The Fly Room: The Invention of Genetics, the Science of Evolution

by William deJong-Lambert
Bronx Community College, CUNY

The 2017 Nobel Prize in Medicine or Physiology was awarded to three scientists who studied domestic fruit flies—*Drosophila melanogaster*—in outer space to understand how humans have adapted to life on earth.[1] This adaptation of fruit fly research to the farthest reaches of human experience may not seem surprising, given that they were the first animals ever brought into orbit, and have been used to study so many diverse facets of life on this planet. But how did we and the flies get here?

This story begins in a tiny room on the top floor of Schermerhorn Hall at Columbia University. It was January 1910, and Columbia University geneticist Thomas Hunt Morgan (1866-1945) had just spotted a white-eyed fly in a bottle. All the other flies' eyes were red. Morgan's sighting of the white-eyed *D. melanogaster* would be one of four discoveries that would lead to him to win the Nobel Prize in Physiology and Medicine twenty-three years later. Morgan's other three were the students—Alfred H. Sturtevant (1891-1970), Calvin Bridges (1889-1938), and H.J. Muller (1890-1967)—who dissuaded him from his initial doubts about, and led him to realize the truth concerning, the three reasons he won the award: One, Darwin's theory of evolution; Two, Gregor Mendel's theory of heredity; Three, the existence of the gene.

Morgan was among the first to receive a PhD in Zoology in the U.S. in 1890. To his generation of biologists, Darwinism was too speculative—a topic more appropriate for the editorial page of a newspaper than publication in a scientific journal. First of all, Darwinian natural selection did not make sense in terms of the current theory of heredity, Francis Galton's biometrical regression to the mean. Second, Darwin's theory of slow, cumulative change was contradicted by the "mutation theory" of Hugo de Vries (1848-1935)—which implied evolution was the result of sudden, radical alterations in species. Three, Darwin had focused attention on the outer world—the environment—offering only a vague belief in "gemmules," elusive particles he falsely believed were transmitted in the bloodstream.[2]

While the rediscovery of Gregor Mendel's (1822-1884) three laws of heredity, (including the one-to-three ratio of dominant and recessive traits), proved Galton wrong, they also implied an organism's habitat was irrelevant to evolutionary change. Indeed, according to Morgan's British colleague William Bateson (1861-

1926), Mendel's Laws would have been rediscovered sooner had not Darwin distracted biologists with his fruitless theories about the role of nature.

And yet Morgan had his doubts about Mendelism, as well. One, if traits were either dominant or recessive, then how come we are not either all boys or all girls? Two, the term "gene." It sounded too much like "eugenics"—the science of human breeding—that was proving more attractive to amateurs and ideologues whose goal was to reproduce the "elites," and discourage the reproduction of the "inferior." Three, they didn't even exist. According to Morgan, all this talk of genes was a "superior jugglery," a "Mendelian ritual" of inventing "facts" by retroactively citing imaginary "factors" to account for the unexplainable. Morgan was going to need a lot more evidence if he was going to be persuaded of the existence of a single substance that accounted for all of life and heredity.

Morgan's sex problem was solved in 1914 when Sturtevant, Bridges, and Muller finally got him to reread an article by his former student from Bryn Mawr, Nettie Stevens, who it was now revealed had discovered the Y chromosome seven years before.[3] This after-the-fact recognition was like the rediscovery of Mendelism, of which Morgan was now finally convinced by the discovery of sex-linked heredity.
His suspicions concerning evolution and the gene would similarly be solved in the years that followed, a story I tell in the book I began writing fourteen years ago this past summer. In the years between, I received funding from numerous organizations to visit archives throughout the U.S. and Europe, researching the biographies of the scientists I describe in my narrative. These include, in addition to the biologists listed above, L.C. Dunn (1893-1974), Theodosius Dobzhansky (1900-1975), J.B.S. Haldane (1892-1964) and Julian Huxley (1887-1975).

Dunn, a farm boy from upstate New York, applied to the Fly Room while finishing his botany studies at Dartmouth. Morgan turned him away, so instead Dunn ended up working with one of Morgan's friendly rivals—William E. Castle (1867-1962) of the Bussey Institute at Harvard University. Though Dunn hoped to be able to still study fruit flies under Castle, the focus of the Bussey was mammals—rats and mice in particular. Though Dunn would become among his generation's most important mouse geneticists, there is a reason *D. melanogaster* remains the model organism to this day.

