Secondhand and Thirdhand Smoke from Cigarettes, Marijuana and E-Cigarettes

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Outline

- Smoke basics
- Secondhand smoke
- Thirdhand smoke
- Tobacco and Marijuana
- E-Cigarettes
- Cardiovascular Effects of Secondhand Smoke and E-Cigs
- Summary

What is an aerosol?

- Gases + Droplets of oils and waxes + small particles

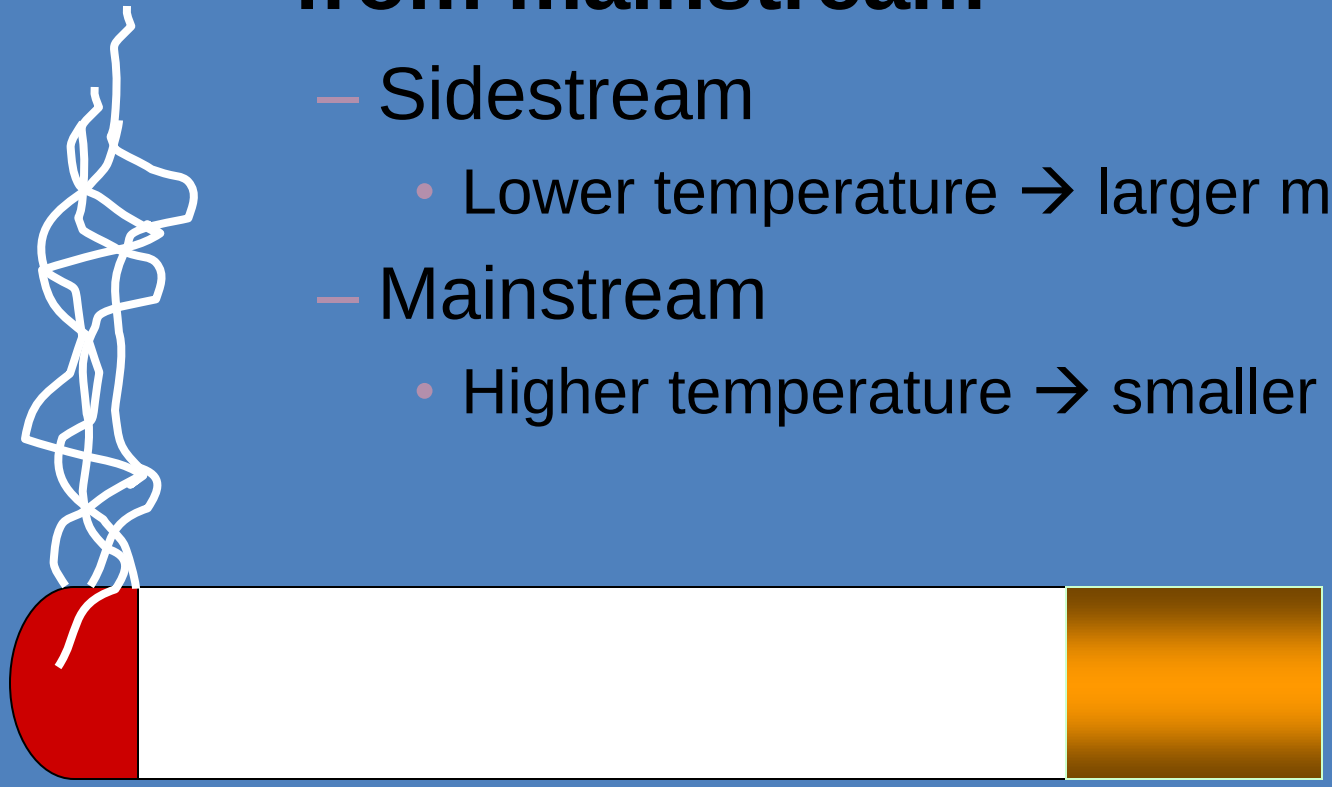
- Smoke is an aerosol
- E-cigarette “vapor” is an aerosol
- Marijuana “vapor” is an aerosol
- Air freshener spray is an aerosol

Cigarettes as a Model Combustion Aerosol

Or: Burning Leaves in Your House is a Bad Idea

Sidestream smoke is more toxic than mainstream smoke

- **Sidestream is chemically different from mainstream**
  - Sidestream
    - Lower temperature → larger molecules
  - Mainstream
    - Higher temperature → smaller molecules



What is Secondhand Smoke?

