Low Frequency Noise and Health Effects

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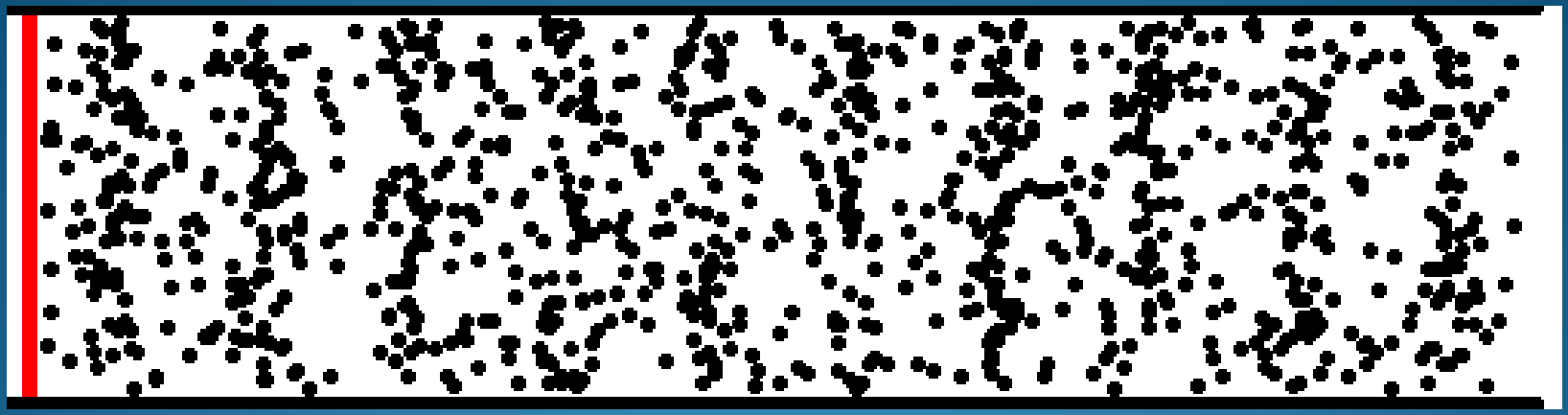
Defintions

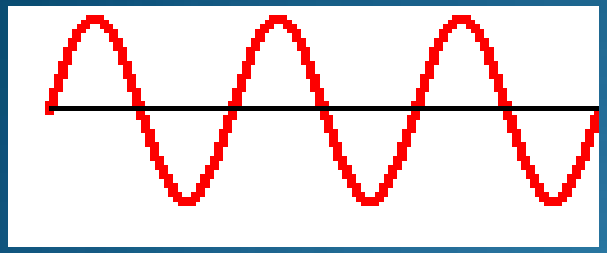


“Noise” is a pressure wave.

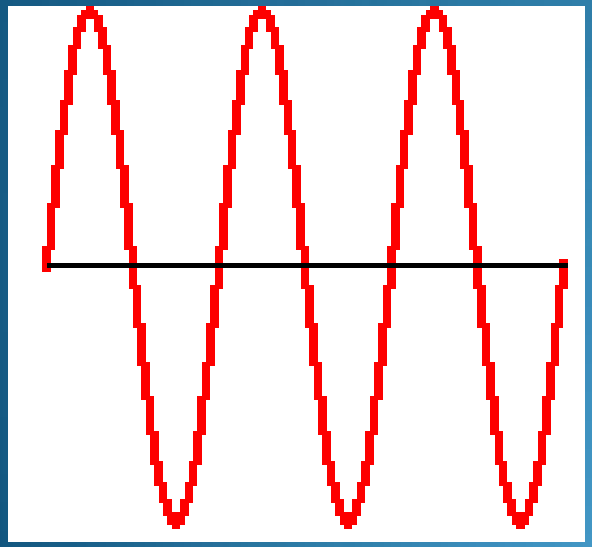
Because acoustic phenomena are waves, they require 2 parameters to be described:

Amplitude & Frequency

Defintions



Lower Amplitude



Higher Amplitude

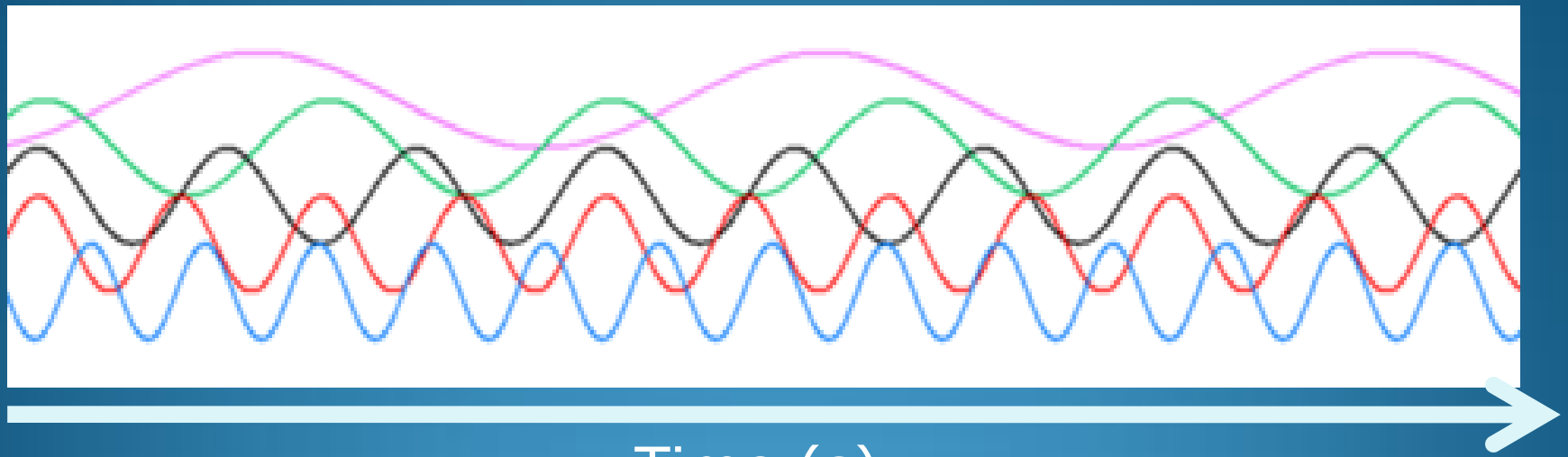
Waves with different amplitudes.

