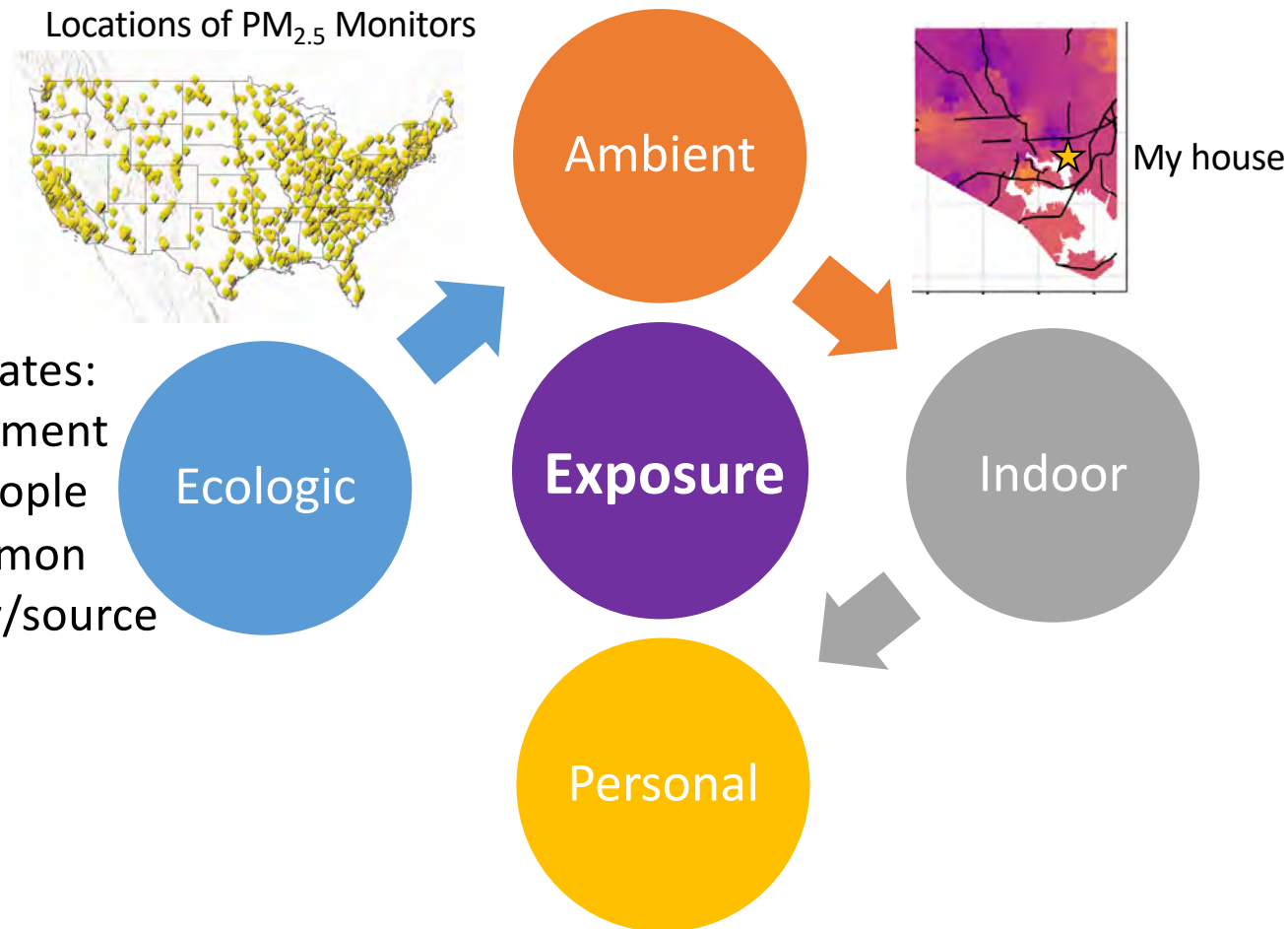


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PM Exposure to Health Effect



What do we mean by “Exposure”?



Ecological estimates:
exposure assessment
for groups of people
based on a common
location/activity/source

<https://epa.maps.arcgis.com/home/index.html>

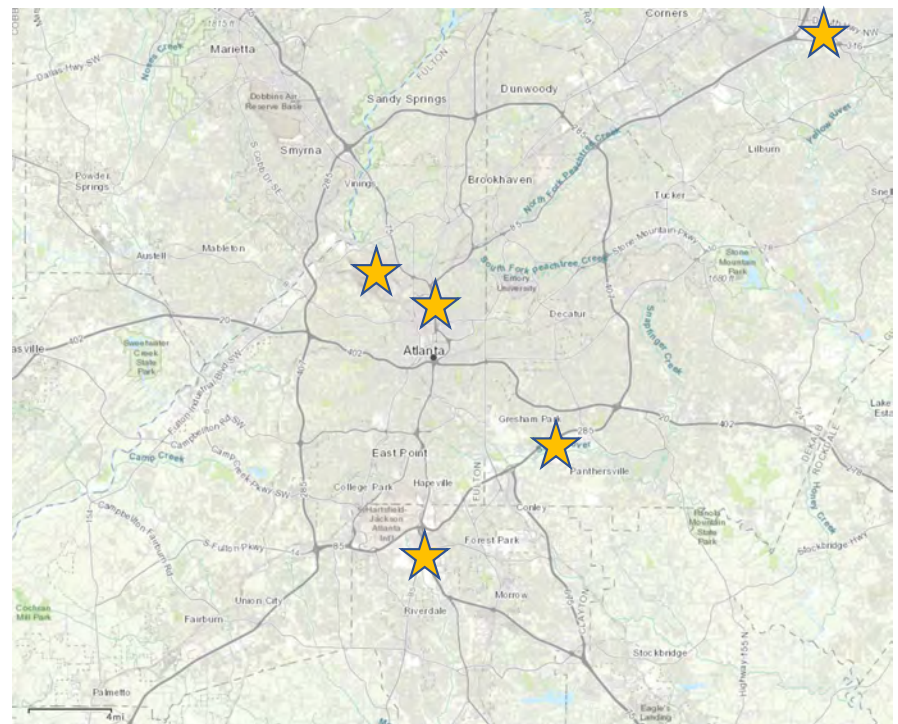
This presentation was developed under Assistance Agreement No. RD835871 awarded by the US EPA to Yale University. It has not been formally reviewed by EPA. The views expressed in this document are solely those of the authors and do not necessarily reflect those of the agency. EPA does not endorse any products or commercial services mentioned in this presentation.

