The art/science of experimental evolution

Christopher Marx

Organismic and Evolutionary Biology
FAS Center for Systems Biology
Harvard University
cmarx@oeb.harvard.edu
www.oeb.harvard.edu/faculty/marx/

Experimental evolution: basics and examples

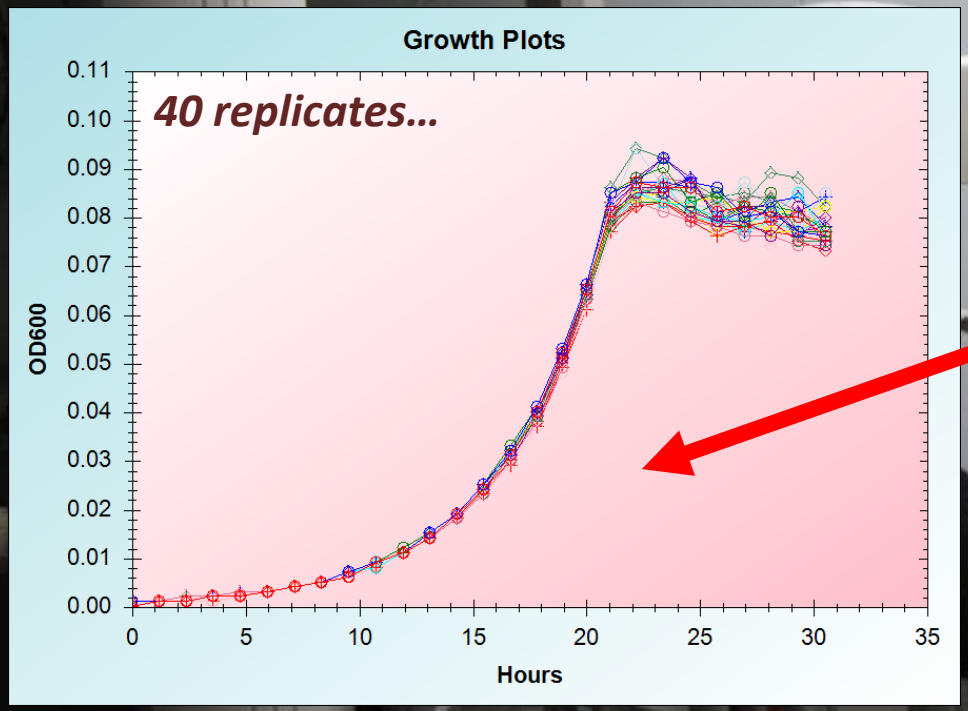
1. How cultures are started and why
2. Bacterial growth and fitness competitions
3. Identifying beneficial mutations via genome resequencing
4. Mutations are not just SNPs
5. Selective coefficients of mutations are not constants, but functions of other competitors, environment, and other alleles (*i.e.*, epistasis)

Establishing populations: Lenski LTs as example

Dynamics of bacterial growth

High-throughput culturing…

Automated, robotic growth system



(Miki Lee, Nigel Delaney, Lewis Ward)

