

Environmental Sex Determination



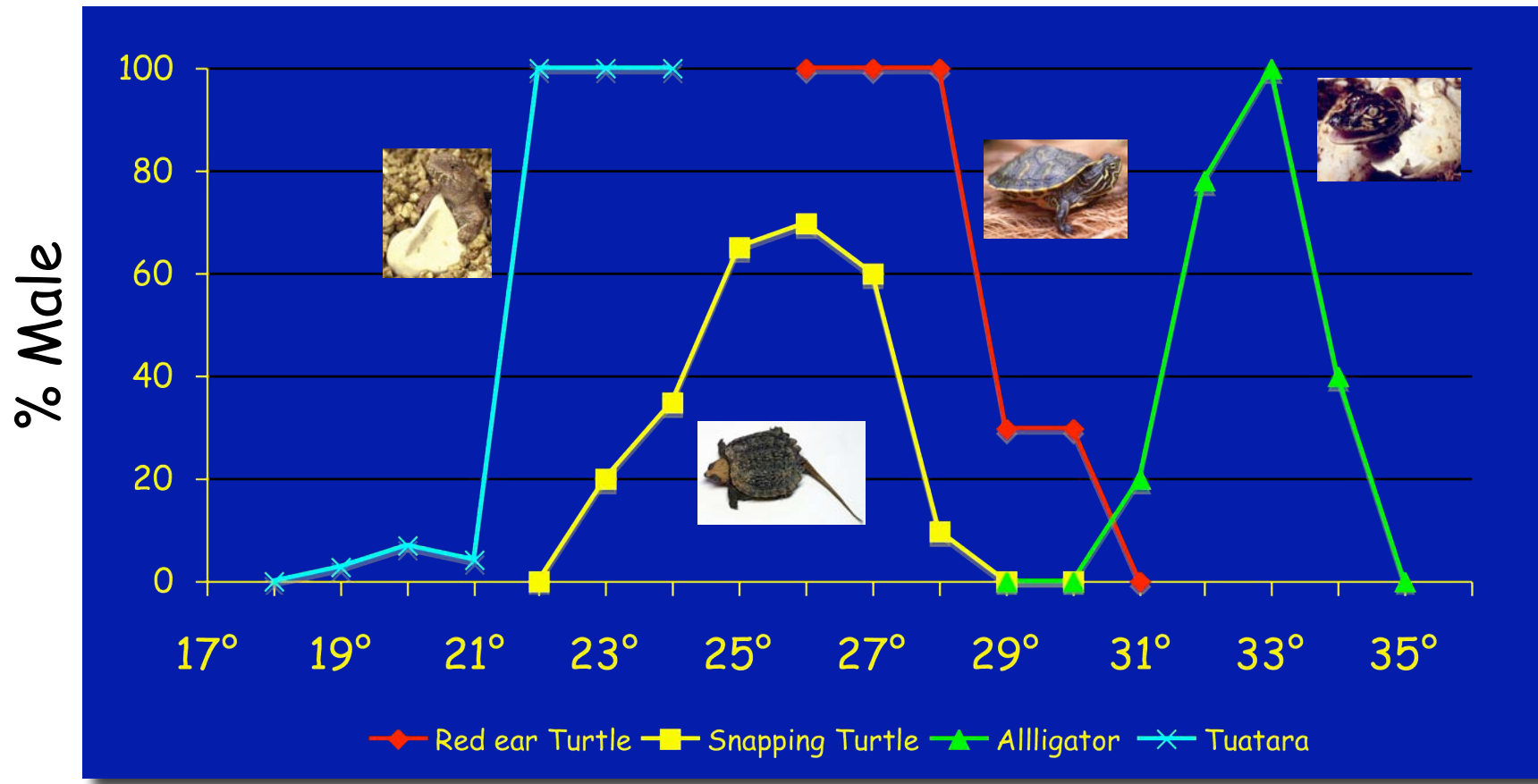
Temperature Sex Determination

- Common in many vertebrate species
 - Some fish
 - cool males/ warm females
 - Some anurans and salamanders
 - cool females/warm males
 - Many turtles
 - generally cool males/warm females
 - Exception snapping turtle
 - female warm and cool/ male at moderate temperature

TSD 2

- Some lizards
 - cool females/warm males
- All crocodilians
 - cool female/warm male
 - Also
 - cool and hot females
 - males at moderate temperatures
- Some birds? Not observed to date
- Not observed in mammals

TSD Reptiles



Mechanisms

- *Hypothesis*
 - Temperature alters estrogen production by the gonad, which influences differentiation
 - Temperature-dependent aromatase activity in European Pond turtle (*Emys obicularis*)
- Effect only on embryo early in differentiation

