Gender 2016 Vincent H. Resh

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Bruce Jenner won the decathlon at the Montreal Olympics in 1976. The decathlon was the special sport to the Greeks in the original Olympic Games; it was the ultimate test of a man's athletic abilities. Even today, the winner of the decathlon event in the Olympics is typically described as the "World's Greatest Athlete." After his victory, Bruce Jenner was a celebrity. His image was featured on boxes of Wheaties cereals and he was on the cover of *Playgirl* Magazine. He married, had 6 children, and received additional fame (or to some infamy) through his relationship to the Kardashian clan on reality television.

In July 2015, in a photoshoot for *Vanity Fair* magazine, Bruce Jenner announced that he was now Caitlyn Jenner. She stars in a reality television series "*I am Cait*", which focuses on his to her gender transition. Jenner, a Republican, said on her television show that although she does not support Donald Trump, she thinks he would be good for women's issues. This man's man of Olympic fame has chosen to be known as a woman.

General Mills put Jenner's picture on a box of Wheaties, and did so for 7 years. He was replaced by Olympic star and gymnast Mary Lou Retten. After his announcement of his gender transition, General Mills released a statement that "Bruce Jenner continues to be a respected member of Team Wheaties." After a negative response to this statement by some activists, General Mills clarified it by saying: "Bruce Jenner has been a respected member of Team Wheaties, and Caitlyn Jenner will continue to be." This series of events with Bruce and Caitlin Jenner made me consider an issue in far more detail than I ever had before: what do we mean when we say someone is a man or a woman? In this essay, I will examine these issues through current research in the biological sciences, touching on a variety of current issues that are being discussed in the media.

To me, morphological features, which are usually referred to as either primary sexual characteristics such as genitals, or secondary sexual characteristics such as men's beards and women's enlarged breasts, were the obvious characteristics that I had thought about. Well, this maybe not the best approach to take.

Getting back to the Olympics, Russian and Eastern European athletes that competed in women's events for decades had their primary sexual characteristics—even the morphology of their genitals—checked to see if they were in fact the appropriate gender for competing in a women's event. In the past decade, testosterone levels were tested both as a surrogate for these examinations and for evidence of doping.

I had spent many years working in Thailand and other parts of Southeast Asia, and transgendered Katooys or lady boys were certainly part of the local landscape, and even of the

culture there. As a result of surgical enhancement and modified cosmetic appearance, it was often hard to distinguish them from those Thais that biologically were born as women.

After a while, the key difference I found useful in appraising their birth gender was the presence of an Adam's apple, which is characteristic of males. An Adam's apple is hard to change surgically and a fairly consistent indicator of maleness, even if other parts of the body are surgically or hormonally altered.

In terms of Caitlyn Jenner, she has indicated that she has undergone some cosmetic surgery, but she also has indicated that she neither has undergone sex-reassignment surgery nor has she ruled it out in the future. Jenner stated that, for her, "life as a woman is primarily a matter of mental state and lifestyle."

But perhaps more reliable than morphological features, there is a genetic basis for determining gender. Humans have 23 pairs of chromosomes. The presence of two X chromosomes in females and of an X and a Y chromosome in males determines our biological sex. As you probably know, each of these sex chromosomes—an X or a Y—comes from one of our two parents. Fathers are the ones who determine the sex of the child by donating either an X or a Y chromosome. Mothers donate only X chromosomes.

But genetics isn't quite that straight forward either. Linda Hunt, who we regularly hear advertising *The California Arts and Lectures* series, is a female but she only has one X chromosome. This is a condition known as Turner's syndrome and it appears in about 0.1-0.5% births. You may also remember that Linda Hunt won an Academy Award for playing a male photographer, Billy Kwan, in the 1982 movie "The Year of Living Dangerously." She once remarked in an interview that her character Billy Kwan "is supra-personal [with] layers of sexual ambiguity."

So if the genetics isn't straight forward in terms of whether we are either XX females or XY males, it's even more complicated when we look at human behavior related to gender. Let's start by looking at behavioral differences among men and women, which is certainly a topic that can, with a clever title, lead to a best-selling book. John Grey's "*Men are from Mars Woman are from Venus*" produced a cottage industry for him in his successive books such as "*Mars and Venus in Love*", "*Why Mars and Venus Collide*", "*Mars and Venus on a Date*", and "*Mars and Venus in the Bedroom.*"

And there are numerous other books that are out there dealing with gender differences and behavior. Television host Steve Harvey wrote "*Act Like a Lady, Think Like a Man.*" And, of course, there are the derogatory titles, "*If Men Could Talk, Here's What They'd Say*", "*Men and Other Reptiles",* and "*Why Cucumbers are Better Than Men.*"

Actually, morphology and behavior are closely related to the topic of genetics in terms of determining gender and its characteristics, so let's look at the sex chromosomes in a bit more detail. To review, a person with two X chromosomes is biologically considered a female and one with one X and one Y is a male. Of course, as we mentioned with the XO female, chromosomes aren't always so straightforward and there are combinations of three sex chromosomes such as XXY and XYY males. And there are even XXX and sometimes, but rarely, an individual with four or five X chromosomes.

