

Simulating Language

6: Evolving innate signalling systems

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Quick recap and comprehension check

How we are modelling production/reception matrices in python

	s1	s2	s3
m1	1	2	0
m2	0	1	1
m3	0	3	4

```
my_matrix =  
[ [ 1, 2, 0 ],  
  [ 0, 1, 1 ],  
  [ 0, 3, 4 ] ]
```

- Which signal would this sender produce for m3?

A: s1

B: s2

C: s3

D: s4

How we are modelling production/reception matrices in python

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```
my_matrix =  
[ [ 1, 2, 0 ],  
  [ 0, 1, 1 ],  
  [ 0, 3, 4 ] ]
```

- **How would you access the row of association strengths for m1?**

A: `my_matrix[0]`

B: `my_matrix[1]`

How we are modelling production/reception matrices in python

	s1	s2	s3
m1	1	2	0
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```
my_matrix =  
[ [ 1, 2, 0 ],  
  [ 0, 1, 1 ],  
  [ 0, 3, 4 ] ]
```

- **How would you access the strength of association between m2 and s1?**

A: `my_matrix[0][1]`

B: `my_matrix[1][0]`

How we are modelling production/reception matrices in python

	s1	s2	s3
m1	1	2	0
m2	0	1	1
m3	0	3	4

```
my_matrix =  
[ [ 1, 2, 0 ],  
  [ 0, 1, 1 ],  
  [ 0, 3, 4 ] ]
```

- **Can you tell, by looking at the python code, that this is a production matrix rather than a reception matrix?**

A: No

B: Yes

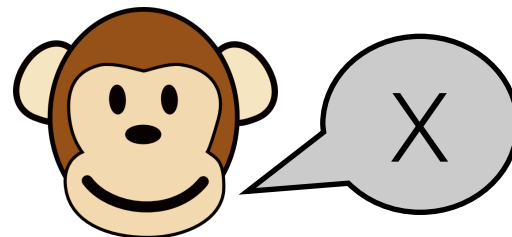
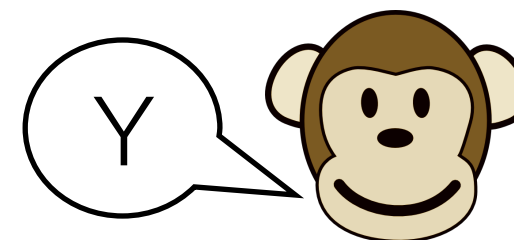
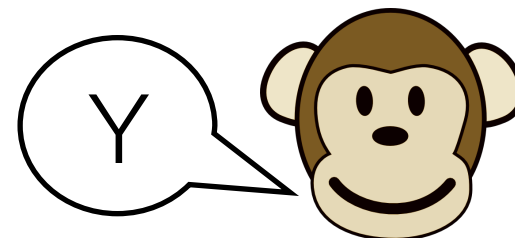
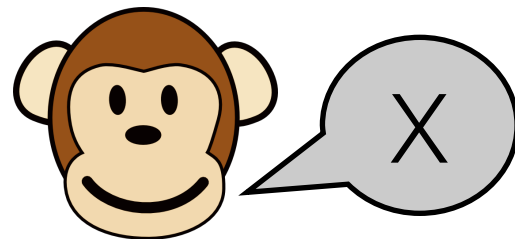
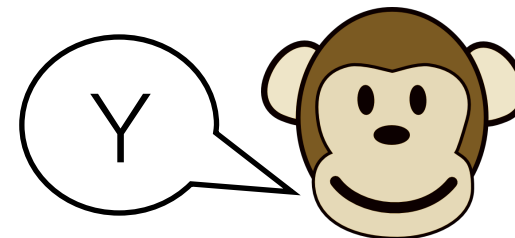
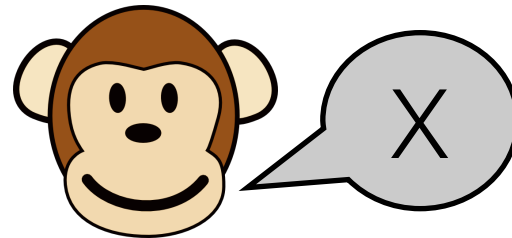
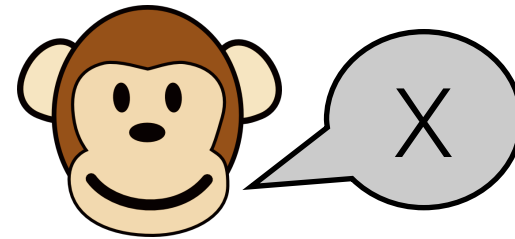
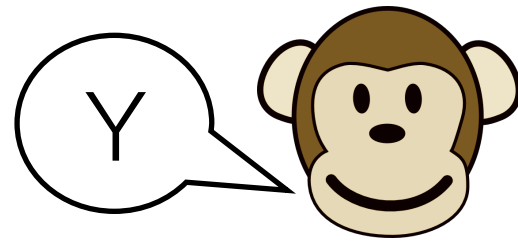
Moving on