Sex Differentiation in Fish

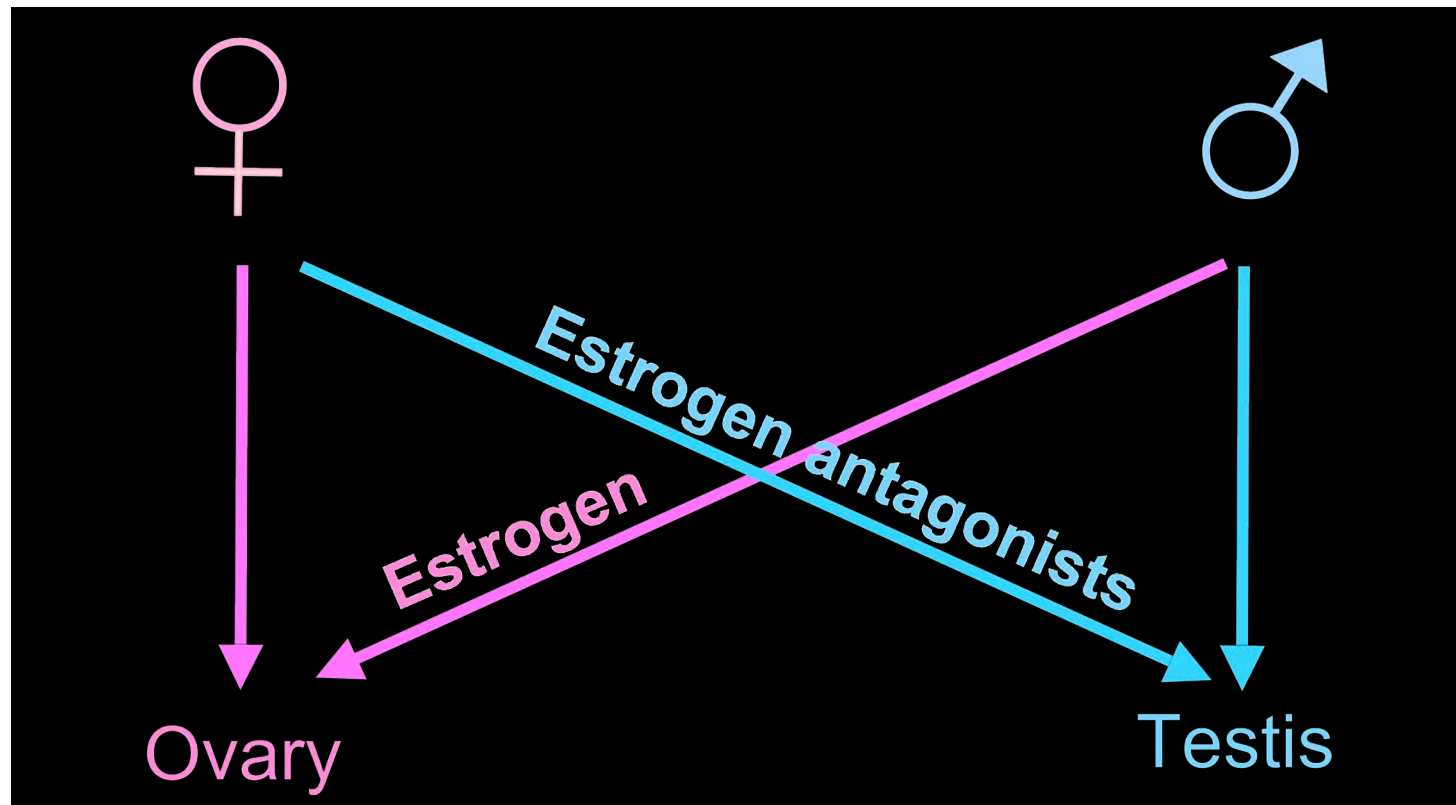
XX / XY / Temperature



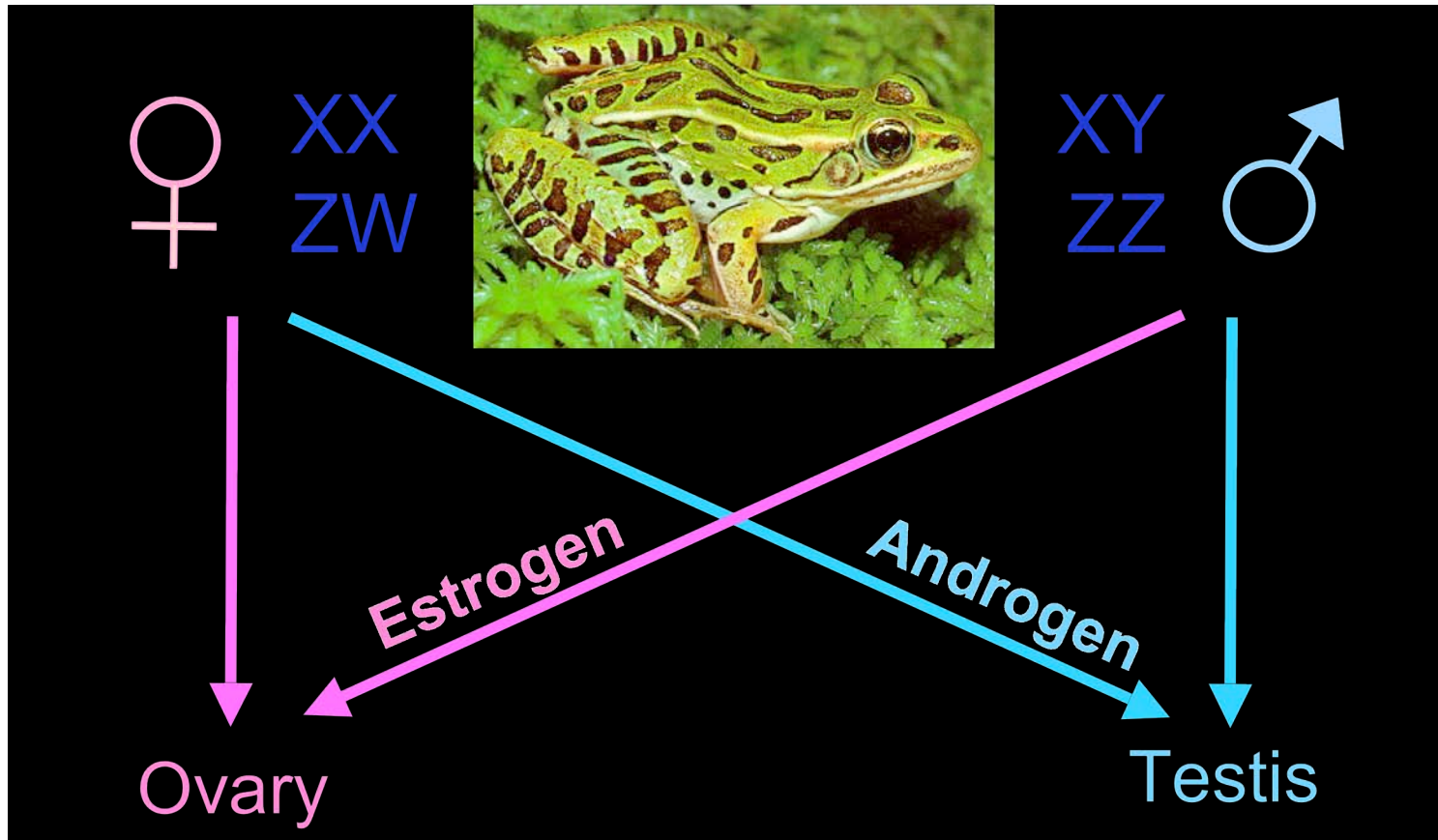
(WY, WX, XX) / (YY, XY)



