

Brain Preservation

as a medical treatment for life extension:
current status and future prospects

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Brain Preservation Purpose or Goal

To postpone a terminal condition until medicine and technology can heal the affliction in question.

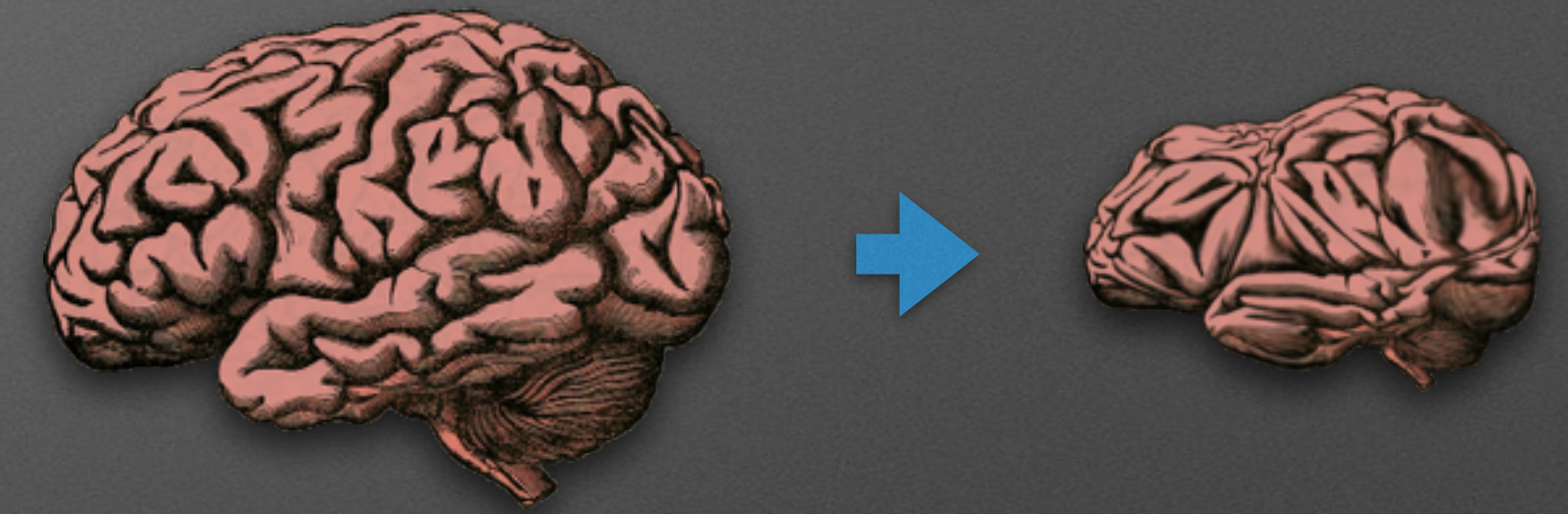
The only remotely viable option yet devised is cryonics.

Cryonics Challenges

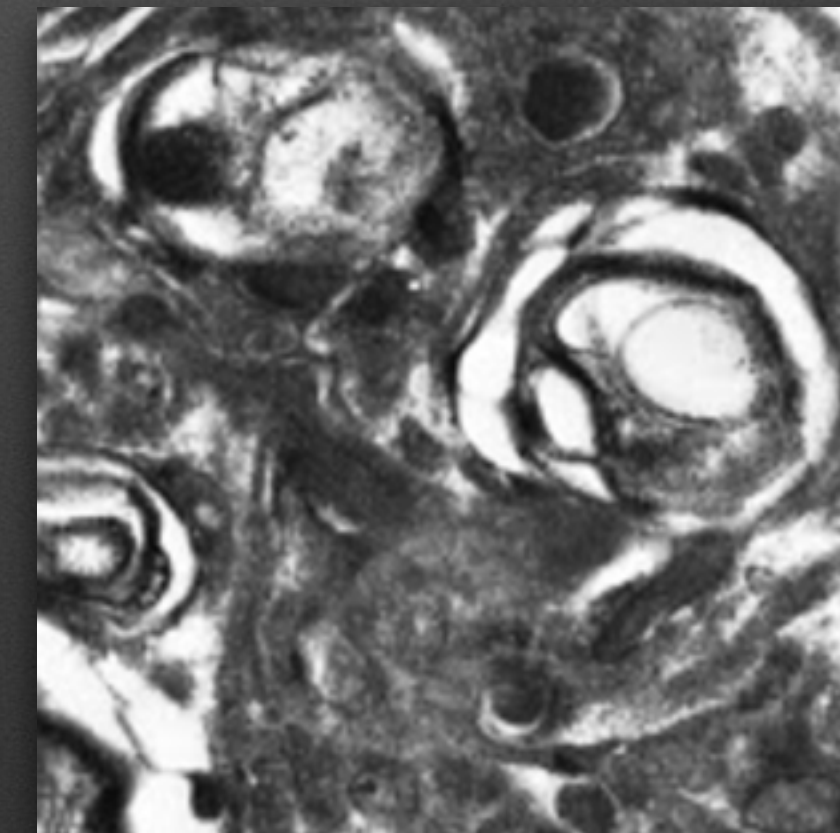
- *Ice crystals*: Previously problematic, now solved by ice blockers, cryoprotectants, and vitrification.



- *Shrinkage & deformation*: Cryoprotectant procedure drives out water, which dehydrates, shrinks and deforms brain.



- *Ultrastructure unconfirmed*: Images often unconvincing.



- *Speculative revival*: requires futuristic, nanotech reconstruction, *if even possible* (perhaps salient information is destroyed).

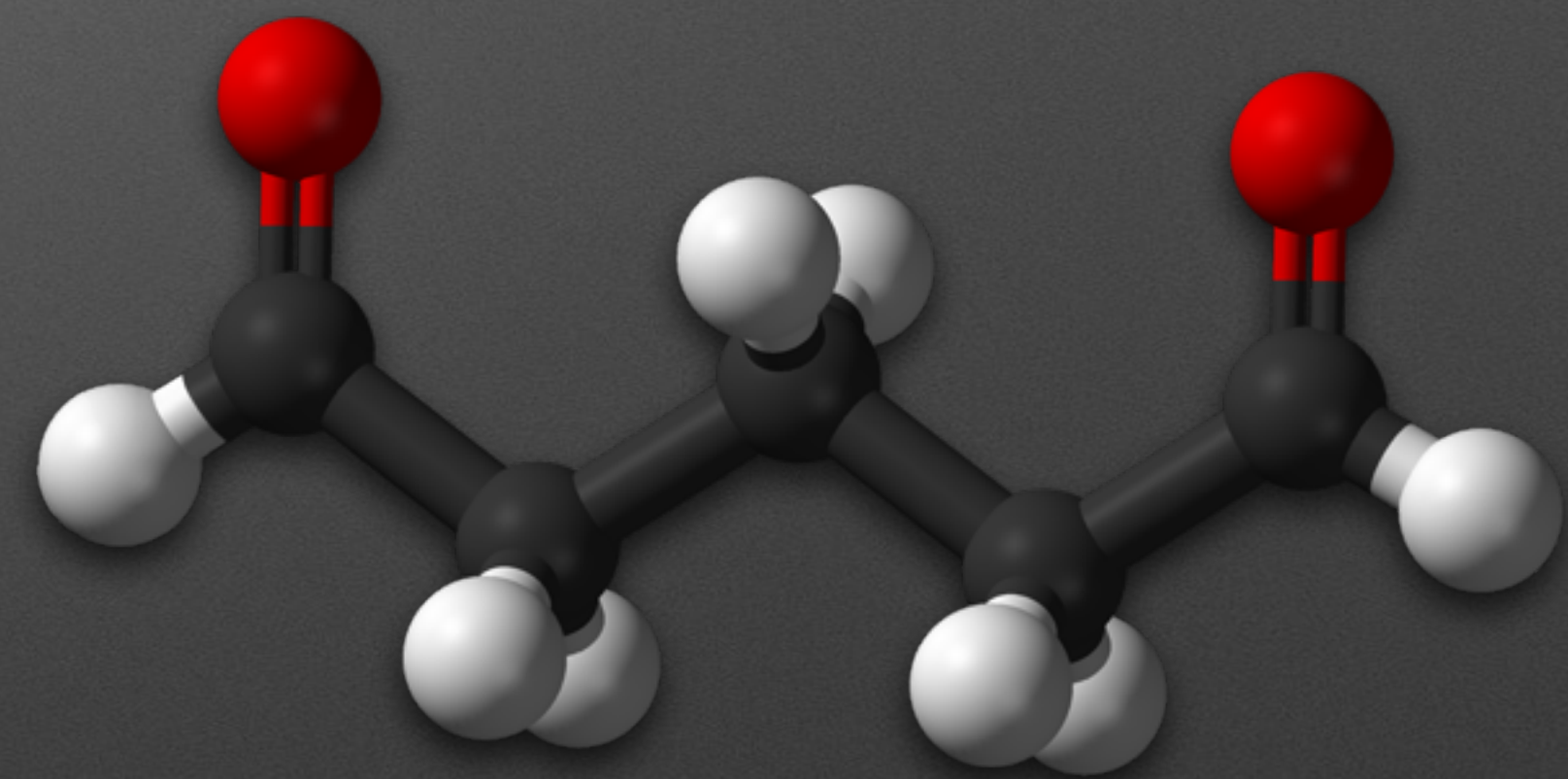
- This situation motivated the BPF prize.



