Selection

Owing to this struggle for life, variations, however slight and from whatever cause proceeding, if they be in any degree profitable to the individuals of a species, in their infinitely complex relations to other organic beings and their physical conditions of life, will tend to the preservation of such individuals and will generally be inherited by the offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of a species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term Natural Selection.

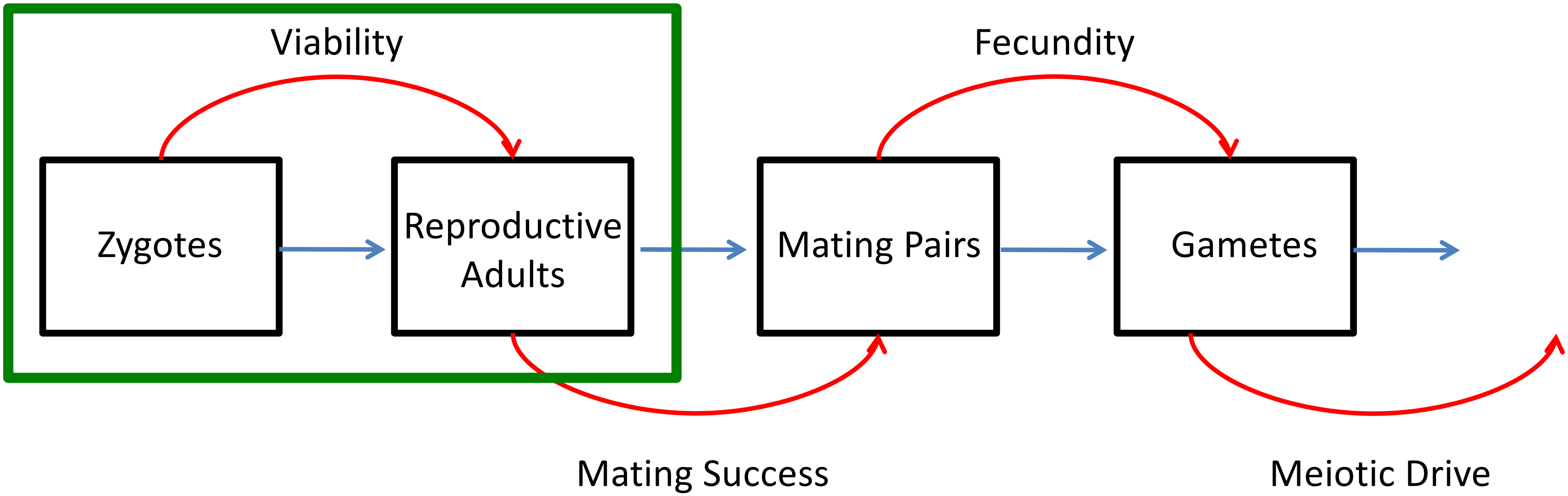
Charles Darwin, The Origin of Species (1859)