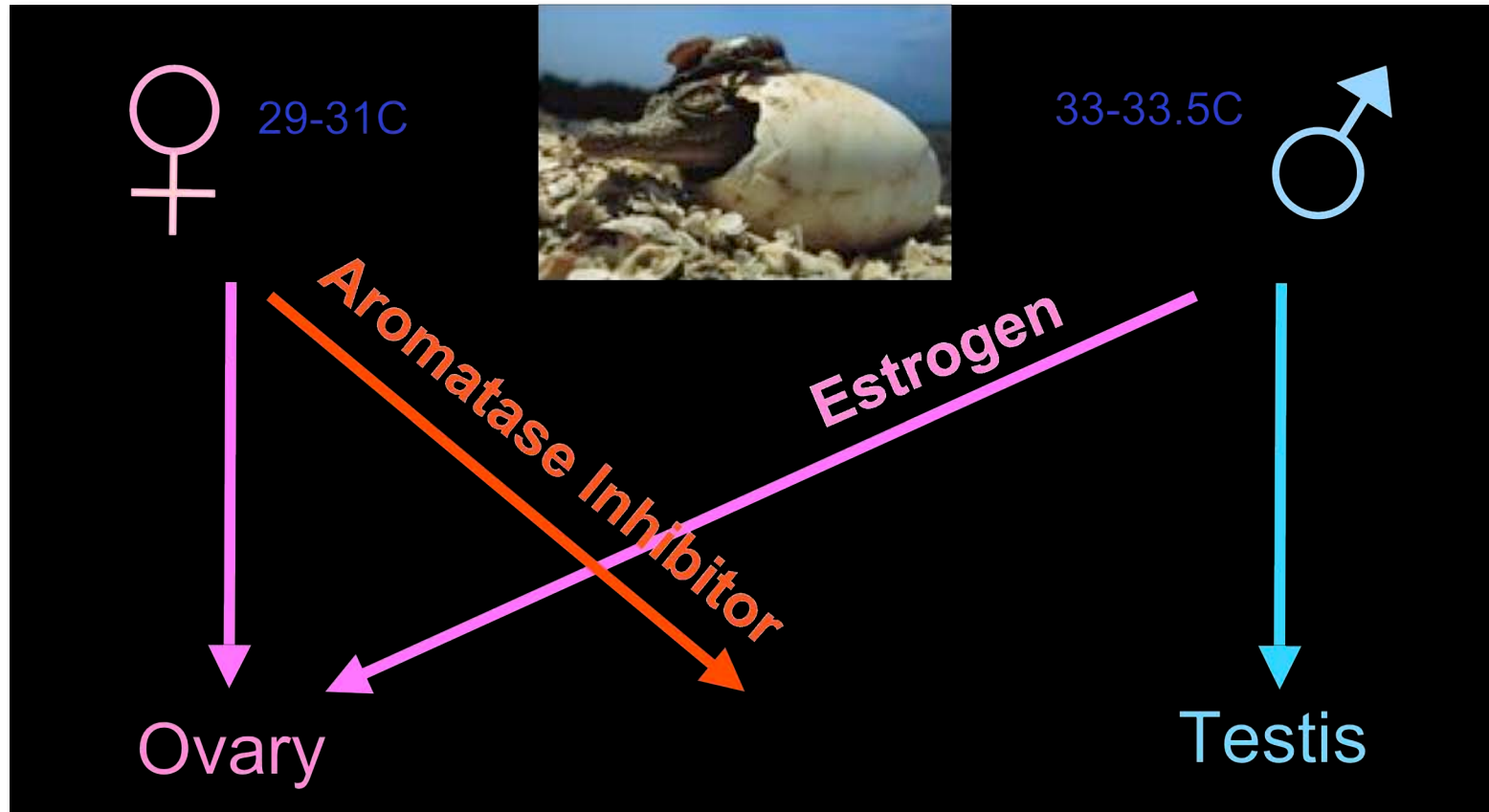
Social cues



Sex Differentiation in Frogs



Sex Differentiation in Alligators

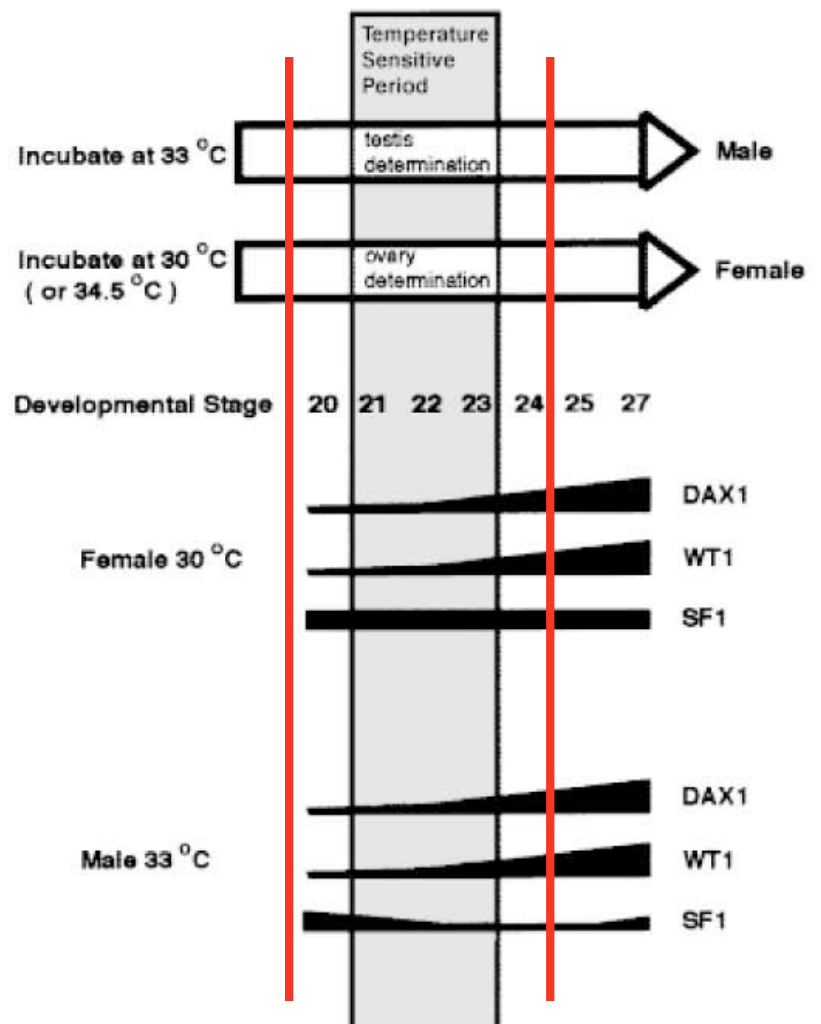


TSD and Genes

- Alligators have no SRY gene
- Gonadal differentiation
 - DAX-1
 - SF-1
 - WT-1
 - SOX9
 - AMH
 - DMRT-1
 - P450arom
 - ER α β
 - Heat Shock

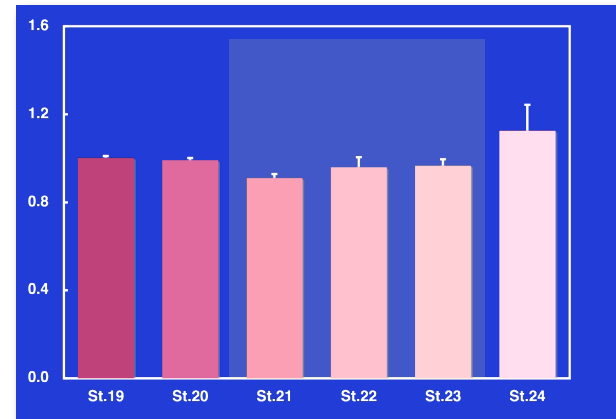


Female Gonads (♀)

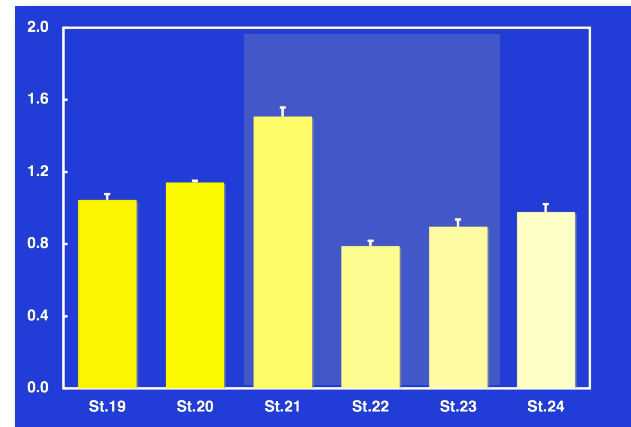


Western & Sinclair JEZ 290 (2001)

