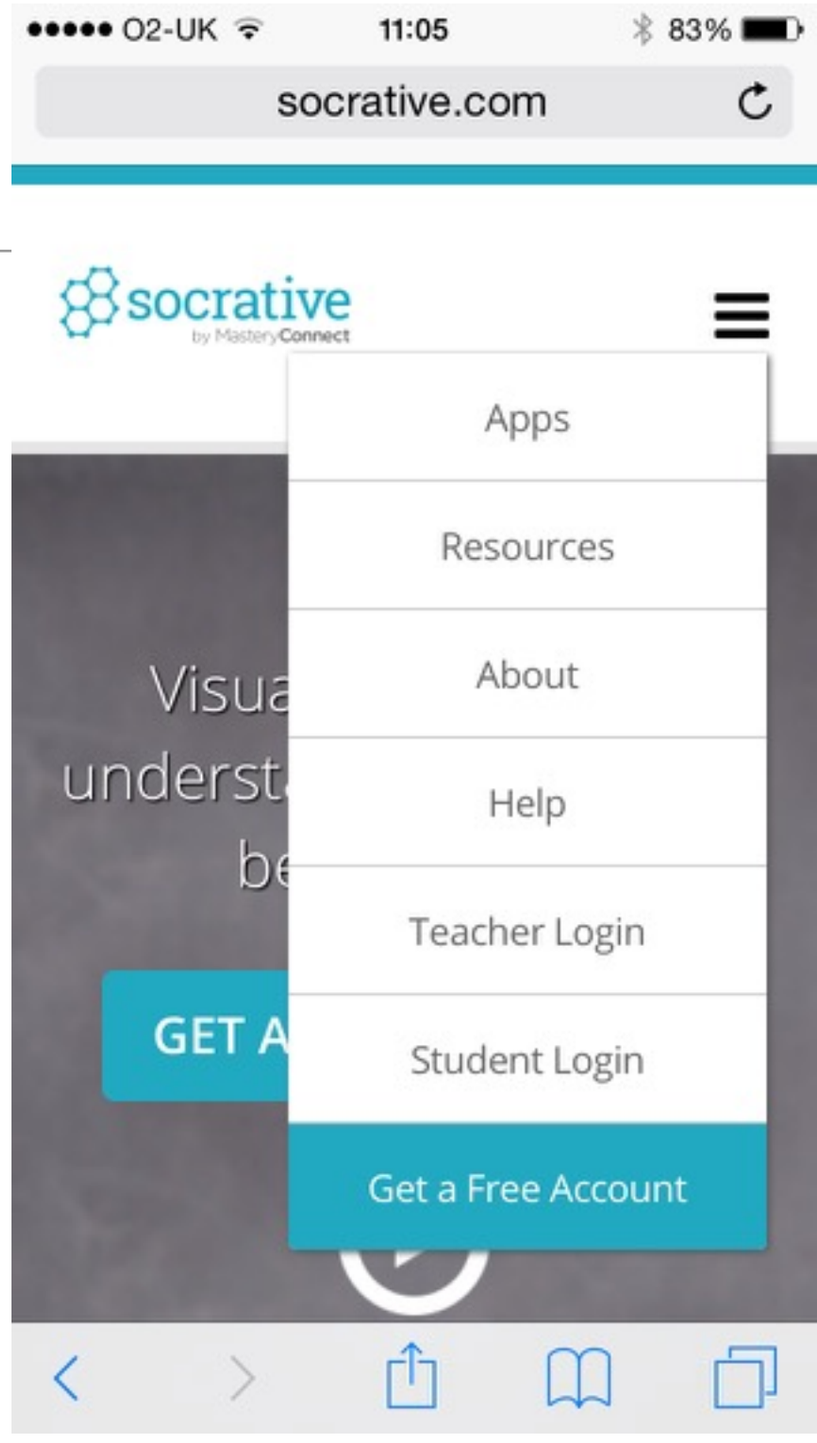
While you are waiting...

- Go to **socrative.com**
- Log in as a student, enter room number **SIMLANG2016**



Simulating Language
Lecture 3: 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

	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]

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 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
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

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 select a signal for that meaning according to the producer's production matrix
3. Use winner-take-all again to see which meaning corresponds to that signal in the receiver's reception matrix
4. If the receiver's meaning is the same as the sender's, count as success

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

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?

