

TAFE WHSO Conference Brisbane, June 2 2009

Wood dust, welding fumes and all that

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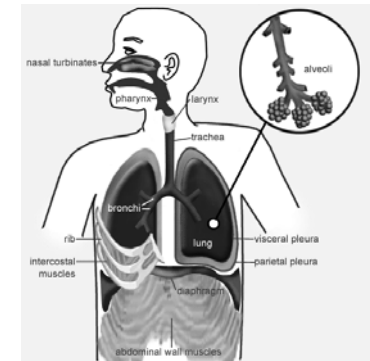
Topics

- Wood Dust
- Welding Fumes
- Will also visit
 - Industrial Ventilation
 - Ultra violet (solar & welding)
 - Protection from swine flu
 - Respiratory protection

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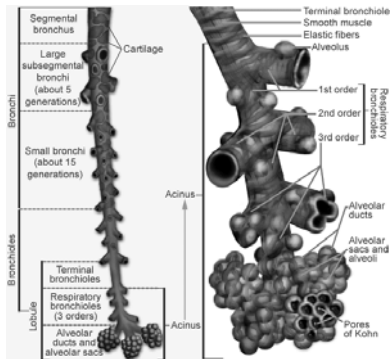
Lungs



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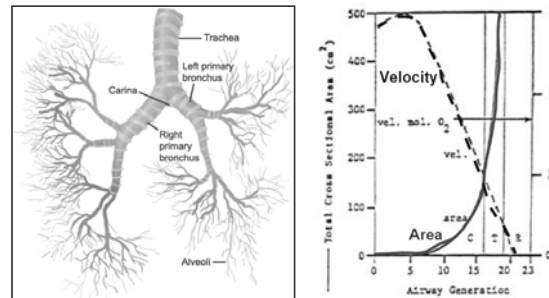
Lungs



http://www.mmi.mcgill.ca/eidelman/lect12/pulmonaryventilation.htm
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Lungs



http://www.mmi.mcgill.ca/eidelman/lect12/pulmonaryventilation.htm
http://www.medlib.com/edu/turner/MedEd/medicine/pulmonary/physio/y02.htm

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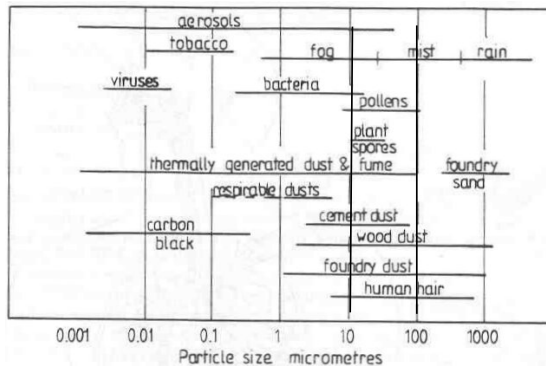
Three numbers to remember

- 100 microns
 - **Dust** larger than this is not inhaled
- 10 microns
 - **Dust** larger than this does not penetrate deep into the lungs
- 3 microns
 - **Fibres** larger than this diameter do not penetrate deep into the lungs

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Aerosol sizes



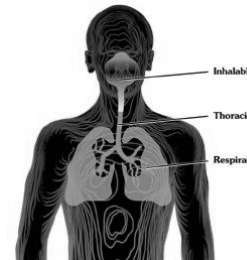
Source: Grantham Fig 5.1

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Sizes

- Respirable
- Inhalable (inspirable)
- "Total"
- Respirable < 10 microns



http://www.skinc.com/headline/perspective.html

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Aerodynamic diameter

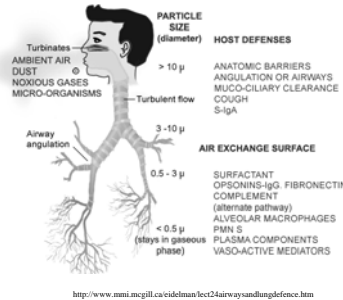
- The **aerodynamic diameter** of a particulate (dust or fibre) is
 - the diameter of an equivalent sphere with the same density as water but with the same aerodynamic diameter
- This means it would drop through the air to the ground in the same time

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Lung deposition

- Impaction
- Sedimentation
- Diffusion



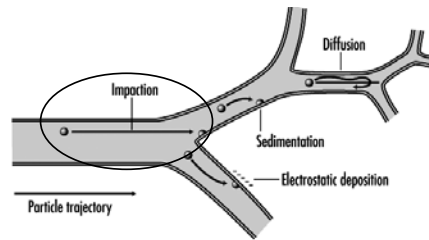
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Impaction

- An inertial overshoot onto a surface.



