Short Introduction to Atmospheric Sciences in Urban Areas

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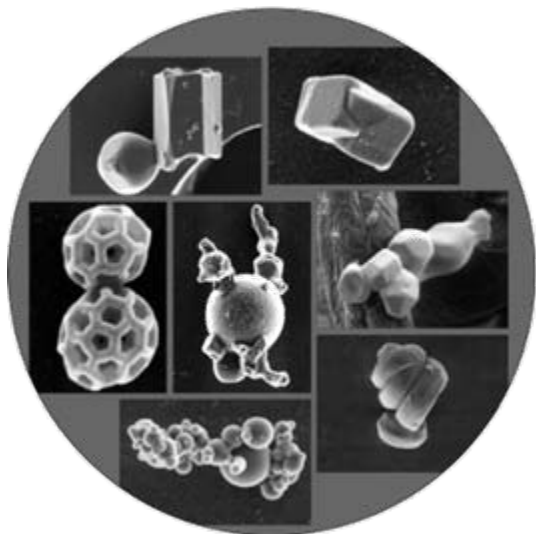
Introduction

- ➢ *research topics & motivation*

Bioparticles & Biomolecules

- ➢ *fungal spores, bacteria, DNA, proteins (allergens)*

Outlook

- ➢ *challenges & perspectives*

Atmospheric Gases & Particles

Aerosol: suspension of nano/micro-particles in a gas

(atmosphere: excl. clouds & fog)
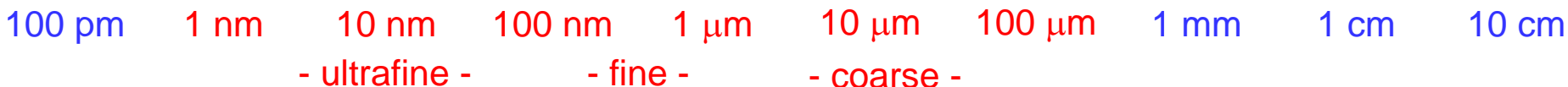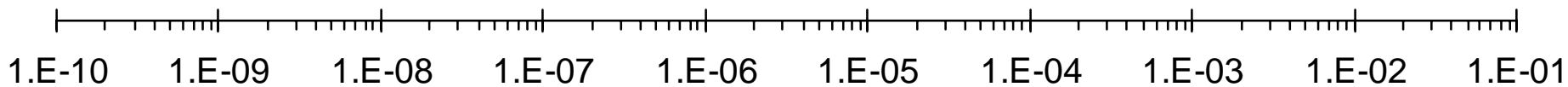
Snow Flakes, Graupel & Hail
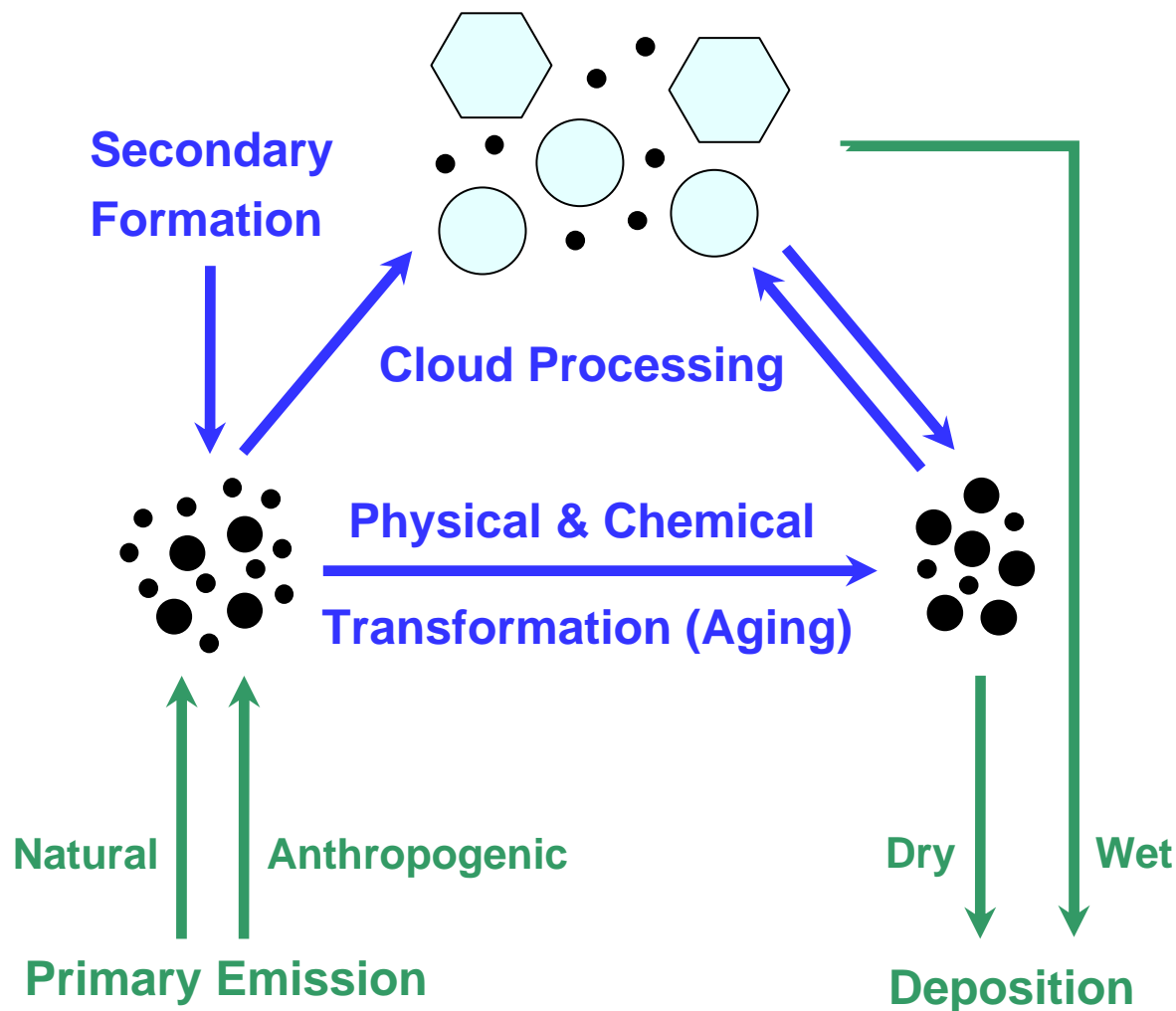
Rain Droplets