Genetically, there is a concurrence of about 98.5% when each of the three billion DNA units in our 23,000 or so genes is compared with those of pigmy chimpanzees, our closest relatives. But many genes on the X chromosome are inactivated and a new tally of Y chromosomes really yields what to me is a startling comparison. Men and women differ from each other by 1-2 percent of their total genomes.

This 1-2 % difference is about the same as that between a male human and a male chimpanzee, or a human woman and a female chimpanzee. David Page, a world-renowned geneticist at the Whitehead Institute in Cambridge, Massachusetts, has expressed this point quite provocatively: "We all recite the mantra that we are 99% identical and take political comfort in it. But the reality is that the genetic differences between males and females absolutely dwarf all other differences in the human genome."

Of course humans aren't unique among animals in having differences between male and female genetics. For example, some animals have been shown to have up to 15% of their genes more active in one sex than the other. And in some cases, environmental factors determine gender. In alligators and turtles, for example, sex is determined by the temperature at which the egg is incubated during a developmentally sensitive period. And for some fish, it's the proportion of the difference in genders that already exist in the population they are born into that determines their sex.

Let's take a more detailed look at the X chromosome first. Actually, they called it X because so little was known about it. Our Y chromosome was then named simply following the alphabet along. The history of naming vitamins worked in a similar alphabetic sequence—Vitamin A was discovered first, then B, etc..

However, the X chromosome does much more than specify reproductive characteristics. It is a rich repository of genes that are vital to brain and other aspects of human development. In the 22 other pairs of non-sex chromosomes—which are all those except the X and the Y—two copies of every gene are especially handy when one of those paired genes is defective. When this occurs, the working version of the gene can step in and can specify enough of the essential protein that is needed. Men having only one X chromosome can't do this with their sex chromosomes. Women with two X chromosomes normally can.

In a process not fully understood, although females have 2 X chromosomes that are active at conception, one of these X chromosomes de-activates early in the developing embryo, and it becomes condensed. It's then referred to as a Barr body. This modified X chromosome has important consequences in sex determination that we'll come back to.

Then let's go to the Y chromosome. Actually, the Y chromosome is a bit of a comedown compared to the X. It's puny in size relative to the X, has far fewer genes, and many of the genes it carries can be deleterious to survival through embryological development and early life. One theory of why there are 106 male newborns to 100 females is that the Y chromosome is far lighter than the X because it has far less material on it. Therefore, the lighter sperm with a Y chromosome can swim faster and thus have a better chance of fertilizing an egg than does a sperm with an X chromosome. These ratios become even at about 5-6 years of age because of higher survival of female infants.

When our cells divide, each of the chromosomes in our body duplicates itself. What then happens in the egg cells is a process called recombination where two X chromosomes line up and there is an exchange of some of the genetic material between them. This is an important source that produces variation making us different from our parents and siblings. Of course, males have an X and a Y so in our cell division and the production of sperm cells there can be none of this recombination. This is because the gene for maleness—called SRY, which stands for the Sex-Determining Region Y chromosome—would slip into an X chromosome and then fertilized offspring would all be males. As a result, most genes on the Y chromosome have been rendered useless because of mutations that couldn't be protected as occur in our other chromosomes that are not involved in sex determination.

This reduction in genes on the Y chromosome has prompted many popular news articles suggesting that the tiny Y chromosome will wither away, until it simply vanishes and the male sex would become extinct. This of course would leave women with a need to invent some virgin-birth method of reproduction and the resulting need to propagate a sexless species. Many other animals, including invertebrates and vertebrates, have done this successfully. Of course, the threat of our becoming a sexless species is not likely to happen in that the number of genes on the Y chromosome appears to have stabilized.

The SRY gene—the gene that makes us male—appeared a long time ago, about 320 million years in fact. Then, the Y chromosome was the same size as the X and the two chromosomes each had about 800 genes in common. Today, they share about 19 of these genes.

There's a cute ditty about the first words that Adam said to Eve—"Madam, I'm Adam." This is a palindrome—if you read it front to back, or back to front, the same phrases (minus punctuation) result. Actually, the Y chromosome consists of 8 palindromes that form a hairpin shape when they divide, which brings the two arms of the chromosome together. This is a critical step that almost always goes right. But, if it goes wrong, the Y chromosome could be absent in the fertilized egg. Then, an egg with only 1 chromosome—an X—results. This is called Turner's syndrome, like Linda Hunt has. For a long time, these single X individuals were thought to be missing the X from their father but actually, they also could be missing because of a defunct Y chromosome.

