Simulating Language
Lecture 3: Evolving innate signalling systems

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Quick recap

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] ]
```

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

  A: Hmm. I don't know.

  B: my_matrix[0]

  C: my_matrix[1]

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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 strength of association between m2 and s1?**

  A: Hmm. I don't know.

  B: my_matrix[0][1]

  C: my_matrix[1][0]

How we are modelling production/reception matrices in python

	s1	s2	s3
m1	1	2	0
m2	0	1	1
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```
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

How we are evaluating communicative accuracy: Monte Carlo simulation

- Build a simulation of thousands of communication events between two agents, a producer and a receiver.

- For a particular producer and receiver, do the following:

1. Pick a random meaning
2. Use winner take all to generate a signal for that meaning according to the producer's production matrix
3. Use winner take all again to see what meaning corresponds to that signal in the receiver's reception matrix
4. If the receiver's meaning is the same as the original one, count as success

- Repeat 1-4 thousands of times and return the proportion of these "trials"

New stuff

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?

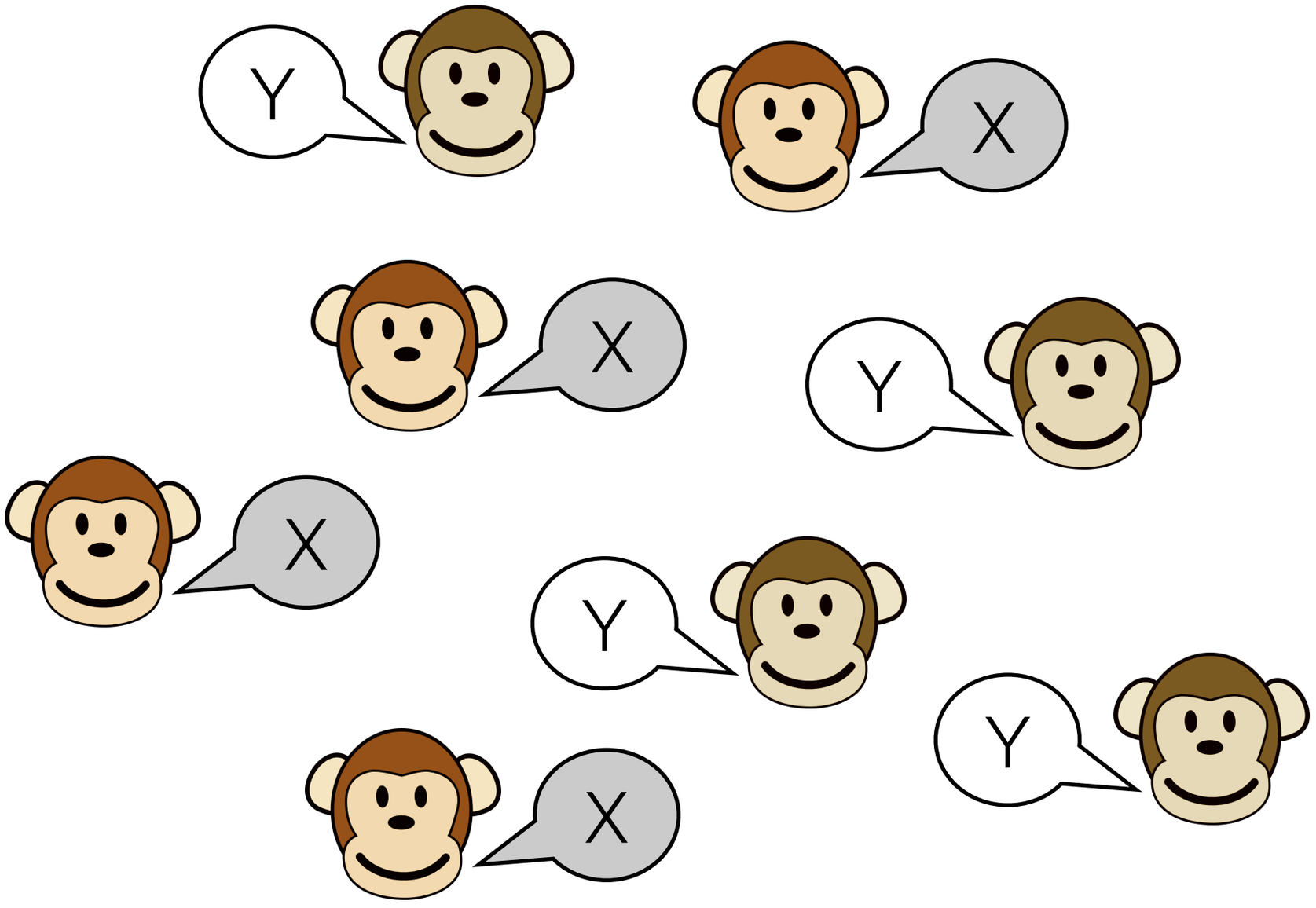
- We need to model it...