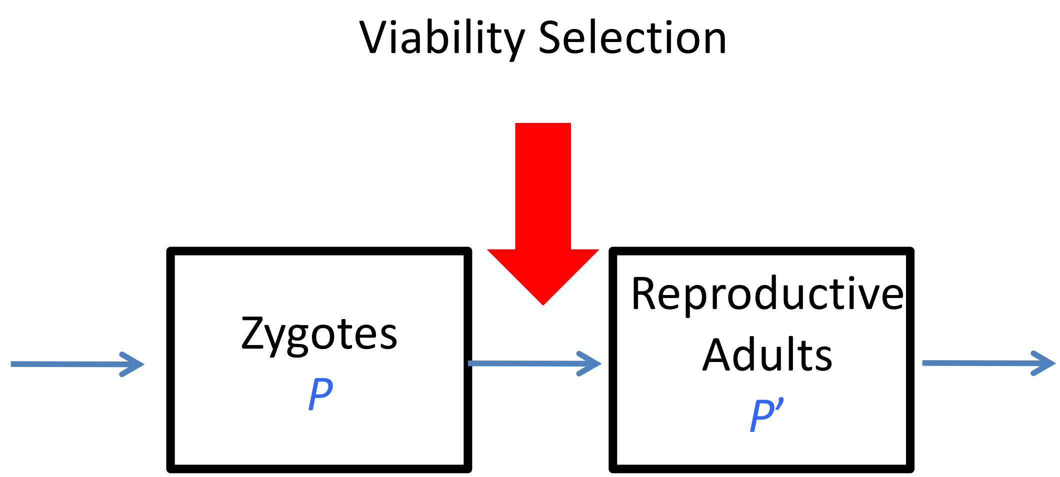
Natural Selection

- More offspring produced that can survive/reproduce
- Individuals differ in ability to survive/reproduce (due to genotype)
- Genotypes that promote survival
  - Present in excess at reproductive age
  - Contribute disproportionately to offspring

Key points

- Selection acts on individuals
- Adaptation is a population process


Viability
Fecundity
Zygotes
Reproductive Adults
Mating Pairs
Gametes
Mating Success
Meiotic Drive



Viability Selection
Zygotes
P
Reproductive
Adults
P'

Model Assumptions

- Diploid individuals
- One locus (2 alleles)
- Sexual reproduction
- Discrete generations
- Random mating
- Infinite population size
- No mutation
- No migration
- Fitnesses constant

Fitness

- Individual: proportional contribution of offspring to next generation
- Genotype: average fitness for all individuals with that genotype in the population
- With VS, fitness is probability of survival to reproductive age

Absolute Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Adult Frequencies	p^2w_{11}	$2pqw_{12}$	q^2w_{22}

$$\overline{w} = p^2 w_{11} + 2pq w_{12} + q^2 w_{22}$$

Absolute Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	**A_1A_1**	**A_1A_2**	**A_2A_2**
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Adult Frequencies	$p^2 w_{11}$	$2pq w_{12}$	$q^2 w_{22}$
Normalized Adult Frequencies	$p^2 w_{11} / \overline{w}$	$2pq w_{12} / \overline{w}$	$q^2 w_{22} / \overline{w}$

$$p' = \frac{p^2 w_{11} + pq w_{12}}{\overline{w}} \qquad \Delta_s p = p' - p = \frac{p^2 w_{11} + pq w_{12} - p\overline{w}}{\overline{w}}$$

Relative Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}

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Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	w_{12}/w_{11}	w_{22}/w_{11}

Relative Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	w_{12}/w_{11}	w_{22}/w_{11}
Relative fitness	1	$1-hs$	$1-s$

s: Coefficient of selection

h: Dominance coefficient
$h = 0$: A_1 dominant
$h = 1$: A_1 recessive
$0 < h < 1$: incomplete dominance
$h = 0.5$: codominant
$h < 0$: overdominance
$h > 1$: underdominance

Relative Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	w_{12}/w_{11}	w_{22}/w_{11}
Relative fitness	1	$1-hs$	$1-s$
Adult frequencies	p^2	$2pq(1-hs)$	$q^2(1-s)$

$$\overline{w} = p^2 + 2pq(1-hs) + q^2(1-s)$$

Relative Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	w_{12}/w_{11}	w_{22}/w_{11}
Relative fitness	1	$1\text{-}hs$	$1\text{-}s$
Adult frequencies	p^2	$2pq(1\text{-}hs)$	$q^2(1\text{-}s)$
Normalized adult frequencies	$p^2/\ \overline{w}$	$2pq(1\text{-}hs)/\overline{w}$	$q^2(1\text{-}s)/\overline{w}$

Relative Fitness

2 alleles: A_1 (p), A_2 (q)

Genotypes	**A_1A_1**	**A_1A_2**	**A_2A_2**
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	w_{12}/w_{11}	w_{22}/w_{11}
Relative fitness	1	$1-hs$	$1-s$
Adult frequencies	p^2	$2pq(1-hs)$	$q^2(1-s)$
Normalized adult frequencies	$p^2/\overline{w}$	$2pq(1-hs)/\overline{w}$	$q^2(1-s)/\overline{w}$

