3 Adaptationism & niche construction

Stavros Ioannidis / MA Cont. Phil.

From Paley 1802, *Natural Theology*, ch. 1-3

For this reason, and for no other, viz. that, when we come to inspect the watch, we perceive (what we could not discover in the stone) that its several parts are framed and put together for a **purpose**, *e. g.* that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day etc. …

the inference, we think, is **inevitable**, that **the watch must have had a maker**: that there must have existed, at some time, and at some place or other, an **artificer** or artificers who **formed it for the purpose which we find it actually to answer;** who **comprehended** its construction, and **designed** its use. …

Nor, fourthly, would any man in his senses think the existence of the watch, with its various machinery, accounted for, by being told that it was **one out of possible combinations of material forms**; that whatever he had found in the place where he found the watch, must have contained some internal configuration or other; and that this configuration might be the structure now exhibited, viz. of the works of a watch, as well as a different structure.

Nor, fifthly, would it yield his inquiry more satisfaction to be answered, that there existed in things **a principle of order**, which had disposed the parts of the watch into their present form and situation. **He never knew a watch made by the principle of order**; nor can he even form to himself an idea of **what is meant by a principle of order, distinct from the intelligence of the watch-maker**. …

Neither, lastly, would our observer be driven out of his conclusion, or from his confidence in its truth, by being told that he knew nothing at all about the matter. He knows enough for his argument: he knows **the utility of the end**: he knows the **subserviency and adaptation of the means to the end.**

every indication of contrivance, every manifestation of design, which existed in the watch, **exists in the works of nature**; with the difference, on the side of nature, of being greater and more, and that **in a degree which exceeds all computation**.

From Darwin 1859, *Origin of Species*, Introduction

> In considering the Origin of Species, it is quite conceivable that a naturalist, reflecting on the **mutual affinities** of organic beings, on their **embryological relations**, their **geographical distribution**, **geological succession**, and other such facts, might come to the conclusion that each species **had not been independently created, but had descended, like varieties, from other species**.
>
> Nevertheless, such a conclusion, **even if well founded, would be unsatisfactory**, until it could be shown **how** the innumerable species inhabiting this world **have been modified**, **so as to acquire that perfection of structure and coadaptation** which most justly excites our admiration.

Naturalists continually refer to **external conditions**, such as climate, food, &c., as the only possible cause of variation. In one very limited sense, as we shall hereafter see, this may be true;

but it is **preposterous** to attribute to mere external conditions, **the structure, for instance, of the woodpecker**, with its feet, tail, beak, and tongue, **so admirably adapted to catch insects under the bark of trees.**

In the case of the **mistletoe**, which draws its nourishment from certain trees, which has seeds that must be transported by certain birds, and which has flowers with separate sexes absolutely requiring the agency of certain insects to bring pollen from one flower to the other, it is equally preposterous to account for the structure of this parasite, **with its relations to several distinct organic beings**, by the effects of external conditions, or of habit, or of the volition of the plant itself.

The author of the 'Vestiges of Creation' would, I presume, say that, after a certain unknown number of generations, **some bird had given birth to a woodpecker, and some plant to the misseltoe**, and that these had been **produced perfect** as we now see them; but this assumption seems to me to be **no explanation**, for it **leaves the case of the coadaptations of organic beings to each other and to their physical conditions of life, untouched and unexplained**.

It is, therefore, of the highest importance to gain a clear insight into the means of modification and coadaptation.

Adaptationism

Gould & Lewontin (1979):
The Spandrels of San Marco and the Panglossian Paradigm

Dr. Pangloss: 'Things cannot be other than they are. . . Everything is made for the best purpose. Our noses were made to carry spectacles, so we have spectacles. Legs were clearly intended for breeches, and we wear them'.

Voltaire, *Candide or Optimism*


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Gould & Lewontin against adaptationism

-Adaptive vs **Adaptation**

-> importance of **evolutionary history** before offering an adaptive explanation

-> it is not the case that every character exists **because it is useful** (spandrels, vestigial traits, hitchhikers, exaptation, developmental constraints)

-ignoring **non-adaptationist** explanations
-> e.g. skeletal structure of tetrapod limbs
-> adaptationist -> organisms as a mosaic of distinct traits

-The adaptationist programme is **not falsifiable**
-> just-so stories -> how-possibly explanations

Kinds of adaptationism

-> **Empirical** adaptationism
-natural selection the cause for most traits

-> **Explanatory** adaptationism
-explanation of adaptations is the central problem in biology

-> **Methodological** adaptationism
-the study of good design as the best method of studying organisms

Kinds of adaptationism

Godfrey-Smith (2001, 336) on **empirical adaptationism**:

"Natural selection is a **powerful and ubiquitous force**, and there are **few constraints** on the biological variation that fuels it. To a large degree, it is possible to predict and explain the outcome of evolutionary processes by attending only to the role played by **selection**. No other evolutionary factor has this degree of causal importance."

Kinds of adaptationism

Godfrey-Smith (2001, 336) on **explanatory adaptationism**:

"The apparent **design** of organisms, and the relations of **adaptedness** between organisms and their environments, are the **big questions, the amazing facts in biology**. Explaining these phenomena is the core intellectual mission of evolutionary theory. Natural selection is the key to solving these problems; selection is the **big answer**. Because it answers the biggest questions, selection has **unique** explanatory importance among evolutionary factors."

Kinds of adaptationism

Godfrey-Smith (2001, 337) on **methodological adaptationism**:

"The best way for scientists to approach biological systems is to look for features of adaptation and good design. Adaptation is a good 'organizing concept' for evolutionary research."

Kinds of adaptationism

-> an **empirical argument** against Explanatory Adaptationism

Amundson (1998):
constraints on **adaptation** vs constraints on **form**

-typical example: maintaining common structural designs in very different organisms

-Gould: 'persistence of Type' equally important problem, that cannot be solved by the theory of natural selection

-BUT: stabilising selection / chance -> explanations for the conservation of body plans?

