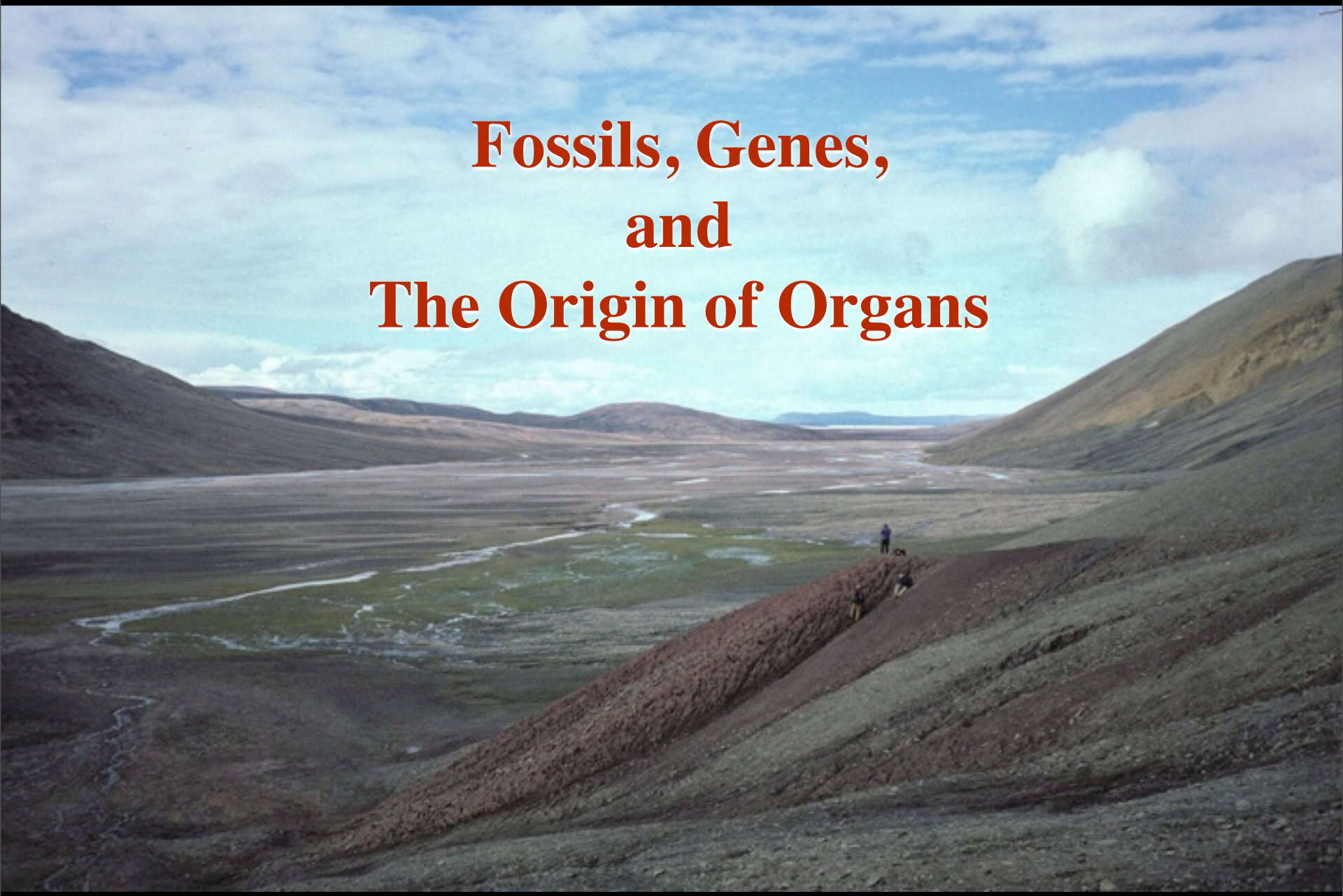
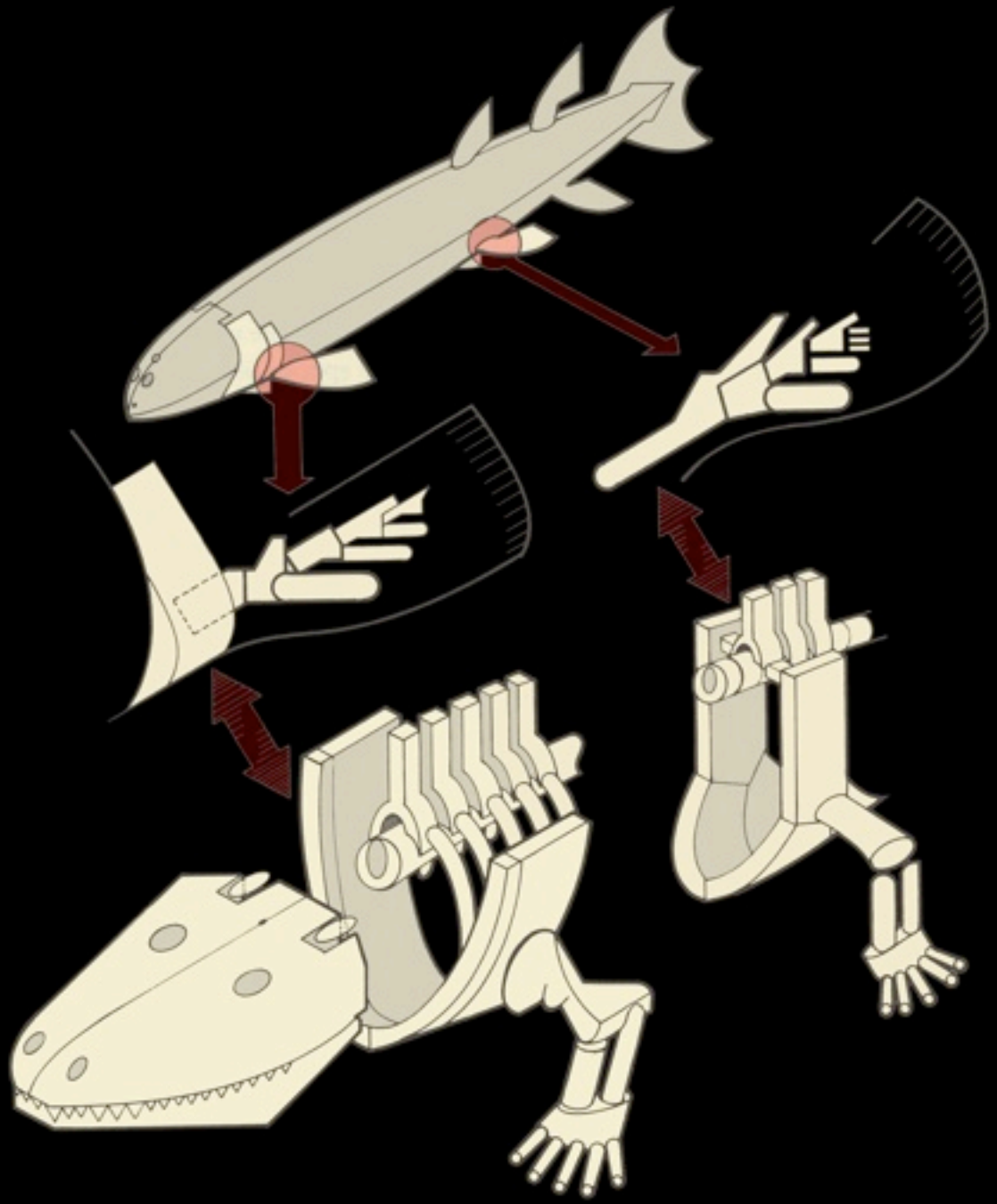
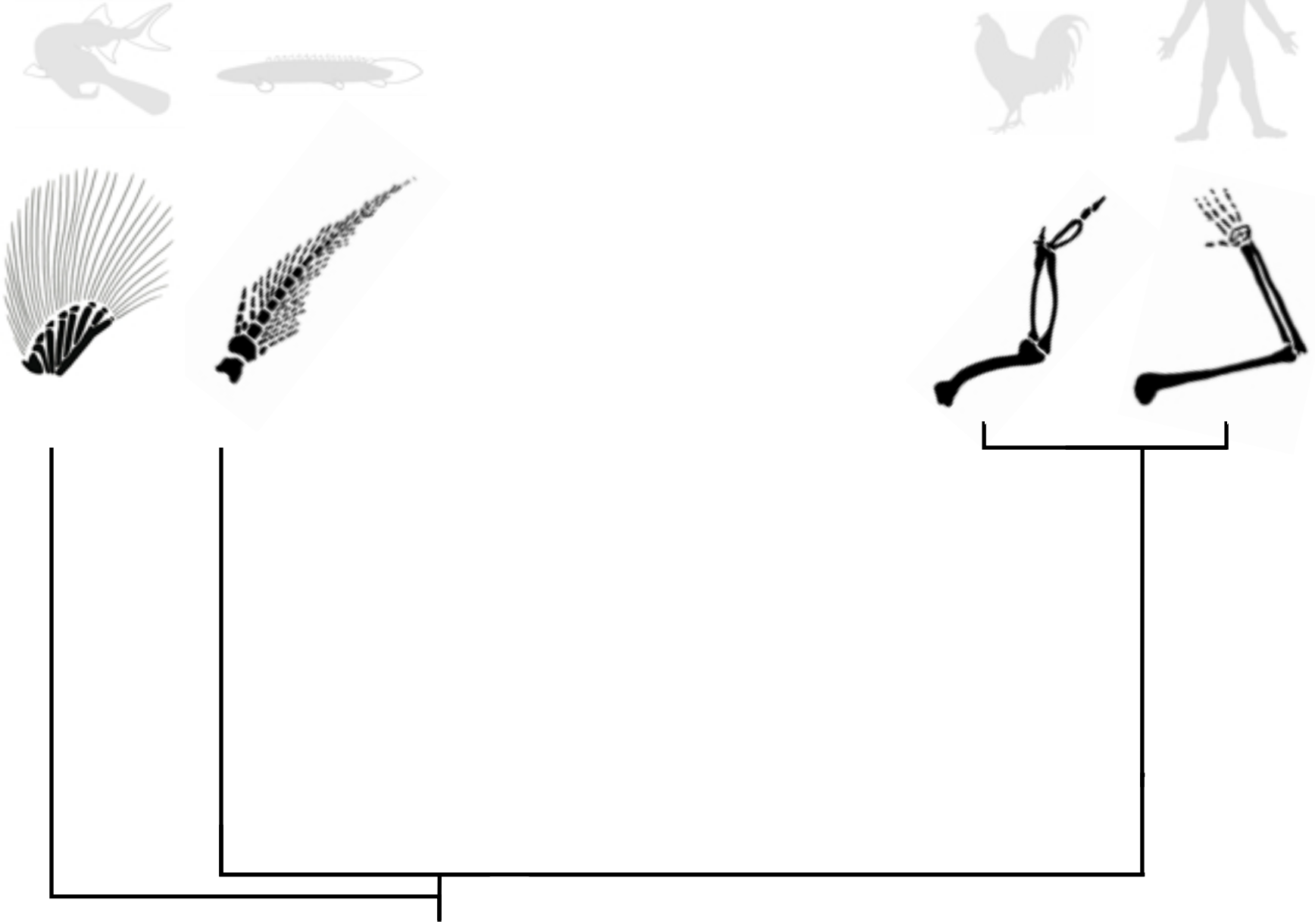

Fossils, Genes,
and
The Origin of Organs



modified from Radinsky 1987

EXTANT

EXTINCT



EXTANT

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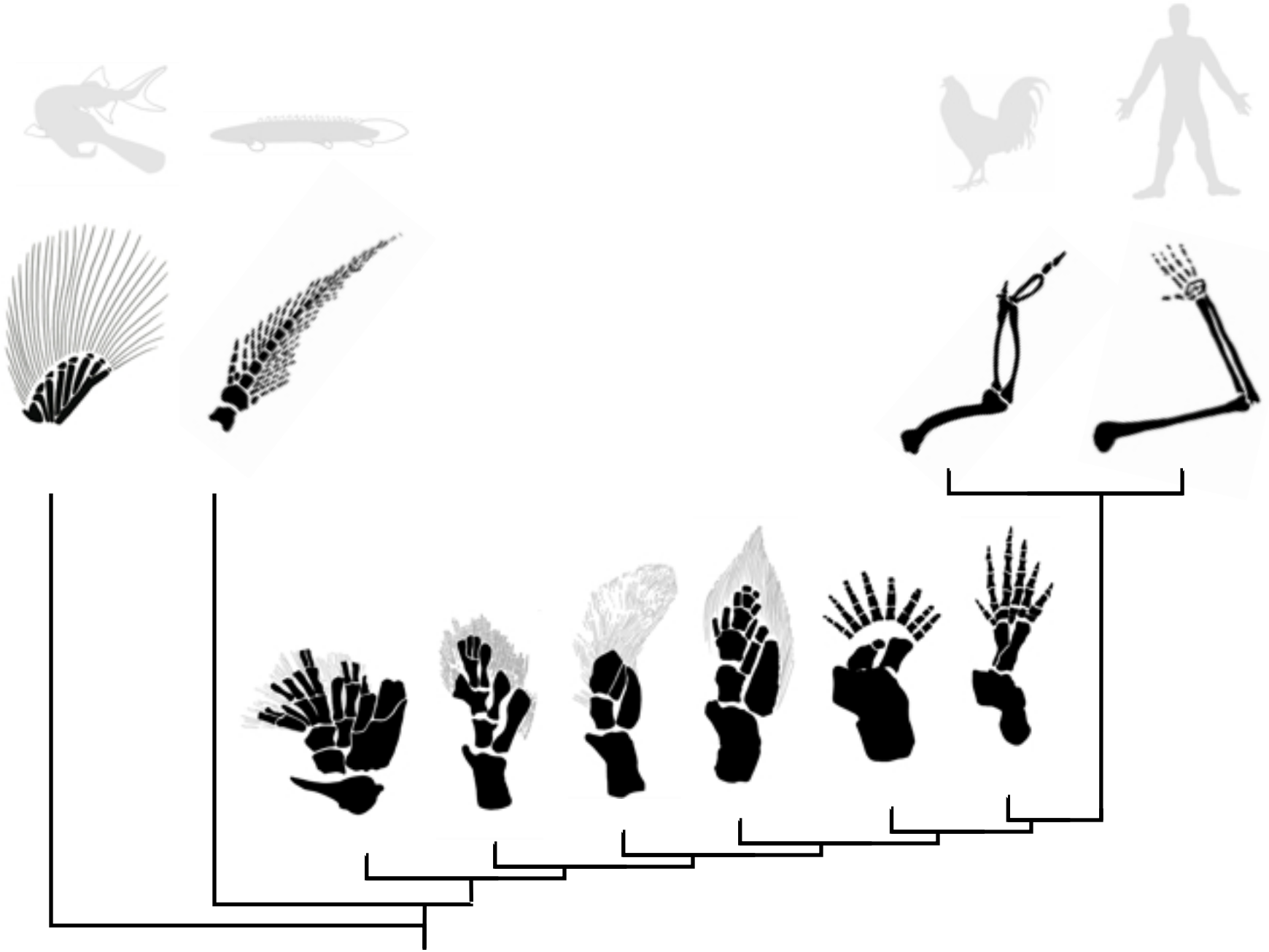
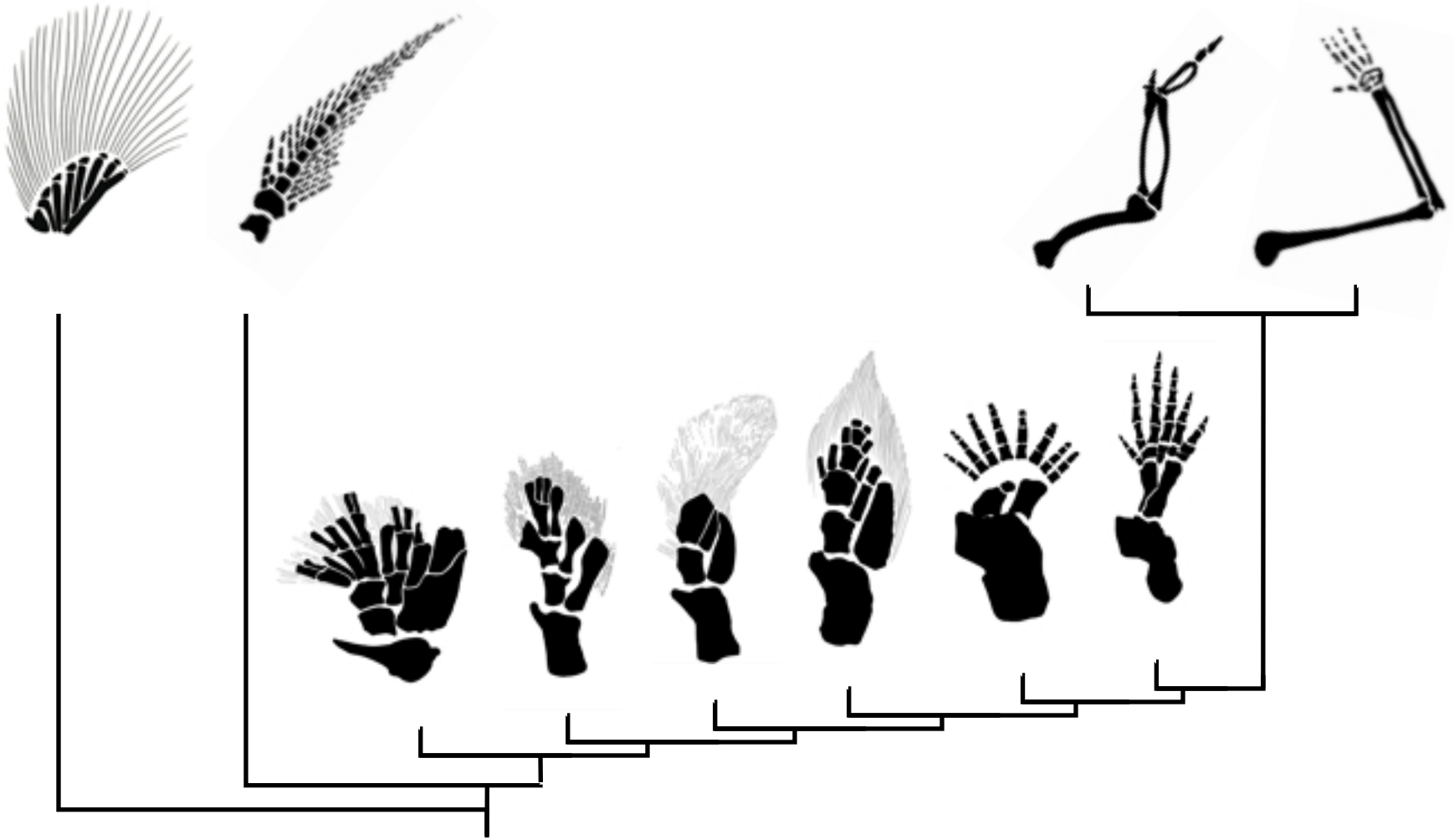


EXTANT

EXTINCT

Expeditions targeted to key parts of the tree of life



Developmental genetics of non-model organisms

Expeditions targeted to key parts of the tree of life

EXTANT

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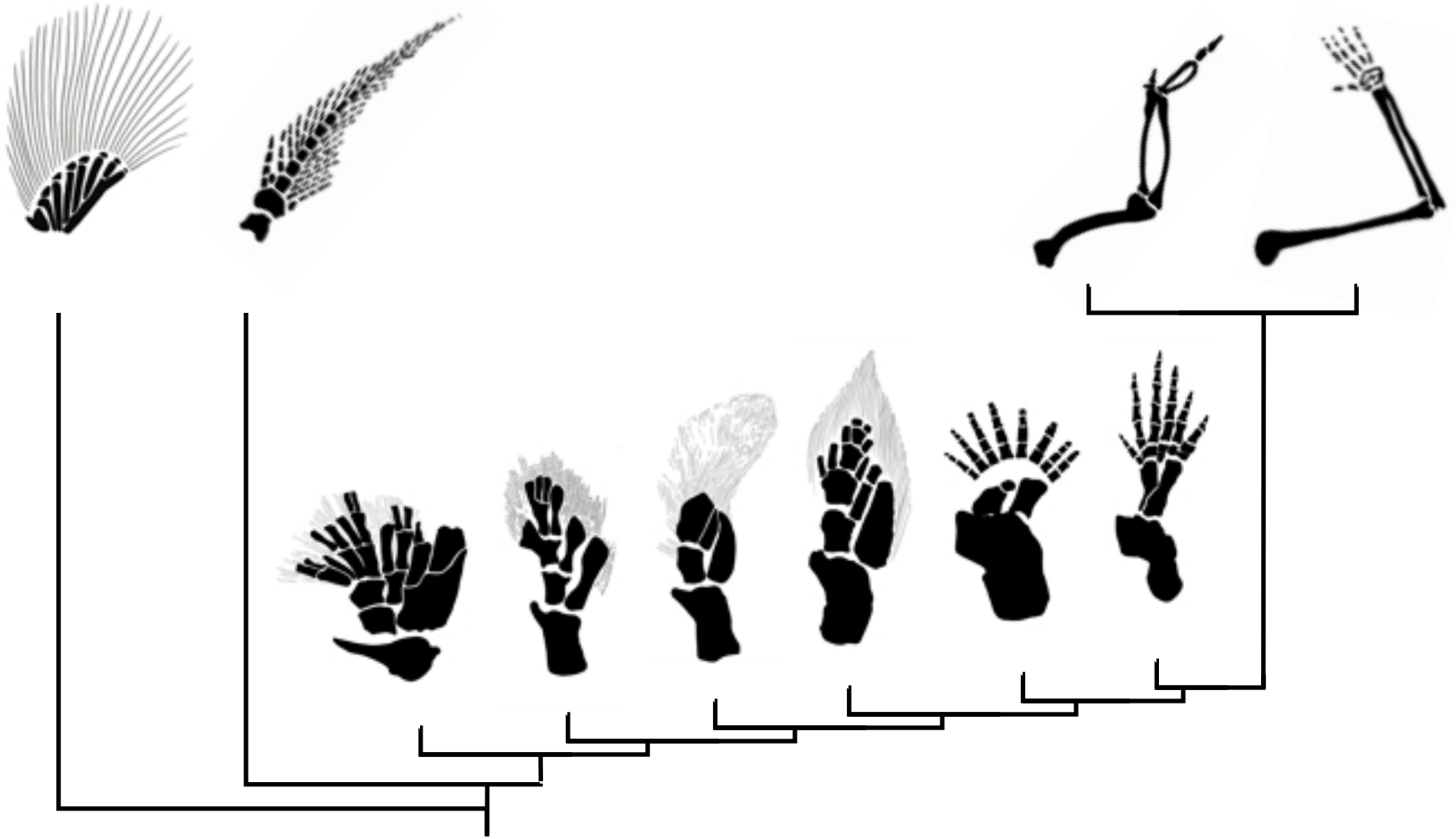
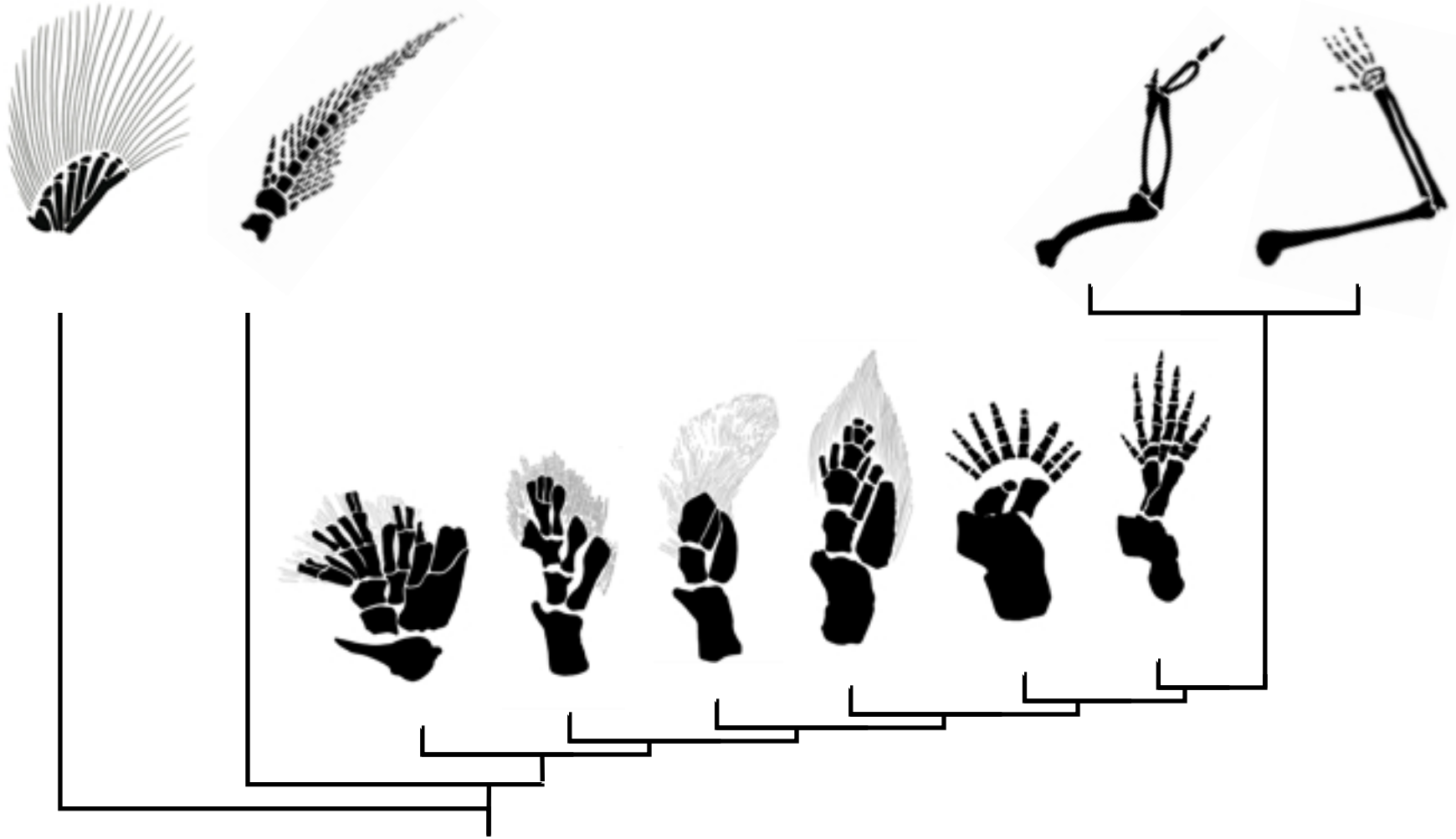


