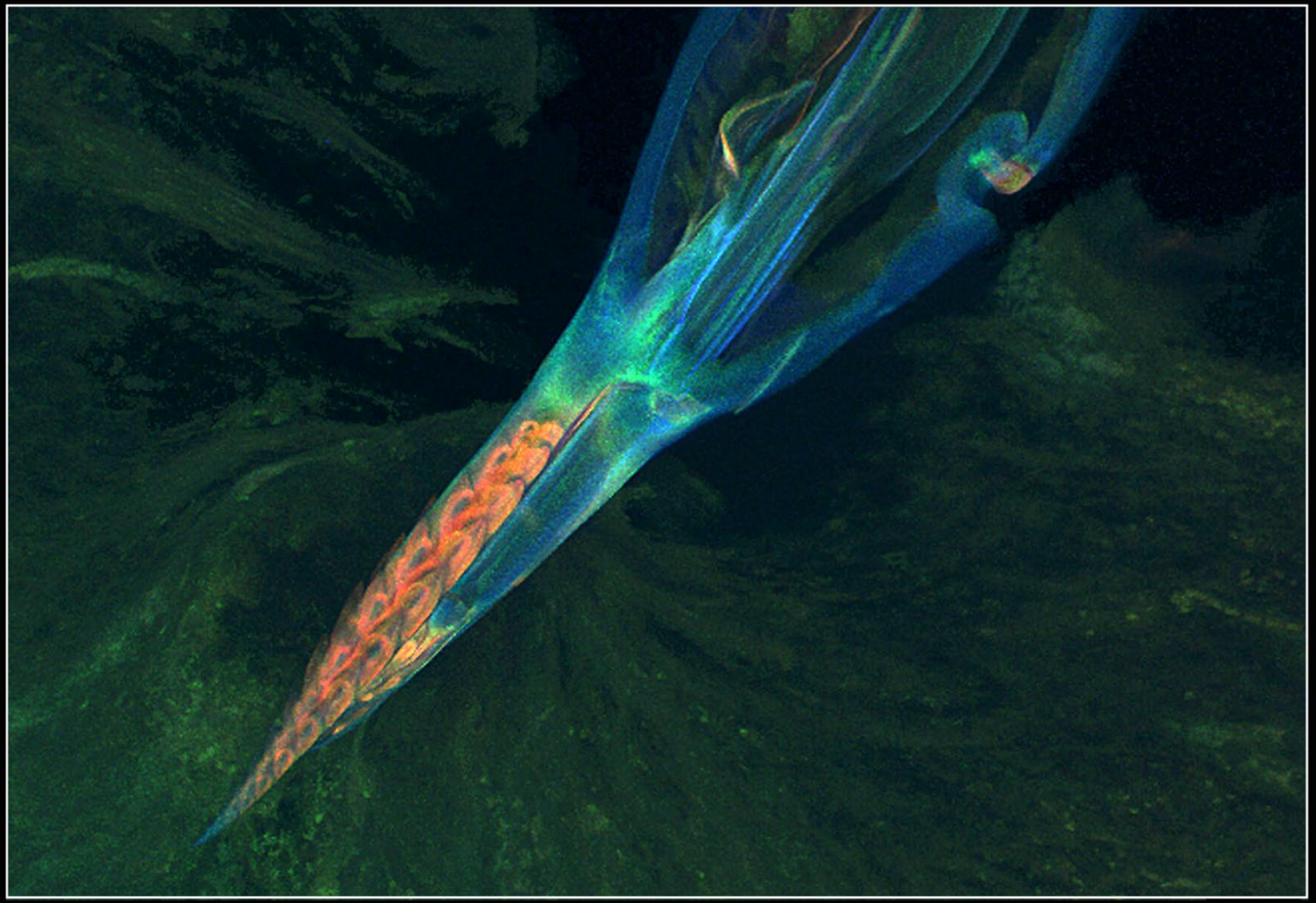


Science and Engineering Visualization Challenge
2004 - 1st Place (published in *Science* 305:1903)
(sponsored by the National Science Foundation and the journal *Science*/AAS)
2004 - Nikon Small World Photomicrography Competition
Credit: Marna E. Ericson and Uli Munderloh

Autofluorescence of Tick Nymph on a Mammalian Host
Laser scanning confocal microscopy
captured the autofluorescence of a common
deer tick as it feasted on the ear of a golden hamster.

Autofluorescence of tick nymph on a mammalian host.

This image won 1st place in the photography division of “The Creative Visualization Challenge“, an international competition jointly sponsored by Science Magazine and the National Science Foundation.. This competition was initiated to “showcase and encourage an increasingly important aspect of science: the ability to convey the essence and excitement of research in digitized images, color diagrams, and even multimedia presentations. When that research is depicted vividly and comprehensibly in pictures, everybody benefits”. (Science, Vol 305, Issue 5692, 1904, 24 September 2004)

This image results from a collaborative effort with colleagues Ulrike Munderloh, Mike Herron, and Tim Kurtti (Department of Entomology, U of MN) and Jesse Goodman from the FDA. Indeed this NIH-sponsored-research on human granulocytic Anaplasmosis is a disease of particular concern in the upper Midwest.

Blood-feeding ticks create an intradermal lesion, an inflammatory focus which attracts first-line immune responders such as neutrophil granulocytes. A biopsy of hamster ear, with tick, was collected under anesthesia, fixed, and sectioned. The hypostome of Ixodes scapularis nymph inserted into the ear of a hamster is shown at 4 days post infestation. The groove on the dorsal side is cut tangentially and the denticles (ventral side) appear orange. Using laser scanning confocal microscopy (LSCM), autofluorescence from the green, red, and far-red regions of the light spectrum was captured. It is a composite of 150 different optical slices all merged together in one single in-focus image. (200X magnification). We believe this is the first LSCM image of blood-feeding ticks at a lesional site on a mammalian host.

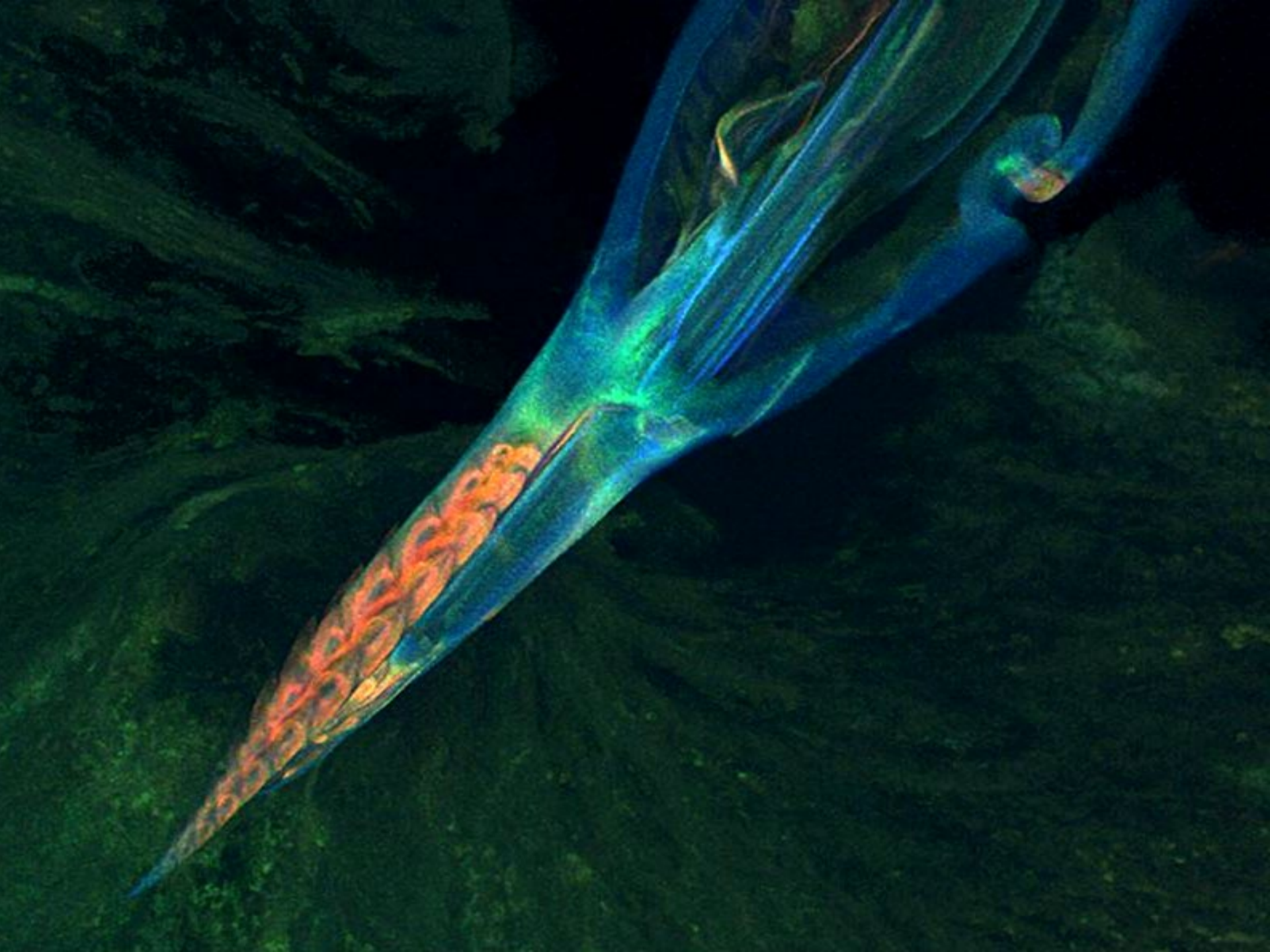
The image was created to:

a) visualize the tick at the bite site,

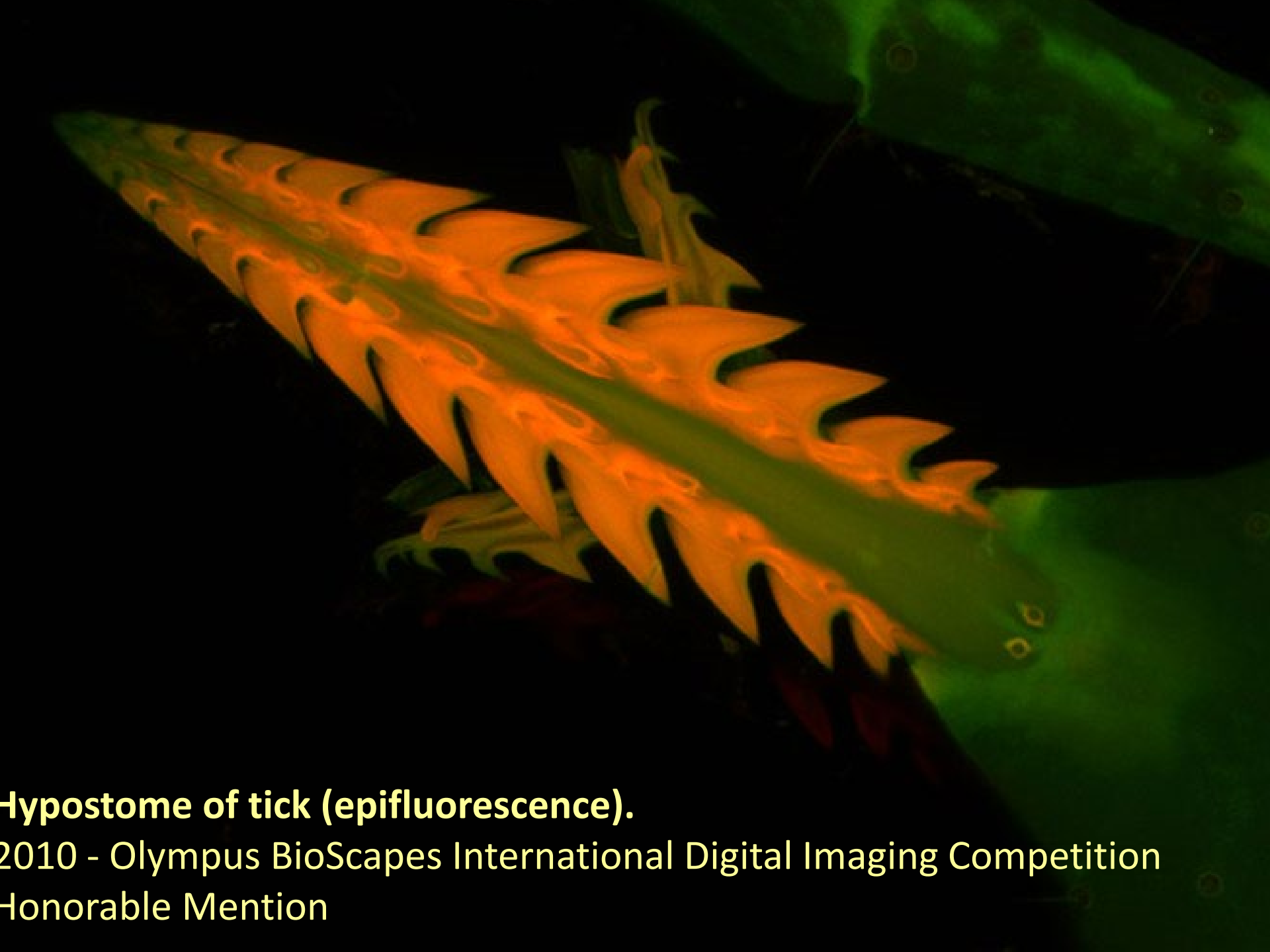
b) as a negative control in an antibody-binding experiment, and

c) to determine endogenous autofluorescence both of the hamster ear and the tick nymph.

The potential of autofluorescence as a valuable tool in understanding tick/host interactions and the beauty of this image was unanticipated in our pursuit of in vivo evidence that infection of microvascular endothelium may be an important step during early pathogenesis and persistence of tickborne bacterial infection of anaplasmosis. And lastly, the endogenous fluorescence clearly demonstrates the need for strict controls in imaging of biological tissue.



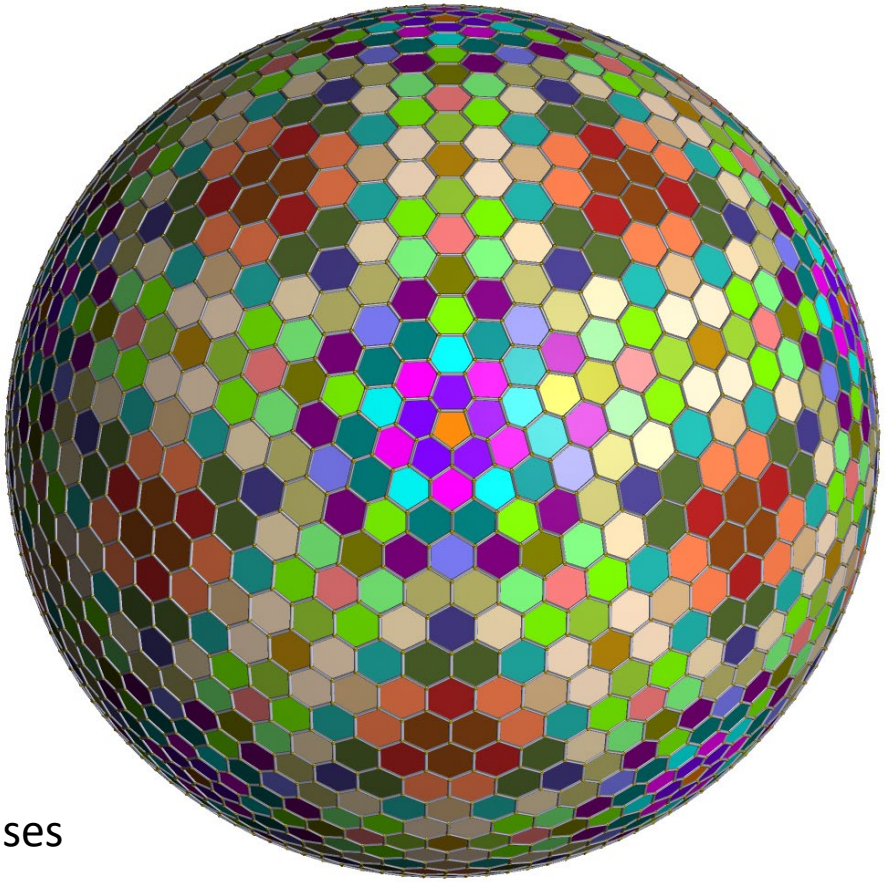
Marna Ericson, PhD
Digital Imaging Center
Department of Dermatology
University of Minnesota Medical School



Hypostome of tick (epifluorescence).
2010 - Olympus BioScapes International Digital Imaging Competition
Honorable Mention

Co-infections

- Diseases manifestations overlap.
- Common insect vectors.
- Time-course of infections vary.
- Invoke different response mechanisms in the host.
- *Bartonella* spp. VERY common in Lyme cases resistant to treatment.
- Difficult to detect.