Density of Monitoring Networks

Philadelphia: 6.1 M in metro area



Atlanta: 6.0 M in metro area



Opportunity: Low-cost sensor networks

Large Gradients in Concentrations Around Sources

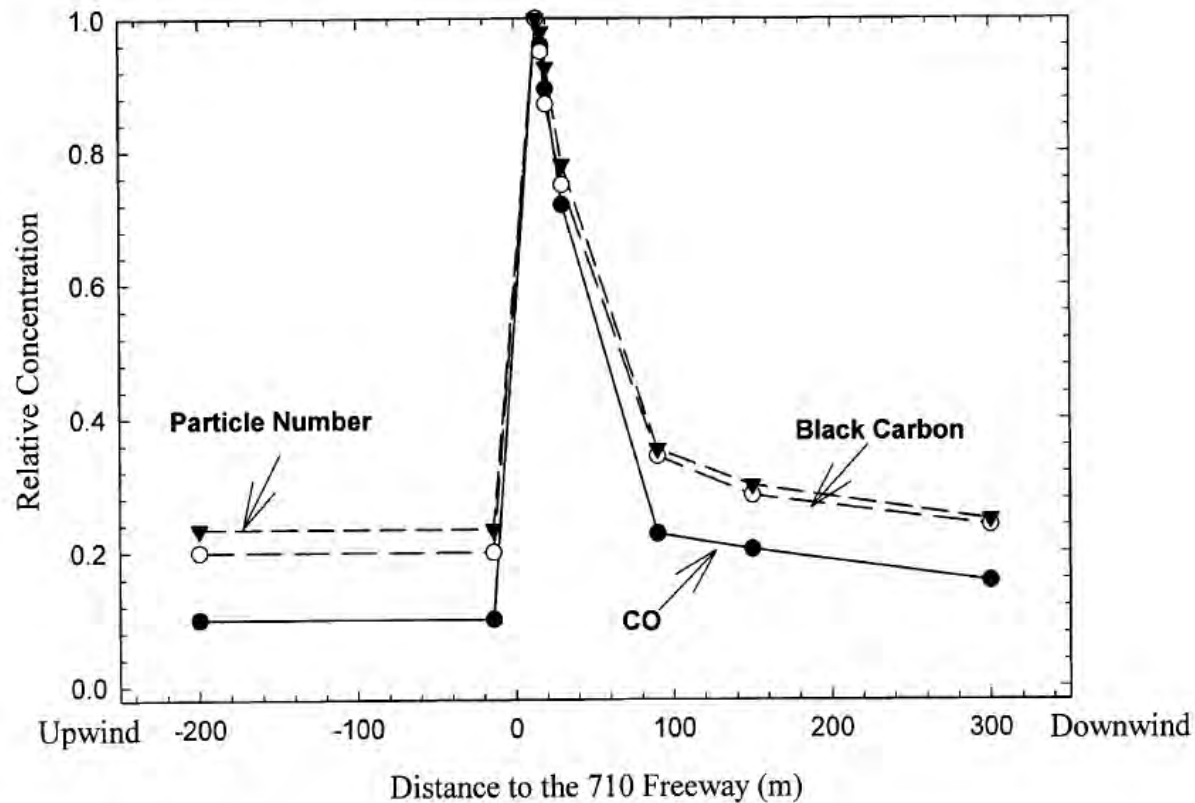


Fig. 8. Relative particle number, BC, CO concentrations versus distance from the 710 freeway.

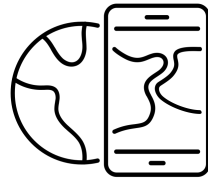
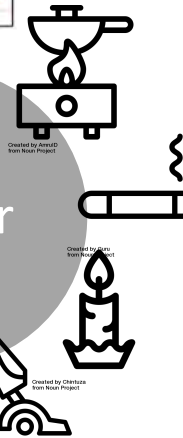
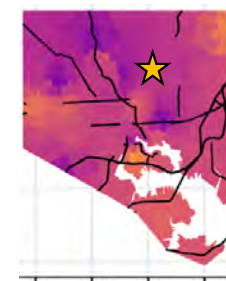
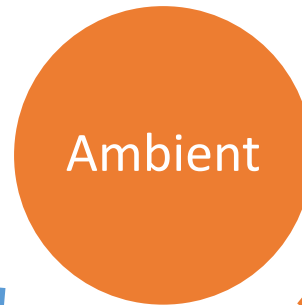
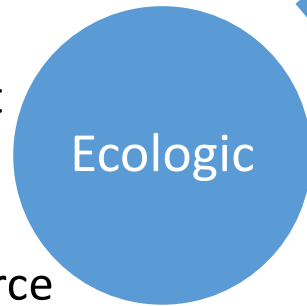
Zhu et al. *Atmos. Env.* 36 (2002) 4323-4335
[doi.org/10.1016/S1352-2310\(02\)00354-0](https://doi.org/10.1016/S1352-2310(02)00354-0)

What do we mean by “Exposure”?