Fog & Cloud Droplets

Gas Molecules

Aerosol Particles

Proteins   Viruses   Bacteria   Spores   Pollen

Diameter/Radius (m)

1.E-10	1.E-09	1.E-08	1.E-07	1.E-06	1.E-05	1.E-04	1.E-03	1.E-02	1.E-01
100 pm	1 nm	10 nm	100 nm	1 μm	10 μm	100 μm	1 mm	1 cm	10 cm

- ultrafine -   - fine -   - coarse -

Atmospheric Processes & Effects

MPIC

Secondary Formation

Cloud Processing

Physical & Chemical Transformation (Aging)

Natural **Anthropogenic**

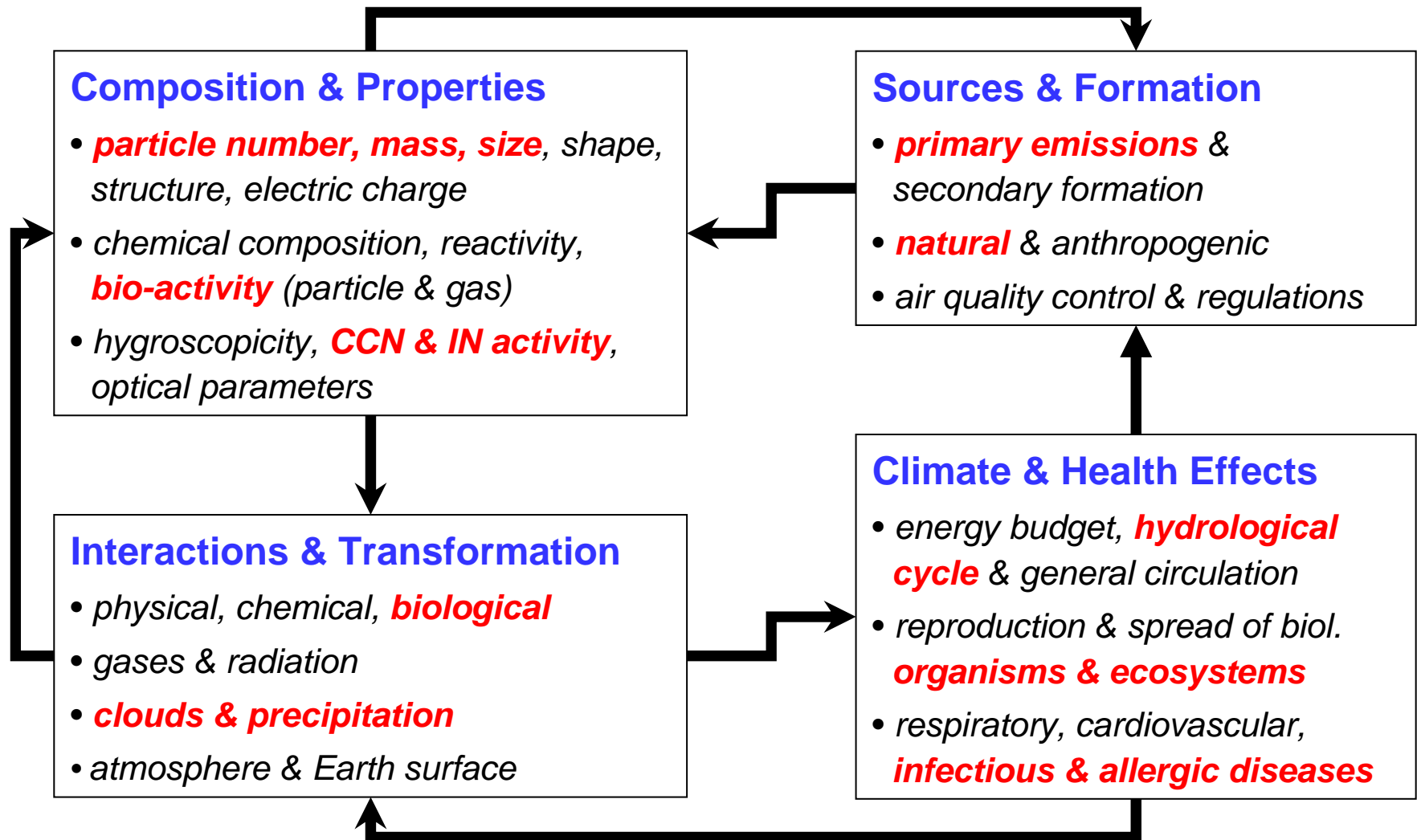**Primary Emission**

Dry **Wet**

Deposition

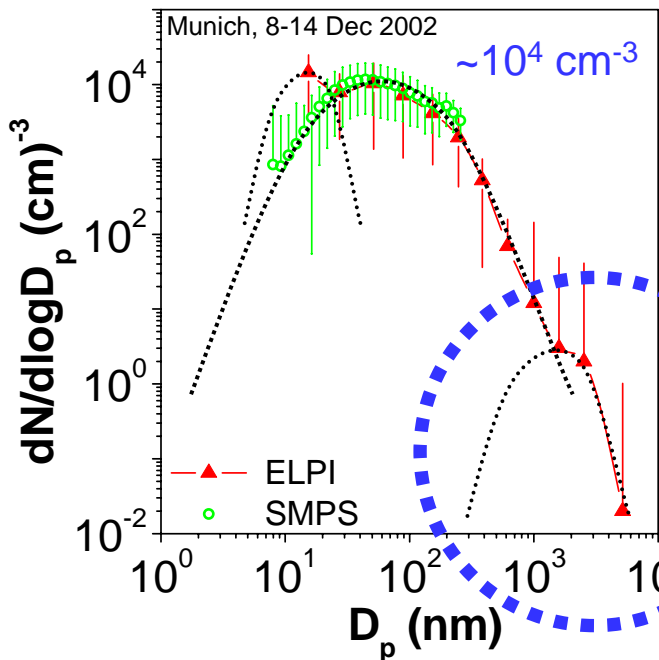**Atmosphere & Climate**

- clouds & precipitation
- trace gases
- radiation

Quantitative Description & Human Influence ?

- human, animal & plant diseases
- spread of organisms

Biosphere & Human Health

Pöschl, 2005; Fuzzi et al., 2006

Atmospheric Feedback Loops

MPIC

Composition & Properties

- ***particle number, mass, size**, shape, structure, electric charge*
- *chemical composition, reactivity, **bio-activity** (particle & gas)*
- *hygroscopicity, **CCN & IN activity**, optical parameters*

Sources & Formation

- ***primary emissions** & secondary formation*
- ***natural** & anthropogenic*
- *air quality control & regulations*

Interactions & Transformation

- *physical, chemical, **biological***
- *gases & radiation*
- ***clouds & precipitation***
- *atmosphere & Earth surface*

Climate & Health Effects

- *energy budget, **hydrological cycle** & general circulation*
- *reproduction & spread of biol. **organisms & ecosystems***
- *respiratory, cardiovascular, **infectious & allergic diseases***

Pöschl, 2005; Fuzzi et al., 2006

Aerosol Properties

Polluted/CBL

Munich, 8-14 Dec 2002

~10^4 cm^{-3}

$dN/dlogD_p$ (cm)$^{-3}$

D_p (nm)

ELPI
SMPS

Clean/FT

Zugspitze, 6 Nov 2002

~10^2 cm^{-3}

$dN/dlogD_p$ (cm^{-3})

D_p (nm)

