CHROMOSOME FUSION PP SCRIPT Title: **CHROMOSOME FUSION**

SYNOPSIS

This short PowerPoint show can be used to introduce the **Chromosome Fusion** lesson (ENSI site: <http://www.indiana.edu/~ensiweb/lessons/c.fus.les.html>. It can also be used to provide a quick exposure to the compelling corroboration of human-chimp common ancestry based on the striking similarities of their chromosome banding patterns (see **Chromosome Comparisons** Lesson: <http://www.indiana.edu/~ensiweb/lessons/chromcom.html>. Both the lesson and the PowerPoint presentation of Chromosome Fusion does this in an **inquiry** fashion. Since our large chromosome #2 closely matches two shorter chimp chromosomes placed end-to-end, it is **hypothesized** that our #2 chromosome resulted from the end-to-end fusion of those two shorter chromosomes early in hominid ancestry. This is tested by looking in the purported fusion zone for the DNA sequence that characterizes the telomeres (ends) of chromosomes. The lesson directs the search of two online DNA databases to find that sequence in the fusion area. It also offers a page showing that sequence for those unable to use the web. A portion of that sequence is included in the PowerPoint presentation as "Results," to share and discuss with the class.

Sequence: Ideally, this PPP should follow the Chromosome Comparisons PPP (or even better, the Chromosome Comparisons *lesson*). Doing both lessons provides one of the easiest and most compelling experiences students can have to show our close biological relationship to the apes, especially when used in conjunction with other lessons on the site, e.g., **Molecular Sequences and Primate Evolution** (where students compare details of beta hemoglobin in several different species), and the **Skulls** lesson. This congruence of different lines of evidence (consilience) is critical for students to fully understand the power of science, and the reason why evolution is such a powerful and widely accepted fact. At the very least, students should have a chance to be shown these two PPPs, with commentary and opportunity for discussion.

Diagrams (based on photographs) of the banded late-prophase chromosomes of **hominoids** (humans, chimpanzees, gorillas and orangutans), compared side-by-side, reveal striking similarities, even many identical chromosomes and segments. Other diagrams (including DNA sequences and the Synteny diagrams) are taken from the websites used in the lesson.

POWER POINT PRESENTATION SCRIPT: (Slides are numbered)

1. Title: Chromosome Fusion

2 Question "MOST STRIKING?" (ask students "What is most striking about this slide of chromosome diagrams." Hopefully, they will notice the strong similarities within each set of chromosomes. If necessary, click, and show "Compare the Banding Patterns." Once someone comments on their similarities, click again to show caption "6 longest chromosomes of humans (Hu) are matched with 7 chromosomes from three ape species." You can follow this by pointing out that the matching chromosomes from each species are placed together with the corresponding chromosome number of the human chromosome (first one in each foursome). If they've done the Chromosome Comparison lesson, they may recall that the entire karyotypes of all four species show a similar high degree of similarity, but we are showing only the first 6 human chromosomes (and their ape counterparts) so we can enlarge them and see details here. Click.

3. Question "Colored Tips? Click again: "Why are the chromosome tips colored?" [Rhetorical, although you might want to take guesses, for fun.] Click
4. CHROMOSOME PARTS. Sample chromosome appears. Click, and Centromere is labeled. Click again, and info that "All Chromosomes have telomeres at their ends (like shoelace aglets!). Click again, and the Head Telomere label flies in (tip of shortest arm); Click again and the Tail Telomere flies in. Click, and info: "Telomeres have a unique DNA sequence..." Click, and a sample of DNA ladder shows, with the typical telomere sequence. You might want to point out the tandem repeats of: ttaggg ttaggg, etc. with lots of ggg's and no c's in the top row, and lots of ccc's and no g's in the bottom (complimentary) row. However, this detail will be brought out later, so you could skip it here. Click.

5. Let's Narrow Our Focus: Showing just the first six human chromosomes, and the chimp chromosomes that match (gorilla and orangutan chromosomes have been removed). Click.
6. QUESTIONS; showing our #2 chromosome next to two shorter chimp chromosomes whose banding patterns closely match our #2 chromosome. Click. Why are TWO shorter chimp chromosomes needed to match our #2 chromosome? Click. Could our #2 chromosome have formed by the FUSION of TWO shorter chromosomes found in chimpanzees today?...LIKE THIS...? Click.