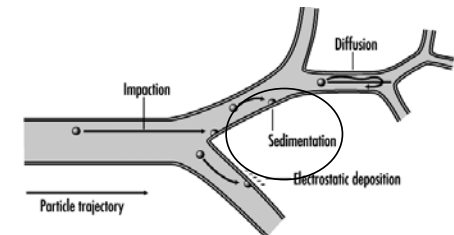
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Sedimentation

- Dropping out of the airflow.



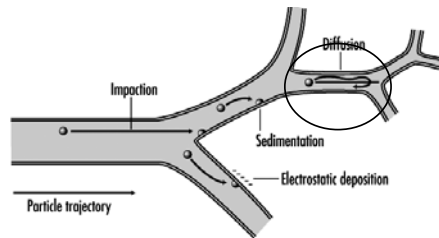
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Diffusion

- Random movement caused by individual air molecules on dust particles



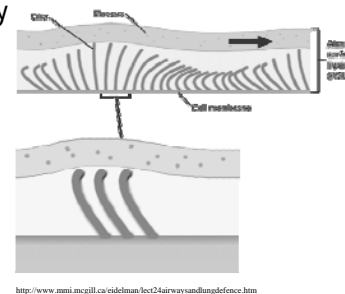
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Lung clearance – fast phase

- Approx 1 day
 - Cilia
 - Coughing



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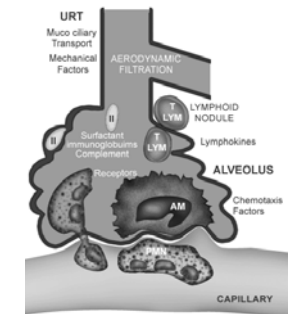
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Lung clearance - slow phase

- Months
 - Macrophages
 - Lymphatics

Note: Smoking causes paralysis of cilia thus reducing lung clearance. Increased coughing is a compensatory effect



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"Nuisance" dusts

- TLV 10 mg m⁻³
- Relatively low risk
 - or effects sometimes not well documented

TLV® - Threshold Limit Value
www.acgih.org

ACGIH - American Conference of Governmental Industrial Hygienists

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Mechanism of aerosol formation

- Mechanically Generated
 - Wood dust
- Thermally generated
 - Welding fumes

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Wood Dust

- UK 2 studies (1965 and 1968)
 - Nasal cancer
 - Furniture and cabinet workers
- 1970s US National Cancer Institute study
 - 37 nasal cancers listed as the cause of death
 - 8 were furniture workers
- IARC → human carcinogen
 - International Agency for Research on Cancer



http://www.emedicine.com/ent/topic413.htm

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Wood dust toxicity

- Initially hard wood
- Also soft wood
- Mechanism?
 - Dust deposits in nose
 - Nasal mucosa dries
 - Mucociliary clearance stops
 - Wood dust stays there longer
 - Carcinogens have longer to act
 - Welding

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Welding fumes

- A very complex topic
- Welding produces metal vapour
- Individual atoms condense to form fume, often partially oxidized
 - nanoparticles
- Fume particles agglomerate
 - Like bunches or grapes
 - Sometimes in a long strings

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Engineering Controls

Industrial Ventilation

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Dilution ventilation

- Low toxicity material
- Small quantities
- Emission slow and predictable
- Exhaust fan near emission
- Flow from person to source
- Fresh air not contaminated
- Adequate makeup air

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Welding fumes

- Which direction should they go?



www.osh.dol.gov.tz/.../part08-10.html

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Welding fumes

- So why are most exhausts above?