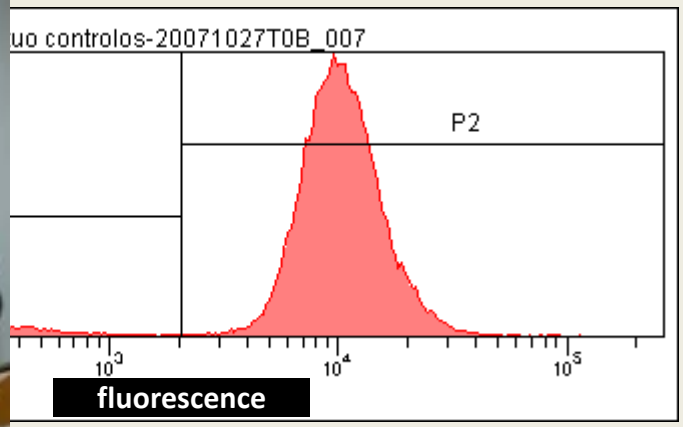
Fitness determined via competitions

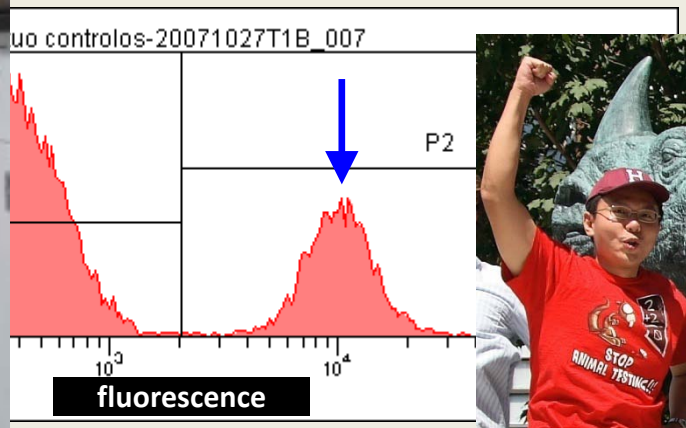
Fluorescent fitness assay

The alternative…

v Cytometry

Fluor. ancestor



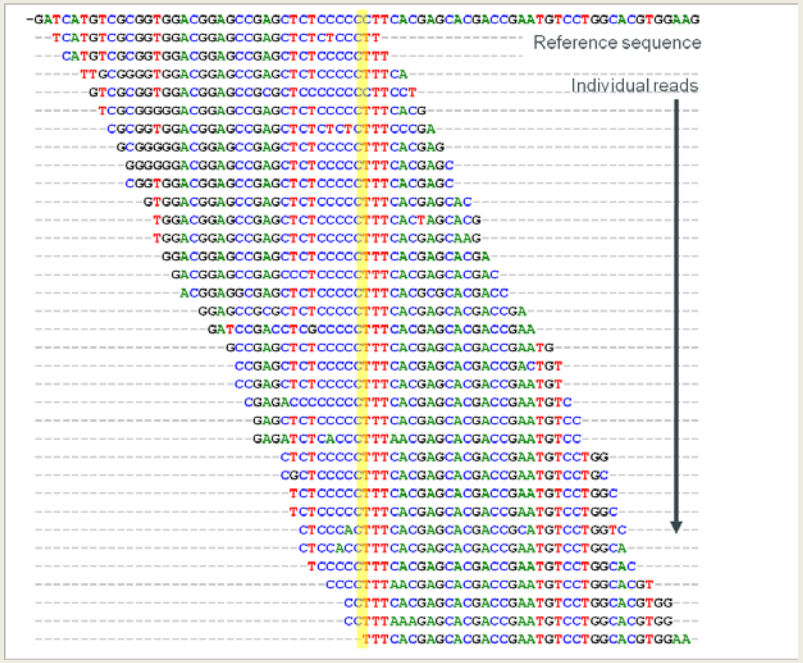


(David Chou)

(Lee et al., 2009. Evolution)

