# Environmental Sensing and Anticipatory Acclimation

## An Information-Based Framework

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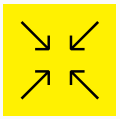
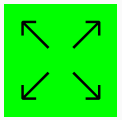
# Contents



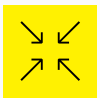
# Stress and

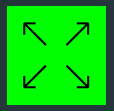


# Sensing

# Stress: one word and many meanings

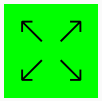
- Stress as a state of an organism.
- Stress as a condition of the environment.
- Stressor as a factor of the environment.
- Stress as detrimental to fitness or biomass production.
- Stress as enhancer of fitness.
- Eustress and distress.
- Stress and strain.

Idea:  stress depends on an external force on the organism.



# Sensing

- Sensing of the state of the *environment*.
- Sensing of the state of the *organism*.
- Sensing is needed for communication.

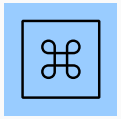
Idea:  sensing is ‘exploration’ by an organism.

# Stress and sensing are intertwined

- Stress can be sensed.
- Sensing can inform about current and future stress.
- Sensing can contribute to stress avoidance.
- Sensing can contribute to stress tolerance.
- Sensing can contribute to stress enhancement.

The outcome of sensing is frequently an acclimation response selected during evolution.

# Information and



# Memory

# Cues and signals as sources of information

Cues: emission is “accidental”.

Signal: emission is “beneficial” (communication).

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Cues: emission is “accidental”.
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- Cues and signals carry information.
- Once sensed, decoding extracts information.
- Memory is storage of information.
  pause
- Natural selection stores information.
- Epigenetic and other types of regulation store information.
- The phenotype stores information.

