鱼类性别分化发育的遗传基础

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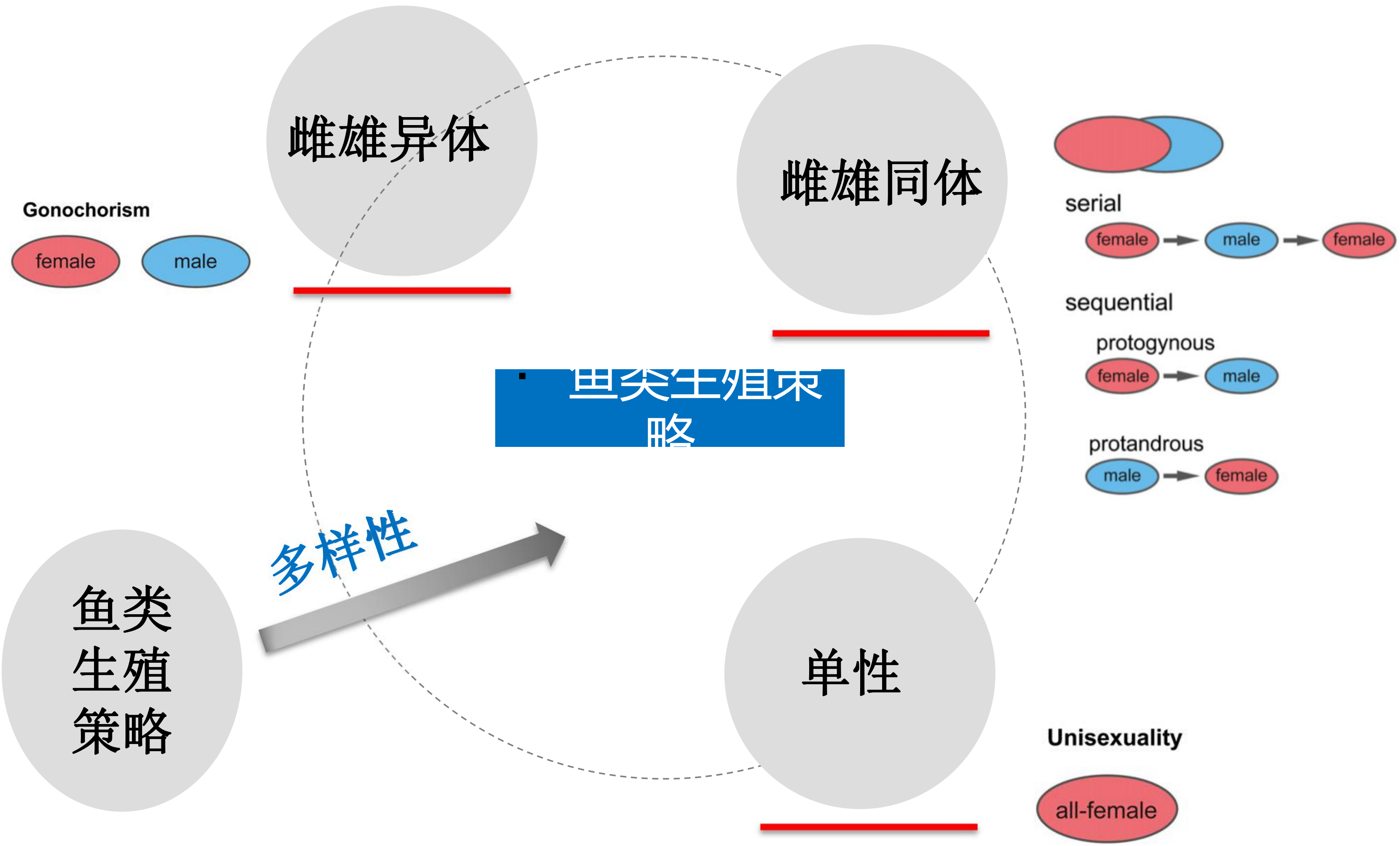
鱼类生殖策略的多样性


雌雄异体
Gonochorism
female
male
雌雄同体
serial
female
male
female
sequential
protogynous
female
male
protandrous
male
female
鱼类生殖策略
多样性
鱼类
生殖
策略
单性
Unisexuality
all-female