Aldehyde-Stabilized Cryopreservation (ASC)

- In early 2016, Robert McIntyre's team at 21st Century Medicine won the *BPF Small Mammal Prize* (rabbit brain).

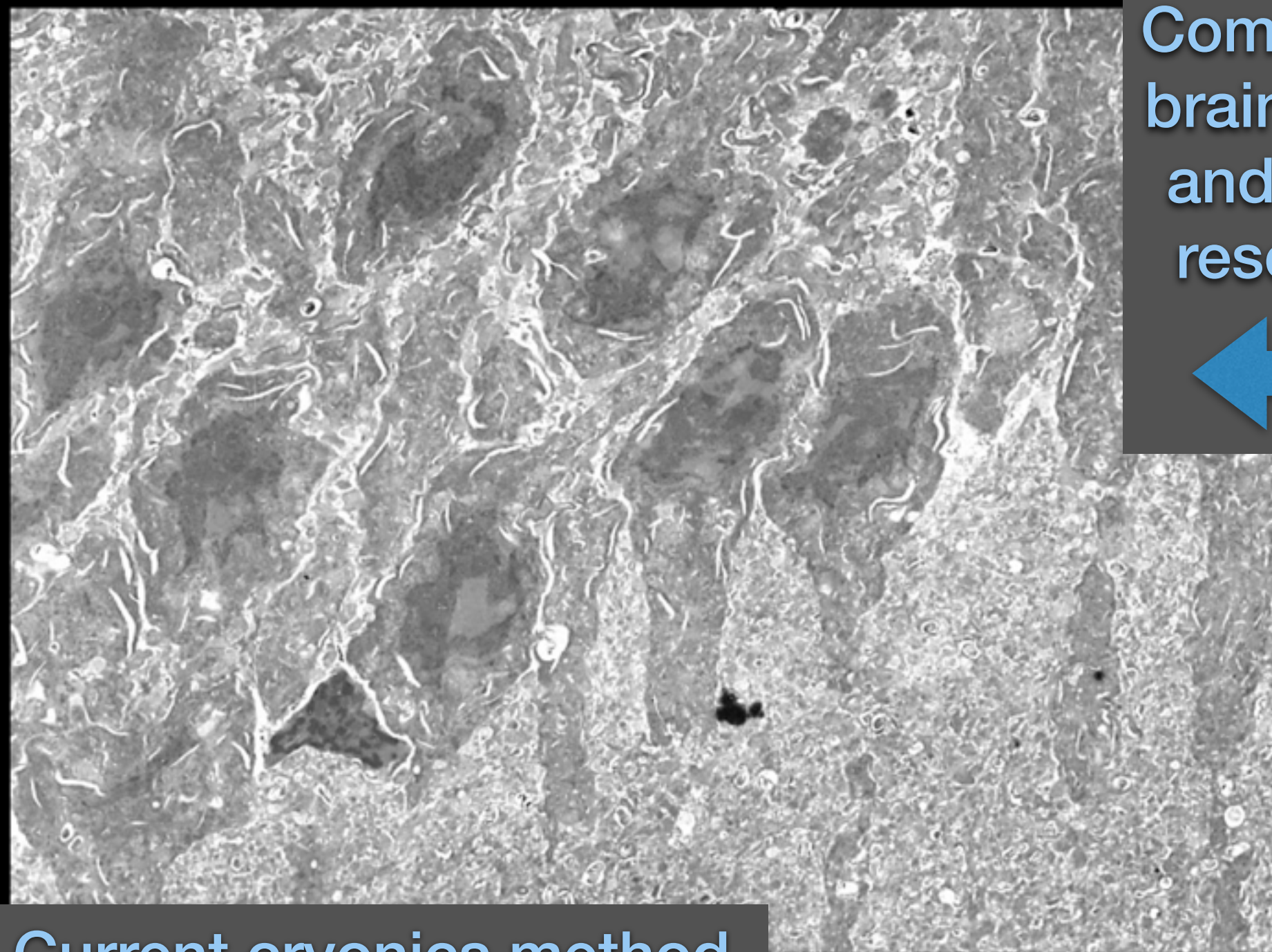
- ASC precedes vitrification with *glutaraldehyde perfusion* to lock and cross-link proteins:



