Adaptive beach mouse color pattern biology essay

Science, Biology

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A Single Amino Acid Mutation Contributes to Adaptive Beach Mouse Color Pattern

In mammals, coat color arguably varies the most among rodents. Some of the most extreme variation occurs in deer mice (genus Peromyscus), which have served as the subject of many classic studies in mammalogy starting almost a century ago. In particular, one species of deer mouse, Peromyscus polionotus, shows a tremendous amount of variation in coat color over short geographic distances. These mice occur throughout the southeastern United States (i. e., Alabama, Georgia, South Carolina and northern Florida), where they are commonly referred to as " oldfield mice" because they inhabit abandoned agricultural fields with dark loamy soils. In these habitats, mice have dark brown dorsal coats, a light grey belly, and a sharply bi-colored tail, which is typical for many wild rodents. These old-field mice also have colonized the sand dunes and barrier islands off the Gulf Coast of Alabama and northern Florida and independently the coastal habitat on the Atlantic seaboard. These sand-dwelling populations are commonly referred to as " beach mice." Research indicates that the maintenance of different coat colors among subspecies/populations is achieved through top-down predation pressure from visual hunters. Eumelanin is a dark pigment responsible for brown coloration in mouse fur. Eumelanin production is achieved through a multi-step biosynthetic pathway occurring in melanocyte cells. A functional MC1R protein binds to a melanocyte stimulating hormone to begin the process. If the MC1R protein does not function properly, binding does not occur and the pathway leading to eumelanin production cannot

start. A hair follicle is a complex organ and has many different structures associated with it. Differences in fur color in beach mouse are best described by examining melanocyte cells at the base of the hair follicle in the Papilla. Eumelanin is produced in the melanocyte cells and is expressed in the cortex cells of the hair. Proteins are large molecules composed of one or more long chains of amino acids. They are an essential part of all living organisms, especially as structural components of body tissues such as muscle, hair, and collagen. They also form important enzymes and antibodies. Activation of the MC1R protein occurs when it successfully binds to a molecule called an α melanocyte stimulating hormone (α-MSH). If instead the MC1R protein binds to a different molecule, an agouti stimulating peptide, a biosynthetic pathway begins that produces pheomelanin rather then eumelanin. However, assuming that α-MSH binding occurs, cAMP synthesis begins and in turn stimulates the expression of four genes: c (Tyr), Tryp1, Tyrp2 and p. The c(Tyr) gene codes for an enzyme called tyrosinase that catalyzes a reaction in a biosynthetic pathway that converts the amino acid tyrosine into a molecule called dopaquinone. The Tyrp1 and Tryp2 genes code for tyrosine-related enzymes that catalyze reactions in a subsequent pathway that converts dopaquinone into eumelanin. The p gene codes for a protein that also aids in this process. Eumelanosomes are then made in the Golgi apparatus of the melanocyte that are then transported out of the melanocyte to the hair cortex. Without the successful binding of an α-MSH molecule by the MC1R protein the multistep biosynthetic pathway that results in eumelanin synthesis is not initiated. Therefore, structural changes to the MC1R protein as a result of a genetic mutation could make it non-

functional and result in a different coat color due to a change in pigment production. This is often the case in coastal populations of beach mice where coat colors are lighter than their inland neighbors. There are several ways, at a cellular level, that production of Eumelanin can be disrupted. The gulf-coast populations of P. polionotus have a mutation in their MC1R protein that makes it non-functional. This results in a disruption in the production of Eumelanin. A single nucleotide substitution mutation changes the properties of the resulting MC1R protein. The mc1r gene is located in Chromosome #16 in mammals. It codes for the MC1R protein that is involved in intracellular Eumelanin synthesis. A single nucleotide substitution mutation in the mc1r gene causes a change in amino acid #67 in the MC1R protein chain. When amino acid #67 is cysteine, the MC1R protein is unable to effectively bind the α-MSH. This changes the pigment pathway and eumelanin is not produced. The absence of a " functional" MC1R protein does not guarantee a population of mice with dark fur. In reality, the system is much more complicated than a single-gene regulation scenario. While all of the genes responsible for differences in fur phenotypes, data show that it is partially responsible.