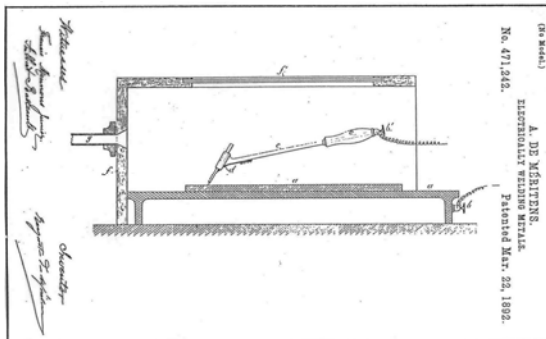
www.osh.dol.gov.tz/.../part08-10.html

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Ventilation 1892, welding

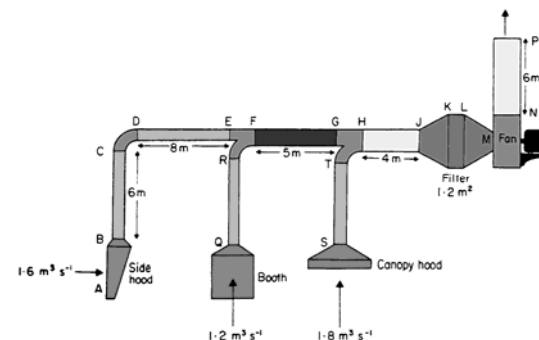


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Typical Industrial Ventilation system



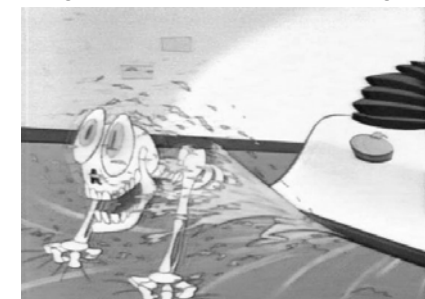
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Ventilation Myth 1

- Sucking air is the same as blowing air



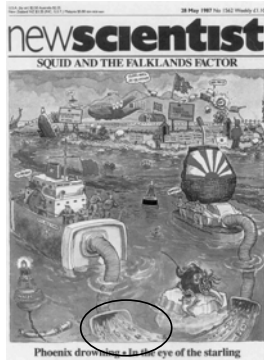
Source: Ren & Stimpy cartoon

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Ventilation Myth 1...

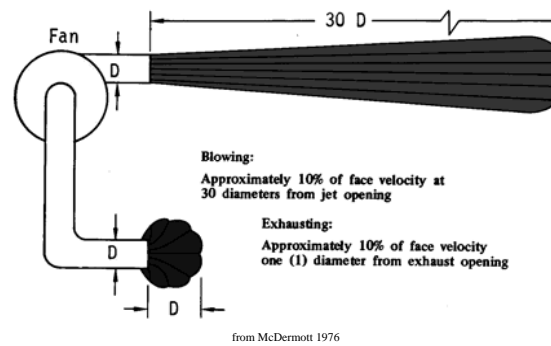


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Ventilation Myth 1...



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Ventilation Myth 2

- Denser than air vapours sink to the floor
 - Consider vapour with density twice air at 1000 ppm. Room temperature is 20 C
 - Will it sink to the ground?

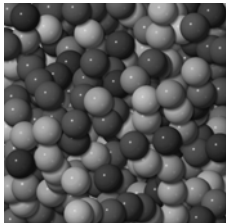
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Ventilation Myth 2...

- Qualitatively (see notes for calculations)
 - Consider a bag of 1000 marbles
 - One marble weighs twice as much
 - Does this make a big difference?



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Ventilation Myth 2...

- Density difference
 - % difference is

$$\frac{(1,000 \times 2 + 999,000 \times 1) - 1,000,000 \times 1}{1,000,000} \times 100 = 0.2\%$$
- Temperature gradient to ceiling ~say 1 °C
- PV=nRT, but P, V constant so nT = constant
 - $T_{\text{bench}} = 20 \text{ C} = 273 + 20 = 293 \text{ ° K}$
 - $T_{\text{ceiling}} = 21 \text{ C} = 273 + 21 = 294 \text{ ° K}$, 1 degree higher
 - Density proportional to number of atoms = n_{bench} or n_{ceiling} moles
 - Change in density = $(n_b - n_c)/n_b = 0.34\% \gg 0.2\%$

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Ventilation Myth 2 (in detail)...