Meanwhile Dunn had to deal with his mentor's insistence that sperm and eggs can produce both males and females. Therefore, according to Castle, a female-producing sperm could only unite with a female-producing egg, and a male-producing egg could only unite with a male-producing sperm. Castle also refused to believe the Fly Room view that genes are strung in a flat line along the chromosome, and wasted hours of Dunn's time having him construct 3-D models made of wire and string to display his alternate theories.[4]

That Dunn looked into the Fly Room from an outsider's point of view helped him solve one of its most persistent controversies: genetics and eugenics being treated as synonyms. Not even its most enthusiastic eugenicist—Muller (whose son's middle name was "Eugene")—was comfortable with this. Thanks to his reputation as a geneticist, Dunn was appointed to a task force which ultimately helped shut down the Eugenics Record Office at Cold Spring Harbor, before going on to purge its influence from the earliest breeding publication in the United States, *The Journal of Heredity*.

Dobzhansky arrived in Morgan's lab on a Rockefeller fellowship in 1927, just two years before Morgan moved to the California Institute of Technology. Though Dobzhansky intended to spend one year learning from the cocky American upstarts he admired from afar, three things happened next no one anticipated.

One, Soviet dictator Joseph Stalin launched massive industrialization and collectivization campaigns, accompanied by a reign of terror, that forced Dobzhansky to realize his hopes of continuing back home the research he'd begun with Morgan were not to be.

Two, when it came to the application of genetics to the study of evolution, the Russians were one step ahead of the U.S.—however this progress was about to be reversed by the shifting political winds which would leave biology beneath the purview of Stalin's handpicked dictator, Trofim Denisovich Lysenko.

For this reason, three, Morgan would do everything in his power to make sure Dobzhansky could remain in his lab, where he would one day supersede Sturtevant as the Fly Room's star.

If Dobzhansky's contribution came in terms of the qualitative research showing how genetics operated beyond the walls of the Fly Room in nature, Haldane covered the quantitative side with his work on the mathematics of natural selection.[5] Haldane descended from a prominent Scottish family—whose members included his father, John Scott Haldane—a celebrated physiologist with whom he helped design the gas mask used by British troops in the First World War. Haldane's precocious fascination with genetics was encouraged by another of the Fly Room's critics, the above-mentioned Bateson, who challenged their belief in the "crossing-over" of genes during meiosis. Instead, Bateson contended that traits were either "attracted to" or "repulsed from" one another.[6]

Despite Bateson, not to mention his own resentment of the confident Americans who usurped Britain's position at the forefront of studies in evolution, Haldane became one of the Fly Room's most famous followers. Haldane was well-known (and some circles notorious), for his popular writings on scientific topics including *Daedalus*, a satire of eugenics.[7] As with Dunn's work, Haldane's musings on a future where politicians would run for office with promises like breeding babies with prehensile tails so they could regain the evolutionary benefit of hanging from trees, undermined the notion that genetics should—or even could—be used to create a better humanity. Haldane's point was driven home in the best-selling novel it inspired, Aldous Huxley's (1894-1963) *Brave New World*.

Like his older brother Julian, Aldous was the grandson of T.H. Huxley—a.k.a., "Darwin's bulldog"—the most prominent defender of evolution in Darwin's heyday. Though Julian Huxley also became a celebrated writer—not to mention a regular contributor to the BBC, and public personality whose positions included Secretary of the London Zoo—he initially sought his career as a geneticist in order to live up to the scientific fame of the family name. In this, Huxley was doomed to failure, because his interests were not focused enough for laboratory work. Instead, Huxley became prominent for using his hobby, bird watching, to revise Darwin's theory of sexual selection.

Huxley argued that females play a role as important as males when it came to courting the opposite sex. It was an important insight, but still not enough to get him elected to the Royal Society until long after he believed the honor was overdue.

Huxley's studies of sexual selection may also easily be read as justifications for his numerous affairs. The resulting turmoil—along with his insecurity over being able to match the esteem of his grandfather among scientists—led to repeated stays in sanatoriums to treat his depression. Nevertheless, Huxley's close friendship with Muller enabled him to become among the Fly Room's most important ambassadors to the public at large. It was to this audience he would address with *Evolution: The Modern Synthesis*, his magnum opus on the relationship between *D. melanogaster* and natural selection.

The narrative of my book reflects the three themes of the synthesis: One, Heredity; Two, Genetics; Three, Evolution. Though the extent to which heredity shapes fate and personality is most prominent with Huxley, Mendel's three-to-one ratio is directly addressed in my book's final chapter when Morgan wins the Nobel Prize. He was the sole awardee because the maximum number was three, meaning someone had to be left out. In practical terms it was Muller, who had essentially been kicked out of the Fly Room in 1914 when Huxley dropped by and asked Morgan to recommend someone to join him in founding the Biology department at Rice University. The most obvious way Morgan left him out was by only dividing the prize money between himself, Sturtevant, and Bridges.

