

Meritxell Riera Bellés Bachelor's Degree in Biology

INTRODUCTION

Epigenetics denotes stable changes in **gene activity** that do not involve changes in the DNA sequence. Epigenetic marks can be gained or lost stochastically, giving rise to the so called **epimutations**, and/or in response to **environmental factors**. Epigenetics is increasingly recognized as an additional source of **potentially adaptative variation** in the form of epialleles, and also as **stabilizer of plastic responses** to environmental perturbations. However, to play a significant role in evolution epigenetic changes must be established in the **germ-line** and maintained through **reprogramming**.

OBJECTIVES: to provide a critical review of current ideas on the mechanisms of **transgenerational inheritance** of epigenetic changes, and the role of epigenetics as elicitor of **phenotypic variation** and **rapid adaptative evolutionary change**.

RESULTS I. TRANSGENERATIONAL INHERITANCE

1. Germ-line establishment of epigenetic variation

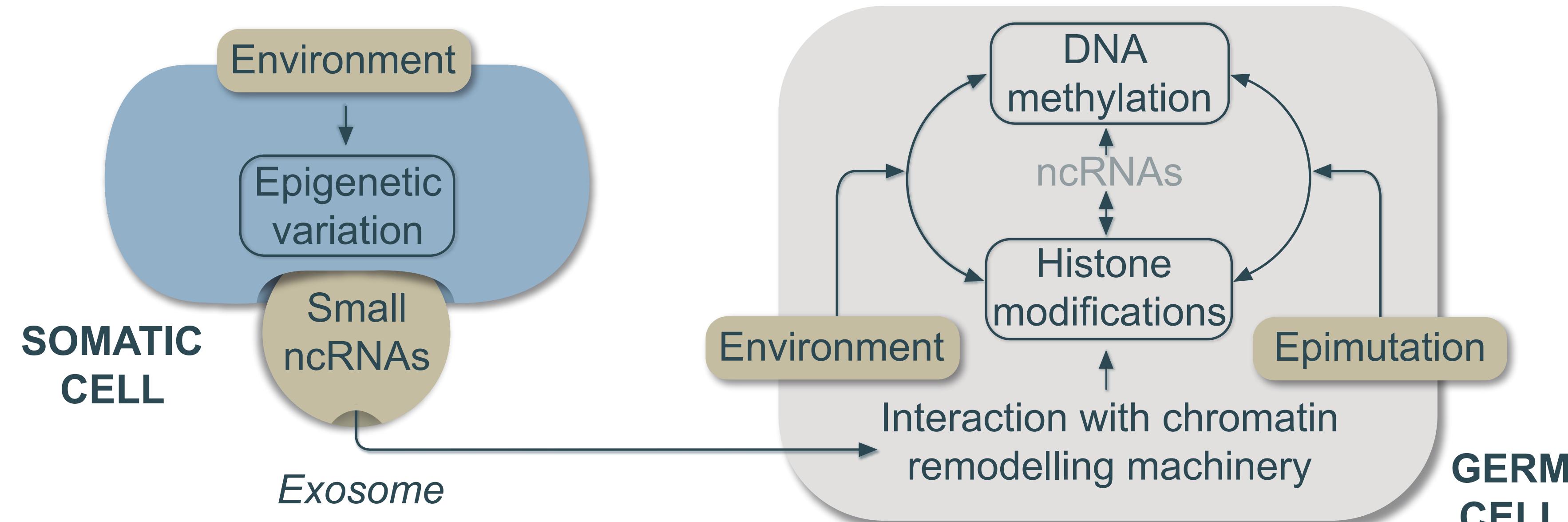


Figure 1. Plausible pathways of germ-line establishment of epigenetic variation

2. Maintenance of epigenetic marks through reprogramming

Epigenetic mark	Maintenance	Mechanism	Region
DNA methylation	KRAB proteins	Recognition and propagation	TE and regulatory regions of genes
H3K9me3	HP1 + ncRNAs (?)	Recognition and propagation	Constitutive heterochromatin
H3K27me3	PRC2 + ncRNAs	Recognition and propagation	Regulatory regions of genes