Amplitude of acoustical phenomenon is measured in Decibel (dB).

For acoustical phenomena to be heard, it must have a certain amplitude.

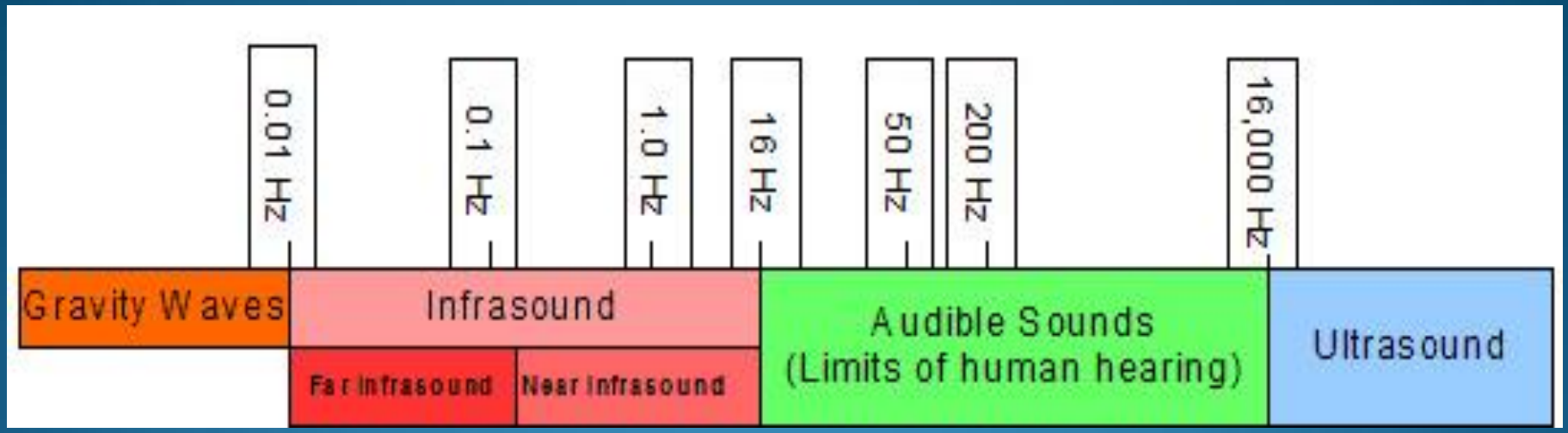
Defintions

Frequency, measured in Hertz, is the number of cycles in each second



Humans do not equally perceive all frequencies

Acoustical Spectrum



- **Audible frequencies: 20 Hz – 20 000 Hz**
- **Inaudible: Infrasound, < 20 Hz**
  Ultrasound, > 20 000 Hz

Most sensitive frequencies:
500 Hz – 8000 Hz

Erroneous assumption:

"What you can't hear won't hurt you"

Host must perceive agent of disease otherwise it will not be harmful ? (!)

This is the logical conclusion that follows from the (false) assumption that acoustical phenomena only affect the human via the auditory system.

Measuring Noise

- To protect against hearing loss and other maladies induced via the auditory system, such as annoyance.
- No need to measure that which is not heard because "what you can't hear won't hurt you".
- Must concentrate on the frequencies which will cause hearing impariment (500 Hz – 8000 Hz).

Hence, the use of dBA unit which simulates human hearing

dBA Unit

- dBA provides a measure of the amplitude as if being heard by the human auditory system.
- dBA unit is commonly used in legislation.
- The A-filter simulates human hearing
- dBA de-emphasizes all acoustical phenomena below 500 Hz, and ignores infrasound.

Is this, then, the most appropriate unit to be measuriing low frequency noise?

The usefulness of dBA

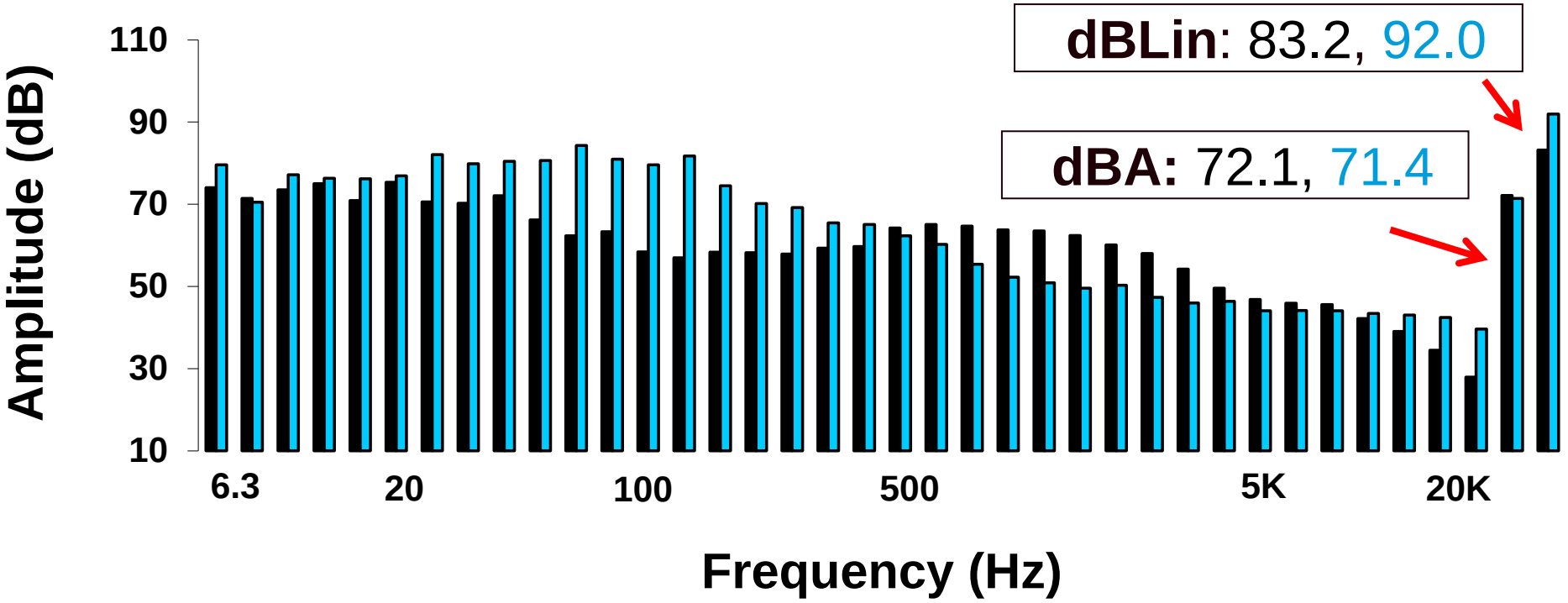
Cockpit	**72.1 dBA**
Stopped Train	**71.4 dBA**
Automobile @ 120Km/h	**71.2 dBA**

Theoretically, these are comparable acoustical environments…

… But are they really?

