

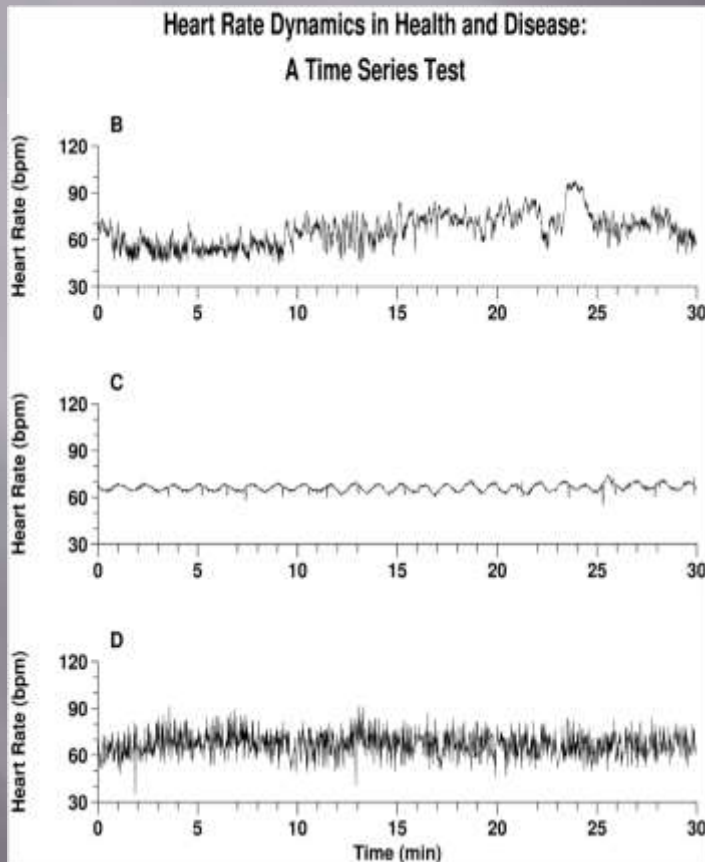
SELF-SIMILARITY IN THE HEARTBEAT TIME SERIES OF MICE

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How Math Can Help Save Lives

Study



- Interaction between Mathematics and Physiology
- Apply mathematical concepts to biomedical problems

Experiment



Purpose

▣ Previous Research

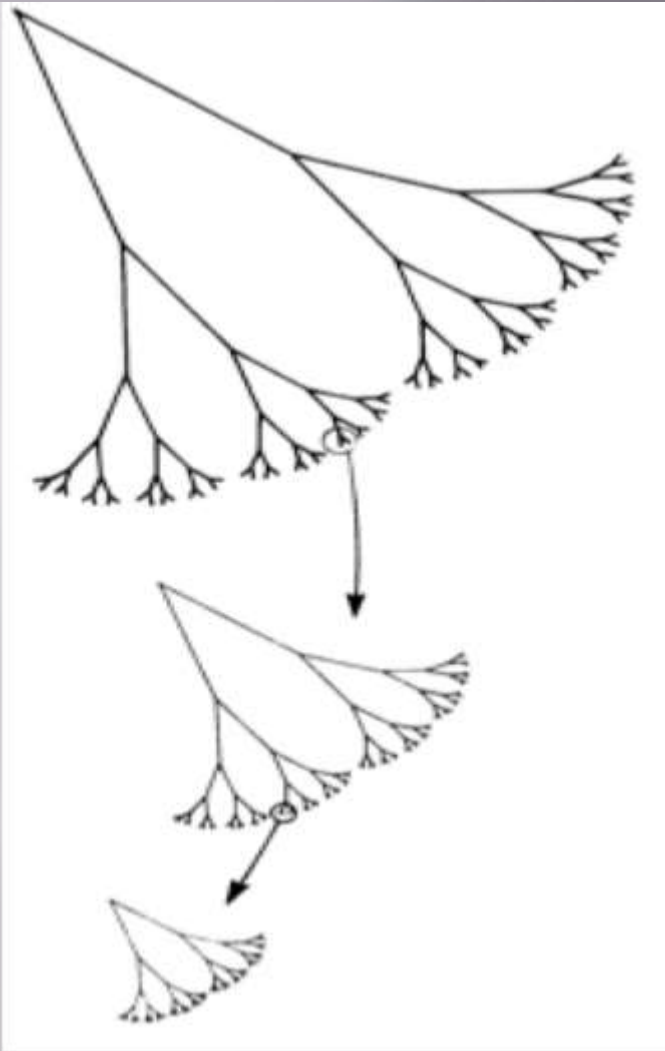
- Found self-similarity in human heartbeat
- Identify features in mouse heart rate rhythms