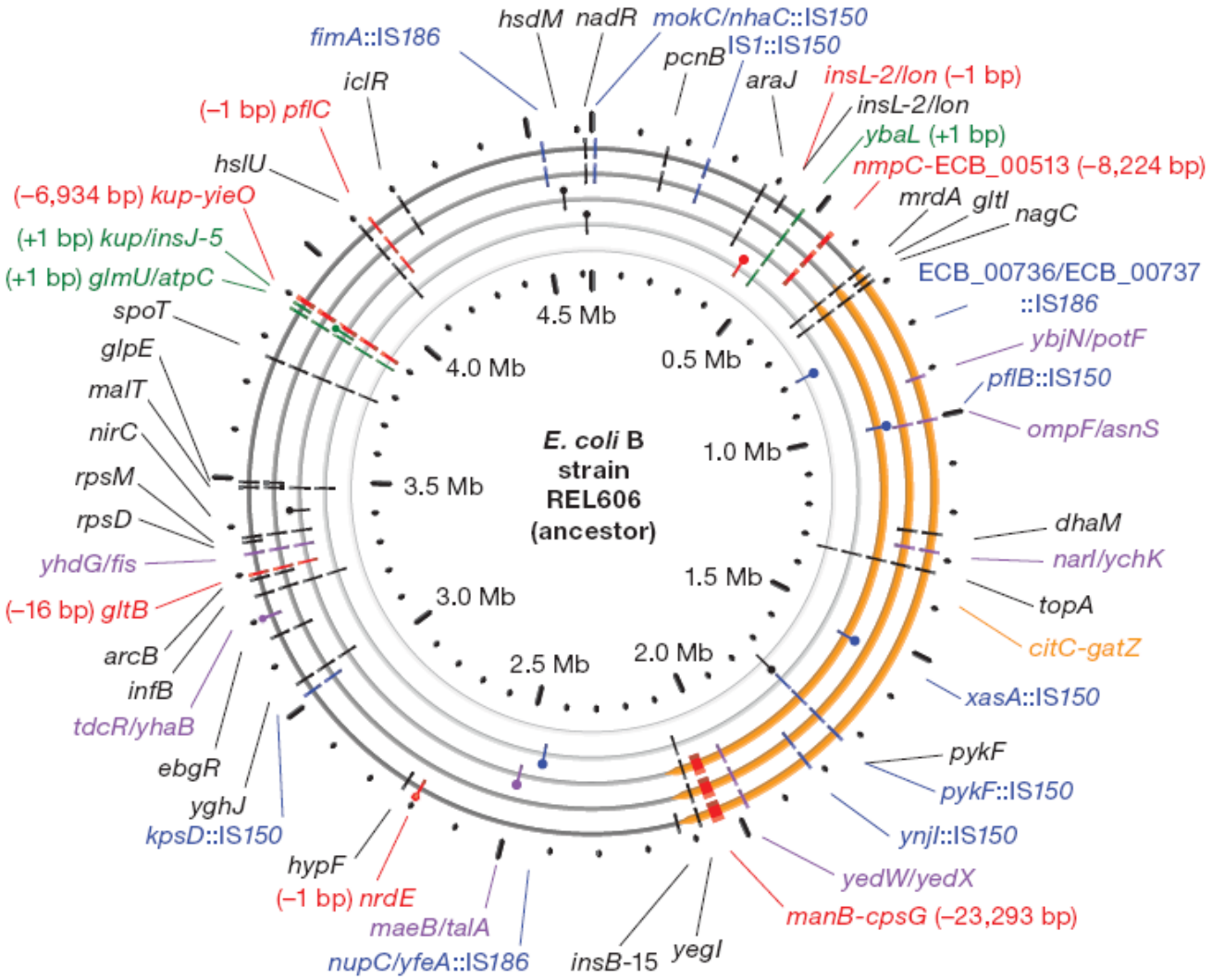
Calculating fitness (W) and dynamics of W_{ave}

Genetic basis via re-sequencing



(Nigel Delaney)

Sequence data from 20K gen. *E. coli* isolate



(Barrick et al., 2009. Nature)

