

# Sex determination different animals

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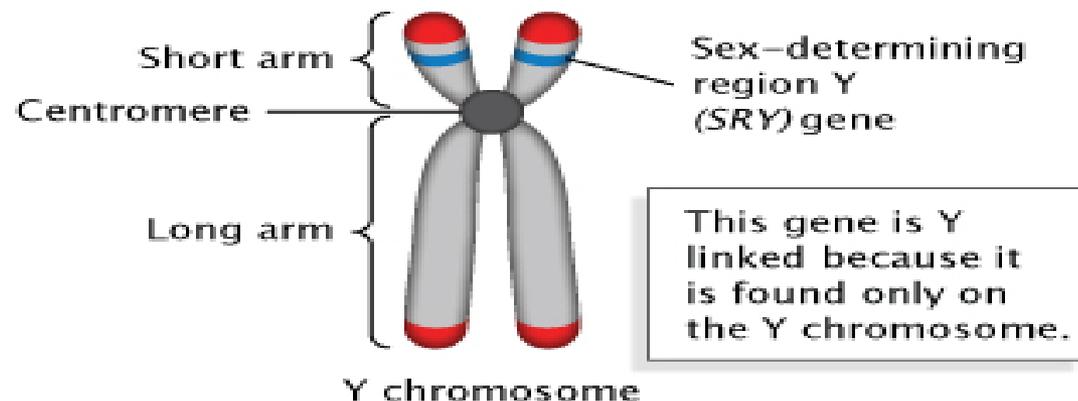
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# Sex determination Human

- ✓ In placental mammals, the presence of a Y chromosome determines sex.
- ✓ Normally, cells from females contain two X chromosomes, and cells from males contain an X and a Y chromosome.
- ✓ Individuals with 47,XXY and 47,XYY karyotypes are males, while individuals with 45,X and 47,XXX karyotypes are females.
- ✓ David C. Page Using DNA hybridization with probes corresponding to different regions of the Y chromosome, Page discovered that sex-reversed males carried genes from a 140-kilobase region on the short arm of the Y chromosome (Figure 1).

# Location of SRY gene on Y chromosome



- Presumably, this region had been transferred to the X chromosome during a translocation (Page et al., 1985).
- Subsequent experiments narrowed down this region (McLaren, 1991) and found that one gene, the sex-determining region of the Y, or SRY, was the master regulator of sex determination.
- The presence of just this region from the Y chromosome is thus sufficient to cause male development (Koopman et al., 1991)

# Role of SRY gene

- ✓ In human embryos, the SRY gene encodes a unique transcription factor that activates a testis-forming pathway at about week seven of development.
- ✓ Early embryo has two systems of ducts, Wolffian and Müllerian ducts, which are capable of developing into the male and female reproductive tracts, respectively.
- ✓ SRY gene product stimulates to develop into a testis, the testis begins producing two hormones, testosterone and anti-Müllerian hormone, or AMH.
- ✓ Testosterone and one of its derivatives, dihydrotestosterone, induce formation of other organs in the male reproductive system, while AMH causes the degeneration of the Müllerian duct.
- ✓ In females, who do not contain the SRY protein, the ovary-forming pathway is activated by a different set of proteins. The fully developed ovary then produces estrogen, which triggers development of the uterus, oviducts, and cervix from the Müllerian duct.
- ✓ In mammals, the *DMRT1* gene product is a critical member of the testis-forming pathway initiated by *SRY*. Two copies of the *DMRT1* gene are necessary for testis development, located on chromosome number nine.

# Sex Determination in Birds: Z and W Chromosomes

- ✓ In birds, sex is determined by chromosomes known as the Z and W, and females are the heterogametic sex (WZ- Female, ZZ- Male ).
- ✓ Investigations led to the discovery of the *DMRT1* gene on the chicken Z chromosome (Nanda *et al.*, 1999).
- ✓ In mammals, the *DMRT1* gene product is a critical member of the testis-forming pathway initiated by *SRY*. Two copies of the *DMRT1* gene are necessary for testis development, even in the presence of *SRY*.
- ✓ In mammals, both sexes have two copies of *DMRT1*, because it is located on an autosome (specifically, chromosome 9). In chickens, by contrast, only males possess two copies of *DMRT1*, as it is located on the Z chromosome.
- ✓ One can readily see that the Z chromosome is significantly larger than the W chromosome.

