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Lecture 12:

Implications of animal culture for evolution



Goal

- ▣ **What does the existence of cultural Inheritance change in the process of Evolution?**



Goal

- ▣ What does the existence of cultural **Inheritance** change in the process of **Evolution**?



Goal

- ▣ What does the existence of cultural

Inheritance change in the process of
Evolution?



1)

Heredity



Some definitions

- ▣ **Heredity:**
Patterns of parent-offspring resemblance
- ▣ **Inheritance:**
Underlying mechanisms: transfer of **any kind of information** across generations
- ▣ **Genetic:** DNA sequence (**“Sequencic”**)
- ▣ **Non-genetic inheritance:** Inheritance of phenotypic variation **not** resulting from **DNA sequence variation**



Some definitions

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Patterns of parent-offspring resemblance
Central role in natural selection,
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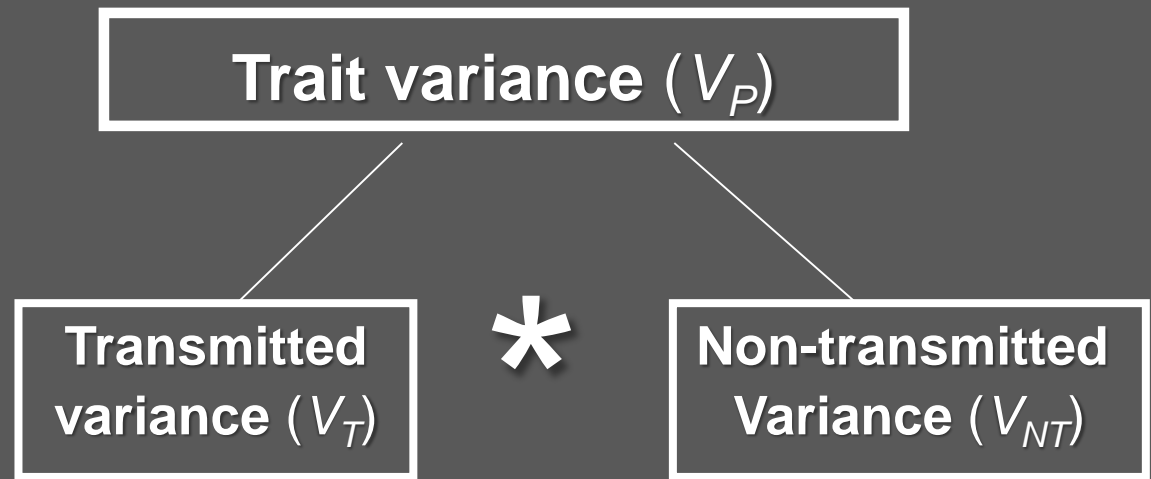
The origin

Darwin “*The Origin of species*” (1859, p.12):

***“Any variation which is not inherited
is unimportant for us”***

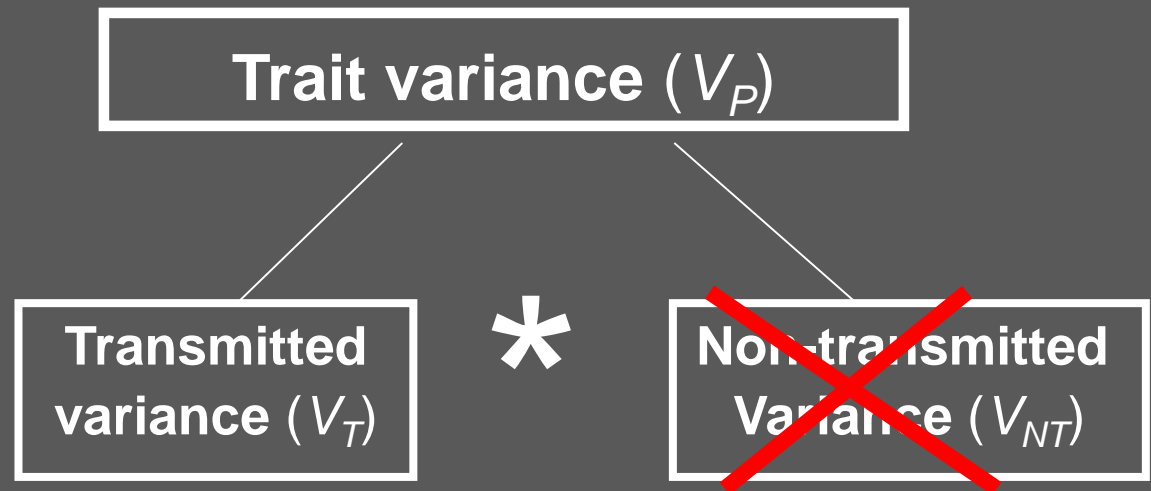
Implying that only the variation that is inherited is
important for natural selection





Danchin *et al. Science*, 2004; Danchin and Wagner *Oikos* 2010;
Danchin *et al.* 2011. *Nature Rev. Genet.* and



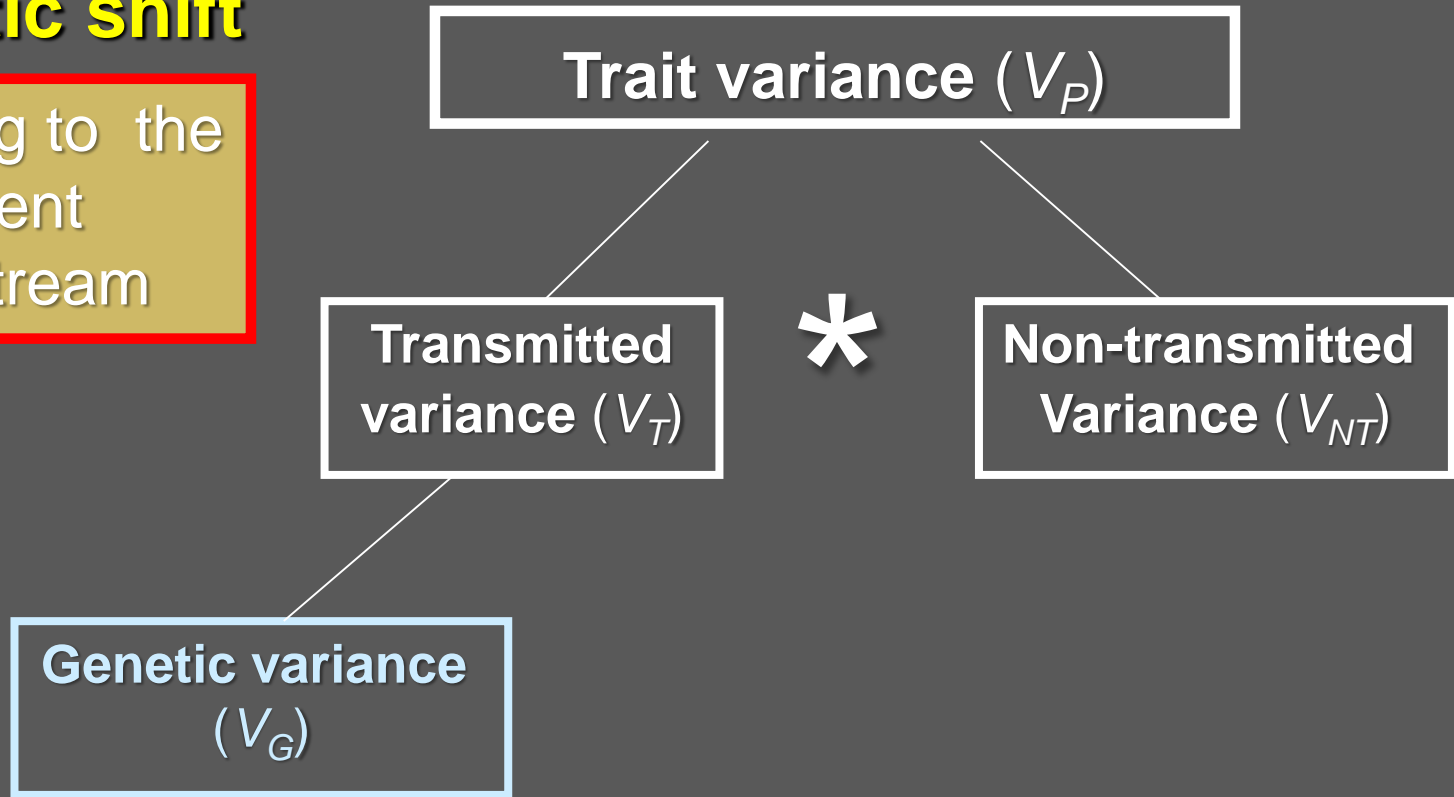


Danchin *et al. Science*, 2004; Danchin and Wagner *Oikos* 2010;
Danchin *et al.* 2011. *Nature Rev. Genet.*



Semantic shift

According to the
current
mainstream

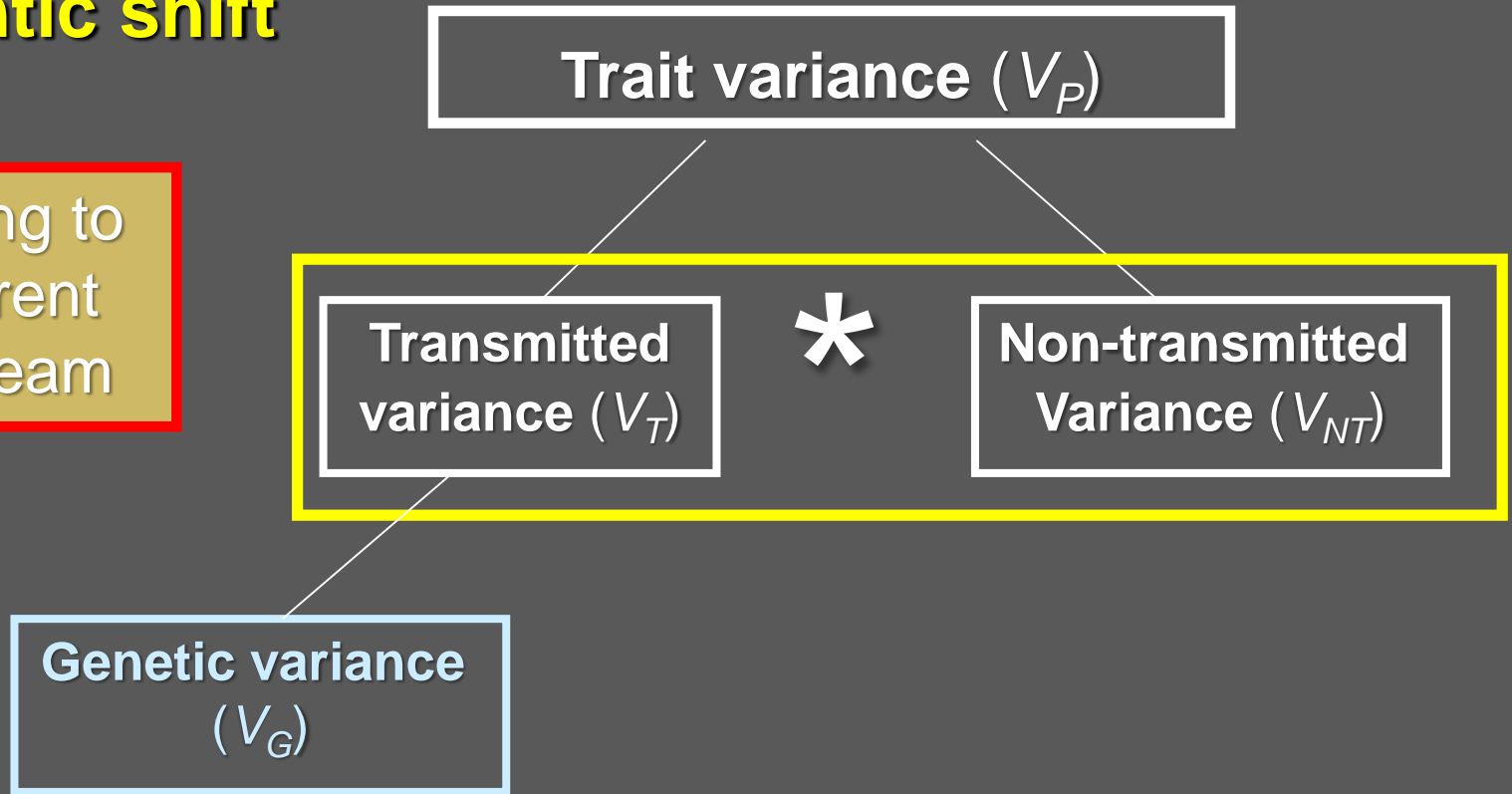


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Semantic shift

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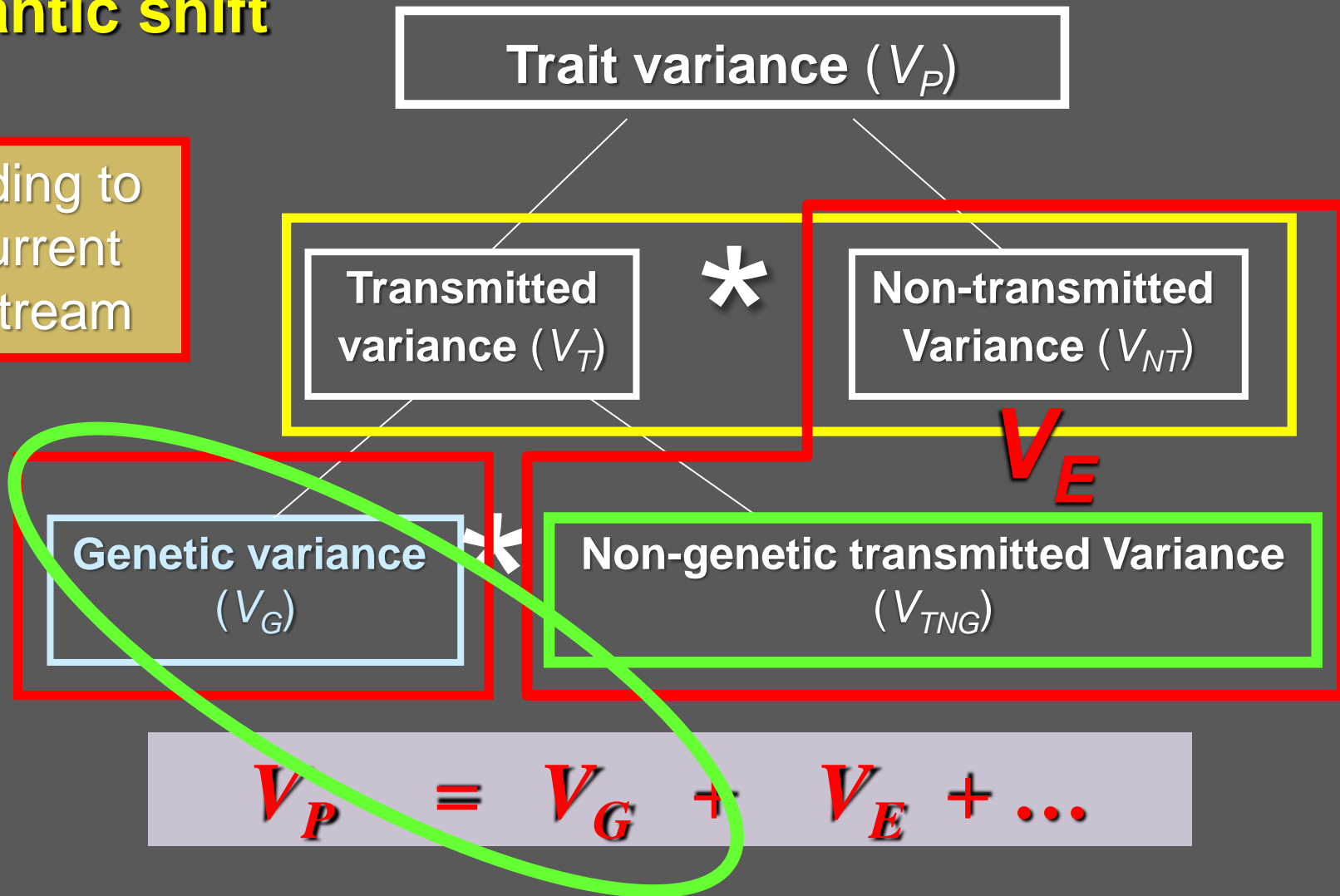


