Molecular Breeding for Fruit Quality Challenges and Opportunities

Why fruit quality?

Flavor is generally accepted to be poor. Improved flavor can impact eating habits and therefore, health.

Fruits and vegetables are the major source of micronutrients in the diet. Up to 50% of the world's population suffers from micronutrient malnutrition (WHO).

Quality fruits and vegetables present significant opportunities for profit and diversification.

The concept of “quality” involves manipulation of secondary metabolite pathways. The major issues are:

Defining the targets – which compounds are really important?

Nearly 60% of the compounds in a tomato fruit are unidentified

Developing a reliable assay system that minimizes environmental influences

Defining the targeted metabolic pathways

Defining the genes controlling those pathways

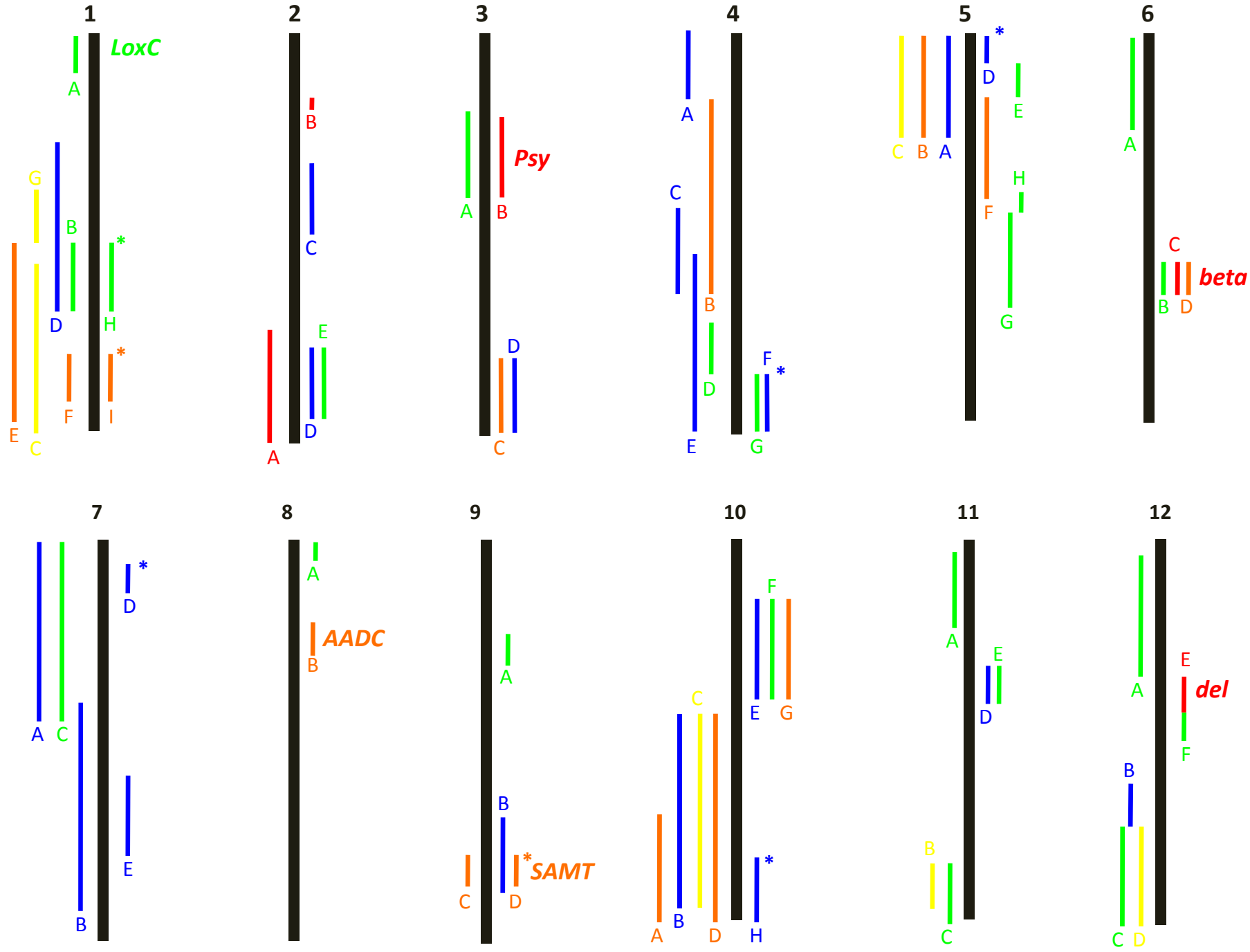
Successful metabolic engineering

The cost of accurate phenotyping greatly exeeds cost of genotyping

THE CHEMICAL CONSTITUENTS OF TOMATO FLAVOR

Sugars: glucose, fructose
Acids: citrate, malate, ascorbate
Volatiles: derived from carotenoids, lipids, amino acids