Locations of PM_{2.5} Monitors



Ecological estimates:
exposure assessment
for groups of people
based on a common
location/activity/source



Created by Andrei Yushchenko
from Noun Project



Created by Wilson Peres
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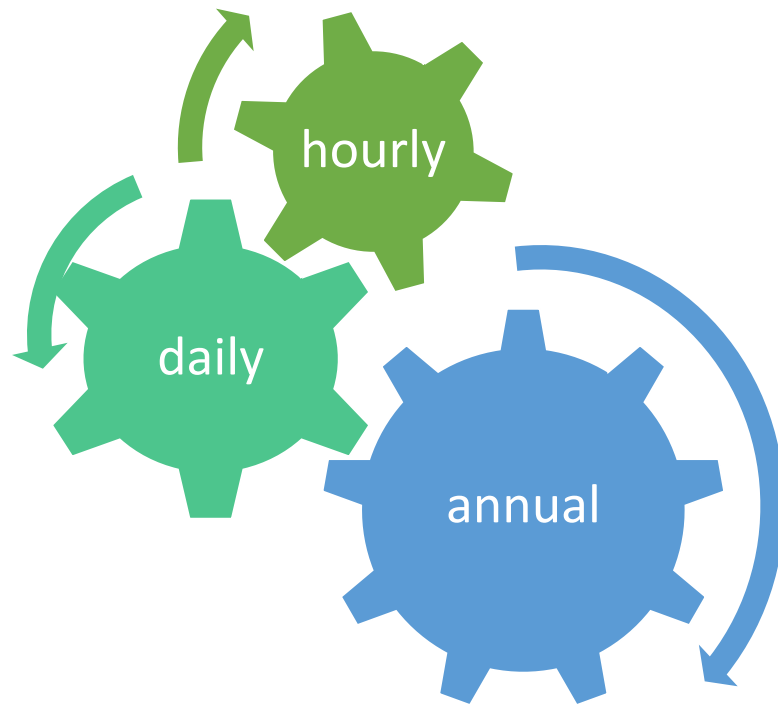
Created by Junit Saengthong
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Created by Clare Jones
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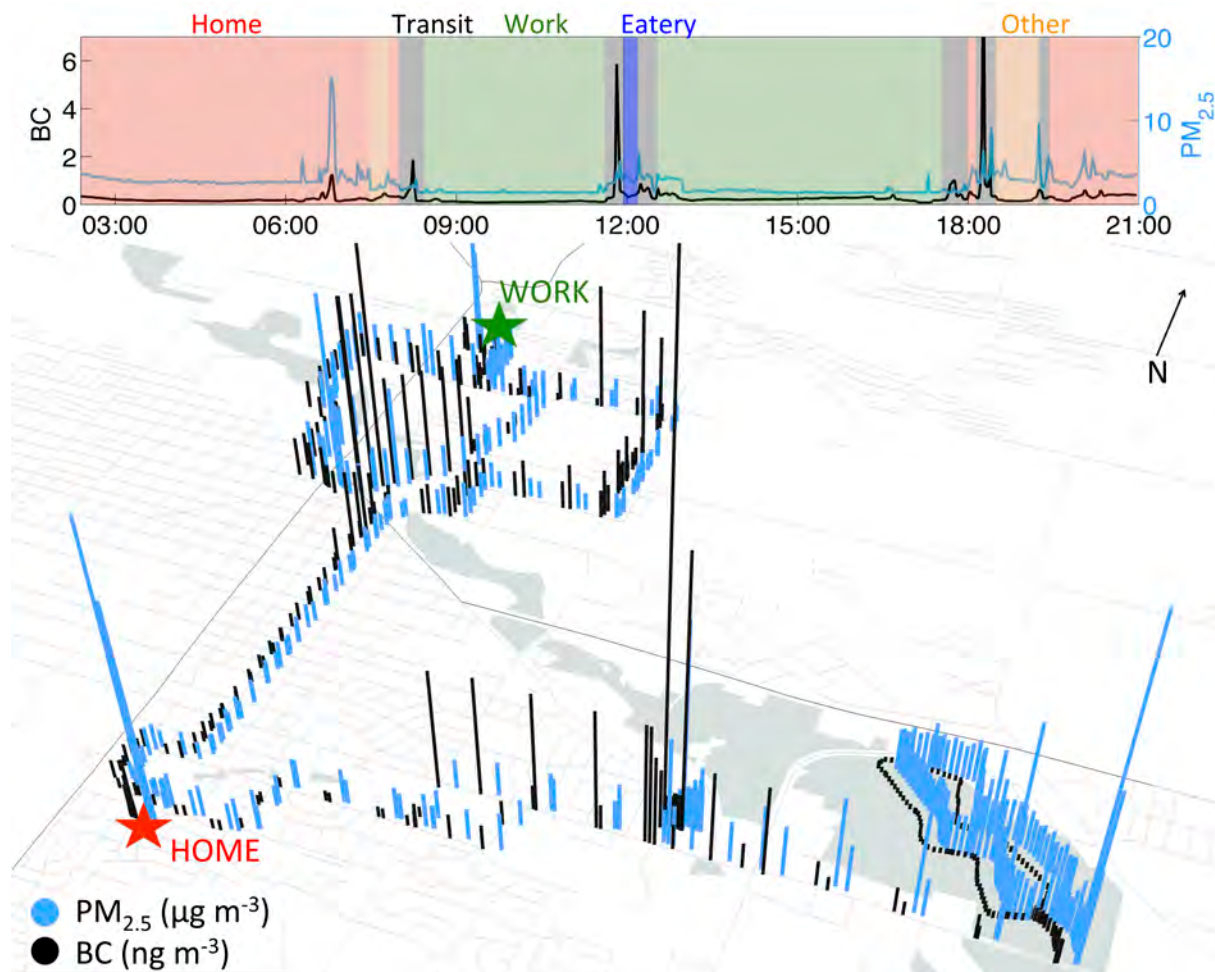
Personal sampling: often
considered “gold standard”.

