Effect of Dust Particles on Human Health

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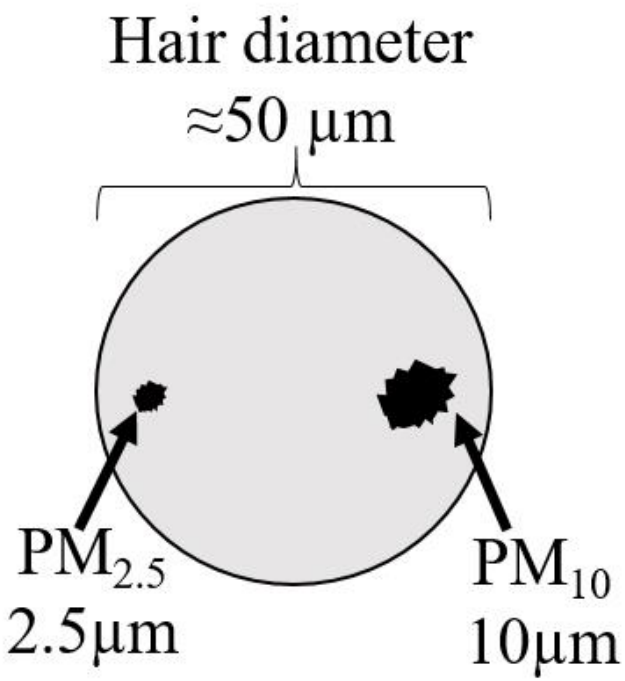
What is an aerosol particle and its origin?

Aerosol - a colloid of fine solid particles or liquid droplets



PM_{10} particles with a diameter <10 μm

$PM_{2.5}$ particles with a diameter <2.5 μm

Dust storm is a meteorological phenomenon common in arid and semi-arid regions.

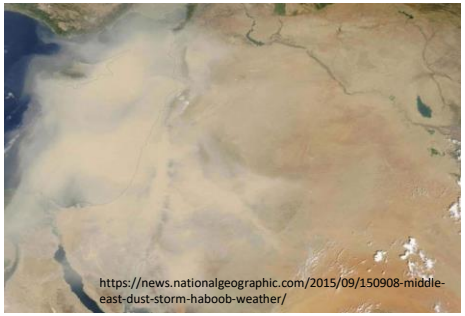
Dust storms occur when strong wind blows loose particles from a dry surface.

Lubbock TX 2018

Tel Aviv, Israel 2010

Increase of aerosol particles

Reduction of air quality → impact on human health



https://www.telegraph.co.uk/news/picturegalleries/worldnews/4967897/Blinding-sandstorm-hits-Kuwait-and-Saudi-Arabia-halting-oil-exports.html?image=3

https://indianexpress.com/article/trending/trending-globally/life-in-the-desert-massive-sandstorm-in-west-africa-turns-sky-red-6397106/

Mediterranean

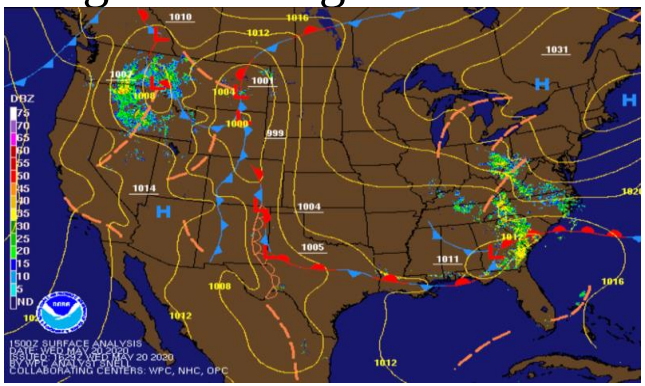
https://www.i24news.tv/en/news/international/middle-east/85403-150915-scientists-baffled-by-middle-east-dust-storm

Strong winds associated with dust storms are a result of two different meteorological disturbances

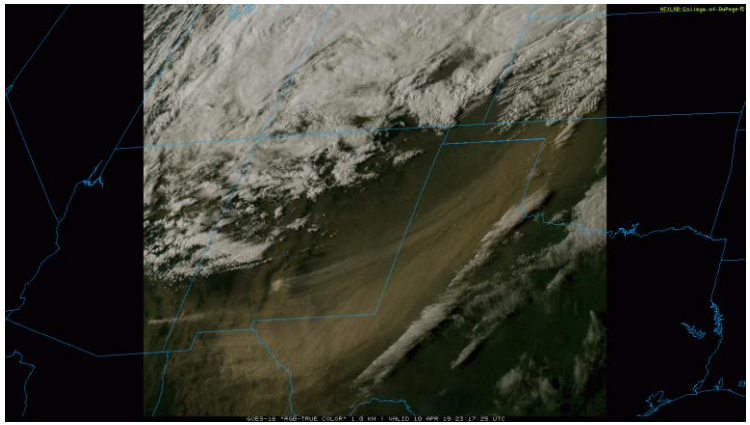
Dust storm vs Haboob (Synoptic vs. Convective)

Synoptic – scale used in meteorology that ranges from hundred of kilometers
(AMS Glossary, 2012)

- Front (warm and cold)
- Cyclones (low and high)
- Troughs and ridges

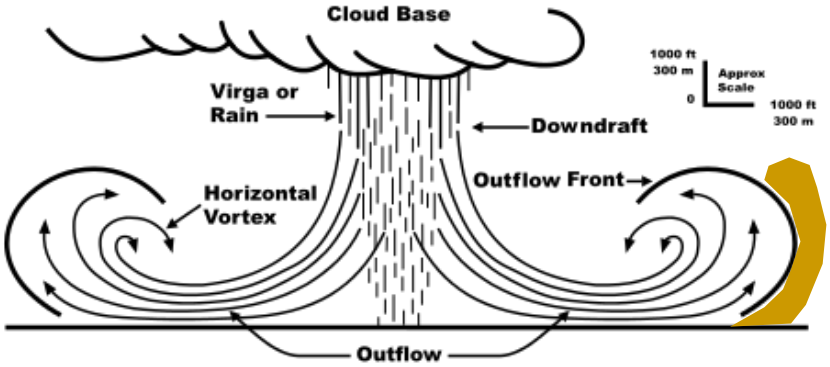


NOAA NWS Archive, 2020



Convective – quick increase of winds as a result of a thunderstorm

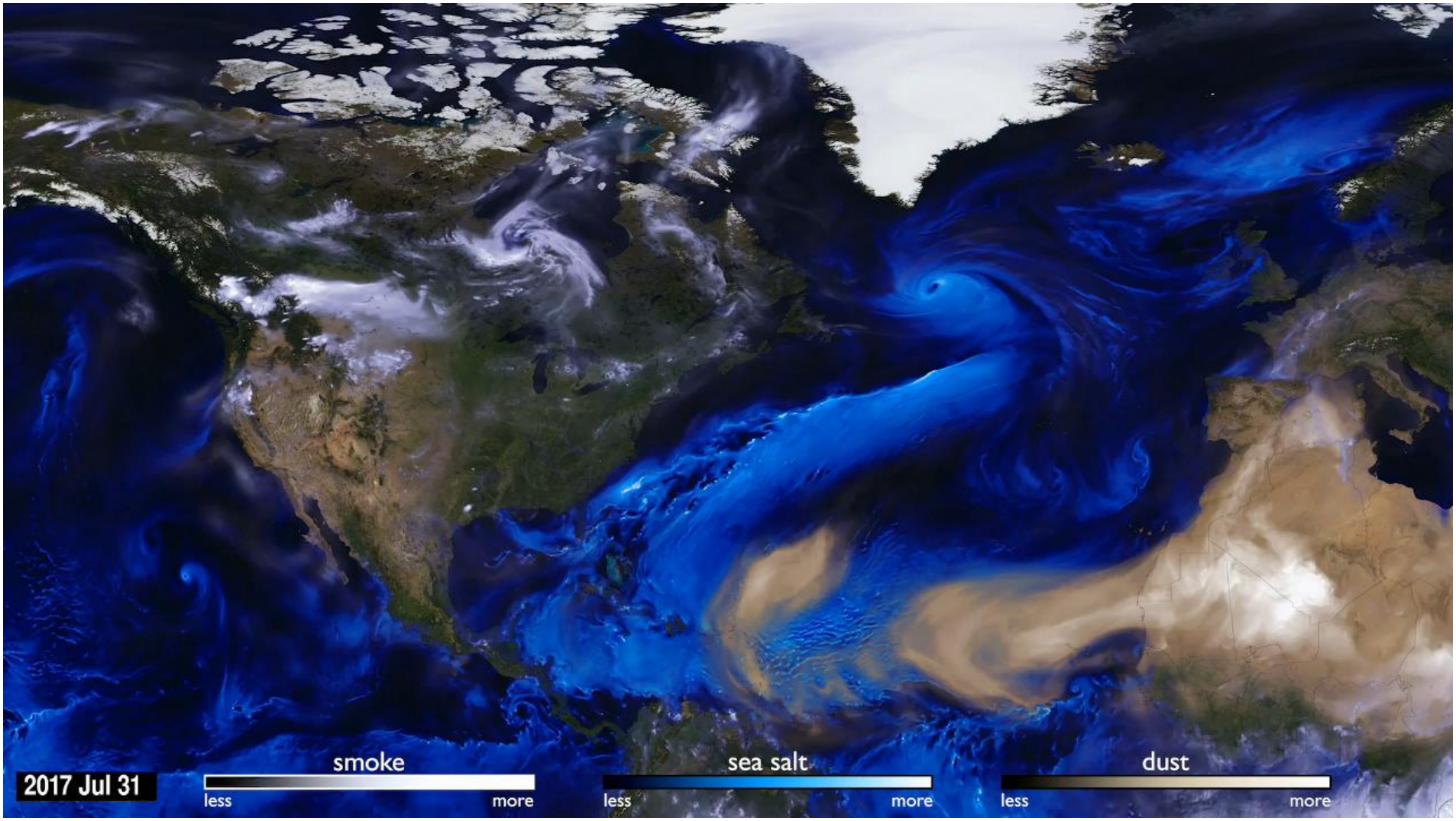
- Outflows
- Micro- and macroburst
- Downburst



