

Departamento de Biologia  
FFCLRP/USP  
***EVOLUÇÃO E SISTEMÁTICA BIOLÓGICA***  
**2023**

***Docentes responsáveis***

Prof. Dr. Eduardo A. B. de Almeida

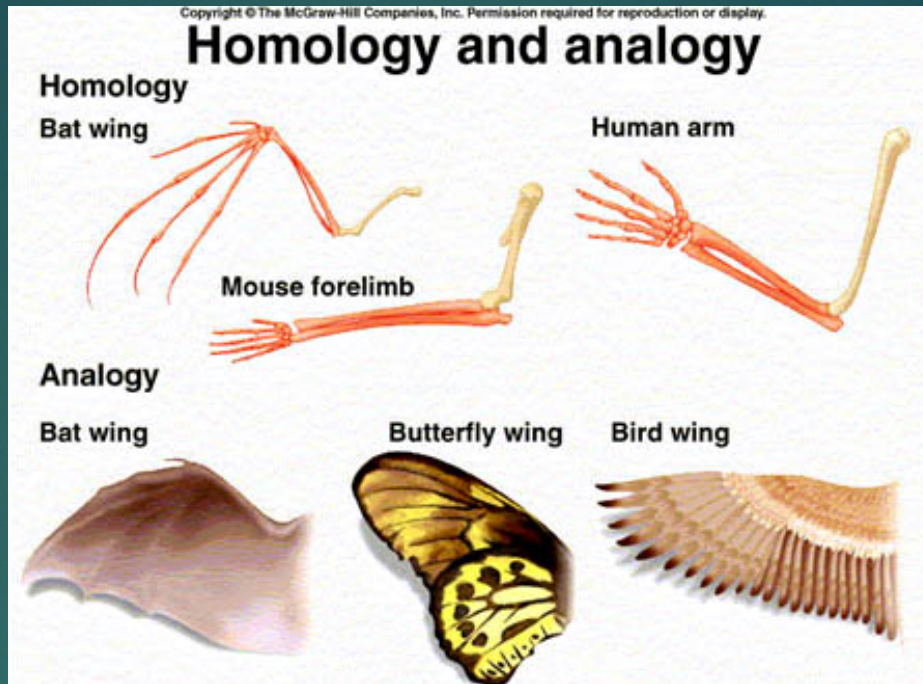
Prof. Dr. Flávio A. Bockmann

Profa. Dra. Maura H. Manfrin

Profa. Dra. Tiana Kohlsdorf

***Homologia***

# HOMOLOGIA - Conceito intuitivo ou induzido?



Analogous Structures (Streamline Appendages)			Homologous Structures (Pentadactyl Limbs)			
<p><b>Shark (fish)</b></p> <p><b>Fin</b></p>	<p><b>Penguin (bird)</b></p> <p><b>Wing</b></p>	<p><b>Dolphin (mammal)</b></p> <p><b>Flipper</b></p>	<p><b>Human</b></p>	<p><b>Cat</b></p>	<p><b>Whale</b></p>	<p><b>Bat</b></p>

# HOMOLOGIA – Etimologia e importância na Biologia Comparada

**Homologia** - do grego *ὁμοως*, "igualmente", "o mesmo", e *λογία*, "ciência", "razão", "relação".

- **Origem** – Grécia Antiga – matemática (geometria)

*"... [Homology is] without question the most important principle in comparative biology" (Bock, 1974)*

*"...its [homology] distinguishing features are its concern with history and its ability to generate and test historical hypotheses and theories by means of comparative method" (Nelson, 1970)*

*"...Homology is thus central to any discussion of phylogeny reconstruction" (Patterson, 1982)*

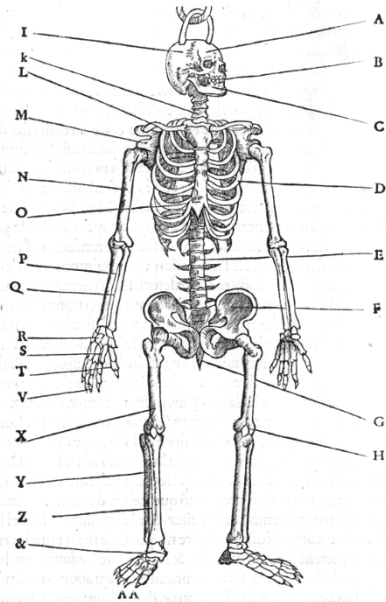
**Ontologia** - ramo da filosofia (metafísica) que estuda a natureza do ser, da existência e da própria realidade

# HOMOLOGIA – ANTES DA TEORIA EVOLUTIVA

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LIVRE I. DE LA NATVRE

Portraict de l'amas des os humains, mis en comparaison de l'anatomie de ceux des oyseaux, faisant que les lettres d'icelle se rapporteront à celle cy, pour faire apparoitre combien l'affinité est grande des vns aux autres.

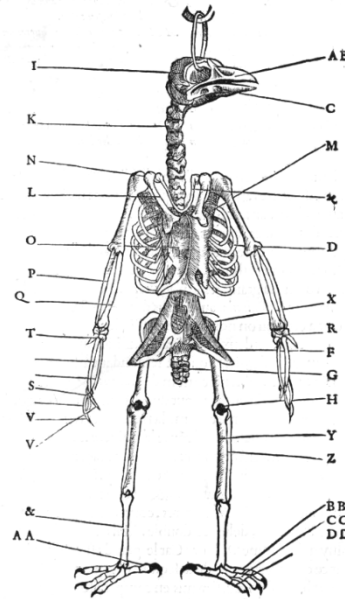


DES OYSEAVX, PAR P. BELON.

41

La comparaison du fufdit portraict des os humains monstre com-  
bien cestuy cy qui est d'un oyseau, en est prochain.

Portraict des os de l'oyseau.



*A B* Les Oyseaux n'ont dents ne loires, mais ont le bec tranchant fort on faible, plus on moins selon l'affaire qu'ils ont eu à mettre en pieces ce dont ils vivent.  
*M* Deux pallerons longs, & estroicts, m en chacun costé.  
*N* L'os qu'on nomme la Lunette ou Fourchette n'est trouué en aucun autre animal, hors mis en l'oyseau.  
*D* Six costes, attachees au coffre de l'estomach par deüx, & aux six vertebres du dos par derriere.  
*F* Les deux os des hanches sont longs, car il n'y a aucunes vertebres au dessous des costes.  
*G* Six osselets au croqion.  
*H I* La rouelle du genoil.  
*I* Les sutures du test n'apparaisent gueres sinon qu'il soit bouilly.  
*k* Douze vertebres au col, & six au dos.  
d iii

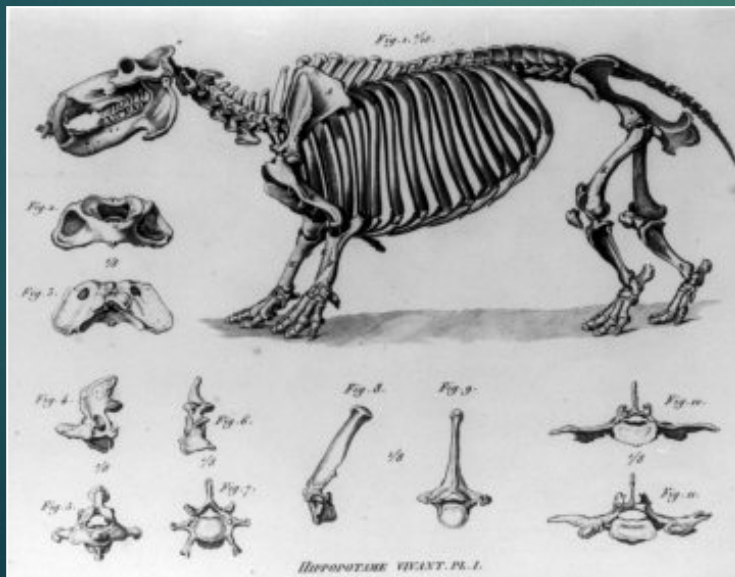
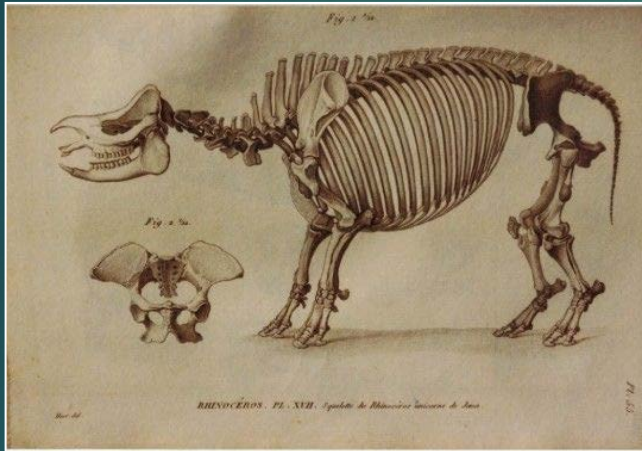


**Pierre Belon**  
(1517, Souletière – 1564, Paris)

Belon, P. (1555) *L'Histoire de la nature des oyseaux*

# HOMOLOGIA – ANTES DA TEORIA EVOLUTIVA

- Catastrofismo (*Revoluções*)
- Princípio da correlação das partes equivalentes (homólogos), que poderiam ser encontrados apenas dentro de grandes divisões ("embranchement") dos seres vivos, mas não entre elas; harmonia entre as partes
- *Cuvier* não era criacionista; organismos eram unidades naturais



**George Cuvier**  
(1769, Montbéliard –1832, Paris)  
Muséum national d'Histoire  
Naturelle

# HOMOLOGIA – ANTES DA TEORIA EVOLUTIVA

- Verdadeiras homologias ("analogies") poderiam ser detectados entre as grande divisões biológicas, existindo, portanto, um plano básico comum subjacente => transmutação das espécies!
- Recorreu à embriologia para encontrar essas semelhanças mais profundas

## PHILOSOPHIE ANATOMIQUE.

TOME PREMIER.

DES ORGANES RESPIRATOIRES

SOUS LE RAPPORT

DE LA DÉTERMINATION ET DE L'IDENTITÉ  
DE LEURS PIÈCES OSSEUSES.

*Avec Figures de 116 nouvelles préparations d'Anatomie.*

PAR M. le Ch<sup>er</sup>. GEOFFROY-SAINT-HILAIRE,

Membre de l'Institut (Académie Royale des Sciences); Professeur-Administrateur du Muséum d'Histoire naturelle, au Jardin du Roi; Professeur de Zoologie et de Physiologie à l'École Normale. De l'Institut d'Égypte. Des Académies de Madrid; de Munich; de Göttingue; de Moscou; de Harlem; de Wettérawie à Hanau; de Mayence; de Marseille; de Bordeaux; de Boulogne, etc. — Et Maire de Chailly, près Coulommiers.

*Cajusvis est hominis errare.*  
Cic. 8. Verr.