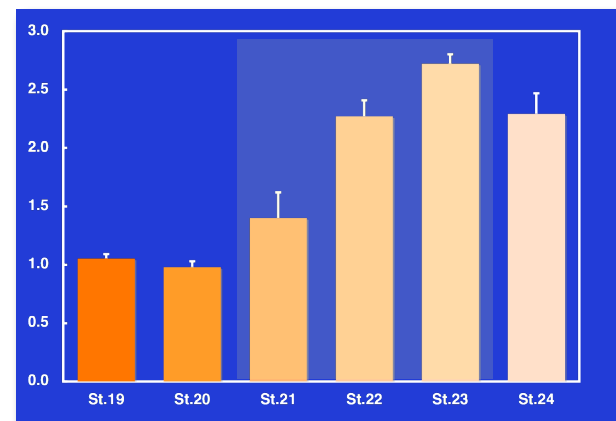
Dax1



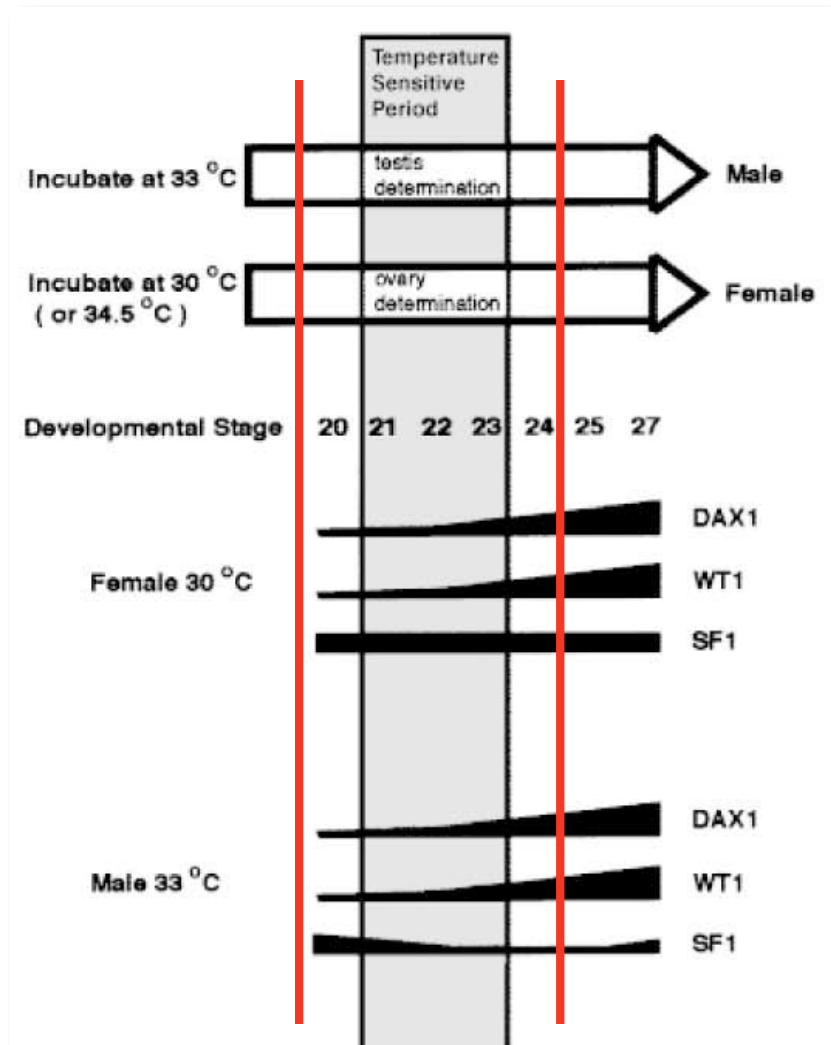
WT1



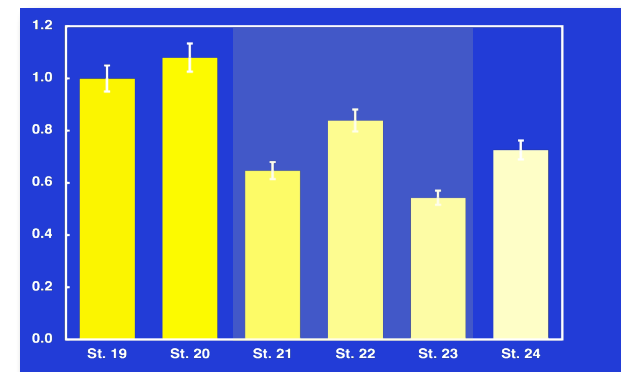
SF1



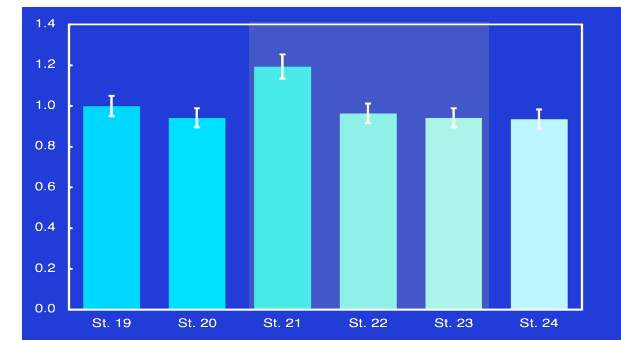
Male Gonads (♂)



