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Title: **Is RNA editing implicated in group II-intron survival in the angiosperm mitochondrial genome?**

Authors: Hiroyo Kagami[1], Hironori Nagano[1, 2], Yoshiya Takahashi, Tetsuo Mikami, Tomohiko Kubo

Affiliation: Research Faculty of Agriculture, Hokkaido University, Japan

Corresponding author: T. Kubo
Research Faculty of Agriculture, Hokkaido University
N-9, W-9, Kita-ku, Sapporo, 060-8589, Japan
gelab@abs.agr.hokudai.ac.jp
Tel/Fax +81-11-706-2484

[1]*These authors contributed equally to this note.*

[2]*Present address: Field Science Center for Northern Biosphere, Hokkaido University, N-11, W-10, Kita-ku, Sapporo, 060-0811, Japan.*

Abstract

Introns may be considered as optional because they are removed from mRNA molecules, but introns are fairly preserved for unknown reasons. Previously, the mitochondrial *rps3* gene of sugar beet (*Beta vulgaris* L., Caryophyllales) was shown to represent a unique example of an intron loss. We have determined the distribution of the *rps3* intron in 19 Caryophyllalean species. The intron was absent from the Amaranthaceae and the Achatocarpaceae. In the Caryophyllaceae, *Dianthus japonicus rps3* was pseudogenized but the intronic sequence was retained. Intact intron-bearing *rps3* copies were cloned from *Portulaca grandiflora* and *Myrtillocactus geometrizans*, members of the sister clade of the Amaranthaceae-Achatocarpaceae-Caryophyllaceae clade. Most of the C-to-U RNA-editing sites in *Portulaca* and *Myrtillocactus rps3* transcripts were homologous in the two species as well as in the sugar beet *rps3*, which, unlike other 12 *rps3* transcripts, lacks editing in the exonic regions around the intron. Provided that the loss of editing preceded the loss of *rps3* intron, it appears conceivable that a requirement for editing could have prevented the loss of group-II introns retained in angiosperm mitochondrial genomes. This interpretation is an alternative to the conventional one that views the loss of editing as a mere trace of RNA-mediated gene conversion.

Keywords: plant mitochondria, mitochondrial genome, evolution, Caryophyllales, Amaranthaceae, group-II intron, retroprocessing

Unlike in animals, introns are prevalent in land plant mitochondrial genes (Knoop 2004; Bonen 2008). In angiosperms, there are ~25 known group I and group II mitochondrial introns that interrupt eleven genes (Kitazaki and Kubo 2010).

The distribution of introns is more or less variable among angiosperm species. A well known example is the group I intron of *cox1*, whose dissemination appears to have involved horizontal transfers and/or occasional losses during angiosperm diversification. As a result, its distribution is not consistent with angiosperm taxonomy (Cusimano et al. 2008; Sanchez-Puerta et al. 2008). Compared to the *cox1* intron, the group II-intron content appears to be rather conservative and intronic variation (presence or absence of the intronic sequence) is fairly well correlated with taxonomy. For example, the distribution of intron 1 of *cox2* (*cox2-i1*) in 30 taxa led De Benedetto et al. (1992) to conclude that the presence/absence of *cox2-i1* has a potential as a phylogenetically informative character.

There is no report of a group II-intron gain in angiosperm mitochondria (Kubo et al. 2011); intronic variation therefore can be interpreted as resulting from intron loss. Currently available information suggests that the loss of group-II introns could involve retroprocessing, an RNA-mediated homologous recombination in which mRNA is reverse-transcribed into cDNA which subsequently recombines with genomic DNA (Geiss et al. 1994). Intron loss through retroprocessing not only erases intronic sequences from the genome but also reduces the necessity for RNA editing, a post-transcriptional mRNA modification of land plants that alters specific cytosine (C) residues to uracil (U). This is because a cDNA sequence that is substituted for a genomic region contains thymine (T) residues at sites that are occupied by C in the original sequence. Therefore, intron loss can be expected to accompany editing site reduction in the exonic regions around the intron (Geiss et al. 1994). In fact, comparison of intron-bearing and intron-lacking copies of three genes (*cox2*, *nad4* and *nad7*) revealed a reduced number of RNA editing sites (Geiss et al. 1994; Itchoda et al. 2002; Sloan et al. 2010). However, while intronic variation in the *cox2*, *nad4* and *nad7* genes appear to have occurred independently several times in different angiosperm lineages (Gass et al. 1992; Pla et al. 1995; Sloan et al. 2010), no such pronounced variability has been reported from other genes. This suggests that some introns tend to be preserved during angiosperm evolution for unknown reasons.

In this context, the *rps3* gene provides a unique example: the sugar beet (*Beta vulgaris* L.) *rps3* lacks introns, while the other angiosperm genes identified to date contain an intron (Laroche and Bousquet 1999; Kubo et al. 2000). To better understand the implications of the loss of the *rps3* intron, we examined the (taxonomic) distribution of the *rps3* intron among the Caryophyllales, to which sugar beet belongs.

A set of primers (P1 and P2) were designed based on the exon-1 and exon-2 sequences of angiosperm *rps3* (*rps3-ex1* and *rps3-ex2*, respectively) to target *rps3-i* (experimental procedures are detailed in supplementary materials). Total cellular DNAs were isolated from 11 species covering 6 families of the Caryophyllales (Table 1) and subjected to PCR using P1 and P2. As shown in Fig. 1a, six species including sugar beet gave PCR products of 170bp. These PCR products were cloned into plasmid vectors for nucleotide sequencing. The six sequences were highly homologous to the intron-less *rps3* of sugar beet mitochondria (Fig. S1a). On the other hand, four other species gave PCR products of ~1.5 kbp (Fig. 1a), which were found to contain intron- and exon sequences (Fig. S1b). No PCR product was amplified from *Dianthus* (Fig. 1a).

The failure to amplify the *rps3* sequence from *Dianthus* suggests the lack of the intact mitochondrial gene. To test this idea, we first amplified the *rps3-ex1* and *rps3-ex2* regions from petunia total cellular DNA using two primer sets (P3 and P4, and P5 and P6, respectively, designed based on DDBJ/GenBank/ EMBL accession no. X67028). The amplified DNA fragments were labeled and then hybridized with a DNA blot containing *Dianthus* total cellular DNA. As shown in Fig. 2, the *rps3-ex2* probe hybridized to a 1.1-kbp *Eco*RI fragment, but the *rps3-ex1* probe failed to identify any bands from *Dianthus*. Therefore, the *rps3-ex1* sequence seems to be missing or to strongly diverge in the *Dianthus* genome. We may ask whether the *rps3-i* sequence is present immediately upstream of *rps3-ex2* in *Dianthus*. Several primers corresponding to sequences of *rps3-i* conserved in angiosperms were used in combination with the P2 primer for amplification trials. PCR products were obtained when we used primer P7 (Fig. 1b). Nucleotide sequencing revealed that the *Dianthus* amplicon contained both the *rps3-ex2* and *rps3-i* sequences (Fig. S1b).

We examined the organization of the angiosperm mitochondrial *rps3* using data in the

public databases. More than 20 complete mitochondrial sequences as well as *rps3* gene sequences from 18 angiosperms are available but, *rps3-i* was absent only from the sugar beet gene (data not shown). In the mitochondrial genome of *Silene latifolia* Poir., which is a member of the Caryophyllaceae as is *Dianthus*, the *rps3-ex1* sequence was missing but a portion of *rps3-i* and almost the entire *rps3-ex2* were present (Fig. S1b). No species possessed intron-less as well as intron-bearing *rps3* copies (Fig. 1 and data not shown). To summarize, intron-less *rps3* copies were detected in Amaranthaceae and Achatocarpaceae, and it seems reasonable to postulate that *rps3-i* was lost in a common ancestor of the two families. This result is congruent with recent phylogenetic models that resolved Amaranthaceae and Achatocarpaceae as two closely related clades (Soltis et al. 2011), with their closest sister clade being the Caryophyllaceae.

Next we addressed the question whether the five RNA editing sites in sugar beet *rps3*, which were confined to *rps3-ex2* (Matsunaga et al. 2011) (Fig. 3 and Fig. S2), could be interpreted as traces of the retroprocessing that erased *rps3-i*. For this purpose, it was necessary to compare editing sites between intron-less *rps3* and intron-bearing *rps3* copies in Caryophyllales. Although Caryophyllaceae is the closest sister clade of Amaranthaceae-Achatocarpaceae in the phylogenetic tree (Soltis et al. 2011), the Caryophyllaceae *rps3* seemed unsuitable because it appeared to be a pseudo gene as was seen in *Dianthus* and *Silene*. We selected *Portulaca grandiflora* and *Myrtillocactus geometrizans*, which belong to the sister clades of Amaranthaceae-Achatocarpaceae-Caryophyllaceae in the order Caryophyllales.

Genomic DNA fragments of *Portulaca grandiflora* that hybridized with the petunia *rps3* probe were cloned, sequenced and assembled into a contig, in which 74-bp *rps3-ex1*, 1215-bp *rps3-i* and 1615-bp *rps3-ex2* sequences were found (DDBJ/GenBank/EMBL accession no. AB666467). This sequence information was used to design a set of primers (P8 and P9) that subsequently were employed to amplify the complete *rps3* gene of *Myrtillocactus geometrizans*. As a result, *Myrtillocactus rps3* was revealed to consist of 74-bp *rps3-ex1*, 1705-bp *rps3-i* and 1609-bp *rps3-ex2* (DDBJ/GenBank/EMBL accession no. AB666468). DNA gel blot analysis indicated that *Portulaca rps3* and *Myrtillocactus rps3* are single-copy genes (Fig. 2).