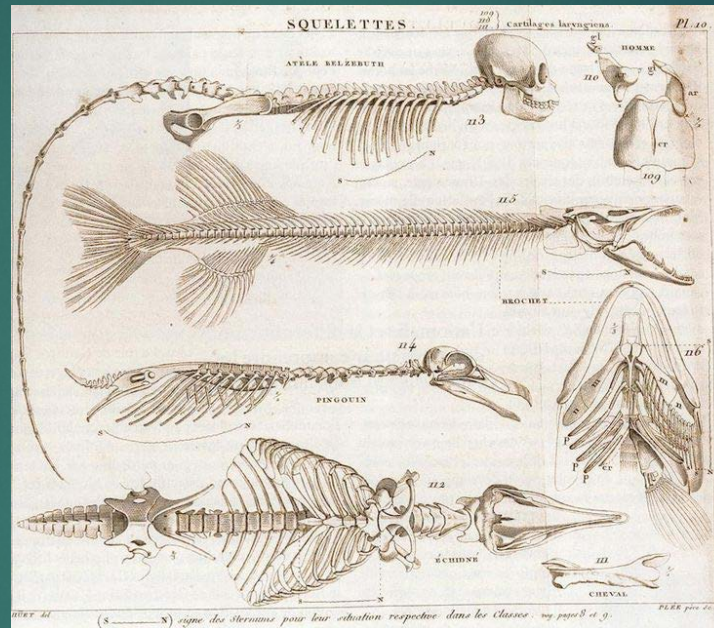
PARIS,

J.-B. BAILLIÈRE,

LIBRAIRE DE L'ACADÉMIE ROYALE DE MÉDECINE,  
ET DU COLLÈGE ROYAL DES CHIRURGIENS DE LONDRES,  
Rue de l'École-de-Médecine, n° 13 bis.

LONDRES, MÊME MAISON, 3 BEDFORD STREET, BEDFORD SQUARE.  
A BRUXELLES, AU DÉPOT DE LA LIBRAIRIE MÉDICALE FRANÇAISE.

1818.



**Étienne Geoffroy Saint-Hilaire**  
(1772, Étampes—1844, Paris)  
Muséum national d'Histoire Naturelle

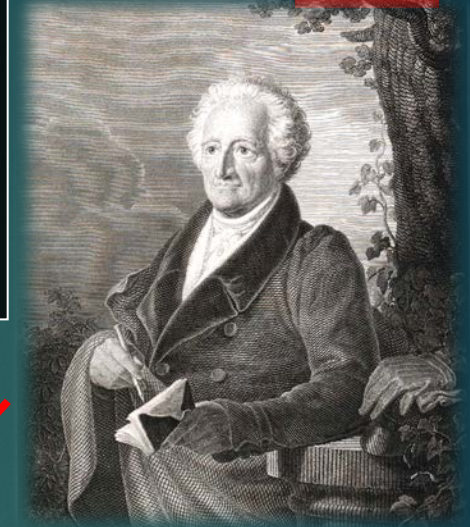
# HOMOLOGIA – ANTES DA TEORIA EVOLUTIVA

## - A anatomia idealista ou transcendental (Alemanha)

- Verdadeiras homologias poderiam ser detectadas entre as grande divisões => o *Grande Plano Básico* comum (*Plano Ideal - Bauplan*) poderia ser resgatado por meio de estudos aprofundados da anatomia

**Karl Ernst von Baer**

(1792, Estonia – 1876, Tartu)  
Albertus-Universität Königsberg  
(Prússia)



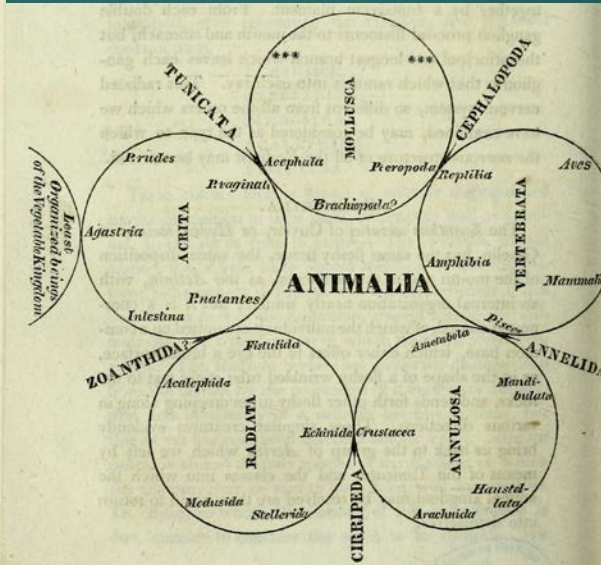
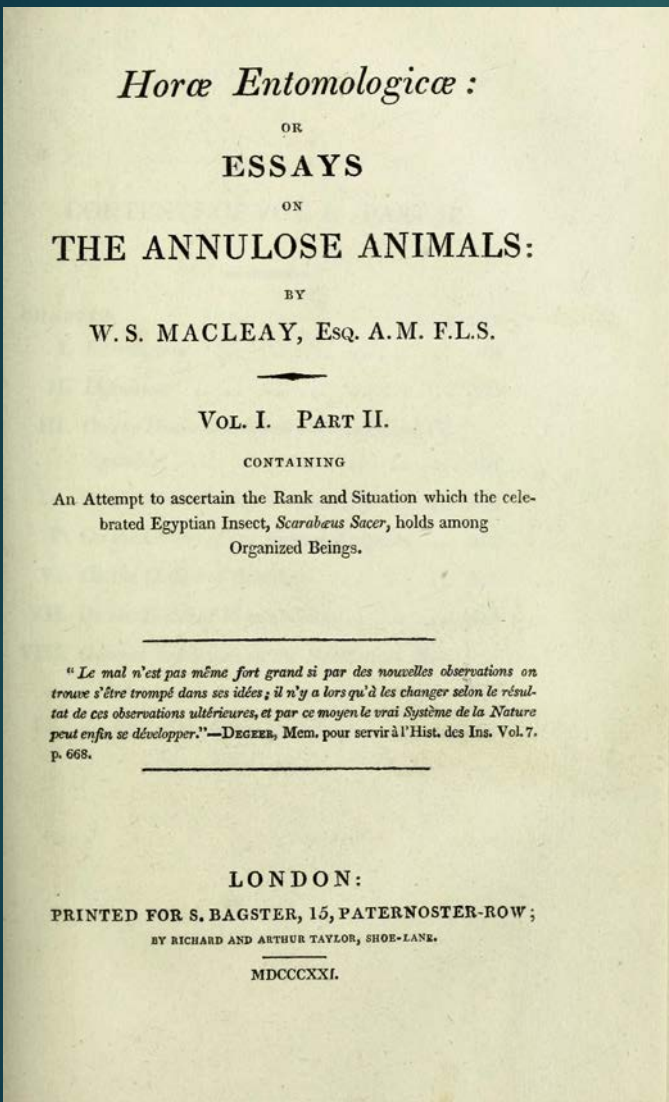
**Johann Wolfgang von Goethe**  
(1749, Frankfurt – 1832, Weimar)

**morfologia**

### **Leis de von Baer (embriologia):**

- As características gerais do grupo à que pertence um embrião aparecem, em seu desenvolvimento, antes das características específicas.
- As relações estruturais específicas se formam depois das genéricas.
- O embrião não passa por estágios pertencentes a outras formas específicas; ao contrário, separa-se delas.
- O embrião de uma forma animal mais avançada nunca se assemelha ao adulto de outra forma animal, somente ao seu embrião.

# HOMOLOGIA – ANTES DA TEORIA EVOLUTIVA



**William Sharp Macleay**  
(1792, Londres - 1865, Sydney)

Macleay (1819-1821), *Horæ Entomologicae*; ou, *Essays on the Annulose Animals*, pt. 1-2.

Similaridade

Função: *analogy*

Forma e Função: *affinity*



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## INTRODUCTORY.

in the Linnæan genus *Scarabæus* bear to each other. I have, moreover, endeavoured to show that the order of these affinities may be represented by two circles meeting at one point, and having altogether an analogous structure at their corresponding points. Relations of analogy have thus been distinguished from those of affinity; and it was advanced by way of example, that though *Dynastes Hercules* might approach nearer to *Scarabæus sacer* in affi-



*Johann Wolfgang von Goethe*  
(1749, Frankfurt – 1832, Weimar)

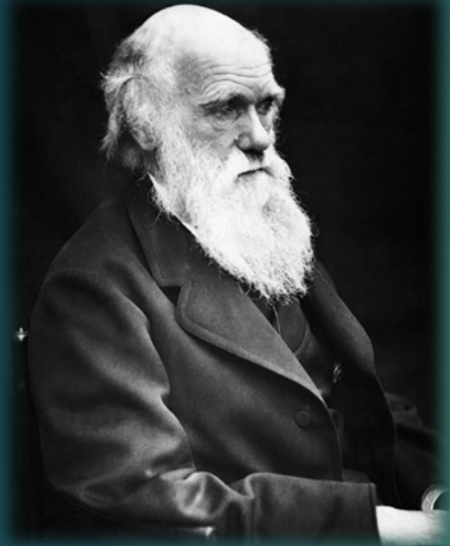
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## ON THE ORDERS

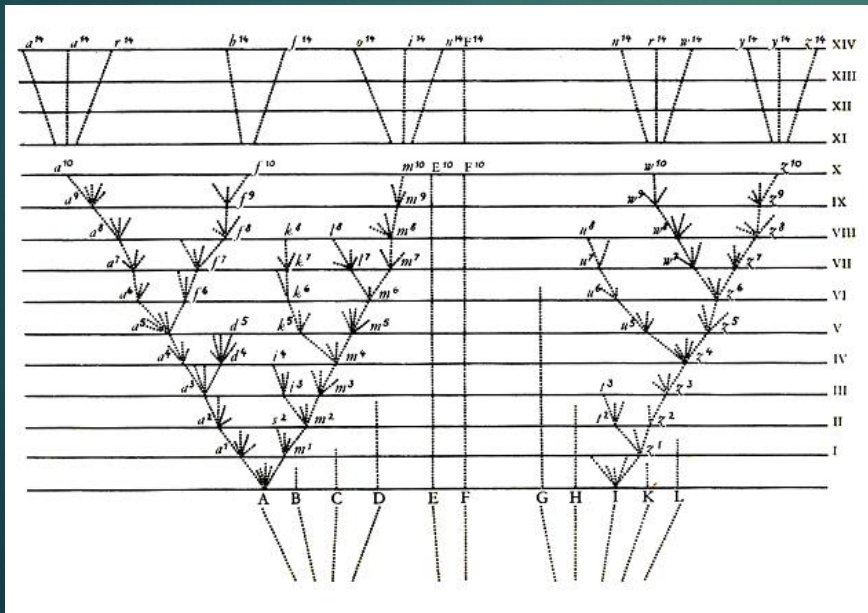
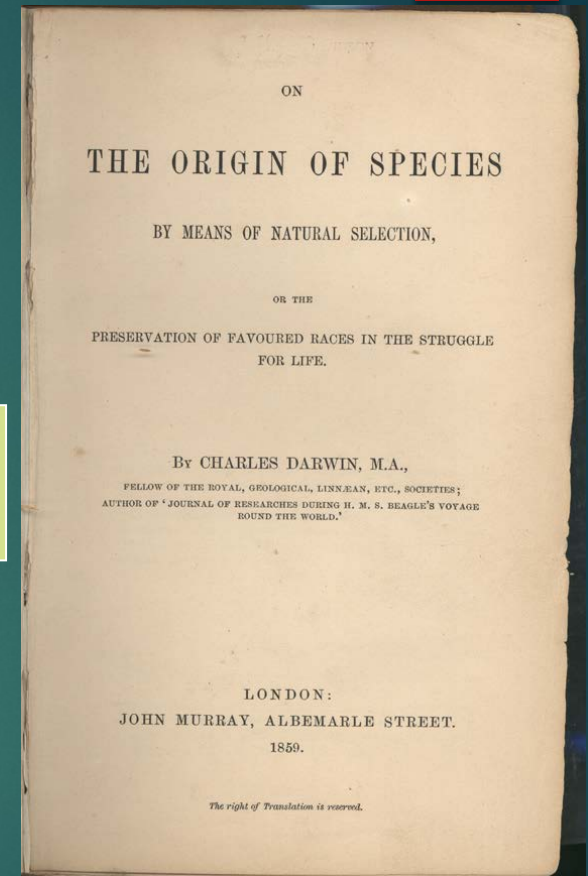
These various considerations have led me to imagine, how truly I have not yet been able to determine, that the test of a relation of affinity is its forming part of a transition continued from one structure to another by nearly equal intervals, and that the test of a relation of analogy is barely an evident similarity in some one or two remarkable points of formation, which at first sight give a character to the animal and distinguish it from its affinities. As a

