

Anthropogenic carbon nanotubes and air pollution

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$\text{PM}_{2.5}$

one of the leading causes of death and disability
worldwide

$\text{PM}_{2.5}$

characterization inside human lung cells ?

Kulkarni, N., Pierse, N., Rushton, L., Grigg, J., 2006.
Carbon in airway macrophages and
lung function in children.
N. Engl. J. Med. 355 (1), 21–30.



Dose-dependent link between carbon content in alveolar macrophages and the decline in lung function,

***But, carbon content was assessed
only by optical microscopy***



Research Article

Anthropogenic Carbon Nanotubes Found in the Airways of Parisian Children

Jelena Kolosnjaj-Tabi ^a, Jocelyne Just ^b, Keith B. Hartman ^c, Yacine Laoudi ^b, Sabah Boudjema ^d, Damien Alloyeau ^e, Henri Szwarc ^a, Lon J. Wilson ^{c,f}, Fathi Moussa ^{a,f}, ^g, ^h

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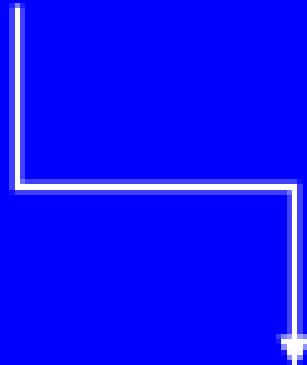
^f Department of Biochemistry, Trousseau-La Roche Guyon Hospital group, Assistance Publique — Hôpitaux de Paris, Pierre et Marie Curie-Paris 6 University, Paris, France



[60]Fullerene (C₆₀)

- Moussa F. et al. “The influence of C60 powders on cultured human leukocytes”. **Fullerenes Science & Technology**, 1995, 3: 333–342.
- Moussa F. et al. “Early effects of C60 administration in Swiss Mice: a preliminary account for *in vivo* C60 toxicity”. **Fullerenes Science & Technology**, 1996, 4: 21–29.

WHITE HOUSE, 2000



THE NATIONAL NANOTECHNOLOGY INITIATIVE



*USA INTO THE NEXT INDUSTRIAL
REVOLUTION*

***SMALLER IS NOT ALWAYS BETTER:
NANOTECHNOLOGY YIELDS
NANOTOXICOLOGY***

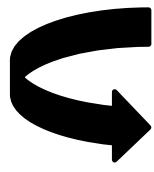
*H.M. Kipen, D.L. Laskin,
Am J Physiol Lung Cell Mol Physiol 289, 696 (2005).*

SAFETY AND ENVIRONMENTAL IMPACT?

Hartman K, Kolosnjaj J, Gharbi N, Boudjema S, Wilson LJ, Moussa F

*“Comparative In vivo Toxicity Assessment of **Single-walled Carbon Nanotubes** in Mice”*

*The 211th Meeting of The Electrochemical Society,
Chicago, USA, May 6-10, **2007.***



Granulomatous reaction

Poland, C.A., et al. Carbon nanotubes introduced into the abdominal cavity of mice show **asbestos-like pathogenicity** in a pilot study.

Nat. Nanotech. **3**, 423-428 (2008)

Takagi, A., et al. **Induction of mesothelioma** in p53+/-mouse by intraperitoneal application of multi-wall carbon nanotube.

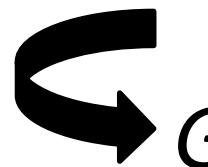
J. Toxicol. Sci. **33**, 105-116 (2008)



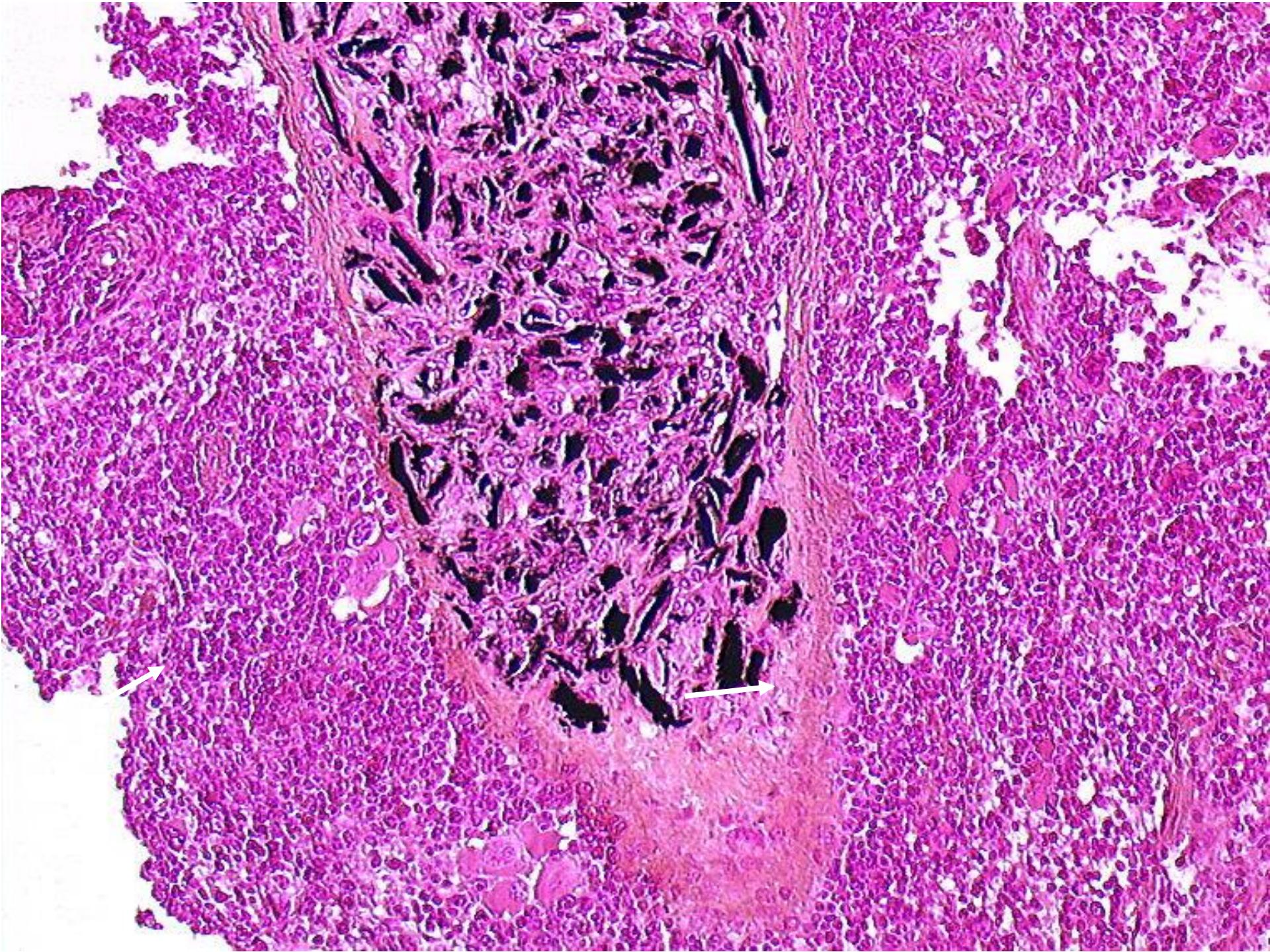
Granulomatous reaction

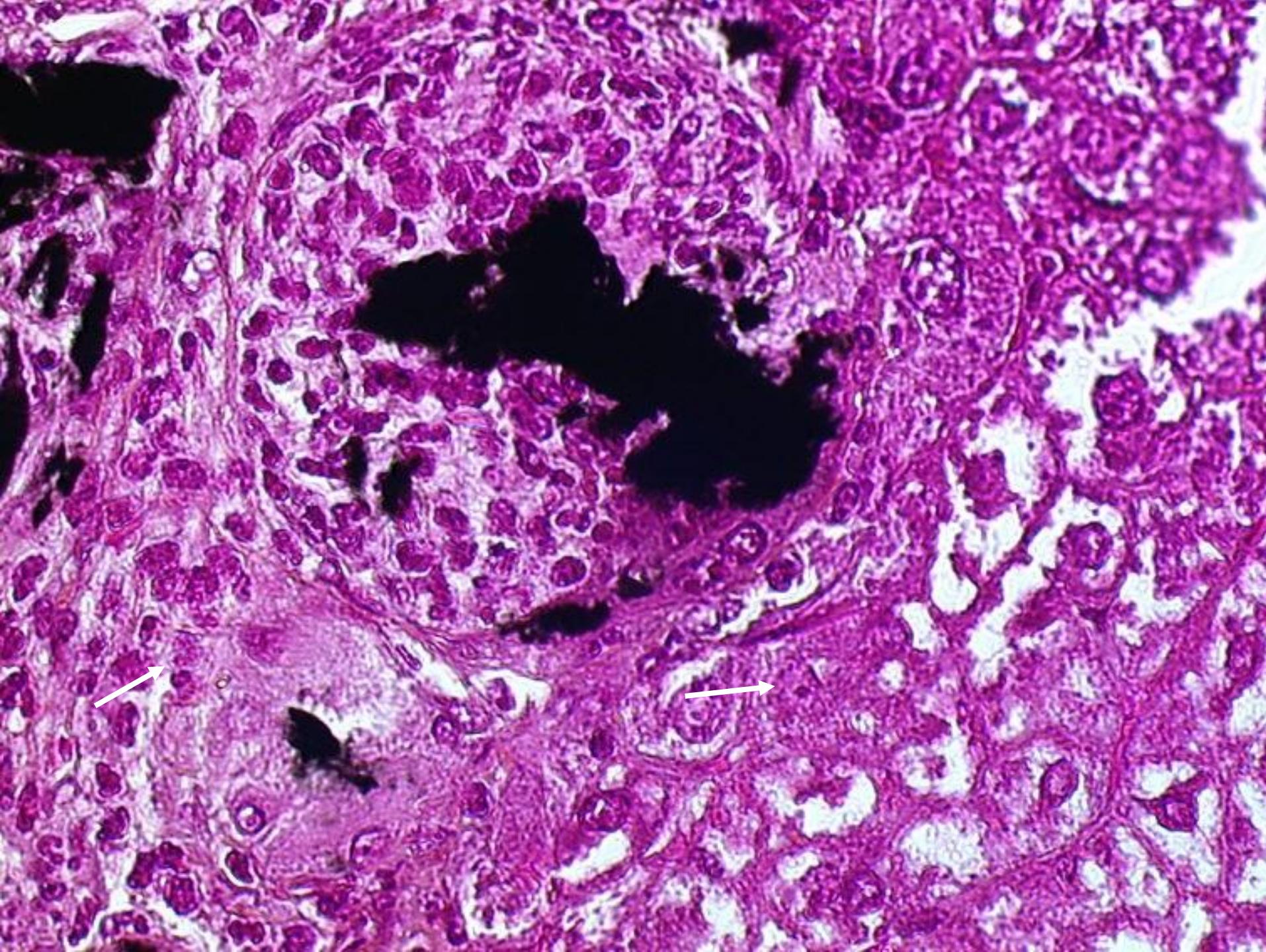
*Kolosnjaj J, KB. Hartman KB, Boudjemaa S, Ananta JS,
Morgant G, Szwarc H, Wilson LJ, Moussa F.
In Vivo Behavior of Large Doses of Ultrashort and Full-Length
Single-Walled Carbon Nanotubes after Oral and
Intraperitoneal Administration to Swiss Mice.*