$$p' = \frac{p^2 + pq(1-hs)}{\overline{w}}$$

$$\Delta_s p = p' - p = \frac{p^2 + pq(1-hs) - p\overline{w}}{\overline{w}}$$

Change in Allele Frequency

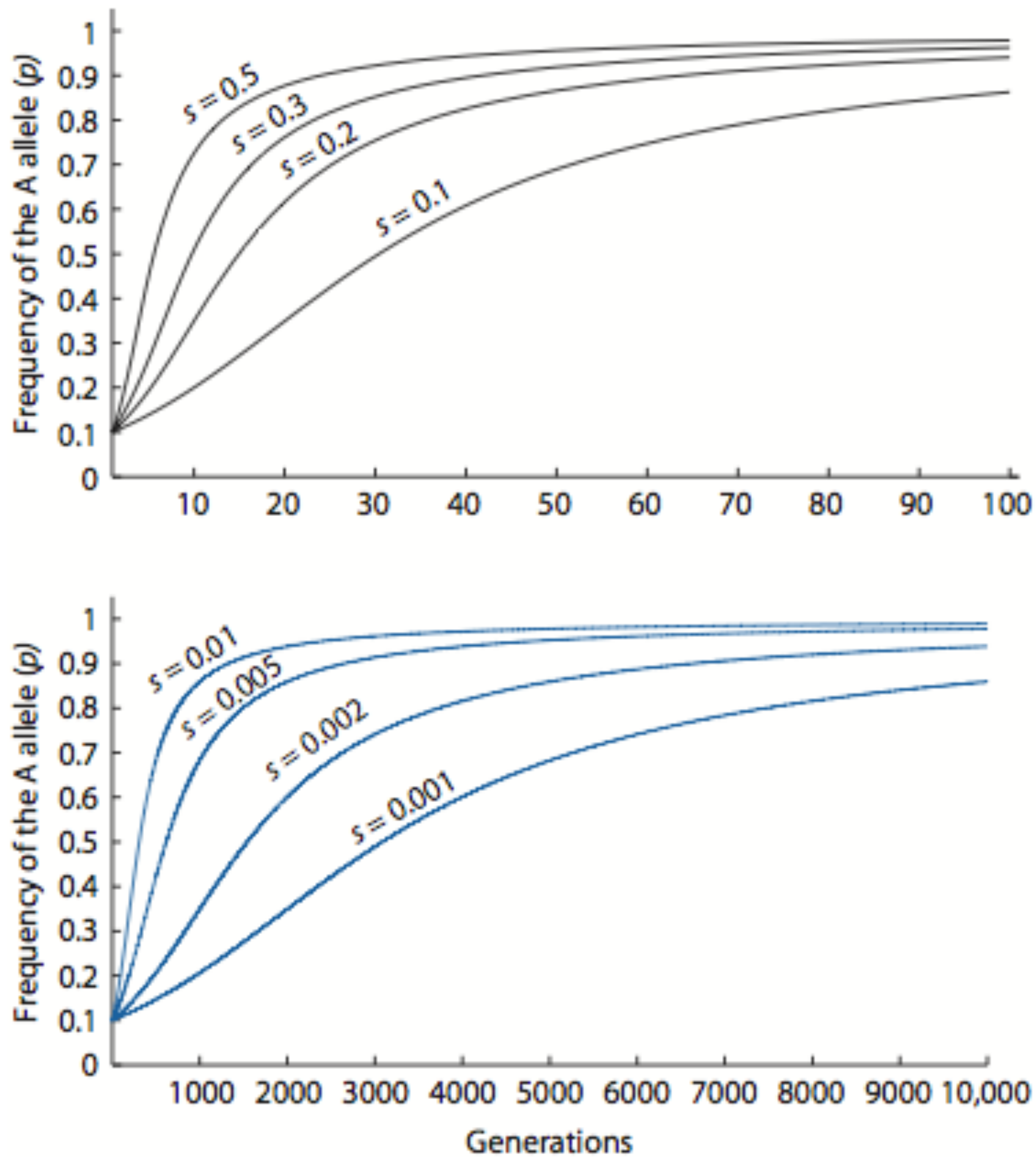
$$\Delta_s p = \frac{pqs(ph + q(1-h))}{\overline{w}}$$