# HOMOLOGIA – O ALVORESCER DA TEORIA EVOLUTIVA

**Teoria da Evolução** – espécies mutáveis ao longo do tempo profundo; toda a diversidade é produto da seleção natural



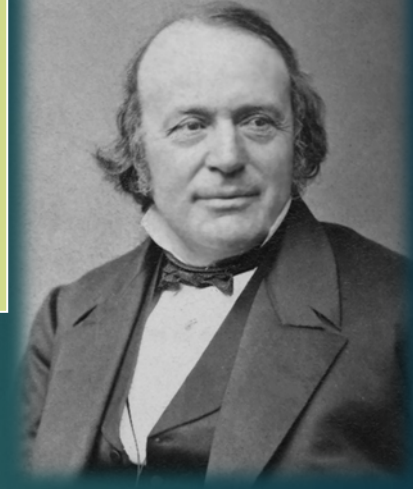
**Charles R. Darwin**  
(1809, Shrewsbury -1882,  
Downe)



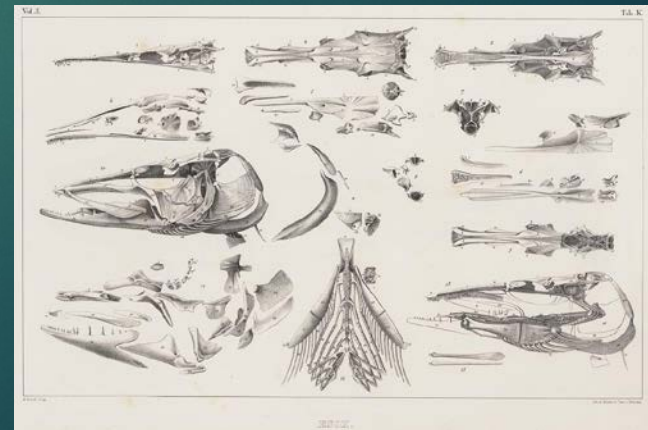
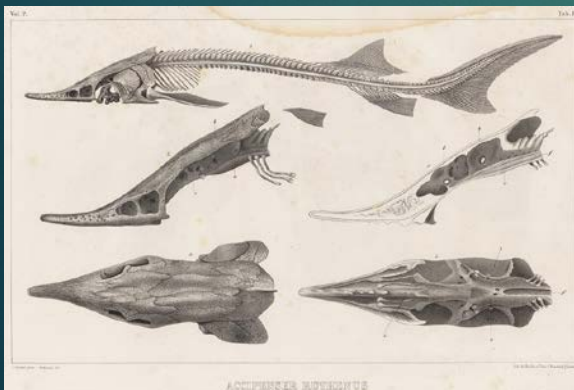
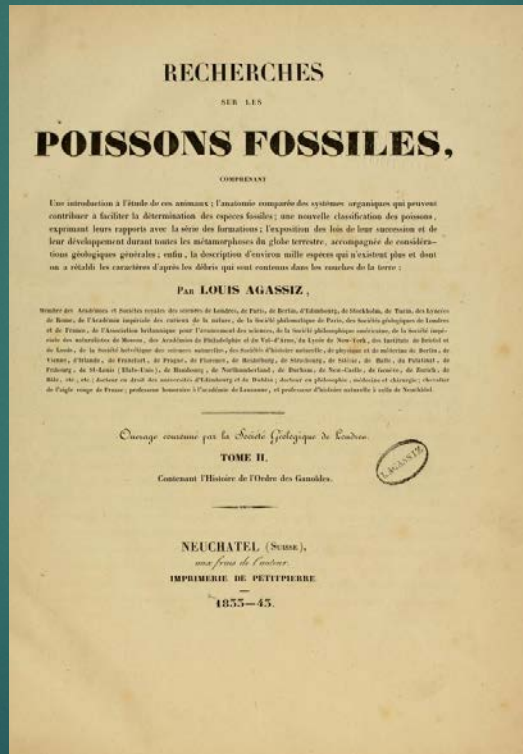
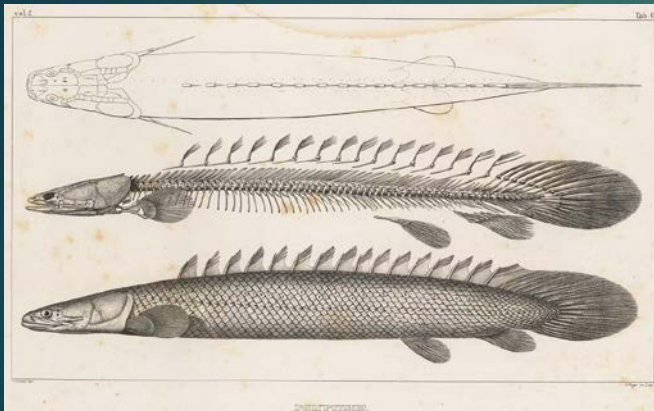
- Conceito de homologia de Darwin incorpora definitivamente a teoria evolutiva – mudança na **ontologia** da **Biologia!**

# HOMOLOGIA – OPOSITORES DA TEORIA EVOLUTIVA

- Continuou a obra de **Spix**, por sugestão de **Martius**; foi discípulo de **Cuvier**;
- Em 1846 ministrou 12 palestras sobre “ *O Plano de Criação como Mostrado no Reino Animal*”, em Boston, à convite de J. A. Lowell
- Em 1859, fundou o **Museu de Zoologia Comparada**
- **Criacionista** - rejeitou a **Teoria da Evolução**
- **Poligenia** - as raças foram criadas separadamente => **racismo**



**Louis Agassiz**  
(1807, Môtier, Suíça -1873,  
Cambridge)  
Universit  de Neuch tel  
Harvard University, Museum of  
Comparative Zoology



Recherches sur les poissons fossiles (1833-1843)

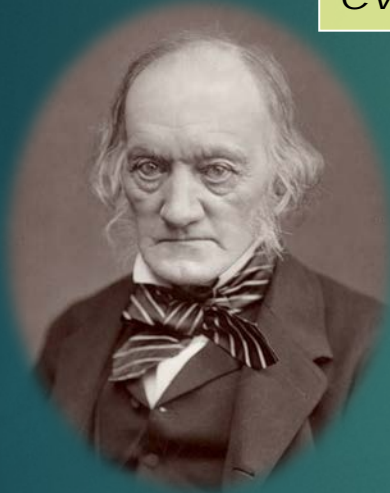
# HOMOLOGIA – OPOSITORES DA TEORIA EVOLUTIVA

- Opositor da *Teoria Evolutiva* – a matéria viva tinha uma “*energia organísmica*”, uma força vital que direcionava o crescimento dos tecidos e que também determinava o ciclo de vida do indivíduo e da espécie.

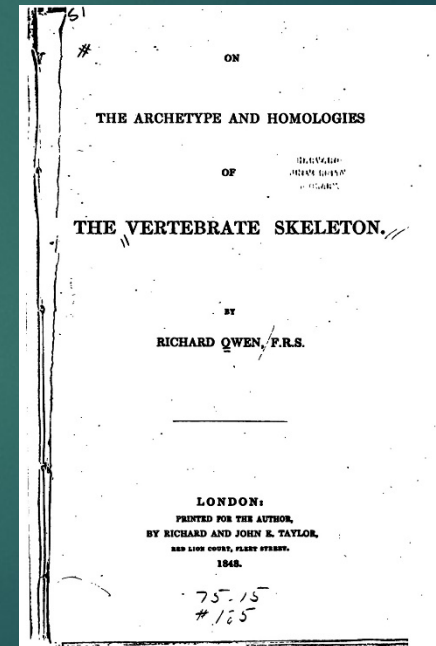
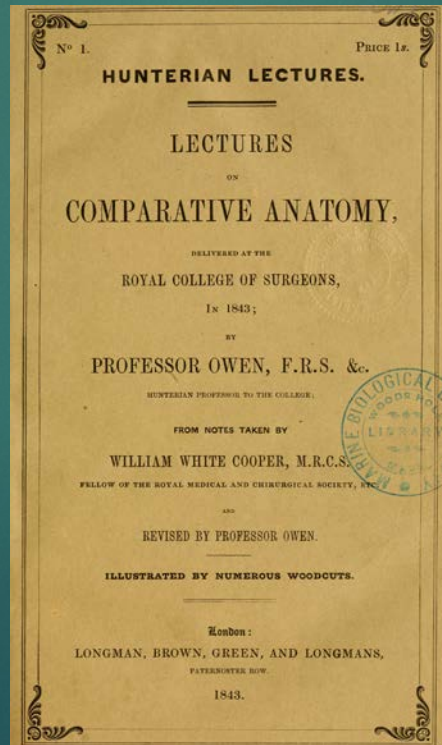


- Reação às críticas religiosas que recebeu pela sua obra *Nature of the Limbs* (1849), na qual sugere que seres humanos surgiram a partir de peixes, devido às leis naturais

**Homologia** – “*The same organ in different animals under every variety of form and function*” (Owen, 1843: 374)



**Richard Owen**  
(1804, Lancaster –1892, Londres)  
British Museum

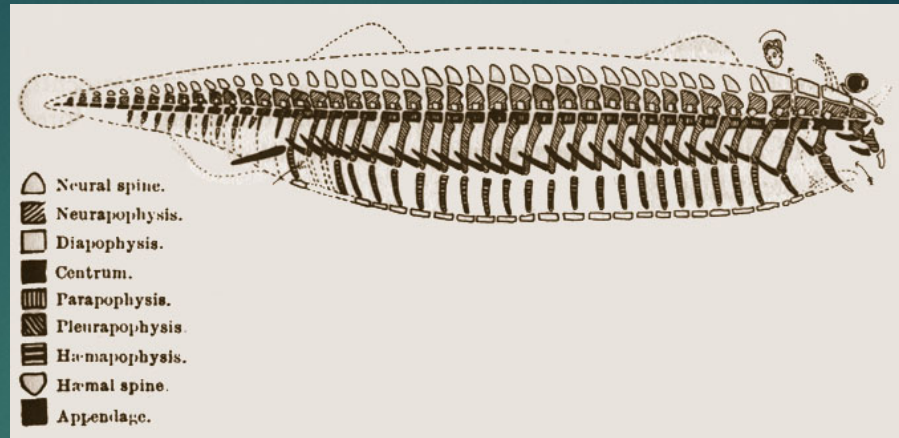


Owen (1843) *Lectures on the comparative anatomy.*

# HOMOLOGIA – OPOSITORES DA TEORIA EVOLUTIVA



**Richard Owen**  
(1804, Lancaster –1892, Londres)  
British Museum



Arquétipo dos vertebrados

**Similaridade**

**Função: Analogia**

**Forma e Função: Homologia**

**Homologia especial:** tipo comum – correspondência entre órgãos de diferentes animais

**Homologia serial (homonímia):** estrutura ou órgão repetido no mesmo animal

**Homologia geral:** relação superior de homologia; parte (ou conjunto de partes) que suporta o tipo geral ou fundamental

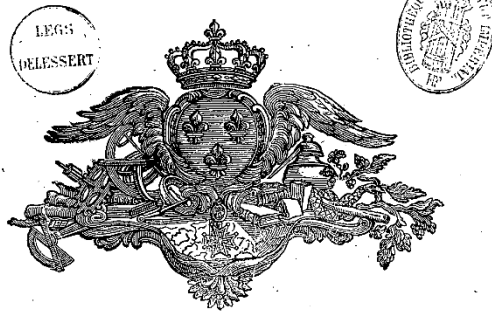
# HOMOLOGIA – UM CASO À PARTE?