# Anticipation and Acclimation

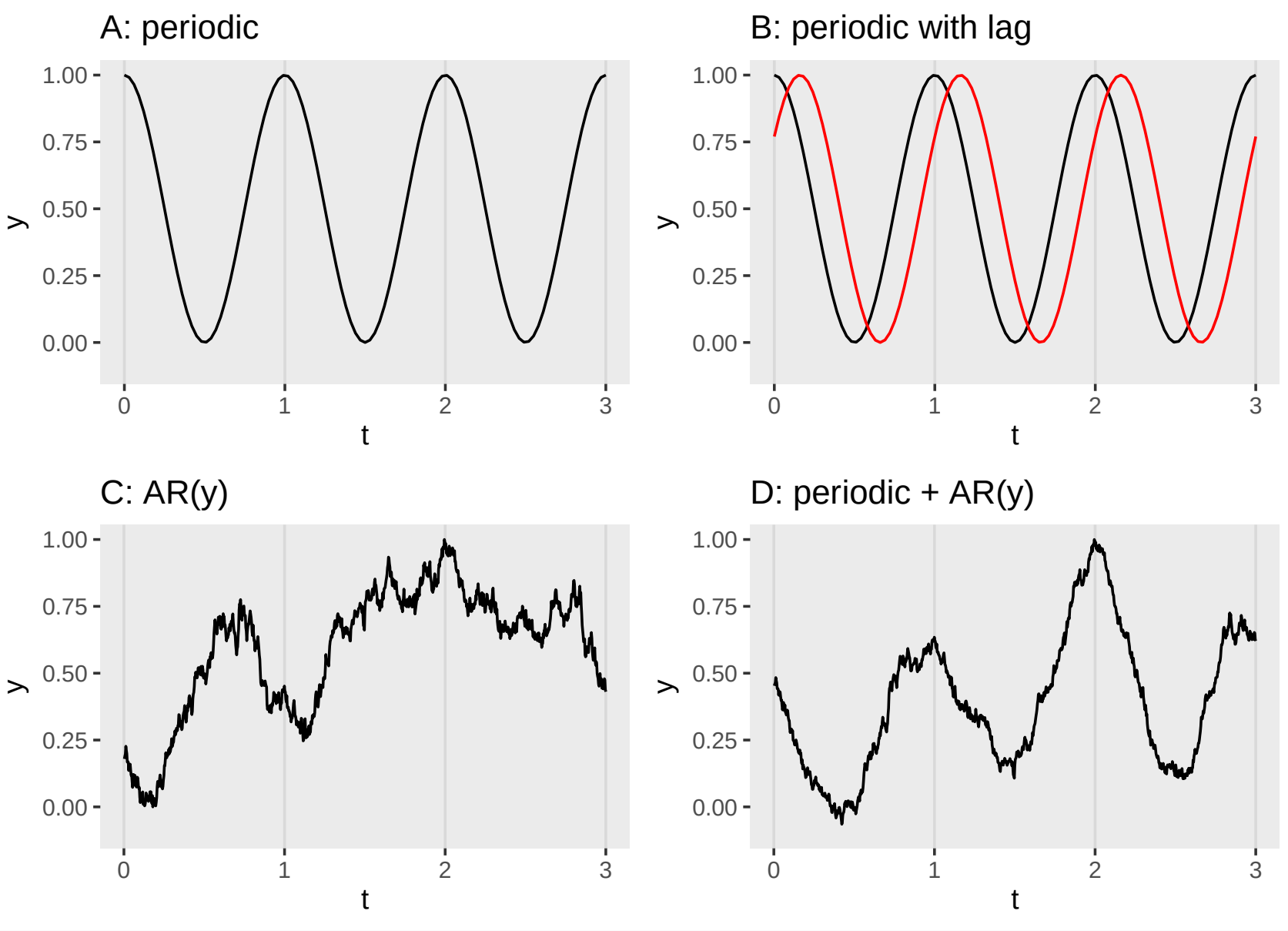
# Anticipation/forecasting and fitness

- Our everyday life depends on forecasting.
- Most of the time we are not aware $\rightarrow$ consciousness is not required.
- e.g. estimating the weight of a cup when lifting it.
  pause
- Plants' life depends on forecasting.
- e.g. winter hardening in perennials.
  pause
- Forecasting relies on *current information* and *memories*.