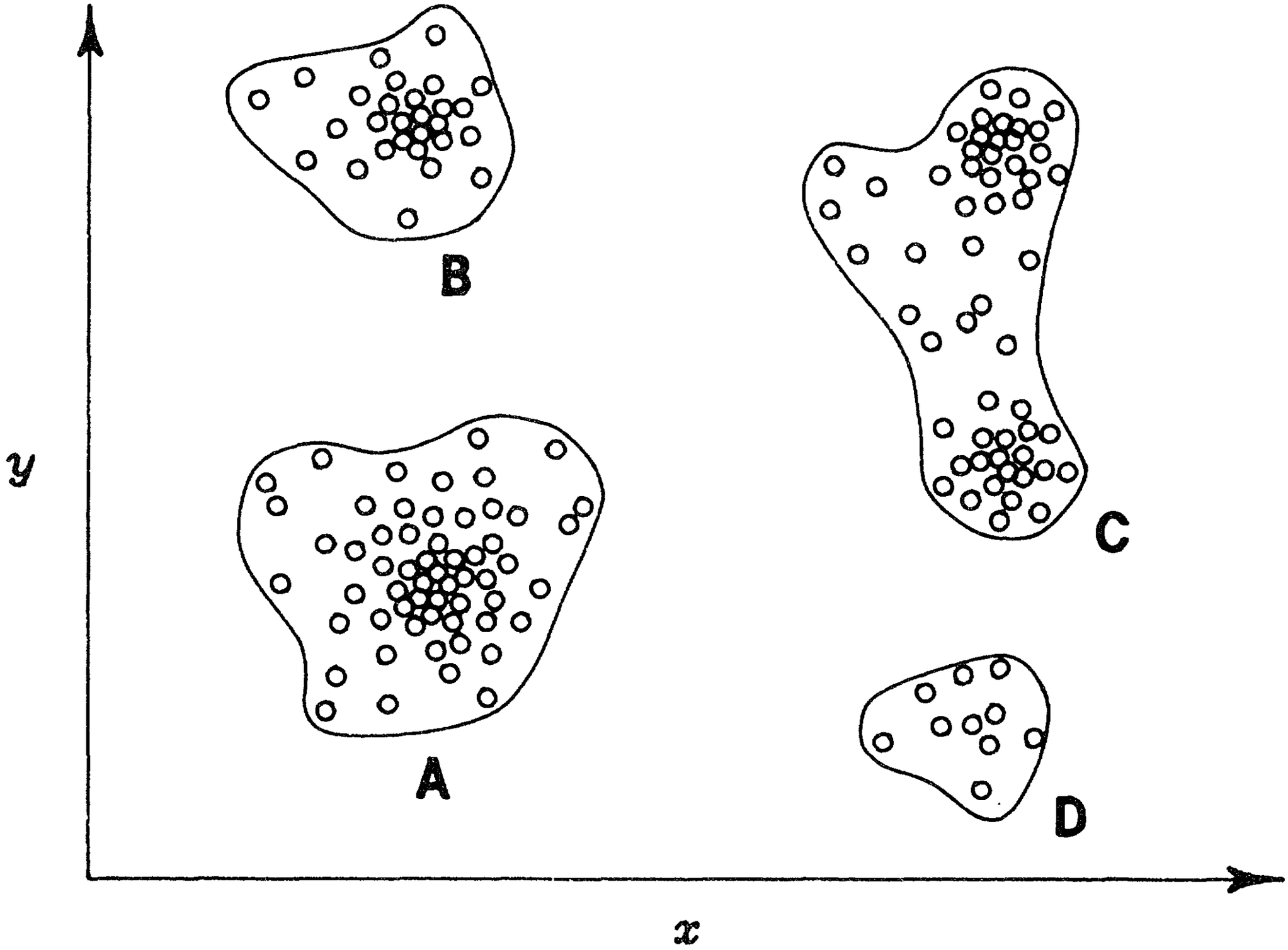


Figure 3.1. The clustering of organisms in morphospace. From P. Alberch's "Developmental Constraints in Evolutionary Processes" in J. T. Bonner, (ed.), *Evolution and Development*. Copyright © 1982 by Springer-Verlag. Reprinted by permission.

εικόνες 3.1 - 3.3 από Amundson 1994

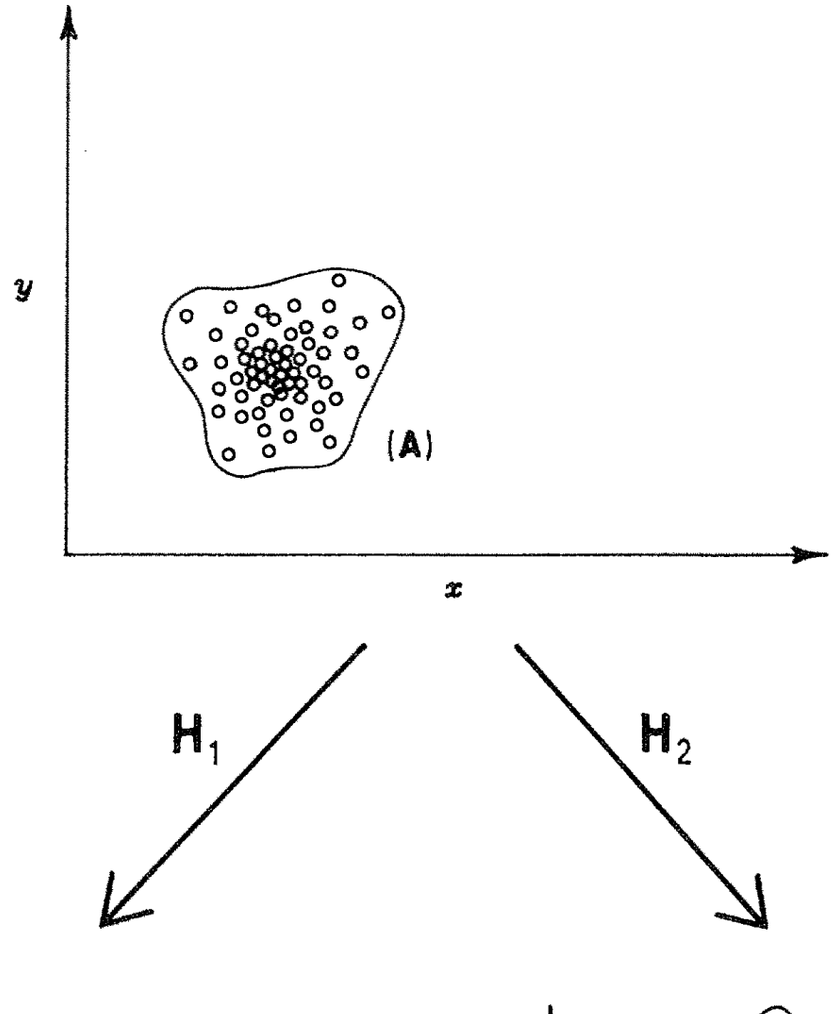


Figure 3.2. Two hypotheses on the effects of removing natural selection from a population. From P. Alberch's "Developmental Constraints in Evolutionary Processes" in J. T. Bonner, (ed.), *Evolution and Development*. Copyright © 1982 by Springer-Verlag. Reprinted by permission.