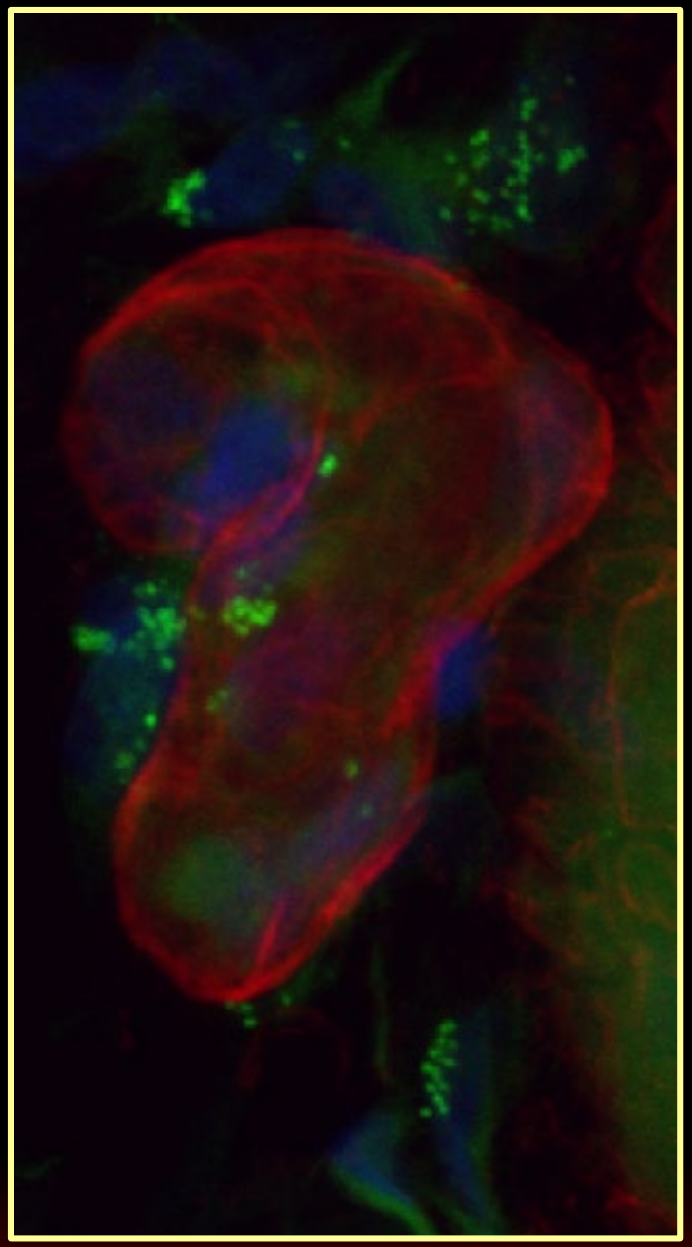
Ixodes scapularis

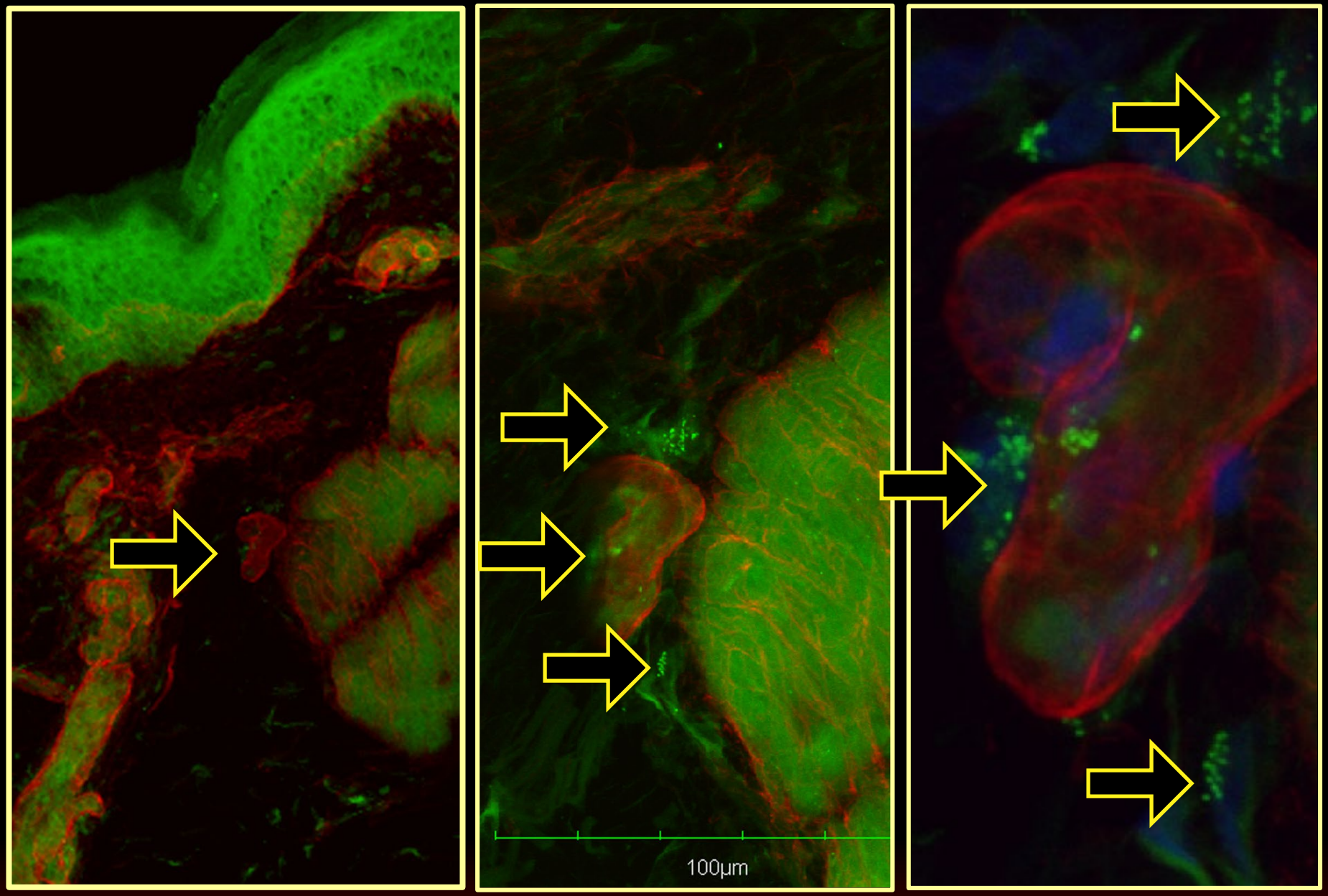
Autofluorescence of tick captured with multi-photon microscopy.

2009 - Science/NSF Science Engineering Visualization Challenge, semi-Finalist– photography.

STEALTH BACTERIA in SKIN

Bartonella henselae (green) found in and around blood vessels (red) in non-lesional calf skin of patient with Bartonella bacteremia.