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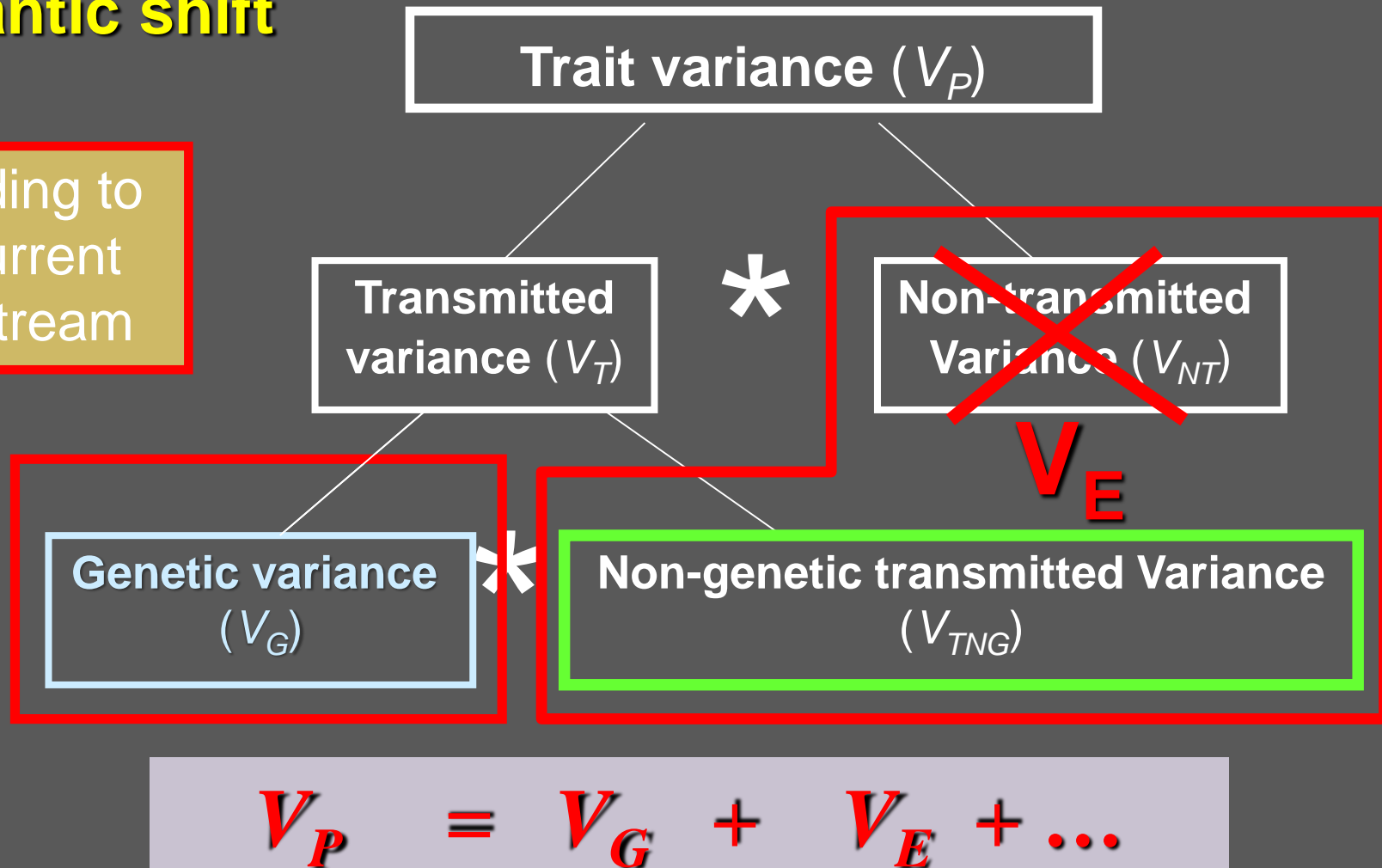


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Semantic shift

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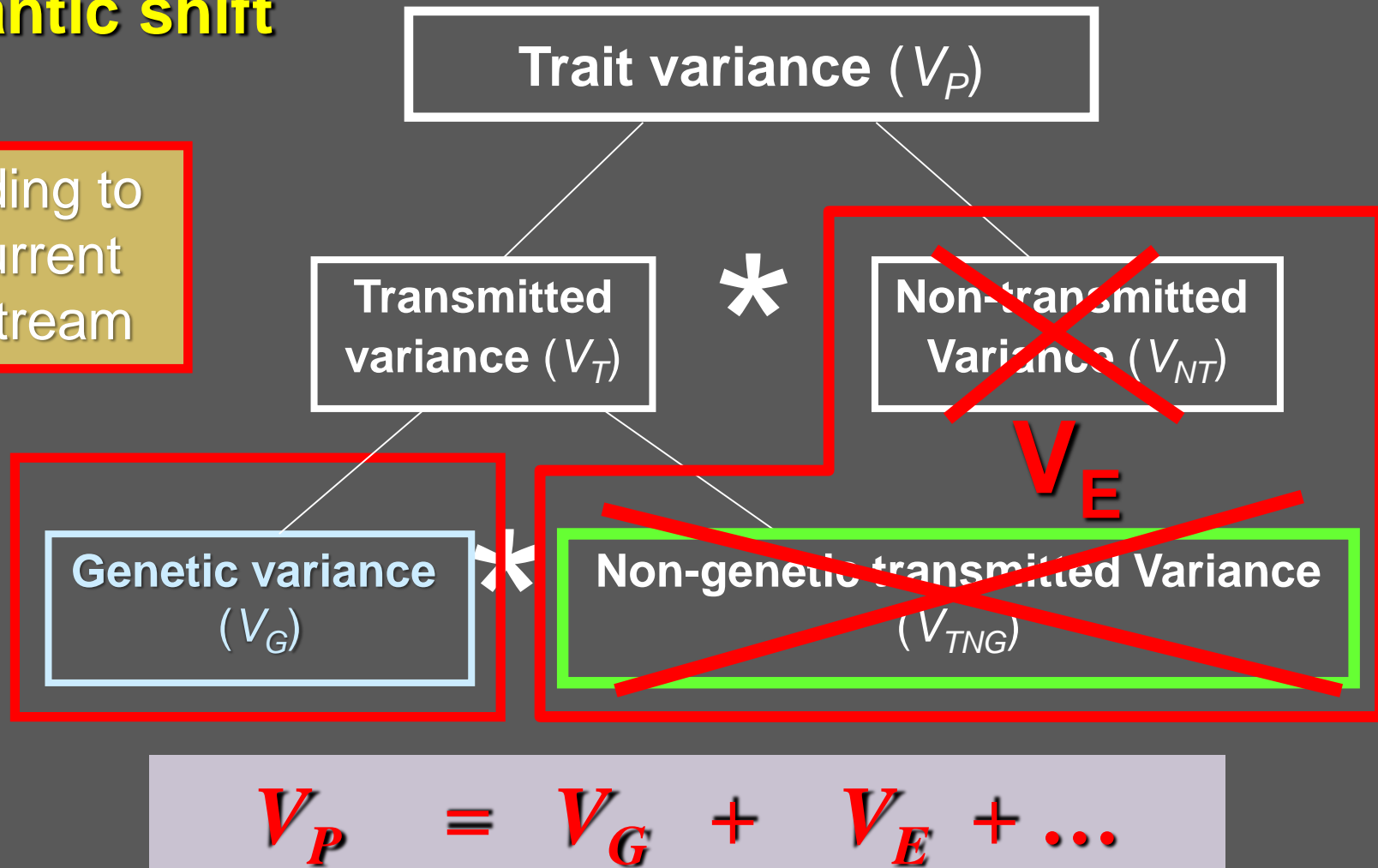


Danchin *et al. Science*, 2004; Danchin and Wagner *Oikos* 2010;
Danchin *et al.* 2011. *Nature Rev. Genet.*



Semantic shift

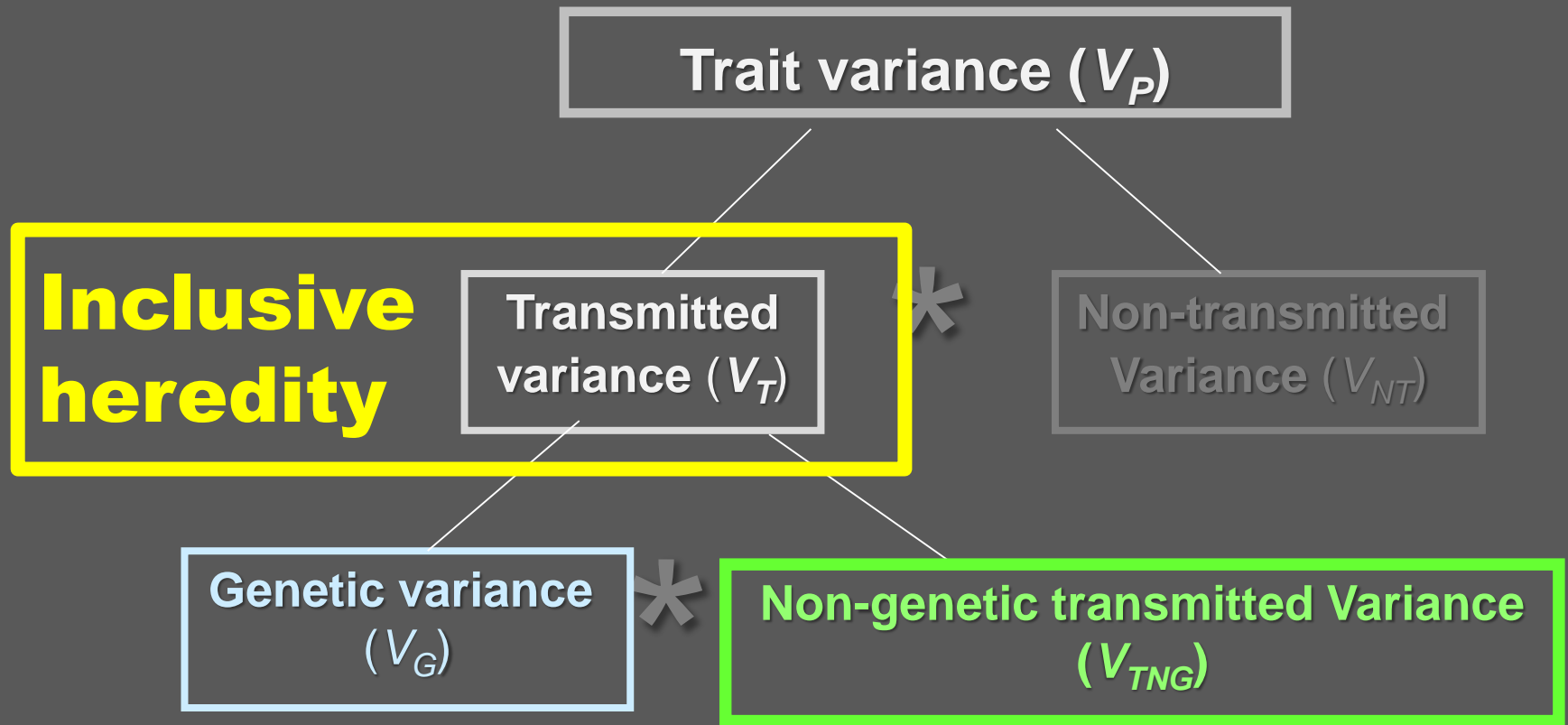
According to
the current
mainstream



Discarding part of the baby with the bathwater

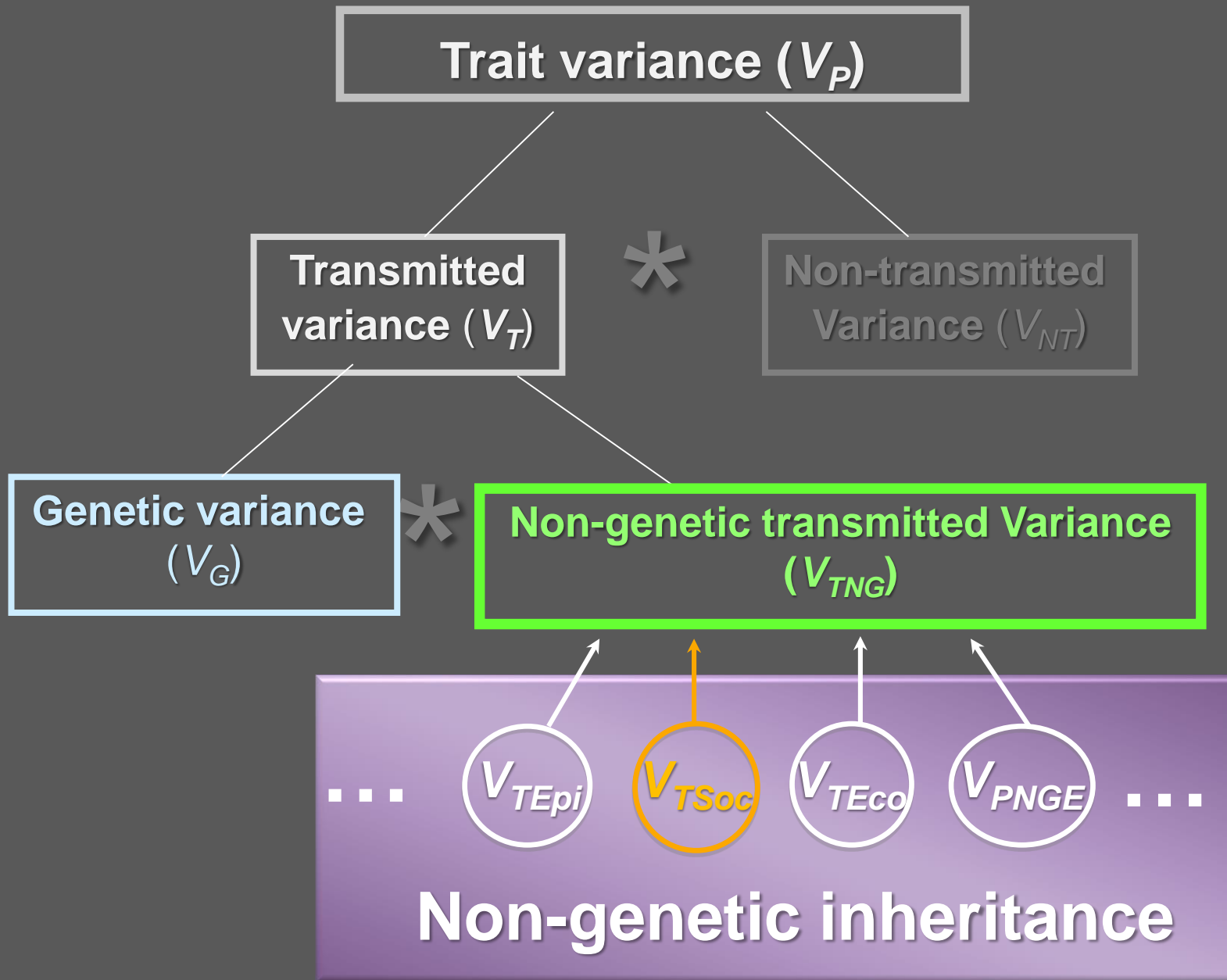
Danchin *et al. Science*, 2004; Danchin and Wagner *Oikos* 2010;
Danchin *et al.* 2011. *Nature Rev. Genet.*





