

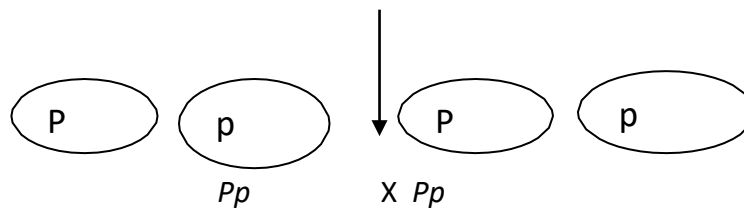
| | | |
|--------------|---|----------------------------------|
| | X tra | Y tra |
| X Tra | XX <i>Tratra</i> Female fertile | XY <i>Tratra</i> Male fertile |
| X tra | XX <i>tratra</i> Male sterile (Transformed) | XY <i>tratra</i> Male fertile |

Ratio: 3 Males: 1 Female

Monogenic control of sex has also been reported in some plants like *Asparagus*, maize, papaya, spinach, etc. *Asparagus* is a dioecious plant. However, rarely female flowers bear rudimentary anthers and male flowers bear rudimentary pistils. Occasionally, male flowers with poorly developed pistils set seed on selfing and segregate in 3: 1 ratio of male and female.

Segregation of sex in seed obtained from a rare bisexual flower in *Asparagus* showing monogenic control

Rare male plant when selfed



| | | |
|---|-------------------|---------------------|
| | P | p |
| P | <i>PP</i> Male | <i>Pp</i> Male |
| p | <i>Pp</i> Male | <i>Pp</i> Female |

Ratio: 3 Males: 1 Female

Maize being a monoecious plant bears both female (silk) and male (tassel) inflorescences on the same plant. A recessive gene *ba* (barren cob) in homozygous condition (*baba*) makes the cobs barren or non-functional. Similarly, a recessive gene *ts* in homozygous condition (*tsts*) converts the male flowers of tassel into female flowers. Thus, homozygous state of gene *ba* (*baba*) converts the monoecious plant into male. Similarly, gene *ts* in homozygous condition (*tsts*) converts the monoecious plant into female. The plants with both dominant genes (*BaTs*_) are monoecious, with *babaTs*_ normal male, with *Ba_tsts* female, and with *babatsts* rudimentary females.

In papaya, the sex is postulated to be governed by three alleles, viz., *m*, *M1* and *M2* of a single gene. Homozygous recessive (*mm*) produces female plants, heterozygous, viz., *M1m* and *M2m* produce male and hermaphrodite plants, respectively. However, combination of both dominant alleles (*M1* and *M2*) produces inviable plants both in homozygous (*M1M1* and *M2M2*) and heterozygous conditions (*M1M2*). Crosses between female (*mm*) and male (*M1m*) produce females (*mm*) and males (*M1m*) in 1: 1 ratio. Similarly, crosses between female (*mm*) and hermaphrodite (*M2m*) will produce females (*mm*) and hermaphrodite (*M2m*) in 1: 1 ratio. Selfing of hermaphrodite (*M2m*) plants produce hermaphrodite (*M2m*) and female (*mm*) progeny in 2: 1 ratio and about ¼ of the zygotes (*M2M2*) do not survive.

V. Metabolically controlled mechanism: Riddle found that metabolism has some definite role in the determination of sex in pigeon and dove because increased rate of metabolism lead to the development of maleness while decreased rate of metabolism caused femaleness.

VI. Hormonally controlled mechanism: Crew in 1923 reported a complete reversal of sex in hen. Female chicken that have laid eggs been known to undergo not only a reversal of the secondary sexual characteristics such as development of cock feathering, spurs and crewing, but also the development of testis and even the production of sperm cells (primary sexual characteristics). This might have occurred when a disease destroyed the ovarian tissue and in absence of female sex hormones, rudimentary testicular tissue present in center of ovary began to proliferate or multiply and secrete male hormones, which lead to the development of maleness.

Sexual differentiation in man is influenced by hormones. When the testis of the male is removed before puberty, female characteristics of body form, voice and hair pattern develop in the adult. Tumors of adrenals in women are associated with the development of masculine characters such as low-pitched voice and increased growth of hair.