Time Scales of Exposure

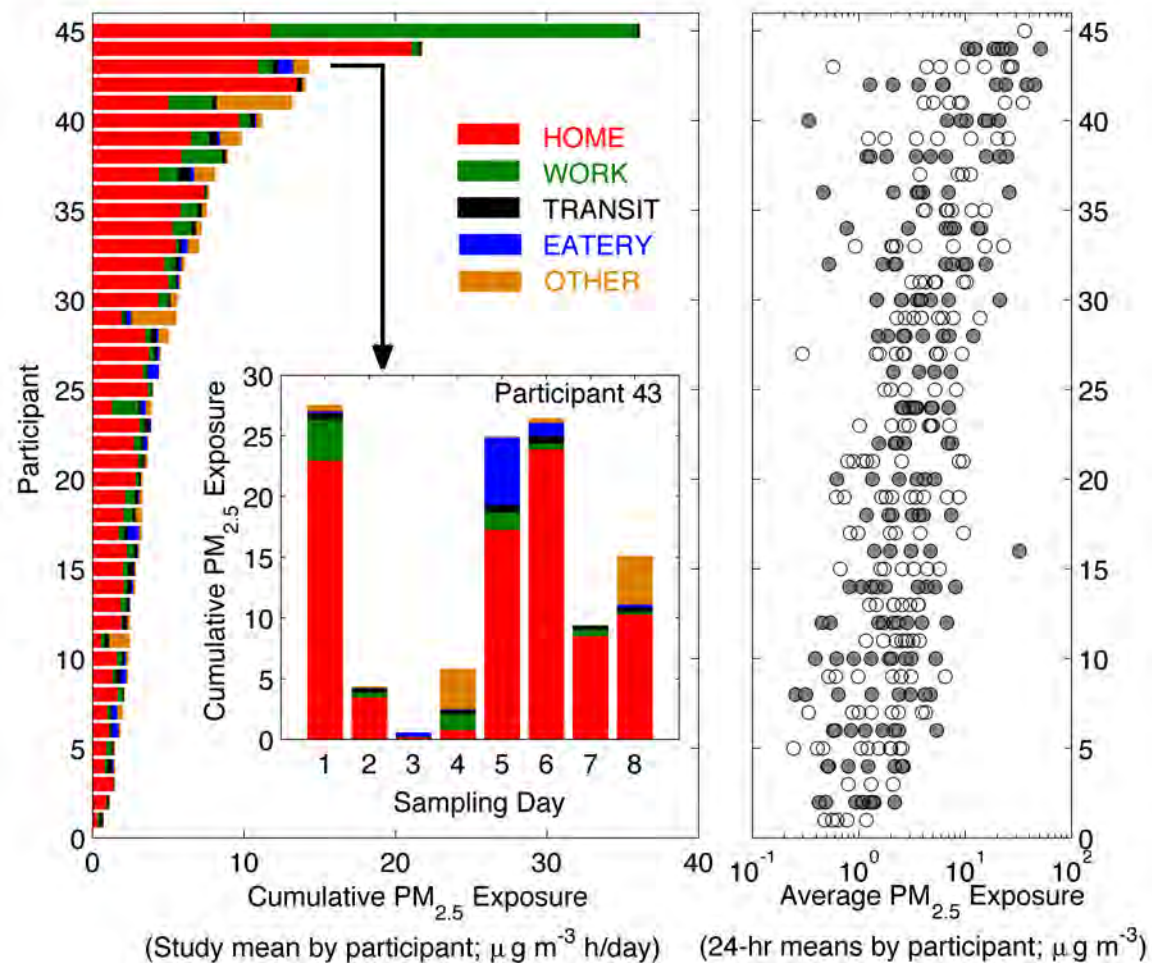


- Regulations
- Acute or chronic health impact
- Time between exposure and onset of health outcome
- Ability to estimate with personal and ecologic approaches