wikipedia

Gifbay.com

2017 Aerosols Simulation

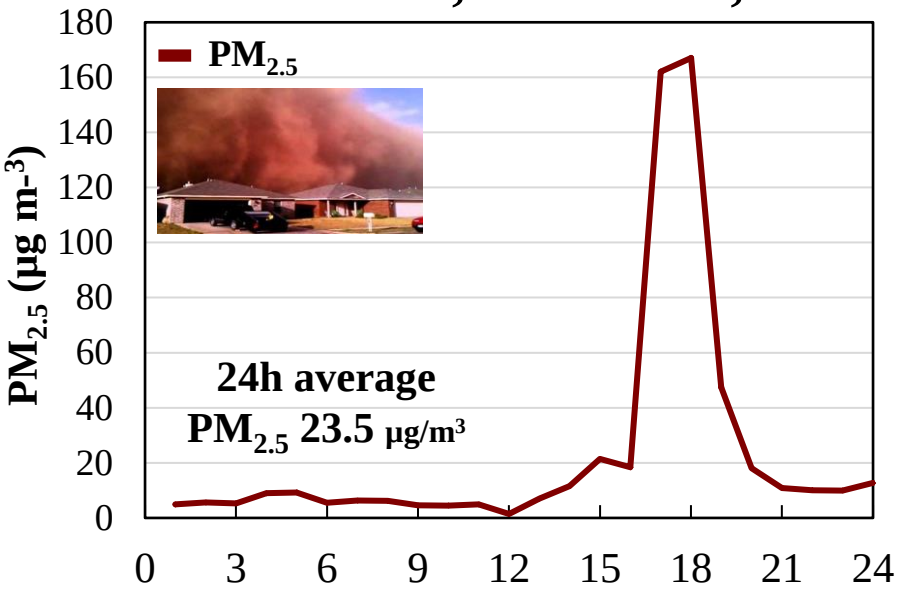


Tracking aerosols over land and water from August 1 to November 1, 2017.

https://gmao.gsfc.nasa.gov/research/science_snapshots/2017/wx_extrema_aerosols.php

https://svs.gsfc.nasa.gov/12772

Lubbock TX, October 17, 2011

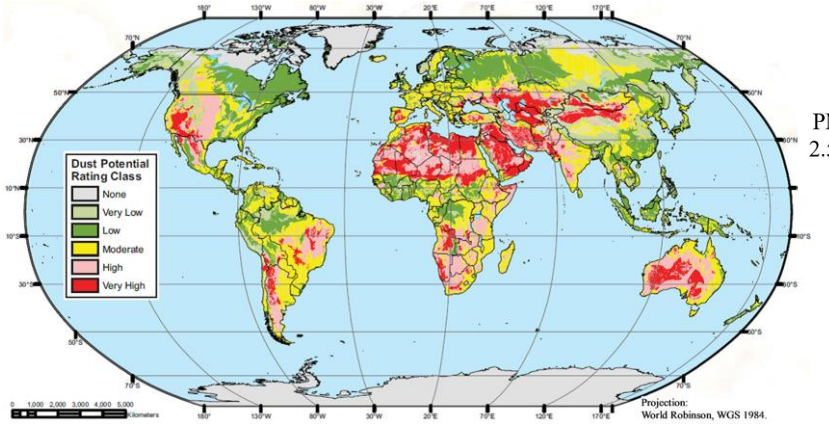


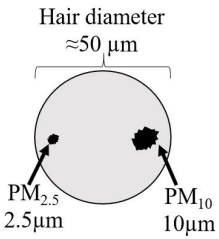
24h mean	WHO	EPA
$PM_{2.5}$ ($\mu g\ m^{-3}$)	25	35
PM_{10} ($\mu g\ m^{-3}$)	50	150

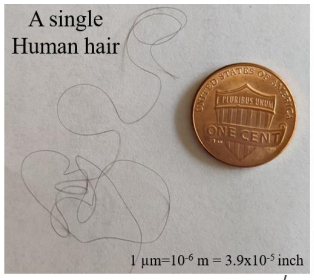
http://www.atmo.ttu.edu/bruning/TTUHaboob-2011Oct17.mp4

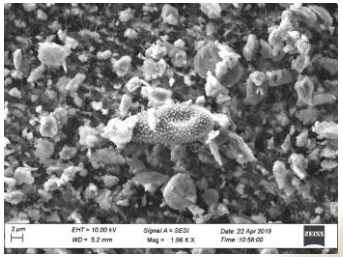
Taken from Dr. Eric Bruning website

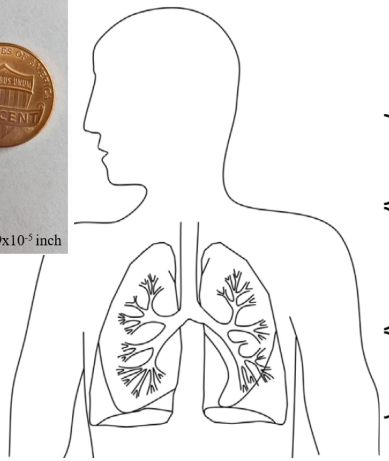
Why should we care?











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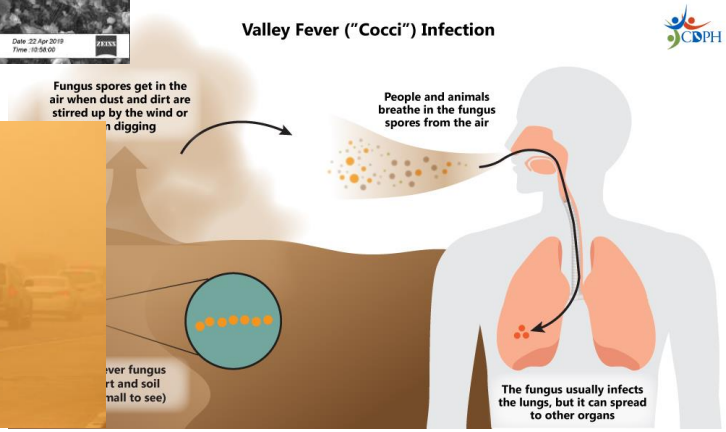
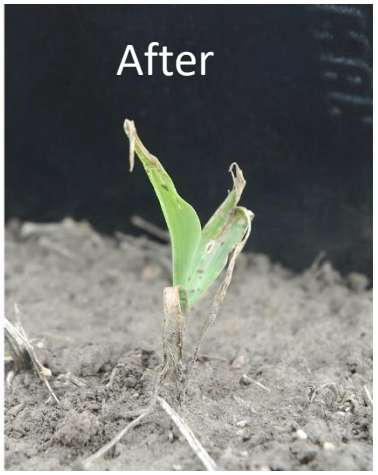