$$(ph + q(1-h))$$

$$\Delta_s p > 0 \text{ if } s > 0$$

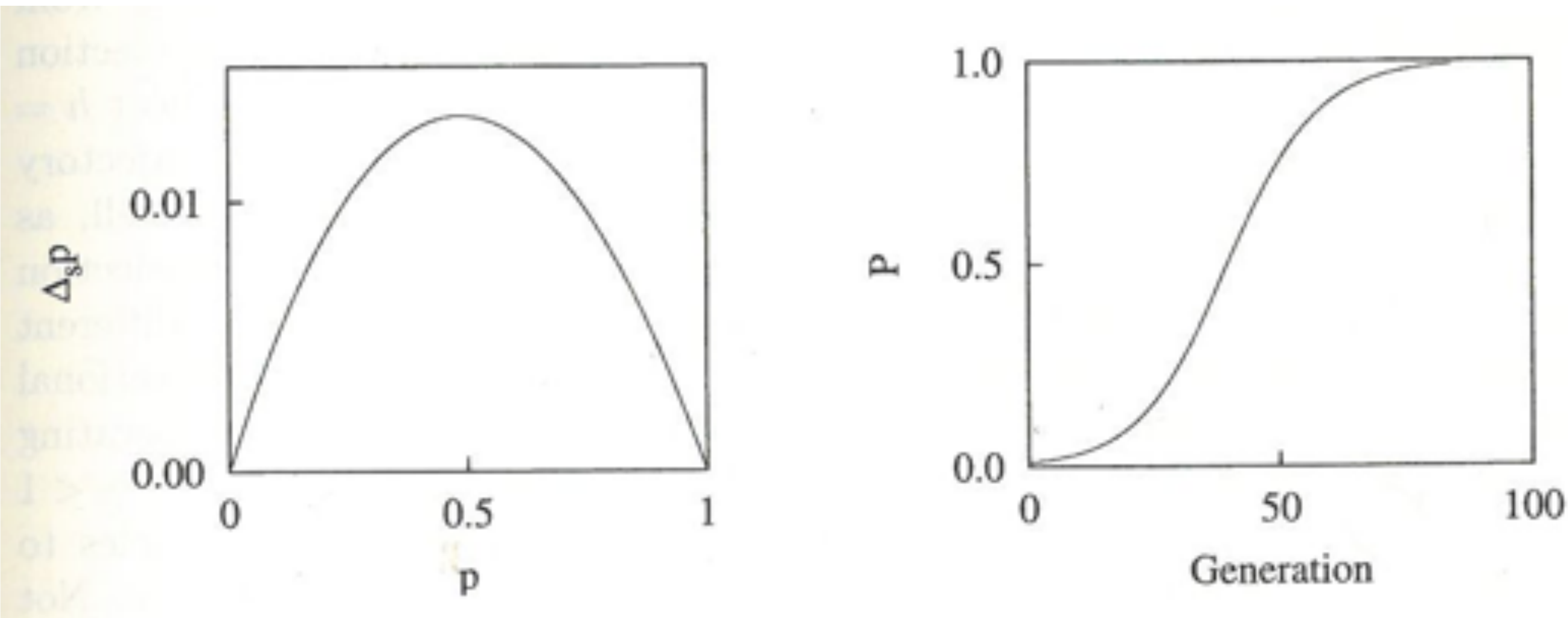
$$\Delta_s p < 0 \text{ if } s < 0$$

Dependency on *s*



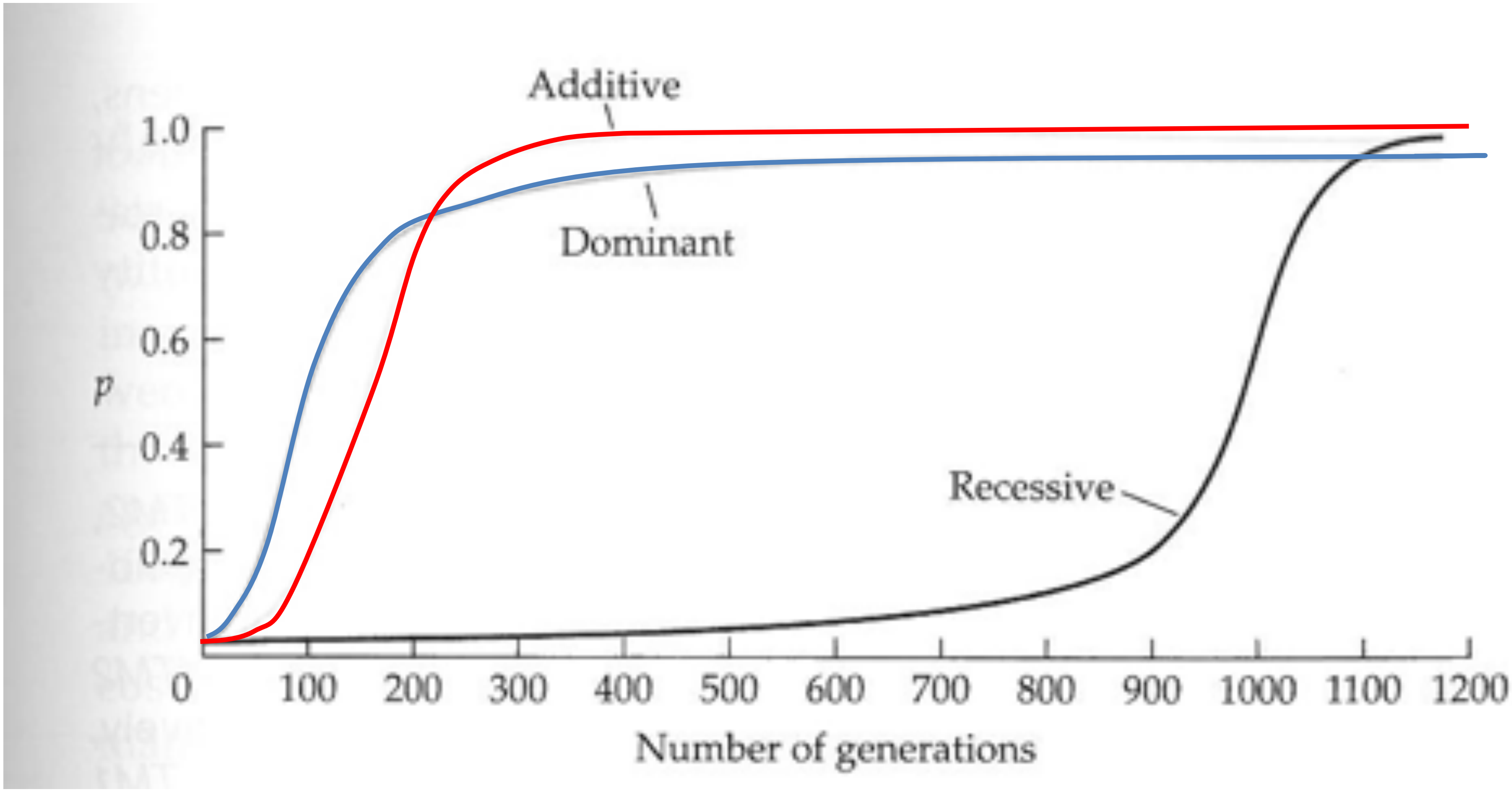
Hamilton 2009

Dependency on *p*



Gillespie 2004

Dependency on *h*



Hartl & Clark 2007

Overdominance

2 alleles: A_1 (p), A_2 (q)

$$h < 0$$

$$w_{11} < w_{12}$$

$$w_{22} < w_{12}$$

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	1-hs	1-s

Overdominance

2 alleles: A_1 (p), A_2 (q)

