Anni Hämäläinen: “The role of environmental factors in maintaining adaptive pace-of-life variation …”

**Description for the general public**

Animals live in changing and often unpredictable environments. To ensure survival, health, and successful reproduction, frequent adjustments are needed in the way energy from food or body fat is directed to different functions. Recently, researchers have found that the beneficial bacteria living in the digestive tract of animals (gut microbiome) could be playing a role in making these adjustments to the environment. The mammal gut microbiome breaks down indigested food to extract more energy, vitamins and minerals from food. The bacteria also produce “short-chain fatty acids”, molecules that the host can use in its metabolic processes and provide energy to gut and liver cells and other organs. Eventually, the coordinated adjustments of host genes and gut bacteria could determine how well an individual performs in given environmental circumstances. For example, the microbiome could help the host survive on a poorer diet by extracting more energy from the food.

Limited food or other vital resources in the environment can slow down growth or reproduction, weaken the immune system, and lead to aggression between neighbors that compete for the same resources. However, individual animals vary in terms of how much energy they need for their basic metabolism, and how quickly they can grow and reproduce. This variation is thought to be because a high metabolism and a faster “pace of life” may be more successful when food is plentiful and there are few competitors around, but such a fast pace may be too energy-expensive when food is scarce. The metabolic rate is determined partially by genes, and partially by the environment. Environmental conditions experienced very early in life, even before the birth, can permanently shift the average metabolic rate of an individual, and influence the way in which energy is divided between different requirements, such as growth, reproduction, and supporting the immune system. Especially, stress experienced by mothers during early pregnancy can change the behavior and pace of life of the offspring, in such a way that prepares the young for certain environmental challenges, such as limited food resources. Such adjustments can include changes to the composition of bacteria in the microbiome. Given the increasing evidence of the importance of the microbiome for physical and mental health, this is also of interest in humans. Therefore, basic research is needed to understand how host metabolism, the microbiome and the environment interact, and to understand how the host-microbiome units (known as the “holobiont”) have evolved together.

We will test whether and how the evolutionary change in the metabolic capacity of animals affects their ability to cope with challenging environmental conditions, and what role the gut microbiome plays in adjusting the animals to the prevailing surroundings. We will do this with bank voles (*Myodes glareolus*, a small, common rodent) from a unique experimental-evolution system. We will compare voles from lines that have been selectively bred for higher metabolic capacity for nearly 30 generations with those from non-selected control lines, which retained a lower, normal metabolic capacity. In a set of laboratory experiments, we will temporarily feed pregnant mothers and young individuals a calorie-reduced diet, and measure the reversible and permanent changes in the performance and microbiome of the offspring and the young voles. We will examine whether and how the changes differ between the selected and control lines. We will then test whether the findings from the laboratory experiments hold in a natural environment. To this end we will release voles from both the high-metabolism and control lines into the same field enclosures, and monitor their reproduction, survival, and microbiome over the summer, and their relative survival over winter. With these experiments, we will have a unique opportunity to examine how the host metabolism, the microbiome, and environmental conditions experienced throughout life interact to determine individual performance. Taken together, these results will provide clues about the ways in which animal populations adapt over time to cope with environmental challenges.