Different Genes, Different Trees

Using NCBI Resources (COBALT) to

Describe and Explain

Differential Phylogenetic Tree Presentations

Sublime Dynamite feat.
Brandon Boswell, Mary Knight, and Richard (Jake) Zimny

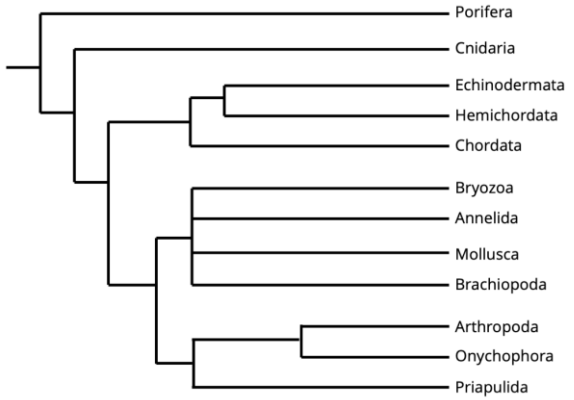
One Answer?

- Students EXPECT a single, objective answer

- Here, different genes will produce different phylogenetic trees

- Selected 5 genes and ALL produced different trees:

    1. Factor VIII (F8)
    2. Factor IX (F9)
    3. Cytochrome c,
    4. HOXA2 (Homeobox A2)
    5. HOXD13 (Homeobox D13)



https://www.digitalatlasofancientlife.org/learn/animal-phylogeny/

Background

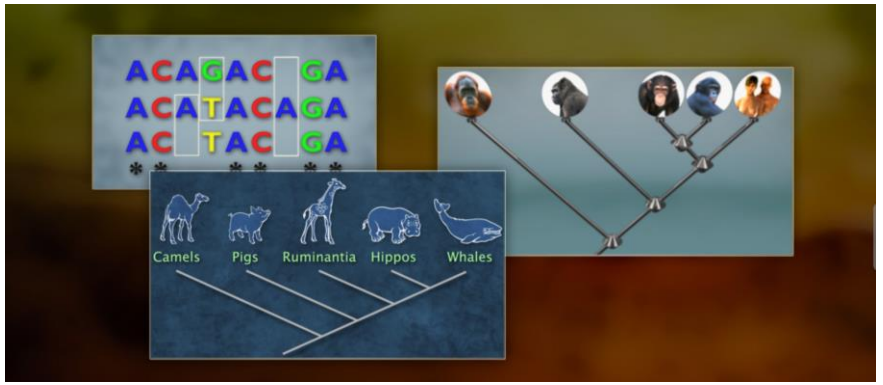
- High School Biology or AP Biology class

- LEARNING OBJECTIVES
  - EVO-3.B: Describe the types of evidence that can be used to infer an evolutionary relationship
  - EVO-3.C: Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness.

https://apstudents.collegeboard.org/ap/2019-05/ap-biology-course-and-exam-description.pdf

Lesson Plan Overview

- HHMI Biointeractive - Creating Phylogenetic Trees from DNA Sequences
  - https://www.biointeractive.org/classroom-resources/creating-phylogenetic-trees-dna-sequences
- Students complete:
  - https://www.biointeractive.org/sites/default/files/Phylogenetic_trees_click_learn_worksheet.pdf
- Discuss how phylogenetic tree can be used to infer evolutionary relationships
- Different Genes



CREATING PHYLOGENETIC TREES FROM DNA SEQUENCES

INTRODUCTION

This worksheet complements the Click and Learn "Creating Phylogenetic Trees from DNA Sequences" developed in conjunction with the 2011 Holiday Lectures on Science, "Bones, Stones, and Genes: The Origin of Modern Human."

PROCEDURE

Answer the following questions as you proceed through the activity slides.