Dust Storm Alerts NSW, 2020


Paul Green


Ahmed Jadallah, Dubai, 2015

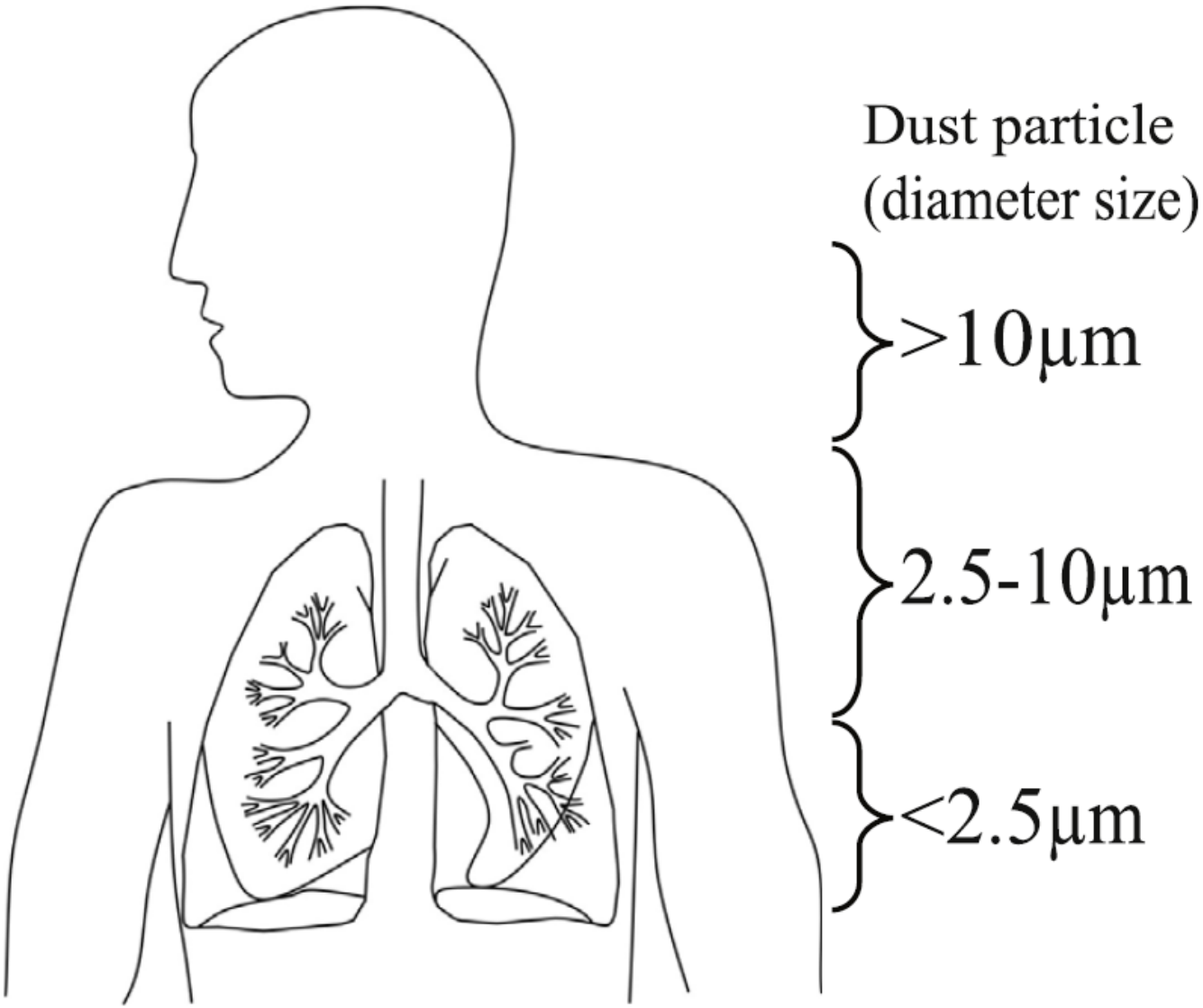
Institute of Agriculture and Natural Science




Joe Merchant

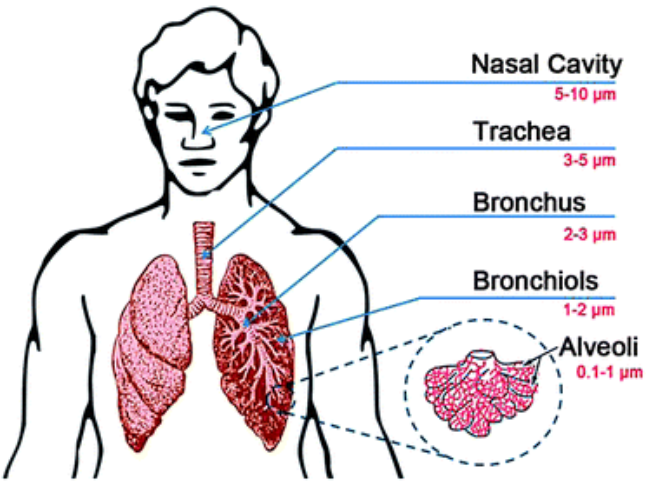

Julio Reyes

What happens when we breathe them?



Ardon-Dryer et al.2019

What is the effect of dust particles on health?



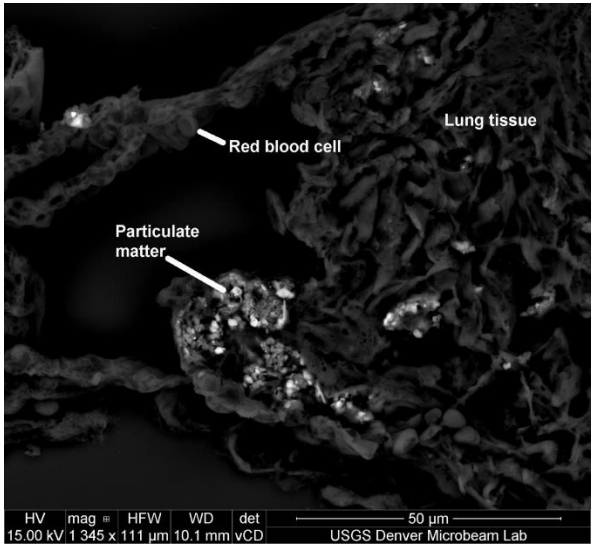
http://www.omafra.gov.on.ca/english/livestock/swine/facts/93-003.htm

Coarse particles (>2.5µm) affect respiratory conditions such as:

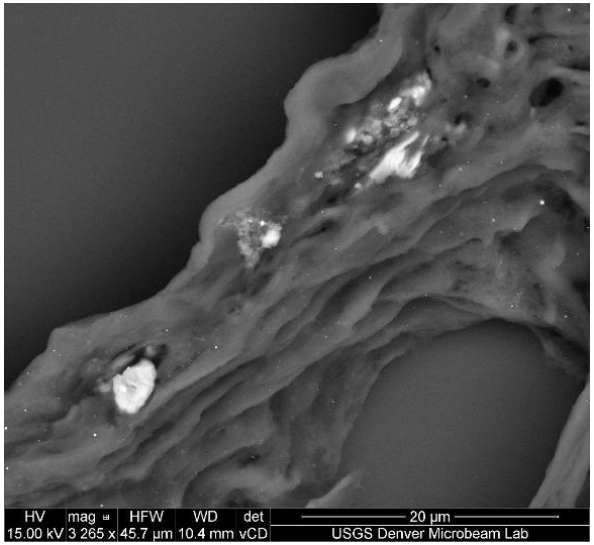
- Asthma
- Chronic obstructive pulmonary disease (COPD)
- Airway infections

Fine particles (<2.5µm) can lead to cardiovascular events (any incidents that may cause damage to the heart muscle)

Sandstrom and Forsberg 2008



http://goldrushcam.com/sierrasuntimes/index.php/news/local-news/11860-investigating-lung-disease-in-iraq-and-afghanistan-military-veterans



https://www.sciencebase.gov/catalog/item/57ec2b60e4b090825010b86b

Identification of PM in Lung Tissue after dust storm exposure

Backscattered electron image acquired with a scanning electron microscope of lung tissue (darker areas) and particulate matter (lighter areas).