性别决定、性别分化和性腺发育

性别决定

有性生殖生物中，决定雌、雄性别分化的机制；在细胞分化与发育水平上，是指由于某些性别决定基因的活动，胚胎发生了雌性和雄性的性别差异。

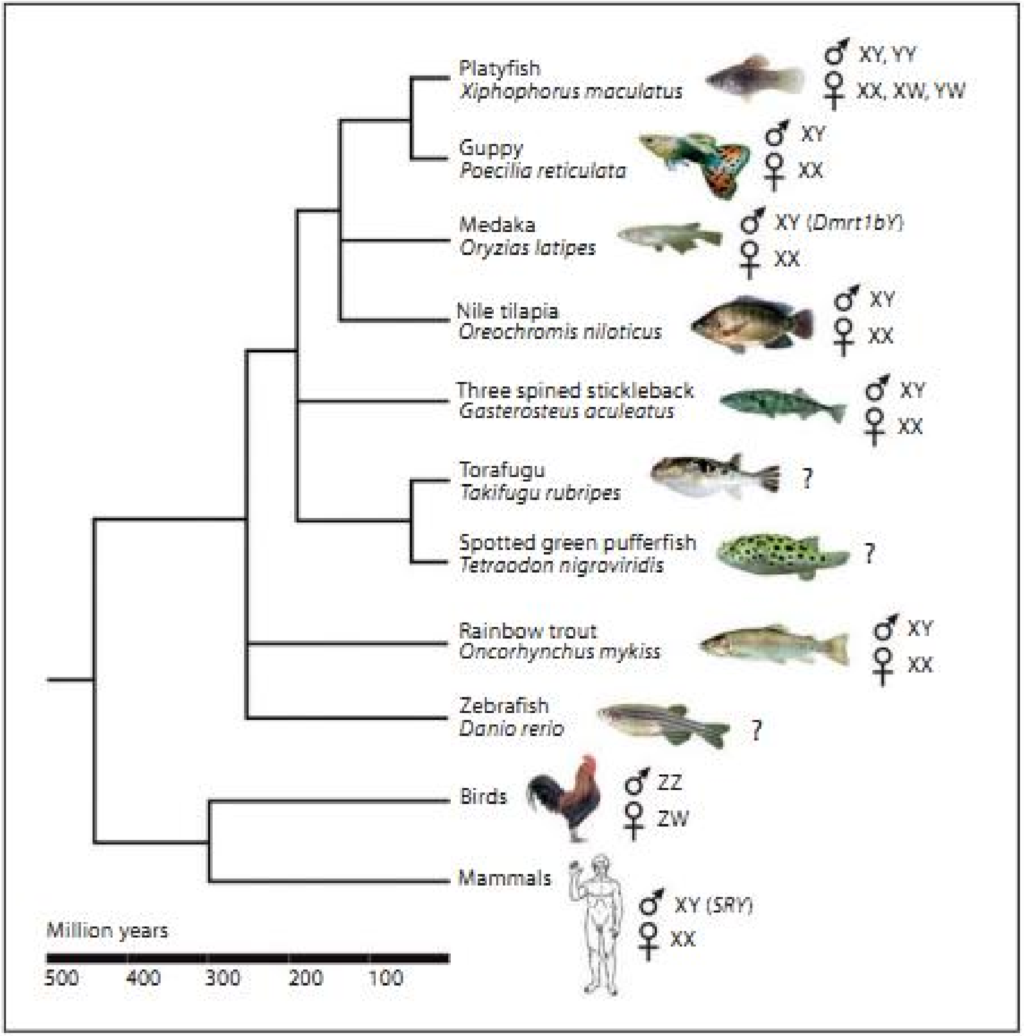
性别分化

性别分化是指受精卵在性别决定的基础上，进行雌性或雄性性状分化的过程。

性腺发育

雌性和雄性性别性状发生分化后，雌雄生殖系统在相关基因的调控下逐渐生长和成熟的过程。

鱼类性别决定系统的多样性



鱼类的性染色体决定型主要表现为XX/XY 和ZZ/ZW两大系统， 少数也表现为XX/XO， XX/XY1Y2，X1X2X1X2/X1X2Y，X1X2X1X2/X1X2X1， 或ZZ/ZO和ZZ/ZW1W2 等类型。

- （J.-N. Volff, et al., 2007）
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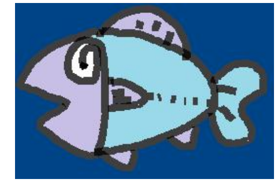
影响鱼类生殖生理活动因素

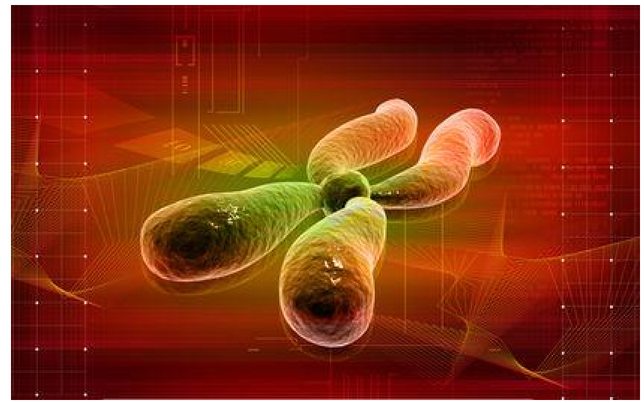


- 在硬骨鱼类中, 性别决定一般是由遗传因素(遗传性别决定)和环境因素(环境性别决定)共同作用的, 而且这种作用是一个可塑性过程.
- 遗传因子
  - 性染色体
  - 性别决定相关基因
  - 内分泌激素
- 环境因子(温度、光照及pH因子等)
- 环境与遗传因子交互作用

鱼类性别决定的遗传基础

性染色体、性别决定相关基因、激素

鱼类的性别决定系统几乎包括了脊椎动物所有的性染色体类型。目前，一般认为鱼类的性染色体决定类型主要有6类：



（1）XY型

（2）ZW型

（3）XO型

（4）ZO型

（5）复性染色体型：

包括X1X1X2X2/X1X2Y型、W1W2Z/ZZ型、XY1Y2/XX型等。

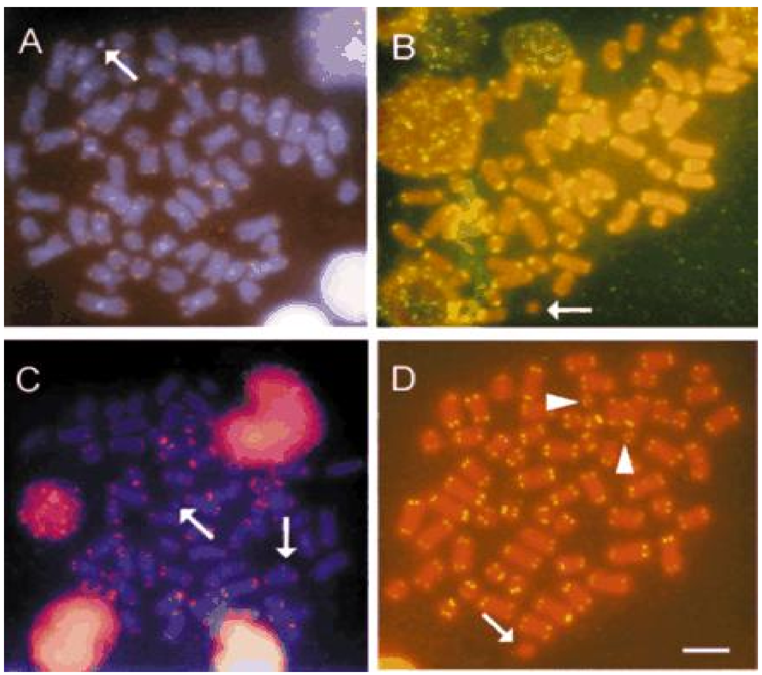
（6）常染色体型：

即用现有技术手段未能发现任何异型性染色体， 性别可能主要由常染色体决定，例如斑马鱼。

（Penman D J, et al.，2008）

尽管鱼类染色体类型多种多样，大多数鱼类的性染色体与常染色体在形态上无法区分。

- Almeida-Toledo 和 Foresti（2001）对900多种热带淡水鱼进行研究发现只有32(约4%)种鱼类有性染色体的分化。
- Nagahama (2002)对1700种鱼类进行细胞遗传学鉴定，发现只有10%左右在染色体形态上有差异。



（Ocalewicz， etal.， 2004）

Chromosomes of androgenetic rainbow trout after PRINS with telomere primers.

目前发现性染色体的部分鱼类有：

species	genotypes	References
Medaka (Oryzias latipes)	XX/XY	Aida (1921)；Matsuda (2005)
Rainbow trout (Oncorhynchus mykiss)	XX/XY	Thorgaard (1977)
Guppy (Poecilia reticulata)	XX/XY	Nanda et al. (1990, 1992,1993)
Tilapia	XX/XY	Baroiller et al. (2009)
Channel catfish (Ictalurus punctatus)	XX/XY	Tiersch et al. (1992)
African catfish (Clarias gariepinus)	XX/XY	Kovacs et al. (2000)
Atlantic salmon (Salmo salar)	XX/XY	McGowan and Davidson(1998)
Three-spined stickleback (Gasterosteus aculeatus)	XX/XY	Griffiths et al. (2000)
Nile tilapia (Oreochromis niloticus)	XX/XY	Ezaz et al. (2004)