1. Briefly explain how scientists draw relationships between organisms based on shared anatomical features.

2. How are DNA sequences used to deduce evolutionary relationships?

3. What is one advantage of building phylogenetic trees using DNA comparisons rather than anatomical features?

Same 6 species for all genes

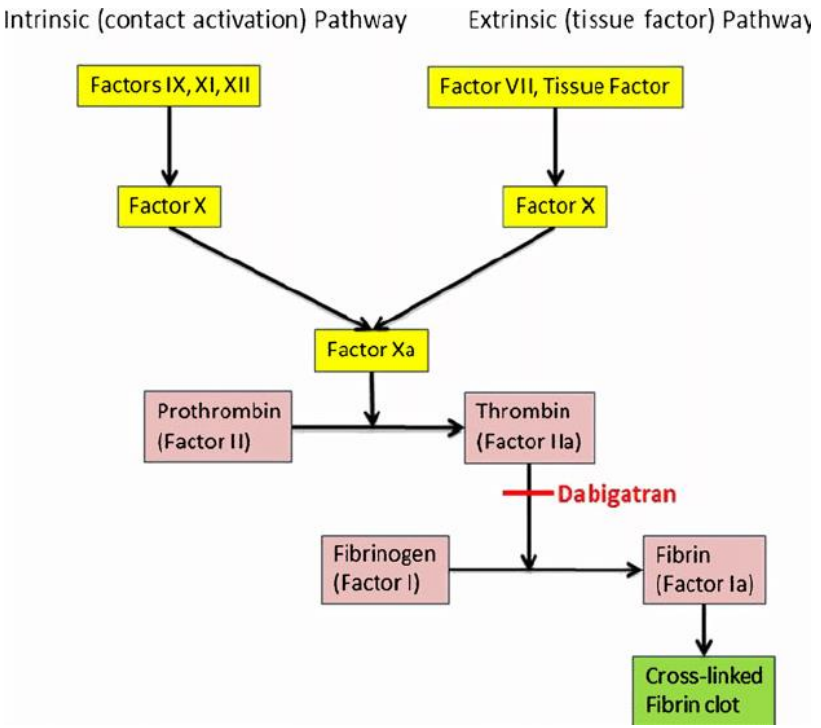
- Human (Homo sapiens)
- Dog (Canis familiaris)
  - Our apologies to **Dr.** Pickles
- Gallus gallus (chicken)
- Alligator mississippiensis (swamp puppy)
- Microcaecilia unicolor (limbless amphibian)
- Protopterus annectens (lungfish)

https://en.wikipedia.org/wiki/Microcaecilia

https://en.wikipedia.org/wiki/West_African_lungfish

Factor VIII (F8)

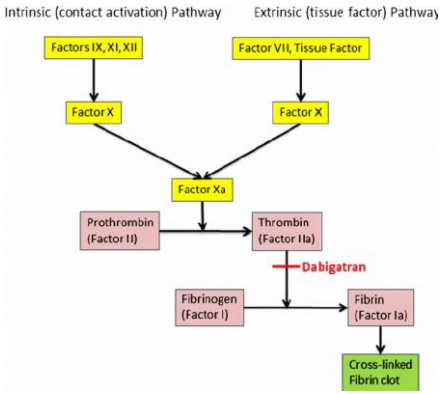
- Crucial blood clotting protein
- **Function**: Essential role in the coagulation cascade
  - Cofactor for Factor IXa, which activates Factor X. Activated Factor X (Xa) then converts prothrombin into thrombin, leading to the formation of a fibrin clot.
- **Clinical Significance:**
- **Hemophilia A**: A deficiency or dysfunction of Factor VIII causes Hemophilia A, a genetic disorder characterized by a tendency to bleed excessively.
  - X-linked recessive pattern
  - primarily affects males, while females can be carriers.
  - Reduced ability to form stable blood clots, leading to prolonged bleeding after injuries, spontaneous bleeding episodes, and joint damage.
- **Gene**: The F8 gene, located on the X chromosome (Xq28), encodes the Factor VIII protein.



Factor 8

coagulation factor VIII isoform X2 [Protopterus annec
coagulation factor VIII [Gallus gallus]
coagulation factor VIII [Alligator mississippiensis]
coagulation factor VIII [Microcaecilia unicolor]
coagulation factor VIII isoform a preproprotein [Homo sapi
coagulation factor VIII precursor [Canis lupus familiaris]

Factor IX (F9)



- A critical protein in the blood coagulation process.
- **Function:** It plays an essential role in the intrinsic pathway of the coagulation cascade, which is necessary for the formation of blood clots to stop bleeding.
  - When activated (Factor IXa), works with activated Factor VIII to activate Factor X.
  - Activated Factor X then converts prothrombin into thrombin, which leads to the conversion of fibrinogen into fibrin, forming a blood clot.
- **Clinical Significance:**
- Hemophilia B (Christmas disease): Factor IX deficiency or dysfunction
  - Genetic bleeding disorder characterized by a tendency to bleed excessively due to the inability to form stable blood clots.
  - Inherited in an X-linked recessive pattern, primarily affecting males
  - F9 gene, located on the X chromosome encodes the Factor IX protein.
  - Mutations in the F9 gene can lead to a reduction or complete absence of functional Factor IX, causing Hemophilia B.