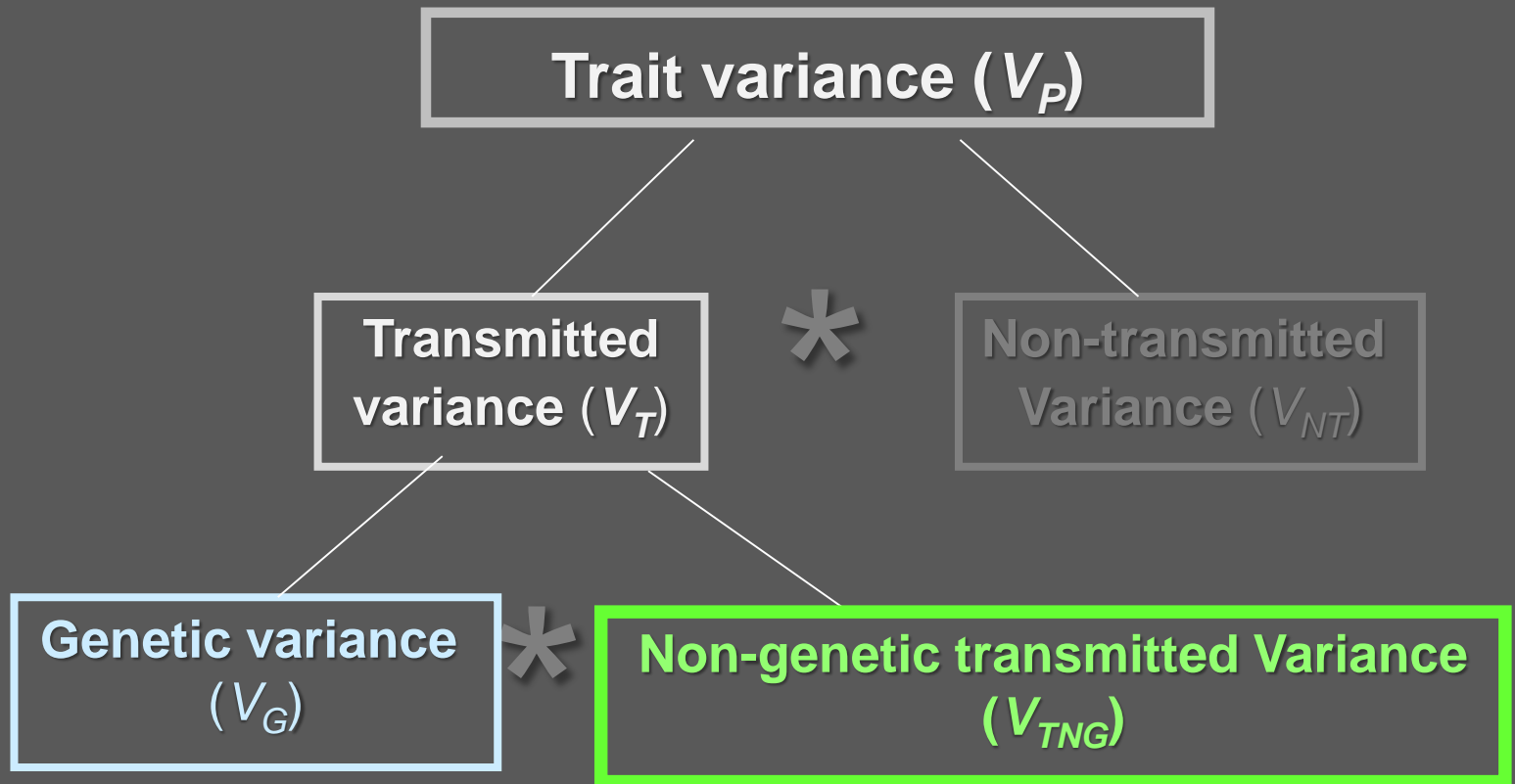
Danchin *et al. Science*, 2004; Danchin and Wagner *Oikos* 2010;
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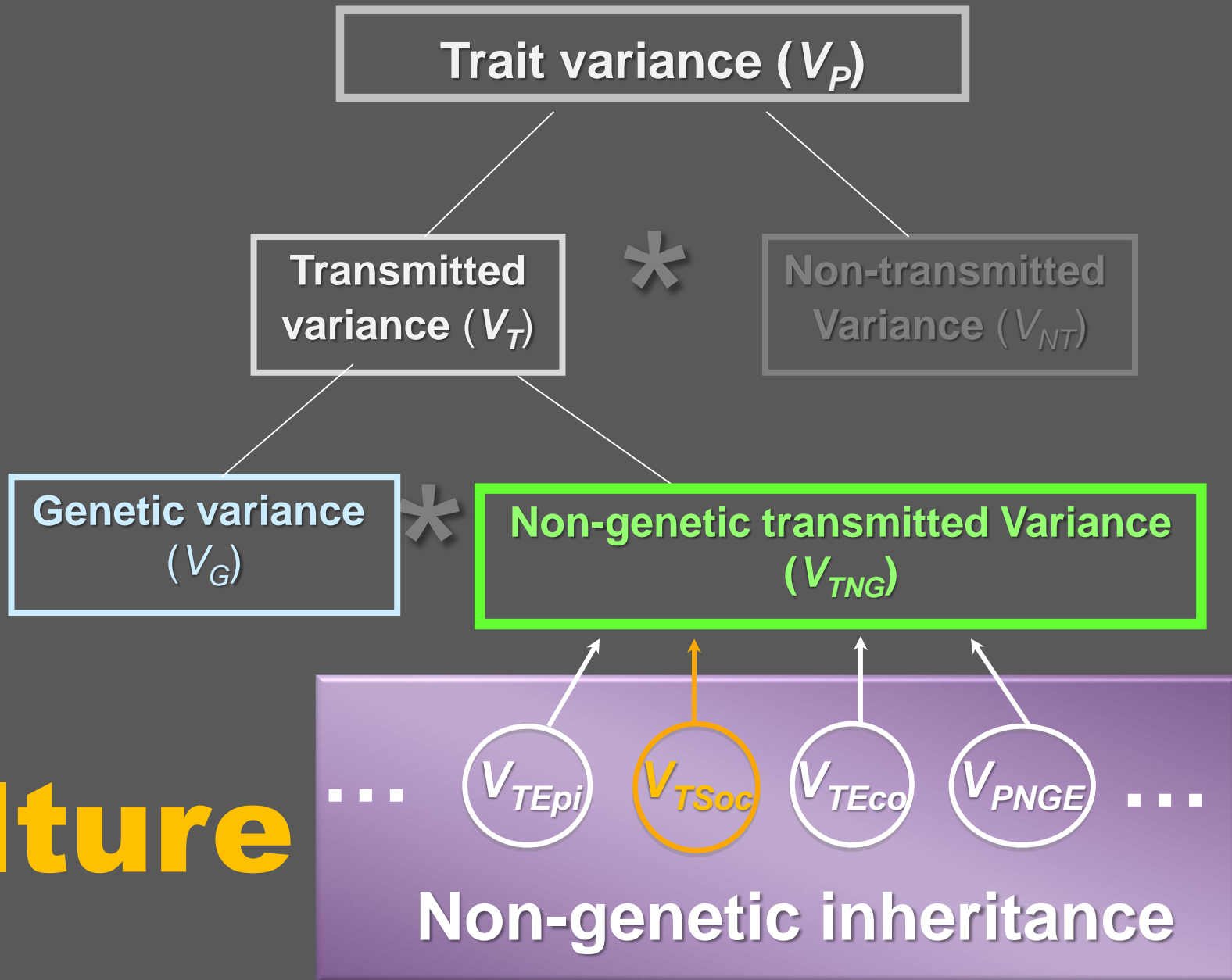
**For the
existence
of V_{TNG}**

Francis *et al. Science*, 1999
Anway *et al. Science*, 2005
Jablonka & Lamb 2005, *Evolution in four dimensions*
Danchin *et al. Science*, 2004
Danchin & Wagner *Oikos* 2010
Danchin *et al.* 2011. *Nature Rev. Genet.*
Wang *et al.* 2017 *Biol. Reviews*
and many references therein

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Culture



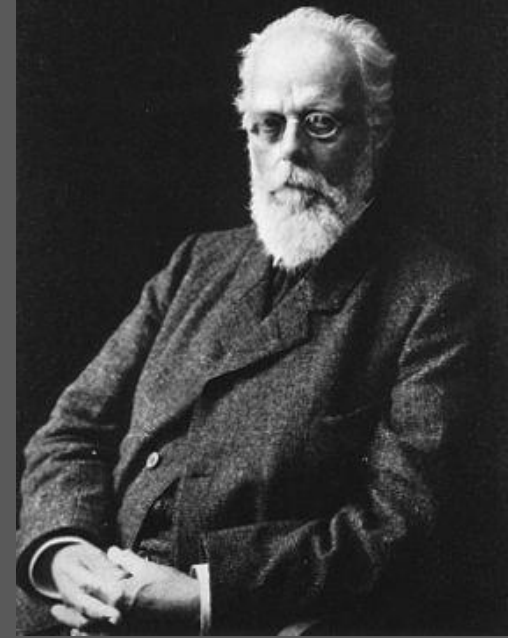
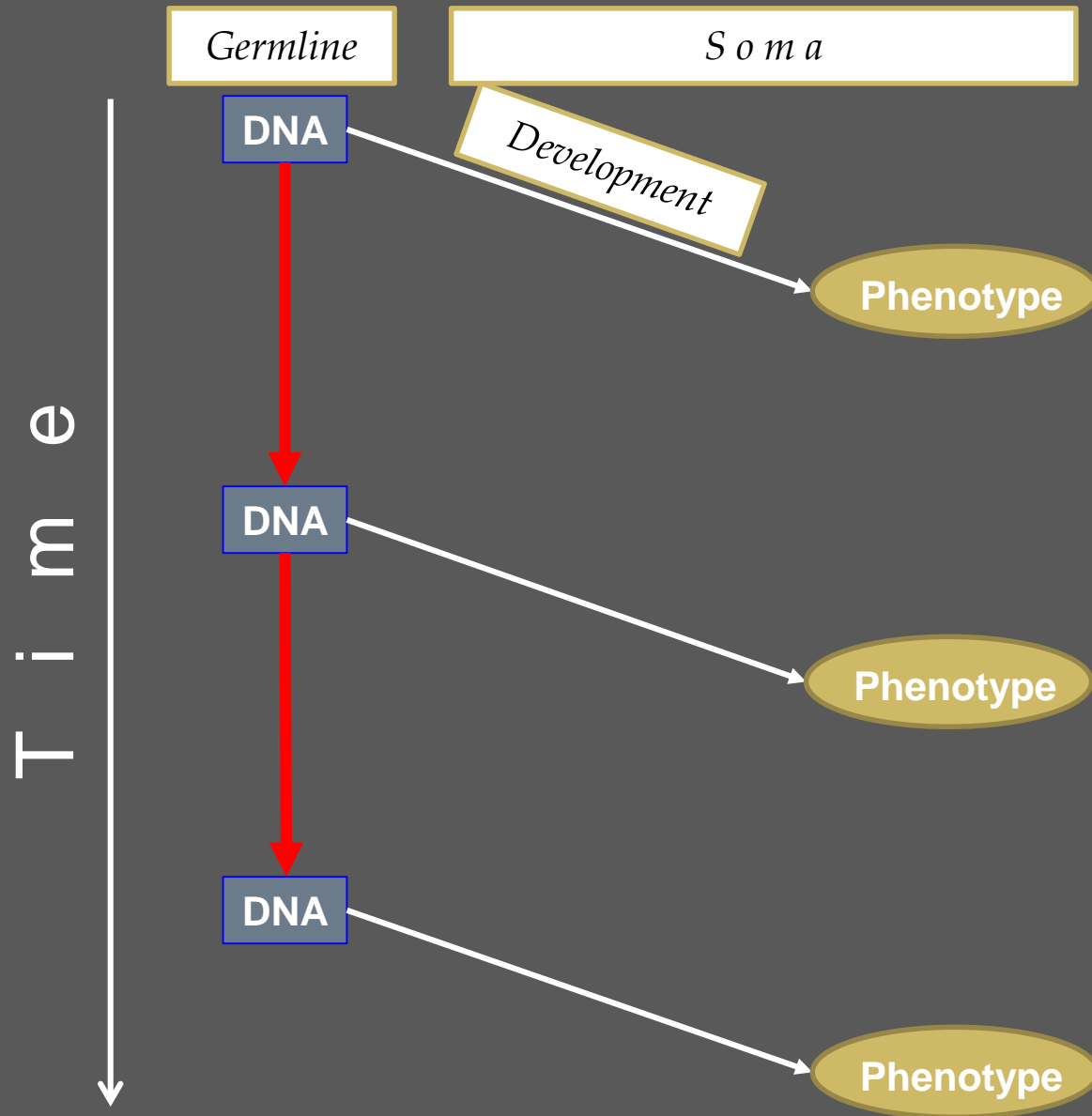
Danchin *et al. Science*, 2004; Danchin and Wagner *Oikos* 2010;
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Heredity produces fluxes of
information across generations
generating informational dynamics

=> What kind of intergenerational
information fluxes are generated
by cultural heredity?