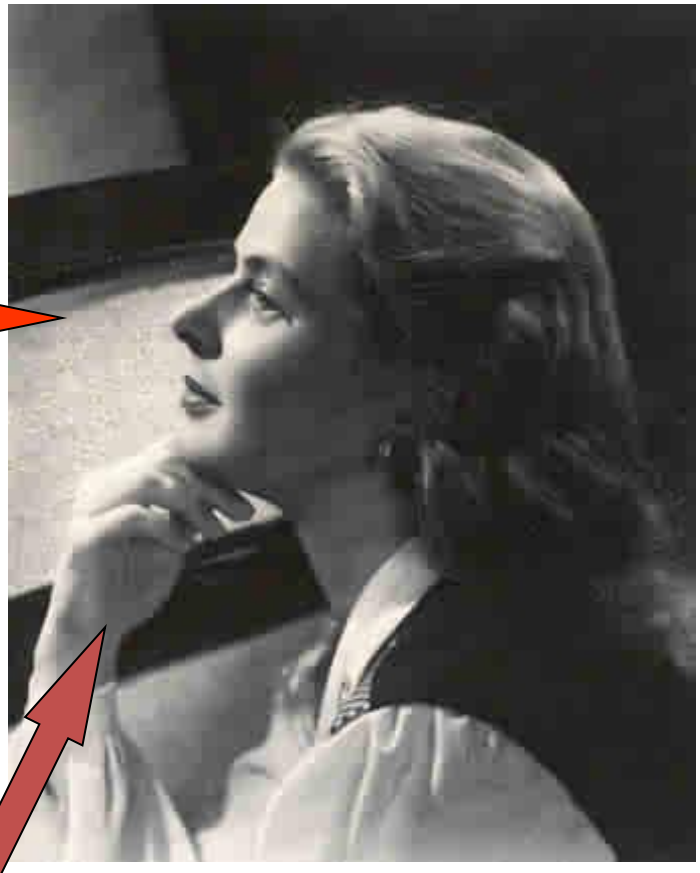
- 85% Sidestream:15% exhaled Mainstream

- Combustion creates thousands of different chemical compounds:
  - **Gas phase inorganic:** CO_2, H_20, CO, NH_3
  - **Very volatile organic compounds (VVOCs):** formaldehyde, acrolein, 1,3-butadiene
  - **Volatile organic compounds (VOCs):** benzene, toluene, NMDA
  - **Semi-volatile organic compounds (SVOCs):** Nicotine, some PAHs and TSNAs
  - **Particulate matter:** benzo(a)pyrene, NNK, THC

Thirdhand Smoke

SHS

THS



Indoor Surfaces

What part of secondhand smoke creates thirdhand smoke?

- Particles and droplets of oils and waxes (Tar)
- 10% of secondhand smoke is tar