ACS Nano 2010, 4 (3), 1481–92



Granulomatous reaction





*Murr, L.E., Bang, J.J., Esquivel, E.V., Guerrero, P.A.,
Lopez, A., 2004.*

*Carbon nanotubes, nanocrystal forms, and complex
nanoparticle aggregates in common fuel-gas
combustion sources and the ambient air.
J. Nanoparticle Res. 6 (2–3), 241–251.*



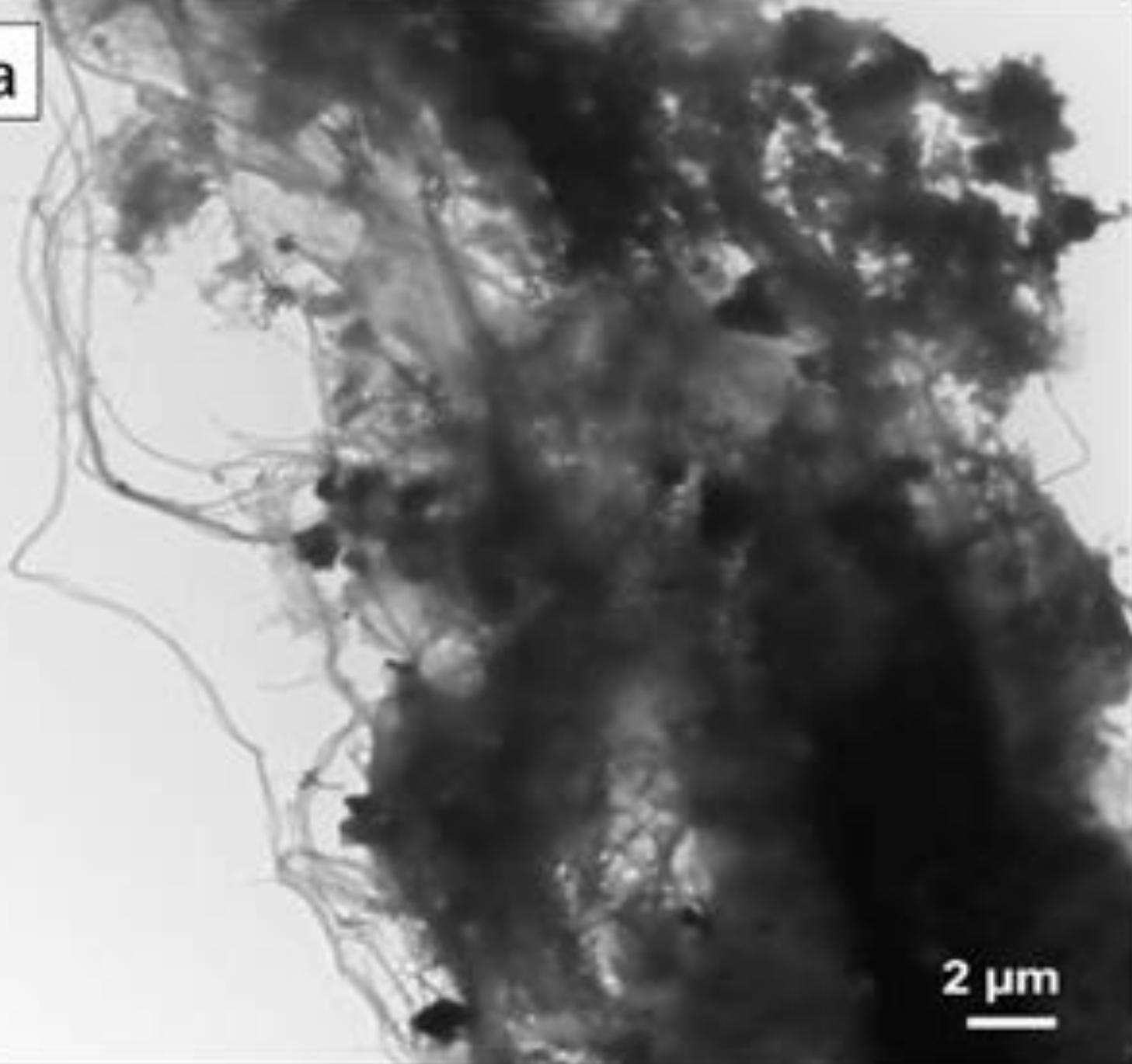
*Humans routinely breathe
carbon nanotubes*