ELPI
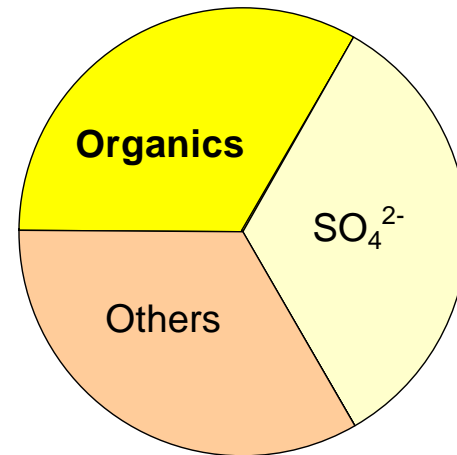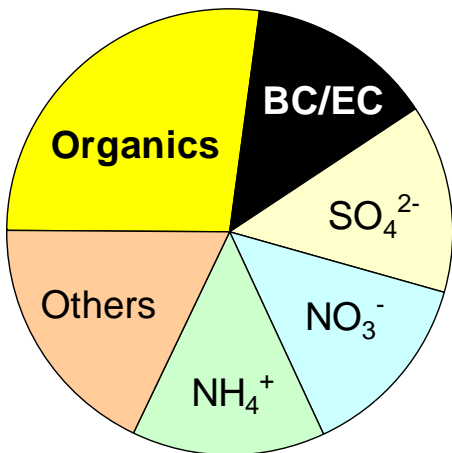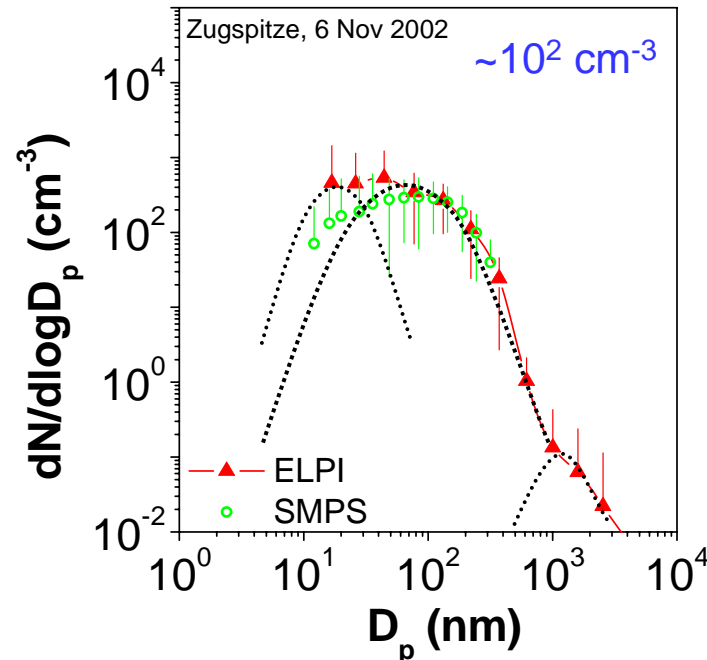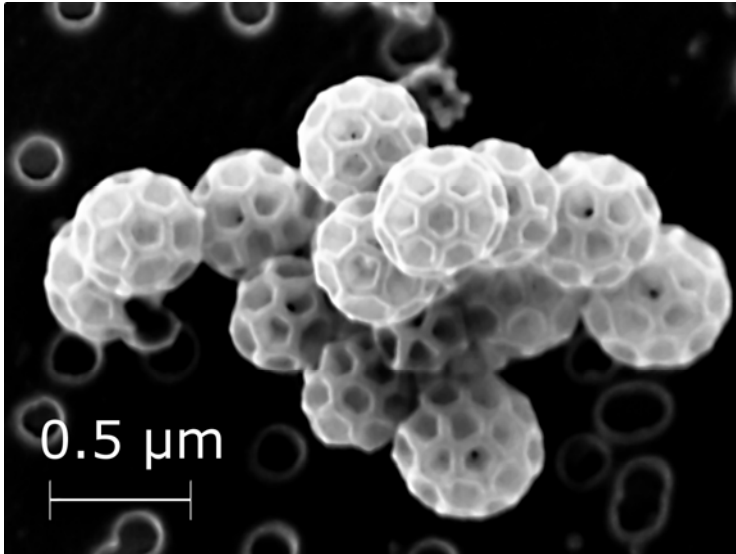SMPS

Size & Concentration
highly variable

**CCN & IN
Optics
Reactivity
Bio-Activity**

Composition & Structure
*highly variable
largely unidentified*

BC/EC
Organics
SO_4^{2-}
NO_3^-
Others
NH_4^+

Organics
SO_4^{2-}
Others

Pöschl, 2005

Bioparticle Structures

Brochosomes (Cicadellidae)

Bacteria & Spores (Fungi)

