Regulation of the timing of tomato fruit ripening

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Background

Following anthesis (the fertilisation of a plant oocyte by pollen), tomato fruit first grow in size to a stage known as Mature Green and then, after a quiescent period of 7-9 days, the first signs of ripening appear at a point known as Breaker. Research in recent years has uncovered the components of a genetic bistable switch that is flicked from one state to another during the Mature Green and Breaker stages. The key issues now are (a) how do tomato fruit know when it is time to flick the switch and (b) what are the components of the mechanism for this?

The current study

Very recent evidence has revealed a gene (codenamed HFP) whose expression is influencing the number and content of subcellular organelles known as plastids (which incidentally also have DNA and genes of their own). The latter produce the pigments to give tomatoes their green and subsequent red colour. Over-expression of this gene over-produces these plastids leading to more highly pigmented fruit which ripen earlier. Hence, there is interplay between fruit size, plastid number/size/content and the signal(s) causing the initiation of ripening.

Plastids contain their own DNA and formation of new plastids by binary fission requires replication of this DNA (shown in green in Fig. 1), which is partially regulated by nuclear-encoded genes (shown in black). There is negative feedback to regulate plastid DNA copy number and ensure that the process is controlled (shown in green). Plastids also send signals (in green) to the nucleus to express genes whose proteins are used in plastids for its metabolism.

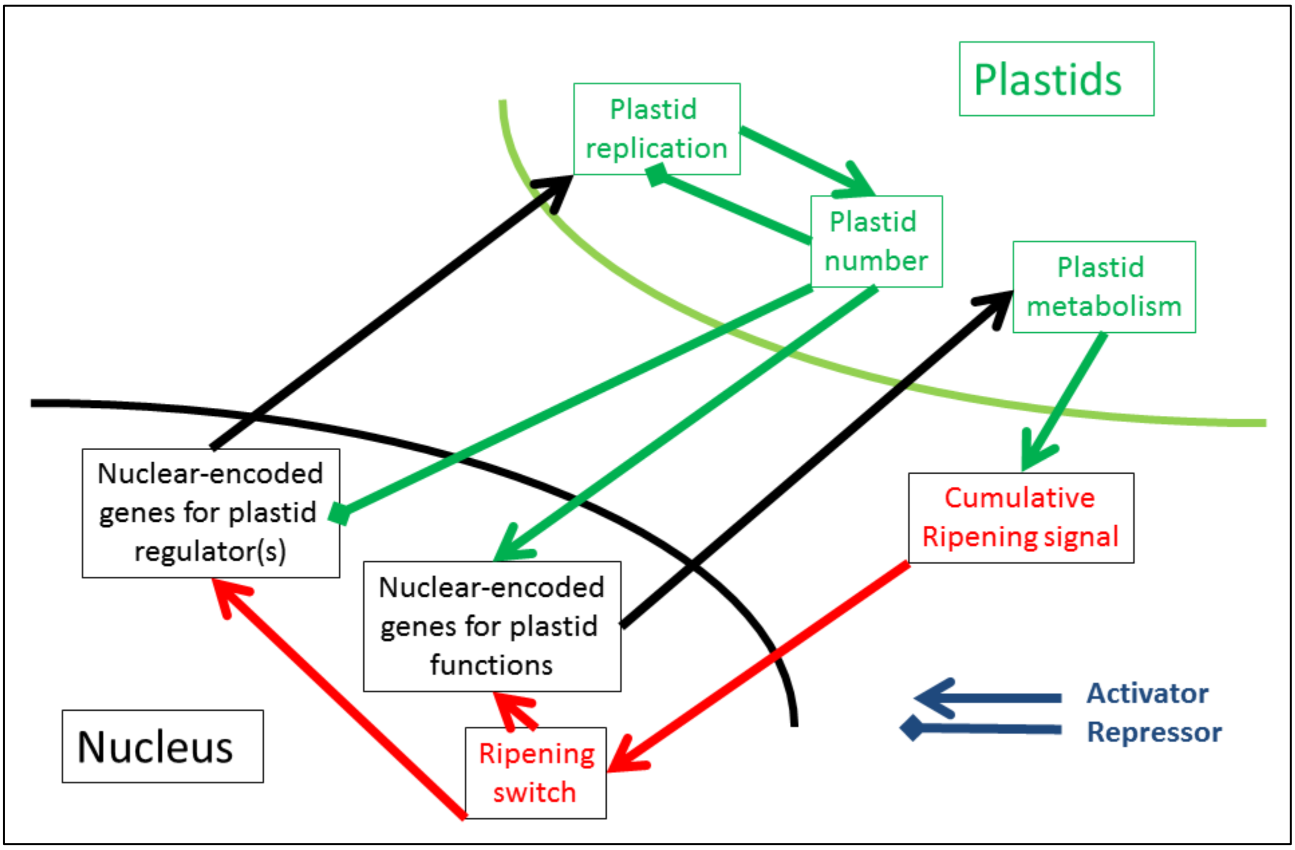

Fig 1. The network for plastid influence on timing of tomato ripening

Overexpressing the gene HFP1 results in increased plastid number and pigment content and an earlier switch to ripening. Hence, we hypothesise that plastids generate some ripening signal which (upon reaching an appropriate threshold) flicks the switch for ripening to begin (shown in red).

The process shown in the figure is set against the fact that the tomato fruit are growing and hence needing an increasing supply of plastids for the photosynthesis that the fruit carry out.

Questions

The key question to be addressed is: how (if at all) is HFP connected to the ripening switch? Initial steps would involve modelling a small network. Variables include plastid number, plastid size, chlorophyll content (the green pigment) plus a small number of other factors.

Data available

We have gene-expression and metabolite profile-data for wild type tomato lines and also data for ripening mutants and GM lines over-expressing and knocking down the HFP gene from which it might be possible to discern components. The literature on plastid biology is extensive. More sophisticated informatics analysis is not necessary, but if the relevant expertise were available it could be employed to uncover extra specific factors.