RESULTS II. EPIGENETICS AND EVOLUTION

1. Potentially adaptative stochastic variation

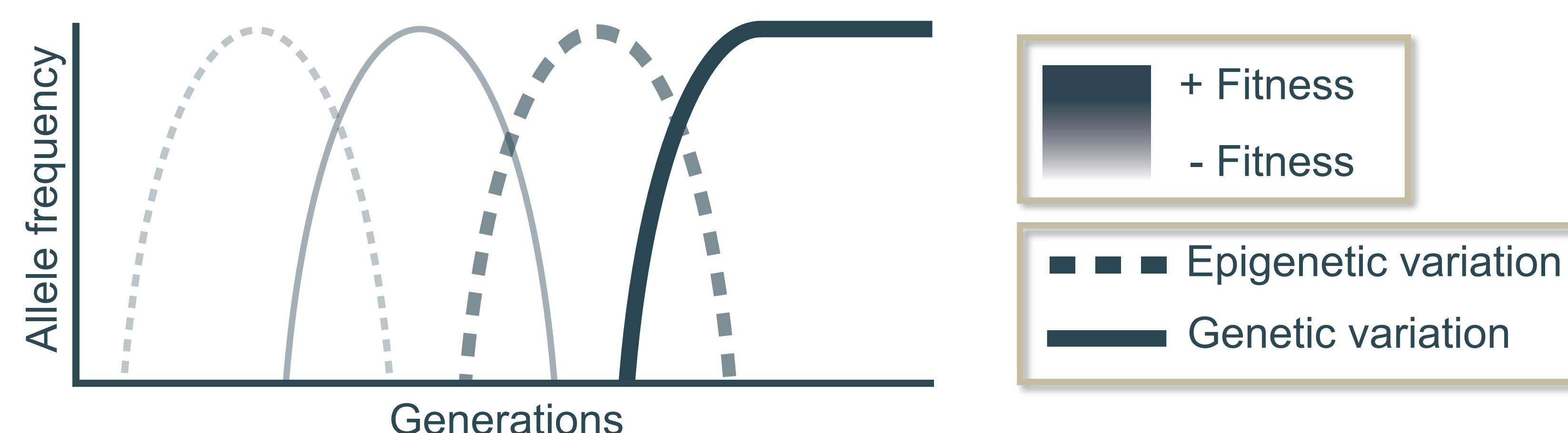


Figure 2. Evolutionary model dynamics using two variation systems in a multi-peak landscape

