Activity 6

HUMANS & CHIMPS:

All in the Family

Two humans
Photo courtesy of SMM
Four chimps
Photo courtesy Curt Busse

No one would mistake you for a chimpanzee. Chimps have long arms and short legs, large canine teeth, a body covered with hair, a bent posture, and they walk on their legs and knuckles. Humans, on the other hand, have short arms and long legs, small canine teeth, relatively hairless bodies, and an upright posture. Take a trip to a zoo and check out the differences. Chimps resemble the gorillas, orangutans, and other apes behind bars more than they resemble the onlookers. As for humans, there is no one like us on Earth, right?

Wrong. Scientists were surprised to learn from DNA studies that humans are genetically very similar to chimps. The differences in our DNA are very hard to find. Our genes match so closely that we can catch many of the same diseases. Humans can even receive blood transfusions from chimps. If you think there is no one like us, think again.

Scientists are thinking twice, too. Svante Pääbo is the director of the Max Planck Institute for Evolutionary Anthropology in Germany. He and his colleague Henrik Kaessmann compare chimpanzees and humans to understand what their genetic similarities mean. If our DNA is so close, does it mean that chimps are our closest living relatives? If so, when did we share an ancestor, and how did we evolve to be different?

Svante Pääbo is director of the Max Planck Institute of Evolutionary Anthropology in Germany.
Photo courtesy Svante Pääbo.

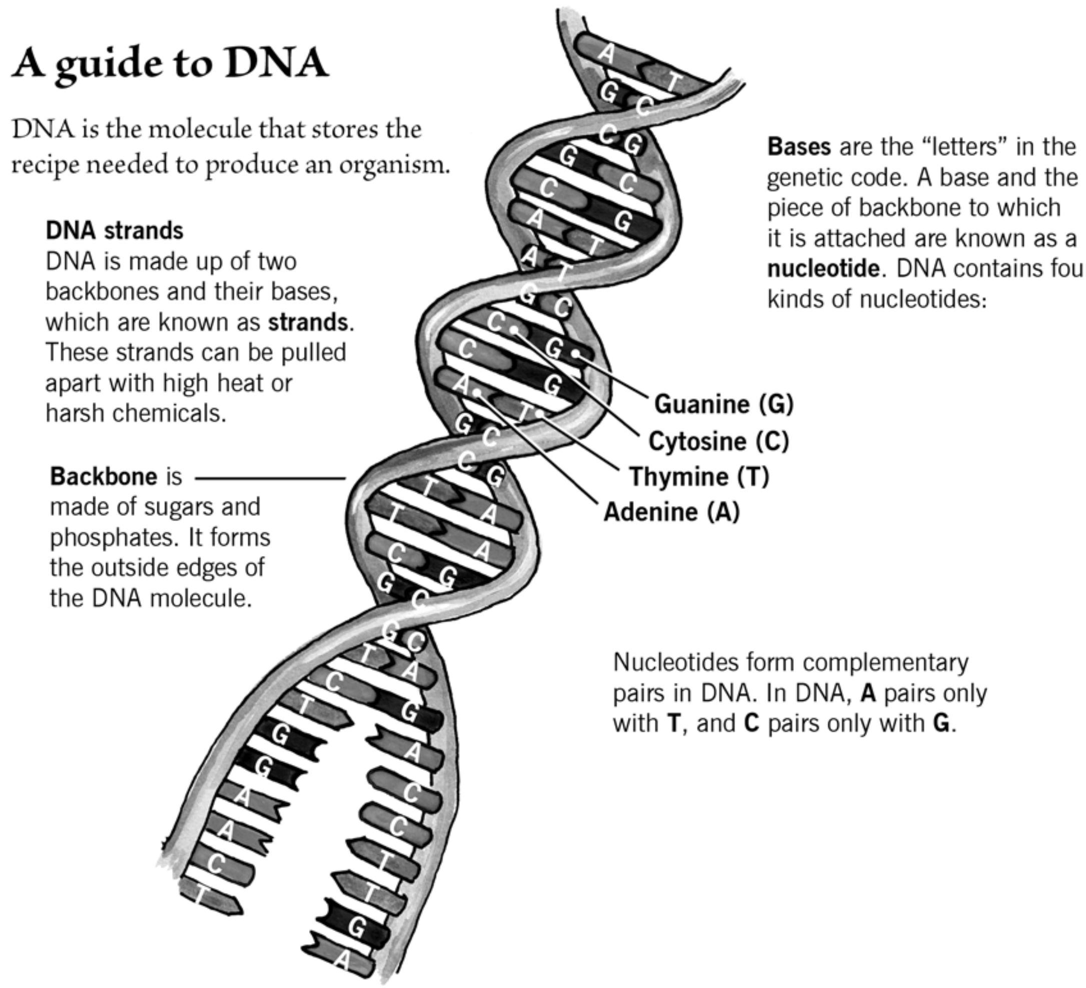
Henrik Kaessmann is at the University of Lucerne, Switzerland.
Photo courtesy Henrik Kaessmann.