Thirdhand Smoke starts with <u>Tar</u>

What is Thirdhand cigarette smoke? The 3 R's

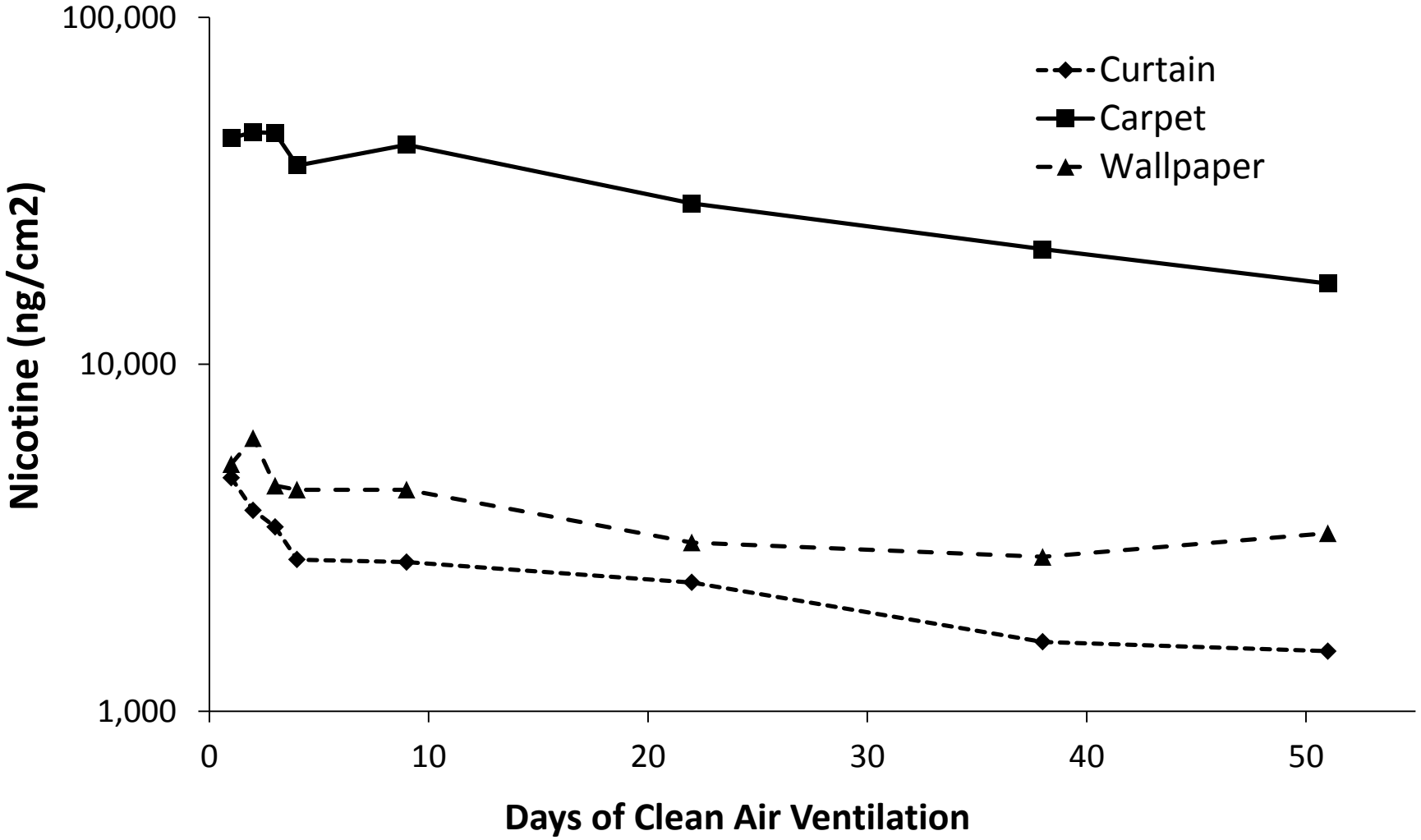
Chemicals in cigarette smoke that:

- ***Remain*** on surfaces and in dust
- ***Re-emit*** back into the gas phase
- ***React*** with other chemicals in the environment to make new chemicals

Remain

- Tar chemicals stick to surfaces before they can be removed by ventilation
    - Walls, carpet, dust, people…
- Tar absorbs into porous materials
- Tar contains nicotine and many toxins and carcinogens
    - Nitrosamines
    - Polycyclic aromatic hydrocarbons
- Persistence increases exposure time

