CHROMOSOME CONNECTION 2

Comparison of Human and Ape Chromosomes
Adapted from the *Becoming Human* Lesson
by Larry Flammer

SYNOPSIS

Students are taken on a chromosome comparison "adventure", in which the banding patterns are compared on the chromosomes of humans and apes. Degrees of similarities, and some causes of their differences are explored. Inferences about relationships based on those similarities are also examined in a compelling way.

MAIN CONCEPT

Modern apes and humans evolved from a common ancestor.

ASSOCIATED CONCEPTS

1. The evidence that humans have evolved from non-humans is stronger than that for evolution within most other groups.
2. Many features of modern organisms reflect the structure of their ancestors in ways that are not adaptive.
3. Scientific explanations confirmed by different lines of evidence are stronger, more likely to be accurate.
4. The degree of chromosome similarity between two species indicates the degree of their biological relationship.
5. Hypotheses about past events can be tested by looking for revealing patterns in the present.

ASSESSABLE OBJECTIVES: Students will...

1. actively engage in the careful analysis of chromosome banding patterns.
2. identify examples of inversion in homologous chromosomes.
3. demonstrate their understanding that degrees of similarities in chromosomes correspond to degrees of evolutionary relationship.
4. associate degrees of similarity with the relative timing of evolutionary divergence.

MATERIALS

Teacher Packet (these 4 pages)
Background Information sheet (2 pages)
Activity Packet (4 pages)
Page of Cutouts (to cut out and place in envelope)
Worksheet (optional form)
Teacher's Answer Key (1 page) Send request to Webmaster using your school email address.
Envelopes (1/team) for 7 paper cutouts to manipulate
Complete Chromosome Diagrams (karyotypes) of humans and apes (1 page, for overhead)
Primate Cladogram based on Chromosome Banding Patterns (1 page, for overhead)

TIME REQUIRED

This activity can be easily completed in one 45 minute period.

TEACHING STRATEGY & PREPARATION

This activity can be effectively and easily inserted into any one of several parts of your course. For example:

1. Following your lessons comparing hominid and ape skulls and their chronology, introducing evolution.
2. As part of your evolution unit in which you can show this as one of several independent lines of evidence pointing consistently to a conclusion of evolution in general, and/or human evolution in particular.
3. As part of your unit on molecular biology, where you can point out the striking similarities in proteins and/or DNA sequences between different species, the patterns of which closely match the degrees of relationships based on morphology.
4. As part of your unit on genetics, where you take a look at chromosomes in general, or karyotyping in particular.
5. As a human example of **how scientific understanding is strengthened** (to be pointed out wherever you do this):
   a. Scientists use the simplest explanation consistent with all their data (parsimony, or "Occam's Razor").
   b. MILEs (Multiple Independent Lines of Evidence), all pointing to the same conclusion and explaining all the observations, provides a major strength in scientific explanations.

Students may work on this independently, in pairs, or small teams (3-4), as preferred. It could even be given as a homework assignment, and discussed/reviewed the next day.

PREPARATION:

1. Provide handout materials for every student. Print **Background Information** on both sides of a single sheet. Assemble and staple the 4 pages of the **Activity Packet**. To simplify checking student/team work, provide the formatted Worksheet, where students can record answers to questions asked in the Activity Packet. This will allow the Activity Packets to be re-used, especially if placed in plastic sleeves.

2. Prepare cutout pieces showing chromosomes and bullet marks for students to manipulate. These (7 pieces per envelope) should be cut out and placed in envelopes, making a classroom set of envelopes, with one envelope for each team, or each student, if preferred. You can have a lab assistant do this, or have your students do it the first time, but keep the envelope packets for re-use every period/year.

PROCEDURE

A dramatic introduction is always an impressive way to open a topic. What you do, or how you do it may depend on the context and the topics that preceded this one? However, a general approach could include dressing like an old-time detective (French coat and fedora hat, or a "Sherlock Holmes" outfit). If you can do a good "Inspector Clouseau" impression, go with it! Do something to suggest **the science of investigating crimes**. On the other hand, be sensitive to student experiences with violence You don't want to be perceived as glorifying violence.

However, you could have a spent bullet (obtained from police, or a firing range, or fake it!) that you could pull out of your pocket (in a plastic bag), hold up in front of the class, and ask "If this bullet was found at a crime scene, could we tell what gun it came from?" "How?" Some students will probably know that scratch marks can be compared to bullets fired from suspected guns. If not, give a brief description of how this is done, and the principles involved. Then hand out the lesson, and let them proceed on their own.

DISCUSSION: When completed, discuss the results with the class, getting responses from 2-3 different teams for each item, and discussing any differences in responses, ultimately bringing about clarification and reinforcement of the key points. [For appropriate responses and some points of discussion, email request (from school email address) to the Webmaster.] When finished, show your class the complete page of **Chromosome Diagrams** (karyotypes) of ape and human chromosomes (using overhead or PowerPoint). Note the striking similarities throughout. Then display and discuss the **Primate Cladogram** based on Chromosome Banding Patterns (overhead or PP). You can point out where and when various chromosome changes are thought to have occurred (based on chromosome morphology and DNA analyses).

ASSESSMENT

Use some or all of the Check Questions, along with a few additional questions in a quiz to see if they fully grasp the main concept. Be sure to test for the stated Assessment Objectives.