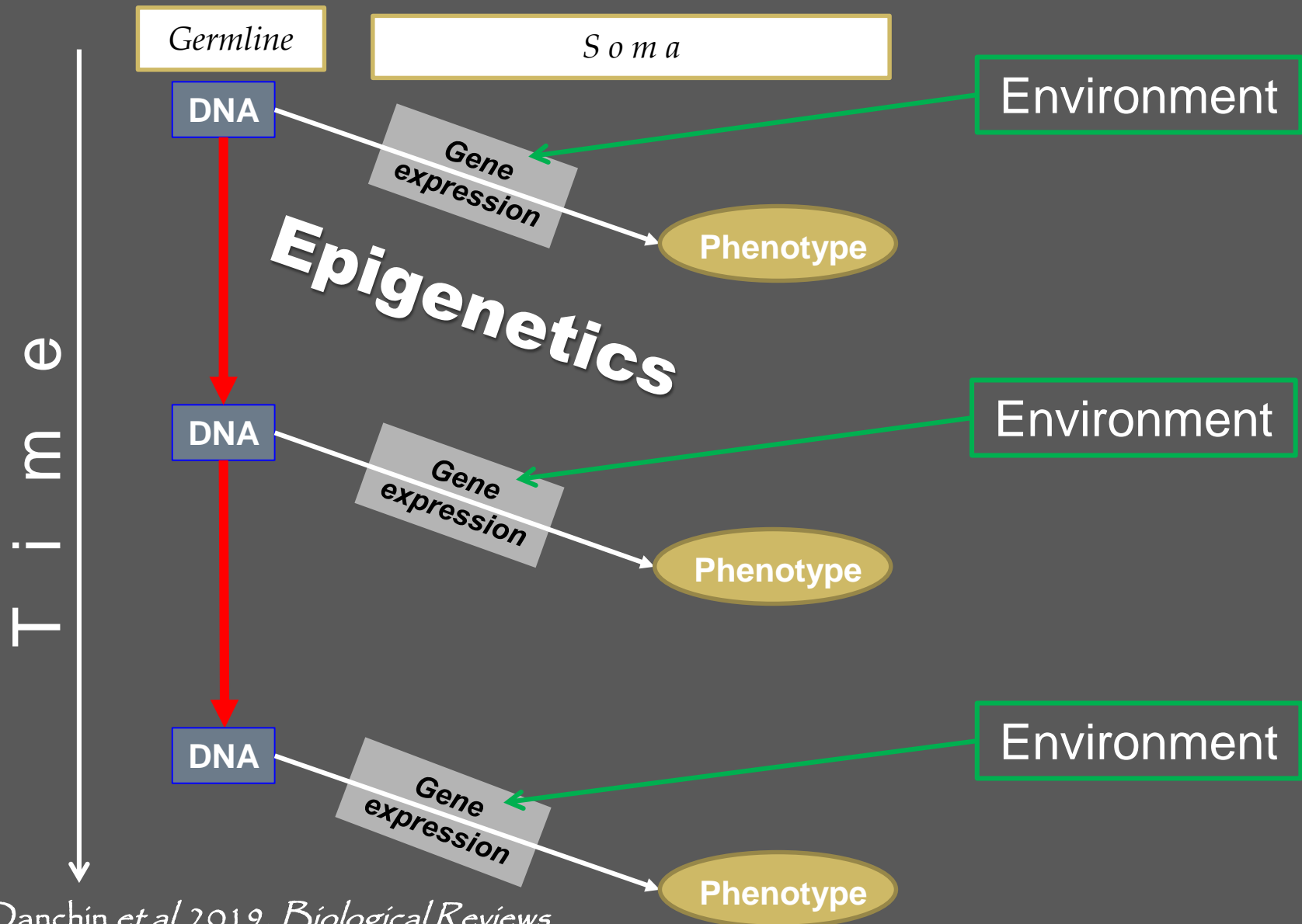




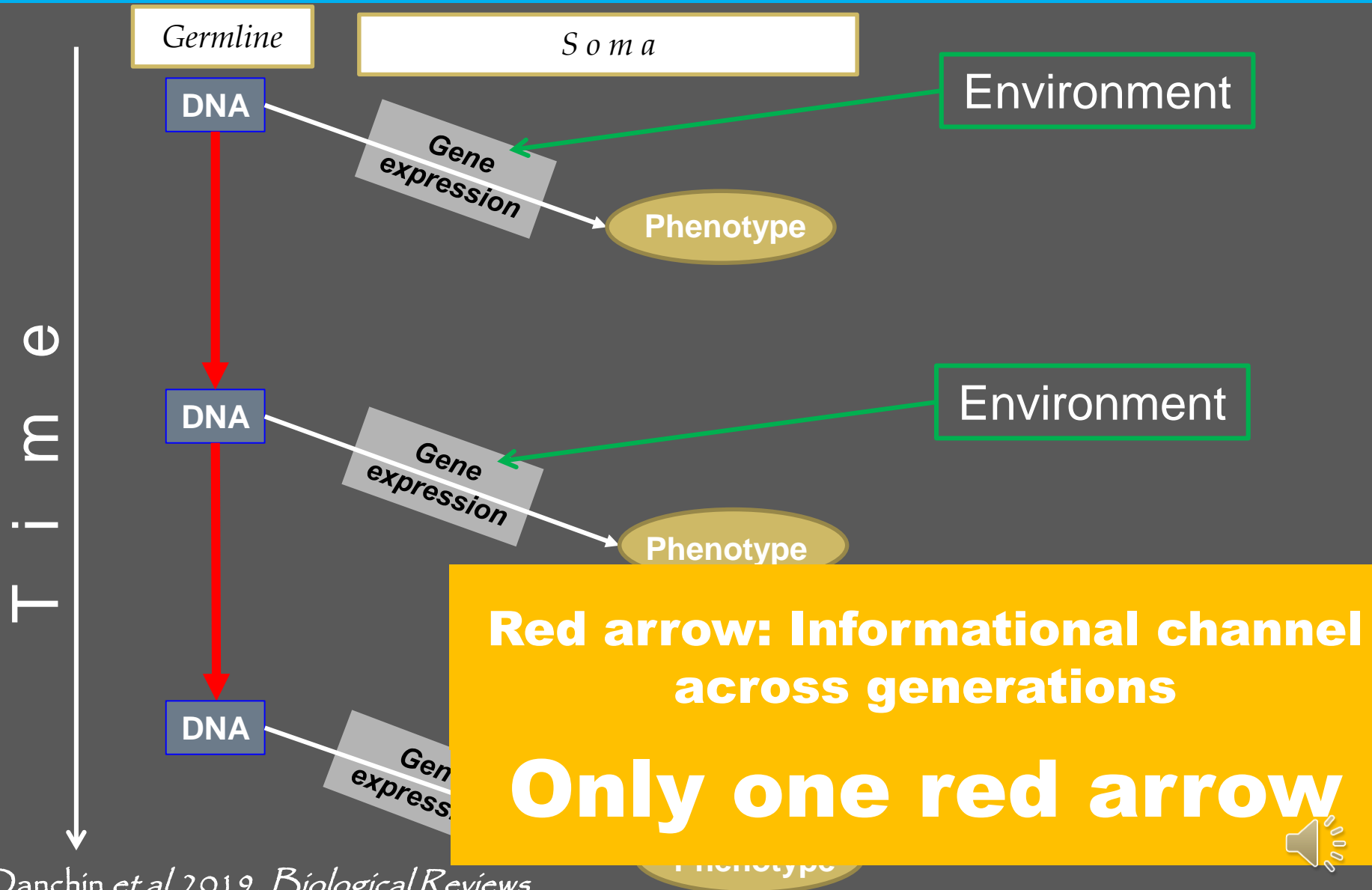
- After Darwin, **Weismann** (1889) separated **germ plasm** (\approx genotype) vs **soma** (\approx phenotype)
- => Wilson (1896), and then Maynard Smith (1965) produced this diagram of inheritance ruling out the inheritance of acquired characters



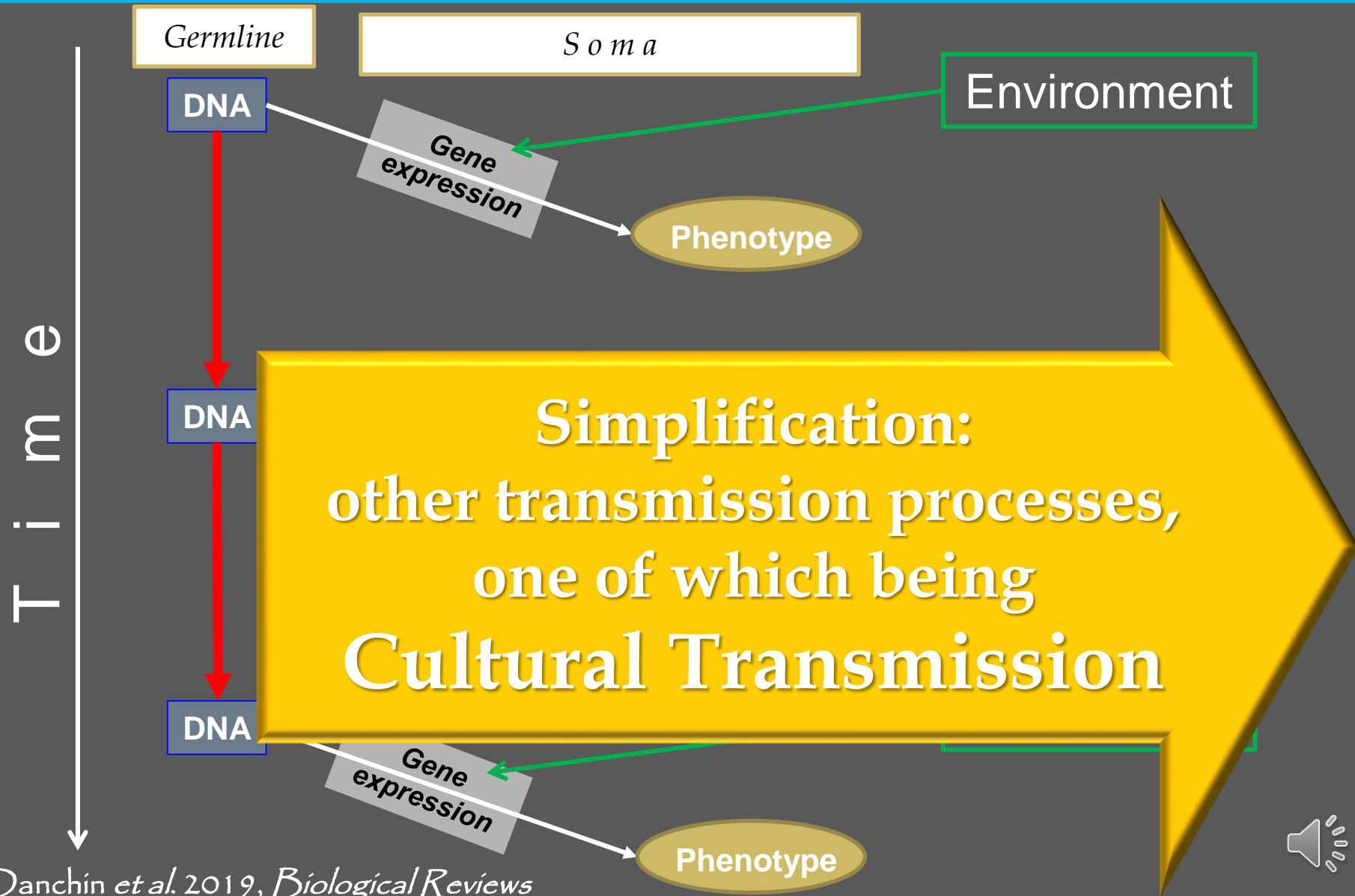
Two important additions



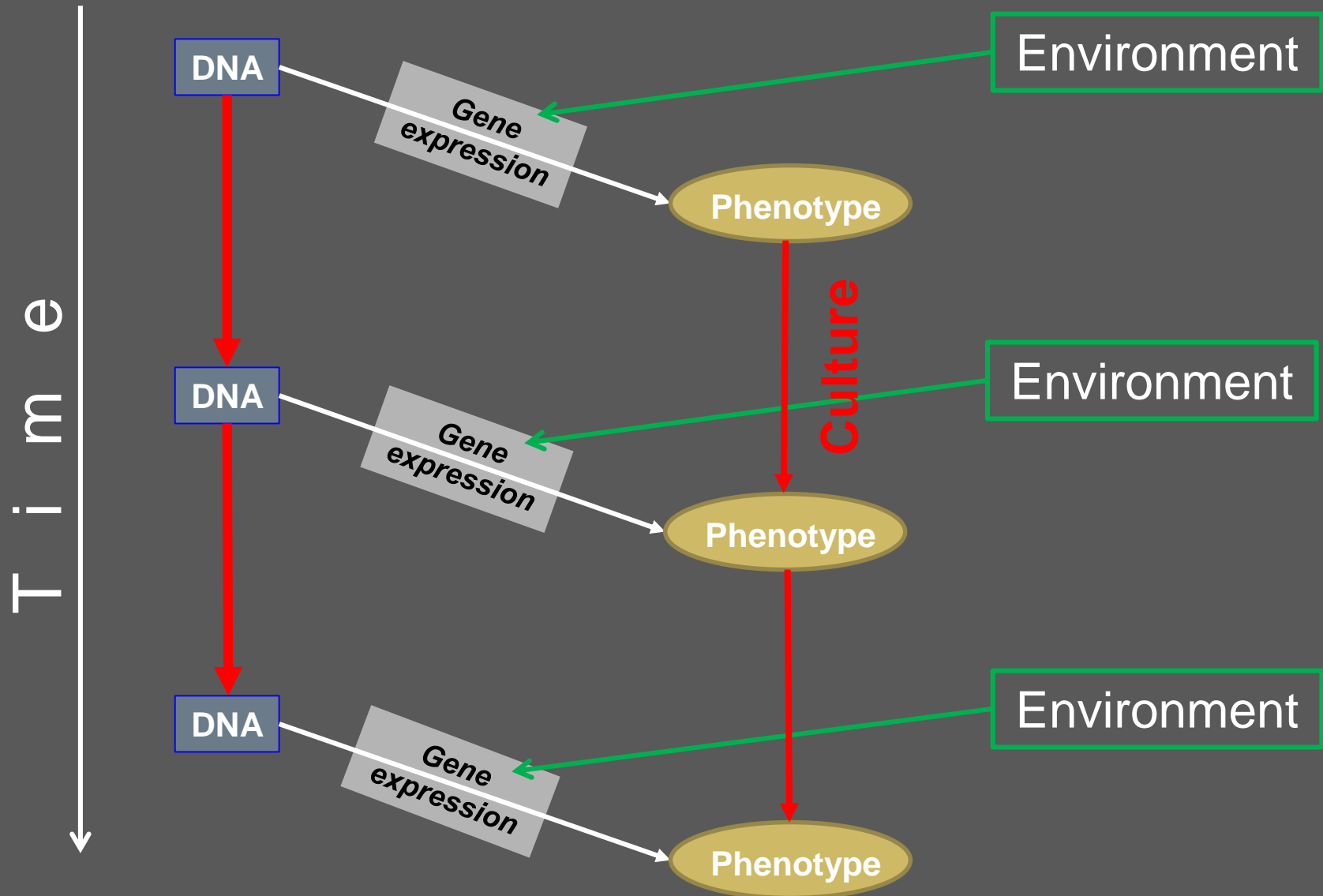
The canonical vision of inheritance according to the **Modern Synthesis**



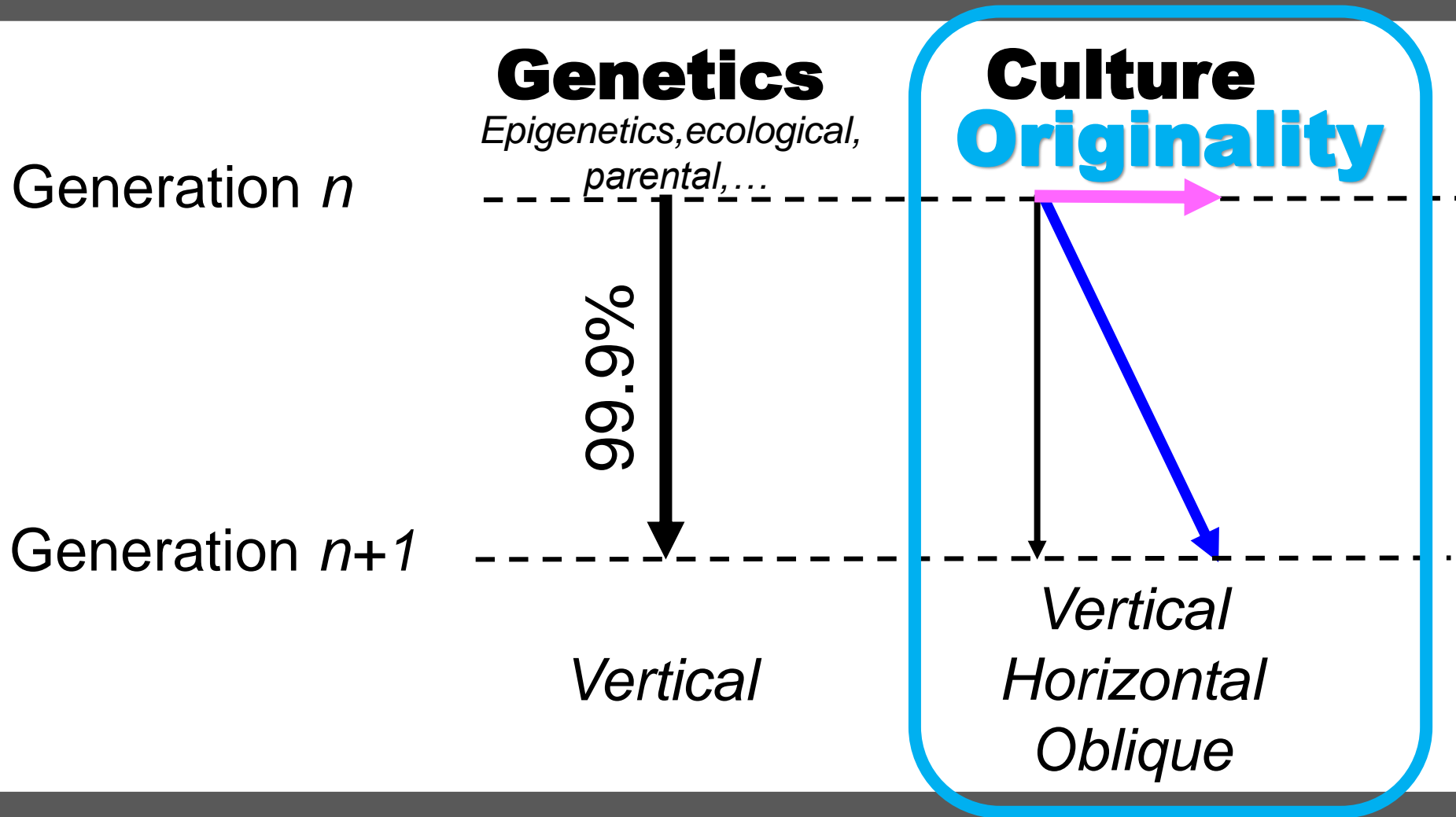
The canonical vision of inheritance according to the **Modern Synthesis**