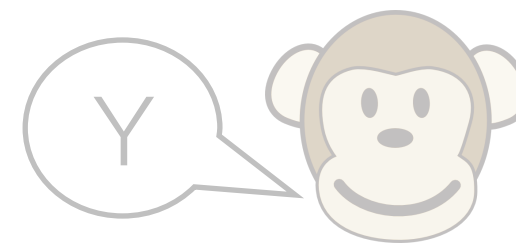
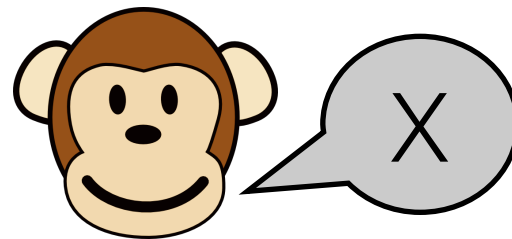
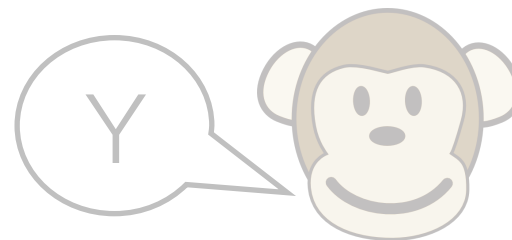
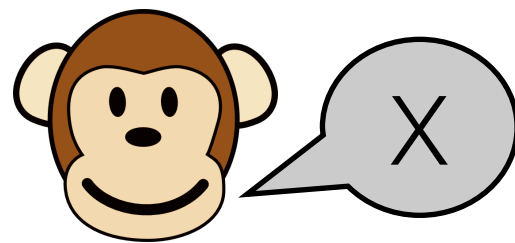
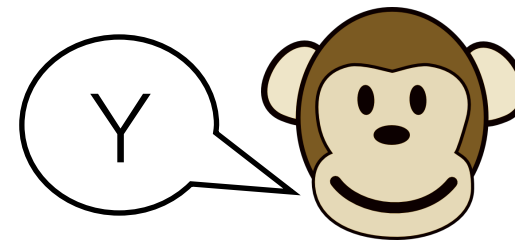
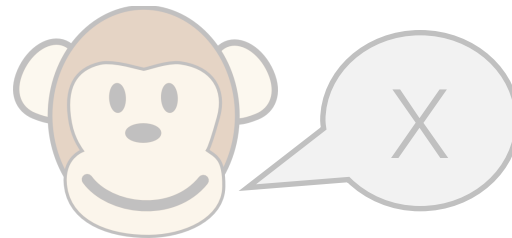
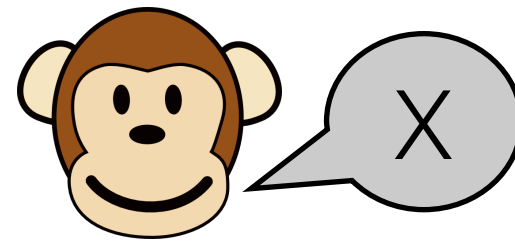
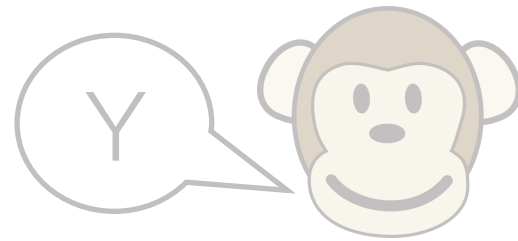
Where do these signalling matrices come from?