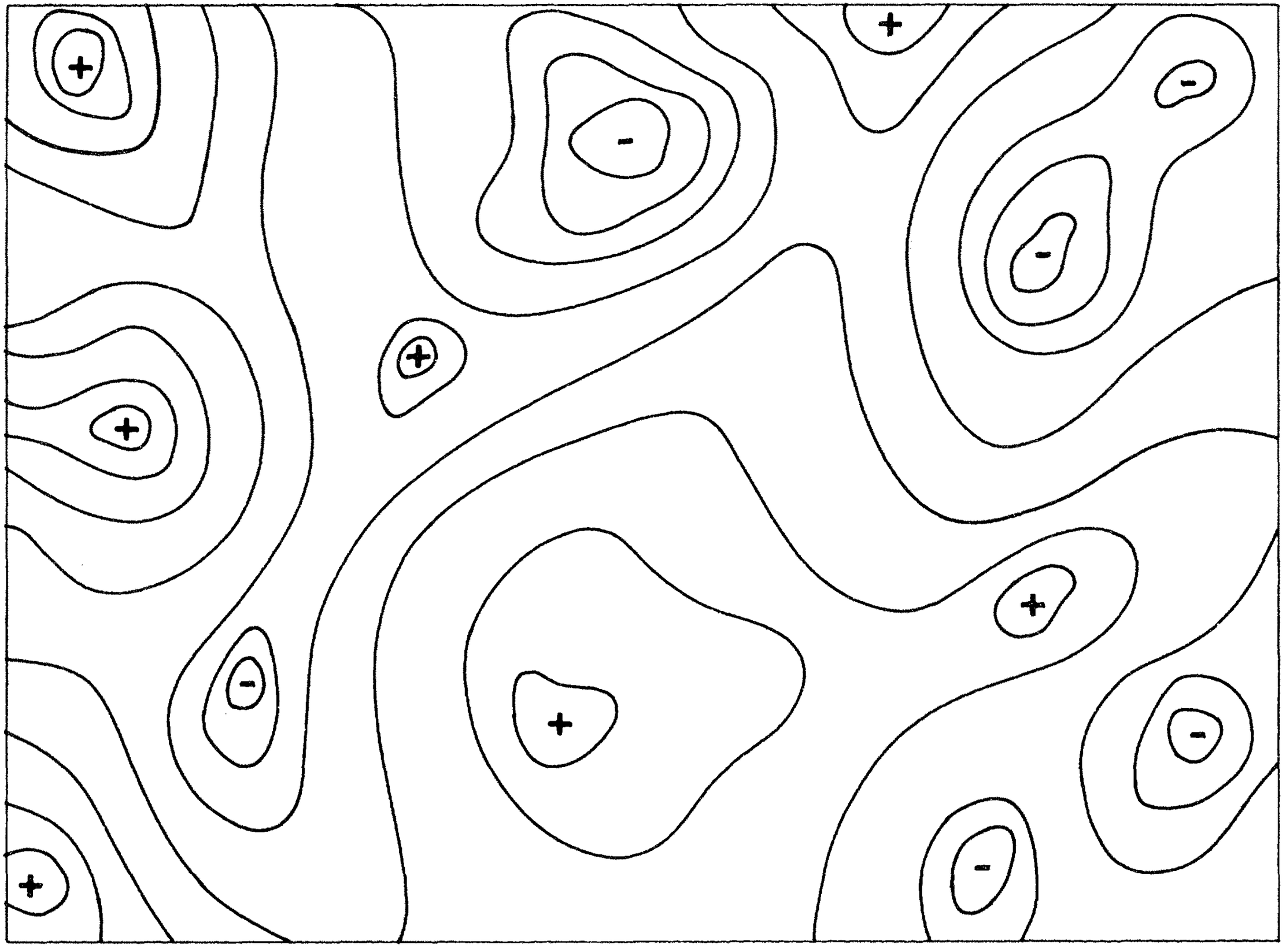


Figure 3.3. An example of an adaptive landscape in the sense of S. Wright. The x and y axes would represent genetic space. Contour lines connect points of equal adaptive value; plusses and minuses are areas of high and low adaptivity.

Kinds of adaptationism

-> a **conceptual argument** against Explanatory Adaptationism

-independent characterisation of complex adaptations necessary (i.e. independently of the action of natural selection)

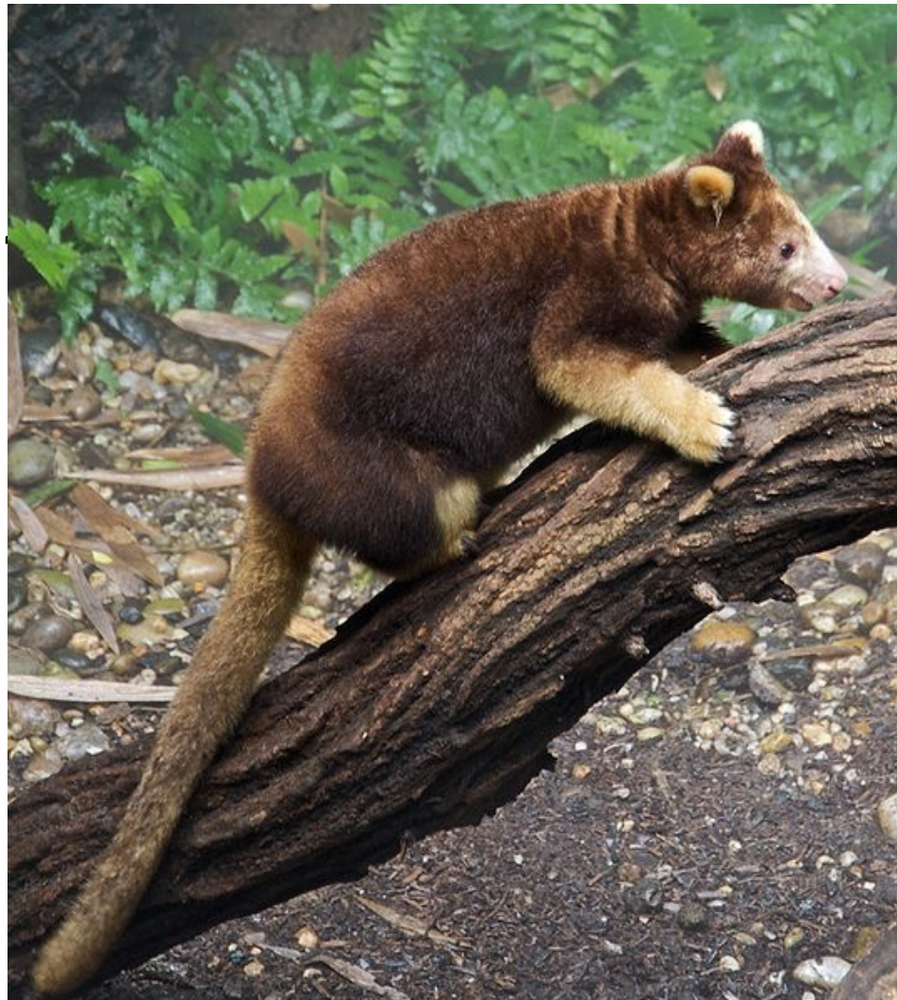
Kinds of adaptationism

-> problems for <u>Empirical</u> Adaptationism

-selection, **history** of evolutionary lineage and **chance** are factors to explain adaptations

-why selection more important?
-and how exactly can we test such claims?