**Pediatric Pulmonology and Allergy Center of Paris
Groupe Hospitalier Trousseau – Laroche Guyon**



***65 Broncho-alveolar lavage fluid residues
of asthmatic children***

a



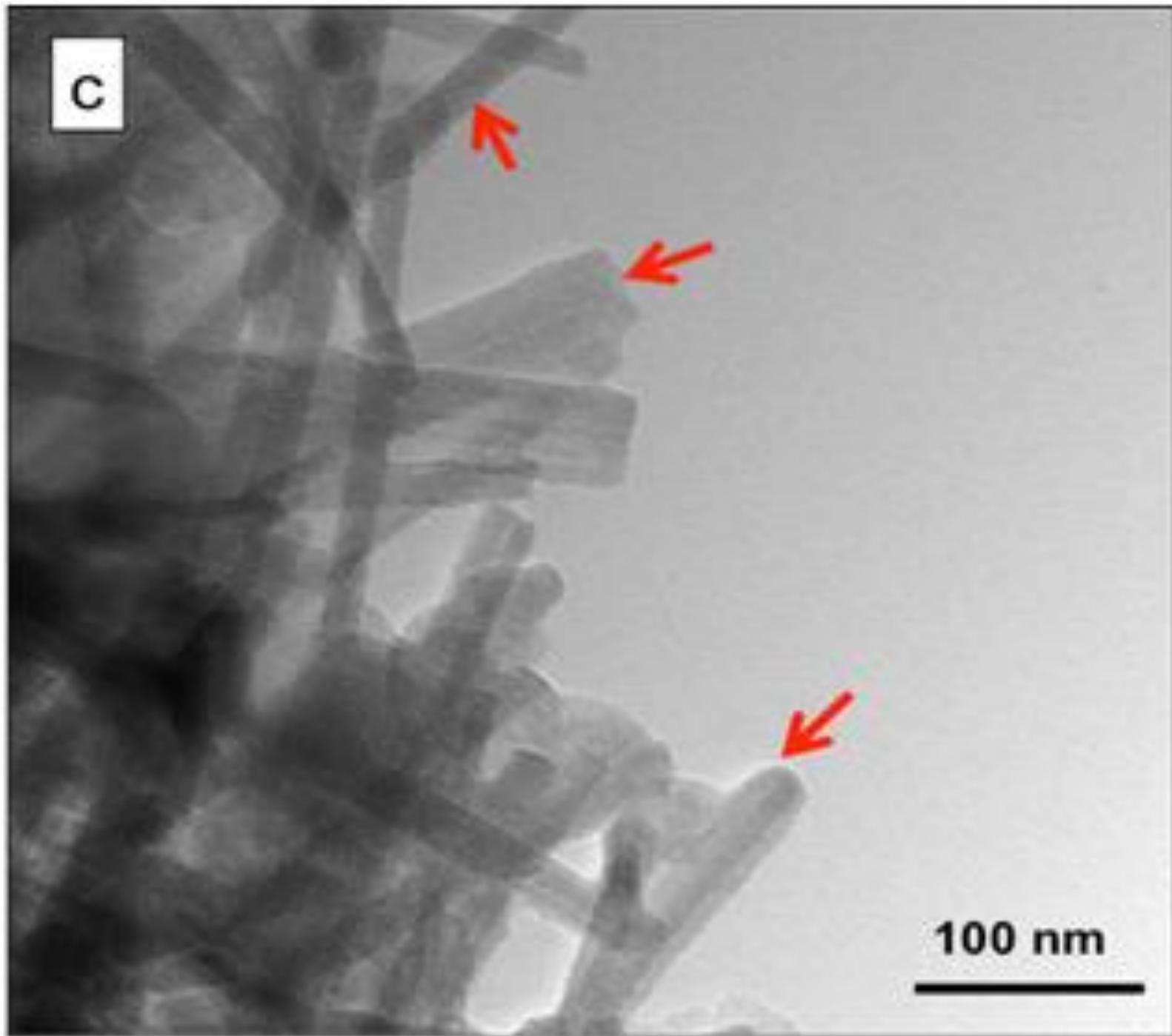
2 μm

b



500 nm





100 nm

Vehicle exhausts and dust

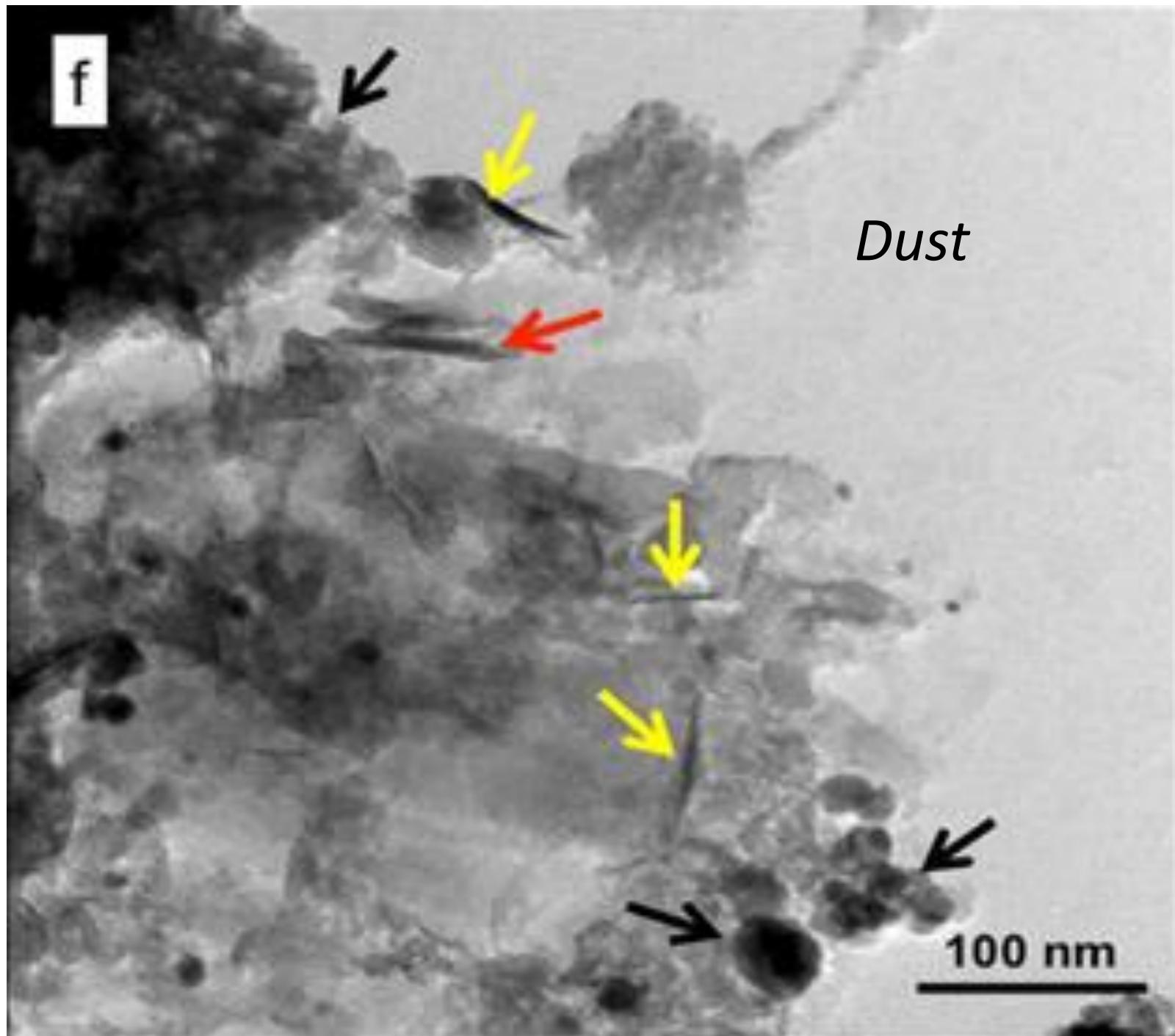
e

Dust

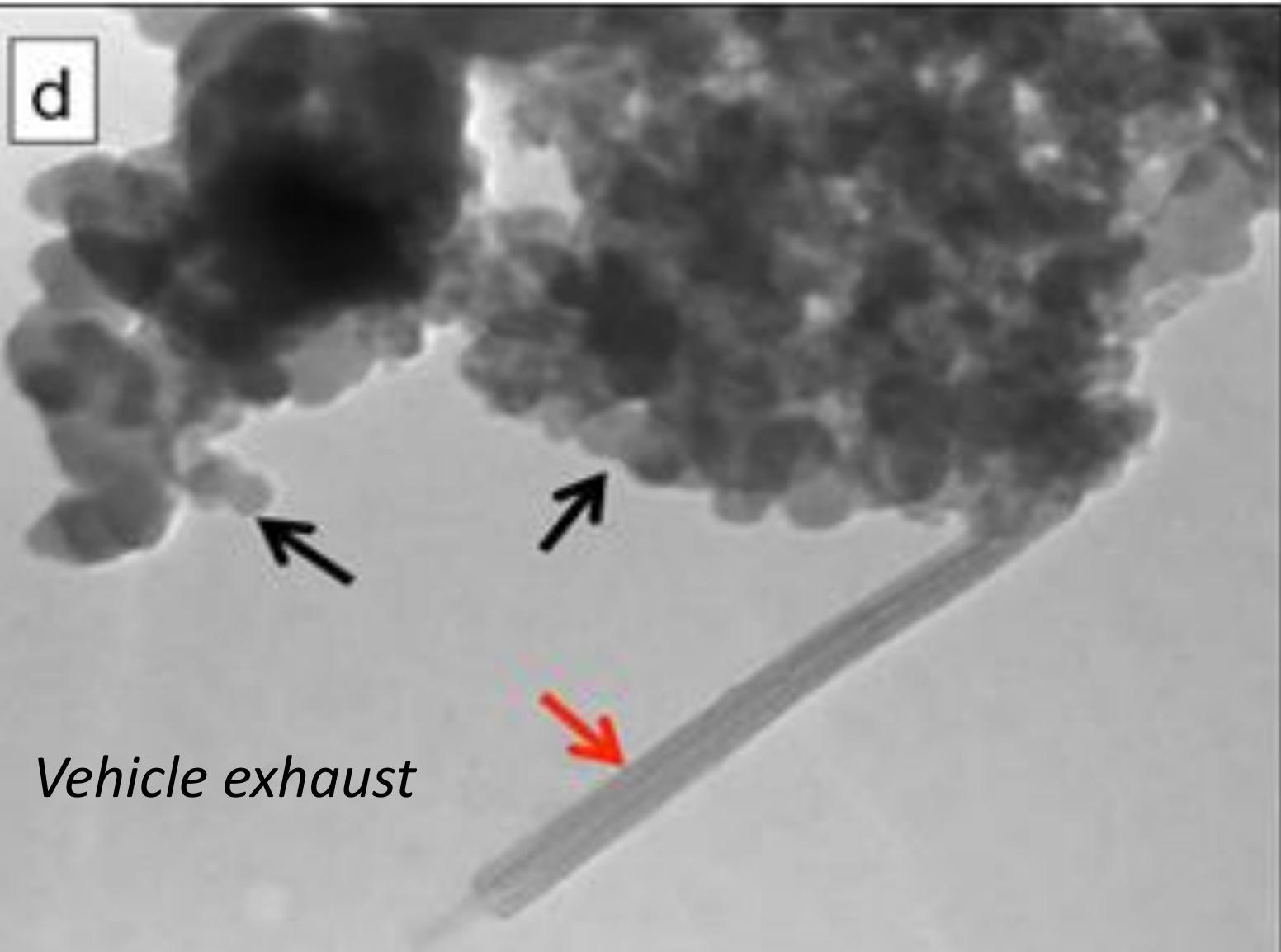


100 nm

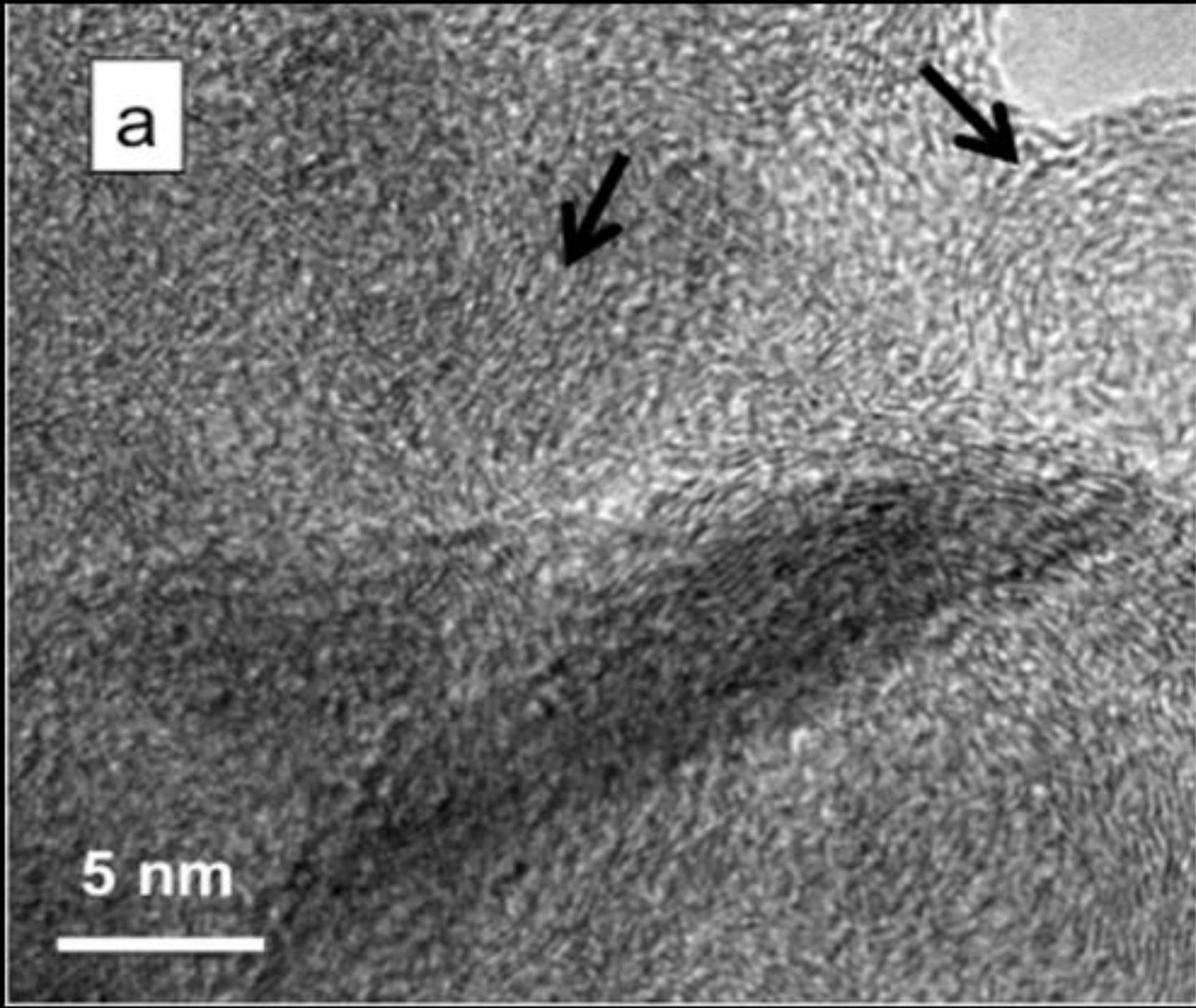
A horizontal black line with the text "100 nm" above it, representing a scale bar.