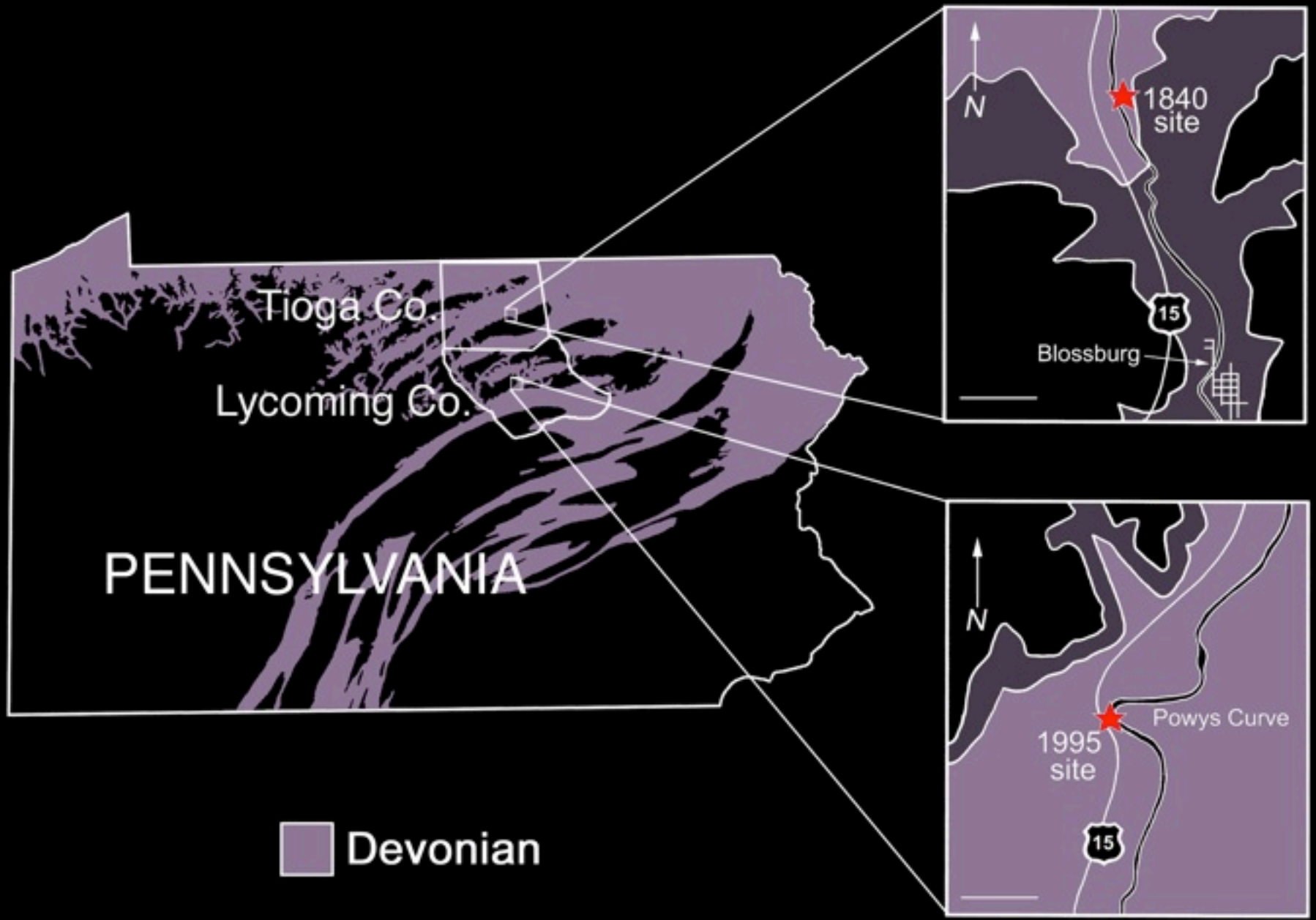
Developmental genetics of non-model organisms

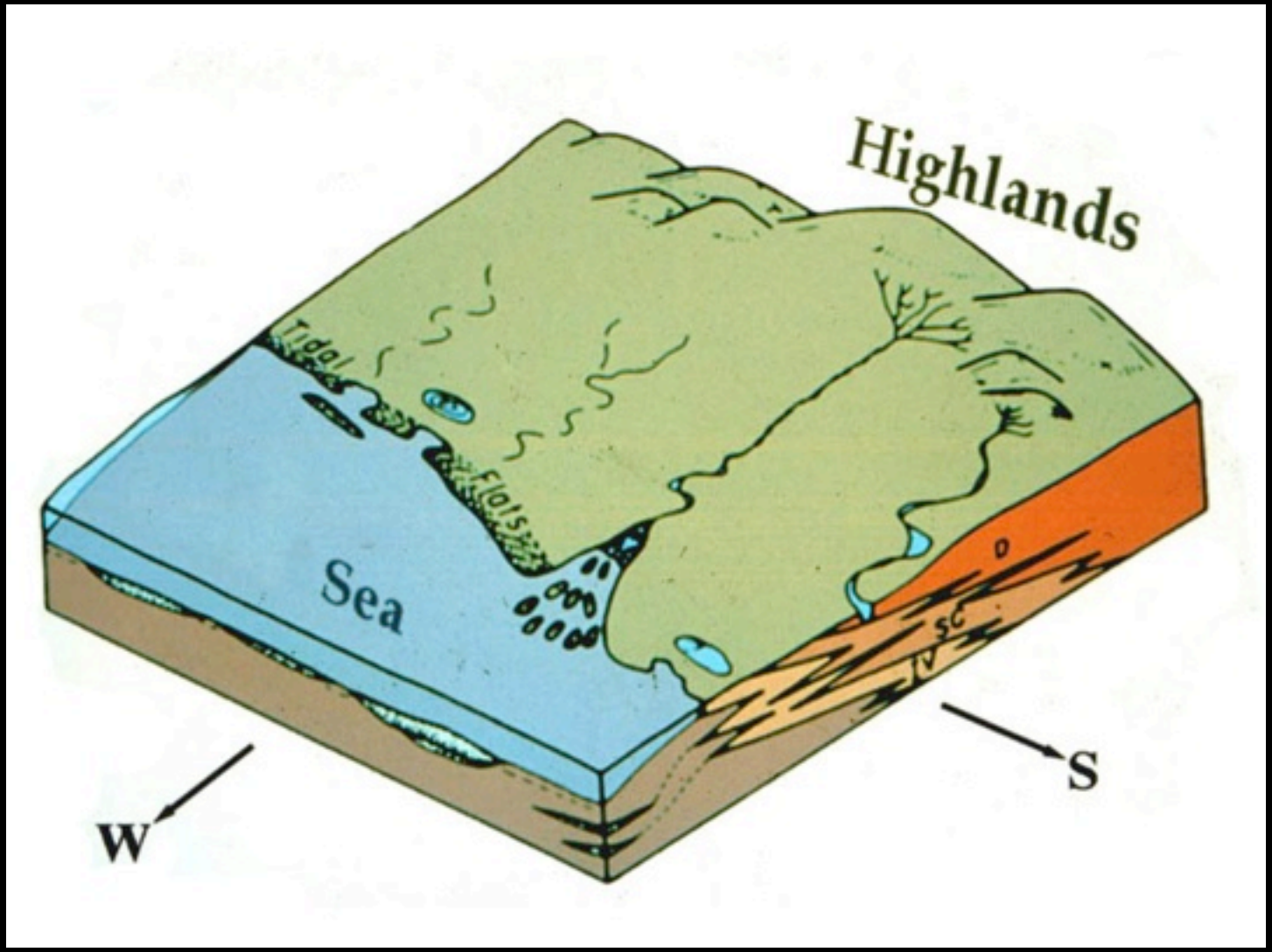
Expeditions targeted to key parts of the tree of life

EXTANT

EXTINCT

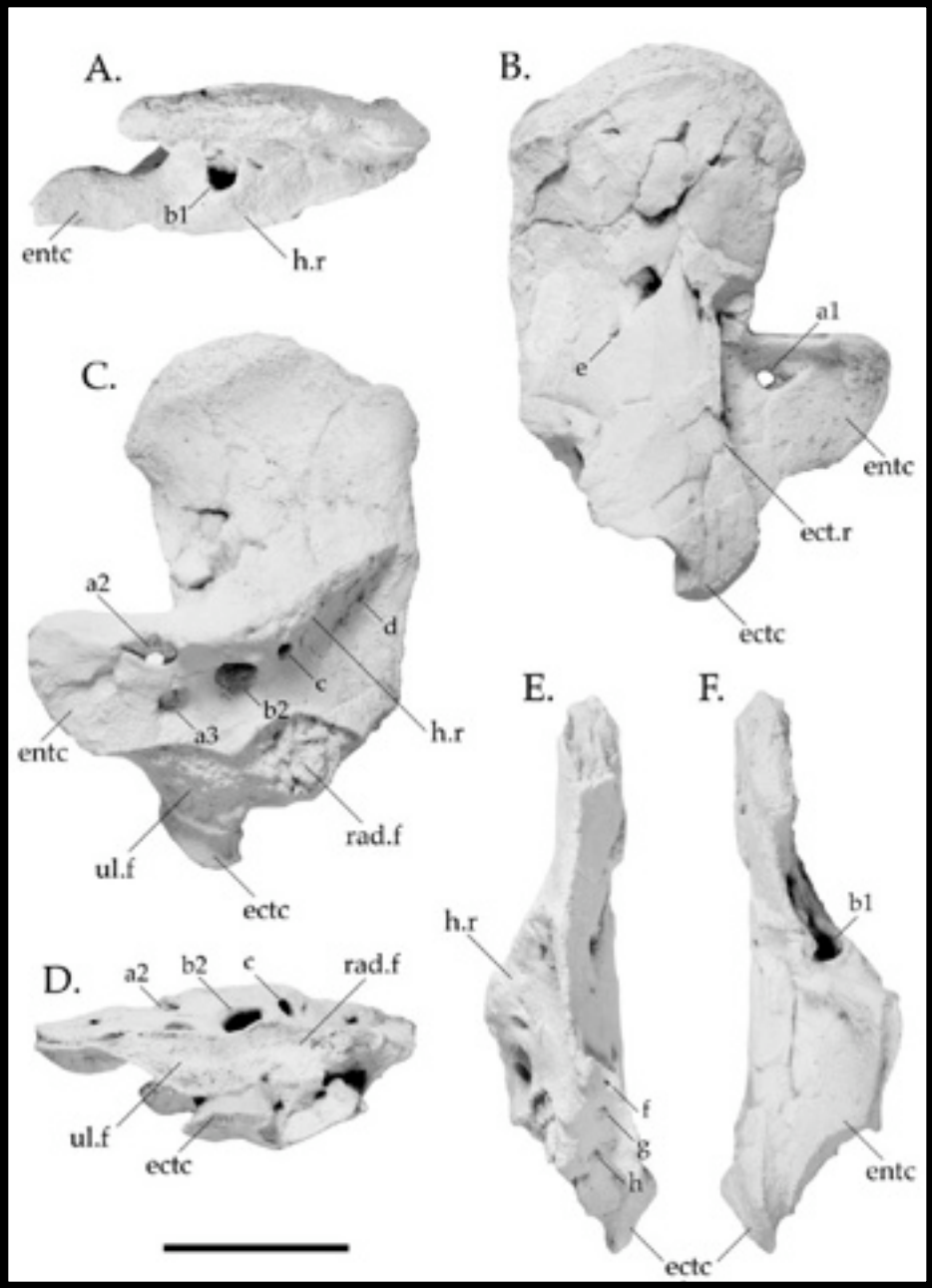



Tioga Co.
Lycoming Co.
PENNSYLVANIA
Devonian
N
1840
site
15
Blossburg
N
Powys Curve
1995
site
15


Highlands
Tidal
Flats
Sea
O
SC
V
W
S

CW

Science
2 April 2004
Vol. 304 No. 5667
Pages 1–152 $10
AAAS


A.
b1
entc
h.r
B.
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e
entc
ect.r
ectc
C.
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d
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ectc
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ectc
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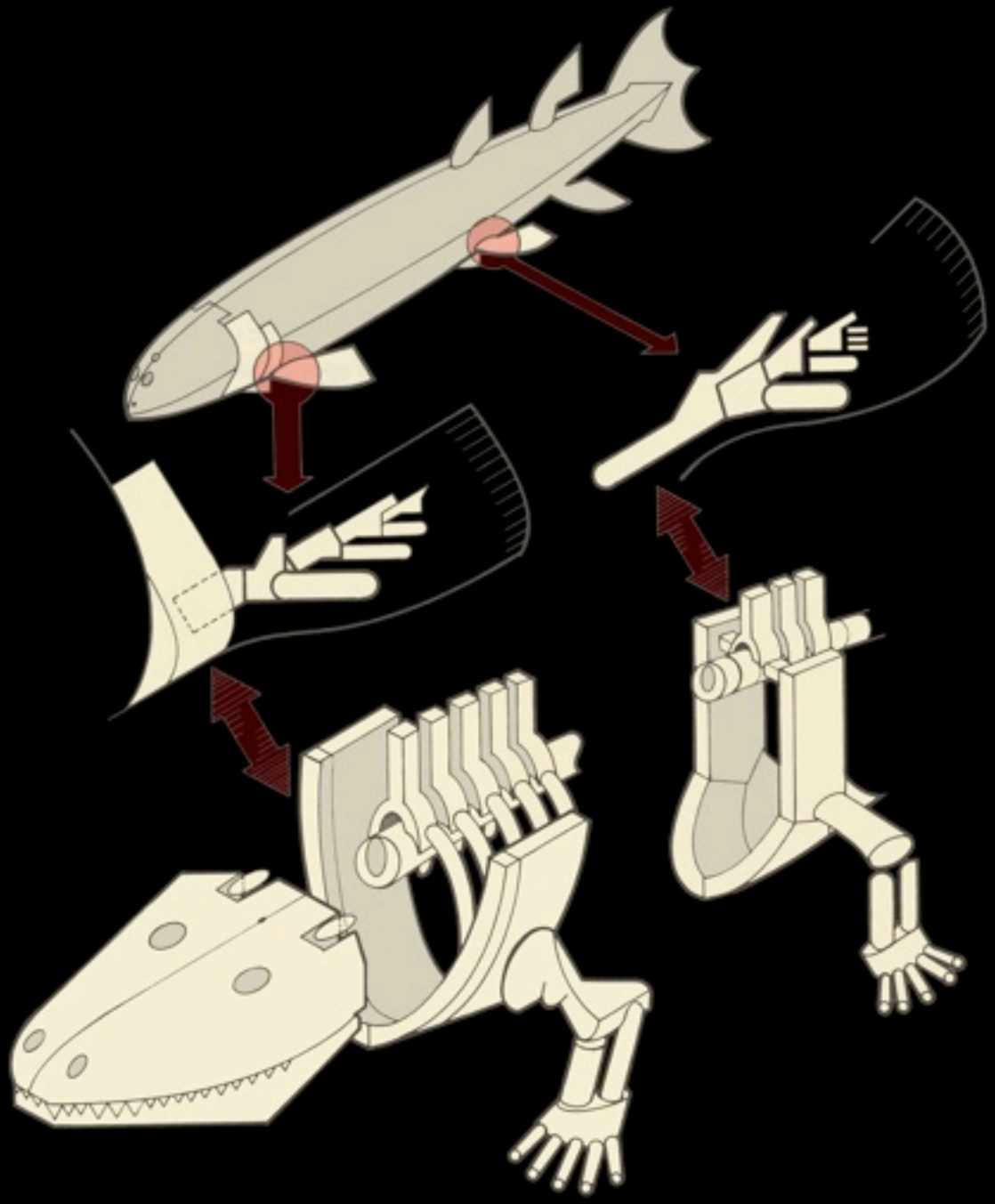
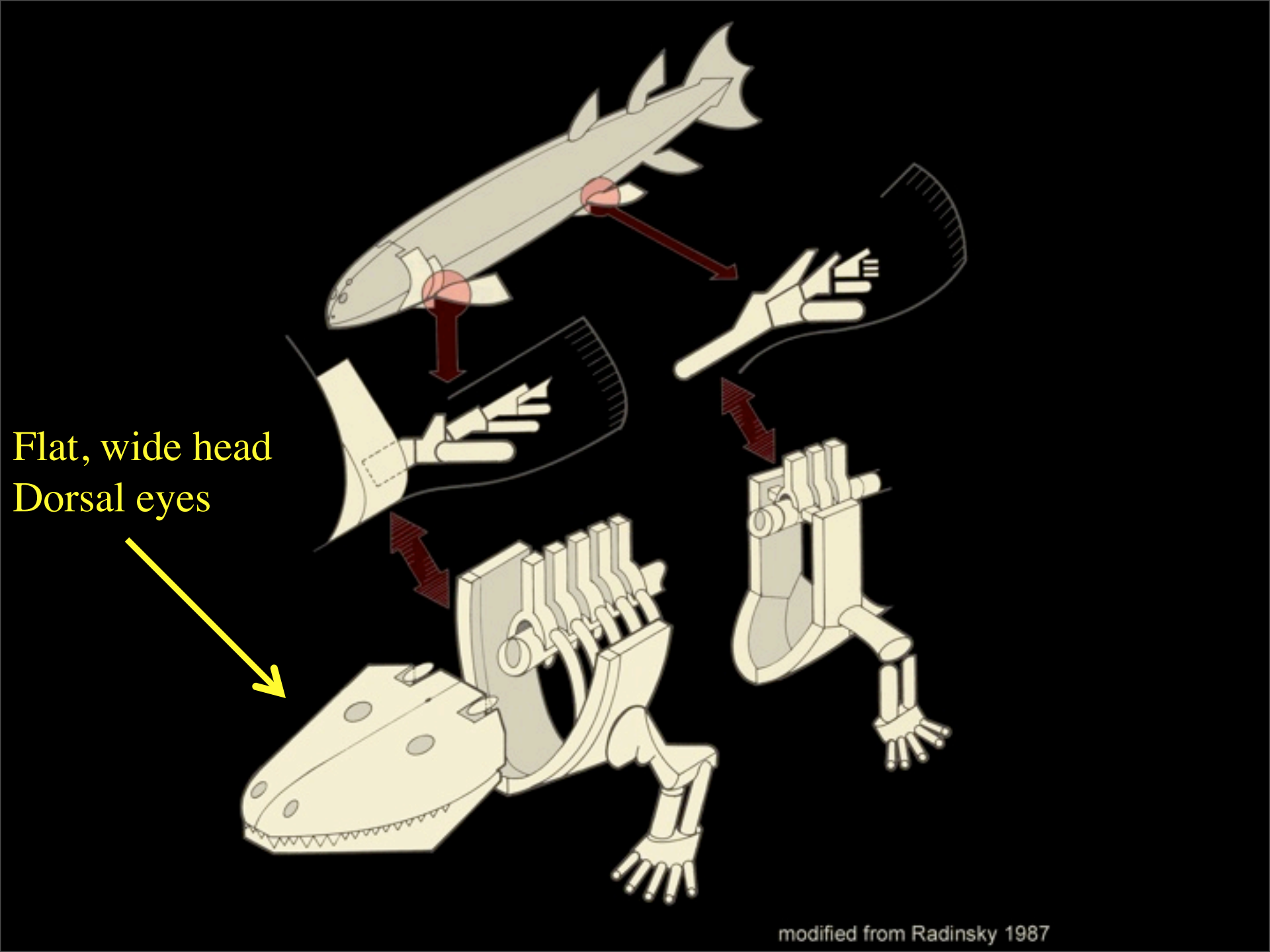
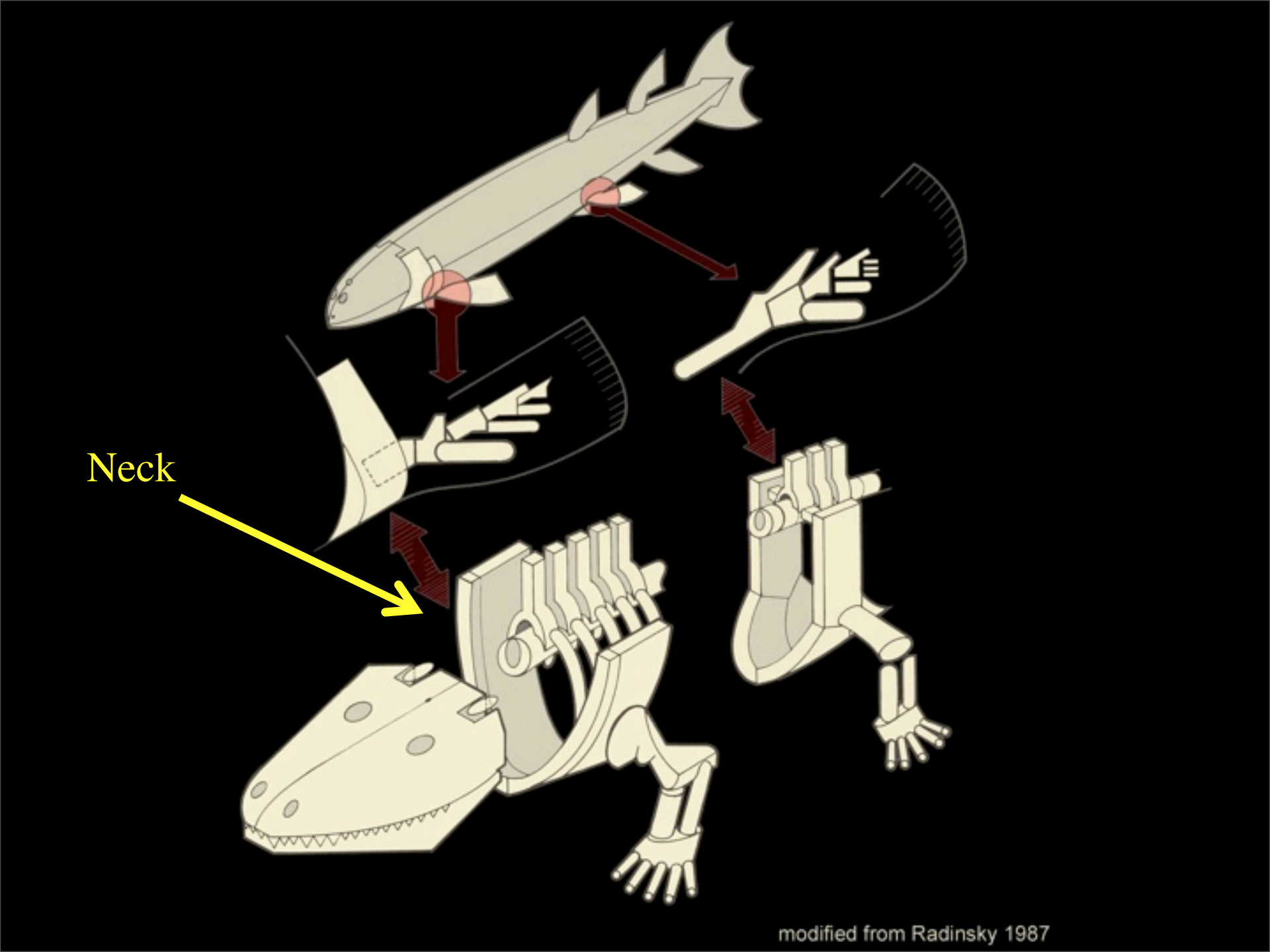
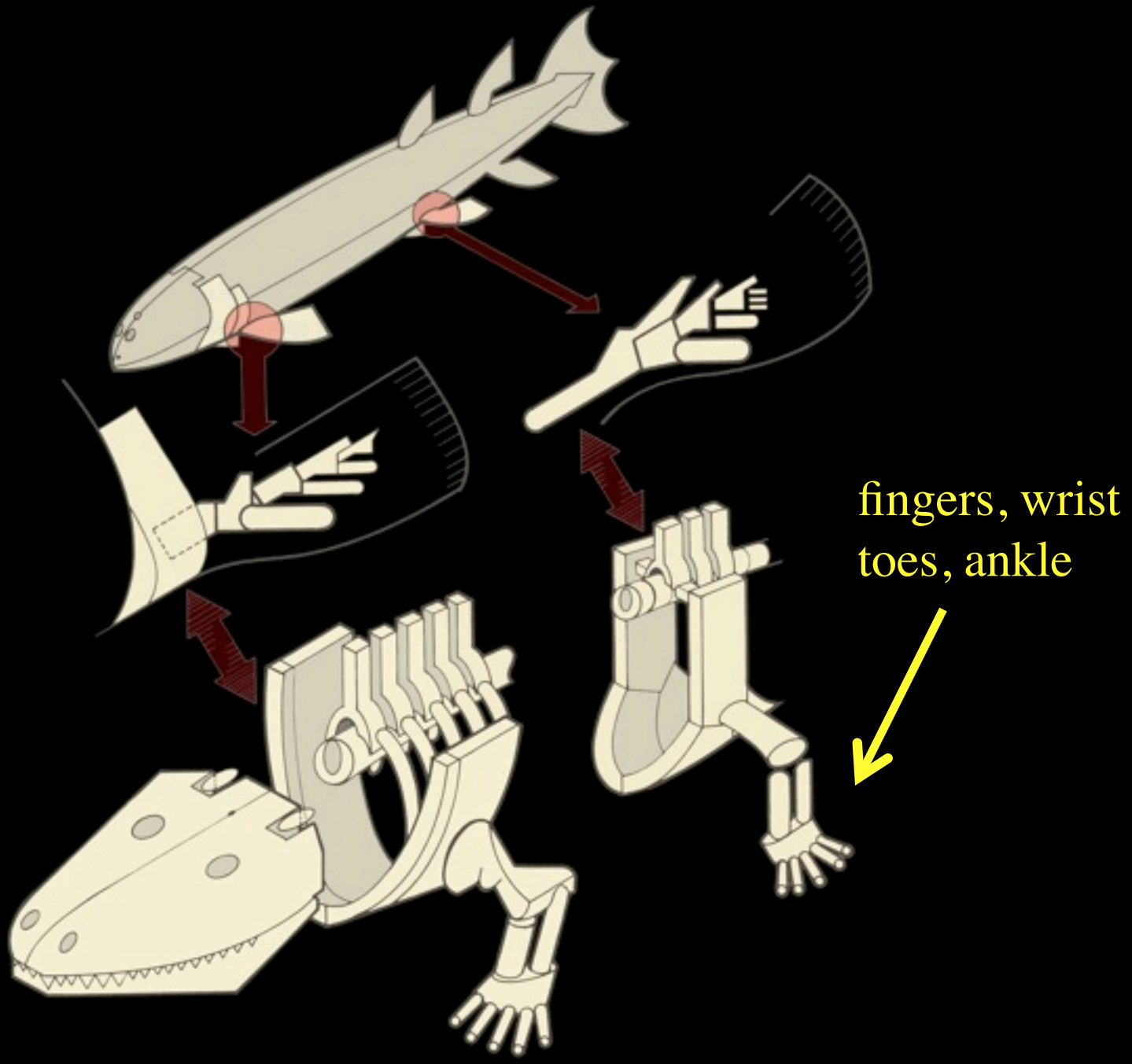
b1
entc



modified from Radinsky 1987


Flat, wide head
Dorsal eyes
modified from Radinsky 1987


Neck
modified from Radinsky 1987



modified from Radinsky 1987

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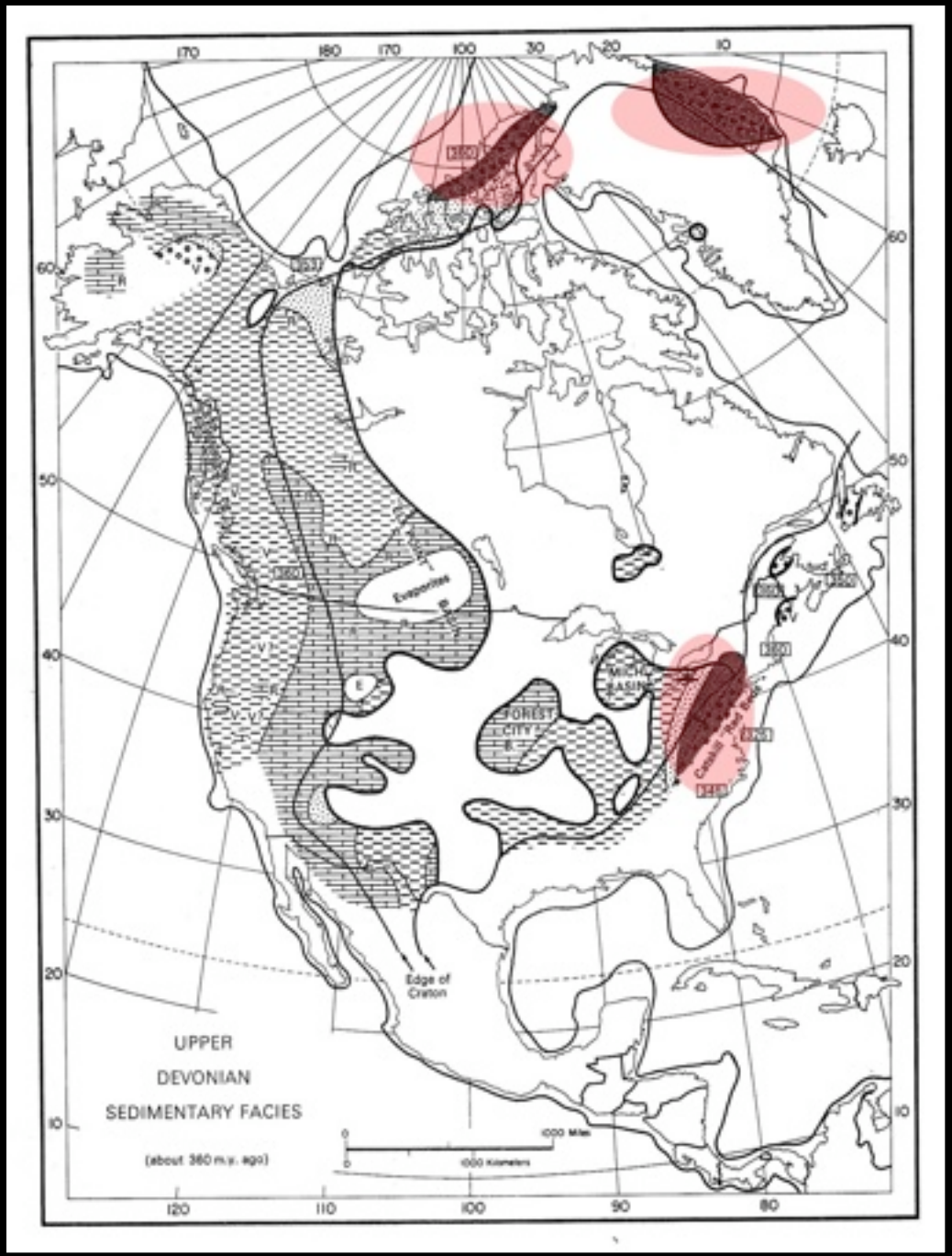