Volatile	[ppb]	Precursor	Odor
cis-3-hexenal	12,000	lipid	tomato/green
β-ionone	4	carotenoid	fruity/floral
hexanal	3,100	lipid	green/grassy
β-damascenone	1	carotenoid	fruity
1-penten-3-one	520	lipid	fruity floral/green
2+3-methylbutanal	27	Ile/Leu	musty
trans-2-hexenal	270	lipid	green/grassy
2-isobutylthiazole	36	Ile?	tomato vine
1-nitro-2-phenylethane	17	Phe	musty, earthy
trans-2-heptenal	60	lipid	green/grassy
phenylacetaldehyde	15	Phe	floral/alcohol
6-methyl-5-hepten-2-one	130	carotenoid	fruity, floral
cis-3-hexenol	150	lipid	green/grassy
2-phenylethanol	1,900	Phe	nutty, floral
3-methylbutanol	380	Leu	earthy, musty
methyl salicylate	48	chorismate	wintergreen


1
LoxC
2
3
Psy
4
5
6
beta
7
8
AADC
9
SAMT
10
11
12
del

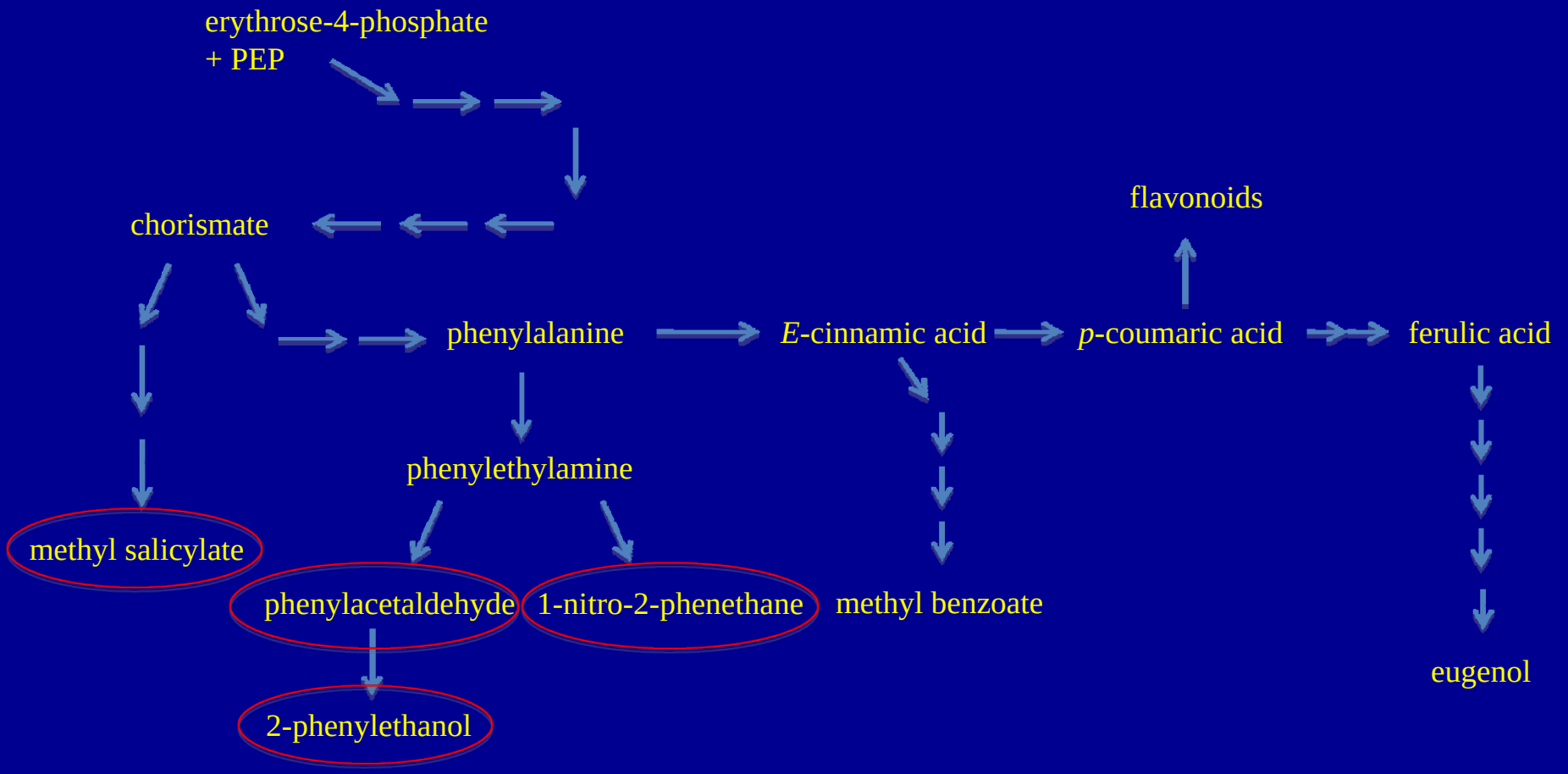
The next steps: How **do we convert this information into valuable materials?**