d



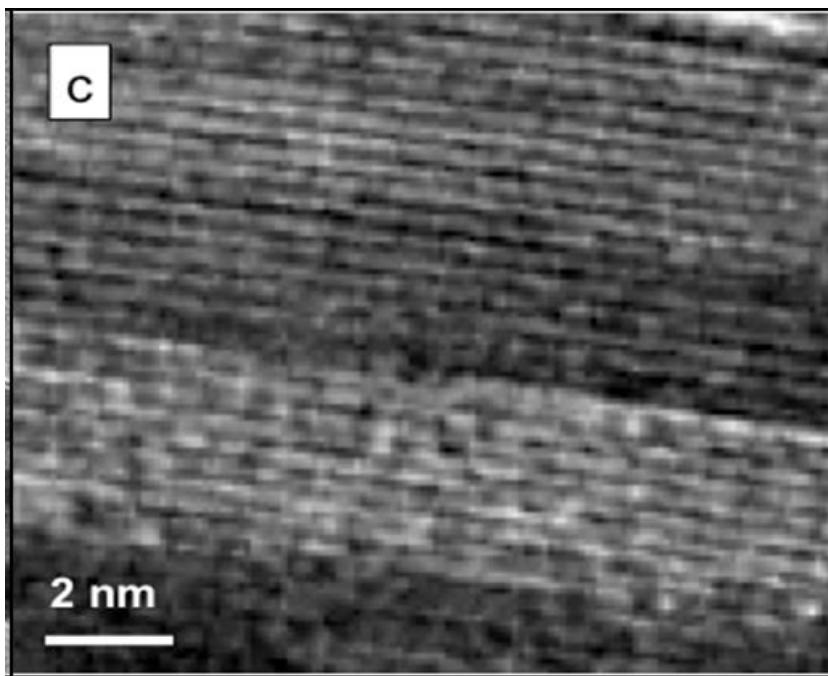
100 nm
—



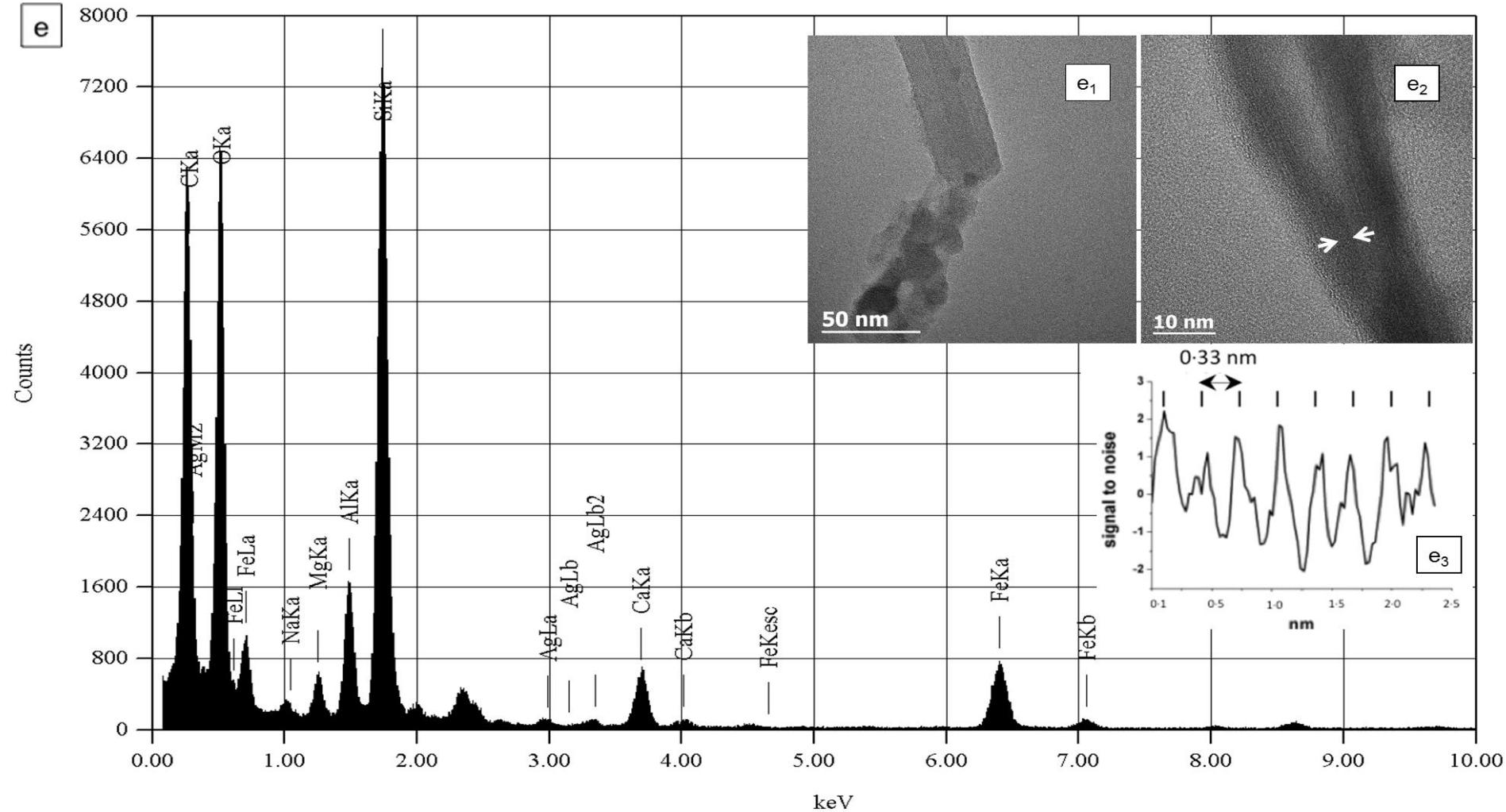
b

20 nm



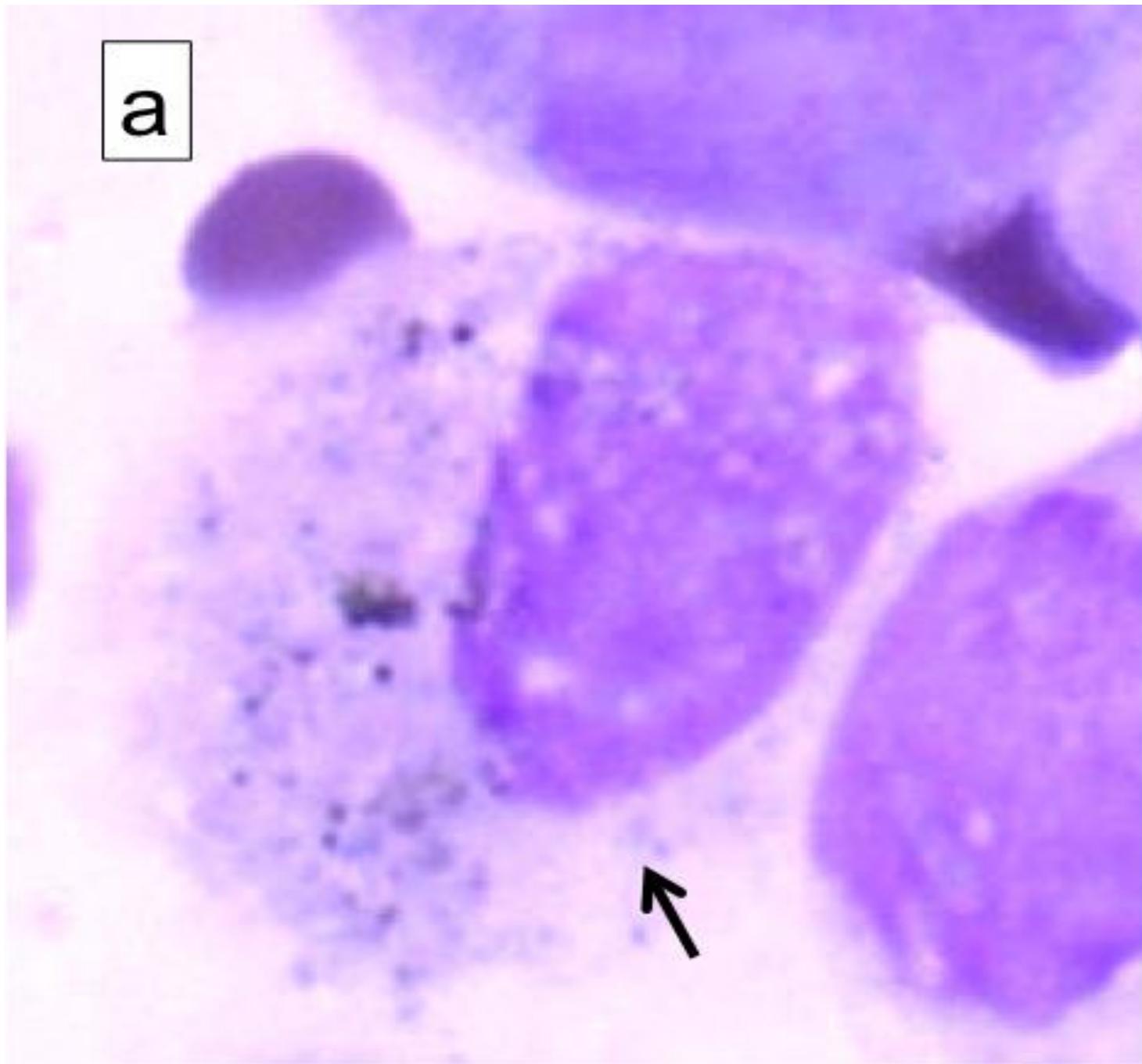


e

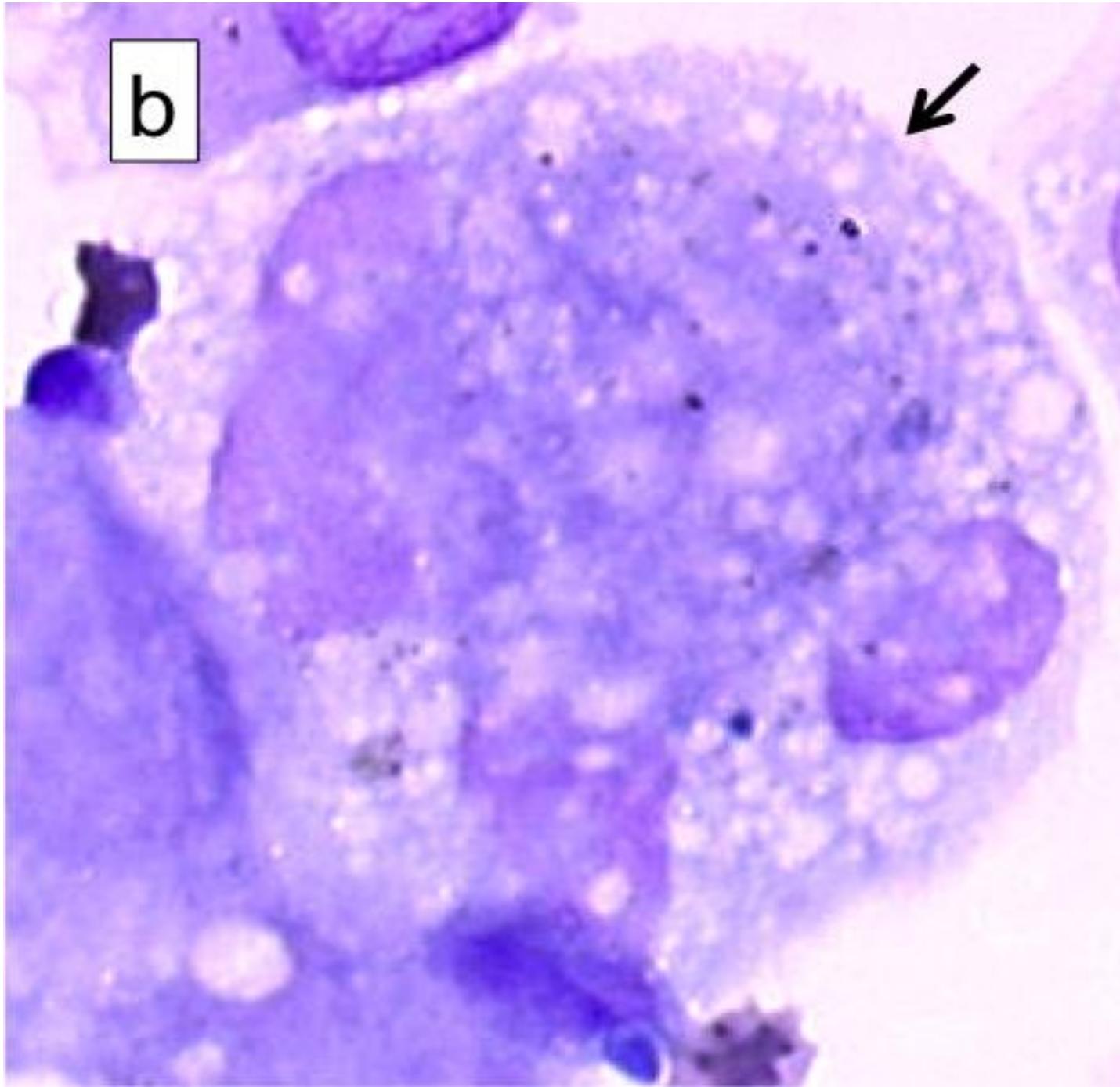


