Development of Learning
Development of Learning

- **Nature**
  - Organismal (Genetic) influences
    - Genotype – What information is on the genes (chromosomes)
    - Phenotype – What those genes express (appearance)
  - Nurture
    - Environmental influences
Genes and Development

- Father of Genetics
- Gregory Mendel

Table 14.1 The Results of Mendel’s F1 Crosses for Seven Characters in Pea Plants

<table>
<thead>
<tr>
<th>Character</th>
<th>Dominant Trait</th>
<th>×</th>
<th>Recessive Trait</th>
<th>F2 Generation</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower color</td>
<td>Purple</td>
<td>×</td>
<td>White</td>
<td>709:324</td>
<td>3.39:1</td>
</tr>
<tr>
<td>Flower position</td>
<td>Axial</td>
<td>×</td>
<td>Terminal</td>
<td>651:207</td>
<td>3.14:1</td>
</tr>
<tr>
<td>Seed color</td>
<td>Yellow</td>
<td>×</td>
<td>Green</td>
<td>6022:3031</td>
<td>3.01:1</td>
</tr>
<tr>
<td>Seed shape</td>
<td>Round</td>
<td>×</td>
<td>Wrinkled</td>
<td>5474:1850</td>
<td>2.99:1</td>
</tr>
<tr>
<td>Pod shape</td>
<td>Inflated</td>
<td>×</td>
<td>Constricted</td>
<td>882:959</td>
<td>2.95:1</td>
</tr>
<tr>
<td>Pod color</td>
<td>Green</td>
<td>×</td>
<td>Yellow</td>
<td>428:153</td>
<td>2.83:1</td>
</tr>
<tr>
<td>Stem length</td>
<td>Tall</td>
<td>×</td>
<td>Dwarf</td>
<td>787:357</td>
<td>2.24:1</td>
</tr>
</tbody>
</table>
Genes

- Humans
  - 25,000 – 30,000 Genes
    - sequences of DNA on Chromosomes
      - Structural
      - Regulatory
Alleles

- Alleles
  - Alternate forms of a gene
    - Homozygous and Heterozygous
    - Dominant and Recessive
Punnet Squares

- **Cross**
  - Purple vs. White
- **F₁ Generation**
  - All Purple
- **F₂ Generation**
  - 3:1 Ratio
Genotype vs. Phenotype

- **Genotype** – information on genes
- **Phenotype** – what is expressed

![Diagram](Ratio 1:2:1) ![Diagram](Ratio 3:1)

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Nature

- Genetics control
  - Genes $\rightarrow$ Proteins $\rightarrow$ Behavior
- Innate = behavior with fixed genetic basis
  - (Tinbergen 1948 – FAP)
MAPs - Modal Action Patterns (Barlow 1968)

- Typical pattern with variation due to experience
- Ex. Warbler songs
Development of Behavior

- **Worker Bee Behavior**

![Graph showing the development of behavior in worker bees.](image)
Gene Activity

<table>
<thead>
<tr>
<th>Equivalent Drosophila gene</th>
<th>Expression ratio (F/N)</th>
<th>Typical colonies</th>
<th>Single-cohort colonies</th>
<th>Putative function</th>
</tr>
</thead>
<tbody>
<tr>
<td>fax</td>
<td>0.63</td>
<td>YN</td>
<td>OF</td>
<td>Axonogenesis</td>
</tr>
<tr>
<td>fax</td>
<td>0.65</td>
<td></td>
<td></td>
<td>Cell adhesion</td>
</tr>
<tr>
<td>BM-40-SPARC</td>
<td>0.52</td>
<td></td>
<td></td>
<td>Glycogen phosph.</td>
</tr>
<tr>
<td>GlyP</td>
<td>0.65</td>
<td></td>
<td></td>
<td>Oxidoreductase</td>
</tr>
<tr>
<td>GlyP</td>
<td>0.72</td>
<td></td>
<td></td>
<td>Rho small</td>
</tr>
<tr>
<td>CG7322</td>
<td>0.70</td>
<td></td>
<td></td>
<td>monomeric GTPase</td>
</tr>
<tr>
<td>Rab10</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG32703</td>
<td>2.45</td>
<td></td>
<td></td>
<td>MAP kinase</td>
</tr>
<tr>
<td>Eip71CD</td>
<td>1.86</td>
<td></td>
<td></td>
<td>Methionine sulfoxide reductase</td>
</tr>
<tr>
<td>Tps1</td>
<td>1.74</td>
<td></td>
<td></td>
<td>Trehalose-6-phosphate synthase</td>
</tr>
<tr>
<td>Tps1</td>
<td>1.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG11334</td>
<td>1.80</td>
<td></td>
<td></td>
<td>Translation regulator</td>
</tr>
<tr>
<td>CAH1</td>
<td>2.35</td>
<td></td>
<td></td>
<td>Carbonic anhydrase</td>
</tr>
<tr>
<td>Inos</td>
<td>1.98</td>
<td></td>
<td></td>
<td>Inositol-3-phosphate synthase</td>
</tr>
<tr>
<td>CG5966</td>
<td>1.34</td>
<td></td>
<td></td>
<td>Triacylglycerol lipase</td>
</tr>
<tr>
<td>HLH3B</td>
<td>1.43</td>
<td></td>
<td></td>
<td>Transcription factor</td>
</tr>
<tr>
<td>U2af50</td>
<td>1.18</td>
<td></td>
<td></td>
<td>Pre-mRNA splicing factor</td>
</tr>
</tbody>
</table>
Social Environment and Task Specialization