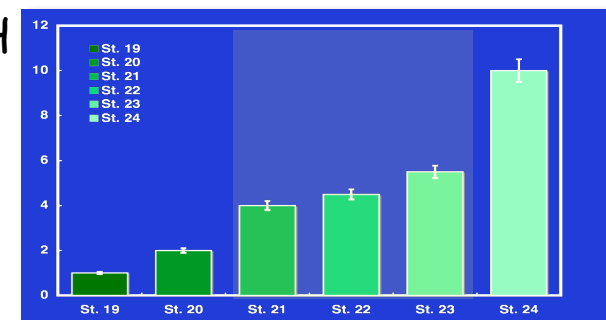
WT1



Sox9



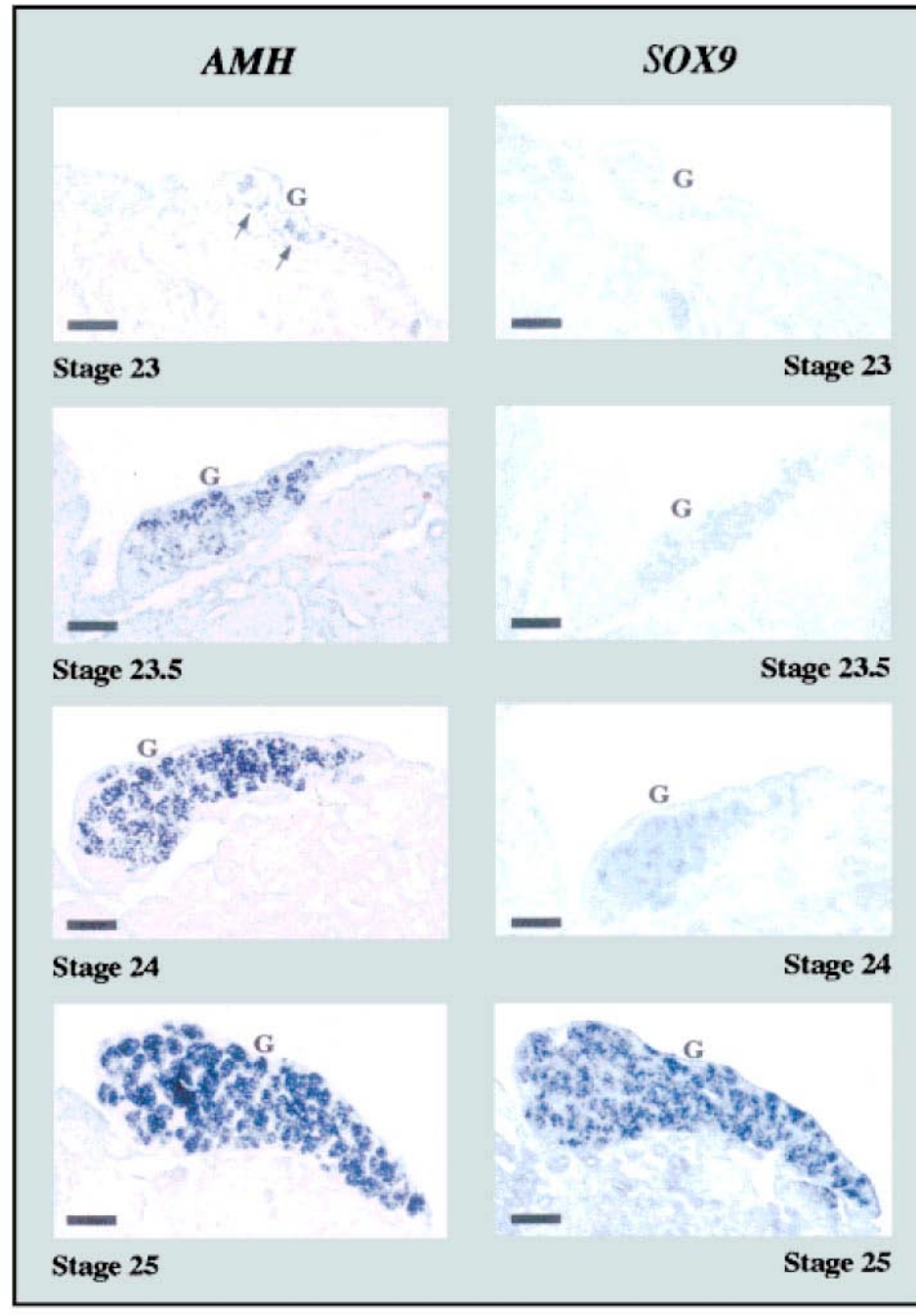
AMH



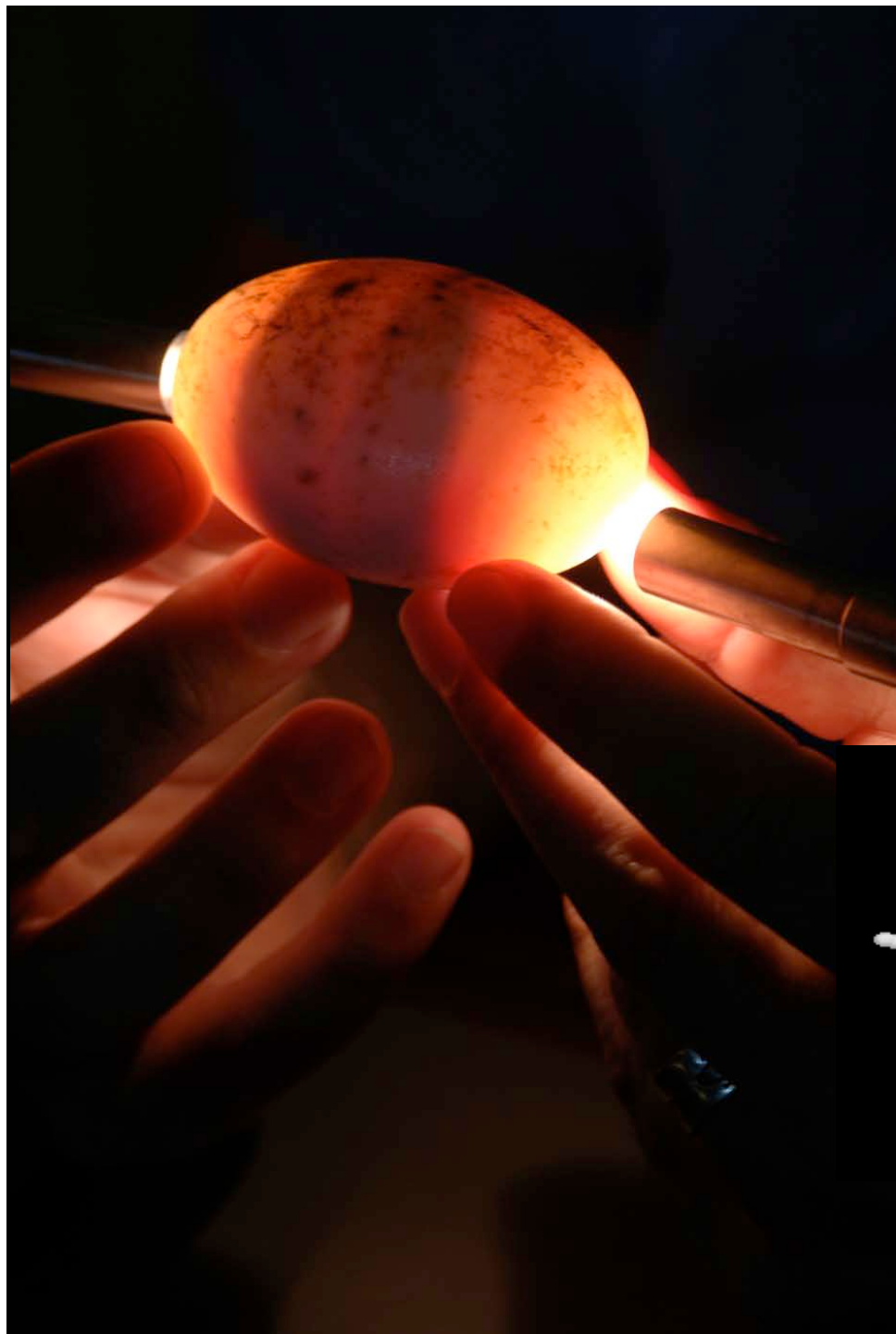
Western & Sinclair JEZ 290 (2001)

American Alligator

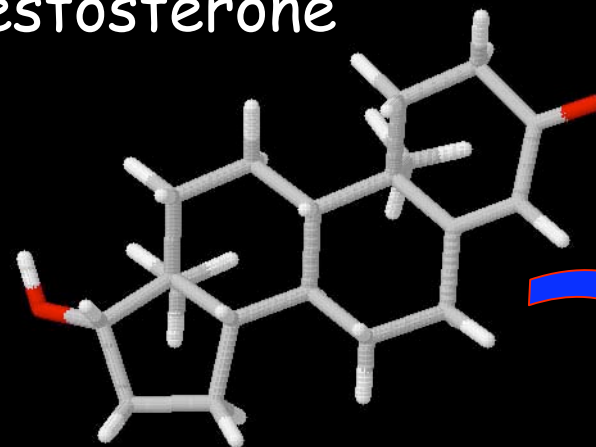
Embryos @
33°C



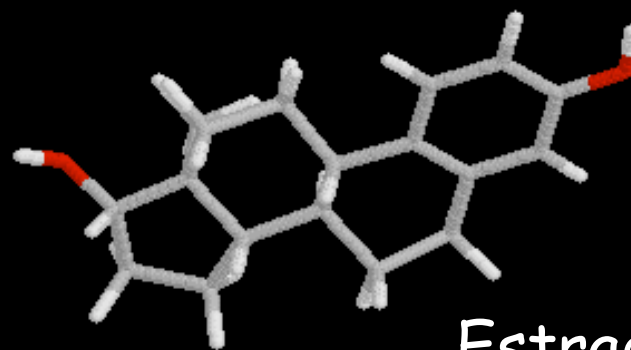
Western & Sinclair
JEZ 290 (2001)



