Environmental Sensing and Anticipatory Acclimation

An Information-Based Framework

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Rovaniemi, 15 March 2023

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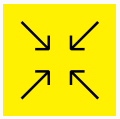
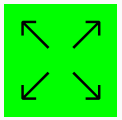
Contents



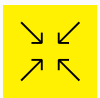
Stress and



Sensing

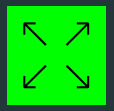
Stress: one word and many meanings

- 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 exerting a pressure or limitation.

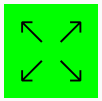
Stress involves a comparison

- Reference = ‘optimal environment’ $\rightarrow$ always under stress.
- Reference = ‘average environment’ $\rightarrow$ sometimes under stress.
- Reference = ‘another genotype’ under the same environment $\rightarrow$ E $\times$ G.
- Function evaluated: fitness $\rightarrow$ ecological/evolutionary stress: adaptation vs. maladaptation.
- Function evaluated: biomass or yield $\rightarrow$ production/economic stress.

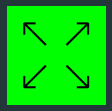


Sensing: one word and many meanings

- Sensing of the state of environment.
- Sensing of the internal state of an organism.
- Sensing as detrimental to fitness or biomass production.
- Sensing as enhancer of fitness or biomass production.

Idea:  sensing is ‘exploration’ and acquisition of information by an organism.



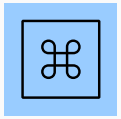


Stress and sensing are intertwined

- 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 acclimation, and has been selected through evolution and determines experienced stress.

Information and



Memory

Cues and signals as sources of information

Cues: emission is “accidental”.

Signal: emission is “beneficial” (communication).

Cues and signals as sources of information

Cues: emission is “accidental”.

Signal: emission is “beneficial” (communication).