目前发现性染色体的部分鱼类有：

species	genotypes	References
Chinook salmon (Oncorhynchus tshawytscha)	XX/XY	Brunelli and Thorgaard (2004)
Triacanthus brevirostris	XX/XO	Choudhury et al.(1982)
Blue tilapia (Oreochromis aureus)	WZ/ZZ	Campos-Ramos et al. (2001)
Leporinus obtusidens	WZ/ZZ	Nanda et al. (1992)
Pufferfish (Takifugu rubripes)	WZ/ZZ?	Cui et al. (2006)
Leporinus sp.	WZ/ZZ	Solari (1994)
Lepidocephalichthys guntea	WZ/ZO	Sharma and Tripathi (1988)
Eigenmannia sp.	X1X1X2X2/X1X2Y	Almeida-Toledo and Foresti (2001)
Platyfish (Xiphophorus maculatus)	XX, WX/ WY；XY/YY	Kallman (1984)

鱼类性别决定的遗传基础

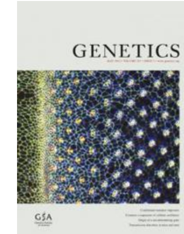
性染色体、**性别决定相关基因**、激素

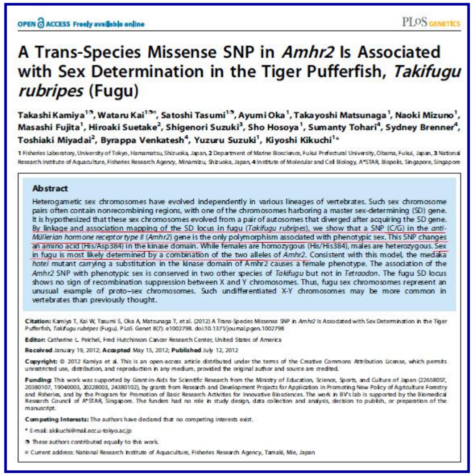
- ********************************

Gene	Protein Function
* Sf1	Nuclear receptor
* Sox9	Transcription factor
* Dax1	Nuclear receptor
* Amh	Hormone
* Dmrt1	Transcription factor
* Wnt4	Signaling molecule
* FoxL2	Transcription factor
* Cyp19	Transcription factor

- 雄性性别决定
- 雌性性别决定

性别决定的遗传基础




OPEN ACCESS Freely available online PLoS GENETICS

A Trans-Species Missense SNP in *Amhr2* Is Associated with Sex Determination in the Tiger Pufferfish, *Takifugu rubripes* (Fugu)

Takashi Kamiya, Wataru Kai, Satoshi Tasumi, Ayumi Oka, Takayoshi Matsunaga, Naoki Mizuno, Masashi Fujita, Hiroaki Suetake, Shigenori Suzuki, Sho Hosoya, Sumanty Tohari, Sydney Brenner, Toshiaki Miyadai, Byrappa Venkatesh, Yuzuru Suzuki, Kiyoshi Kikuchi

Abstract

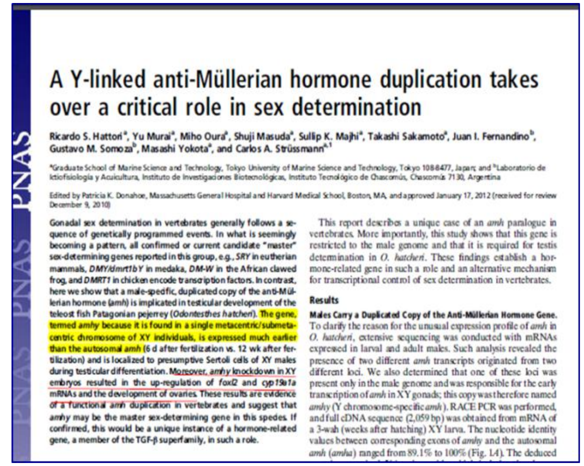

nature COMMUNICATIONS

ARTICLE

Received 13 Mar 2014 | Accepted 19 May 2014 | Published 20 Jun 2014

Co-option of *Sox3* as the male-determining factor on the Y chromosome in the fish *Oryzias dancena*

Yusuke Takehana, Masaru Matsuda, Taijun Myosho, Maximiliano L. Suster, Koichi Kawakami, Tadasu Shin-I, Yuji Kohara, Yoko Kuroki, Atsushi Toyoda, Asao Fujiyama, Satoshi Hamaguchi, Mitsuru Sakaizumi & Kiyoshi Naruse


PNAS

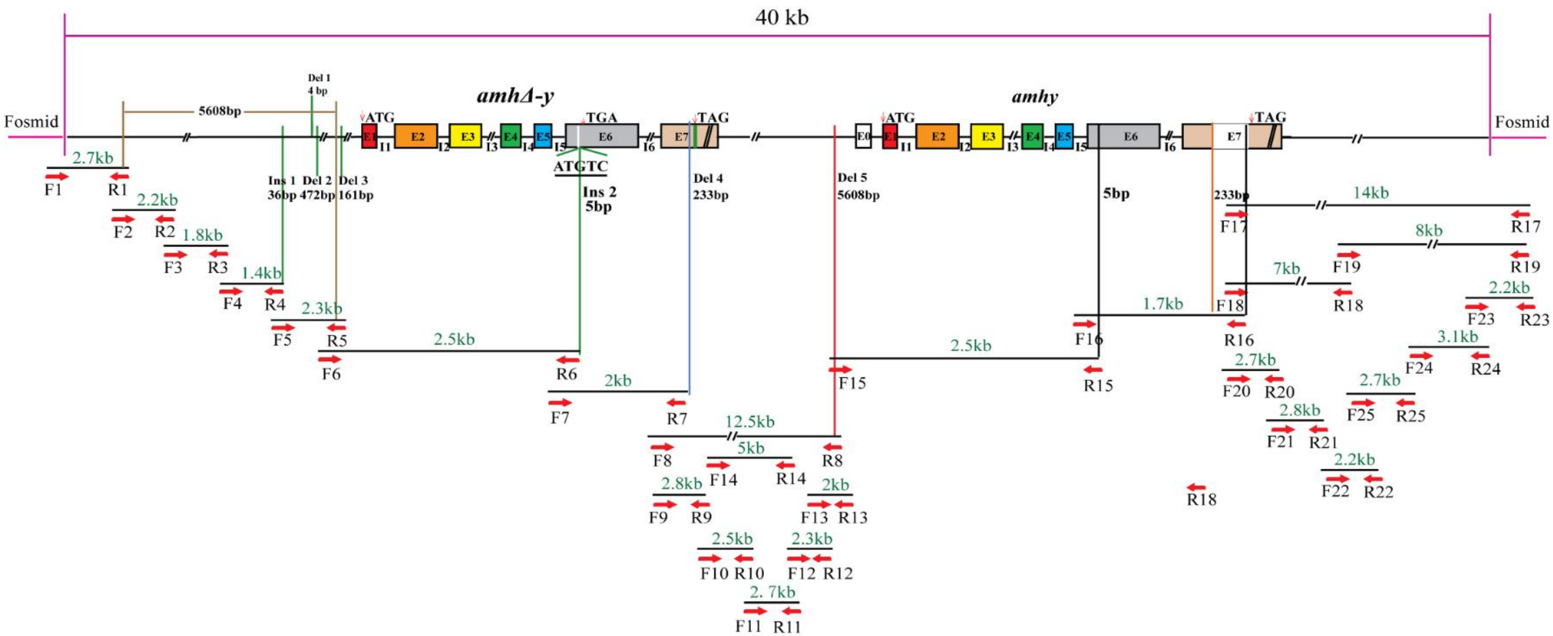
A Y-linked anti-Müllerian hormone duplication takes over a critical role in sex determination