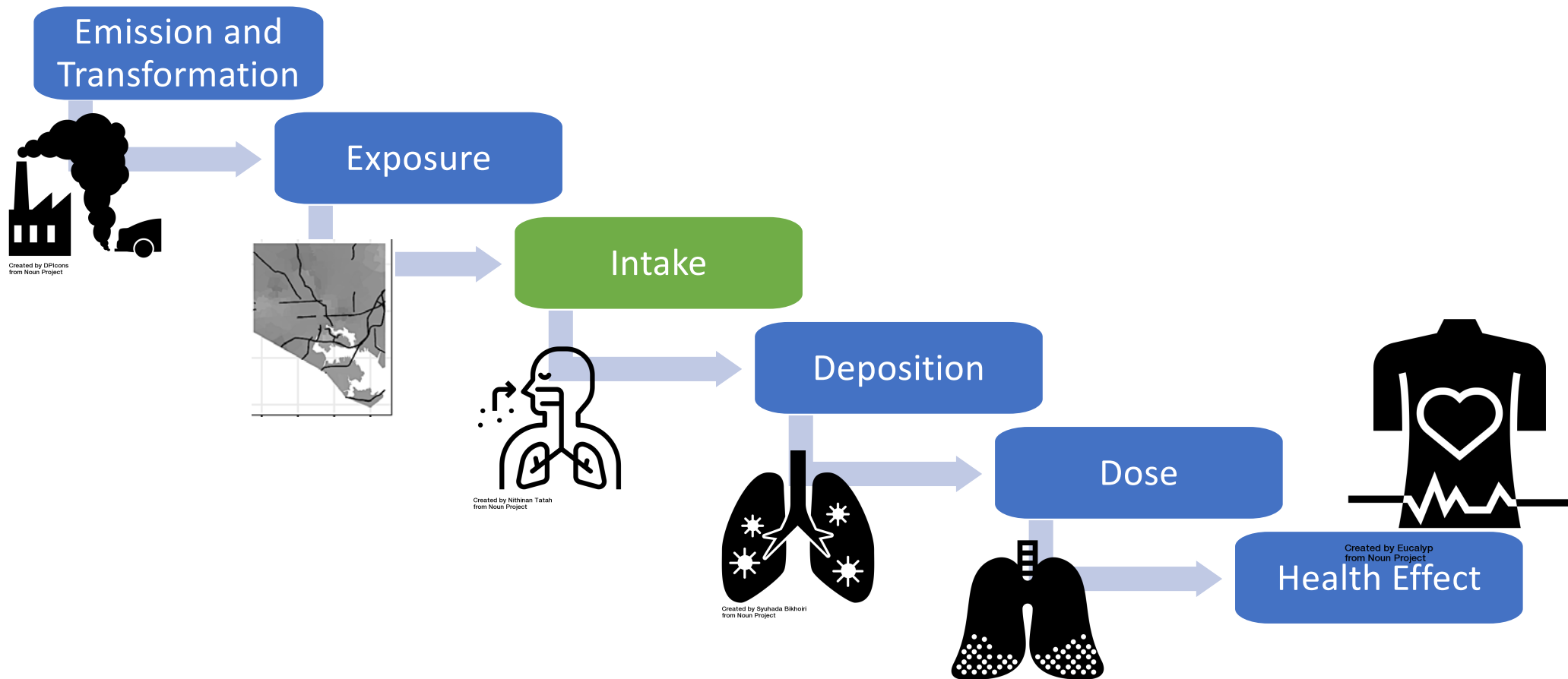
Example: Personal Exposure with GPS



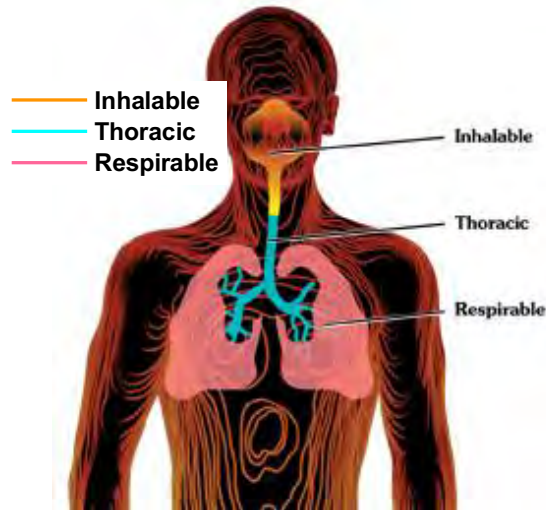
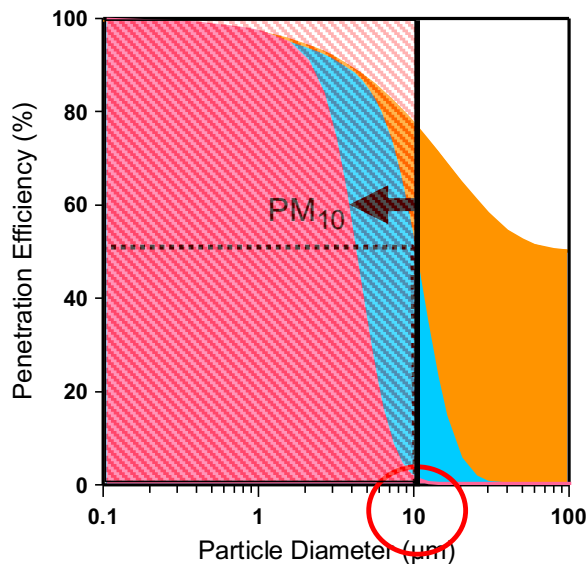
Variability: By Person, Day, Microenvironment



PM Exposure to Health Effect



Not all Particles Sizes Penetrate the Respiratory Tract



In **occupational settings** estimating personal exposures as an intake fraction, either inhalable or respirable, is common.