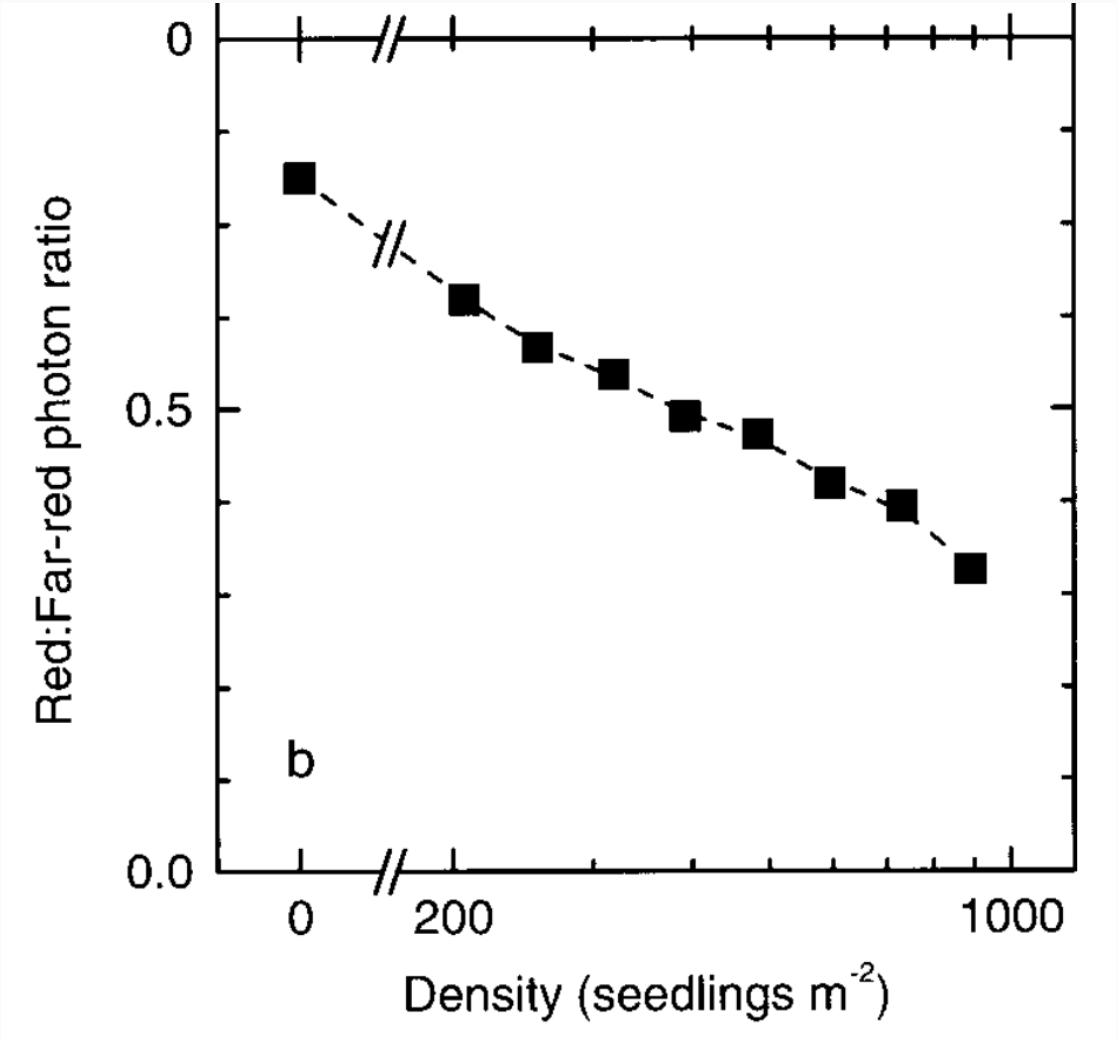
# Information makes forecasts possible

- Cue/signal and predicted event need to be correlated.
- Cross-correlation and autocorrelation both work.
- The sign of correlation is irrelevant.
- Cue/signal should precede the predicted event…
- …long enough for acclimation to take place.
- Correlation can be spatial, temporal or both.
- “Noise” in spatial/temporal cues/signals can be “smoothed out”.