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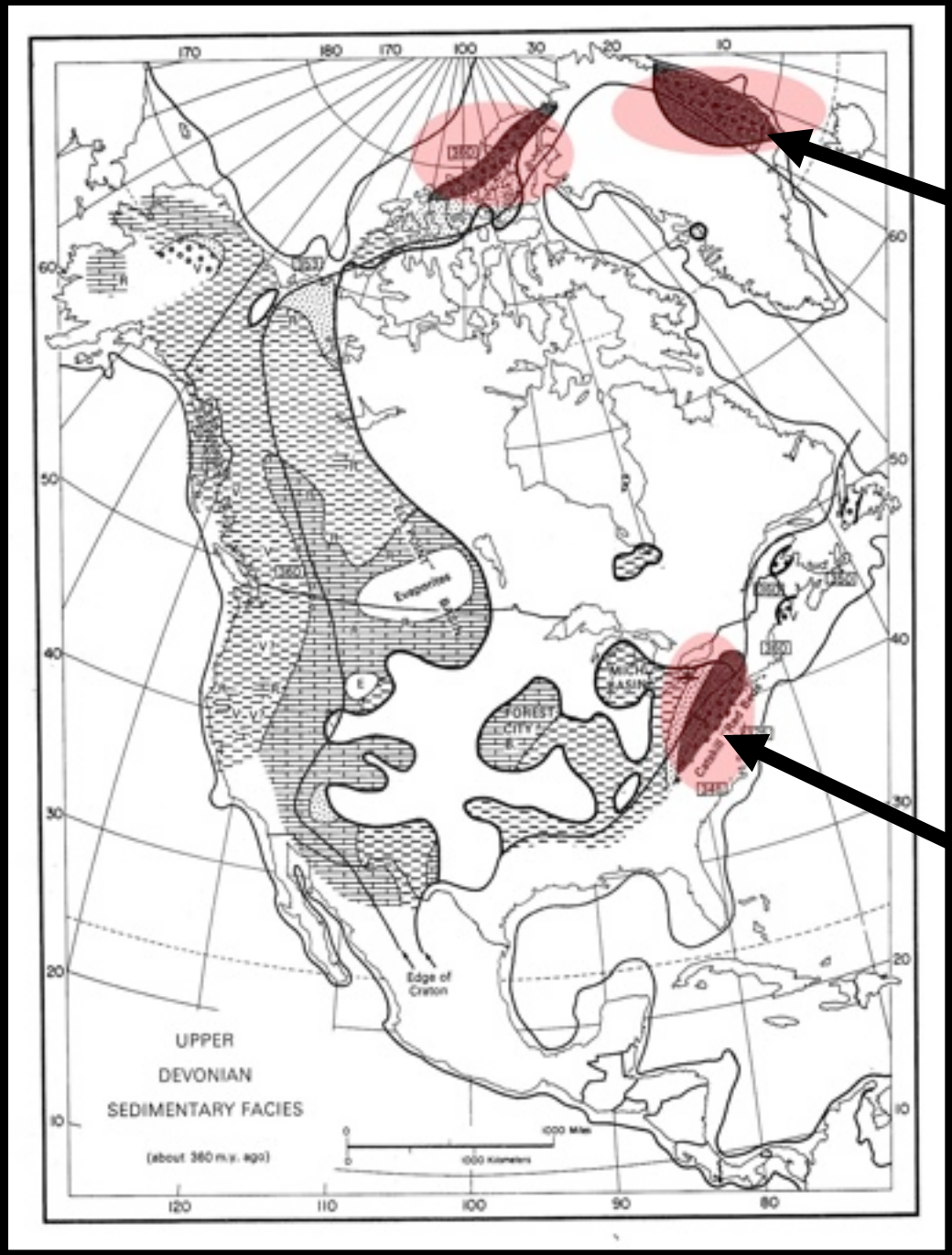

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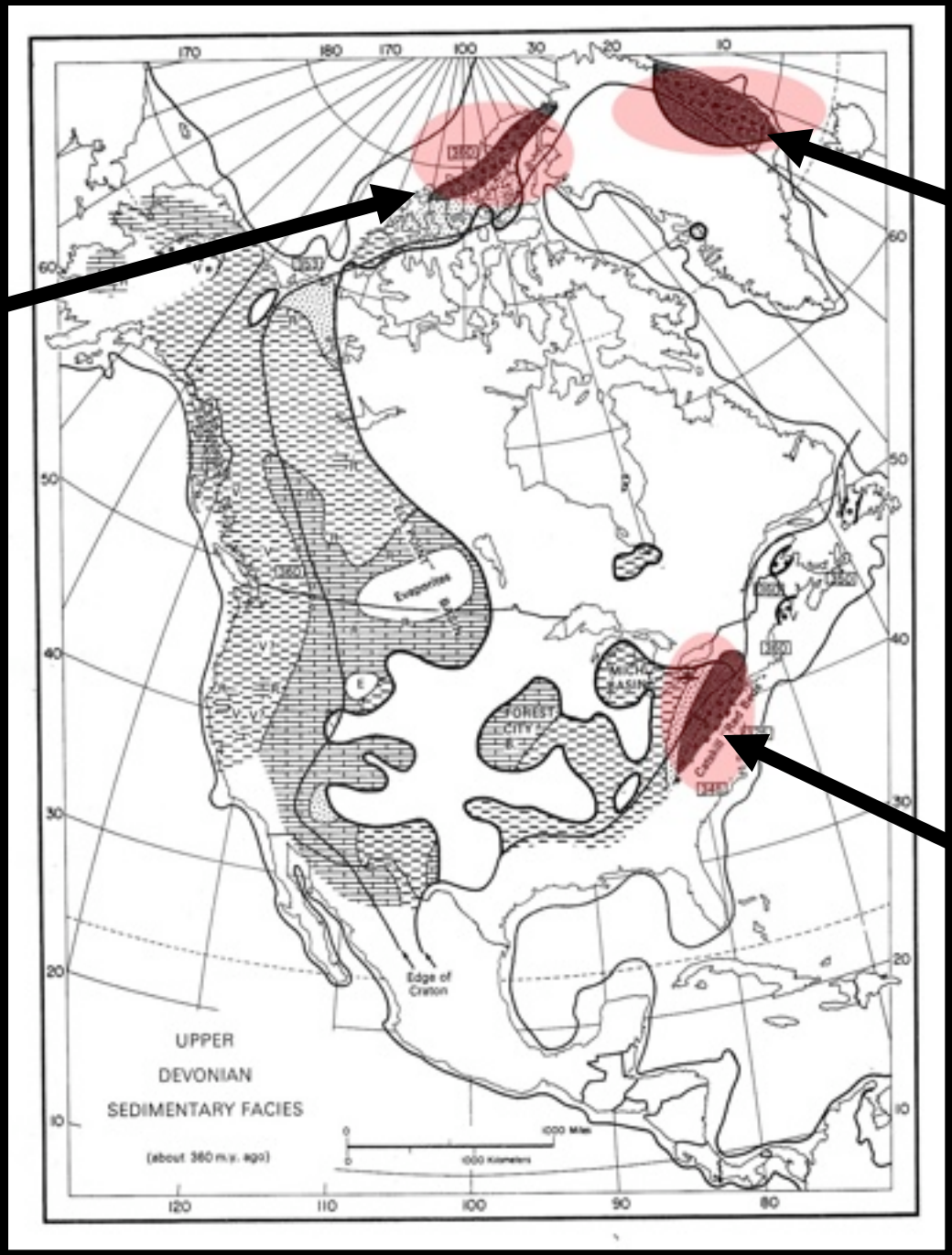
Arctic Islands unexplored



East Greenland well studied

Ongoing Catskill Project

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BULLETIN OF CANADIAN PETROLEUM GEOLOGY
VOL. 24, NO. 4 (DECEMBER 1976), P. 485-639

THE MIDDLE-UPPER DEVONIAN CLASTIC WEDGE OF THE FRANKLINIAN GEOSYNCLINE

ASHTON EMBRY[1] AND J. EDWARD KLOVAN[2]

[1], 335 - 8th Avenue S.W., Calgary, Alberta.
nt of Geology, University of Calgary, Calgary, Alberta.

Composition — Fine-grained sandstones in the Fram Fm are quartz arenites and quartzose lithic arenites (Plate 24, Fig. 4). The average composition of five fine-grained sandstones from the type section is 70 ± 3 per cent quartz; 1 ± 1 per cent feldspar; 5 ± 2 per cent rock fragments (mainly shale); 6 ± 2 per cent chert; 12 ± 3 per cent clay (mainly kaolinite, minor illite and chlorite); 3 ± 3 per cent calcite; 2 ± 2 per cent porosity. Biotite and muscovite are also present and are usually concentrated in dark laminations along with carbonaceous material. Heavy minerals are rare and consist mainly of tourmaline, zircon, rutile and garnet. Most grains are subround.

Part of the quartz content is authigenic cement. The clay is interpreted to be mainly of diagenetic origin and tends to occur in the coarser sandstones. Sparry calcite is clearly a cement and is most common in very fine grained sandstones and coarse siltstones. The samples point counted had a fairly low calcite content (max. 9 per cent) but others range as high as 30 per cent.

The average composition of five shales from the type Fram Fm is 65 ± 6 per cent quartz; 3 ± 1 per cent feldspar; 15 ± 4 per cent kaolinite; 12 ± 3 per cent illite; 1 ± 1 per cent chlorite; and 1 ± 1 per cent calcite.

Paleocurrents — Cross-beds were measured throughout the type section of the Fram Fm. The paleocurrent pattern (Fig. 30) is unimodal and indicates sediment transport to the southwest. Visual estimates of cross-bed orientation on eastern Grinnell Peninsula suggest a similar sediment transport direction.

Age — Palynological control is limited to spot samples collected near the base, middle and top of the formation of both the type section and the east Grinnell Peninsula locality. The available data indicate an age of Early to Middle Frasnian (*Medius* and *Maclarenii* zones) (Chi, *pers. comm.*, 1975). Plant and fish collections made by the Fram expedition also indicate a Late Devonian age (Nathorst, 1904; Kiaer, 1915).

Environment of Deposition — The lithologies, sedimentary structures, cyclicity and fossil content of the Fram Fm suggest a meandering-stream environment of deposition. Sandstone units are interpreted to be point-bar and channel-fill deposits, whereas the shale-siltstone units are of overbank origin.

The Fram Fm is similar to the Catskill Fm of Pennsylvania (*pers. obs.*), which is also interpreted to be of meandering-stream origin (Allen and Friend, 1968). The main lithologic difference between the two is

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PLATE 24

Fig. 1. Basal conglomeratic portion of sandstone unit in Fram Fm, Bird Fiord area. Note basal scour surface and plant fragments (upper right) in sandstone.

Fig. 2. Siltstone with root markings, Fram Fm, Bird Fiord area.

Fig. 3. Siltstone with mud cracks, Fram Fm, Bird Fiord area.

Fig. 4. Photomicrograph of fine-grained, quartzose lithic arenite from Fram Fm, Bird Fiord area.

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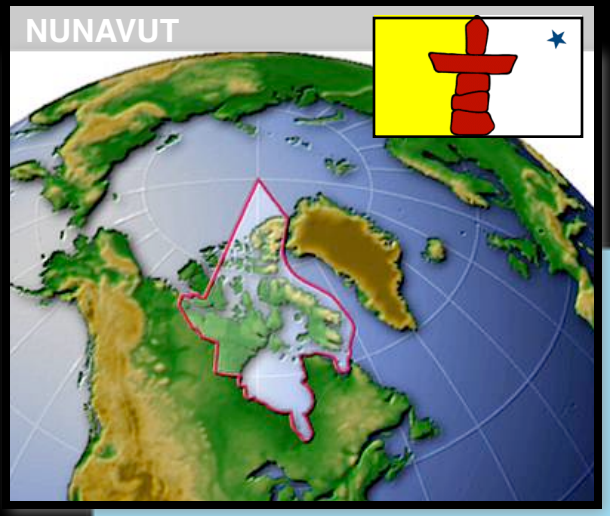
Fiord area.



Middle-Upper Devonian at surface

1999 camps

2000 camps

2002 camps

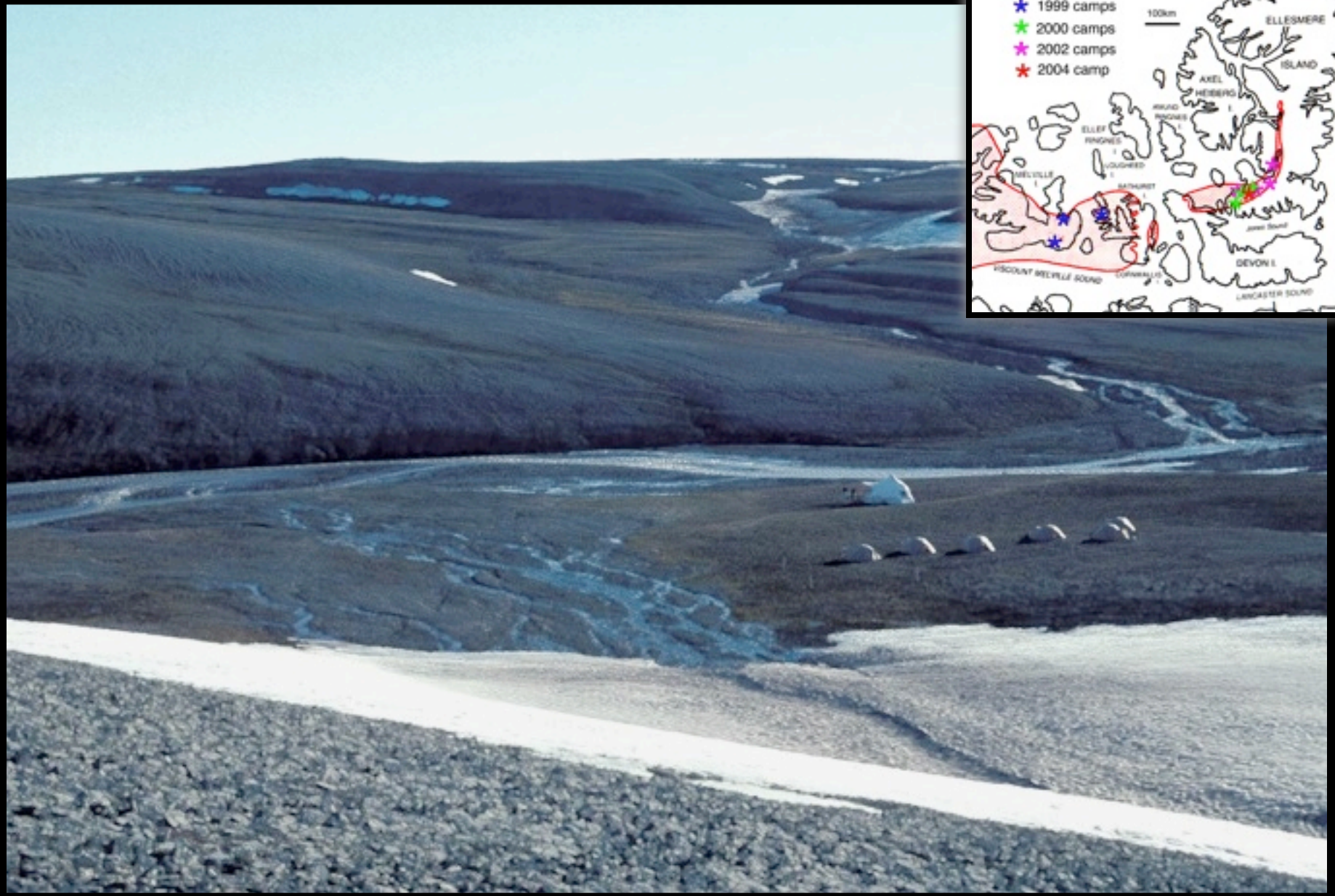
ELLESMERE ISLAND

ARCTIC OCEAN

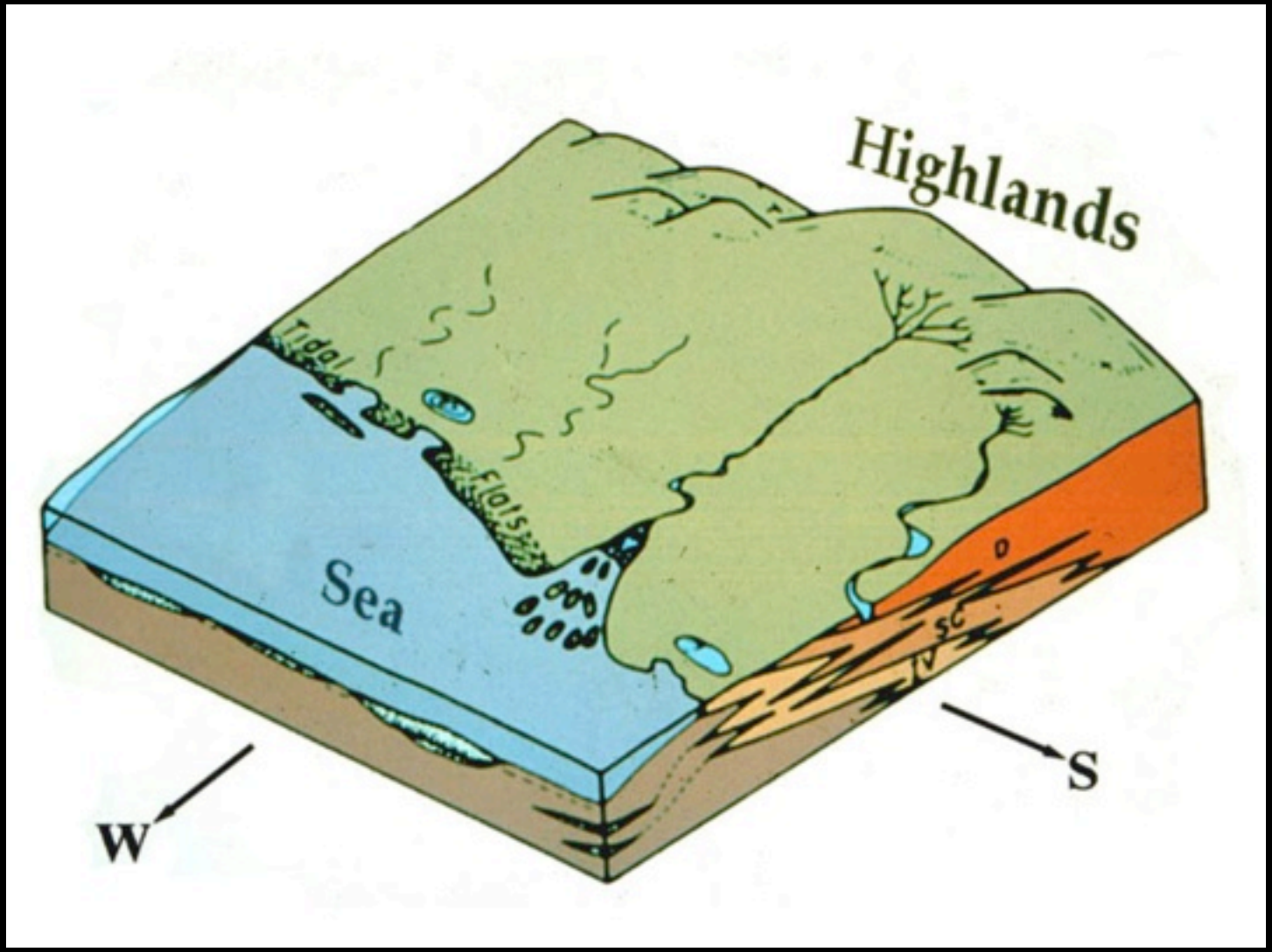
MELVILLE IS.

100km

AGE	SOUTHERN ELLESMERE ISLAND
DEVONIAN LATE FAMENNIAN	
DEVONIAN LATE FRASNIAN	NORDSTRAND POINT FORMATION
DEVONIAN LATE FRASNIAN	HELL GATE FM.
DEVONIAN LATE FRASNIAN	FRAM FM.
DEVONIAN MIDDLE GIVETIAN	HECLA BAY FORMATION
DEVONIAN MIDDLE EIFELIAN	STRATHCONA FIORD FM.
DEVONIAN MIDDLE EIFELIAN	UPPER BIRD FIORD FORMATION
DEVONIAN MIDDLE EIFELIAN	LOWER BIRD FIORD FORMATION


Middle-Upper Devonian clastic wedge at surface or in subsurface
1999 camps
2000 camps
2002 camps
2004 camp
100km
ELLESMERE ISLAND
AXEL HEIBERG
ELLEF RINGNES
AMUND RINGNES
MELVILLE
BATHURST
CORNWALLIS
DEVON I.
JONES SOUND
VISCOUNT MELVILLE SOUND
LANCASTER SOUND

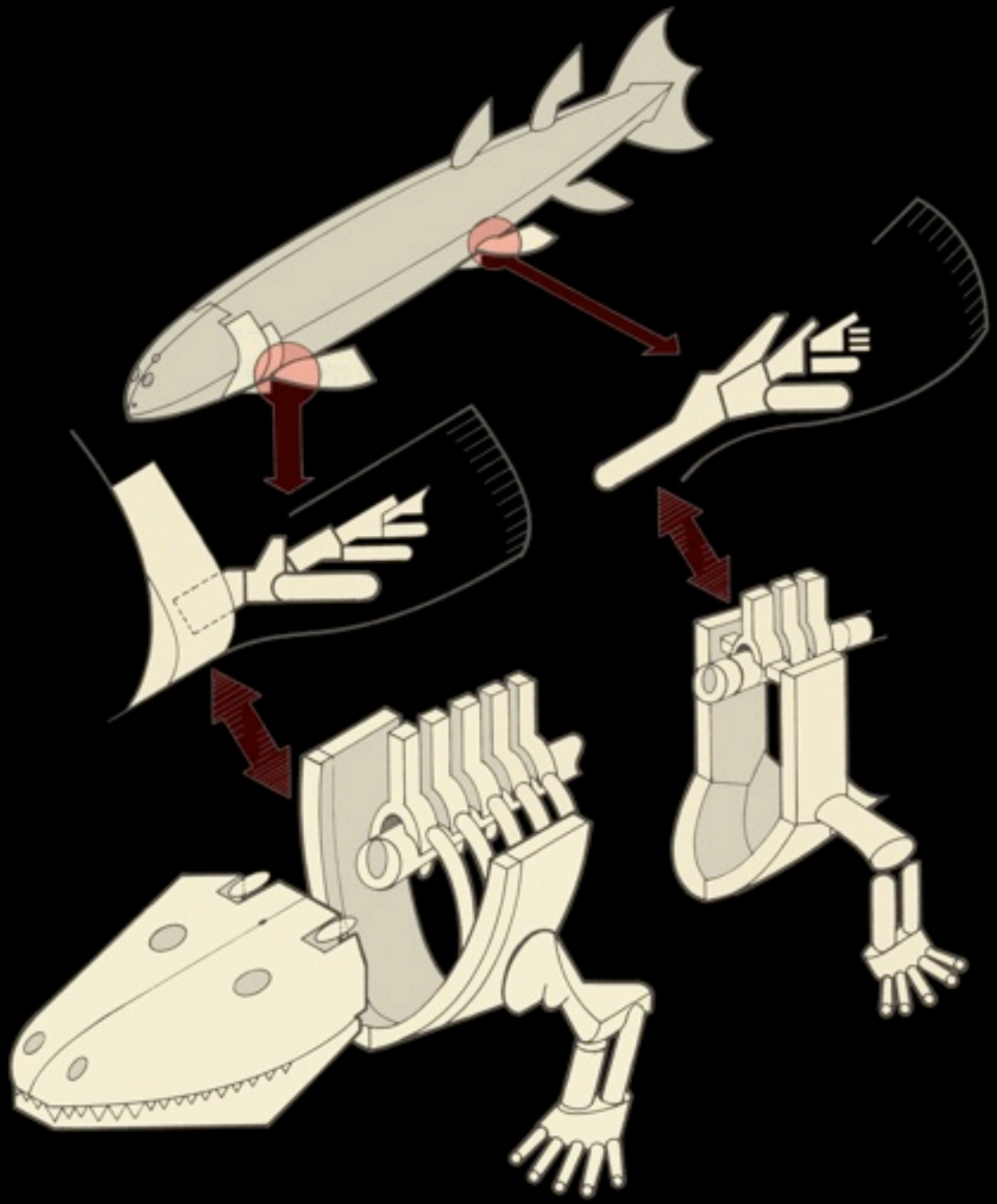
Middle-Upper Devonian clastic wedge at surface or in subsurface
1999 camps
2000 camps
2002 camps
2004 camp
100km
ELLESMERE ISLAND
AXEL HEIBERG
ELLEF RINGNES
MELVILLE
BATHURST
DEVON I.
LANCASTER SOUND


Highlands
Tidal
Flats
Sea
O
SC
V
W
S

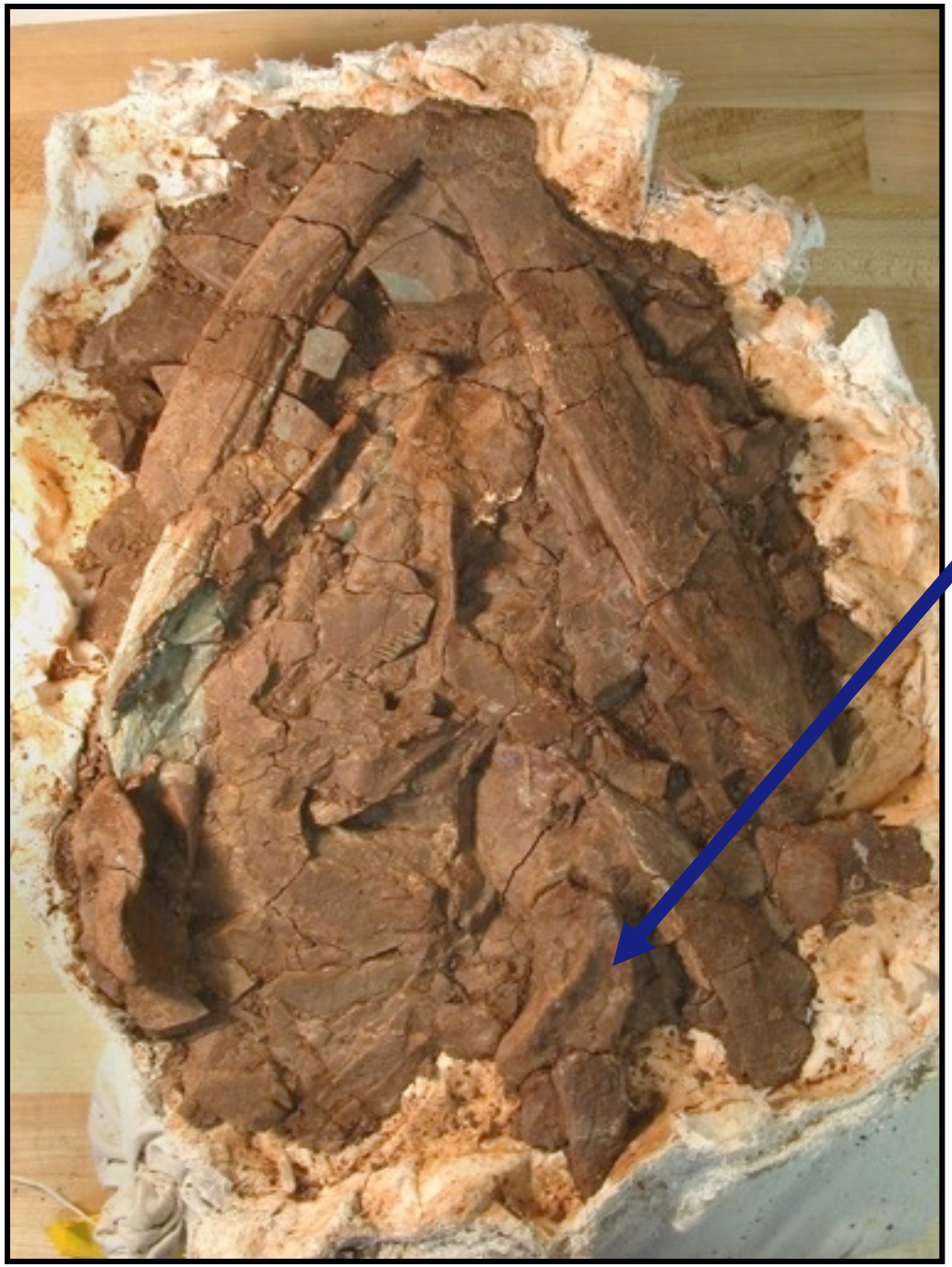
Middle-Upper Devonian clastic wedge at surface or in subsurface
1999 camps
2000 camps
2002 camps
2004 camp
100km
ELLESMERE ISLAND
AXEL HEIBERG
ELLEF RINGNES
MELVILLE
BATHURST
DEVON I.
VISCOUNT MELVILLE SOUND
LANCASTER SOUND