- ...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**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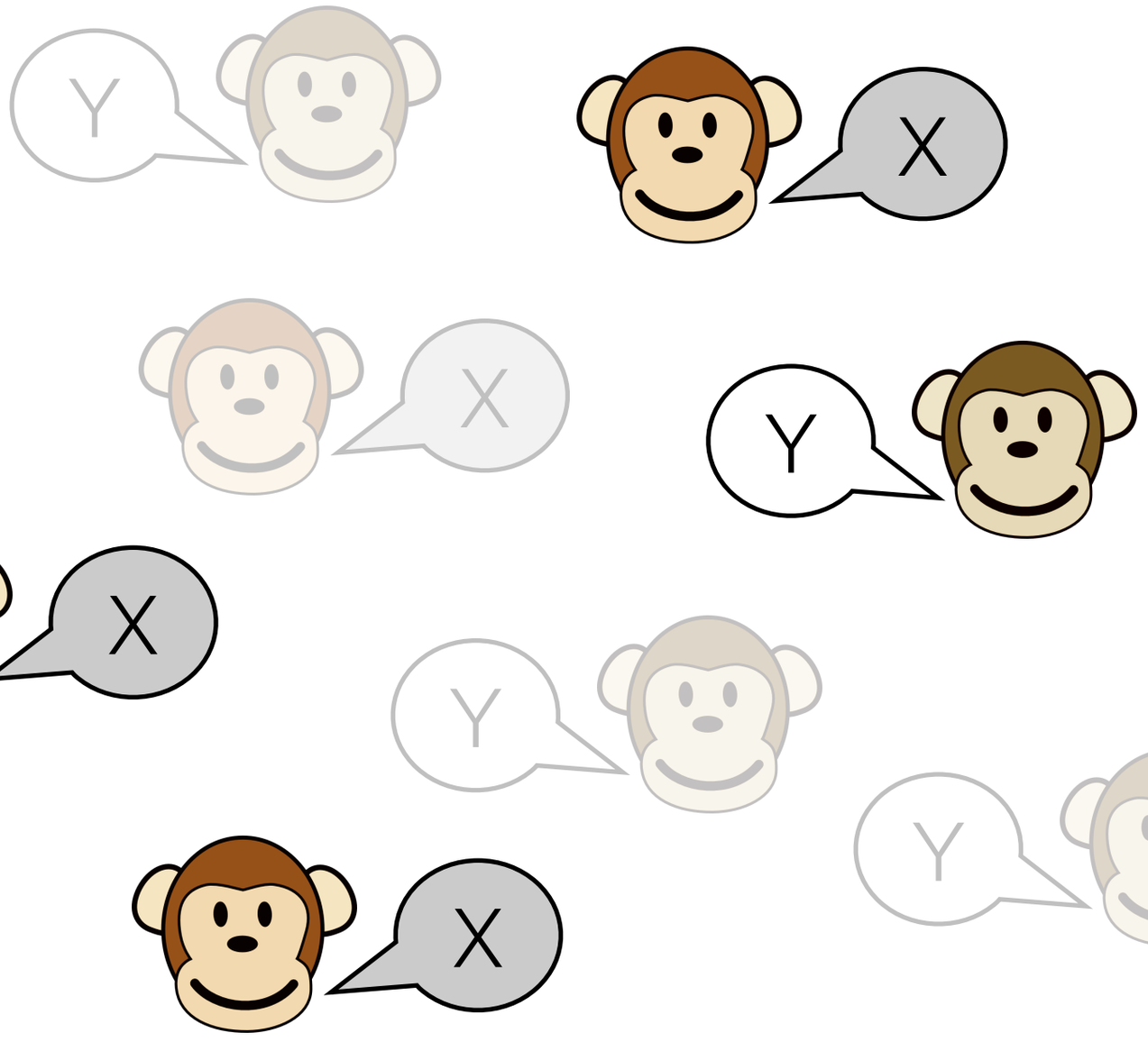
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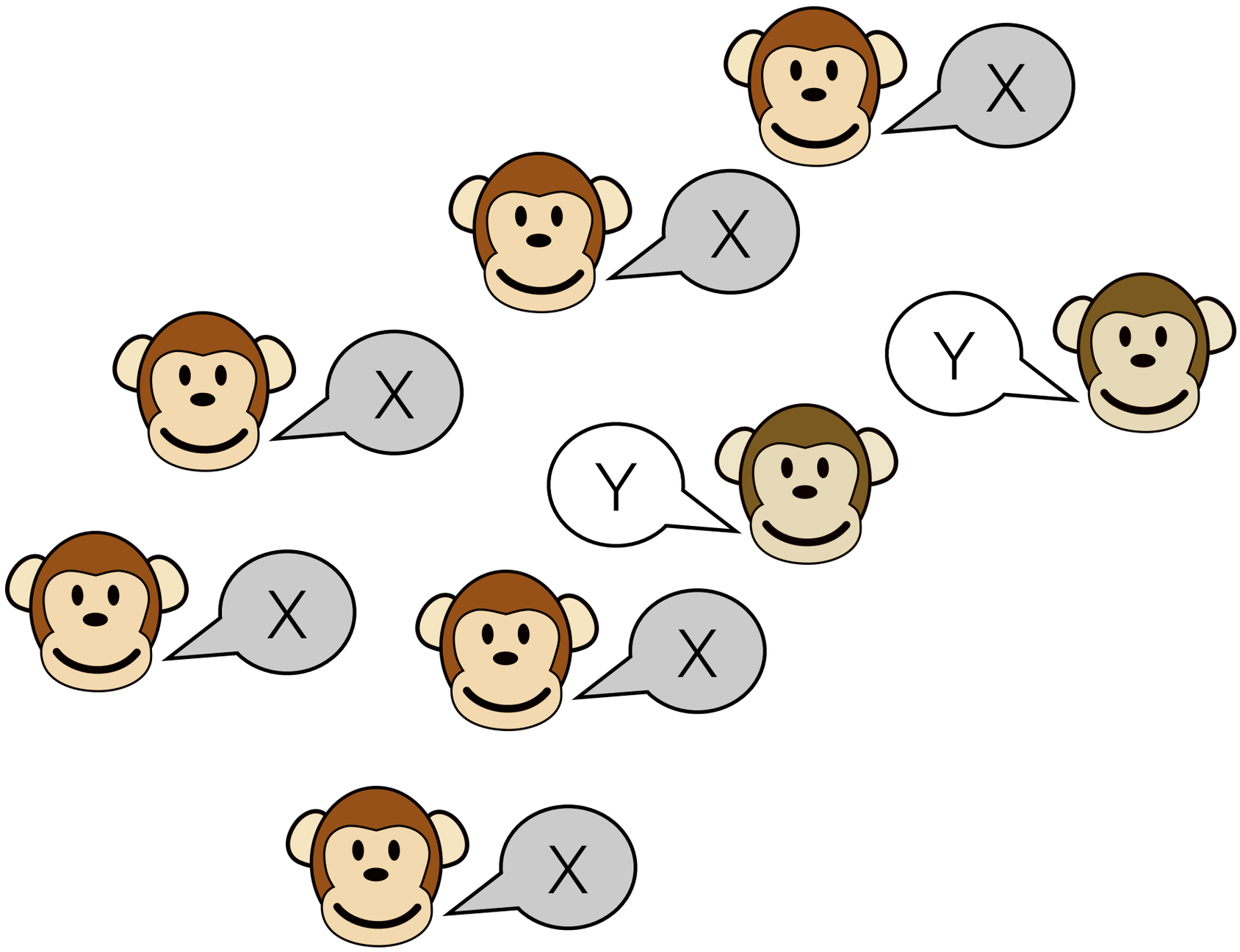
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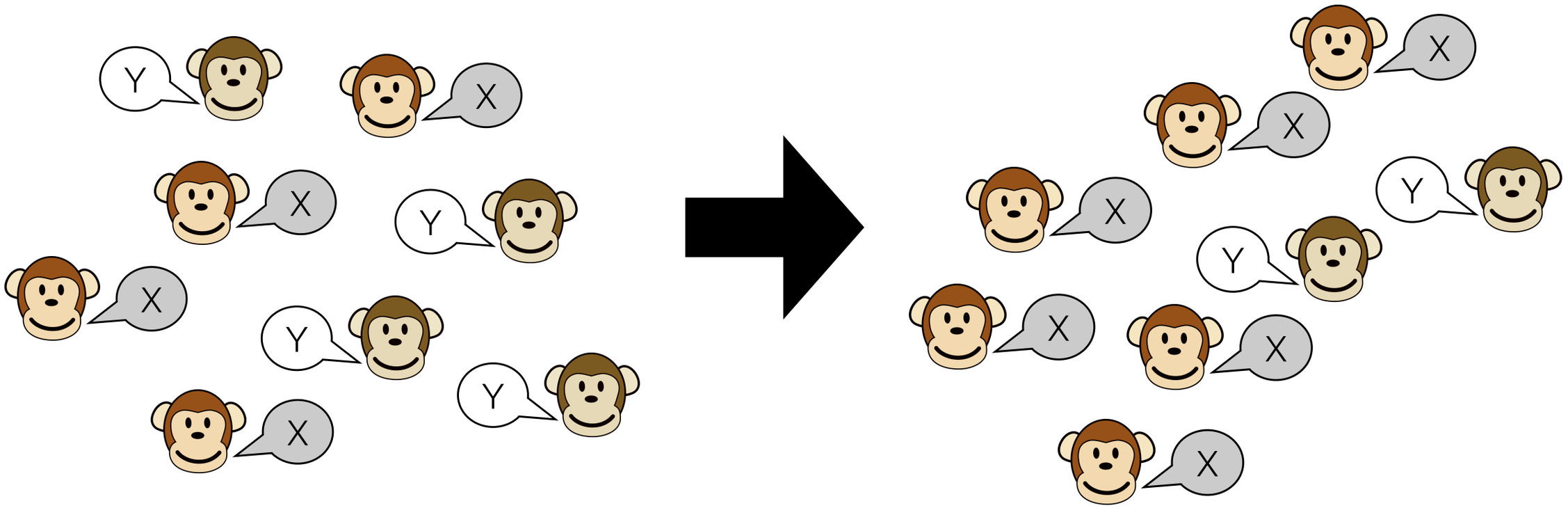