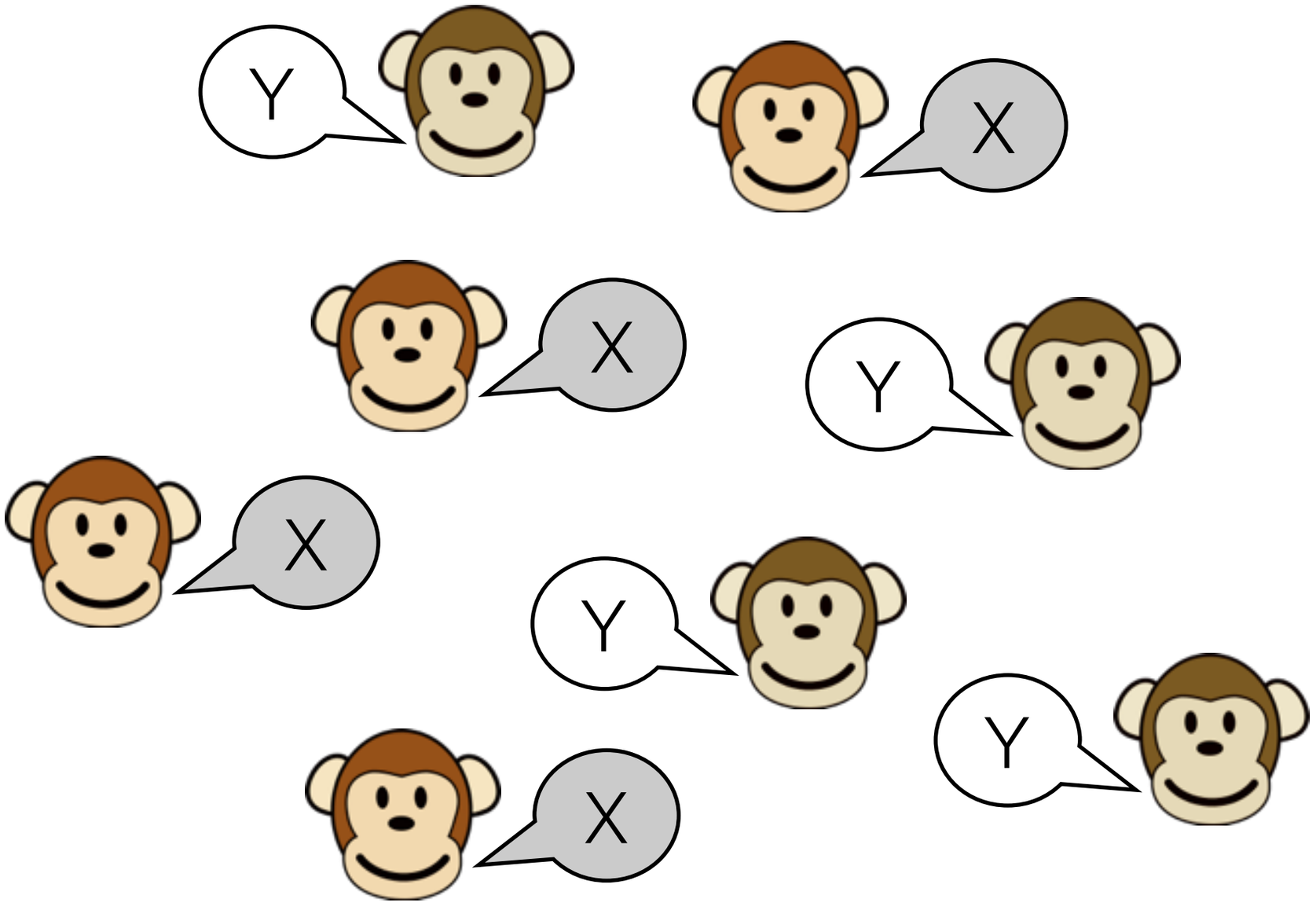
- We need to model it...