DNA is the best tool we have for investigating how closely two species are related. Before DNA was discovered, scientists drew family trees based on similarities in anatomy, the physical structure and appearance of organisms. They relied on the fact that close relatives look more alike than unrelated individuals. In some cases, however, looks can be deceiving. Two friends may look as alike as sisters, while two sisters may look like they belong in different families. Sometimes it takes DNA "fingerprinting" to settle a question of family ties.

How do scientists read family histories in DNA? DNA is a long molecule made up of four chemical substances called nucleotides (NEW-klee-oh-tides). The nucleotides are named Adenine, Thymine, Cytosine, and Guanine, and they are usually abbreviated as A, T, C, and G. The nucleotides line up along the DNA molecule's length like words in a sentence. When an organism reproduces, DNA copies its nucleotides. The copying process is not exact, and sometimes a nucleotide may be left out, or two nucleotides may be switched. These changes are called mutations.

Our DNA is a combination of the DNA we inherit from our parents, plus the new mutations (changes in the nucleotides). When we produce children, we pass along our DNA plus new copying mistakes, and the mutations keep adding up. Most of these mutations have little or no effect on an organism, but their presence in our DNA helps to preserve a record of our accumulated changes over time. The mutations can be used like a trail of breadcrumbs to trace a species back to its ancestors.

Scientists line up the DNA sequences of different species, compare the nucleotides letter for letter, and count the differences. The more differences that accumulate



Science Museum of Minnesota (SMM) Adam Wiens, Lonnie Broden illustration.

between two species, the longer they have been evolving separately. DNA works as a kind of clock that ticks off evolutionary time.

Svante Pääbo has been counting the DNA differences in humans and other species for many years. Pääbo was the first scientist to develop a way to extract DNA from fossil humans and compare it to the DNA of living humans and chimps. Amazingly, he was able to extract the DNA from the arm bone of a 40,000-year-old Neanderthal, an extinct human-like species that lived in Europe. Then he compared it to samples of human and chimp DNA. Based on the number of differences, he estimated that Neanderthals and humans had a common ancestor half a million years ago. Chimps shared an ancestor with Neanderthals and humans much further back in time.

Pääbo and his colleague, Henrik Kaessmann, then traced the ancestry of humans and chimps to find out when they shared a common ancestor. The scientists took a segment of human DNA about 10,000 nucleotides long. The segment is called Xq13.3 for its location on the X chromosome. The scientists counted the number of nucleotides that were different. They discovered that humans and chimps averaged only about 100 differences out of 10,000 nucleotides on that length of DNA. That is a difference of about 1%.

Genetic studies like Pääbo's support a rich fossil record of human and chimp evolution. Researchers have uncovered the bones of ancient primates that shared ape and human characteristics. From these fossils, a general picture of our most recent common ancestor is emerging. The great, great, great (etc.) grandmother of chimps and humans was a primate who lived in Africa about five or six million years ago.

One of the most famous fossil discoveries so far is Lucy, an almost complete skeleton of a female ancestor who lived about four million years ago. Lucy stood erect and walked like a human, but she was as small as a chimpanzee, and she had a chimp-like brain. Lucy shows us just how chimp-like our ancestors were a few million years back.

Svante Pääbo and other DNA researchers are now focusing on the 1% difference between human and chimp DNA. They are hoping to find answers to the question everyone is asking: Why do we look so different when our genes are so much alike?

In this activity you are invited to compare humans and chimpanzees, inside and out, learn how to tell time with DNA, and decide for yourselves whether we should keep chimps in a zoo or invite them to Thanksgiving dinner.

PART ONE

Chimps vs. humans

People have long been fascinated by how similar chimpanzees look to humans. But just how similar—and different—are we? Take a close look and compare a chimp and a human side by side. Create a set of human and chimp attribute cards based on what you find.