Testosterone



P450_{aromatase}

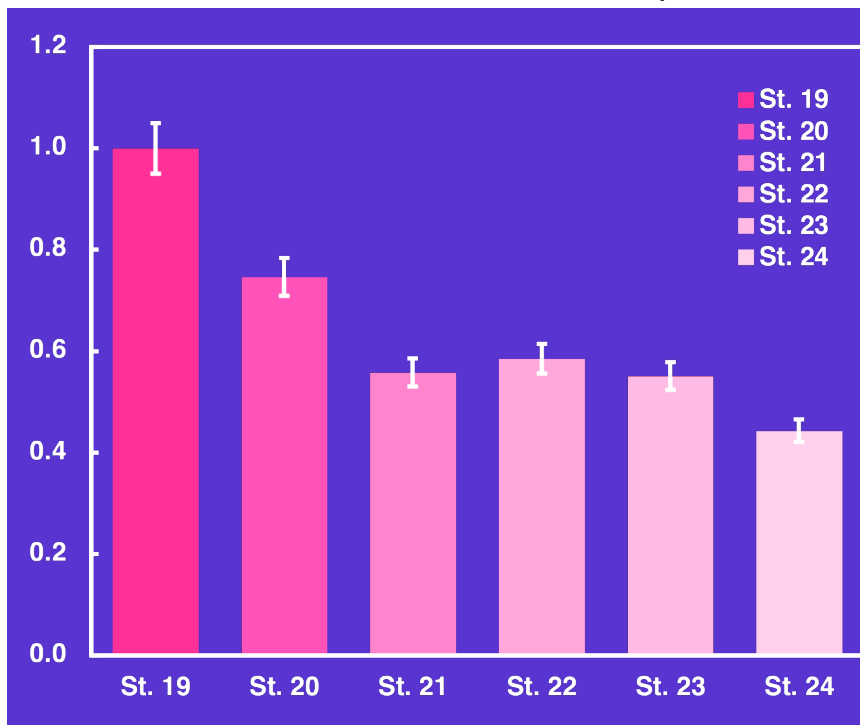


Estradiol-17 β

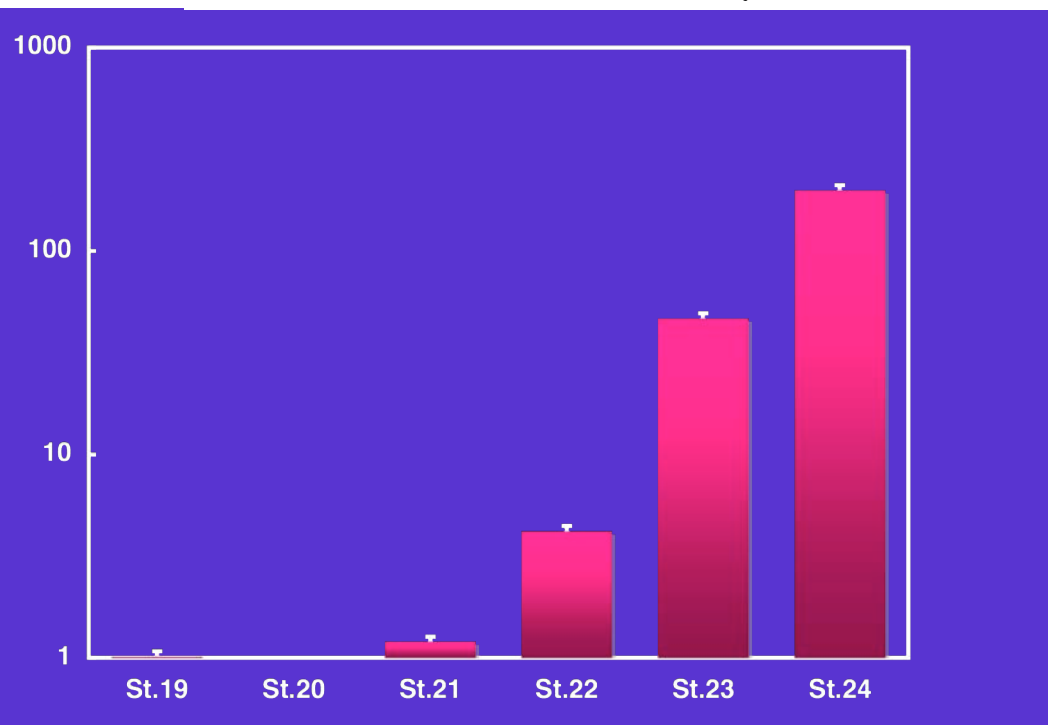
Quantitative Gene Expression in *GAMs*

P450_{aromatase}

Male Gonads (♂)

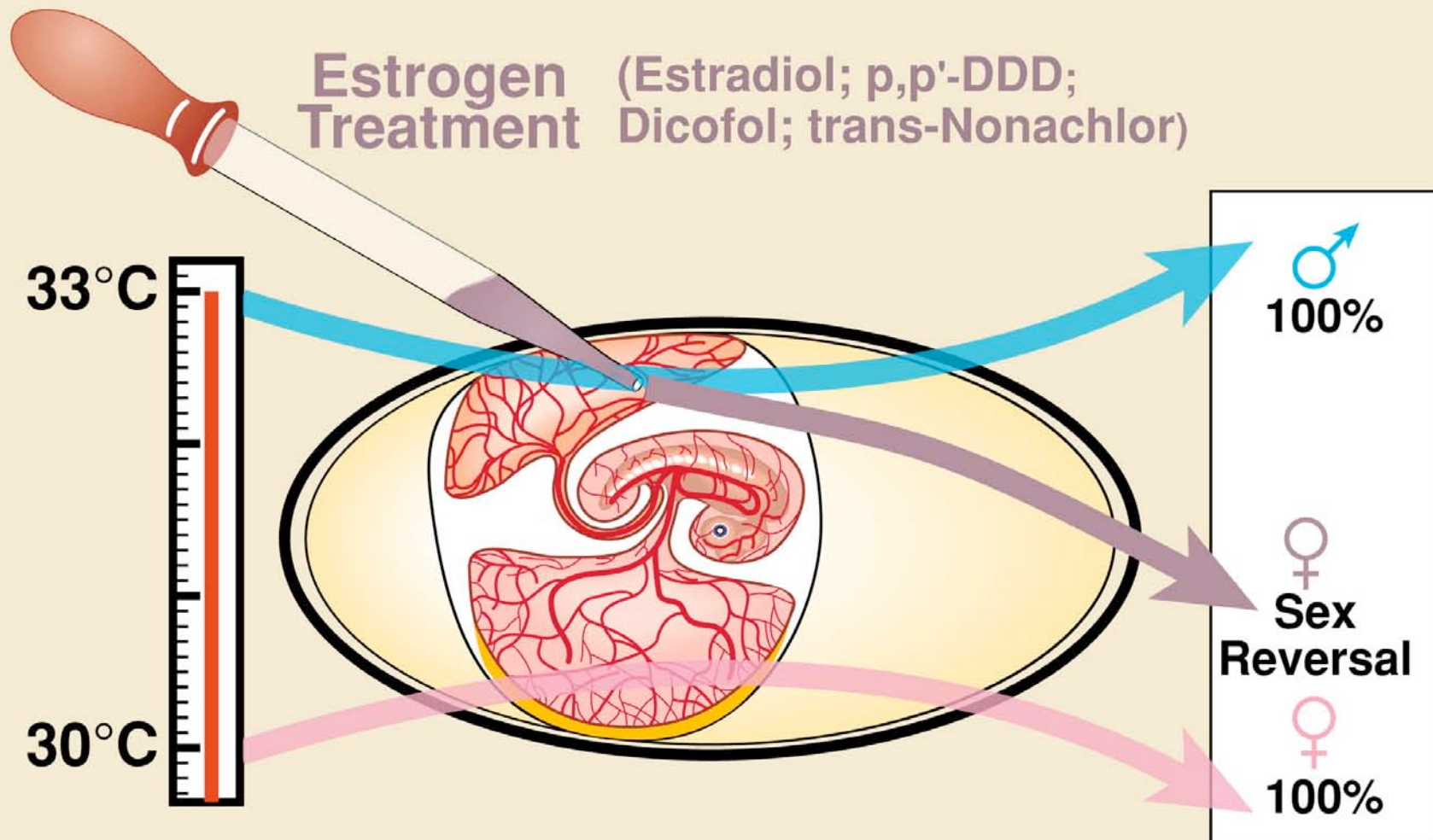


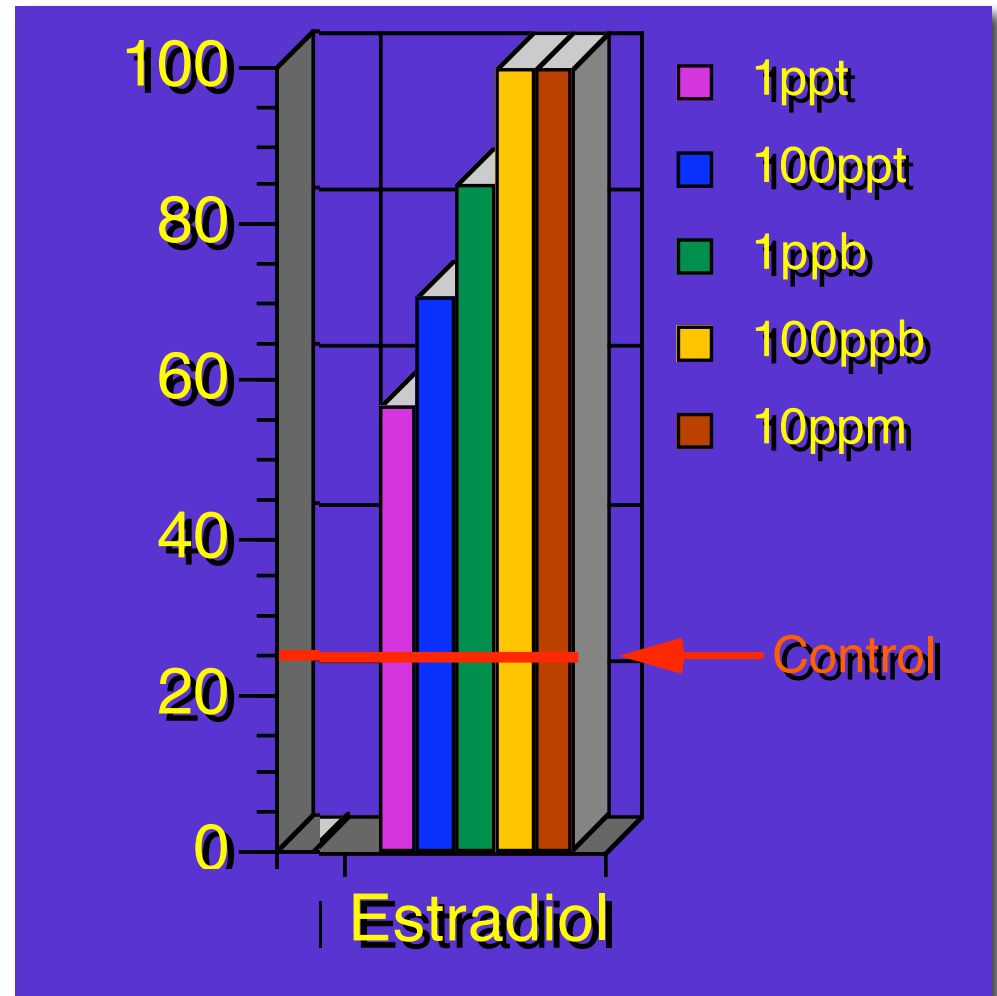
Female Gonads (♀)



