Benefits of having large brain seem obvious. Large brain allows for storing and processing complex information enabling outsmarting competitors or foes. Why then large brains and associated cognitive abilities were developed by so few animals, including man? Is it for example possible for a fish, such as a shark from a classic Steven Spilberg's horror 'Jaws' to be as crafty and mean as humans? The answer to this question seems to lie in extremely high energetic costs of running brain tissue: fuelling large brain fitted into shark's body would simply prove impossible, as it would be unsustainable in a fish having metabolic rate an order of magnitude lower than that of a mammal of similar size. Thus, the craftiness of Spilberg's shark is just another Hollywood legend. The question, however, remains: what made mammals, particularly hominids, capable of breaking energetic barriers imposed by brain's veracious appetite for energy and developing elaborate structures of the central nervous system allowing to comprehend, and ultimately creating culture and civilisations?

The answer to this question, still in the form of research hypotheses centers around the explanation of mechanisms of evolution of the functional nexus of (1) large brain and its metabolic costs of maintenance, (2) maintenance costs of other vital and energetically expensive organs, (3) total energy expenditures, covering (1) and (2). This nexus, of course, also includes the most interesting piece of the puzzle- cognitive abilities, as its acquirement through investment in extra neurons is likely to be traded-off for a direct investment in extra offspring.

In 1995 paleoanthropologist Leslie Aiello and physiologist Peter Wheeler linked all the above elements in a still hotly debated the "Expensive Tissue' hypothesis. They reasoned that brain size increment, characteristic for the evolution of hominids, was 'financed' thanks to a reduction of other expensive tissues, namely the gut. Indeed, apart from the brain, the gut incurs extremely high metabolic costs amounting to a half of energy budget of a mammal in a resting state. According to Aiello i Wheeler reduction of the gut size was compensated by increased foraging capabilities in brainier hominids having access to easier to digest and energy dense food- such as meat. Thus, calories saved on expensive gut could have been shunted to always energy hungry brain. The Expensive Tissue hypothesis therefore predicts the existence of an inverse relation between brain and gut size.

It is worth to note, however, that brain enlargement does not need to be 'financed' through reduction of the gut, if increasing cognitive capabilities allow for covering the costs of both, the brain and the gut. In such a case one can expect a positive, not negative relation between the two. Moreover, it is likely that the evolution of high energy expenditures characteristic for birds and mammals was associated with the natural selection for high aerobic capacity, allowing for extremely intense physical exercise, such as sprint. Under this scenario one can expect a positive correlation between brain size (and cognitive abilities) and aerobic capacity—the nexus not consider in the frame of the 'Expensive Tissue' hypothesis.

To date, studies on the evolutionary scenarios and hypotheses outlined above have brought mixed conclusions. Perhaps the main reason for their inconclusiveness was their comparative character, as in the absence of paleontological data, they were primarily based on wide- scale comparisons of brain and gut size of extant species. A promising approach, which may shed light on the mechanisms underlying the rise of large brains is that, offered by experimental evolution re-creating, by means of artificial selection, evolutionary processes leading to brainier animals. The proposed project employs this approach through a set of cognitive analyses along with physiology and anatomy of lines of laboratory mice divergently selected for Basal Metabolic Rate (BMR, reflecting metabolic costs of maintenance of the brain and the gut) or Peak Metabolic Rate (PMR, reflecting aerobic capacity). Apart from the between-line differentiation of metabolic rates, those mouse lines also differ with respect to masses of metabolically active internal organs (heart, liver, small intestines and kidneys). Most importantly, pilot analyses carried out in the course of the preparation of this proposal also showed that mice with high BMR have larger brains than their low BMR counterparts. Thus, the mouse lines introduced above constitute an excellent subject of studies aimed at unraveling mechanisms of the evolution of brain size. This, along with interdisciplinary nature and scientific significance of goals position the proposed project in the forefront of research on the anatomic and physiological basis of evolution of cognitive abilities.