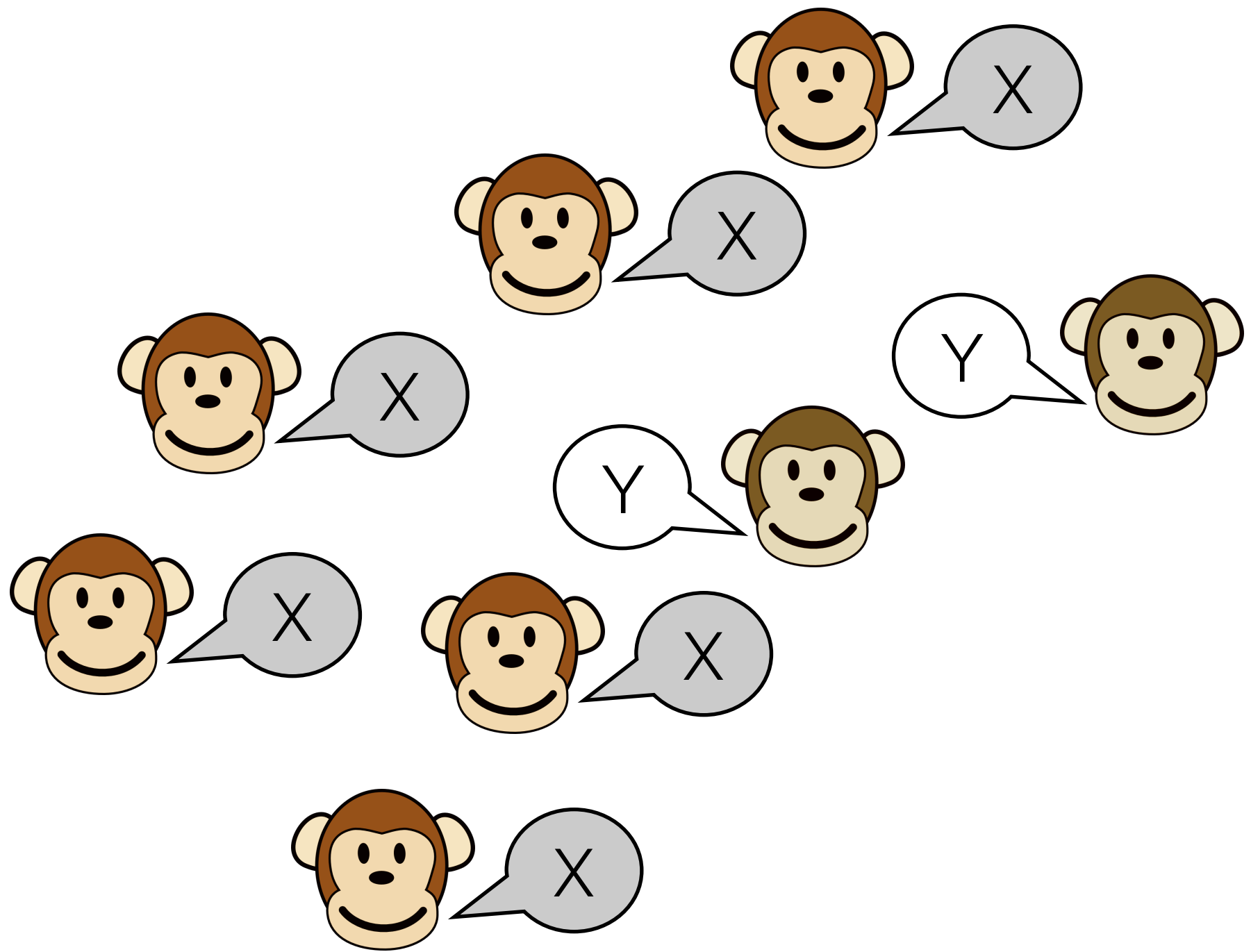
- Alarm calling systems are typically **innate**: they are somehow the result of the organism's genes
- How would an organism end up with a set of genes that gives them a good communicative accuracy score?
- **Theory**: natural selection will give us organisms with genes that specify signalling systems which have high communicative accuracy
- But can we be sure this is right?
- We need to model it...
- ...but first, quick recap on some basic theory