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

Anticipation and Acclimation

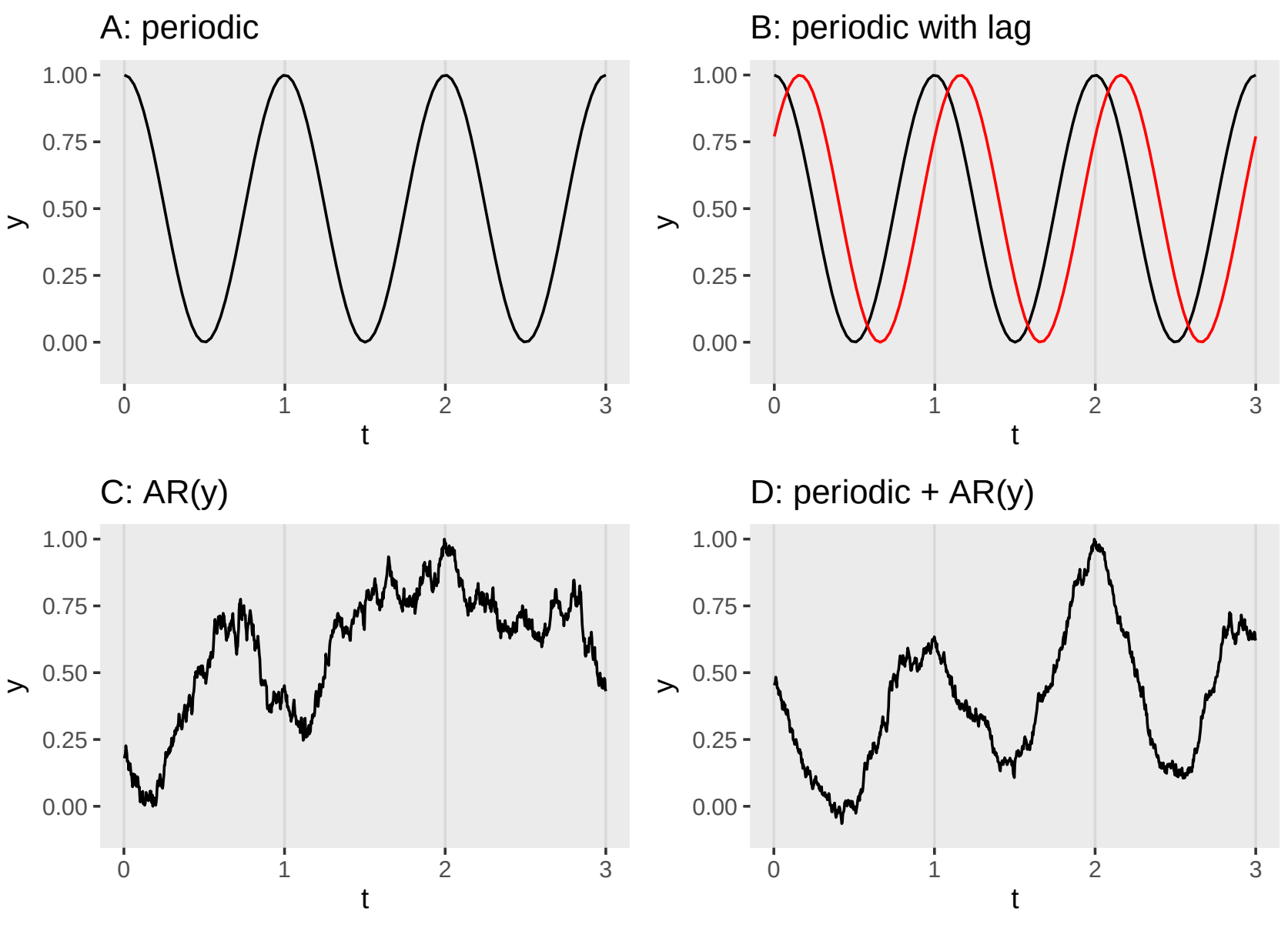
Anticipation/forecasting and fitness

- Our everyday life depends on forecasting all sorts of events every minute.
- Sometimes we do this consciously, but most of the time we are not aware of what our brain is doing.
- Perception of cues and memories are sources of information.
- e.g. estimating the weight of a cup when lifting it.

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.
- “Random noise” in spatial/temporal cues/signals can be “smoothed out”.