Confocal image series, increasing magnification, of *Bartonella henselae* (green, arrows) in non-lesional calf skin of patient with Bartonella bactermia.

Bartonella Tracks/Skin Lesions

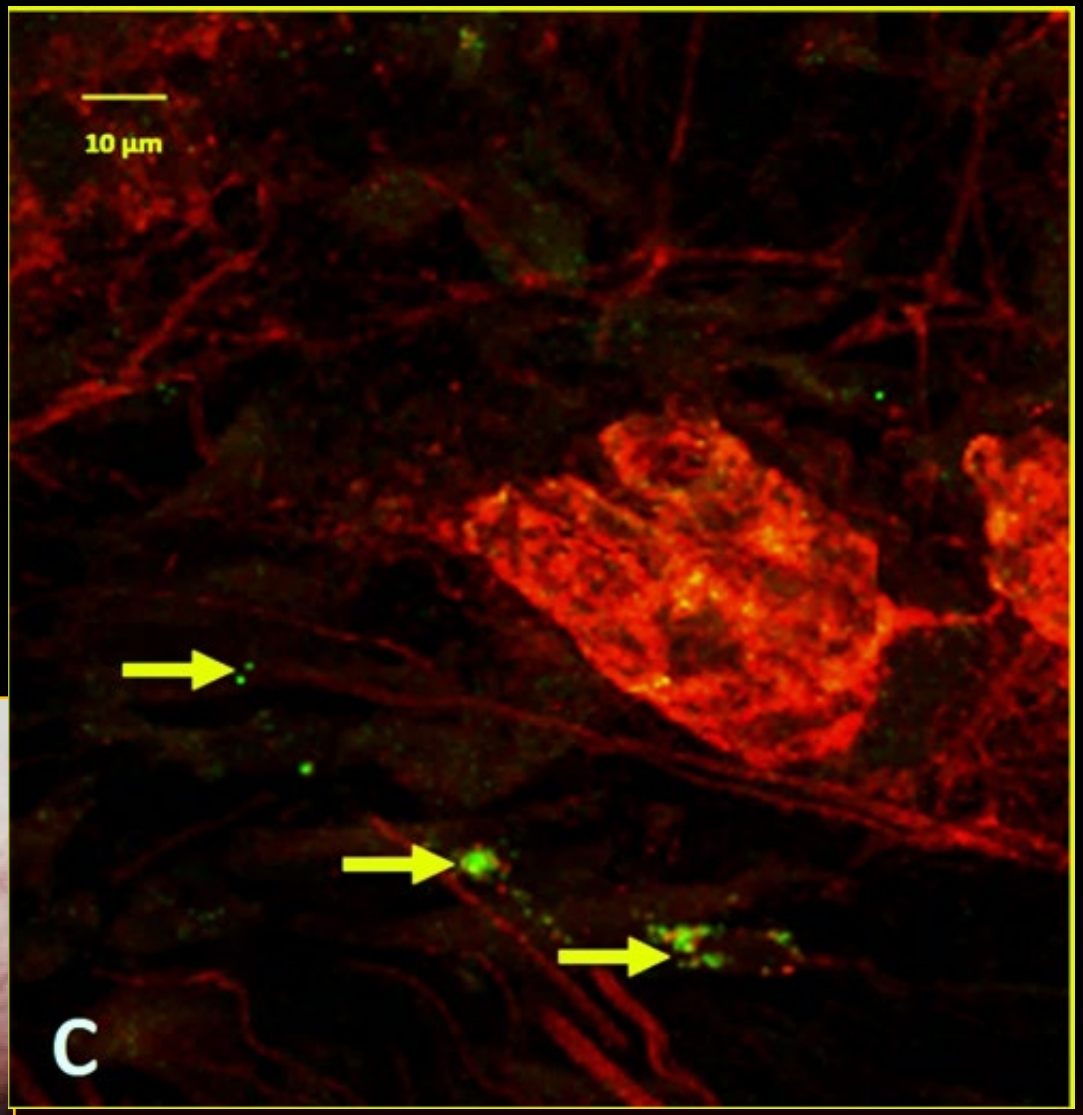
Bacterial adhesion to structural dermal elements may induce collagen malformation resulting in unusual linear formation.

- unilateral distribution
- no steroid ingestion
- not Ehler's Danlos – *collagen defects*
- not lifting weights
- can change coloration

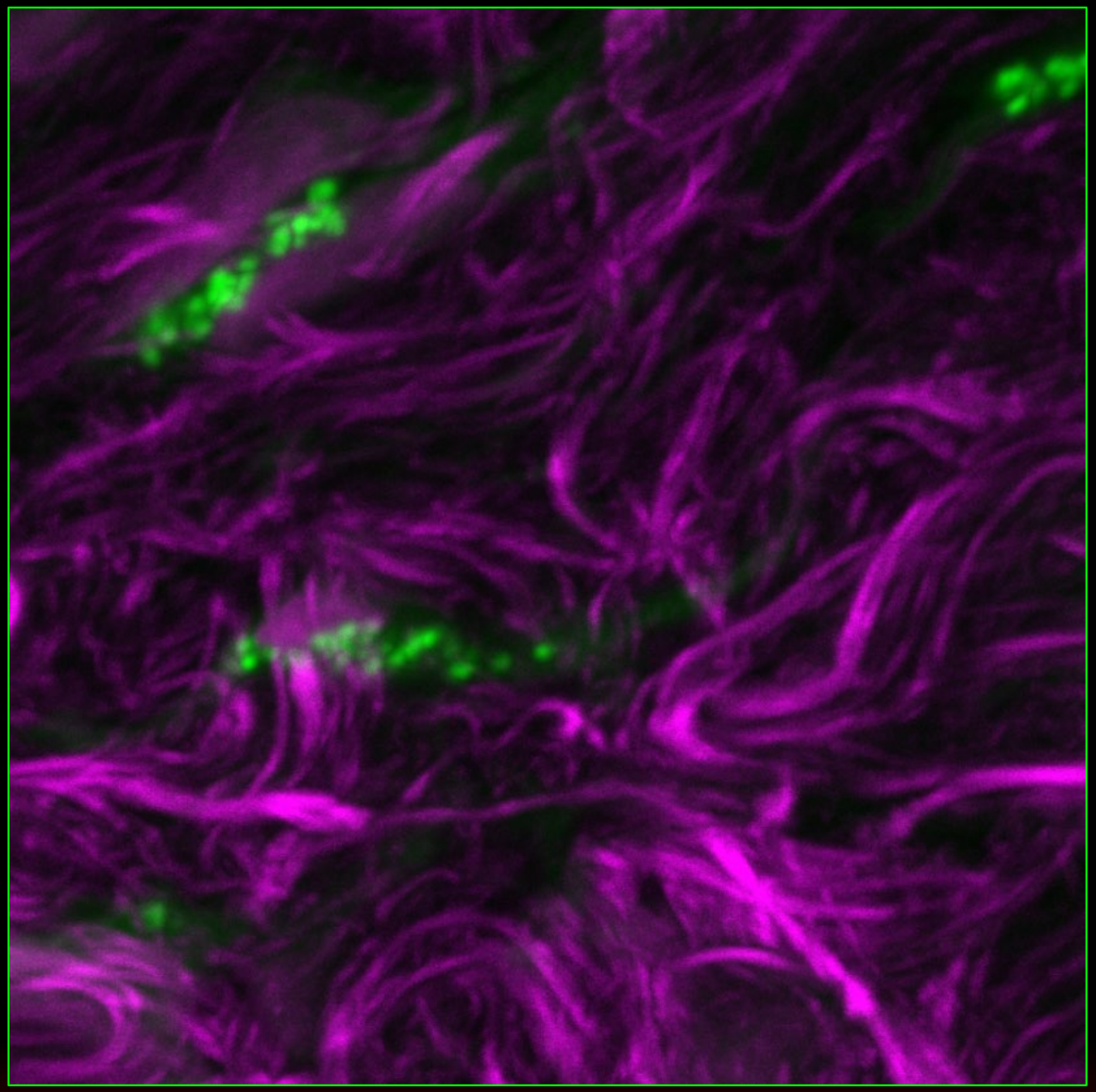
Patient Symptoms:

fatigue
headaches
memory loss
disorientation
peripheral neuropathic pain
loss of coordination
tick contact

Maggi et al, Parasit Vectors. 2013.