Ricardo S. Hattori, Yu Murai, Miho Oura, Shuji Masuda, Sullip K. Majhi, Takashi Sakamoto, Juan I. Fernandino, Gustavo M. Somoza, Masashi Yokota, and Carlos A. Strüssmann

在吕宋青鳉、恒河青鳉、河豚、尼罗罗非鱼、牙汉鱼和虹鳟中分别鉴定出了性别决定相关基因Gsdf, Sox3, Amhr2, Amhy和SdY.进一步研究还证实, Dmy, Sox3, Amhr2 和SdY 基因的突变以及Amhy基因的敲降都导致了XY型雌鱼, 而Sox3,SdY和Gsdf的转基因过表达则产生XX 型雄鱼,说明他们是雄性决定基因, 在雄性决定过程中起着关键作用.

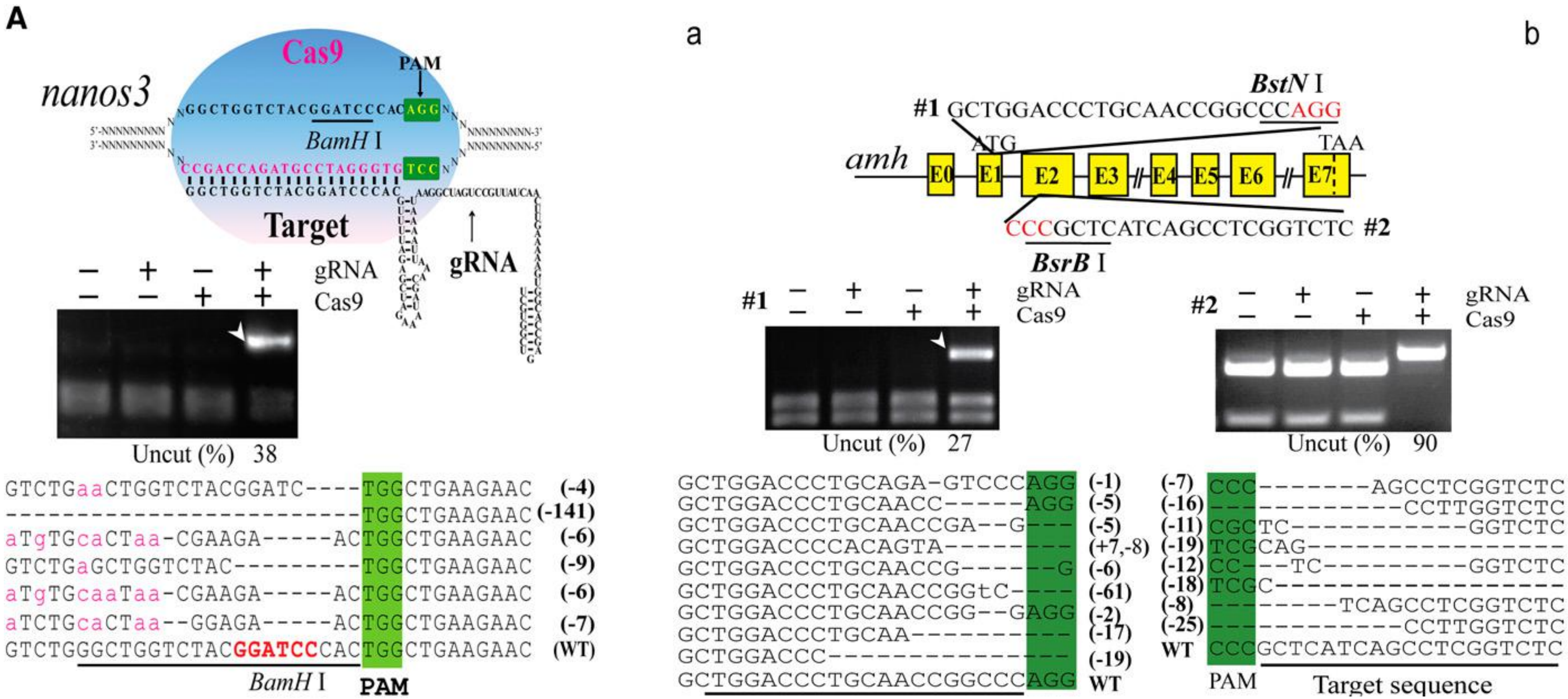
PLOS GENETICS

· A Tandem Duplicate of Anti-Müllerian Hormone with a Missense SNP on the Y Chromosome Is Essential for Male Sex Determination in Nile Tilapia, *Oreochromis niloticus*



