

# Embryonic Temperature Programs Phenotype in Reptiles

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# About the review...

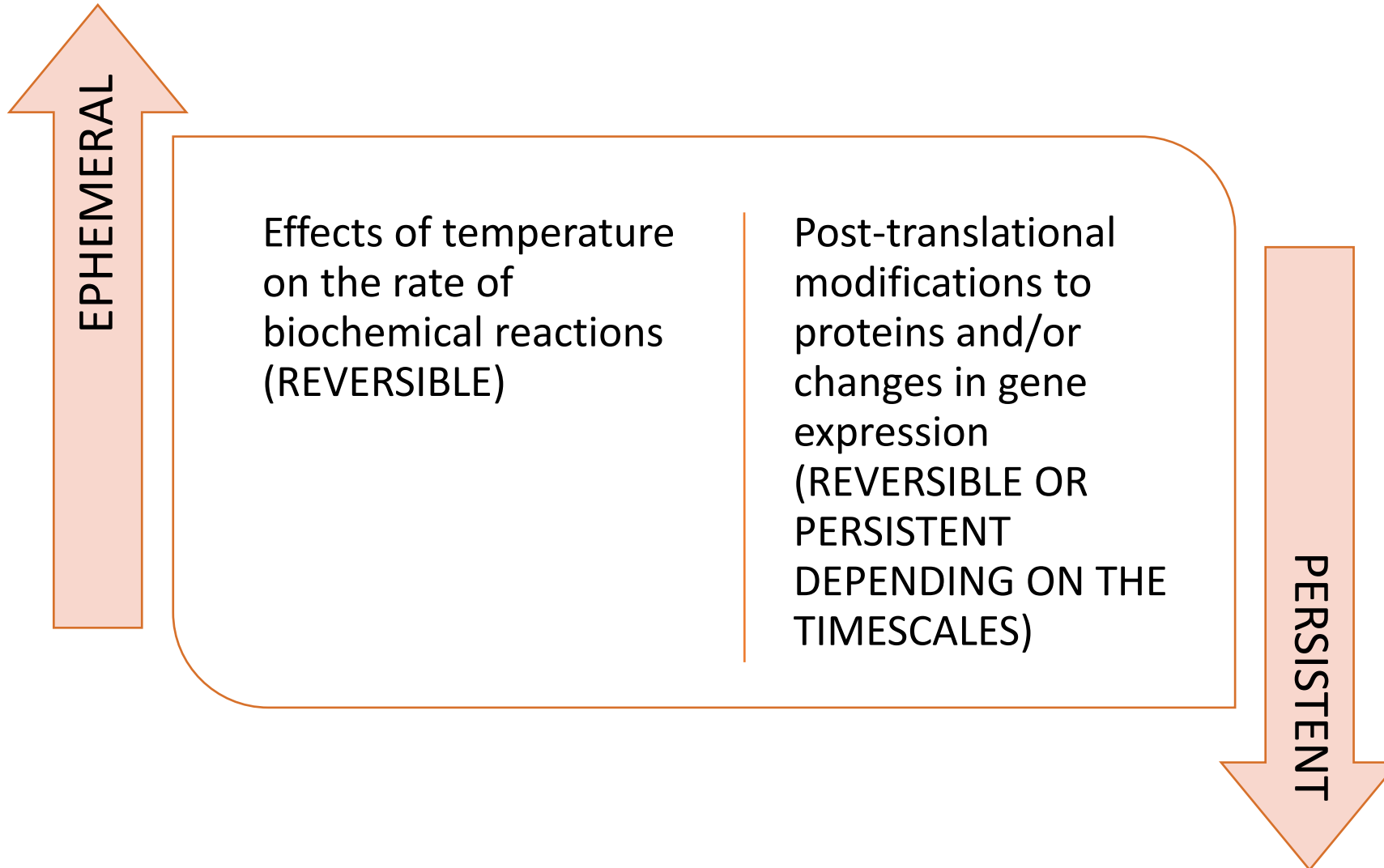
## Introduction

- Physics of the temperature effects on biochemical reactions
- General pattern of thermal effects on physiology
- Thermal acclimation in ectotherms

## Main topic

- Developmental programming of phenotype by temperature during embryogenesis (i.e., permanent developmental effects)