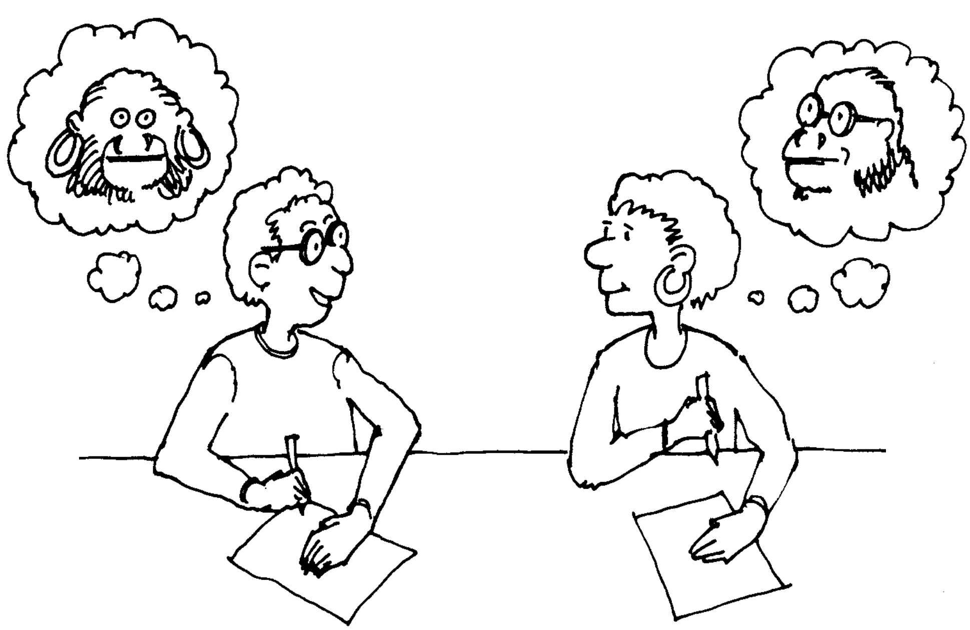
Work with a partner or in a small group

Each team of two or more will need:

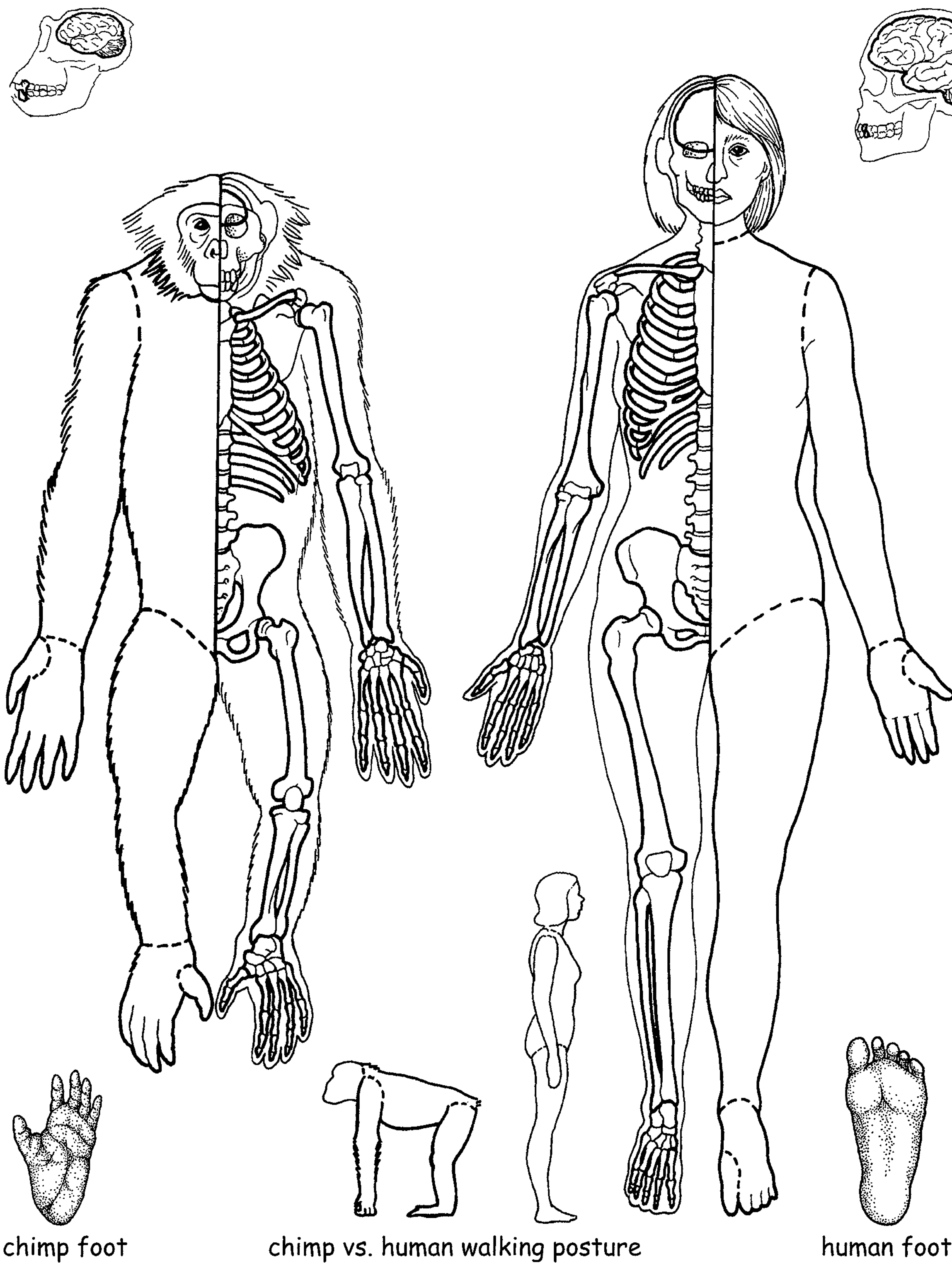
- Chimpanzee vs. Human sheet
- Comparing Creature Features sheet
- Feature Cards (blanks; one sheet per group)
- Hidden Feature Cards (one sheet per group)
- tape
- scissors

1 What's Human… What's Not.

a Check out the Chimpanzee vs. Human sheet. Cut out the Comparing Creature Features sheet and match the half to the other species on the Chimpanzee vs. Human sheet. Tape the half into place if it helps.