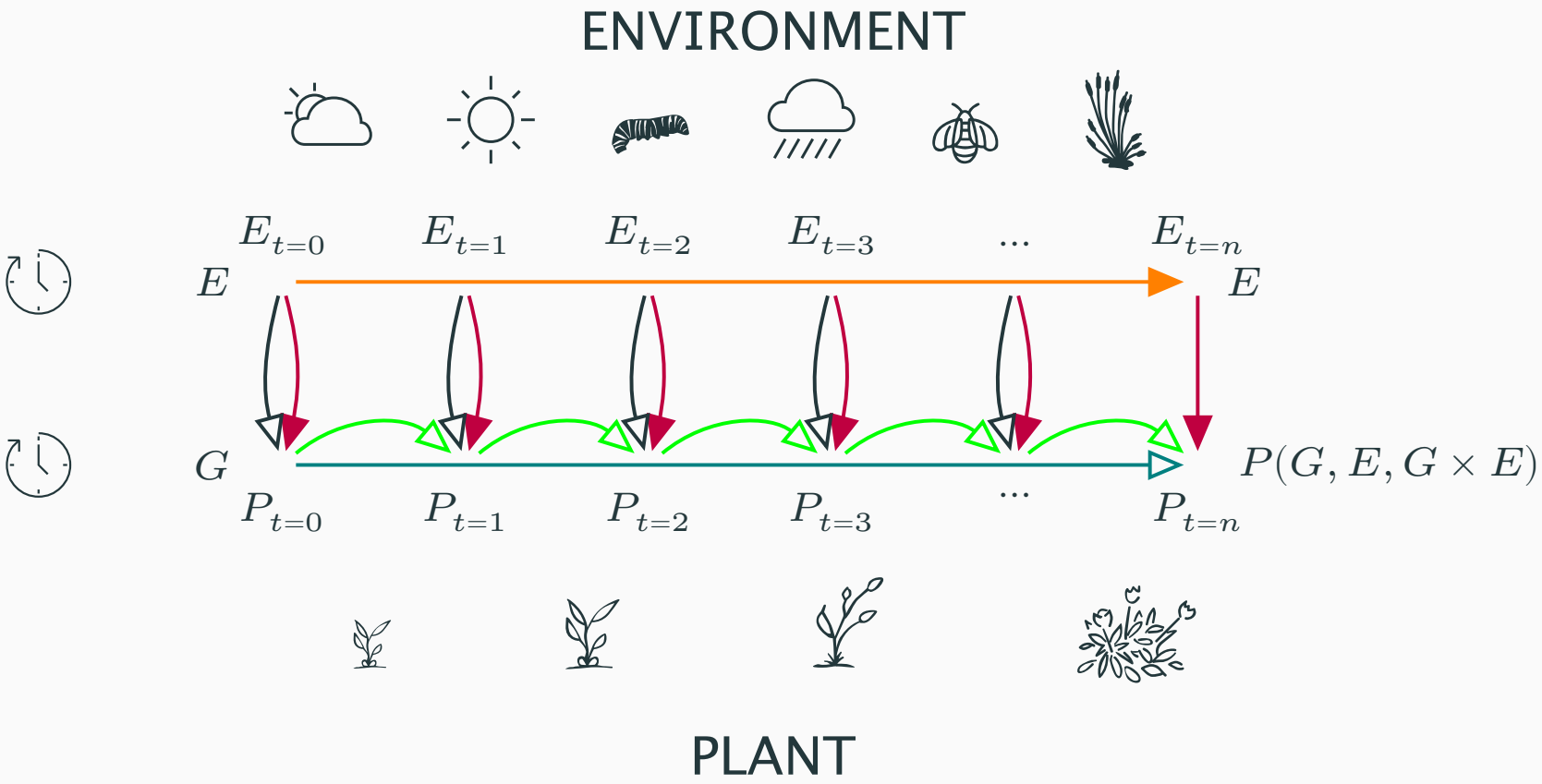
Correlations in the environment



Forecasting and resource investment

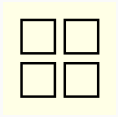
- There are reliable and unreliable sources of information.
- Forecasting can depend on a single reliable predictor or…
- …on a combination of several less reliable predictors.
- Predictors *do not need* to have a direct cause-effect relationship.
- Forecasts are subject to errors…
- …outcomes $\rightarrow$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

Acclimation is a process in time



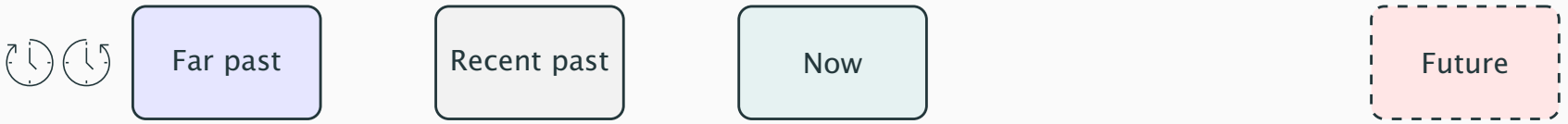
Acclimation depends on plasticity

- 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 (?).