To determine the RNA editing sites, reverse transcription (RT) PCR was performed using leaf (*Portulaca*) or stem (*Myrtillocactus*) total RNA as templates with two sets of primers (P8 and P10, and P11 and P9). Nucleotide sequencing of ten independent clones from amplicons of each RT-PCR revealed three and five C-to-U RNA editing sites in *Portulaca* and *Myrtillocactus*, respectively (Fig S2). All but one editing event (depicted as e8 in Fig. S2) improved the similarity of the amino acid sequence with homologues from other species (data not shown). One editing event (e8) in *Myrtillocactus* did not alter the amino-acid specificity of the codon (i.e. silent editing). Three editing sites identified in *Portulaca rps3* transcripts were found also at homologous positions in sugar beet (e22, e27 and e28 in Fig S2). Two editing sites (e14 and e19) that were edited in sugar beet but not in *Portulaca* corresponded to adenosine (A) and T residues in the *Portulaca* genome, respectively. In *Myrtillocactus*, four out of the five editing sites matched with sites in sugar beet (Fig S2). The silent editing in *Myrtillocactus* (e8) was not detected in sugar beet and *Portulaca*. One of the five editings in sugar beet (e19) appeared to be unnecessary in *Myrtillocactus* because a T residue was present at the corresponding site (Fig. S2).

We complemented our own data with the publicly available data regarding *rps3* transcript editing from 12 different plant species (Fig. S2). RNA-editing sites that were experimentally identified or predicted using a computer program (sources are summarized in Table S1) numbered 37 (e1 to e37) in total. This analysis revealed that *rps3* transcripts of sugar beet, *Portulaca* and *Myrtillocactus* are devoid of editing events in their 5' (e1 to e7) and 3' (e29 to e37) regions (Fig. 3 and Fig. S2), and that the number (3 to 5) of RNA editing sites in these three *rps3* transcripts is clearly smaller than that (7-17) in other *rps3* transcripts. We placed *rps3-i* loss and loss or gain of e1 to e7 and e29 to e37 editings at positions on the phylogenetic tree that maximized parsimony (Fig. 3). This analysis favored the loss of the 16 editing sites prior to the evolutionary separation of sugar beet, *Myrtillocactus* and *Portulaca*, although another possibilities cannot be excluded.

There have been some reports suggesting a possible association between RNA editing and group-II intron. For example, the editing frequency at the e4 site of rice *rps3* was lower in unspliced RNA than in spliced RNA (Kurihara-Yonemoto and Kubo 2011). Similar

observations of differential editing status between unspliced and spliced RNA have been reported from petunia *cox2*, maize *cox2*, wheat *cox2*, wheat *nad4* and wheat *nad7* (Sutton et al. 1991: Yang and Mulligan 1991; Li-Pook-Than et al. 2007). Furthermore, mRNAs transcribed from modified mitochondrial genes whose group-II introns had been removed were less frequently edited compared to mRNAs transcribed from the original intron-bearing genes (Castandet et al. 2010). The possible association between RNA editing and the presence of a group-II intron suggested by these reports allows us to speculate that the loss of *rps3-i* from the genome might affect certain RNA editing events. Modification of the editing sites by genomic C-to-T substitution (or cDNA-mediated gene conversion that does not affect intron content but reduces editing sites) would weaken the significance of *rps3-i* for *rps3* expression. Consequently, the loss of *rps3-i* could have become inconsequential in the Caryophyllales lineage leading to sugar beet, *Myrtillocactus* and *Portulaca*. This hypothesis calls for further evaluation in future studies.

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Table 1 Plant materials used in this study and presence/absence of *rps3-i*

Species	Family	*rps3* intron	Cultivar/ Source
Beta vulgaris L.	Amaranthaceae	-[a]	cv. 'TK81mm-O'/ Hokkaido Agricultural Research Center, National Agriculture and Food Research Organization, Japan
Chenopodium album L.	Amaranthaceae	-	Botanic Garden, Hokkaido University, Japan
Celosia argentea L.	Amaranthaceae	-	cv. 'Yachiyo Keitou'/ Tohoku Seed CO., LTD., Japan
Gomphrena haagena Klotzsch	Amaranthaceae	-	Sakata Seed CO., Japan
Spinacia oleracea L.	Amaranthaceae	-	Local market
Achatocarpus praecox Griseb.	Achatocarpaceae	-	Royal Botanic Gardens, Kew, UK
Dianthus japonicus Thunb.	Caryophyllaceae	+[b]	Takii & CO., LTD., Japan
Basella alba L.	Basellaceae	+	Sakata Seed CO., Japan
Mirabilis jalapa L.	Nyctaginaceae	+	Sakata Seed CO., Japan
Myrtillocactus geometrizans (Mart. ex Pfeiff.) Console	Cactaceae	+	Local market
Portulaca grandiflora Hook.	Portulacaceae	+	Sakata Seed CO., Japan

[a]Absence, [b]Presence

Figure legends

Fig. 1 PCR amplification of *rps3-i* from the 11 species listed in Table 1. **a** PCR amplification with primers P1 and P2. Size markers are shown on the right (bp). **b** PCR amplification with primers P7 and P2 using *Dianthus japonicus*, *Basella alba*, *Mirabilis jalapa*, *Myrtillocactus geometrizans* and *Portulaca grandiflora* total DNAs as templates. Size markers are shown on the right (bp).

Fig. 2 DNA gel blot analysis using 5 μg of total cellular DNA digested with *Eco*RI. Petunia *rps3-ex1* and *rps3-ex2* sequences were used as probes. The sample was electrophoresed in a 1% agarose gel. Sugar beet (Beta), *Myrtillocactus geometrizans* (Myrtillocactus), *Dianthus japonicus* (Dianthus) and *Portulaca grandiflora* (Portulaca) were subjected to this experiment. Size markers are shown on the left (kbp).

Fig. 3 Phylogenetic relationship among 15 plant species including sugar beet (Beet), *Portulaca grandiflora* (Portulaca), *Myrtillocactus geometrizans* (Myrtillocactus), grapevine (Grape), *Arabidopsis thaliana* (Arabidopsis), rapeseed, *Oenothera berteriana* (Oenothera), sunflower, watermelon, zucchini, petunia, tobacco, papaya, *Magnolia x soulangeana* (Magnolia) and rice, based on Soltis et al. (2011) and the Angiosperm Phylogeny Website (http://www.mobot.org/mobot/research/apweb/). Branch length does not indicate phylogenetic distance. Arrows pointing to top indicate loss of editings and intron, while arrows pointing downwards highlight gain of editings. *rps3* organization and its editing status (for e1-e7 and e29-e37 only) is shown on the right (for details, see Fig. S2). Boxes with numbers following the letter ‘e’ indicate specific residues depicted in Fig. S2. Filled, gray and open boxes represent experimentally confirmed editing, editing predicted *in silico*, and no editing, respectively. Horizontal lines between the boxes indicate *rps3-i*.

Experimental details

1. Isolation of nucleic acids

Total cellular DNA was isolated according to Doyle and Doyle ('Isolation of plant DNA from fresh tissue'. ***Focus*** 12:13-15, 1990). Total RNA was isolated by using RNeasy Plant Mini Kit (Qiagen, Valencia, CA). Isolated RNA samples were further purified by incubation with RNase-free DNase I (Takara Bio, Ohtsu, Japan) according to the manufacturer's instructions.

2. Molecular cloning

PCR was done using BlendTaq (Toyobo Life Science, Osaka, Japan). Reverse transcription (RT) PCR was performed according to Singer-Sam et al. ('Measurement by quantitative PCR of changes in *HPRT*, *PGK-1*, *PGK-2*, *APRT*, *MTase* and *Zfy* gene transcripts during mouse spermatogenesis.' ***Nucleic Acids Research*** 18: 1255-1259, 1991). PCR products were cloned into the pBluescript vector (Stratagene, La Jolla, CA). Nucleotide sequences were determined using Li-COR4200L (Li-COR, Lincoln, NE) or ABI3130 (Applied Biosystems, Foster City, CA).

3. Hybridization

Genomic DNA was transferred onto Hybond N+ membrane (GE Healthcare UK, Amersham Place, England) after gel electrophoresis. DNA fragments of interest were labeled with alkaline phosphatase using the AlkPhos Direct DNA labeling system (GE

Healthcare UK). Hybridization was done according to the manufacturer's instruction.