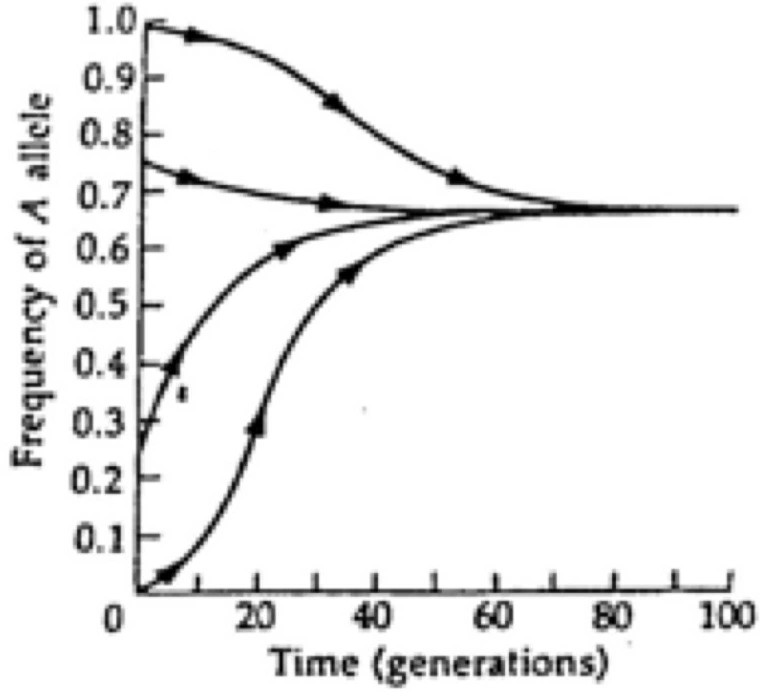
$h < 0$

$w_{11} < w_{12}$

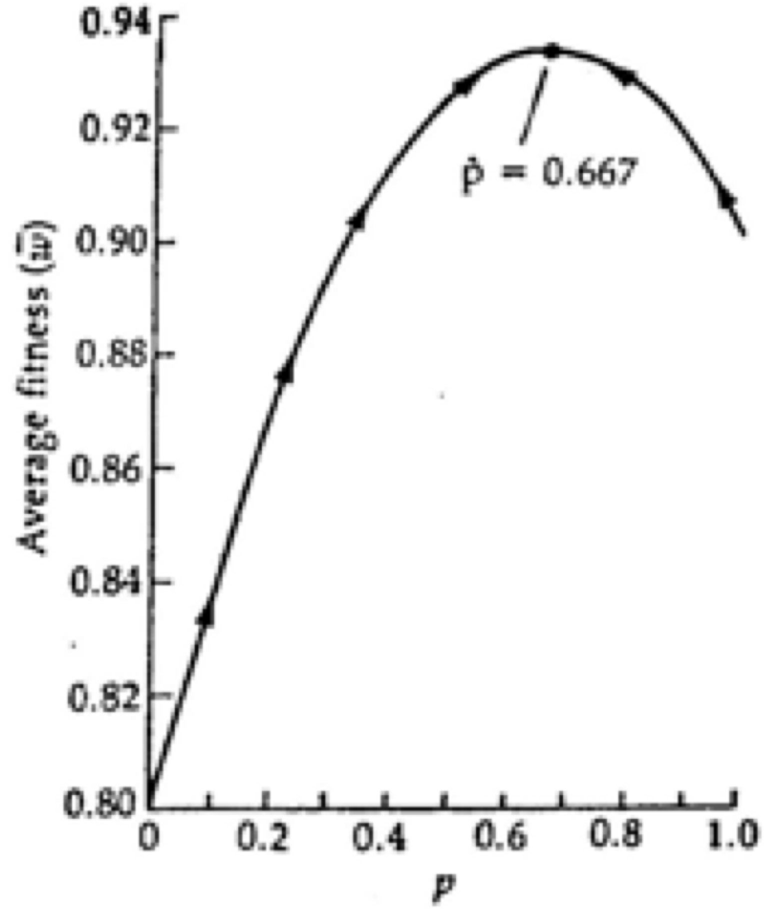
$w_{22} < w_{12}$

Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	1-hs	1-s
Relative fitness	1-s	1	1-t

Overdominance



(a)



(b)

Hartl and Clark

Underdominance

2 alleles: A_1 (p), A_2 (q)