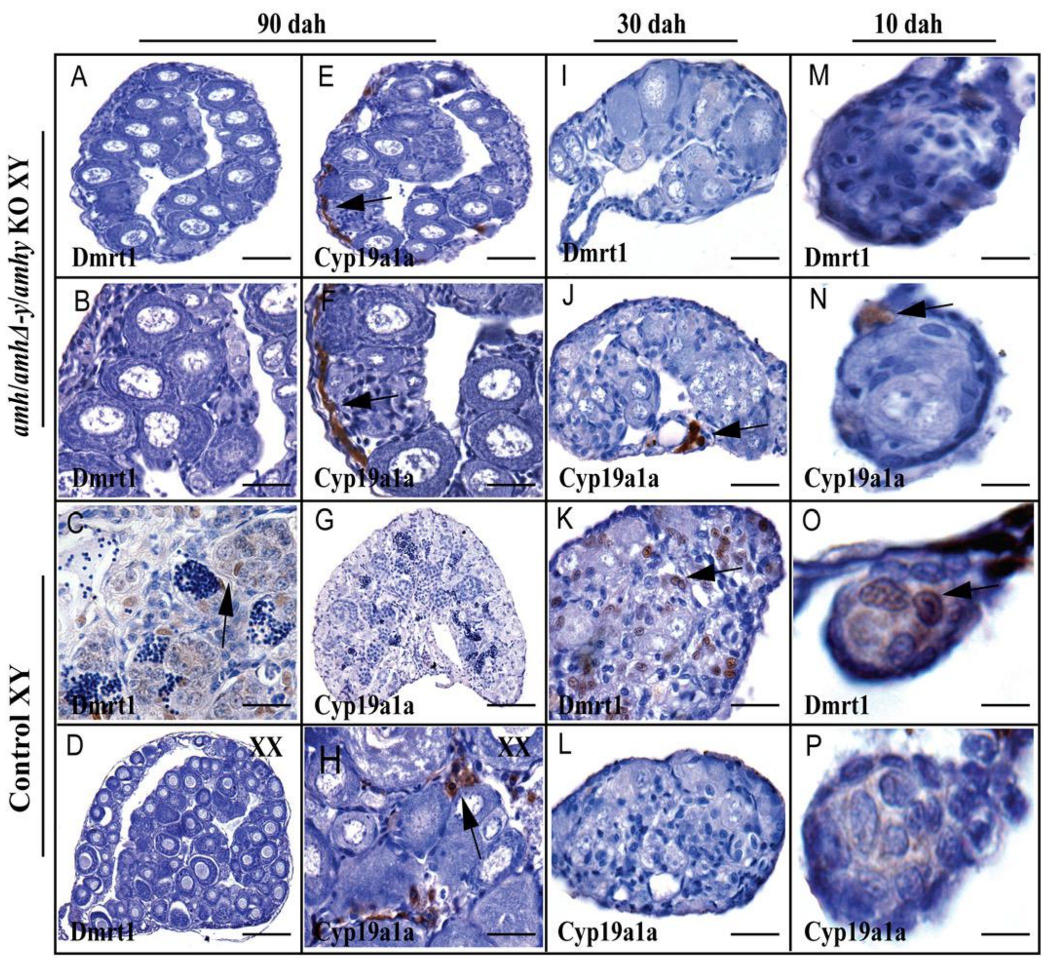
· Confirmation of the assembled sequence by gene specific primers. Twenty five pairs of gene specific primers were designed in the differential regions of amhy and amh Δ -y to amplify fragments with overlapping ends from the Y156 fosmid.

gRNA design and Cas9 mRNA in vitro transcription

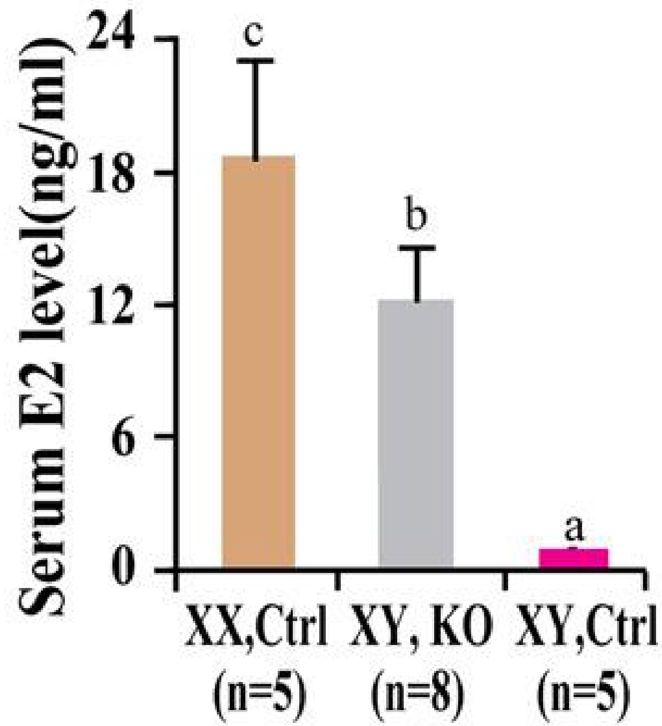


- Figure 1 Efficient disruption of tilapia genes by CRISPR/Cas9.
- (Li M, et al.,2015)

· Amhy knockout by CRISPR/Cas9 resulted in male to female sex reversal in XY fish

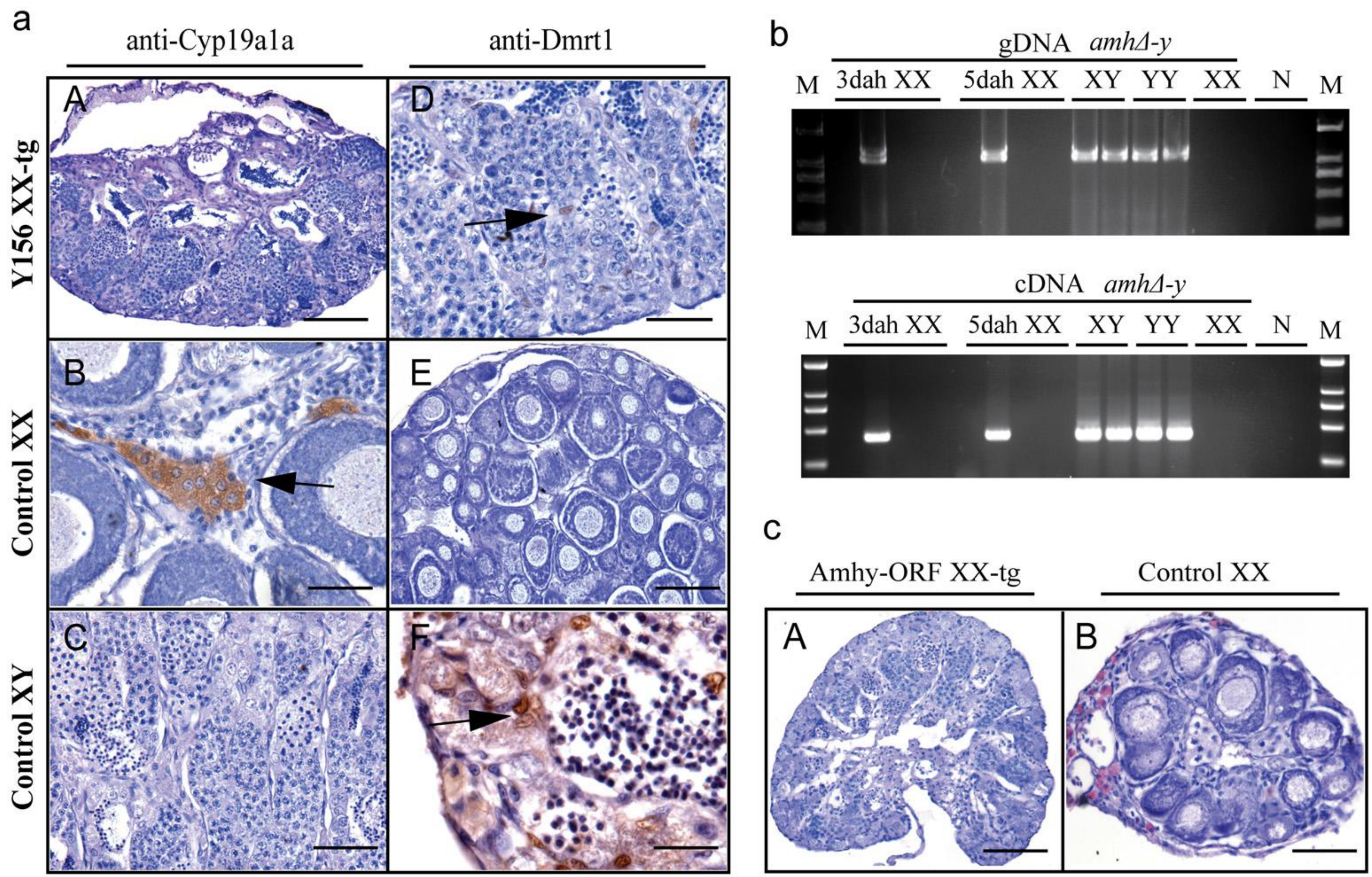


· Fig 3b. The amh/amh Δ -y/amhy knockout F0 XY fish showed male to female sex reversal

