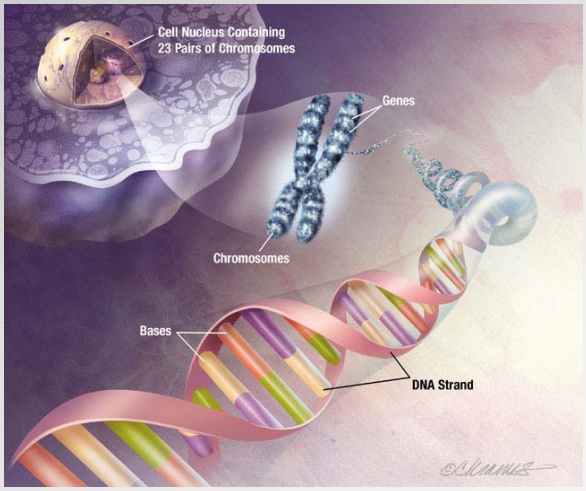
The Blueprint Idea

- Genes provide the blueprint for life
- Without the blueprint no life is possible
- Genes drive development

What are genes and what is their function?

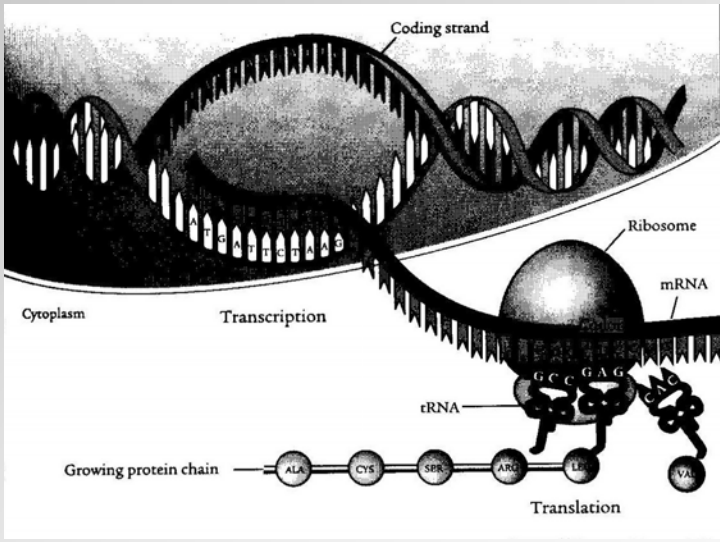
- Genes are segments of DNA
- DNA consists of 2 long chains of nucleotides twisted into a double helix and joined by hydrogen bonds between the complementary bases adenine and thymine or cytosine and guanine
- Genes code for polypeptides (proteins)!
- Genes do not code for behavior!



Gene Expression

Gene expression consists of 2 processes:

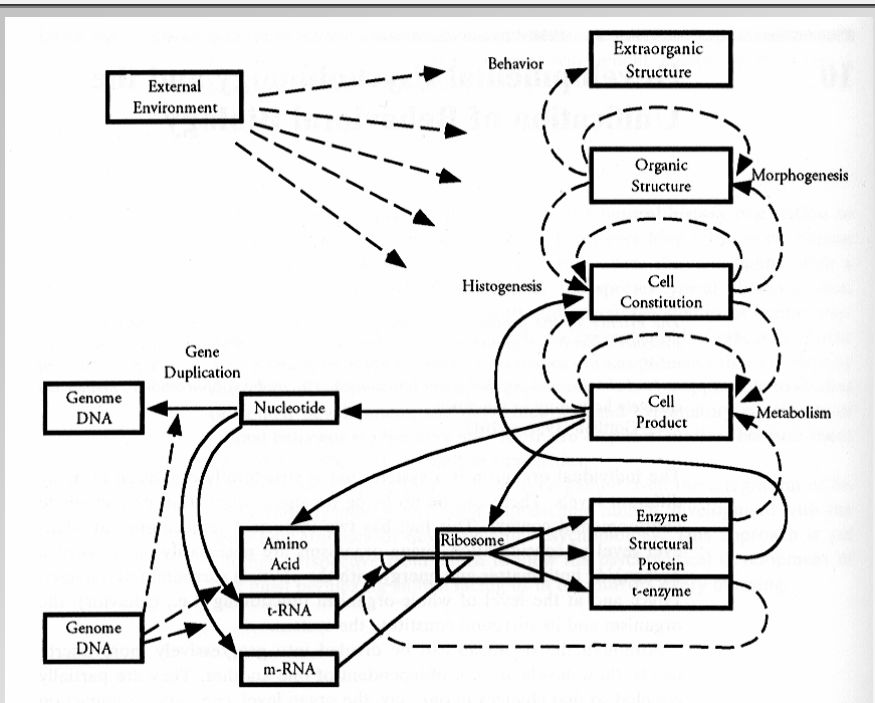
- Transcription - the DNA double helix separates at the site of a gene and transcribing enzymes copy one of the strands of nucleotides into a complementary mRNA strand
- Translation - After the mRNA is transported from the nucleus, it joins ribosomes in the cytoplasm where it is translated. Each codon (or triplet of bases in the mRNA is complementary to a specific tRNA and each tRNA brings a specific amino acid and then adds it to the growing protein chain



How do we get from genes to behavior?