7. [Chimp chromosome #12 is shown (and labeled). Click, and another, shorter, chromosome appears beside it. After a moment (NO clicking), it will rotate to a vertical position above the original #12, and shift down to meet it, head-to-head. The upper chromosome is labeled #13. Click, and our #2 chromosome appears on the far right side. Click again, and it flies across the screen to be side-by-side with the chimp's #12 and #13 combination, and it's labeled "Human #2." Click
8. The final image of the previous slide appears. Click, and the possible "Fusion Area?" is labeled. Click again, and "PREDICTION: If fusion occurred, then we should see **DNA evidence** of the head-to-head telomeres together near the middle of our #2 chromosome." Right? Click.
9. Sample chromosome appears, with labels. Click, and "DNA - DNA Sequence for **Telomeres**:" appears, followed by short sample below it. Click, and "NOTICE: T**andem Repeats** in Telomere" are shown in color, followed by "Repeated 800-1600 times in each Telomere." Click.

10. EXPECTATIONS: Click > "What will you look for?" > tandem repeats in fusion area; > "Where will you look for them?" > middle of our chromosome #2; > "How can you look for them?" > search online DNA database; > "What if evidence is NOT found?" > fusion may not have happened. [Try to elicit response to each question before clicking to the answer, and on to next question.] Click.

11. CHROMOSOME FUSION: Click: Read the lesson > Do the lesson - Go online > Discuss the results > Explanation? STOP HERE if students are going to do the lesson themselves. If not, you can continue on (or start here for discussion following the lab).
12. STOP HERE repeated.

13. RESULTS [A portion of the full page of the purported Fusion Region is shown here. You might want to see if students can pick out the pattern of tandem repeats near the middle.] Click.
14. RESULTS CLARIFIED: [Same portion as shown in previous slide, with the two head telomere regions colored (red and blue). Click, and "HEAD 12" and "HEAD 13" labels fly in. Click, and "See where the head-to-head fusion occurred?" flies in. [Students should indicate that it's at the point of red-blue color change, and why.] Click.

15. [OPTIONAL] QUESTIONS RAISED: WHY THE SUDDENT CHANGE? (focus on fusion point):
Why do the TANDEM REPEATS **suddenly change**
from ttaggg to ccctaa?
Why so many **slight variations** in the
number of t's, a's, g's, and c's in each repeat?
DO THE LESSON, and find out!
16. [OPTIONAL] WHY SO FEW REPEATS? (Telomere segments shown again)
Count the TANDEM REPEATS in both telomere segments.
(only about 37 ttaggg repeats in Head 13; about 88 ccctaa repeats in Head 12)
Should be 800 to 1600 repeats, so…
Why so many FEWER than typically found in telomeres?
DO THE LESSON and find out!

17. **Further Confirmation**: Comparison of DNA in Our Chromosome #2 with... [and the Chimp comparison fades in on the left). Ask a student or two to explain what the diagram shows. They should point out how the Chimp Chromosome #13's DNA (green) perfectly matches the *upper* end of the DNA in Our #2 Chromosome, while the Chimp Chromosome #12's DNA (pink) perfectly matches the *lower* end of the DNA in Our #2 Chromosome. If not, *you* should. Then ask "What would you expect if we compared our #2 DNA with another animal's?" [Hopefully, students will guess that there will be less matching, or whatever!] Click, and a Dog comparison diagram flies in from the right. Students should notice that portions of our #2 match segments from eight different chromosomes in the dog! Ask "Conclusion from this?" [Students should suggest that **our** chromosomes are more similar to **chimps** than to dogs, or something like that.] Ask "How could we check this generalization?" Hopefully, someone will suggest that we look at other chromosomes. Say "Let's DO that!" Click.
18. **Another Confirmation:** This time, we are looking at our Chromosome **#3**, and comparing its DNA to that of Chimps, and then of Dogs. Follow the same procedure as for slide #15. You might ask at the end: "What would you expect from checking our other chromosomes?" [Should be about the same comparisons seen with our #2 and #3]. They can do that, if interested, by going to the Sanger-Genome site (Part C of the Chromosome Fusion lesson, item #19, which provides an easy way to do this, a process called "Synteny.")

19. **Re-Check Banding Patterns:** A look at the 6 sets of chromosomes shown in the beginning, with a red arrow pointing to our chromosome #3, and the matching chimp chromosome. Ask students what they notice about the pair. They should see, upon careful comparison, that they are, indeed, IDENTICAL! Click…
    Compare other chromosomes online: Human with Chimp, Dog,… Click…
    [See Part C of the Chromosome Fusion lesson, item #19, doing "Synteny"]
20. **MULTIPLE EVIDENCE:** Click > Compare hominoid **chromosomes** [if they haven't already]; > Compare hominoid **skulls** [if they haven't already]; > Study pattern of hominid **chronology** [if they haven't already]; > Compare primate **hemoglobins** [if they haven't already]; > What do ALL of these patterns suggest? [Take responses from students; hopefully, "common ancestry within primates" or its equivalent will come out.]
    Click: "DO THE LABS!" [if they haven't, and you have planned to do them.]

END.