

Sex-determining Region Y in Mammals ^[1]

By: Cox, Troy Keywords: [Sex-Related Gene On Y](#) ^[2] [Sex Determination Processes](#) ^[3]

The Sex-determining Region Y (*Sry* in mammals but *SRY* in [humans](#) ^[4]) is a gene found on Y chromosomes that leads to the development of male phenotypes, such as [testes](#) ^[5]. The *Sry* gene, located on the short branch of the Y chromosome, initiates male embryonic development in the XY [sex determination](#) ^[6] system. The *Sry* gene follows the central dogma of molecular biology; the DNA encoding the gene is transcribed into messenger RNA, which then produces a single *Sry* protein. The *Sry* protein is also called the testis-determining factor (TDF), a protein that initiates male development in [humans](#) ^[4], placental mammals, and marsupials. The *Sry* protein is a transcription factor that can bind to regions of testis-specific DNA, bending specific DNA and activating or enhancing its abilities to promote testis formation, marking the first step towards male, rather than female, development in the embryo.

In [humans](#) ^[4] the first step in the development of an organism's sex is the inheritance of an X chromosome from the mother, and either an X or Y chromosome from the father. Typically, an XX individual develops as a female and an XY individual develops as a male. Studies by [University of Kansas](#) ^[7] zoologist Clarence Erwin McClung in Lawrence, Kansas at the turn of the twentieth century helped researchers focus on the roles of chromosomes for [sex determination](#) ^[6]. McClung theorized that there were two distinct types of [spermatozoa](#) ^[8], each of which resulted in different forms of fertilized eggs, leading to either male or female development. Nettie Maria Stevens, a post-doctorate researcher at [Bryn Mawr College](#) ^[9], located near Philadelphia, Pennsylvania, expanded upon McClung's theory in 1905, observing that [spermatozoa](#) ^[8] are of two distinct forms, containing either an X or a Y chromosome. Based upon her research on [sex determination](#) ^[6] in insect species, Stevens concluded that the Y chromosome carries the genetic material that leads to male development.

Stevens's work identified the Y chromosome as a heritable structure that somehow caused [sex determination](#) ^[6] in the embryo. Her results supported the theory proposed in the early 1890s by zoologist researcher Walter Sutton at [Columbia University](#) ^[10] in New York City, New York and biologist Theodore Boveri at [University of Würzburg](#) ^[11] in Würzburg, Germany, that chromosomes contain genetic material. At that time, however, researchers couldn't detail the mechanism through which chromosomes work to induce changes in the cell. Experiments conducted by Frederick Griffith in 1928 at the Ministry of Health in London, England confirmed the existence of a factor in cells capable of transferring genetic information.

In 1944 Oswald Avery, Colin Macleod, and Maclyn McCarthy, at the [Rockefeller Institute](#) ^[12] for Medical Research in New York City, New York, discovered that chromosomes contain DNA, the molecule that encodes an organism's genetic information. The discovery of DNA's structure in 1953 by [James Watson](#) ^[13] and [Francis Crick](#) ^[14] at the Cavendish Laboratory in Cambridge, UK enabled researchers to develop biochemical technologies, such as Polymerase Chain Reaction, which can replicate a single DNA sequence several million times. These techniques enabled researchers to describe the mechanisms that underlie developmental pathways, including the role of *SRY* gene in [sex determination](#) ^[6].

Starting in the early 1980s, research teams in London, UK led by Robin Lovell-Badge at the National Institute for Medical Research and Peter Goodfellow at the Cancer Research UK London Research Institute sought to identify the [genes](#) ^[15] present on the Y chromosome that induced male development. Scientists first scanned the Y chromosomes of several mammals for the presence of [genes](#) ^[15] involved in testis formation. The scientists claimed that the gene would encode for the testis-determining factor (TDF), a protein responsible for causing testis to develop in embryos. The team found a sequence on the Y chromosomes of several species of mammals. The transcripts from those sequences were all found only in [testes](#) ^[5]. The gene, designated the Sex-determining region Y, provided a candidate for expression of the TDF.