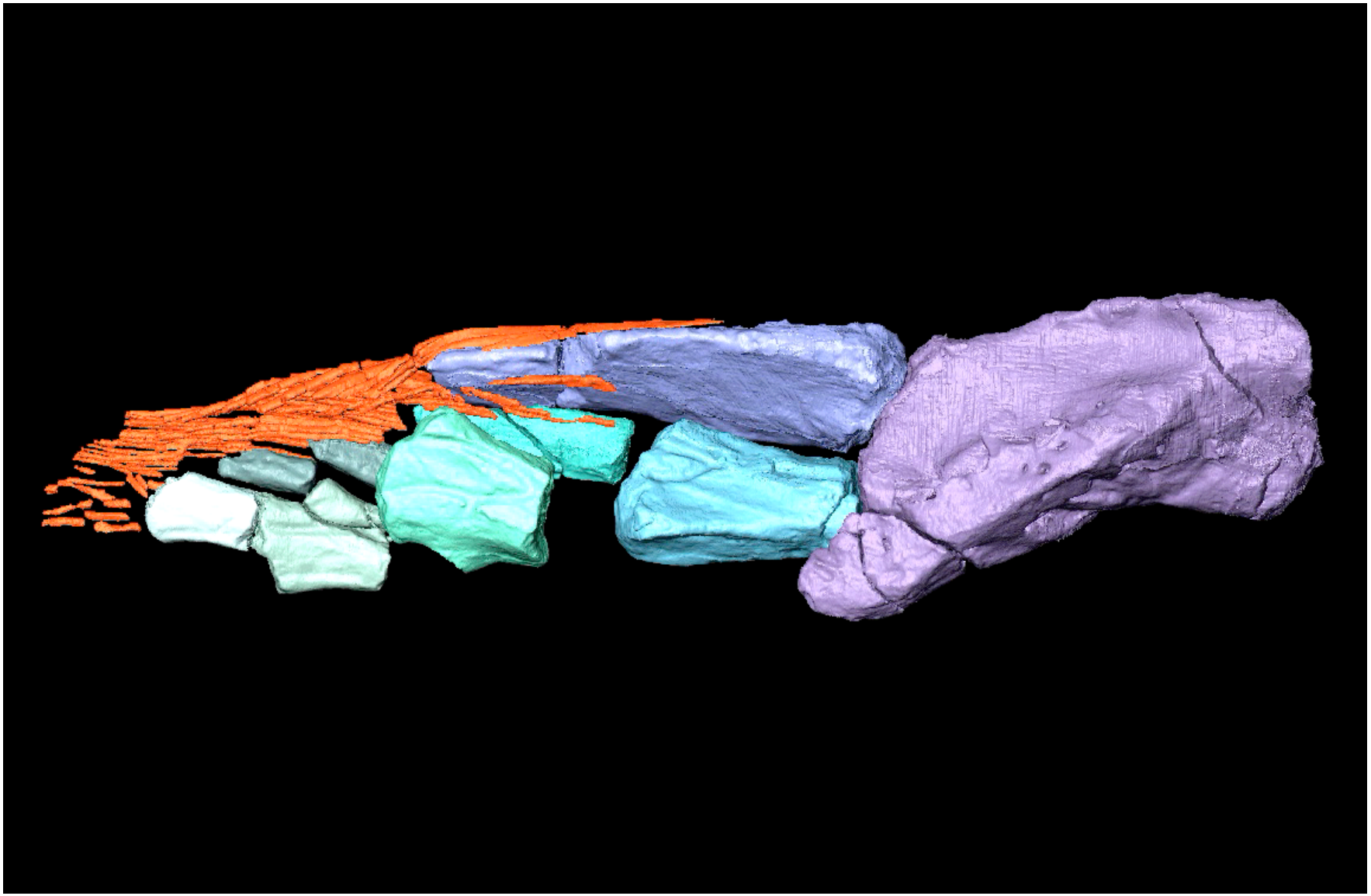
Middle-Upper Devonian clastic wedge at surface or in subsurface
1999 camps
2000 camps
2002 camps
2004 camp
100km
ELLESMERE
ISLAND
AXEL HEIBERG
ELLEF RINGNES
MELVILLE
BATHURST
CORNWALLIS
DEVON I.
VISCOUNT MELVILLE SOUND

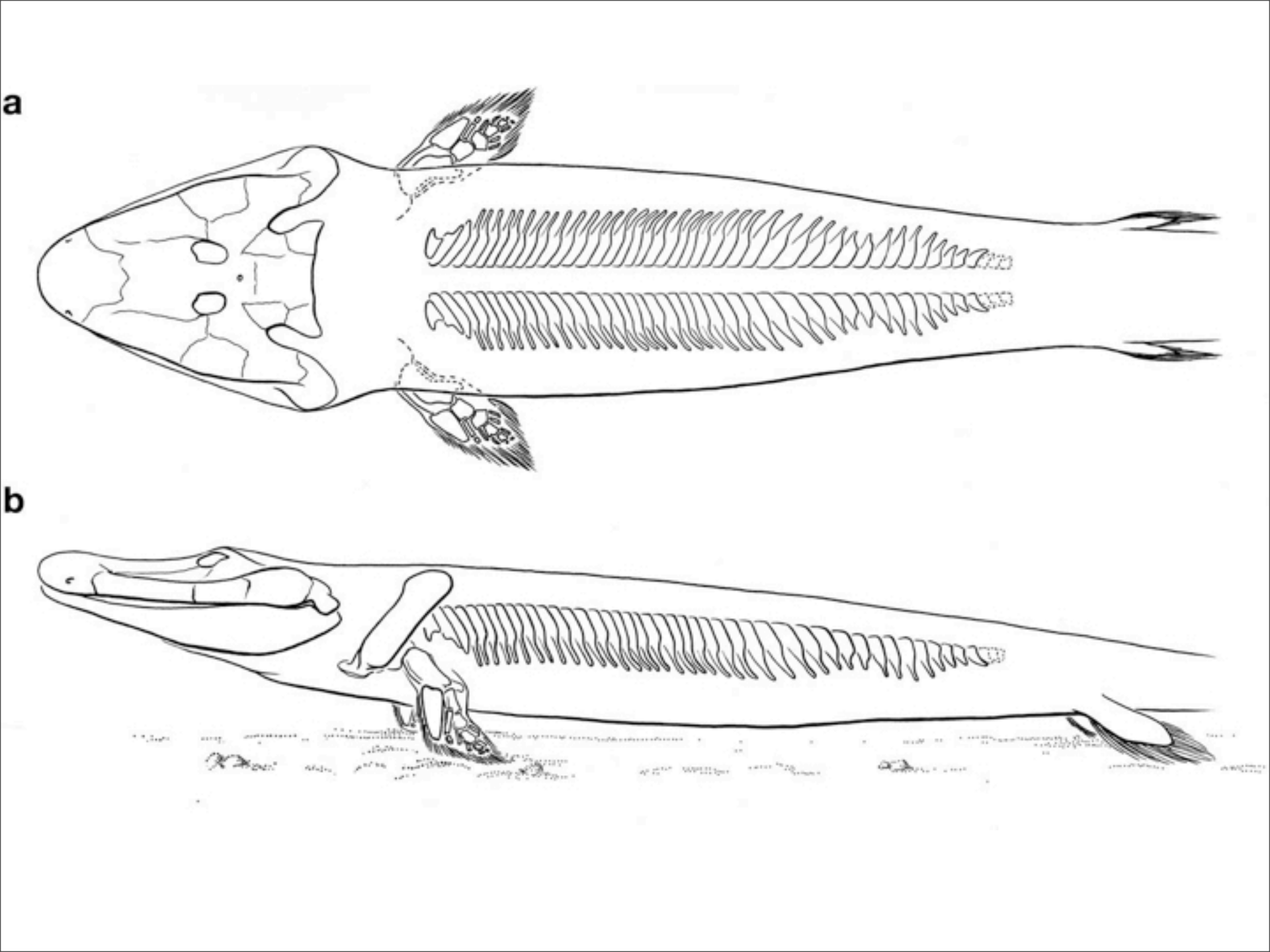
Site NV2K17, southern Ellesmere Island, 2006