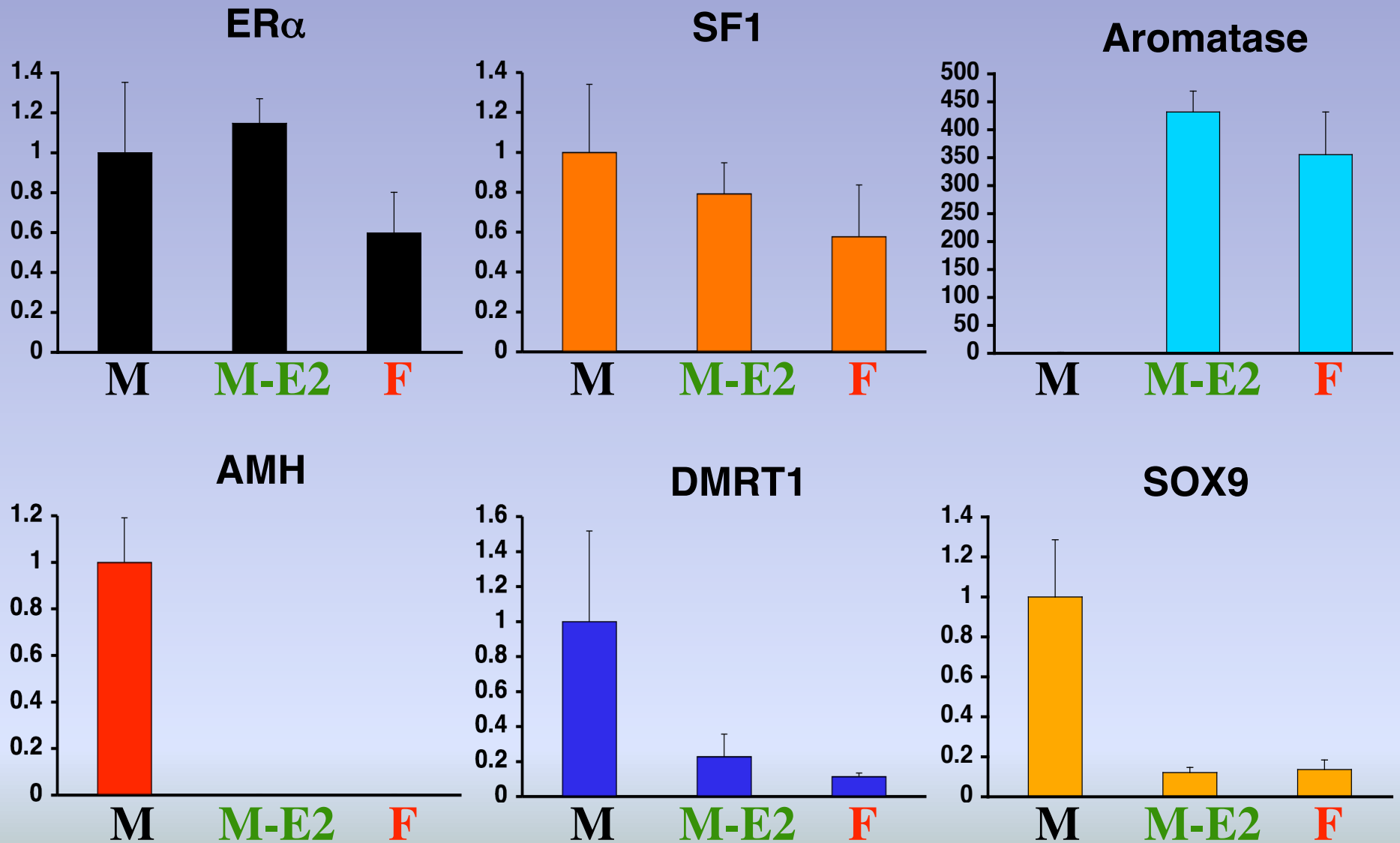
Katsu et al., unpubl. data

Sex Determination in Alligators



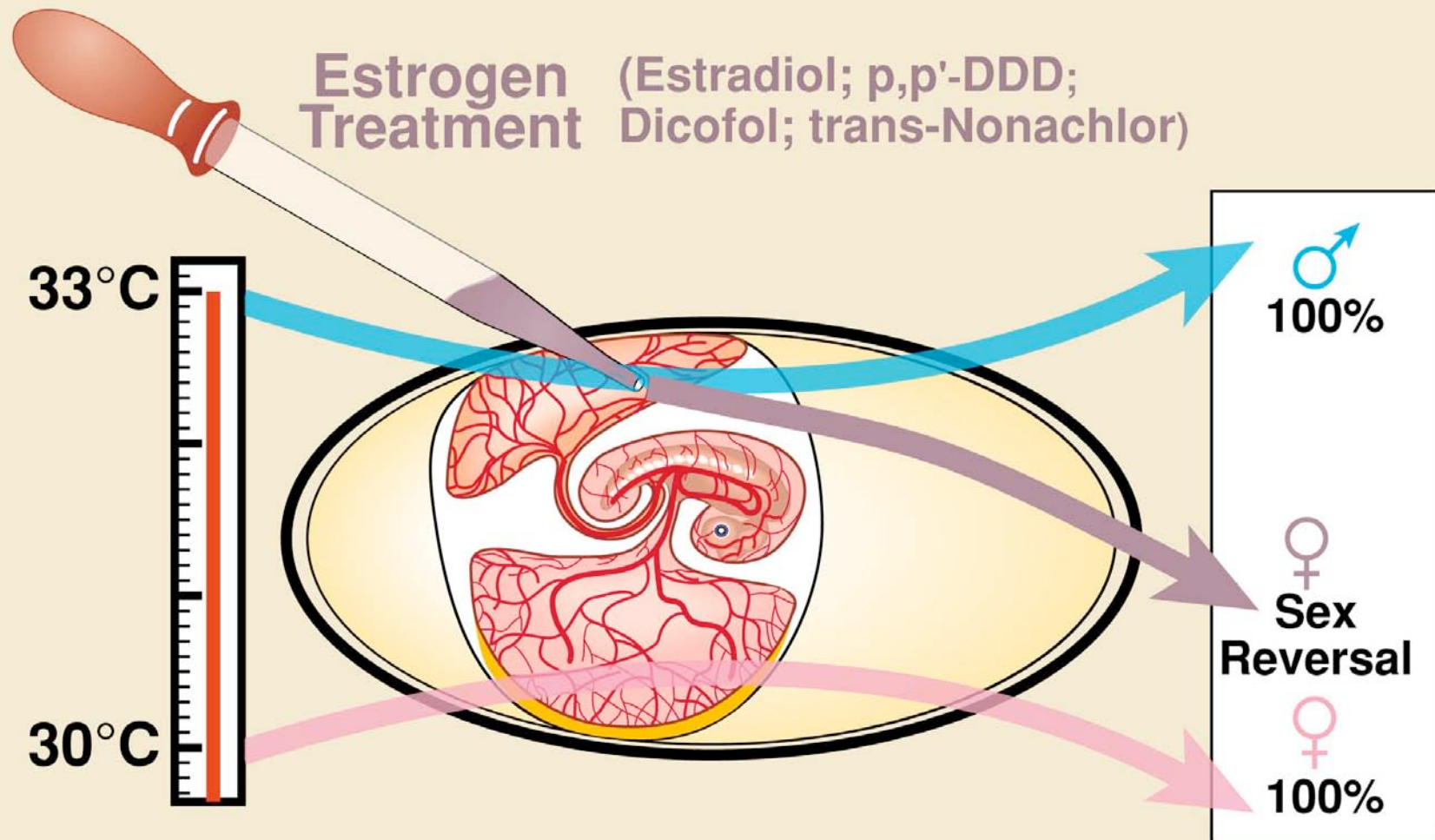


Gene Expression in Neonatal Gonads Incubated at Male or Female Temperatures, or at Male Temperature Exposed to Estrogen

