Impact of micro and nanoplastics on human respiratory and immunological systems

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MOMENTUM Microplastics and Human Health Consortium

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Microplastics can enter the body via:

- The lungs (inhalation)
- The gut (ingestion)
- The skin (minor route)

80% of human intake is from inhalation

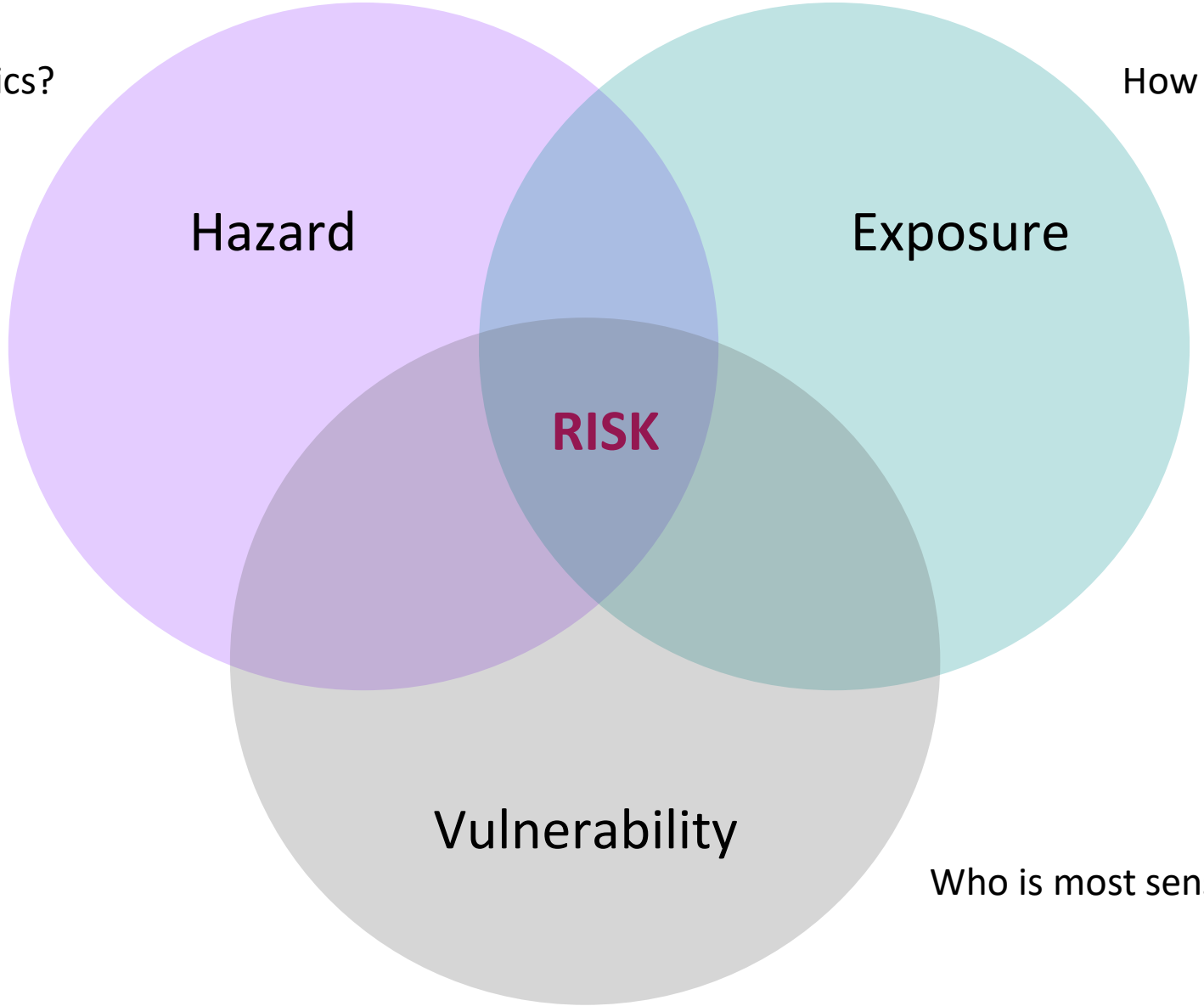
Cox et al, Envir Sci Techn 2019

What are the risks of microplastics inhalation?

What is risk?

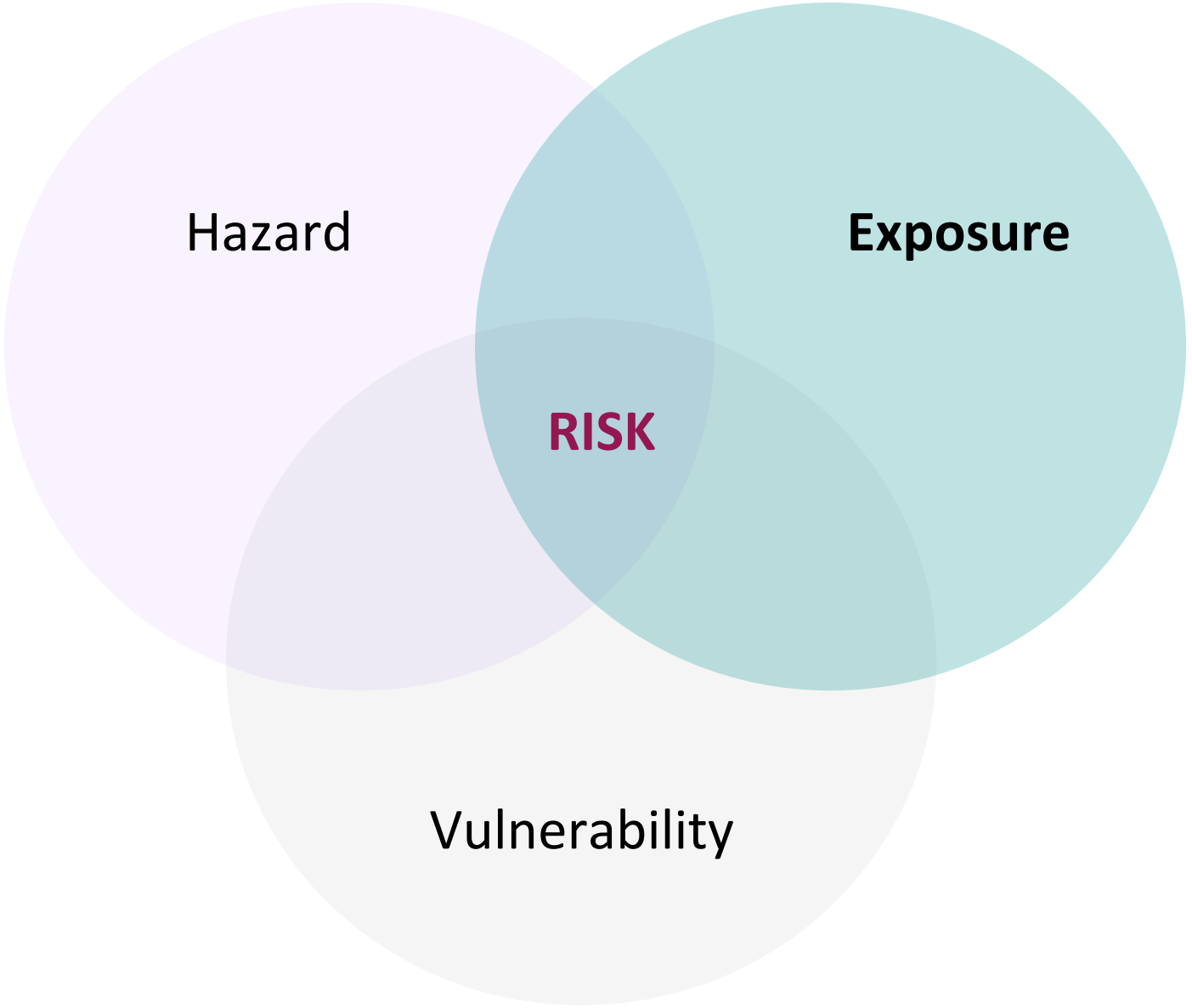
How toxic are microplastics?

How much are we exposed to?



Who is most sensitive?

How much are we exposed to?