The recent Supreme Court case about the constitutionality of Proposition 8 in California, which specified that "only marriage between a man and a woman is valid or recognized in California" brought about many interesting discussions about gender issues. For example, an *amicus curiae* briefing by Cal State Professor Maria Nieto emphasized that the terms man and woman refer to gender and are quite distinct from the biological sex determinations of "male" and "female." She emphasized with numerous examples that roughly in 1 in 2000 births, sex determination is indeterminate. That is, the chromosomal determination of sex does not necessarily match their gender.

This of course is an issue that we have seen in discussions about sex determination in the Olympic Games. In 1936, the head of the US Olympic committee, the controversial Avery Brundage, raised issues about the gender of a Czech runner and an English shot-putter that competed as females. Both later had sex change surgery and became males.

In 1950, the IAAF—the International Association of Athletics Federations—recommended that sex determination should be done by each competing country. In the 1998 Olympics, it was required to be done and be standardized. The first attempts at gender determination in the Olympics were referred to as the "nude parade." Examinations of external genitals of competing female athletes were done individually by physicians. If an athlete's clitoris was above a certain size they were deemed to be men and not allowed to compete in women's events. This approach was appealing to the Olympic committee because it was cheap and rapid. Of course, it was also demeaning, not based on much science, and finally abandoned in 1968.

The next approach, started in 1968 involved Barr body testing. Remember, the Barr body is an inactivated and condensed X chromosome. Presumably, males wouldn't have Barr Bodies because they only have one X chromosome, and it's activated and not condensed in size. So if the athlete competing in a female event didn't have a Barr body, they were disqualified. The problem was that some females, such as Linda Hunt, are XO with a single X chromosome and no Barr body. But more importantly, XXY males would have a Barr body! One of their X chromosomes would be de-activated and condensed. Even more confusing, some XX females and XY males have mosaics of chromosome in their blood cells so in fact XX females and XY males could fail the test.

Then the Olympic Committee tried other approaches. They looked for the presence of the SRY gene. This is normally present on the Y chromosome and induces development of the testes and other male sexual characteristics. However, this assumes that the developmental pathways continue normally. This testing was begun in 1992 but discontinued in 1999.

One other attempt was tried—testosterone levels—which are also used in the doping tests. The problem is that there is overlap in testosterone levels between male and female athletes. When this approach was used, athletes that were competing in female events were disqualified unless they underwent surgery to remove gonads or were treated pharmaceutically to reduce testosterone levels. For athletes that failed any of these gender tests the Olympic Committee gave them a recommendation—fake an injury, and then withdraw from the competition quietly. By following this advice, the actual reason for having to withdraw would not be widely known. Some did, but many brought suit against this practice. Finally, all mandatory gender testing stopped in1996 but periodic tests have continued until just before the Rio Olympics this past summer.

Now let's turn to the 2016 Olympics. The South African runner Caster Semenya handily won the 800 meter women's competition. In the past, she has been scrutinized, often brutally, about her gender by her competitors, sports officials, and journalists. One competitor called her a man and the head of track and field's governing body said "She's a woman but maybe not 100%." She was barred from competition for a time and subjected to numerous sex-determination tests.

Semenya has hyperandrogenism. This condition results in high levels of testosterone being produced in her body. An Australian newspaper reported that this higher than average level resulted from the presence of internal testes. Disputes over Semenya's sex finally lead to suspension of testosterone tests in track and field competitions. An arbitration panel noted that

there is no scientific evidence that higher testosterone levels in women athletes provide a more significant competitive edge then say, nutrition, access to coaching and training facilities, or other genetic and biological variants among athletes.

It's not only in the Olympics that gender issues will continue to be part of the ongoing discussions in society, and they will very likely continue in the future. For example, questions about gender identity and sexual orientation have been added to admissions applications used by the University of California system regarding the prospective students "gender identity." The choices are: "male; female; transsexual male/man; transsexual female/woman; gender queer/gender non-conforming; and different identity." The application also asks "what sex were you assigned at birth, such as on an original birth certificate?" There, the only two choices are: male or female. These questions are voluntary and the University states that responses to these questions do not impact admissions decisions.

I want to conclude with a comment made by Natalie Angier, a long-time science writer for the *New York Times*. To me, she expresses current ideas about gender, sex determination, and our understanding of the X and Y chromosomes beautifully.

It was in a Mother's Day article written May 1, 2007—and the message applies to all of us, including Caitlin Jenner: "Every daughter, then, is a walking mosaic of clamorous and quiet chromosomes, of fatherly sermons and maternal advice, while every son has but his mother's voice to guide him."

Genetically, the Y chromosome does make us male. But looking at it in the big picture, it is the X chromosome that has the higher-value genetic material. So, with our one X chromosome that comes from our mothers, we all mainly have our mother's voice to guide us. In essence, at least genetically, we all really are mama's boys.