Inhalable Sampler

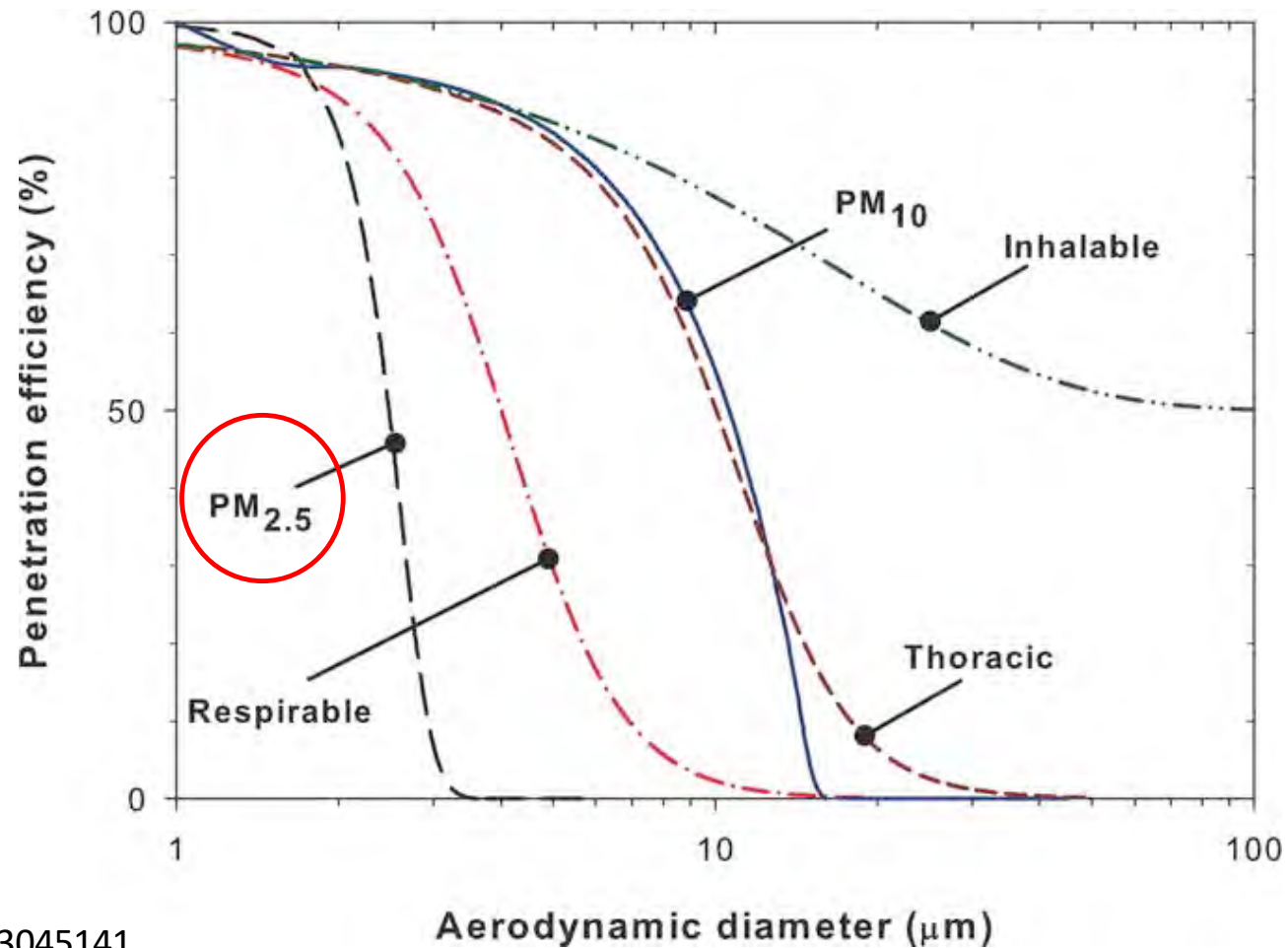


Respirable Sampler

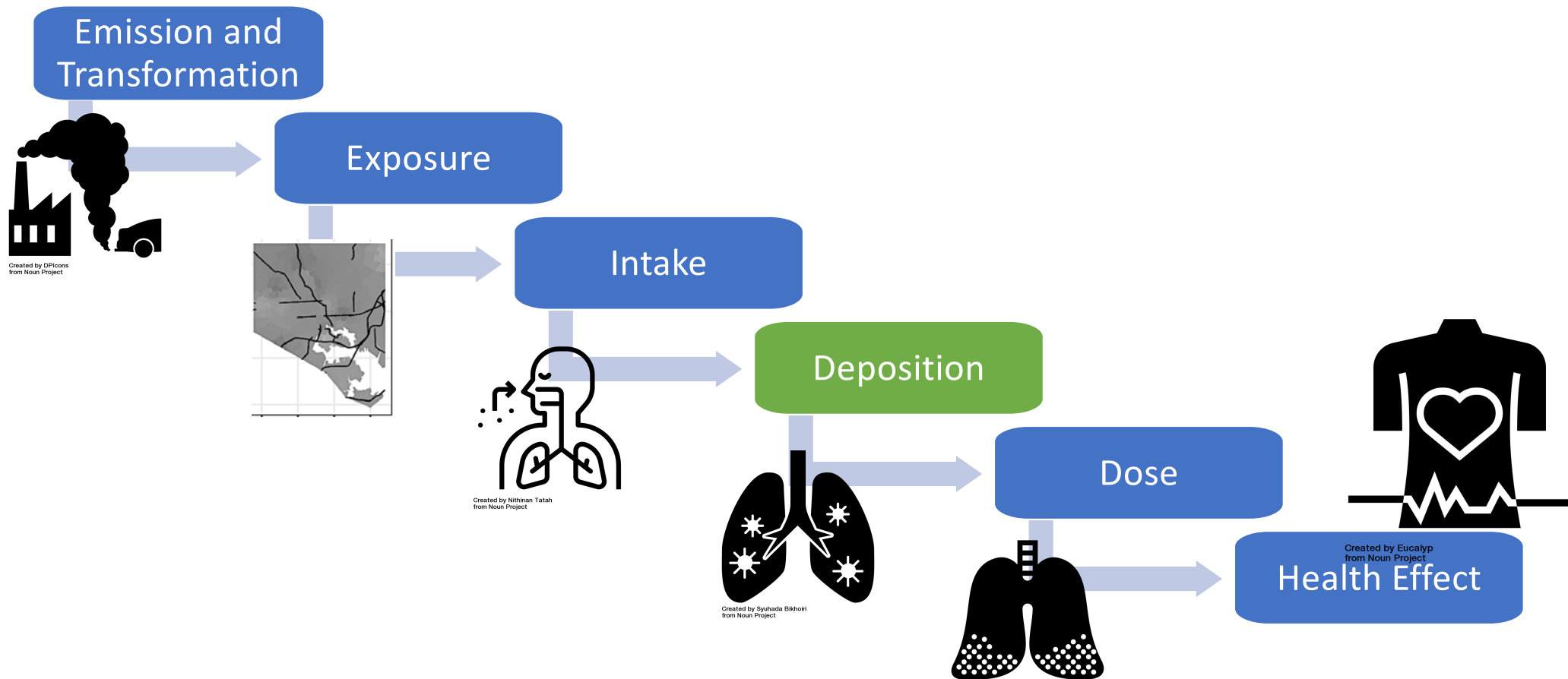


Image credits:
<https://www.skcltd.com/knowledge-library/product-selection-guides/particulate-sampler-selection-guide.html>