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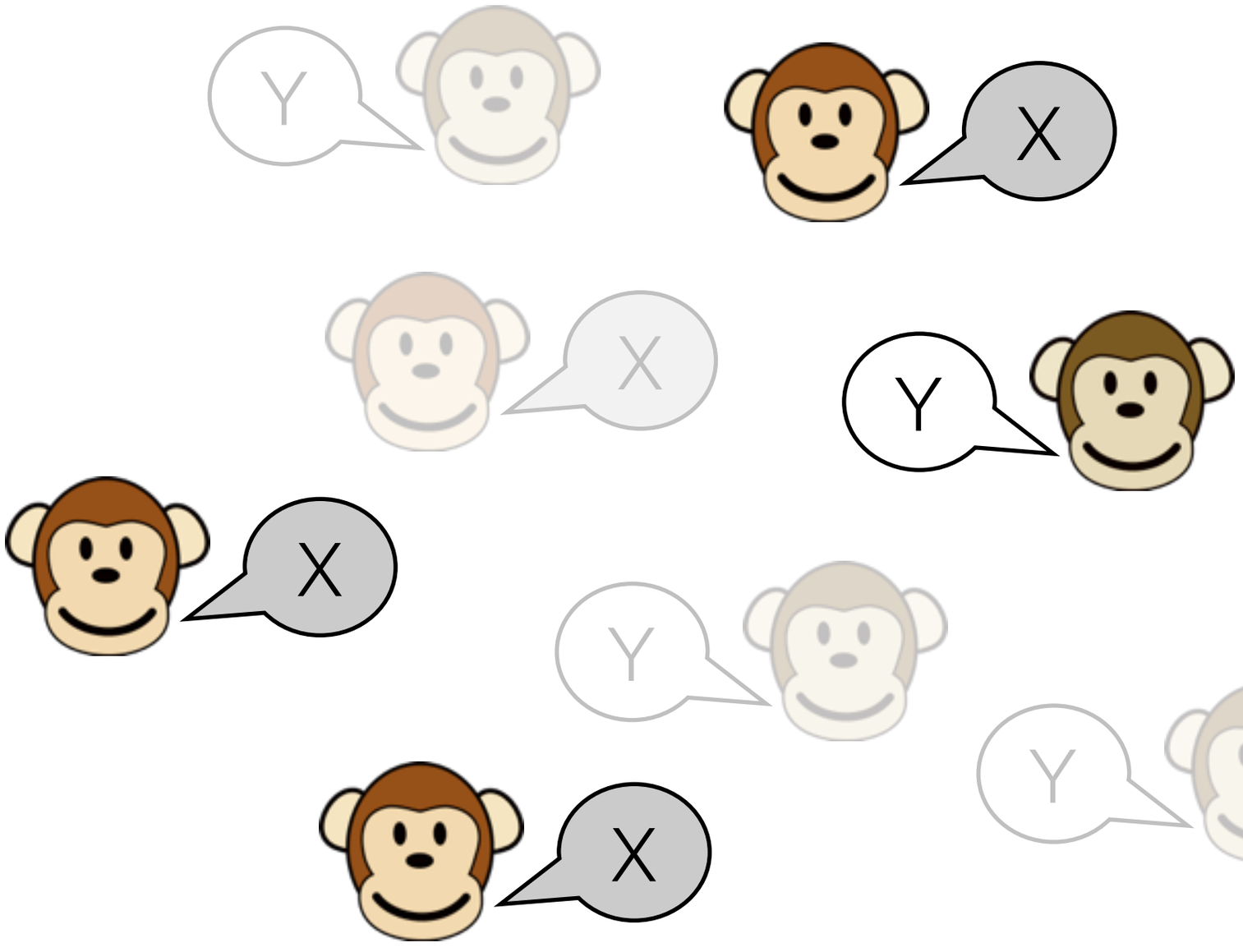
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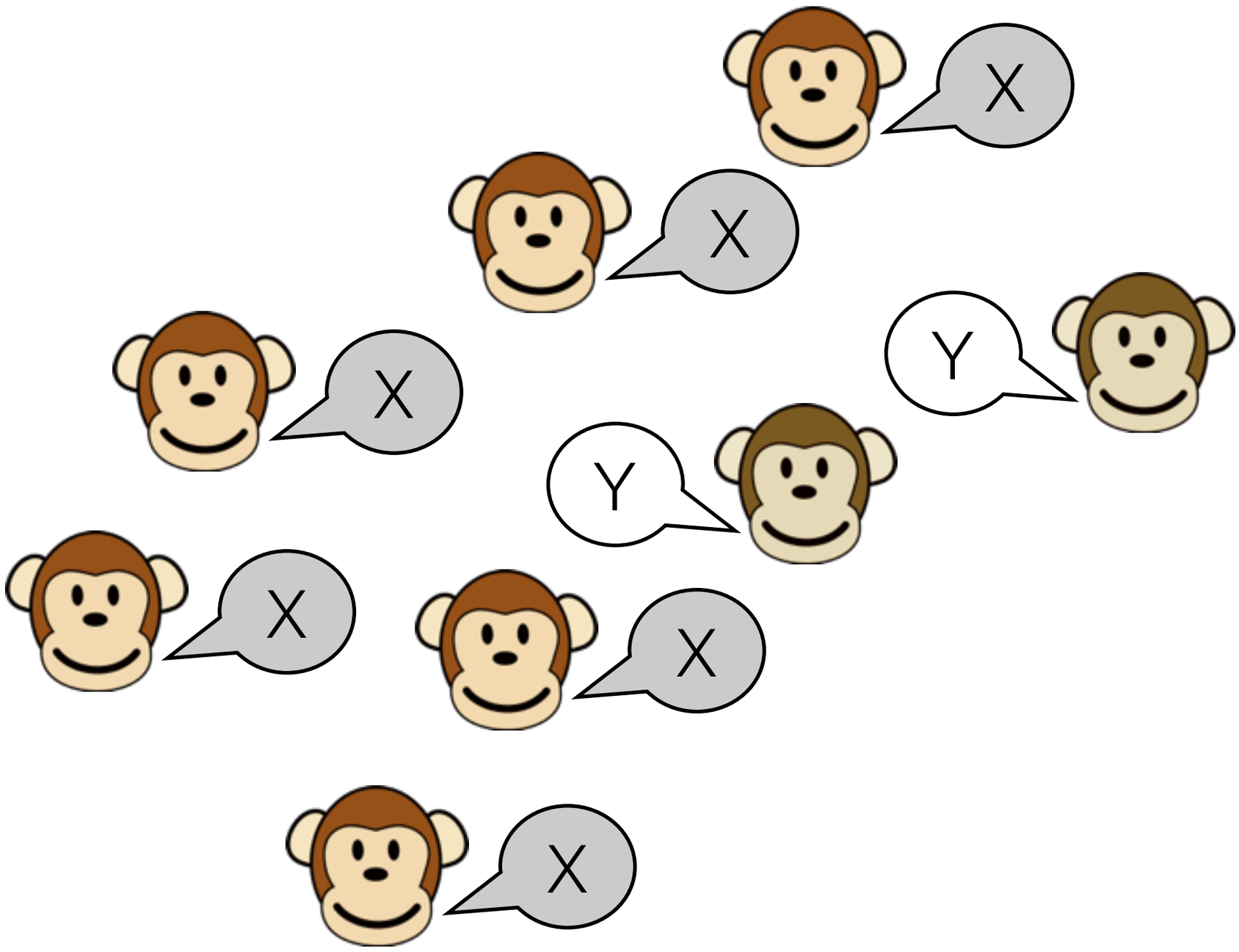