Helas, 2005; Wittmaack et al., 2005

Bioparticle Detection
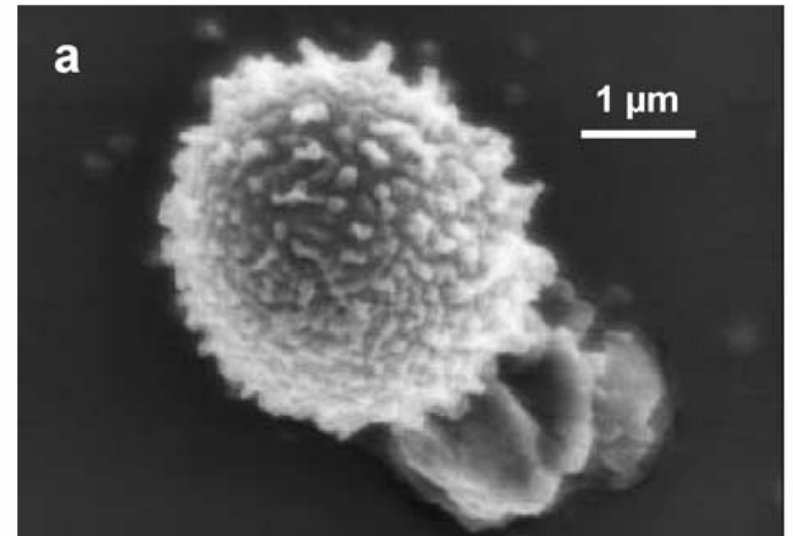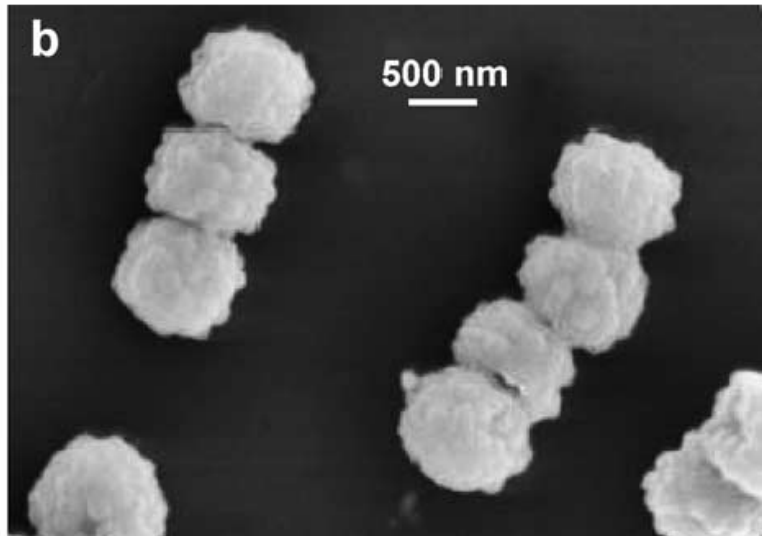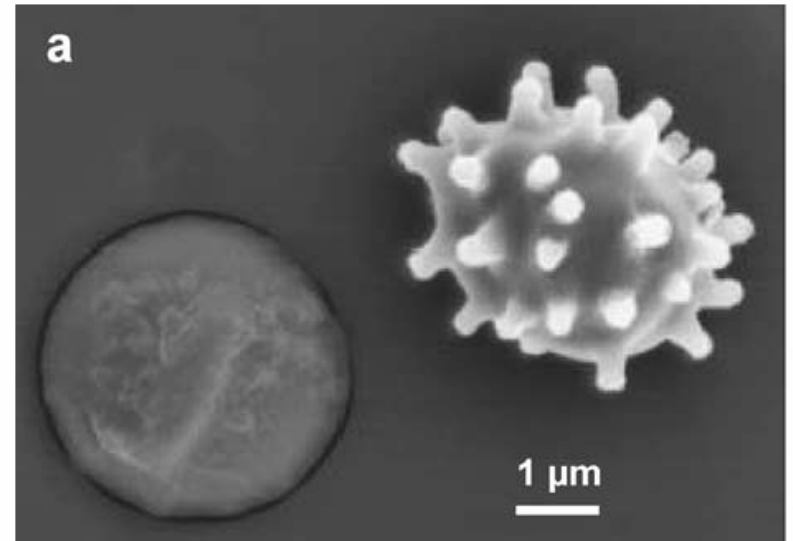
Measurement Instrument, Location, Time & Air Masses

➢ Ultraviolet Aerodynamic Particle Sizer (UVAPS)