Sequences of genes and SNPs are far and away the limiting step at present.

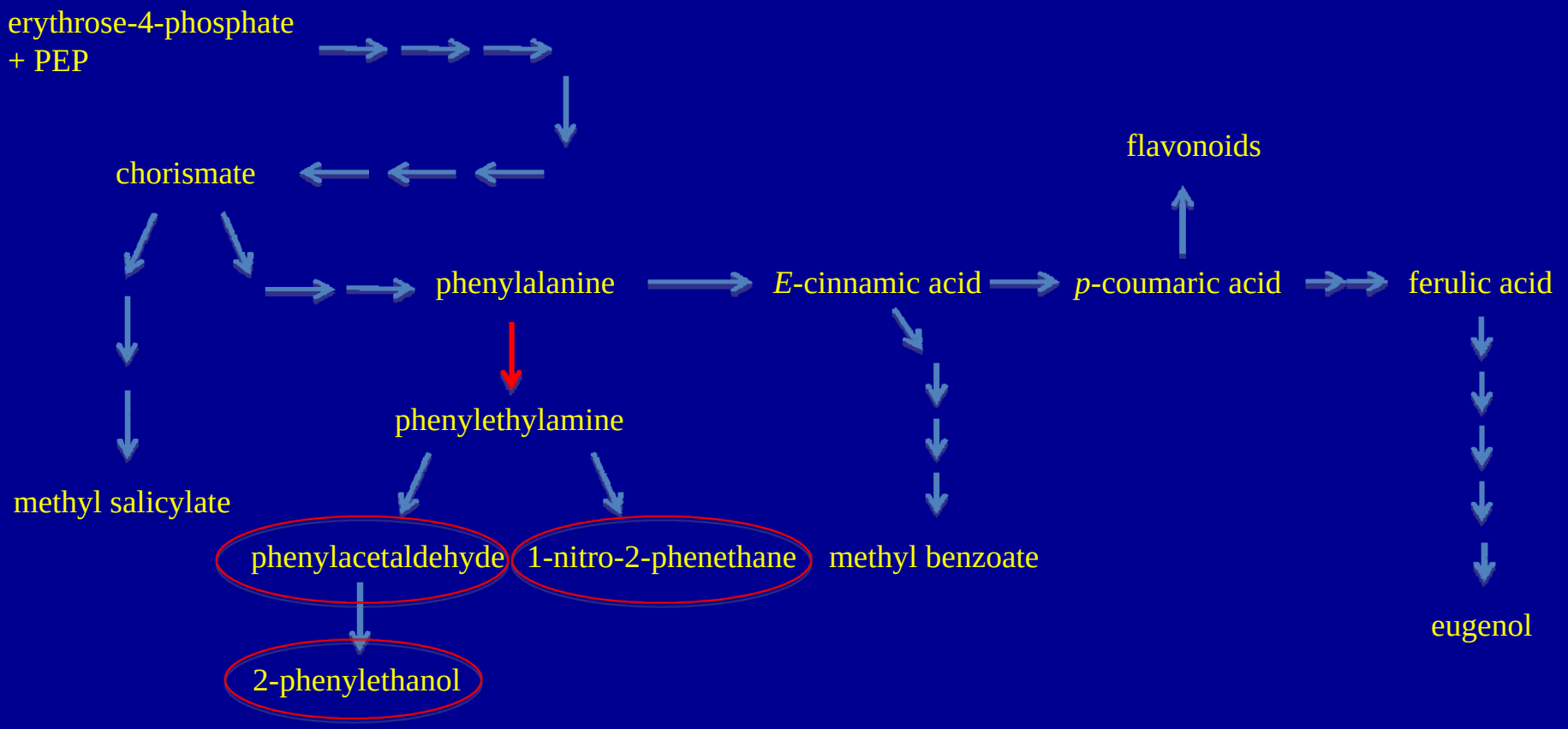
For non-transgenic approaches to quality improvement, there is very little genetic diversity in breeding materials.