- **Homonímia** (Homologia seriada ou homologia iterativa): "representative or repetitive relation in the segments of the same organism" (Owen, 1848)

## HISTOIRE DE L'ACADÉMIE ROYALE DES SCIENCES.

ANNÉE M. DCCLXXIV.

Avec les Mémoires de Mathématique & de Physique,  
pour la même Année,  
Tirés des Registres de cette Académie.



A PARIS,  
DE L'IMPRIMERIE ROYALE.

M. DCCLXXXVIII.

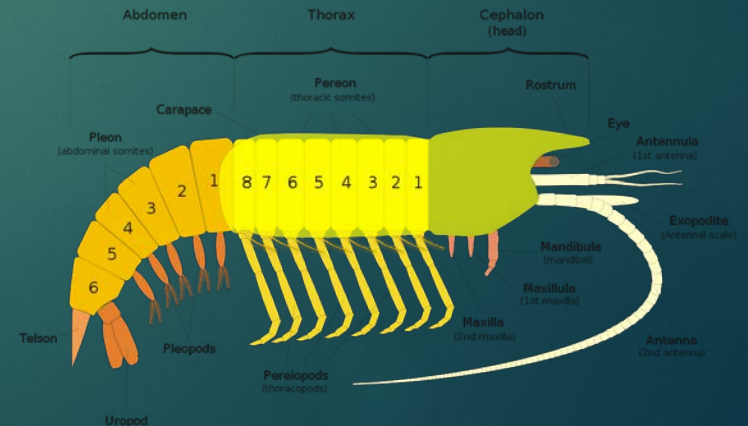
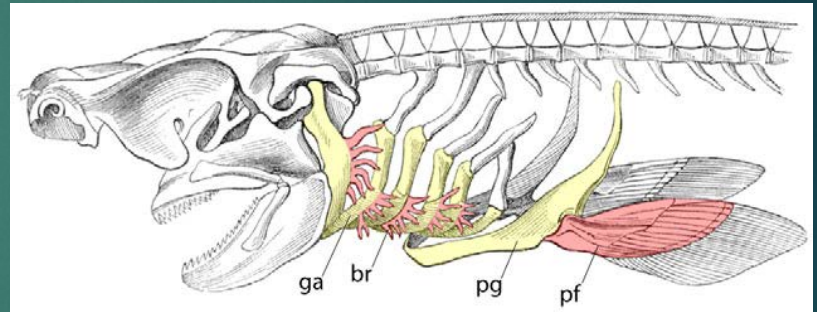
254 MÉMOIRES DE L'ACADÉMIE ROYALE

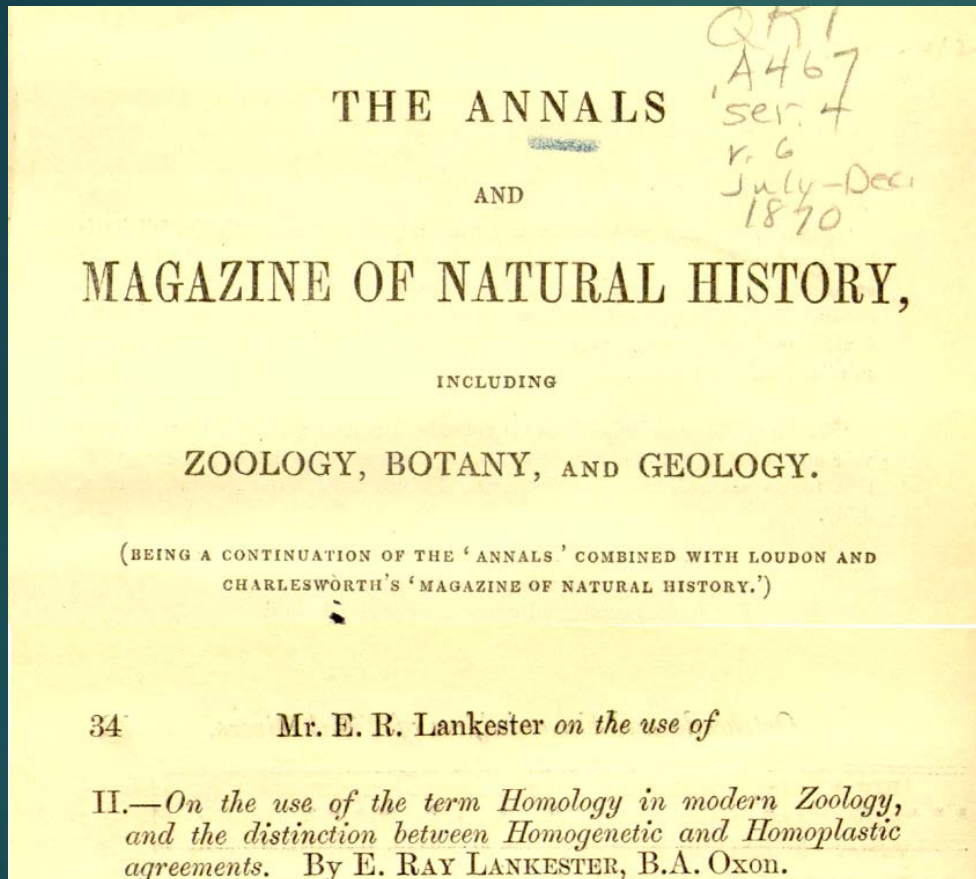
### M É M O I R E

Sur les Rapports qui se trouvent entre les usages & la  
structure des quatre extrémités dans l'Homme  
& dans les Quadrupèdes.

Par M. VICQ-D'AZYR.

**Félix Vicq d'Azyr**  
(1748, Valognes – Paris, 1794)





**Edwin Ray Lankester**  
(1847, Londres –1929, Chelsea)  
University College London e  
Oxford University

342 Mr. E. R. Lankester *on the use of the term "Homology."*

XXXII.—*On the Use of the Term "Homology."*  
By E. RAY LANKESTER.

*To the Editors of the Annals and Magazine of Natural History.*

# HOMOLOGIA – NO CONTEXTO DA TEORIA EVOLUTIVA

**Edwin Ray Lankester**  
(1847, Londres –1929, Chelsea)  
University College London e  
Oxford University



**Similaridade**

**Função: Analogia**

**Forma e Função: Homologia**

**Homoplasia:** “dependeria da ação comum de causas e moldagens ambientais na partes homogêneas ou por outras razões”

**Homogenia:** “dependeria da herança de um parentesco comum”



# HOMOLOGIA – NO CONTEXTO DA TEORIA EVOLUTIVA

- Estudos sobre anatomia comparada dos vertebrados (1864)
- A favor da teoria da evolução de Charles Darwin; foi orientador de Ernst Haeckel.

UNTERSUCHUNGEN  
ZUR  
VERGLEICHENDEN ANATOMIE  
DER  
WIRBELTHIERE

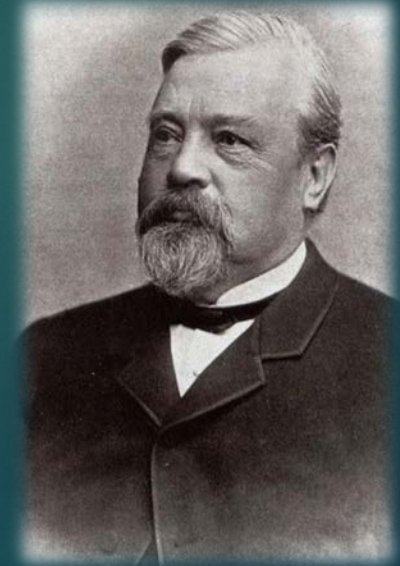
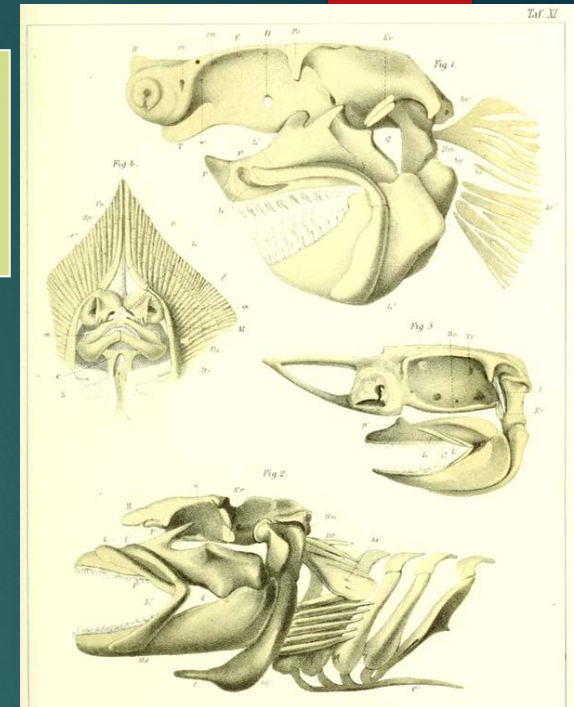
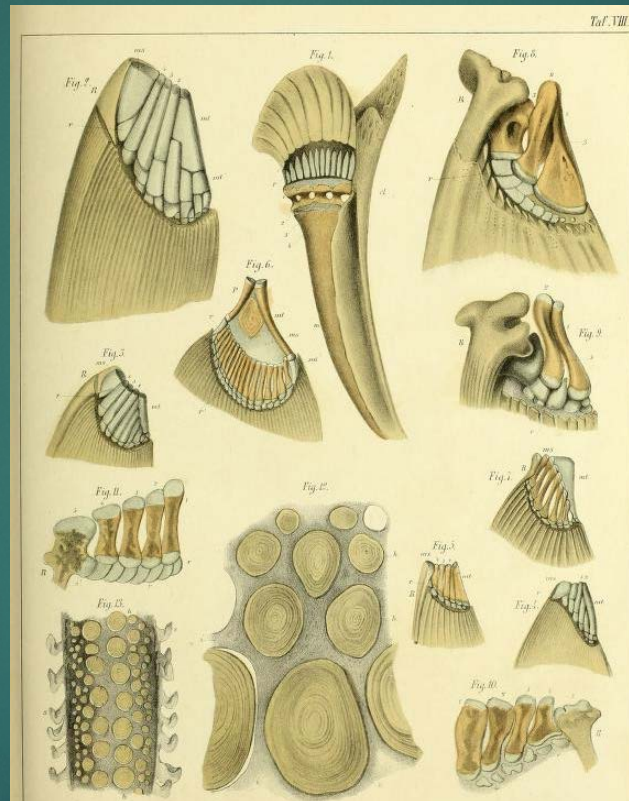
VON  
Dr. CARL GEGENBAUR,  
PROFESSOR DER ANATOMIE IN JENA.