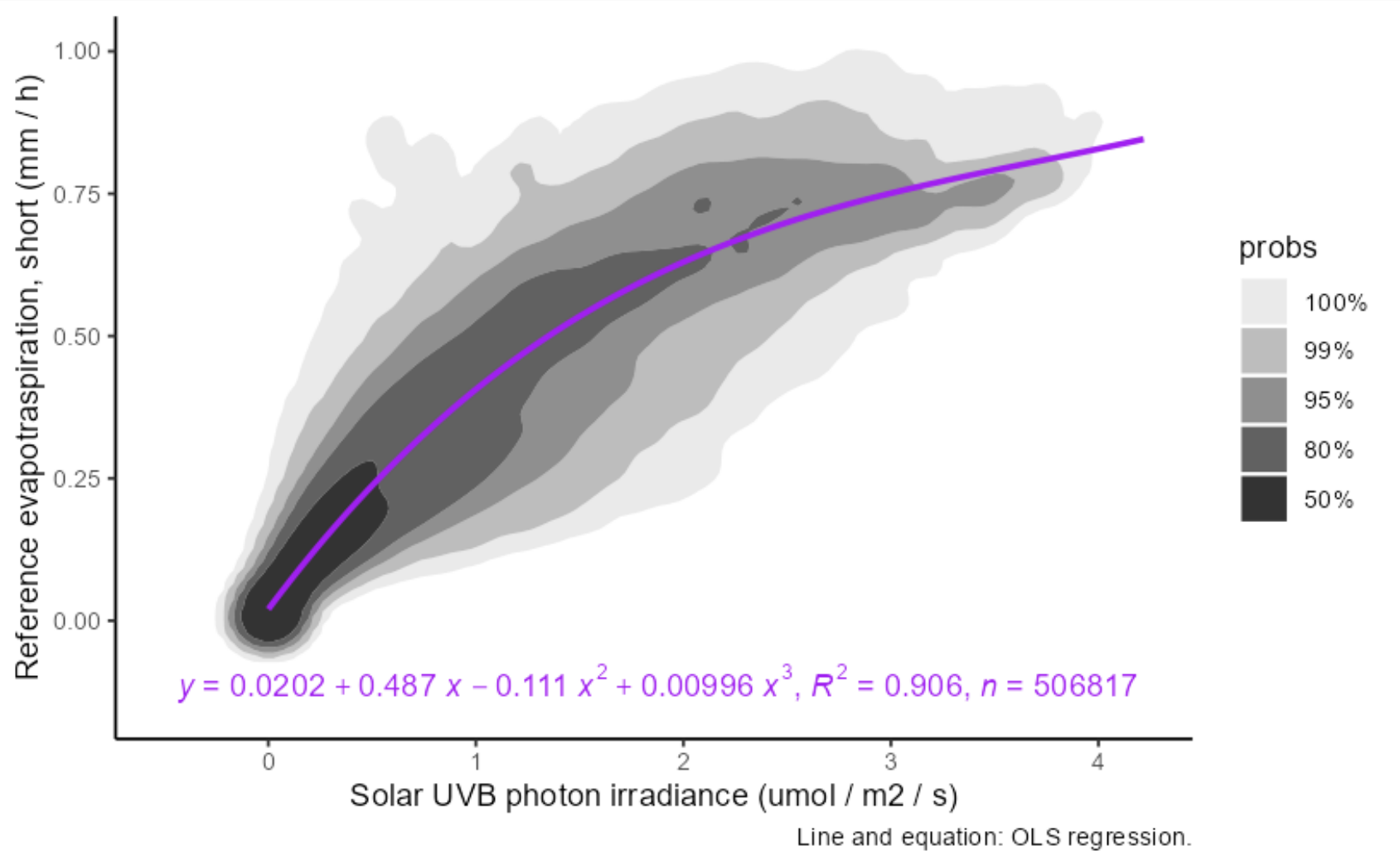
# Correlations in the environment



# Planting density and lateral red:far-red ratio



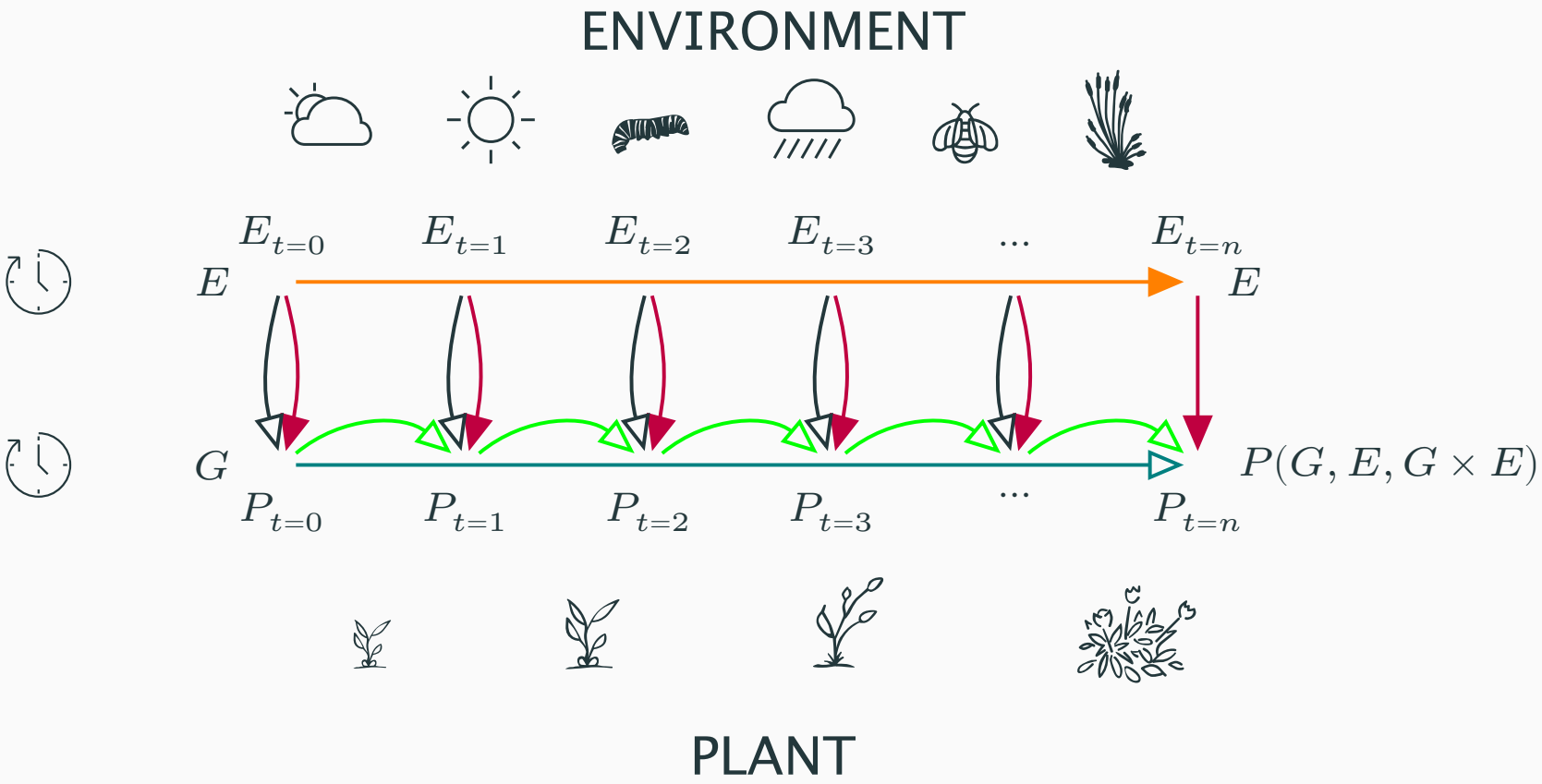
# Potential evapotranspiration and UV-B irradiance



# Forecasting and resource investment

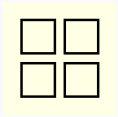
- There are reliable and unreliable sources of information.
- Forecasting can depend on a single reliable predictor or…
- …on a combination of several less reliable predictors.
- Predictors *do not need* to have a direct cause-effect relationship.
- Forecasts are subject to errors…
- …outcomes $\rightarrow$ described by probabilities.
- Dynamic context $\rightarrow$ repeated-tuning of responses.

