THE MAKING OF HUMAN HERMAPHRODITES

(1) The majority of humans come in two varieties: male and female. Genetic males have 46 chromosomes, two of which are called sex chromosomes X and Y. Genetic females also have 46 chromosomes, two of which are called X and X. In most cases, genetic males (46XY) develop male reproductive organs and genetic females (46XX) develop female reproductive organs. There are, however, cases of humans who are born with both testicular as well as ovarian tissues, essentially a combination of both male and female structures. Organisms with both are called hermaphrodites. The word hermaphrodite comes from Greek mythology. Hermes was the Olympian god of transitions and Aphrodite was the goddess of love. They had a son named Hermaphroditos who fused himself with a female deity to possess both sexes and become a hermaphrodite. Mythology aside, how do real human hermaphrodites form?

(2) One type of human hermaphrodite is called a 46XX,46XY hermaphrodite chimera. A chimera is an individual who has a mixture of cells from two genetically different sources or cell lines. For a person who is 46XX,46XY, this means that some of their cells come from a female source and some come from a male source. This is what produces both testicular and ovarian tissue. How is it possible for one person to have cell lines from two different people in their body?

(3) First you must understand some things about human fertilization. Human eggs and sperm cells contain 23 chromosomes, which is half the number needed to form a human with 46 chromosomes. An egg contains 23X, meaning that one of the 23 chromosomes in the egg is always an X sex chromosome. A sperm cell contains *either* 23X *or* 23Y. This means that a sperm cell can contain an X chromosome or a Y, but not both. If a 23X sperm fertilizes an 23X egg, a 46XX genetic female embryo is produced. If a 23Y sperm fertilizes a 23X egg, a 46XY genetic male embryo is produced. Normally every woman releases only one egg a month from an ovary, but at times two eggs are released and if both are fertilized by sperm, two embryos will form. This is what produces non-identical (fraternal) twins.

(4) In some cases, the two separate embryos do not stay separated during development. One embryo can envelop the cells of the other embryo creating a single embryo with a mixture of two distinct cell lines. If one of the embryos was a genetic male (46XY) and the other was a genetic female (46XX), then the combination of the two could produce a chimera with sex organs that contain a mixture of testicular tissue, from the 46XY cells, and ovarian tissue, from the 46XX cells.

(5) Human hermaphrodism can also arise due to the effects of the SRY gene. This gene is found on the Y chromosome and it is responsible for creating a protein called the testis-determining factor. The SRY gene is responsible for initiating male sex determination in genetic males (46XY). The SRY gene is active between the 6^{th} and 8^{th} weeks of male embryo development. During this time, the SRY gene also inhibits the formation of female reproductive structures which would otherwise form without the gene.

(6) In a male embryo, if the SRY gene on the Y chromosome is defective in some cells but active in others, the cells with the active SRY genes can form testicular tissue and the cells with the inactive SRY gene can form ovarian tissues. With both male and female reproductive tissues, the offspring will become a 46XY hermaphrodite.

(7) 46XX hermaphrodites can also form when the SRY gene is accidentally transferred from a Y chromosome to a X chromosome in a sperm cell during the process of sperm formation. Normally, X chromosomes would never carry an SRY gene. If a sperm with an X chromosome carrying the SRY gene fertilizes an egg it can still form an embryo. If the SRY gene is defective in all the embryonic cells, the embryo

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becomes a genetic female. However, if some cells contain active SRY genes and some don't, the embryo can form a mixture of testicular and ovarian tissues, thus forming a 46XX hermaphrodite.

(8) In many cases, hermaphrodites live healthy and normal lives and many may never know they are hermaphrodites, though some may have fertility issues. Some researchers are beginning to support the idea that humans should be regarded as having more than just two sexes, and that intersex people are more common than we think.

(9) If you think hermaphrodism is strange, then you might be in for a surprise. Though the majority of humans are not hermaphroditic, there are many organisms that typically are. Most plants are hermaphrodites. Flowers are the reproductive organs of plants. Some plants can produce flowers that contains both male and female reproductive organs, and others can cause half of their flowers to form female structures and half to form male structures. As well, most invertebrates (organisms without spines) like worms, slugs and snails are also hermaphrodites. Several species of fish are also hermaphroditic. Hermaphrodism in nature is common and has its advantages. Hermaphrodites do not need to find mates of the opposite sex as every member of the species is a potential mating partner.

Article Questions

1) In humans, genetic females have _____ sex chromosomes and genetic males have _____ sex chromosomes. In humans, the _____ cells determine the sex of the offspring.

2) What is a hermaphrodite?

3) What is a chimera?

4) Why is a 46XX,46XY hermaphrodite considered a chimera?

5) Where is the SRY gene normally located and what is it usually responsible for?

6) How can the SRY gene cause a genetic female to produce a mixture of ovarian and testicular tissues?

7) Give examples of organisms that are mostly hermaphroditic.