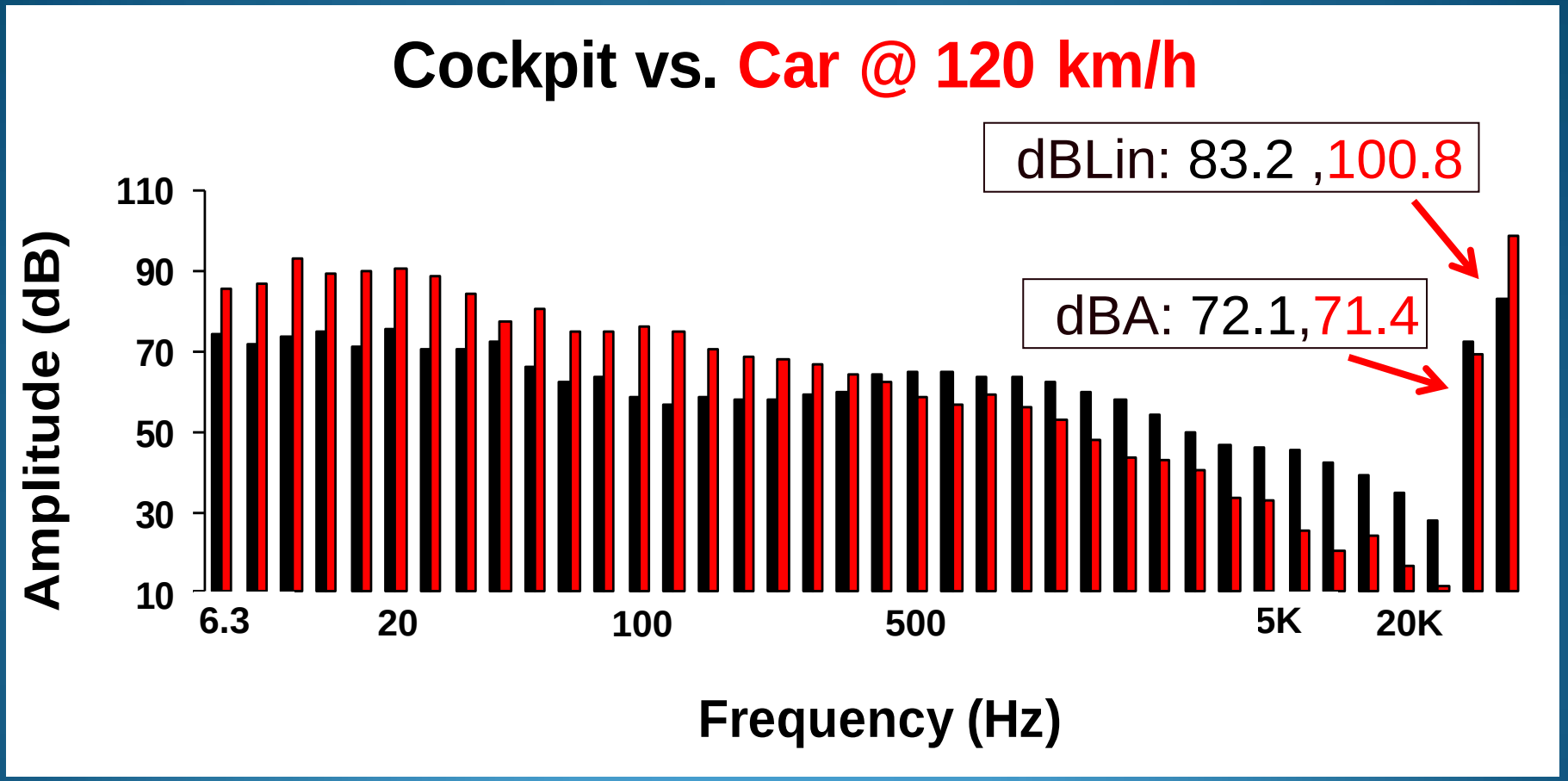
The usefulness of dBA

Cockpit vs. Stopped Train



dBLin = dB without A filter, i.e. linear

The usefulness of dBA



dBA unit is inadequate for measuring low frequency noise (LFN), < 500 Hz

Our Team's Research

- Began in 1980
  (today called *vibroacoustic disease* or VAD project)
- Initially focused on aeronautical technicians.
  -- Epilepsy among 10% (vs. 0.2%)
  -- Neurological changes
    Auditory Brainstem Evoked Potentials
    P300 Evoked Potentials
    Asymmetry of brain potentials
  -- Humor and cognition: aggressiveness, depression, memory and attention disorders.