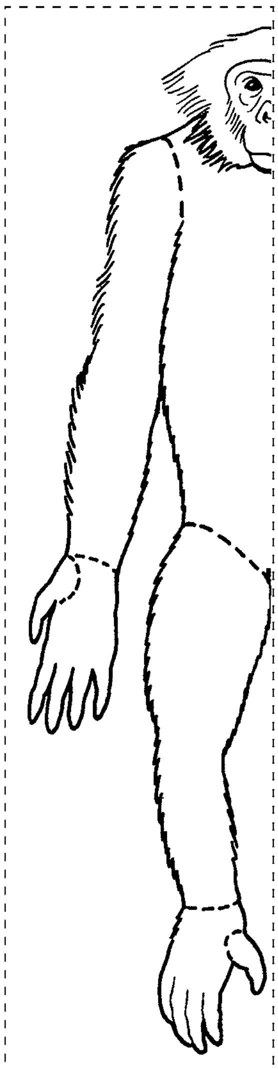
Chimpanzee vs. Human



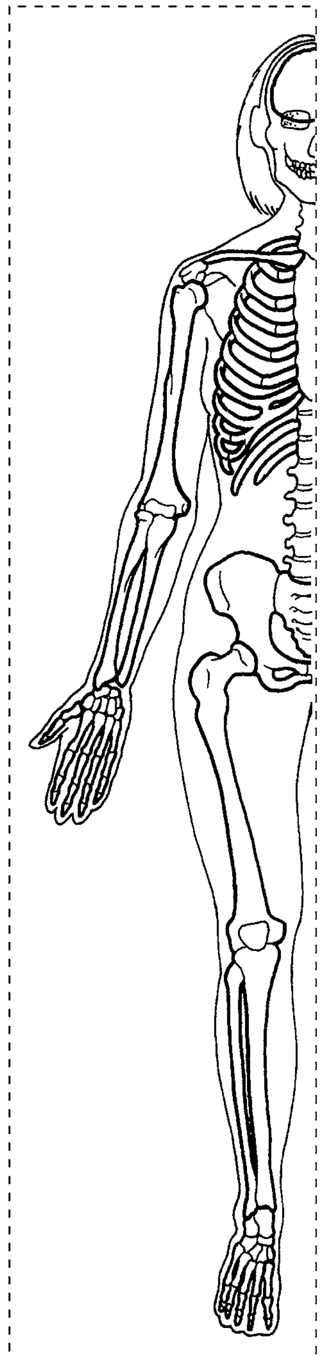
Comparing Creature Features

Cut out the half drawings along the dotted lines. Match each half to the opposite species on the Chimpanzee vs. Human sheet for easy comparison.

Cut on dashed lines.



Tape the chimp opposite the human.



Tape the human opposite the chimp.

Cut cards apart on the dashed lines.

Feature Cards

Fill them with your observations.

Chimps have...	Humans have...	Both chimps and humans have...	

b Write your observations about the similarities and differences on the blank Feature Cards. First cut the cards out. Then take about ten minutes and list as many features as you can. Then write one observation per card.

For instance:

"Chimps have fur."

" Humans have smooth skin with tiny hairs."

Here are some things to notice:

Bone shapes	Finger lengths	Teeth
Ear position	Skull shape	Limb lengths
Posture	Butt muscles	Face shapes

2 Sorting Out Differences

a Sort all the Feature Cards you wrote into three piles: Chimps, Humans, or Chimps and Humans.

b Now cut and read the Hidden Feature Cards. These cards are about human and chimp features that you can't see in a picture. Sort them into the same three piles. You may have to guess where they fit. *(Don't look now, but the answers are on the last page of Activity 6.)*

3 Consider This

Would you say that humans and chimps are more different than they are alike… or more alike than they are different? Why?

Hidden Feature Cards

Cut cards apart on the dashed lines.

Lives in territories that are defended by roving males. Practices aggressive and sometimes lethal behavior against its neighbors.

Has a large brain relative to body size.

These are social animals that live in communities. The top ranking male leads the community.*

Uses hand gestures and facial expressions to communicate.

They are also able to use a computuer keyboard to communicate.

When they are sick they dose themselves with medicinal herbs.

Males weigh up to 110 pounds and females up to 85 pounds. The average lifespan is 50 years.*

These animals yawn (although no one knows exactly why). Yawning is contagious among group members.

Has a long childhood and loves to play.

Develops a lifelong bond with its mother.

Linda Allison illustration

PART TWO

It's molecular time

DNA is no ordinary stuff. DNA carries the recipe for assembling proteins into living organisms. This long molecule also acts like a clock, helping scientists estimate how long two species have been separated from a common ancestor. When DNA makes a copy of itself, it isn't always perfect. Mistakes can happen. One nucleotide (Adenine, Thymine, Cytosine, or Guanine) might be missing, duplicated, or two nucleotides might switch positions. Scientists like Svante Pääbo have discovered that these mistakes (mutations) accumulate at a regular rate over millions of years, like the steady tick of a clock. Scientists can use this knowledge to date different copies or generations of DNA. This is what scientists call the "molecular clock."