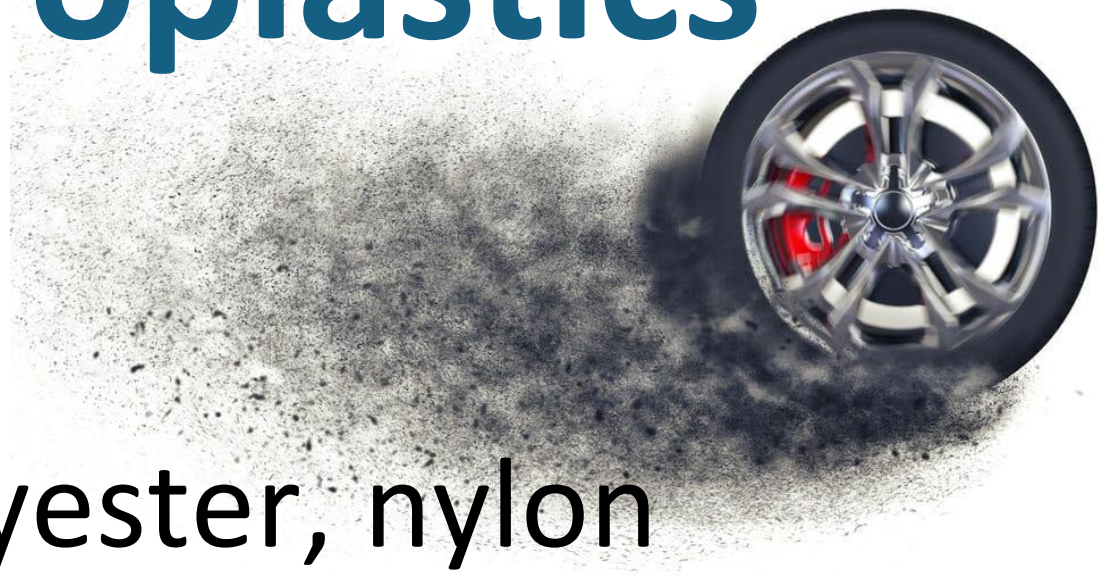


Exposure to microplastics in the air

- **Outdoor:** 1-20 particles/m^3
- **Indoor:** up to 500 particles/m^3

References

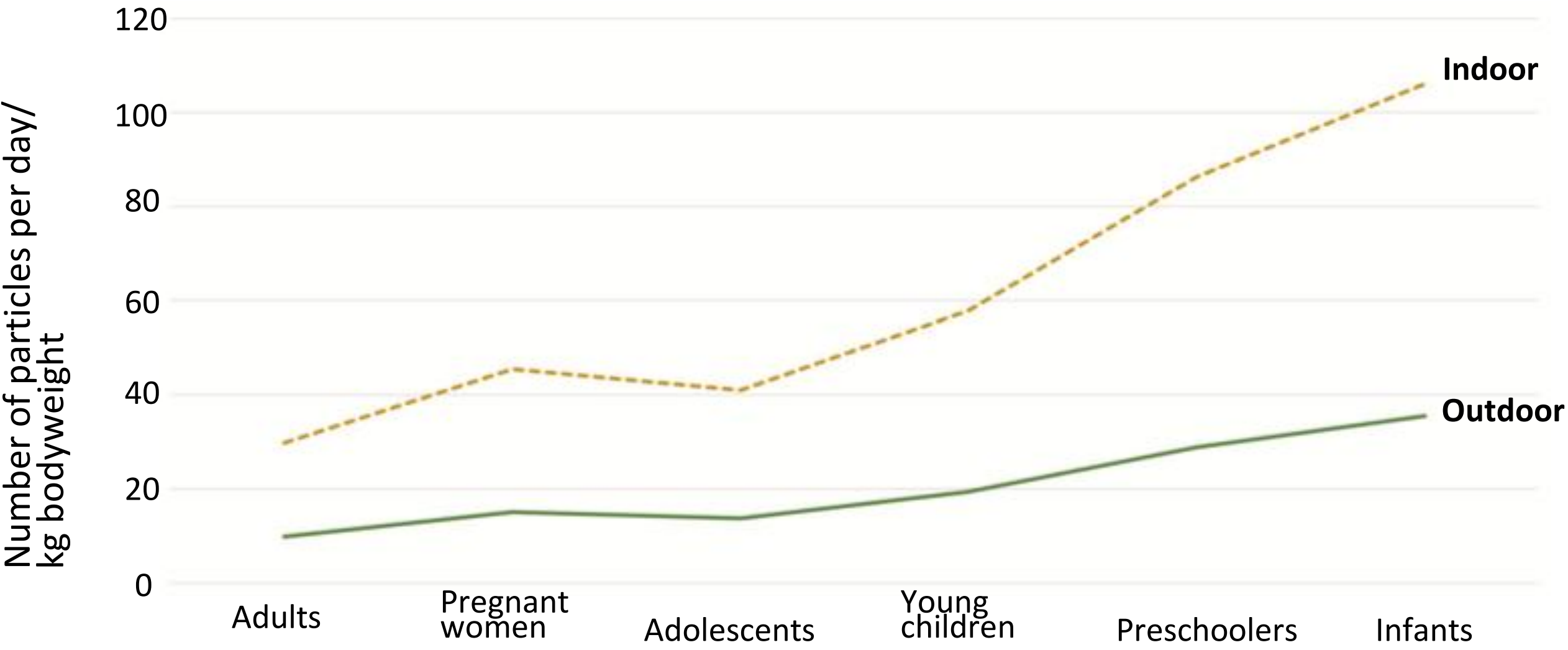
Exposure to microplastics



- **Outdoor:** Tire abrasion
- **Indoor:** Textiles like polyester, nylon

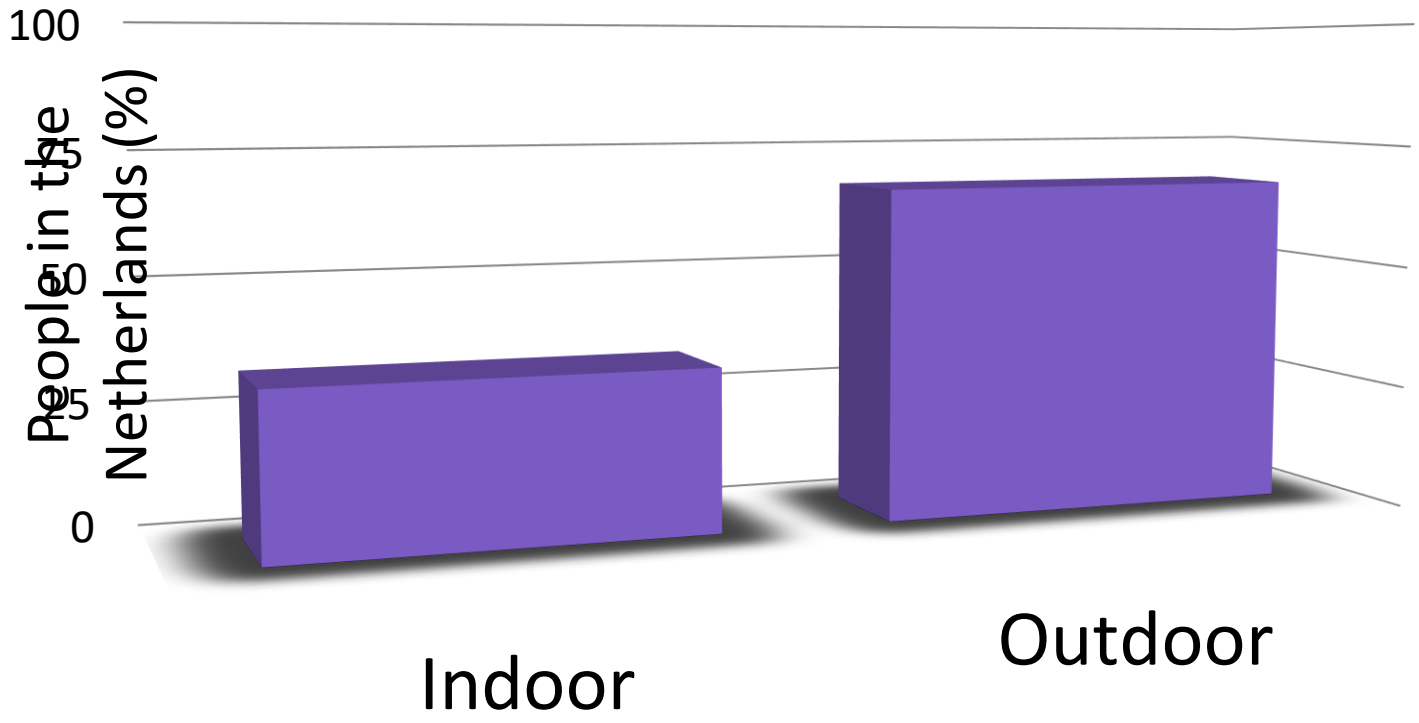
References

Estimated human exposure



Eberhard et al J Exp Sci Envir Epidem 2024

Where do people think these indoor microplastics come from?



Data from national survey, Geiger&Maltagliati

Which ones can enter the lungs?

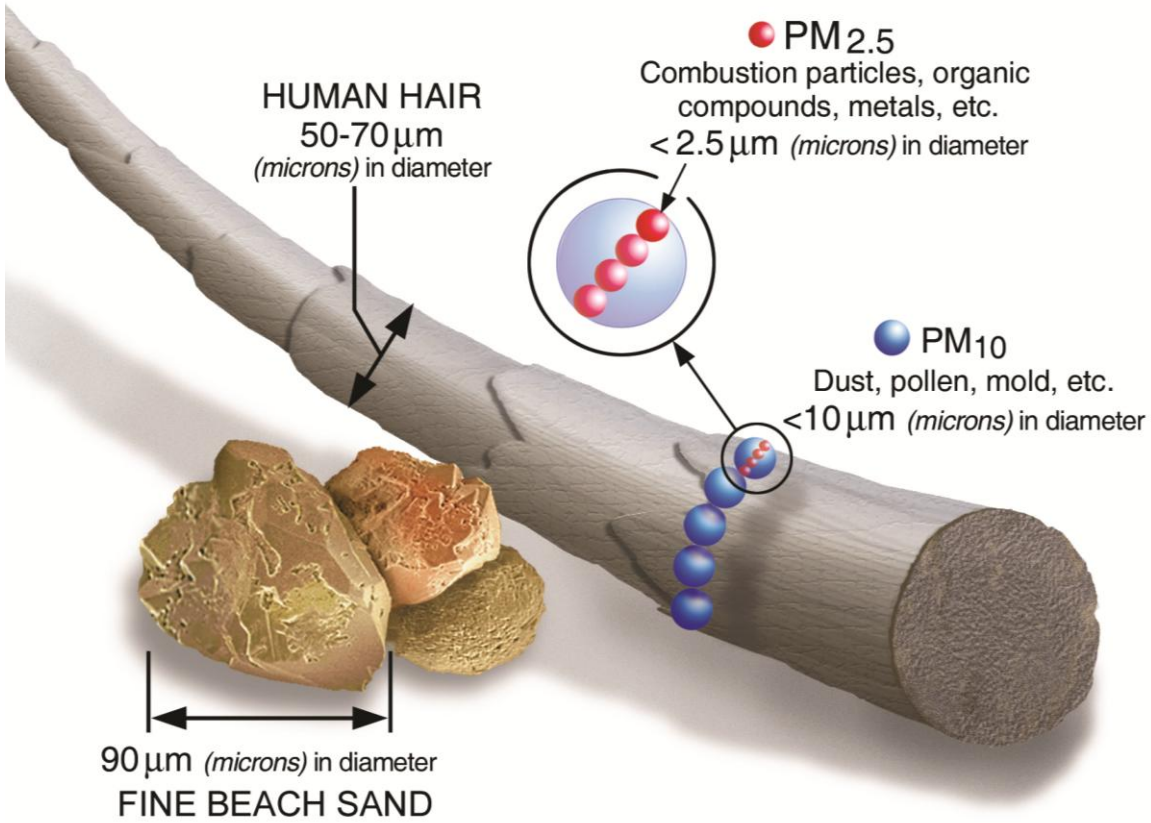
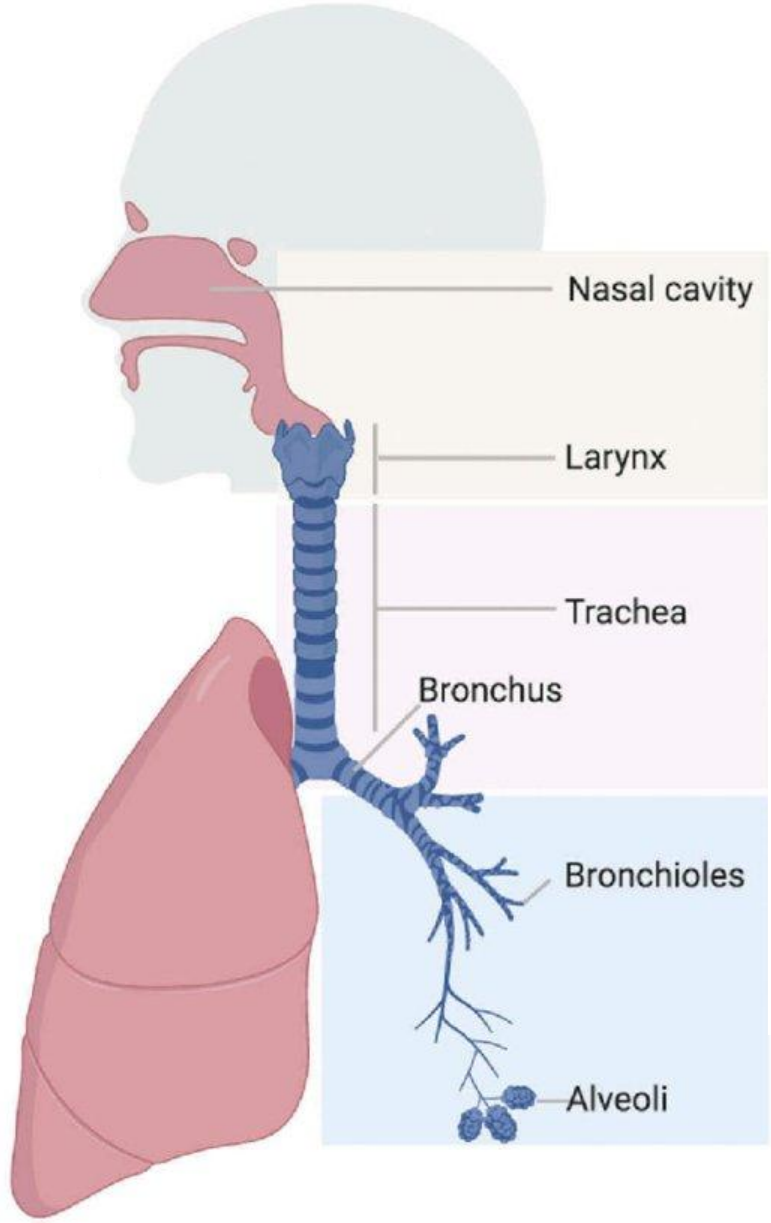