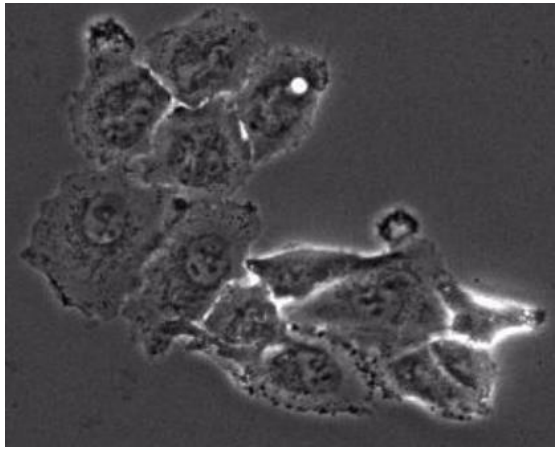
Epidemiological studies, In Vivo (animal) & In vitro (cells) methods

Epidemiological studies

https://www.rd.com/funny-stuff/medical-cartoons/

In vivo (animal)

In vitro (cells) Tissue culture



Epidemiological studies

- Increase in the number of emergency room visits
- High demand of asthma medications
- Increase in children clinic visits for conjunctivitis
- Aggravation of COPD and pneumonia
- Premature birth and low birth weigh
- Increasing risk of allergic symptoms
- Transportation of pathogenic microorganisms

Impact of dust storm on health

Positive correlation

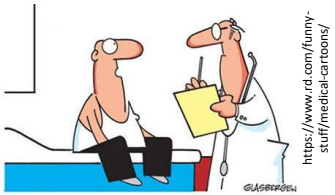
Japan	*Matsukawa et al. 2014*
USA	*Grinesk et al. 2011*
Cyprus	*Middleton et al. 2008*

No significant correlation

Australia	*Merrifield et al. 2013*
Spain	*Tobías et al. 2011*

Dust effect on Human health

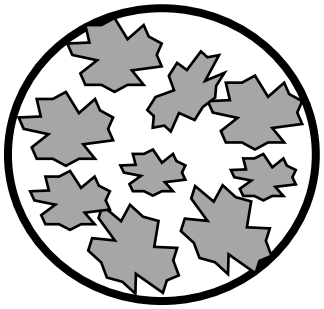
Epidemiological studies

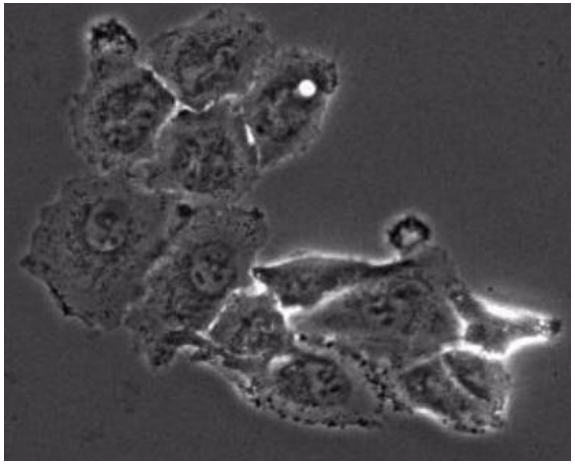


In vitro (cells) Tissue culture

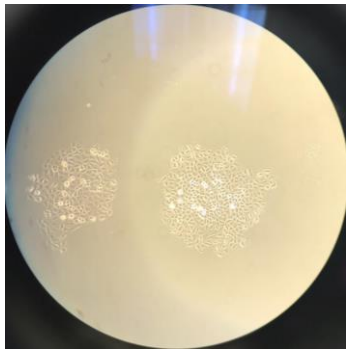
Cell population

Single cell level

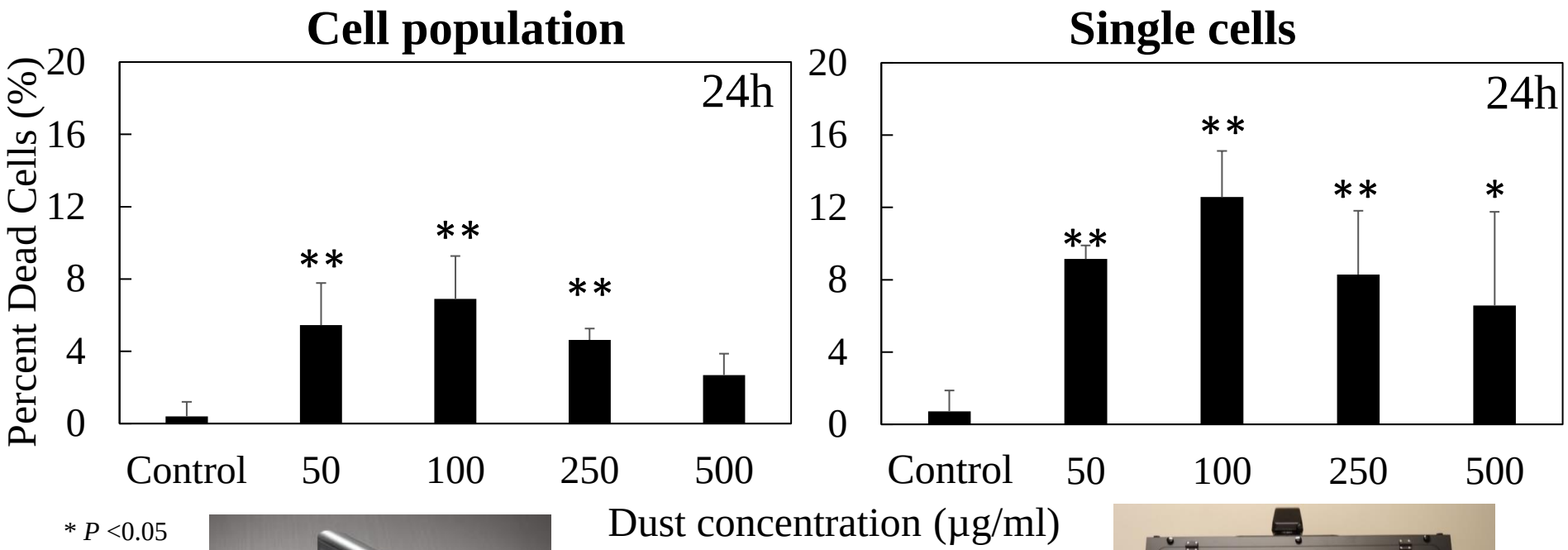




Cell line- A549



Effect on cell viability - Montmorillonite particles (A549 cell type)

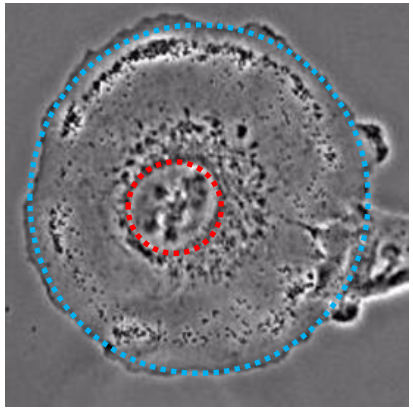


* $P < 0.05$
** $P < 0.01$

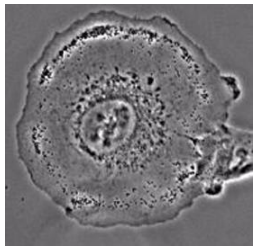
Similar values and patterns of % of cell death

Single cell analysis

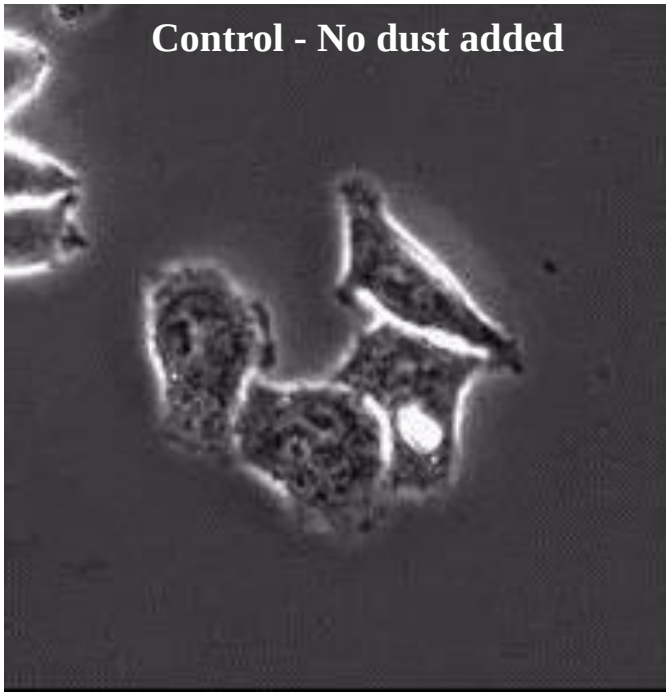
Cell line - A549 Human lung epithelial cell line (Type II).
A model for human epithelial lung cells.