➢ Max Planck Institute for Chemistry, Mainz, Germany; 5 May 2006

➢ suburban university campus

➢ urban & rural air masses

Measurement Results & Illustration

➢ 3-D plot: x = D_p, y = fluorescence intensity, z = dN/dlogD_p

➢ D_p of fluorescent bioparticles (FBAP) mostly around ~ 3 µm

➢ FBAP plume at sample #200

MPIC_N408_2006-05-05.A12

Treutlein, 2007

Fungal Spores

Size & Abundance

➤ *~ 2-20 µm, ~ 10^3-10^5 m^{-3}*

➤ **tropical rainforest (wet):**
  ~ 2 µg m^{-3}, ~ 30% of PM10

➤ **extratropical background:**
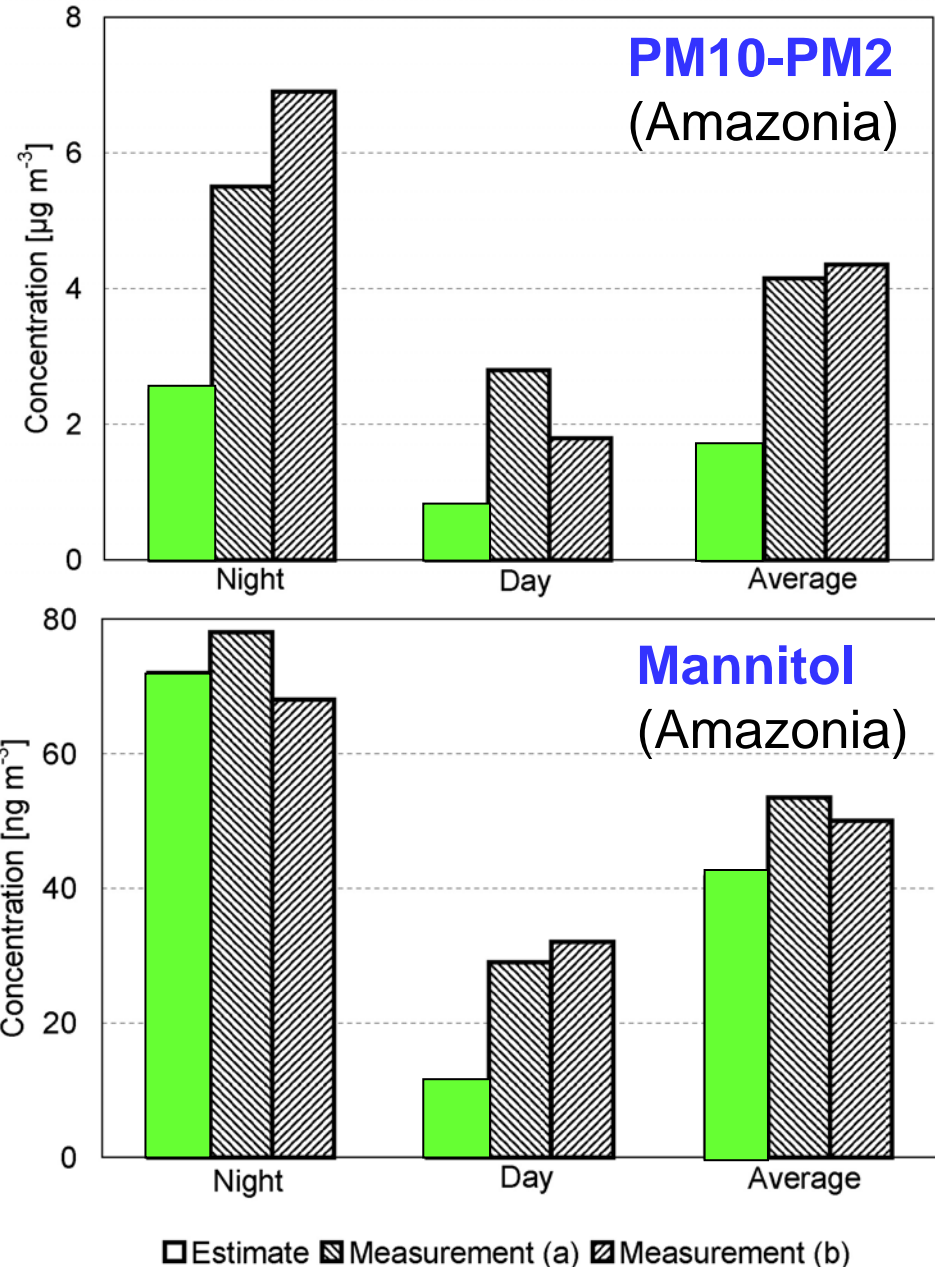 *~ 0.3 µg m^{-3}, ~ 1% of PM10*
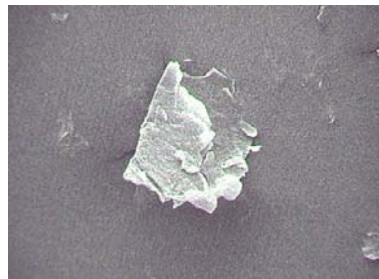
  Bauer et al., 2002

Asco- & Basidiospores

➤ actively discharged
  (hygroscopicity, surf. tension)

➤ enhanced at high RH *(night)*

➤ molecular tracer: mannitol

➤ global emission estimate:
  ~ 60 m^{-2} s^{-1}(land), ~ 17 Tg y^1