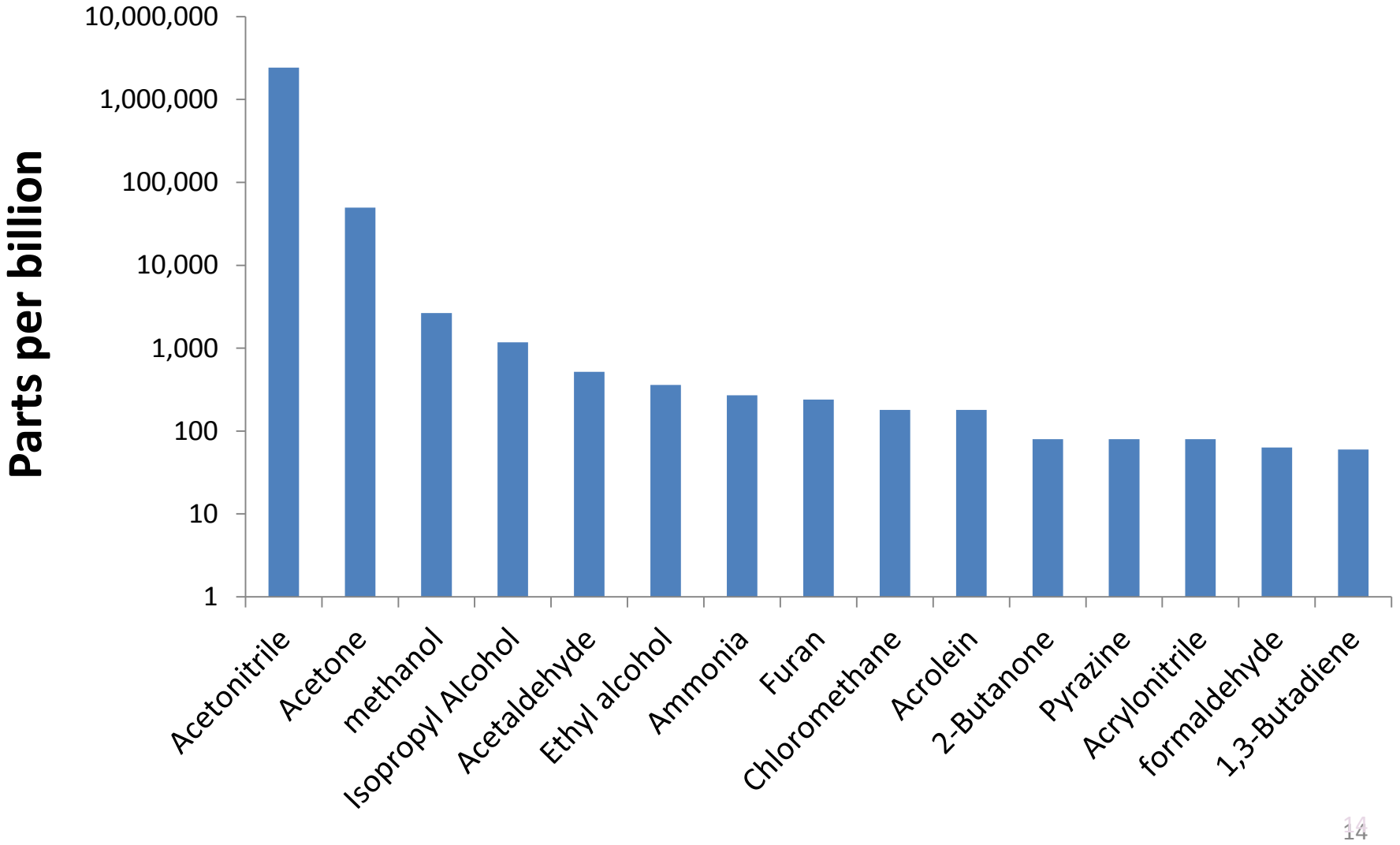
Nicotine persists in surfaces
(after smoking ends)



Re-Emit

- Combustion forces tar chemicals (normally solids or liquids) into the air
- Tar cools, condenses and sticks to surfaces
- Once on a surface, each chemical reaches equilibrium
- Fraction in the air depends on the chemical