- PV=nRT ideal gas equation
- T is absolute temperature (K)
- 1 mole = 6.02×10^{23} atoms = 24.45 L at 20 C
- but P, V constant so nT = constant
- Number of atoms in moles, $n \propto 1/T$
- $n_{\text{bench}} = n_b$, $n_{\text{ceiling}} = n_c$
 - $n_b \propto 1/T_b$ and $n_c \propto 1/T_c$
- $T_b = 20 \text{ C} = 273 + 20 = 293 \text{ K}$
- $T_c = 21 \text{ C} = 273 + 21 = 294 \text{ K}$
 - Density proportional to number of atoms = n_b or n_c moles
 - Change in density = $(n_b - n_c)/n_b = (1/T_b - 1/T_c) \times T_b = 0.34\% \gg 0.2\%$

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Myth 2...

- By comparison, a difference in temperature of 1 °C changes the density of air by about 0.3%
- Random air currents mix air from floor to ceiling in most workplaces
- Use data from wet chemistry lab

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The BBQ effect

- You stand downwind of a BBQ and smoke gets in your eyes
- You move upwind, but smoke still gets in your eyes
- Why?

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Vortex shedding – Heard Island



<http://www.lehigh.edu/~fluids/tjp3/flowpics/island5.jpg>

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Vortex shedding (BBQ effect)...

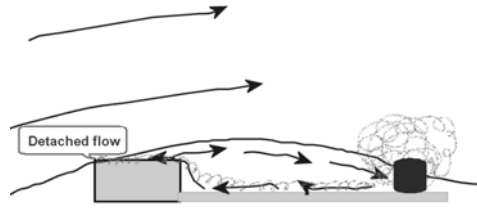


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Flow detachment...



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Convection by body heat



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Combined effect in fume cupboard

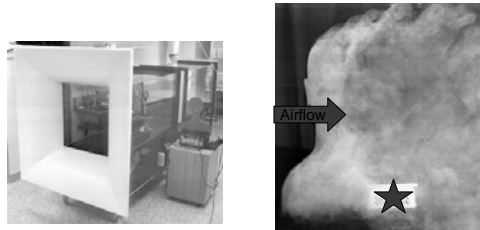


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BBQ Effect in wind tunnel

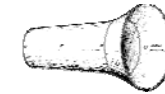


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Hoods



- Hoods
 - Shape airflow to capture contaminant
 - Accelerate air smoothly into duct
 - *Bad hood design stuffs up everything*



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Concept: Hood design

- Imagine a black hole...



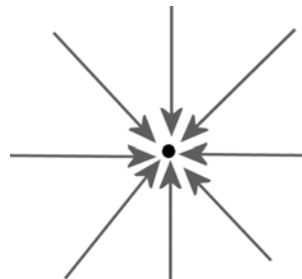
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Hoods...(2)

- Air is sucked towards the black hole



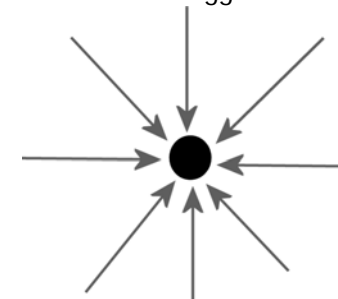
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Hoods...(3)

- Lets make the hole bigger...



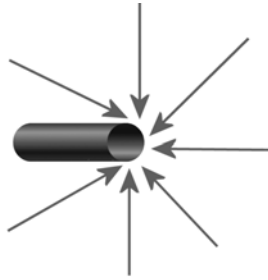
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Hoods...(4)

- And attach a pipe to it...



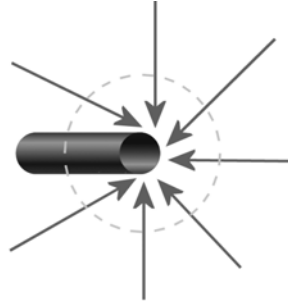
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Hoods - Capture zone (5)

- Contaminants are collected within this zone



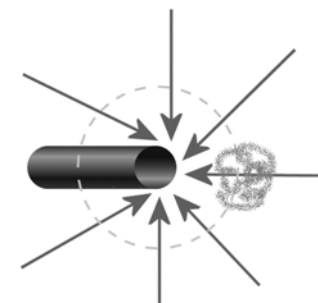
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Hoods – Capture zone (6)

- But often much escapes...