4. Nucleotide sequences of oligonucleotide primers

P1, 5'-TTTCGGTAAGGCTGAATCGTAGTTC-3'

P2, 5'-GGAAAGCCAAAGGTGAGTCTCGT-3'

P3, 5'-AGTAAAGTCTAAGCGCATAT-3'

P4, 5'-CTGGGAGAACTAAAAGACTG-3'

P5, 5'-GACTCTATTTATTATTATGGT-3'

P6, 5'-CGTTCAAATAATAGTTGTACCCGTACGG-3'

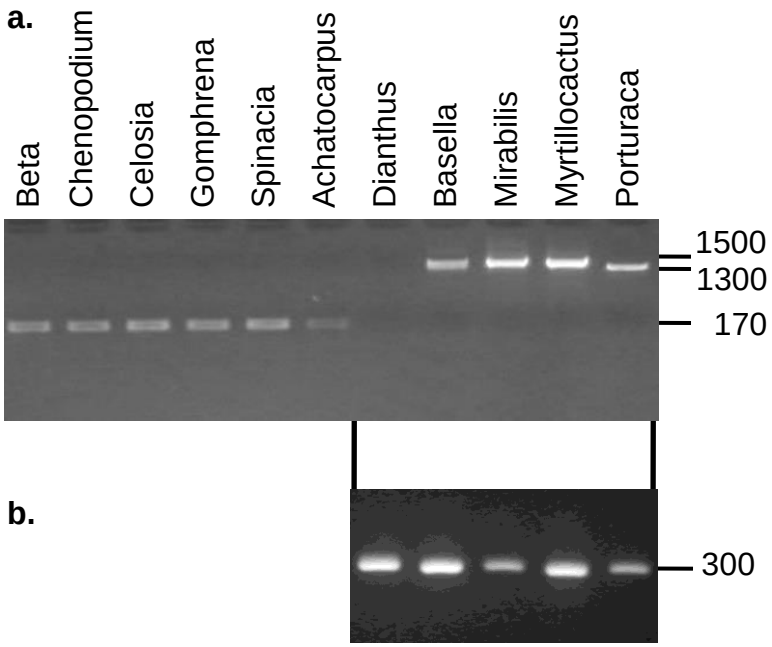
P7, 5'-CATCTCAAAGTATAGGGCAAAGGA-3'

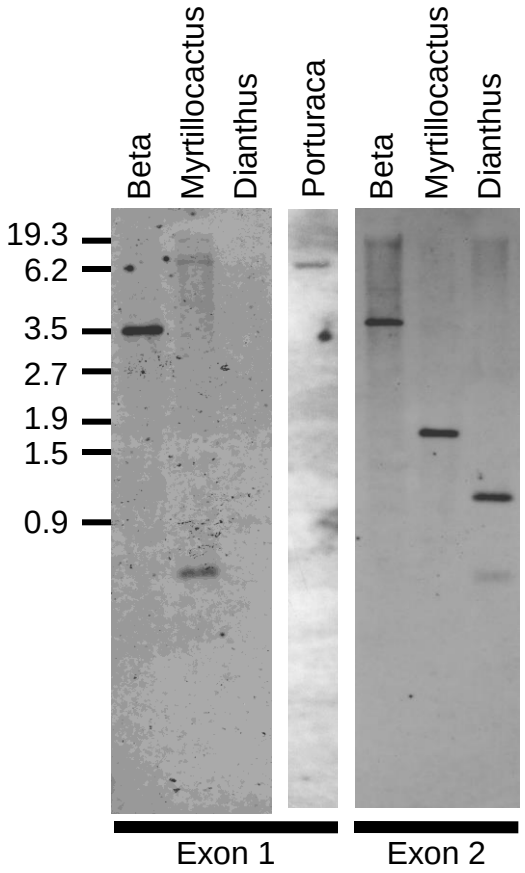
P8, 5'-ATATATGGCACGAAAAGGAAATCC-3'

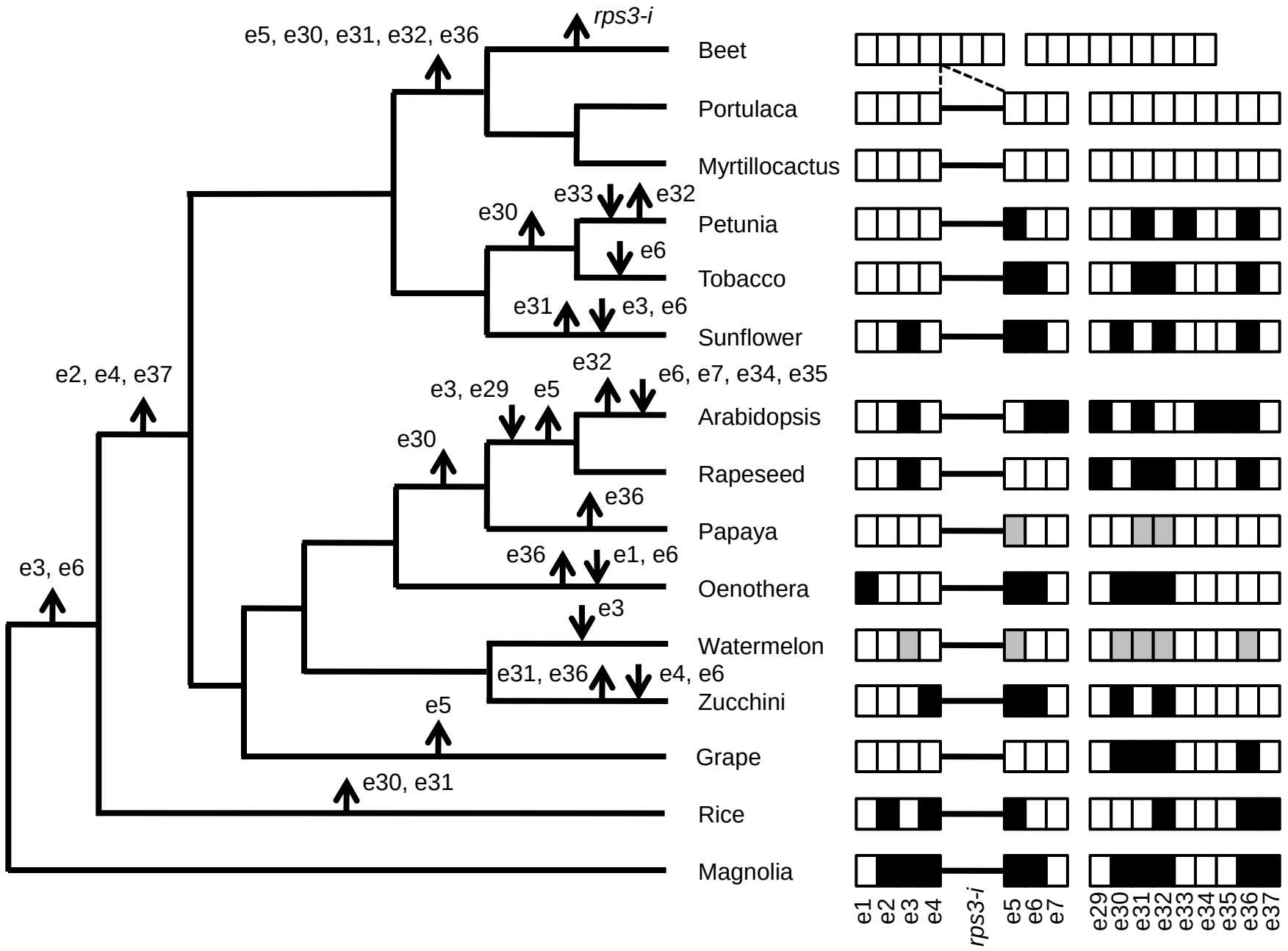
P9, 5'-TTTTCATTTTTGACTATAAGAAATCC-3'

P10, 5'-GTATTGAATAAGTATTGCAT-3'

P11, 5'-AGACCTTCCTTCAATTATTTGG-3'


a.
Beta
Chenopodium
Celosia
Gomphrena
Spinacia
Achatocarpus
Dianthus
Basella
Mirabilis
Myrtillocactus
Porturaca
1500
1300
170
b.
300


Beta
Myrtillocactus
Dianthus
Porturaca
Beta
Myrtillocactus
Dianthus
19.3
6.2
3.5
2.7
1.9
1.5
0.9
Exon 1
Exon 2


rps3-i
e5, e30, e31, e32, e36
Beet
Portulaca
Myrtillocactus
e33
e32
e30
Petunia
e6
Tobacco
e31
e3, e6
Sunflower
e2, e4, e37
e32
e6, e7, e34, e35
e3, e29
e5
Arabidopsis
e30
Rapeseed
e36
Papaya
e36
e1, e6
e3, e6
Oenothera
e3
Watermelon
e31, e36
e4, e6
Zucchini
e5
Grape
e30, e31
Rice
Magnolia
e1 e2 e3 e4 rps3-i e5 e6 e7 e29 e30 e31 e32 e33 e34 e35 e36 e37

a.

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Beta            AGTTGGTTTAATGATTATTATTATAGTAAATTAGTATATCAAGATCTCAATCTGAGATCT     60
Chenopodium     AGTTGGTTTAGTGATTATTATTTTGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
Celosia         AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
Gomphrena       AGTTGGTTTAGTGATTATTATTTTAGTAAATTAGTCTATCAAGATATCAATCTGAGATCT     60
Spinacia        AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
Achatocarpus    AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
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b.