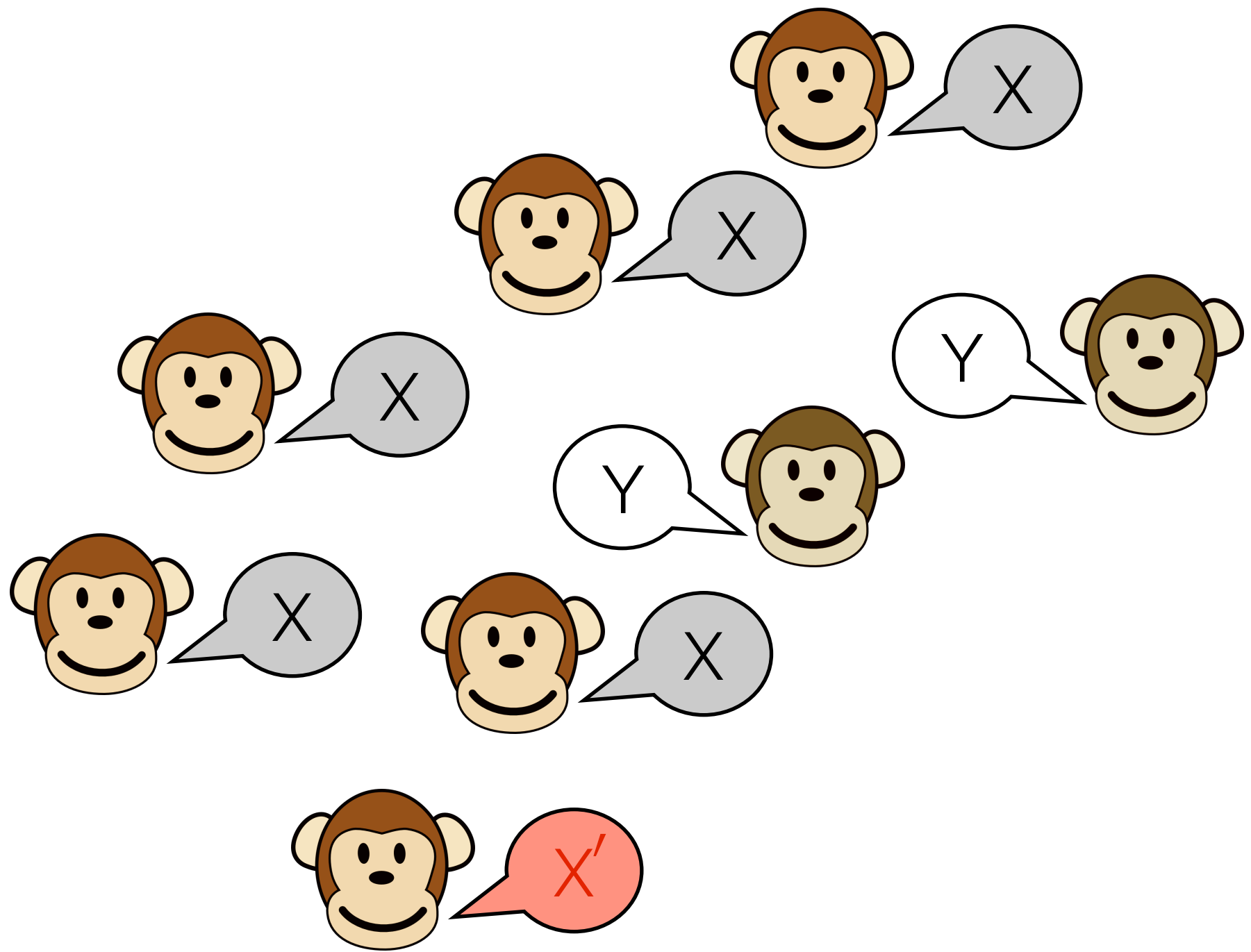
Evolution by natural selection

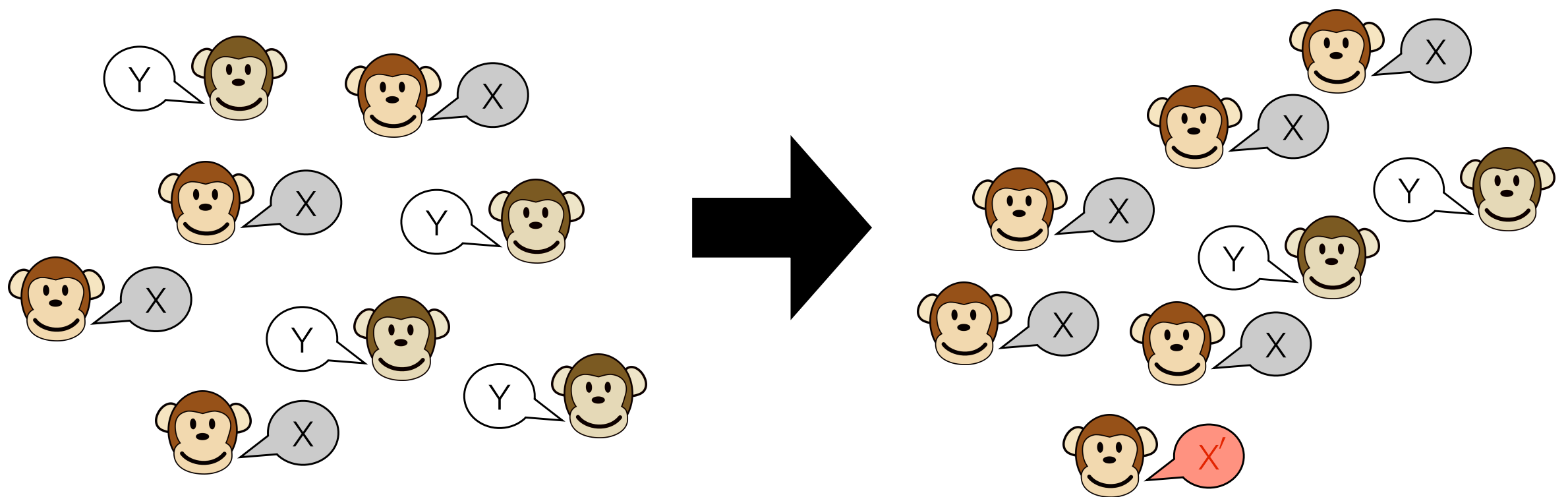
- Natural selection: the process by which genotypes with higher fitness increase in frequency in a population
- The inevitable consequence of **heritable variation in fitness**