*5 freshly collected BALF samples
with intact airway cells*

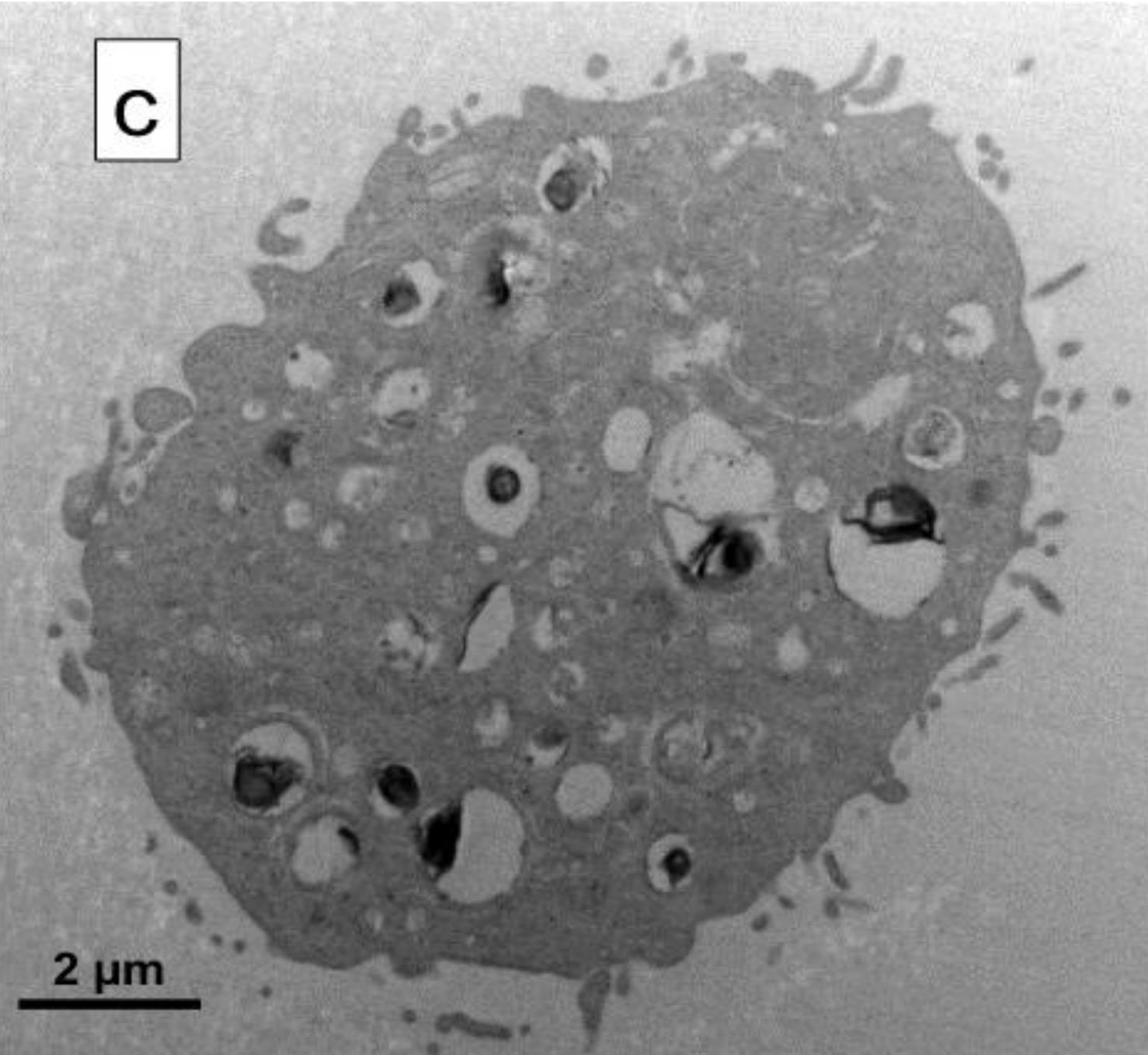
a



b

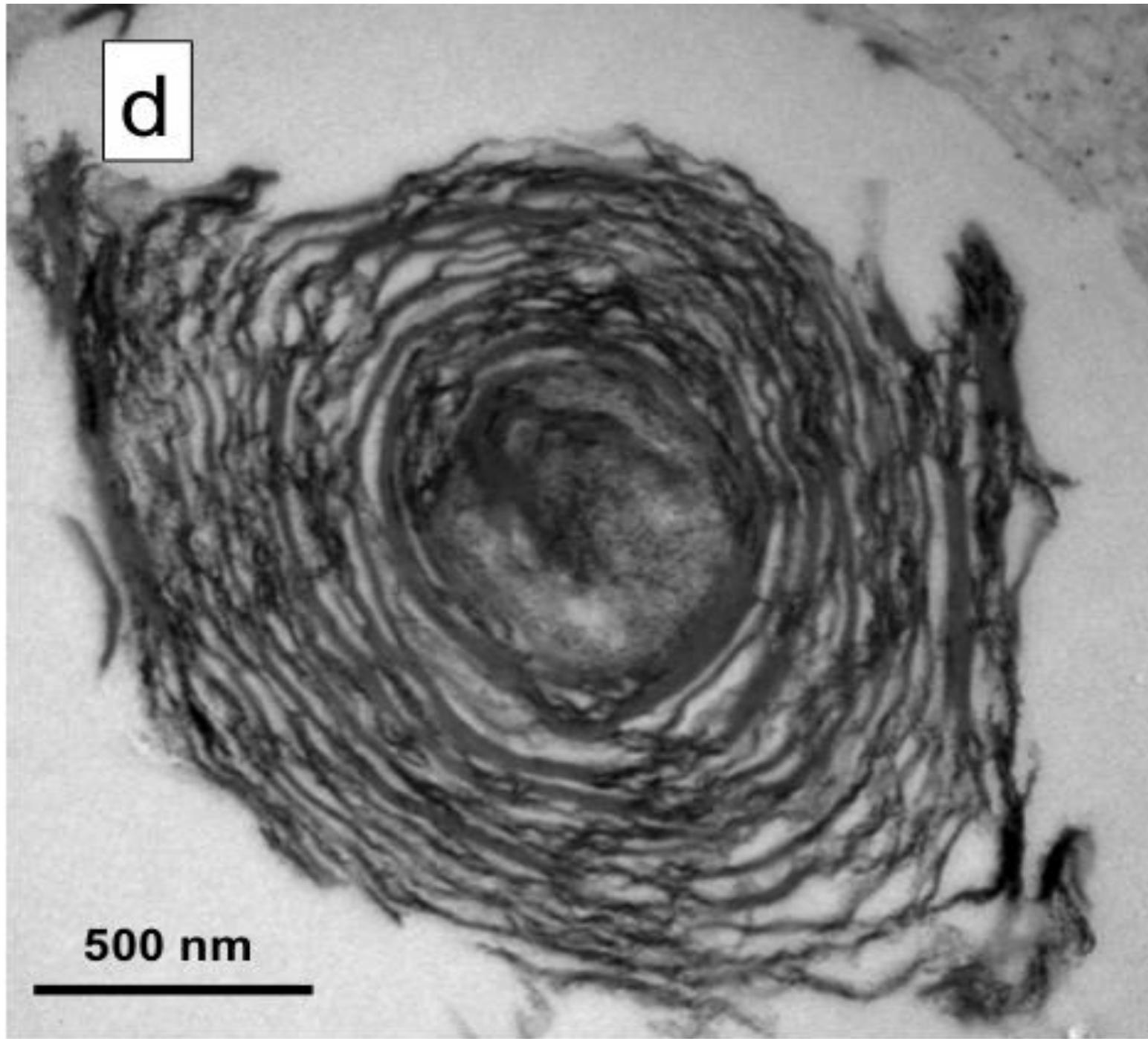


C



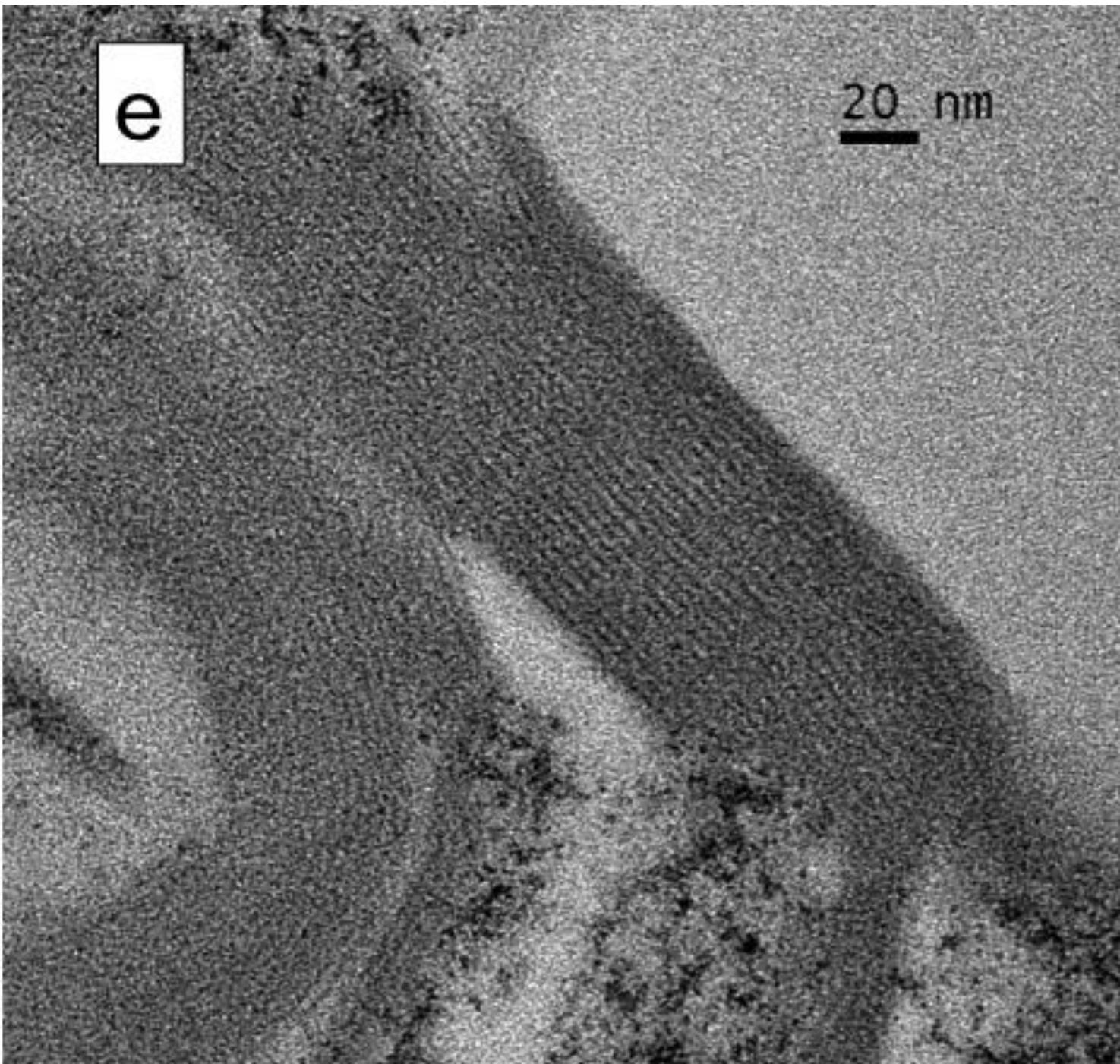
2 μ m