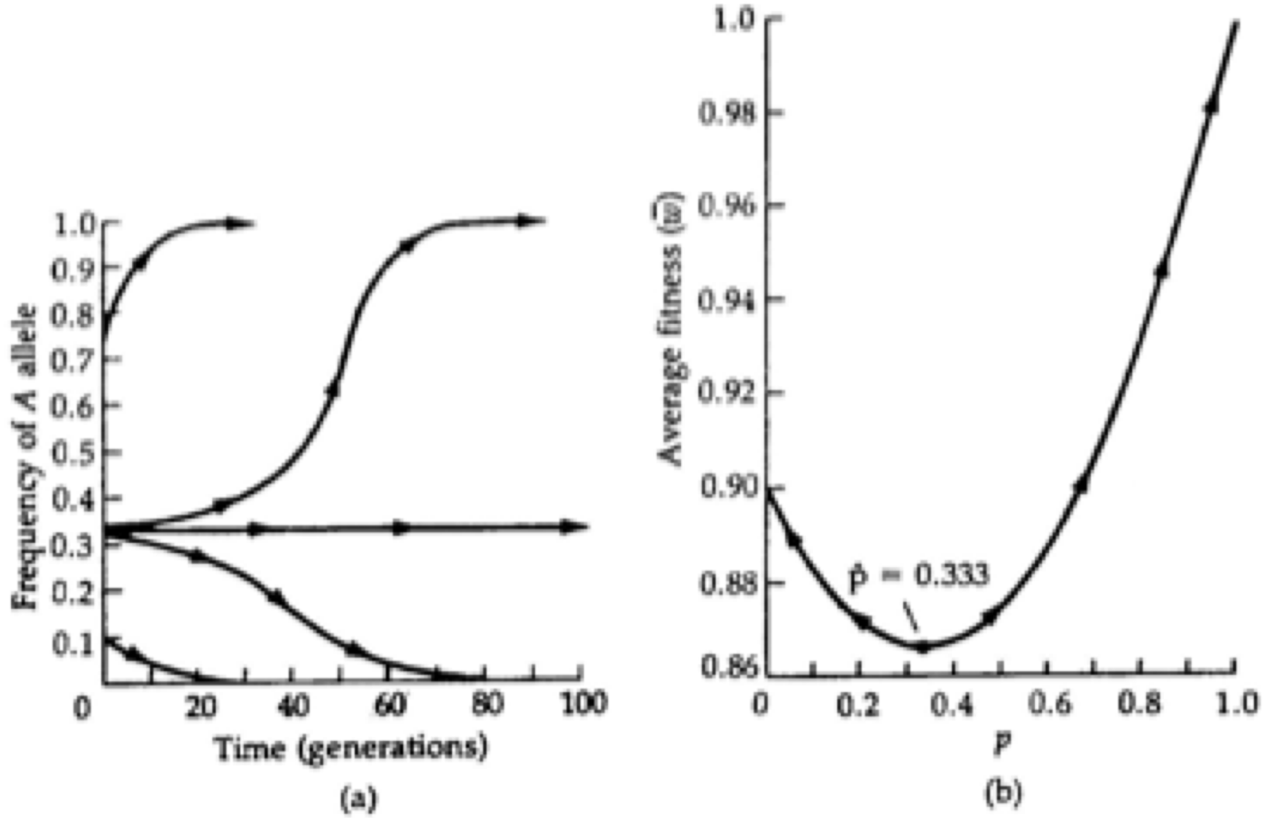
$$h > 1$$

$$w_{12} < w_{11}$$

$$w_{12} < w_{22}$$

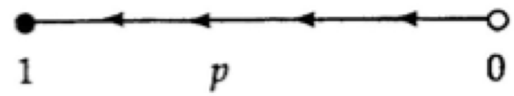
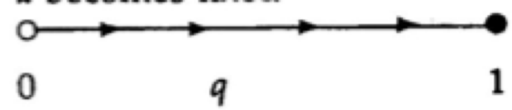
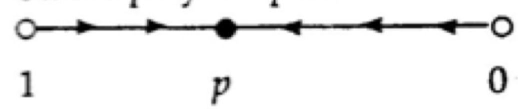
Genotypes	A_1A_1	A_1A_2	A_2A_2
Zygotic Frequencies	p^2	$2pq$	q^2
Absolute fitness	w_{11}	w_{12}	w_{22}
Relative fitness	1	1-hs	1-s

Underdominance



Hartl and Clark

Table 3. Summary of behavior of the one-locus two-allele viability model.

		AA *Aa* *aa*	
Directional selection			
	Case 1	$w_{11} > w_{12} > w_{22}$ 	*A* becomes fixed 
	Case 2	$w_{11} < w_{12} < w_{22}$ 	*a* becomes fixed 
Overdominance			
	Case 3	$w_{11} < w_{12} > w_{22}$ 	Stable polymorphism 
Underdominance			
	Case 4	$w_{11} > w_{12} < w_{22}$ 	Unstable equilibrium