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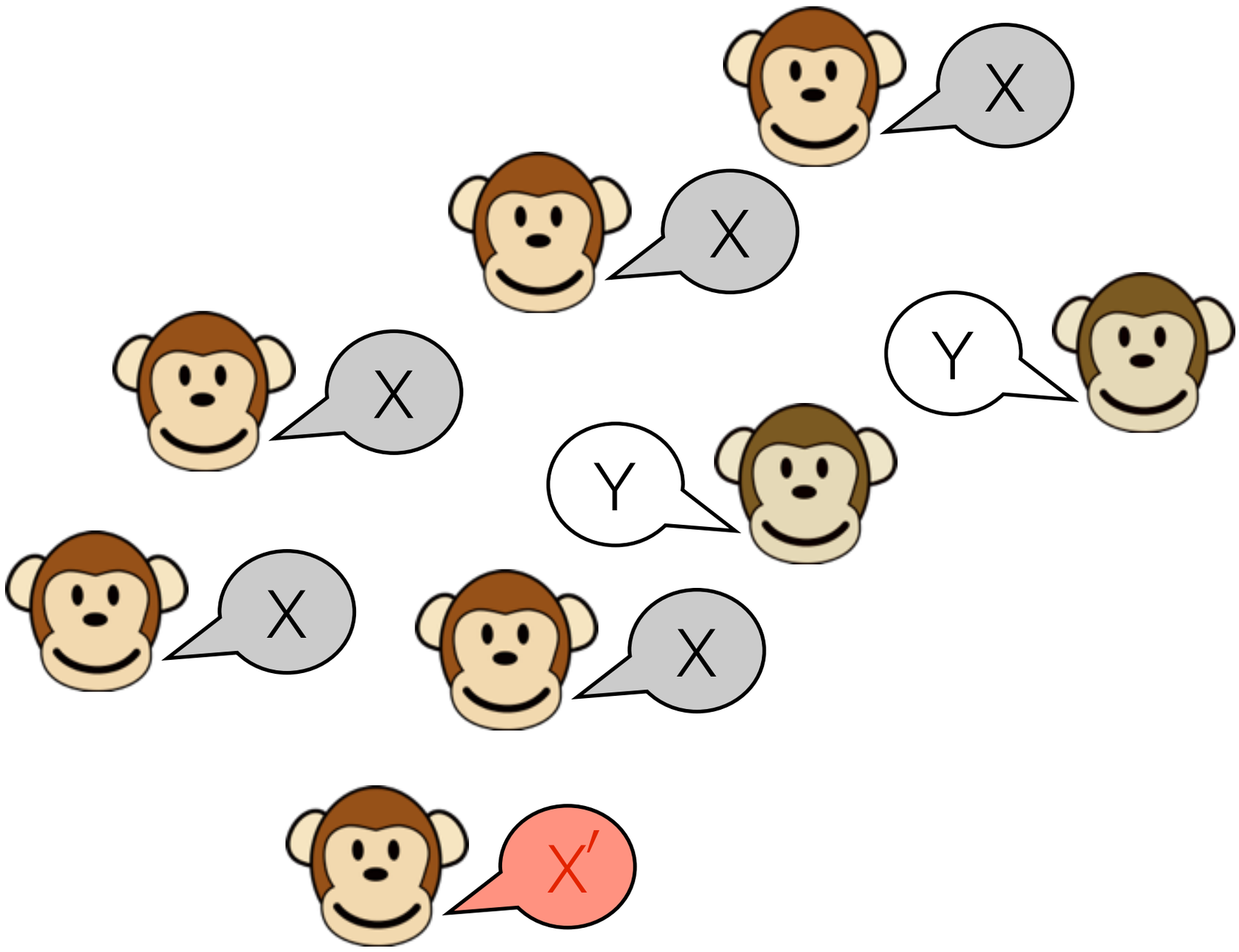
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