ERSTES HEFT.  
CARPUS UND TARSUS.

MIT SECHS TAFELN.

LEIPZIG,  
VERLAG VON WILHELM ENGELMANN,  
1864.

UNIVERSITY  
COLLEGE  
LONDON



**Carl Gegenbaur**  
(1826, Würzburg -1903, Heidelberg )  
Universität Jena; Universität Heidelberg

# HOMOLOGIA – NO CONTEXTO DA TEORIA EVOLUTIVA



**Ernst Haeckel**  
 (1834, Potsdam, Prússia-  
 1919, Jena)  
 Universität Jena

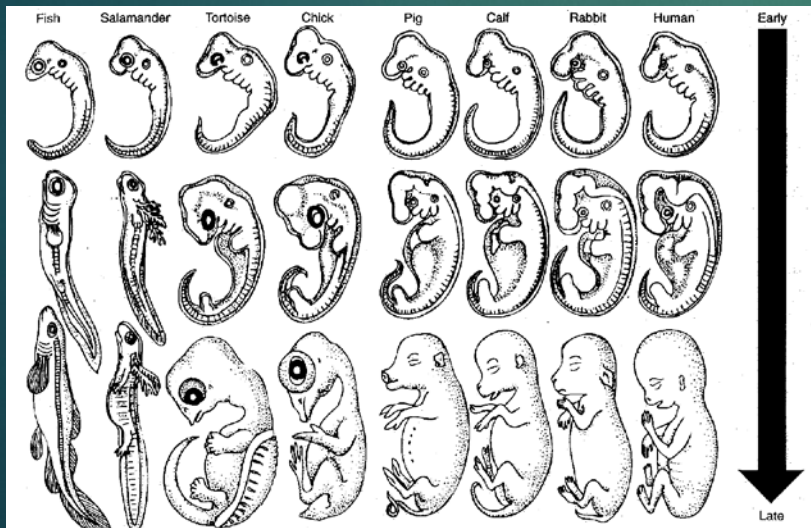
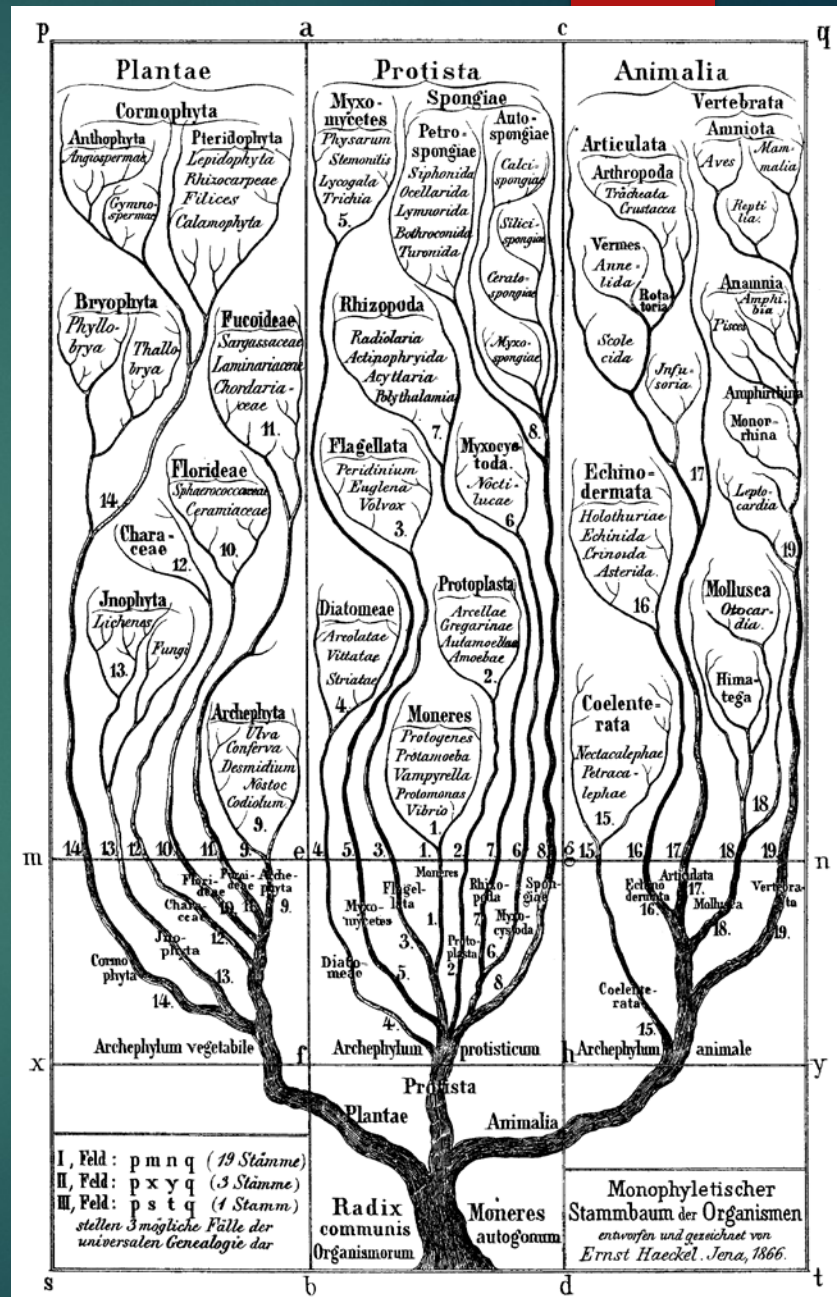
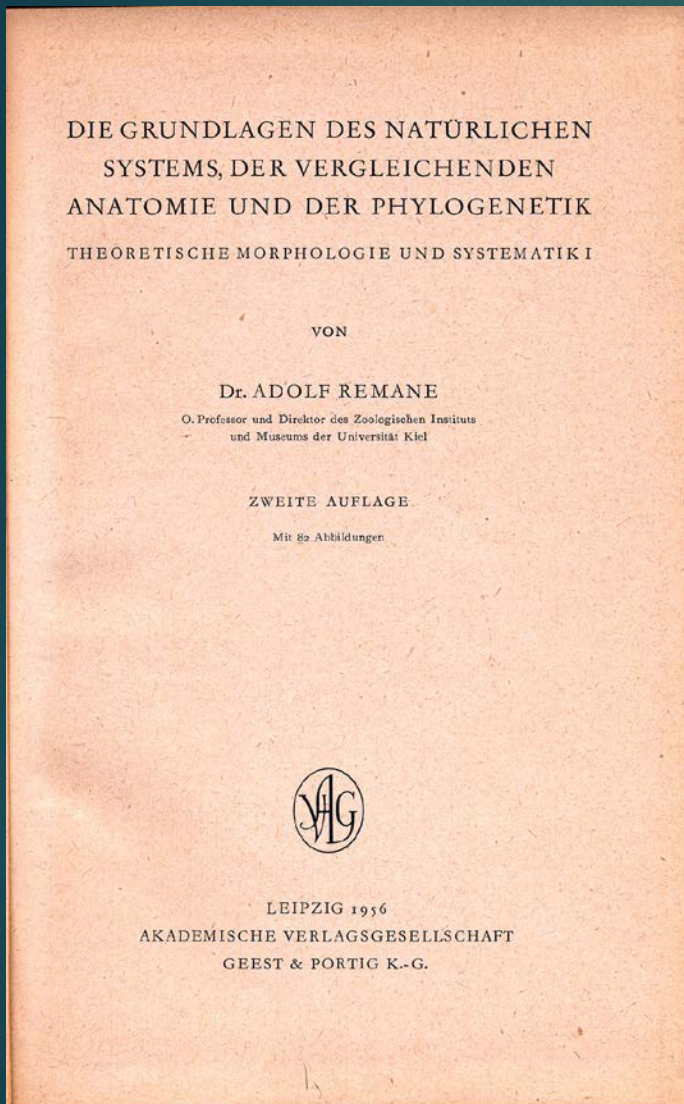


FIGURE 5.38 Haeckel's comparison of early embryonic stages across vertebrate groups. Eight species are shown across the figure. The youngest developmental stage of each is at the top of the figure followed by two successively older stages below.  
 After Haeckel.  
[www.bible.ca](http://www.bible.ca)  
 Vertebrates, Kenneth V. Kardong, 1998, p 191





## **Adolf Remane**

(1898, Krotoszyn, Polônia -1975, Plön), aos 65 anos  
Instituto Zoológico e Museu da Universidade de Kiel (N  
Alemanha)

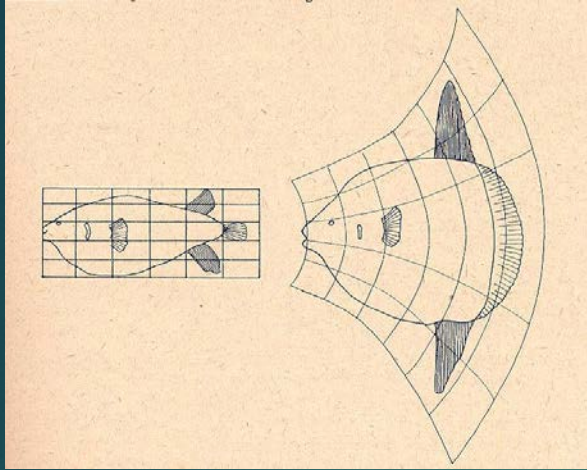
- Princípios sistemáticos importantes em sua obra:  
*distinção entre caracteres primitivos e derivados,*  
*espécies basais, padrões basais e comparações*  
*com grupo-externo*
- crítico da morfologia idealista alemã

*Os Fundamentos do Sistema Natural, Anatomia Comparada e Filogenética.*  
*Morfologia Teórica e Sistemática I. (Remane, 1952, 1956)*

# HOMOLOGIA – TEORIA EVOLUTIVA CONSOLIDADA

## 1) Critério de localização

a) Semelhança de localização topográfica.



c) Semelhança de localização na estrutura.