Our Team's Research

- 1984 – National Public Health Award

- 1987 – Death of patient / aircraft technician

Autopsy findings:

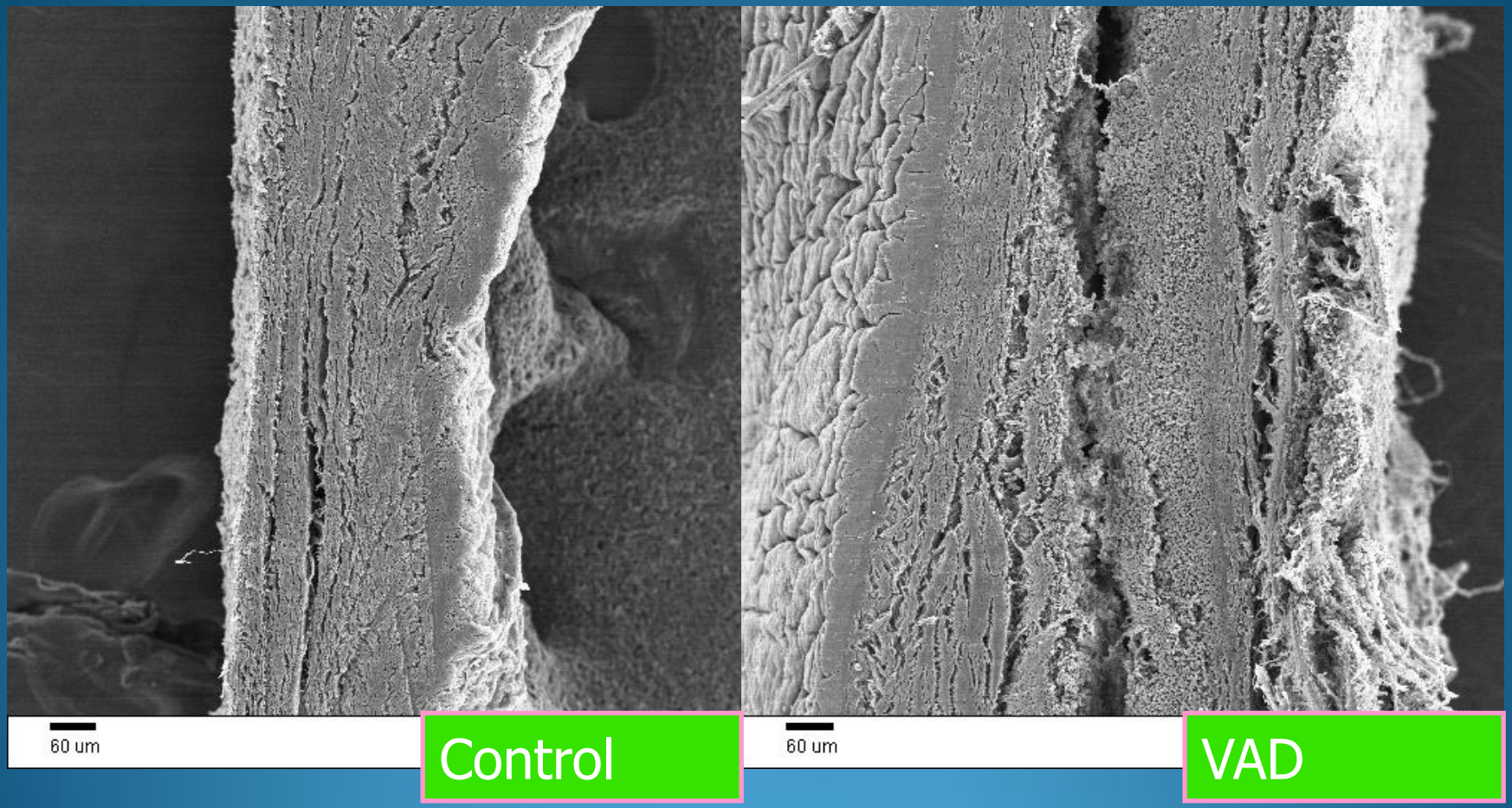
- 2 tumors (kidney and brain)
- Lung fibrosis
- Abnormal thickening of cardiovascular structures (pericardium and valves)

Disease not restricted to the Central Nervous System

Cardiovascular Thickening

- Can be seen through echo-imaging
- Echocardiograms in aircraft technicians revealed thicknening of cardiovascular structures, namely the pericardium.
- The pericardium is a sac that surrounds the heart and is <0.5 mm thick. In VAD patients it can reach 2.3 mm.
- Thickening due to LFN exposure is *unrelated to pericarditis* – no diastolic dysfunction is present, absence of inflammatory processes.

Pericardial Thickening



Scanning microscopy of Control & VAD patient pericardia. Note: scales in both images are equal.

Our Team's Research

Pericardial thickening is due to the abnormal growth of organized collagen.

- 1992 – begin using animal models (Wistar rats)