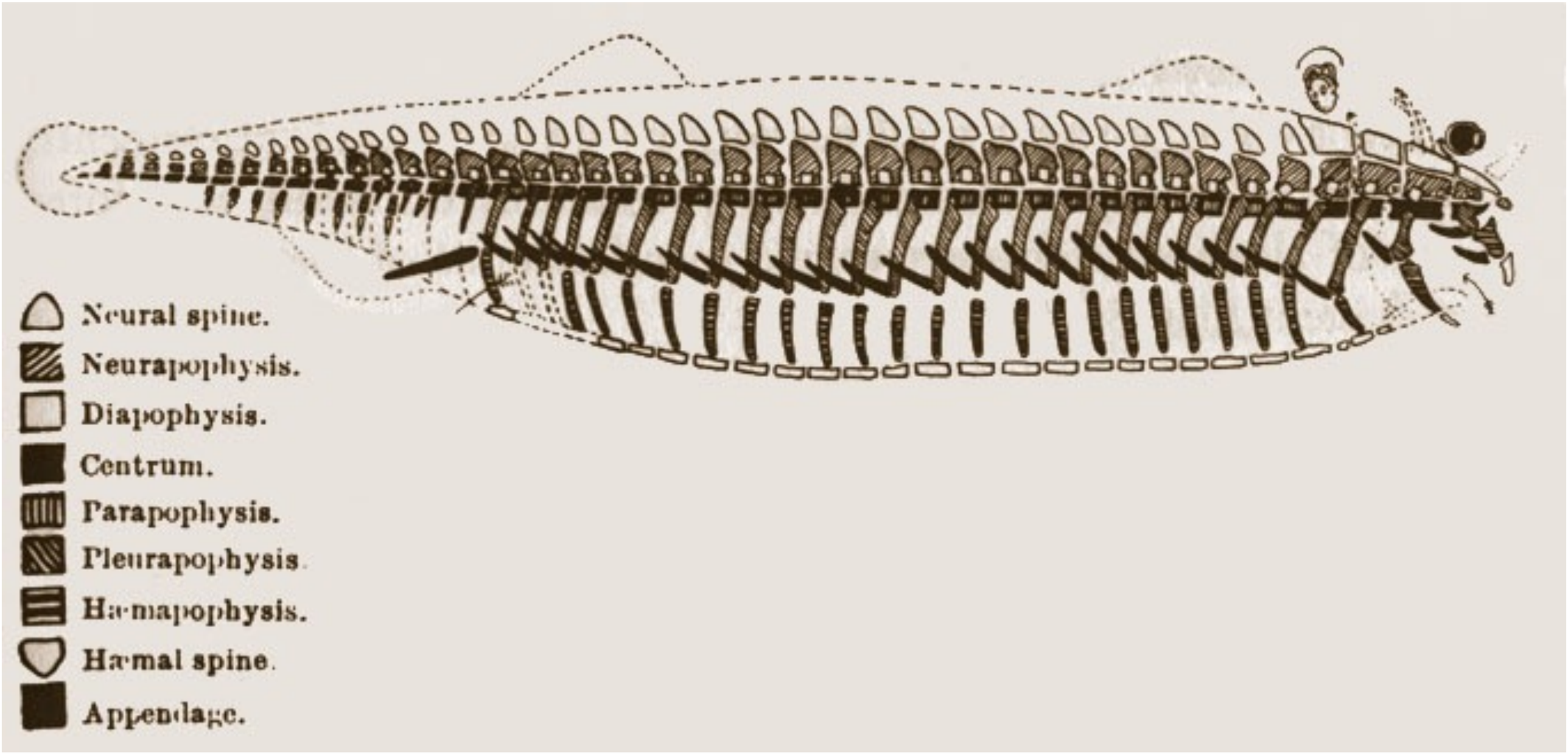
-> Sterelny & Griffiths



Structuralism and the concept of the Bauplan

-Bauplan - body plan

-> explanation through classification



The vertebrate archetype skeleton by Owen. On the next page, the archetype along with fish, reptile, bird, mammal, and human skeletons. From Owen's *On the Archetype and Homologies of the Vertebrate Skeleton* (London: Van Voorst, 1848), plate II.

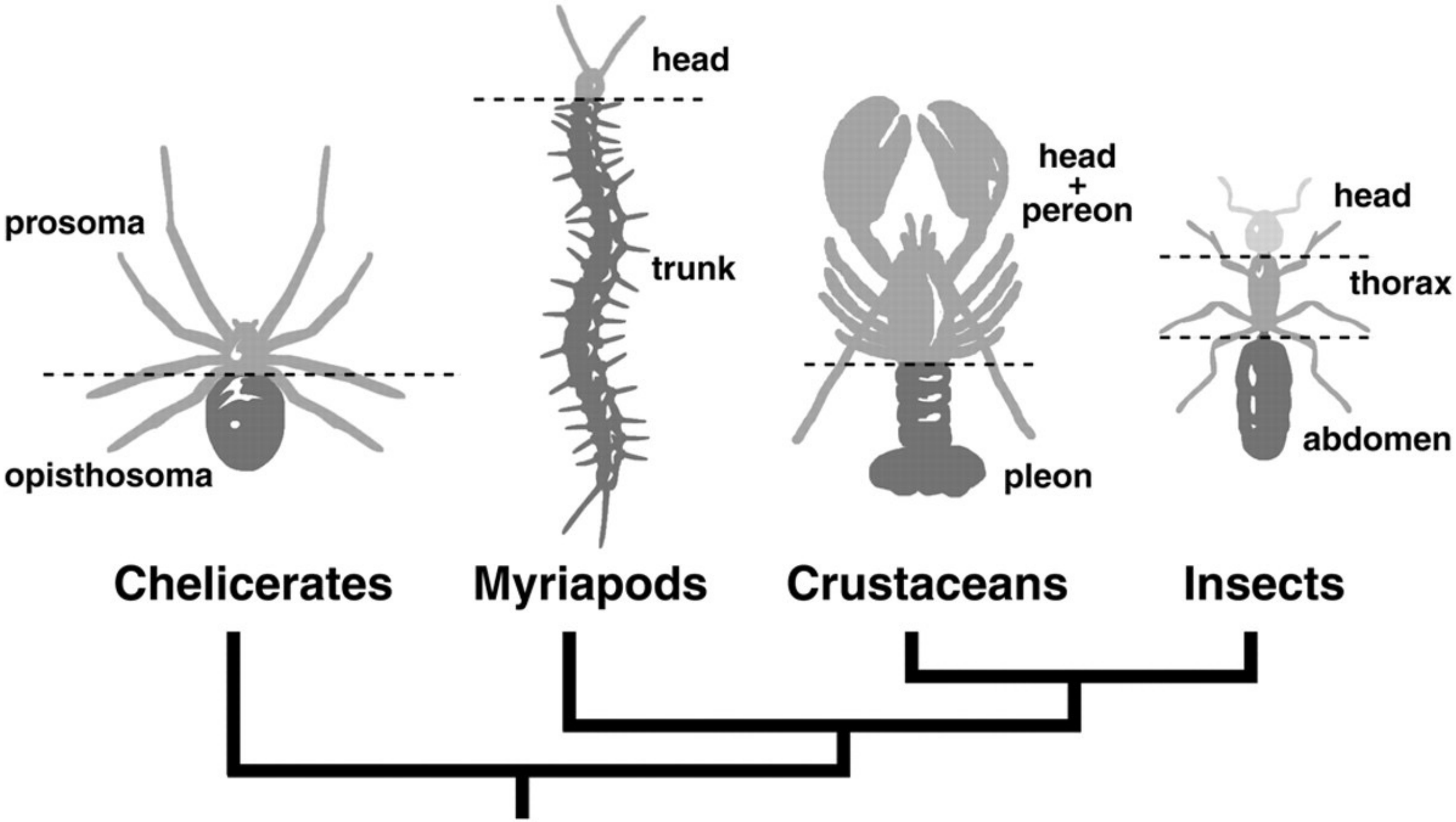
Fig. 1 Urtelotypus.

Fig. 2 Bos.