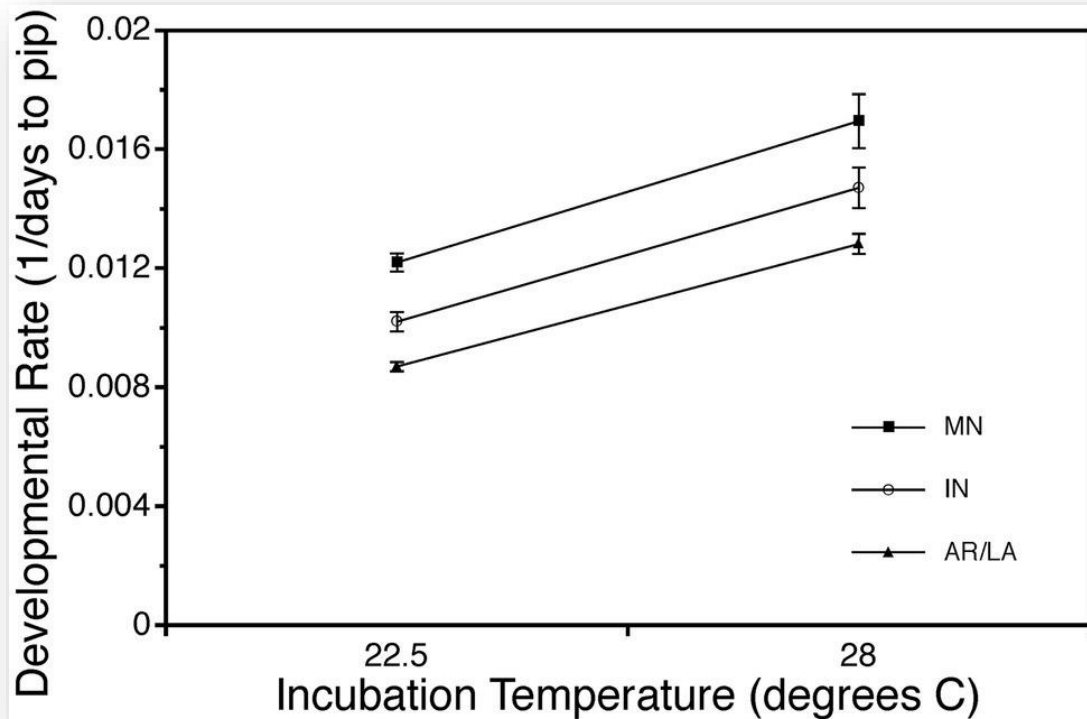
# Biophysical effects of temperature



# Developmental effects of temperature

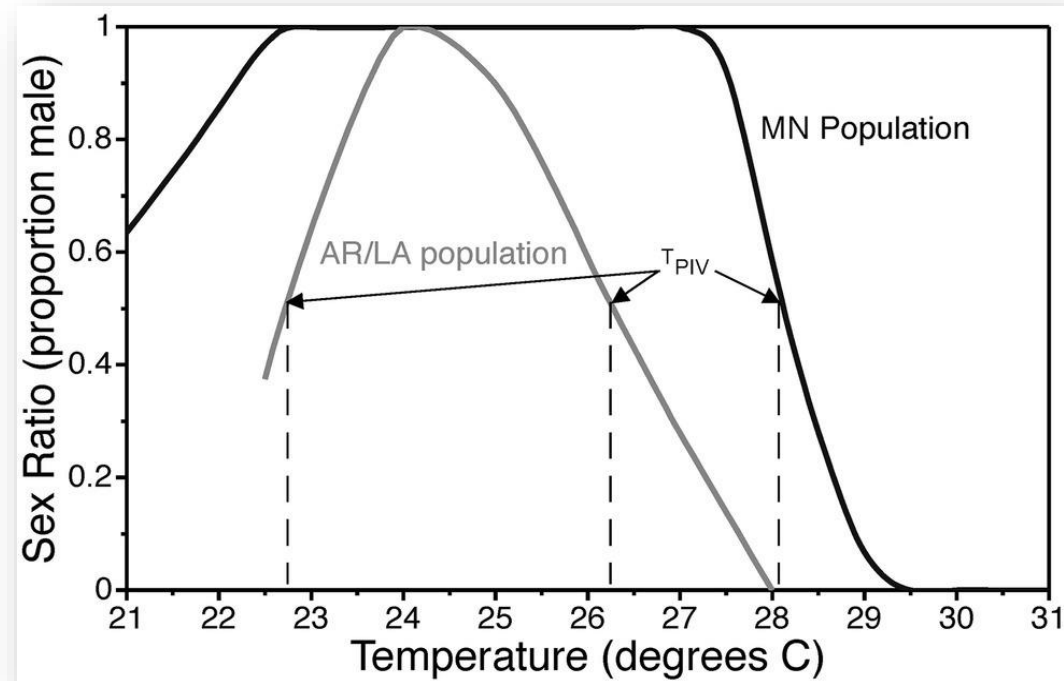
As incubation temperature increases, reptile embryos develop faster and hatch sooner

