

# **SFI Workshop on the Origins & Implications of Time in Physical & Adaptive Systems**

June 18-20

## **Meeting Synopsis**

The timescales of adaptive phenomena are not trivially reducible to the timescales of physics and chemistry. It is through the manipulation of mechanisms that influence the perception of space and time that levels of organization, individuality, and societies arise. In manipulating space and time—in constructing slow timescales (e.g. long-lived phenotypes, robust patterns of inheritance, institutions) coupled to stable spatial aggregations—adaptive systems reduce uncertainty locally (store information), creating (to varying degrees) ordered, predictable, environments conducive to adaptation and ultimately conducive to extracting energy to do work.

The importance of space is appreciated in the study of complex phenomena particularly in ecology and social evolution where it has been identified as a major factor supporting the evolution of cooperation (e.g. by promoting repeated interactions). Time has also been a focus of attention but in a more descriptive and disciplinary sense. It is widely recognized that in adaptive systems there are many timescales and that there are a multitude of biological clocks and rhythms structuring behavior from the molecular level on up to social and economic systems. How timescales arise and, in particular, interact, how they are controlled and exploited, and how perception and cognition influence the capacity of adaptive systems to manipulate and exploit time, are questions that are much less well understood and are the core motivation for this meeting.

We believe to make progress on these questions we must first step back and recognize that the concept of time pervades everything that we believe about the physical & biological universe. And furthermore despite this pervasiveness the concept of time is not (yet?) a unitary one. It involves a number of disparate but related aspects, from the mechanics of timekeeping to the joining of time and space in Einstein's relativity. This workshop will focus on one crucial aspect: the arrow of time, distinguishing what we call "the past" from "the future." We will start with a review of the latest understanding of the relationship between the arrow of time, entropy and the second law of thermodynamics. This will lay the foundations for the rest of the meeting. From fundamentals we move to time and information in adaptive systems. On the final meeting day, we will circle back to where we started, asking if the relationship between time and entropy in physical systems is the same as it is in adaptive systems, or if in adaptive systems, perhaps because of their unique capacity to manipulate (over evolution and within lifespans) how they perceive time, time has a different relationship to entropy.

The meeting will be organized around three themes (1) fundamentals of time in physical systems, (2) origins, construction and exploitation of timescales in adaptive systems, and (3) the relation between the arrow of time and perception. This meeting aims to be synoptic and will span a very significant range of adaptive phenomena related to time.

## Talks

We'd like this meeting to be informal and discussion heavy but it is a diverse group so we need to lay the foundations first—we are asking each speaker to provide background to critical issues with respect to time in her/his research area. The talks should not be work talks but should lay out the big questions and be provocative. At the end of each “session”, we have designated a discussion leader who should make a few provisional remarks and get the discussion going around themes common to that session and, when possible, running across sessions. **Please aim for 20 minute “talks” with 10 minutes of specific discussion.**

## Agenda

### Monday June 18

8:30AM Continental breakfast at SFI

9:00AM Introductions around the room

### Big Picture Meeting Issues

9:15AM Sean Carroll

9:45AM Jim Hartle

10:15AM David Krakauer

10:45AM Coffee Break

11:00AM David Wallace

11:30AM Discussion of common themes led by **Eric Smith**

12:30PM Lunch

### Perception & Computation

1:30PM Jessica Flack

2:00PM Jessica Cantlon

2:30PM Coffee Break

2:45PM Christopher Jarzynski

3:15PM Malcolm MacIver

4:15PM Discussion of common themes led by **Jenann Ismael**

**5:15PM Adjourn**

**7:00PM Group dinner at La Boca**

### Tuesday June 19

8:30AM Continental breakfast at SFI

### Timescales of Life

9:00AM Eric Smith

9:30AM Lin Chao

10:00AM Coffee Break

10:30AM Dan Schrag

11:00AM Doug Erwin

11:30AM Discussion of common themes led by **David Krakauer**

12:30PM Lunch

### **Growth, The Long View**

1:30PM Ole Peters

2:00PM Michael Mauboussin

2:30PM Eddie Lee

3:00PM Coffee Break

3:15PM Coleen Murphy

3:45PM Geoffrey West

4:15PM Discussion of common themes led by **David Wallace**

5:15PM Adjourn—*self organize for dinner*

**7:30PM SFI Community Lecture Panel Discussion with Jennifer Ouellette, Sean Carroll, David Krakauer and Jim Hartle on The Nature of Time**

### **Wednesday June 20**

8:30AM Continental breakfast at SFI

### **Circling Back to the Big Picture**

9:30AM Jenann Ismael

10:00AM Coffee Break

10:15AM Discussion of common themes across meeting led by **Sean Carroll, Jessica Flack, David Krakauer & Jim Hartle**

12:15PM Lunch at SFI & adjourn