See if you can tell time using the molecular clock method. First, compare copies of tiny segments of DNA for differences (mutations) in the nucleotides. Then use the mutation rate to date the copies.

Work with a partner

Each team will need:

- Generations of Copies sheet
- scissors

1 Down to DNA

a Below is a short segment of DNA that is nine nucleotides long. The first line of nucleotides is from a living organism. The second line is from a close ancestor. Underline the nucleotide in the ancestor DNA line that is different from the living DNA. This difference in the DNA code is a mutation site.

LIVING DNA

A	C	A	T	A	T	T	A	C

ANCESTOR DNA

A	T	A	T	A	T	T	A	C

The letters represent nucleotides:

- **A** = Adenine
- **T** = Thymine
- **C** = Cytosine
- **G** = Guanine

2 Sorting Out Sequences

a Cut out all the sequences of DNA from the Generations of Copies sheet.

b You have a nine nucleotide sequence from a section of DNA similar to what you might find from a living human. Look for the sequence with the label "living DNA."

c Now find the closest ancestor. It is the sequence that differs by only one nucleotide. The remaining sequences you have cut out are each older ancestors. Each older ancestor has more mutations or differences.

d Sort the sequences in order from the living human (the present) to the oldest ancestor (longer and longer ago).

3 Consider This

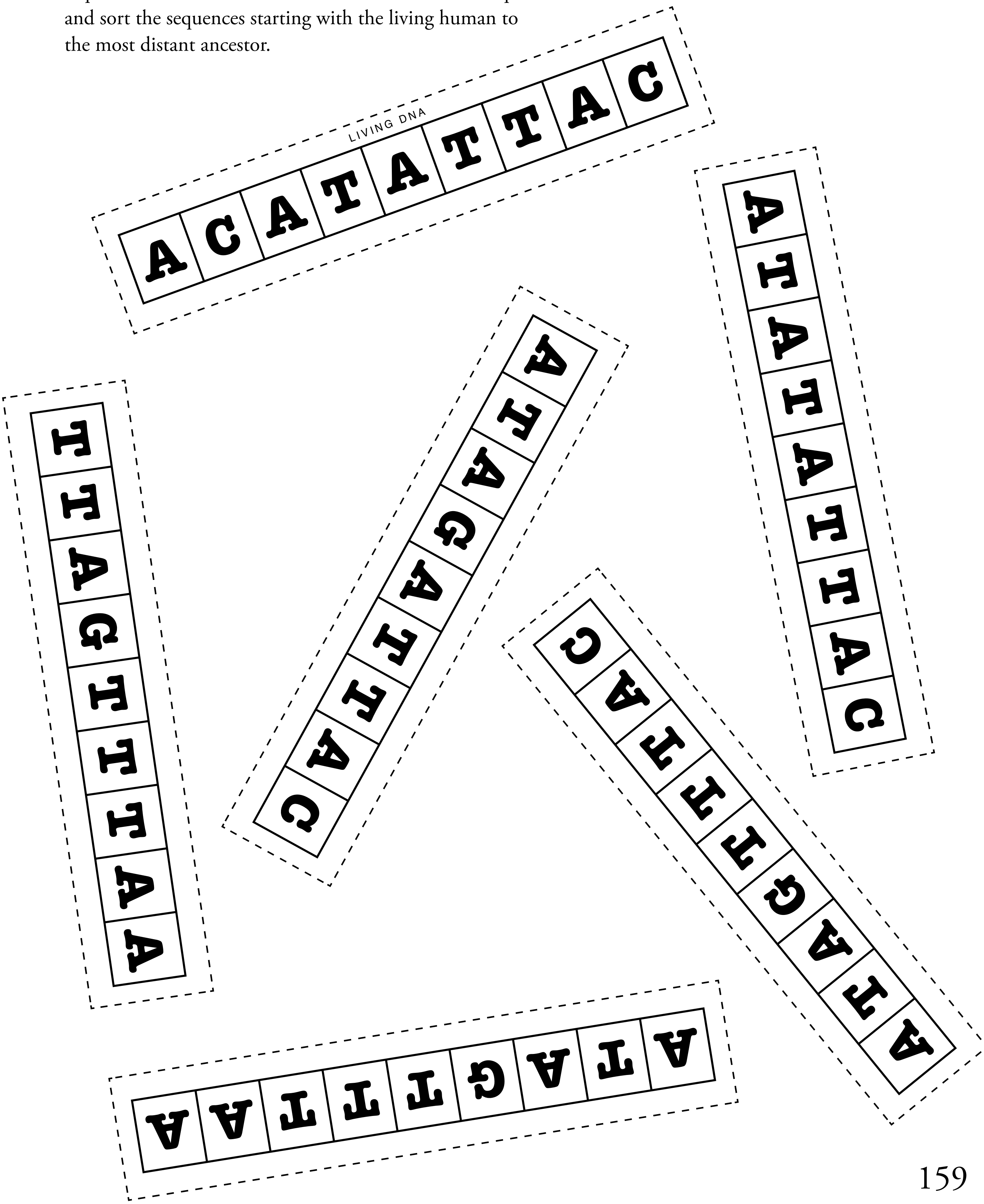
Now make the DNA tell time. Assume that the rate of mutation in this DNA segment is one difference for every 10,000 years.

a Based on the rate of mutation, how many years different are the oldest and the newest DNA segments?

b How long ago did the oldest ancestor live?