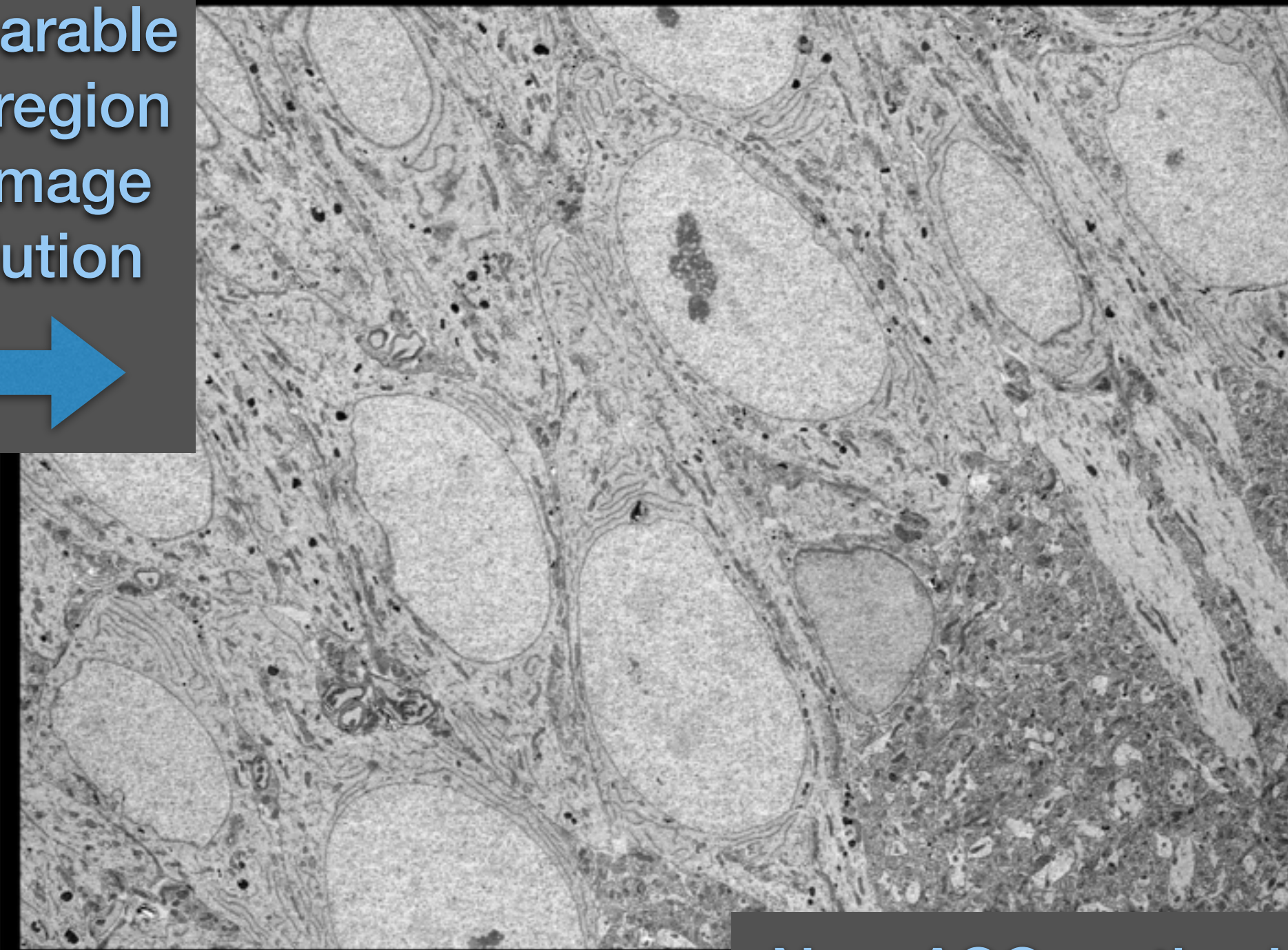
Glutaraldehyde molecule

- ✦ Buys time to perfuse cryoprotectants slowly at lower concentrations, without shrinkage and deformation.
- ✦ Similarly, enables slower temperature drop.

Ultrastructure Preservation Comparison

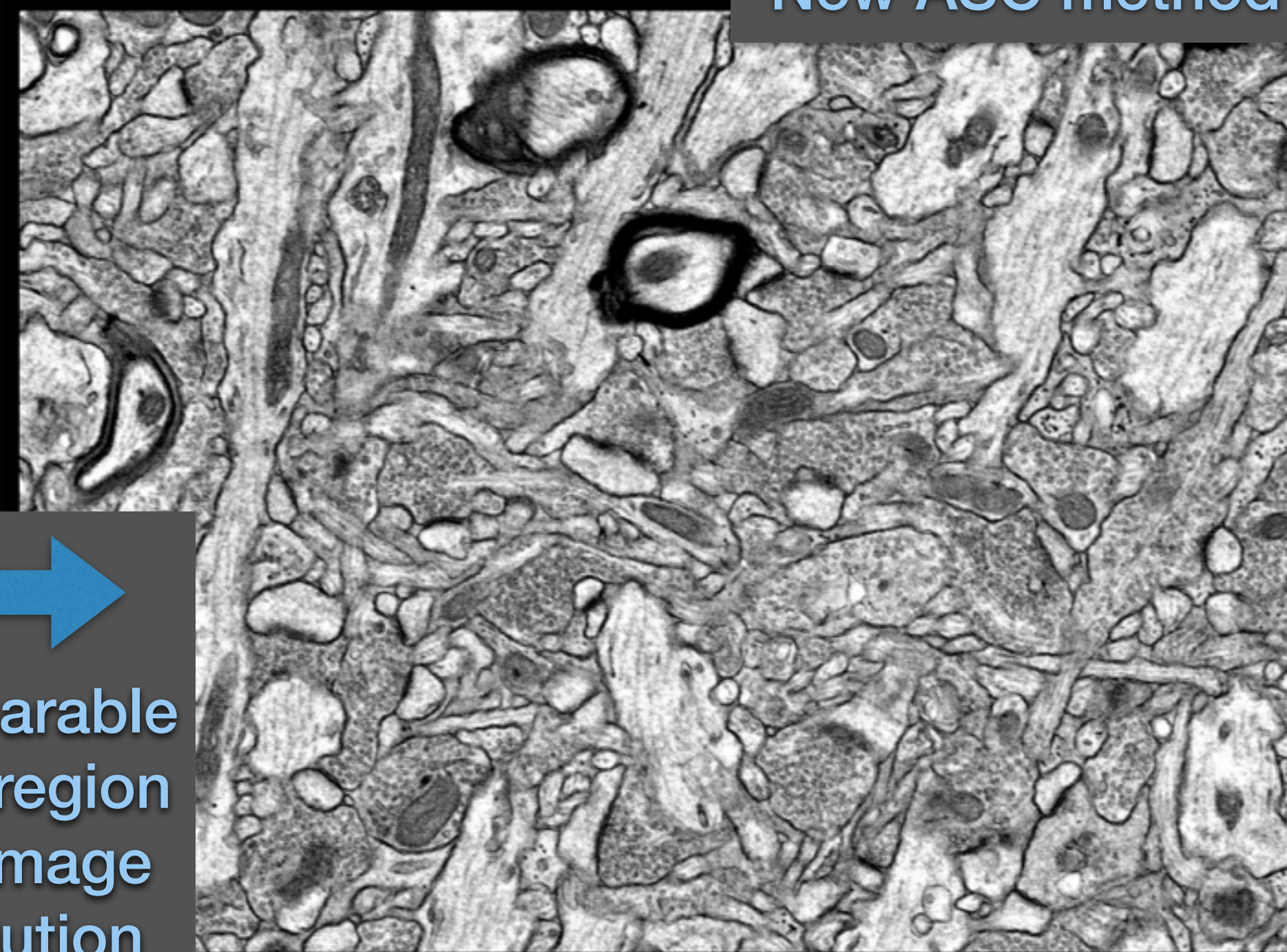
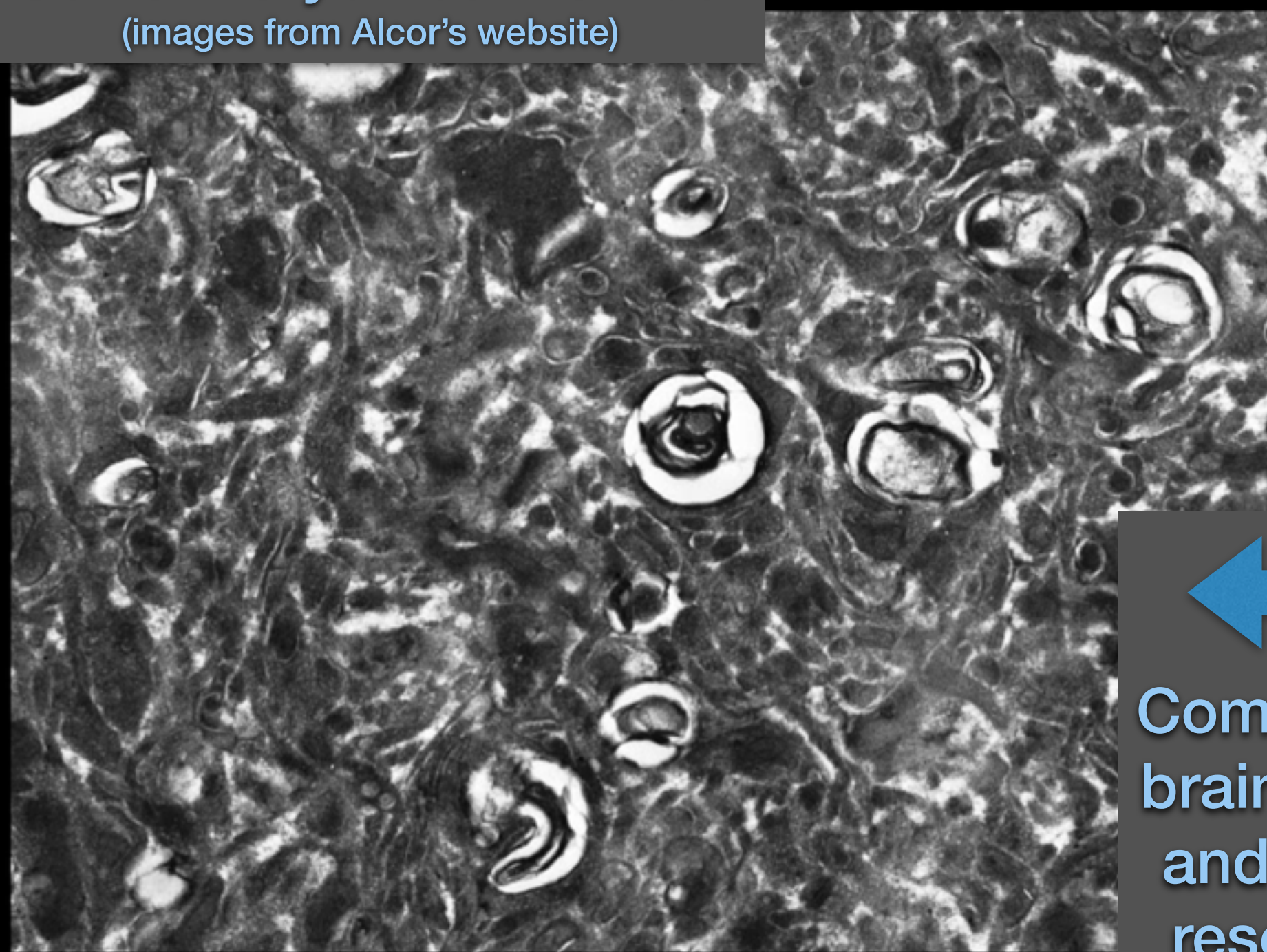