Evolution by natural selection, adaptation and the appearance of design

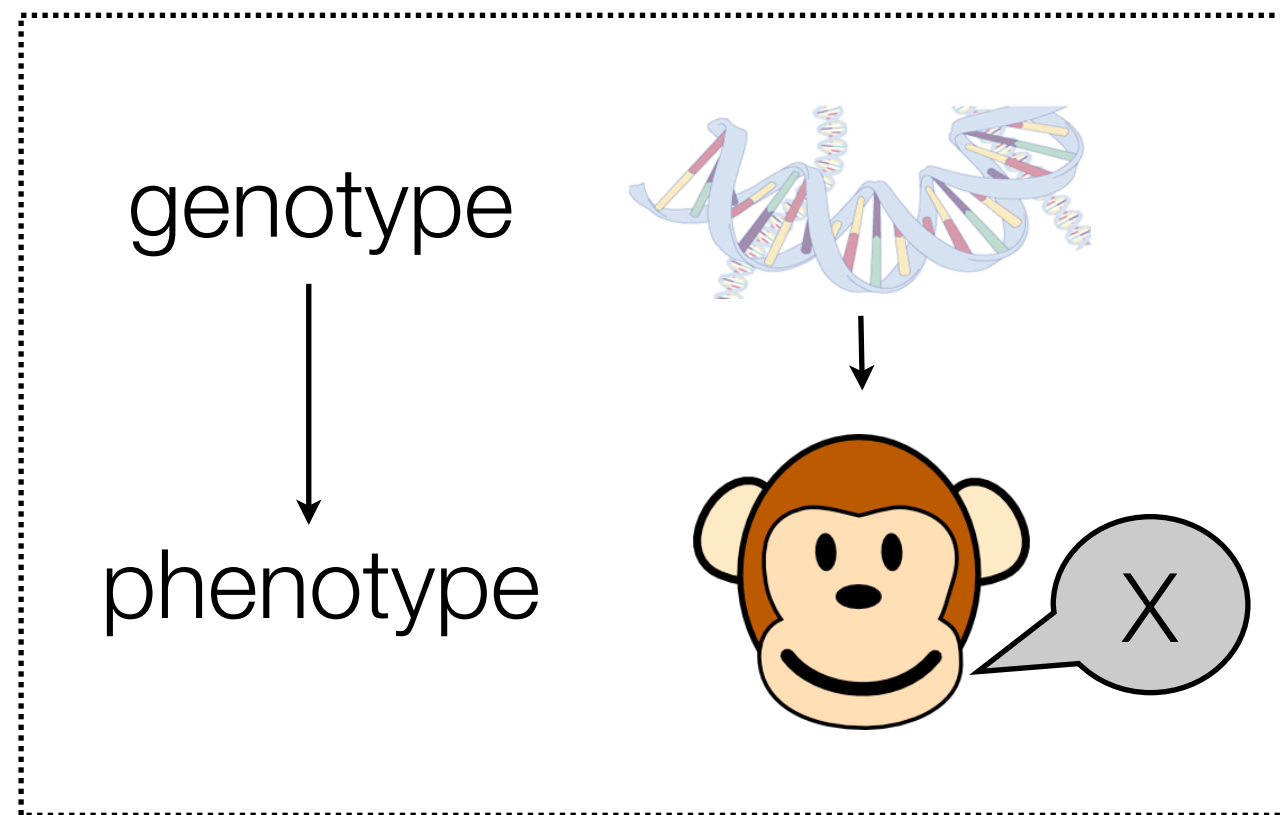
- Natural selection leads to **adaptation**
 - “‘design’ in life - those properties of living things that enable them to survive and reproduce in nature.” (Ridley, 1996, p. 5)
- Only natural selection produces adaptations (let's come back to that!)

Interlude: human language is an adaptation, true or false?

When answering, think about what it means for a trait to be an adaptation

Modelling evolution

- Many ways of modelling evolution. One approach: *genetic algorithms*
- Key ingredients:



Modelling evolution

- Many ways of modelling evolution. One approach: *genetic algorithms*
- Key ingredients:

1. A population of organisms
2. A task they are trying to succeed at
3. A measure of how *fit* they are at this task
4. A way of selecting the fittest
5. A way of allowing the genes of the fittest to survive
6. A mechanism for introducing variation into the gene pool

Our model

- Simplify things a bit: Treat genes and phenotype as equivalent and get rid of sex
- The simulation:
 1. Create a population of random signal matrices
 2. Assess each member of population for fitness (based on communication)
 3. Pick a parent based on fitness
 4. Copy parent (with chance of mutation) to create new offspring
 5. Do 3 & 4 enough times to come up with a new population that's the same size as the old one
 6. Replace old population with new one
 7. Repeat steps 2 to 6 many times

Main research question

- Under what conditions will we see the emergence of “optimal” communication systems? (i.e. when will we see a stable population of agents in which any pair of agents would have a communicative accuracy of 1.0)
- Main parameter: *how do we assess fitness?*
- **What is the *fitness function*?**
- Key considerations:
 - How do you pick communicative partners?
 - Who gets rewarded for successful communication?
- Find out answers in the labs on Tuesday and Thursday