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Basella         CATCTCAAAGTATAGGGCAAAGGAGAAAGGGCTTTGACTTTGTCTACCGGGATTCAACAC     60
Mirabilis       CATCTCAAAGTATAGGGCAAAGGATCAAGCGCTTTTACTTTGTCTCCCGGGATTCACCAC     60
Myrtillocactus  CATCTCAAAGTATAGGGCAAAGGATCTTTGGTTTTGACTTTGTCTCCAGGGAATCACCAT     60
Portulaca       CATCTCAAAGTATAGGGCAAAGGATCTTTGGTTTTGACTTTGTCTCCAGGGAATCACCAT     60
Dianthus        CATCTCAAAGTATAGGGCAAAGGATGAAGCGCTTTGACTTTGTCTCCCGGGATTCGCCAC     60
Silene          CATCTCAAAGTATAGGGCAAAGGATGAAGCGCTTTGACTTTGTCTCCCGGGATTCACCAC  76149

Basella         AGGTTCGGTTTCAGAGCTGTGTGA--TG---GGTAACTATCCTGCACGGTTCGGAGAGCA    115
Mirabilis       AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTGACTATCCTGCACGGTTCGGAGAGCA    115
Myrtillocactus  AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTCACTATCCTGCTCGGTTCGGAGAGCA    115
Portulaca       AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTCACTATCCTGCTCGGTTCGGAGAGCA    115
Dianthus        AGGGTGGCTTTGAGAGCCGTGTGATGTGATAGGTTACTTTCCTGCACGGCTC-G-GAG-A    117
Silene          AGGTTGGGTTTGAGAGCCGTG-----TGATAGGTTACTATCCTGCACGGTTCGGAGAGCA  76094