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Hoods – 1903 adjustable hood

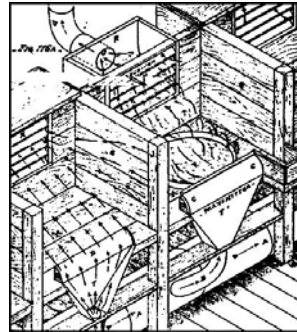


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Hoods – 1903 Push-pull

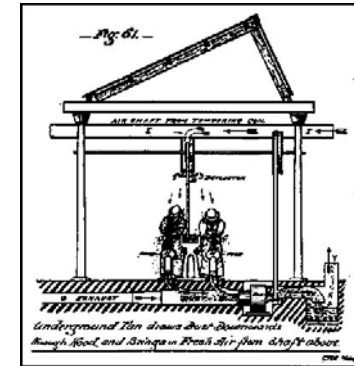


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Hoods – 1903, LEV and air cleaning

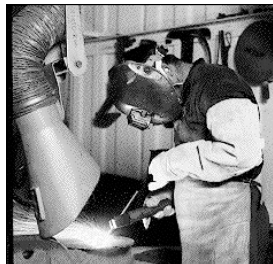


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Hoods - welding



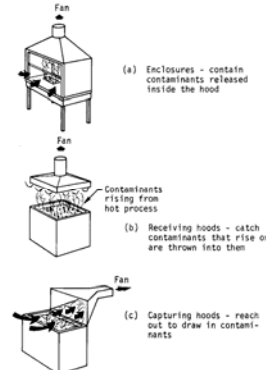
<http://www.safetyline.wa.gov.au/PageBin/hazgen0003.htm>

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Hood types

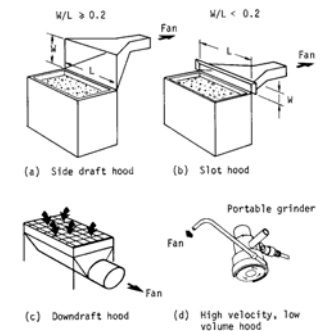


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Captor Hoods



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Hoods – entry losses

Hood type	Shape	Hood entry loss factor, fraction of duct VP
Unflanged		0.90
Flanged		0.50
Rounded		0.03
45° taper		0.10
Slot		1.78 of slot VP

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Hoods – entry losses

- Energy losses as air is accelerated into hood
- Efficient hoods are like merging lanes onto a motorway
- Most hoods are poorly designed
- Calculated in terms of the velocity pressure



www.isaust.org.au/~aesa_entrprodetail18.html

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Hoods – Total enclosure for toxics



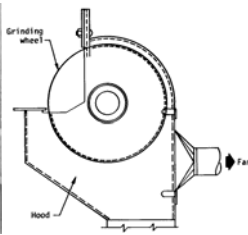
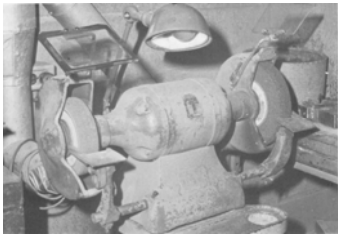
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Hoods - Grinder

- Is yours connected?

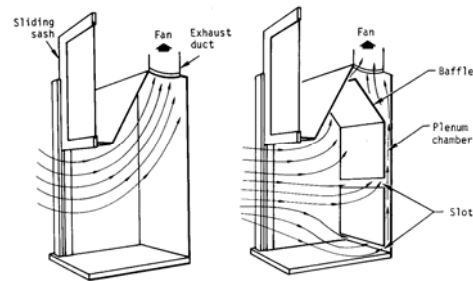


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Hoods – Fume cupboards



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Ducts

- Connect hood to air cleaner or fan
- Too large, then
 - \$\$\$
 - Sedimentation (transport velocity too low)
- Too small
 - Huge pressure drops
 - Try breathing through a straw...
 - Noise + + +

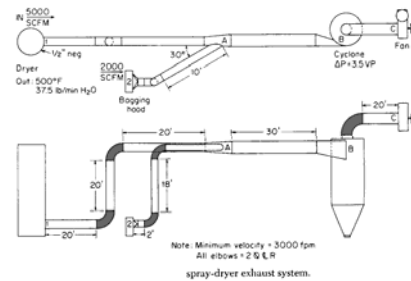
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Ducts - Bends

- Think of a highway...



