"Henry! Our party's total chaos! No one knows when to eat, where to stand, what to.... Oh, thank God! Here comes a border collie!"
Is any particular behavior controlled by genes or by the environment?
Farm-fox experiment
Novosibirsk, Siberia

Heritability:

• A measure of how strongly a phenotype is influenced by genes

Total phenotypic variation =
Heritability:
Canalization
How we study relative contributions of genes & environment in the development of behavior
Genes produce polypeptides (e.g., proteins) through transcription and translation via RNA.

One gene often affects multiple traits.

[Diagram showing gene, RNA, enzyme, biochemical reaction, and traits with the term 'pleiotropy' at the bottom right]
Polygenic Traits

• When alternative alleles in **two or more** genes all play a major role in the expression of a particular phenotype

• Quantitative polygenic traits (Quantitative Trait Loci – QTL)

at least 3 loci affect the production of melanin
Polygenic inheritance and pleiotropy compared

Polygenic inheritance

Multiple genes

Single trait (e.g., skin color)

Pleiotropy

Single gene

Multiple traits (e.g., sickle-cell disease)
Epistasis

• A gene interaction in which the effects of an allele at one gene hide the effects of alleles at another gene

• Labrador retriever coat color
  
  Gene 1: B - Controls color
  Gene 2: E - Controls expression of B
  
  –BBEE and BbEe --> Black
  –bbEE and bbEe --> Brown
  –BBee, Bbee, or bbee --> Golden
Fixed Action Patterns (FAP)
What causes attack behavior in male stickleback fish

**Ultimate:**

**Proximate:**
FAP in male stickleback fish

– https://www.youtube.com/watch?v=ZfcGZCGdGVE

(a) A male three-spined stickleback fish shows its red underside.
The ontogenetic trajectory of a worker honey bee

- Cleaning cells
- Feeding larvae
- Feeding nestmates
- Packing pollen
- Foraging

Relative probability of task performance vs. Age of bee (days)
Use of gene arrays: gene activity varies in the brains of nurse bees and foragers

The hive environment can turn gene expression ‘up’ or ‘down.’
Levels of the messenger RNA produced when the *for* gene is expressed
Gene Knockout Experiments

• single gene-effects
Cross-fostering Experiments to look at genetic and environmental effects

- Cross-fostered meadow voles exhibited significantly more parental care.
Different wintering sites of blackcap warblers
Funnel cage for recording the migratory orientation of captive birds
Selective breeding experiments

- Blackcap warbler migration routes (Berthold et al.)
Selective breeding experiments

- Blackcap warbler migration routes (Berthold et al.)

![Hybrids oriented in an intermediate direction](image.png)

Why might that be bad for the birds?
TOOLBOX 4.2 Figure 1. Stress tests. Three tests used to examine the behavioral response to stressful conditions: (a) time spent in open versus walled areas, (b) time spent in the center of an arena versus near the wall, and (c) time spent in a light versus a dark area.
FIGURE 4.4. QTLs for mouse behavior. Chromosomal distribution of QTLs linked to anxiety in mice. (From Wills-Owen and Flint, 2006)

QTLs for anxiety behavior have been found on all nineteen autosomal (nonsex) chromosomes, as well as the X chromosome in mice.