▣ Present Research

- Verify self-similarity in healthy mouse heartbeat
- Simulate disease by inducing drugs
- Distinguish healthy heart rate from the disease
- Challenge the result with other mathematical concepts

Self-Similarity

Geometric View

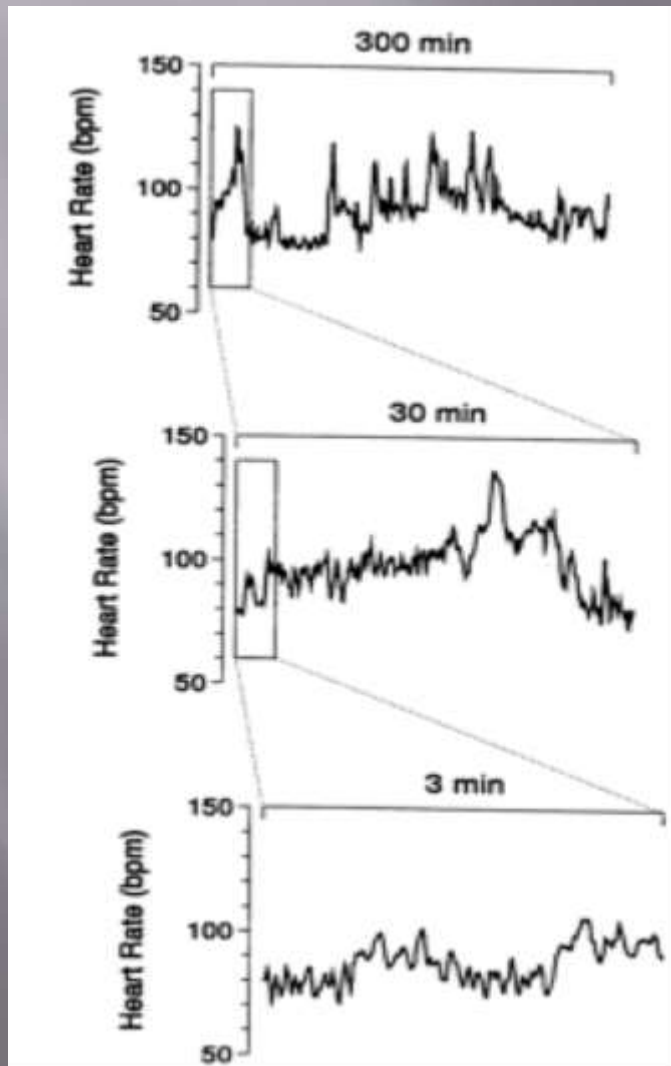


- ▣ **Definition:** Appearing the same at all magnifications.

- ▣ Many structures in nature display self similarity.
 - trees
 - coastlines
 - mountains
 - anatomic structure

Self-Similarity Cont'd

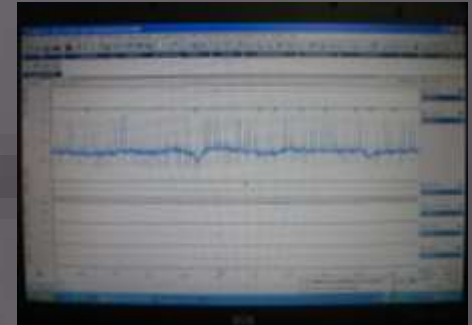
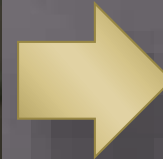
Dynamic View