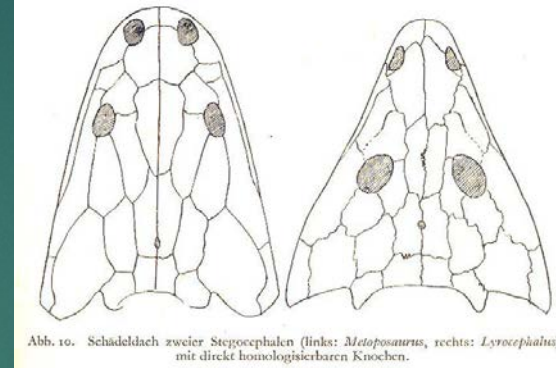


Abb. 10. Schädeldach zweier Stegocephalen (links: *Metastenosaurus*, rechts: *Lyrocephalus*) mit direkt homologisierbaren Knochen.

b) Posicionamento da semelhança com figuras ou corpos geometricamente semelhantes.

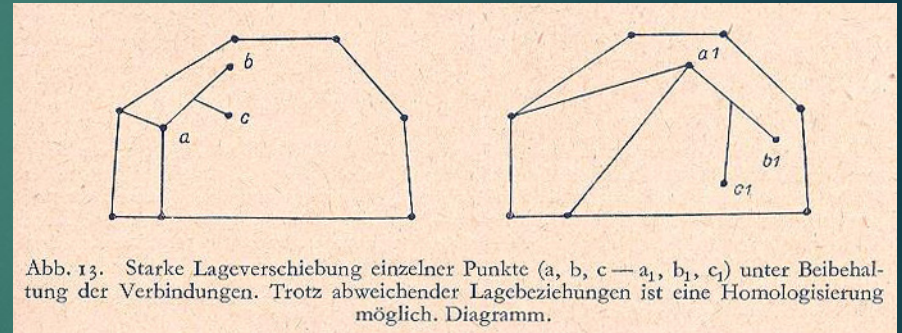


Abb. 13. Starke Lageverschiebung einzelner Punkte (a, b, c — a<sub>1</sub>, b<sub>1</sub>, c<sub>1</sub>) unter Beibehaltung der Verbindungen. Trotz abweichender Lagebeziehungen ist eine Homologisierung möglich. Diagramm.

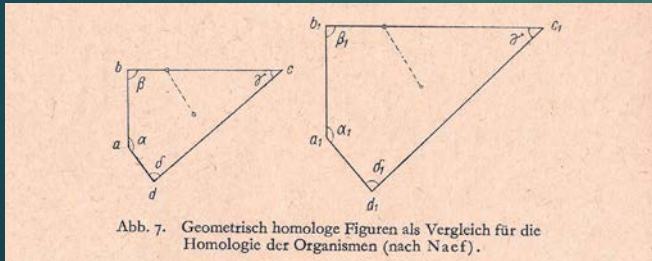


Abb. 7. Geometrisch homologe Figuren als Vergleich für die Homologie der Organismen (nach Naef).

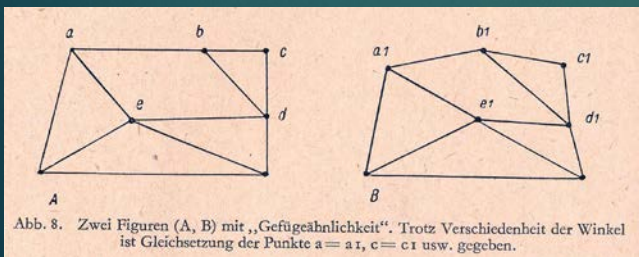


Abb. 8. Zwei Figuren (A, B) mit „Gefügeähnlichkeit“. Trotz Verschiedenheit der Winkel ist Gleichsetzung der Punkte a = a<sub>1</sub>, c = c<sub>1</sub> usw. gegeben.

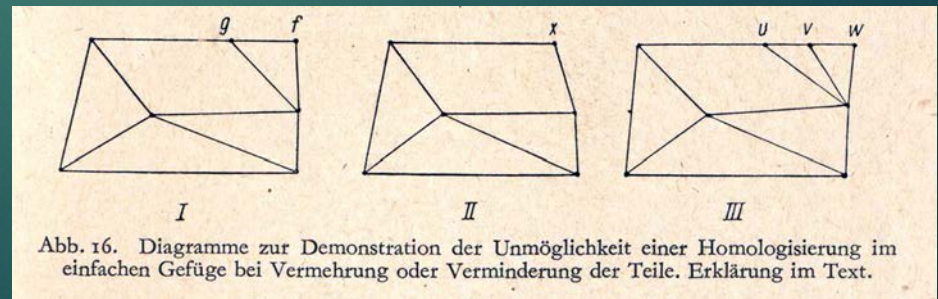
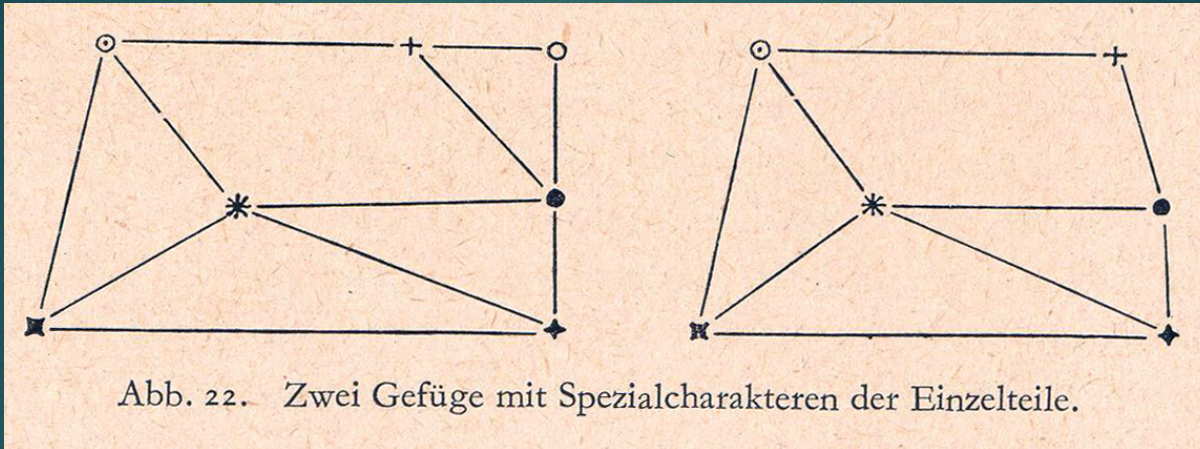
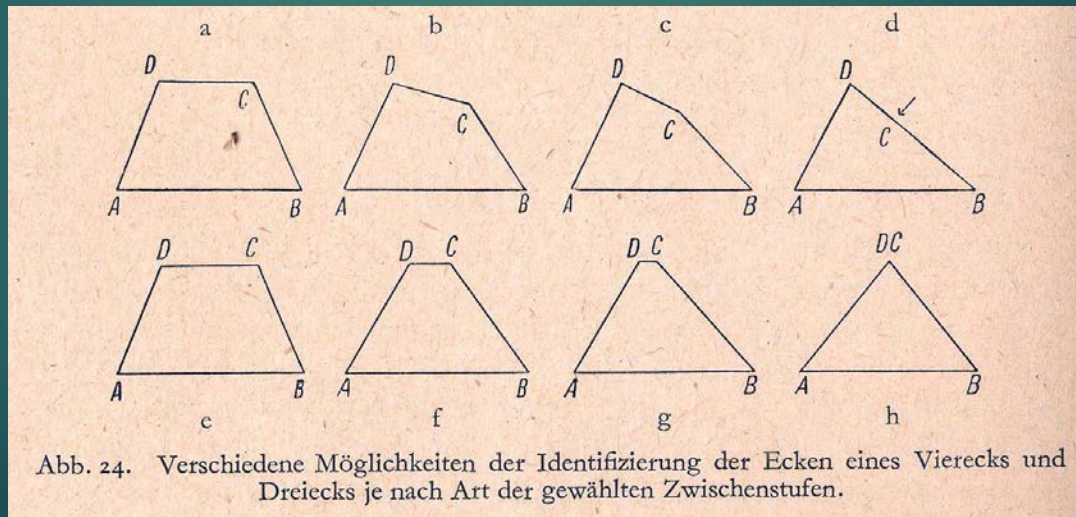


Abb. 16. Diagramme zur Demonstration der Unmöglichkeit einer Homologisierung im einfachen Gefüge bei Vermehrung oder Verminderung der Teile. Erklärung im Text.

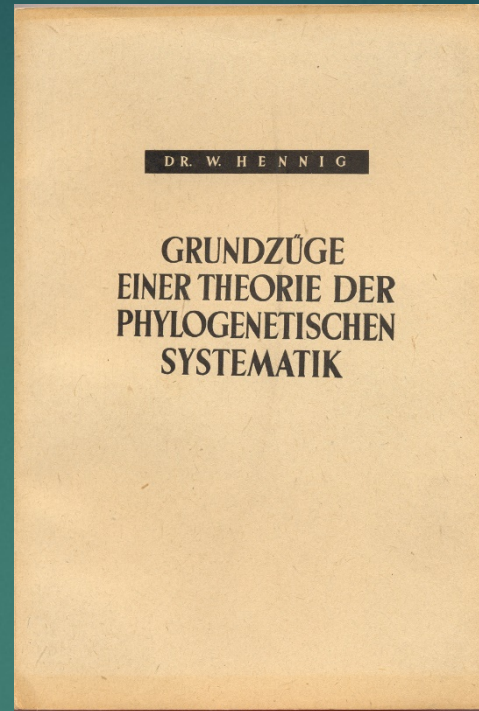
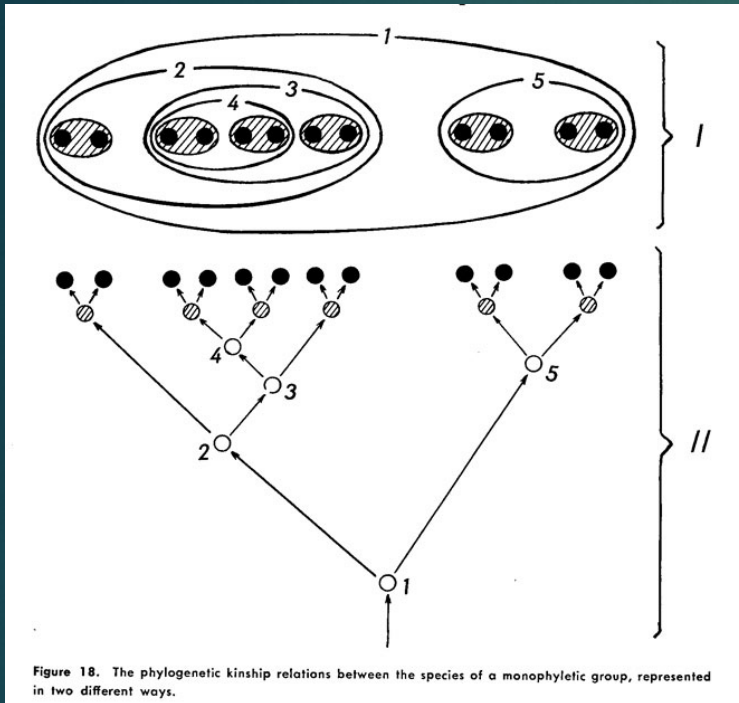
## 2) Critério de qualidade especial das estruturas.