Confirmation of the *Sry* gene encoding the TDF came from several experiments that focused on mutations in the *SRY* gene. Early evidence came from research conducted by Peter Goodfellow and his teams at both the Cancer Research UK London Research Institute and the National Institute for Medical Research in the late 1980s and early 1990s. That research showed that mutations in the *Sry* gene halted the embryonic development of [testes](#) ^[5], resulting in organisms that possessed a Y chromosome but expressed female phenotypic characteristics. Robin Lovell-Badge and her team at the National Institute for Medical Research later confirmed *Sry* gene's role in [sex determination](#) ^[6] in an experiment where researchers injected *Sry* gene sequences into chromosomally female (XX) mice embryos during early embryonic development, and the embryos developed into males.

Throughout the 1990s, several researchers argued that *Sry* protein acted directly upon the genital ridge, the region in early embryonic development from which either the [ovary](#) ^[16] or the testis form. Researchers assumed that *Sry* protein helped change epithelial cells into Sertoli cells. Sertoli cells are only in males and produce key proteins and [hormones](#) ^[17] during male development. However, later scientists argued that *SRY* protein indirectly induces mesonephric cells to migrate into the genital ridge. *SRY* protein causes cells in the genital ridge to secrete a chemotactic factor that causes cells from the adjacent

mesonephros to migrate in to the genital ridge. The mesonephric cells, rather than SRY protein directly, induce the genital epithelial cells to become Sertoli cells.

Researchers have linked mutations in the *SRY* gene to forms of sex reversal. One example is Swyers syndrome, a condition in which a person who has XY sex chromosomes develops the physical characteristics of a female. Mutations in the *SRY* gene account for between fifteen to twenty percent of cases of Swyers syndrome. Additionally, the presence of *SRY* gene in genetically XX individuals results in XX male syndrome. This state often results from improper crossing over between X and Y chromosomes during meiosis^[18] in the father, resulting in the presence of SRY gene sequences in X chromosomes.