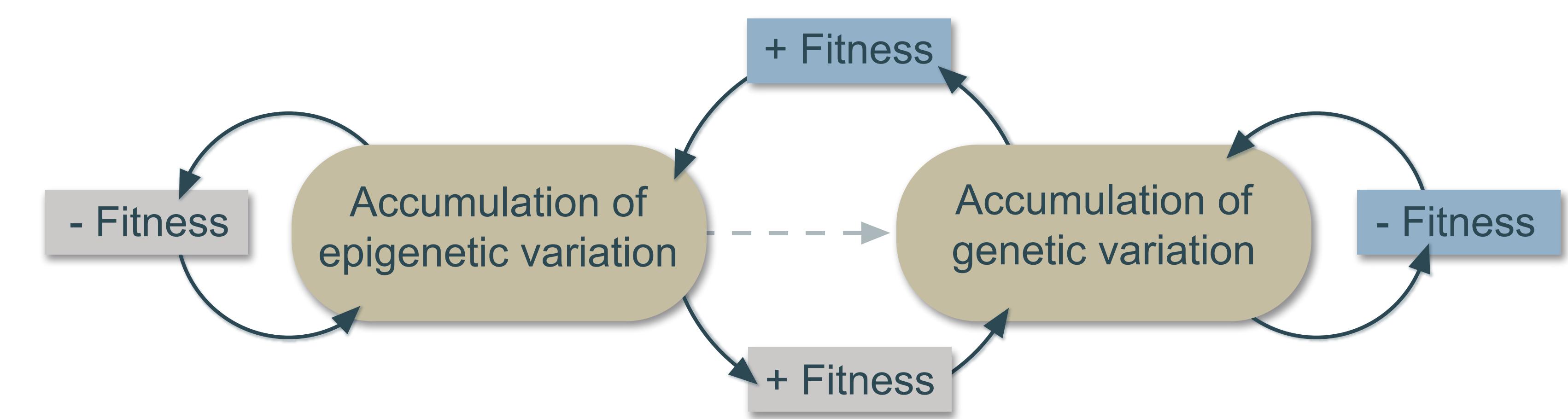


Figure 3. "Stepping stone" effect of two variation systems

2. Stabilization of phenotypic plasticity

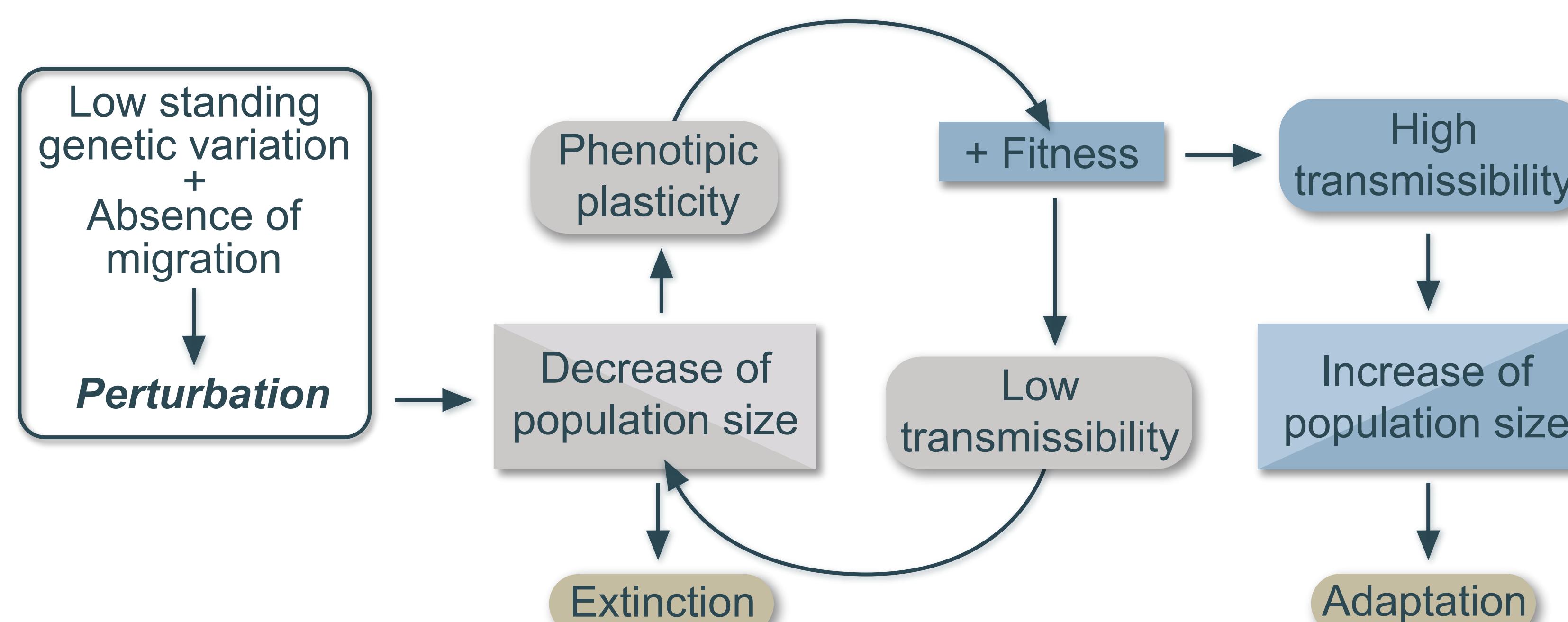


Figure 4. Schematic representation of evolutionary rescue through exploration, stabilization and transmission of an adapted phenotype