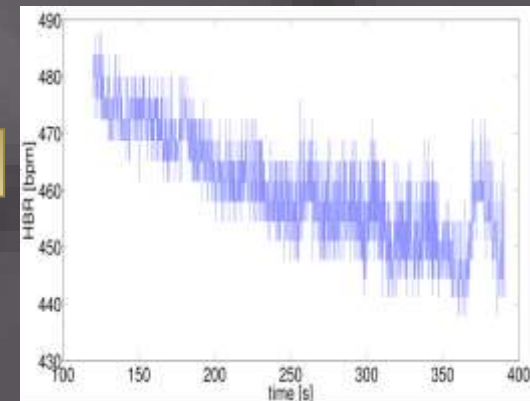
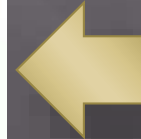
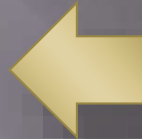
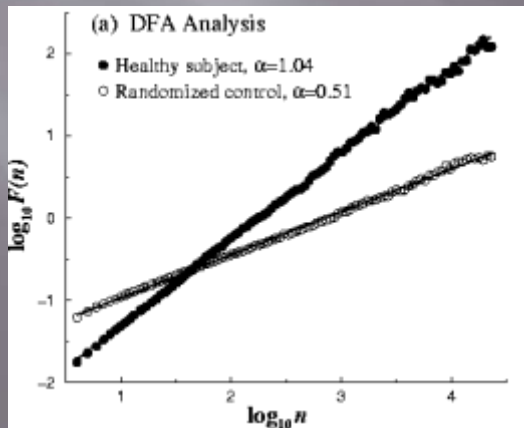
- Self-Similarity in healthy heart rate time series
 - Irregular appearance at all magnifications
 - Statistically self-similar on different time scales

Procedure

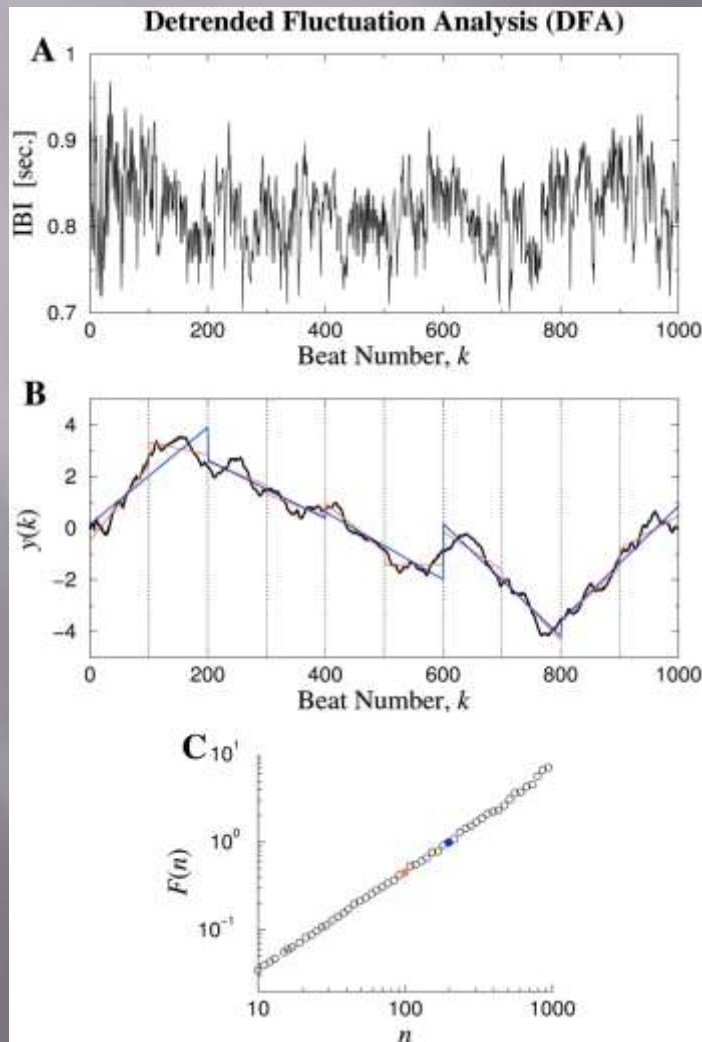
1. Measurement



2. Analysis



Detrended Fluctuation Analysis (DFA)