Current cryonics method
(images from Alcor's website)



New ASC method

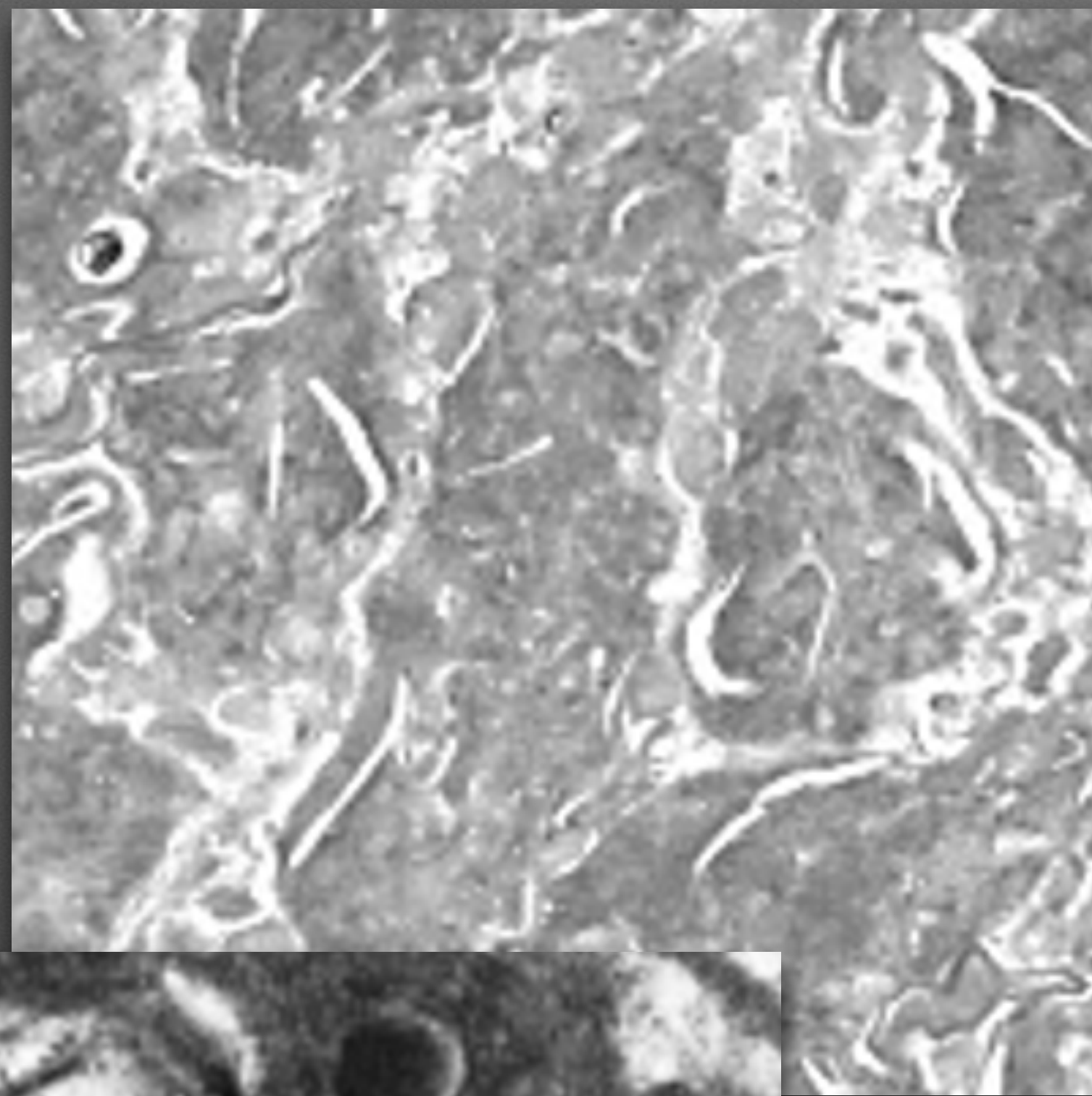
Comparable
brain region
and image
resolution
↔