Basella         CTTTTAGGCTGACTTGGTGAATGGGAGACAAAGTATCAAGGAAGAAAGAAGGAGTTCTTC    175
Mirabilis       CTTTTCGTCTGCGTTGGTGAATGGGAGCCCCCCTATCAAGCAAGAAAGAAGCAGTTCTTC    175
Myrtillocactus  CTTATAGTCTGCATTGGTGAATGGAAGAAGACCTATCTTT-----------GAGTTCTTC    164
Portulaca       CTTATAGTCTGCATTGGTGAATGGAAGAAGACCTATC-----------AAGGAGTTCTTC    164
Dianthus        -TTTTAGTCTGCGTTGGTGAATGGGAGCCCCACTATCAAGCAAGAAAGAAAGAGTTCTTC    176
Silene          CTTTTAGTCTGCGTTGGTGAATGGGAGCCCCACTATCAAACAAGAAAGAAACTGTTCTTC  76034
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Basella         CCACTTCTACTTAAAATGTCAACATTGACTCTATTTATTATTATACTAAATTTTTATATC    235
Mirabilis       CCACGGC------GGA-GTCACCATTGACTCTATTTATTATTATGGTAAATTAGTATATC    228
Myrtillocactus  CCACTTCTACTTAAAATGTAAACATTGACTCTATTTATTATTATGGTAAATTAGTCTATC    224
Portulaca       CCACTTCTACTTAAAATGTCAACATTGACTCTATTTATTATTATAAAAAATTAGTCTATC    224
Dianthus        CCACGGC--------A-G--AA-ATTGACTCTCTTTATTATTATGGTAAATTAGTATATC    224
Silene          TTT-TT--GAGTAGGGCGG-AA-ATTGACTCTATTTATTATTATGGTAAATTAGTATATC  75979
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Fig. S1 Sequence comparison of portions of *rps3*. **a** Part of the nucleotide sequences of PCR products shown in Fig. 1a. The boundary between *rps3-ex1* and *rps3-ex2* is shown by a vertical line. **b** Part of the nucleotide sequences of PCR products shown in Fig. 1b. Sequence data of *Silene latifolia rps3* (HM562727) is included. Dashes are included for maximum matching. The boundary between *rps3-i* and *rps3-ex2* is indicated by a vertical line

```
                      e1                                                  e2
Beet              ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Portulaca         ATGGCACGAAAAGGAAATCCTATTTCGGTAAGGCTAGGGCTGAATCGTAGTTCAGATTCA    60
Myrtillocactus    ATGGCACGAAAAGGAAATCCGATTTCGGTCAGACTTGGGCTTAATCGTAGTTCTTCTTCT    60
Petunia           ATGGCACGAAAAGGAAATCCTATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Tobacco           ATGGCACGAAAAGGAAATCCTATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Sunflower         ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Arabidopsis       ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGGAAAAAATCGTAGTTCAGATTCA    60
Rapeseed          ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGGAAAAAATCGTAGTTCAGATTCA    60
Papaya            ATGGCACGCAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Oenothera         ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Watermelon        ATGGCACGAAAAGGAAATCCTATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Zucchini          ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Grape             ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Rice              ATGGCACGAAAAGGAAATCCAATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATCCA    60
Magnolia          ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATCCA    60

                     e3   e4                    e5
Beet              AGTTGGTTTAATGA TTATTATTATAGTAAATTAGTATATCAAGATCTCAATCTGAGATCT   120
Portulaca         AGTTGGTTTAGTGA|TTATTATTATAAAAAATTAGTCTATCAAGATATCAATCTCAGATCT   120
Myrtillocactus    TCTTGGTTCAGTGA|TTATTATTATGGTAAATTAGTCTATCAAGATATCAATCTCAGATCT   120
Petunia           AGTTGGTTTAGT---|TATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT   117
Tobacco           AGTTGGTTTAGTGA|TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT   120
Sunflower         AGTCGGTTCAGTGA|TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTTAGATCT   120
Arabidopsis       AGTCGGTTCAGTGA|GTATTATTATGGTAAATTTGTGTATCAAGATGTCAATCTGAGATCT   120
Rapeseed          AGTCGGTTCAGTGA|GTATTATTATGGTAAATTTGTGTATCAAGATGTCAATCTGAGATCT   120
Papaya            AGTTGGTTCAGTGA|TTATTATTATGGTAAATCGGTGTATCAAGATGTAAATCTGAGATCT   120
Oenothera         AGTTGGTTCAGTGA|TTATTATTATGGTAAATCAGTCTATCAAGATGTCAATCTGAGATCT   120
Watermelon        AGTCGGTTCAGTGA|TTATTATTATGGTAAATCACTGTATCAAGATGTCAATCTGAGATCT   120
Zucchini          AGTTGGTTCAGTGA|TTATTATTATGGTAAATCACTGTATCAAGATGTCAATCTGAGATCT   120
Grape             AGTTGGTTCAGTGA|TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT   120
Rice              AGTCGGTTCAGTGA|TTATTATTATGGTAAATCATTGTATCAAGATGTCAATCTTAGATCT   120
Magnolia          AGTCGGTTCAGTGA|TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT   120

                     e6
Beet              TATTTTGGTTCGATACGTCCACCTACGAGACTTACCTTTGGCTTTCGCCTCGGTAGGTGT   180
Portulaca         TATTTCGCTTCGATACGCCAACCCACGAGACTCACCTTTGGCTTTCGACTCGGTAGGTCT   180
Myrtillocactus    TATTTCGCTTCGATACGCCAACCCACGAGACTCACCTTTGGCTTTCGACTCGGTAGGTCT   180
Petunia           TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   177
Tobacco           TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Sunflower         TATTTCGGTTCGATACGTCCACCTACTAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Arabidopsis       TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTCGGCTTTCGTCTCGGTAGGTGT   180
Rapeseed          TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Papaya            TATTTCGGTTCGATACGTCCACCTACGAGACTAACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Oenothera         TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Watermelon        TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Zucchini          TATTTCGGTTCGATACGTCCACCTACGAGACTGACCTTTGGCTTTCGTCTTGGTAGGTGT   180
Grape             TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Rice              TATTTCAGTTCGATACGTCCACCTACGATACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Magnolia          TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
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                    e7
Beet              ATTATTATACATTTTCAAAAACGAACATTCATTAATTTCTTTCTTCCTCGTCGACCACAA   240
Portulaca         ATTATTATTCATTTTCAAAAGAGAACTTTCATTCATTTCTTTATTCCCCGTAGTCCACGA   240
Myrtillocactus    ATTATTATTCATTTTCAAAAGAGAACTGTAATTCATTTCTTTATTCCCCGTAGTCCACGA   240
Petunia           ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   237
Tobacco           ATTATTATACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Sunflower         ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Arabidopsis       ATTATTCTACATTTTCCTAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Rapeseed          ATTCTTCTACATTTTCCTAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Papaya            ATTATTCTACATTTTCCTAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Oenothera         ATTATTCTACATTTTCCCAAAAGAACATTTATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Watermelon        ATTATTTTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCTCGTCGACCACGA   240
Zucchini          ATTATTTTACATTTTCCCAAAATCACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Grape             ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCTCGTCGACCACGA   240
Rice              ATTATTCTACATTTTCCCAAAAGGACATTCATTCATTTCTTTCTTCCCCGTCGACCACTA   240
Magnolia          ATTATTCTACATTTTCCCAAAAGGACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
                                      e8    e9
Beet              CGACGGAAACGACGCAAAAAATCCAGACCCGGAAAGACGAAG------------------   282
Portulaca         CGAAATAAAAAAAGGGAAAAATCCAGACGCGAAAGGAAGAAGAAGATAGCAATG------   294
Myrtillocactus    CGAAAGAAAAAAGGGGAAAAATCCAGACGCGAAAGGAAGAAGAAGTACGCAATG------   294
Petunia           CGACTGAAACGACGCGAAAAATCCAGACCCGTAAAGGAGAAG------------------   279
Tobacco           CGACTGAAACGACGCGAAAAATCCAGACCCGTAAAGGAGAAG------------------   282
Sunflower         CGACAGAAACGACGCGAAAAATCCAGACCCGGAAAGGGGAAG------------------   282
Arabidopsis       CGACTGAAACGACGTGAAAAAACTAGACCCGGAAAGGAGAAG------------------   282
Rapeseed          CGACTGAAACGACGTGAAAAAACTAGACCCGGAAAGGAGAAG------------------   282
Papaya            CGACTGAAACGACGCAAAAAAACCAGACCCGGAAAGGAGAAG------------------   282
Oenothera         CGACTGAAACGAGGCAAAAAATCCAGACCCGGAAAGGAGAAG------------------   282
Watermelon        CGACTGAAACGACGCGAAAAATCCAAACCCGGAAAGGAGAAG------------------   282
Zucchini          GGACTGAAACGACGCGCAAAATCCAAACCCGGAAAGGATCAG------------------   282
Grape             GGACTGAAACGACGCGAAAAATCCAGACCCGGAAAGGAGAAG------------------   282
Rice              CGACTAAAACGACGCGACAAATCAAGACCCGGAAAGGATAAG------------------   282
Magnolia          CGACTGAAACGACGCGACAAATCAAGACCCGGAAACGTGA--------------------   280
                                                                 e10 e11
Beet              ------GGCCGGTGGTGGGA---ATTGGGG------AAAGTCGGGCCGATCGAGTGTCTT   327
Portulaca         AAGATTGCCCAGTGGTGGGA---ATTTGGGCCACCAAAAGTAGGGAAGATCGAATGTATT   351
Myrtillocactus    AAGATTGCCCAGTGGTGGGA---ATTTGGG------AAAGTAGGGAAGATCGAATGTCTT   351
Petunia           ------GGCCGGTGGGGGGC---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   324
Tobacco           ------GGCCGGTGGGGGGC---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   327
Sunflower         ------GGCCAGTGGTGGGC---ATTTGGT------AAAGTCGGGCCGATCGGGTGTCTT   327
Arabidopsis       ------GGCCGGTGGTGGACGACATTCGGG------AAAGCCGGGCCGATCGAGTGTCTT   330
Rapeseed          ------GGCCGGTGGTGGACGACATTCGGG------AAAGCCGGGCCGATCGGGTGTCTT   330
Papaya            ------GGCCGGTGGTGGACGACATTCGGG------AAAGTCGGGCCGATCGGGTGTCTT   330
Oenothera         ------GCCCGGTGGTGGGA---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   327
Watermelon        ------GGCCGGTGGTGGGC---ATTTGGG------AAAGTCGGGCCAATCGGGTGTCTT   327
Zucchini          ------GGCCGGTGGTGGGC---ATTTGGG------AAAGTCGGGCCAATTGGGTGTCTT   327
Grape             ------GGCCGGTGGTGGGC---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   327
Rice              ------GGCCGGTGGTGGGC---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   327
Magnolia          ------------------------------------------------------------   280
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Beet              TATTCAA------GCGAGGGTAGAAAAGAAGAACGAAACGAAGTGAGAGACCGAAGGGCC   381
Portulaca         TCTTCAACTTCTTTTTCCAGTCGAAAATCAGAAGGAAAGAAAGTGAGAGGCTTTTGTGCC   411
Myrtillocactus    TCTGAAACTTCTTTTTCCAGTCTACAAGAAGAAGGAAAGAAAGTGTTAGGCTTTTGTGCC   411
Petunia           CATTCAA------GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   378