Cell Nuclei
Cell Cytoplasm



A549 were used in many studies : *Schwarze et al. 2002; Veranth et al. 2008; Freyria et al. 2012; Naimabdi et al. 2016*



Follow the cells for long time duration (up to 72h), image was taken every 15 min

With the single cell method we can

- Monitor the behavior of each individual cell o
- Identify the interaction of each cell with the d
- Detect cell time-of-death.
- Identify type-of-death (e.g. cell explosion).


ELSEVIER

Environmental Research
Available online 7 November 2019, 108891
In Press, Journal Pre-proof

The effect of dust storm particles on single human lung cancer cells

Karin Ardon-Dryer [a, b], Caroline Mock [a], Jose Reyes [a], Galit Lahav [a]

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Dust particles

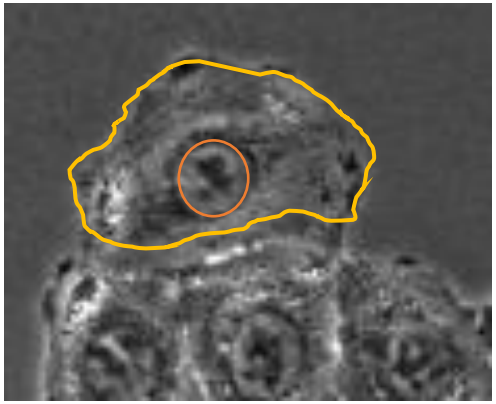
A wide range of dust concentrations (doses) was used:
10, 25, 50, 100, 250, 500, 1000 and 5000 µg/ml.

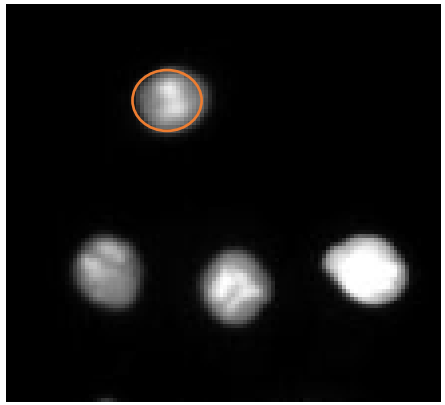
**These are not atmospheric concentrations rather concentration in the lungs*

After Dust added

Low dust Concentration High dust Concentration

Tracking cells exposed to dust can be done with the cells nuclei marker

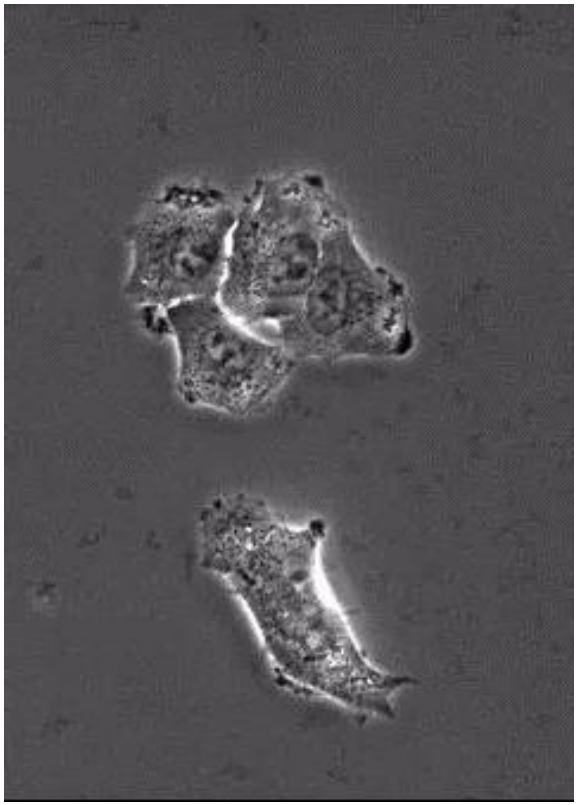


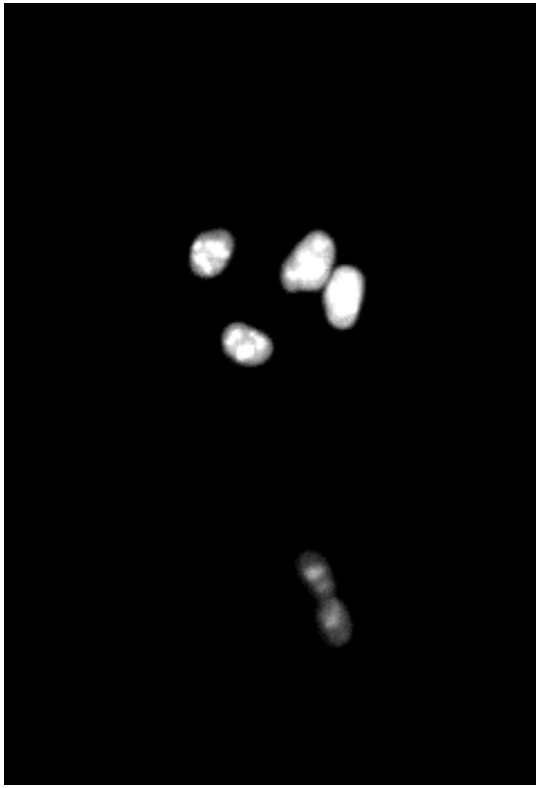


Nuclei marker - fluorescent protein in the cells nuclei

lentiviral construct EF1a-mCerulean3-NLS, a constitutive fluorescent nuclear marker