Cultural heredity



Transmission mode

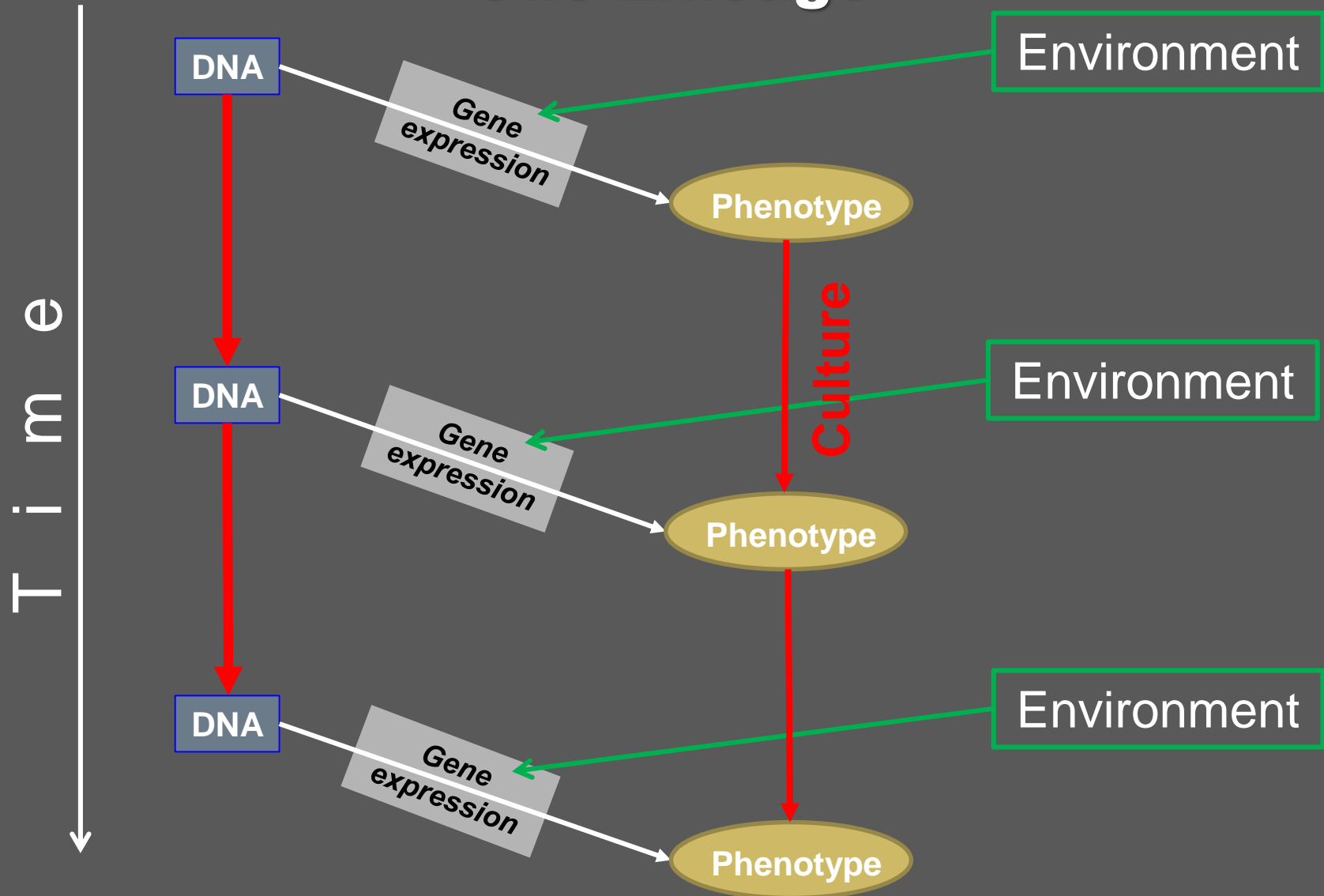


▣ **May drastically affect evolution**

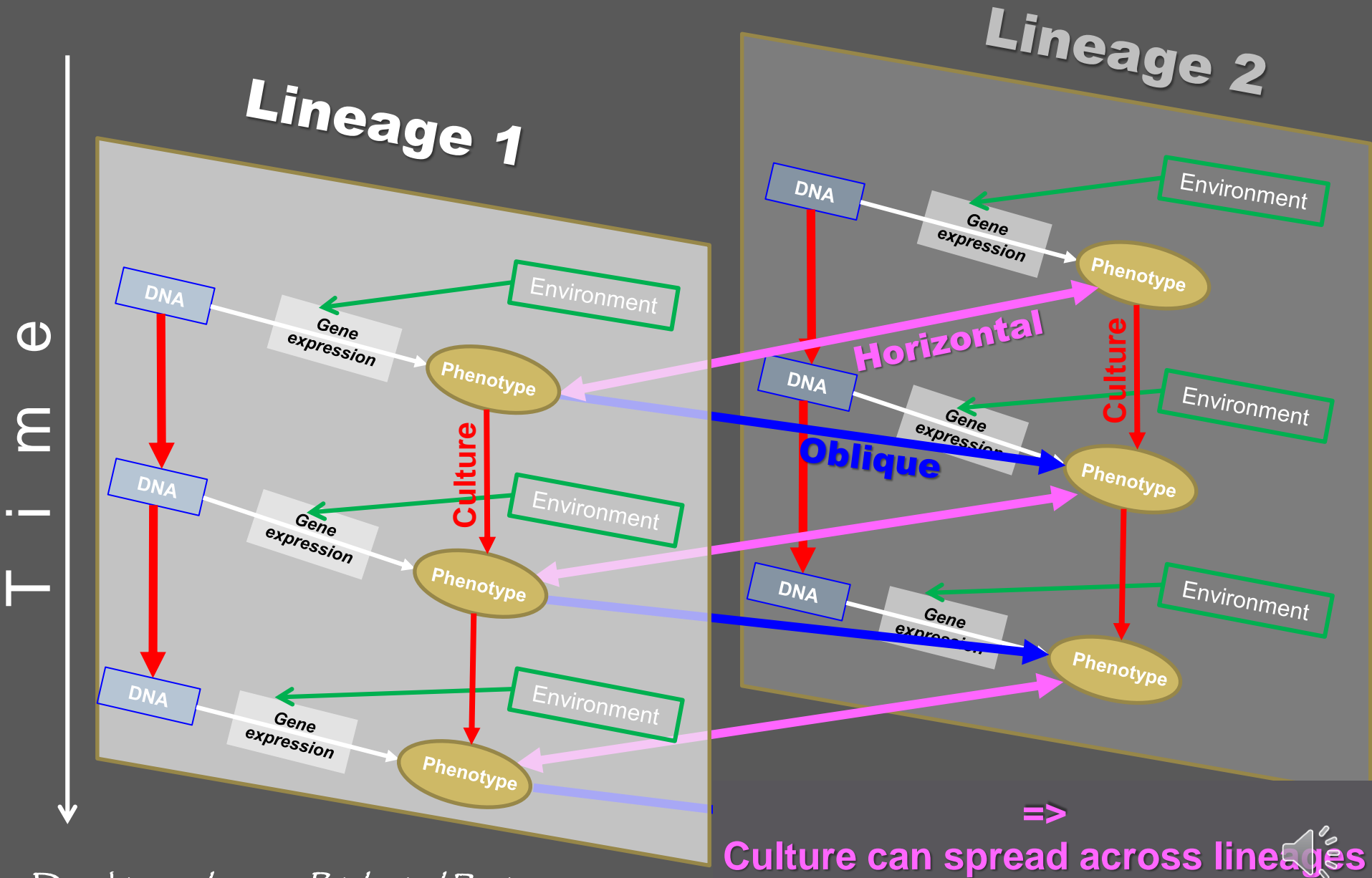


Originality of Cultural heredity

One Lineage



Originality of Cultural heredity



Goal

- ▣ What does the existence of cultural **Inheritance** change in the process of **Evolution**?



2)

Evolution



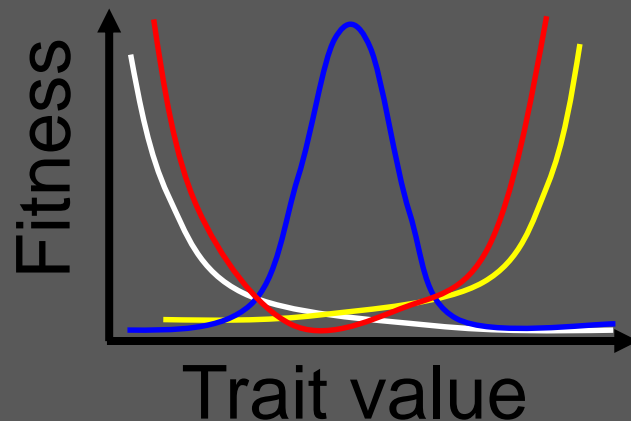
▣ **Classical definition:** “The process by which the frequencies of **genes** change over generations”

▣ Today, **two major processes**

- **Evolution through natural selection**

- ▣ Occurs as soon as 3 conditions are fulfilled

- (a) \exists **variation** among individuals on a trait (ie phenotypic variation, V_P)
 - (b) \exists a **consistent relationship** between trait value & fitness (capacity to avoid predators, acquire mates,...) = **Selective pressure**



- ▣ **Classical definition:** “The process by which the frequencies of **genes** change over generations”
- ▣ **Today, two major processes**
 - **Evolution through natural selection**
 - ▣ Occurs as soon as 3 conditions are fulfilled
 - (a) ∃ variation among individuals on a trait (ie phenotypic variation, V_P)
 - (b) ∃ a consistent relationship between trait value & fitness (capacity to avoid predators, acquire mates,...) = **Selective pressure**
 - (c) Trait variation should be transmitted (i.e. **heritable**)
Parent-Offspring resemblance
 - **Evolution through drift**
 - ▣ Same condition except that condition (b) is replaced by **random** selection



Applying natural selection to cultural variance

⇒ Must meet the 3 conditions of evolution by natural selection

- **Variation**, Change, Innovation
- **Selective pressure**
- **Cultural variants are Inclusively heritable**
(through social learning)
Parent-offspring resemblance

⇒ Social learning can lead to cultural evolution **only** if variants (or their descendants) persist across generations (traditions)

May evolve (ie be modified) within 1 generation



Applying natural selection to cultural variance

⇒ Must meet the 3 conditions of evolution by natural selection

- **Variation**, Change, innovation
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Parent-offspring resemblance

⇒ Only cultural variants persisting (accumulating) over generations can produce **cultural evolution**



Applying natural selection to cultural variance

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⇒ Only cultural variants persisting (accumulating) over generations can produce **cultural evolution**

⇒ Inclusive definition of evolution:

“Processes by which frequencies of variants change over generations” Bentley *et al.* (2004)



The importance of variation

▣ Classical d
the frequen
generations

▣ Today, **two major processes**

- **Evolution through natural selection**

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Parent-Offspring resemblance

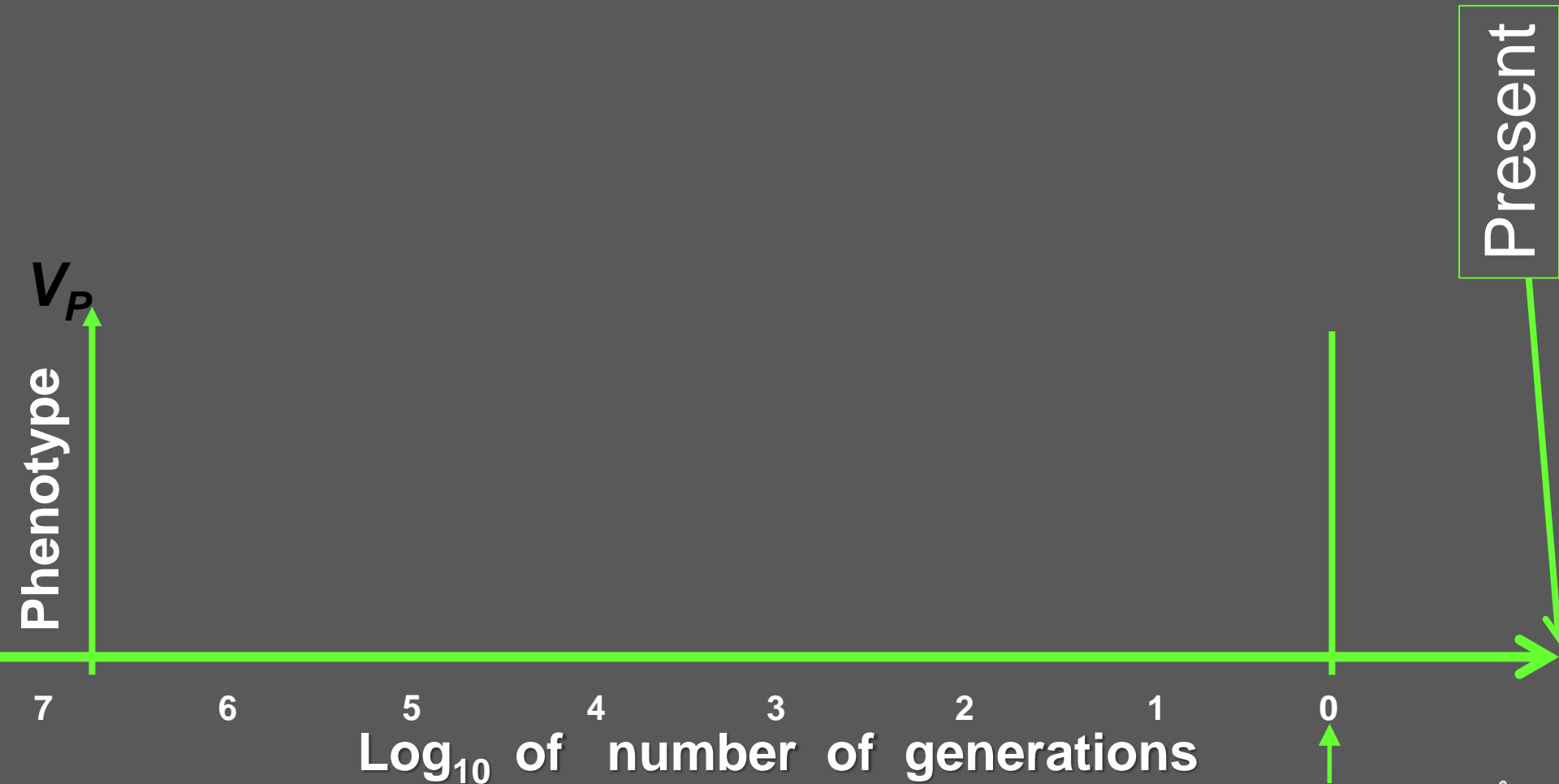
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Sources of phenotypic variation