Generations of Copies

Below is a sequence of nucleotides from DNA that is similar to what you might find from a living human ("Living DNA"). The rest are sequences from five different ancestors. Cut out the sequences and sort the sequences starting with the living human to the most distant ancestor.



PART THREE
Mutations up close

Scientists like Pääbo line up the DNA sequences of different species. They compare the nucleotides A, T, C, G, letter for letter, and count the differences. The differences are the number of mutations in the DNA code that have accumulated over time. The more differences that accumulate between species, the longer the species have been evolving separately.

The genetic code of humans and chimps is billions of letters long. Working out a method for comparing DNA sequences between the two species is one of the problems that genetic scientists must solve. Today this is your challenge too. Only about 1% of the DNA in the chimp and human genes is different. Can you pinpoint the differences?

Work with a partner

Each team will need:

- Chimp vs. Human DNA Sequences sheets, pages 162 and 163, parts 1 and 2 (taped together)
- scissors

1 Comparing DNA

a Compare the Chimp vs. Human DNA Sequences. The sequences are located on the X chromosome, and they are called Xq13.3. These are the small sections of the DNA that Svante Pääbo and his group use to make chimp/human comparisons. Look for any differences (mutations) between the chimp and human sequences.

b How to read the chart:

- In the chart you will find the same stretch of DNA (about 2,700 nucleotides long) for a chimpanzee (top) and a human (bottom).
- The vertical lines show where the DNA is the same for chimps and humans.
- A tiny Pääbo figure shows where there's a difference in the chimp and human DNA.

c How many Pääbos can you find?

2 Consider This

Did you expect more or fewer differences between chimp and human DNA? Why?

Part 1

CHIMP DNA (START) G G T C A C G C T G G C A A C C A T G T G G A A G A T G A A T T G A A G A A A T G G G A C A C A G G G A A T C C A A A T C A C T T T G G G A CHIMP
HUMAN DNA (START) G G T C A C G C T G G C A A C C A T G T G G A A G A T G A A T T G A A G A A A T G G G A C A C A G G G A A T C C A A A T C A C T T T G G G A HUMAN

CHIMP C C T G T G A C A G T C C A A A G C A A A G G G A A T A G T T G G T C A C C C T A T T A G A T T A G A A T T T A A A G T A A A A G T C A G A T A T G G CHIMP
HUMAN C C T G T G A C A G T C C A A A G C A A A G G G A A T A G T T G G T C A C C C T A T T A G A T T A G A A T T T A A A G T A A A A G T C A G A T A T G G HUMAN

CHIMP G T A T C C A G T T T T G C A C T T T T C C A A A G C A A C T T C A T A T G C A G C A A C T A A C A G C A T T C A C T T C T G C T G A T G A T C T G A CHIMP
HUMAN G T A T C C A G T T T T G C A C T T T T C C A A A G C A A C T T C A T A T G C A G C A A C T A A C A G C A T T C A C T T C T G C T G A T A A T C T G A HUMAN

CHIMP T C A A A T G G T T T T C T T T C T C T A A C A T A A T G A C T G A G C T T C A C T A C A A A T T G C A C T A T A C T A A C T T G C A C C A T A C A T CHIMP
HUMAN T C A A A T G G T T T T C T T T C T C T A A C A T A A T G A C T G A G C T T C A C T A C A A A T T G C A C T A T A C T A A C T T G C A C C A T A C A T HUMAN

CHIMP C C T G T G T C T A A C C C A G A T T A A A T A G T T G G C C A A A T T A T C C A C T C T T A C A C A A G A A T A C A C A A C T T C T T T G T T C T C CHIMP
HUMAN C C T G T G T C T A A C C C A G A T T A A A T A G T T G G C C A A A T T A T C C A C T C T T A C A C A A G A A T A C A C A A C T T C T T T G T T C T C HUMAN

CHIMP C A A A T G G C T C A A T T A T C C T G T T G A A A T A C T A G T G T G T A T T T G A A A T G G C A C A A A T G G A A A T T A A T G A T C T C C A G T CHIMP
HUMAN C A A A T G G C T C A A T T A T C C T G T T G A A A T A C T A G T G T G T A T T T G A A A T G G C A C A A A T G G A A A T T A A T G A T C T C C A G T HUMAN

