Thesis Project Portfolio

OrChID-Bio: Organs-on-a-Chip with Integrated Detection of Bioluminescence

(Technical Report)

Ticking Clocks: Social Acceleration and a Culture of Sleep Deprivation Among Students

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

One important yet overlooked aspect of human health is the influence of circadian rhythms. Circadian rhythms are the natural regulation of the sleep-wake cycle and recur over approximately twenty-four hours. These rhythms affect various levels of synchronization within the body's cells, organs, and nervous system, and long-term physiological and behavioral desynchronization of circadian rhythms has been linked to disorders ranging from cardiovascular disease to depression. While the significance of circadian rhythms to physical and mental wellbeing has been clinically established, the complexity of these patterns means that there are still major uncertainties regarding what, precisely, impacts circadian rhythms on the cellular, individual, and societal levels. At the cellular and individual scales, influences on circadian rhythms can be biomedically analyzed by leveraging technologies such as transgenics and microfluidics to replicate human physiology in the laboratory. The technical project focused on developing an integrated device which combined bioluminescence monitoring with organs-on-a-chip to allow for real-time monitoring of circadian rhythms. These rhythms are also affected by societal level factors and sociocultural norms that alter the sleep-wake behaviors of the people who experience them. The STS paper uses the framework of social acceleration to examine the social and technical developments that create a cultural pattern of poor circadian rhythms among undergraduate students.

Studying circadian rhythms in the laboratory is difficult due to their inherently dynamic and time-sensitive nature, for which there are few suitable techniques. One method is to perform bioluminescence analysis on multi-dimensional organoids, using bioluminescent gene reporters to track circadian oscillations in cell cultures which utilize factors such as mechanical stretch and an artificial blood supply to replicate actual physiology more accurately. However, this is a

technique whose usefulness is limited by an inability to perform on-chip analyses. The technical research integrated a micro-photomultiplier tube with a commercial organ-on-a-chip system to create a new, hybrid device. This prototype enables future research in the area to leverage real-time, in situ bioluminescent monitoring and analysis with a cost-, time-, and labor-effective system that can be used to enhance physiological modelling and clinical research capabilities.

The STS paper focuses on improving understanding circadian rhythms in the sociotechnical rather than physiological dimension. The research sought to answer the question of how the technological and social developments of modern society have influenced norms around circadian rhythms and lead to the creation of a culture where student sleep deprivation is normalized. Ethnographic interviews on the subject of sleep were conducted with eight undergraduate students at the University of Virginia, and the collected data was examined through the lens of social acceleration in order to understand the cultural construction of student sleep behaviors. The social acceleration framework introduced by Hartmut Rosa was used to contextualize the attitudes expressed by the students amidst broader trends such as accelerating pace of life and increased time pressure. The research showed that student culture normalizes unhealthy circadian patterns to such a degree that sacrificing sleep is seen as an inescapable part of the college experience. Social expectations and technological availability combine in the student culture to create both an intense time pressure and a desire for temporal sovereignty such that the norms of the community have established sleep deprivation as not only expected but encouraged.

Both the STS and technical research projects thus contribute to knowledge of the complex network of elements which contribute to and arise from human circadian rhythms. The technical project does so by developing a device to improve future clinical methodologies while

the STS paper highlights the ways in which even biomedical patterns are influenced by sociotechnical constructions. Future research investigating the influence of circadian rhythms can thus acknowledge either or both of those dimensions, as both contribute to understanding the importance of circadian rhythms and their influences on human health and behaviour.