Fig. 3. Equidum

Fig. 4 Ursus

Fig. 5 Mammale


prosoma
opisthosoma
head
trunk
head
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thorax
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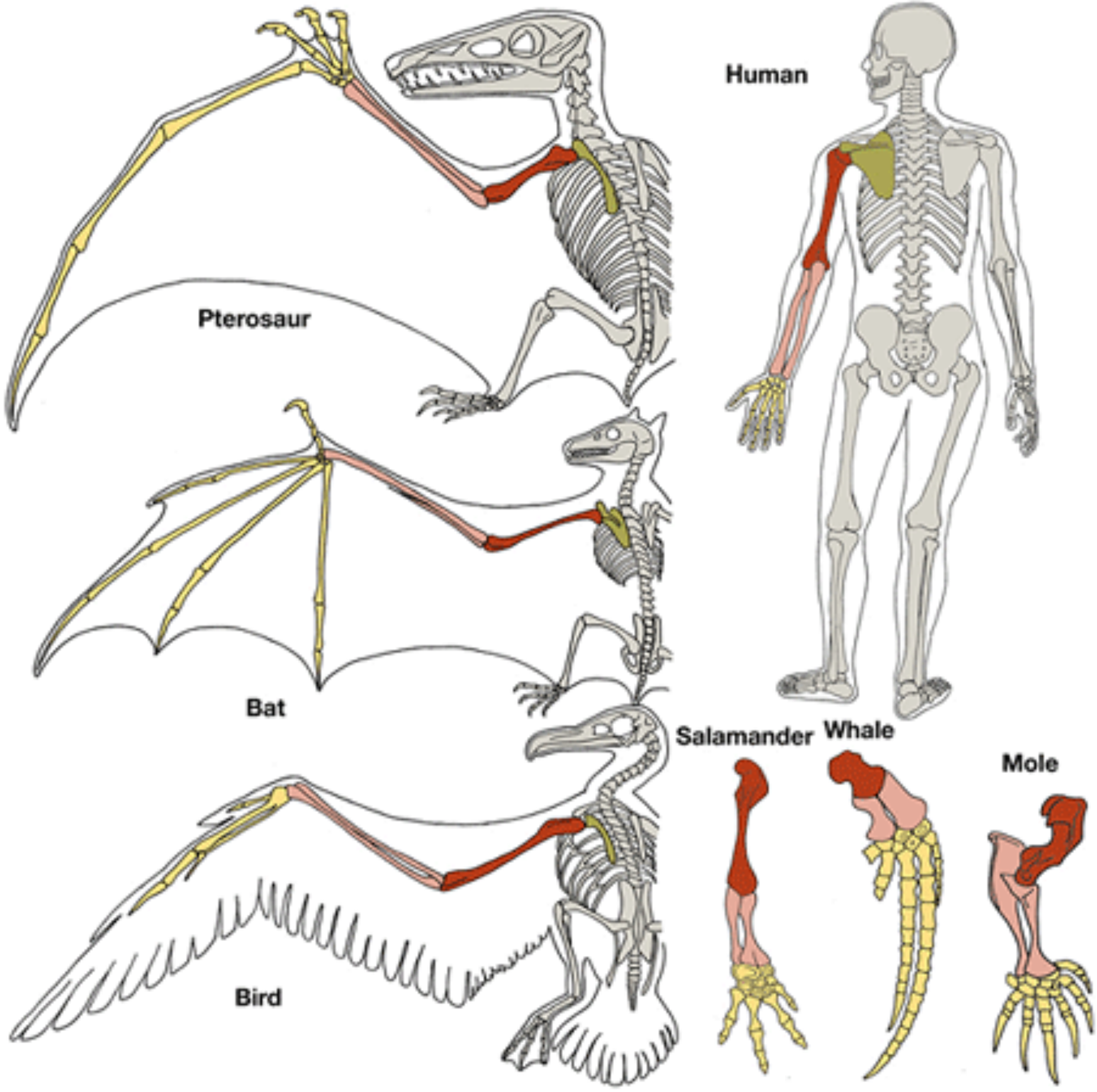
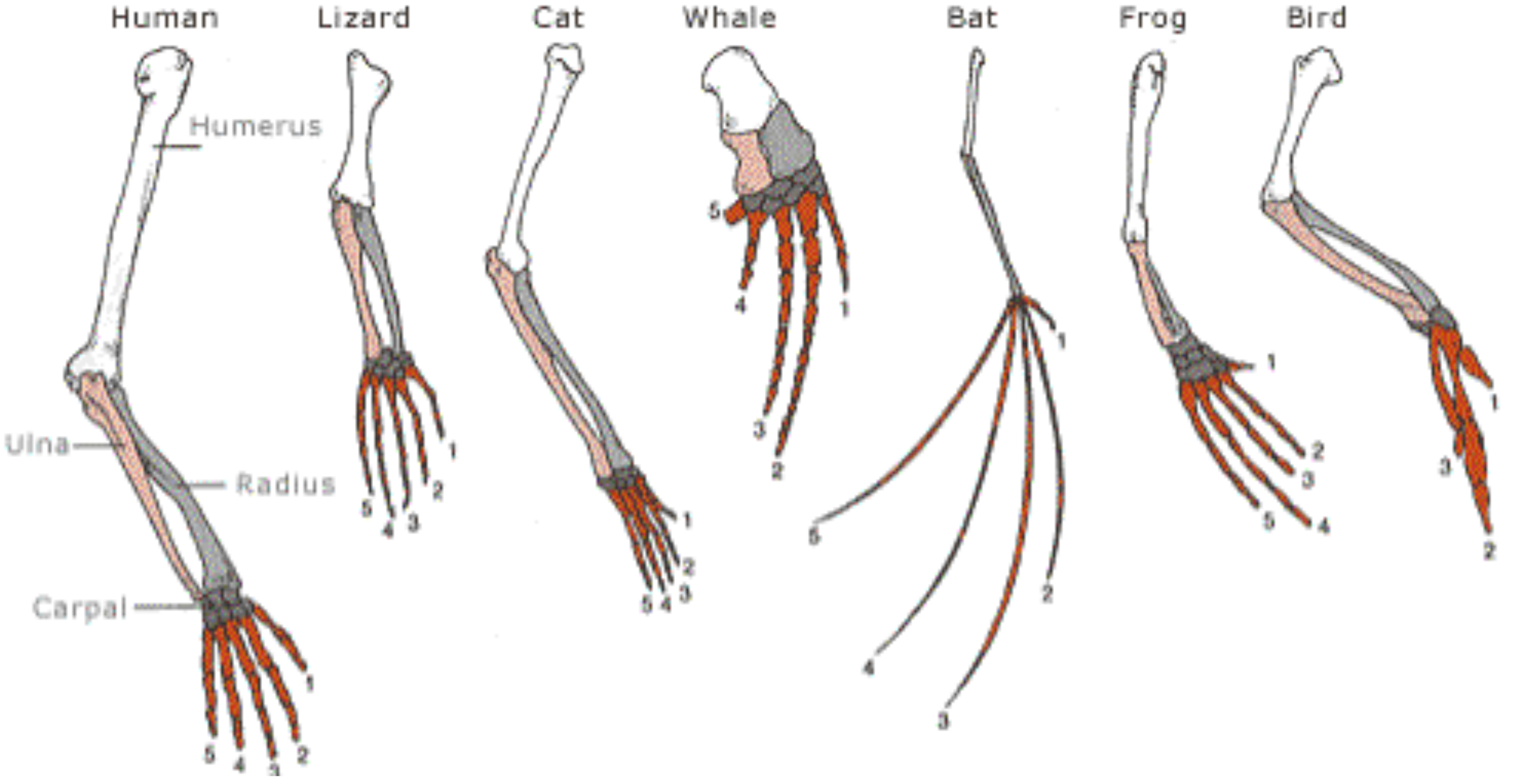
Chelicerates
Myriapods
Crustaceans
Insects