Animals from different incubation temperatures are marked by different traits (e.g. body size and shape, behaviour, residual yolk, sexual phenotype)



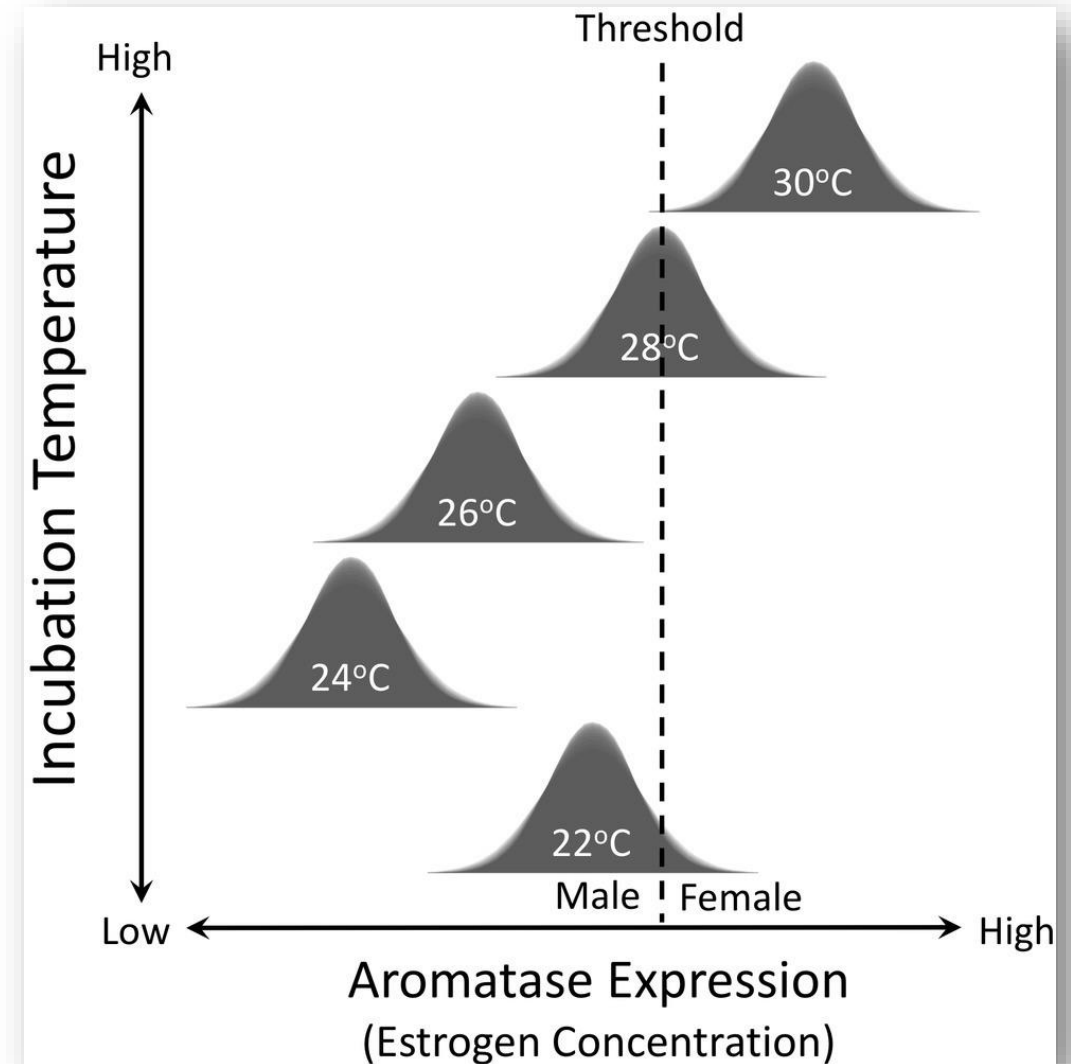
# Temperature-Dependent Sex Determination (TSD)

- Temperature is transduced into a binary response, with individuals developing either testes or ovaries (but not as intersexes)
- Reaction norms for TSD follow 3 patterns: MF (Ia), FM (Ib) and FMF (II)
- TSD is determined by a combination of genetic and environmental factors
- Reaction norms for TSD varies both among and within species