d



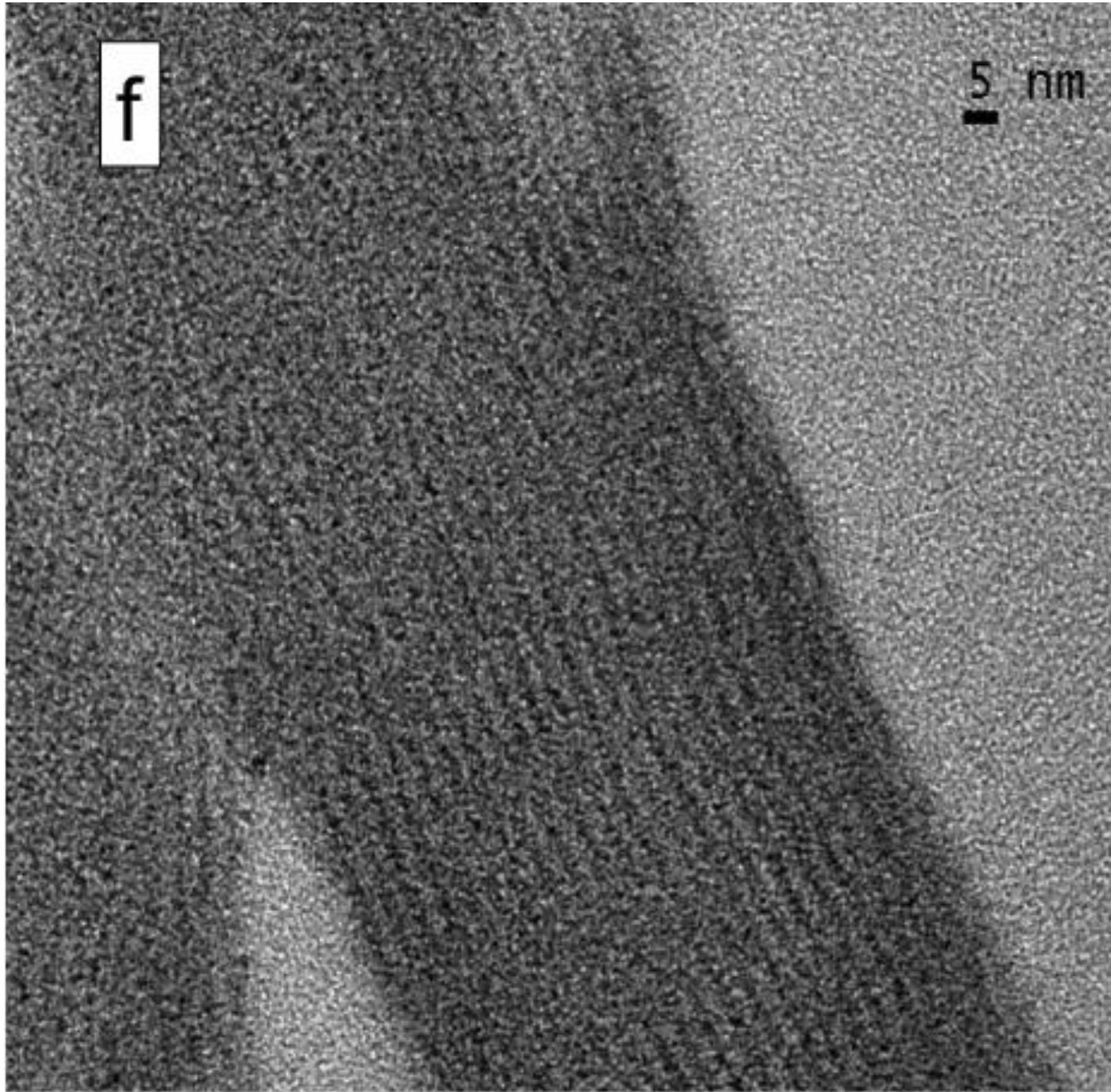
e

20 nm



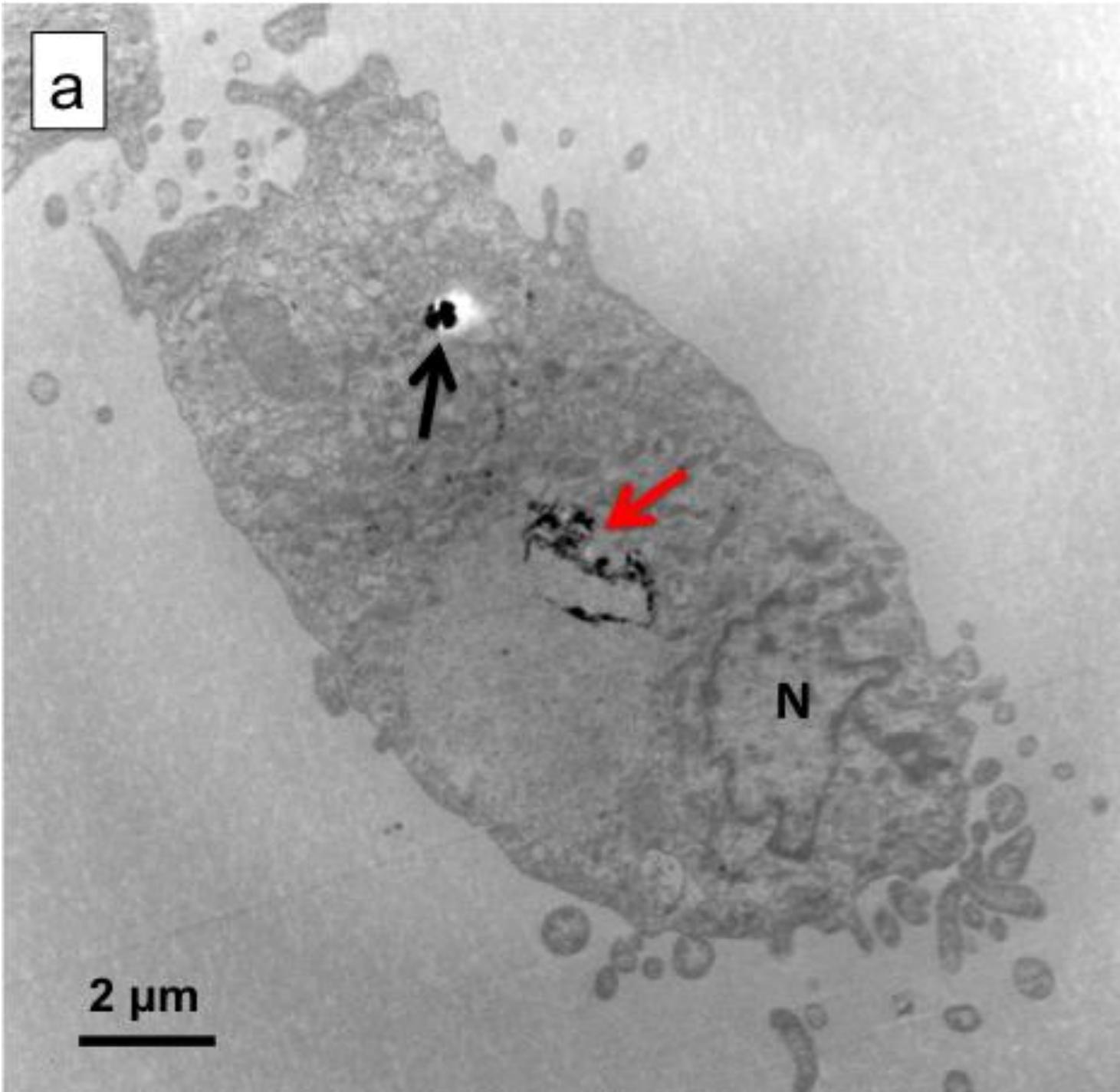
f

5 nm



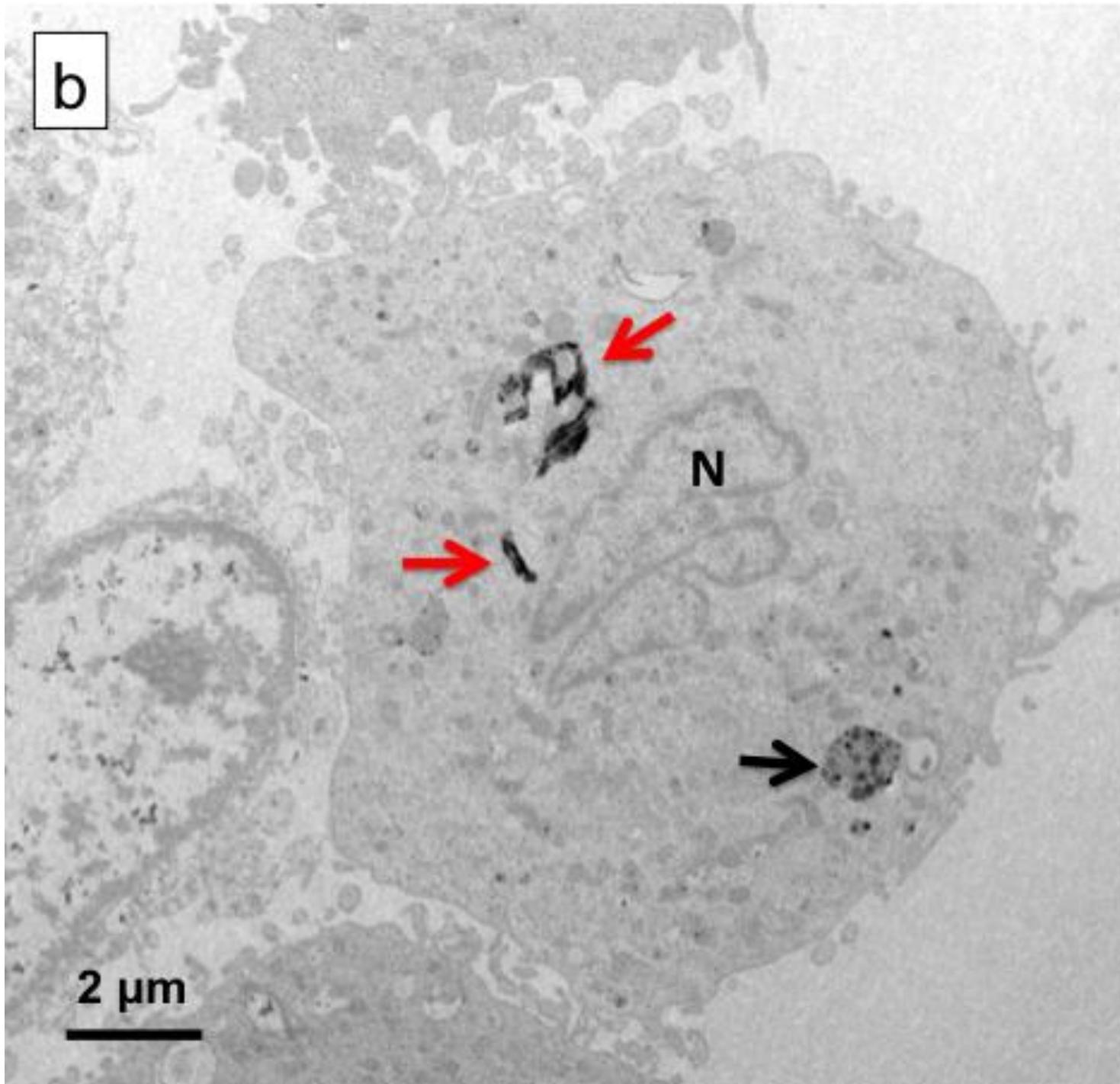
Black material = lamellar bodies (lung surfactant)