VII. Sex determination in *Coccinia indica* and *Melandrium album*:

| Ploidy level | Chromosome Constitution (Autosomes) + (Allosomes) | Sex Expression | X/A ratio |
|--------------|---|----------------|------------|
| Diploid | AA + XX | Female | 1.00 |
| Diploid | AA + XY | Male | 0.50 (1/2) |
| Diploid | AA + XYY | Male | 0.50 (1/2) |
| Triploid | AAA + XXX | Female | 1.00 |
| Triploid | AAA + XXY | Male | 0.67 (2/3) |
| Tetraploid | AAAA + XXXX | Female | 1.00 |
| Tetraploid | AAAA + XXXY | Male | 0.75 (3/4) |

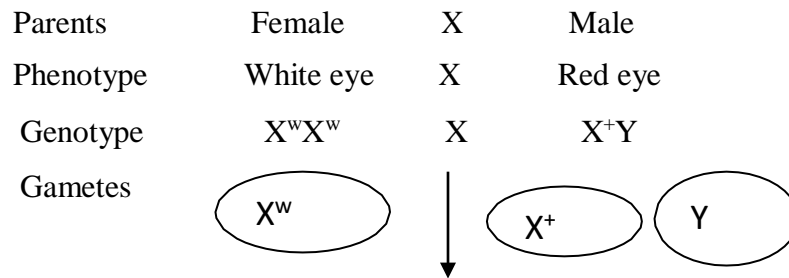
In these two organisms, studies have revealed that irrespective of number of ‘X’ chromosomes, and / or autosomal sets, presence of a single ‘Y’ chromosome is essential to produce male flowers in diploid, triploid and tetraploid species. The pistillate plants are XX and the staminate plants are XY.

Sex determination due to environmental Factors: In many reptiles, sex is determined by environmental factors like temperature. In most turtle species only females are produced at high temperature (30 – 35°C) while only males are produced at low temperatures (23 – 28°C). Sex ratio changes suddenly from all males to all females with just change in temperature of 2°C during the incubation. In Crocodiles and Lizards, (reverse is the case) the males are produced at high temperature while females are produced at low temperature. In *Bonellia viridis*, a marine worm, all larvae are genetically and cytologically similar. If a particular larva settles near proboscis of adult female, it becomes a male individual. If larva develops freely in water, it becomes a female. In some plants, sex determination depends on day length, temperature and hormones. For example, in cucumber (*Cucumis sativa*) and muskmelon, treatment with ethylene enhances production

SEX LINKED INHERITANCE

The characters for which genes are located on sex or ‘X’ or analogous ‘Z’ chromosomes are known as sex linked traits. Such genes are called sex linked genes and linkage of such genes is referred to as sex linkage. Inheritance of such genes or characters is known as sex linked inheritance. The sex linkage was first discovered by

T.H. Morgan in *Drosophila* and the first sex linked gene found in *Drosophila* was recessive gene 'w' responsible for white eye colour.

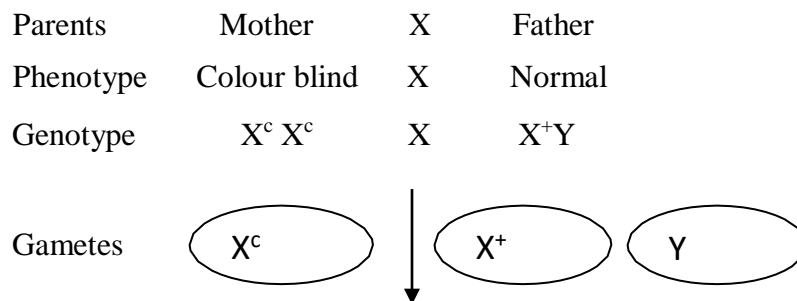


| | | |
|-------|-----------------------------|---------------------------|
| | X^+ | Y |
| X^w | $X^w X^+$ Red eye female | $X^w Y$ Red eye female |

When white eyed females are crossed with wild type (red eye) males, all the male offspring have white eyes like the mother and all the female offspring have red eyes like their father.

In human beings, colour blindness and haemophilia (bleeder's disease) are well known hereditary characters showing a peculiar relationship to sex.

Colour blindness: A marriage between colour blind woman and a normal man gives rise to all normal daughters and colour blind sons.