Image from US EPA



Picture: 10.1080/14760584.2019.1692657

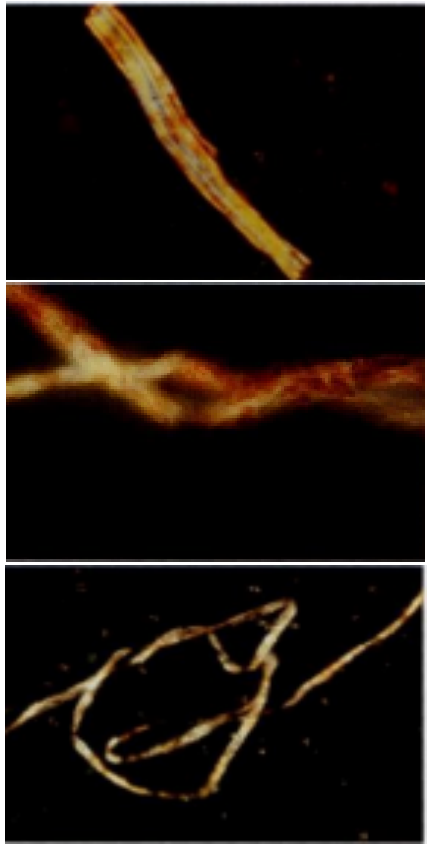
Nose
> 100 µm

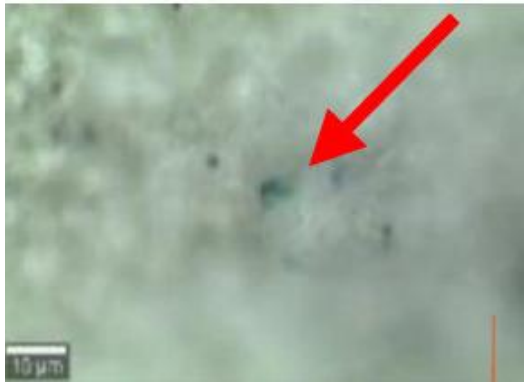
Wind pipe
< 100 µm

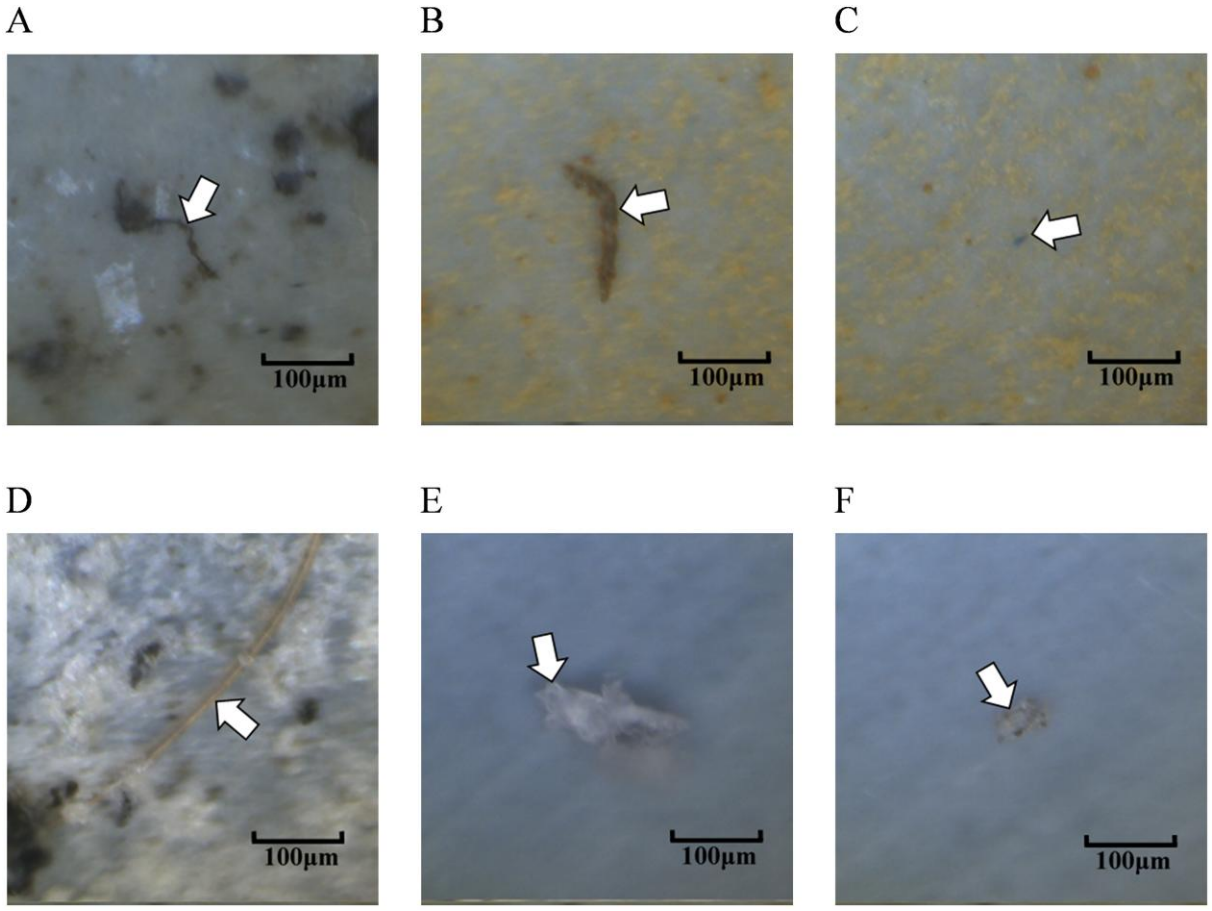
Airways
< 10 µm

Air sacs
< 5 µm

Exposure: microplastics are found in lung tissue







Most common: polyester, nylon, polyurethane

Pauly et al Cancer Epidemiol Biomarkers Prev 1998
Amato-Laurenco et al. J Haz Mat 2021
Jenner et al. Sci Total Envir 2022

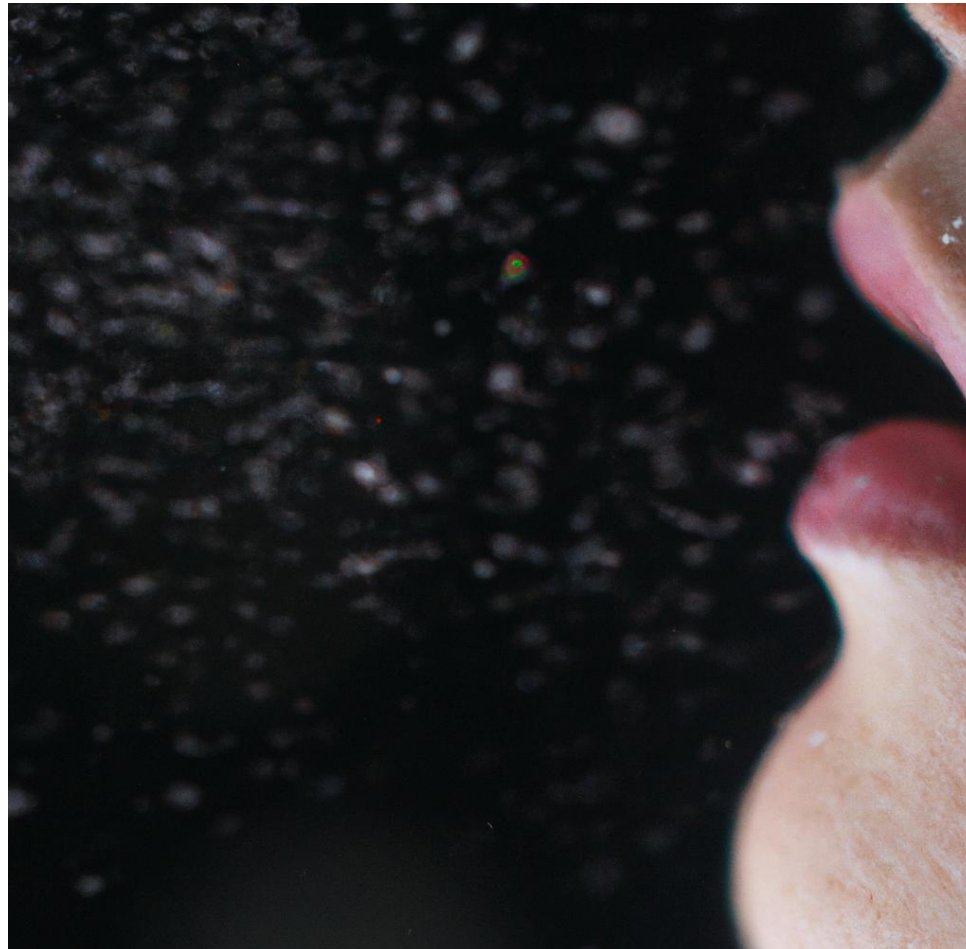
How toxic are microplastics?