Sources

1. Avery, Oswald T., Colin M. MacLeod, and Maclyn McCarty. "Studies on the Chemical Nature of the Substance Inducing Transformation of Pneumococcal Types: Induction of Transformation by a Deoxyribonucleic Acid Fraction Isolated from Pneumococcus Type III." *Journal of Experimental Medicine* 79 (1944): 137–158. <http://profiles.nlm.nih.gov/ps/access/CCGMHL.pdf>^[19] (Accessed December 16, 2013).
2. Berta, Phillippe, J. Ross Hawkins, Andrew H. Sinclair, Anne Taylor, Beatrice L. Griffiths, Peter N. Goodfellow, and Marc Fellous. "Genetic Evidence Equating SRY and the Testis-Determining Factor." *Nature* 348 (1990): 448–50.
3. Boveri, Theodor. "Über mehrpolige Mitosen als Mittel zur Analyse des Zellkerns." [On Multipolar Mitosis as a Means of Analysis of the Cell Nucleus]. *Verhandlungen der Physikalisch-Medizinischen Gesellschaft zu Würzburg* 35 (1902): 67–90. <http://publikationen.ub.uni-frankfurt.de/frontdoor/index/index/docId/15991>^[20] (Accessed December 16, 2013).
4. Capel, Blanche, Kenneth H. Albrecht, Linda L. Washburn, and Eva M. Eicher. "Migration of Mesonephric Cells Into the Mammalian Gonad Depends on Sry." *Mechanisms of Development* 84 (1999): 127–31.
5. Gilbert, Scott. *Developmental Biology*^[21], 8th edition. Sunderland: Sinauer Associates, 2006.
6. Griffith, Fred. "The Significance of Pneumococcal Types." *Journal of Hygiene* 27 (1928): 113–159. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2167760/pdf/jhyg00267-0003.pdf>^[22] (Accessed December 16, 2013).
7. Gubbay, John, Jérôme Collignon, Peter Koopman, Blanche Capel, Androulla Economou, Andrea Münsterberg, Nigel Vivian, Peter Goodfellow, and Robin Lovell-Badge. "A Gene Mapping to the Sex-determining Region of the Mouse Y Chromosome is a Member of a Novel Family of Embryonically Expressed Genes." *Nature* 348 (1990): 245–50.
8. Koopman, Peter, Andrea Münsterberg, Blanche Capel, Nigel Vivian, and Robin Lovell-Badge. "Expression of a Sex-determining Gene During Mouse Testis Differentiation." *Nature* 348 (1990): 450–52.
9. Koopman, Peter, John Gubbay, Nigel Vivian, Peter Goodfellow, and Robin Lovell-Badge. "Male Development of Chromosomally Female Mice Transgenic for Sry." *Nature* 351 (1991): 117–121.
10. McClung, Clarence Erwin. "The Accessory Chromosome—Sex Determinant?" *The Biological Bulletin*^[23] 3 (1902): 43–84. <http://www.biobull.org/content/3/1-2/43.full.pdf+html>^[24] (Accessed April 25, 2013).
11. Sinclair, Andrew H., Phillippe Berta, Mark S. Palmer, J. Ross Hawkins, Beatrice L. Griffiths, Matthijs J. Smith, Jamie W. Foster, Anna-Maria Frischauf, Robin Lovell-Badge, and Peter N. Goodfellow. "A Gene from the Human Sex-Determining Region Encodes a Protein with Homology^[25] to a Conserved DNA-Binding Motif." *Nature* 346 (1990): 240–44.
12. Stevens Nettie Maria. *Studies in Spermatogenesis with Especial Reference to the "Accessory Chromosome"*. Washington D.C.: Carnegie Institution of Washington^[26], 1905. <http://www.archive.org/details/studiesinspermat01stevrich>^[27] (Accessed April 25, 2013).
13. Stevens Nettie Maria. *Studies in Spermatogenesis with a Comparative Study of the Heterochromosomes in Certain Species of Coleoptera, Hemiptera and Lepidoptera, with Especial Reference to Sex Determination*. Washington D. C.: Carnegie Institution of Washington^[26], 1906. <http://www.archive.org/details/studiesinspermat01stevrich>^[28] (Accessed April 25, 2013).
14. Sutton, Walter S. "On the morphology^[29] of the chromosome group in *Brachystola magna*." *The Biological Bulletin*^[23] 4 (1902): 24–39. <http://www.biobull.org/content/4/1/24.full.pdf+html>^[30] (Accessed April 25, 2013).
15. Watson, James D., and Francis H.C. Crick. "A Structure for Deoxyribose Nucleic Acid." *Nature* 171 (1953) 737–738. <http://profiles.nlm.nih.gov/ps/access/SCBBYW.pdf>^[31] (Accessed December 16, 2013).

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Publisher

Arizona State University. School of Life Sciences. Center for Biology and Society. Embryo Project Encyclopedia.

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Last Modified

Wednesday, July 4, 2018 - 04:40

DC Date Accessioned

Wednesday, January 1, 2014 - 00:38

DC Date Available

Wednesday, January 1, 2014 - 00:38

DC Date Created

2013-12-31

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- [23] <https://embryo.asu.edu/search?text=Biological%20Bulletin>
- [24] <http://www.biolbull.org/content/3/1-2/43.full.pdf+html>

- [25] <https://embryo.asu.edu/search?text=Homology>
- [26] <https://embryo.asu.edu/search?text=Carnegie%20Institution%20of%20Washington>
- [27] <http://www.archive.org/details/studiesinspermat01stevrich>
- [28] <http://www.archive.org/details/studiesinsperma00stevgoog>
- [29] <https://embryo.asu.edu/search?text=morphology>
- [30] <http://www.biolbull.org/content/4/1/24.full.pdf+html>
- [31] <http://profiles.nlm.nih.gov/ps/access/SCBBYW.pdf>
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- [33] <https://embryo.asu.edu/library-congress-subject-headings/testis>
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- [35] <https://embryo.asu.edu/library-congress-subject-headings/chromosomes>
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- [37] <https://embryo.asu.edu/library-congress-subject-headings/sex-determination-genetic>
- [38] <https://embryo.asu.edu/library-congress-subject-headings/sex-differentiation>
- [39] <https://embryo.asu.edu/library-congress-subject-headings/human-chromosomes>
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- [48] <https://embryo.asu.edu/library-congress-subject-headings/goodfellow-p-peter-1951>
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