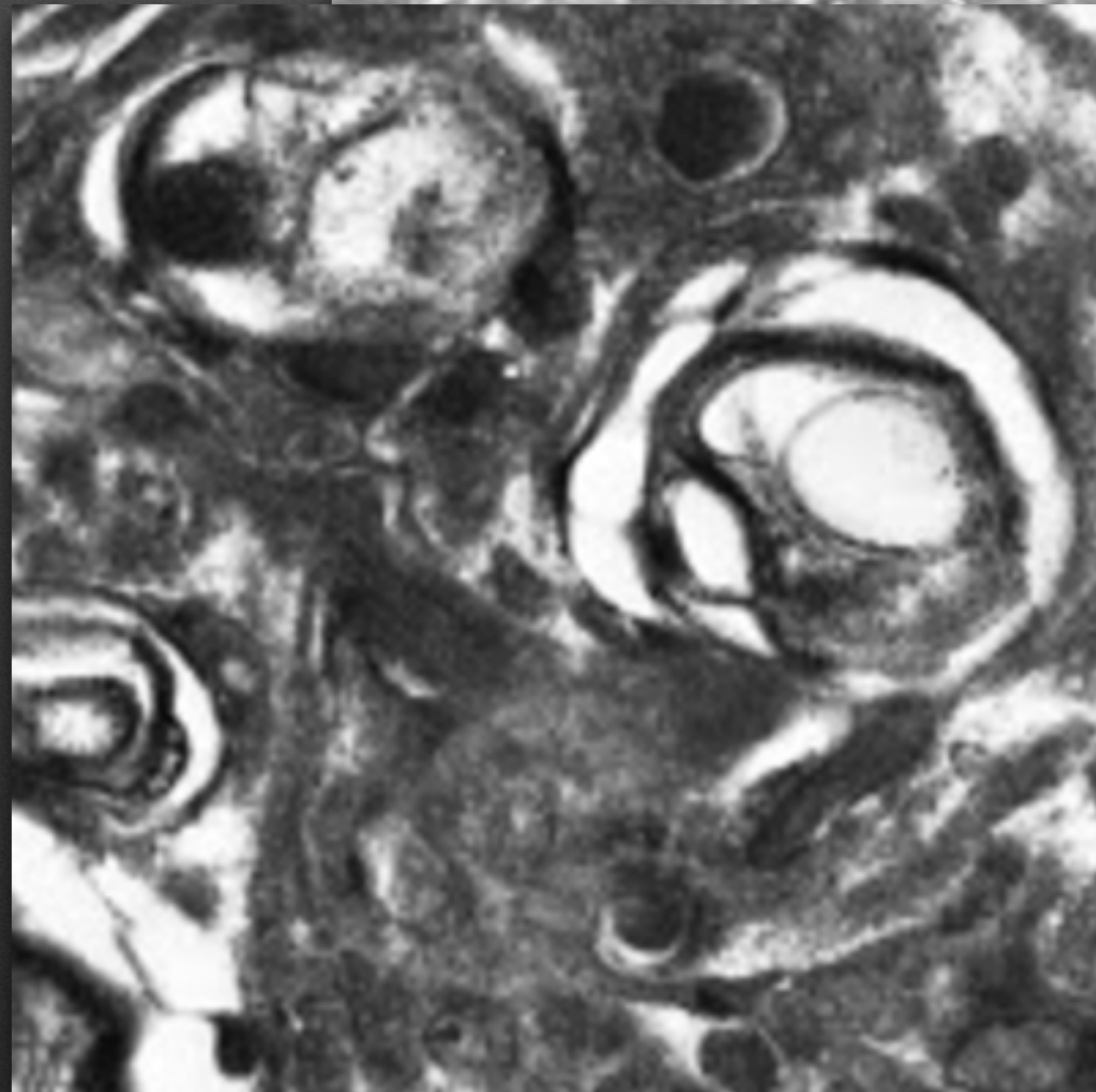
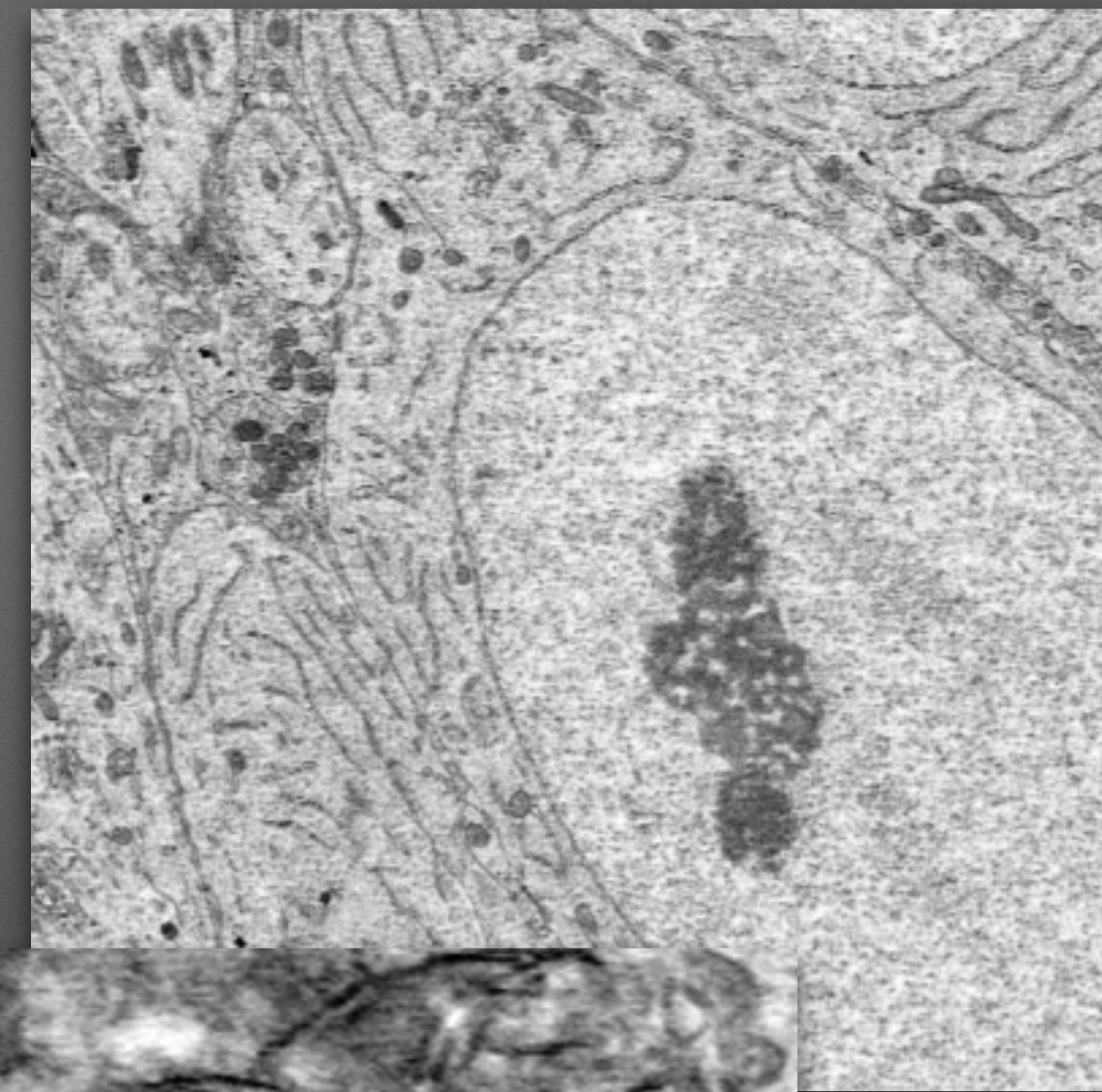
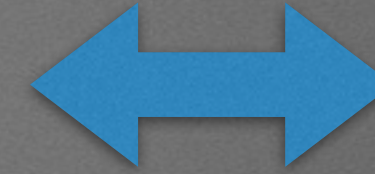
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Ultrastructure Preservation Comparison