Hazards of inhalable microplastics

LUNG

- Particle-related
- Additive-related
- Adsorbant-related

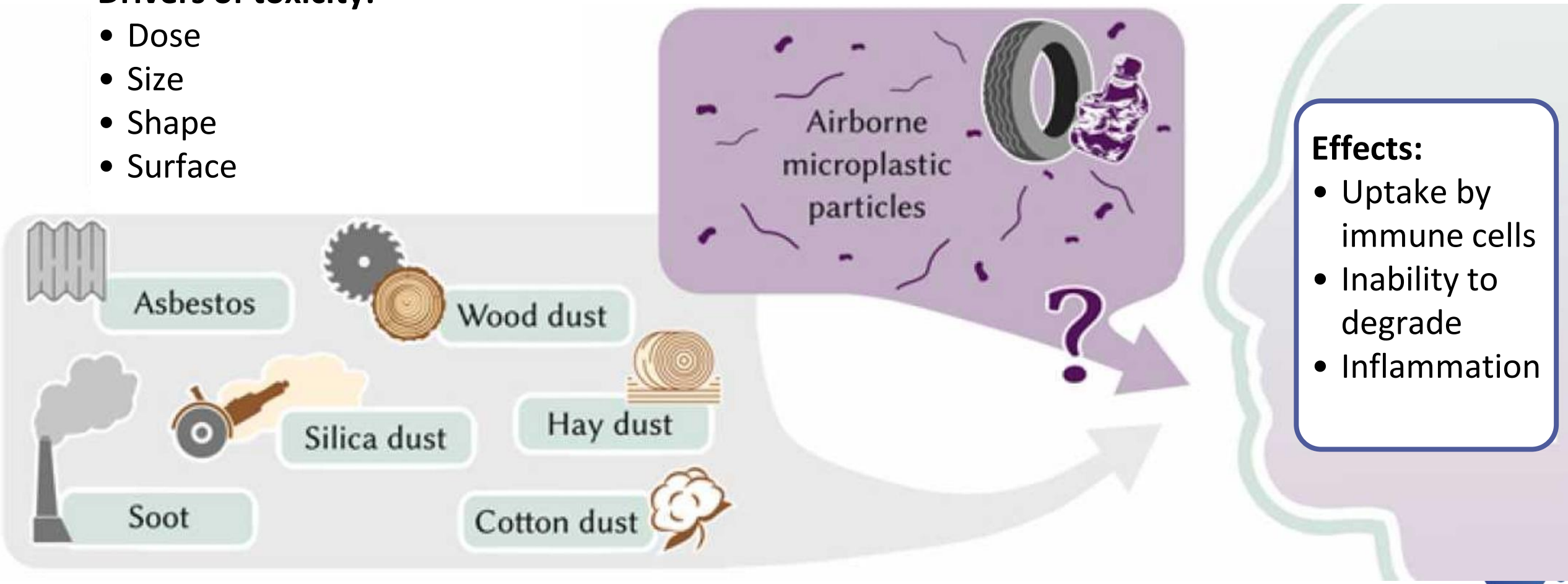
OTHER ORGANS



Hazards: particle/fiber toxicity

Drivers of toxicity:

- Dose
- Size
- Shape
- Surface

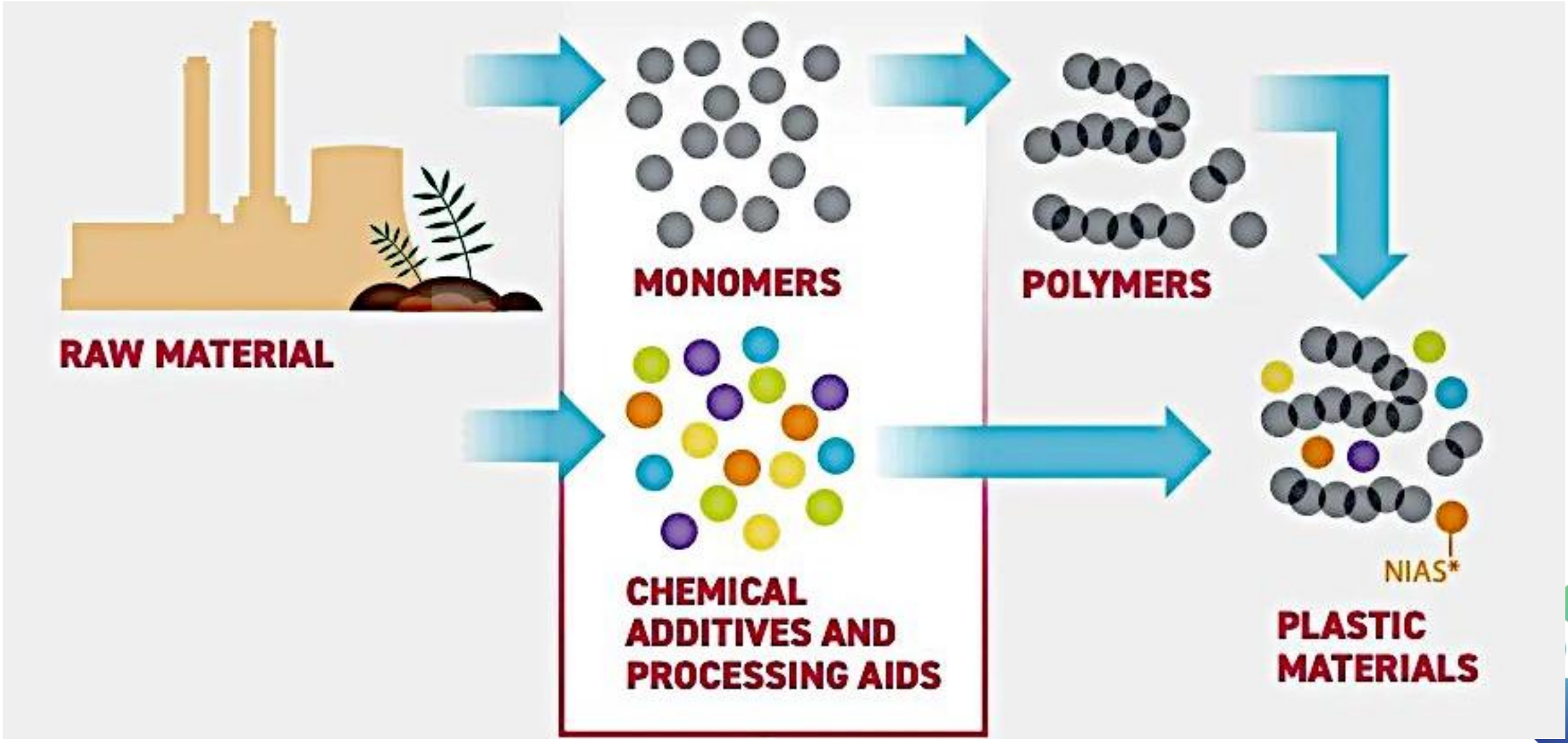


Effects:

- Uptake by immune cells
- Inability to degrade
- Inflammation

Adapted from Wieland et al. J Haz Mat 2022

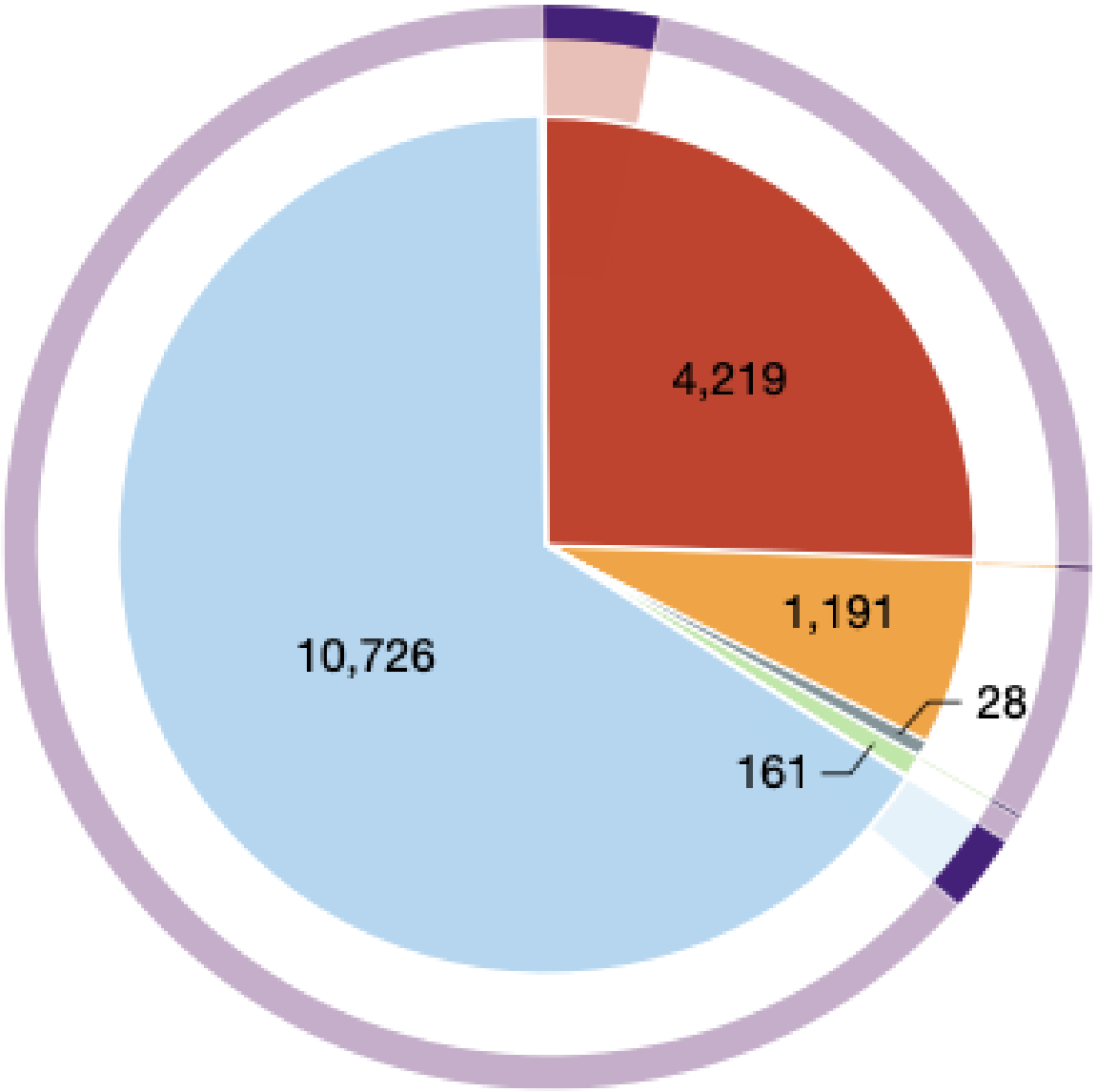
Hazards: additives in plastic



*NIAS = non-intentionally added substances, including (1) break-down products of polymers, additives and other chemicals in plastics, (2) impurities, (3) contaminants from processing such as production and recycling, and (4) reaction byproducts.