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Evolution by natural selection, adaptation and the appearance of design

- 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

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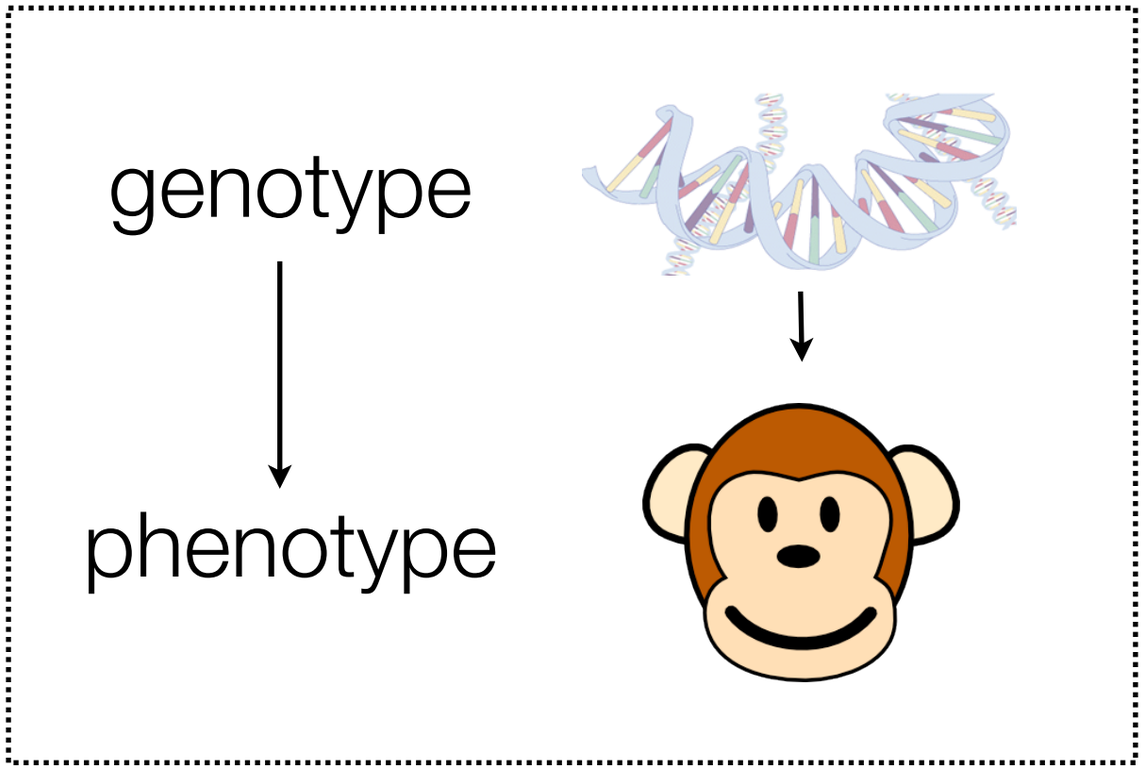
Modelling evolution

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

- Key ingredients:



Modelling evolution

- Many ways of modelling evolution. One approach: *genetic algorithms* (see Mitchell, 1998)

- 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
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 Monday and Thursday, and in the reading for next Friday’s lecture.