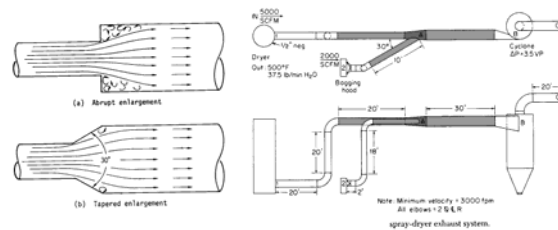
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Ducts – Junctions

- Think of a highway...



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Air Treatment

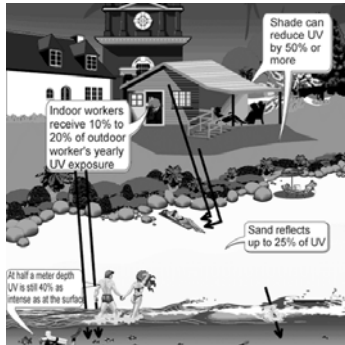
- Sedimentation boxes
- Cyclones
- Filters
- Scrubbers
- Electrostatic Precipitators
 - etc
- None!
 - Ask the suppliers
- Usually before the fan

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Ultra violet outdoors



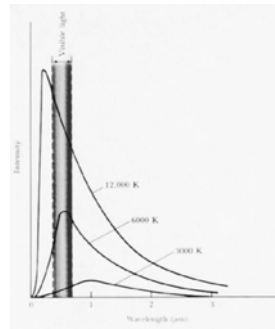
<http://www.arpansa.gov.au/uvrg/envIRON.htm>

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Black Body Radiation



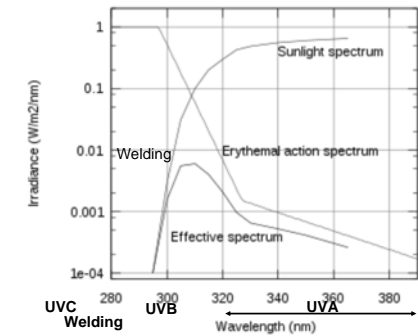
http://zebu.uoregon.edu/~imamura/122/lecture-3/stellar_spectra.html

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UV Action Spectra



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Sunscreens

- Half the thickness, 10x the transmission
- SPF 16 becomes SPF 1.6



<http://www.uow.edu.au/health/thermal2001/sunscreen.jpg>



<http://sallini.com/tumors/caricatures/sunscreen.jpg>

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So what how much is the SPF reduced when 25% the thickness is applied?

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Car windscreen

Window Glass Protection Factors		
Glass	PF	UPF
Car side	12	12
windscreen (laminated)	75	50+
Window glass (house)	10	10
Office building glass	80	50+

•Protection Factor (PF) measures the decrease in UV light transmitted
 •PF of 50 means there is a 50-fold reduction in the amount of UVR transmitted
 •UPF (Ultraviolet Protection Factor) same but max of 50
http://www.arpansa.gov.au/is_upf.htm

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Photo-kerato-conjunctivitis

- "Sunburn" of the cornea and conjunctiva
 - Welder's flash
 - Snow Blindness
- Severe pain, blurred vision, tearing
 - Sloughing of epithelial cells
- Recovery within 24 to 48 hours
 - Clinical recovery with no visible effects, **BUT**
 - Repeated episodes may affect endothelial health

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Swine Flu

& respiratory protection

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Swine flu

- Droplets
- Contact
- Airborne
 - Office of Health Protection (2006). Interim Infection Control Guidelines for Pandemic Influenza in Healthcare and Community Settings. Canberra, Australian Government Department of Health and Ageing.