UN environment

>16,000 in chemicals found in plastic



Chemicals of concern

Less hazardous

Not hazardous

Being investigated

NO DATA!

Globally regulated

Not regulated

Monclus et al. Nature 2025

Microplastics as pollutant carriers

Kinigopoulou et al. J Mol Liq 2022

Hazards:

Lung effects?

Occupational exposures

Polyvinyl chloride (PVC)
- Asthma
- Dust lungs
- Scarred lungs
- Lung cancer

Polyamide (nylon)
- Lung inflammation
- Scarred lungs
- Lung cancer

Artificial stone (silica+polyacrylate)
- Dust lungs
- Scarred lungs

Vasse et al. ERR 2024

Our research question

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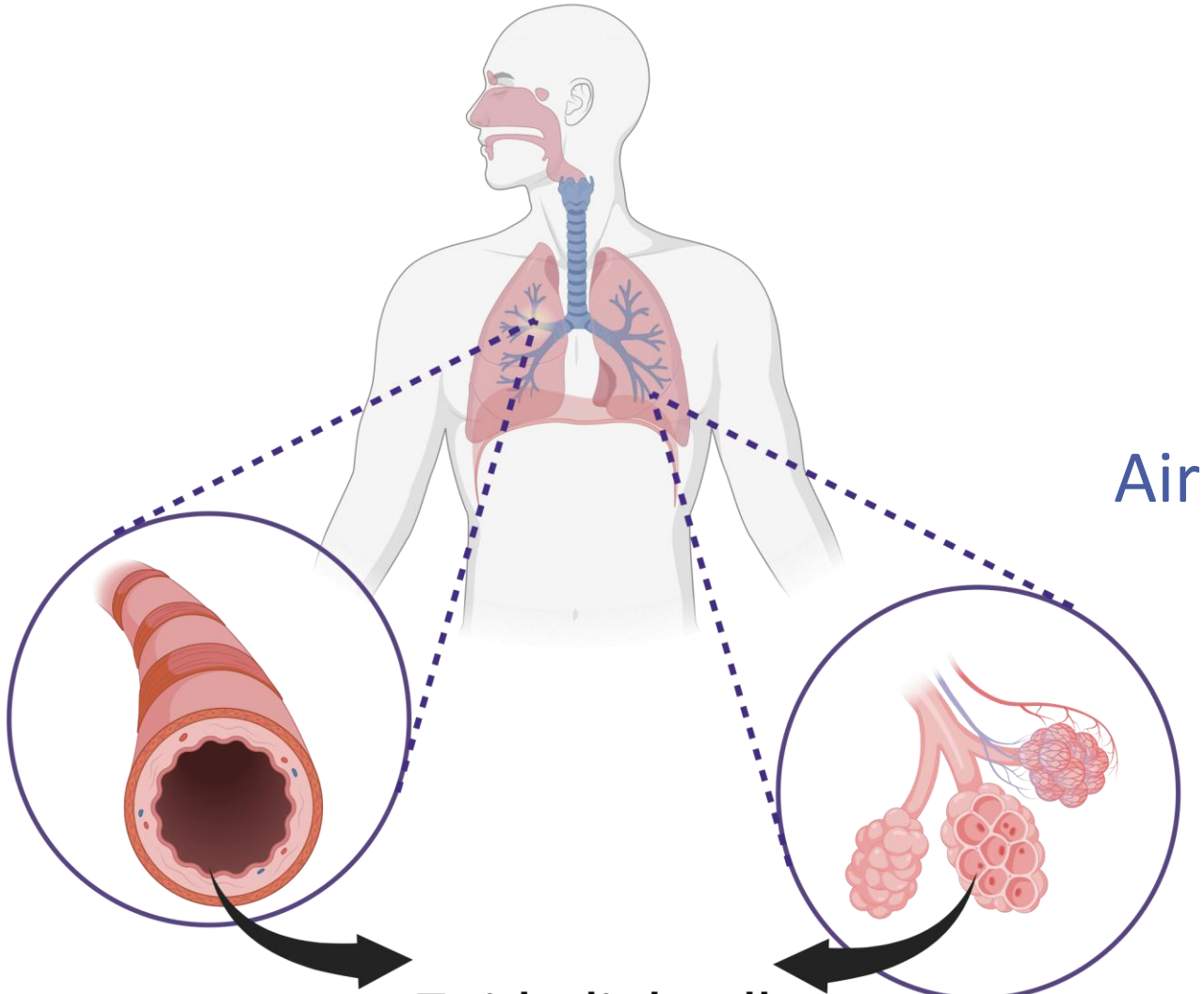
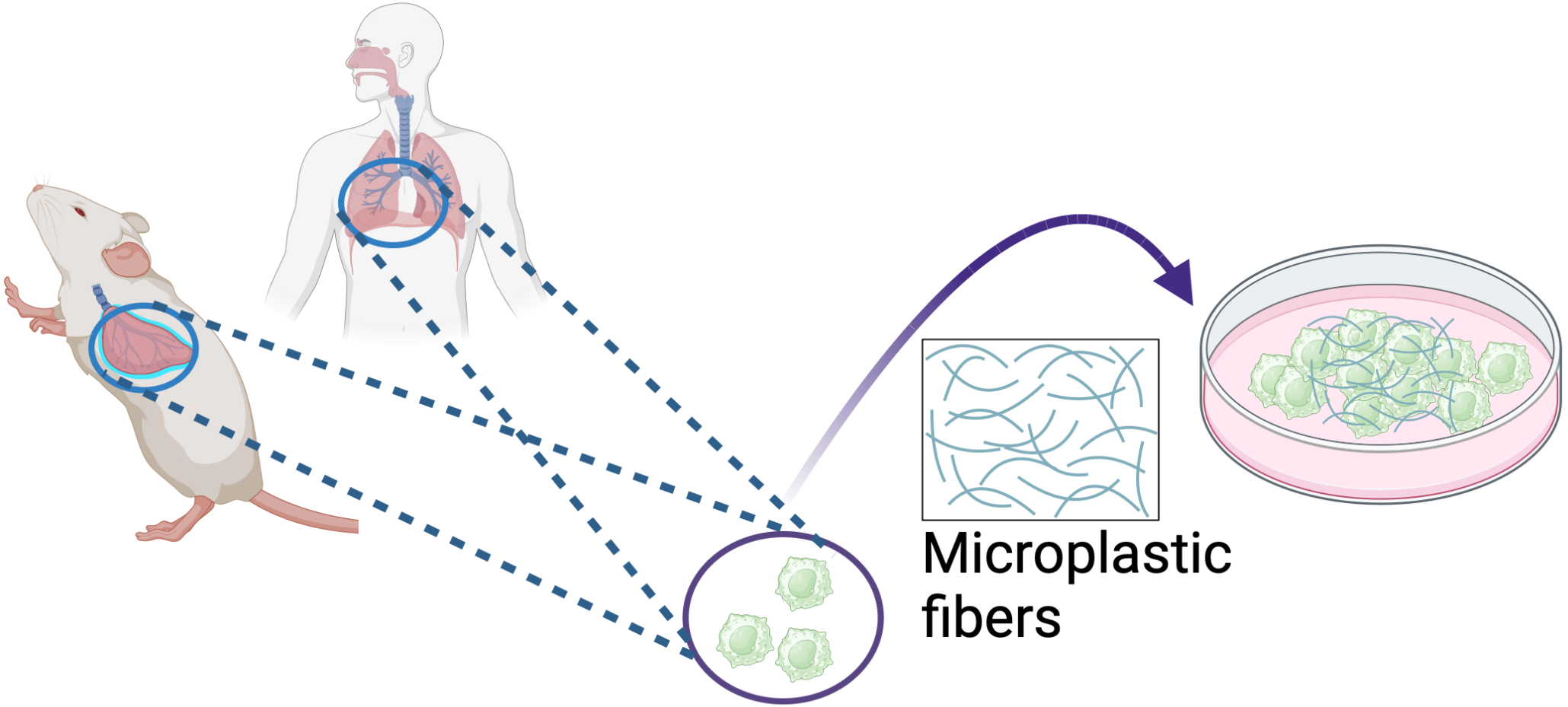
- Most exposure from being indoor
- Indoor mostly textile microplastics

What do textile microplastics to the lungs?

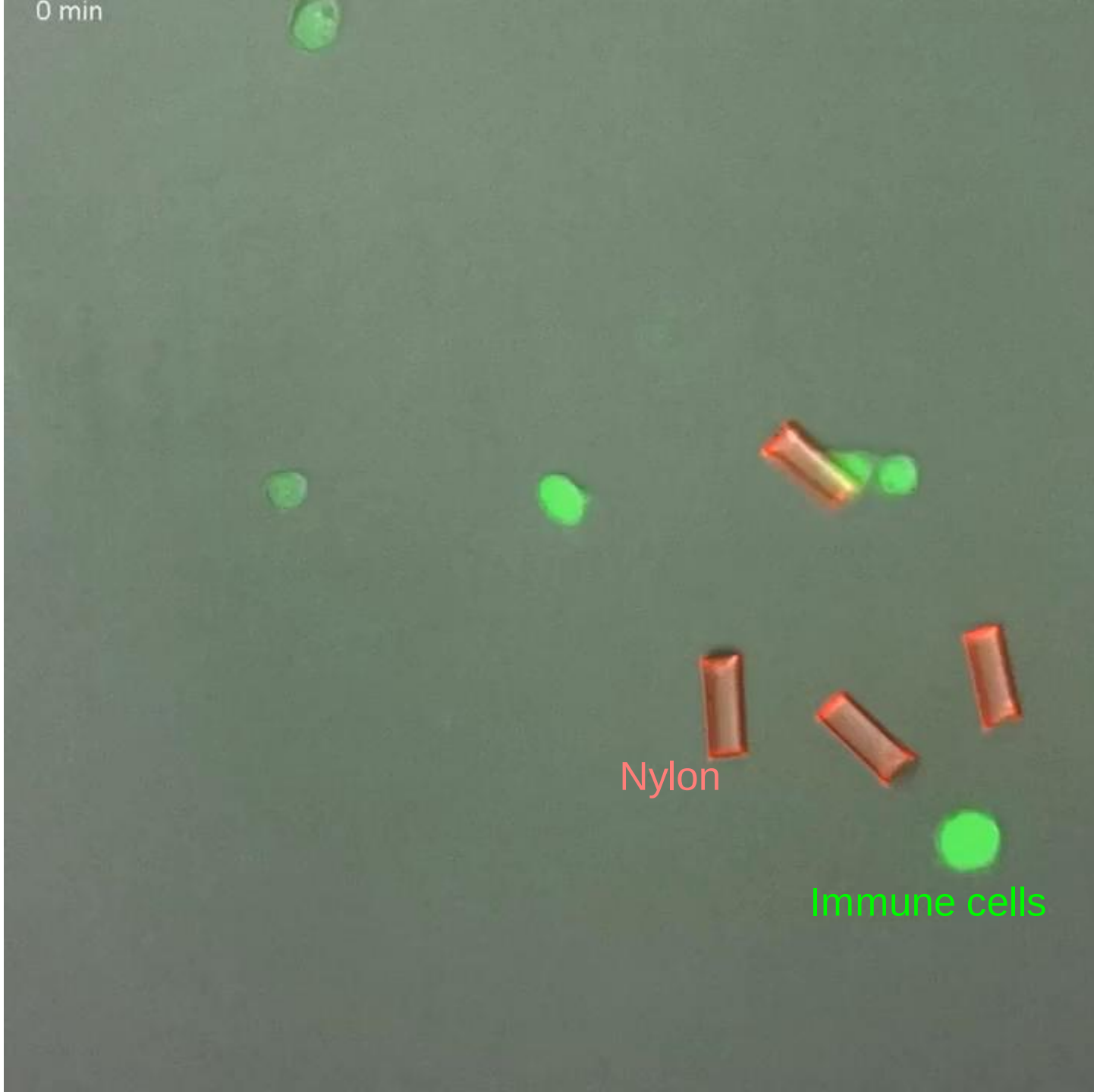
Which cells are first exposed to microplastics?