Muller was a difficult personality—notorious for his "priority complex"—meaning he was convinced others took credit for his discoveries.[8] This reputation followed Muller throughout his career, and is probably best evidenced in the fact that he presumed credit for the Nobel Prize awarded to one of his students, James Watson, for his co-discovery, along with Francis Crick, of the chemical structure of DNA. According to Muller, "Watson and Crick" would never have become a pair of famous names if not for him.[9]

Muller's obsession was not limited to his own field. He was also fixated on matching the progress physicists had made with the atom. If the most basic unit of physical nature could be divided, then what about the primary unit of life—the gene?[10] Once Muller's battles with Fly Room critics like Castle and Bateson who argued that the gene was unstable, or didn't even exist, were resolved in his favor, Muller won the final prize with his own Nobel in 1946 for discovering that radiation mutates genes, an experiment Morgan himself had attempted unsuccessfully decades before. By

this time, he had nearly destroyed his career by betting his hopes on reversing the anti-genetic tide launched by Stalin's protégé, Lysenko, and "radioactivity" would have become the metaphor of his relationships. The theme of genetics is evident in the role of the Fly Room's other principle members.

Sturtevant was Morgan's star student for a reason. He was the first to ever compose a map of where a given group of genes were located on the chromosome. Bridges was the engineer of Fly Room logistics. He managed the bottle stocks of mutants and designed experiments. He built the temperature controlled cabinets where they lived and took charge of every aspect of the flies' existence—including the "fly morgue," a quart-sized bottle of alcohol where they were disposed once no longer needed.

Genetics was also at the time inseparable from eugenics. They were widely regarded as the same thing. Why would you not use what was known about the mechanics of heredity to manage the reproduction of humans? Other recurrent themes include sex, automobiles, Soviet scientific utopia as well as the flies themselves—a metaphor for the promise of the new, speed, efficiency—endlessly reiterating and producing all the book's other themes—the last of which is evolution.

For genetics to get from Sturtevant's drawing of a straight line with six dots along it indicating the genes B, O, C, P, R, M in order on the chromosome, beyond into physical world, required qualitative and quantitative research. This is where Dobzhansky comes in—a scientist in exile, witnessing from afar fate of former colleagues—his former mentors Iurii Filipchenko and Nikolai Vavilov in particular—as they are slowly forced to conform to the new order under Stalin in the Soviet Union. Once Filipchenko accepts the fact that his favored student and friend is really not coming back after all, he begins again with one in the letters he'd numbered to be sure Dobzhansky received them all and read them order. Soon after, the lab he'd founded was taken from him for his refusal to accept the doctrines of Marxist science, and he died at age 48 of meningitis.[11]

Vavilov refused to accept that Dobzhansky was not coming back, and assumed he would have to anyway. He visited Dobzhansky one last time in California—as Dobzhansky was settling in to the new frontier of southern California—the orange

groves and lemon trees, Sears and Roebuck catalog, his Model-T Ford. Vavilov confessed he wore a kind of goggles that enabled him to ignore certain things, and encouraged him to put them on as well, promising that good research would always be supported. But by the time Vavilov returned on his last trip to the U.S. not long after he'd stopped bothering, and told Dobzhansky to stay.[12] It was only thanks to Morgan's direct intervention with U.S. President Herbert Hoover's Labor Secretary that Dobzhansky escaped deportation. Vavilov was ultimately arrested and died of starvation in a Soviet prison.

Afterward Dobzhansky used the math of the biometricians such as Haldane to break down the walls of Fly Room and took its discoveries outside. By chasing a wild cousin of *D. melanogaster*, *D. pseudoobscura*, throughout the American Midwest, up into Canada, down into Mexico, Central and South America—Dobzhansky showed how genes are propagated in the living lab of nature. His impact upon his new locale, which he went so far to adapt to by adopting the middle name "Juan," was so great, he is today credited as the fourth—and only non-native—founder of genetics in Brazil.