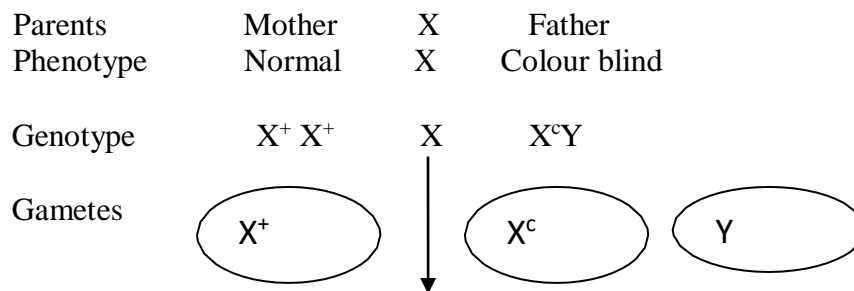


| | | |
|-------|------------------------------|----------------------------|
| | X^+ | Y |
| X^c | $X^c X^+$ Normal daughter | $X^c Y$ Colourblind son |

The allele for colour blindness (c) is found on both 'X' chromosomes of mother and therefore she is colour blind. The only one 'X' chromosome of father in this marriage carries a wild type (+) allele and hence he has normal vision. The 'Y' chromosome lacks both the alleles (+ and c). The reduction division produces one kind of egg in contrast to two kinds of sperms. Fertilization results in the usual sex ratio of 1 male: 1 female. All the daughters have normal vision since they receive dominant allele '+' from their father. All the sons are colour blind, because their single 'X' chromosome derived from mother carries the allele 'c' for colour blindness. This result is known as crisscross inheritance because daughters are normal like father and sons have colour blindness like mother. However, the daughters are heterozygous carriers. This crisscross method of inheritance is characteristic of sex-linked genes. This peculiar type of inheritance is due to the fact that Y chromosome carries no alleles homologous to those on the X chromosome. Thus, males carry only one allele for sex linked traits. This one allelic condition is termed as hemizygous in contrast to homozygous and heterozygous possibilities in female. The expression of recessive gene in hemizygous condition is termed as pseudo-dominance.

The inheritance of colour blindness can be studied in the following three others possible types of marriages:

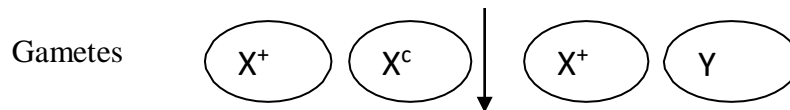
a) Marriage between normal woman and colour blind man:



| | | |
|-------|---------------------------------------|-----------------------|
| | X^c | Y |
| X^+ | X^+X^c Normal daughter (Carrier) | $X^+ Y$ Normal son |

b) Marriage between normal (carrier) woman and normal man:

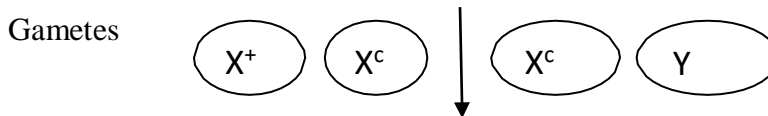
Parents Mother X Father
 Phenotype Normal X Normal
 Genotype $X^+ X^c$ X $X^+ Y$



| | | |
|-------|------------------------------|-----------------------------|
| | X^+ | Y |
| X^+ | $X^+ X^+$ Normal daughter | $X^+ Y$ Normal son |
| X^c | $X^c X^+$ Normal daughter | $X^c Y$ Colour blind son |

c) Marriage between normal (carrier) woman and colour blind man:

Parents Mother X Father
 Phenotype Normal X Colour blind
 Genotype $X^+ X^c$ X $X^c Y$



| | | |
|-------|------------------------------------|-----------------------------|
| | X^c | Y |
| X^+ | $X^+ X^c$ Normal daughter | $X^+ Y$ Normal son |
| X^c | $X^c X^c$ Colour blind daughter | $X^c Y$ Colour blind son |

Results of possible four marriages make it clear why there are more colour blind males than females in the population. In three marriages colour blind sons were produced where as in only one of the marriages, colour blind daughters were observed, where the mother is heterozygous (carrier) and the father is colour blind. Nearly all colour blind women must come from the last type of marriage, since the only other possible source of colour blind females is mating between two colour blind persons – naturally a rare occurrence.

Haemophilia is a recessive sex-linked disease and the inheritance pattern of haemophilia is similar to that of colour blindness in human beings.