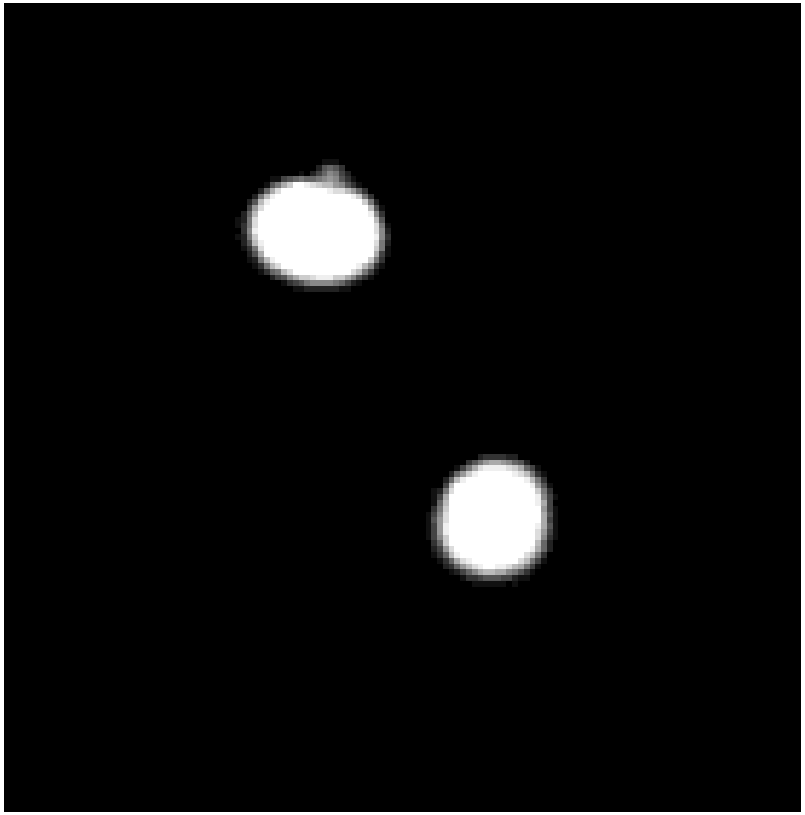
Tracking cells exposed to dust



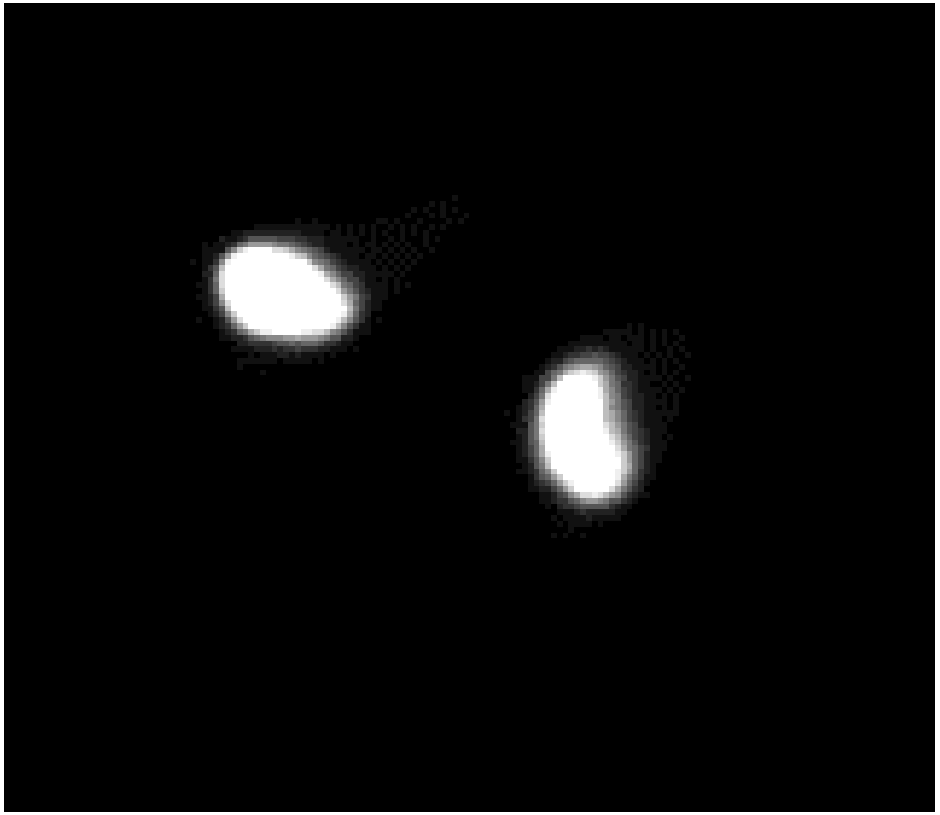


Tracking the cells that were exposed to dust allow us to identify cell death

Living cells



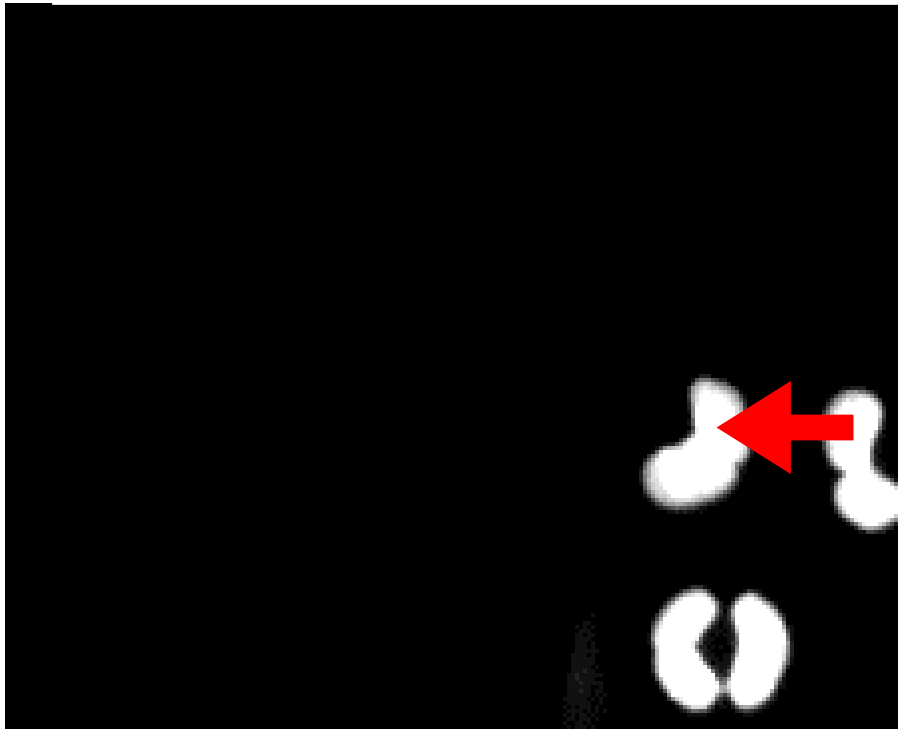
Dying cells

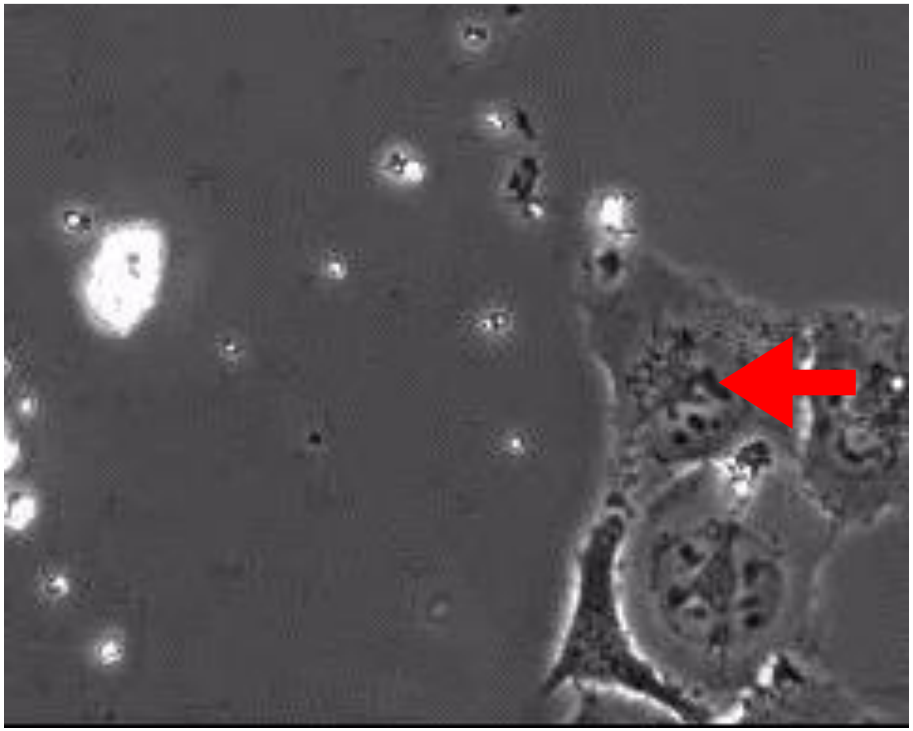


Why are the cells dying?

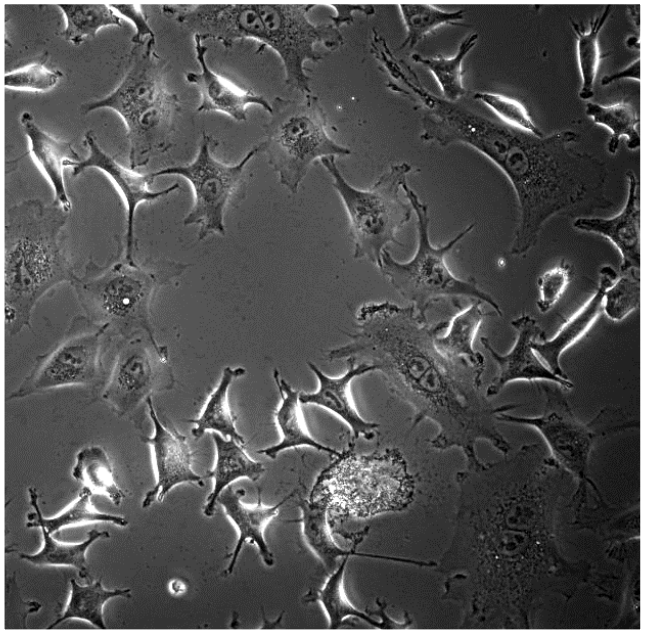
The cells are engulfing the dust particles

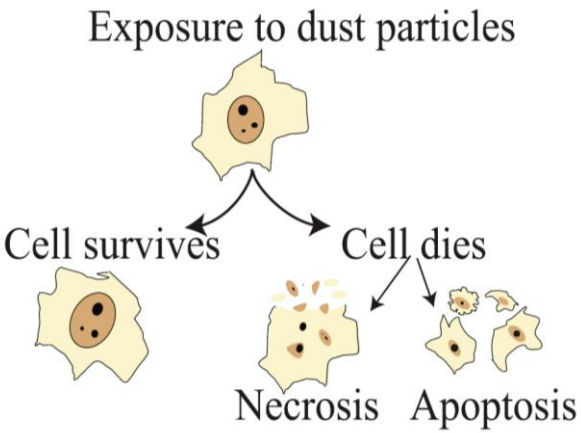
Phagocytosis - process in which a cell engulfs a particle, digests it, and expels the waste products.