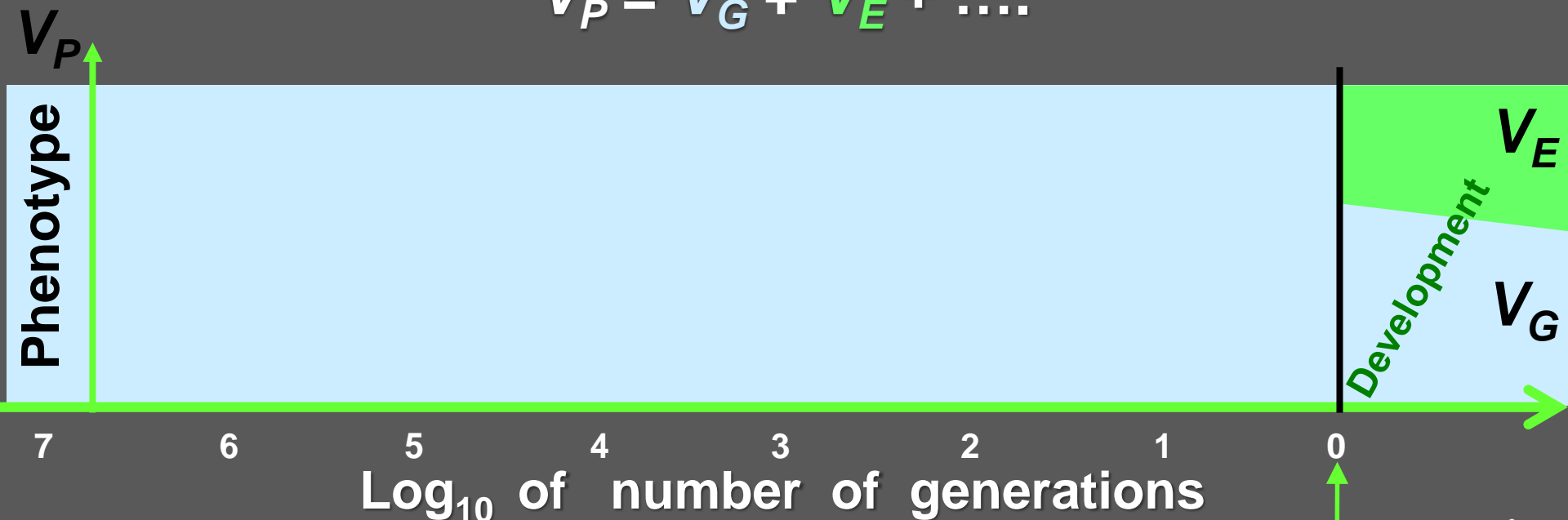


Sources of phenotypic variation

- ▣ Variation in information from many generations ago (genetics)
- ▣ Variation in experience since fertilization (phenotypic plasticity)

This is current the vision of inheritance according to the
Modern Synthesis of Evolution

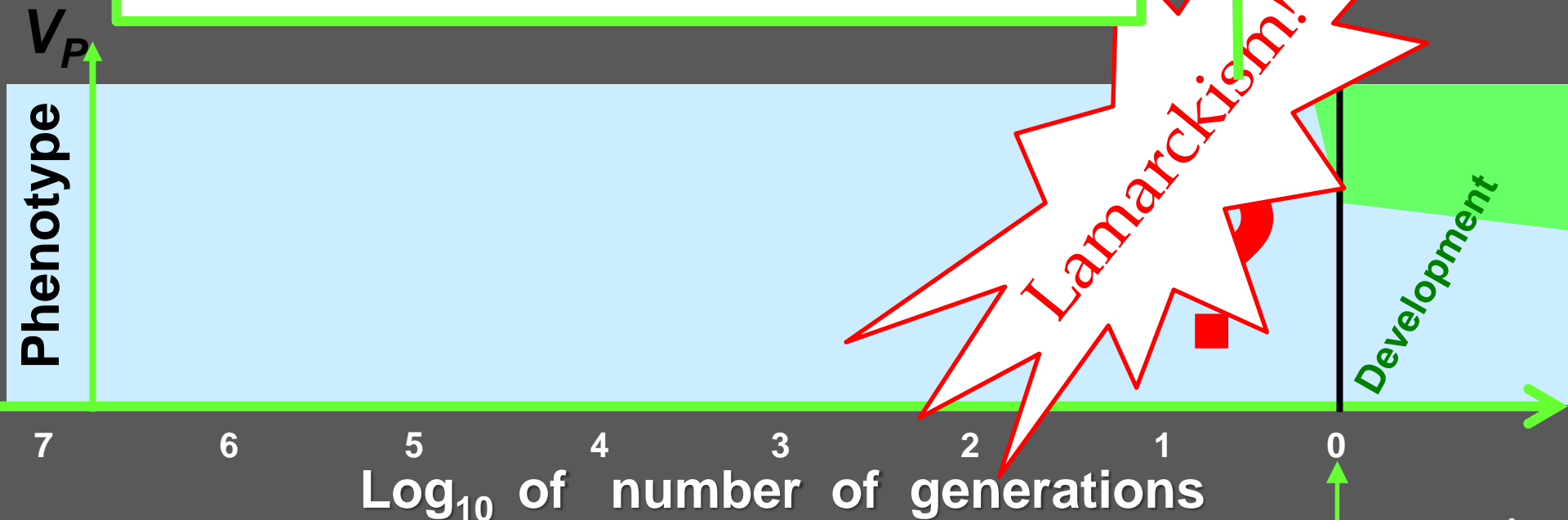
$$V_P = V_G + V_E + \dots$$



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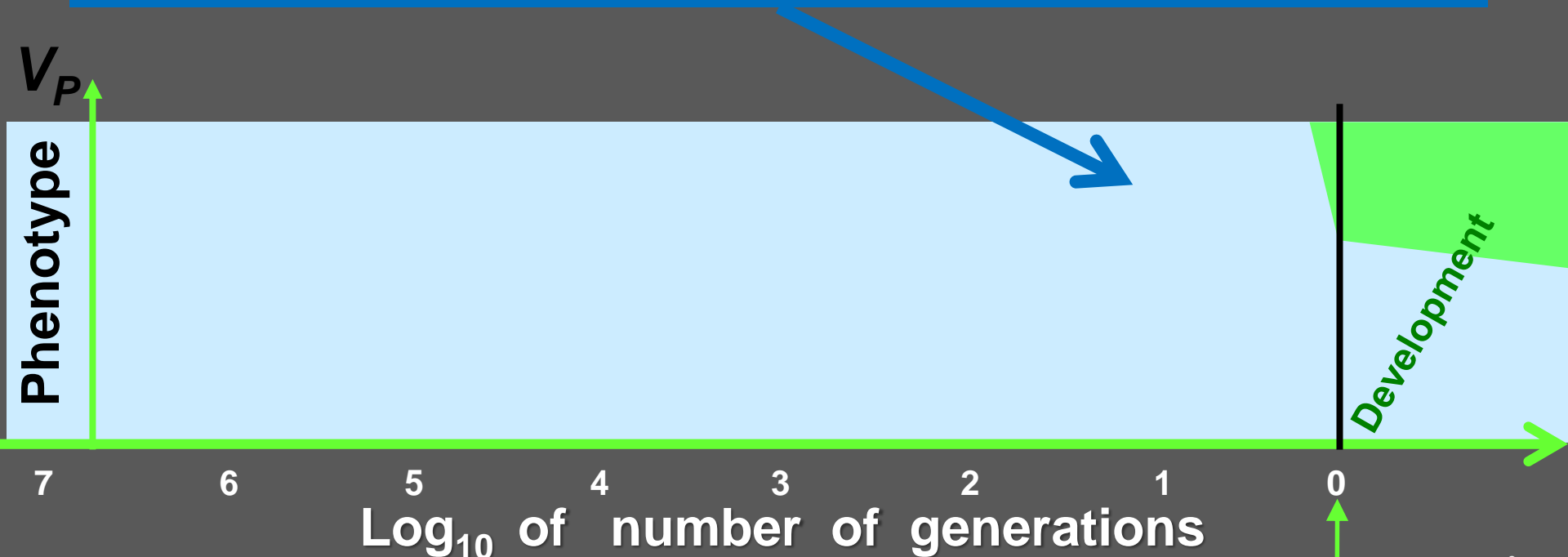
Environmental information gathered by recent ancestors *far more up-to-date and thus a far better predictor of the environment*



Sources of phenotypic variation

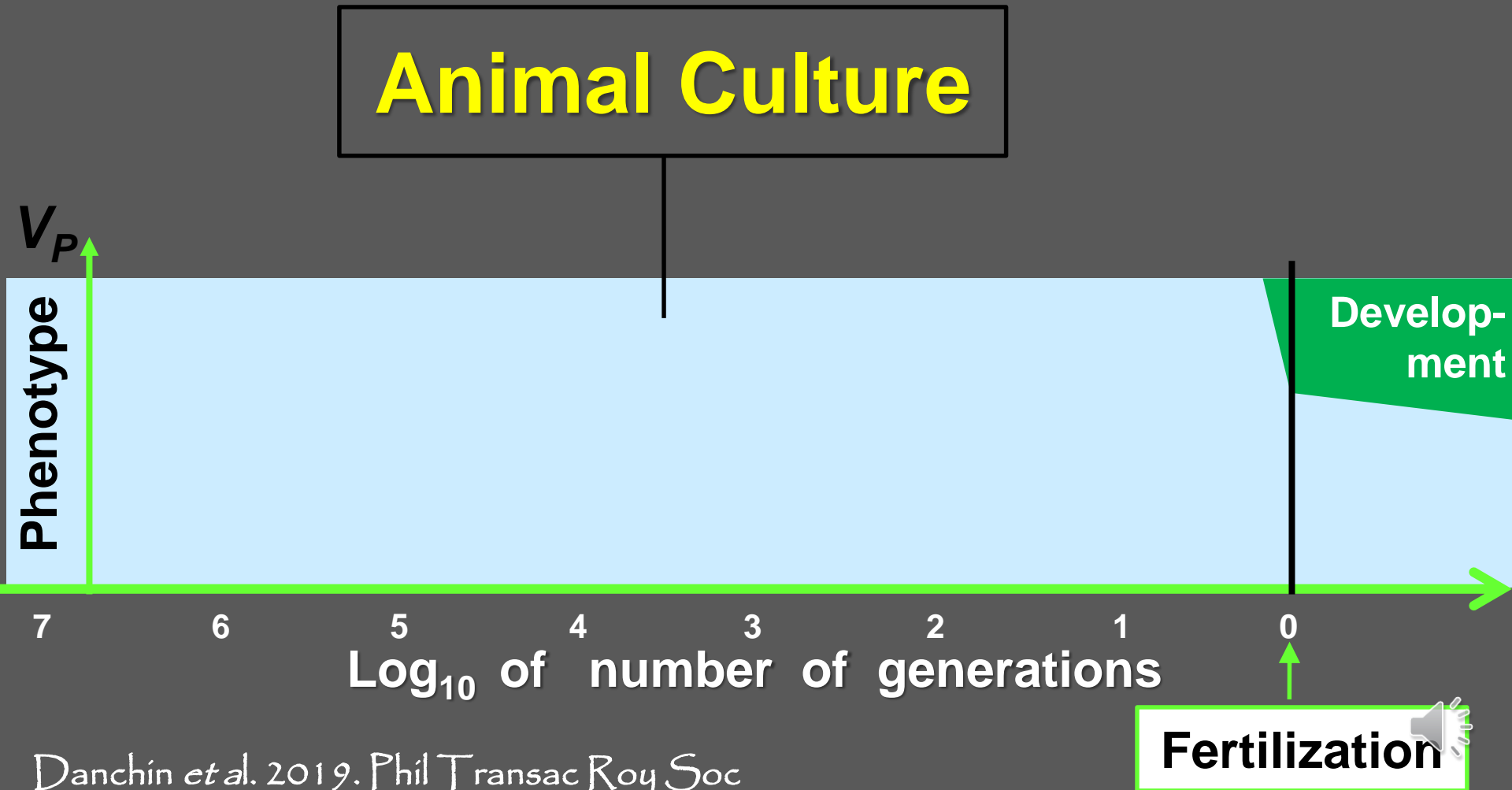
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Accruing evidence for the inheritance of recent environmental effects