EXTENSIONS & VARIATIONS

For a quick **interactive online experience** in matching primate chromosomes, go to the ***Becoming Human*** website <http://www.becominghuman.org/>, click on "Learning Center," then click on "Activities." Select "Chromosome Connection," then click to begin. Follow the directions there to match the chromosomes. The lesson plan (same name) offered there was created for the site, and further modified and adapted for its version on the ENSI site, courtesy of the author. Take a look at the other two interactives and other features on the BH site.

An excellent followup lesson to this one is the **Chromosome Fusion** lesson, at http://www.indiana.edu/~ensiweb/lessons/c.fus.les.html, where students discover (online) the DNA evidence that confirms that our chromosome #2 resulted from the fusion of the two chromosomes still found today in the apes. Very compelling confirmation (MILE) of the findings in the Chromosome Connection lesson.

Other logical **followup lessons**: Explore the molecular differences in beta hemoglobin from humans, apes, and other primates, as done in "**Molecular Sequences & Primate Evolution**" on *ENSIweb* at: <http://www.indiana.edu/~ensiweb/lessons/mol.prim.html>. And, if not already done, do the "**Hominoid Cranial Comparison**" lesson, using replica skulls of hominoids (hominins and apes): <http://www.indiana.edu/~ensiweb/lessons/hom.cran.html>.

NOTE: New Taxonomy for hominoids (apes and humans). Recent molecular and genetic studies on these species have made a strong case for their revised classification. See details at: <http://www.indiana.edu/~ensiweb/lessons/new.tax.html>.

The Chromosome Connection lesson could be done as part a series of **crime scene scenarios** that serve as an engaging example of science: a process of digging out clues to figure out the most likely solution to a problem. In this context, the more familiar use of fingerprint comparisons could also be discussed. An excellent online resource for various forensic ideas and strategies can be found at <http://www.courttv.com/forensics%5Fcurriculum/>. There are also a couple of crime scene lessons on the ENSI site: "The Case of the Missing Computer Chip" at http://www.indiana.edu/~ensiweb/lessons/crime.html, and "A Crime Against Plants" at http://www.indiana.edu/~ensiweb/lessons/plcr.les.html. A excellent discussion of the role of **evolution** in **crime scene** studies can be found at <http://evolution.berkeley.edu/evolibrary/news/060301_crime>. It's called "Evolution at the scene of the crime", on the *Understanding Evolution* site (UC Berkeley)

Important point: Be sure to point out to your students that **crime scene science** is largely **historical science**, not the classical **experimental science** typically presented as the only form of science. Fields in which historical science is used extensively include paleontology, astronomy, geology, evolution science, and forensic science. This is very useful and legitimate science where events cannot be repeated, so we look for clues and patterns, leading to hypotheses about which predictions can be made, and we then look for evidence to check the predictions.

REFERENCES & RESOURCES

The interactive activity presented here is modified and adapted from the lesson of the same name on the *Becoming Human* website (for which it was created by Larry Flammer). It is a variation of a similar lesson: "**Chromosome Comparisons**" (by ENSI teacher Beth Kramer), at <http://www.indiana.edu/~ensiweb/lessons/chromcom.html>, and a simpler lesson by ENSI teacher Larry Flammer: "**Chromosome Clues**" in the PBS/WGBH-Evolution *Teacher's Guide* (page 24), available free from <http://www.pbs.org/evolution>. The lesson can be downloaded directly from <http://www.pbs.org/wgbh/evolution/educators/teachstuds/unit5.html>. If you would like a sharper Chromosome Clues **diagram**, contact the **webmaster**. Each of these variations emphasizes different aspects, and they vary in the time needed and sophistication.

Alberts, Bruce, et al. 1989. *Molecular Biology of the Cell*. Garland Publishers. Chiasmata, p.848, fig. 15-11.

Flammer, Larry. 1983. "Karyotype Komparison." Classroom activity.

Klein, Richard G. 1999. *The Human Career*. Univ. of Chicago Press. p. 71.

Kramer, Beth. 1995. "Comparison of Human and Chimpanzee Chromosomes". Classroom activity.

Wallace, B. 1966. *Chromosomes, Giant Molecules, and Evolution*. New York: W.W. Norton & Co., Ch.2.

Yunis, J.J. and O. Prakash, 1982. "The origin of man: A chromosomal pictorial legacy". *Science*, 215, 1525-1529.

ATTRIBUTIONS

The inspiration for this was the article by Yunis and Prakash in *Science* (1982), showing the striking similarities of ape and human chromosomes. The similarity of this and the patterns of bullet scratches was seen in an article by Frank T. Awbrey in *Creation/Evolution* (Vol.2 No.3, 1981), where he referred to the discussion of this concept by Bruce Wallace in *Chromosomes, Giant Molecules, and Evolution* (Norton, 1966). The present lesson grew out of a 1983 classroom activity by L. Flammer, ideas from an activity by ENSI teacher Beth Kramer, adaptations for the *Becoming Human* web site, and significant suggestions from Eugenie Scott and Eric Meikle of NCSE. Taxonomic revisions were provided by Martin Nickels, Professor Emeritus of Anthropology at Illinois State University (and one of the ENSI co-directors).