Factor IX (F9)

coagulation factor IX [Protopterus annectens]

LOW QUALITY PROTEIN: coagulation factor IX [Microcaecilia unicolor]

coagulation factor IX precursor [Gallus gallus]

coagulation factor IX [Alligator mississippiensis]

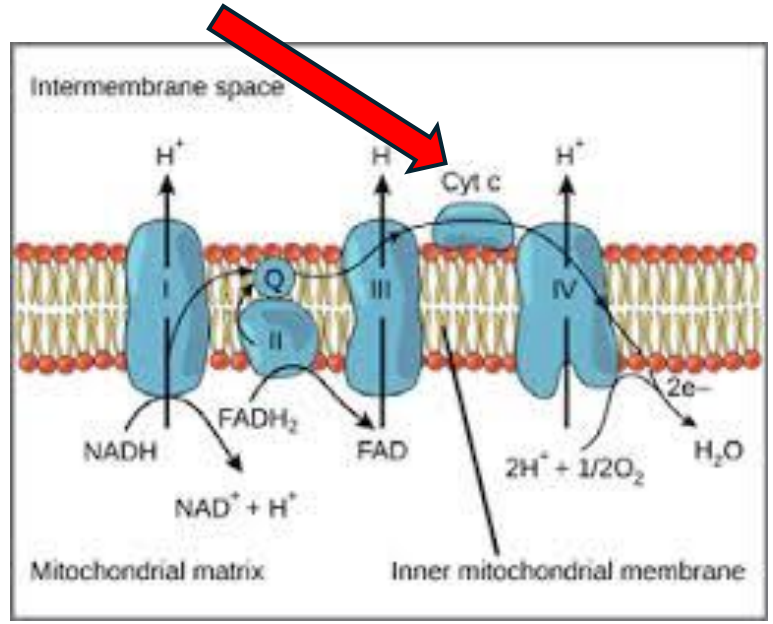
coagulation factor IX isoform [Homo sapiens]

proprotein [Canis lupus familiaris]

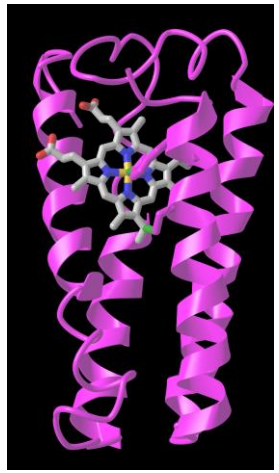
Cytochrome C

- Small (100 to 104 amino acids), highly conserved protein
- Crucial role in cellular respiration and energy production in nearly all eukaryotic organisms

- **Role in the Electron Transport Chain:**
    - **Electron Carrier**: An electron carrier in the electron transport chain
        - Transfers electrons between Complex III (cytochrome bc1 complex) and Complex IV (cytochrome c oxidase) within the inner mitochondrial membrane.



https://www.chem.tamu.edu/rgroup/marcetta/chem362/HW/2019%20Student%20Posters/The%20Role%20of%20Cytochrome%20c%20in%20the%20Electron%20Transport%20Chain.pdf



https://www.ncbi.nlm.nih.gov/Structure/icn3d/?mmdbid=1CGO&bu=1

Cytochrome C

cytochrome c [Microcaecilia unicolor]

cytochrome c [Homo sapiens]

cytochrome c [Gallus gallus]

cytochrome c [Protopterus annectens]

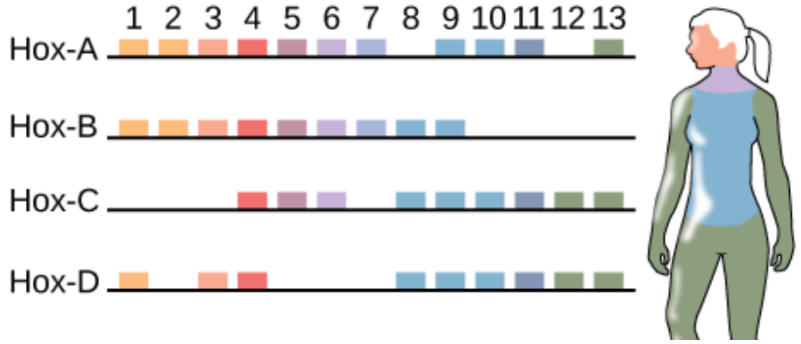
cytochrome c [Canis lupus familiaris]

