Course Syllabus - **TIME: HUMAN VIEWS ON THE PROGRESS OF EXISTENCE**

Language of Instruction: English
Professor: Jordi Garcia Ojalvo
Professor's Contact and Office Hours: jordi.g.ojalvo@upf.edu, from 9h to 17h
Course Contact Hours: 15 hours
Recommended Credit: 2 ECTS credits
Weeks: 1
Course Prerequisites: None
Language Requirements: Recommended level in the European Framework B2 (or equivalent:Cambridge Certificate if the teaching language is English, DELE or 3 semesters in the case of
Spanish)

Course structure: Seminar
Course classification: Introductory

Course Description:

The concept of time is deeply ingrained within the human mind. We experience the passage of time innately, and feel a natural difference between the past, the present, and the future. Yet, some of the descriptions of the universe that science offers us provide no reasons for which the past and the future should be different, and in some others the need for the concept of time itself is not at all evident. This course aims to present an overview of how time is understood by different sciences, in particular physics and biology, and how it relates to the way in which we humans experience the progress of existence. We will discuss concepts such as the arrow of time, the multiverse, embryonic development, and aging. The discussions will also refer to the view of time from the perspective of the arts, including literature, painting, and music. Finally, we will explore how we humans measure time, both with artificial devices that we have built over the last centuries, and with our own genes.

Learning Objectives:

- To gain a basic knowledge of the different ways in which science understands the concept of time.
- To relate the concepts of time provided by physics and biology.
- To become familiar with a variety of artistic works that deal with time in non-standard ways, and to relate these views with recent scientific advances.
- To understand the different ways in which we measure time, including our innate ability to establish the time of day through our circadian clock.

Course Workload

During the course, students will be required to read papers, essays or book fragments. They will work on a short project addressing one of the topics discussed in the course, and present it to the class at the end of the course.

Methods of Instruction:

The course will consist of lectures, discussions sessions, and student presentations. All course materials, including slides, handouts and readings will be made available either in advance or right after class.

Method of Assessment

Participation in lectures and debates: 20%
Course project: 40%
Final Exam: 40%

Absence Policy

Attending class is mandatory and will be monitored daily by professors. The impact of absences on the final grade is as follows:

Absences	**Penalization**
Up to one (1) absence	2 points subtracted from final grade (on a 10 point scale).
Two (2) absences	The student receives an INCOMPLETE for the course

The BISS attendance policy does not distinguish between justified or unjustified absences. The student is deemed responsible to manage his/her absences.

Emergency situations (hospitalization, family emergency, etc.) will be analyzed on a case by case basis by the Academic Director of the UPF Barcelona International Summer School.

Classroom Norms:

· No food or drink is permitted.
· There will be a ten-minute break during the class.
· Students must come to class fully prepared.

Course Contents:

1. Social time: our perception of time through history
2. Deep time: geological and evolutionary time
   - 2.1. The timeline of earth
   - 2.2. The timeline of life on earth
   - 2.3. The molecular clock
3. Measuring time
   - 3.1. Human-made clocks through history
   - 3.2. The longitude problem
   - 3.3. Coordinated universal time
4. From absolute to relative time
   - 4.1. From classical mechanics to special relativity
   - 4.2. Time as a fourth dimension: the space-time continuum
   - 4.3. Time travel
5. The arrow of time
   - 5.1. From microscopic reversibility to macroscopic irreversibility
   - 5.2. Entropy and the second law of thermodynamics
   - 5.3. Cosmological time: from the big bang to the heat death of the universe

6. The garden of forking paths
   - 6.1. Fermat's principle and light refraction
   - 6.2. Feynman's quantum paths: The principle of least action
   - 6.3. The many-worlds interpretation of quantum mechanics
7. Biological time
   - 7.1. Measuring biological time: circadian rhythms and synthetic clocks
   - 7.2. Developmental time
   - 7.3. Aging of cells
   - 7.4. Aging of organisms

Required Readings:

The professor will indicate mandatory readings during the course.

Recommended bibliography:
Students are encouraged to consult the following sources on their own.

Borges, Jorge Luis. "The garden of forking paths". *Collected fictions*. Penguin, 1962.

Carroll, Sean M. *From eternity to here: the quest for the ultimate theory of time*. Penguin, 2010.

Feynman, Richard Phillips, Robert B. Leighton, and Matthew Sands. *The Feynman lectures on physics,* vol. 2, chap. 19. Addison-Wesley, 1979.

Glass, Leon, and Michael C. Mackey. *From clocks to chaos: the rhythms of life*. Princeton University Press, 1988.

Halpern, Paul. *The quantum labyrinth: how Richard Feynman and John Wheeler revolutionized time and reality*. Hachette, 2017.

Kreitzman, Leon, and Russell Foster. *The rhythms of life: The biological clocks that control the daily lives of every living thing*. Profile books, 2011.

Kumar, Sudhir. "Molecular clocks: four decades of evolution." *Nature Reviews Genetics* vol. 6, no. 8: 654, 2005.

Marrison, Warren A. "The evolution of the quartz crystal clock." *Bell System Technical Journal* 27, no. 3: 510-588, 1948.

Palmer, John D. *The living clock: The orchestrator of biological rhythms*. Oxford University Press, 2002.

Rovelli, Carlo. *The order of time*. Penguin, 2018.

Fitzgerald, F. Scott. *The curious case of Benjamin Button*. Colliers, 1922.

Sobel, Dava. *Longitude: The true story of a lone genius who solved the greatest scientific problem of his time*. Macmillan, 2005.

Winfree, Arthur T. *The geometry of biological time*. Springer, 2001.

Last revised, January 2023