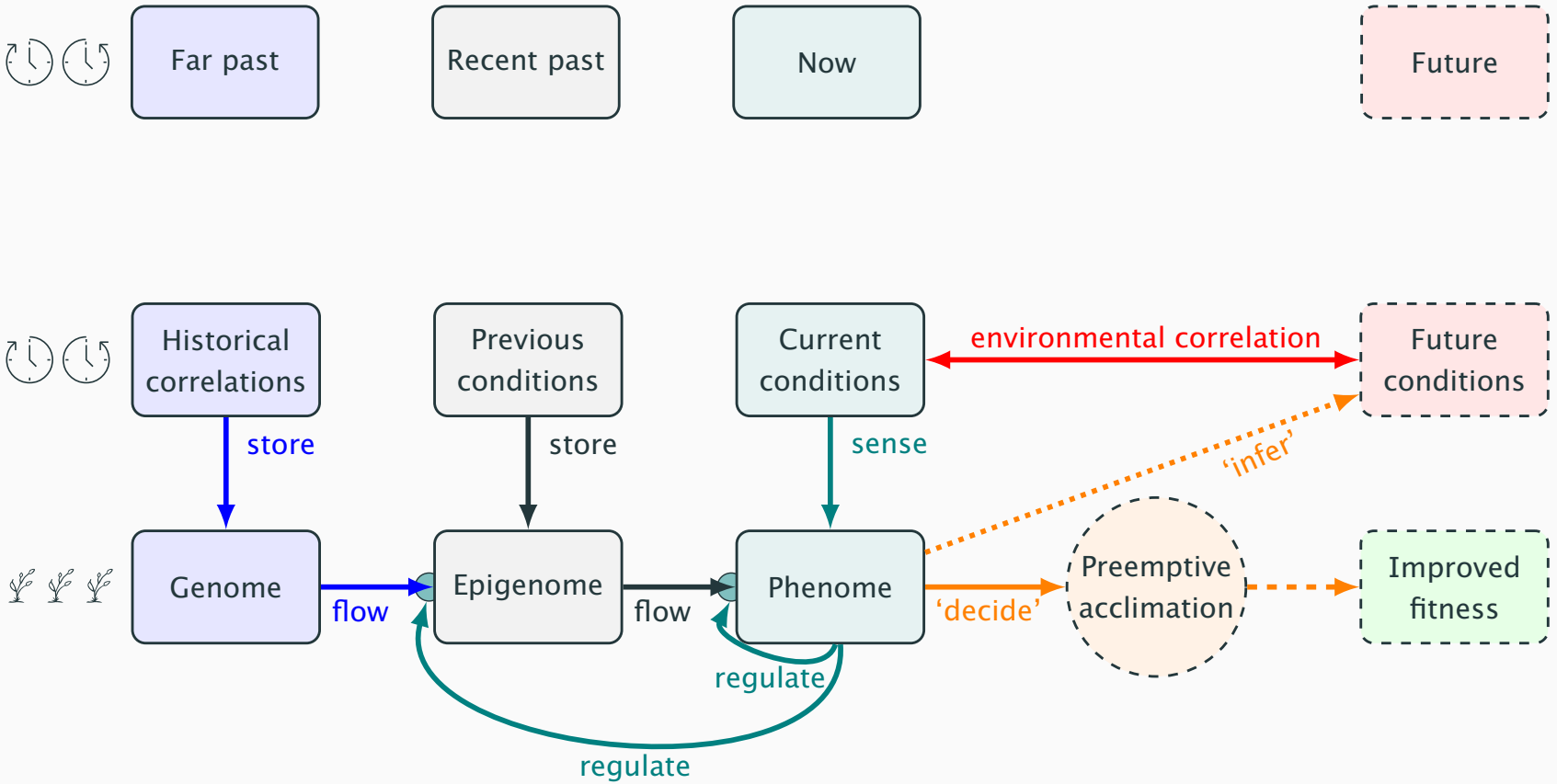


Framework and  Plants

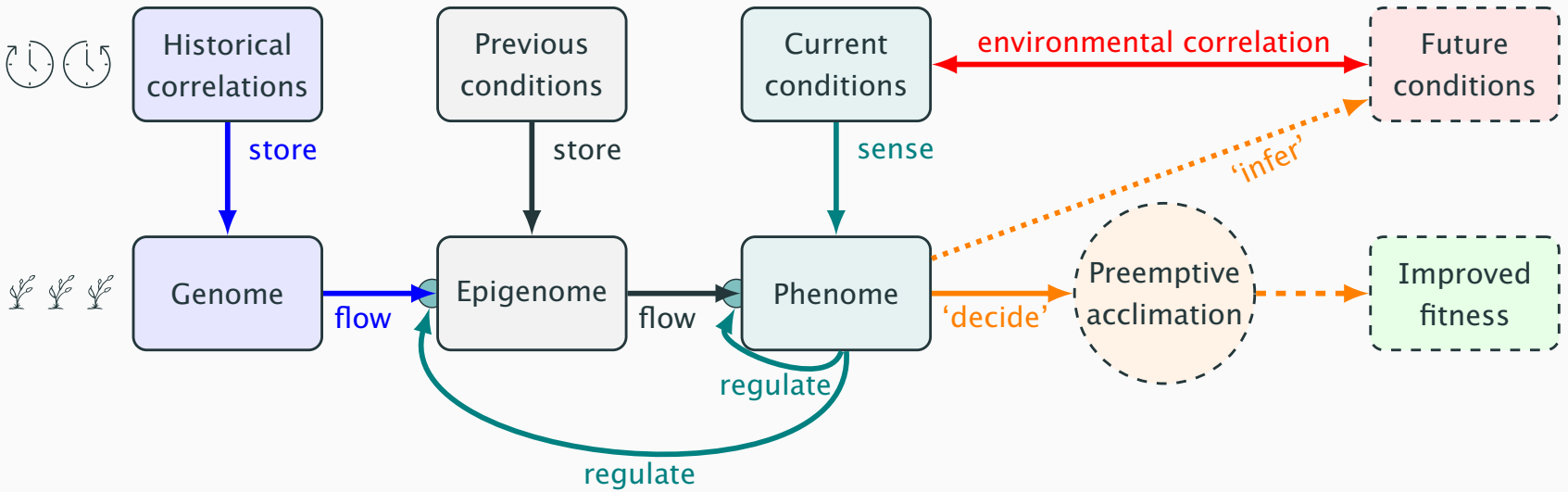
Information-based framework of acclimation