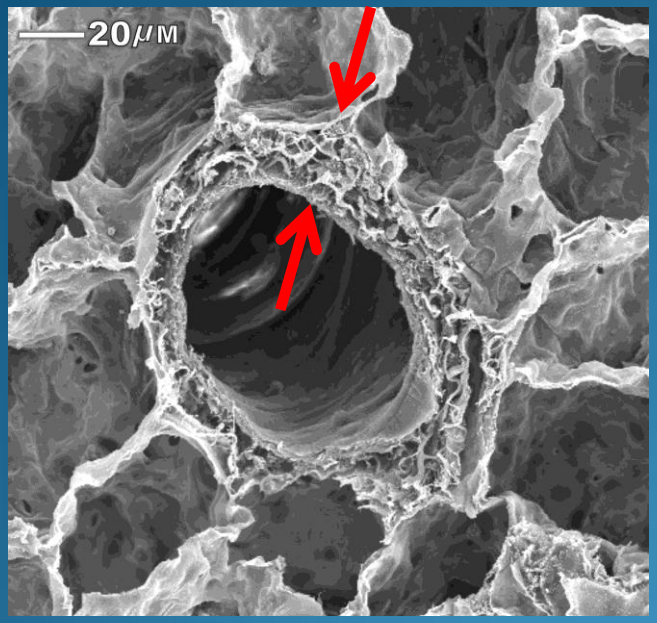
-- Thickening of blood vessel walls

-- Fibrosis of respiratory system structures

-- Disruption of cilliary populations

-- Fusion of actin-based structures

Blood Vessel Wall Thickening



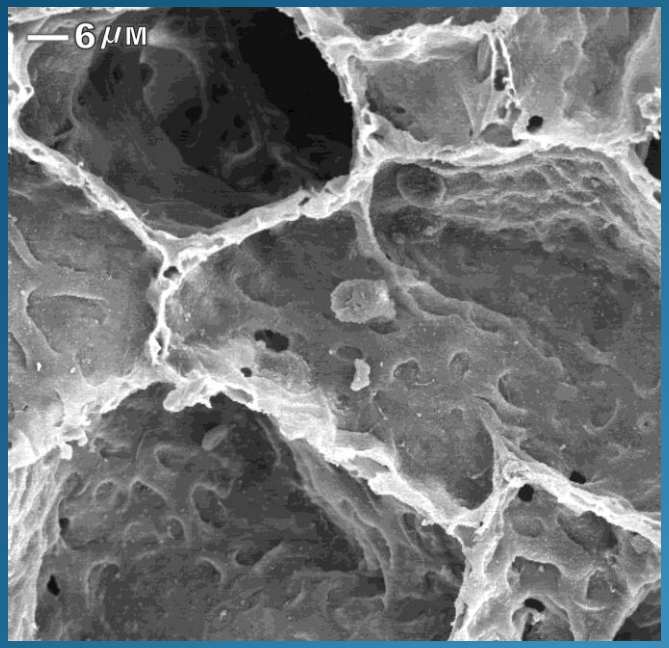
LFN-Exposed Rat

In VAD patient

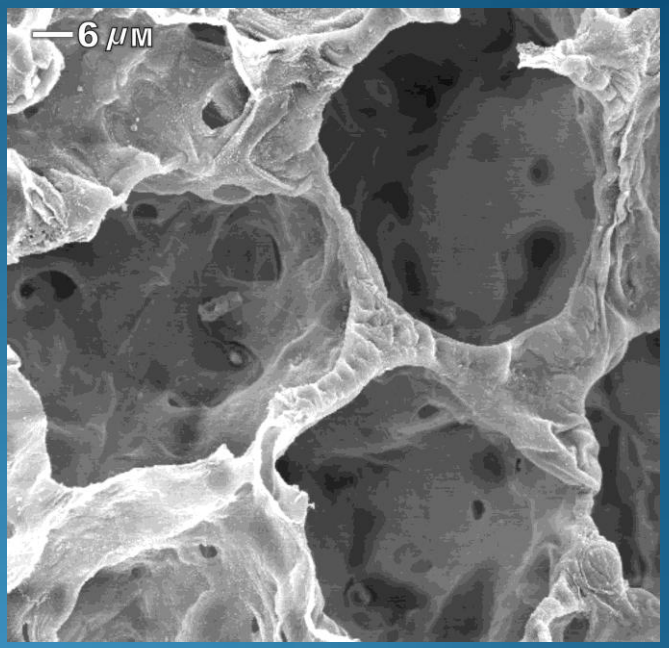
Thickening of media layer decreases lumen size and can ultimately cause ischemia...