https://portal.ct.gov/lib/deep/air_monitoring/instrumentation/frm.jpg
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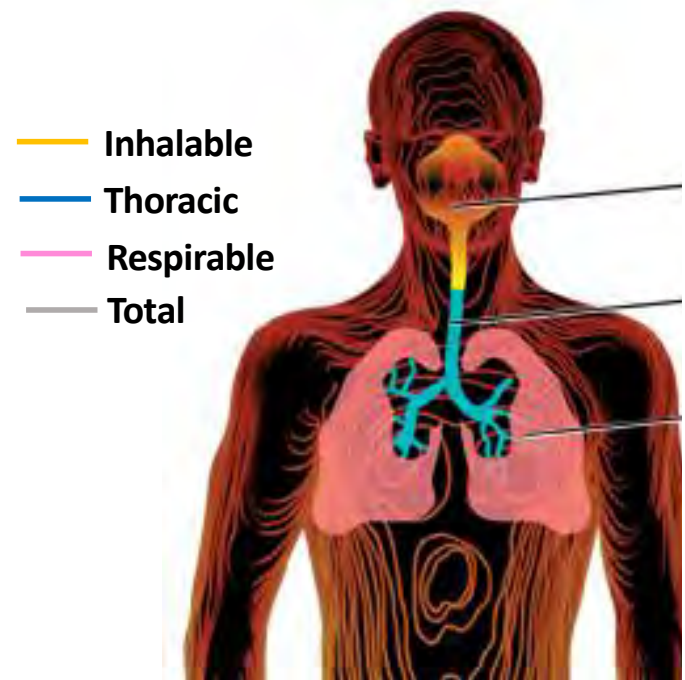
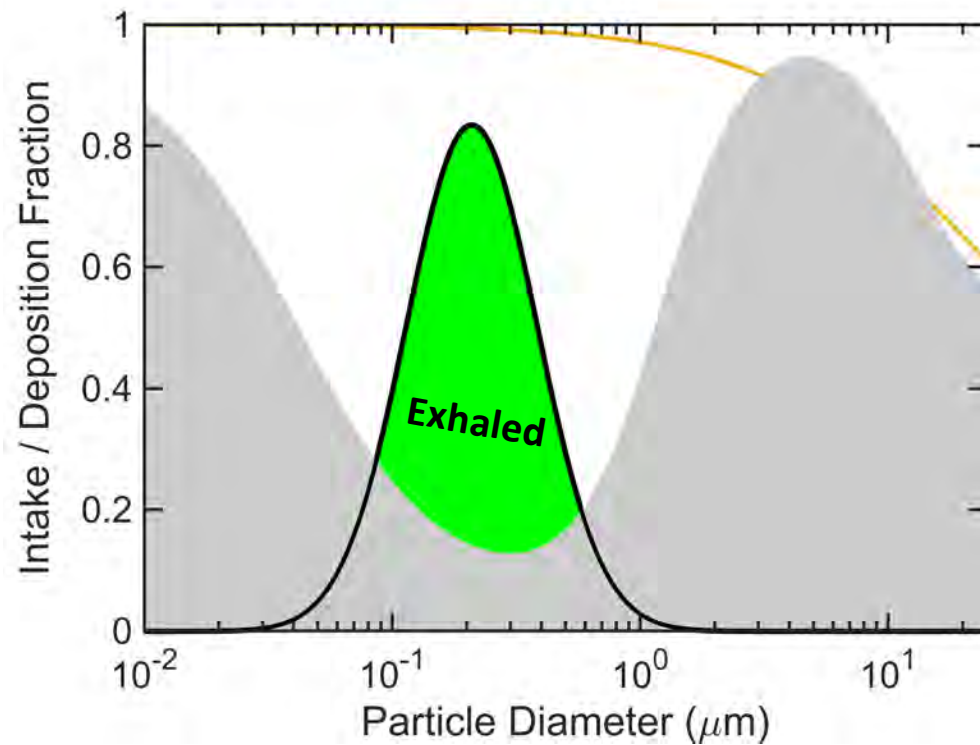
Common aerosol sampling metrics