  Elbert et al., 2006

Poster: Elbert et al., 2007
Wed, Block 3, 13:30, XY0206

PM10-PM2 (Amazonia)

Mannitol (Amazonia)

☐ Estimate ▨ Measurement (a) ▧ Measurement (b)
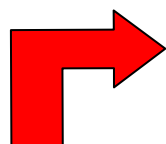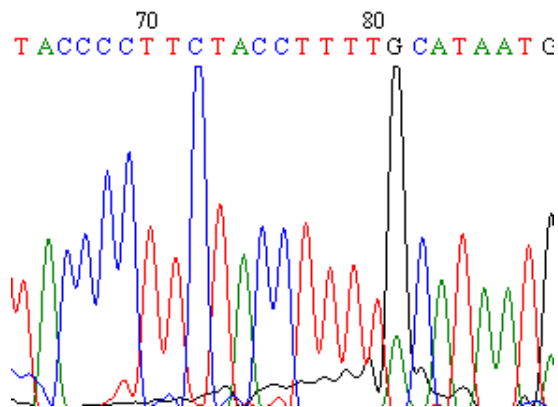
DNA & Molecular Genetic Analysis

Bioparticles
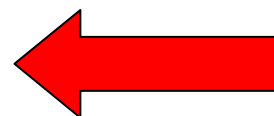
DNA Extraction

Genetic identity and diversity of bioparticles

Sequence Analysis

DNA Amplification (PCR)

DNA in urban PM2.5: ~7 ng m^{-3} (Munich, Germany)

$\Rightarrow$ *inhalation of ~1 µg (equiv. 10^5 human genomes) per day*   *Despres et al., 2007*

Poster: Despres et al., 2007, **Wed, Block 3, 13:30, XY0205**

Proteins

Proteins in Urban Dust & Air Particulate Matter

Sample	Protein (g/kg)	Nitrated Protein (mg/kg)	Nitration Degree (%)
Road Dust (< 100 μm)	~ 1	~ 0.1	~ 0.06
Window Dust	~ 3	~ 1	~ 0.03
Air PM 2.5 (< 2.5 μm)	~ 20	~ 7	~ 0.04