... An Organic Basis for Cardiovascular Disease

Thickening Alveolar Walls



Control rat

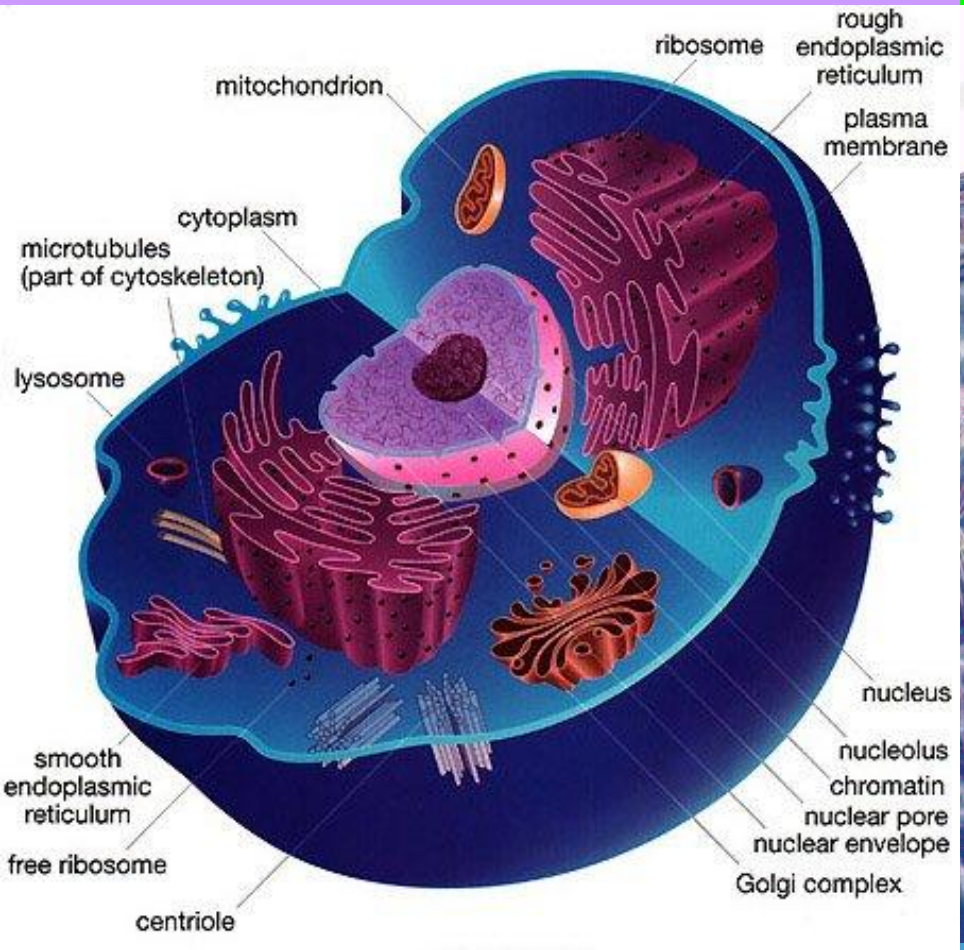


LFN-exposed rat

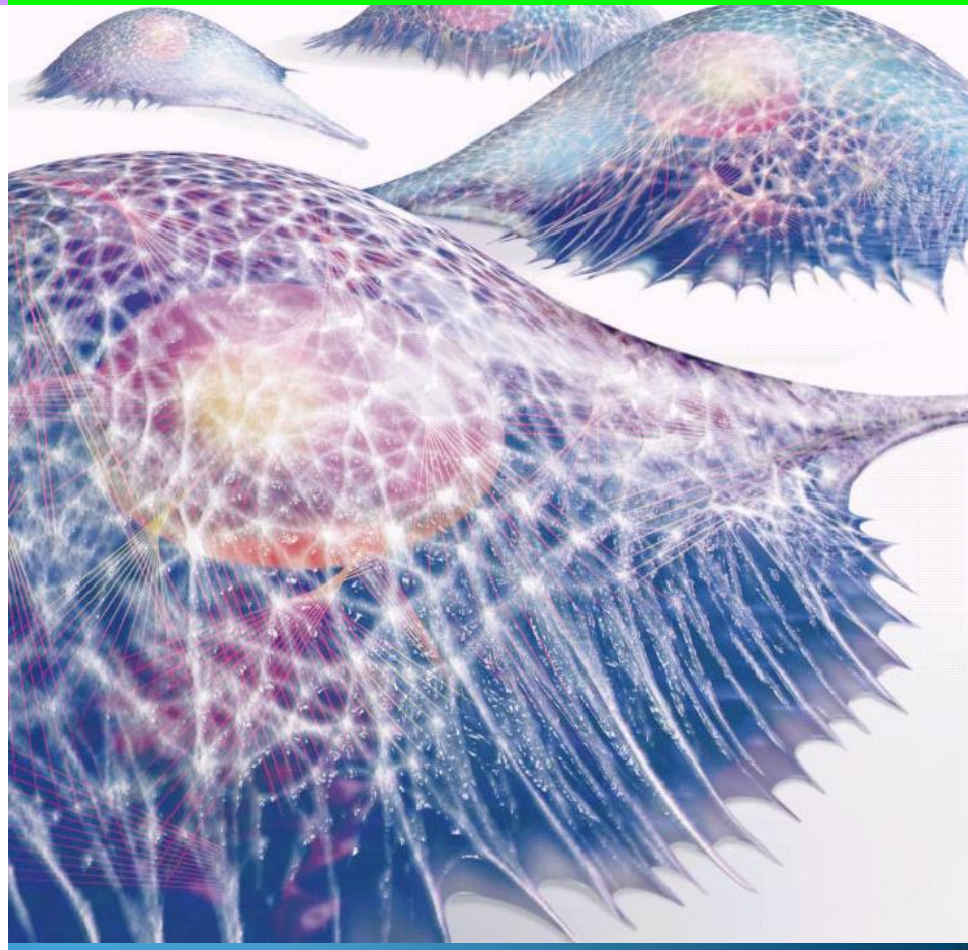
Thickening caused by abnormal proliferation of collagen. Note: scales in both images are equal.

LFN-Induced Pathology

Elastic-Continuum (Balloon) Model



Cytoskeleton Tensegrity-Based Model



LFN-Induced Pathology

- Characterized by the abnormal production of organized collagen.
- Can be preliminarily assessed with echo-imaging techniques.
- Develops over years of exposure to LFN.
- Has been identified in several occupational groups (aeronautical, heavy industry, factories).
- Has been identified in several environmental settings, such as in LFN-rich homes.

WT –case: Disclaimer

No anti-technology sentiments;

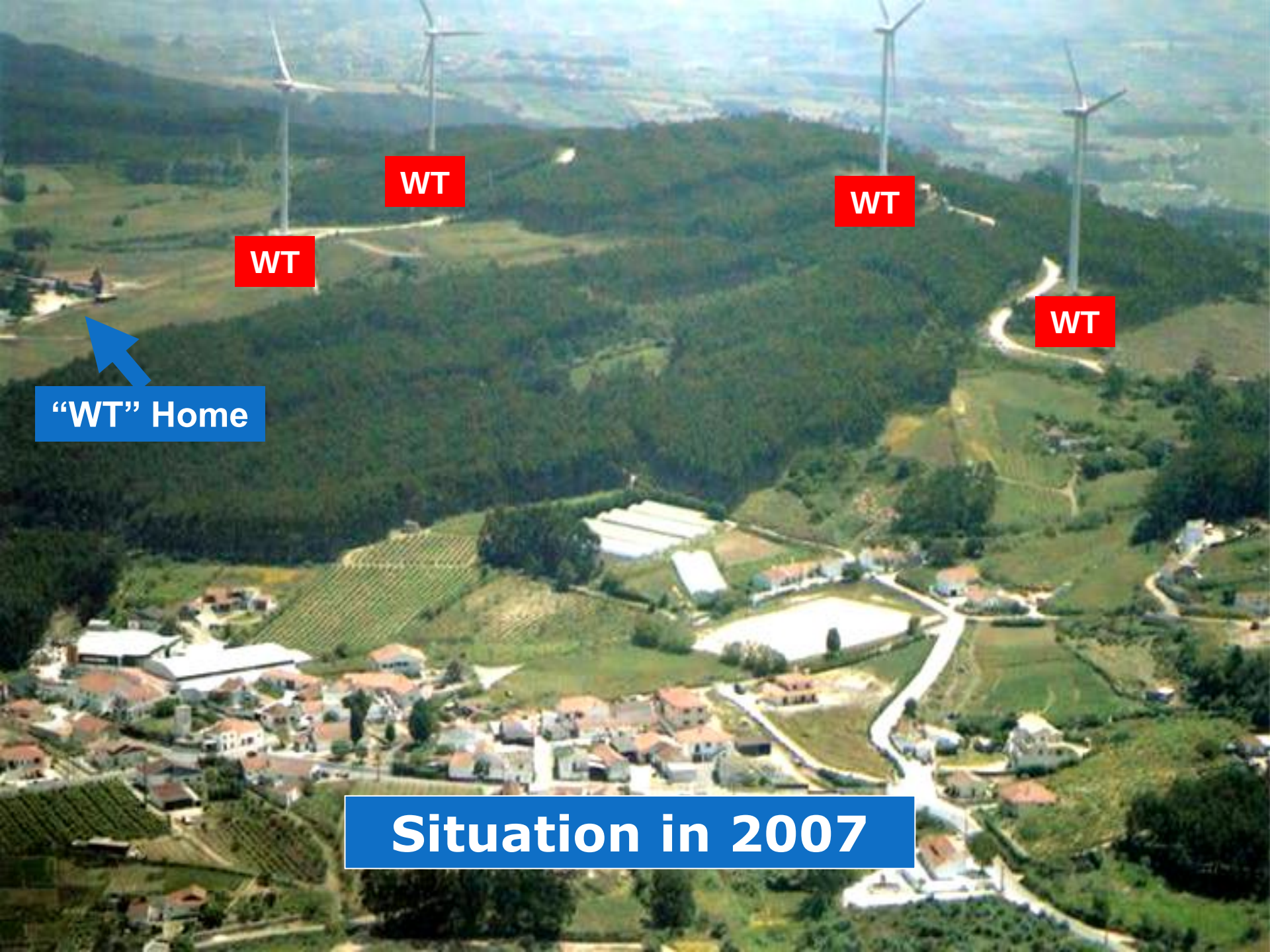
Wind Turbines are welcome additions to modern technological society;

Data is scrutinized under one, and only one, agenda - pure scientific inquiry;

Not a report arguing against the implementation of Wind Turbines;

Not members of accredited firm that conducted the acoustical measurements;

The consulting activities provided to these families are of a purely academic and scientific nature and hence are pro bono.