# Acclimation is a process in time



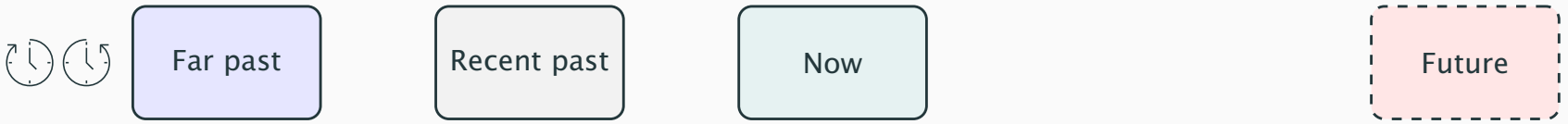
# Acclimation depends on plasticity

- Many responses take time $\Rightarrow$ must be triggered in advance.
- Slower responses need to be triggered earlier than faster ones.
- Enhanced readiness to respond allows delaying full commitment.
- Prediction of future environment is error-prone.
- Cost of response is deterministic, benefit is stochastic.
- Acclimation is based on syndromes rather than individual responses (?).



# Framework and  Plants

# Information-based framework of acclimation



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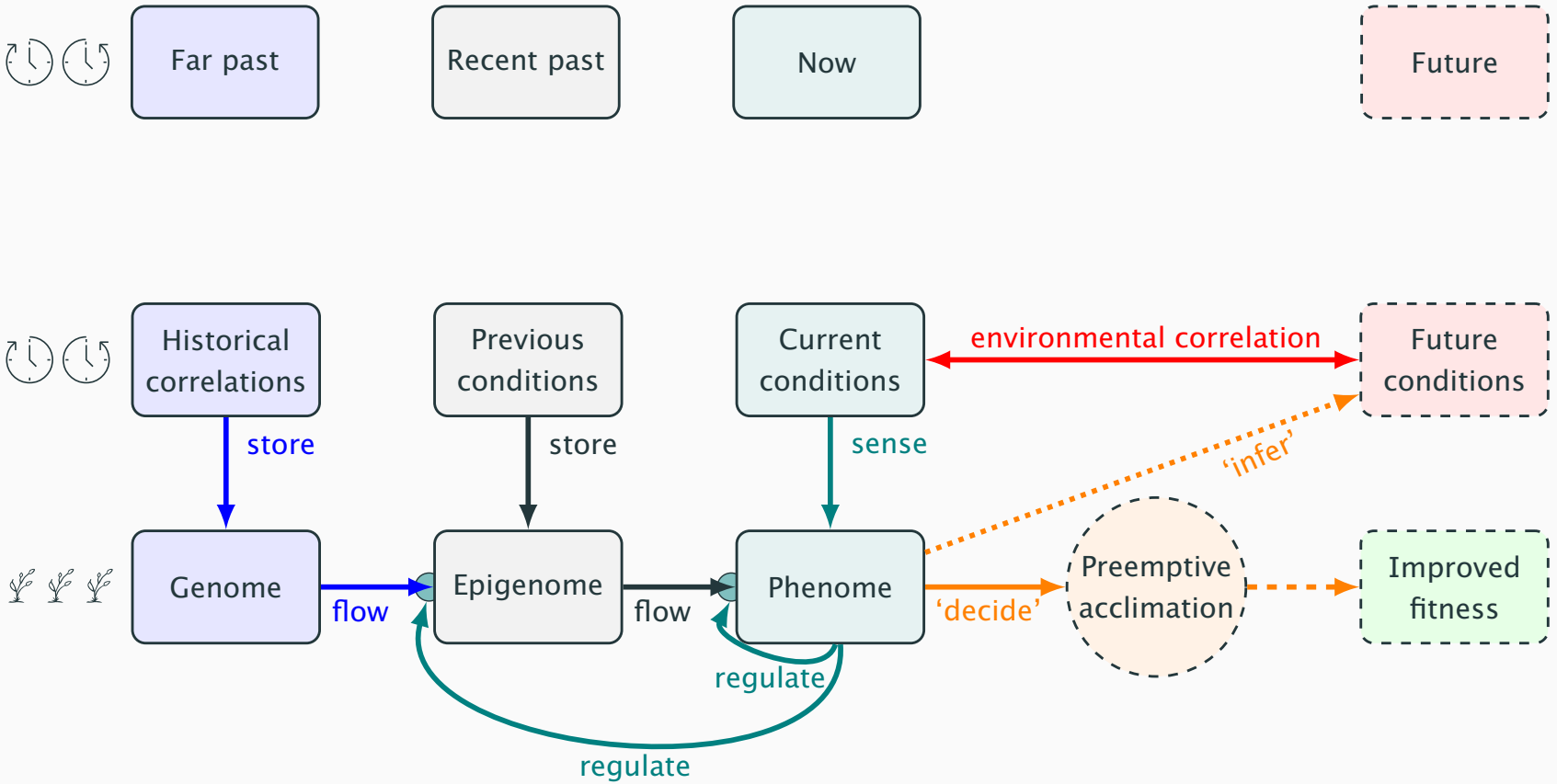