Confocal image of lesional skin stained for Bartonella henselae (green, yellow arrows) and blood vessels (red).



Bartonella henselae (green) intercalated in collagen fibrils (magenta) in non-lesional calf skin of Bartonella bacteremic patient.

Advanced Imaging Technique: Second Harmonic Generation with Multiphoton Laser Scanning Microscopy.

Balakrishnan *et al. Parasites & Vectors* (2016) 9:254
DOI 10.1186/s13071-016-1547-9

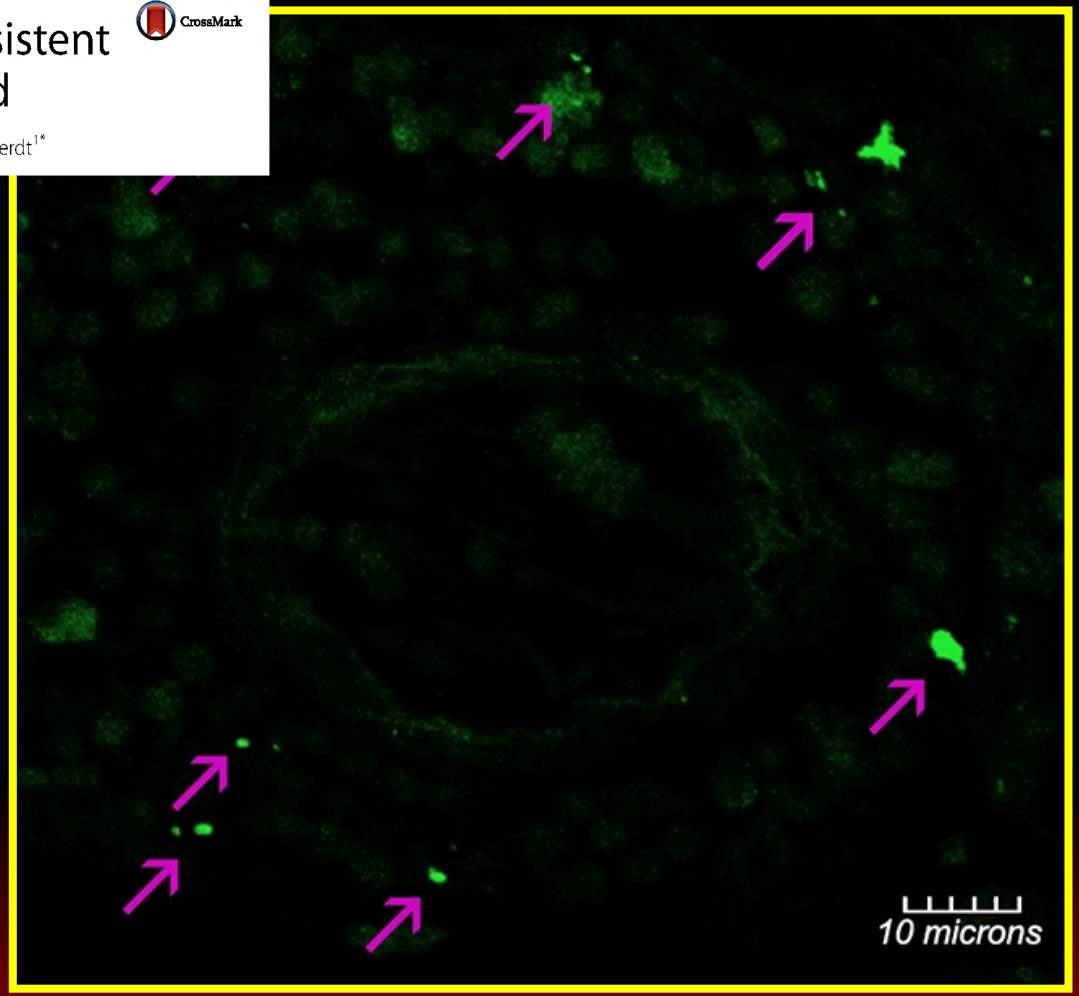
Parasites & Vectors

SHORT REPORT Open Access

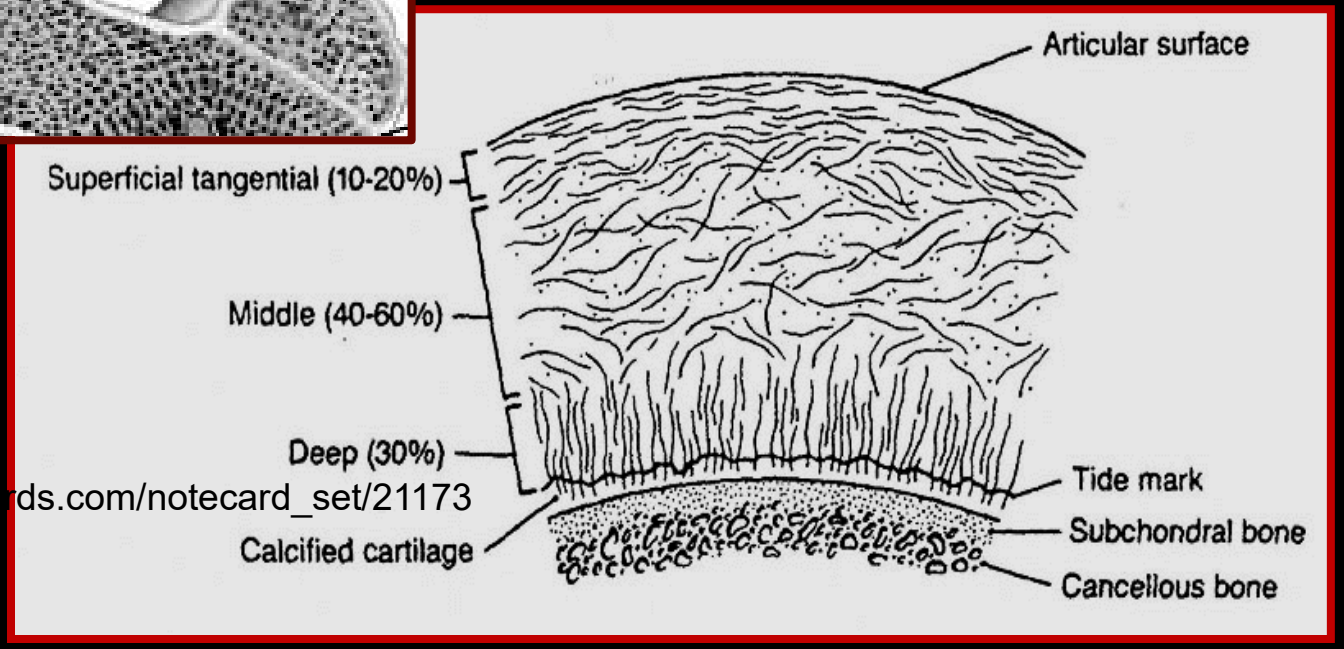
Vasculitis, cerebral infarction and persistent *Bartonella henselae* infection in a child

Vandhakumar Balakrishnan[1], Marna Ericson[2], Ricardo Maggi[1] and Edward B. Breitschwerdt[1*]

Human brain biopsy with *Bartonella henselae* (green, magenta arrows).