Franze et al., 2005

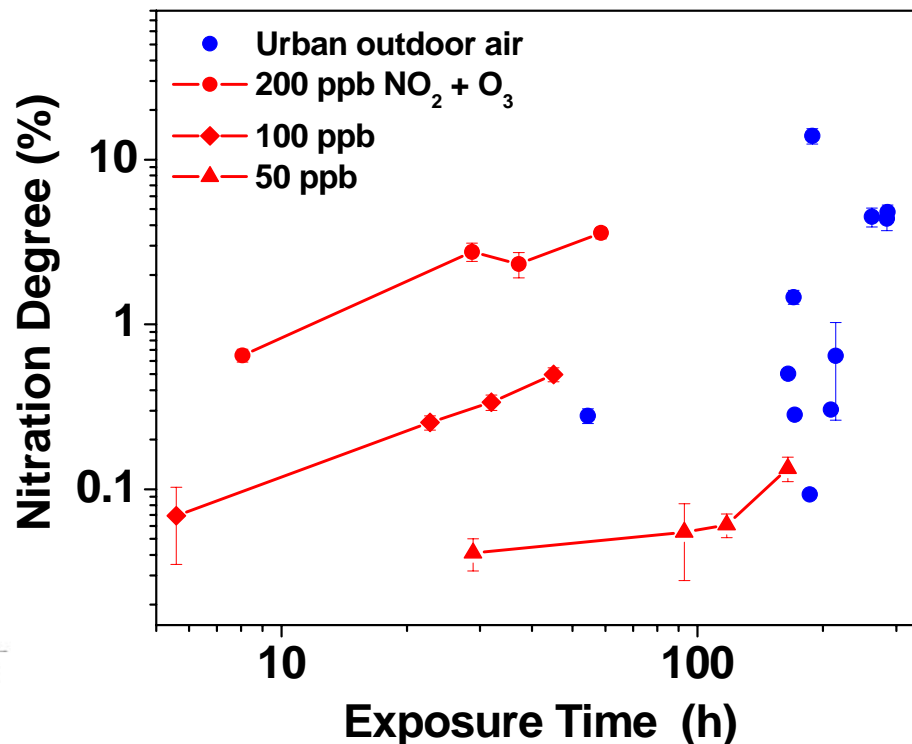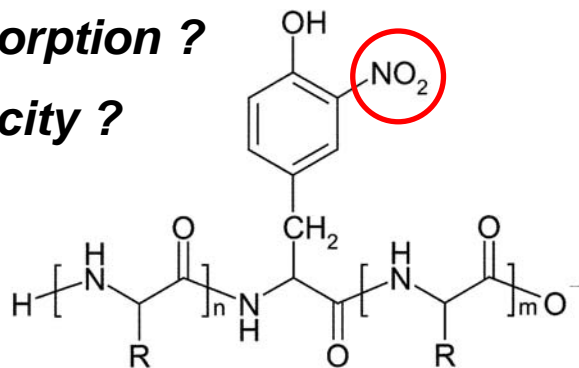## Protein Aging in Polluted Air