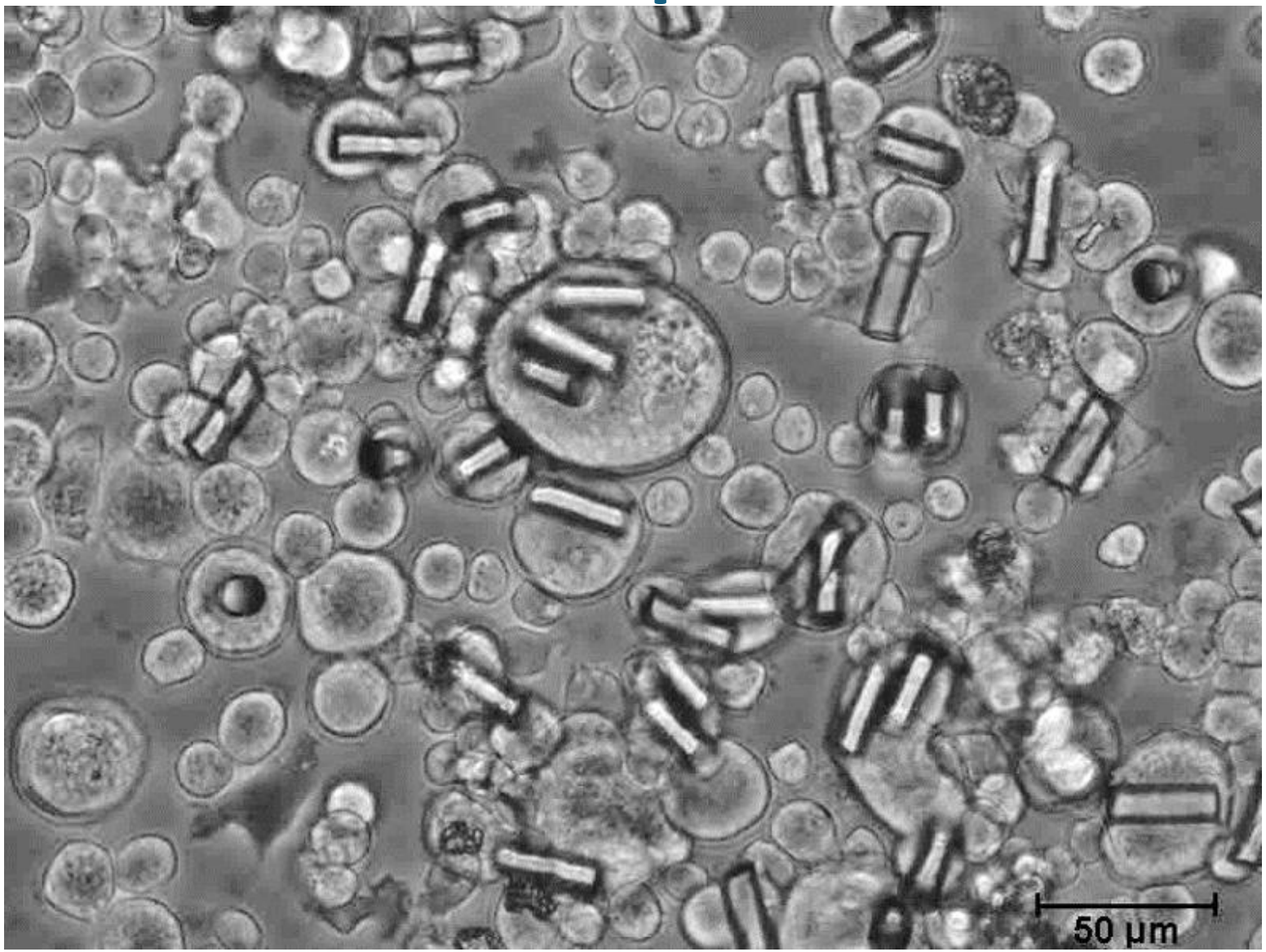
What do textile fibers do to immune cells?



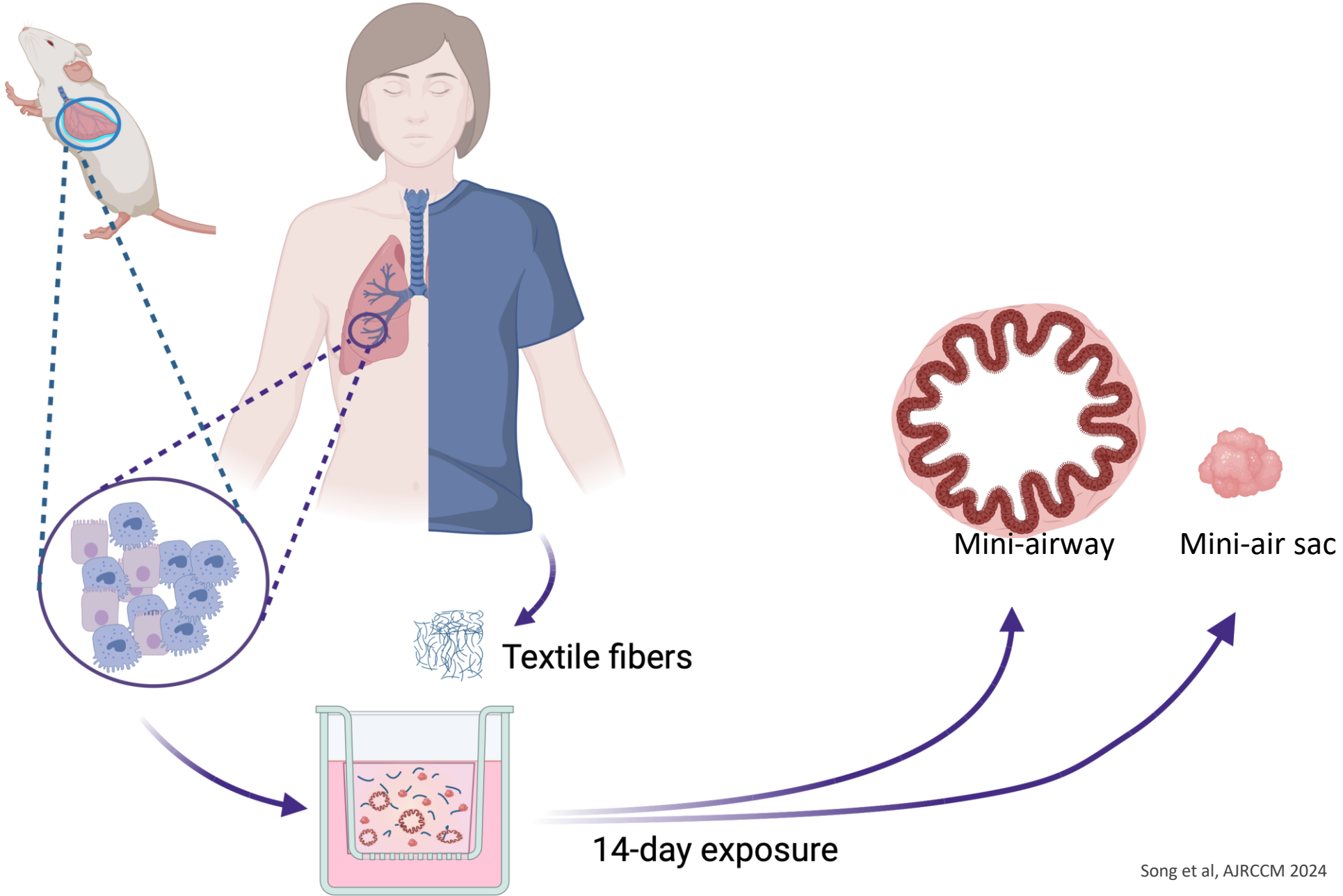
Immune cells chase and eat nylon fibers



Immune cells grow big and angry when eating microplastics



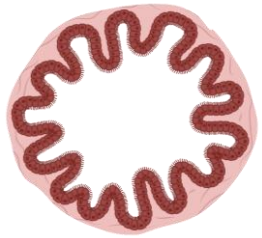
What do textile fibers do to lung epithelial cells?