# W chromosome carry female determining and Z chromosome is male determining factors.

- ✓ The actual trigger for activating the testis-forming pathway in chickens remains unknown.
- ✓ Birds also differ significantly from mammals in that two unique genes on the W chromosome, *FET1* and *ASW*, are necessary for female development. The function of *FET1* is unknown, but it is expressed in the gonads leading up to the time of sexual differentiation (Smith & Sinclair, 2004).
- ✓ Like mammals, chickens also have an indifferent gonad until around day four of development, after which an ovary or a testis starts to develop.
- ✓ Hormones then orchestrate the development of other sex-specific characteristics.
- ✓ In contrast with mammals, however, estrogen is required earlier in sex determination in chickens, and is, in fact, necessary for formation of the ovary. In fact, genetically male chickens can be converted to females if eggs are injected with estrogen at the sensitive stage of development.
- ✓ The ZZ-ZW mechanism of sex determination is not restricted to birds. Within the vertebrates, a similar system of sex determination has been identified in reptiles, as well as in some fishes and amphibians.

# Sex determination in fruit fly *Drosophila melanogaster*

- ✓ In fact, in *Drosophila*, sex is primarily determined by the X:A ratio, or the ratio of the number of X chromosomes to the number of sets of autosomes (Cline & Meyer, 1996). The
- ✓ balance between female-determining factors encoded on the X chromosome and male-determining factors encoded on the autosomes determines which sex-specific pattern of transcription will be initiated.
- ✓ Thus, XX, XXY, and XXYY flies are females, while XY and XO flies are males.
- ✓ Flies are unable to survive with more than two copies of an X chromosome because of the mechanism that they use for dosage compensation. (Dosage compensation refers to the processes by which animals equalize the amount of gene products generated from X-linked genes in males and females. Unlike in mammals, all of the *Drosophila* X chromosomes remain active, and flies adjust the levels of X-linked gene products by doubling expression from the X chromosome in males.
- ✓ *Drosophila* sex determination also differs from mammalian sex determination in several other ways. First, sex determination begins immediately at fertilization, and there is no indifferent period. Furthermore, hormones are not responsible for sex-specific traits.
- ✓ Instead, each cell in the embryo senses the X:A ratio, triggering either the female- or male-specific pattern of transcription. Microarray experiments indicate that the sex-specific differences in gene expression are quite extensive. In fact, roughly 30% of *Drosophila* genes were found to show sex-specific biases in expression (Parisi *et al.*, 2004).

# *Drosophila*, sex is primarily determined by the X:A ratio

X chromosomes	Autosome sets (A)	X:A ratio	Sex
3	2	1.50	Metafemale
4	3	1.33	Metafemale
3	3	1.00	Normal female
2	2	1.00	Normal female
2	3	0.66	Intersex
1	2	0.50	Normal male
1	3	0.33	Metamale