[Alligator mississippiensis]

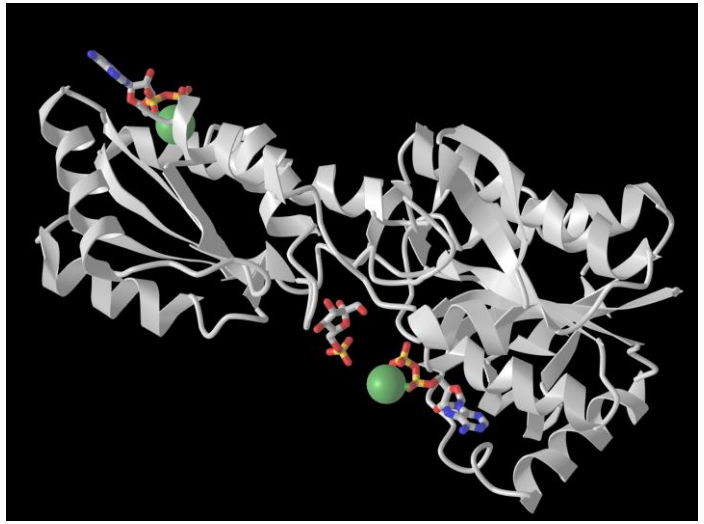
HOXA2 (Homeobox A2)

- Critical gene in the HOX family
  - Embryogenesis - encodes a transcription factor for head and neck structural development
- Establish the body plan
  - Influences patterning and differentiation of cells
- Essential for proper craniofacial development

- HOXA2 gene is located on chromosome 7 (7p15.2)