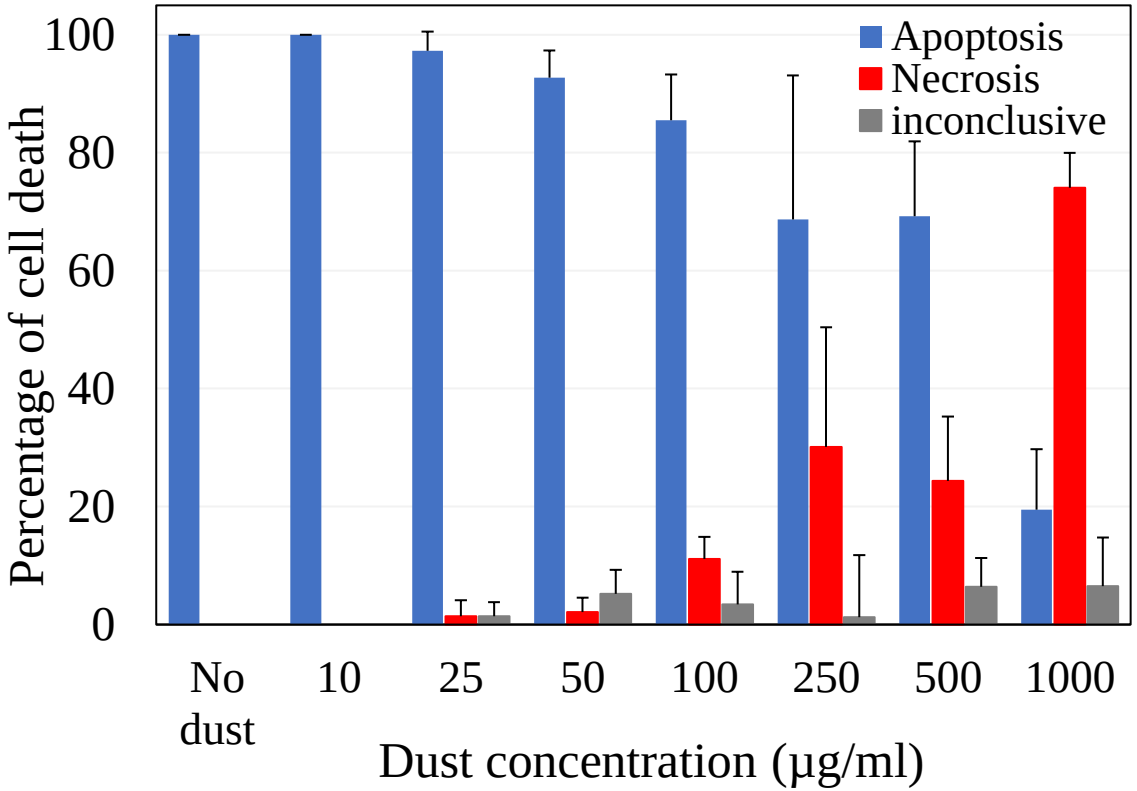


Why are the cells dying?





How are the cells dying?



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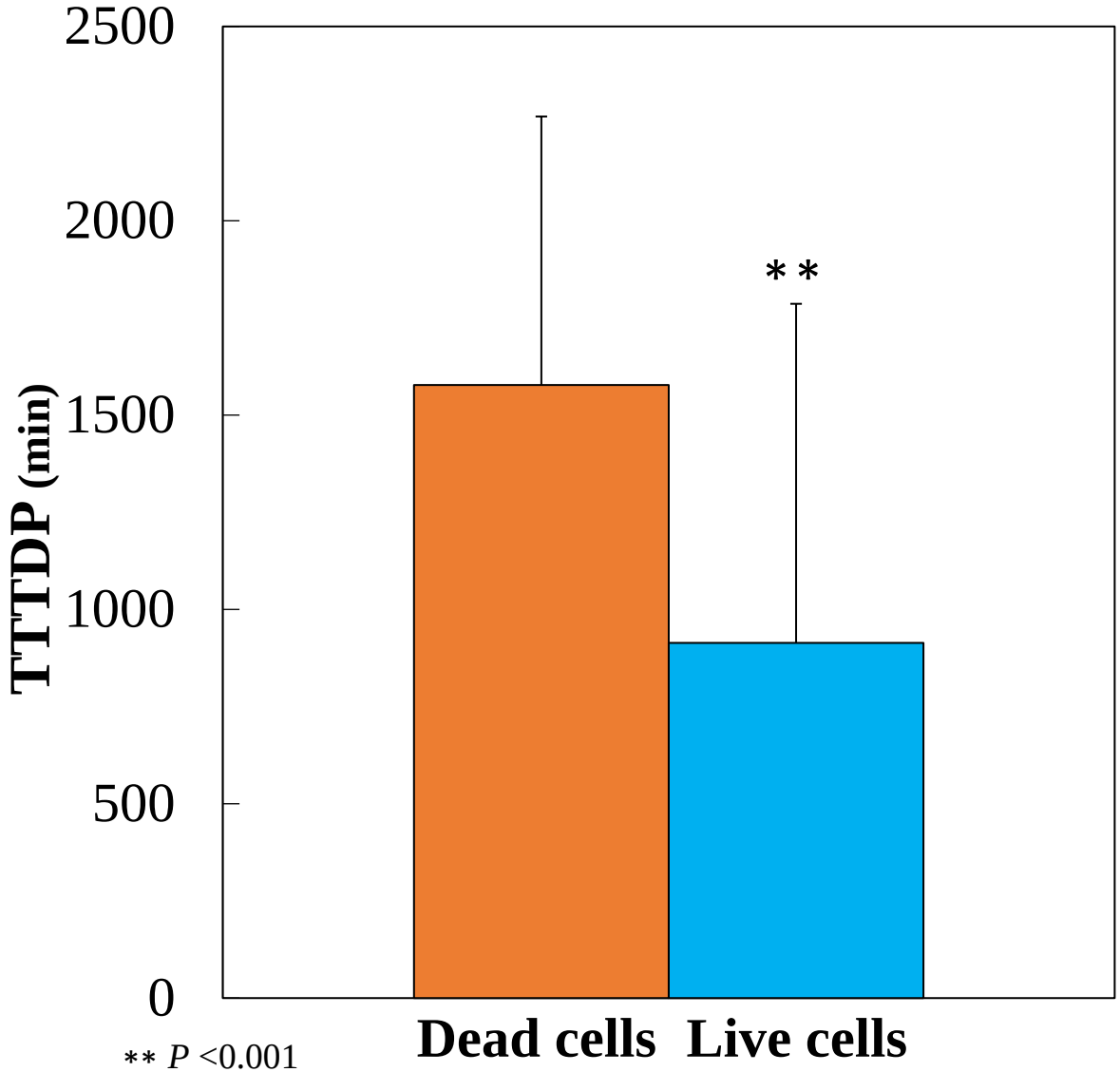
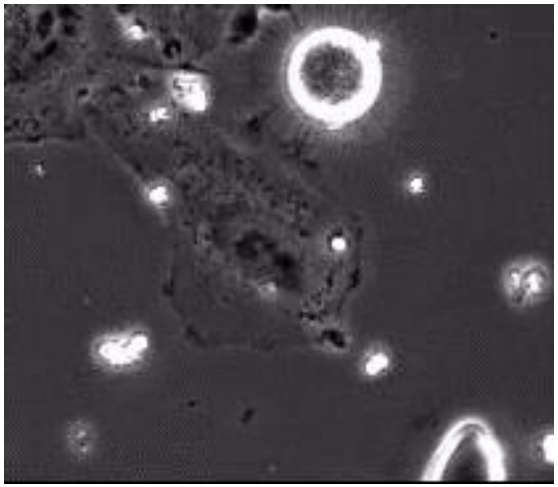
Dead cells show longer Total Time Touching a Dust Particles (TTTDP)



Dust concentration 10-50 (µg/ml)