WT
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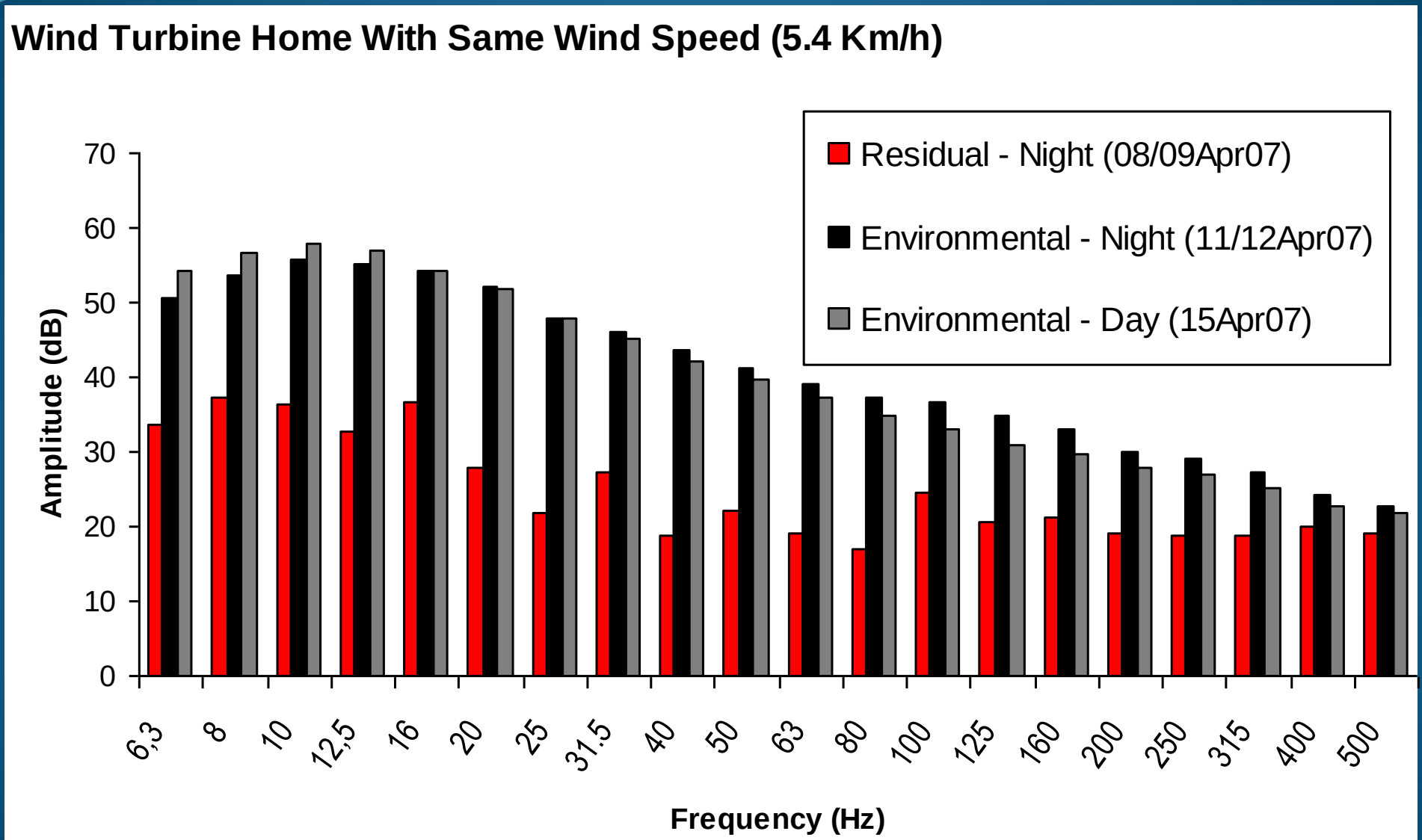
WT
WT
"WT" Home
Situation in 2007

LFN in Master Bedroom



WT Case

- WT began operation in Nov 2006
- Mar 2007: letter from school (12-yr-old):

  "*…It seems that [the child] has lost interest, makes a lesser effort, as if he were permanently tired".*

P300 of 12-year-old:

Jun 2007: **352 ms** *(norm: 300 ms)*

Sep 2007 *(after 2-month away from home)*: **322 ms**

WT Case

Echocardiogram Score *(April 2007)*

--	father	1
--	mother	1
--	12 year old son	1

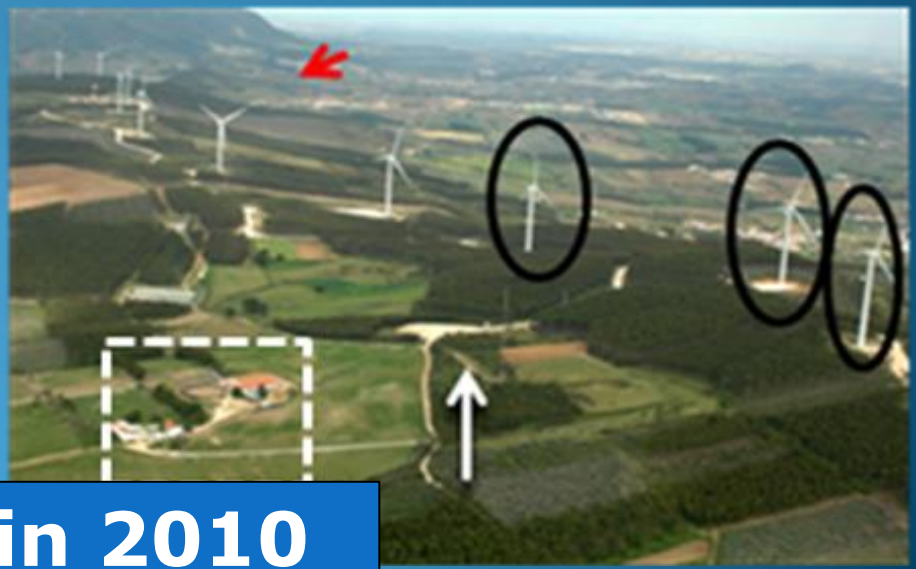
TODAY:

- Wife and children no longer live in this house. P300 of child is normal.
- Husband must stay to tend to thoroughbred Lusitanian horses. His health is visibly deteriorating, with increased cognitive impairment and severe noise intolerance.