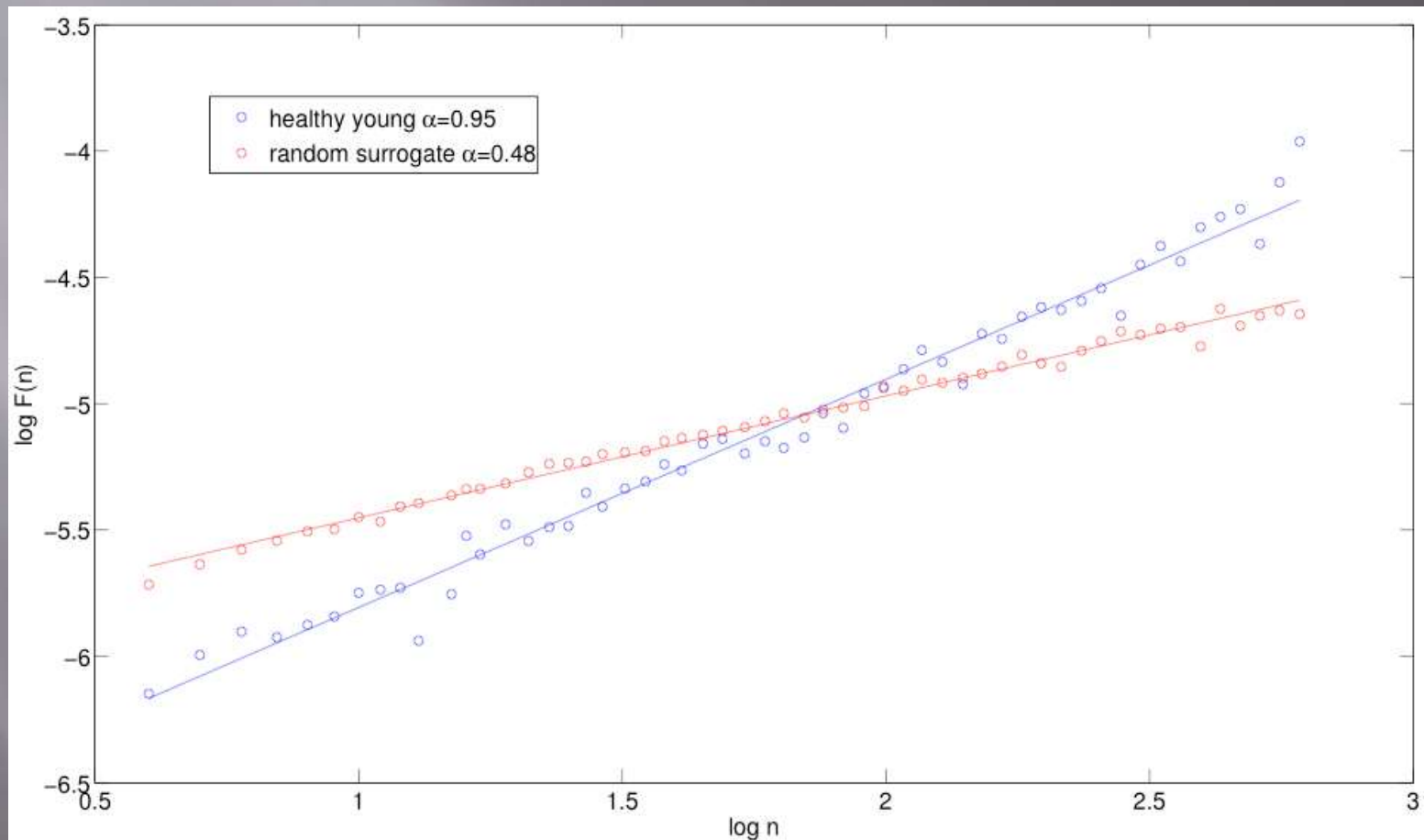
- Illustration of DFA Algorithm

1) $y(k) = \sum_{i=1}^k [B(i) - B_{ave}]$

2) $F(n) = \sqrt{\frac{1}{N} \sum_{k=1}^N [y(k) - y_n(k)]^2}$

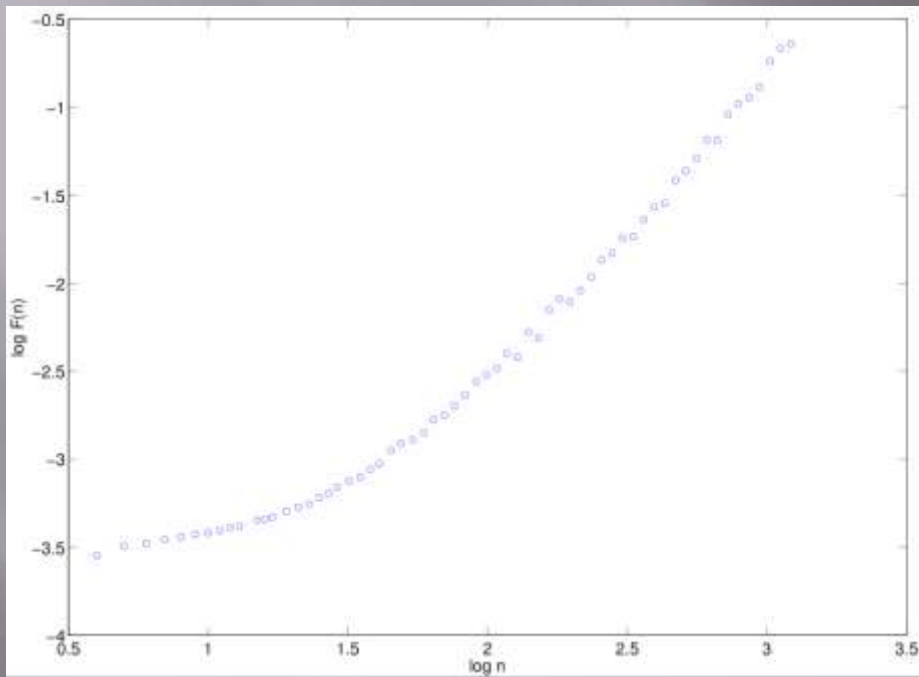
Result #1

Healthy and Randomized Data

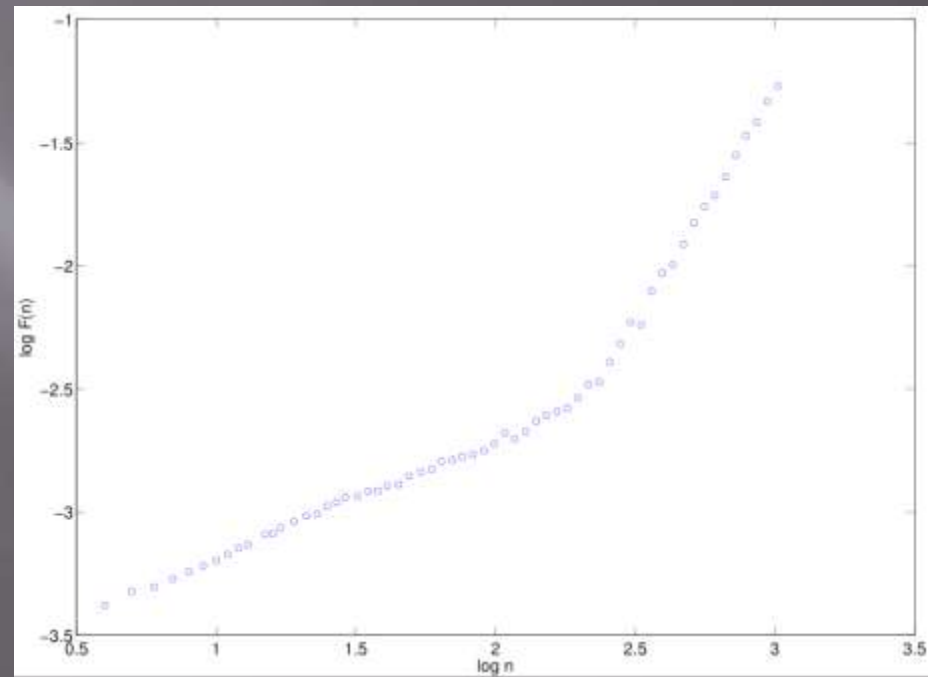


Result #2

Obese



Drug-Induced



Drug: Isoproterenol → Arrhythmias

Conclusions

- ▣ Self-similarity is displayed in the healthy heart rate.
- ▣ DFA analysis is able to detect irregularity (obese and drug-induced mice.)