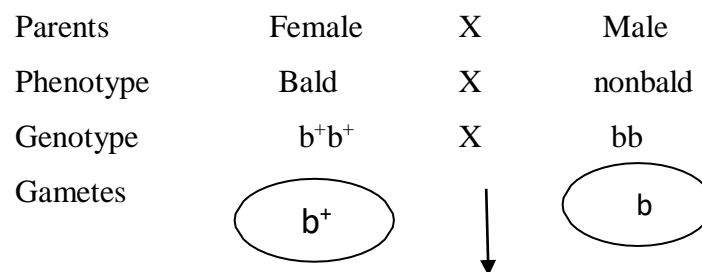
Genes present in the non-homologous region of the Y chromosome pass directly from male to male. In man, the genes present on Y chromosome (holandric genes) such as the gene causing hypertrichosis (causing excessive development of hairs on the pinna of ear) are transmitted directly from father to son.

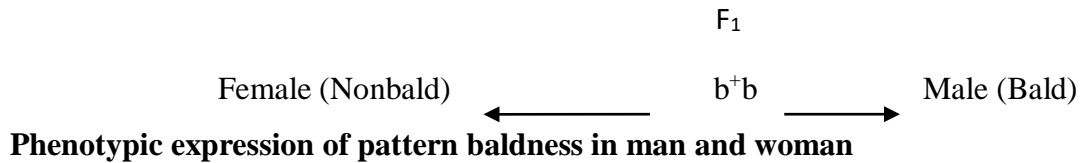
Sex influenced inheritance

Sex influenced genes are the autosomal genes present in both males and females, whose phenotypic expression is different in different sexes in such a way that they act as $X^+ X^c$ dominant in one sex and recessive in the other i.e. in a pair of alleles one seems to be dominant in males while the other in females.

Eg.: Pattern baldness in human beings and horns in sheep. Pattern baldness in human beings is a condition in which a low fringe of hair is present on the head in human beings. It is a genetically inherited condition, where the allele for baldness B is dominant in males and recessive in females. In heterozygous condition, males are bald and females are nonbald. If a woman heterozygous for this gene marries a heterozygous bald man, in the offspring, the ratio of bald to non-bald in males is 3 : 1, while in females it is 1 : 3.

Inheritance of pattern baldness in human being





| Genotype | Phenotype | Genotype |
|-----------|-----------|-----------|
| | Female | |
| $b^+ b^+$ | Nonbald | $b^+ b^+$ |
| $b^+ b$ | Nonbald | $b^+ b$ |
| bb | Bald | bb |

Sex limited characters or Secondary Sexual characters

Sex limited genes are autosomal genes, whose phenotypic expression is limited to one sex only. Their phenotypic expression is influenced by the sex hormones. The sex-limited genes are mainly responsible for secondary sex characters in cattle, human beings and fowl. Eg.: milk production in cattle, beard development in human beings, plumage in male fowls etc.

Milk production in cattle: Just as the cow, the bull carries genes for milk production, but the bull obviously cannot express this trait. Bull may however transmit these genes for $b^+ b$ high milk production to the female progeny and the male progeny are unable to express this trait. Some bulls are so well endowed with such genes that they are known to breed calves, which always yield greater milk than their mothers.

However, in plants no secondary sexual characters are known except the absence of one or the other sporangia.

Differences between sex linked and sex-limited characters

| Sex Linked characters | Sex Limited characters |
|--|--|
| 1. They are located on sex or X chromosome | 1. They are located on sex chromosomes or autosomes |
| 2. They can express in both the sexes | 2. They can express in one sex only |
| 3. Include characters not related to sex | 3. Include primary and secondary sex characters |
| 4. Examples: White eye in <i>Drosophila</i> , haemophilia and colour blindness in human beings | 4. Examples: milk production in cattle, beard development in human beings, plumage in male fowls etc |

Inter sex

In a few rare cases, various mixtures of male and female characteristics may occur in animals, which normally have separate sexes because of various abnormalities of chromosomes or hormonal deficiencies. Such individuals are called inter sex. These can be of two types.

1. Pseudo -hermaphrodites: In mammals, there are rare cases in which, both sexes are well developed in one body, these are abnormal one and hence sterile.

2. Gynandromorphs or gynanders: Among animals and insects that do not have sex hormones, there may be sex intergrades with distinct areas of the body showing male and female tissues. For example: *Drosophila gynander*, a bilateral sex mosaic, is male on one side and female on the other.