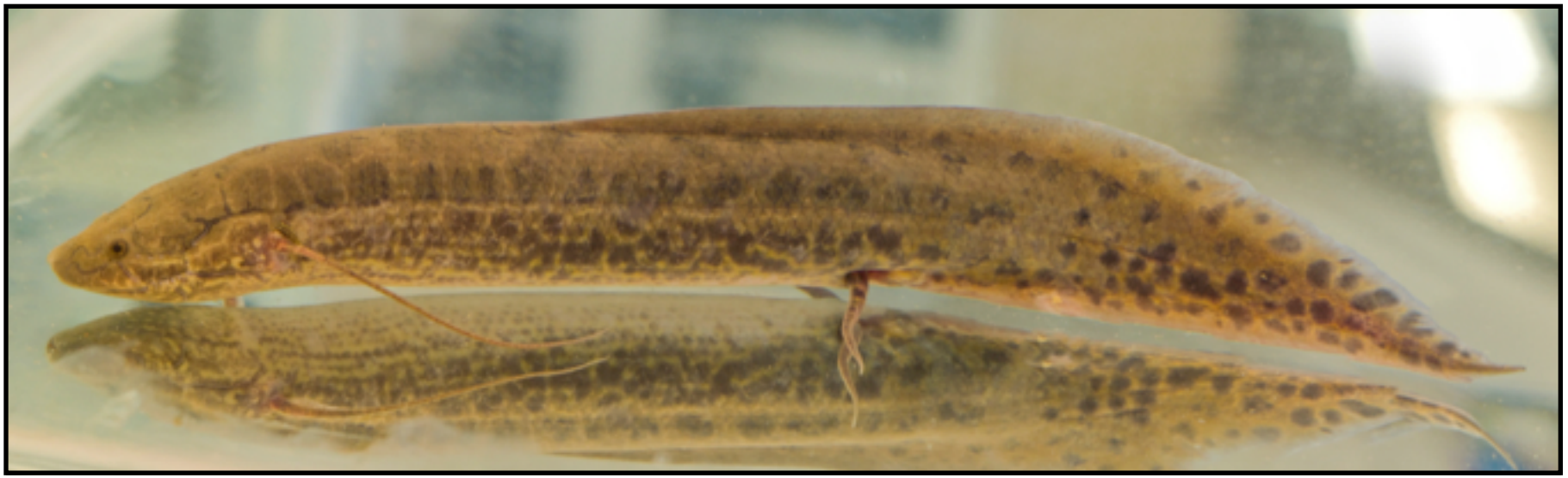
modified from Radinsky 1987

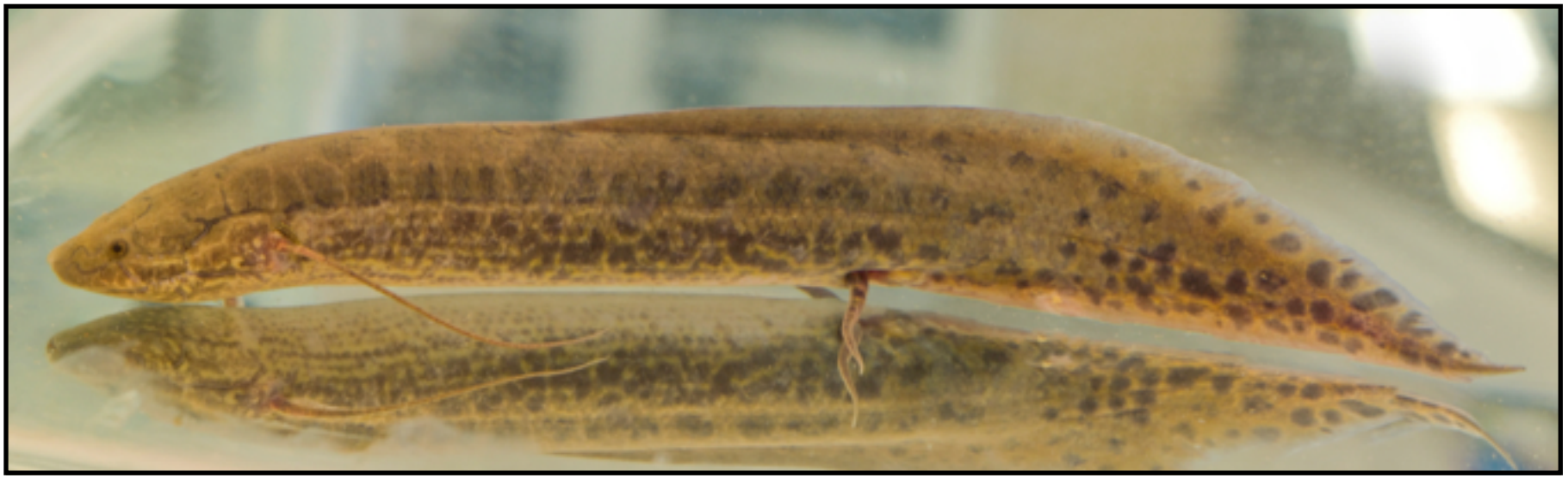


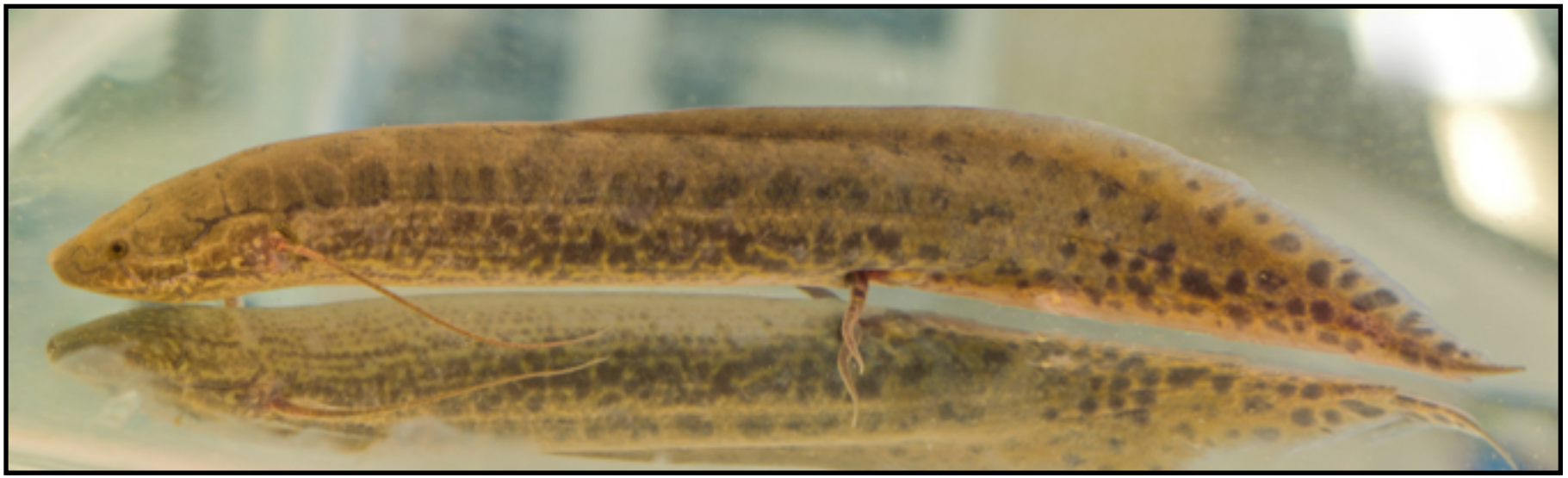


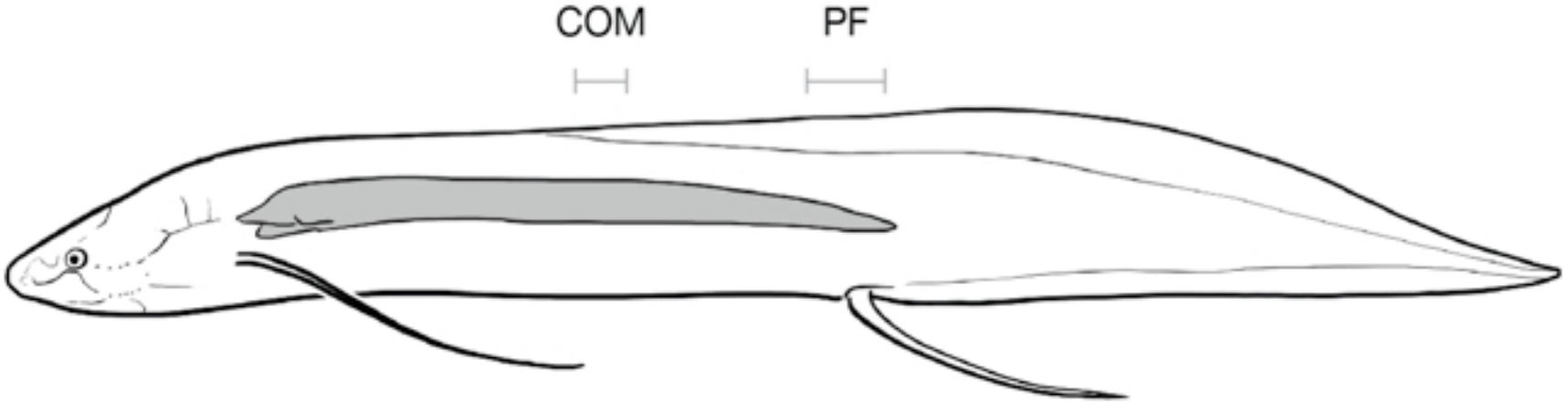

a
b

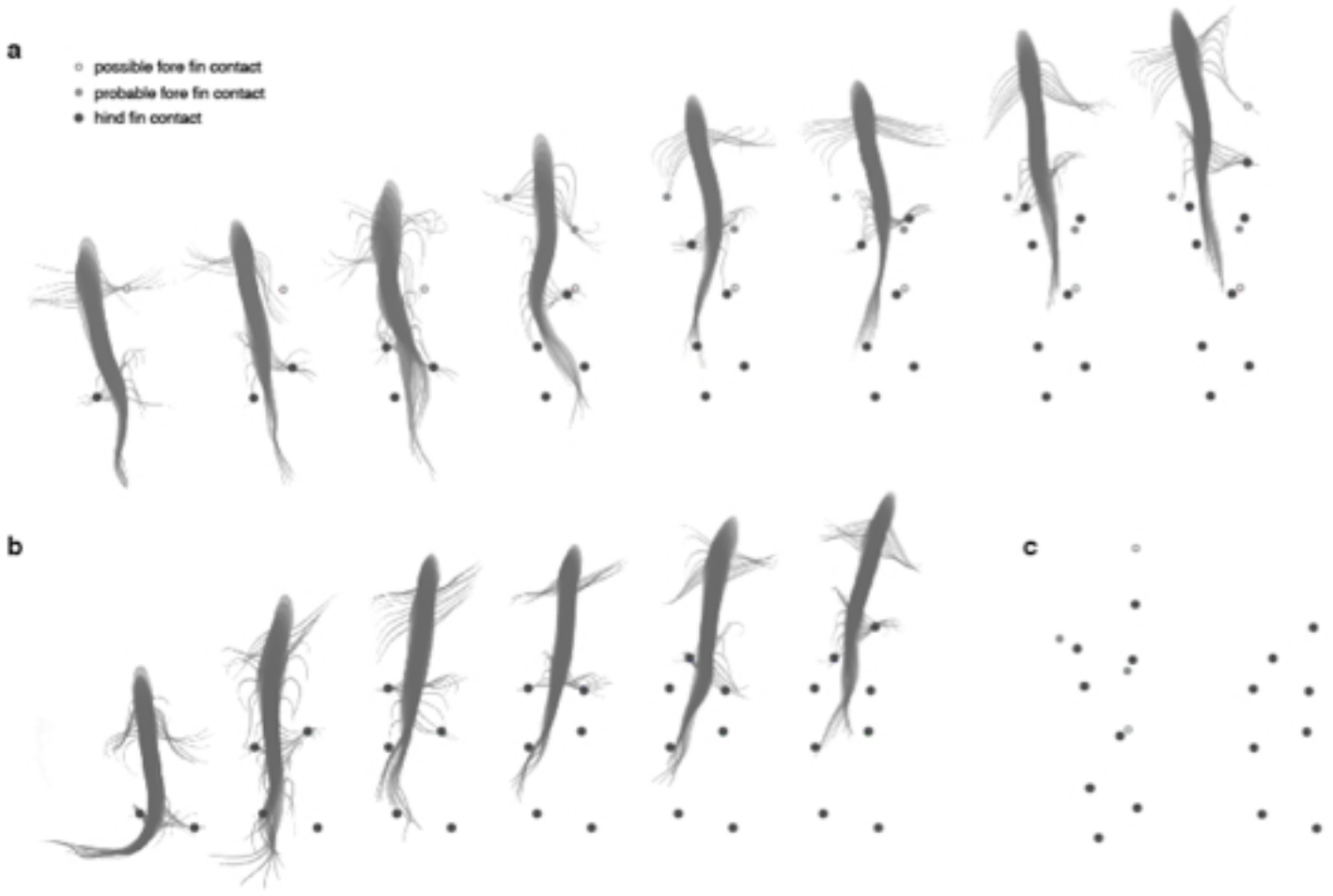
Heather King

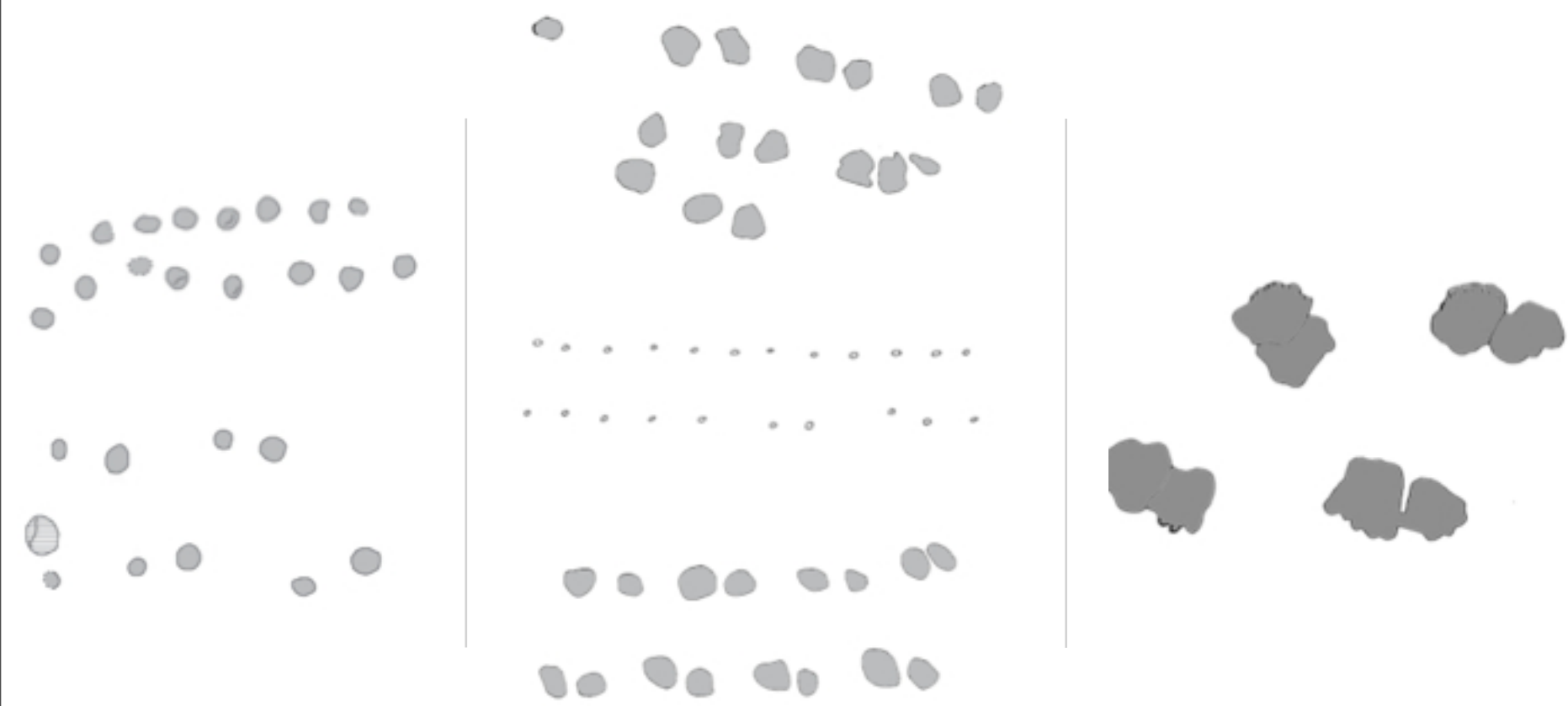


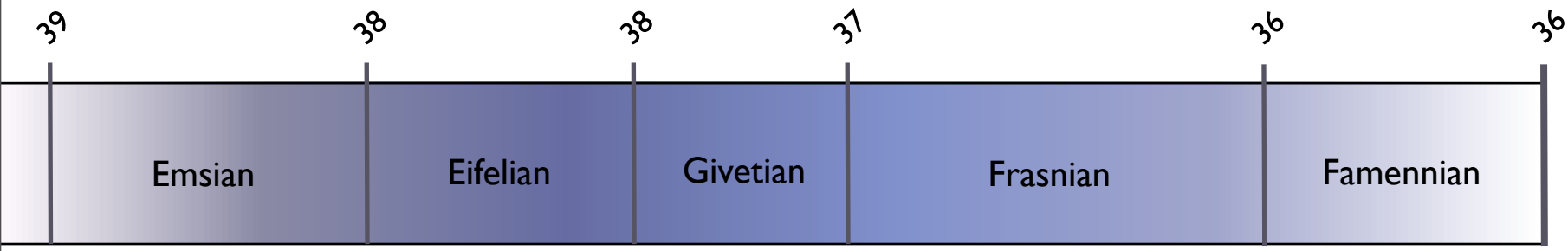




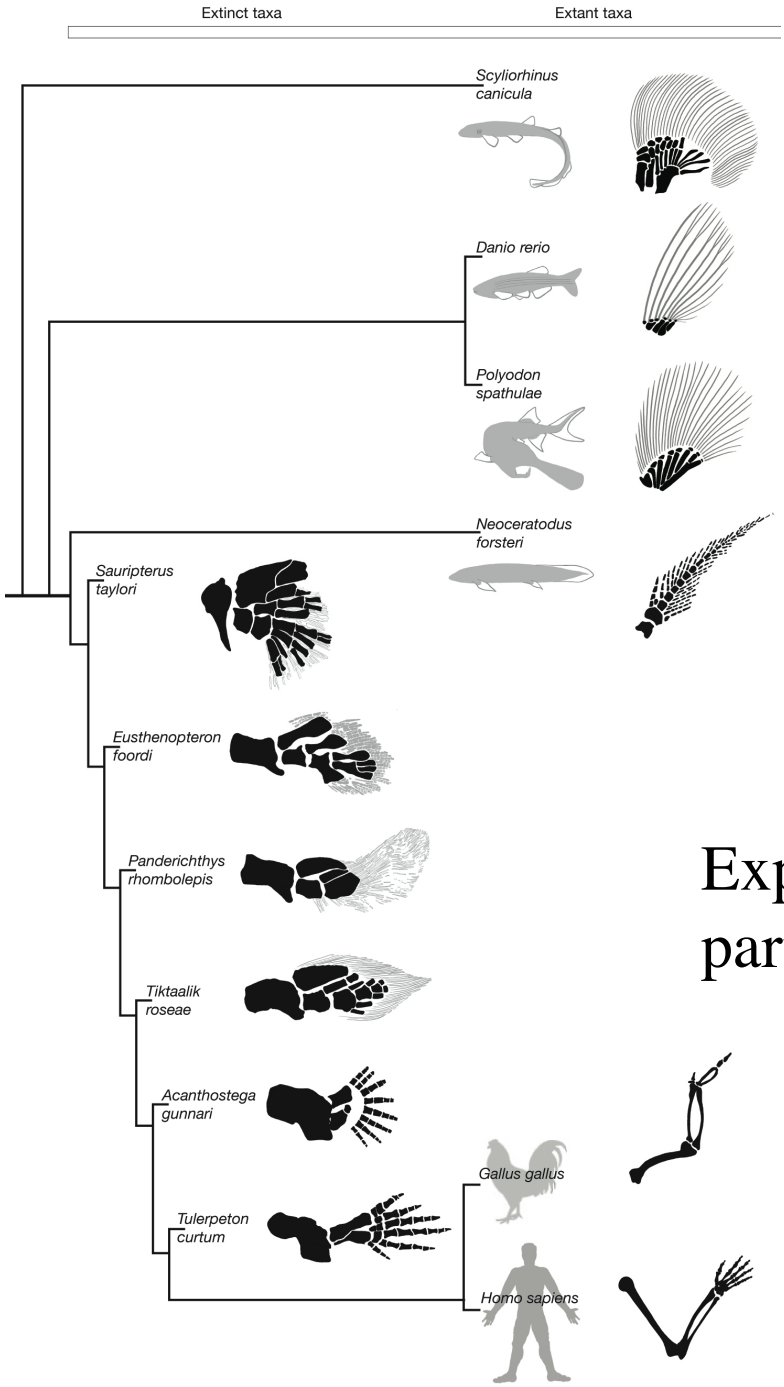

COM
PF


a
possible fore fin contact
probable fore fin contact
hind fin contact
b
c





MID to LATE DEVONIAN

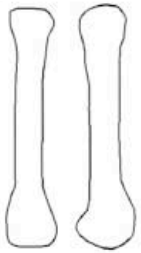


Developmental genetics of non-model organisms

Expeditions targeted to key parts of the tree of life

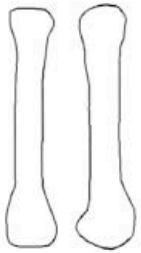
Early Hox Phases

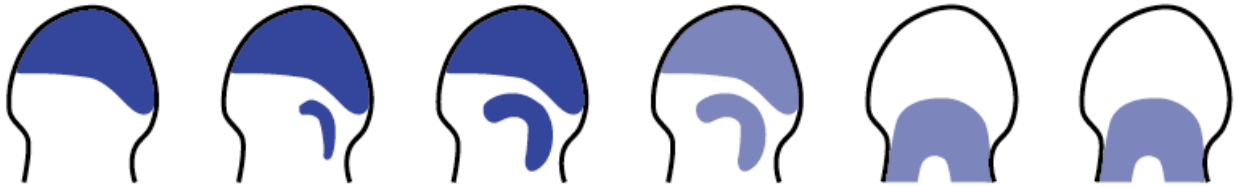
d13	d12	d11	d10	d9	d8



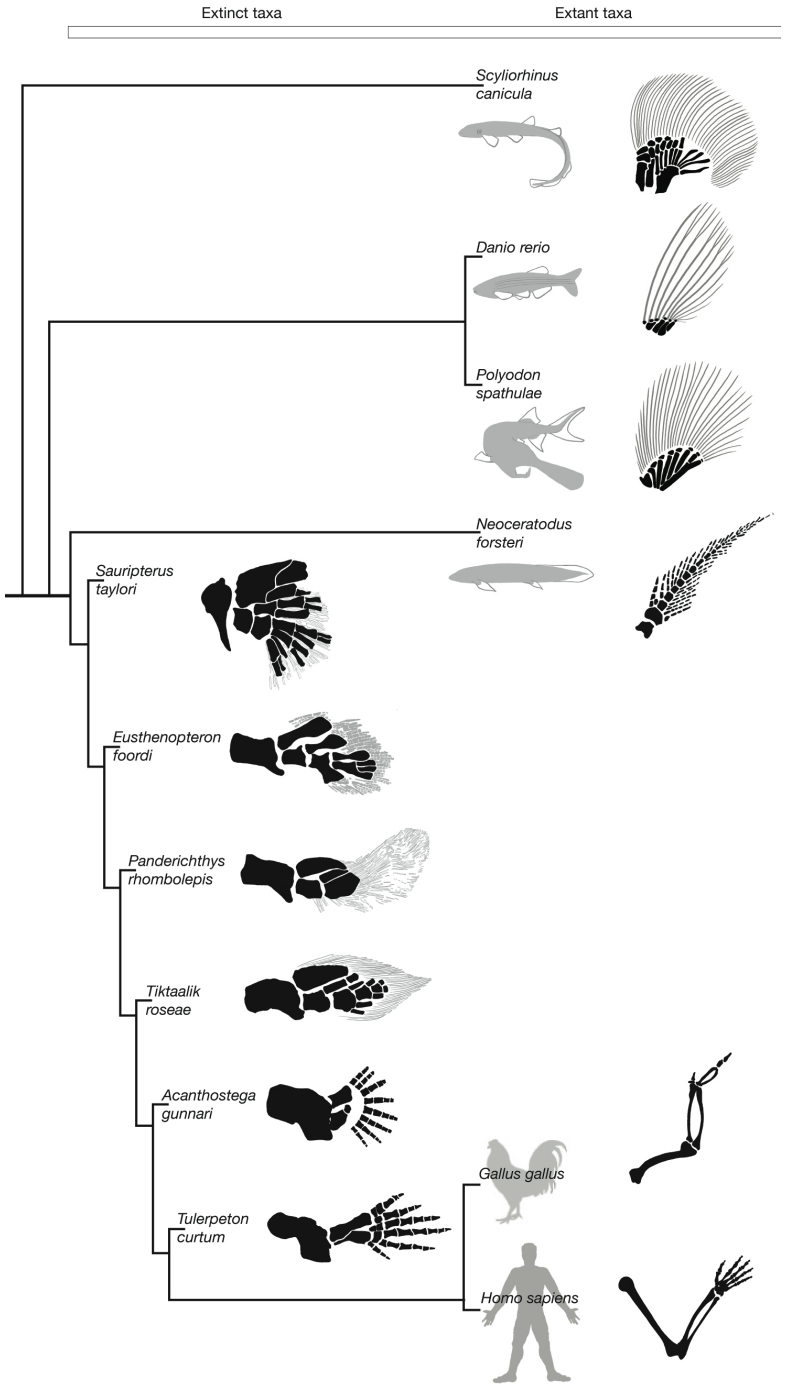
Early Hox Phases

d13 | d12 | d11 | d10 | d9 | d8

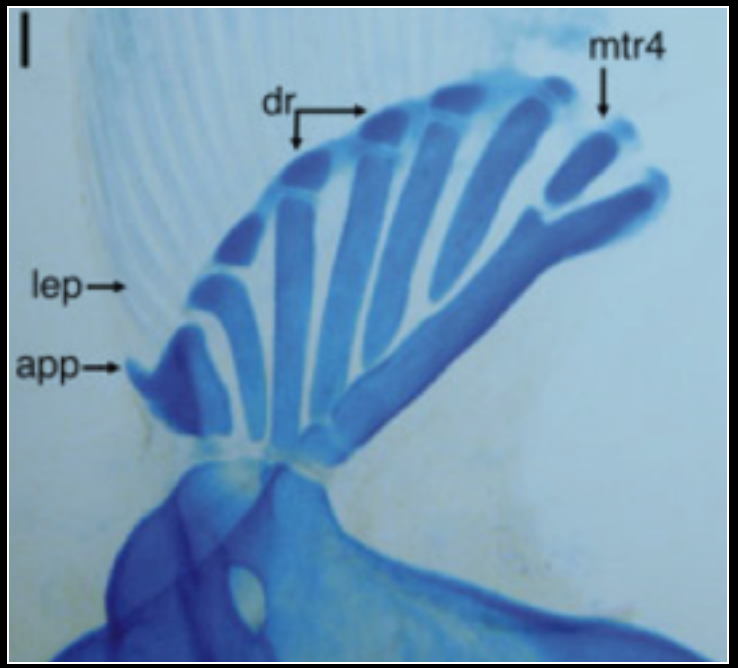




Late Hox Phase



Origin of Late Hox Phases?


mtr4
dr
lep
app

Polyodon pectoral fins - *in situ* hybridization of 5' HoxD genes

Hoxd11

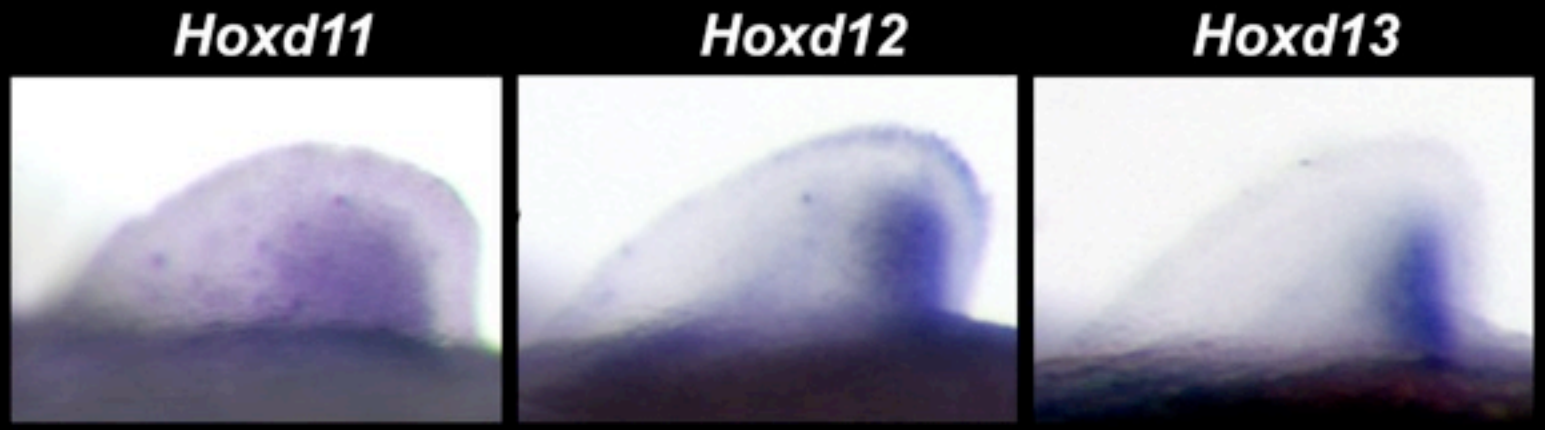
Hoxd12

Hoxd13

Early

Late

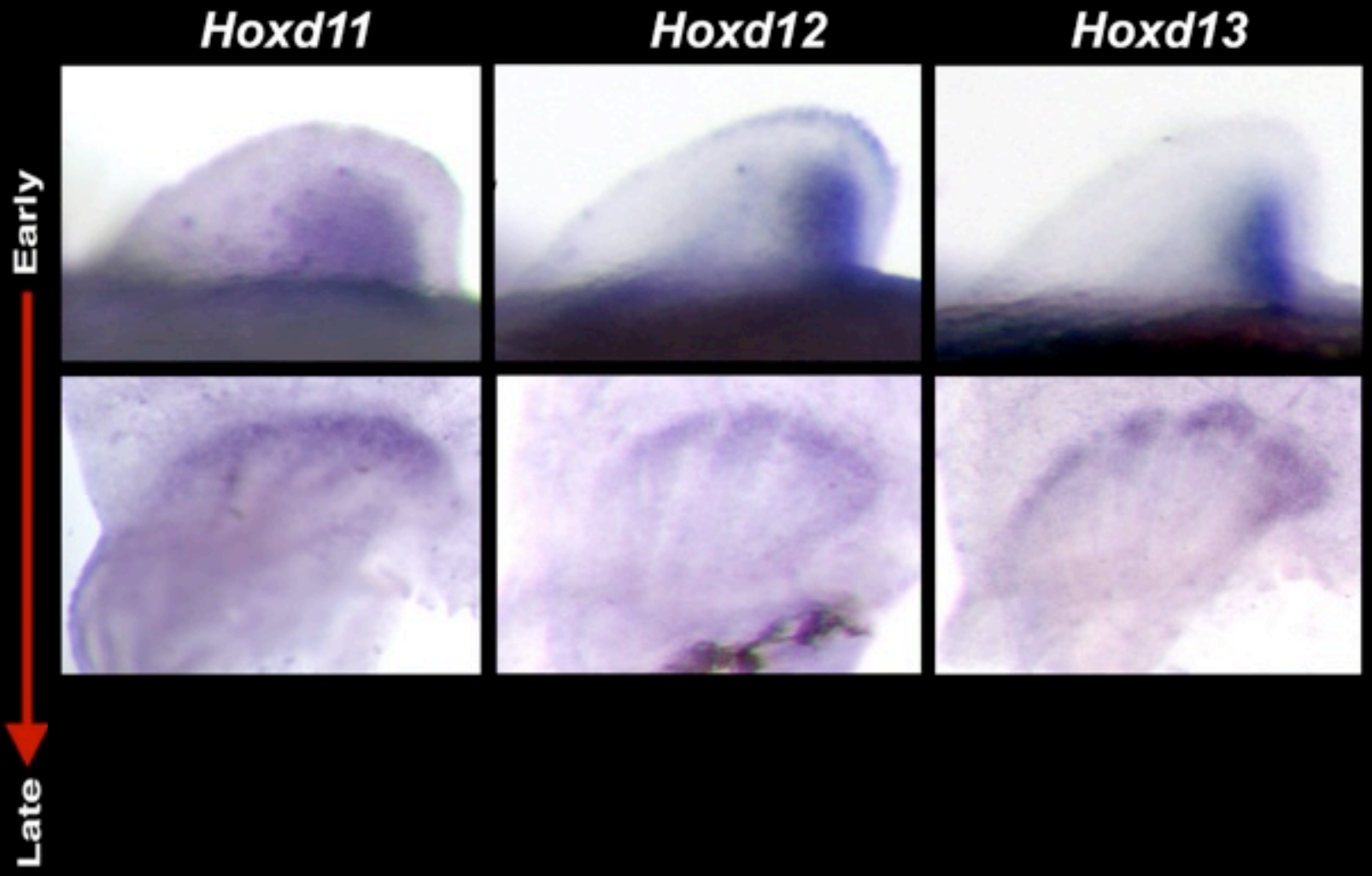
Polyodon pectoral fins - *in situ* hybridization of 5' HoxD genes

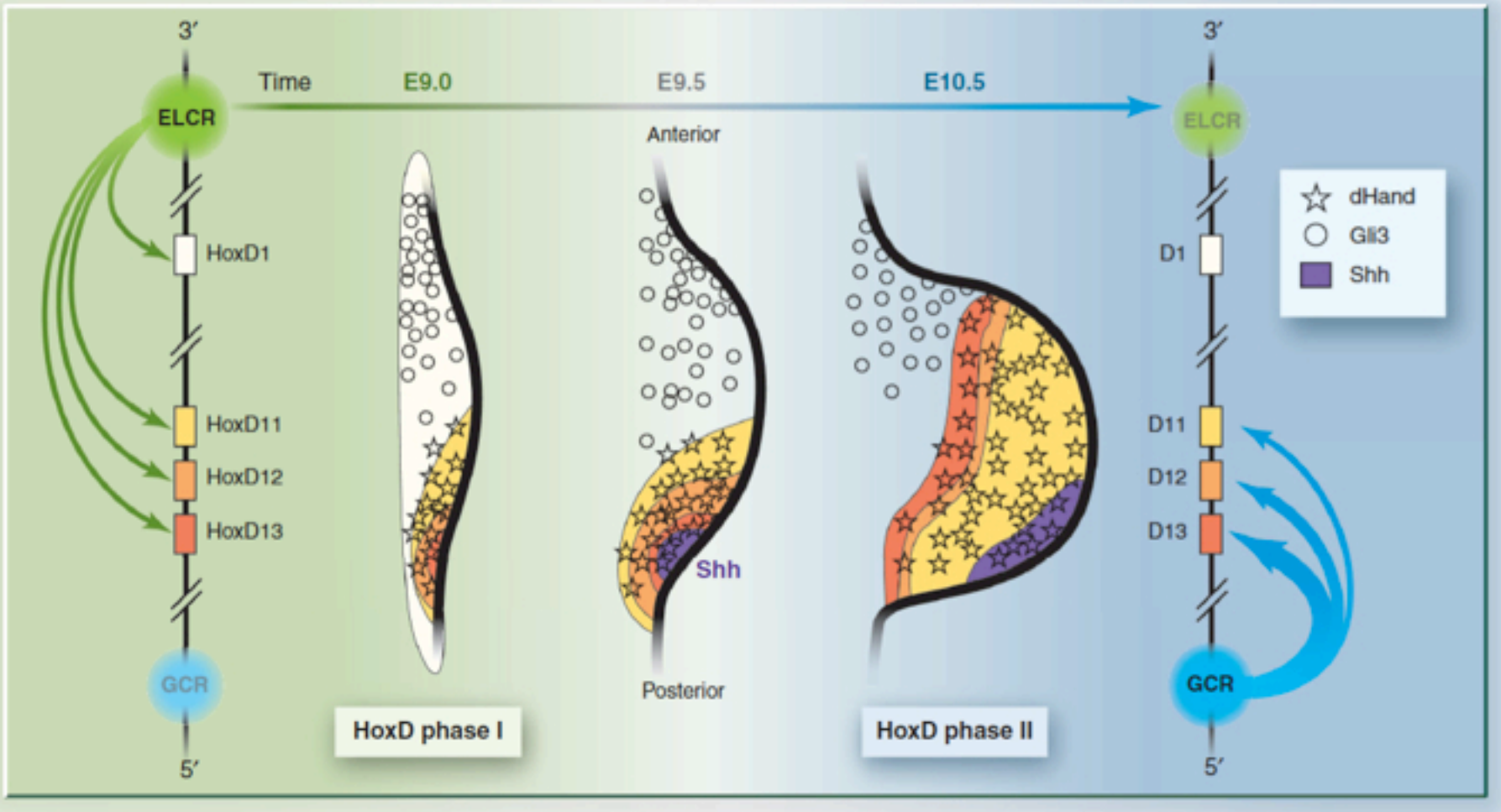


Early

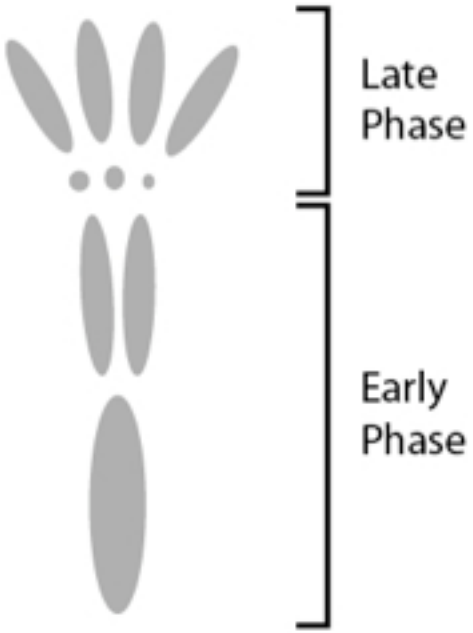
Late

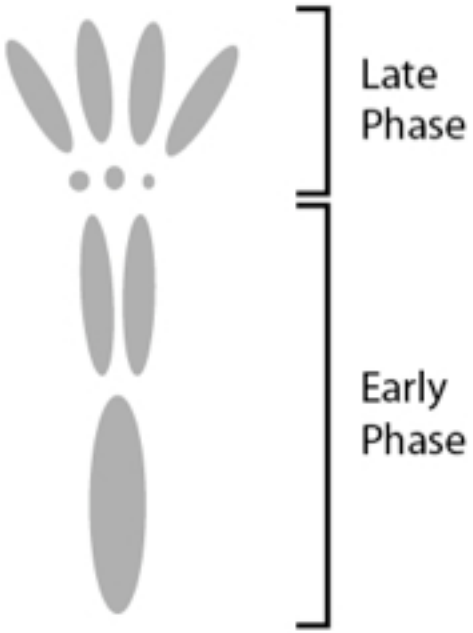
Polyodon pectoral fins - *in situ* hybridization of 5' HoxD genes