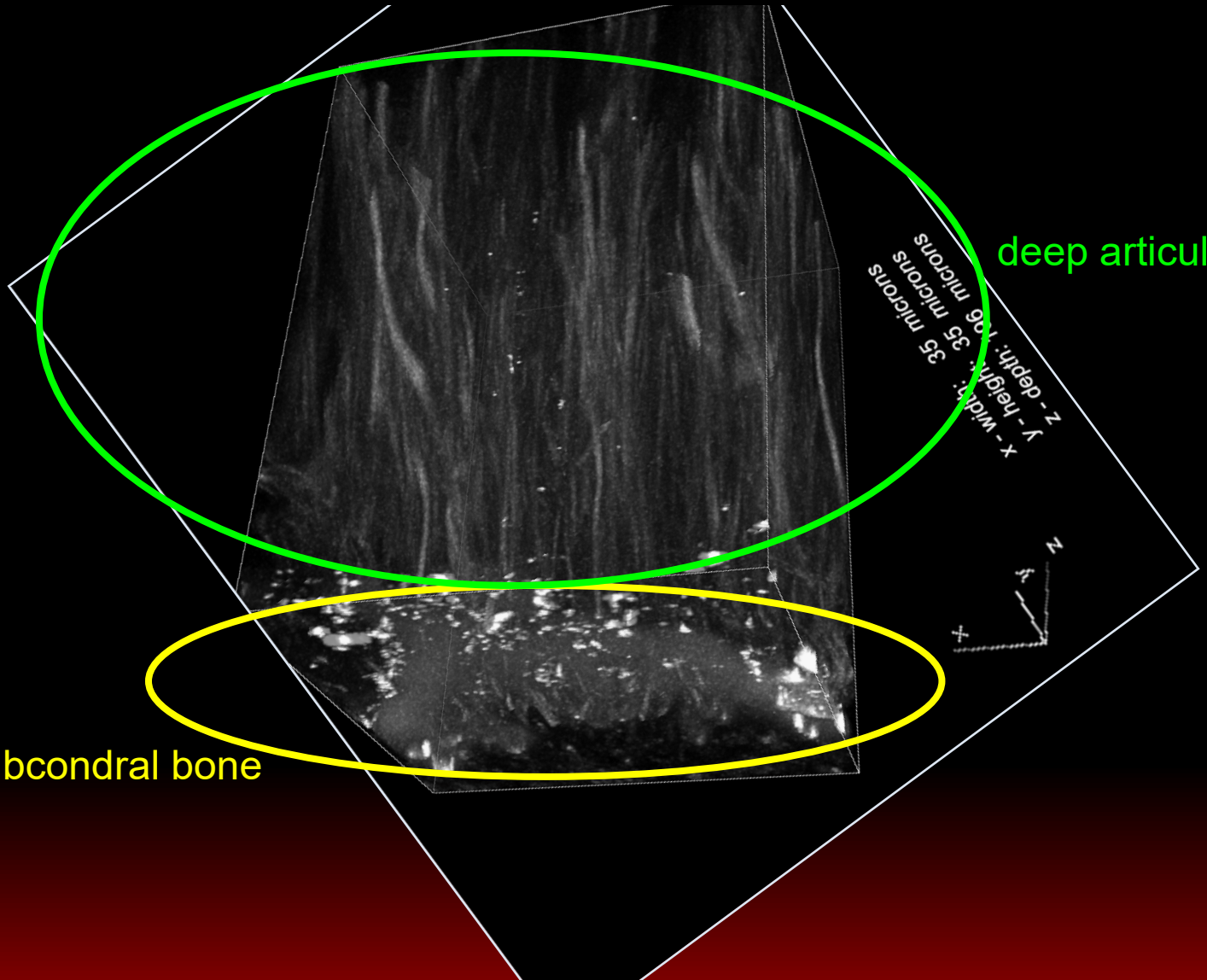


Immunoreactive *Bartonella henselae* detected in resected hip by confocal microscopy and second harmonic generation imaging.

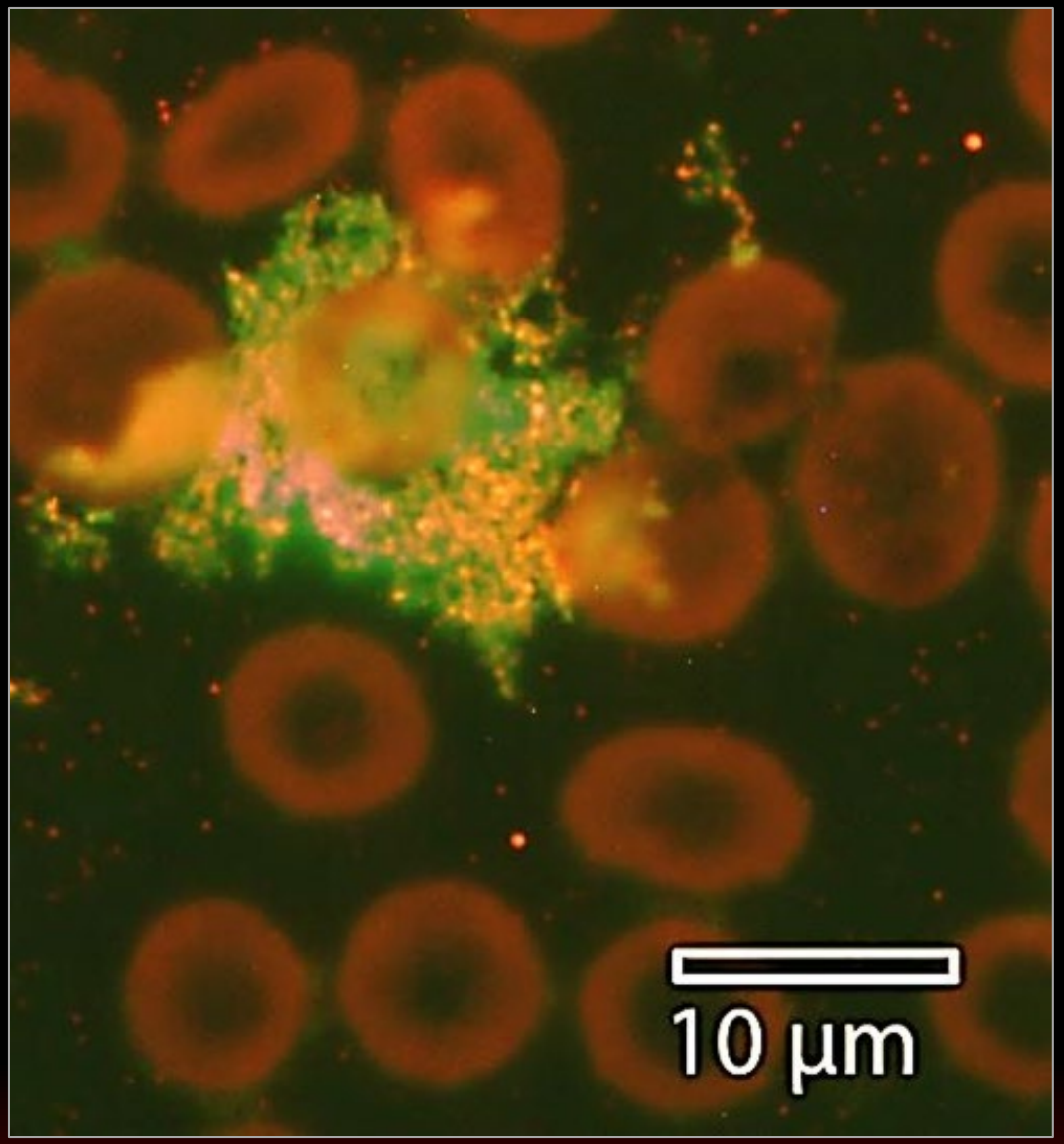


Ericson M, Balakrishnan N, Mozayeni B, Woods C, Dencklau J, Kelly S, Breitschwerdt, E. (2017) "Culture, PCR, DNA sequencing and Second Harmonic Generation (SHG) visualization of Bartonella henselae from a surgically excised human femoral head". Clin Rheum 36(7):1669-1675.DOI 10.1007/s10067-016-3524-2.

Second Harmonic Generation Imaging reveals *Bartonella henselae (white dots) is* abundant in bone supporting cartilage.



Biofilms (green) and *Bartonella henselae* immunoreactivity (magenta) in blood smear of Bartonella bacteremia patient.



3D super resolution microscopy of fixed, immunostained red blood cells from Bartonella bacteremia patient. Bartonella henselae immunoreactivity (red) and red cell membrane protein (green).