For transgenic approaches, knowledge of pathway regulation will severely restrict progress.

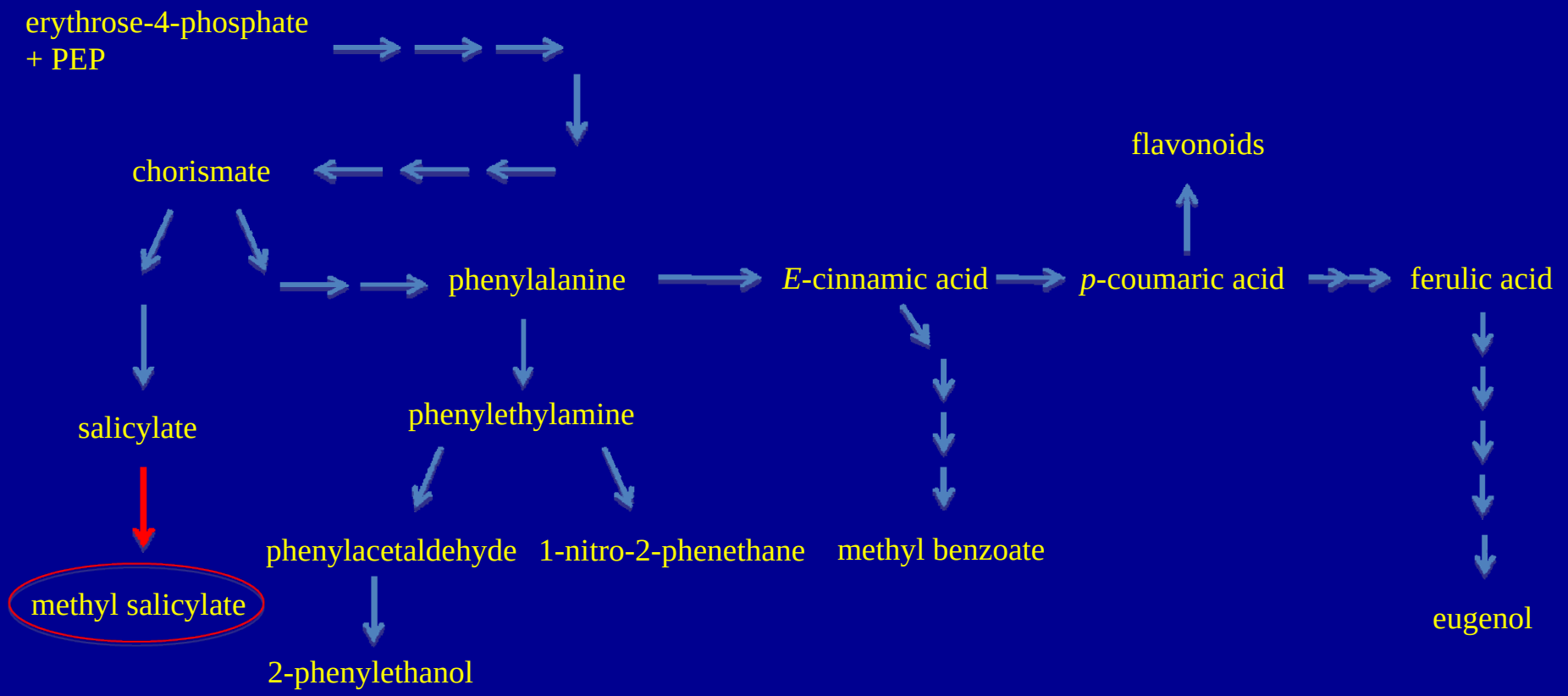
Some examples



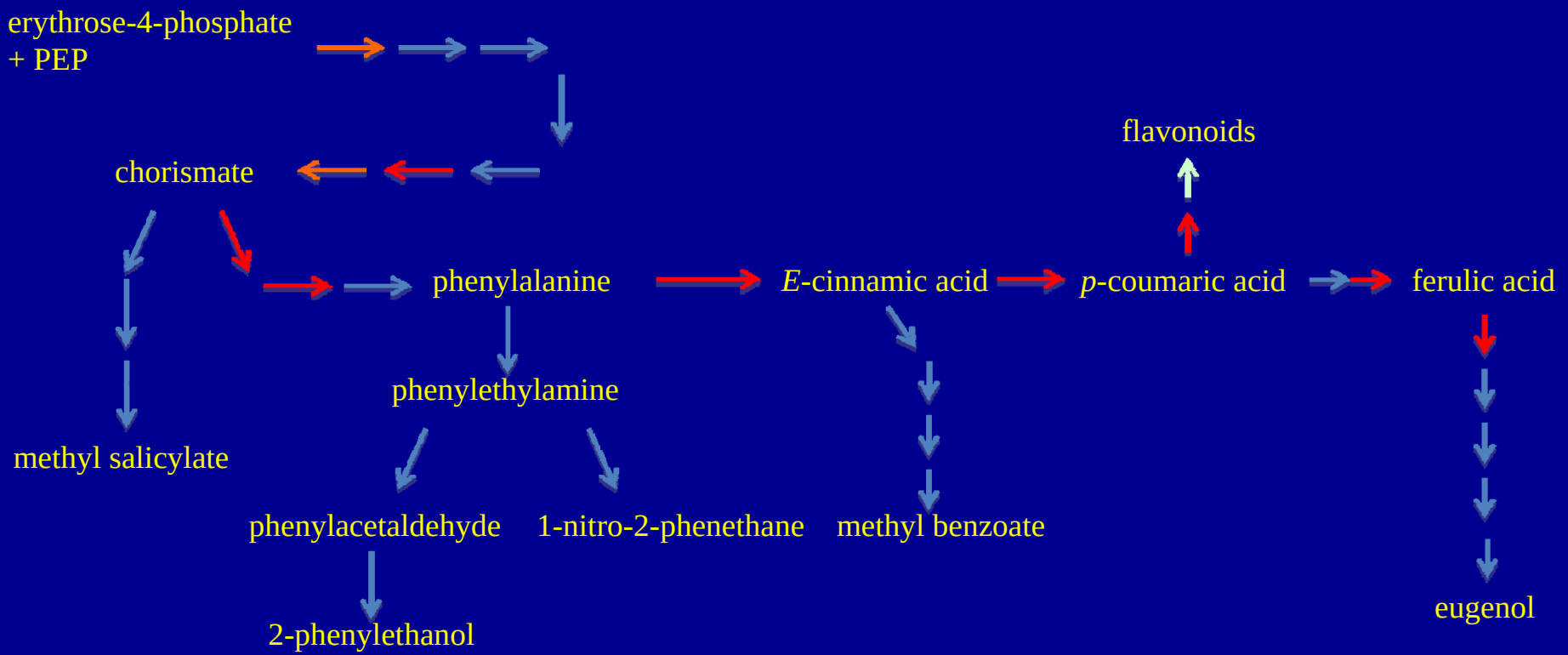
Engineering the first step in a pathway



Engineering the last step in a pathway



Engineering transcriptional control of the entire shikimate pathway



Discussion points – what's limiting?

Separating genetics from environment. Reliable, high-throughput assays of complex phenotypes.

Sequences and alleles of genetic variants. You can't select what's not there.

Basic understanding of pathways and their regulation. How do we break through an iterative process?

A biochemical database for diverse germplasm

L. esculentum

L. pennellii

L. hirsutum