It's a very long and tortuous road!

Early Systems Thinking:Sewall Wright's Developmental System



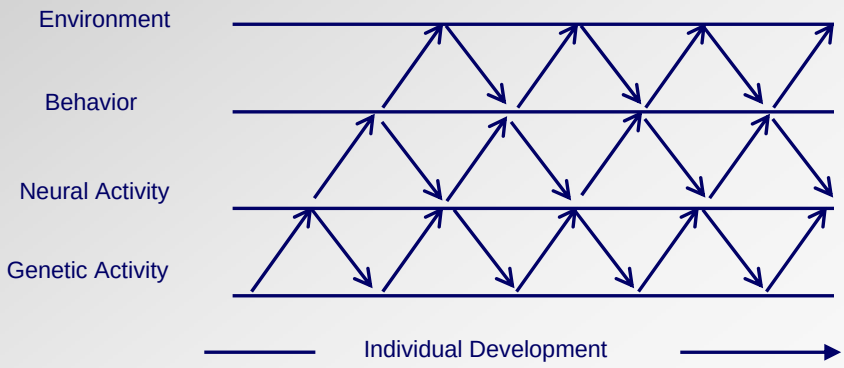
Wright, 1968

Conceptualizing Development

- Development is due to epigenesis (original definition):
  - Concept of epigenesis was borrowed from experimental embryology
  - Epigenesis is defined as the emergence of new structures and functions during the course of individual development
- Problem:
  - Does not specify how emergent properties come into being
- Solution: Probabilistic Epigenesis (Gottlieb)

Probabilistic Epigenesis

- The Concept of probabilistic epigenesis originates in the concept of interaction championed by T. C. Schneirla, Z. Y. Kuo, & D. Lehrman
- The focus of concept is on individual development
- The concept attempts to account for the orderly transformation of an organism over time & for the emergence of new structures & functions at all levels of organization (molecular, subcellular, cellular, organismic)
- Change is due to the horizontal & vertical co-actions of at least 2 components (person-person or sensory stimulation-sensory system)
- Structure and function are reciprocally (bidirectionally) related



Principles of Development

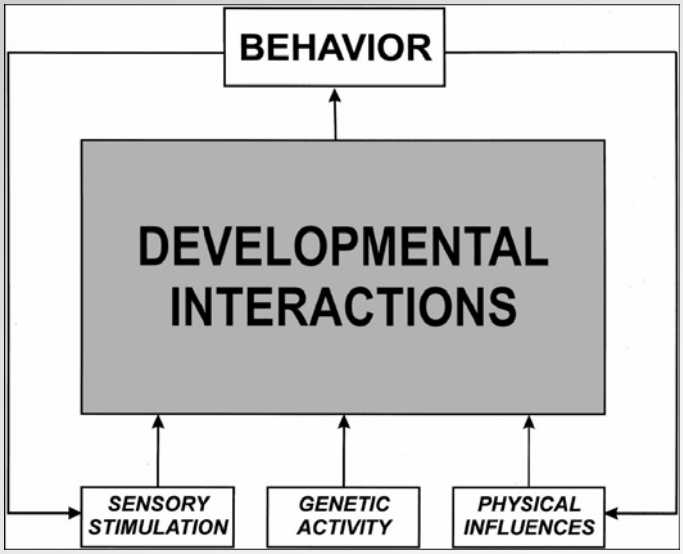
- Canalization – what is it & why does it happen?
  - Holt (1931): narrow meaning where conditioning narrows down the number of movements performed by embryo
  - Kuo (1976): broad meaning where organism starts with a broad array of functional capabilities that are then canalized by the organism's specific experiences at all levels of organism
  - Waddington (1942): species-typical development of physiology and anatomy is buffered (by genes) from external influences and, thus, proceeds regardless of assaults from such influences (metaphor of ball rolling down the epigenetic landscape)

Principles of Development

- Canalization – contd.
  - Gottlieb (1991): developmental systems view supplants the "empty metaphor of epigenetic landscape" and genetic determinism
    - e.g. female coral reef fish becomes a male as a function of environmental influences
    - RNA diversity, and thus DNA activity, is affected by enrichment or deprivation
    - Mallard duck embryos must hear their own vocalizations & those of their siblings prior to hatching to correctly identify their species-specific call after hatching
    - Development of hypertension in spontaneously hypertensive rats does not depend on their genetic constitution, anatomy, or physiology but on the interaction of the pups with their hyperactive, hypertensive mothers