This is the story I tell, the metaphor of the flies and their researchers, their followers, the symbiotic relationship between us and them, animals and humans. There are the anecdotes like Sturtevant stopping the car as the family took cross-country road trips back and forth between the California Institute of Technology, where Morgan relocated his lab just as the Great Depression hit, to Woods Hole, Massachusetts—where Fly Room denizens spent their summers—so he could collect flies in a promising place. Or Bridges interrupting yet another covert liaison with a female admirer to snag a fly from the air to preserve in one of the test tubes he kept in his socks. That Bridges used the money Morgan awarded him from the Nobel Prize to construct a streamlined speedster he dubbed "Lightning Bug," is likely the best testament to how deeply these scientists identified the fly with themselves as an ideal.[13] The Rockefeller Foundation archives have been essential to my creation of a narrative which erases the boundaries between fruit flies and people.

[1] https://www.nasa.gov/ames/research/space-biosciences/fruit-fly-lab-ffl-01-engineers-blog

[2] The two biographies of Morgan are Ian Shine and Sylvia Wrobel, *Thomas Hunt Morgan: Pioneer of Genetics* (Kentucky: The University of Kentucky Press, 1976); and Garland Allen, *Thomas Hunt Morgan: The Man and His Science* (Princeton, NJ: Princeton University Press, 1979). See also Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution and Inheritance* (Cambridge, MA: Harvard University Press, 1982); Vassiliki Betty Smocovitis, *Unifying Biology: The Evolutionary Synthesis and Evolutionary Biology* (Princeton, NJ: Princeton University Press, 1996); Elof Axel Carlson, *Mendel's Legacy: The Origin of Classical Genetics* (Cold Spring Harbor, NY: Cold Spring Harbor Press, 2004).

[3] NM Stevens, (1905) "Studies in Spermatogenesis, with Especial Reference to the 'Accessory Chromosome,'" Washington, DC, Carnegie Institution of Washington, Publication 36, NM Stevens; "Studies in Spermatogenesis Part II, A Comparative Study of Heterochromosomes in certain Species of Coleoptera, Hemiptera, and Lepidoptera with Especial Reference to Sex Determination," Washington, DC, Carnegie Institution of Washington, Publication 36, Part II, (1906); Elof Axel Carlson, *Genes, Radiation and Society: The Life and Work of H.J. Muller* (Ithaca, NY: Cornell University Press, 1981), p. 85.

[4] W.E. Castle, "The Inconstancy of Unit Characters," *The American Naturalist* 46/546 (1912): 352-362; W. E. Castle, "Piebald Rats and the Theory of Genes," *Proceedings of the National Academy of Sciences* 5 (1919): 126-130.; H.J. Muller, "Are the Factors of Heredity Arranged in a Line," *The American Naturalist* LIV/631 (1920): 97-121. See also Carlson, *Genes, Radiation and Society*, p. 82.

[5] Theodosius Dobzhansky, *Genetics and the Origin of Species* (New York: Columbia University Press, 1937); J.B.S. Haldane, *The Causes of Evolution* (London: Harper and Brothers, 1932).

[6] William Bateson, "The progress of genetics since the rediscovery of Mendel's Paper." In J.P. Lotsy ed. *Progressus rei Botanicae* (Jena: G. Fischer, 1906).

[7] J.B.S. Haldane, *Daedalus or Science and the Future* (London, U.K.: Kegan Paul, 1923).

[8] Morgan described Muller's problematic relationship to himself, Bridges and Sturtevant in a letter to Otto Mohr. See Ian Shine and Sylvia Wrobel, *Thomas Hunt Morgan: Pioneer of Genetics* (Kentucky: The University of Kentucky Press, 1976), p. 90. See also Nobel Laureates on Scientific Research. Oral History Interview. Harriett Zuckerman and Hermann J. Muller, Bloomington, Indiana, December 12, 1963, p.p. 6-7, 11, 13.

[9] Zuckerman, p. 51.

[10] See Luis Campos, *Radium and the Secret of Life* (Chicago, IL: University of Chicago Press, 2015).

[11] See correspondence between Dobzhansky and Filipchenko in Mikhail Konashev ed., *МАКСИМУМ ВОЗМОЖНОГО: Переписка Ф. Г. Добржанского с отечественными биологами: 1920–1970 гг., Часть 1, Переписка Ф. Г. Добржанского с отечественными биологами: 1920–1930-е гг.* [*The Maximum Possible: Correspondence F.G. Dobzhansky with his biological homeland: 1920-1970, Part I, Correspondence F.G. Dobzhansky with his biological homeland: 1920-1930*(St. Petersburg: Nestor History, 2014)], p.p. 7-396.

[12] The Reminiscences of Theodosius Grigorievich Dobzhansky. Oral History Collection, Butler Library, Columbia University (1962), p.p. 174-175.

[13] "Transport: Biologist's Bug," *Time*, May 4, 1936. See also https://vimeo.com/60233891.