Tobacco           CATTCAA------GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   381
Sunflower         CATTCAA------GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   381
Arabidopsis       CATTCAA------GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   384
Rapeseed          C------------GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   378
Papaya            CATTCAA------GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   384
Oenothera         CATTCAA------ACGATGATACAGAAGAAGAACGAAACGAAGTAGGAGGCCGGGGGGCA   381
Watermelon        CATTCAA------GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGAGGCA   381
Zucchini          CATTCAA------GTGACGATACAGAAGAAGAACGAAACAAAGTGAGAGGCCGGGAGGCA   381
Grape             CATTCAA------GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   381
Rice              CATTCAA------GCGAGGGTACAGAGGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA   381
Magnolia          ----------------------------------------------GAGGCCGGGGGGCA   294
                                                                      e12
Beet              GGGAAAAGAGTCGAGTCGAT---CAGGCTTGACGACCAGAAAAAGCAAAACGAAATCCGG   438
Portulaca         GGGAAAAGAGTTGAGTCGAT---CATGCTCGACGACCAGAAAAAGAAAAACGAAATCAGG   468
Myrtillocactus    GGGAAAAGAGTTGAGTCGAT---CATGCTCGACGACCAGAAAAAGAAAAACGAAATCAGG   468
Petunia           GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGATCGGGAGAAGCAAAACGAAATCAGG   435
Tobacco           GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGATCGGGAGAAGCAAAACGAAATCAGG   438
Sunflower         GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG   438
Arabidopsis       AGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAAAAGCAAAACGAAATCCGG   441
Rapeseed          AGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAGAAGCAAAACGAAATCCGG   435
Papaya            GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAGAAGCAAAACGAAATCCGG   441
Oenothera         GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG   438
Watermelon        GAGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAAAAGCAAAACGAAATTCGG   438
Zucchini          GAGAAAAGAGTGGAGTCGATGATCAGGCTCGACGACCGGGAAAAGCAAAACGAAATTAGG   441
Grape             GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAAGAAGG   438
Rice              GGGAAAAGAGTCGAGTCGAT---C----------GACCGGGAGAAGCAAAACGAAATCAGG   426
Magnolia          GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG   351
                         e13
Beet              GTTTGGCCAAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Portulaca         ATTTGGAAAAAAAAGAAGCAAGGCTATGGATACCATGACCGATCAACATCCATAAAGAAT   528
Myrtillocactus    ATTTGGAAAAAAAAGAAGCAAGGCTATGGATACCATGACCGATCAACATCCATAAAGAAT   528
Petunia           ATTTGGCCGAAAAAGAAGCAAGGCTATGGATACCATGACCGATCACCATCGATAAAGAAA   495
Tobacco           ATTTGGCCGAAAAAGAAGCAAGGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Sunflower         ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Arabidopsis       GGTTGGCCGAAAAAAAAACAACGCTATGGATACCATGACCGATTACCCTCGATAAAGAAG   501
Rapeseed          GGGTGGCCGAAAAAAAAACAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   495
Papaya            ATTTGGCCGAAAAAAAAGCAAGGCTATAGATACCATGACCGATCACCATCGATAAAGAAG   501
Oenothera         ATTTGGCCGAAAAAGAAGCAAGGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Watermelon        ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Zucchini          ATTTGGCCGAAAAAGAAGCAAGACTATGGATACCATGACCGATCACCATCGAGAAAGAAG   501
Grape             ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCAATCACCATCGATAAAGAAG   498
Rice              ATTTGGCCGAAAAAGATGCAACGTTATGGATACCATGACCGATCACCATCGAGAAAGAAG   486
Magnolia          ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGAGAAAGAAG   411
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                                e14
Beet              AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGAGGTT   558
Portulaca         CATCTTTCTAAAGAACTTCGGGGGAGCGGGGAATTAAAGCAGCCGAAATACGCAGAGGTT   588
Myrtillocactus    CATCTTTCGTCATCACTTCGGGGAAGCGGGGAATTAAAGCAGCCGAAATACGCAGAGGTT   588
Petunia           AATCTGTCTAAATCACTTCGTGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGATT   555
Tobacco           AATCTTTCTAAATCACTTCGTGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGATT   558
Sunflower         AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGCTT   558
Arabidopsis       AATCTTTCTAAATCACTTCGGATCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   561
Rapeseed          AATCTTTCTAAATCACTTCGGATCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   555
Papaya            AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAACTACGCCGGGGTT   561
Oenothera         AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   558
Watermelon        AATCTTTCTAAATTACTTCGCGTCAGCGGGGCCTTCAAGCATCCGAAATATGCCGGAGTT   558
Zucchini          AATCTTTCTAAATCACTTCGCGTCAGCGGGGCCTTCAAGCATCCGAAATATGCCGGAGTT   561
Grape             AATCTTTCTAAATTACTTCGGGTCAGCGGGGCCTTCAAGCATCTGAAATACGCCGGGGTT   558
Rice              AATTTTTCTAAATCACTTCGGGTGAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   546
Magnolia          AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   471

                                  e15                   e16 e17
Beet              GTAAATGACATAGCCTTTCTGATAGAAAATGATTCTTCCTTCAAAAAAACGAAGTTATTC   618
Portulaca         CTAAATAACATAGAATTTCTGATAGAAAAAAAATCTTCCTTCAAAAAAACGAAGTTATTC   648
Myrtillocactus    CTAAATAACATAGAATTTATGATCGAAAAAAAAGAATCCTTCAAAAAAACGAAGTTATTC   648
Petunia           GAAAATGACATAGCCTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACAAACTTATTC   615
Tobacco           GAAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACAAACTTATTC   618
Sunflower         GTAAATGACATAGCCCTCCTAAA------TGACGACTCCTTCAGAAAAACGAAGTTATTC   612
Arabidopsis       GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAAAAAAACGAAGTTATTC   621
Rapeseed          GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   615
Papaya            GTAAATGACATAGCGTCCCTGATAGAAAATGACGACTCCTTCCGAAAAACGAAGTTATTC   621
Oenothera         TTAAATGACATAGCCTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   618
Watermelon        GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   618
Zucchini          GTAAATGACATAGCGTTCCTGATCGAAAATGACGACTCCTTCAGAAAAACTCAGTTATTC   621
Grape             GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   618
Rice              GTAAATGACATAGCCTTCCTGA--------------------TAGAAAA------------   577
Magnolia          GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTCCAGAAAAACTAAGTTATTC   531

                                                  e18
Beet              AAGTTCTTTTTCCCAAAGAAGTCA---------CGCTACGACGGCCCGACAAGTCATCTA   669
Portulaca         AAGTTCTTTTTCAAAAAAACGAAGTACAG---CTACAAAAAAAAAACATCAAAGTCATCTA   705
Myrtillocactus    TTTTTCTTTTTCAAAAAAACGAAGTACAG---CTACAAAAAAAAAACATCAAAGTCATCCA   705
Petunia           AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACCGCCCGACGAGTCATCTA   666
Tobacco           AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACCGCCCGACGAGTCATCTA   669
Sunflower         AAGTTCTTTTTCTCAAAGAAGTCAAAGAAGTCCCCCTCCGACAGCCCGACGAGTCATCCA   672
Arabidopsis       AAGTTATTTTTCCAAAATAAGTC---------CCGCTCCGACGGCCCGACGAGTTATCTA   672
Rapeseed          AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTTATCTA   666
Papaya            AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGACCCGACGAGTCATCTA   672
Oenothera         AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTCATCTA   669
Watermelon        AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTCATCTA   669
Zucchini          AAGTTCTTTTTCCCAAATCAGTC---------CCGCTCCGACGGCCCGACGAGTCATCTA   672
Grape             AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTCATATA   669
Rice              ------------------------------------TGACGGCCCGACGAGTCATCTA   599
Magnolia          AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGGCGGCCCGACGAGTCATCTA   582
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                                                                e19
Beet              CTTAAAAGGACCCTCCCTGCAGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   729
Portulaca         CTTAAAAGGACACTCGCAGCAGTCAGACCTTCCTTCAATTATTTGGTCATGCAATACTTA   765
Myrtillocactus    CTTAAAAGGACACTCGCAGCAGTCAGACCTTCCTTCAATTATTTGGTCATGCAATACTTA   765
Petunia           CTTAAAAGGACCCTCCCCGCAGTCCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   726
Tobacco           CTTAAAAGGACCCTCCCCGCAGTCCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   729
Sunflower         CTTAAAAGGACCCTCCCTGCGGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   732
Arabidopsis       C------GGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTTTTTGGTCATGCAATACTTT   726
Rapeseed          C------GGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTTTTTGGTCATGCAATACTTT   720
Papaya            CTTAAAAGGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   732
Oenothera         CTTAAAAGGACCCCCCCTGCAGTGCGTCCCTCCTTGAATTATTCGGTCATGCAATACTAT   729
Watermelon        CTTAAAAGAACCCTCCCCGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   729
Zucchini          CTTAAAAGAACCCTCCCCGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   732
Grape             CTTAAAAGGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   729
Rice              CTAAAAAGGACCCTCCCCGCTGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTT   659
Magnolia          CTTAAAAGGACCCTCCCTGCTGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   642
                                                                      e20
Beet              TTGAATACAAAGAAAAAAATGCATTCCGATCCCGTCCTAGTTCTCAATCATTTCGTGGCA   789
Portulaca         TTCAATACAAAGAACAAAATACATTTCGATCCAGTACTAGTTCTAAATCATTTCGTCGAA   825
Myrtillocactus    TTCAATACAAAGAACAAAATACATTTCGATCCAGTAAGCGTTCGTCATCATTTCGTCGAA   825
Petunia           TTGAATACAAAGAACAAAATACATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   786
Tobacco           TTGAATACAAAGAACAAAATTCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   789
Sunflower         TTGAAGACAAAGAACCAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGAA   792
Arabidopsis       TTTAATACAAAGAACCAAATTAATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   786
Rapeseed          TTTAATACAAAGAACCAAATGAATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   780
Papaya            TTGAATACAAAGAACCAAATTCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   792
Oenothera         TTGAATACAAAGAACCAAATGCATTTCGACCCCCTCGTAGTTCTCAATCATTTCGTGGCA   789
Watermelon        TTGAATACAAAGAACAAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   789
Zucchini          TTGAATACAAAGAACAAAATGCATTTCGACCCCGTCGGAGTTCTCAATCATTTCGTGGCA   792
Grape             TTGAATACAAAGAACCAAATTCATTTCGACTCCGTCGTAGTTCTCAATCATTTCGTGGCA   789
Rice              TTTAATACAAAGAACAAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   719
Magnolia          TGGAATACAAAGAACAAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   702


Beet              CCGGGCGTGGTTGAACCATCCACGATGAATAGAGCTAATGCGCA---GGGAGGAAGCTTA   846
Portulaca         CCGGGAGTGCTTGAAACATCTACGATGAATAGAATACTAGTAAA---GGAAAGAAACTTA   882
Myrtillocactus    CCGGGAGTGCTTGAAACATCGCAGATGAATAGAATACGTTTAAA---GGAAAGAAACTGT   882
Petunia           CCGGGCGTGGCTGAACCATCTACGATGGGGGGGAGCTAATGCACA---GGGAAGAAGCTTA   843
Tobacco           CCGGGCGTGGCTGAACCATCTACGATGGGGGGGAGCTAATGCACA---GGGAAGAAGCTTA   846
Sunflower         CCGGGCGTGGTTGAACCATCTACCATGGGGGGGAGCTCATGCACA---GGGAAGAAGCTTA   849
Arabidopsis       CCGGGCGCCGCTGAACCATCTACGATGGGGAGAGCGAATGCACA---GGGAAGAAGCTTA   843
Rapeseed          CCGGGCGCGGCTGAACCATCTACGATGGGGAGAGCGAATGCACA---GGGAAGAAGCTTA   837
Papaya            CCGGGCGTGGCTGAACCATCTACGATGGGGAGAGCGAATGCACA---GGGAAGAAGCTTA   849
Oenothera         CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATCGACA---GGGAAGAAGCAAC   846
Watermelon        CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATACACA---GGGAAGAAGCTTA   846
Zucchini          CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATACACA---GGGAAGAAGCTTA   849
Grape             CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATGCACA---GGGAAGAAGCTTA   846
Rice              CCGGGTGTGGCTGAACCATCTACGATGGGGGGAGC------GAA---GGGAGGAAGCTTA   770
Magnolia          CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATGAACA---GGGAGGAAGCTTA   759
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Beet             GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTGGAAAGCTCGACCAGCCAGAAAAAG   906
Portulaca        GATAAGAGAATACCGTCTCGCATCGCTTTTTTTGTCGAAAGATCGAACAGCGAGAAAAAG   942
Myrtillocactus   CTTCAGAGAATACGTTCTCGCATCGCTTTTTTTGTCGAAAGATCGAACAGCGAGAAAAAG   942
Petunia          GATAAAAGAATAGCTTCTTGCATCGCTTTTTTTGTAGAAAACTCGACCAGCGAGAAAAAG   903
Tobacco          GATAAAAGAATACGTTCTTGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   906
Sunflower        GATAAGAGAATACGTT------TCGCTTTTTTTGTCGAAAGCTCGACCAGCGAGAAAAAG   903
Arabidopsis      CAGAAGAGAATACGTTCTCGTATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   903
Rapeseed         CAGAAGAGAATACGTTCTCGTATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   897
Papaya           GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   909
Oenothera        GAGTTGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACTAGCGAGAAAAAG   906
Watermelon       GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   906
Zucchini         GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   909
Grape            GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   906
Rice             GATAAGAGAATACGCTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   830
Magnolia         GATAAGAGAATACGCTCTCGCATCGGTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG   819

Beet             TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC   966
Portulaca        GATTTGACAGAAGAAAAAAAGAGCTTGACACACTTCATTCGAAAAAAAAATGATCTGCGA  1002
Myrtillocactus   GATTTGACAGAAGAAAAAAAGAGCTTGACACACTTCATTCGAAAAAAAAATGATCTGCGA  1002
Petunia          TGTTTGGCCGAAGCCAAAAAGAGGGTGACCCACTTTATTCGCCAAGCGAATGATCTTCGC   963
Tobacco          TGTTTGGCCGAAGCCAAAAAGAGGGTGACCCACTTTATTCGCCAAGCGAATGATCTTCGC   966
Sunflower        TTTTTGGCCGAAGACAAAAA---GTTGACCCACTTCATTCGCTGGTCGAATCATCCTCGC   960
Arabidopsis      TGTTTGGCCGAAGCCAAAAATAGGTTGACCCACTTCATTCGCTTGGCGAATGATCTTCGC   963
Rapeseed         TGTTTGGCCGAAGCCAAAAATAGGTTGACCCACTTCATTCGCTTGGCGAATGATCTTCGC   957
Papaya           TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC   969
Oenothera        AGTTTGGCCGAAGACAAAAAGGGGTTGCCCCACTTCATTCGCCAAGAGAATGATCTTCGC   966
Watermelon       TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGT   966
Zucchini         TGTTTGGCCGAACCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCAAATGATCTTCGT   969
Grape            TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC   966
Rice             TGTTTGGCCCGAGCCAAAAAGAGGTTGATCCACTTCATTCGCCAAGCGAATGATCTTCGC   890
Magnolia         TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC   879

Beet             TTCGCGGGAAGAAGAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC  1026
Portulaca        TTCGAGGGGGACAGAAAAAACCAACATACAACTCTTTCCTTTCTTCGGTGCTACCTTCTTC  1062
Myrtillocactus   TTCGAGGGGGACAGAAAAAACAACATACAACTCTTTCCTTTCTTCGGTGCTACCTTCTTC  1062
Petunia          TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTT  1023
Tobacco          TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTT  1026
Sunflower        TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC  1020
Arabidopsis      TTCGCGGGAACAACTAAAACCACCATCTCGCTCTTTCCATTCTTCGGTGCTACCTTTTTC  1023
Rapeseed         TTCGCGGGAACAACTAAAACCACCATCTCGCTCTTTCCATTCTTCGGTGCTACCTTTTTC  1017
Papaya           TTCGCGGGAACAACAAAAACCACGATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC  1029
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Watermelon       TTCGCGGGAACAACAAAAACAACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC  1026
Zucchini         TTCGCGGGAACAACAAAAACAACCATATCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC  1029
Grape            TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC  1026
Rice             TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTT   950
Magnolia         TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC   939
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                    e22
Beet                TTTCCAAGGGATGGAGTTAGAGTTTATAATAACCTGTTTTTTAAAGATGCCCGGGAACAA  1086
Portulaca           TTTCCAAGGGATGGAGTAAGAGTAAATAAGAACAAATTTCCAAAAAATGCAAGGGGACGA  1122
Myrtillocactus      TTTCCAAGGGATGGAGTAAGAGTCAATTCTAAAGAATTTCCAAAAAATGCAAGGGAACGA  1122
Petunia             TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGAGGATGCCCGGGAACAA  1083
Tobacco             TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGAGGATGCCCGGGAACAA  1086
Sunflower           TTTCCAAGGGATGGGGTTGGGGTGTATAAGAA---ATTTTTTGAGTATGCCCGGGAACAA  1080
Arabidopsis         TTTCTAAGAGATGGGGTTGGGGTGTATAATAACCTT---------GATGCTCGGGAACAA  1074
Rapeseed            TTTCTAAGAGATGGGGTTGGGGTGTATAATAACCTT---------GATGCCCGGGAACAA  1068
Papaya              TTTCTAAGAGATGGGGTTGGGGTGTATAAGAACCTTTTTTTTTGAGGATGCCCGGGAACAA  1089
Oenothera           TTTCCCAGGGATGGGGTTGGGGTGTATAAGCACCTTTTTTTTTGAGGATGCCCGGGAACAA  1086
Watermelon          TTTCCAAGGGATGGGGTTGGGATGTATAAAAACCTTTTTTTTTGAGGATACCCGGGAACAA  1086
Zucchini            TTTCCAAGGGATGGGGTTGGGATGTATAAAAACCTTTTTTTTTGAGGATACCCGGGAACAA  1089
Grape               TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTTGAGGATGCCCGGGAACAA  1086
Rice                TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCCATTTTTTGAGTATGCCCGGGAACAA  1010
Magnolia            TTTCCAAGGGATGGGGTTGGGGTGTATAAGGAACTCTTTCTTGAGGATGCCCGGGAACAA   999
                                                    e23
Beet                CTCCTAGGTCAATTAAGGATAAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG  1143
Portulaca           ATACTAAGAAAATTAAGGAGAAAATGTTGGAACCTCATGGGAAAGGA---TAAGGTAATG  1179
Myrtillocactus      ATAGACAGAAAATGTTGGAGAAAATGTTGGAACCTCATGGGAAAGGA---TAAGGTAATG  1179
Petunia             CTCCTAGGTCAATTAAGGAGAAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG  1140
Tobacco             CTCCTAGGTCAATTAAGGATAAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG  1143
Sunflower           CTCCTACGAAAATTCAGGAAAAAATGTTGGAACCTCATGGCTAAGGA---TAAGGTAATG  1137
Arabidopsis         CTCCTCAATCAATTAAGGGTCAAATGTTGGAACCTCGTGGGTAAGGA---TAAGATAATG  1131
Rapeseed            CTACTCAATCAATTAAGGGTCAAATGTTGGAACCTTTTGGGTAAGGA---TAAGGTAATG  1125
Papaya              CTCCTAGAAAAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG  1146
Oenothera           CTCCTAGGTCAATTAAGGATCAAATGTTGGAAGCTCATGGGTAAGGA---TAAGGTAATG  1143
Watermelon          CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATA  1143
Zucchini            CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGAGGATAAGGTAATA  1149
Grape               CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG  1143
Rice                CTCCTAGGTCAATTAAGGATCAAATGTAGGAACCTCATGGGTAAGGA---TAAGGTAATG  1067
Magnolia            CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---GAAGGTAATG  1056

Beet                AAATTGATAGAAAAATTCATAGATCTAGGTGGGATAAGAGAATTGATAAAGGGAATAGAG  1203
Portulaca           AAATTGATAGAAAAATTCATAGATCTGGGGGGGATAAGAGAATTGATAAAGGGAATAGAG  1239
Myrtillocactus      AAATTGATAGAAAAATTCATAGATAACGGGGGGATAAGAGAATTGATAAAGGGAGTAGAG  1239
Petunia             GAATTGATAGAGAAATTCATAGACCTAAATAGGATAGGAGAATTGATAAGGGGAATAGAG  1200
Tobacco             GAATTGATAGAGAAATTCATAGACCTAAATAGGATAGGAGAATTGATAAGGGGAATAGAG  1203
Sunflower           GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG  1197
Arabidopsis         GAATTGATAGAGAAATTAAAAAACCTAGGTGGGATAGAAGAATTGATAAAGGTAATAGAT  1191
Rapeseed            GAATTGATAGAGAAATTCAAAAACCTAGGTGGGATAGAAGAATTGATAAAGGTAATAGAT  1185
Papaya              GAATTGATAGAGAAATTGAGAAACCTAGGTAGGATAGAAGAATTGATAAAGGGAATAGAG  1206
Oenothera           GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG  1203
Watermelon          GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG  1203
Zucchini            GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG  1209
Grape               GAATTGATAGATAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG  1203