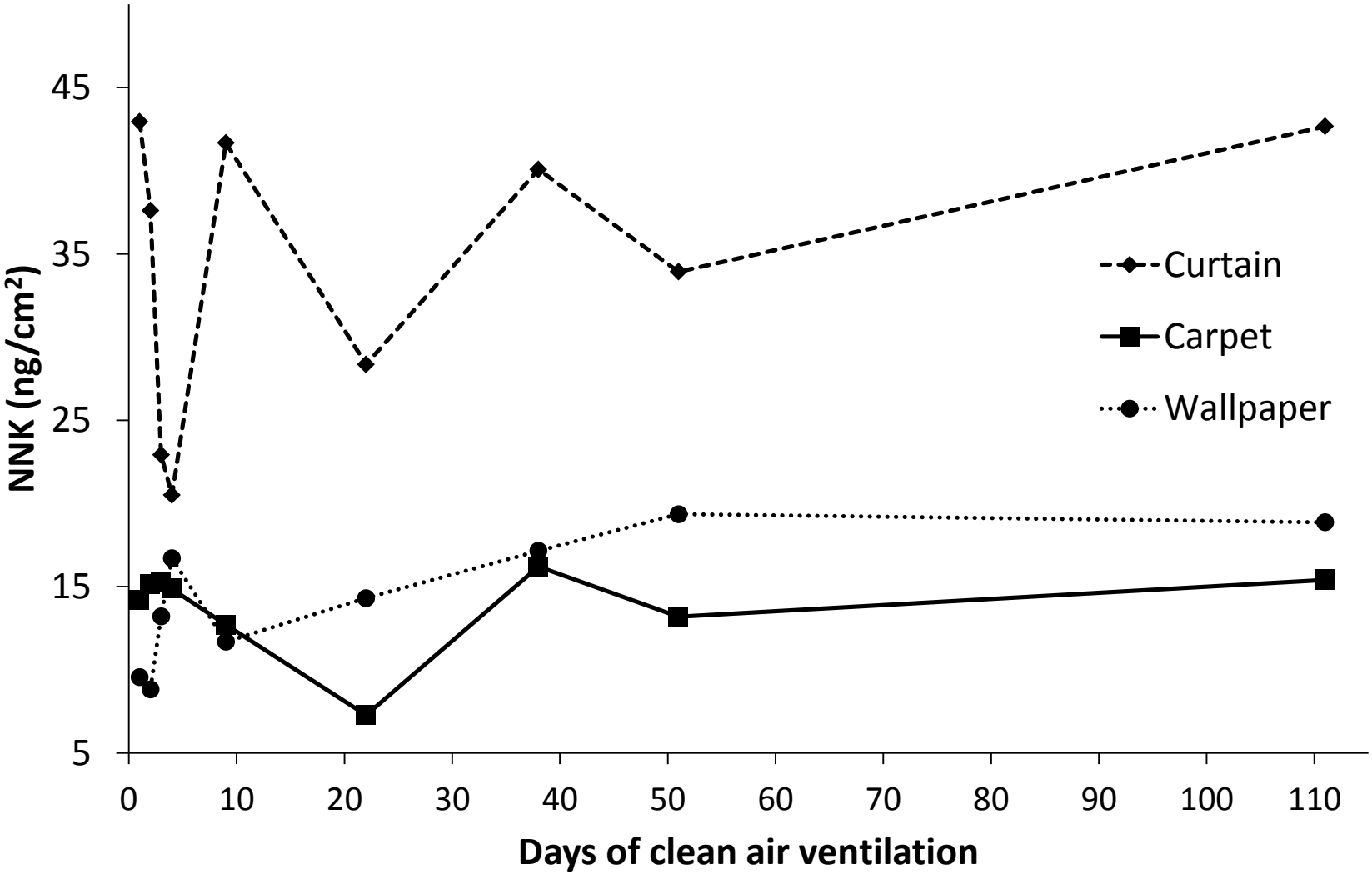
Paper exposed to smoke off-gasses volatile chemicals