CHIMP A G C C C C T T T T C T A T T A T G C T A A A G C T T C T T C C T C T C T C T C C T G C T C C C C A T C C A C C A C T T T T C T C G G A A G A C T A T CHIMP
HUMAN A G C C C C T T T T C T A T T C T G C T A A A G C T T C T T C C T C T C T C T C C T G C T C C C C A T C C A C C A C T T T T C T C G G A A G A C T A T HUMAN

CHIMP T C T A A C A C A C A T A A T T T T A T T T A T A G C A G C A C T C T T C T T A C T T C C C A A C A C A G C T G T C C T T C C T G C T G C T C A A G A CHIMP
HUMAN T C T A A C A C G C A T A A T T T T A T T T A T A G C A G C A C T C T T C T T A C T T C C C A A C A C A G C T G T C C T T C C T G C T G C T C A A G A HUMAN

CHIMP G G T T T T C T A C A C T C T C A G C T A G A G C T T T T T C A T C A A G T C T C T C C A A C T C C C A A A G T A A T T T T C T T G T C T A C G C A C CHIMP
HUMAN G G T T T T C T A C A C T C T C A G C T A G A G C T T T T T C A T C A A G T C T C T C C A A C T C C C A A A G T A A T T T T C T T G T C T A C G C A C HUMAN

CHIMP C A T T C T T T A A T G C A C T T C A A G G T G G C A T A C A T G T C C C C A C A A C C T C A C T T C A G T C A G T A C T T C T G T G G C T T T G A A CHIMP
HUMAN C A T T C T T T A A T G C A C T T C A A G G T G G C A T A C A T G T C C C C A C A A C C T C A C T T C A G T C A G T A C T T C T G T G G C T T T G A A HUMAN

CHIMP C T C T A G T T T G A A G T G C T C T G T C C A G G G T A C A T G C T T C C T A T T C C A A A G G T C A G G A C C A T T A A A A G A G A T G C C T T T CHIMP
HUMAN C T C T A G T T T G A A G T G C T C T G T C C A G G G T A C A T G C T T C C T A T T C C A A A G G T C A G G A C C A T T A A A A G A G A T G C C T T T HUMAN

CHIMP G A A A A G C A G A A A A A T C A G C C A C C A T C T C T G A A A T A A C A G G A T T C A C T T A C A A A G T G T G T C T C T A A A T A C T A T A C A CHIMP
HUMAN G A A A A G C A G A A A A A T C A G C C A C C A T C T C T G A A A T A A C A G G A T T C A C T T A C A A A G T G T G T C T C T A A A T A C T A T A C A HUMAN

CHIMP T G C A G G A A T G G A A A A C C A A A C A C C A C A T G T T C T C A C T T A T A A G T G G G A G C T G A A T G A T G G G A A C A C A T G G A C A C A CHIMP
HUMAN T G C A G G A A T G G A A A A C C A A A C A C C A C A T G T T C T C A C T T A T A A G T G G G A G C T G A A T G A T G G G A A C A C A T G G A C A C A HUMAN

CHIMP G A T G C T G G G C T T A A T A A C T A G G T G A T G G G A T G A T C T T T G C A G C A A A C G A C C A T G A C A C A C A T T T A C C T A T G T C A C CHIMP
HUMAN G A T G C T G G G C T T A A T A A C T A G G T G A T G G G A T G A T C T T T G C A G C A A A C G A C C A T G A C A C A C A T T T A C C T A T G T C A C HUMAN

Cut and tape to the top of DNA part 2.

DNA sequence courtesy of Henrik Kaessmann and Svante Pääbo.

Part 2

Line up the columns of nucleotides on DNA part 1 with DNA part 2. Then tape the bottom of DNA part 1 to this line.

CHIMP T T A T G T A G G A A G A C C A A C A G T T G A G G T T T G C C T G T G A C T G A G G G T T T T T T G G G A C A T A G T A T T T T C A G T G C T A A A CHIMP
HUMAN G T A T G T A G G A A G A C C A A C A G T T G A G G T T T G C C T G T G A C T G A G G G T T T T T T G G G A C A T A G T A T T T T C A G T G C T A A A HUMAN

CHIMP A A T T G A G C A A T T T T G A A G A C T G C T T G A G G A G T C A A A G A T G A T T T C A T T T A T A A A A C A T G A A A T G T T A T A A A A A A G CHIMP
HUMAN A A T T G A G C A A T T T T G A A G A C T G C T T G A G G A G T C A A A G A T G A T T T C A T T T A T A A A A C A T G A A A T G A T A T A A A A A A G HUMAN

CHIMP A T C C A T T A A C C T A T T T C T T A T T C C A A T A T T T T T C A A T T T T G T A C T A T C T G C C A A C C C T C A T C A A T T C C T A A C T C T CHIMP
HUMAN A T C C A T T A A C C T A T T T C T T A T T C C A G T A T T T T T C A A T T T T G T A C T A T C T G C C A A C C C T C A T C A A T T C C T A A C T C T HUMAN