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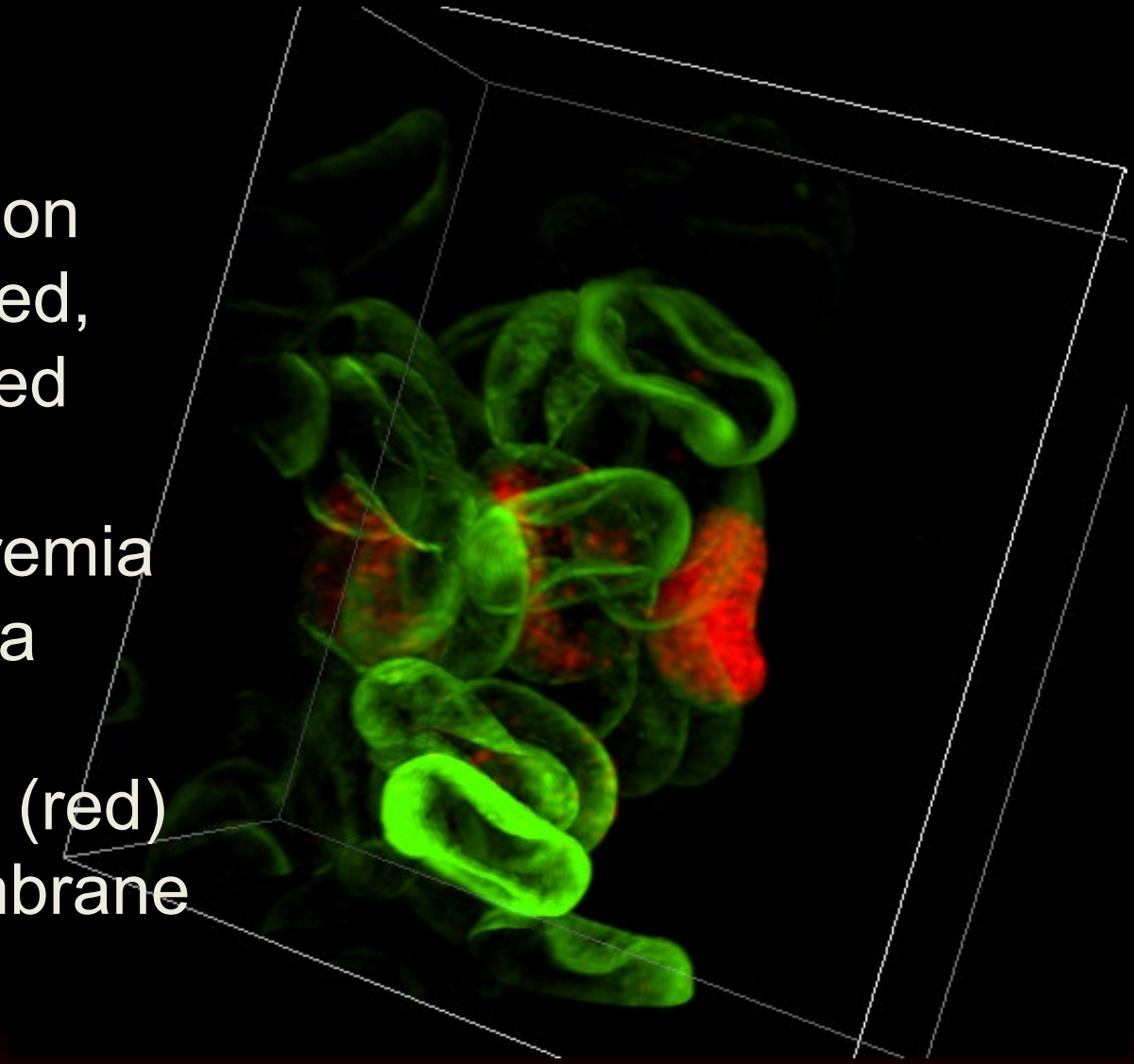
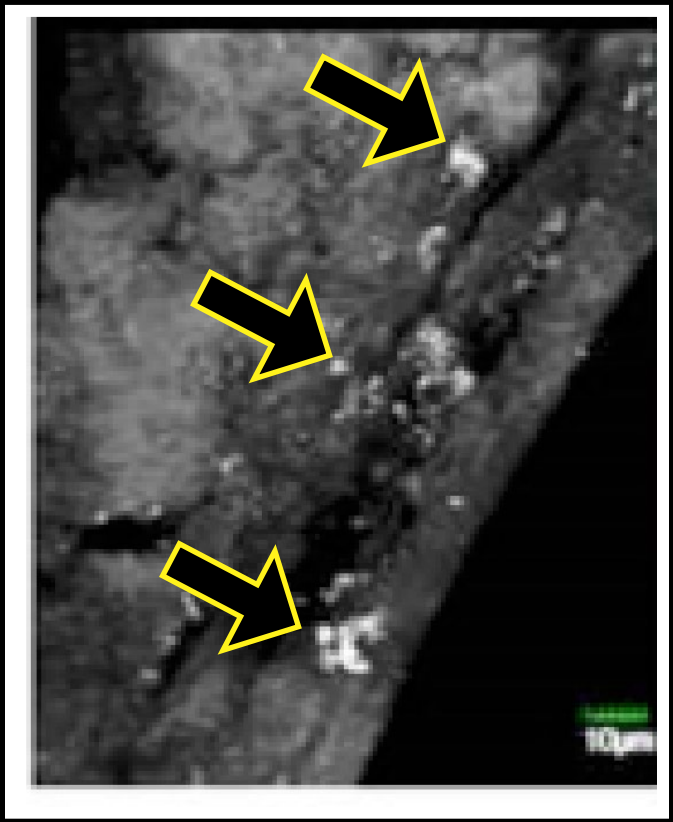
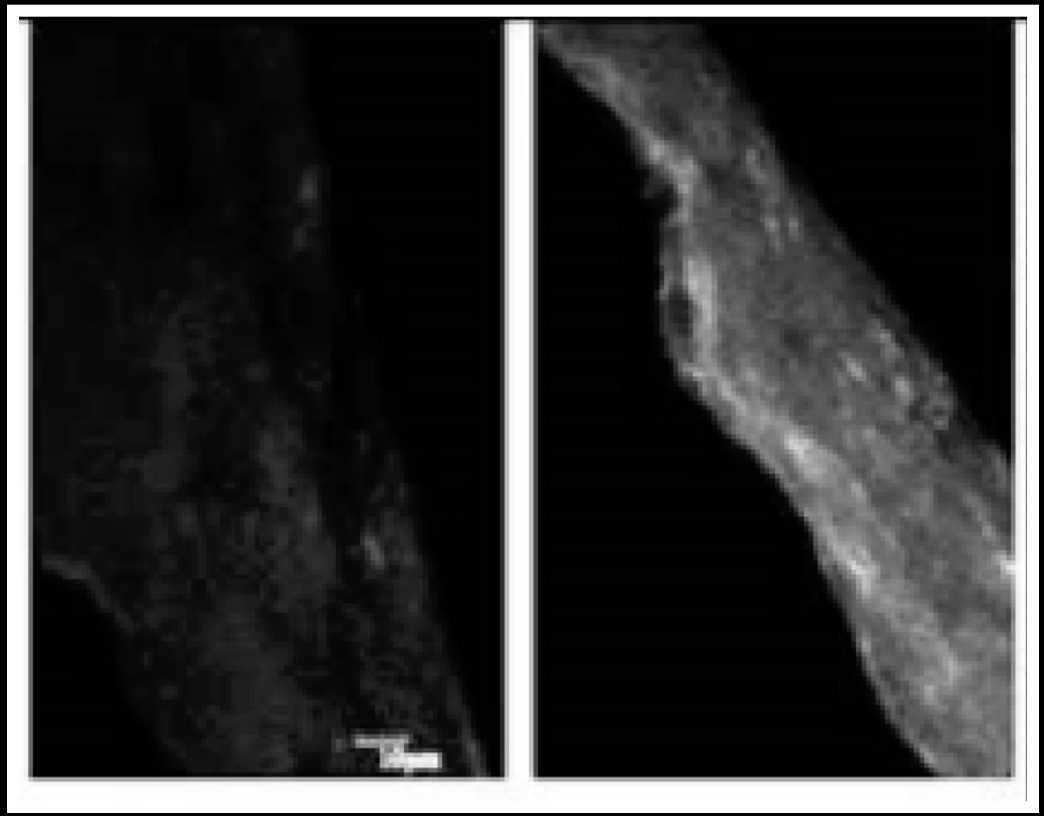




Bartonella henselae immunoreactivity (arrows).