React

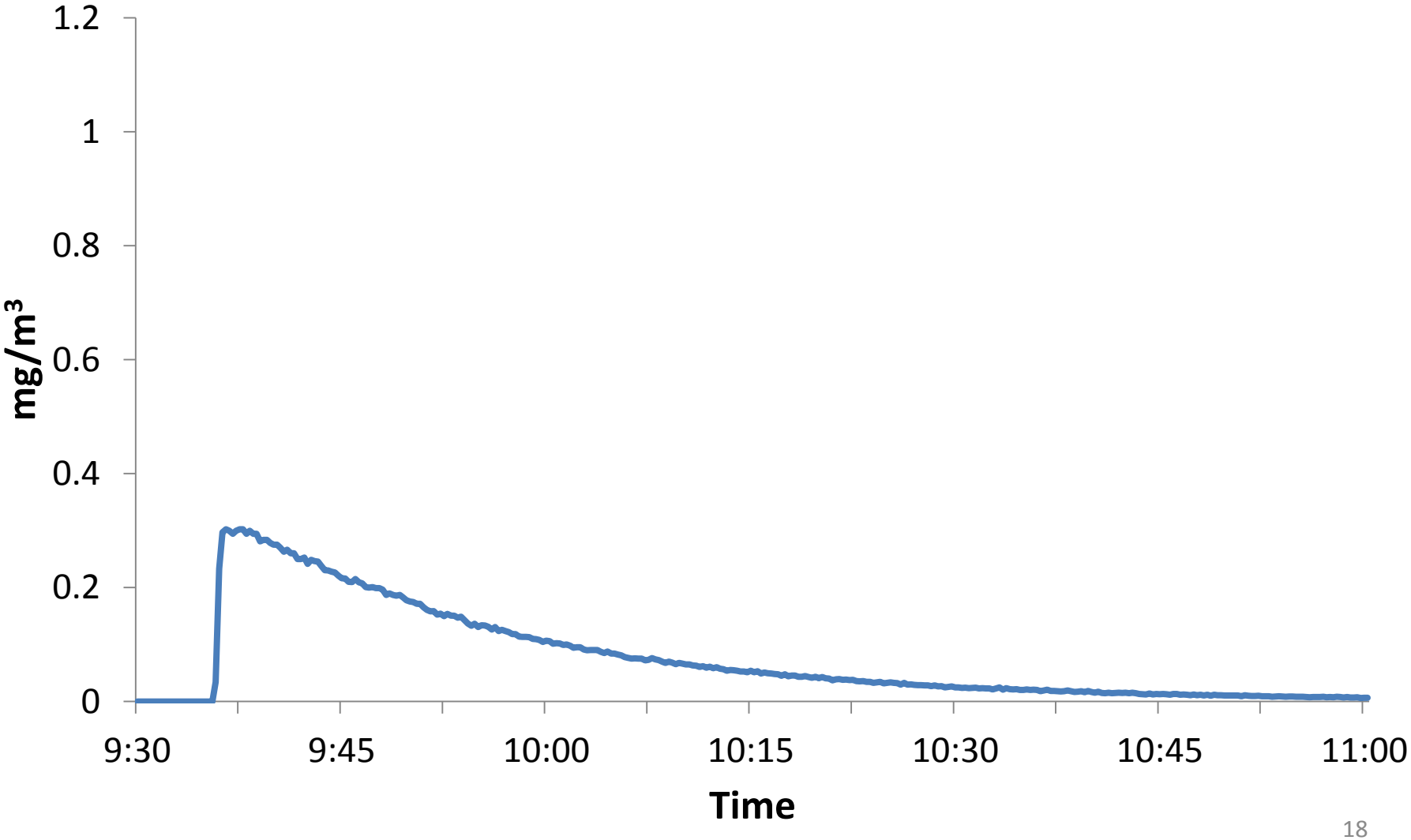
- Where there are chemicals, there are chemical reactions
- Which reactions do we know about?
  - Nicotine + nitrous acid = **NNK**
    - » Carcinogen
  - Nicotine + ozone = **formaldehyde**
    - » Carcinogen
  - Tar + ozone = **ultrafine particles**
    - » Can cause heart and lung disease