■ See blog.dbohs.com

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Respiratory Protection

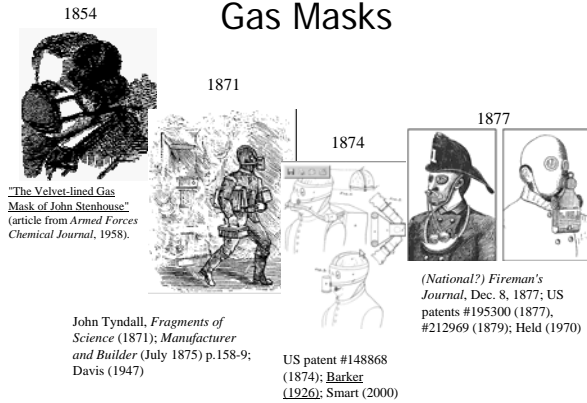
- Hierarchy of Control
- "There is no such thing as complete protection"

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Gas Masks



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WW I Gauze Masks



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WWII Mickey Mouse mask



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1918 Flu Pandemic



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Protection Factors (PF)



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Filtration

- Gases – diffusion
 - Molecular process
- Particulates – more mechanical
 - Impaction
 - Sedimentation
 - (Electrostatic)
 - Diffusion – only for very fine
 - eg fumes

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Fit

- Usually the limiting factor
- Facial shape
- Facial hair
 - 1-2 cm/month
 - 10,000-20,000 microns/month
 - 330 – 660 microns /day
 - 14 – 28 microns/hour
- But respirable dust < 10 microns

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Control

- Swine flu is a strain of influenza A
- Spread is by
 - Airborne route
 - Droplets and aerosols
 - Contaminated surfaces

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Swine flu

- New version of the H1N1 strain which caused the 1918 flu pandemic
- Current treatments do work, but there is no vaccine
- Good personal hygiene, such as washing hands, covering nose when sneezing advised
- Influenza A kills up to 500,000 a year

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Australian Government Guidelines 2006

- Australian Government "**Interim Infection Control Guidelines for Pandemic Influenza in Healthcare and Community Settings**" (Office of Health Protection 2006)
"The relative contribution and clinical importance of the different modes of influenza transmission are currently unknown"

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US Guidelines 2007

- **2007 Guideline for isolation precautions: preventing transmission of infectious agents in health care settings**" (Siegel, Rhinehart et al. 2007)
 - 100 pages and reviews 1100 publications
 - Influenza - "Airborne spread predominates"

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1918 Spanish Flu

- H1N1 strain
- 40% of the world's population were infected
- 50 million people died, particularly young adults



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1957 Asian flu

- H2N2 strain from wild ducks
- 2 million killed
- Elderly vulnerable



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1968 Hong Kong Flu

- H3N2 strain
- Around one million died

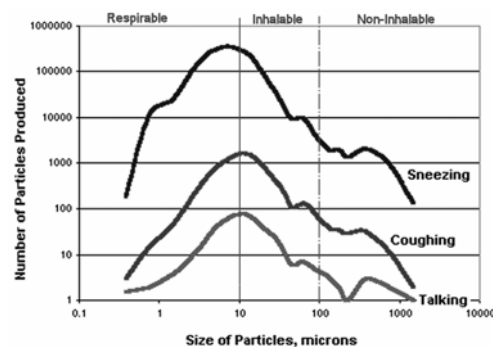


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Source of aerosols



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Coughs, sneezes, talking

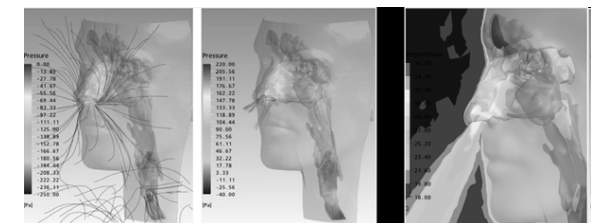
- A single **cough** is equivalent to talking for 5 minutes
- A single **sneeze** at 1 m equivalent to talking to a person for several hours

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Nasal airflow



- **Inhalation** – from all directions
- **Exhalation** – in jets
- Mouth breathing common
- similar flow patterns
<http://www.zib.de/visual/gfx/nose/nose-breathing.png>

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Sneezes

- Some 32% of women hold in their sneeze
- Many people sneeze differently in public than in private
- 48 percent say they either put their finger under their nose or pinch their nose