# Temperature-Dependent Sex Determination (TSD)

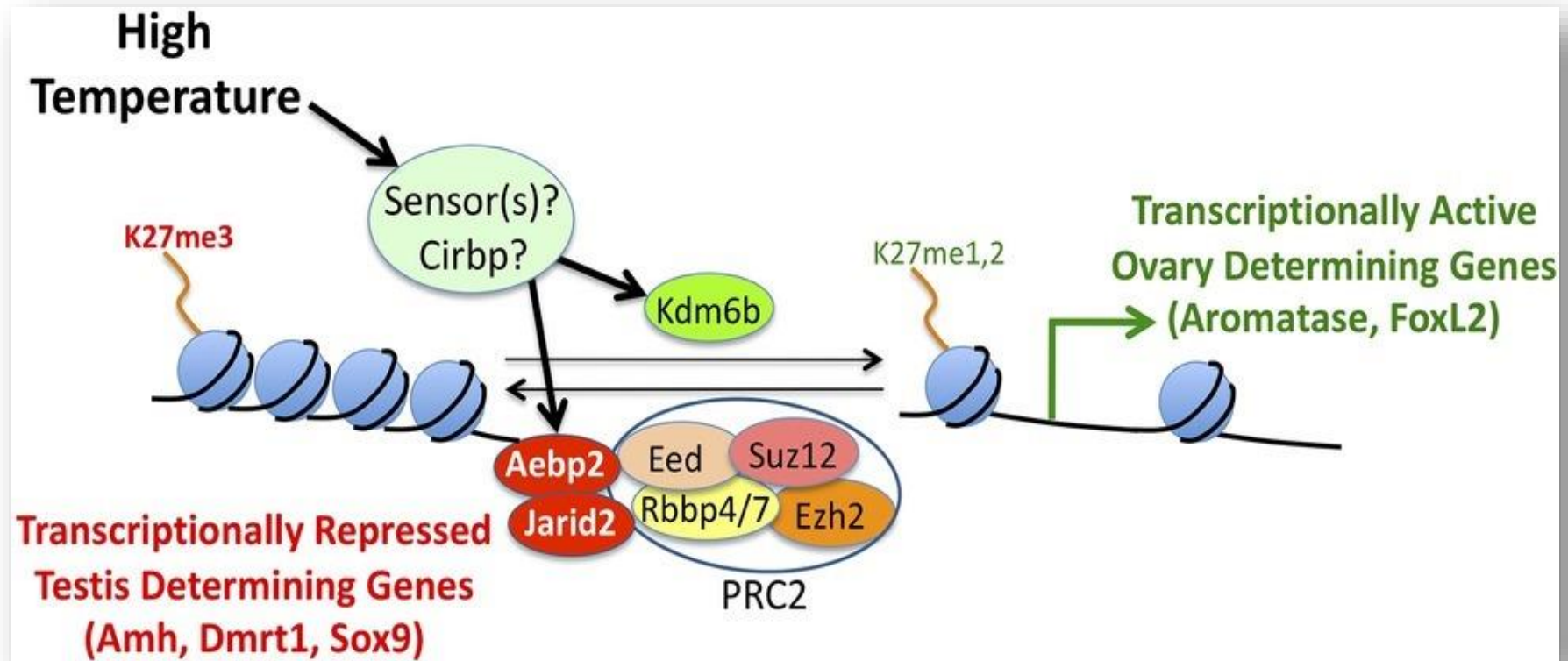
- **Aromatase** is likely to be a key factor in sex determination
- If estrogen concentration in embryonic gonads is below a critical threshold, gonads develop into testes
- Conversely, if they are above this threshold, gonads develop into ovaries





# Temperature-Dependent Sex Determination (TSD)

The hypothesized mechanism that regulate **aromatase** expressions in embryonic gonads



# Current research on epigenetic mechanisms

- The specific molecular factors that transduce temperature into a biological signal are largely unknown but there is increasing evidence that these factors target epigenetics
- Post-translational modifications of histones and DNA methylation are key epigenetic marks that play a part in development
- Changes in DNA methylation mediate various environmental effects on phenotype
- Differential DNA methylation at sex-determining genes may be a critical factor for sex-determination (studies of hatchlings testes and ovaries)





# Incubation temperature programs quantitative traits

## Metabolism

Snapping turtle

- Resting metabolic rate and circulating thyroid hormone concentration decreased with increasing incubation temperature

## Endocrine Physiology

Leopard gecko

- Steroid hormone synthesis, persistent effects

## Growth Physiology

Green anole, Murray-River  
turtle, broad-snouted  
caiman

- Cooler incubation temperature produced hatchlings that grow faster

## Brain and Behaviour

5 turtle species and  
leopard gecko

- Thermoregulation, righting, swimming, sociosexual behaviour



# To sum up...

- Incubation temperature has significant effects on phenotypes
- Phenotypic differences appear to be permanent developmental effects
- Recent work suggests that epigenetic marks like DNA methylation and histone modifications may mediate these persistent effects
- These effects translate to nature, but more research is needed
- Global warming is likely to have an impact on reptiles in the wild