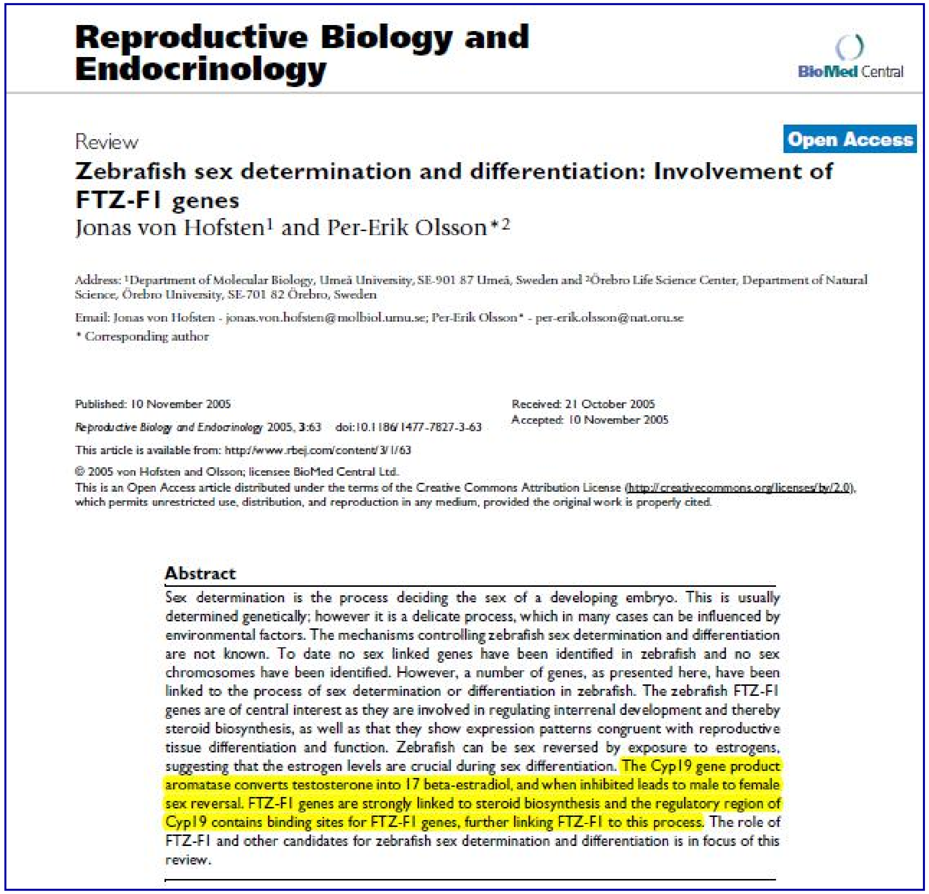


· Fig 3c. Higher serum E2 was observed in the sexreversed XY fish compared with the XY control.

· Overexpression of Y156 fosmid or Amhy ORF causes female to male sex reversal in F0 XX fish



斑马鱼性别决定



Reproductive Biology and Endocrinology

BioMed Central

Review

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Zebrafish sex determination and differentiation: Involvement of FTZ-F1 genes

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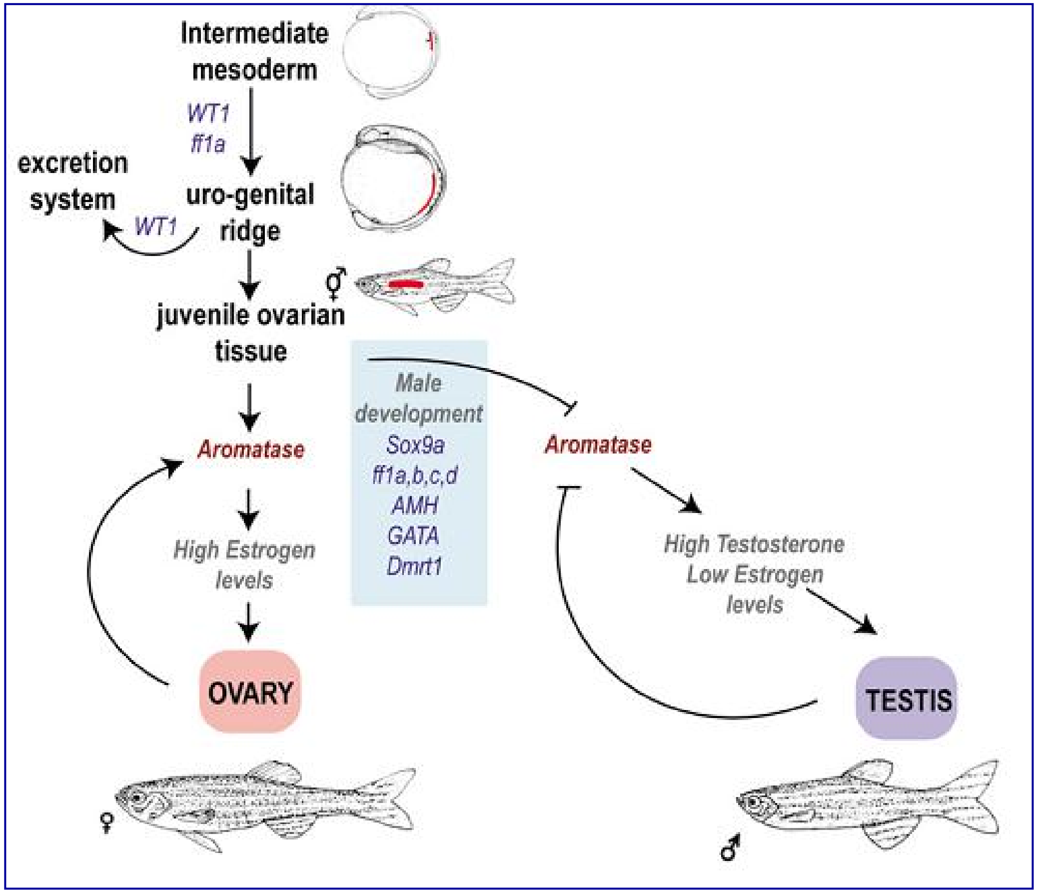
This article is available from: http://www.rbej.com/content/3/1/63