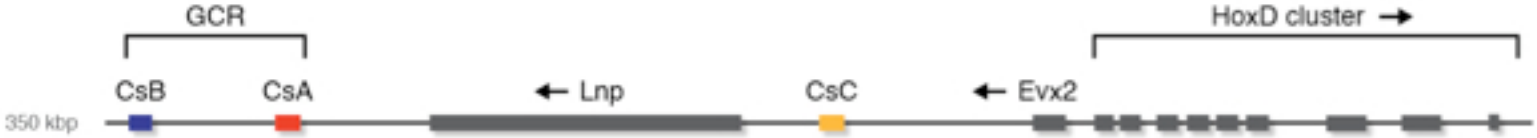


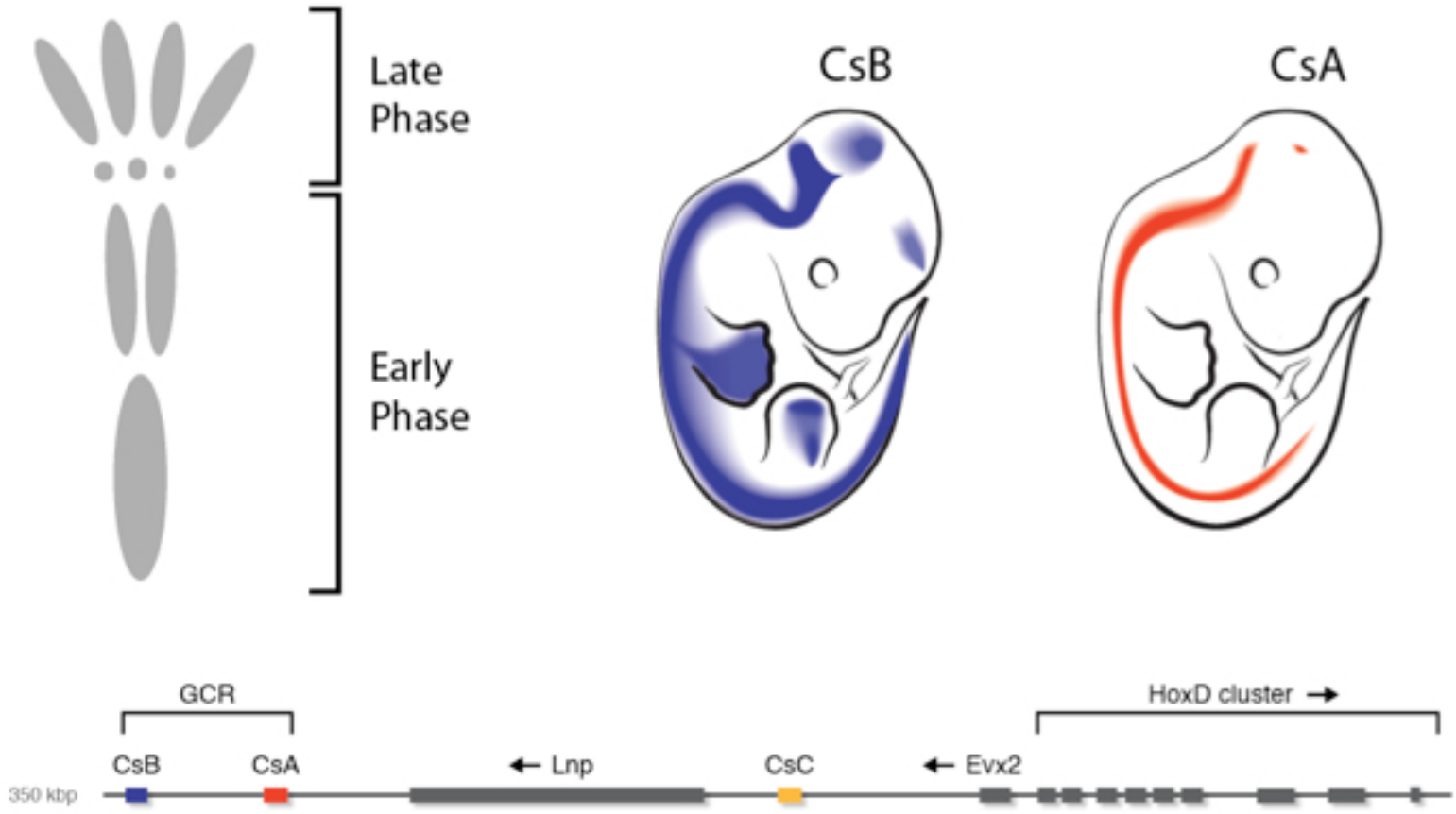


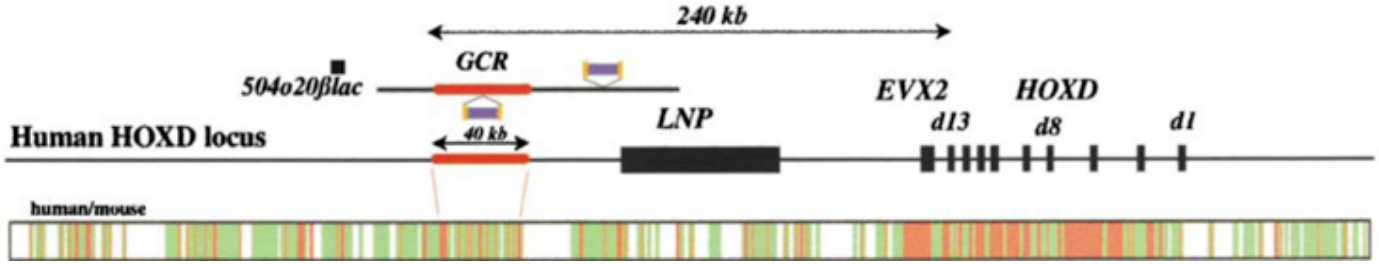
Source: Deschamps, 2004


Late
Phase
Early
Phase

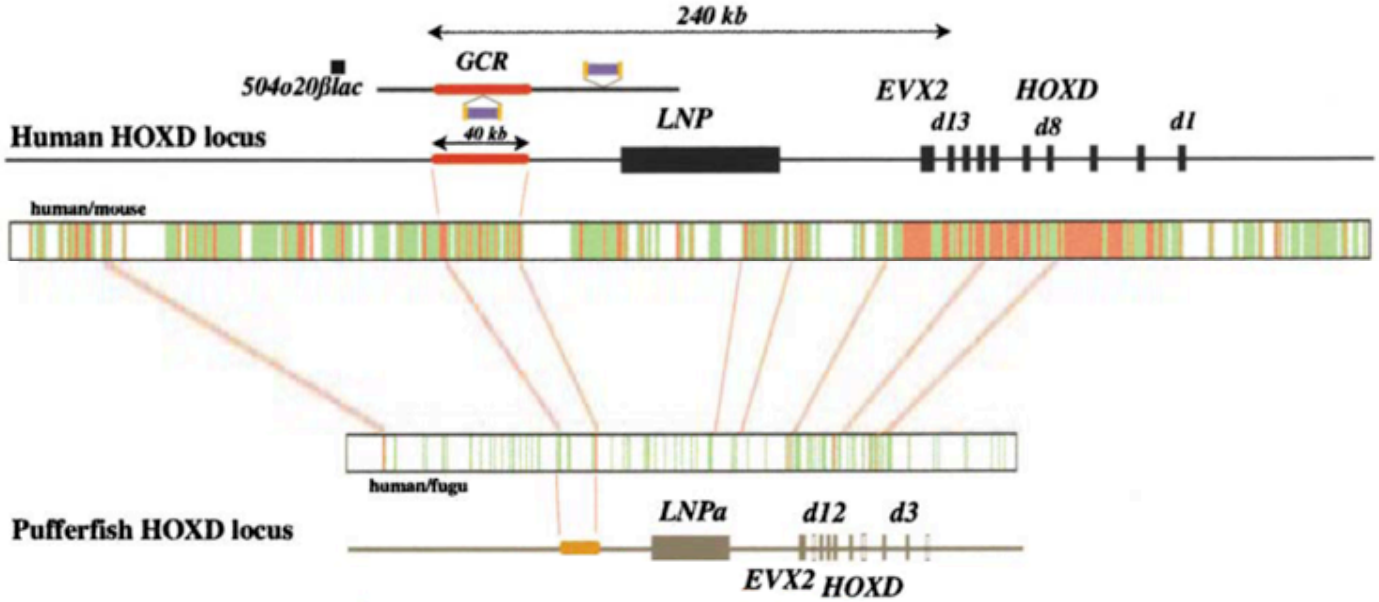

Late
Phase
Early
Phase


GCR
HoxD cluster
CsB
CsA
Lnp
CsC
Evx2
350 kbp

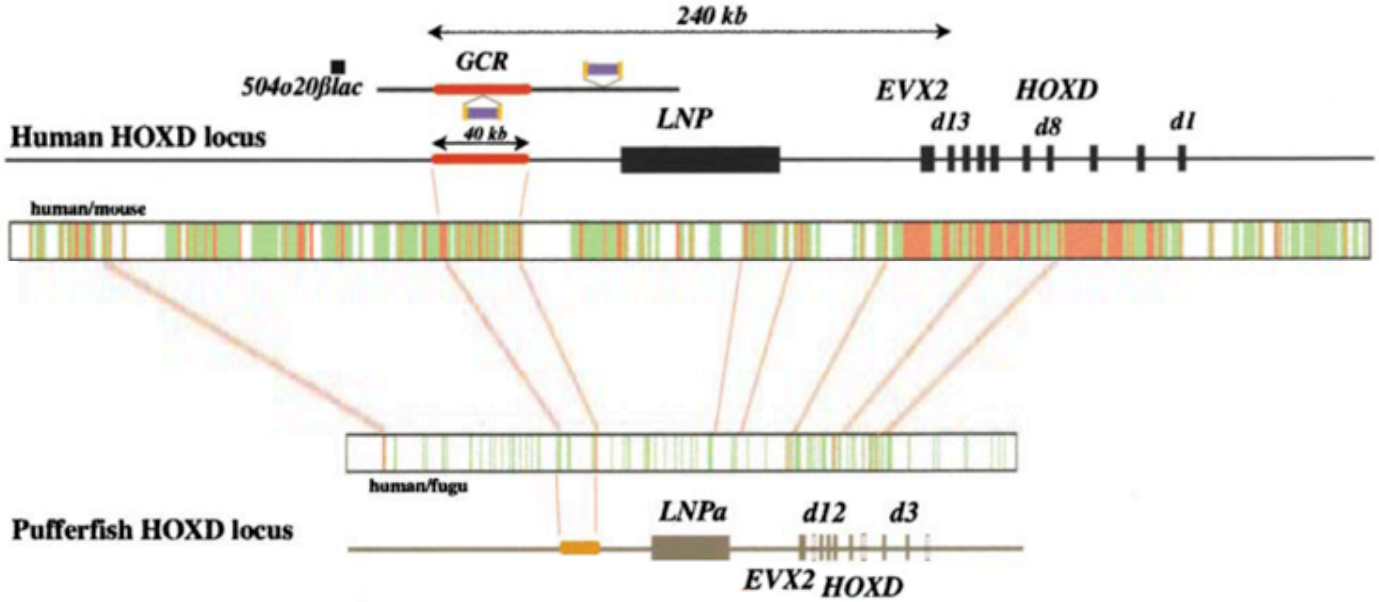

Late
Phase
Early
Phase
CsB
CsA
GCR
HoxD cluster
CsB
CsA
Lnp
CsC
Evx2
350 kbp



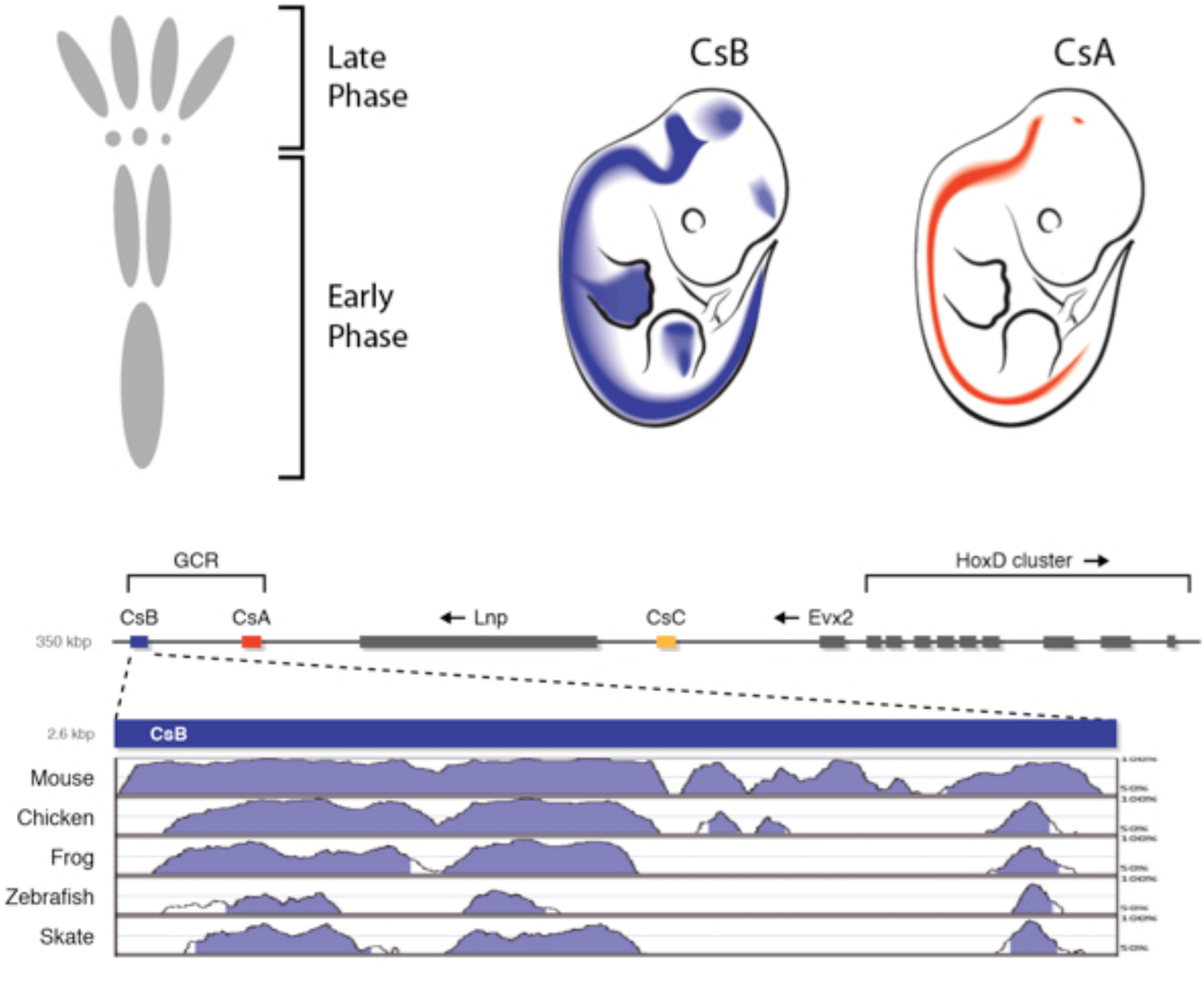
Modified from: Spitz & Duboule, 2003

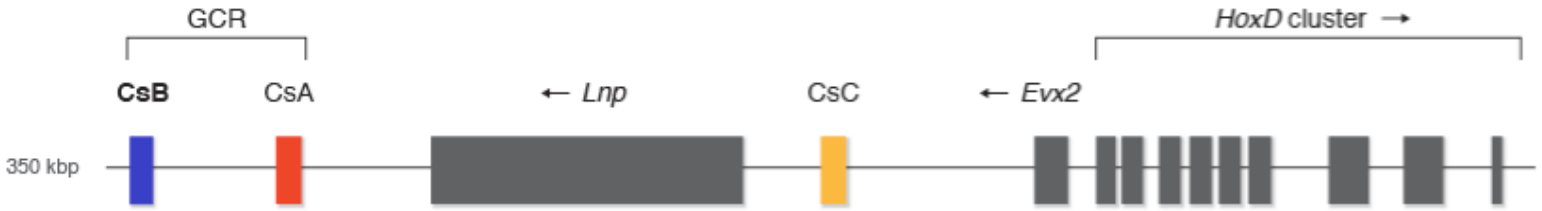


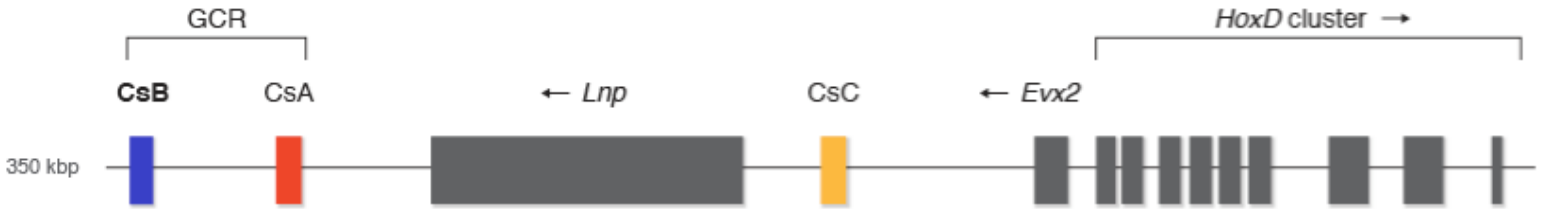
Modified from: Spitz & Duboule, 2003

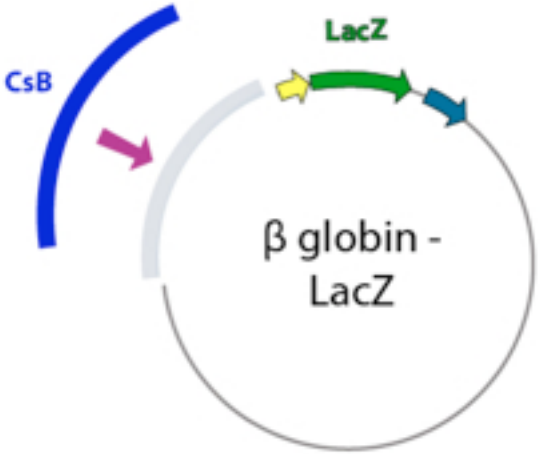


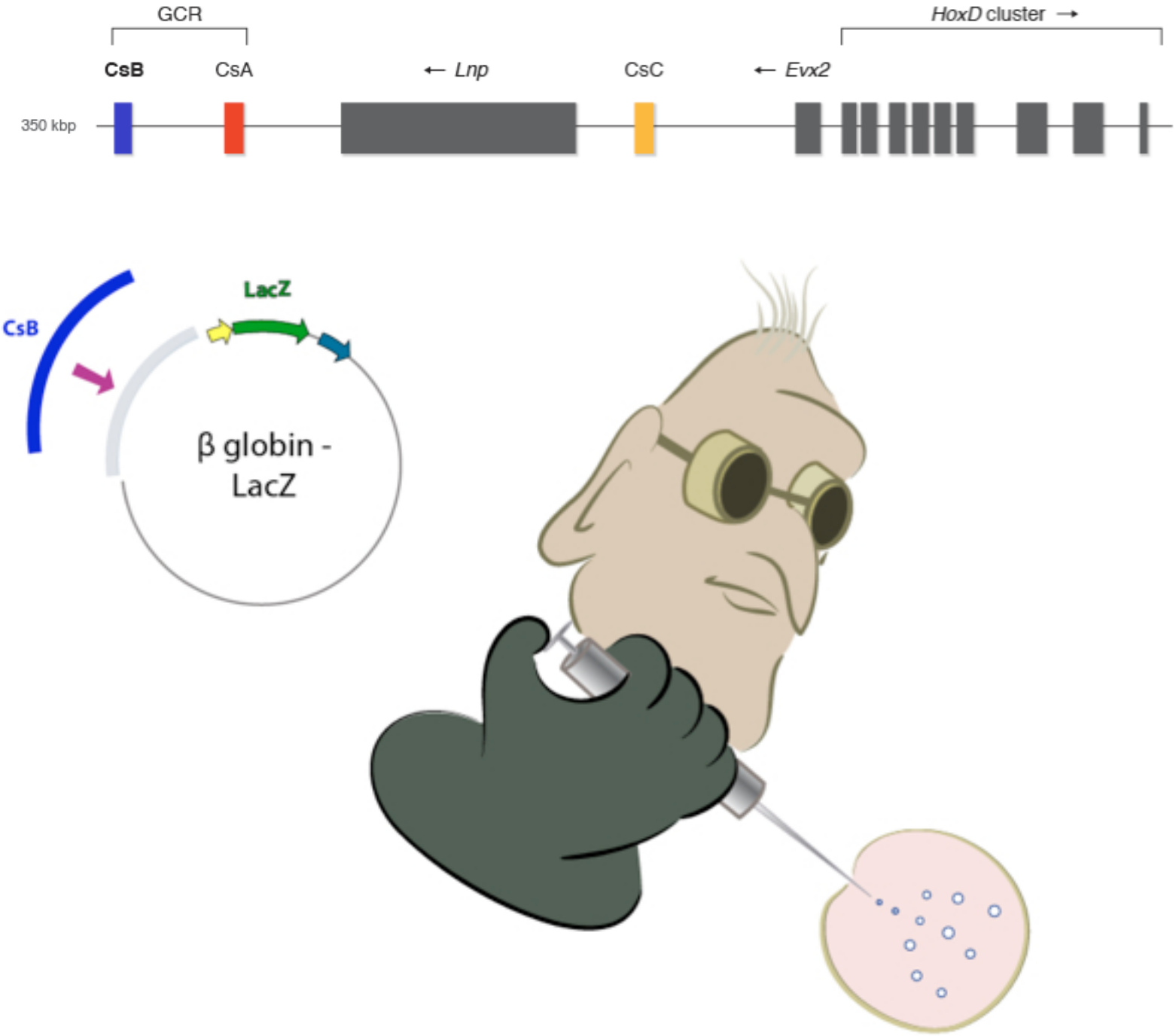
Modified from: Spitz & Duboule, 2003

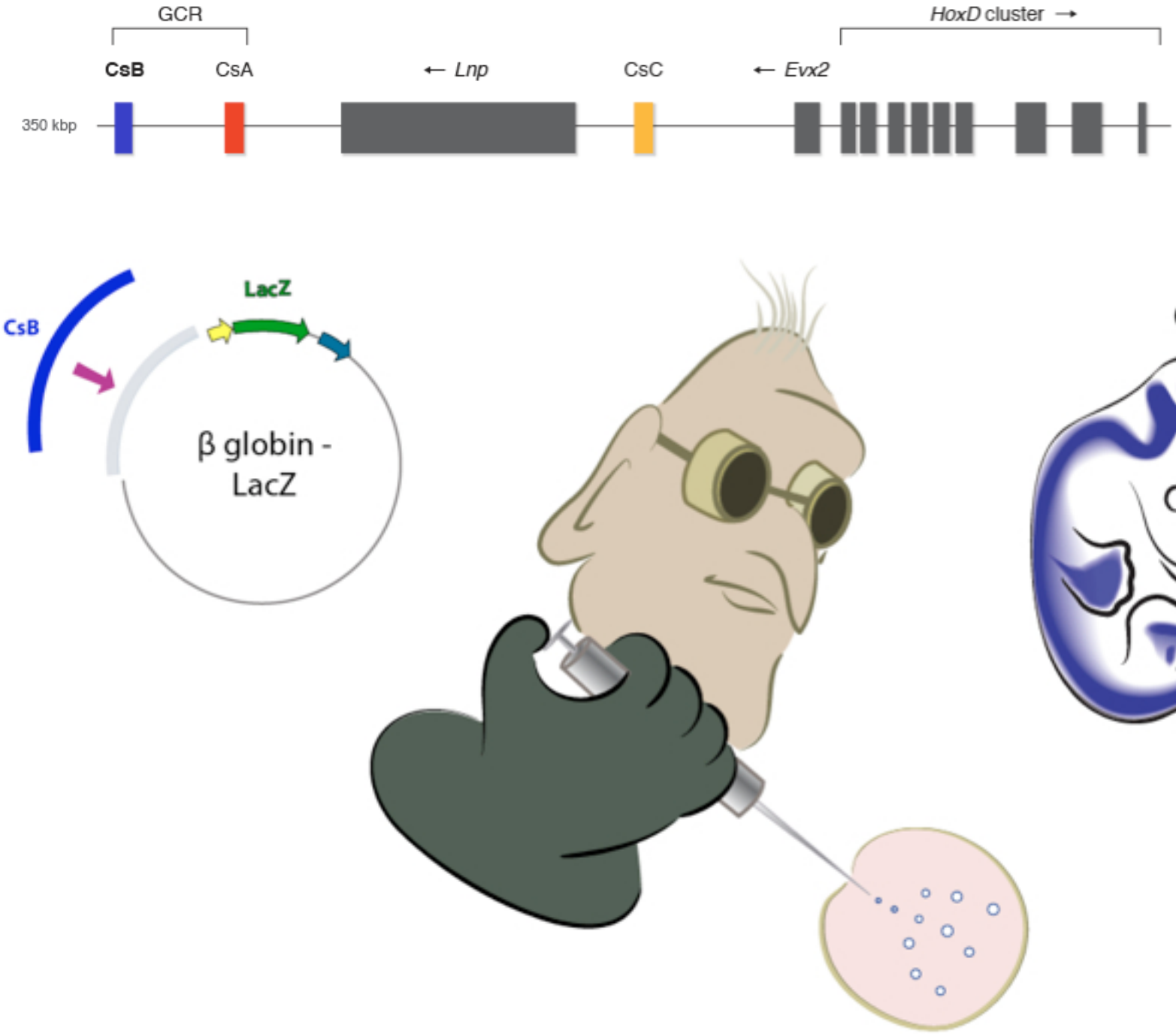

Late
Phase
Early
Phase
CsB
CsA
GCR
HoxD cluster
CsB
CsA
Lnp
CsC
Evx2
350 kbp
2.6 kbp
CsB
Mouse
Chicken
Frog
Zebrafish
Skate