NNK persists in surfaces (after smoking ends)



Thirdhand Smoke Emits Particles

“Secondary” particles from Thirdhand Smoke



Thirdhand Smoke is a persistent environmental contaminant

- **Remains**
  - Weeks and months of ventilation do not remove Thirdhand Smoke
  - **Re-Emits**
  - Nicotine, formaldehyde, acetonitrile, acetone and other volatile chemicals
- **Reacts**
  - Nicotine reacts to form NNK
  - THS reacts to form particles

Charting the Unknown: Data from Marijuana and E-Cigarettes

Similarities between tobacco and marijuana smoke

- Leaf contains high concentrations of oils and waxes
- Nicotine and THC both survive combustion
- It doesn't matter what you burn: **Combustion creates complex, toxic aerosols**

Toxins in Sidestream

	Health Effects	Tobacco	Marijuana
weight (mg)		788	769
puffs		13	15
tar (mg)	Multiple	24	50
CO (mg)	Inhibits respiration	62	54
Ammonia (mg)	Irritant	5.6	14.3
Nicotine (mg)	Addictive	5	0
NOx (mg)	Inflame lung	1.2	2.3
Formaldehyde (µg)	Carcinogen	886	383
Acrolein (µg)	Cardiotoxin	437	566
HCN (µg)	Toxin	84	685
Benzo (a) pyrene (ng)	Carcinogen	91	101
NNK (ng)	Carcinogen	92	0

Moir et al., 2008

E-Cigarette Toxins

- Even smaller particles
  - Median diameter for cigarettes: 110-340 nm
  - Median diameter for e-cigarettes: 5-50 nm
  - E-cigarette particles evaporate faster
- Nicotine
  - No sidestream but, more spills and leaks
- Formaldehyde
  - 4-100 X less
- Acrolein
  - Equal to 10 X less
- Flavorings: benzaldehyde (cherry), cinnamonaldehyde …

Marijuana e-cigarette aerosols

- Terpenes are odorant, active chemicals found in cannabis, tobacco and e-liquids
    - Limonene, Pinene, Linalool, Myrcene and others
- Secreted by same plant glands that make THC
- Can be used to reduce viscosity of hash oil in vape pens
- React to form particles in air
  - Research on air fresheners