Abstract

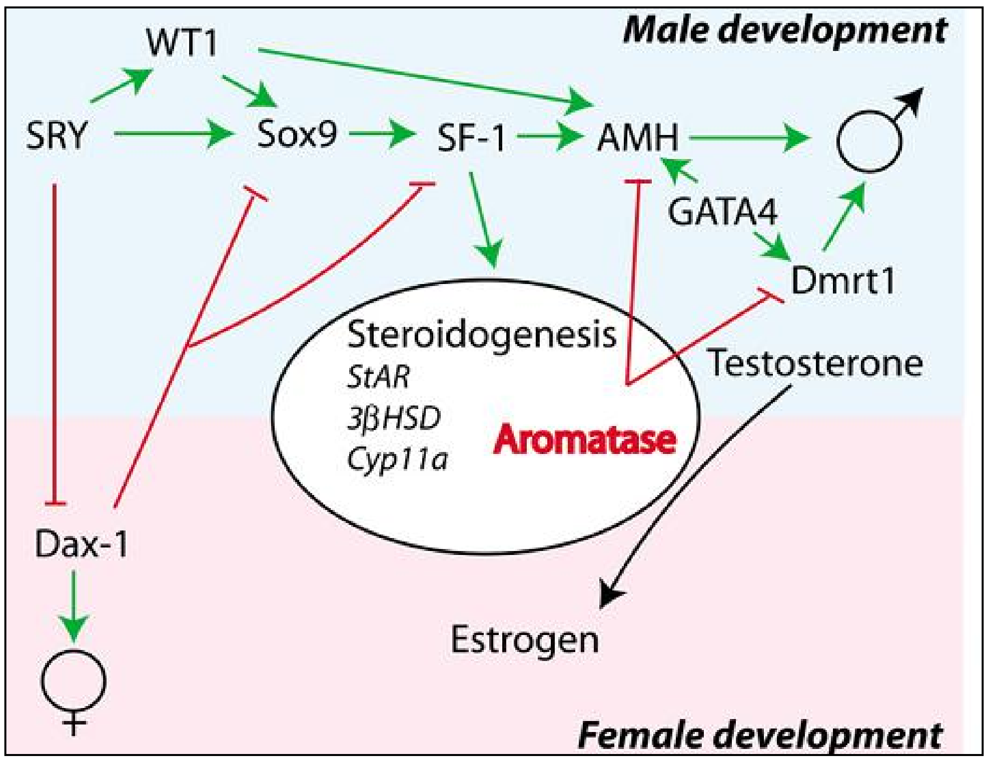
Sex determination is the process deciding the sex of a developing embryo. This is usually determined genetically; however it is a delicate process, which in many cases can be influenced by environmental factors. The mechanisms controlling zebrafish sex determination and differentiation are not known. To date no sex linked genes have been identified in zebrafish and no sex chromosomes have been identified. However, a number of genes, as presented here, have been linked to the process of sex determination or differentiation in zebrafish. The zebrafish FTZ-F1 genes are of central interest as they are involved in regulating interrenal development and thereby steroid biosynthesis, as well as that they show expression patterns congruent with reproductive tissue differentiation and function. Zebrafish can be sex reversed by exposure to estrogens, suggesting that the estrogen levels are crucial during sex differentiation. The Cyp19 gene product aromatase converts testosterone into 17 beta-estradiol, and when inhibited leads to male to female sex reversal. FTZ-F1 genes are strongly linked to steroid biosynthesis and the regulatory region of Cyp19 contains binding sites for FTZ-F1 genes, further linking FTZ-F1 to this process. The role of FTZ-F1 and other candidates for zebrafish sex determination and differentiation is in focus of this review.



（ **J Von Hofsten., PE Olsson, 2005** ）

斑马鱼性别分化

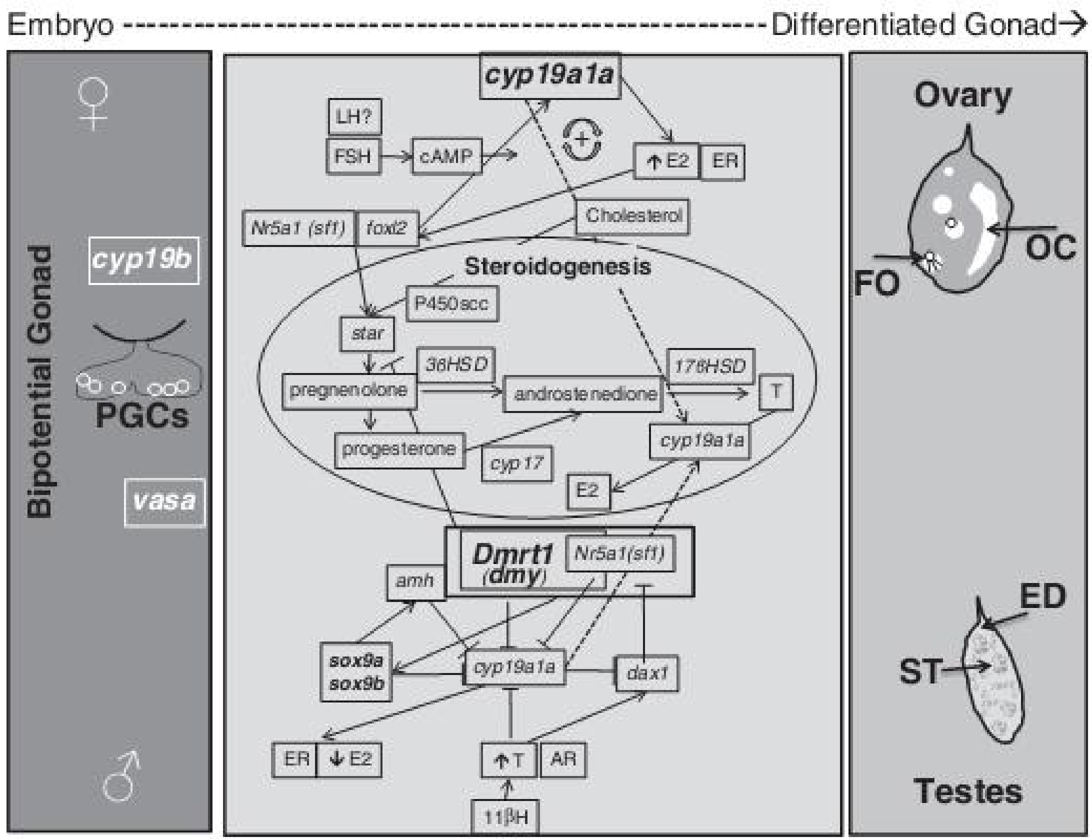
Von Hofsten和 Olsson (2005)以斑马鱼为模型，提出了P450arom 在性别决定与性别分化中发挥主要作用。在雌性个体中，P450arom一直维持雌激素的水平，促进卵巢的发育；而在雄性个体中，P450arom的表达受到雄性性别决定基因的抑制，不能产生雌激素，性腺发育为精巢。