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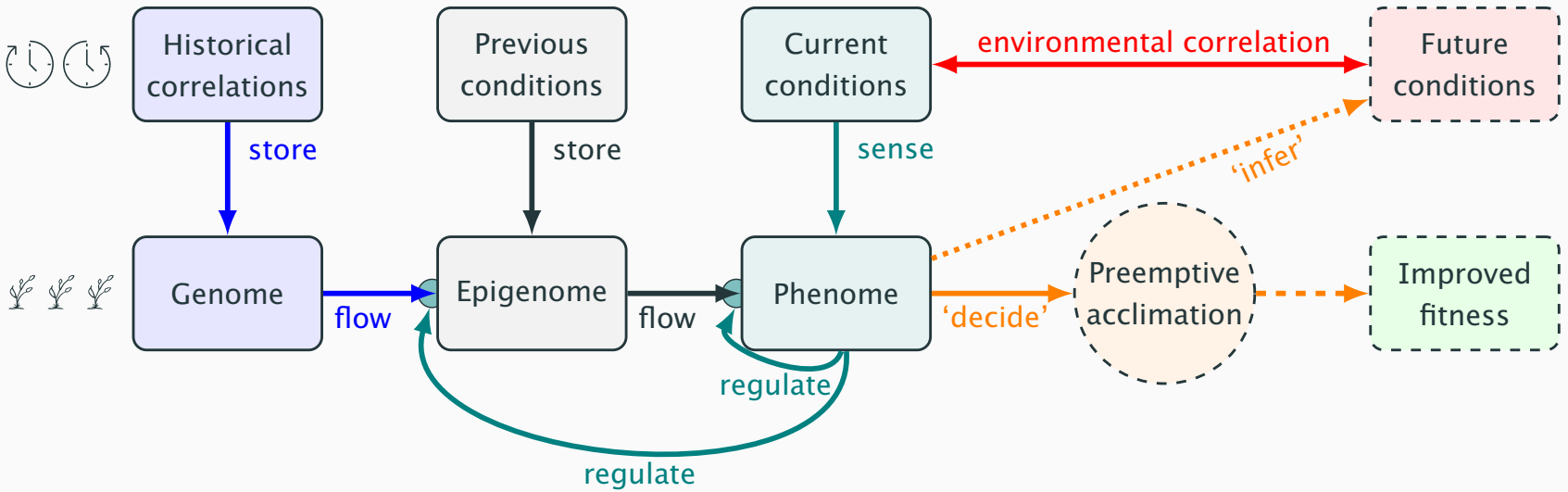
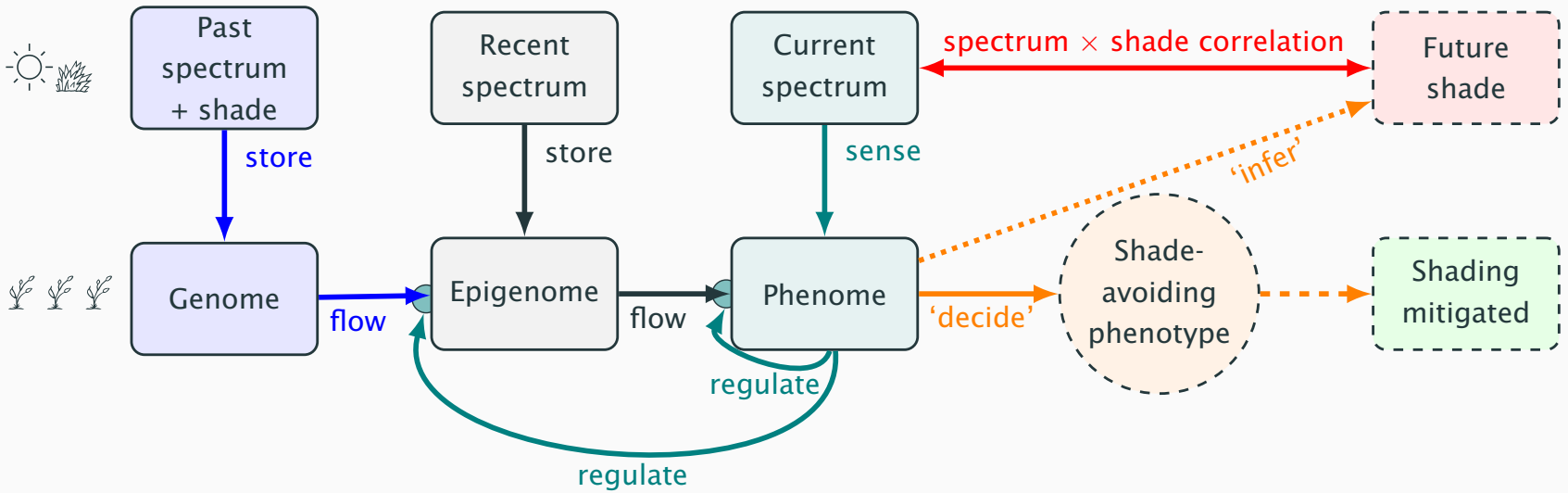
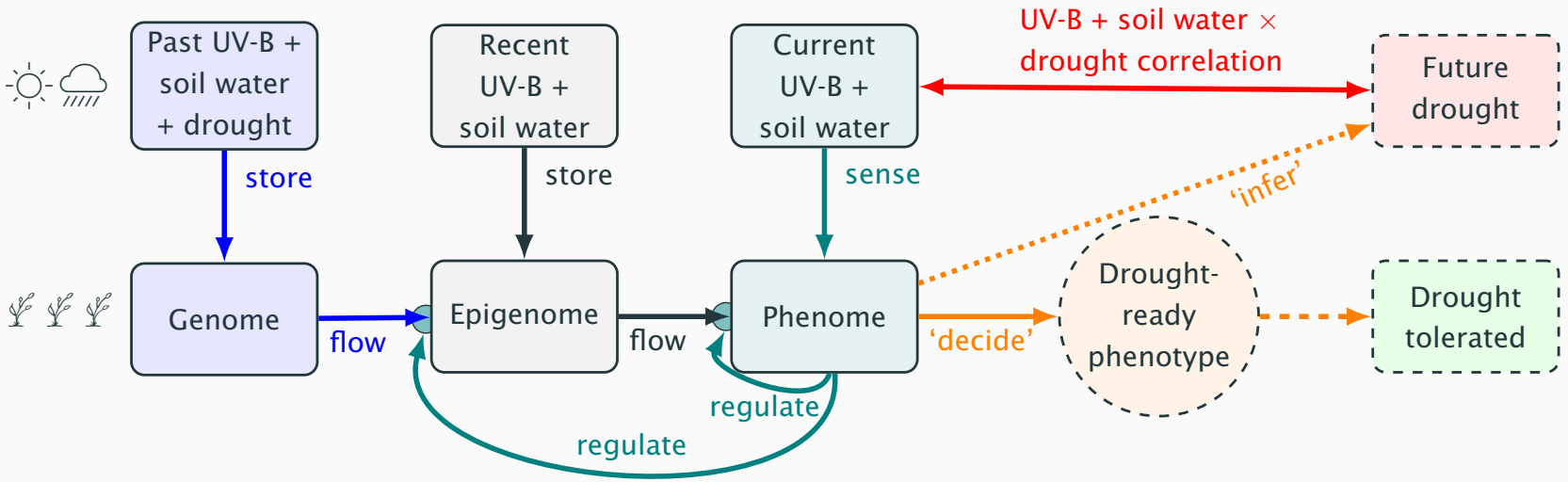