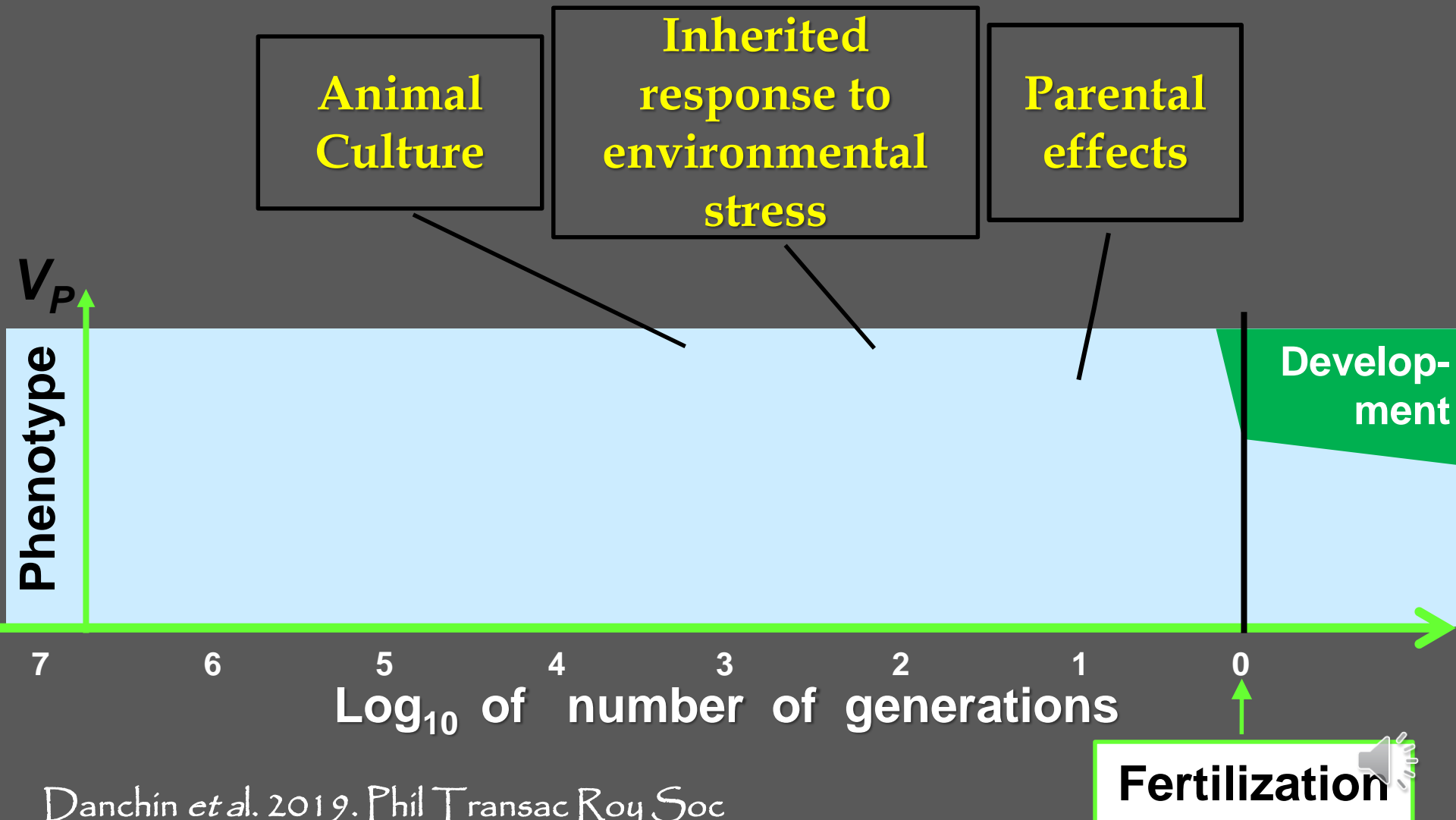
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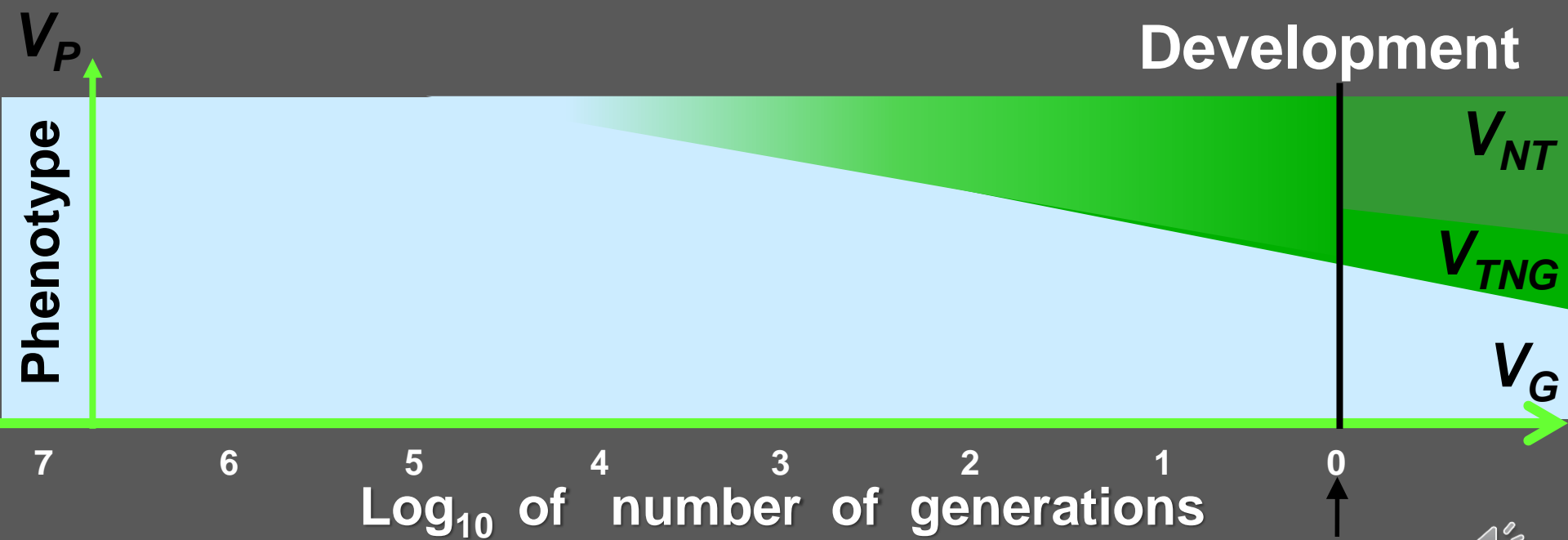
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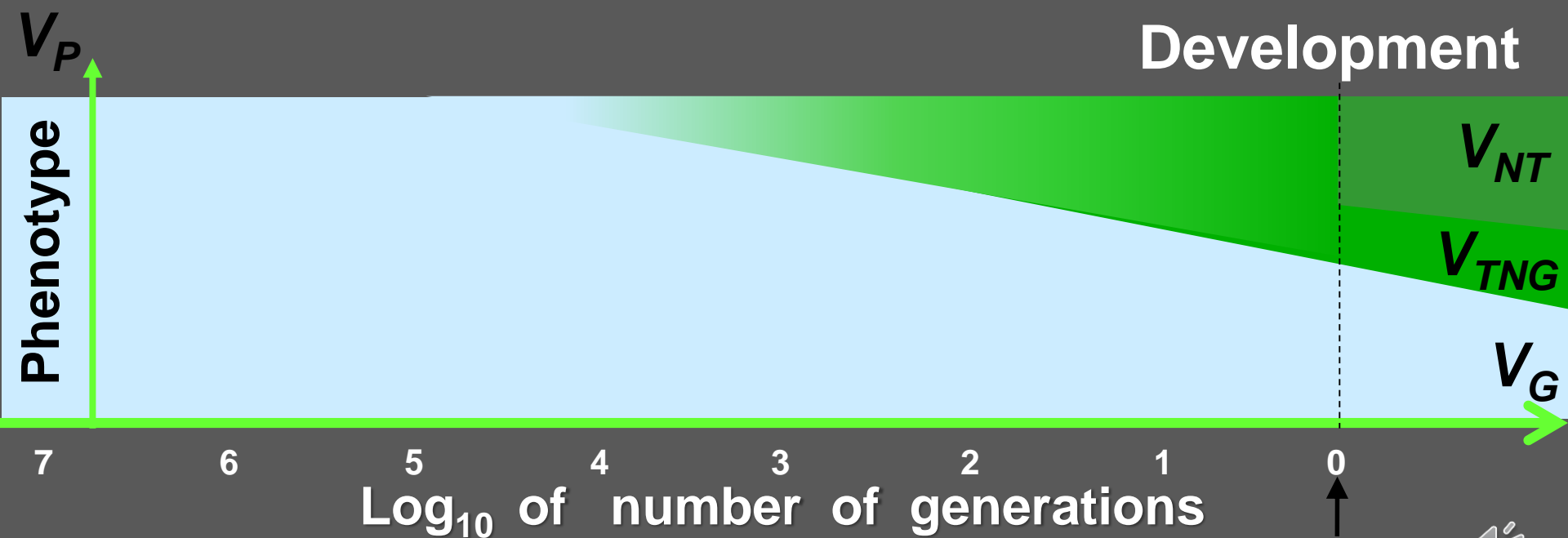


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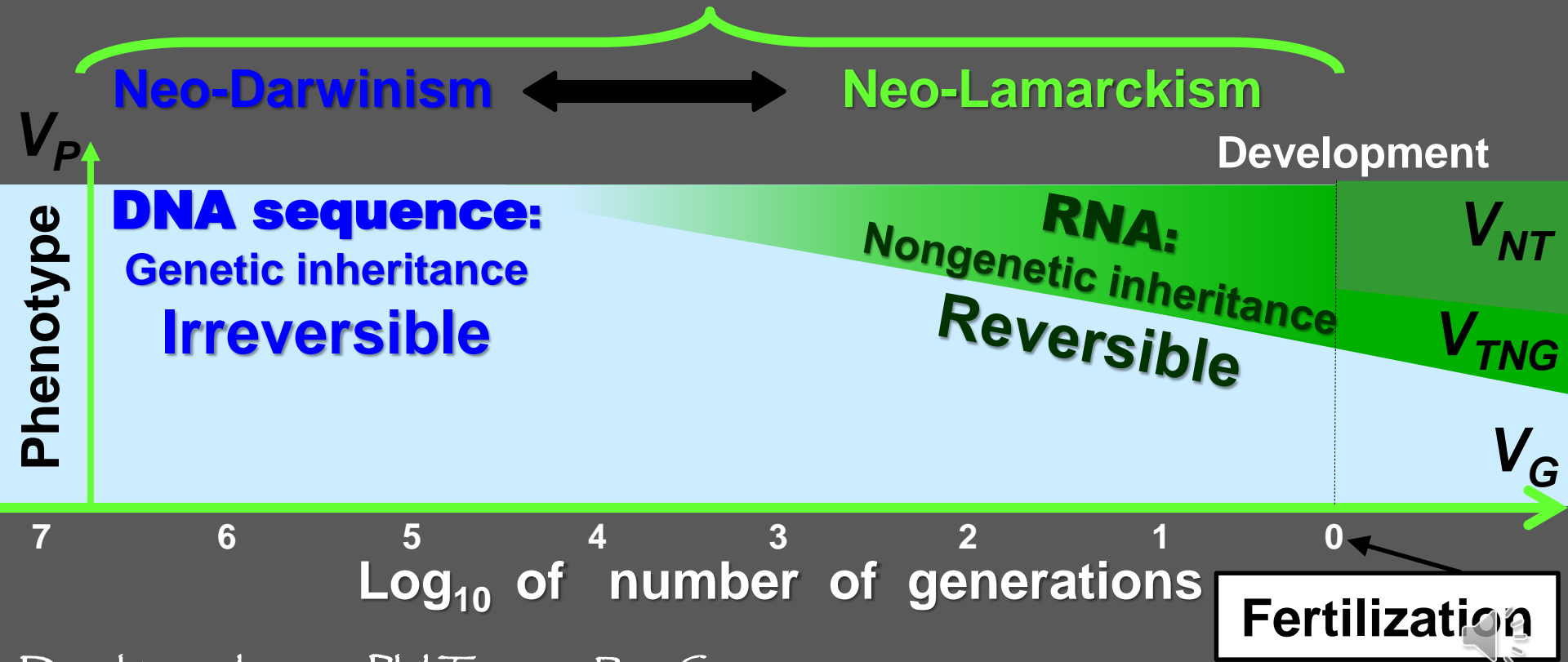




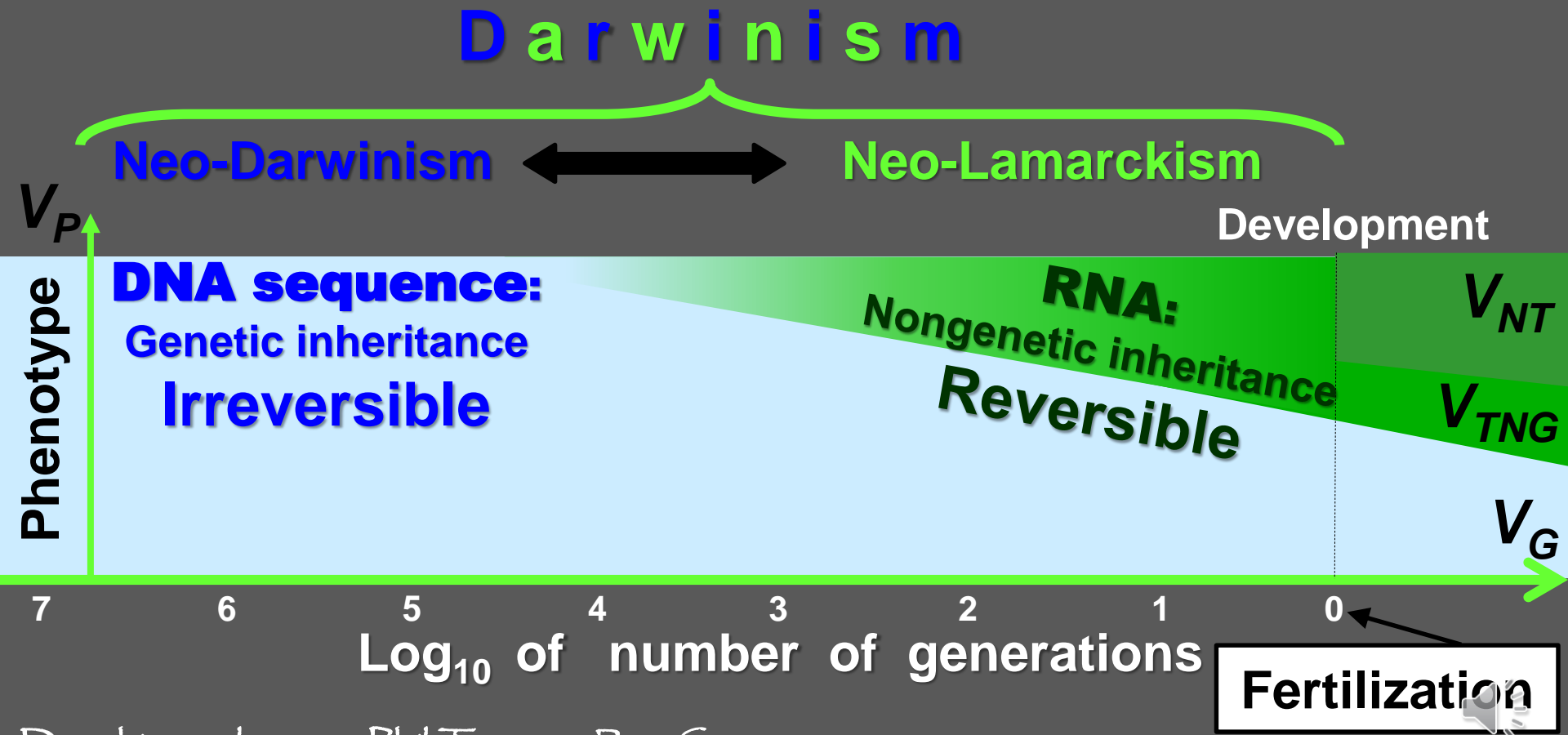
Sources of phenotypic variation

- ▣ Variation in information from many generations ago (genetics)
- ▣ Variation in experience since fertilization (phenotypic plasticity)
- ▣ **Also variation in the history of more recent ancestors** (nongenetic inheritance)

Darwinism



Informational dynamics within 'inclusive evolutionary synthesis'

