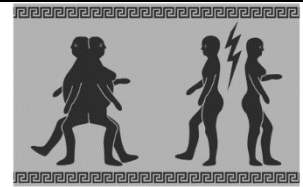




Stories of Science: Nettie Stevens & Sex Determination

The story about Nettie's trail blazing as a female academic and geneticist.

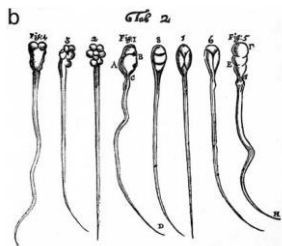
Humans have been fascinated by the differences between men and women since the dawn of civilisation and many cultures have mythological stories regarding the origin of the sexes which include the division from a single origin, such as the Judeo-Christian story of Eve created from one of Adam's ribs or the ancient greek myth of Zeus splitting apart a spherical, two-faced, four-legged creature into two parts to limit humans power and condemn them to a life searching for their other halves.



Ancient Greek mythology believed man and woman were split from a powerful whole by the gods.

Aristotle and Ancient theories of sex determination

Throughout antiquity scientists and philosophers put forward many theories as to how sex was determined and many people tried (without success) to control the sex of their offspring, preferring males due to the perceived strength, their value to the community and laws of primogeniture where wealth and power could pass only to male heirs. Many theories arose from the myths of a split origin; some believed that sex was determined by the position of the fetus in the womb - with males on the right, females on the left (a myth which survives in old-wives tales today). Others believed that males were formed from semen of the right testis, while females from semen of the left testis; and one can only wince at the thought of experimental procedures that may have been carried out to attempt to prove such theories in an age before anaesthetics. Aristotle (384-322BC) didn't believe the idea of a sidedness to sex determination; he had observed children of both sexes born following positioning on the left and the right of the womb and men with only one testis fathering both male and female children. Instead he believed that sex was determined by the balance of "elements": fire (from male semen) and blood (from female menstruation) determined the sex of the child. Whilst Aristotle's theories are obviously incorrect, he did correctly postulate the importance of male semen in the determination of sex, however no-one would observe a sperm cell within semen for another 2000 years.



Van Leeuwenhoek's sketches of rabbit and dog sperm

Antonie Van Leeuwenhoek and the Microscope

The first microscope was invented by a Dutch cloth merchant and lens maker named Antonie van Leeuwenhoek (1632-1723) in the 1670s. He is known as the Father of Microbiology for his extensive study and meticulous drawings of the "animalcules" he found in bodily fluids and the city of Delft's drinking water which subsequently revolutionised biology. One of his first studies was on the animalcules found in the semen of humans, rabbits and dogs and he immediately recognised their importance in the formation of embryos. Though the debate about the importance of sperm would rage a while longer and included a infamous experiment by Italian Scientist Lazzaro Spallanzani (1729-1799) who made tiny tight silk pants for frogs in order that he could show the pants inhibited fertilization unless he collected the frog semen from the pants for artificial insemination of frog eggs.

Nettie Stevens and XY Chromosomes

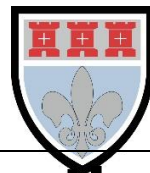
By the 19th century it was well established that fertilisation occurred when the male sperm and female egg fused but it was still unclear what subsequently determined the sex of the embryo. A biologist named Nettie Stevens (1861-1912) would discover the answer. Nettie was born in Vermont, USA to a wealthy father who had enough money to send Nettie and her sister Emma to school, something that was very unusual for girls to do at that time, in fact Nettie and her sister were two of only three girls to graduate from their school during the course of a decade. Nettie was a remarkable student, graduating nearly at the top of her high school class, completing a four-year higher study course at Westfield State University in just two years. She then became a teacher to earn enough money to go on to further university study, becoming one of the first women to study at Stanford University where she obtained both a Bachelors and Masters degrees. She went on to study for a PhD at Bryn Mawr University, a women's college which was among the first colleges to allow women to study for a doctorate. During her PhD under the supervision of Thomas Hunt Morgan (1866-1945), Nettie received a scholarship to spend time studying in Germany where she read about Gregor Mendel's (1822-1884) work on inheritance in pea plants which had been largely unrecognised by many geneticists of the time. Nettie returned to the USA, finished her PhD (at the age of 41) and started studying the genetics of mealworm beetles for her postdoctoral work. While studying the chromosomes of the mealworm beetle, she noticed that male beetles had one mis-paired pair of chromosomes. Male beetles had a large X-shaped chromosome and a much smaller Y-shaped chromosome, while female beetles had a pair of large X-shaped chromosomes. As a student of Mendel's model of inheritance, Nettie recognised that the smaller Y-chromosome could exhibit dominant male traits and confer the sex of the beetle.



Nettie Stevens

Death and Recognition

In the same year (1905) that Nettie was completing her research into mealworm beetles, Edmund Wilson at Columbia University was studying insect sperm and identified that there were two types of sperm with either X or Y chromosomes. However, Wilson was not familiar with Medelian genetics and believed that sex must be confired by the entire chromosome set, not by a single dominant chromosome. Nettie would be proved correct, but not before she died of Breast Cancer in 1912, just after she'd been awarded the research position at Bryn Mawr that she'd always longed for, but in the end was too ill to ever take up. Before her death, Wilson and her supervisor Morgan were often invited to conferences to discuss their findings on X and Y chromosomes but Nettie was not, despite the fact that they disagreed with Nettie's hypothesis about the dominance of Y-chromosomes. After her death Wilson was often credited as the sole discoverer X and Y chromosomes but Morgan always championed Stevens' work and credited her in his acceptance of the 1933 Nobel Prize for Physiology for his wider work on chromosomes and inheritance



Comprehension and Reflection Questions

1. The Greeks believed in "Soul Mates" that there was one perfect partner for each person, how did this manifest in their mythology?

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2. Why did ancient civilizations want to be able to control the sex of their offspring?

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3. Van Leeuwenhoek was a cloth merchant for a living, why might he have been motivated to invent a microscope?

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4. Van Leeuwenhoek's early experiments were on the often-contaminated water supplies of Delft, what do you think he saw under the microscope when he examined his local drinking water.

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5. Nettie Stevens primary worked in staining insect cells and examining them under a microscope. Why did she work on insect cells?

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6. Nettie would not have been able to see the chromosomes in all cells, at what stage of the cell cycle would Nettie have been able to observe the chromosomes in her stained cells under the microscope?

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7. Gregor Mendel was a Czech monk – why do you think his work went unrecognized for several decades?

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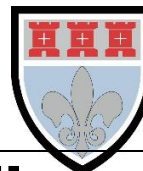
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8. Why did Morgan and Wilson not believe Nettie Steven's dominant Y-chromosome theory?

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Extension Activities

Ideas for things to do next:

Draw a Mendelian Square to explain why there is a 50:50 chance that a baby born is male:female.

Consider why meiosis (the process of making haploid gametes) is reductive dividing down to a single copy of each chromosome) rather than destructive (destroying one copy of each chromosome). What advantages are there to the reductive process? What problems might a destructive method come across?

Further Reading

Ideas for things to read next:

Stevant et al (2018) A Brief History of Sex Determination

http://bit.ly/Sci_Stories_SexDetermination

Antonie van Leeuwenhoek

https://en.wikipedia.org/wiki/Antonie_van_Leeuwenhoek

Frogs in Pants

<https://nypost.com/2017/06/10/scientists-learned-how-babies-are-made-by-dressing-frogs-in-pants/>