# X:A ratio, triggering either the female- or male-specific pattern of transcription.

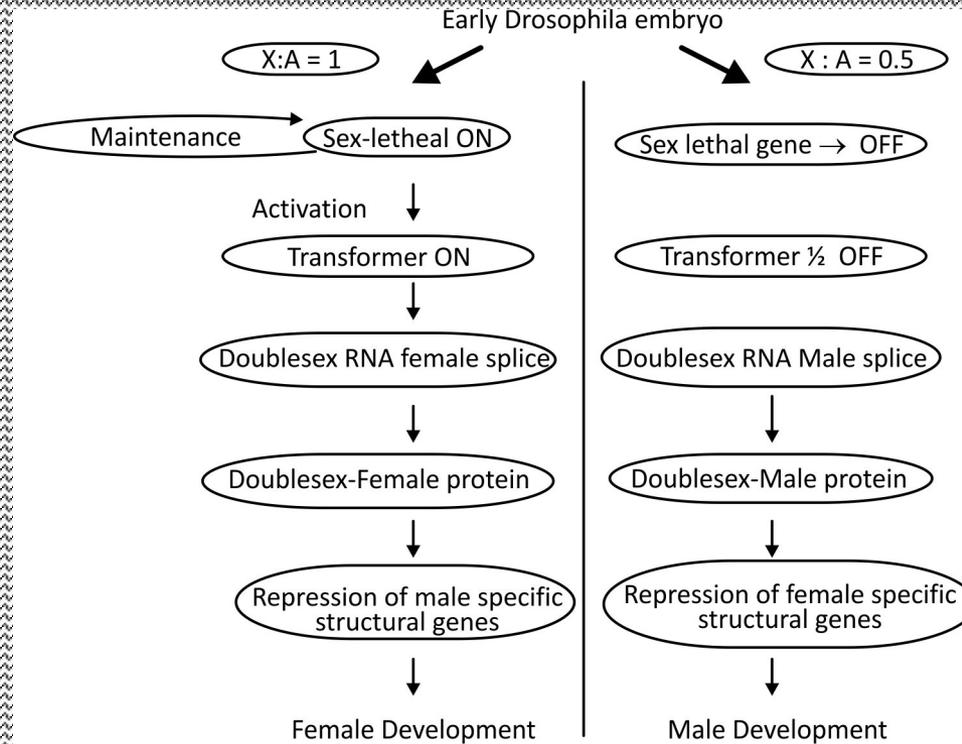


Fig. : Development of male and female in drosophila

# Sex Determination and Environment

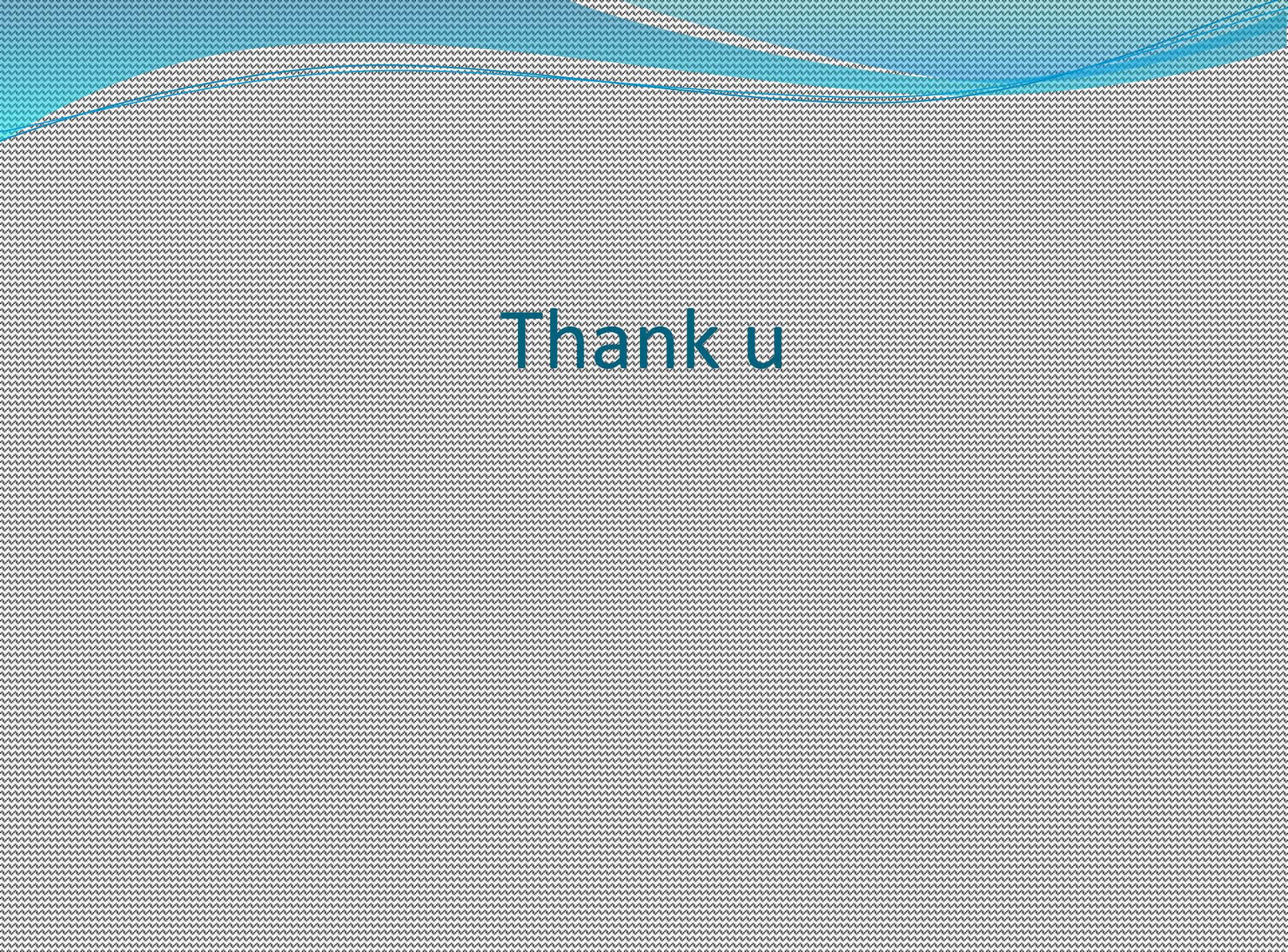
- ✓ Temperature also has a strong influence on sex determination in certain groups of reptiles. For example, in crocodylian reptiles and most turtles, sex is determined by egg incubation temperature.
- ✓ There are several variations on this theme. In the alligator snapping turtle, *Macrolemys temminckii*, incubation of eggs below 22°C or above 28°C gives rise to females, while incubation at intermediate temperatures produces predominantly males.
- ✓ In the European pond turtle, *Trachemys scripta*, incubation temperatures above 30°C produce all females, whereas incubation temperatures below 25°C produce all males. At 28.5°C, equal numbers of males and females are produced.
- ✓ In *E. orbicularis*, the critical temperature-dependent component appears to be synthesis of the enzyme aromatase, which converts androgens, such as testosterone, into estrogens. At higher temperatures, increased aromatase activity produces more estrogens, which biases the sex ratio toward more females.

# Sex Determination in Insects

- ✓ Insects are the most diverse class of organisms show considerable diversity in their mechanisms of sex determination (Saccone *et al.*, 2002).
- ✓ The majority of insects have dimorphic sex chromosomes that can be distinguished cytologically.
- ✓ Animals with two different sex chromosomes are of heterogametic sex, and they are thus able to produce two types of gametes.
- ✓ System is reversed from human in butterflies and moths (order Lepidoptera): females are the heterogametic sex, while males are homogametic.
- ✓ The sex chromosomes in Lepidoptera are designated W and Z.
- ✓ W chromosome is usually associated with the development of female characteristics. When the W chromosome is absent, ZZ develops into males and ZO develop into females.

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- ✓ A moth known as *Talaeoporia tubulosa* uses the ambient temperature to control sex determination in the absence of W chromosome. When temperatures are warm, the Z chromosome is found on the inner spindle and more female eggs are produced, whereas in colder conditions, the Z chromosome moves to the outer pole, resulting in greater production of males (Traut *et al.*, 2007). This system corresponds to the adaptive advantage of favoring the production of female offspring when conditions are good (warm) and resources for their subsequent reproduction are more likely to be available.
- ✓ Some grasshoppers also use a single-chromosome (XX/XO) sex determination system; here, males have only one sex chromosome, so they are considered to be XO. Thus, males are the heterogametic sex, because they produce two different kinds of gametes.
- ✓ The system of chromosomal sex determination is even further reduced in certain genera of mosquitoes, in which the two sexes are chromosomally indistinguishable. Sex in this homogametic group is thought to be determined by a dominant male-determining factor.



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