

SOME literature on theory in evolutionary biology; in particular from devo-evo perspective.

Multivariate response to selection, Mutational matrix (is mutation structured at arrival?)

Lande, R., 1979 Quantitative Genetic Analysis of Multivariate Evolution, Applied to Brain: Body Size Allometry. *Evolution* 33: 402-416.

Lande, R., and S. J. Arnold, 1983 The Measurement of Selection on Correlated Characters. *Evolution* 37: 1210-1226.

Additivity vs nonadditivity

No epistatic variance does not mean no epistasis:

Cheverud, J. M., and E. J. Routman, 1995 Epistasis and its contribution to genetic variance components. *Genetics* 139: 1455-1461.

Epistasis as constraint:

Bridgham, J. T., E. A. Ortlund and J. W. Thornton, 2009 An epistatic ratchet constrains the direction of glucocorticoid receptor evolution. *Nature* 461: 515-519.

It is not about single interactions: Directional epistasis contributes to response

Hansen, T. F., and G. P. Wagner, 2001 Modeling genetic architecture: a multilinear theory of gene interaction. *Theor Popul Biol* 59: 61-86.

Development matters for distribution of mutational variance and hence evolution (experiment: Alberch)

Alberch, P., and M. J. Blanco, 1996 Evolutionary patterns in ontogenetic transformation: from laws to regularities. *Int J Dev Biol* 40: 845-858.

Alberch, P., and E. A. Gale, 1983 Size dependence during the development of the amphibian foot. Colchicine-induced digital loss and reduction. *J Embryol Exp Morphol* 76: 177-197.

Cheverud, J. M., 1984 Quantitative genetics and developmental constraints on evolution by selection. *J Theor Biol* 110: 155-171.

Schluter, D., 1996 Adaptive radiation along genetic lines of least resistance. *Evolution* 50: 1766-1774.

Problems of evolvability

Cost of complexity / curse of dimensionality

Fisher's geometric model (assuming universal pleiotropy): "mutations must be small!"

Orr, H. A., 2000 Adaptation and the cost of complexity. *Evolution* 54: 13-20.

Fisher, R. A., 1930 *The Genetical theory of Natural Selection*. Oxford, UK: Oxford University Press.

complex adaptation (also: variation vs. variability)

Wagner, G. P., and L. Altenberg, 1996 Perspective: Complex Adaptations and the Evolution of Evolvability. *Evolution* 50: 967-976.

Measuring constraints/ distribution of genetic variation

Dimensionality of genetic variation / Conditional evolvability

- Hansen, T. F., and D. Houle, 2008 Measuring and comparing evolvability and constraint in multivariate characters. *J Evol Biol* 21: 1201-1219.
- Hine, E., and M. W. Blows, 2006 Determining the effective dimensionality of the genetic variance-covariance matrix. *Genetics* 173: 1135-1144.

Structural properties of GP map contributing to evolvability

General:

- Hansen, T. F., 2006 The evolution of genetic architecture. *Annual Review of Ecology, Evolution and Systematics* 37: 123-157.

Modularity

- Wagner, G. P., M. Pavlicev and J. M. Cheverud, 2007 The road to modularity. *Nature Reviews Genetics* 8: 921-931.
- Wagner, G. P., and J. Zhang, 2011 The pleiotropic structure of the genotype-phenotype map: the evolvability of complex organisms. *Nat Rev Genet* 12: 204-213.
- Zhang, J., and G. P. Wagner, 2013 On the definition and measurement of pleiotropy. *Trends Genet* 29: 383-384.

But:

- Hansen, T. F., 2003 Is modularity necessary for evolvability? Remarks on the relationship between pleiotropy and evolvability. *Biosystems* 69: 83-94.
- Pavlicev, M., and T. F. Hansen, 2011 Genotype-Phenotype Maps Maximizing Evolvability: Modularity Revisited. *Evolutionary Biology* 38: 371-389.