Song et al, AJRCCM 2024

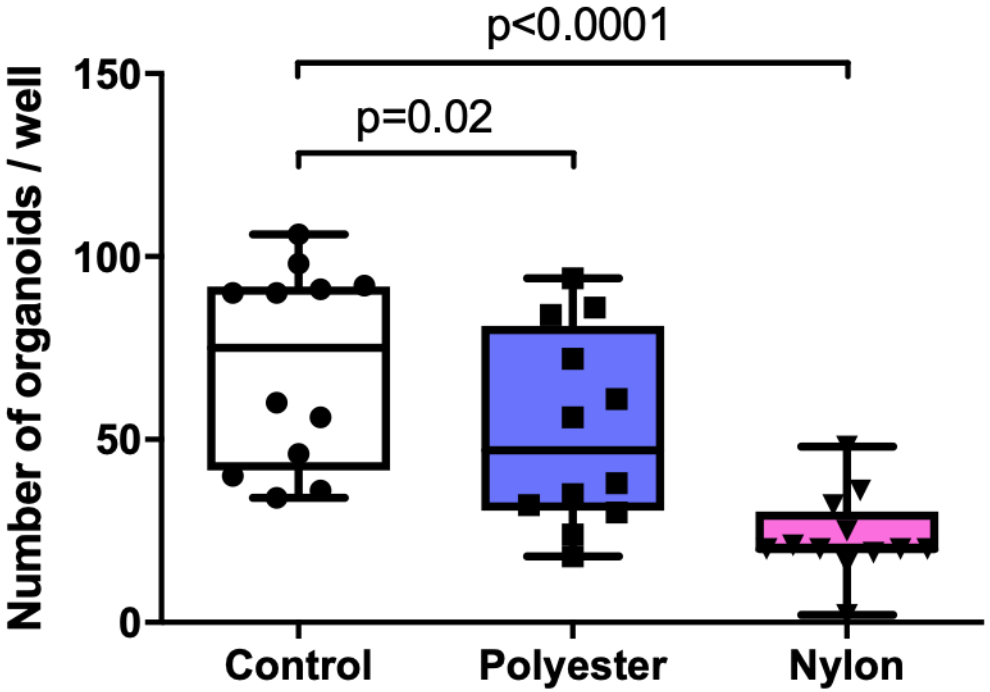
What does it look like in real life?

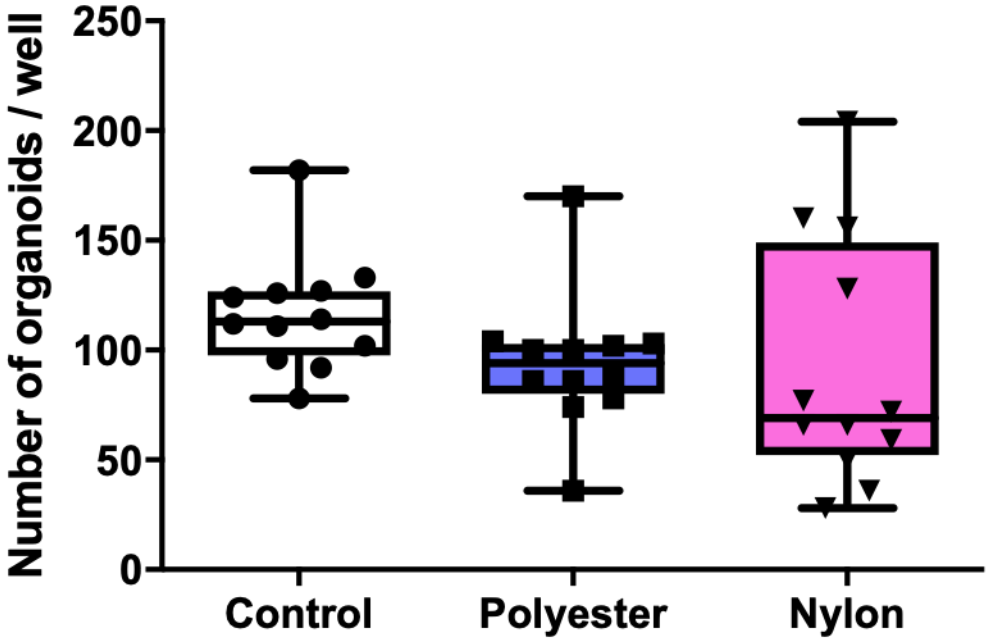
Exposure to nylon or polyester results in fewer airway organoids



Mini-airways

Mini-air sacs

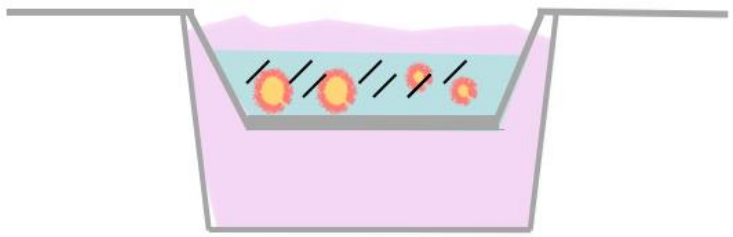




Song et al, AJRCCM 2024

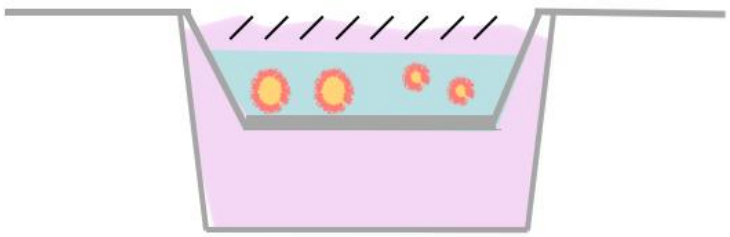
Is the fiber toxic or leaching chemical?