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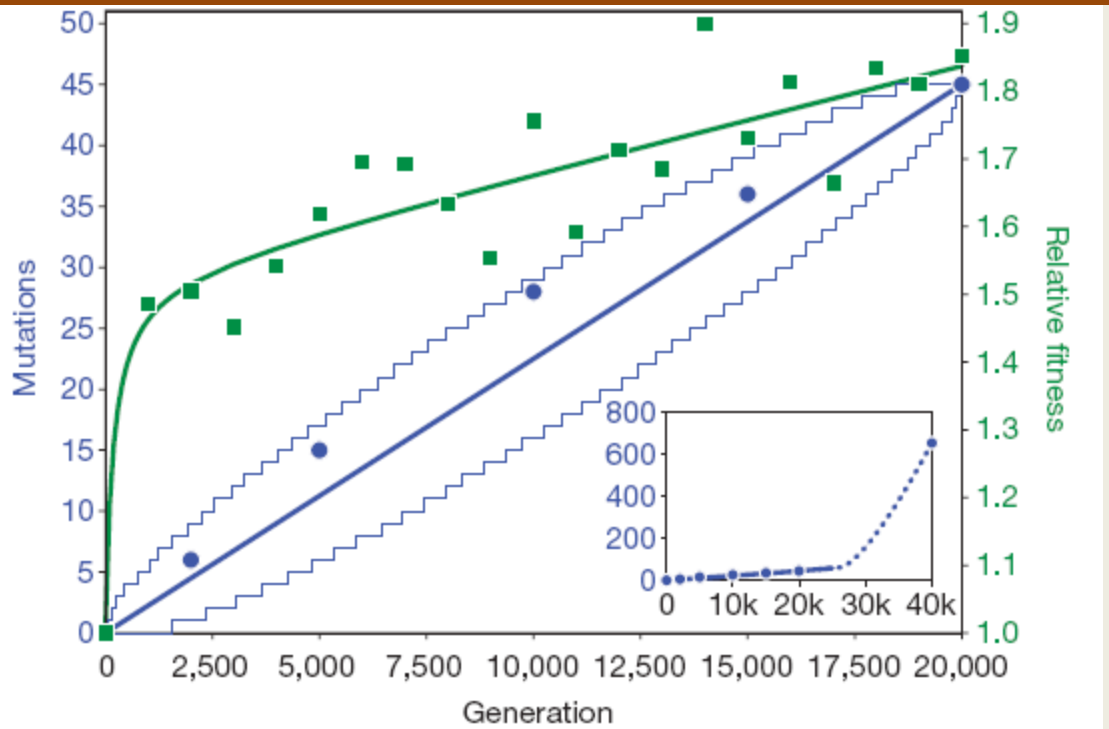


Table 1 | Frequency of parallel mutations in 11 other independently evolved lines

Gene or region	Function	Parallel mutations (%)	Source
nadR	Transcriptional regulator	100	Ref. 42
pykF	Pyruvate kinase	100	Ref. 42
rbs operon	Ribose catabolism	100	Ref. 43
malT	Transcriptional regulator	64	Ref. 44
spoT	Stringent response regulator	64	Ref. 31
mrdA	Cell-wall biosynthesis	45	Ref. 42
infB	Translation initiation factor 2	45*	This study
fis	Nucleoid-associated protein	27	E. Crozat, D.S., unpublished
topA	DNA topoisomerase I	27	E. Crozat, D.S., unpublished
pcnB	Poly(A) polymerase	27	This study
ompF	Outer-membrane porin	18*	This study
rpsD	30S ribosomal protein	18*	This study
rpsM	30S ribosomal protein	0	This study
glmU promoter	Cell-wall biosynthesis	0	M. Stanek, R.E.L., unpublished

* In addition to populations with substitutions, one or more others were polymorphic.

Table 2 | Tests of fitness effect in competition between isogenic constructs

Gene or region	Fitness effect (%)	Significance	Source
topA	13.3	***	Ref. 32
*pykF**	11.1	***	D.S., R.E.L., unpublished
spoT	9.4	***	Ref. 31
nadR†	8.1	***	D.S., R.E.L., unpublished
glmU promoter	4.9	***	M. Stanek, T. Cooper, R.E.L., unpublished
fis	2.9	***	Ref. 32
rbs operon†	2.1	***	Ref. 43
malT	0.4	**	Ref. 44
ompF‡	−9.7	**	D.S., R.E.L., unpublished

(Barrick et al., 2009. Nature)