GCR
HoxD cluster →
CsB
CsA
← Lnp
CsC
← Evx2
350 kbp

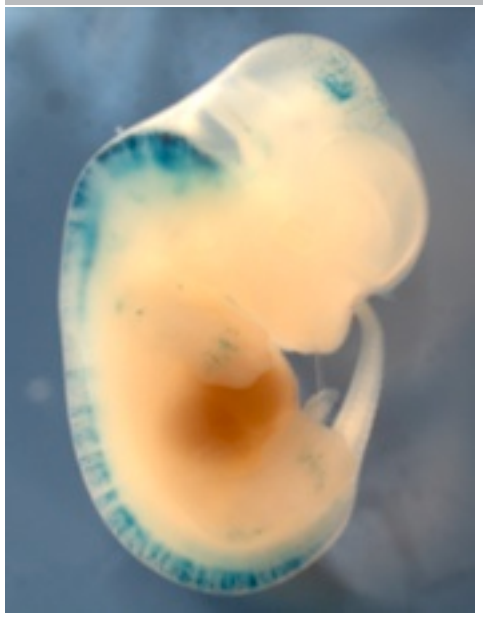

GCR
HoxD cluster →
CsB
CsA
← Lnp
CsC
← Evx2
350 kbp


LacZ
CsB
β globin -
LacZ

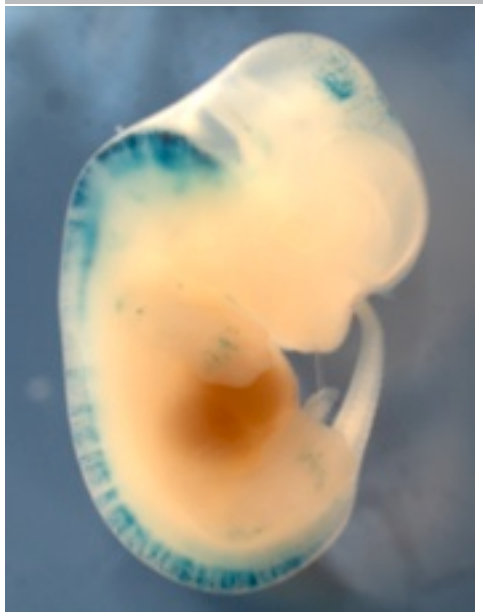

GCR
HoxD cluster →
CsB
CsA
← Lnp
CsC
← Evx2
350 kbp
CsB
LacZ
β globin -
LacZ


GCR
HoxD cluster →
CsB
CsA
← Lnp
CsC
← Evx2
350 kbp
CsB
LacZ
β globin -
LacZ
CsB

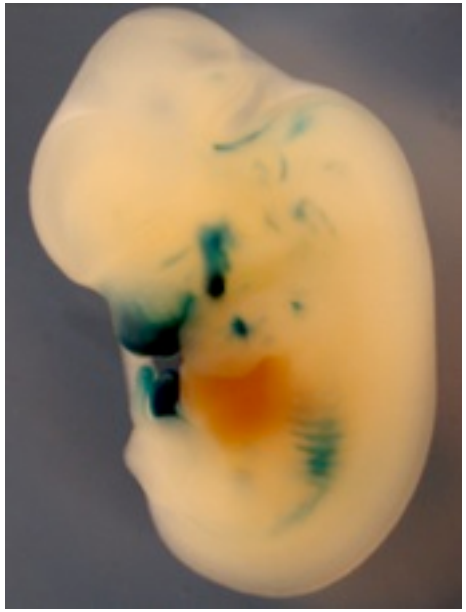
Chicken CsB

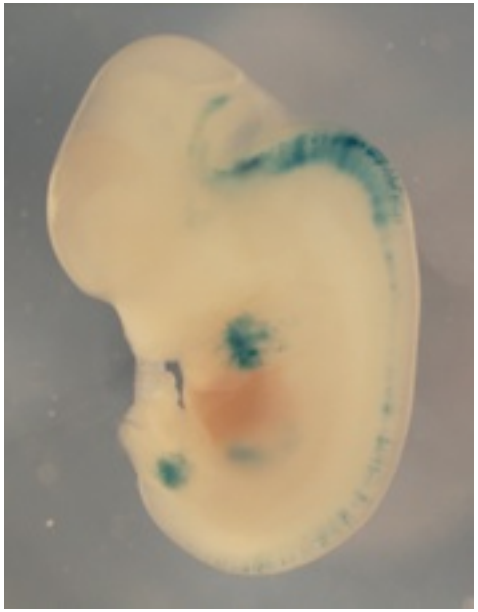


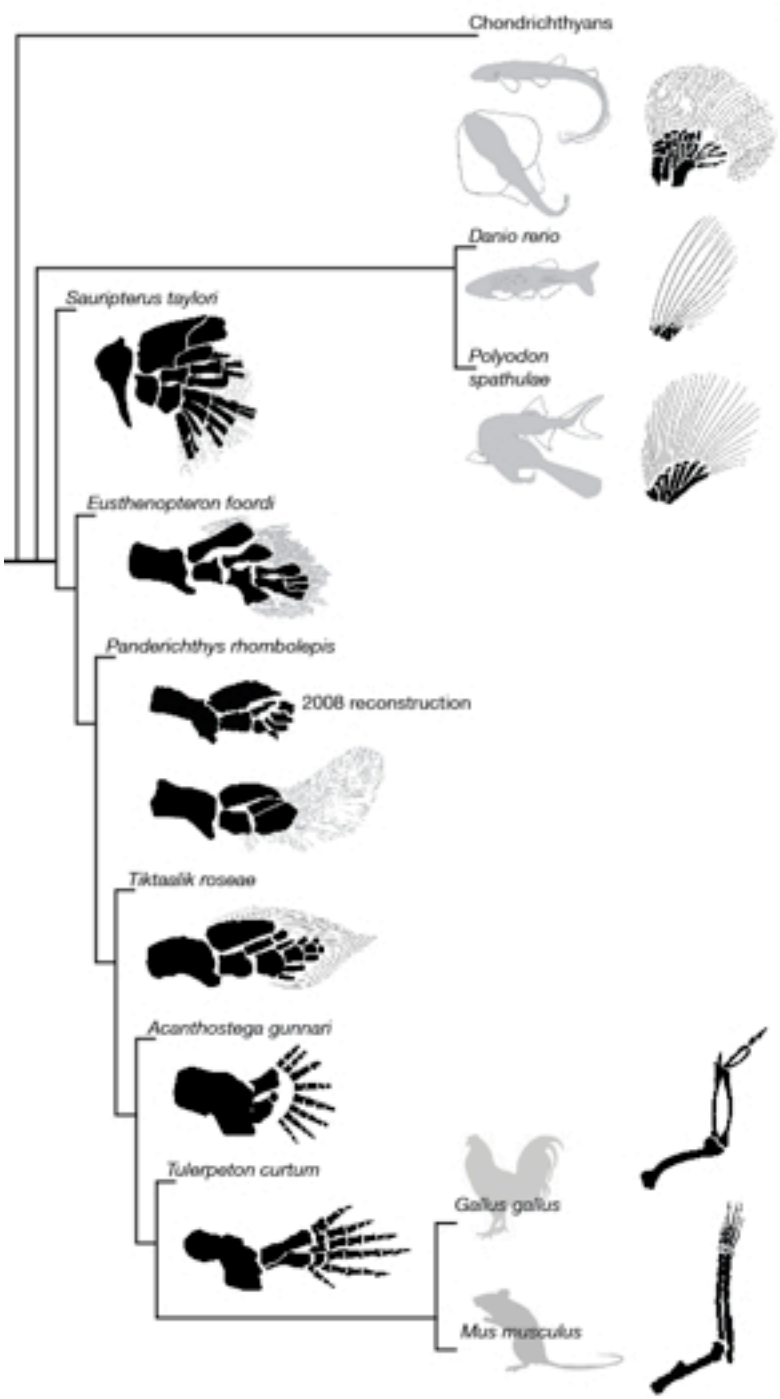
Chicken CsB

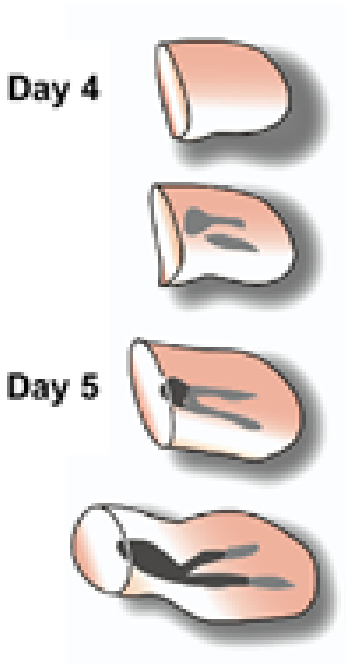


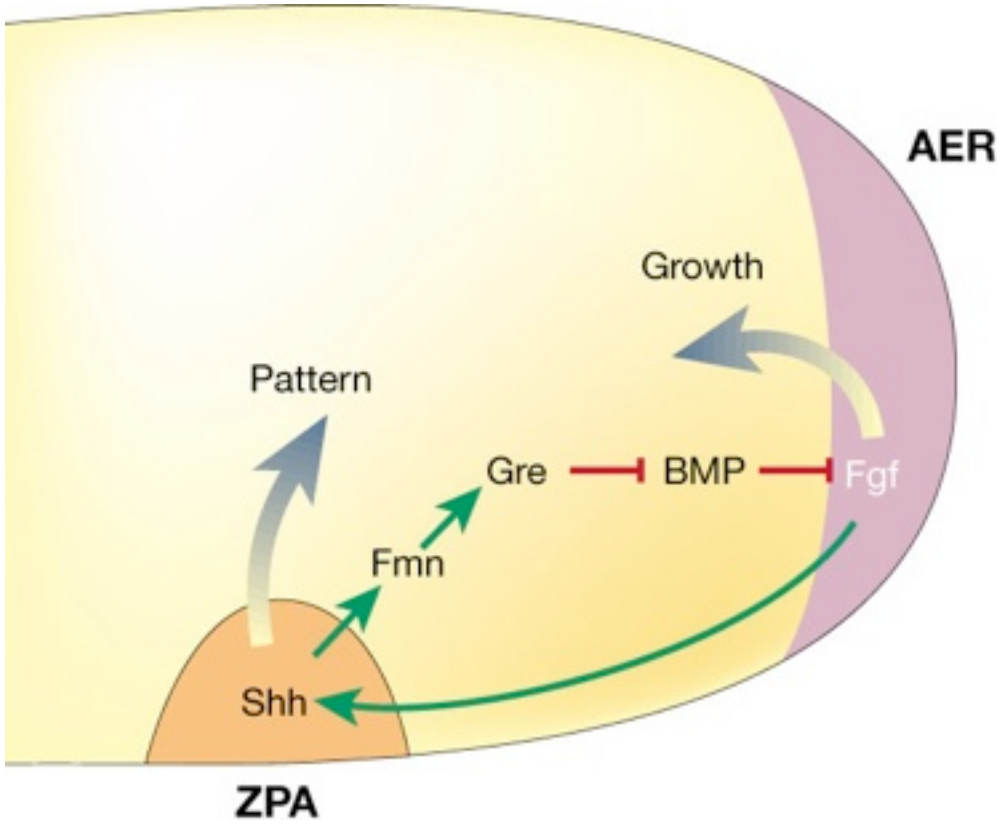
Skate CsB



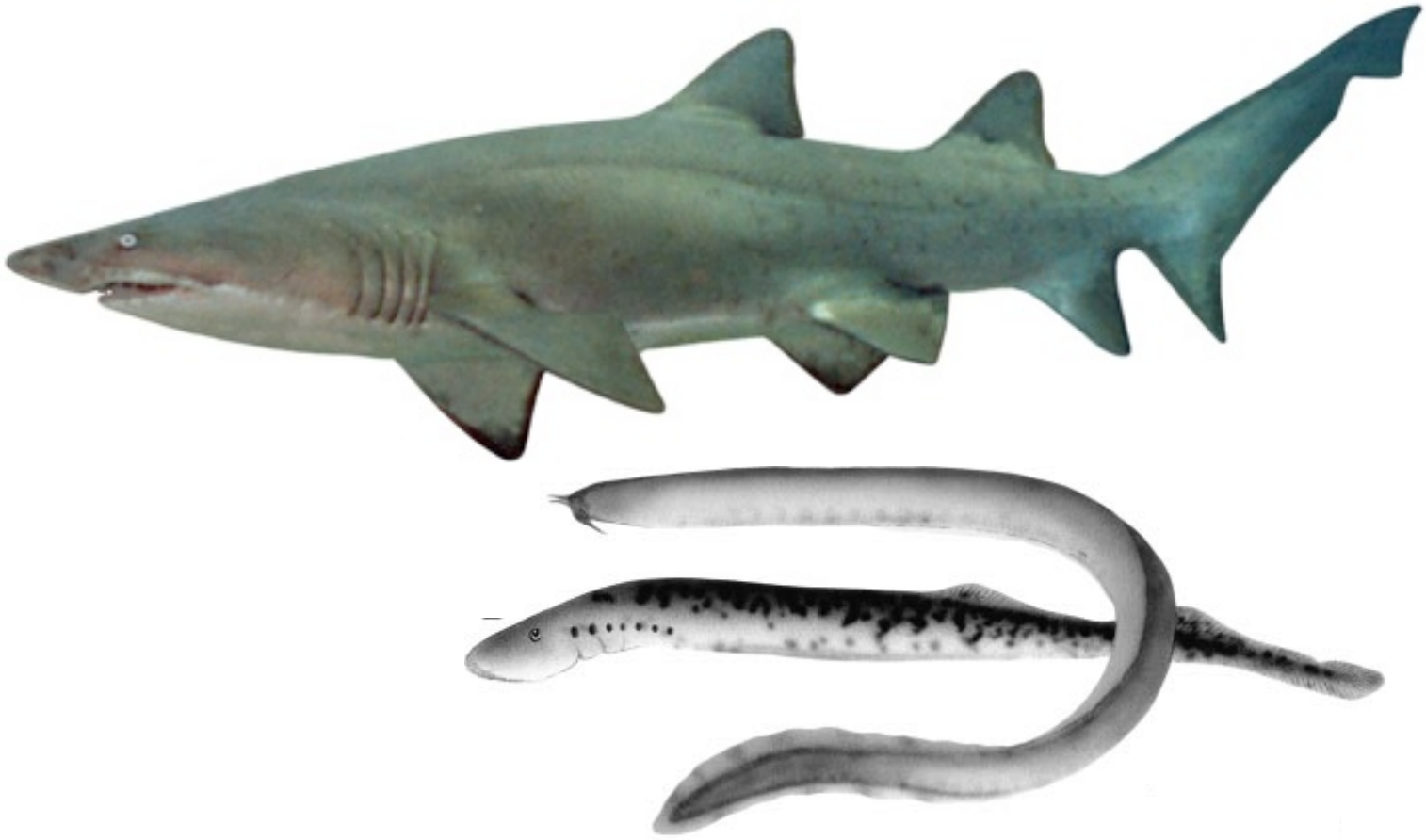



Chondrichthyans
Danio rerio
Sauripterus taylori
Polyodon spathulae
Eusthenopteron foordi
Panderichthys rhombolepis
2008 reconstruction
Tiktaalik roseae
Acanthostega gunnari
Tulerpeton curtum
Gallus gallus
Mus musculus

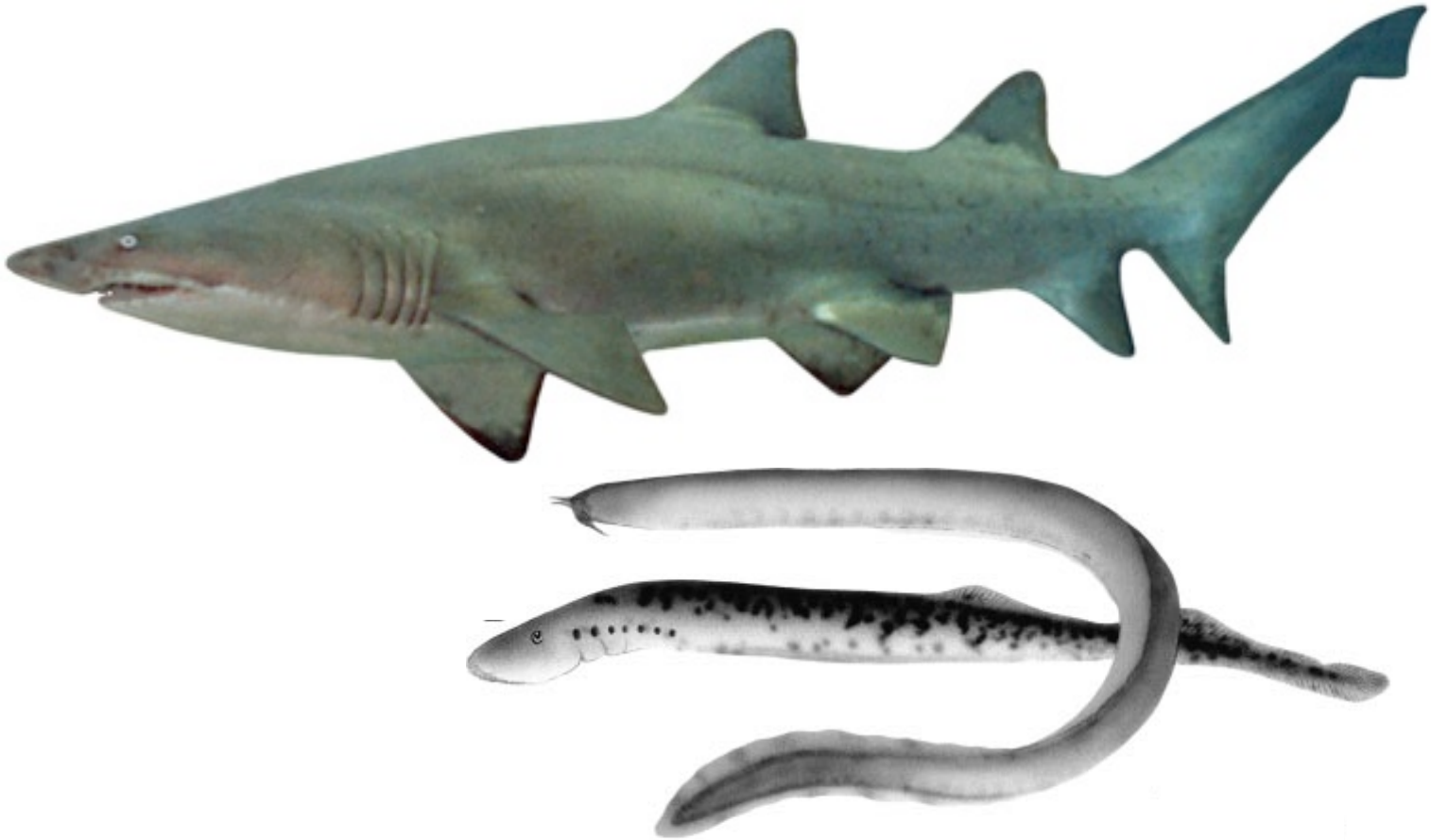

Day 4
Day 5


AER
Growth
Pattern
Gre
BMP
Fgf
Fmn
Shh
ZPA

How did vertebrate appendages arise?

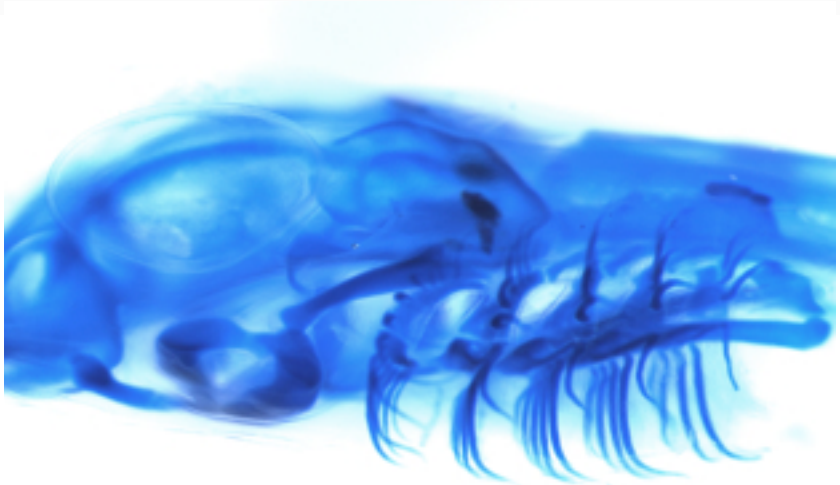


How did vertebrate appendages arise?
How do fins differ from other outgrowths?



mares

Shark gill skeleton

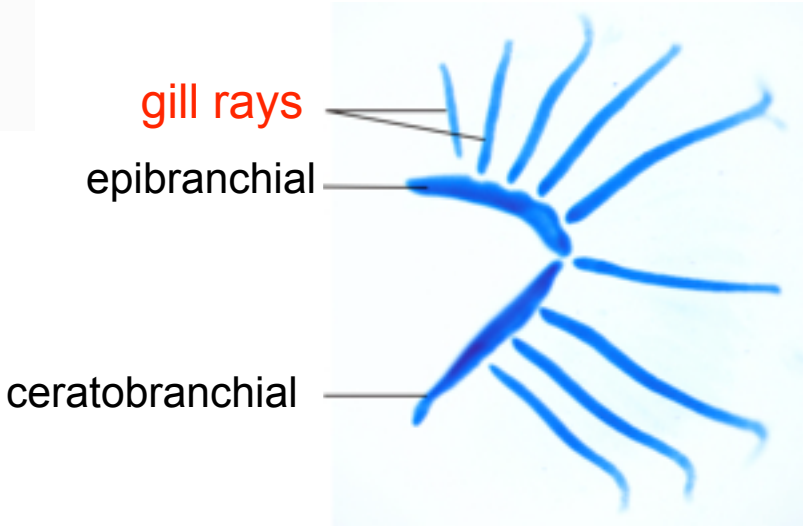


Little skate (*Leucoraja erinacea*)

Shark gill skeleton

Little skate (*Leucoraja erinacea*)

Shark gill skeleton

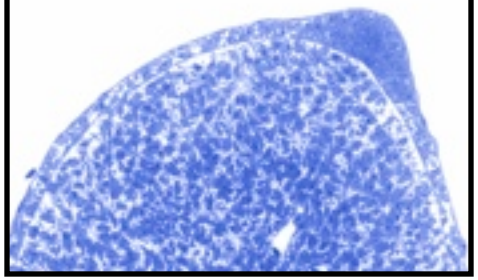


Little skate (*Leucoraja erinacea*)

“AER”

chick limb

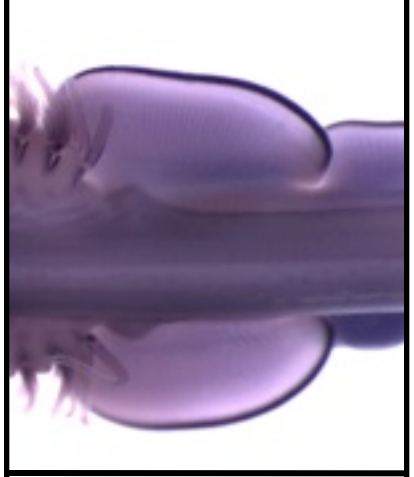
AER



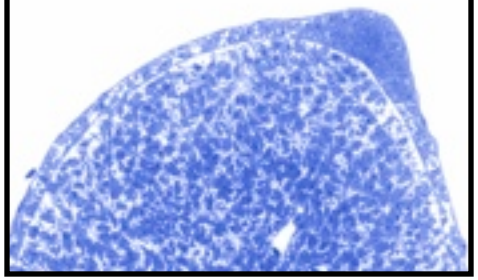
“AER”

chick limb

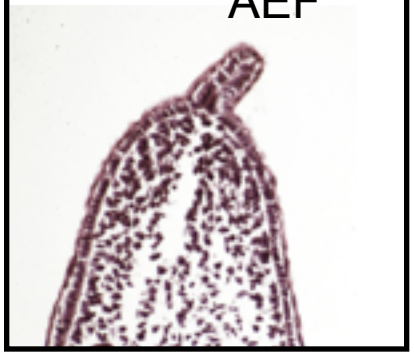
skate fin



AER



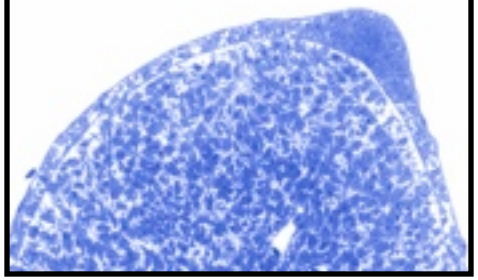
AEF



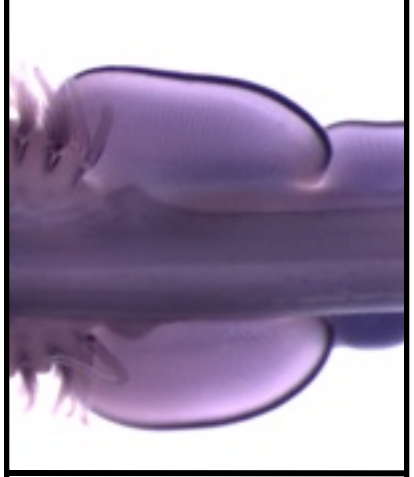
“AER”

chick limb

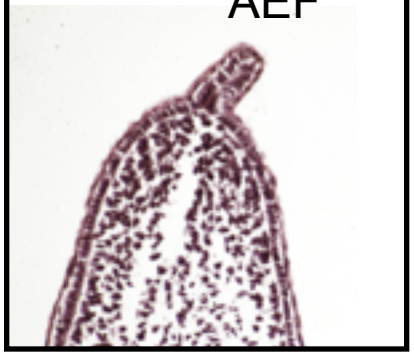
AER



skate fin

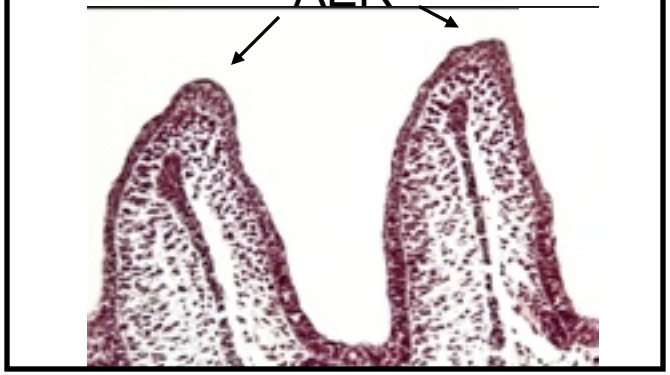


AEF

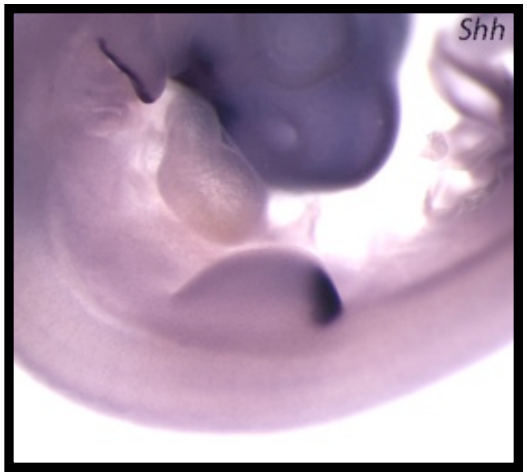


skate arch

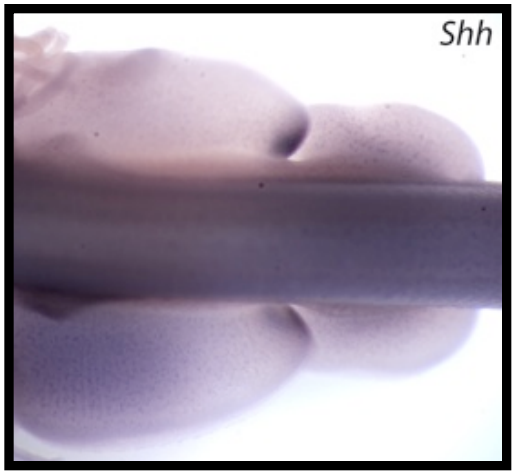
‘AER’



“ZPA”

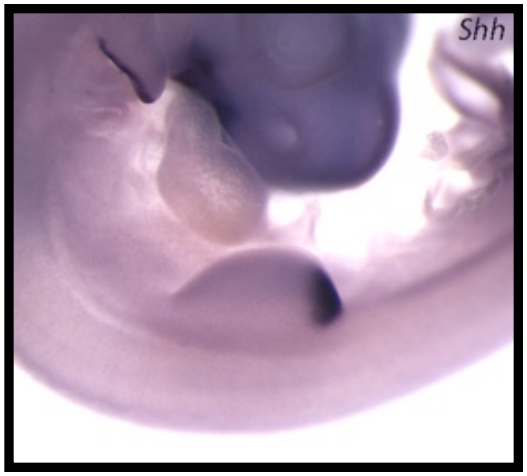


chick limb

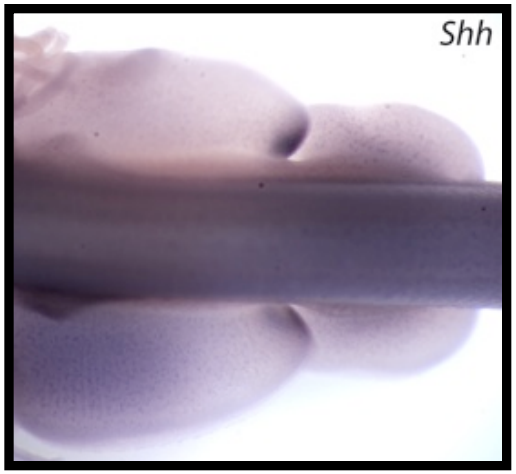


skate fin

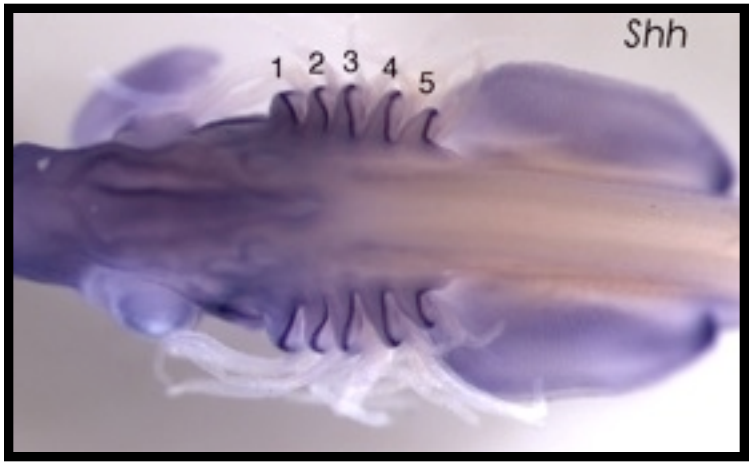
“ZPA”



chick limb

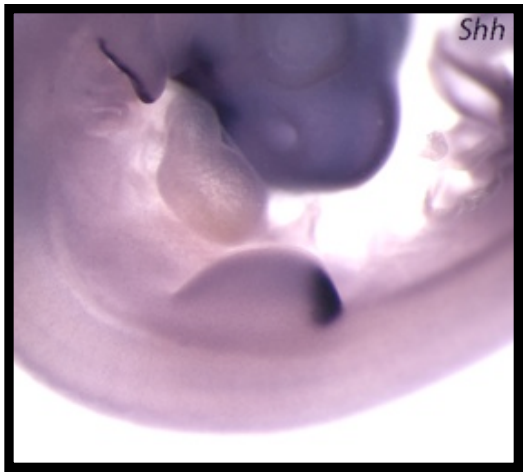


skate fin

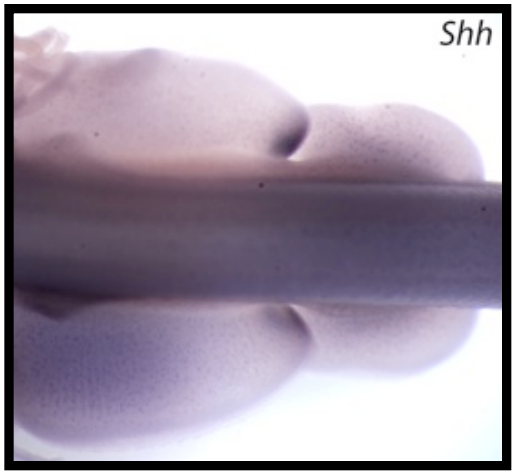


skate arches

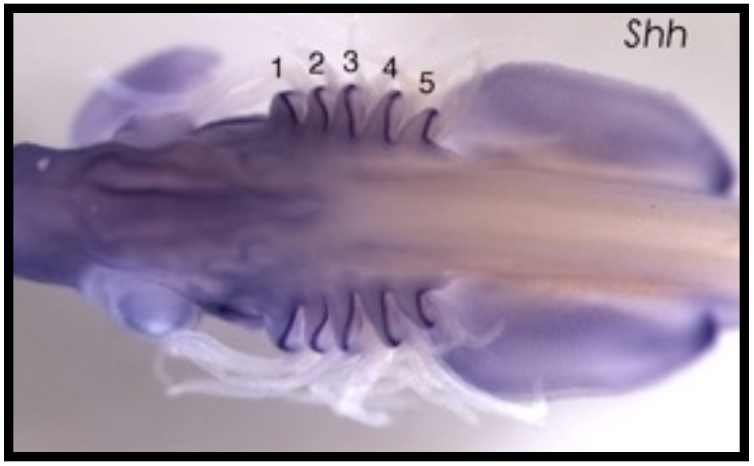
“ZPA”