CHIMP T T C C A G A A A C C T T C A A T A T C T A A A T G C T T C C A T T T C T C C T A G T C T C A C A T A G C A T C C T C C C T C A T C T T A T T T C C T CHIMP
HUMAN T T C C A G A A A C C T T C A A T A T C T A A A T G C T T C C A T T T C T C C T A G T C T C A C A T A G C A T C C T C C C T C A T C T T A T T T C C T HUMAN

CHIMP C A T T C T C C T G C T G C A C C A G C C T G G C A A G G C C C T A A T C G C A G G T T A A G T C C A C A A C A G G T T T T C T T T C T T A C T A T C CHIMP
HUMAN C A T T C T C C T G C T A C A C C A G C C T G G C A A G G C C C T A A T C G C A G G T T A A G T C C A C A A C A G G T T T T C T T T C T T A C T A T C HUMAN

CHIMP C T A A A A T T A T T T T C C T C T A C C C T C T T T T T A C A T G A A C C T G A T T A G T A T C T T C T C C T A T T C C C A T G G T G G C T A A T C CHIMP
HUMAN C T A A A A T T A T T T T C C T C T A C C C T C T T T T T G C A T G A A C C T G A T T A G T A T C T T C T C C T A T T C C C A T G G T G G C T A A T C HUMAN

CHIMP T T G T T T T A G C C C T C A G C T C A A A G A G T A A A T T G A G A T T A T T A G G T G A G A A G A A A T C A A C T T C A T C T A C T G T C C T T T CHIMP
HUMAN T T G T T T T A G C C C T C A G C T C A A A G A G T A A A T T G A G A T T A T T A G G T G A G A A G A A A T C A A C T T C A T C T A T T G T C C T T T HUMAN

CHIMP T G A A T T A T C A C A C T C T T C T A A C C T C C C T C A G G T T T C T C T T T C A T T G A T T G T T C C C T T T C A C T C C T A G A A A A T C A T CHIMP
HUMAN T G A A T T A T C A C A C T C T T C T A A C C T C C C T C A G G A T T C T C T T T C A T T G A T T G T T C C C T T T C A C T C C T A G A A A A T C A T HUMAN

CHIMP C T T A T T C T A G C T C T T T G T T G C C T T C C T G C C C T T C T C T C C A T A G T T G T T T A C A C C A G C T T T T C C T C A C T T T A T A T C CHIMP
HUMAN C T T A T T C T A G C T C T T T G T T G C C T T C C T G C C C T T C T C T C C A T A G T T G T T T A C A C C A G C T T T T C C T C A C T T T A T A T C HUMAN

CHIMP T T A C C C A G A A A G A G G T G A G A A T A G A A T T C C C A G T G C C T C C A A T G C C A G C C T T A C A G A A G T A A T T A C T C T T G G T A C CHIMP
HUMAN T T A C C C A G A A A G A G G T G A G A A T A G A A T T C C C A G T G C C T C C A A T G C C A G C C T T A C A G A A G T A A T T A C T C T T G G T A C HUMAN

CHIMP T C A C T T G A A A G A A G G G T A T G T T G G T G A G T G C C A A A T C C T G A A G G G A A T G A C C A G C A T A G A G T T T T A A C C T A A T A A CHIMP
HUMAN T C A C T T G A A A G A A G G G T A T G T T G G T G A G T G C C A A A T C C T G A A G G G A A T G A C C A G C A T A G A G T T T T A A C C T A A T A A HUMAN

CHIMP G C C A T A A A A A G A A T G A G A T C A T T T C C T T T G C A G G G A C A T G G A T G G A G T T G G A A G C C A T T A T C C T T A G C A A T C T A A CHIMP
HUMAN G C C A T A A A A A G A A T G A G A T C A T T T C C T T T G C A G G G A C A T G G A T G G A G T T G G A A G C C A T T A T C C T T A G C A A T C T A A HUMAN

CHIMP T G G T G A G A A A C A A G A A A C A T T G G A G T C T G T T G G G A G C T G T T G G G T G A G A G A G A G C A T C A G G A A G A A T A G C T A A T G CHIMP
HUMAN T G G T G A G A A A C A A G A A A C A T T G G A G T C T G T T G G G A G C T G T T G G G T G A G A G A G A G C A T C A G G A A G A A T A G C T A A T G HUMAN

CHIMP A A C C C T G C A C A T C C T G C A C A T G T A C C C C T A A A C T T A A A A T A A A A G T T G A A G A A A A T A T G G CHIMP DNA (END)
HUMAN A A C C C T G C A C A T C C T G C A C A T G T A C C C C T A A A C T T A A A A T A A A A G T T G A A G A A A A T A T G G HUMAN DNA (END)

DNA sequence courtesy of Henrik Kaessmann and Svante Pääbo.

PART FOUR
Be a science reporter

Write a short news story about humans and chimpanzees. Tell your readers about how new DNA studies of humans and chimpanzees suggest they are close relatives. Based on what you have learned, explain how you think a modern chimpanzee and a modern human could have a common ancestor.

P.S. Don't forget the headline.

Answer: The hidden feature cards describe both humans and chimps, except for the cards with the asterisk. These cards describes the chimps.