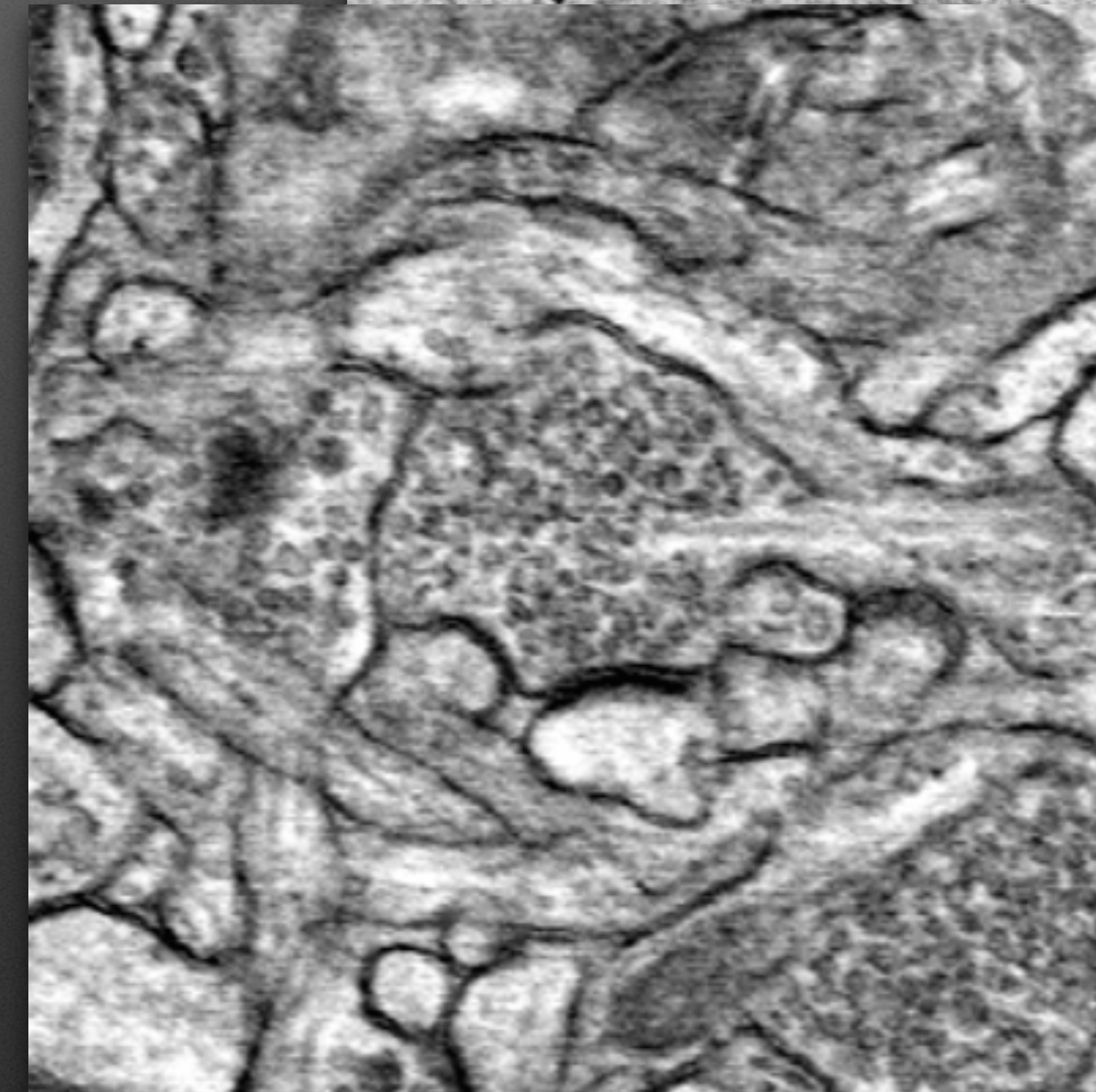
Current cryonics method
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New ASC
method

Memory

Prevailing theory:

Long term **memory** (all experience, knowledge, personality, etc.) is encoded in the **physical synaptic network** that connects neurons, aka, the *connectome*.

Thus, capturing **synaptic details** is the predominant **goal** of brain preservation.

So, how well does ASC preserve synapses?