chick limb



skate fin

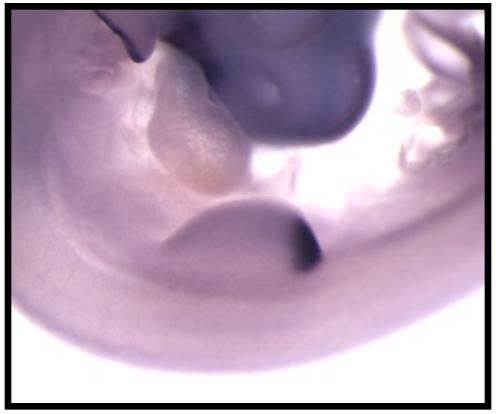


skate arches

Wildtype

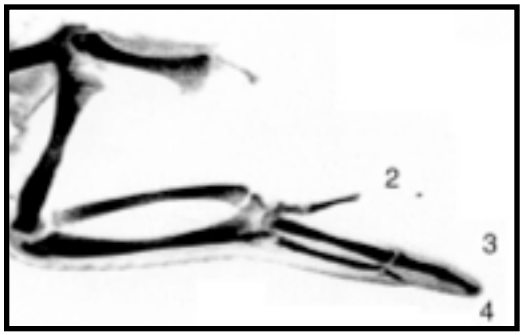
RA treatment

chick limb

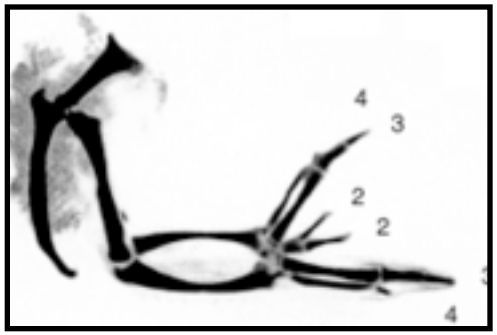


Chick limb

Wildtype



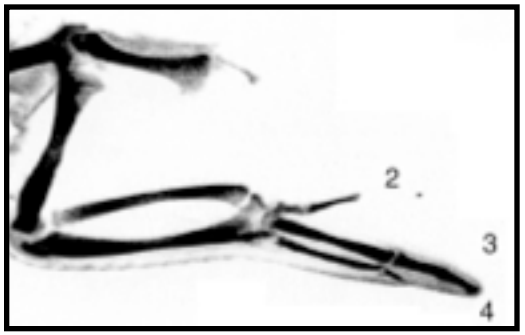
RA treatment

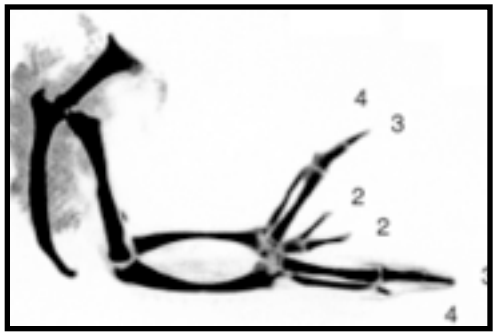


Wildtype

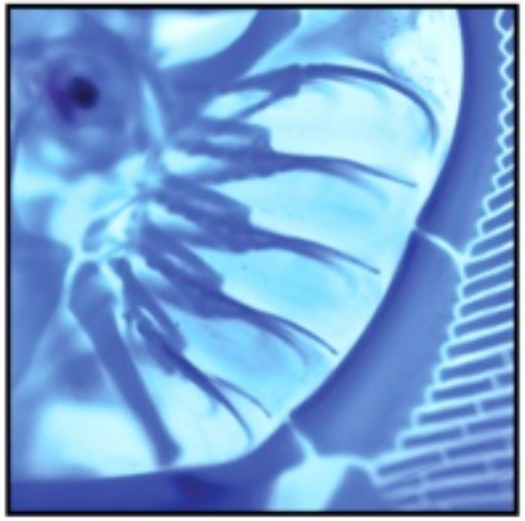
RA treatment

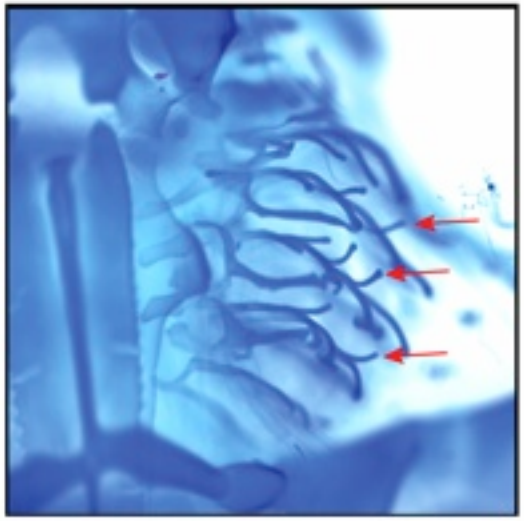
Chick limb





Skate arch



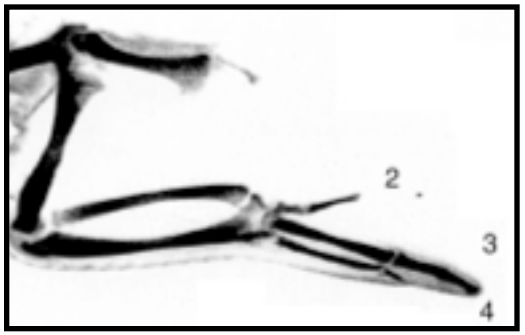


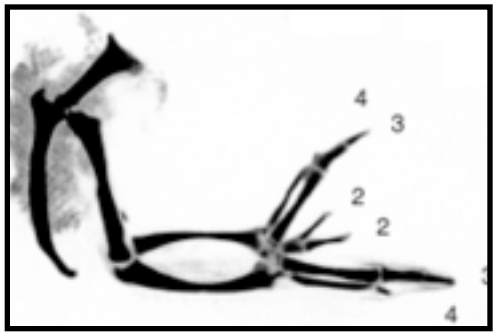
Mirror-image, supernumerary rays

Wildtype

RA treatment

Chick limb

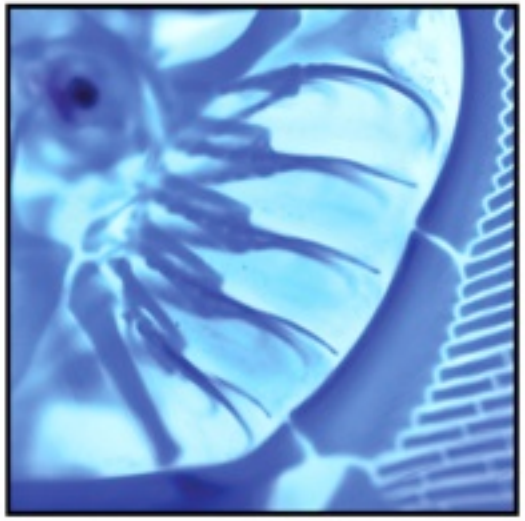


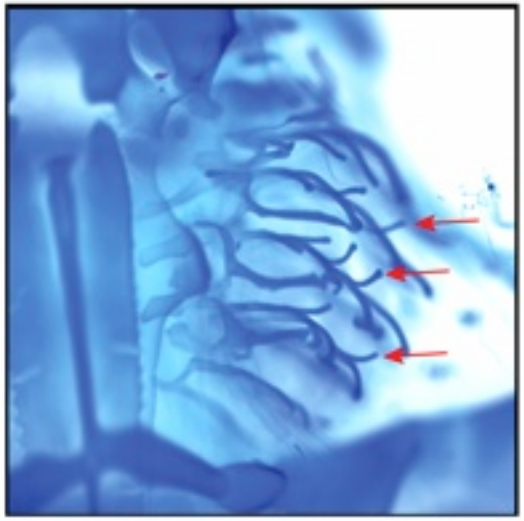


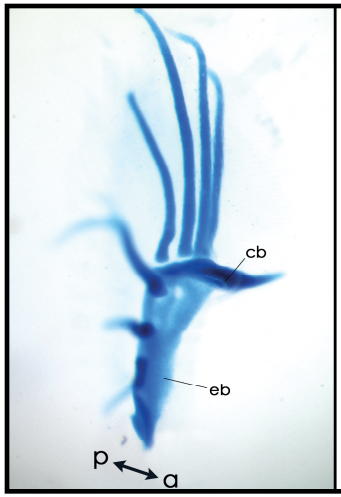
Wildtype

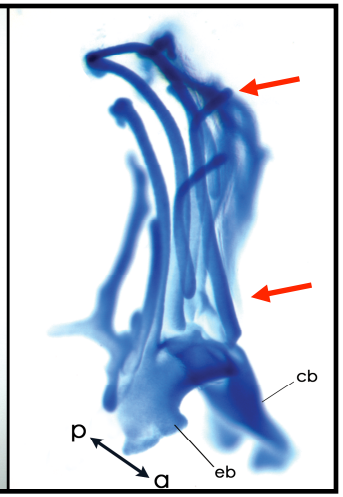
RA

Skate arch

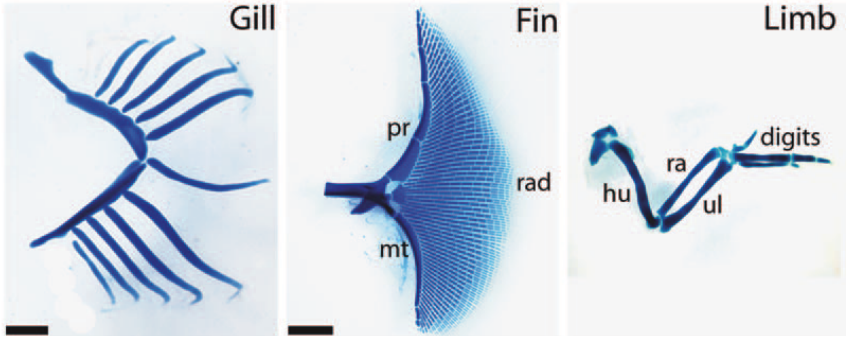


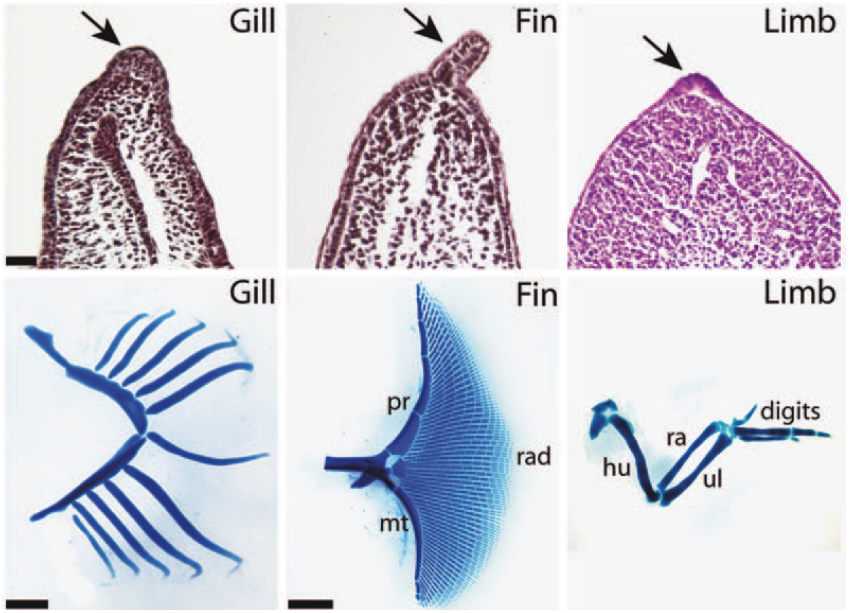






Mirror-image, supernumerary rays


Gill
Fin
pr
rad
mt
Limb
digits
ra
hu
ul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Fin
Limb
Gill
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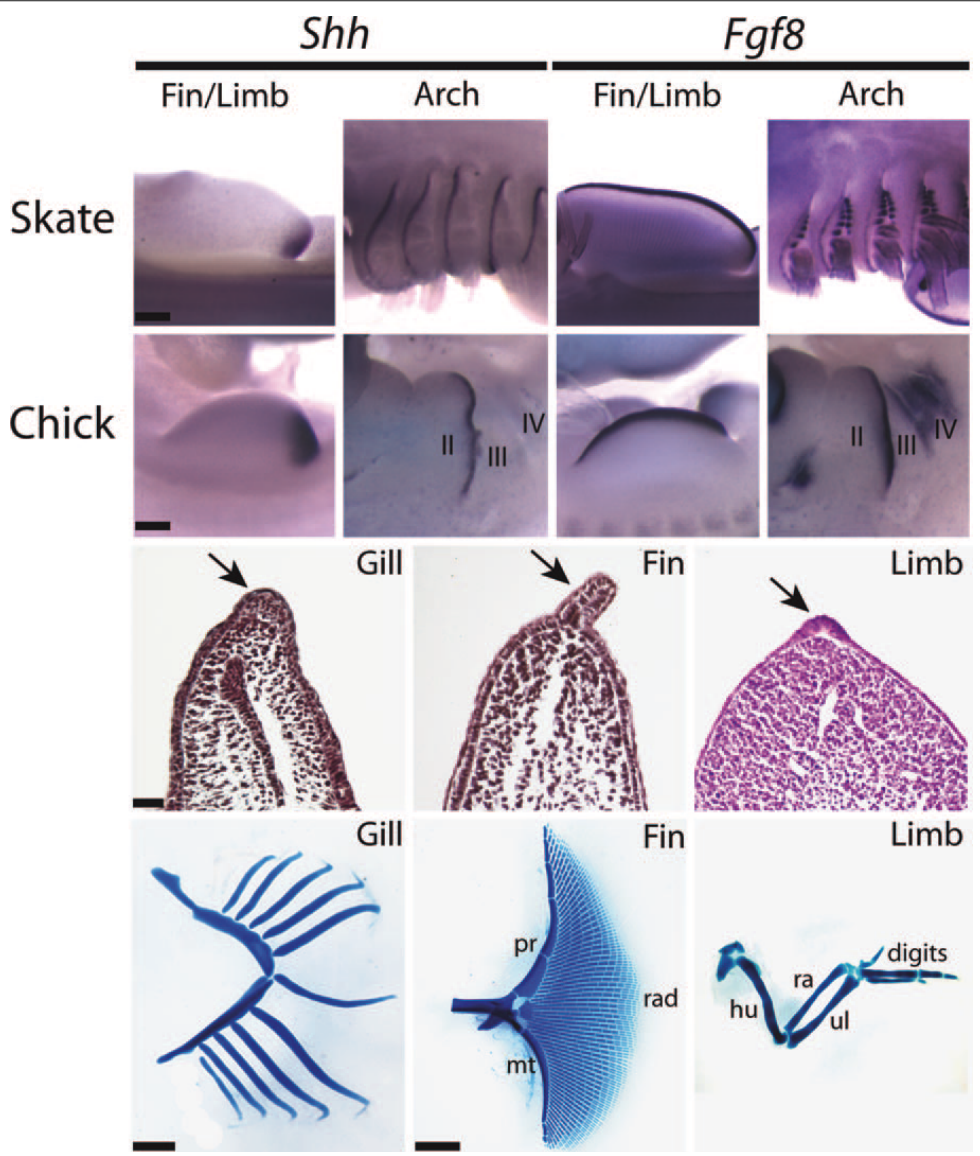
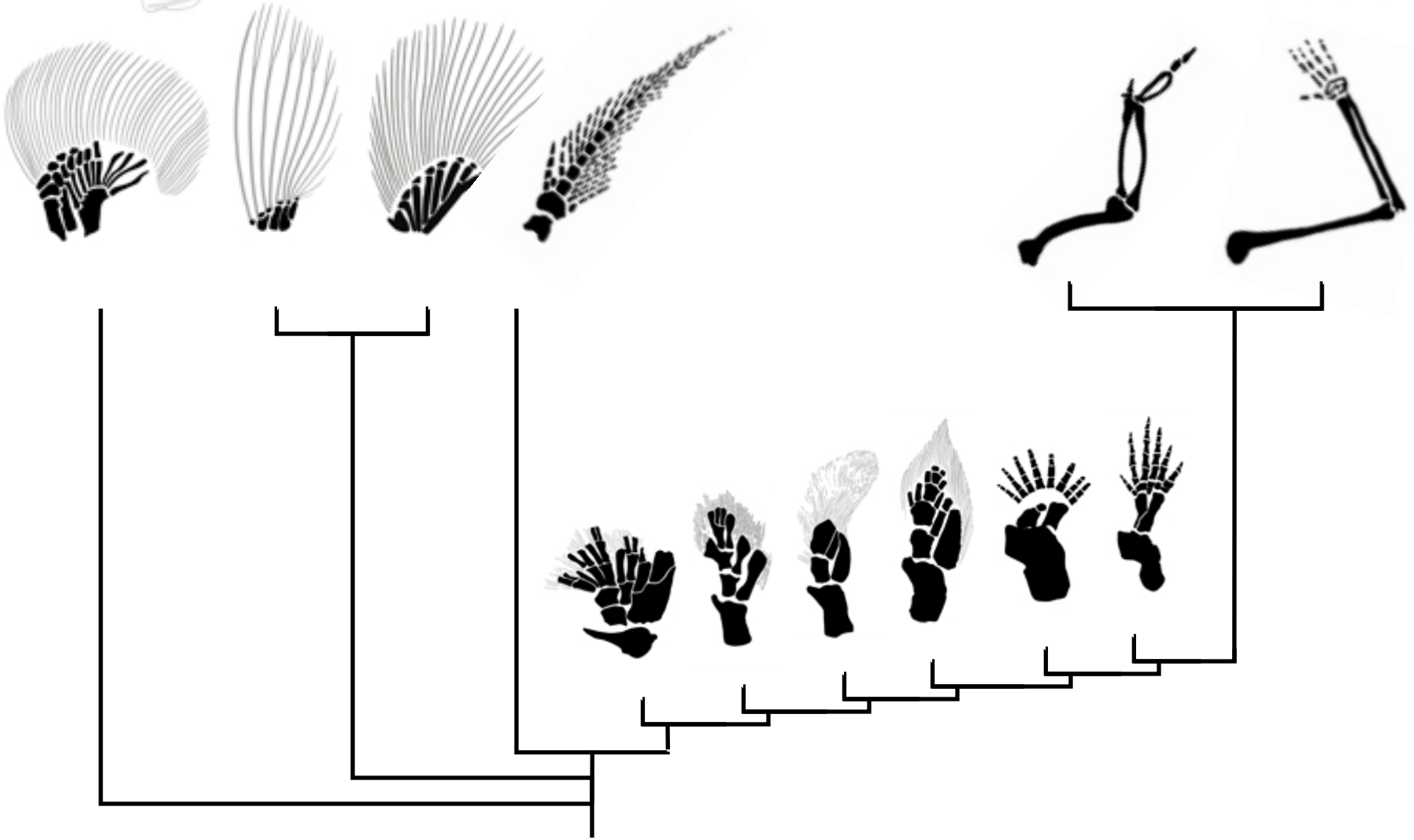

Shh
Fgf8
Fin/Limb
Arch
Fin/Limb
Arch
Skate
Chick
II
III
IV
II
III
IV
Gill
Fin
Limb
Gill
Fin
Limb
pr
rad
mt
digits
ra
hu
ul

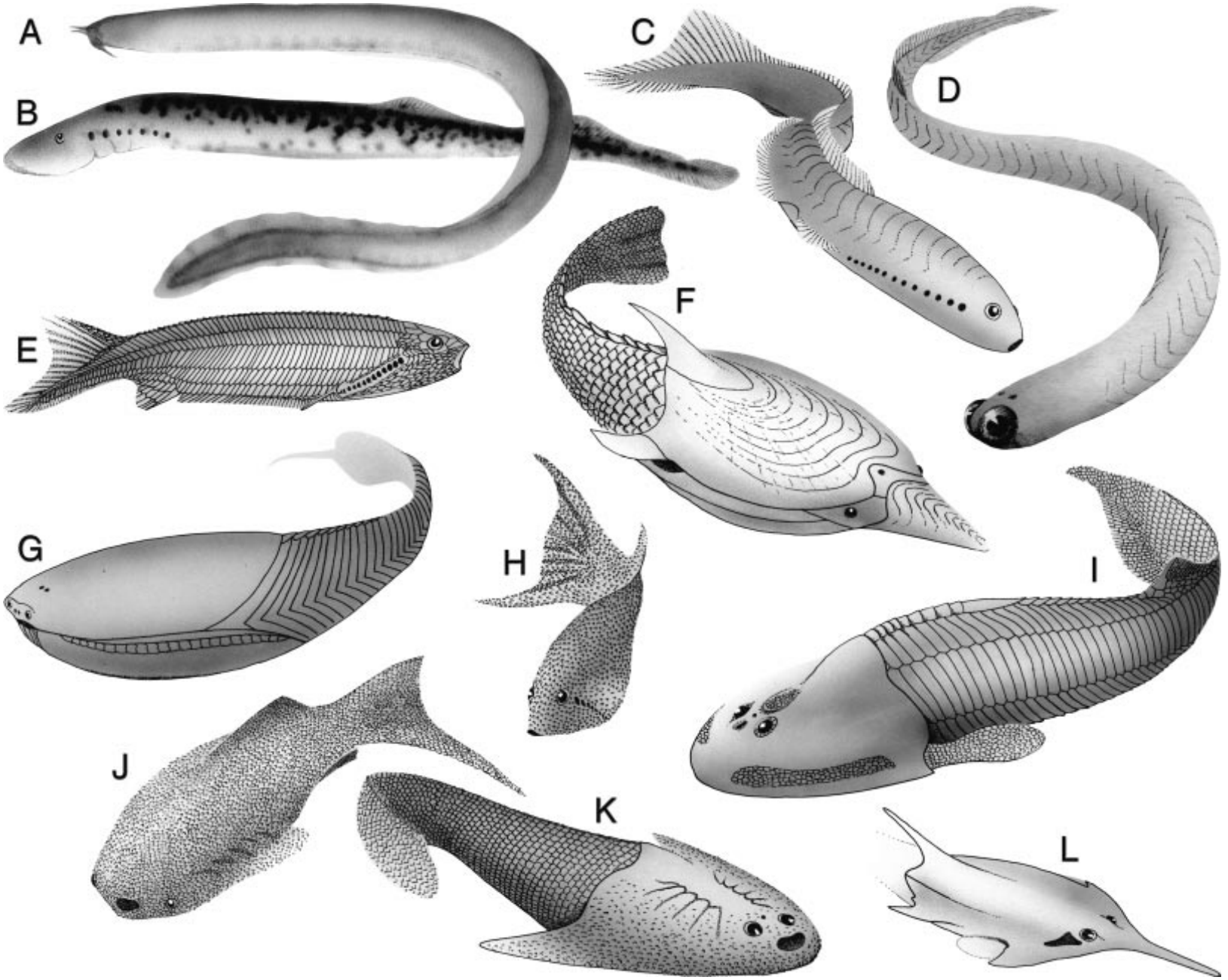
Developmental genetics of non-model organisms

Expeditions targeted to key parts of the tree of life

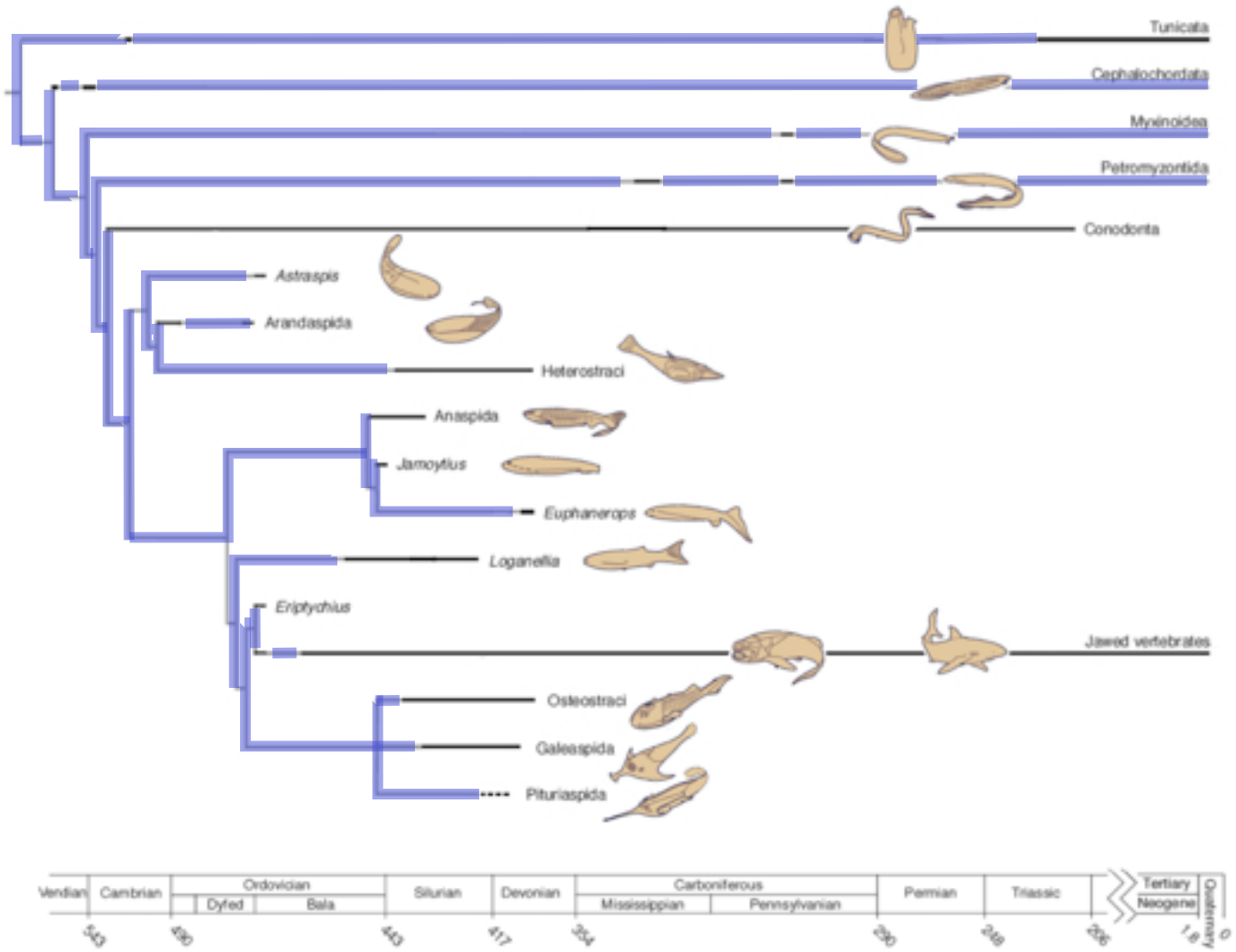
EXTANT

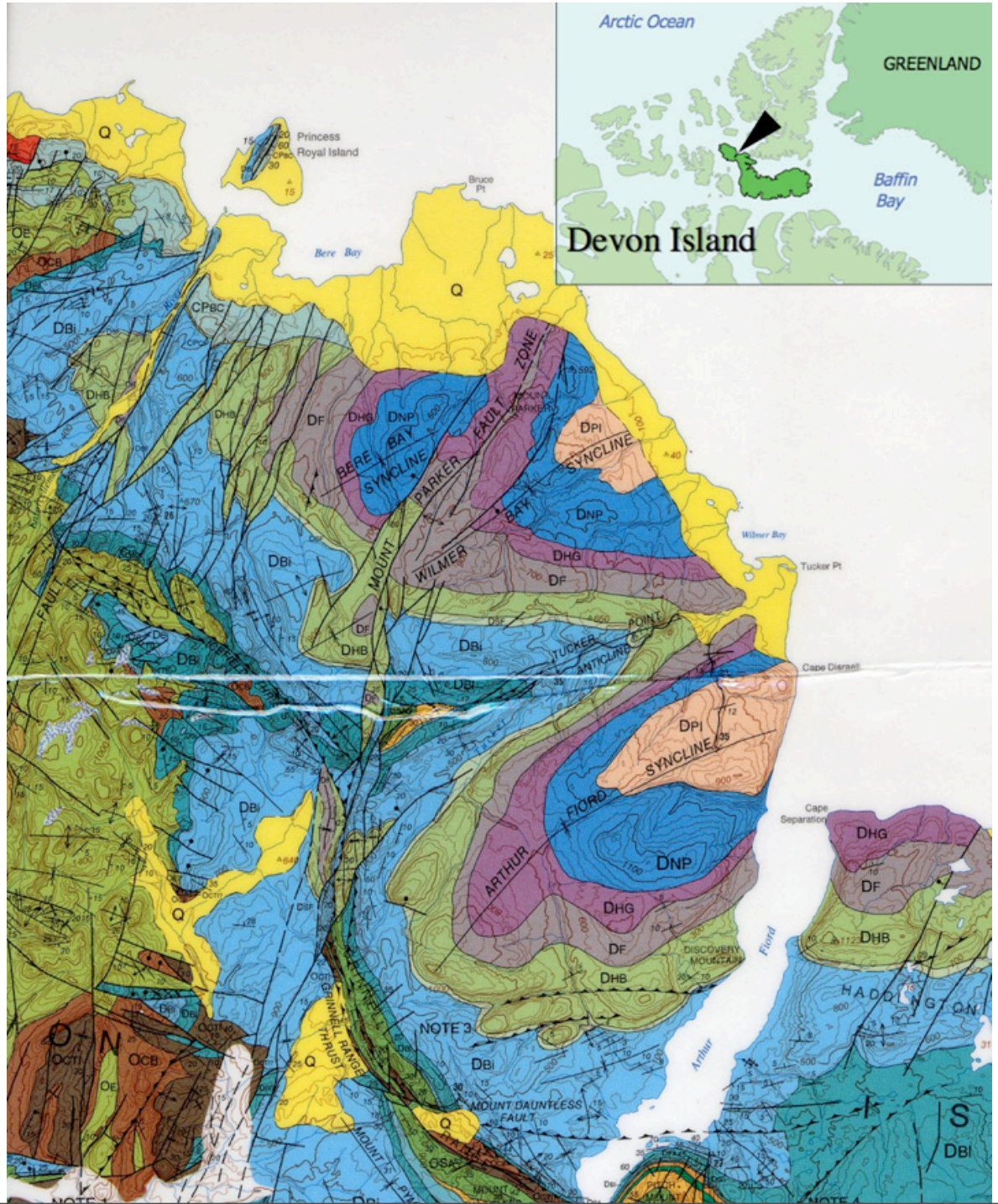
EXTINCT




A
B
C
D
E
F
G
H
I
J
K
L

There are: unknown unknowns (sensu RUMSFELD, 2002)





Arctic Ocean
GREENLAND
Baffin Bay
Devon Island
Princess Royal Island
Bruce Pt
Bere Bay
Wilmer Bay
Tucker Pt
Cape Disraeli
Cape Separation
BERE BAY SYNCLINE
MOUNT PARKER FAULT ZONE
WILMER BAY SYNCLINE
TUCKER POINT ANTICLINE
ARTHUR FIORD SYNCLINE
DISCOVERY MOUNTAIN
Arthur Fiord
HADDINGTON
GRINNELL RANGE THRUST
MOUNT DAUNTLESS FAULT
NOTE 3
Q
DBi
DHB
DF
DHG
DNP
DPI
CPBC
OCB
OE
OCTI
OSA

- Igor Schneider
- Randy Dahn
- Marcus Davis
- Andrew Gillis
- Justin Lemberg

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- Melina Hale, Heather King

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- Nunavut Territory
- Polar Shelf Project
- Grise Fiord Community

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- NSF, NGS, NIH, The University of Chicago
- Academy of Natural Sciences, MCZ Harvard