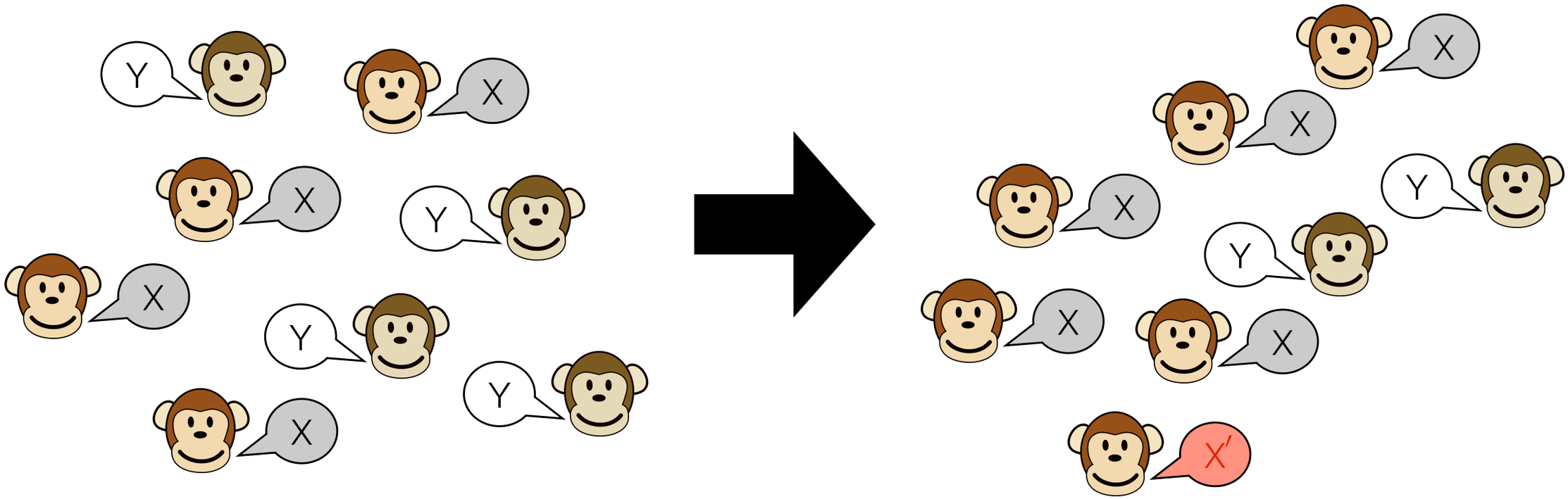
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Evolution by natural selection, adaptation and the appearance of design

