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Opinion Article

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High and low basal metabolic rates developed distinct organ mass and cell sizes

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DESCRIPTION

It is hypothesised that the evolution of multicellular organisms' metabolic rates reflects the evolution of their cell architecture. This is most likely due to a close relationship between cell and nuclei sizes, which are expected to be inversely related to cell metabolism. They investigated the Basal Metabolic Rate (BMR), internal organ masses, and cell nucleus size in different tissues of laboratory mice selected for high to low mass-corrected BMR and four random-bred mouse lines. When compared to low- and high-BMR lines, random-bred lines had intermediate levels of BMR. This pattern, however, was only partially consistent with between-line differences in cell/nucleus sizes. Erythrocytes and skin epithelium cells were smaller in the high-BMR line than in the other lines, but low-BMR and random-bred mice cells were comparable in size. High-BMR mice, on the other hand, had larger hepatocytes, kidney proximal tubule cells, and duodenum enterocytes than other lines. All cell and nucleus sizes were positively correlated, indicating that the nucleus plays a role in cell size regulation. Their findings suggest that the evolution of high BMR involves a reduction in cell size in specialised tissues, such as erythrocytes, whose functions are primarily dictated by surface to volume ratios. High BMR, on the other hand, may result in an increase in cell size in tissues with high transcription and translation, such as hepatocytes. The rate of metabolism, or the intensity with which a multicellular body uses energy obtained from food, is a sum of the energies expended by its cells. Organisms' metabolic rates have evolved dramatically, and body mass is unquestionably the most important determinant of this variation.

Given that body mass evolves as a result of changes in cell number and cell size, a mass scaling of metabolic rate reveals information about the coevolution of cellular metabolism and body mass. Most of the time, They see a slowing increase in metabolic rate with body mass, implying that large organisms evolve cells that are metabolically less active (per cytoplasm unit) than small organisms. The mass scaling of metabolic rate varies across taxonomic groups and may even evolve under experimental conditions, indicating that organisms evolve differential coupling between cellular metabolism and body mass. Statistical models fit to data on metabolic rate and body mass do not capture the entire variance in metabolic rate: equally large organisms have metabolic rates that differ by orders of magnitude. Thus, it appears that the evolutions of cellular metabolism and body mass can be separated. Despite lengthy and heated debates on scaling laws in metabolism, the origin and evolutionary significance of mass scaling of metabolic rates are still unknown. Although emerging evidence has documented links between cell size variation and metabolic rate scaling, most recently proposed explanations of metabolic rate allometries, such as metabolic theory of ecology dynamic energy budgets, still do not consider cell size as a potential factor affecting metabolic rates. Non-linear changes in cell surface area with cell volume, as well as costs associated with plasma membrane maintenance, should result in an inverse relationship between cell size and cell mass-specific metabolic rates, according to (hereafter, cell metabolism hypothesis, Major Histocompatibility Complex (CMH)).

CONCLUSION

Following the assumption that cell metabolic rate is entirely defined by the surface-to-volume ratio; CMH predicts that organisms built from smaller cells will have higher metabolic rates than those built from larger cells of comparable body size.

However, assuming realistically that membrane gradients are maintained, the difference between slope values predicted by CMH must be less dramatic. Furthermore, they do not know how well CMH accounts for mass-independent variation in metabolic rates.