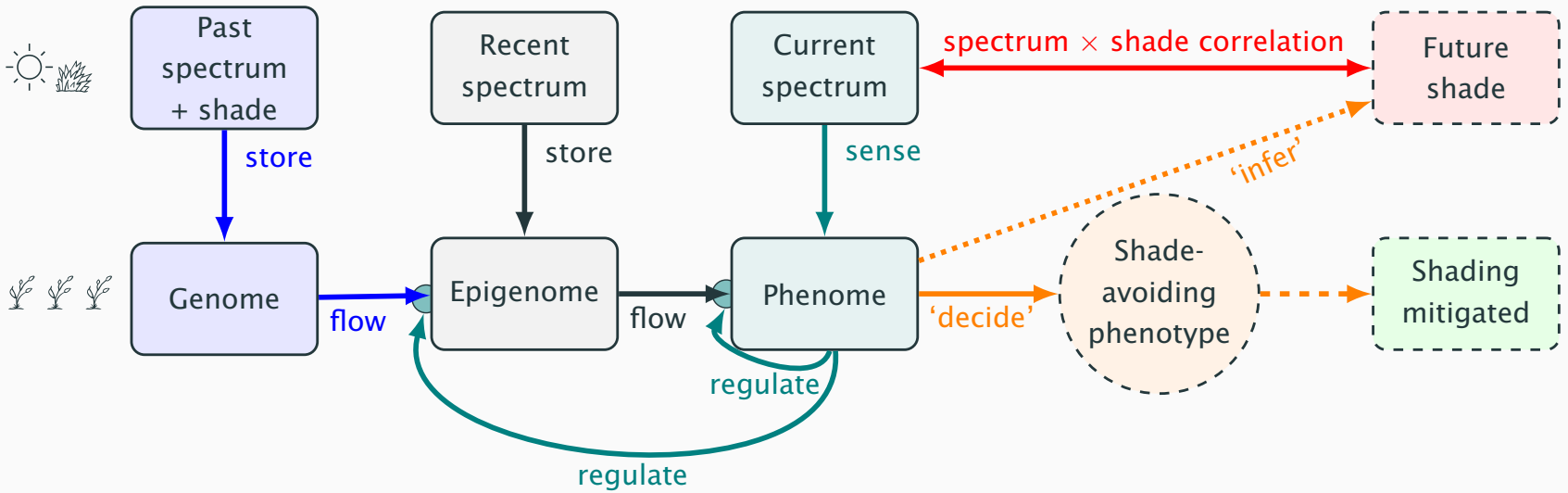
Information-based framework of acclimation



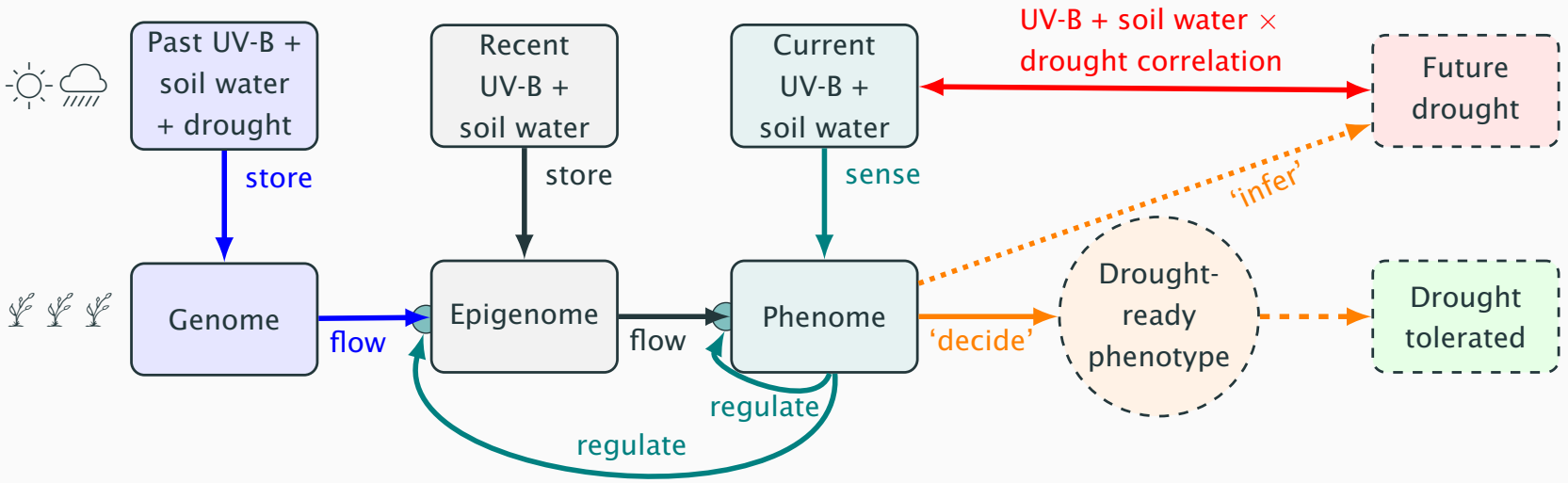
Information-based framework of acclimation