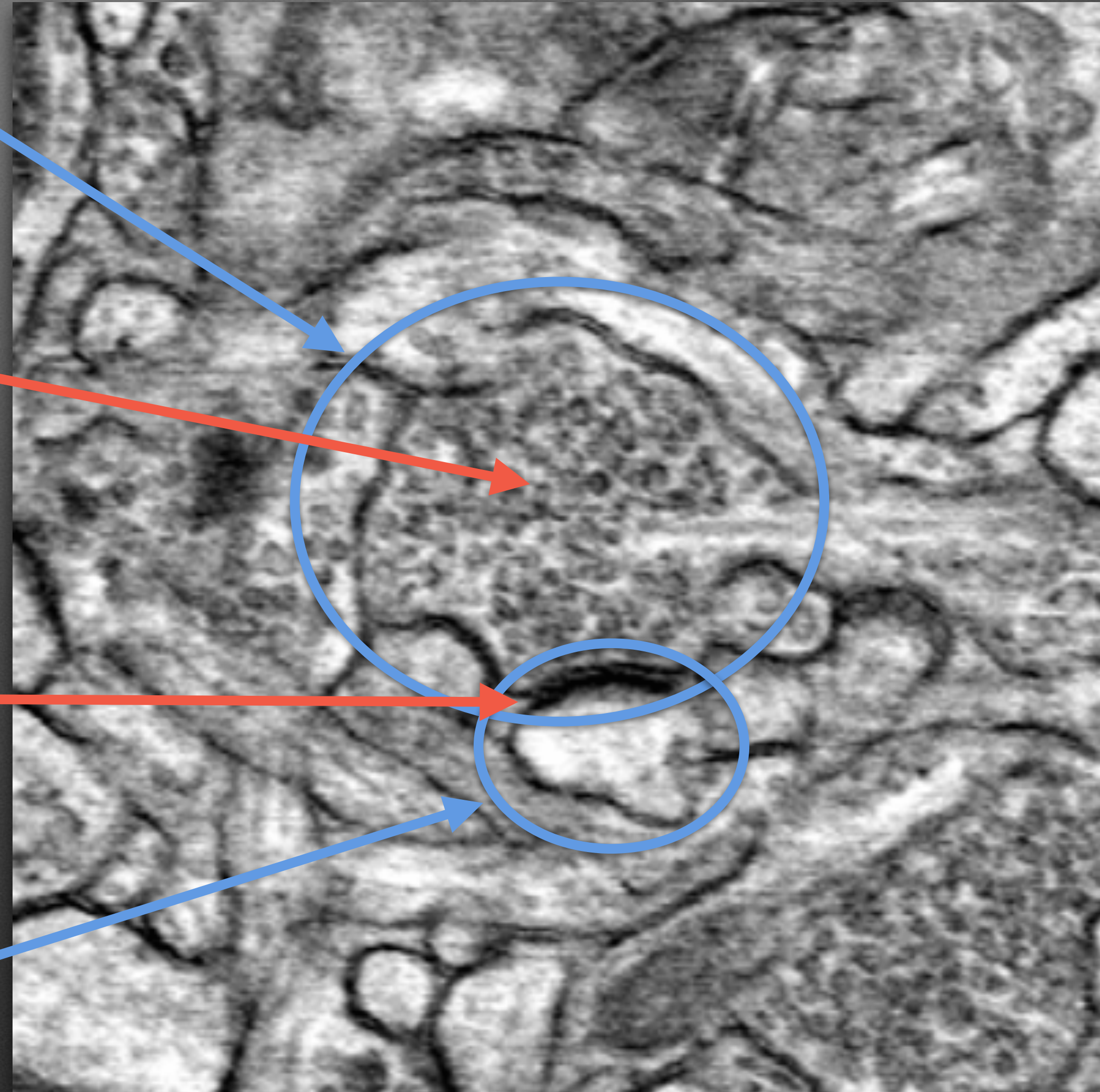
ASC Quality

Axon terminal

Individual
neurotransmitter
microvesicles

Synaptic cleft

Downstream
neural dendrite

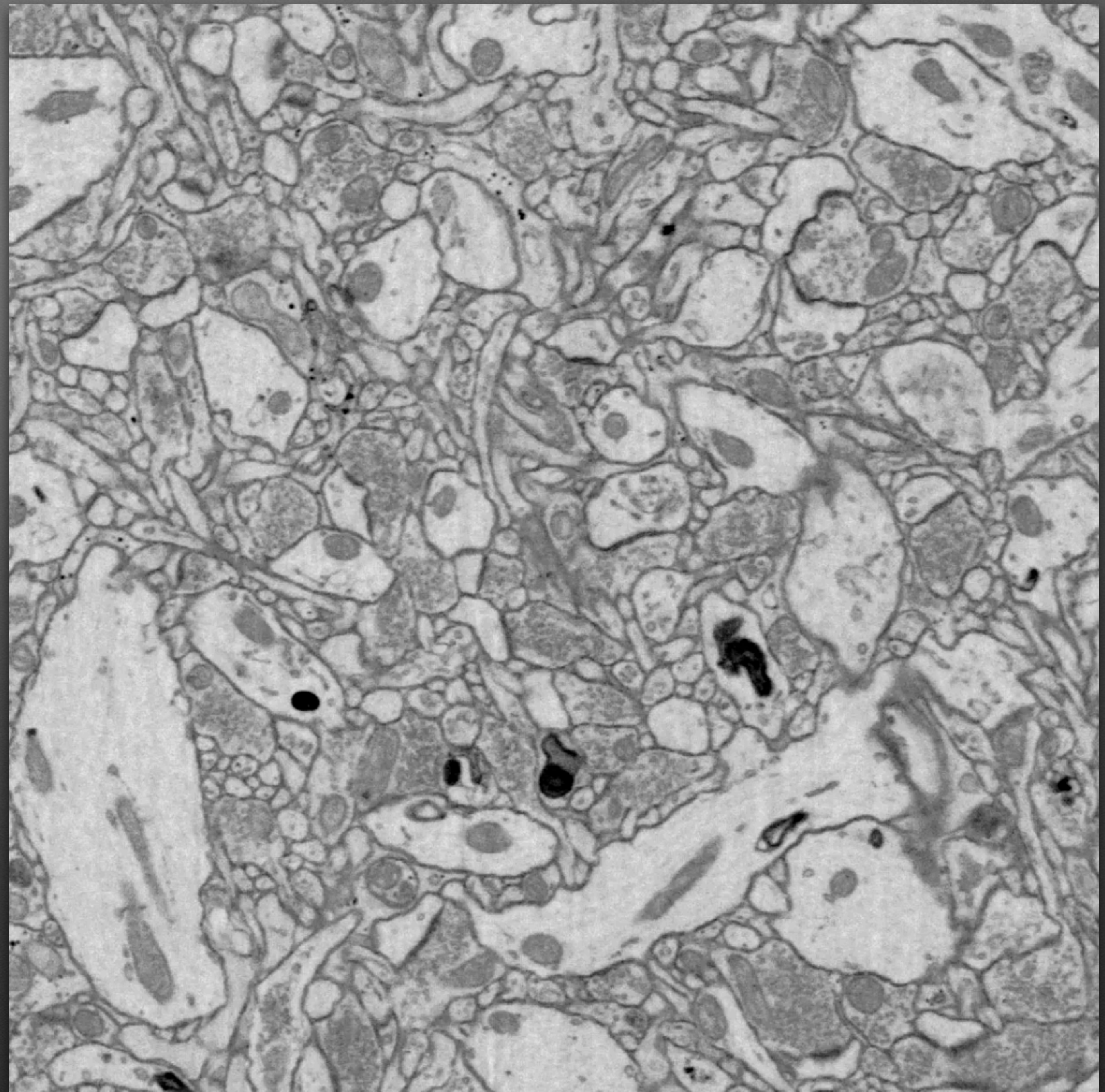
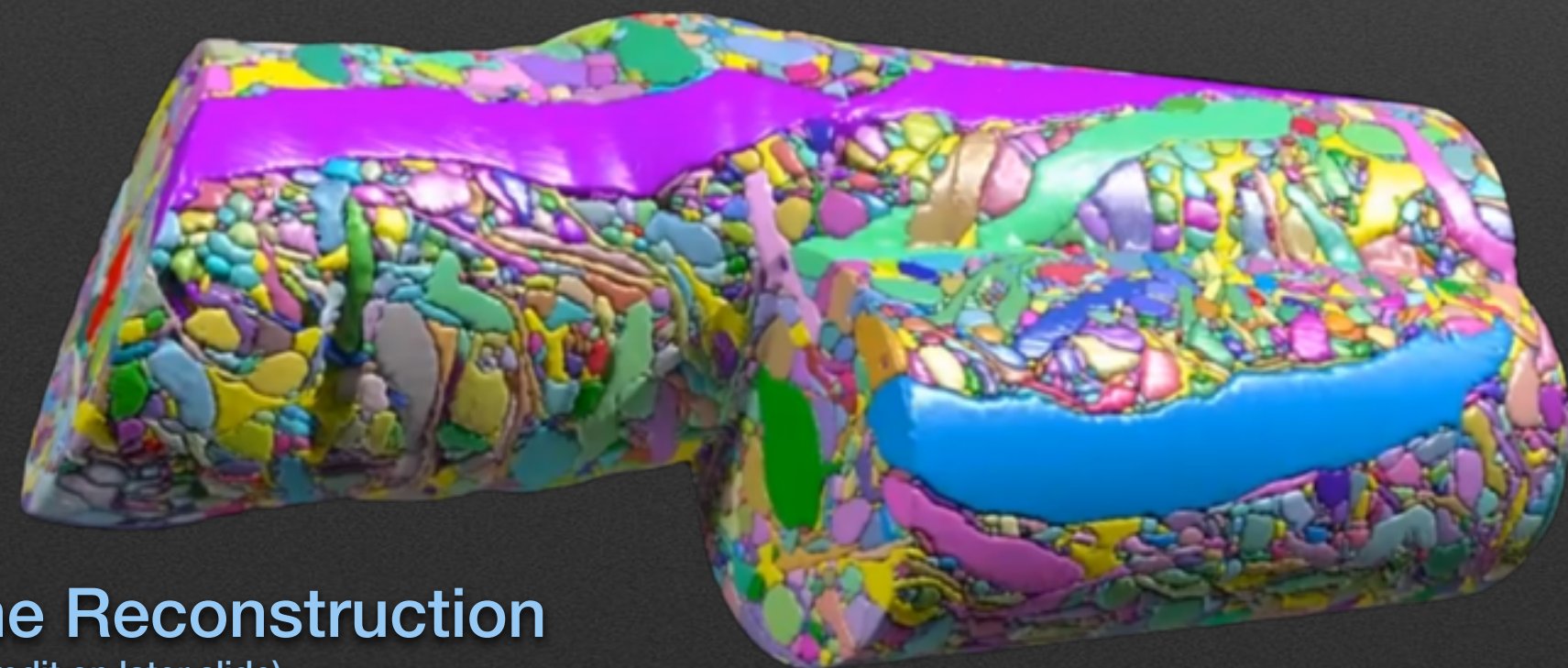


Same image from previous slides

Z-axis (cross-section) Animation

Visualization of the image-processing task used to:

- Confirm preservation quality.
- Infer 3D structure for whole brain emulation.