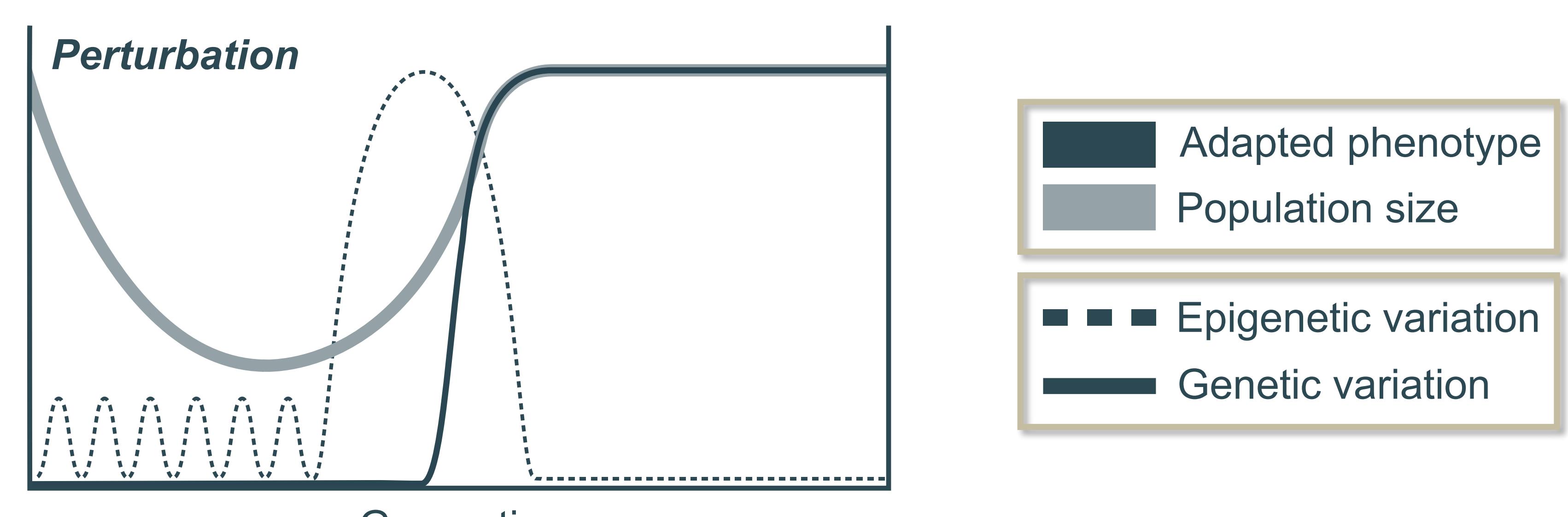


Figure 5. Graphical representation of evolutionary rescue through exploration, stabilization and transmission of an adapted phenotype

CONCLUSIONS

- Transgenerational inheritance of epigenetic variation: **interplay between ncRNAs and other epigenetic marks**.
- Transmissible favourable epigenetic variation: faster and more efficient **adaptation** and/or **evolutionary rescue**.
- Stochastic epigenetic variation: additional source of **potentially adaptative variation** with increased mutation rates, and direct or indirect effects on the **accumulation of potentially adaptative genetic variation**.
- Epigenetic stabilization of phenotypic plasticity in response to perturbations: **increase of population size** and direct or indirect effects on the **accumulation of potentially adaptative genetic variation**.
- Selectable phenotype: complex interplay between genetic variation and **gene regulatory networks**.

REFERENCES

- Szyf, M. (2015) Nongenetic inheritance and transgenerational epigenetics. *Trends Mol. Med.* **21**: 134–144.
- Sharma, A. (2014) Bioinformatic analysis revealing association of exosomal mRNAs and proteins in epigenetic inheritance. *J. Theor. Biol.* **357**: 143–149.
- Tang, W. W. C. et al. (2015) A unique gene regulatory network resets the human germline epigenome for development. *Cell* **161**: 1453–1467.
- Van de Werken, C. et al. (2014) Paternal heterochromatin formation in human embryos is H3K9/HP1 directed and primed by sperm-derived histone modifications. *Nat. Commun.* **5**: 5868.
- Brykczynska, U. et al. (2010) Repressive and active histone methylation mark distinct promoters in human and mouse spermatozoa. *Nat. Struct. Mol. Biol.* **17**: 679–687.
- Klironomos, F. D. et al. (2013) How epigenetic mutations can affect genetic evolution: Model and mechanism. *Bioessays* **35**: 571–578.
- Braun, E. (2015) The unforeseen challenge: from genotype-to-phenotype in cell populations. *Rep. Prog. Phys.* **78**: 036602.