Nylon within cells



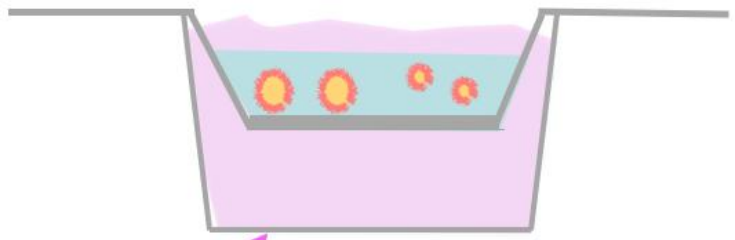
Contact possible

Nylon on top of cells



No contact possible

Wash of nylon

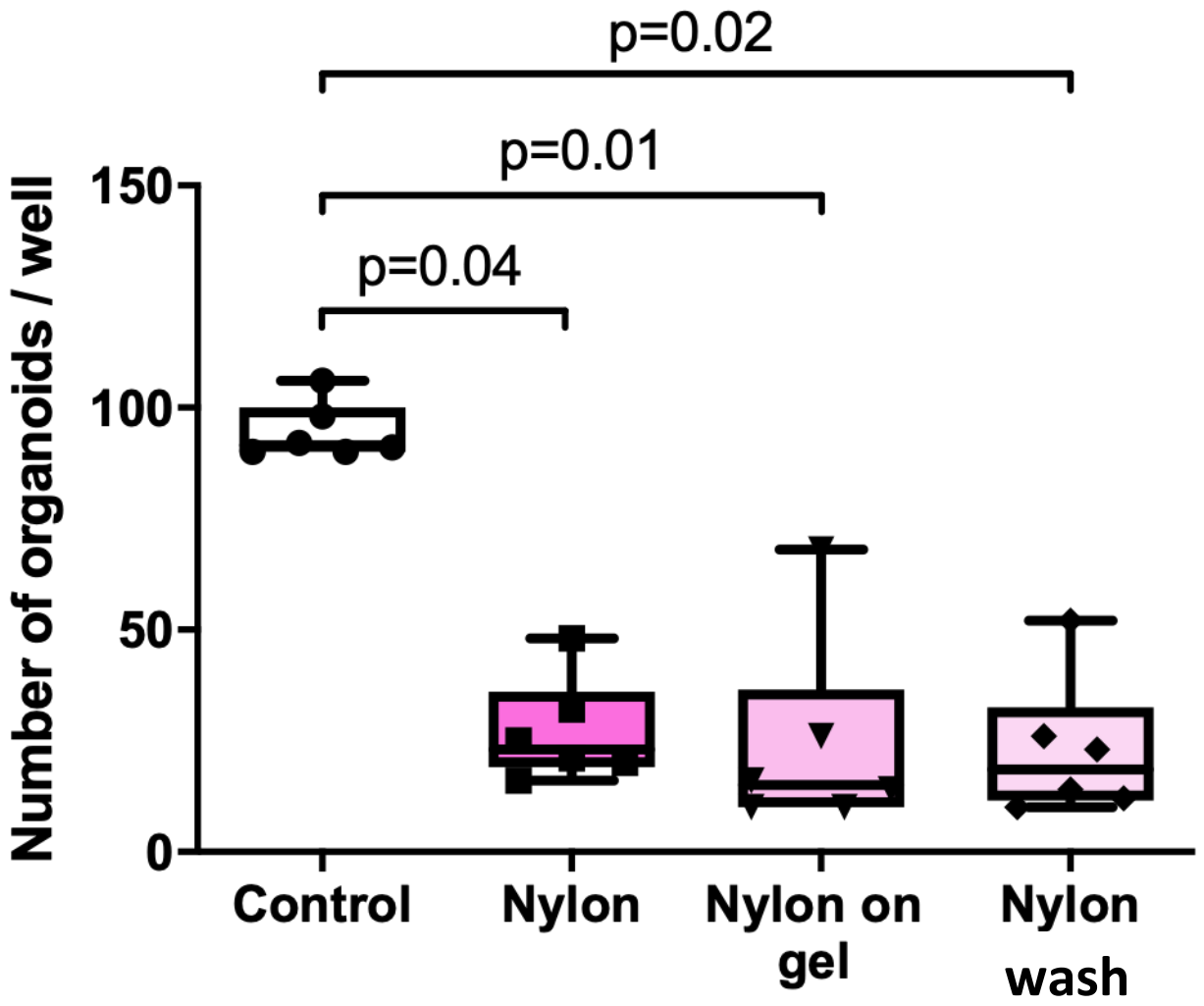


Only washed out chemicals

Nylon fiber wash

Song et al, AJRCCM 2024

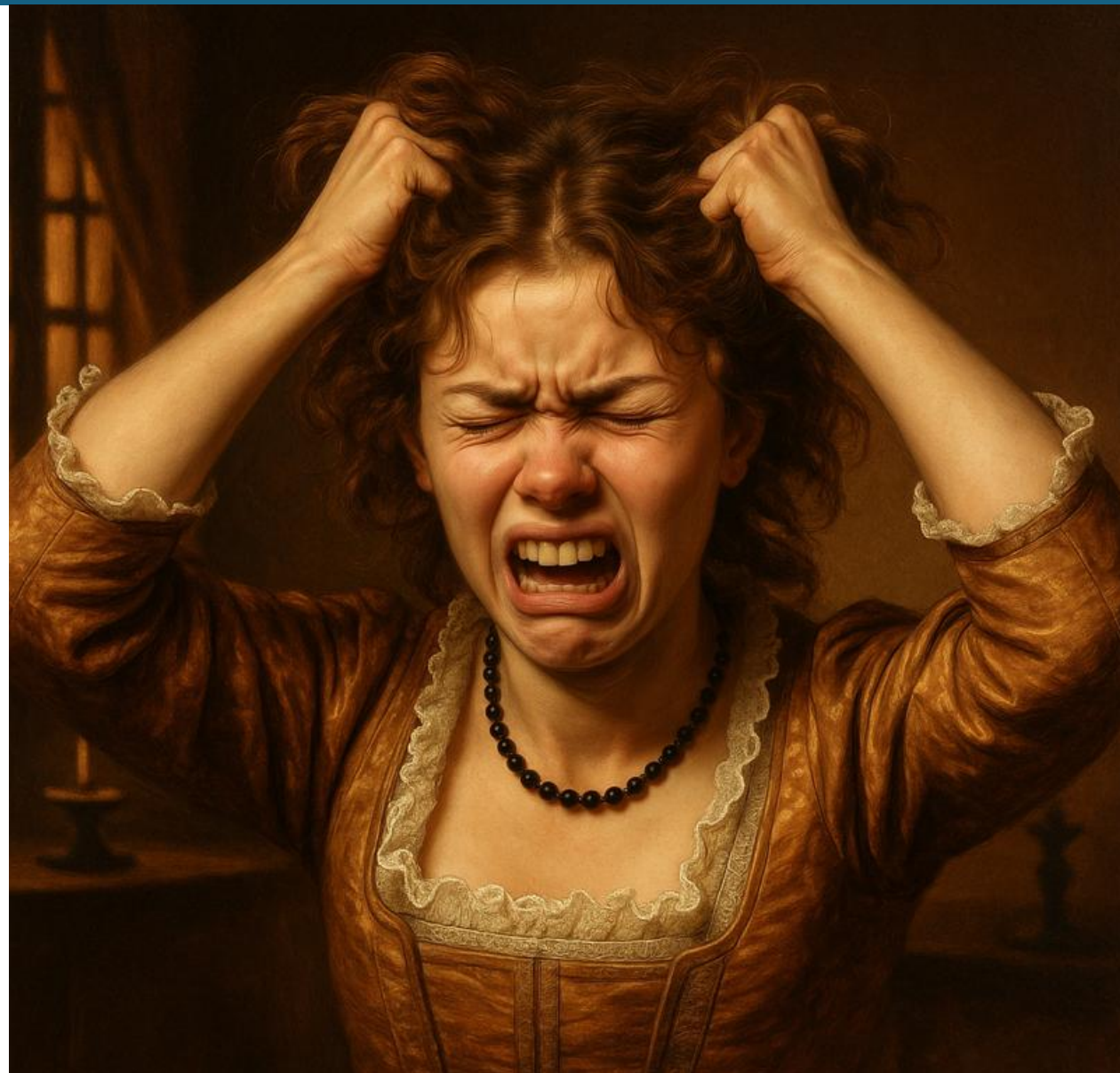
Nylon leachate inhibits airway growth



Song et al, AJRCCM 2024

We are still hunting the culprit chemical(s)

B	C	D	E	F
m/z measured (pos)	Exact Mass	Ions	Name	Molecular Formula
167.0795	166.07226	[M+H]+		
171.0634	170.05611	[M+H]+		
167.0320	166.02474	[M+H]+, [M+Na]+		
168.0636	145.0741	[M+Na]+, [M+H]+	1H,3H,5H-Oxazolo[3,4-c]oxazole-7a(7H)-methanol	C6H11NO3
244.2021	243.19478	[M+H]+		
245.1860	244.17868	[M+H]+	6-(6-Aminohexanamido)hexanoic acid	C12H24N2O3
258.1812	257.17396	[M+H]+		
245.1496	244.14206	[M+H]+, [M+Na]+		
253.1502	252.14288	[M+H]+		
231.1702	230.16293	[M+H]+		
169.0473	146.05804	[M+Na]+, [2M+Na]+	Dimethyl succinate	C6H10O4
157.0473	156.04002	[M+H]+	2',4'-Difluoroacetophenone	C8H6F2O
258.1335	257.12648	[M+H]+, [M-H2O+H]+, [M+Na]+		
227.1753	226.16794	[M+H]+, [2M+H]+, [M	(PA cyclic monomer) 1,8-Diazacyclotetradecane-2,7-dione	C12H22N2O2
246.1333	245.12646	[M+H]+, [M-H2O+H]+, [M+Na]+, [2M+Na]+		
259.1650	258.15755	[M+H]+, [M+Na]+		
243.1704	242.16308	[M+H]+		
272.1964	271.18914	[M+H]+, [M+Na]+		
363.1609	340.17218	[M+Na]+, [M+NH4]+		
286.2127	285.20537	[M+H]+		
246.1333	245.12577	[M+H]+, [M+Na]+, [2M+Na]+, [M-H2O+H]+		
371.2646	370.2575	[M+H]+, [M+Na]+		
157.0472	156.03995	[M+H]+	2',4'-Difluoroacetophenone	C8H6F2O
470.3695	452.3361	[M+NH4]+, [M+H+H	(migrating from polyamide) 1,8,15,22-Tetraazacyclooctacos	C24H44N4O4
285.2397	568.46483	[M+H+H]2+		
358.2322	357.22518	[M+H]+, [M+Na]+		
273.1807	272.1734	[M+H]+		
282.1301	281.12283	[M+H]+		
260.1484	259.14146	[M+H]+, [M-H2O+H]+, [2M+H]+		
282.1305	259.14122	[M+Na]+, [2M+Na]+		
287.1961	286.18874	[M+H]+, [M+Na]+		
235.1417	234.13438	[M+H]+		
372.2479	371.24057	[M+H]+		
467.3223	466.31415	[M+H]+, [M+Na]+		
227.1753	452.33606	[M+H+H]2+	(migrating from polyamide)1,8,15,22-Tetraazacyclooctacos	C24H44N4O4
471.3531	470.34557	[M+H]+, [M+H+H]2+		
359.2171	358.20958	[M+H]+, [M+Na]+		
451.3280	450.32076	[M+H]+		
490.2899	489.28265	[M+H]+		
471.3176	470.31036	[M+H]+		
457.3376	456.32974	[M+H]+, [M+Na]+		
373.2326	372.2257	[M+H]+, [2M+H]+, [M+Na]+, [2M+Na]+, [M-H2O+H]+		
484.3003	483.29327	[M+H]+, [M+Na]+		



Who is most sensitive?

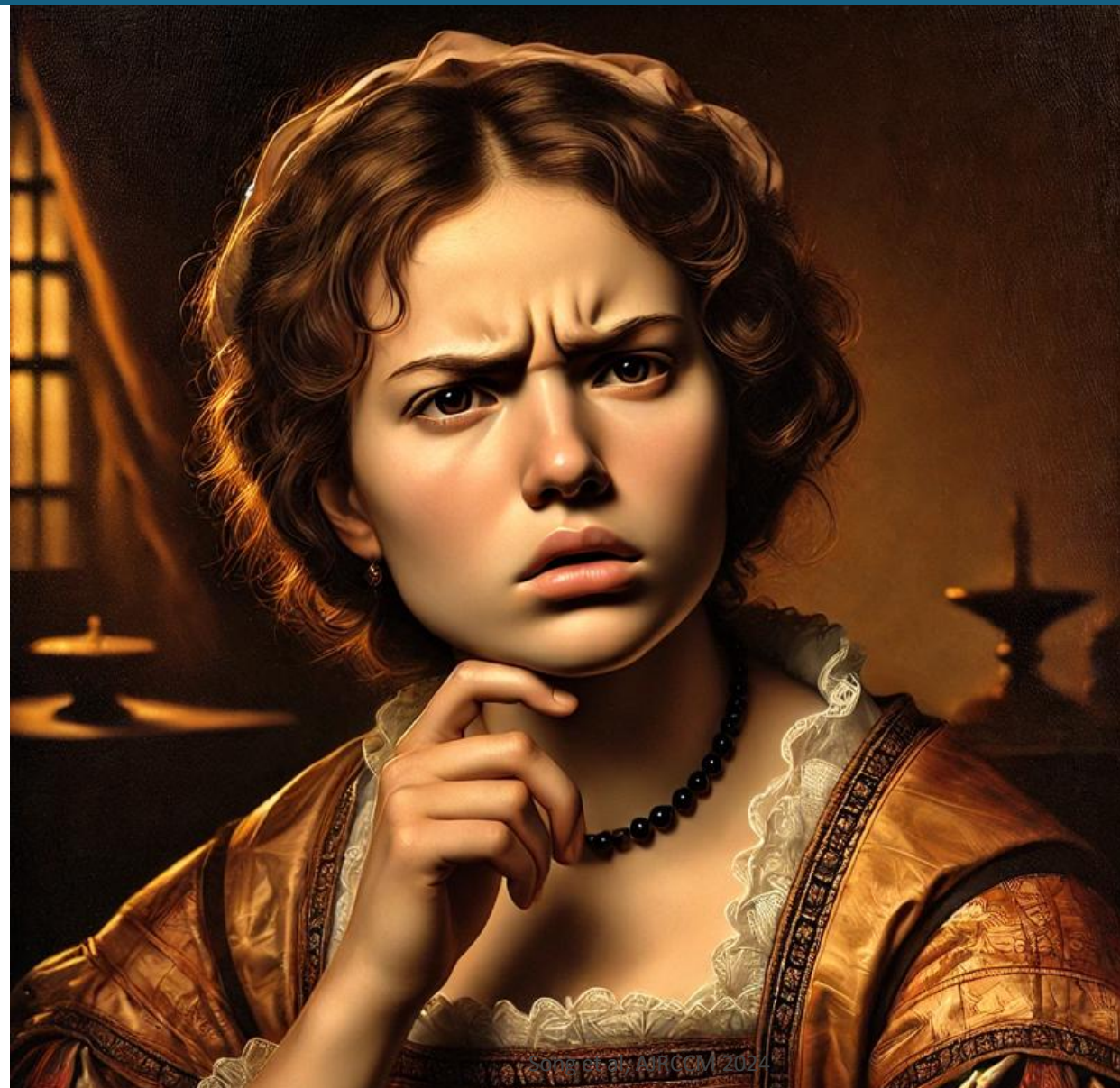
What can we learn from these experiments about susceptibility?

Mini-lungs are a model of:

- Repairing lungs
- Developing/growing lungs

So who is most vulnerable?

- Patients with lung disease?
- Fetuses?
- Children?



What we now know

- Microplastics are a novel type of air pollution
- Nylon fibers are taken up by immune cells
- Nylon inhibits development of mini-airways
- Culprit: leaching chemical(s)
- The biological mechanism behind the loss of airways
- How we can get airways back

Key questions we still need to answer

- ✓ Does this happen in lungs of humans?
- ✓ What is the dose needed to see these effects?
- ✓ How many microplastics get into our lungs per day?
- ✓ Which chemicals leach out of plastics?
- ✓ What do the other hundreds types of plastics do?

Implications

- Most at risk may be:
  - ✓Children?
  - ✓People with a lung disease?
- Is recycling a good idea?
- Are bio-based plastics better?
- Can we regulate fiber or chemical shedding from textiles?

What can we do today?

- Use less plastics
- Ventilating helps (or air purifyer)
- Vacuum cleaning helps
- Don’t eat from plastic containers
- Don’t microwave your food in plastic

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