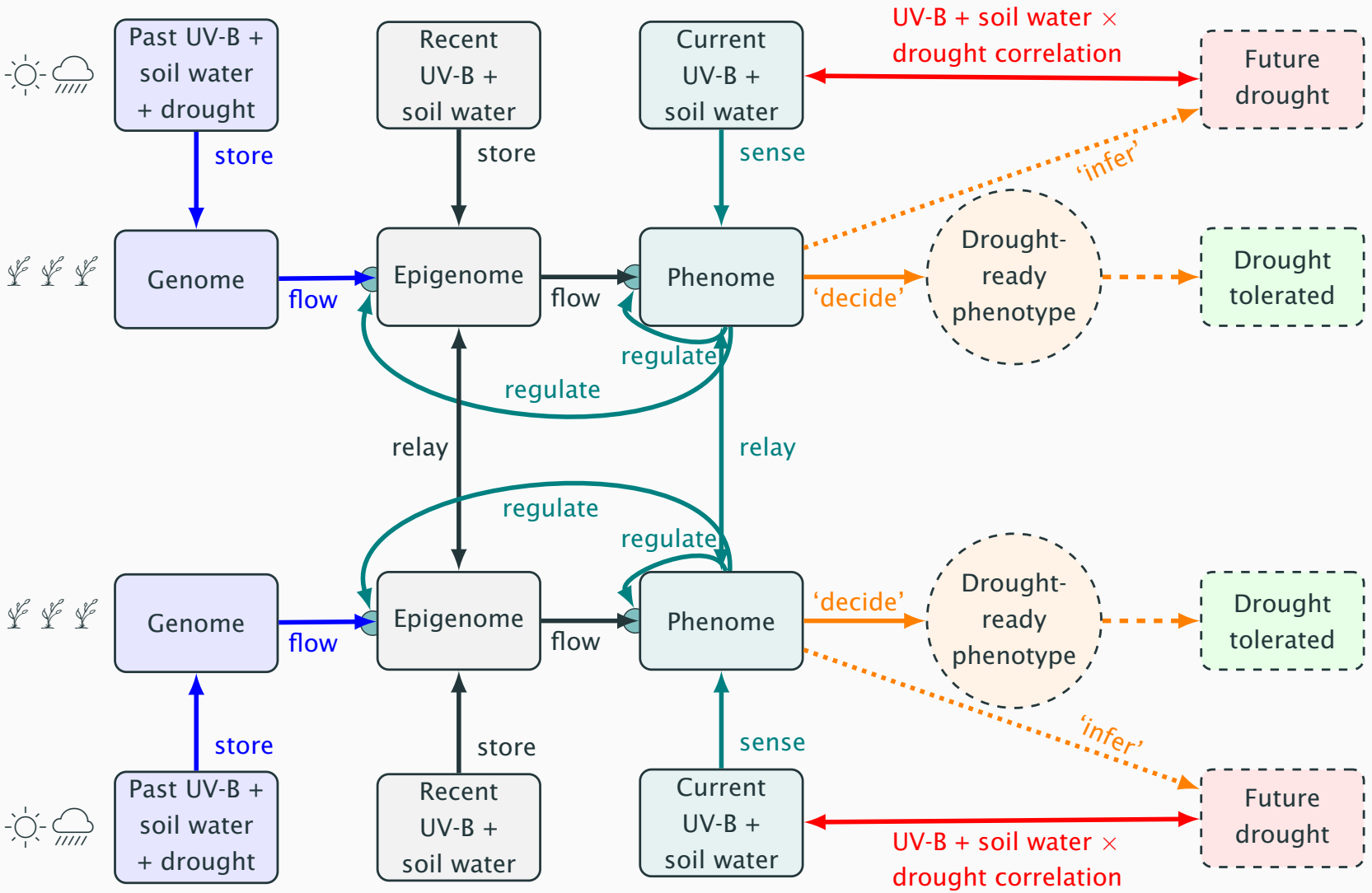
# Preemptive acclimation to shade



# Preemptive acclimation to drought



# Preemptive acclimation to drought



# Data processing mechanism in plants I

- We know something on how decoding works…
- …for some individual cues or signals.
- A frequent *naive model* is a linear chain of events.
- Cue/signal perception $\rightarrow$ direct decoding of information $\rightarrow$ response
- Low R:FR $\rightarrow$ “means shade” $\rightarrow$ shade avoidance response
- Can frequently describe responses to single cues or signals

# Data processing mechanism in plants II

- We know almost nothing on how decoding works…

  …for sets of cues or signals.
- A complex and realistic (?) model is a network of interactions, memories and feedback loops.
- Synchronous and asynchronous perception of cues/signals $\rightarrow$ …

  complex decoding of information $\rightarrow$…adjustment of ready-ness to respond.
- Synchronous and asynchronous perception of cues/signals $\rightarrow$ …

  complex decoding of information + readiness state $\rightarrow$ response.

# Take Home Message

# Temporal and spatial context matters

1. Components of signalling networks can be best teased out in unnatural contexts including single factor experiments.
2. Regulation and signalling interactions can be meaningfully described only in real or realistic contexts preferably using factorial experiments.
3. Describing a syndrome requires in most cases parallel measurements at different levels of organization.
4. Time courses of response and responsiveness need to be followed.
5. Neighbours communicate and share information and miss-information.

# References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- **Novoplansky A**. 2016. “Future Perception in Plants”. In: *Anticipation Across Disciplines*. Springer, pp. 57–70.
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