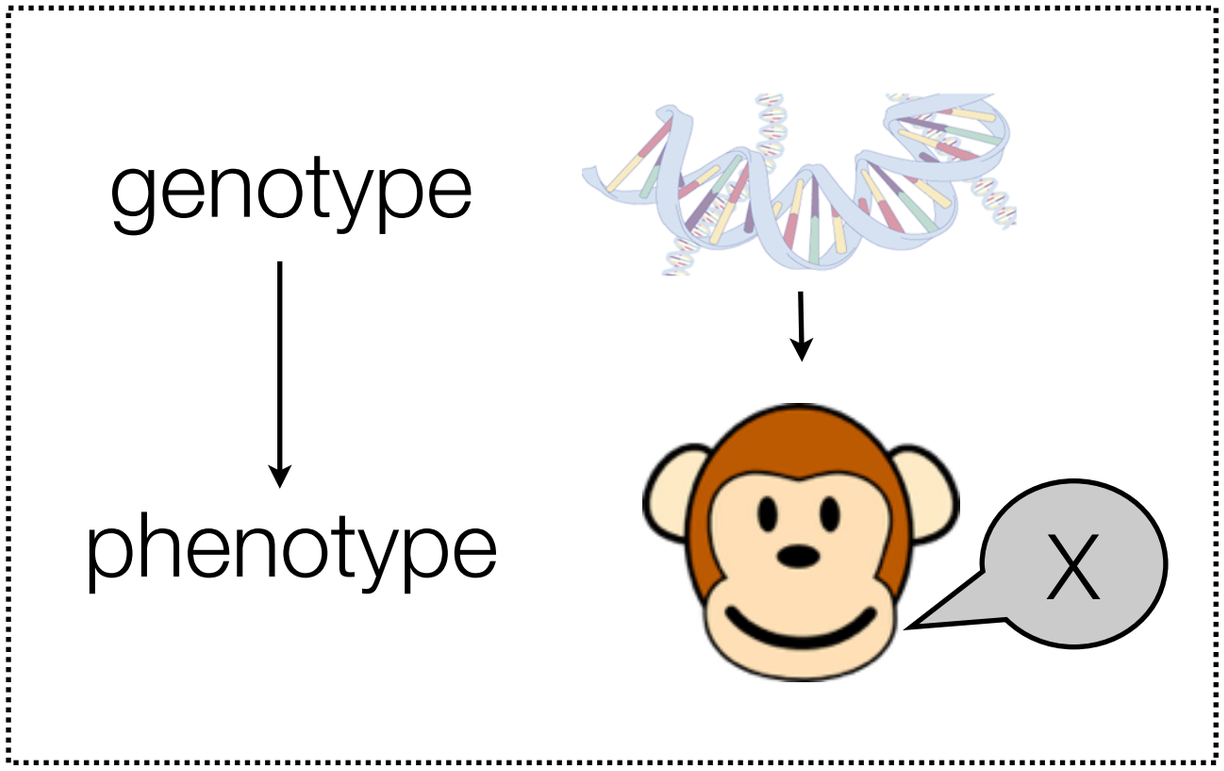
- Natural selection leads to **adaptation**
    - “‘design’ in life - those properties of living things that enable them to survive and reproduce in nature.” (Ridley, 1996, p. 5)
- Only natural selection produces adaptations (let’s come back to that!)

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

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

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 Monday and Thursday, and in the reading