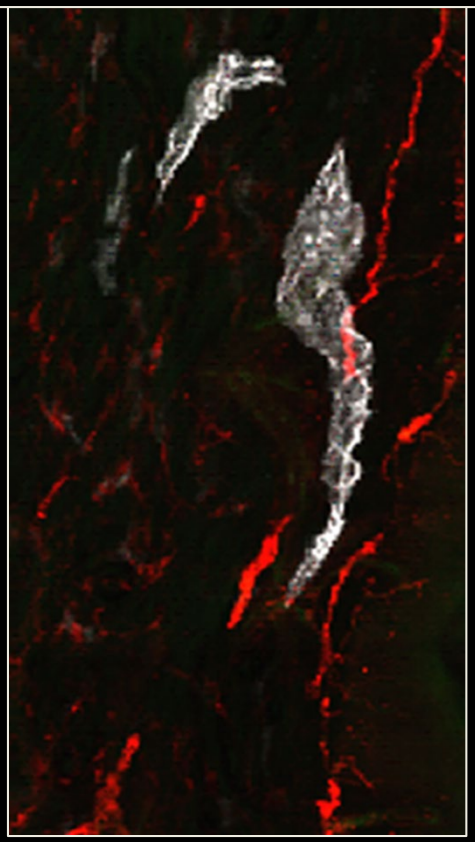


Left: no stain

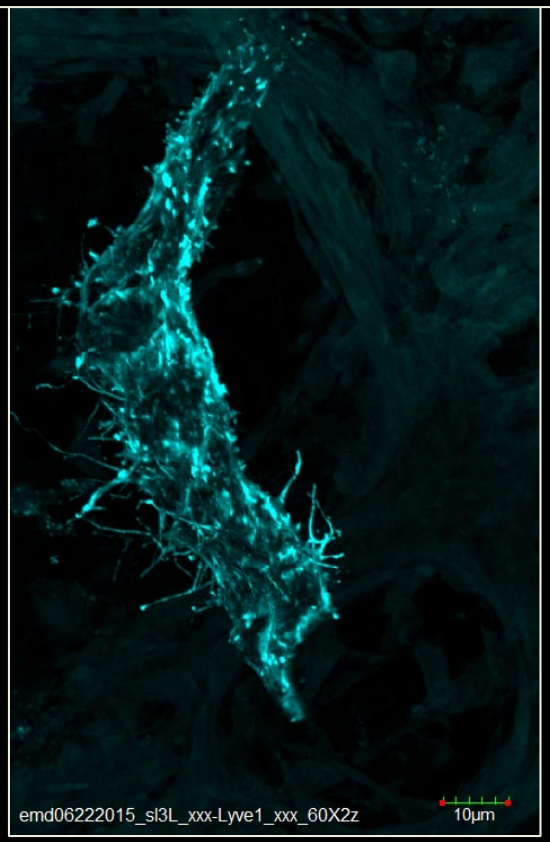
Right: diffuse Biofilm Tracer biomarker (white).

Peripherally inserted central catheter (PIC line) from patient with persistent Bartonellosis harboring *Bartonella* spp. biofilm.

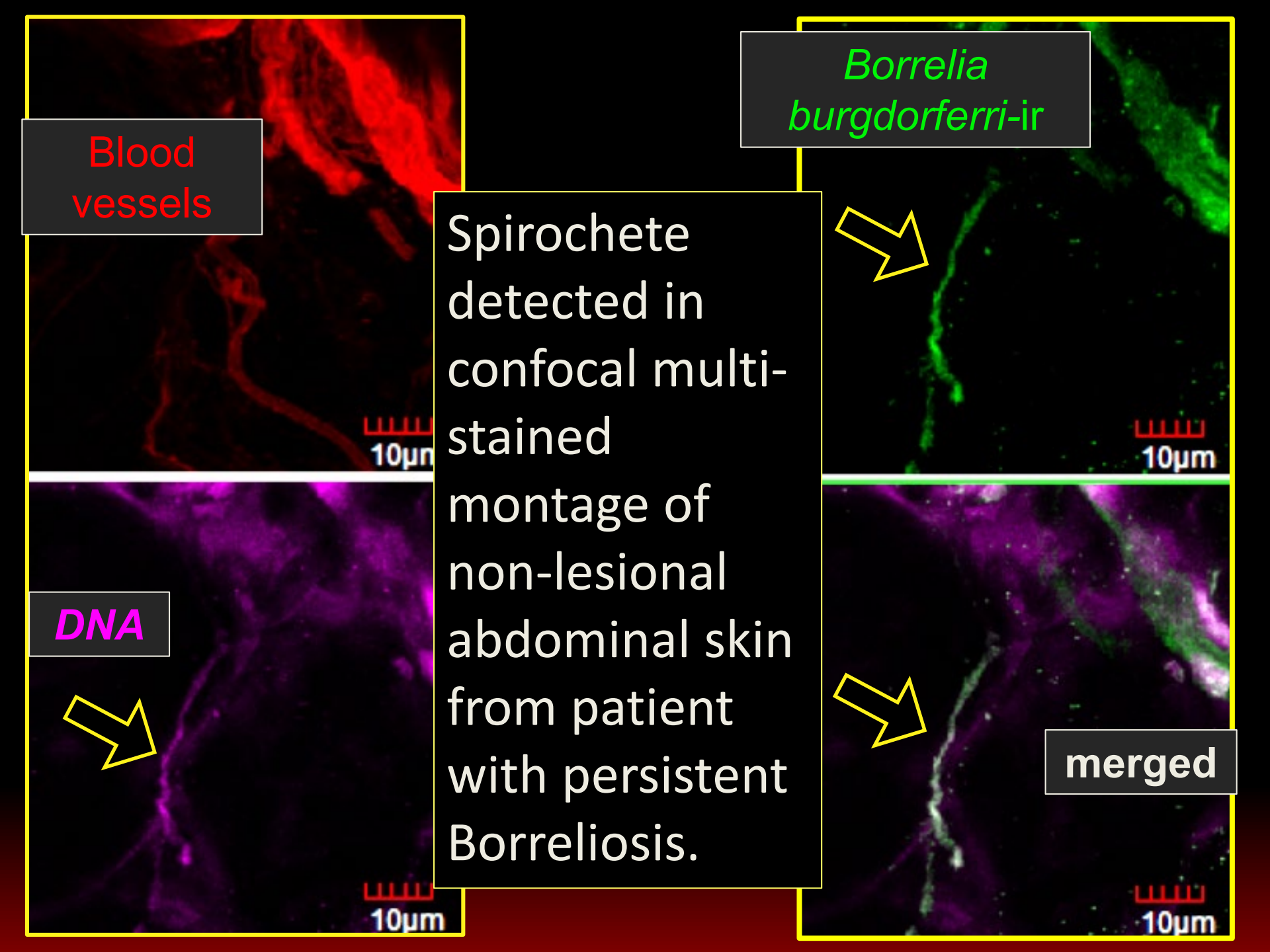
Dermal lymphatic vessels morphology altered in non-lesional skin from patient with Bartonella bacteremia.



Biopsy from non-lesional arm skin from control patient. Lymphatic Vessel (LYVE1) – white.



Non-lesional arm skin from patient with Bartonella bacteremic patient. Lymphatic Vessel (LYVE1) – aqua.


Blood vessels
Borrelia burgdorferi-ir
Spirochete detected in confocal multi-stained montage of non-lesional abdominal skin from patient with persistent Borreliosis.
DNA
merged
10µm
10µm
10µm
10µm

Work with us to beat Bartonella and other Vector-Borne Infections at:
https://crowdfund.umn.edu/?cfpage=project&project_id=24510