Canalization/Robustness

- Draghi, J. A., T. L. Parsons, G. P. Wagner and J. B. Plotkin, 2010 Mutational robustness can facilitate adaptation. *Nature* 463: 353-355.
- Waddington, C. H., 1942 Canalization of development and the inheritance of acquired characters. *Nature* 150: 563-565.
- Wagner, A., 2012 The role of robustness in phenotypic adaptation and innovation. *Proc Biol Sci* 279: 1249-1258.
- Lindquist, S., 2009 Protein folding sculpting evolutionary change. *Cold Spring Harb Symp Quant Biol* 74: 103-108.
- Rutherford, S. L., and S. Lindquist, 1998 Hsp90 as a capacitor for morphological evolution. *Nature* 396: 336-342.
- Siegal, M. L., and J. Y. Leu, 2014 On the Nature and Evolutionary Impact of Phenotypic Robustness Mechanisms. *Annu Rev Ecol Evol Syst* 45: 496-517.

GxE

- Via, S., and R. Lande, 1987 Evolution of genetic variability in a spatially heterogeneous environment: effects of genotype-environment interaction. *Genet Res* 49: 147-156.

The many levels between G and P:

General

- Hallgrímsson, B., H. Jamniczky, N. M. Young, C. Rolian, T. E. Parsons *et al.*, 2009 Deciphering the Palimpsest: Studying the Relationship Between Morphological Integration and Phenotypic Covariation. *Evol Biol* 36: 355-376.

Regulatory level of GP map

- Widder, S., R. Sole and J. Macia, 2012 Evolvability of feed-forward loop architecture biases its abundance in transcription networks. *BMC Syst Biol* 6: 7.
- Gjuvslund, A. B., J. O. Vik, D. A. Beard, P. J. Hunter and S. W. Omholt, 2013a Bridging the genotype-phenotype gap: what does it take? *J Physiol* 591: 2055-2066.
- Gjuvslund, A. B., Y. Wang, E. Plahte and S. W. Omholt, 2013b Monotonicity is a key feature of genotype-phenotype maps. *Front Genet* 4: 216.
- Alon, U., 2003 Biological networks: the tinkerer as an engineer. *Science* 301: 1866-1867.
- Gjuvslund, A. B., J. O. Vik, J. A. Woolliams and S. W. Omholt, 2011 Order-preserving principles underlying genotype-phenotype maps ensure high additive proportions of genetic variance. *J Evol Biol* 24: 2269-2279.

RNA level of G-P map

- Schuster, P., W. Fontana, P. F. Stadler and I. L. Hofacker, 1994 From sequences to shapes and back: a case study in RNA secondary structures. *Proc Biol Sci* 255: 279-284.
- Fontana, W., 2002 Modelling 'evo-devo' with RNA. *Bioessays* 24: 1164-1177.

Evolution of GP map structure (Evolution of evolvability/pleiotropy)

- Kashtan, N., and U. Alon, 2005 Spontaneous evolution of modularity and network motifs. *Proc Natl Acad Sci U S A* 102: 13773-13778.
- Force, A., M. Lynch, F. B. Pickett, A. Amores, Y. L. Yan *et al.*, 1999 Preservation of duplicate genes by complementary, degenerative mutations. *Genetics* 151: 1531-1545.
- Johnson, N. A., and A. H. Porter, 2007 Evolution of branched regulatory genetic pathways: directional selection on pleiotropic loci accelerates developmental system drift. *Genetica* 129: 57-70.
- Pavlicev, M., and G. P. Wagner, 2012 A model of developmental evolution: selection, pleiotropy and compensation. *Trends Ecol Evol* 27: 316-322.

Long-term consequences of “constraints”: individualization of variation

- Wagner, G. P., 2007 The developmental genetics of homology. *Nat Rev Genet* 8: 473-479.
- Wagner, G. P., 2016 What is "homology thinking" and what is it for? *J Exp Zool B Mol Dev Evol* 326: 3-8.
- Arendt, D., J. M. Musser, C. V. Baker, A. Bergman, C. Cepko *et al.*, 2016 The origin and evolution of cell types. *Nat Rev Genet* 17: 744-757.

Historical views of the role of development in evolutionary biology

- Amundson, R., 2005 *The Changing Role of the Embryo in Evolutionary Thought*. Cambridge University Press, Cambridge.

General stuff

- Houle, D., C. Pelabon, G. P. Wagner and T. F. Hansen, 2011 Measurement and meaning in biology. *Q Rev Biol* 86: 3-34.
- O'Malley, M. A., and J. Dupre, 2005 Fundamental issues in systems biology. *Bioessays* 27: 1270-1276.