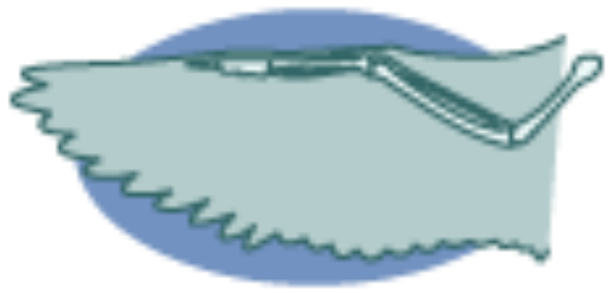

Pterosaur
Bat
Bird
Human
Salamander
Whale
Mole


Human
Lizard
Cat
Whale
Bat
Frog
Bird
Humerus
Ulna
Radius
Carpal

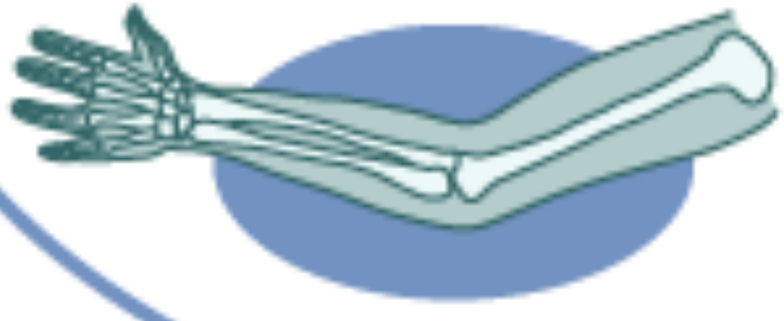
Homologous

lizard

bird



human

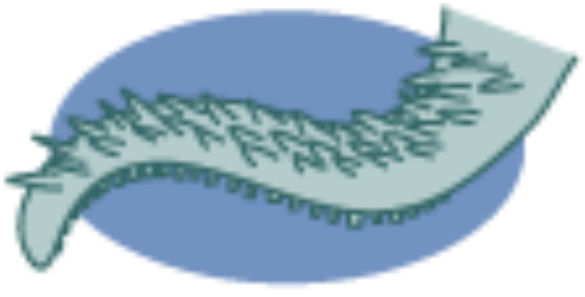


whale

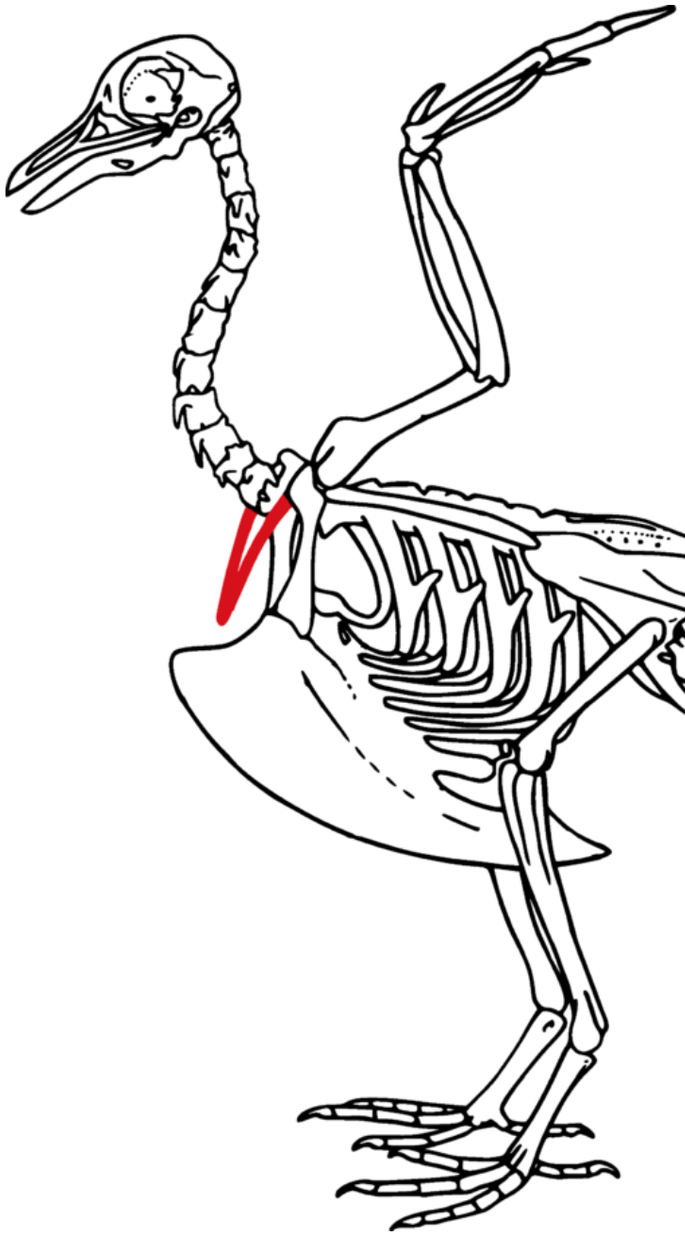
Not homologous

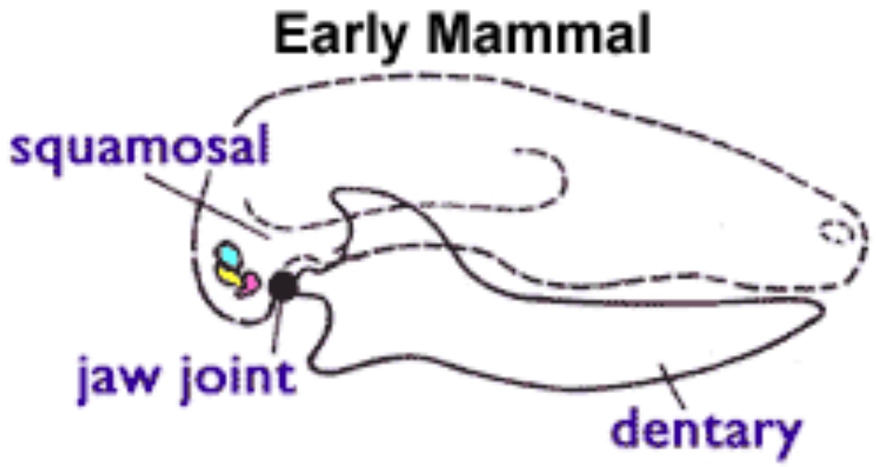
octopus

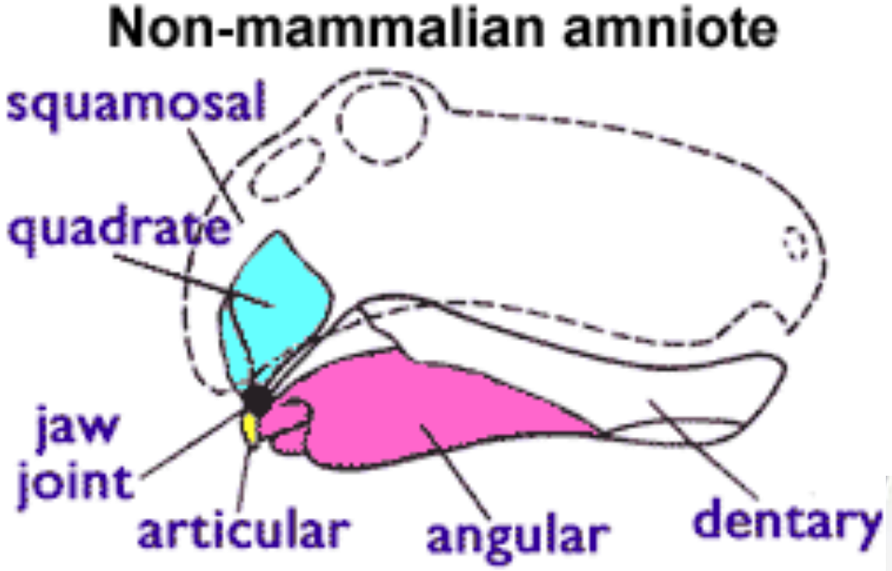
sea star

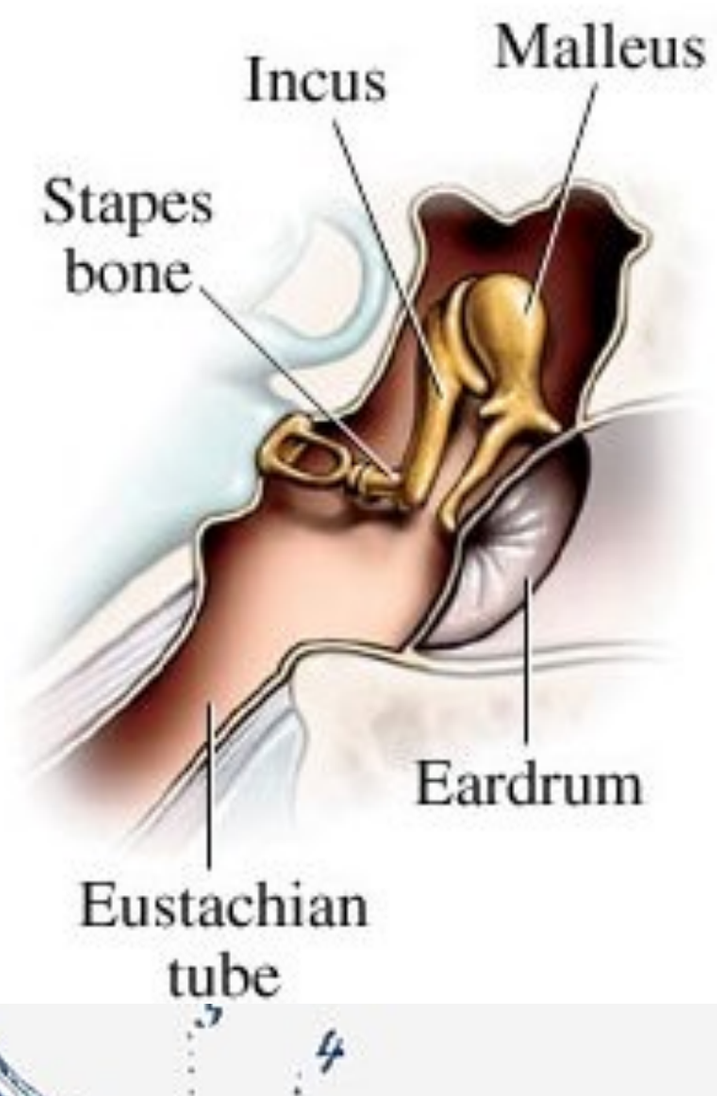


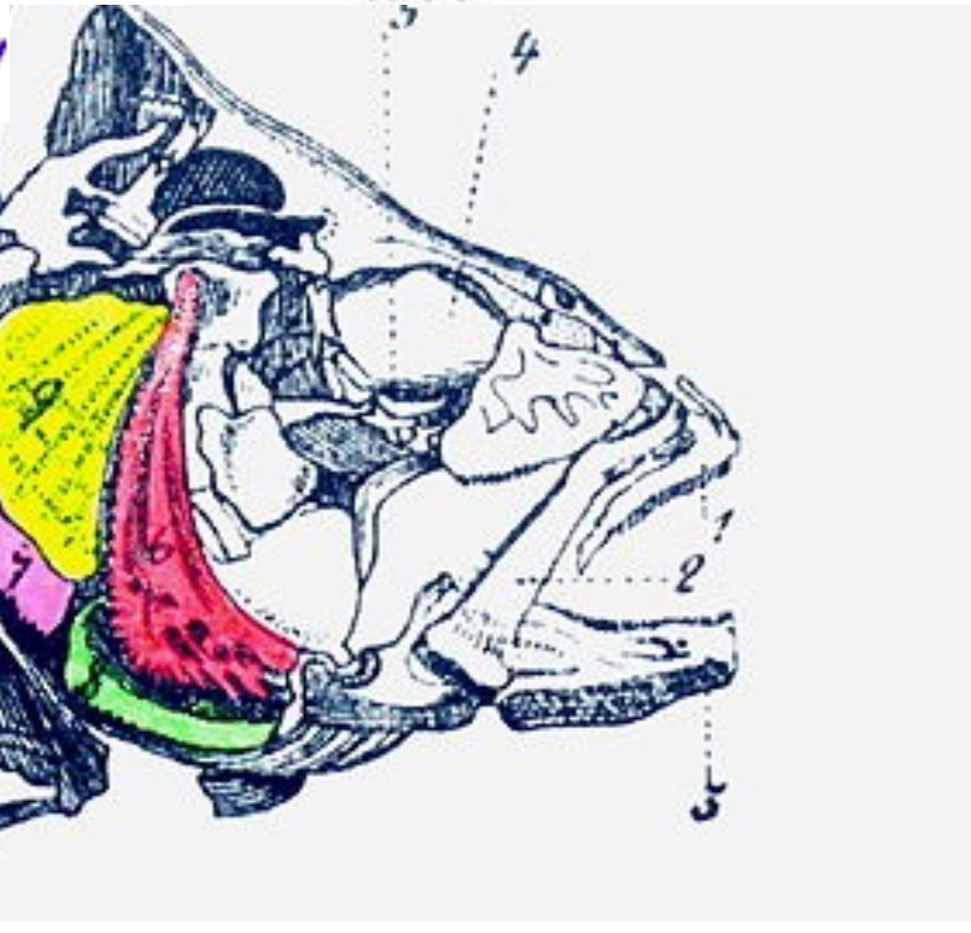
grasshopper




Early Mammal
squamosal
jaw joint
dentary


Non-mammalian amniote
squamosal
quadrate
jaw joint
articular
angular
dentary


Malleus
Incus
Stapes bone
Eardrum
Eustachian tube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It is generally acknowledged that all organic beings have been formed on two great laws-**Unity of Type** and the **Conditions of Existence.** By unity of type is meant that **fundamental agreement in structure**, which we see in organic beings of the **same** class, and which is **quite independent** of their habits of life. On my theory, unity of type is explained by **unity of descent.** The expression of conditions of existence, so often insisted upon by the illustrious Cuvier, is fully embraced by **the principle of natural selection.** For natural selection acts by either **now adapting** the varying parts of each being to its organic conditions of life; or by **having adapted** them in long-past periods of time.