Neural Volume Reconstruction

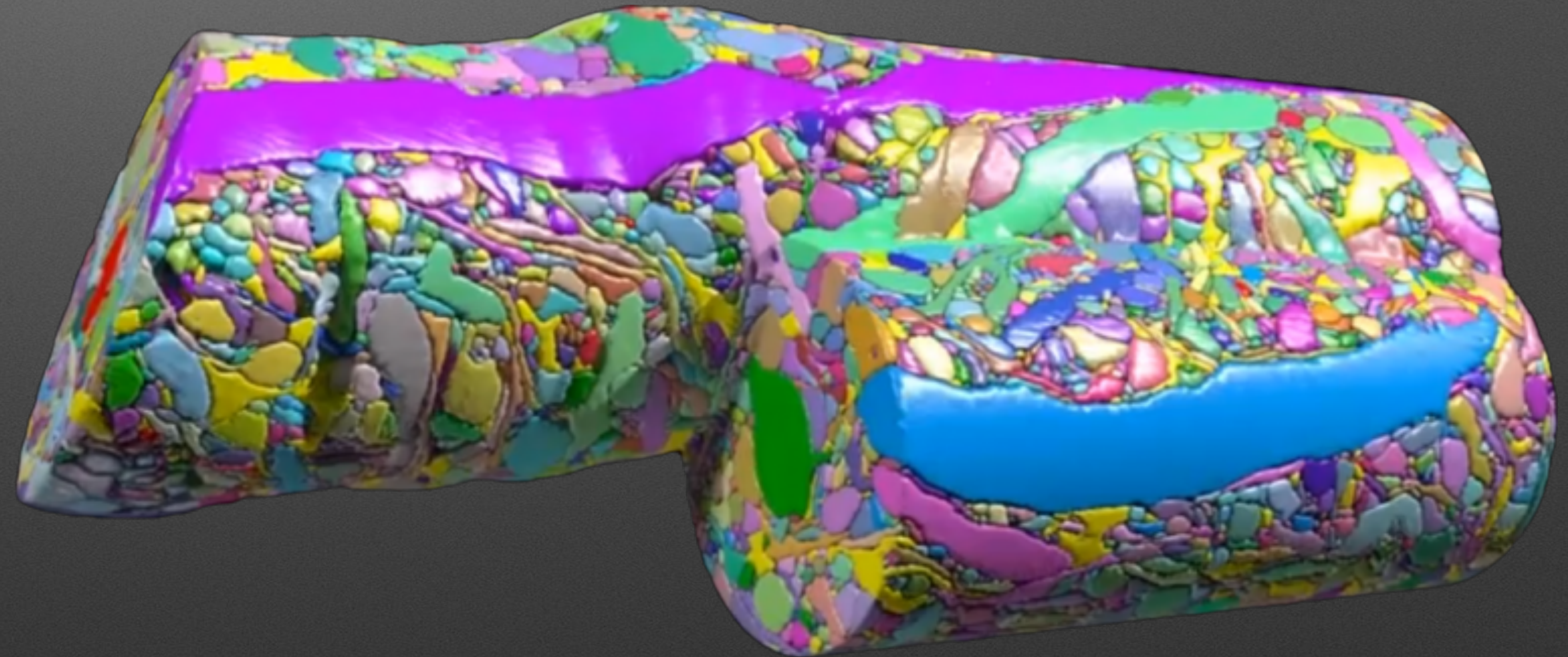
(image credit on later slide)

Revival

- Current cryonics (CC):
 - ✦ Ostensibly supports biological revival.
 - ✦ Supports mind uploading as well.
- ASC:
 - ✦ Possibly confined to mind uploading since glutaraldehyde perfusion may be irreversible.
- Some may see this as a deal-breaker for ASC, but:
 - ✦ **If CC is fundamentally flawed** (if connectome is irreparable), **then CC is not viable** in the first place (false hope).

Serial Section Mind Uploading

1. Slice the brain into 2D sections, e.g., via *Automatic Tape-Collecting Lathe Ultramicrotome (ATLUM)*, achieving 5nm thickness (invented by Jeff Lichtman and Kenneth Hayworth).
2. Image the slices.
3. Infer 3D structure.
4. Build a model.
5. Emulate the model.

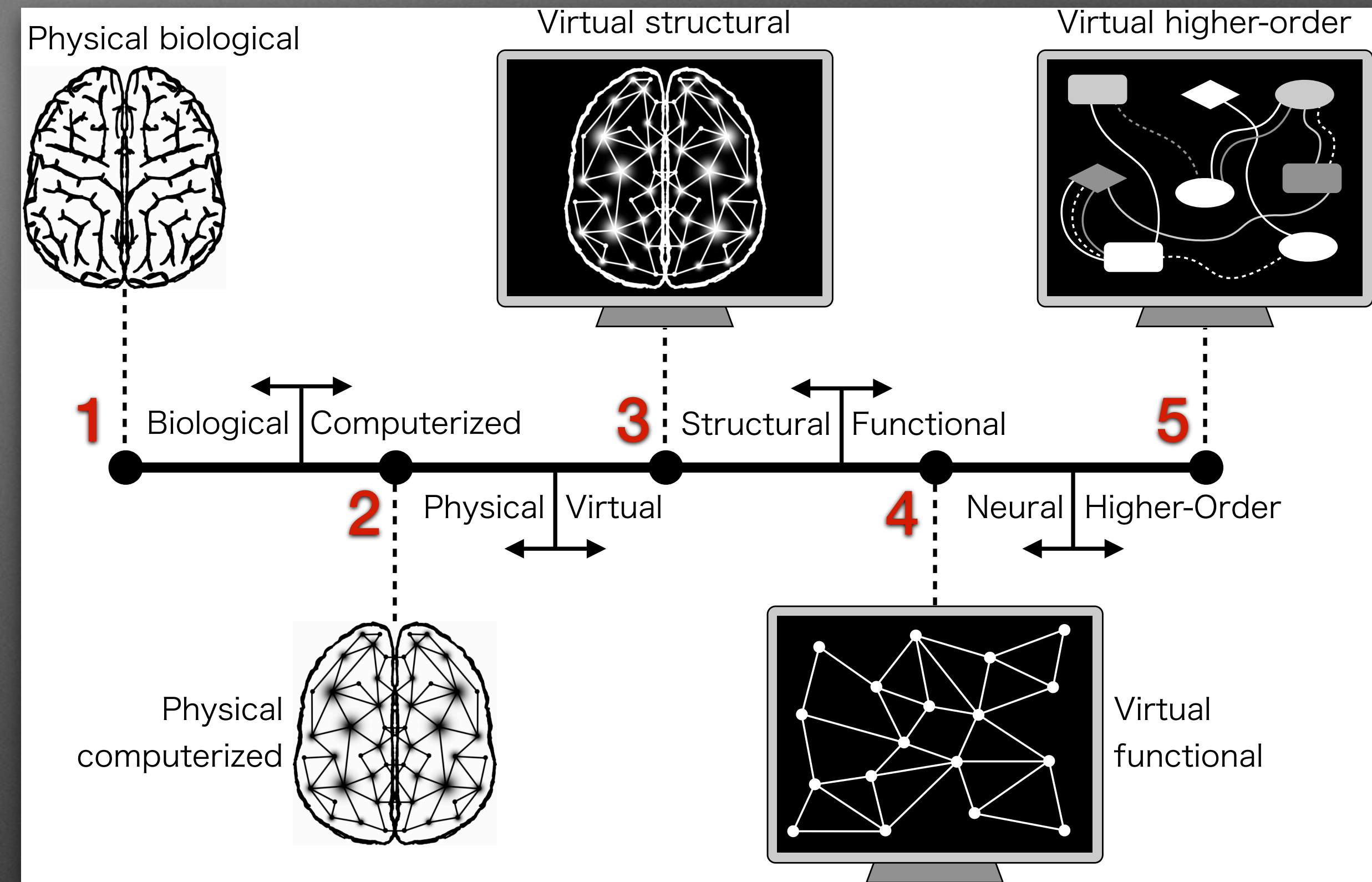


Volume reconstruction via osmium processing, plastic embedding, 30nm sectioning, scanning electron microscopy, and image tracing (ASC should enable comparable feats)

Whole Brain Emulation (WBE)

Spectrum of WBE abstractions:

1. Original organ or biological reconstruction
2. Physical network of billions of “chips”
3. 3D spatial simulation
4. Functional connectome simulation (i.e., conventional neural network)
5. Computational or cognitive simulation (e.g., cortical columns, receptive fields, filter banks, etc.)



From A Taxonomy and Metaphysics of Mind-Uploading

Next Steps and Goals

- ASC is confirmed on rabbit brains ala the 2016 prize.
- Next step: *BPF Large Mammal Prize* (pig brain).
- Then even larger brains.

Ultimate goal:

Establishment of brain preservation as an end-of-life procedure offered in hospitals for otherwise terminal cases