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Classic sneeze

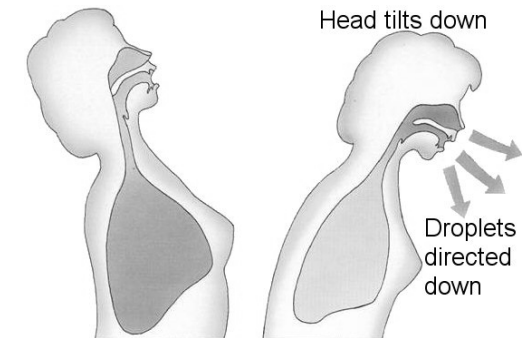


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Actual Sneeze

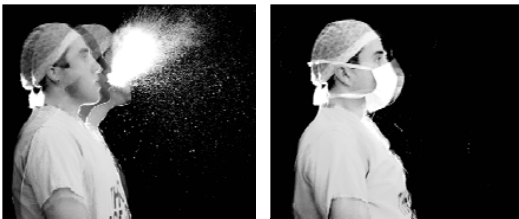


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Effect of surgical mask



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Face masks – what to look for

- P2 or N95 certification
- Two straps around the head
 - Not just around ears
- Insert to permit moulding around nose
- A good fit
 - Need a smaller size for children
- No exhaust valve for infected people

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Fit of face masks

- Usually the limiting factor
- Facial shape – women, children
- Facial hair
 - 1-2 cm/month
 - 10,000-20,000 microns/month
 - 330 – 660 microns /day
 - 14 – 28 microns/hour
- But respirable dust <10 microns

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Face Masks

- **Common myth** in healthcare is that surgical masks protect the wearer
- Use of surgical masks in this role creates fear

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Face masks 1



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Face Masks 2



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Face Masks 3



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Face Masks 4



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Face Masks 5



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Face Masks 6



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Face Masks 7



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Face Masks 8



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Face Masks 9 – 1918 Spanish Flu



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<http://data2.collectionscanada.gc.ca/np/ia/a025025.jpg>
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Face Masks 10 – 1968 Hong Kong Flu



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<http://i1.bia.blogspot.com/>
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Separation

- Common Cold Research Unit UK
 - 10 m
- "Universal Precautions"
 - 1-2 m
- What distance is realistic in crowds?

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Control: Elbow coughing

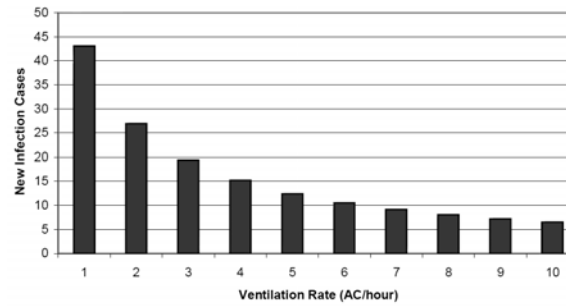


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Control: Effect on room ventilation



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Control: Ventilation

- Where does fresh air come from?
- Where does exhaust (contaminated) air go to?
- How much (%) fresh air, and how much is recycled?
- Filters do little (most infectious agents pass through filters)
- Air flow pattern important

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Control: Humidity

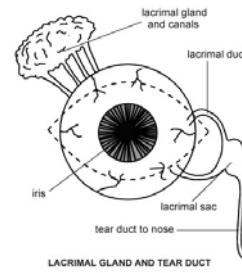
- Low** humidity → droplet fails to drop to floor
- High** humidity → droplet remains viable

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Infection though the eye?



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Contaminated surfaces

- Influenza A
 - Survival on surfaces (22°C, 50-60% RH)
 - Hands** 5 min
 - Paper, porous surfaces 12 h
 - Copper 6 h
 - Stainless steel, plastic 24-48 h

Weber, T. P. and N. I. Stilianakis (2008). "Inactivation of influenza A viruses in the environment and modes of transmission: A critical review." *Journal of Infection* 57(5): 361-373)

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Summary

- Many health hazards are invisible
- Occupational diseases can take years to develop
- Particulates – mechanically or thermally generated?
- Controls are never 100% effective
- Look for bad design in industrial ventilation
- PPE is last resort
 - Respiratory protection is hard to fit and gives limited protection

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Questions?

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