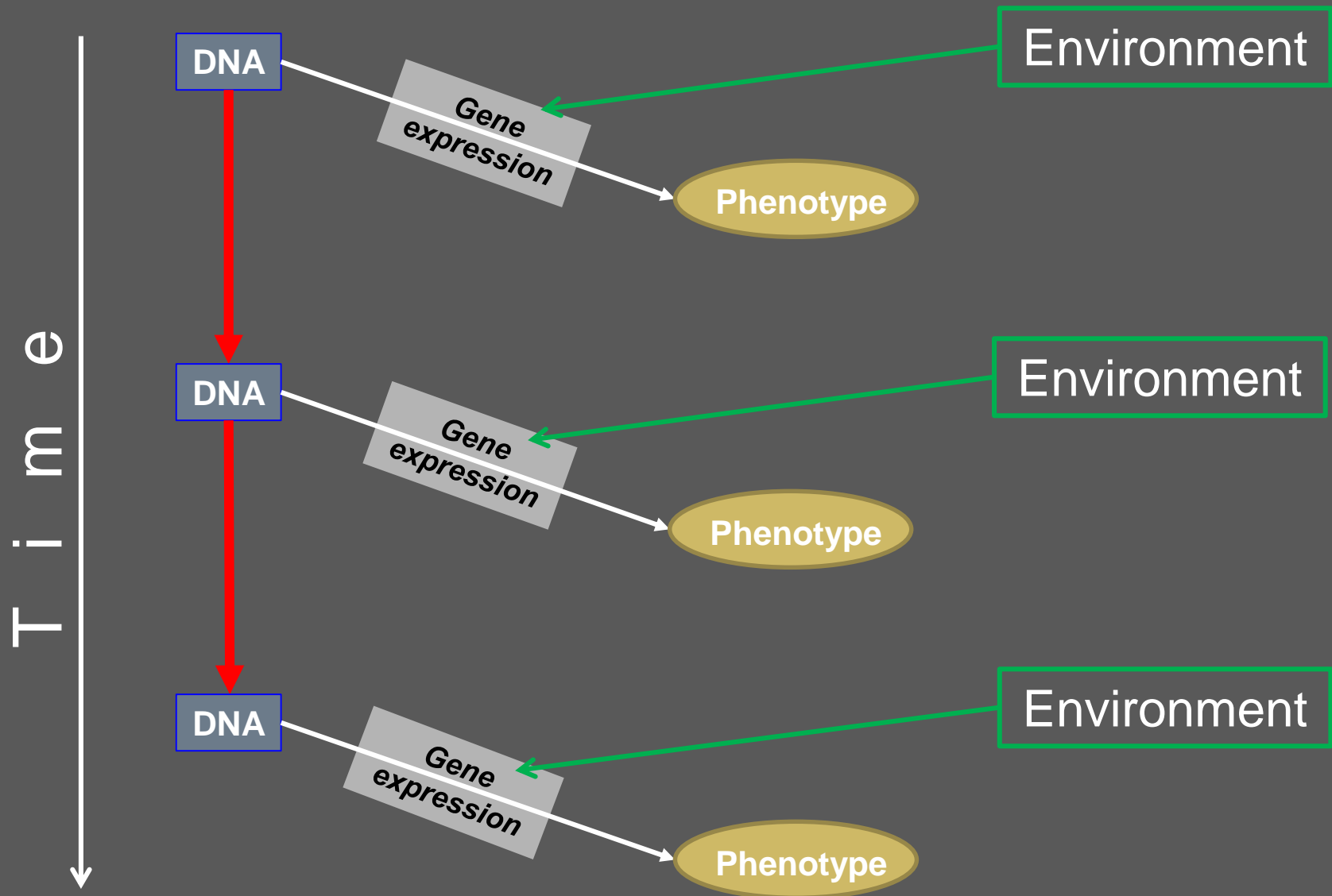


3)

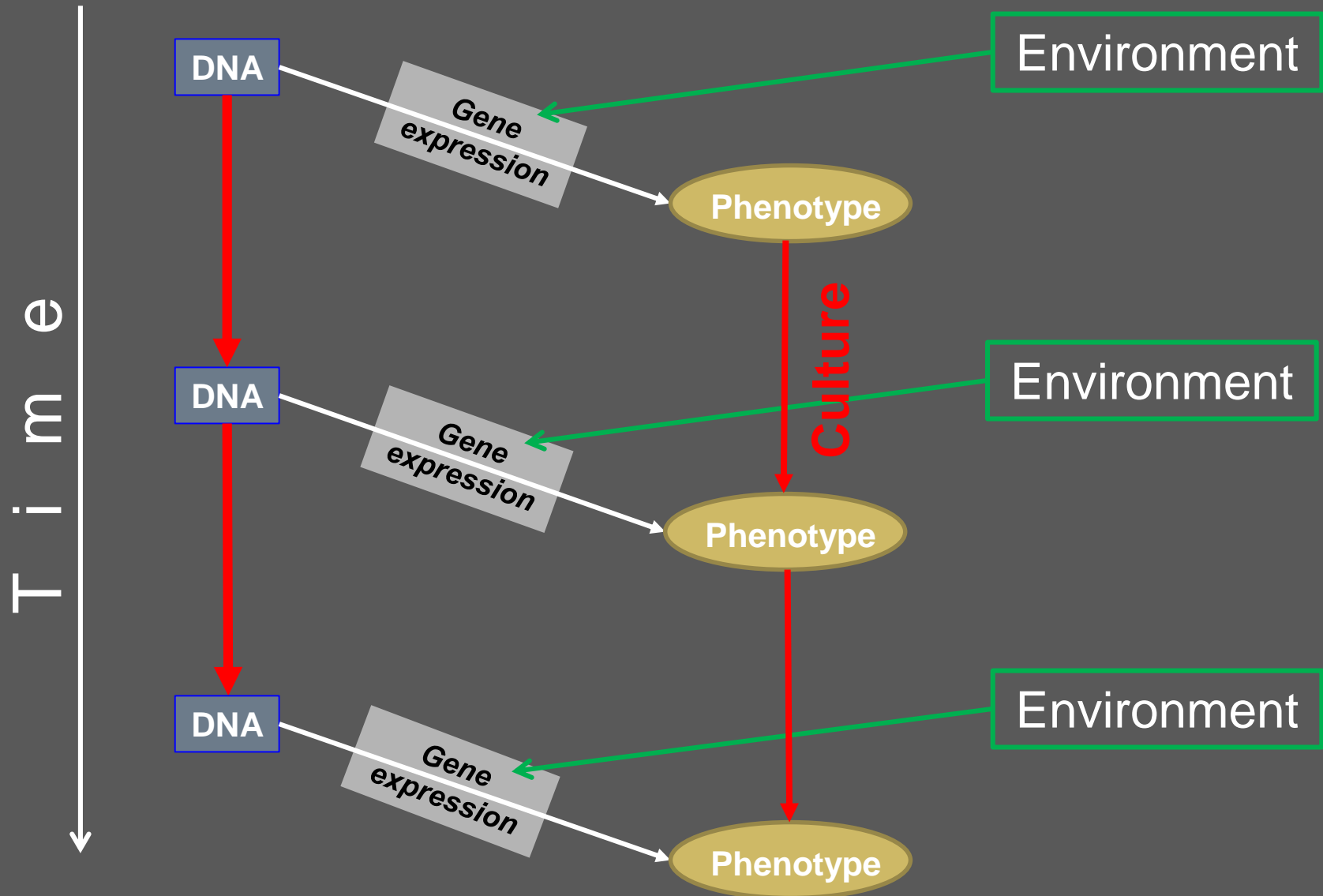
Conclusion



Inheritance according to the **Modern Synthesis of Evolution**

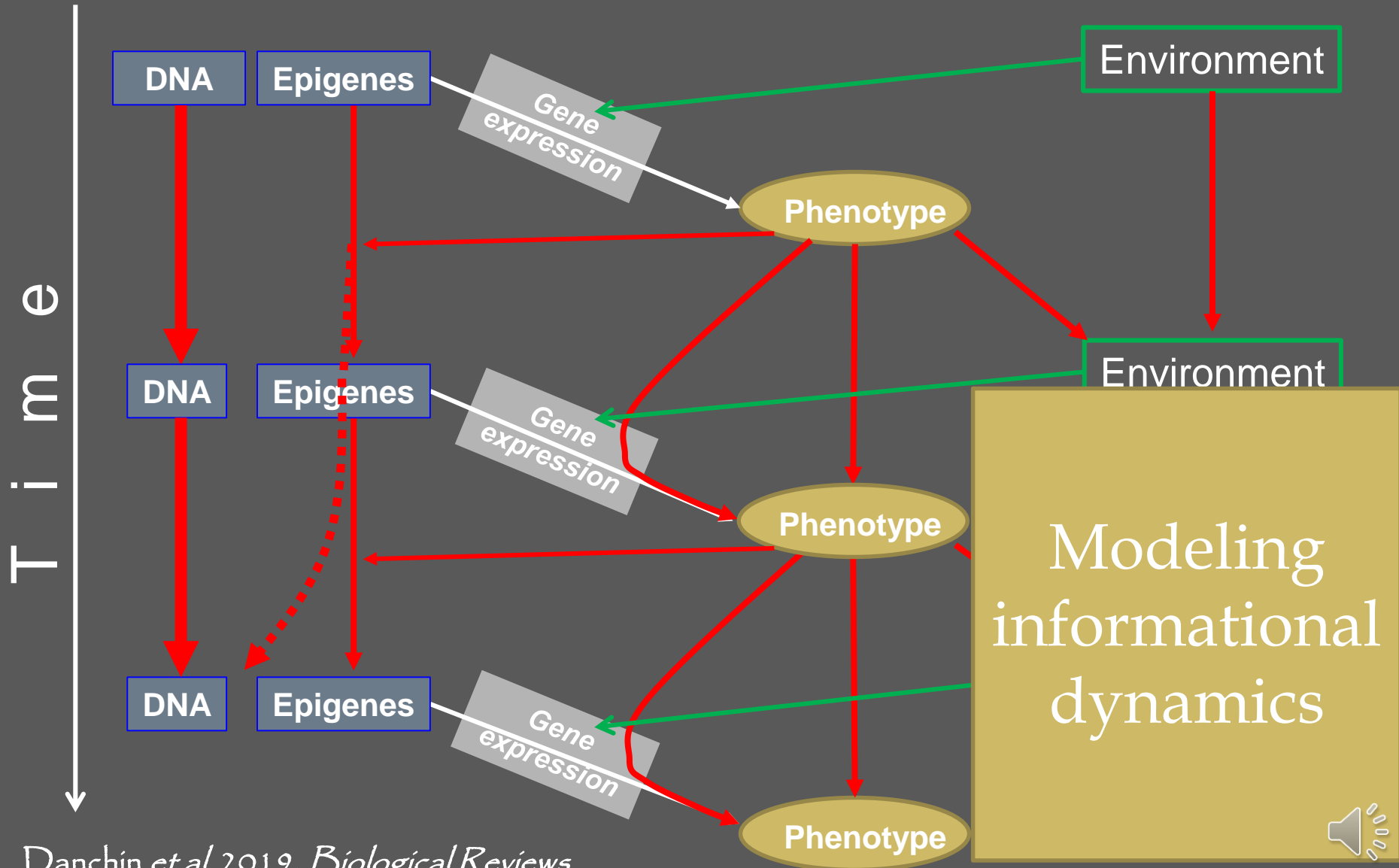


Cultural heredity

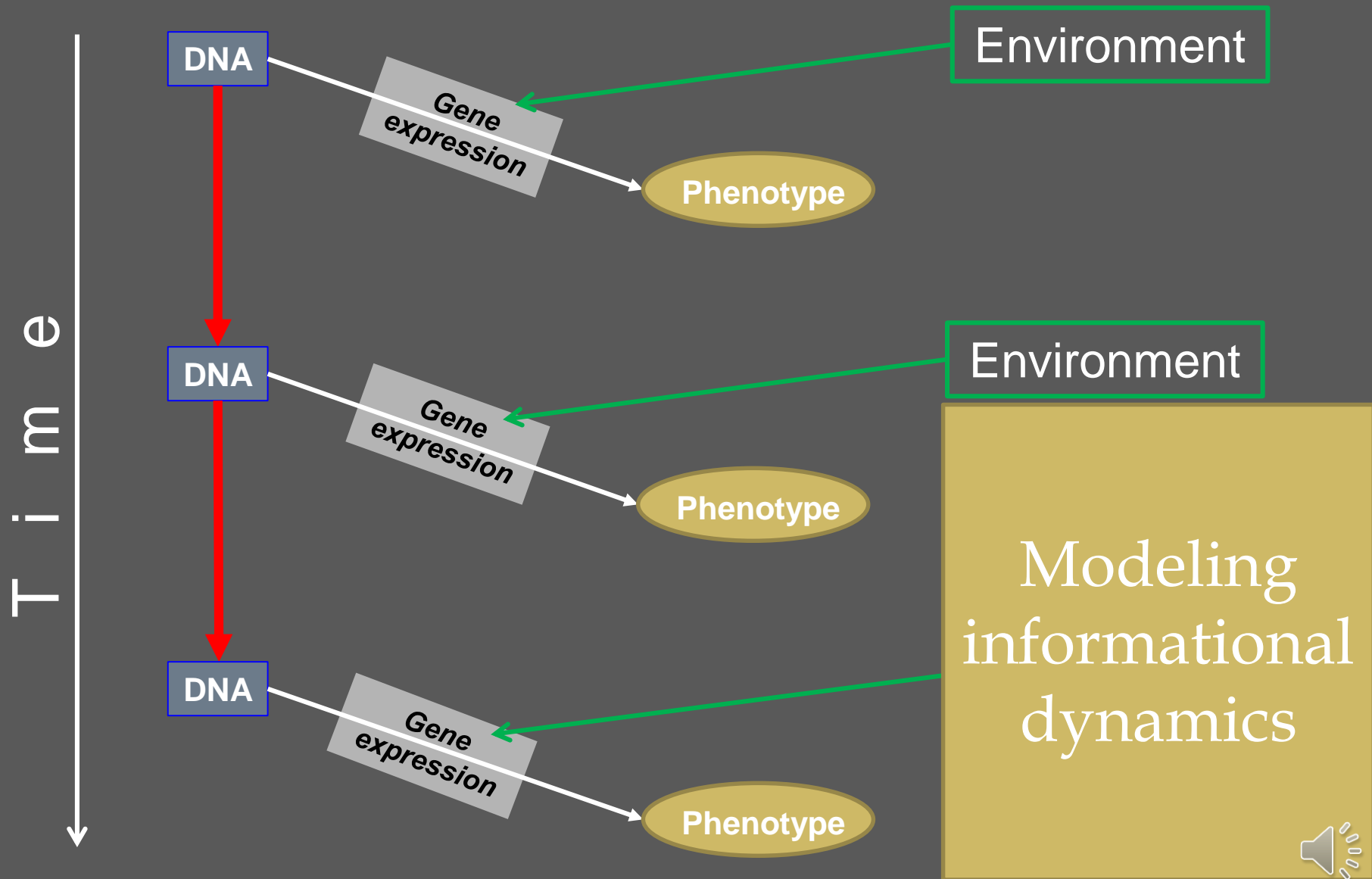


Generalisation

Heredity according to the **Inclusive Evolutionary Synthesis**



Inheritance according to the **Modern Synthesis of Evolution**



Ongoing conceptual leap

Need to multidimensionalize
inheritance to implement the

***“Inclusive Evolutionary
Synthesis”***

Modernising (generalizing) the
Modern Synthesis of Evolution

**One major dimension being animal culture
(originalities)**



Take home message

- ▣ What does the existence of cultural **Inheritance** change in the process of **Evolution**?
- ▣ Now, we just **start to be able to answer that question**
 - Now: the tools and concepts
- ▣ But this is just a beginning
 - There is no empirical study of the consequences of culture in evolution *per se*, yet
- ▣ Entirely open field

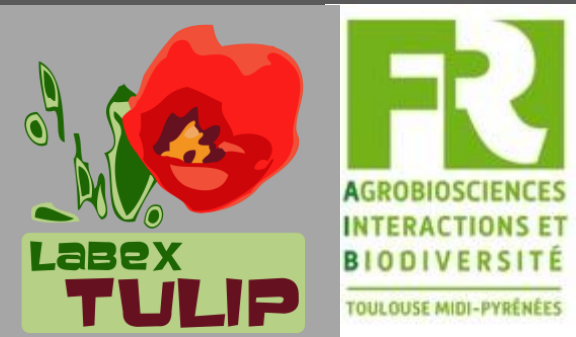


Acknowledgements



Home national
institutions

Our labs



Local
institutions



Funding
Agencies

Cited references

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- ▣ Danchin *et al.* 2019. Early in life effects and heredity: reconciling neo-Darwinism with neo-Lamarckism under the banner of the inclusive evolutionary synthesis. **Phil. Transac Roy Soc B-Biol Sci**.
- ▣ **Plus references therein**