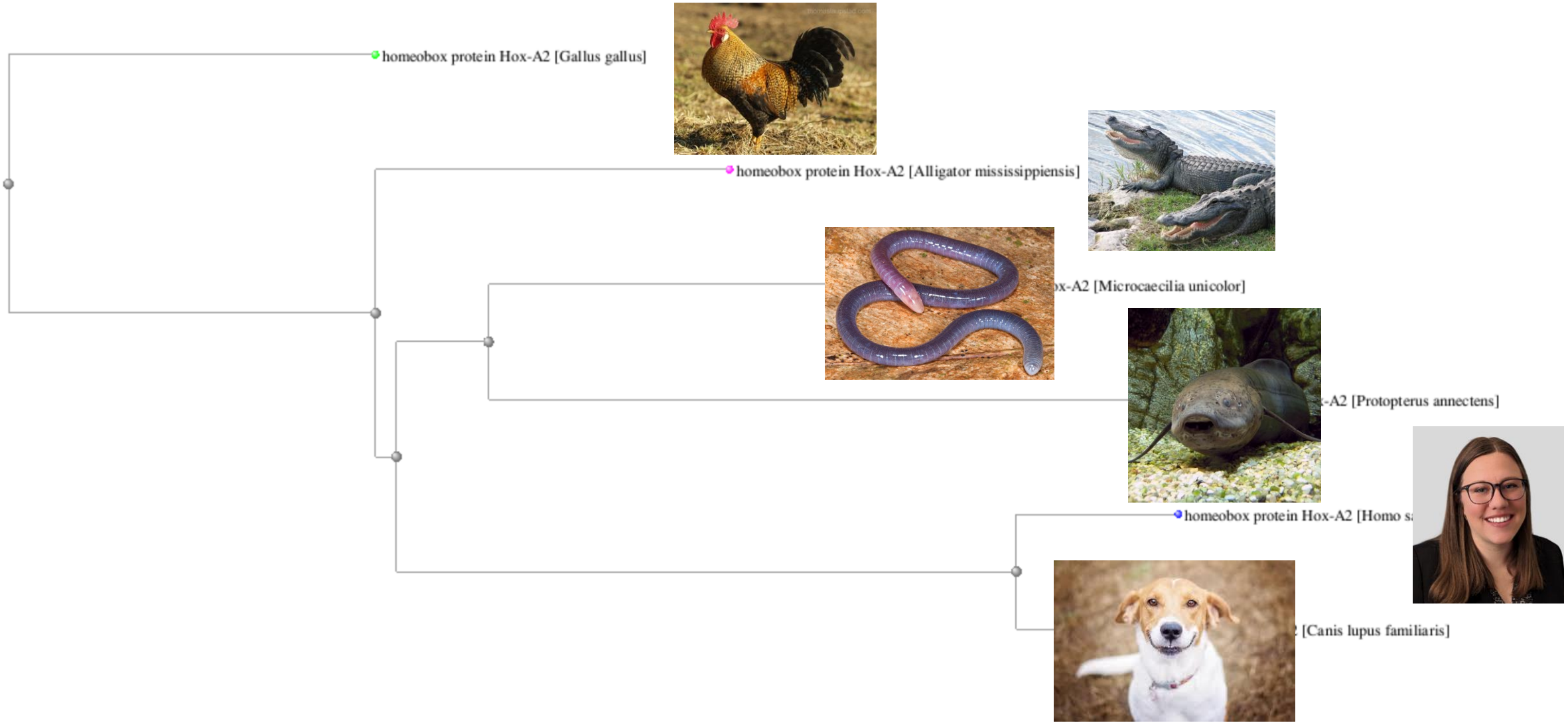


https://courses.lumenlearning.com/wm-biology2/chapter/hox-genes/



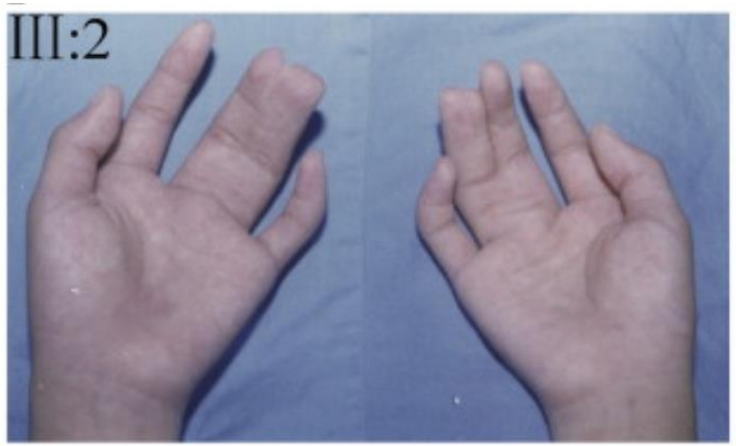
https://www.ncbi.nlm.nih.gov/Structure/icn3d/?mmdbid=3199&bu=1

HOXA2 (Homeobox A2)

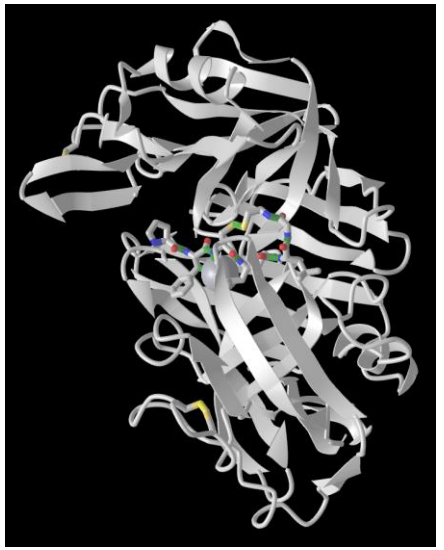


HOXD13 (Homeobox D13)

- Gene in the HOX family
- Development and patterning of the limbs and digits during embryogenesis
- Mutations in HOXD13 - congenital limb malformations such as synpolydactyly and brachydactyly
- Located on chromosome 2 (2q31) as part of the HOXD gene cluster



https://www.researchgate.net/figure/A-novel-missense-mutation-in-HOXD13-causes-a-variant-form-of-SPD-A-Family-pedigree-of_fig1_255957692



https://www.ncbi.nlm.nih.gov/Structure/icn3d/?mmdbid=3239&bu=1

HOXD13 (Homeobox D13)

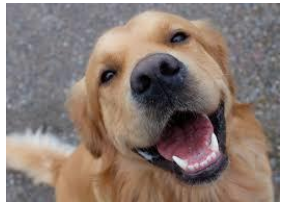
homeobox protein Hox-D13 [Protopterus annectens]

homeobox protein Hox-D13 [Rhinatrema bivittatum]

homeobox protein Hox-D13 [Alligator mississippiensis]

Hox-D13 [Gallus gallus]

homeobox protein Hox-D13 [Homo sapiens]



homeobox protein Hox-D13 [Canis lupus familiaris]