The diagram shows the number of foragers in a colony with different additions:

- Older bees added to colony:
  - Yellow bar: Young resident bees
  - Purple bar: Experimentally added bees

- Young bees added to colony:
  - Yellow bar: Young resident bees
  - Purple bar: Experimentally added bees
Nature vs. Nurture

![Bar graph showing comparison of mRNA units between nurses and foragers across three colonies.](ANIMAL_BEHAVIOR_Eighth_Edition_Figure_3.4)
Nature vs. Nurture
Questions in Behavioral Genetics

- **Proximate Questions**
  - How do genes determine behaviors?

- **Ultimate Questions**
  - What extent of behavior is under genetic control?
Both Genes and Environment

- Imprinting
  - Filial
  - Sexual
- Cross Fostering
- Spatial Learning
Both Genes and Environment

Imprinting

- Filial Imprinting
  - Social attachment to specific object
  - Lorenz (1935)
    - Sensitive period
    - Critical period
Both Genes and Environment

Imprinting

- Sexual Imprinting
  - Direct sexual behavior at some stimulus
  - Longer exposure than filial
Both Genes and Environment
Cross Fostering Experiments

(Mock 1984)

Great Egrets – kill siblings (small food)
Great Blue Herons – rarely kill (large food)
Both Genes and Environment
Spatial Learning

- Black-capped Chickadee
  - Individual differences

![Black-capped Chickadee](image)

![Bar graph showing number of inspections in Alaska and Colorado](image)
Genetic Differences

Adoption

- Test Scores
  - P-O = Parent and Offspring
  - MZ = Identical Twins
  - DZ = Fraternal Twins

![Graph showing correlations of spatial ability for different relationships.](image-url)
Single Gene Effects on Development

- Honeybees (Rothenbuhler - 1964)
  - Hygienic Vs. unhygienic
  - behavior affected by two genes
    - uncap
    - remove
Single (Knockout) Genes

- fosB gene (Brown et al, 1996)
- Drosophila
  - Rover vs. Sitter
Multigenic Effects

1. Nests made with long strips—no tucking behavior
   - Fischer’s lovebird

2. Nests made with short strips—tucking behavior
   - Peach-faced lovebird

3. Hybrid nests made with intermediate-length strips—in first mating season, unsuccessful tucking behavior
   - Hybrid lovebird

4. In later seasons, only head-turning behavior
   - Hybrid lovebird

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Adaptive Features of Behavioral Development

- Social Deprivation
  - Rhesus Monkeys
    1. Rearing in total isolation
    2. Isolate rearing but with wire mother
    3. Peer group rearing
    4. Rearing with mother only
    5. Rearing with mother only but with periods of separation
    6. Rearing in small social groups
Learning
Environmental Influences

- Behaviorism (Watson 1930)
  - behavior results from previous experience
Environmental Influences

- B. F. Skinner (1938)
  - S-R combinations
    - Stimulus
    - Response
  - Operant Conditioning
Learning

- Non-Associative Learning
  - Habituation
  - Sensitization

- Associative Learning
  - Classical Conditioning
  - Operant Conditioning
Habituation

- Persistent waning of a response that results from repeated presentations that are not reinforced
  - Fatigue
  - Sensory Adaptation
Sensitization

- Enhanced response to a stimulus
- Strengthening of a previous response
- Pay attention to what follows
Classical Conditioning

- Ivan Pavlov
  - Salivating Dog
    - US – unconditioned stimulus
    - UCR – unconditioned response
    - CS – conditioned stimulus
    - CR – conditioned response
Operant Conditioning

- **Skinner Box**
  - **Active Avoidance learning**
    - Animal must move in order to avoid some bad stimulus
  - **Passive Avoidance learning**
    - Animal is given negative stimulus for an already existing response
Biased Learning

- Taste
- Nausea
- Sound
- Shock
Learning

Biological Significance

![Bar graph showing the percentage of flavored fluid consumed by vampire bats and insectivorous bats in different treatment groups.](ANIMAL BEHAVIOR, Eighth Edition, Figure 3.44 © 2005 Sinauer Associates, Inc.)
Observational Learning

- Japanese Macaques
  - Young female (Imo)
    - Wash sweet potatoes
    - Dropped wheat into water
  - Others learned through imitation
Stone Play

• Started with Three year old female Japanese Macaque, Glance-6476
• Brought stones from forest stacked them up and knock them down.
• Territorial of her stones. Picked them up when others approached.
• Four years later, had become a daily occurrence
• Usually passed down to younger generations, but not up.
• Not documented in wild, non-provisioned groups. Only those with “Leisure Time”.
What is Cultural Transmission?