鱼类性别决定的遗传基础

性染色体、性别决定相关基因、**激素**

- ********************************

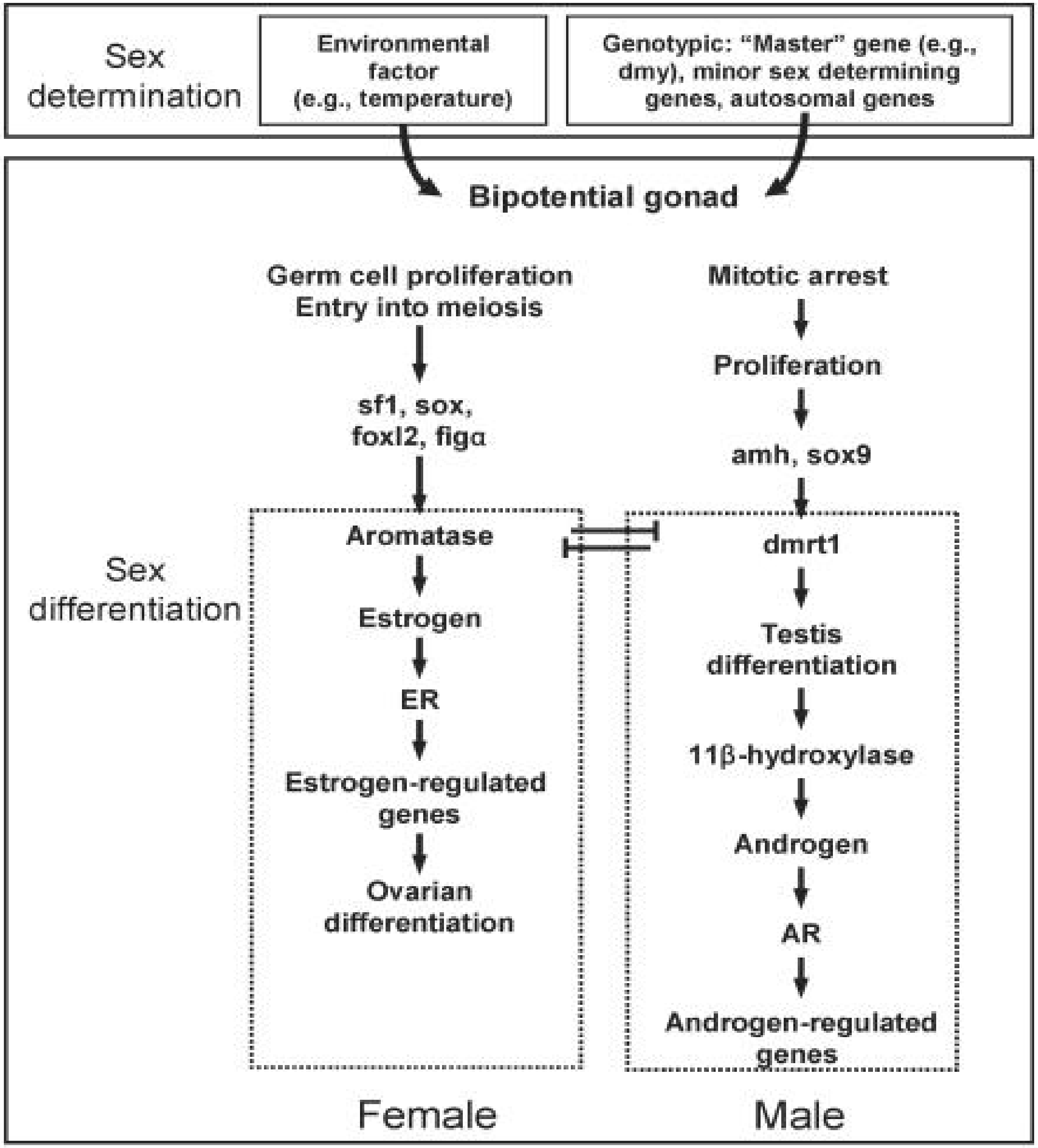


“平衡假说“

“缺失假说”

- Diagram depicting genes involved in sex differentiation in a “typical ” teleost.

- （ J. K. Leet et al., 2011 ）

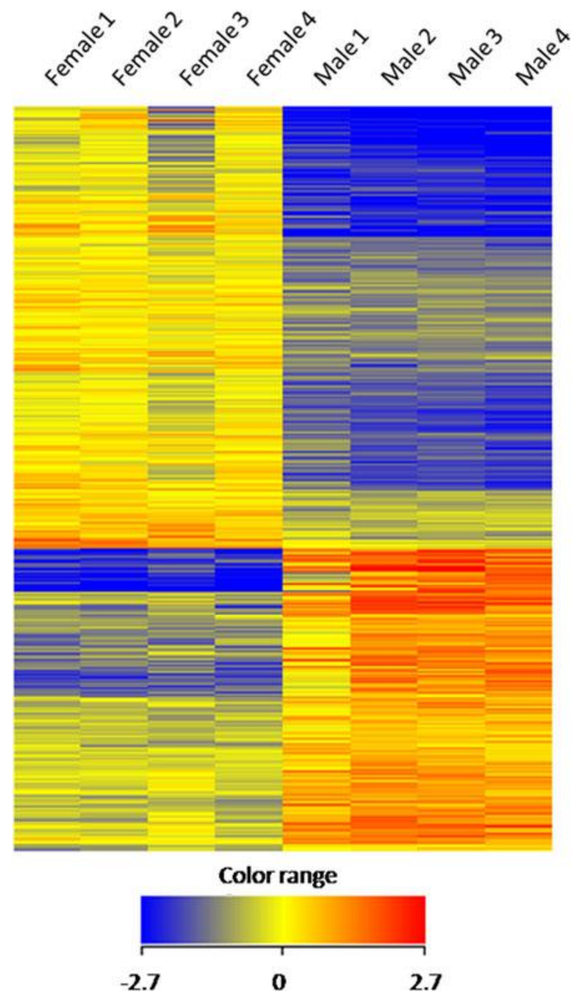


(PIFERRER & GUIGUEN, 2008)

基于新一代高通量测序技术对鱼类性别分化的研究

目前，在尼罗罗非鱼、莫桑比克罗非鱼、半滑舌鳎、蓝鳍金枪鱼、虹鳟、斑马鱼、红鳍东方鲀、大西洋鳕鱼、牙鲆、大菱鲆、稀有鮈鲫、大西洋庸鲽、湖鲟等多种鱼类中开展了性腺转录组测序。

- 1 从全基因组水平了解基因表达情况
- 2 挖掘性腺表达新基因
- 3 获得性腺发育过程中上调和下调及雌、雄差异表达的基因
- 4 发现调控配子发生的新基因及构建基因调控信号通路



- Hierarchical heat map of T. thynnus ESTs differentially
- expressed among male and female gonad tissue.

- Thanks !