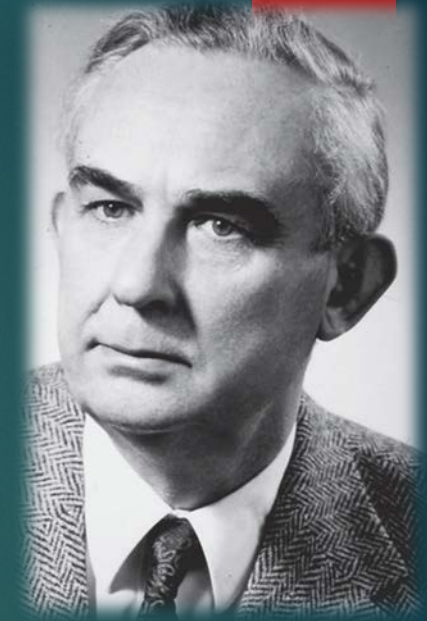
## 3) Critério de ligação por formas intermediárias (critério de continuidade) - ontogenia.



# HOMOLOGIA – O PARADIGMA FILOGENÉTICO

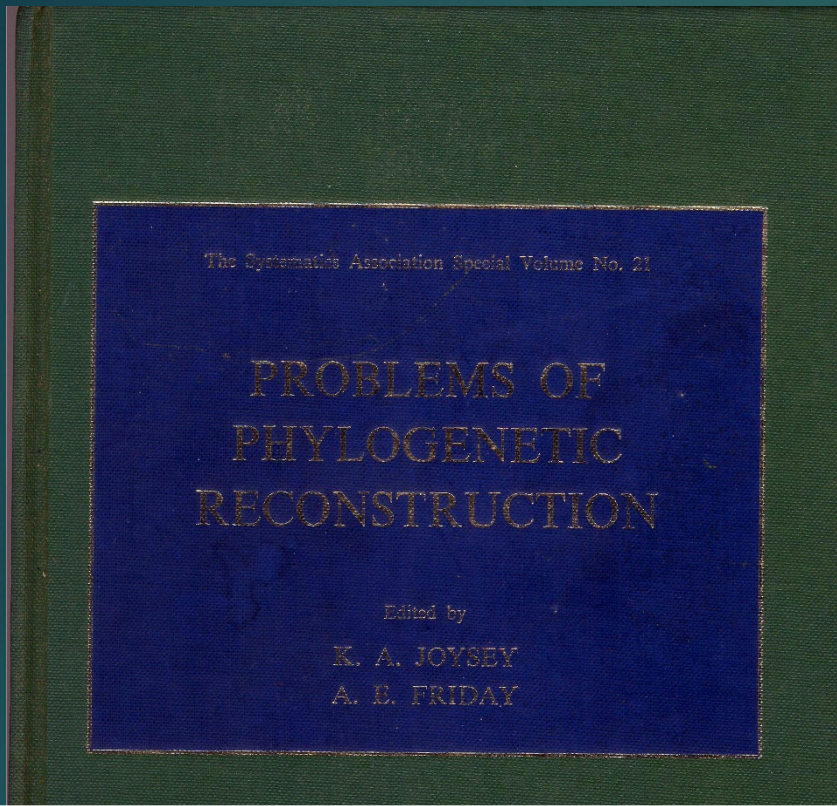


*Teoria geral da  
Sistemática Filogenética*  
(1950)



**Willi Hennig**  
(1913, Dürrhennersdorf - 1976)

- *Homologias* – características hipotéticas testadas por congruência com outras características, sendo derivadas de ancestral comum mais imediato (sinapomorfias, simplesiomorfias, *convergências*, *homoiologias* e *paralelismos* – *homoplasias*!)



**Colin Patterson**  
(1933, London -1998,  
London)  
*British Museum*

## 2. | Morphological Characters and Homology

COLIN PATTERSON

*Department of Palaeontology, British Museum (Natural History),  
London, England*

# HOMOLOGIA – O PARADIGMA FILOGENÉTICO

## 2. | Morphological Characters and Homology

COLIN PATTERSON

*Department of Palaeontology, British Museum (Natural History),  
London, England*

**Homologia = Sinapomorfia**

**- Plesiomorfias não são homologias**

**- Testes de Homologia:**

- **Similaridade** – correspondência topográfica, de forma e função

- **Conjunção** – co-ocorrência de dois caracteres (estados) tidos como homólogos no mesmo organismo não é possível

- **Congruência** – máxima compatibilidade de sinapomorfias (parcimônia)



**Colin Patterson**  
(1933, London -1998, London)  
*British Museum*





# HOMOLOGIA – O PARADIGMA FILOGENÉTICO

*Cladistics* (1991) 7:367–394

## CONCEPTS AND TESTS OF HOMOLOGU IN THE CLADISTIC PARADIGM

**Mário C. C. de Pinna**<sup>1</sup>

<sup>1</sup> *Department of Ichthyology, American Museum of Natural History,  
Central Park West at 79th Street, New York, NY 10024, U.S.A.*

and

*Department of Biology, City College, CUNY, New York, New York 10031, U.S.A.*

*Received 8 March 1991; accepted 22 August 1991*



**Mário C. C. de Pinna**  
(1966, Rio de Janeiro - )

Apenas o teste de congruência de Patterson (1982) é válido (parcimônia) para legitimar/validar uma homologia

**Etapa Conjectural – hipótese de homologia primária**

Teste de congruência

**Etapa Corroborada -> hipótese de Homologia secundária (sinapomorfia)**

# HOMOLOGIA – O PARADIGMA FILOGENÉTICO

## Homologia primária – estágio propositivo de homologia

Taxon	1	2	3	4	5	6	7	8	9	10
<i>Cambessedesia</i>	01	1	2	1	1	012	2	1	2	1
<i>Castratella</i>	2	0	1	1	1	1	3	0	3	1
<i>Chaetostoma</i>	0	1	2	0	0	012	0	0	0	0
<i>Eriocnema</i>	2	1	2	1	1	3	2	0	3	1
<i>Lavoisiera</i>	0	01	23	0	0	0	0	01	03	0
<i>Lithobium</i>	2	0	0	0	0	3	2	1	3	1
<i>Microlicia</i>	0	1	2	0	0	3	0	01	0	0
<i>Rhynchanthera</i>	0	01	2	0	0	012	0	0	0	0
<i>Siphanthera</i>	13	0	1	0	01	4	1	0	1	0
<i>Stenodon</i>	0	1	23	0	0	1	0	0	0	0
<i>Trembleya</i>	0	1	2	0	0	012	0	0	03	01
<i>Tibouchina</i>	01	0	12	0	0	0	4	0	2	1

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Pre (Chimp)	C	T	T	G	A	G	A	A	A	A	T	T	C	T	T	A	G	A	T	A
2 Pme (Lizard)	T	C	T	A	A	A	A	G	A	T	T	A	T	A	T	A	G	A	T	A
3 Pma (Human)	T	T	T	A	A	G	G	A	A	A	T	T	C	T	T	A	A	A	T	T
4 Pfa (Human)	T	T	T	G	A	G	A	A	A	A	T	T	C	T	T	A	G	A	T	A
5 Pbe (Rodent)	T	T	T	A	A	G	A	A	A	A	T	T	T	A	T	A	A	A	T	A
6 Plo (Bird)	T	T	T	A	A	G	A	A	A	A	C	T	C	A	C	A	A	A	T	C
7 Pfr (Monkey)	C	T	T	A	A	G	A	A	G	A	T	T	C	T	T	A	G	G	A	A
8 Pkn (Monkey)	C	T	T	A	A	G	A	A	A	G	T	T	C	T	T	A	G	A	T	A
9 Pcy (Monkey)	C	T	C	A	T	G	A	A	A	A	T	T	C	T	T	A	G	A	T	A
10 Pv (Human)	C	T	T	A	T	G	A	A	A	A	T	T	C	T	C	G	A	A	T	A
11 Pga (Bird)	T	T	T	A	A	G	A	A	A	A	T	T	T	T	C	A	A	A	T	C

## Homologia secundária – estágio testado (por congruência) da proposição de homologia primária => sinapomorfia

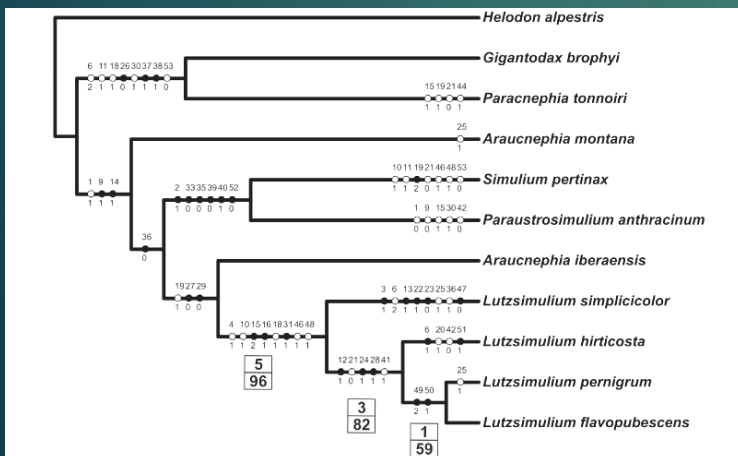
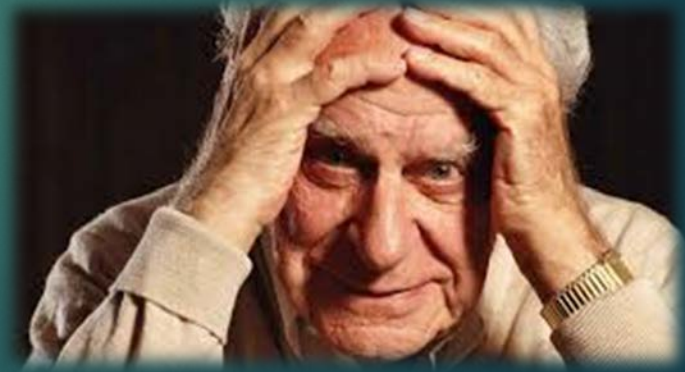


Figure 1. One of two trees obtained with maximum parsimony, unweighted characters, chosen to represent the phylogenetic relationships of the *Lutzsimulium* (81 steps, consistency index = 0.65 and retention index = 0.71, not considering the autapomorphic characters). Only unambiguous apomorphies are represented in the diagram; circles represents apomorphies (white = homoplastic; black = non-homoplastic); the numbers above the circles represent characters and the numbers below refer to character states. Branch support in the boxes: decay index (above) and bootstrap (below).



Karl R. Popper (1902, Vienna -1994, Londres)

# HOMOLOGIA – O PARADIGMA FILOGENÉTICO

O Cladismo transformado ou Cladismo de padrão – Uma ontologia incompatível com programa de pesquisa de Popper?