Rice                GAATTGATAGAGAAATTCATCTACCTAGGTAGGATAGGCAAATTGATAAAGGGAATAGAG  1137
Magnolia            GAATTGATAGAGAAATTCATAGACCTAGGTAGGATAGGAGAATTGATAAAGGGAATAGAG  1116
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                                                                    e24
Beet              ATGATGATAGAGATCATACTGAAAAACATAAGAATTGCTTACGGGTCTAACTCTTATTTG  1263
Portulaca         ATGATGATAGAGATCATACTCAAAAACAGAAGAATTCCCTACGGGTACAACTCGTATTTG  1299
Myrtillocactus    ATGATGATAGAGATCATACTCAAAAACAGAAGAATTCCCTACGGGTACAACTCGTATTTG  1299
Petunia           ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTATTATTTG  1260
Tobacco           ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTATTATTTG  1263
Sunflower         ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTTTTATTTG  1257
Arabidopsis       ATGATGATAGAGATCATACTGAGAAAGAGAGGAATTCCGTACAGGTACAACTCTTATTTT  1251
Rapeseed          ATGATGATAGAAATCATACTGAGAAAGAGAGGAATTCCGTATAGGTACAACTCTTATTTT  1245
Papaya            ATGATGATAGAGATCATATTGAGAAAGAGCAAAATTCCGTACAGGTACAACTCTTATTTA  1266
Oenothera         ATAATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTCTTATTTG  1263
Watermelon        ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTATGGGTACAACTCTTATTTG  1263
Zucchini          ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTATGGGTACAACTCTTATTTG  1269
Grape             ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTCTTATTTG  1263
Rice              ATGATGATAGAGATCATACTGAGAAAGAGGATAATTCCGTACGGGTACAACTCTTATTTG  1197
Magnolia          ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTCTTATTTG  1176

                         e25
Beet              AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  1323
Portulaca         AACGAAGTCAAAAAAATGAGATCTTTCTTAGCTAATAGAACAAAGACTAATACCTTAATA  1359
Myrtillocactus    AACGAAGTCAAAAAAATGAGATCTTTCTTAGCTAATAGAACAAAGACGTCTACCTTAATT  1359
Petunia           AACGAAGTGAAAAAAATGCGATCTTTGTTGTATAATAGAACAAACACTAATACCTTAATT  1320
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Arabidopsis       TACGAAGTCAAAAAAATGCGATCTTTCTTGTCTAATAGAACAAACACTAAGACCTTAATT  1311
Rapeseed          TACGAAGTAAAAAAAATGCGATCTTTCTTGTCTAATAGAACAAACACTAAGACCTTAATT  1305
Papaya            AACAAAGTCAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  1326
Oenothera         AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCATAATT  1323
Watermelon        AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT  1323
Zucchini          AACGAAGTGCAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT  1329
Grape             AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  1323
Rice              AACGAAGTGCAAAAAATGCGATCTTTTTTGTCTAATAGAACAAACACTAATACCTTAATT  1257
Magnolia          AACGAAGTGCAAAAAATTCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  1236

                                              e26      e27
Beet              GAATCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATATCT  1383
Portulaca         TCATCGAAAAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATATCT  1419
Myrtillocactus    GAATCGAAAAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATATCA  1419
Petunia           GAATCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1380
Tobacco           GAATCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1383
Sunflower         GAGTCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGATATCTCT  1377
Arabidopsis       GAGTCAGTCAAAATAAAATCTGTTTATCAAAGCGCTTCTCCGATTGCTCAAGACATCTCT  1371
Rapeseed          GAGTCAGTCAAAATAAAATCTGTTTATCAAAGCGCTTCTCTGATTGCTCAAGACATCTCT  1365
Papaya            GAGTCGGTCAAAATCAAATCTGTTTATCAAAGCGCTTCTCCGATTGCTCAAGACATCTCT  1386
Oenothera         GAGTCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1383
Watermelon        GAGTCAGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1383
Zucchini          GAGTCAGTCAAGATCCAATCCGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1389
Grape             GAGTCGGTCAAGATAAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1383
Rice              GAGTCGGTAAAGATCAAATCTGTTTATCAAAGTGCTTCTCTGATTGCTCAAGACATCTCT  1317
Magnolia          GAGTCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT  1296
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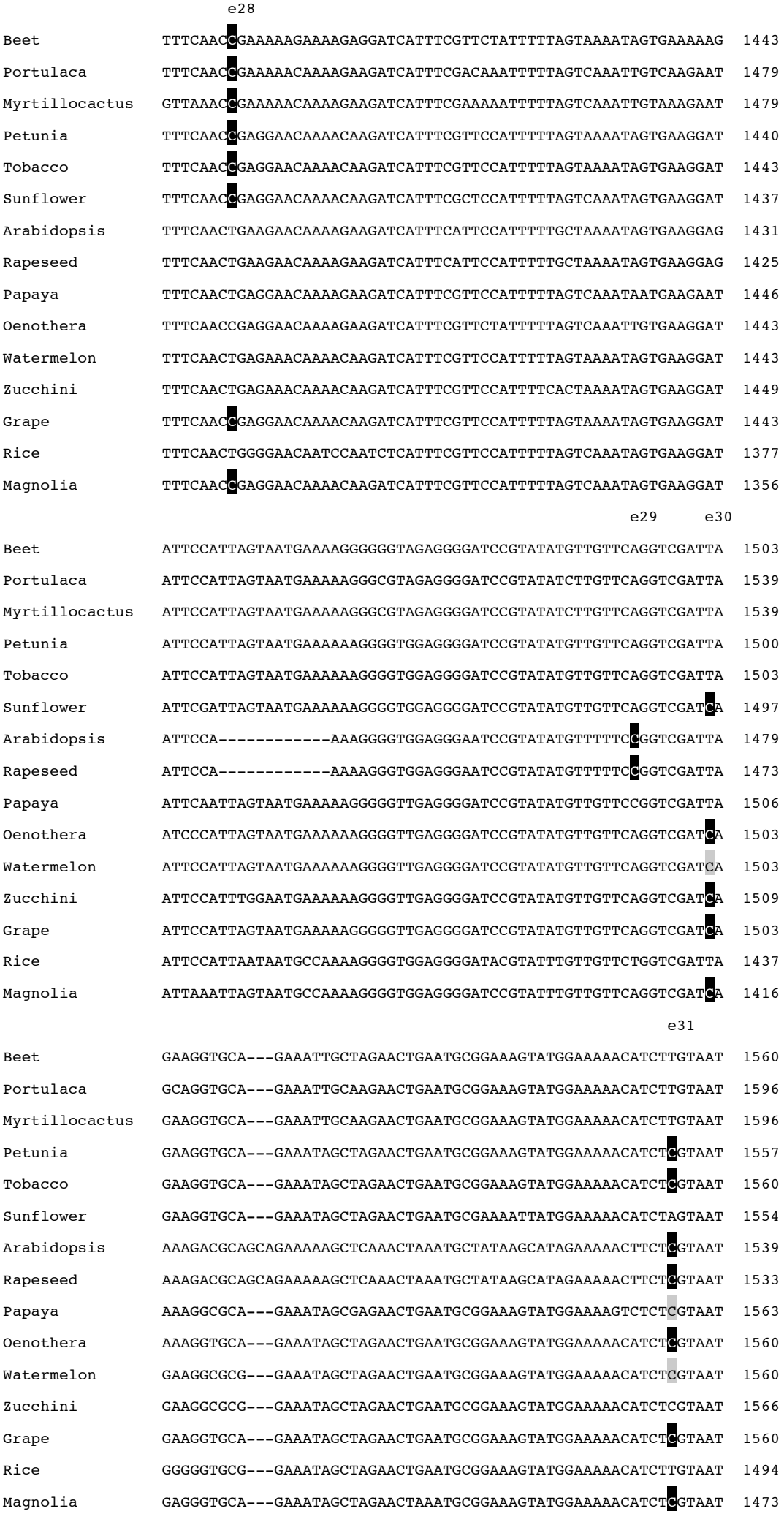
e28
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Portulaca TTTCAACCGAAAAACAAAAGAAGATCATTTCGACAAATTTTTAGTCAAATTGTCAAGAAT 1479
Myrtillocactus GTTAAACCGAAAAACAAAAGAAGATCATTTCGAAAAATTTTTAGTCAAATTGTAAAGAAT 1479
Petunia TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT 1440
Tobacco TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT 1443
Sunflower TTTCAACCGAGGAACAAAACAAGATCATTTCGCTCCATTTTTAGTCAAATAGTGAAGGAT 1437
Arabidopsis TTTCAACTGAAGAACAAAAGAAGATCATTTCATTCCATTTTTGCTAAAATAGTGAAGGAG 1431
Rapeseed TTTCAACTGAAGAACAAAAGAAGATCATTTCATTCCATTTTTGCTAAAATAGTGAAGGAG 1425
Papaya TTTCAACTGAGGAACAAAAGAAGATCATTTCGTTCCATTTTTAGTCAAATAATGAAGAAT 1446
Oenothera TTTCAACCGAGGAACAAAAGAAGATCATTTCGTTCTATTTTTAGTCAAATTGTGAAGGAT 1443
Watermelon TTTCAACTGAGAAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT 1443
Zucchini TTTCAACTGAGAAACAAAACAAGATCATTTCGTTCCATTTTCACTAAAATAGTGAAGGAT 1449
Grape TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT 1443
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e29
e30
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Petunia ATTCCATTAGTAATGAAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTCAGGTCGATTA 1500
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Rice ATTCCATTAATAATGCCAAAAGGGGTGGAGGGGATACGTATTTGTTGTTCTGGTCGATTA 1437
Magnolia ATTAAATTAGTAATGCCAAAAGGGGTGGAGGGGATCCGTATTTGTTGTTCAGGTCGATCA 1416
e31
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Portulaca GCAGGTGCA---GAAATTGCAAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT 1596
Myrtillocactus GAAGGTGCA---GAAATTGCAAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT 1596
Petunia GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT 1557
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Arabidopsis AAAGACGCAGCAGAAAAAGCTCAAACTAAATGCTATAAGCATAGAAAAACTTCTCGTAAT 1539
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Watermelon GAAGGCGCG---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT 1560
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Magnolia GAGGGTGCA---GAAATAGCTAGAACTAAATGCGGAAAGTATGGAAAAACATCTCGTAAT 1473

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                                          e32e33e34    e35              e36
Beet              GTATTACACCAGAAAATTGATTATGCTTCTGCGGAAGTATCTACTCGTTACGGAATCGTA  1620
Portulaca         GTATTAGACCAGAAAATCGATTATGCTTCTGCGGAAGTATCTACTCGTTACGGAATCTTA  1656
Myrtillocactus    GTATTAGACCAGAAAATCGATTATGCTTCTGCGGAAGTATCTACTCGTTACGGAATCTTA  1656
Petunia           GTATTTAACCAGAAAATAGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA  1617
Tobacco           GTATTTAACCAGAAAATAGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA  1620
Sunflower         GTATTTAACCAGAAAATAGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA  1614
Arabidopsis       GTATTTAACCATAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA  1599
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Papaya            GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTTA  1623
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Watermelon        GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTATGGAATCTCA  1620
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Grape             GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA  1620
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Magnolia          GTATTTCACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA  1533
                               e37
Beet              GGTGTCAAAGTGTGGATTTCTTATAGTCCAAAATAA                         1656
Portulaca         GGTGTCAAAGTGTGGATTTCTTATAGTCAAAAATGA                         1692
Myrtillocactus    GGTGTCAAAGTGTGGATTTCTTATAGTCAAAAATGA                         1692
Petunia           GGTGTCAAAGTGTGGATTTCTTATAGTAAAAAAAAAAAGGGACGTGCTATATCCGAAACG 1677
Tobacco           GGTGTCAAAGTGTGGATTTCCTATAGTAAAAAAAAAAAGGGACGTGCTATATCCGAAACG 1680
Sunflower         GGTGTCAAAGTGTGGATTTCATATAGTCAAAAAGAAAGGGGACGTGCTATATCCGAAACG 1674
Arabidopsis       GGTGTCAAAGTGTGGATTTCATATAGTCAAAAAAAAGGGAGACGTGCTATATCCGAAACG 1659
Rapeseed          GGTGTCAAAGTGTGGATTTCATATAGTCAAAAAAAAGGGGGACGTGCTATATCCGAAACG 1653
Papaya            GGTGTCAAAGTGTGGATTTCATATAGTTAA                               1653
Oenothera         GGTGTCAAAGTGTGGATTTCTTATAGTAAGTAA                            1653
Watermelon        GGTGTCAAAGTGTGGATTTCATATAAAAAAAAAAAAAAGGAACGTGTTATATCCGAAACG 1680
Zucchini          GGTGTCAAAGTGTGGATTTCATATAAAAAACAAAAAAAGGAACGTGTTATATCCGAAACG 1686
Grape             GGTGTCAAAGTGTGGATTTCATATAGTAAAAAAAAAAAGGGACGTGCTATATCCGAAACG 1680
Rice              GGTGTCAAAGTGCGGATCTCATATAGTCAAAATAAGAAGGGACGTGCTATATCCGAAACG 1614
Magnolia          GGTGTCAAAGTGCGGATCTCATATAGTAAAAAAAAATAA                      1572


Petunia           TACGAAATATAG  1689
Tobacco           TACGAAATATAG  1692
Sunflower         TACGAAATCTAG  1665
Arabidopsis       TACGAAATATAG  1671
Rapeseed          TACGAAATATAG  1671
Watermelon        TACGAAATATAG  1692
Zucchini          TACGAAATATAG  1698
Grape             TACGAAATATAG  1692
Rice              TACGAAATATAG  1626
```

Fig. S2 Nucleotide sequence alignment of *rps3*-coding regions of sugar beet (Beet), *Portulaca grandiflora* (Portulaca), *Myrtillocactus geometrizans* (Myrtillocactus), grapevine (Grape), *Arabidopsis thaliana* (Arabidopsis), rapeseed, *Oenothera berteriana* (Oenothera), sunflower, watermelon, zucchini, petunia, tobacco, papaya, *Magnolia x soulangeana* (Magnolia) and rice.

Nucleotide residues are numbered from the first base of the initiation codon. Exon/intron boundaries are indicated by vertical lines. Intronic sequences are not considered. Dashes are included for maximum matching. Editing sites are highlighted in black (experimentally confirmed) or gray (predicted), and numbered from e1 to e37. Sources of the data are Matsunaga et al. (Plant Cell Reports, 2011 30: 231-238) and others shown in Table S1