148 cell died before 48h

150 cell remained alive for 72h



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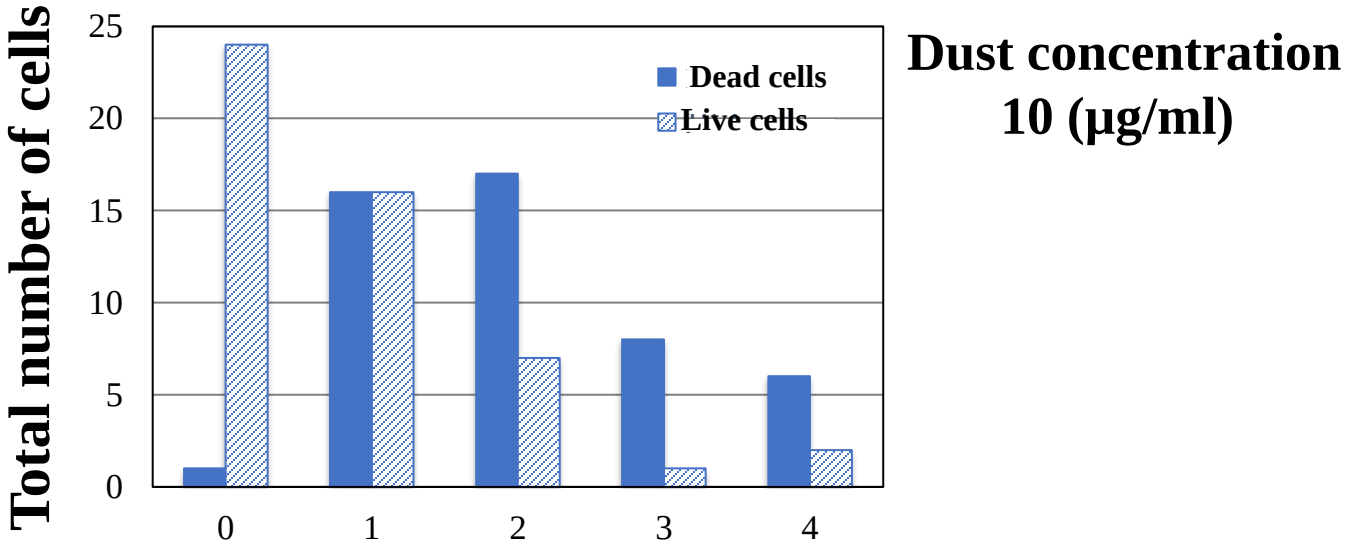
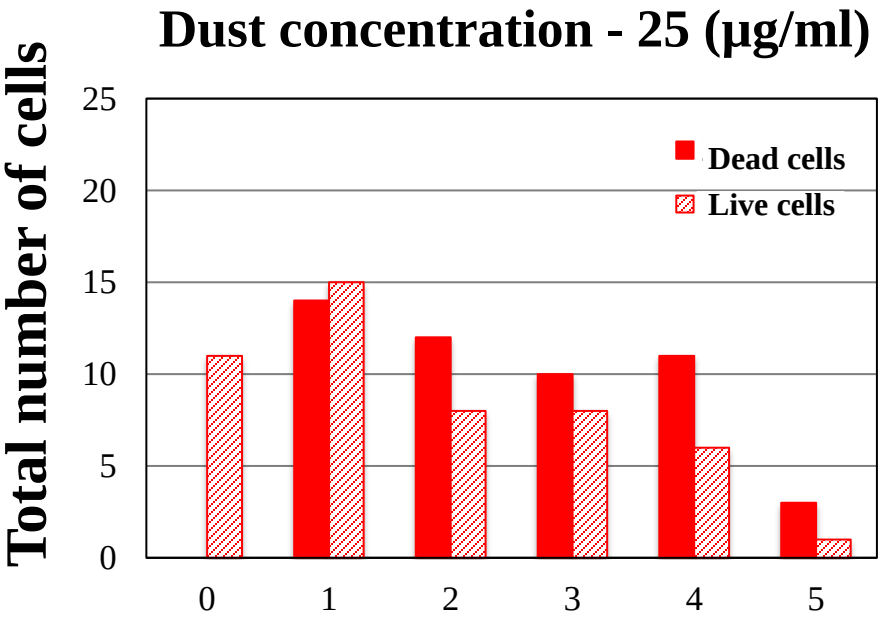
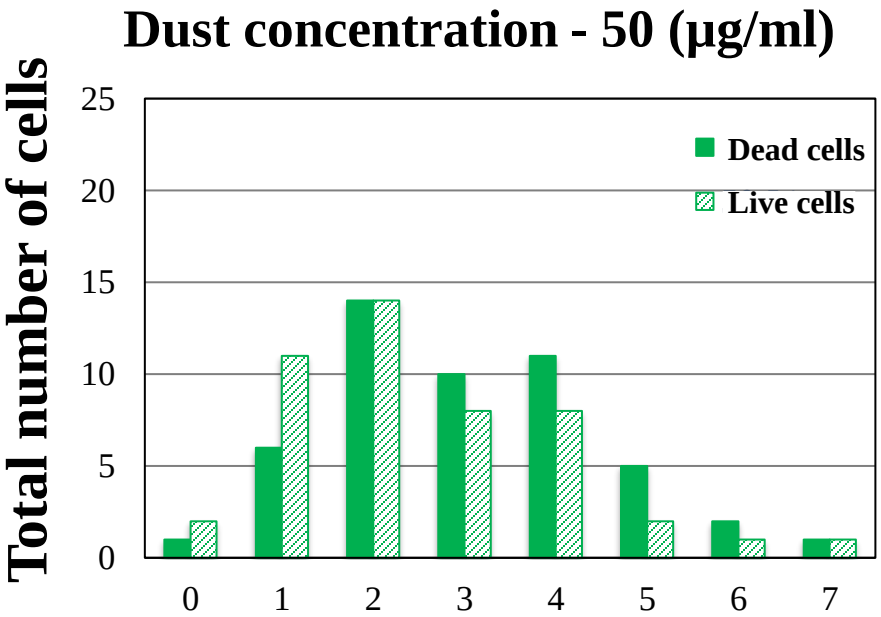
Dead cells touched more particles compared alive cells

(48h)

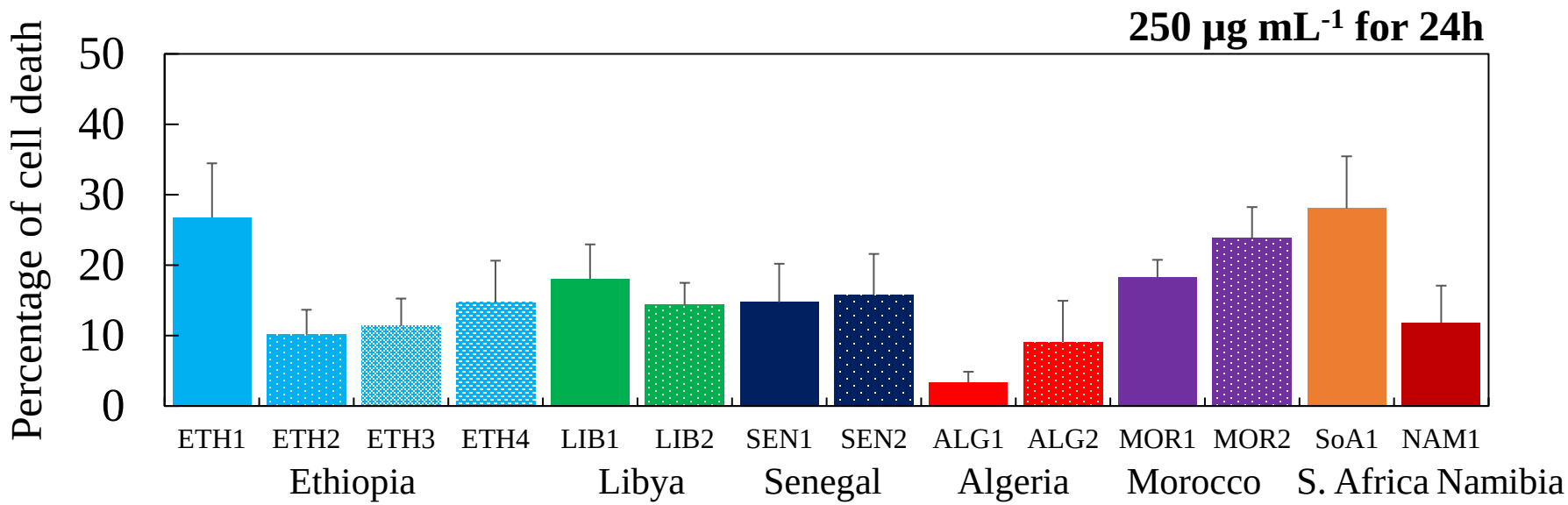






Maximum number of particles who touch a cell

Effect on cell viability 24h - cell population



Is it the particle size? Maybe chemistry? Present of biological particles?

Acknowledgment:

TTU Team

The CH Foundation
The Legacy of Christine DeVitt

Prof Kandler from Technische Universität Darmstadt

Thank you for your attention