Burrowing Beneath the Surface: Celebrating Darwin’s 210th Birthday

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Each year Duquesne University hosts Darwin Day in celebration of Charles Darwin’s Birthday and anniversary of *On the Origin of Species*. The event is an opportunity to remember the importance of science education in today’s world while discussing the impact evolutionary biology has on our lives. This year, the event hosted Dr. Hopi Hoekstra, a Professor of Zoology, Molecular and Cellular Biology and Organismic and Evolution Biology at Harvard University. To begin and honor Darwin’s 210th Birthday, Dr. Hoekstra focused on how Darwin was able to make correct theories regarding evolution as he recognized variation. Darwin noticed how offspring resemble their parents. Therefore, there must be a process for traits to be passed on to each generation.

To further explore the evolutionary ideas of Darwin, science has advanced to use the genetic code to make links between genes and traits. However, many unanswered questions lie within genes and how they affect behavior. Behavioral studies can be difficult to conduct, as there are different approaches to measure behaviors within a species. It was not until the early 80’s when Richard Dawkins created the “extended phenotype” as a way to overcome a challenge amongst behavioral biologists. The concept of extended phenotype suggests that genetic traits can be responsible for behaviors. For example, male Bowerbirds build bowers or nests. They craft it in a particular shape, some containing
blue items to attract the female Bowerbirds. This behavior is common across Bowerbirds, implying a degree of genetic involvement. The behavior appears to be similar within species yet varies between species. Another example of an extended phenotype is the creation of burrows. Burrows are underground passageways in dirt that are used to avoid predators, escape from extreme temperatures, promote various social interactions and assist in food storage and developmental growth. Burrows have evolved in a number of species each with their unique type of burrow. Dr. Hoesktra decided to investigate the genetic basis of burrow formation in different species of deer mice and oldfield mice.

Dr. Hoekstra’s research group’s goal is to focus on the precise DNA code that gives rise to this trait. To accomplish this goal, Dr. Hoesktra’s group studies differences that occur in burrows from two different populations growing in two diverse field sites, central Alabama and off the Gulf Coast of Florida. At each field site, the team identifies burrows with the ultimate goal to catch the mice that escape through a secondary tunnel. Dr. Hoesktra compared and contrasted the types of burrows created by different species. The initial observations identified two burrow traits of this extended phenotype: (1) length and (2) presence or absence of an escape tunnel. Her genetic research focused on comparing the extended phenotype of *Peromyscus maniculatus* (deer mice; central Alabama) referred to as little diggers to *P. polionotus* known as big diggers (oldfield mice; Florida). They first studied if the varying burrow traits were inborn or learned from their parents. To evaluate this question, they cross-fostered pups of each species to be raised by the opposite species parents, and then compared the burrowing behavior. The conclusion was clear; the little diggers still produced small burrows compared to the big diggers regardless of the parents.

To explore the genetic component of creating complex burrows, they used F1 hybrid mice, created through mating *P. maniculatus* to *P.*
polionotus. F1 hybrid mice exhibited complex burrows similar to those of big diggers suggesting that the phenotype was likely dominant. However, when the F1 hybrids were crossed back with the P. maniculatus, big diggers, they created burrows of varying length, thus the results indicated a continuous distribution likely resulting statistically from three to five genes.

Once the genes were identified, Dr. Hoesktra then investigated the underlying behavior differences in digging efficiency, start time of digging during night, and timing across development. The big diggers are more efficient. They start digging immediately and dig the entire time the lights are off. This results in a more complex burrow. In fact, the big diggers start to produce mini-versions of adult-like burrows as early as 17 days after birth. The little diggers are less efficient, do not start digging until about an hour before the lights come on, and do not start creating burrows until about 27 days after birth. Using these behavioral data Hoeskra’s group posits a motivational difference amongst the two species; the big diggers are more motivated to dig, thus, they dig for a longer amount of time. Interestingly, one of the genes linked to this behavior is M5. This is a related gene to the nicotinic acetylcholine receptor, the primary receptor that binds nicotine. Thus, this motivation could be linked to humans with nicotine addiction and may indicate similar reward circuitry in mice as in humans.

After attending the talk, I was able to reflect about why we celebrate Darwin Day. Dr. Hoekstra’s lab successfully applies Darwin’s notion of evolution to Dawkin’s concept of an extended phenotype through looking at the genetic component of mice burrowing behavior. In a previous interview with Proceedings of the National Academy of Sciences (PNAS), Dr. Hoekstra mentioned how her lab verifies Darwin’s idea of evolution’s step-like progression by identifying multiple, small-step mutations that impact phenotype and behavior\(^1\). Dr. Hoekstra’s work is
just one example of how important it is to remember where we started, how we have progressed and where we plan to go as scientists.

References:

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