Selective coefficients are functions, not constants

Selective effect (*s*) can be determined by constructing a strain with particular evolved allele

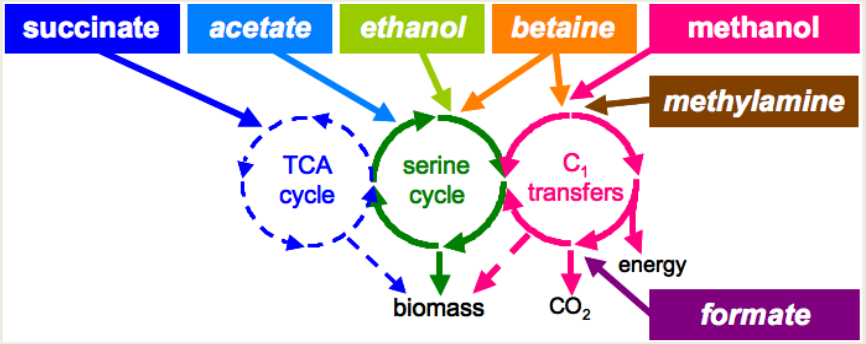
s is not a constant, but can depend upon several factors:

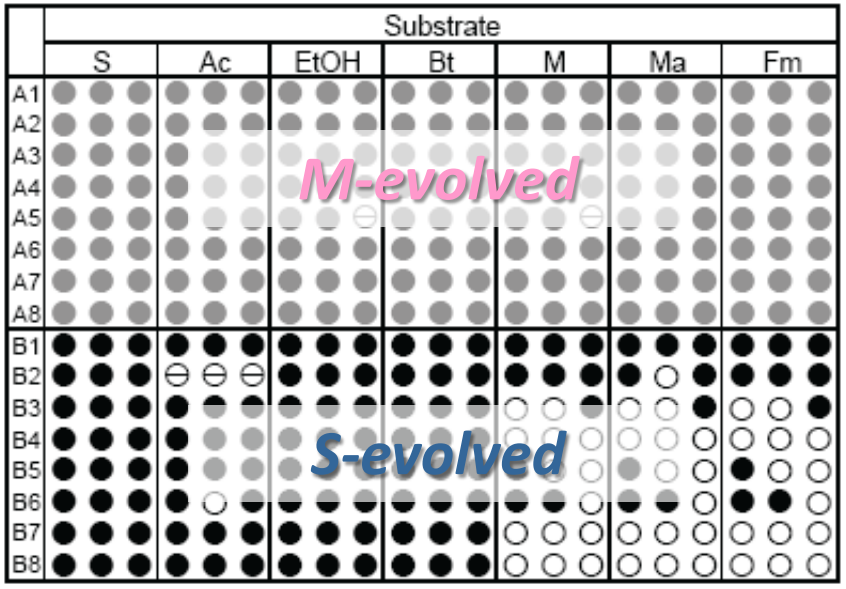
1. Identity and frequency of other competitors (*i.e.*, non-transitive)
2. The selective environment (*i.e.*, GxE interaction)
3. Other alleles (*i.e.*, epistasis or 'GxG')

Fitness as a function of frequency

An example of tradeoffs: *Methylobacterium*

- *Evolved 8 populations on methanol (C_1) or succinate (multi-C) for 1500 generations*
- *Examined substrate use*
- *Half of S-evolved populations lost C_1 use!*
  - *C_1 use quite labile*
  - *Nonmethylobacterium erlenmeyeri?*





(Lee et al., 2009. Evolution)

Other research interests I'd love to discuss…

- Predicting fitness consequences, optimality and epistasis in metabolism
- Selective basis of codon bias
- Determining qualities of the DFE and rate of beneficial mutations
- HGT and evolution – in particular of metabolism and transposable elements
- Cooperation and coevolution in spatially-structured, synthetic microbial consortia

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MARX LAB

Not shown:
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