Legal Proceedings-2007

Standing Court Order:

- WT No. 2 , closest to the home, at 322 m was order to be shut down.
- All other 3 WT were ordered to be shut down during evening (8-11 pm) and night hours (11 pm – 7 am).



Situation in 2010

Effects on Horses

Inability to place the hoof flatly on the ground (tip-toeing, boxy foot or club foot)

Espartaco, Case 4
Born 02May09,
father: Zircão,
mother: Vassoura.

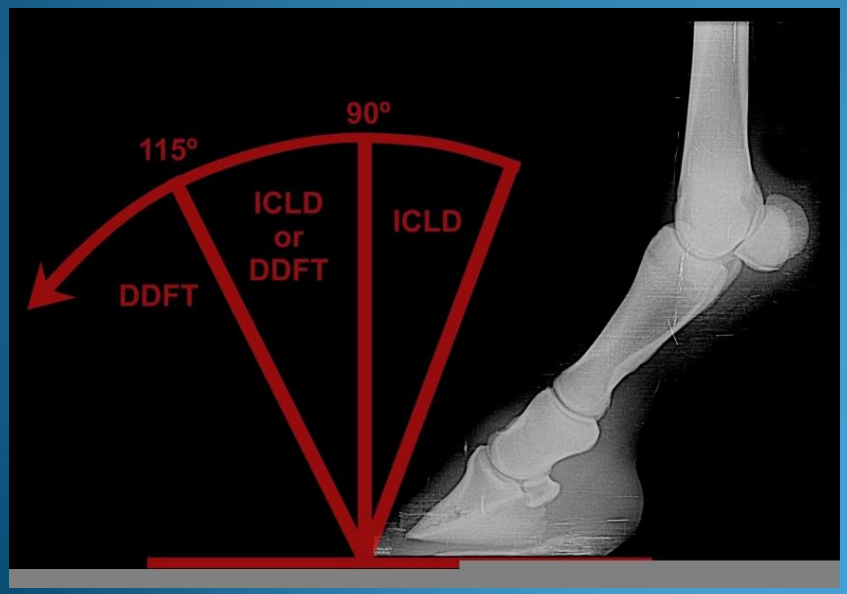
Engenheiro, Case 5
Born 17May09,
father: Zircão,
mother: Zizi.

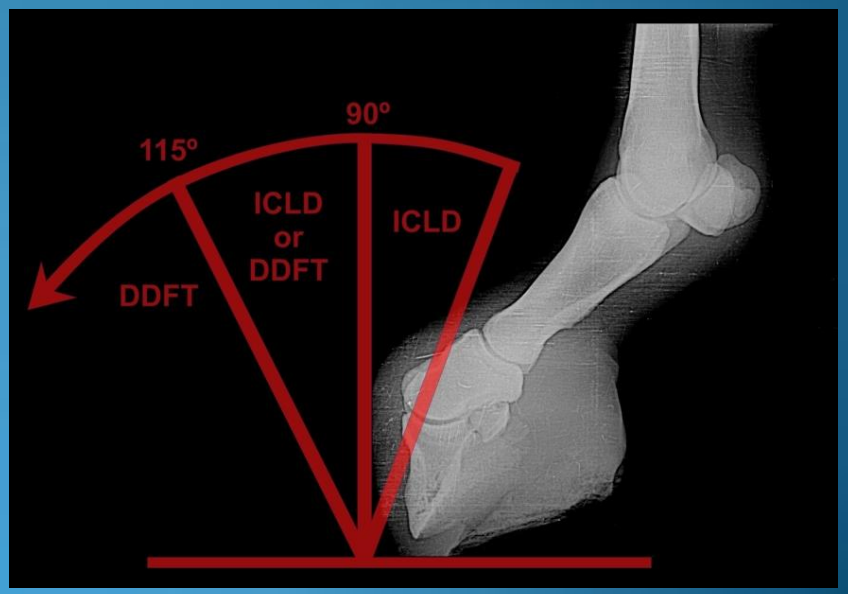
Equine Flexural Limb Deformaties

Espartaco, Case 4
Born 02May09

<u>Right forelimb</u>
Normal alignment
Hoof wall-to-floor angle:>115º.

<u>Left forelimb</u>
Severe EFLD.
Hoof wall-to-floor angle:<115





Effects on Horses

- Ligament biopsy / Corrective surgery
- Tissue analysis

Check for LFN-induced signs, i.e.

- Check for abnormal collagen growth in the absence of inflammatory procceses

Because court proceedings require that the illness take its natural course in order to be assessed, corrective surgery was not performed on all cases.

Case No.	Corrective Surgery	Origin	Abnormal Collagen Growth
1. Canela 26FEB07	YES	**Born on farm** Father: Operário Mother: Juvita	**YES**
2. Desplante 02FEB08	YES	**Acquired** (age: 15 days) Father: Importante Mother. Vassoura	**YES**
3. Dondoca 04APR08 ***CONTROL***	NO	**Acquired** (age: 14 mo.) Father: Urânio Mother: Scalabitana	**NO**
4. Espartaco 02MAY09	NO	**Born on farm** Father: Zircão Mother: Vassoura	**YES**
5. Engenheiro 17MAY09	NO	**Born on farm** Father: Zircão Mother: Zizi	**YES**

Conclusion

- Excessive LFN exposure cause abnormal collagen growth in the absence of inflammatory processes.
- Subjective complaints, such as annoyance and sleep disturbance can depend on previous noise exposure history.
- Noise exposure histories are essential for a scientifically valid clinical surveys.
- Safe distances are, as yet, undetermined.
- dBA units are inadequate for assessing LFN.

Thank you for your attention!

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