- aqueous extract of birch pollen exposed to NO_2 & O_3 or urban air

- nitration degree ≈ nitr.Tyr / tot.Tyr

⇒ *substantial nitration under summer smog conditions*

⇒ *light absorption ?*

⇒ *allergenicity ?*

Allergenicity of Nitrated Proteins

Birch Pollen Allergen Bet v 1

Sensitized Mice

- nitration enhances IgE serum level
  & reaction *(basophil degranulation;*
  Nitro(3.4) = 3.4 nitro-Tyr/Bet v 1a)
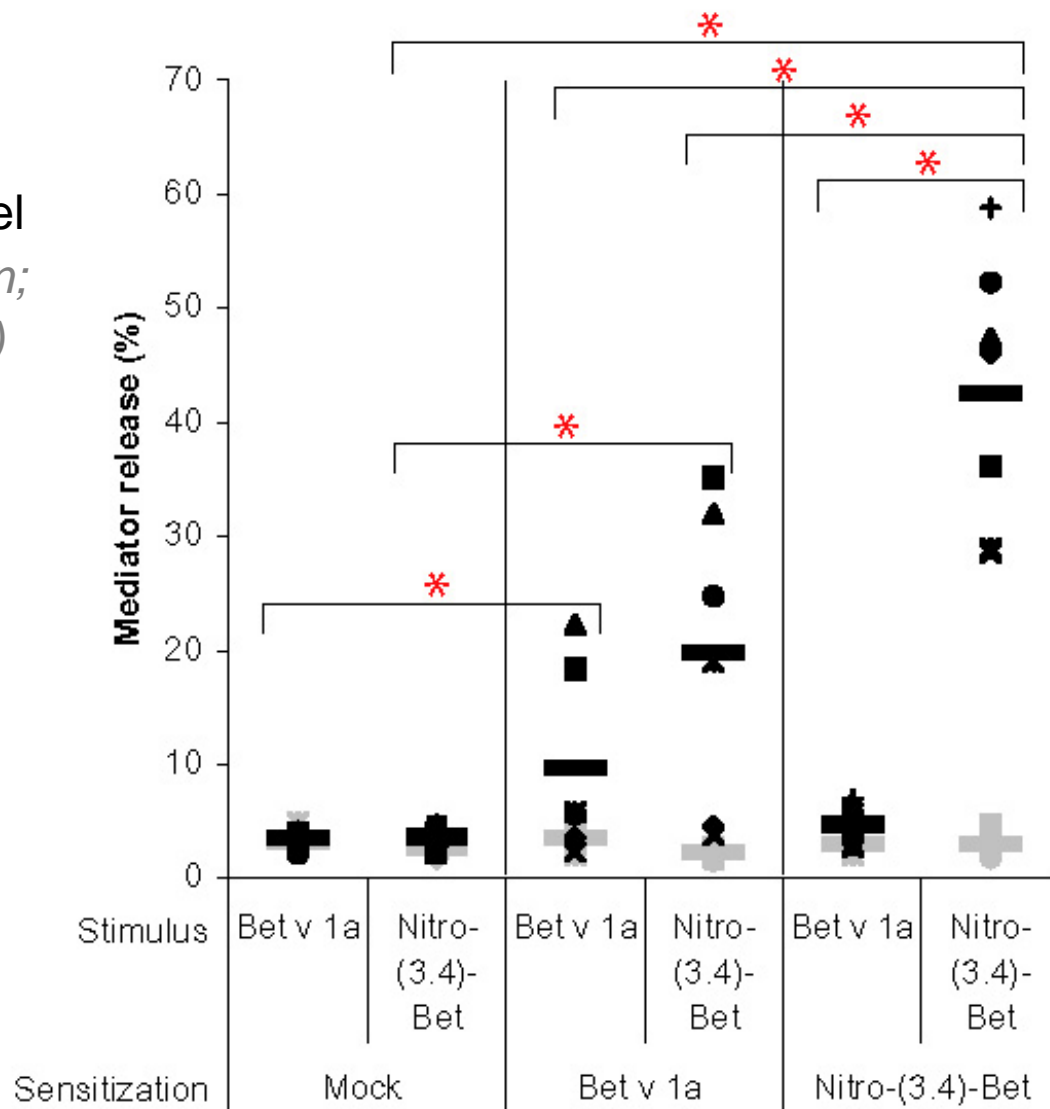
Birch Pollen Allergic Patients
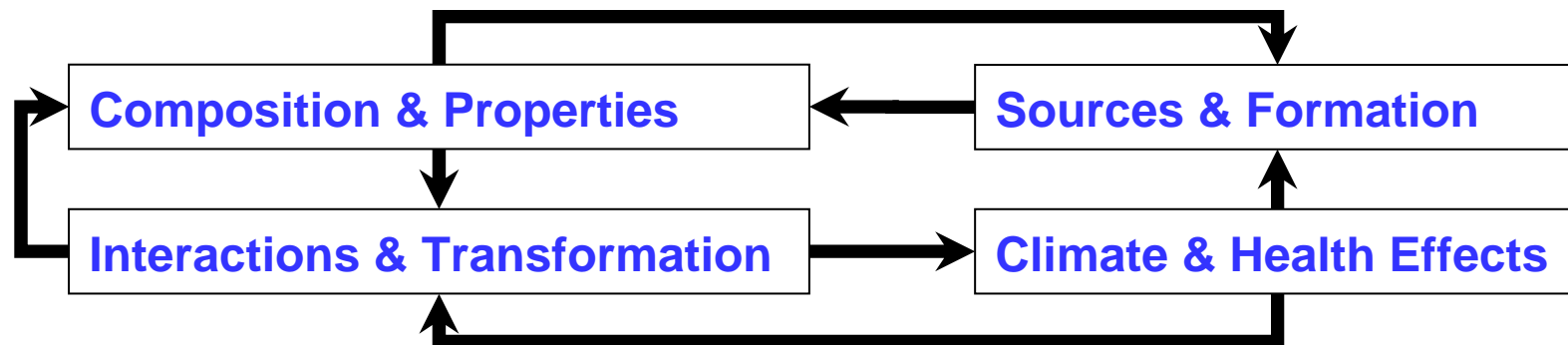
- nitration enhances IgE reaction

Food Allergen Ovalbumin

Sensitized Mice

- nitration: ↑ IgE, IL-5, ↓ IFN-γ

⇒ **nitration of proteins can modify immune response** *(antibody & cytokine levels)* **and enhance allergic sensitization & reaction**

Gruijthuisen et al., 2006

Outlook

Composition & Properties ← **Sources & Formation**

Interactions & Transformation → **Climate & Health Effects**

Challenges & Perspectives

➢ **physical, chemical & biological aerosol climatology**
Megacity Pollution: primary vs. secondary components

➢ **mechanistic elucidation of molecular processes**
Megacity Pollution: photochemical formation & aging

➢ **quantification of local, regional, and global climate & health effects & feedback loops**
Megacity Pollution: gas & particle interactions

➢ **integration of laboratory, field/remote & model studies and of atmospheric, biomedical & engineering research**
Megacity Pollution: side effects of engineering, realistic model systems & conditions for biomedical studies

Pöschl, 2005; Fuzzi et al., 2006