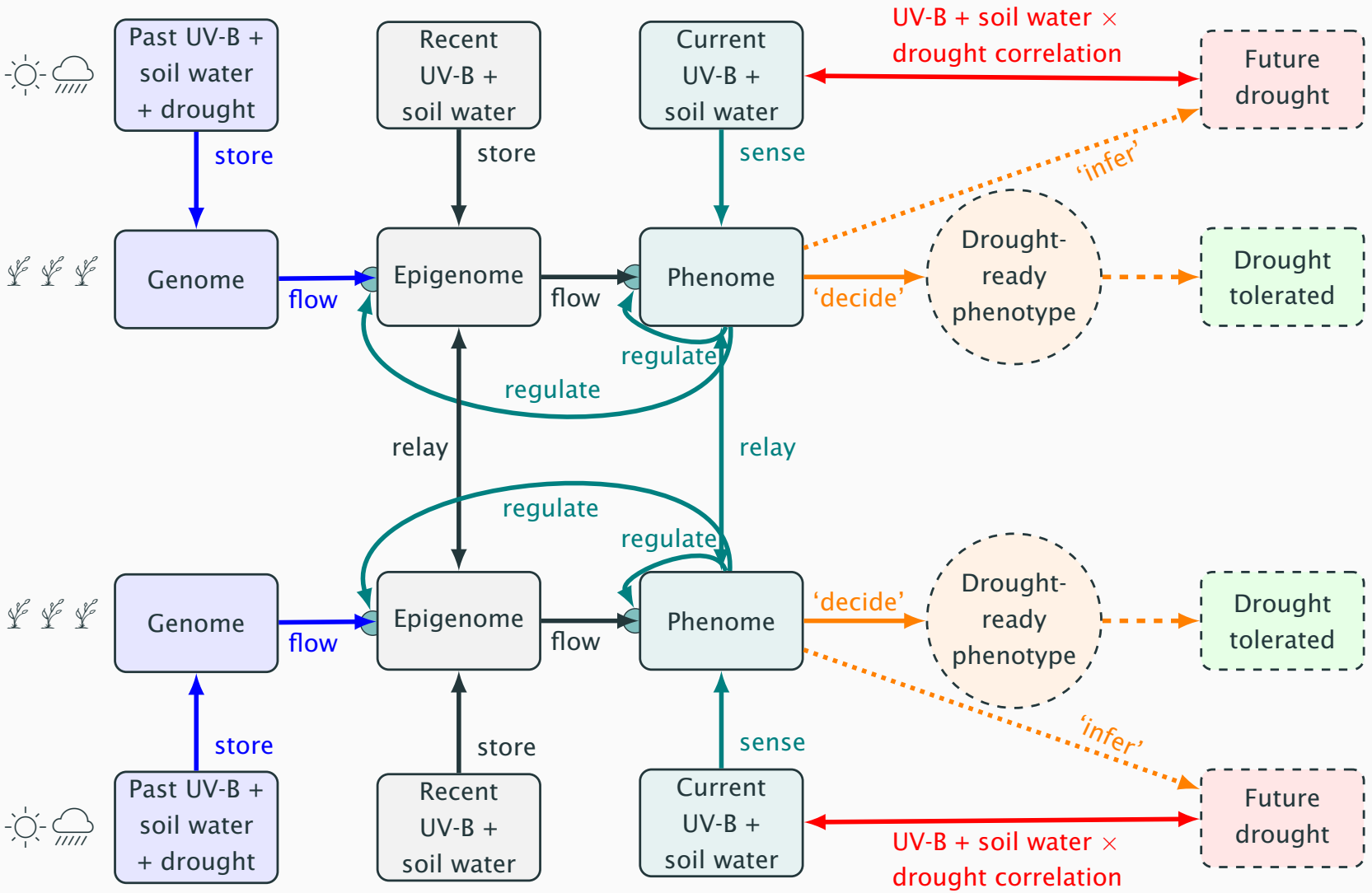
Preemptive acclimation to shade



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.

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