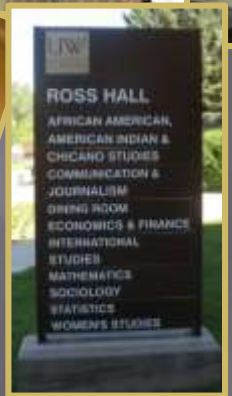
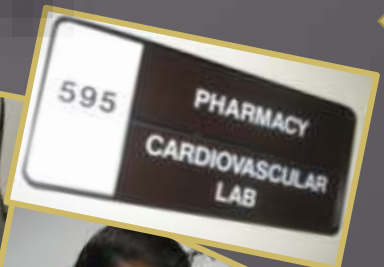
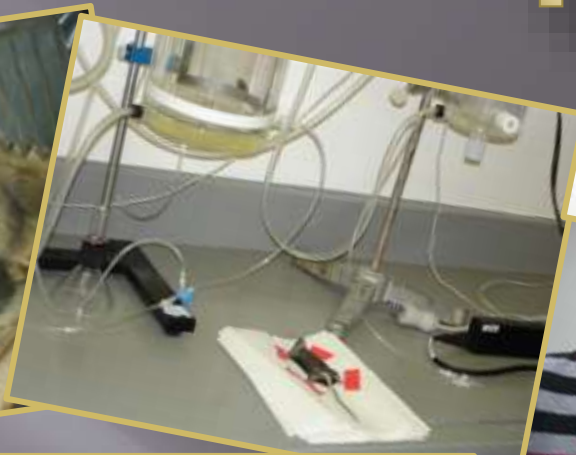
Future Study

- ▣ Apply other mathematical concepts (i.e. Information based similarity index)
- ▣ Test new drugs to stimulate heart condition

Acknowledgements

- ▣ **Dr. Eric Moorhouse**, Mathematics Department, University of Wyoming
- ▣ **Dr. Jun Ren**, College of Health Sciences, University of Wyoming
- ▣ **Michael Stöllinger**, M.Sc. current Ph.D. Student, Mathematics Department, University of Wyoming
- ▣ **Subat Turdi**, M.D current Ph.D. Candidate, College of Health Sciences, University of Wyoming
- ▣ **The McNair Scholars Program**, University of Wyoming
- ▣ **Cardiovascular Laboratory**, College of Health Sciences, University of Wyoming

Questions



Mathematical symbols scattered throughout the image: \equiv , ∞ , \geq , $?$, \div , \neq , $?$, $+$, \int , \approx , \times , $+$, $\frac{1}{2}$, \equiv , \times , $\frac{1}{3}$, $?$, $\frac{2}{3}$, \equiv , \times , $?$, $\frac{1}{6}$, $?$, \times , $\frac{1}{8}$, ∞ , ∞ .