## PHILOSOPHY AND THE TRANSFORMATION OF CLADISTICS

NORMAN I. PLATNICK

### Abstract

Platnick, N. I. (Department of Entomology, The American Museum of Natural History, New York, New York 10024) 1979. *Philosophy and the transformation of cladistics*. *Syst. Zool.* 28:537–546.—Although Hennig presented cladistic methods by referring to a model of the evolutionary process, neither the value nor the success of the methods is limited by the value or success of that evolutionary model. Dichotomous cladograms can be preferred simply on the basis of their maximal information content, without reference to speciation mechanisms. Because only the interrelationships of diagnosable taxa (those with unique sets of apomorphic characters) can be investigated, questions about whether speciation can occur without branching, or whether species become extinct at branching points, are irrelevant to cladistic practice. The distinction between plesiomorphic and apomorphic character states depends not on the reconstruction of actual evolutionary history, but on the discrimination of more general from less general characters; groups based on plesiomorphy are defined by the absence of characters and are therefore artificial. Hence cladistic methods are not the methods of phylogenetics *per se*, but the methods of natural classification in general; phylogenetic conclusions are an extrapolation from hypotheses about natural order. [Cladistics; phylogenetics; characters; natural classification.]



**Norman I. Platnick**

(1951, Bluefield –2020, Filadélfia)

American Museum of Natural History

## FORUM

*Cladistics* 1(1):87–94

## PHILOSOPHY AND THE TRANSFORMATION OF CLADISTICS REVISITED

NORMAN I. PLATNICK<sup>1</sup>

<sup>1</sup>Department of Entomology, American Museum of Natural History, New York NY 10024

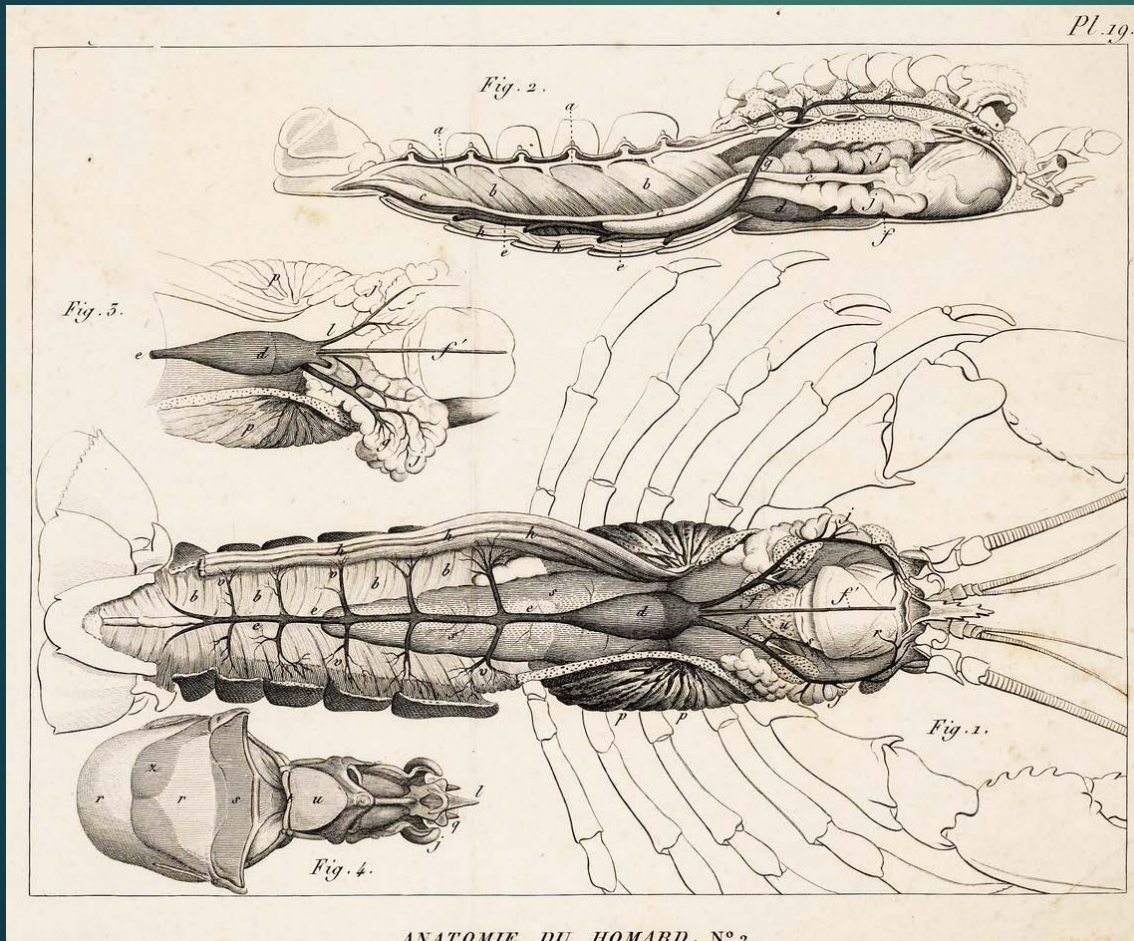
COLIN PATTERSON

British Museum (Natural History)  
Cromwell Road  
London SW7 5BD, England

*Syst. Zool.*, 31(3), 1982, pp. 284–286

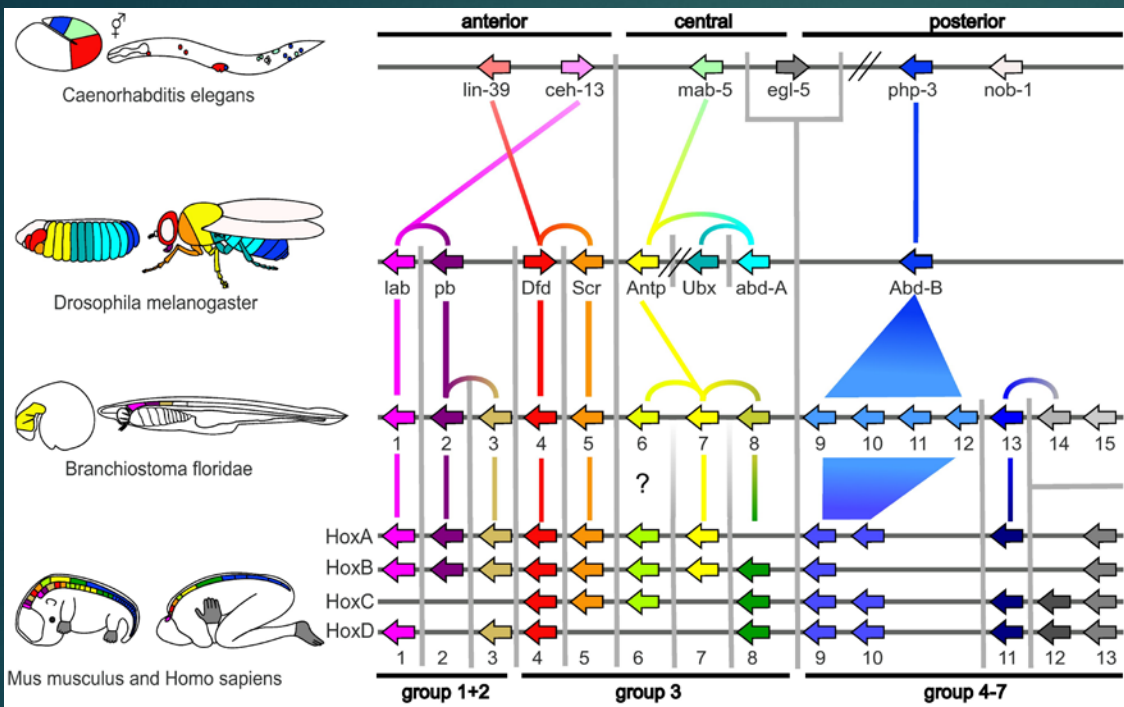
CLASSES AND CLADISTS OR INDIVIDUALS AND EVOLUTION

**Étienne Geoffroy Saint-Hilaire**  
(1772, Étampes—1844, Paris)  
Muséum national d'Histoire Naturelle



" [la fig. 2] est une coupe longitudinale du homard. Nous avons retourné l'animal et placé son ventre en haut et son dos en bas. Dans cette situation les systèmes organiques sont rangés comme chez les mammifères".

# EVO-DEVO – HOMOLOGIA PROFUNDA – UM NOVO PARADIGMA?



Genes *hox* homólogos controlam o desenvolvimento embrionário de diferentes animais, como insetos e vertebrados. Tais genes foram altamente conservados ao longo de centenas de milhões de anos.

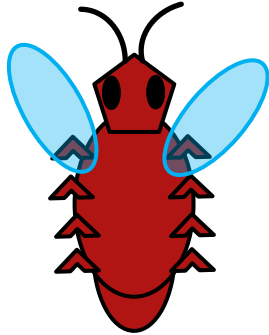
Alterações do gene *pax6* resultam em alterações fenotípicas semelhantes da morfologia função ocular em uma ampla gama de espécies.

	Human	Mouse	Zebrafish	<i>Drosophila</i>
WT				
mut				
	<b>PAX6<sup>-/-</sup></b>	<b>Pax6<sup>-/-</sup></b>	<b>pax6b<sup>-/-</sup></b>	<b>ey<sup>-/-</sup></b>
EQs	cornea opaca iris absent retina degenerate lens opaca aqueous humor of eyeball increased pressure	eye decreased size lens fused to cornea iris morphology absent	eye decreased size lens decreased size retina malformed	eye absent

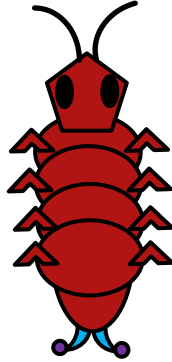


# HOMOLOGIA – EXERCÍCIO

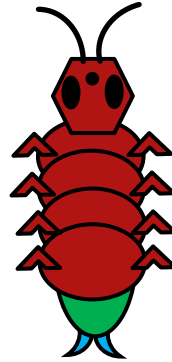
Grupo externo



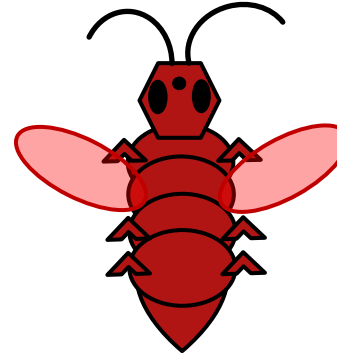
Espécie A



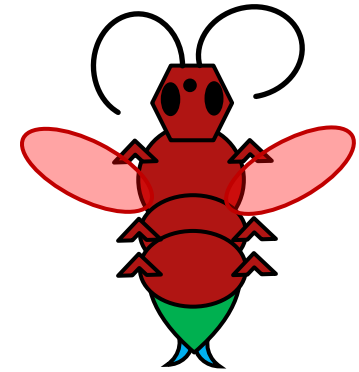
Espécie B



Espécie C



Espécie D



Caracteres	Estados		
1 - Aspecto do tronco	contínuo, com 2 segmentos (0)	com 4 segmentos (1)	com 5 segmentos (2)
2- Forma da cabeça	pentagonal (0)	hexagonal (1)	
3- Forma do último segmento do tronco	arredondado (0)	ponteagudo (1)	
4- Número de olhos	2 (0)	3 (1)	
5- Asa na região anterior do tronco	presente (0)	ausente (1)	
6- Asa na região mediana do tronco	ausente (0)	presente (1)	
7- Comprimento da antena	normal (0)	longa (1)	muito longa (2)
8 - Cor do segmento terminal	vermelha (0)	verde (1)	
9- Apêndice no último segmento	ausente (0)	presente (1)	
10- Processo arredondado no apêndice do último segmento	ausente (0)	presente (1)	