Genes, Interactions & the Development of Behavior

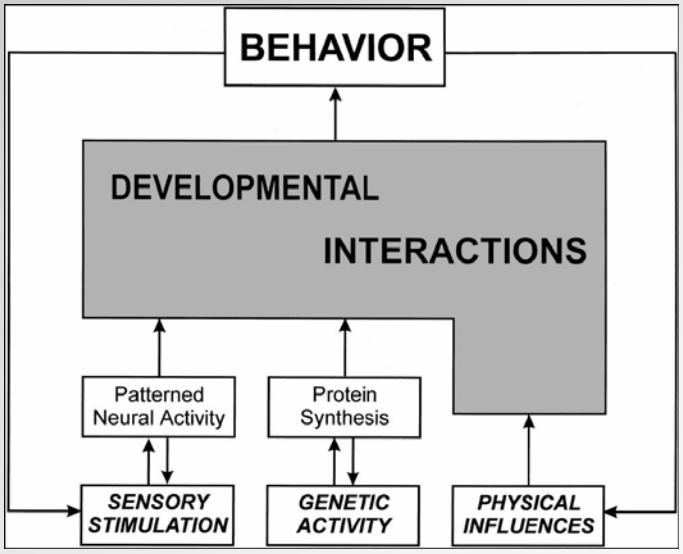
- 1st iteration of model



Johnston & Edwards, 2002

Genes, Interactions & the Development of Behavior

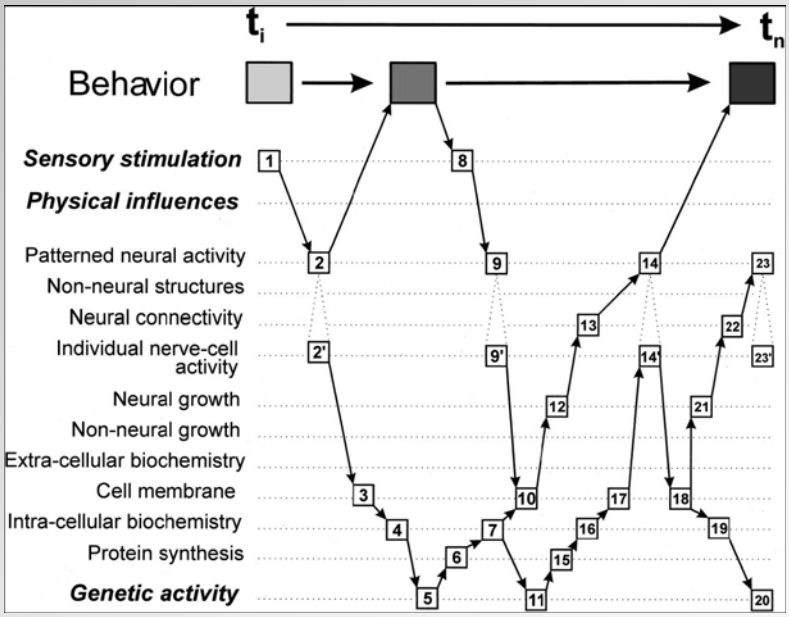
- 2nd iteration of model



Johnston & Edwards, 2002

Genes, Interactions & the Development of Behavior

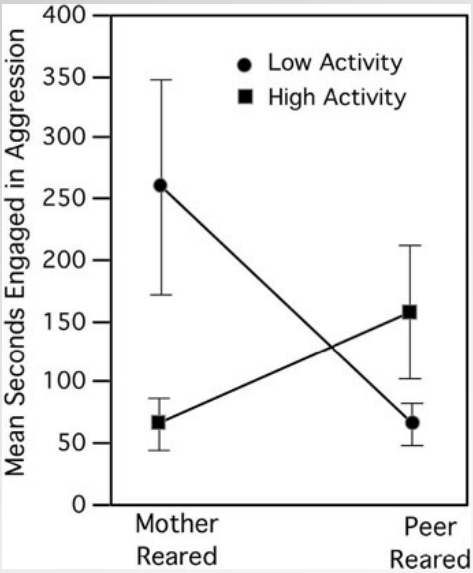
- Final iteration of model



Johnston & Edwards, 2002

Gene-Environment Interaction

- Rhesus monkeys with low MAOA activity (i.e., who had a genetic predisposition to aggression) show different levels of aggression as a function of early-rearing experience
- In other words, it is not genes alone, nor experience alone, but their interaction that results in a given level of aggressivity



Newman, et. al., 2005