

# Six Lectures on the Fundamental Properties of Circadian Clocks by Carl Hirschie Johnson Recorded Autumn 2020

1. Fundamental Properties of Circadian Clocks: *the free-running period ( $\tau$ , FRP), Aschoff's "Rule," the "Gating Hypothesis," et al.*
2. Fundamental Properties of Circadian Clocks: *Temperature compensation, Introduction to Phase Response Curves (PRCs), et al.*
3. Multiple Oscillators: *the A/B model, splitting, et al.*
4. Entrainment I: *the Discrete Model of entrainment, One-pulse Entrainment, et al.*
5. Limit Cycle Oscillators: *Phase Planes, Isochrons, Type 1 vs. Type 0 resetting, et al.*
6. Entrainment II: *Entrainment to Photoperiods/Seasons, why isn't  $\tau$  = 24 hours, et al.*

# Lecture 1

## Fundamental Properties of Circadian Clocks

Characteristics of the free-running rhythm ( $\tau$ , FRP) in *Drosophila* and other organisms:

sustained rhythms in constant conditions

temperature compensation

Aschoff's "Rule"

aftereffects

The "gating" hypothesis

# Lecture 2

## Fundamental Properties of Circadian Clocks

Temperature compensation

The value of "models," and the oscillator model

Introduction to Phase Response Curves (PRCs)

# Lecture 3

## Multiple Oscillators (A/B model, splitting)

Or, how the "black box" approach led to insights that were later vindicated by physiological and molecular experiments

Observations that are difficult to explain by a simple single oscillator  
Transients, strain differences in  $\psi$ , temperature effects, etc.

Pittendrigh's explanation: the A/B oscillator model

Physiological evidence for multiple oscillators  
Splitting, central/peripheral clocks

Implications for jet-lag, health, etc.

# Lecture 4

## Entrainment I Discrete Model & One-pulse Entrainment

Definition of "Entrainment"

Entrainment vs. "Masking"

"Discrete" vs. "Continuous" Entrainment Models

Using PRCs to predict "one-pulse" entrainment ( $\tau - T = \Delta\phi$ )

What does " $\tau - T = \Delta\phi$ " predict ?

Limits of Entrainment/Relative Coordination

General features of entrainment

# Lecture 5

## Phase Planes & Limit Cycles

Phase Planes

Limit Cycle Oscillators

Isochrons

Isochronous Mosquitos and other Beasts

“....a few simple ideas can sort out a great lump of confused data.”

(Peterson, 1980)

# Lecture 6

## Entrainment II: Entrainment to Photoperiods

Entrainment to Complete ( $PP_c$ ) and Skeleton ( $PP_s$ ) Photoperiods

If appropriate  $\Psi$  is the ultimate goal of biological clocks (i.e., phasing your rhythms properly to local time), what are strategies that organisms can use to achieve day-to-day stability of  $\Psi$  ?

Why isn't  $\tau = 24$  hours ? (i.e., why is it CIRCA-dian?)

PRC shape and FRP can modulate entrainment so that ecologically relevant  $\psi$  can be achieved at all seasons (i.e., photoperiods)