Lots of Debate on how to define it.

Behavioral Biologist – A system of information transfer that affects an individual’s phenotype by means of either teaching or some form of social learning.
Why is cultural transmission so important?

- Natural Selection generally takes a long time to bring about change.
- Cultural Transmission can allow complex behaviors to be spread very quickly through a population.
Cultural Transmission
(Types of Learning)

- Interaction without teaching
  - Local Enhancement
  - Social Facilitation

- Social Learning
  - Observational Learning
    - Imitation
    - Copying
  - Teaching
Interaction without teaching (1) – Local Enhancement

- Fish 1 is drawn to where Fish 2 is foraging for food (doing an action).
- Once there, Fish 2 learns nothing else from Fish 1.
Interaction without teaching (2) – Social Facilitation

- A lone Starling is attracted to a group (The group is not necessarily doing an action)
- Safety in numbers
Testing Local Enhancement & Social Facilitation

- Capuchin Monkeys – Tested probability of eating a new (Novel) kind of food.
- Alone, would not eat much
- Alone but could see a group, would not eat (no social facilitation)
- Alone, but could see a group eating (Local Enhancement)

N = Novel food  F = Familiar food
Social Learning (Observational Learning) – Observers learn specific behaviors or responses from others

• Lots of examples involving humans and other animals.

• Chimps learn how to “fish” for termites by watching other chimps.
Albert Bandura and the “Bobo” doll experiment.

Children working art project get one of two treatments:

1) Adult in room yelling and beating up “Bobo” doll.

2) Adult room is calm (“Bobo” doll still in room).

Children then given choice of toys to play with (aggressive vs. nonaggressive).

Angry adult children played with aggressive toys & beat up “Bobo” and yelled same things.
Milgram Experiment (1961)

- Shock Experiment
- http://www.youtube.com/watch?v=4b7YFtiE5EA
Zimbardo Prison Experiment (1971)

Images from the Stanford experiment (with thanks to Philip Zimbardo)
Social Learning - Imitation

- When a *new behavior* is learned from others and the behavior involves some sort of *new spatial* (topographical) manipulation as well as lead to the achievement of some goal.
Imitation – Blue Tits opening milk

- Britain in 1940’s
- One bird probably accidentally opened the foil cap.
- Others learned by watching.
Social Learning - Copying

- An **observer** repeats what a **model** has done.
- Differs from imitation in that it does not have to be new (novel) and does not have to involve some new topographical action.
- Good example, mate-choice copying. Animal already knows how to choose a mate, but it might **copy** what another does.
Mate-Choice Copying in Guppies

Put in for 10 minutes, then released. Female usually choose Male other female choose.
Copying a defense response

Mouse bitten by Stable fly – buries itself.

Observer later buries itself when it sees stable fly.
Teaching

- Complex in defining

- A teacher must:
  1) provide an immediate benefit to students but not to oneself
  2) Teach only naïve students
  3) Impart new information to students faster than they would otherwise receive it.
Teaching in Cheetah’s?

Mom Cheetah’s:

1) Pursue and knock down prey, allow it stand and run off so cubs could finish it off.

2) Carried back live animals to cubs before releasing them.

3) Would run slowly and let cubs take down prey (less common)
Teaching in Meerkats

- Eat many things including scorpions.
- Helpers would bring young pups dead or incapacitated scorpions. Older pups got live scorpions.
- By playing experimental calls, researchers had helpers bringing different things.
Modes of Cultural Transmission

- **Vertical** – Across generations from parents to offspring.
- **Horizontal** – From peer to peer (such as your friends)
- **Oblique** – Across generations, but not via parent/offspring interactions.
Vertical Transmission – Bottlenose Dolphins

• “Beaching” – Will chase a fish out of water and well go up on land to catch it.

• “Sponging” – Will get a sponge and feel around for fish on bottom.

• Primarily seen in Females and their calves.

• Genetic Analysis suggest it is NOT genetic but learned.
Guppies often separate into groups based on similar ages.

Guppies trained to travel two different paths to get food – Long and Short paths.

Naive guppies were put into the tank. They learned path from those of similar age.
Oblique Transmission – Rhesus Monkeys

- Wild-raised more afraid of snakes than lab-raised
- Lab raised that saw an adult (related or not) show fear of snakes learned to the fear (oblique transmission)
- Fear of flowers?, no fear developed
Which is smarter?
Brains grow in a $\frac{3}{4}$ power of body mass.

Humans beat this by a factor of 7.5.

Dolphins = 5.3

Monkeys = 4.8
Physics of Intelligence

Physics of Intelligence

- Increase brain size
- Increase neuron density
- Increase neural connection
- Decrease transmission time

**BOTTOM LINE**
- Slows processing
- Costs too much energy
- Signaling gets too noisy

The Limits of Intelligence
Memory

- **Short Term (working)**
  - Done in the Prefrontal Cortex

- **Long Term**
  - Prefrontal Cortex interact with the hippocampus and the amygdala to
Activities:

- Memory
  - “7”
  - Chunking
- How can we be smarter???