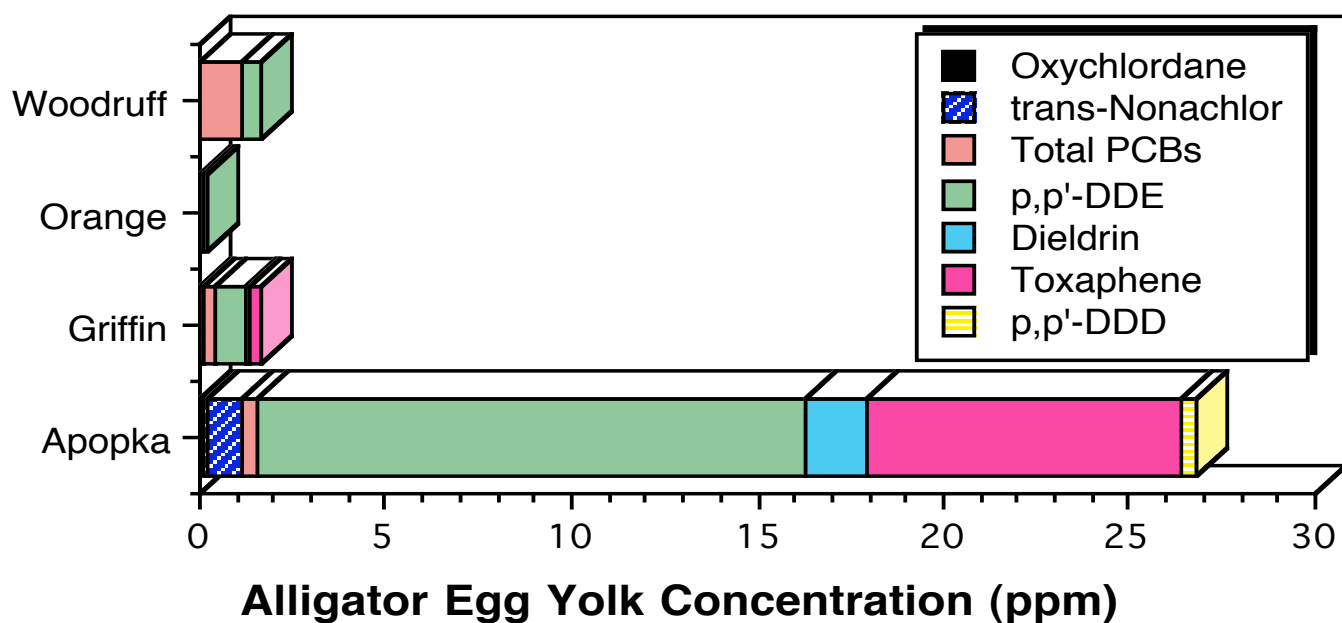


Katsu et al. unpubl. data

Sex Determination in Alligators



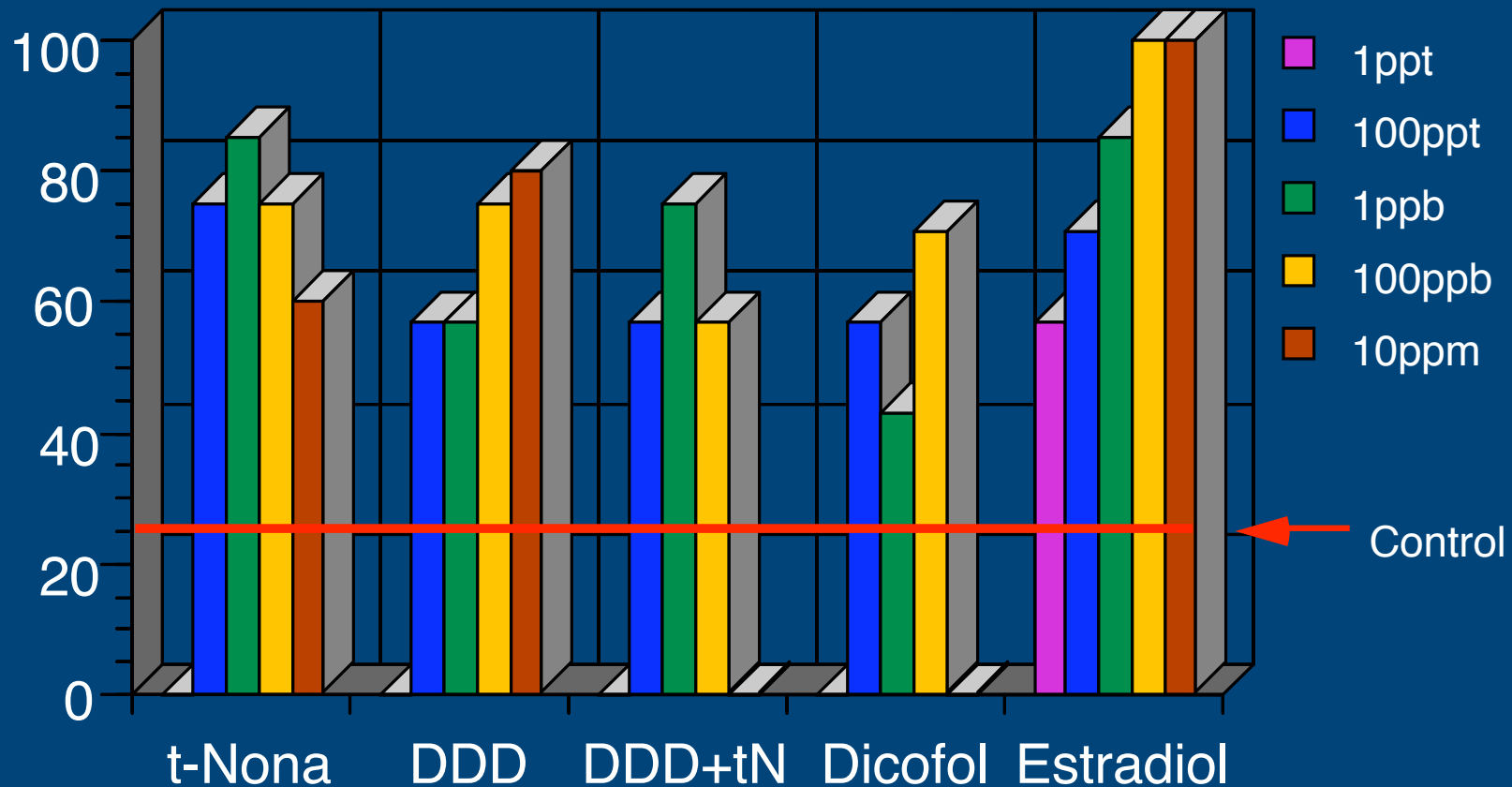
Alligator Egg Contaminants



Woodward et al., unpubl. data

Sex Reversal - % Female

33.0°C : Stage 19 : N = 7-10 eggs / treatment



Guillette et al., unpubl. data