a



2 μ m

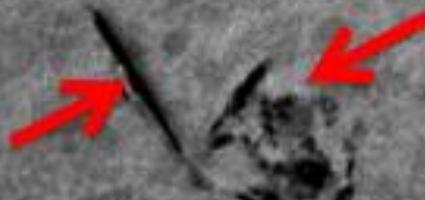
b



2 μm

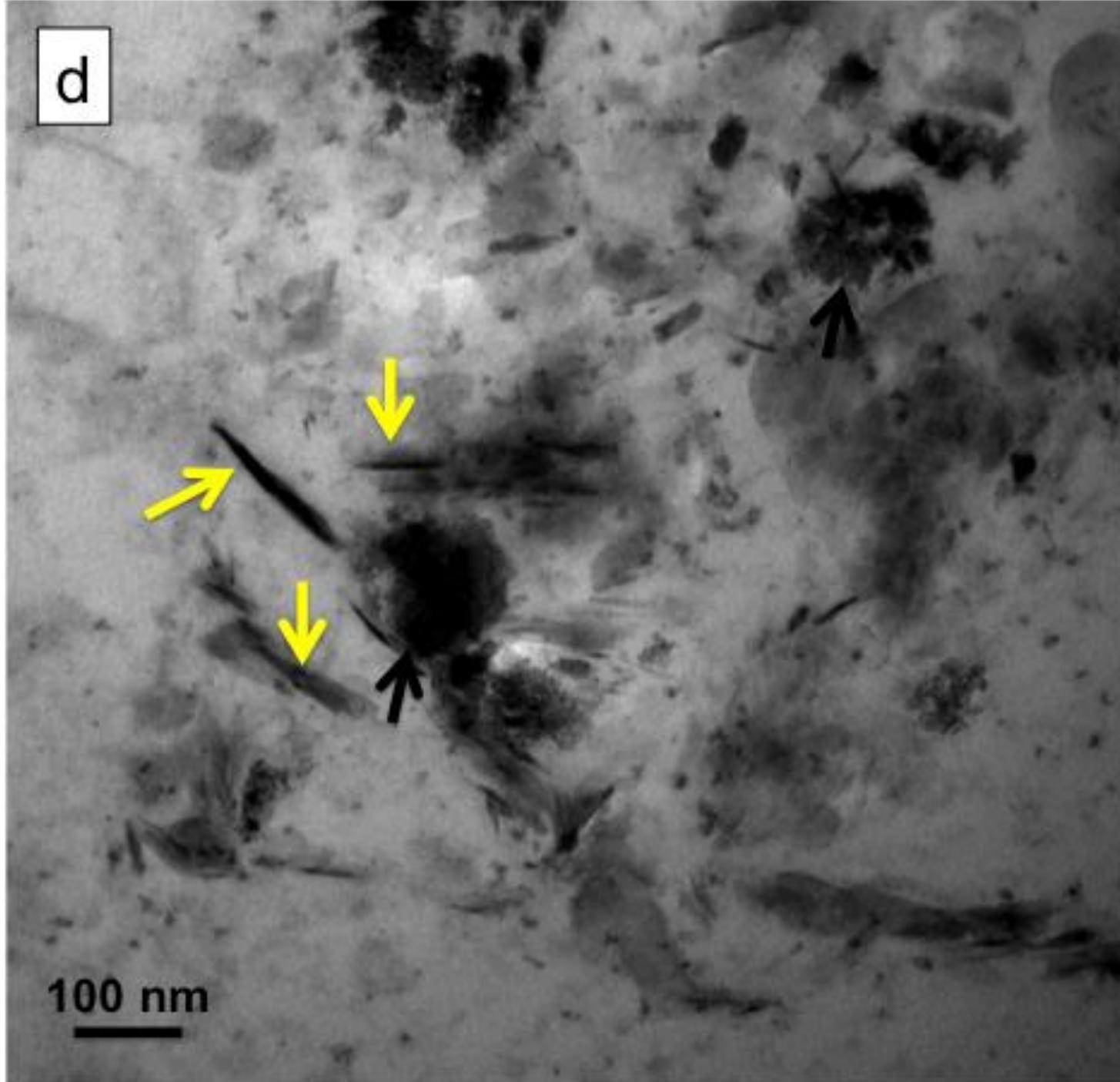
C

N



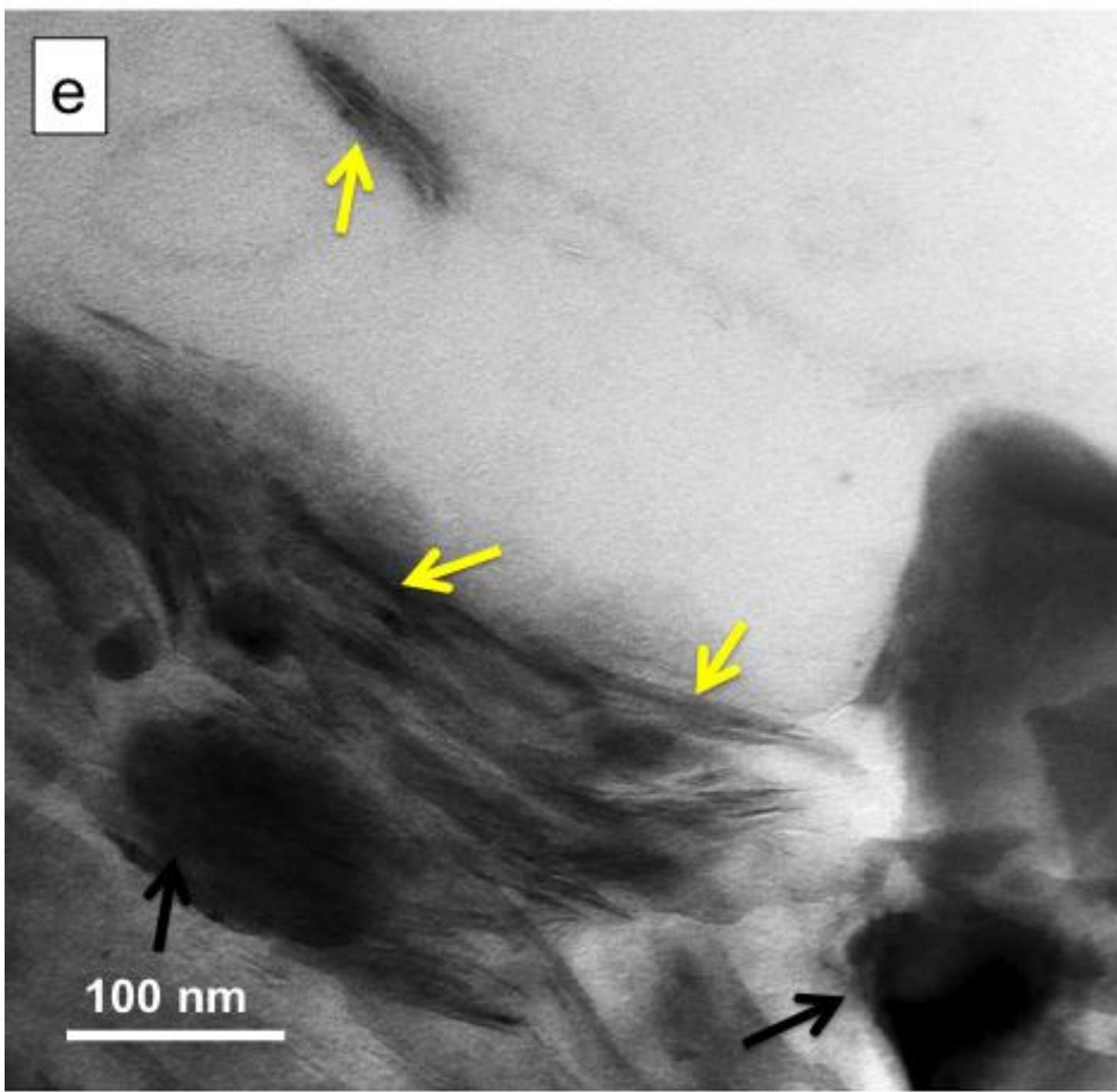
2 μ m

d

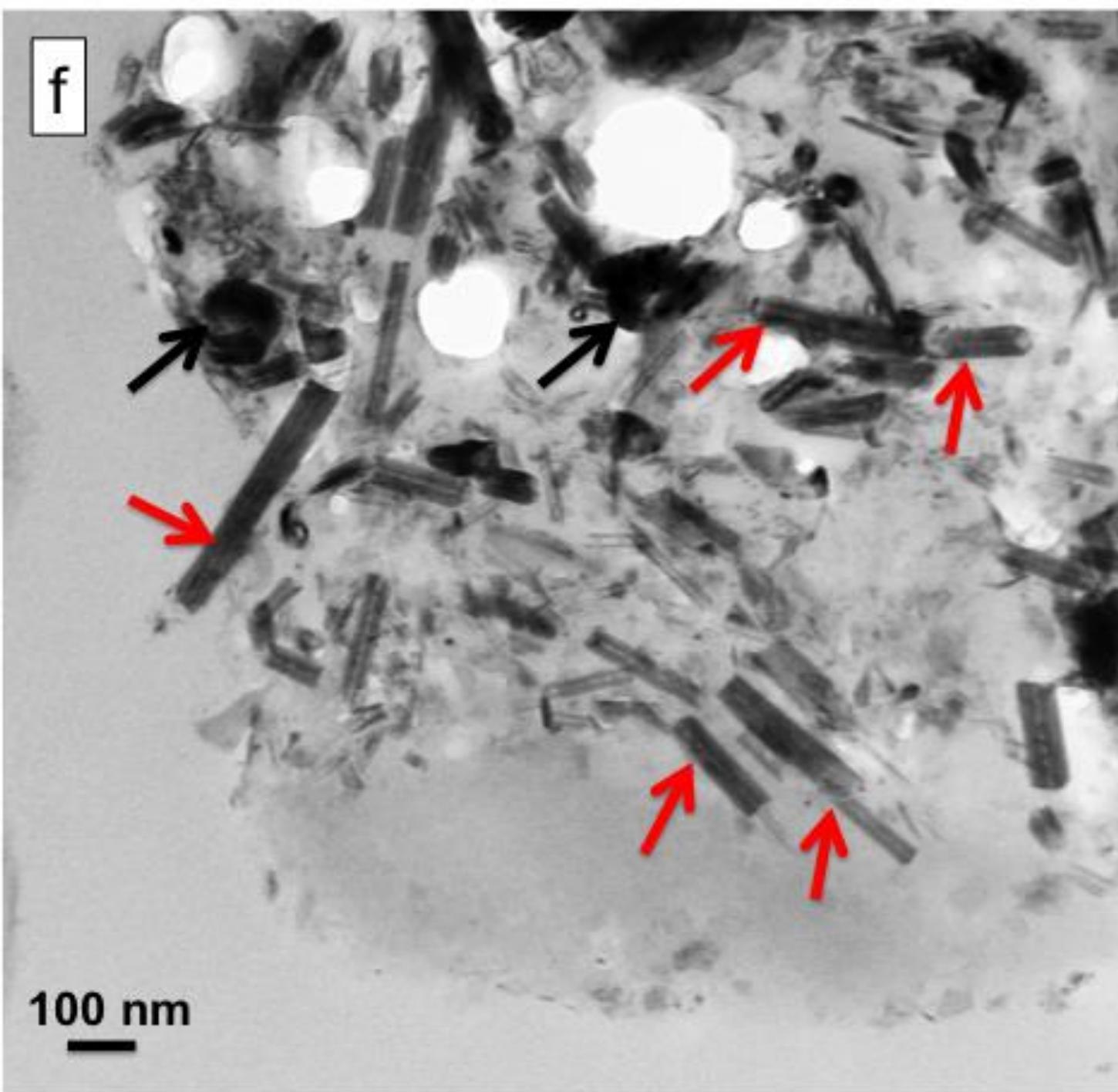


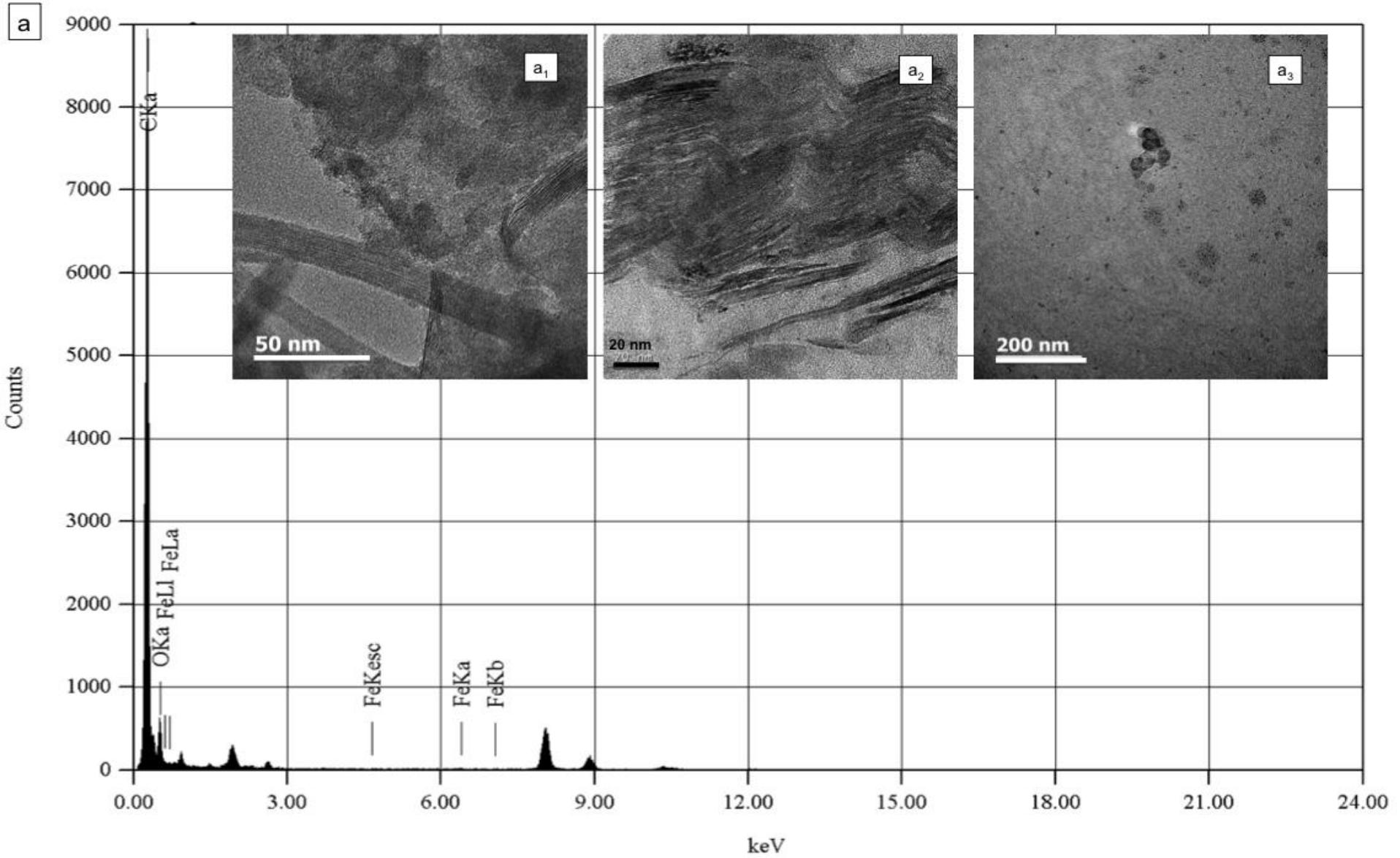
100 nm

e

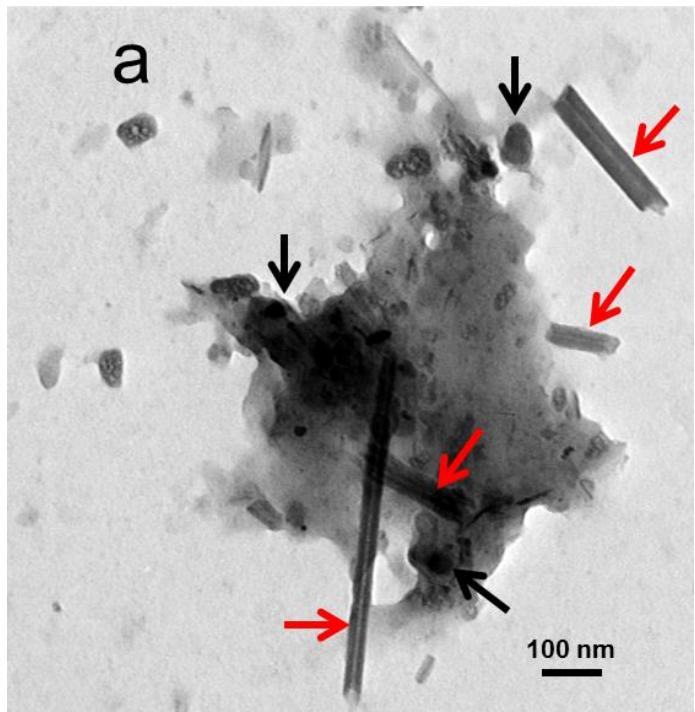


f





a