Toxin Exposure Patterns

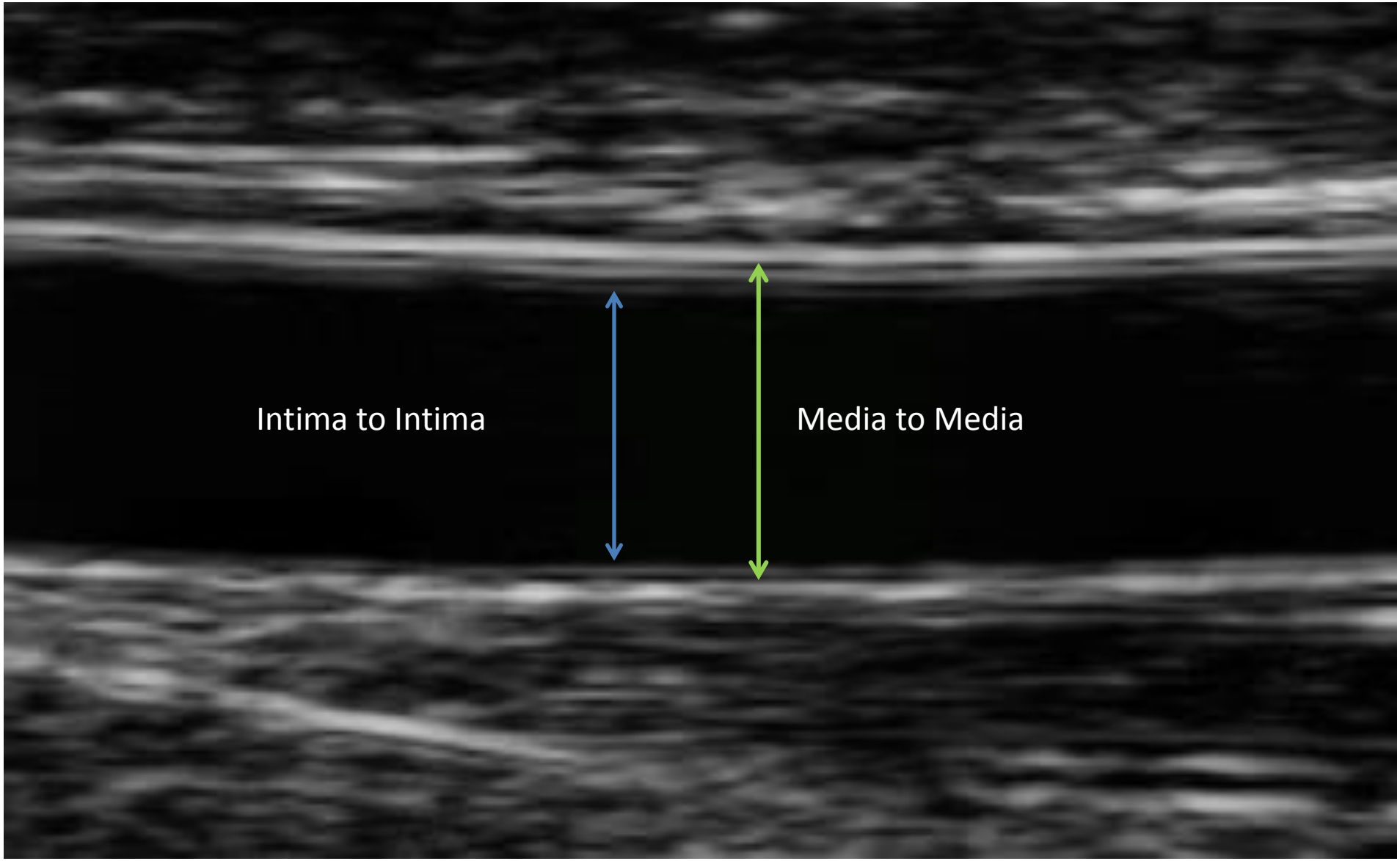
	Users			Non-users	
	Cigarettes	**Marijuana**	**E-cigarettes**	**SHS**	**THS**
Particles	+++	+++	++	++	+
Combustion Toxins	+++	+++	++	++	+
Nicotine	+++	-	++	+	++?
THC	-	+++	-	+	?
Formaldehyde & Acrolein	+++	+++	+	++	+

Flow-mediated dilation (FMD), a predictor of heart attack risk

- Measure diameter of brachial (arm) artery by sonography
- Restrict blood flow in arm with blood pressure cuff for 5 minutes
- Release cuff and measure diameter of brachial artery again.

Healthy blood vessels respond to the rush of blood by dilating.

Flow-Mediated Dilation of the Brachial Artery Measured by Ultrasound



E-Cigarettes reduce FMD in healthy young people

% FMD	Nonsmokers	Smokers
Before Smoking Cigarette	7.83	5.62
After Smoking Cigarette	3.96*	2.82*
Before Using E-Cigarette	7.38	5.88
After Using E-Cigarette	4.56*	3.99*

Carnavale et al. 2016

Conclusions

- If it burns, it creates smoke
  - It doesn't matter if it is tobacco or marijuana
- Aerosols linger in the environment
  - Any aerosol can create THS
- Breathing aerosol particles can increase risk of heart attack