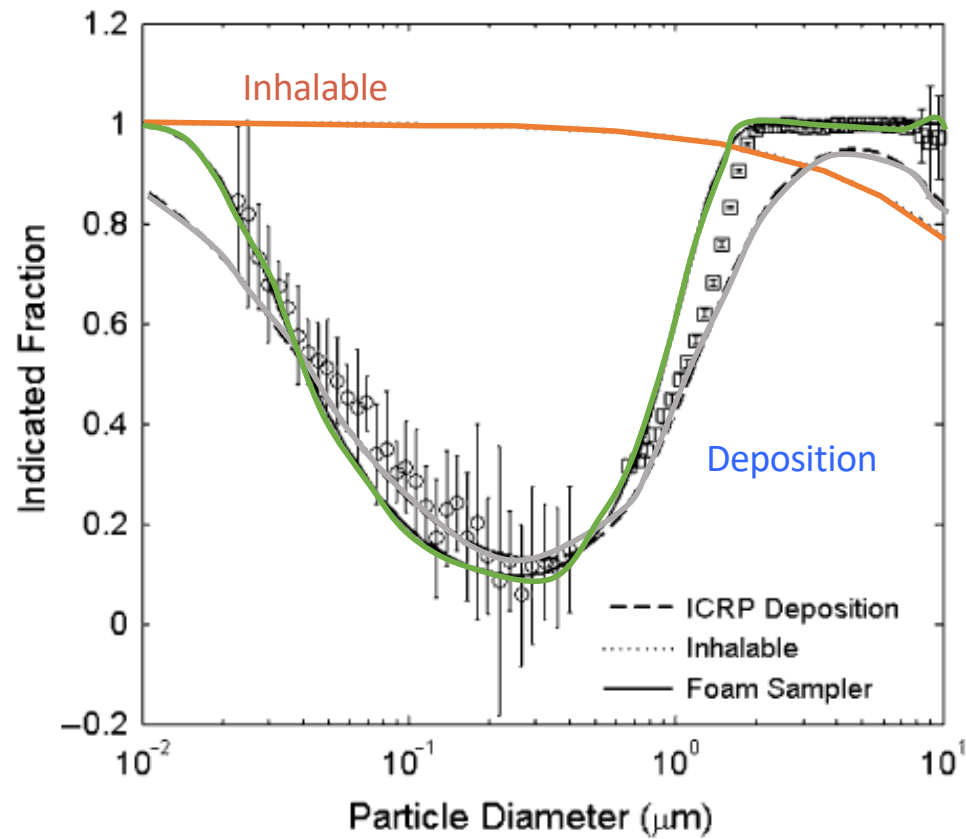
PM Exposure to Health Effect



Where Particles Deposit Matters



Lung Deposition Sampler



Koehler et al. Annal Occup Hyg, **53** 731-738. (2009)

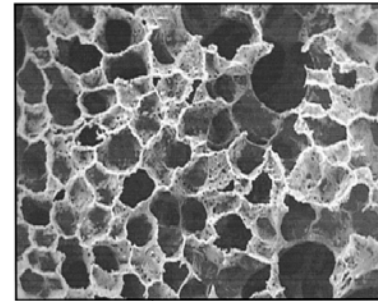
Why Polyurethane Foam?

Human Lung Cast



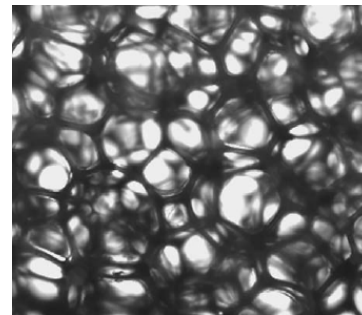
DOI: 10.5320/wjr.v9.i2.8

Aleveoli



DOI: 10.1115/1.1504445

Polyurethane Foam?

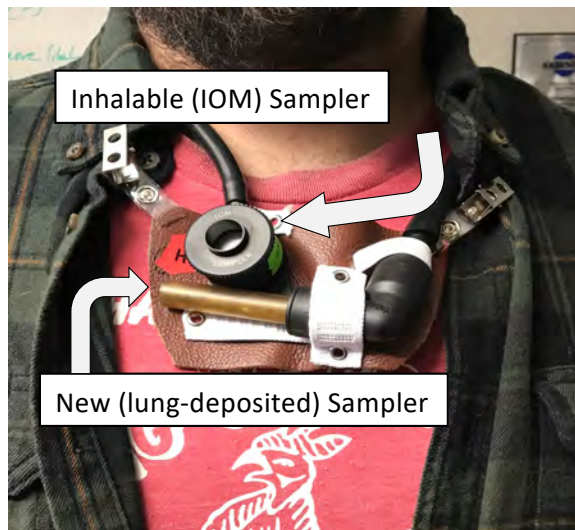


DOI:10.1016/j.jaerosci.2009.02.005

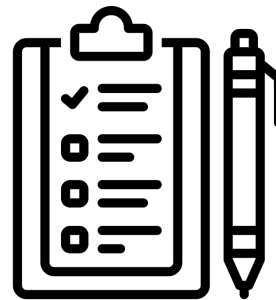
Comparing Intake & Deposition With Dose

Example: Stainless Steel Welders

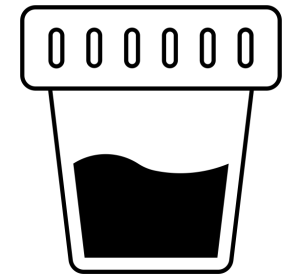
Personal Sampling



Questionnaires



Urinary estimate of Dose



Funding:
NIOSH T42 OH 008428
NIOSH R21 OH 010661

Two non-consecutive Mondays

Newton et al. (2021)

Journal of Aerosol Science 153 (2021) 105721

Only Lung-Deposited Metals Predictive of Urinary Concentrations

	Lung-deposited		Inhalable	
	Coefficient	p-value	Coefficient	p-value
Airborne Chromium	0.07	0.03	0.05	0.41
Urine Creatinine	0.001	0.15	0.001	0.10
Urine Cotinine	-0.01	0.56	-0.01	0.50
24-hr <i>Welding</i>	0.20	0.21	0.20	0.23
Airborne Nickel	0.10	<0.001	0.008	0.92
Urine Creatinine	0.001	0.01	0.001	0.11
Urine Cotinine	-0.01	0.58	-0.007	0.76
24-hr <i>Welding</i>	0.14	0.26	0.13	0.46