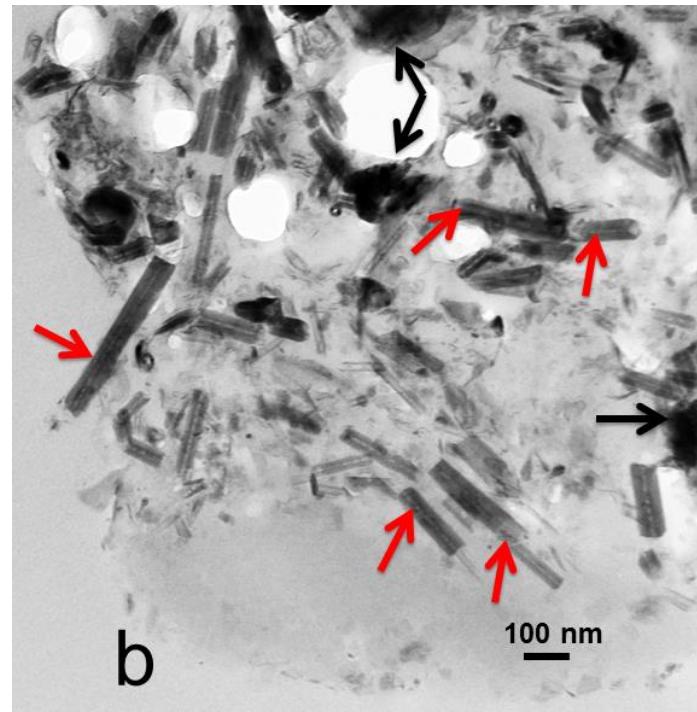


(a) Vehicle exhaust

**(b) Carbon inside
a lung cell vacuole**

→ **Carbon nanotubes**
→ **Carbon nanoparticles**

b



□ CONCLUSION

- ✓ *Humans routinely breathe carbon nanotubes*
- ✓ Previous studies using OM must be reconsidered
 - ✓ TEM, then HRTEM and EDX
 - ✓ CNT toxicity and fate ?