Hence, in fact, the law of the Conditions of Existence is the **higher law;** as it includes, **through the inheritance of former adaptations**, that of Unity of Type.

(Darwin 1859, 206)

Structuralism and the concept of the Bauplan

-Evo-devo (evolutionary developmental biology)

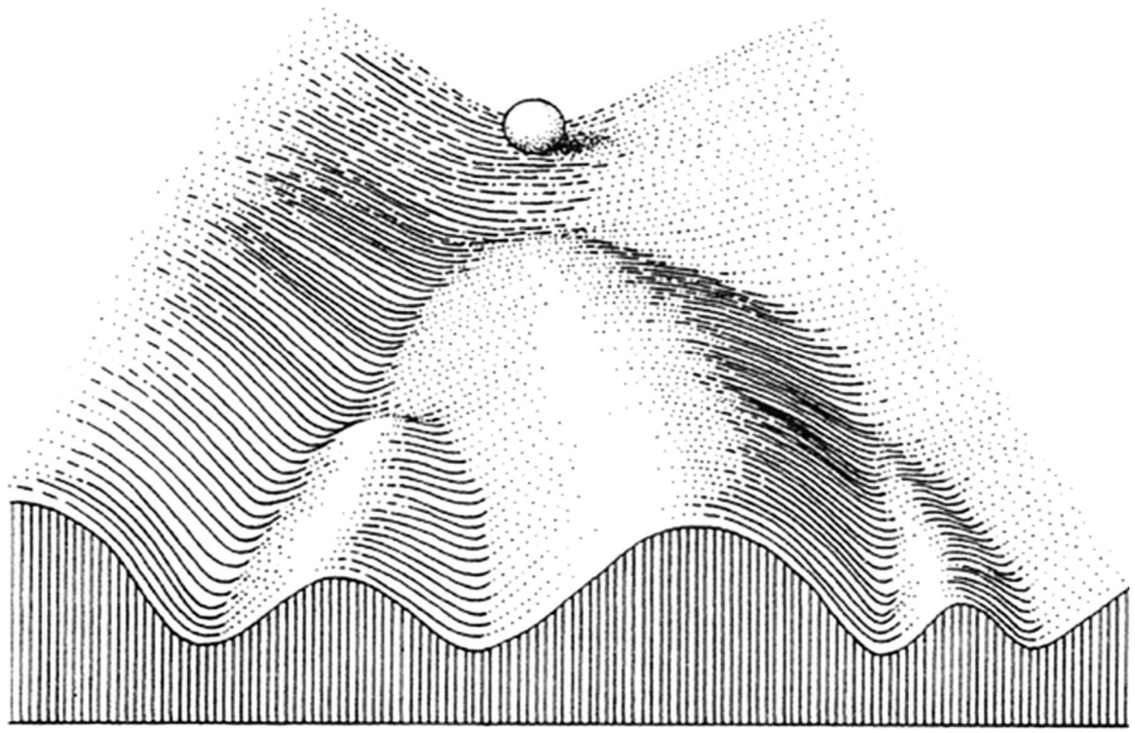
-Amundson: started as adaptations, but <u>are retained for non-adaptationist reasons</u>

-> importance of developmental biology
- **developmental constraints**

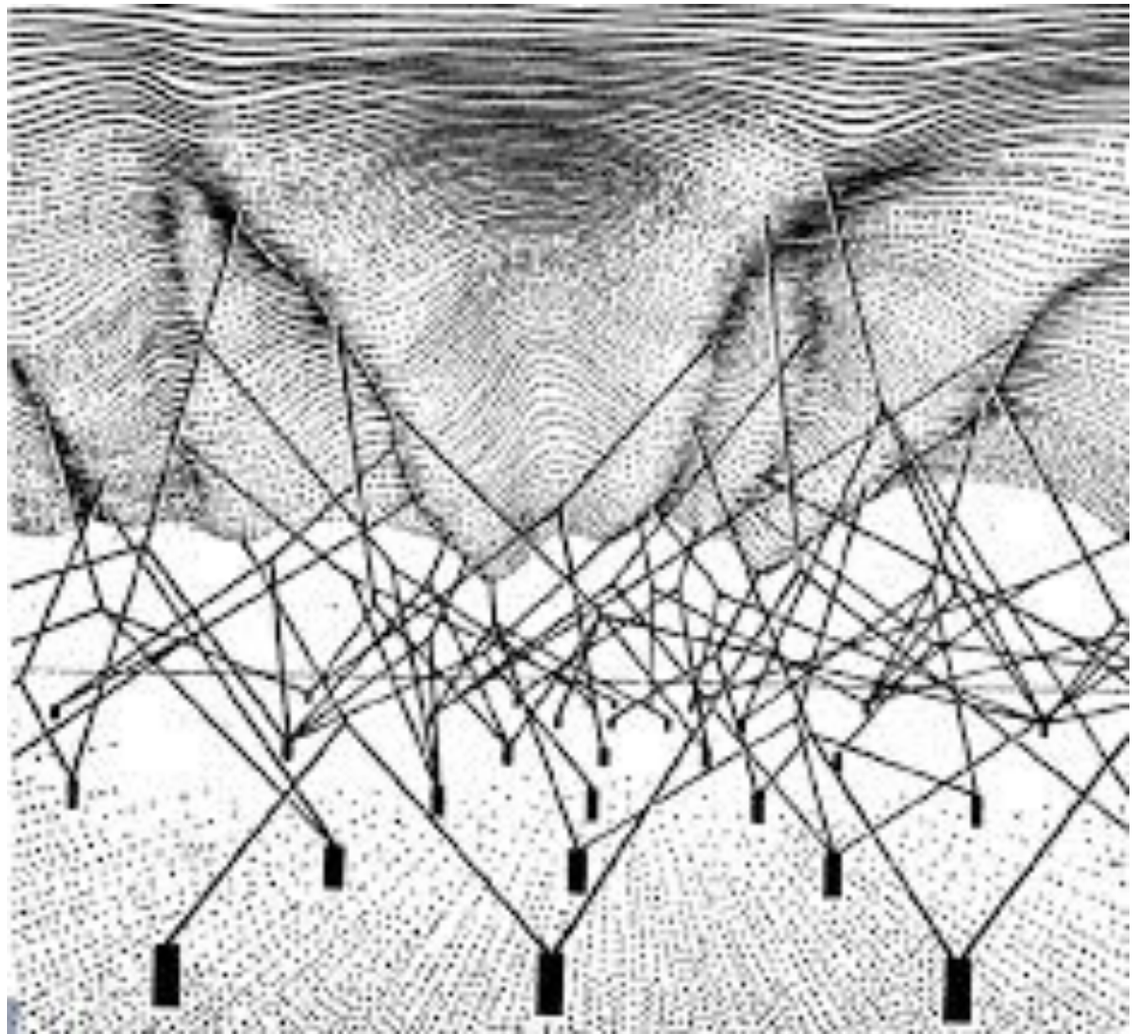
-characters that are preserved not because of a specific environment and NS, but because of how the body plan is developed

Structuralism and the concept of the Bauplan

Waddington
-> developmental canalization

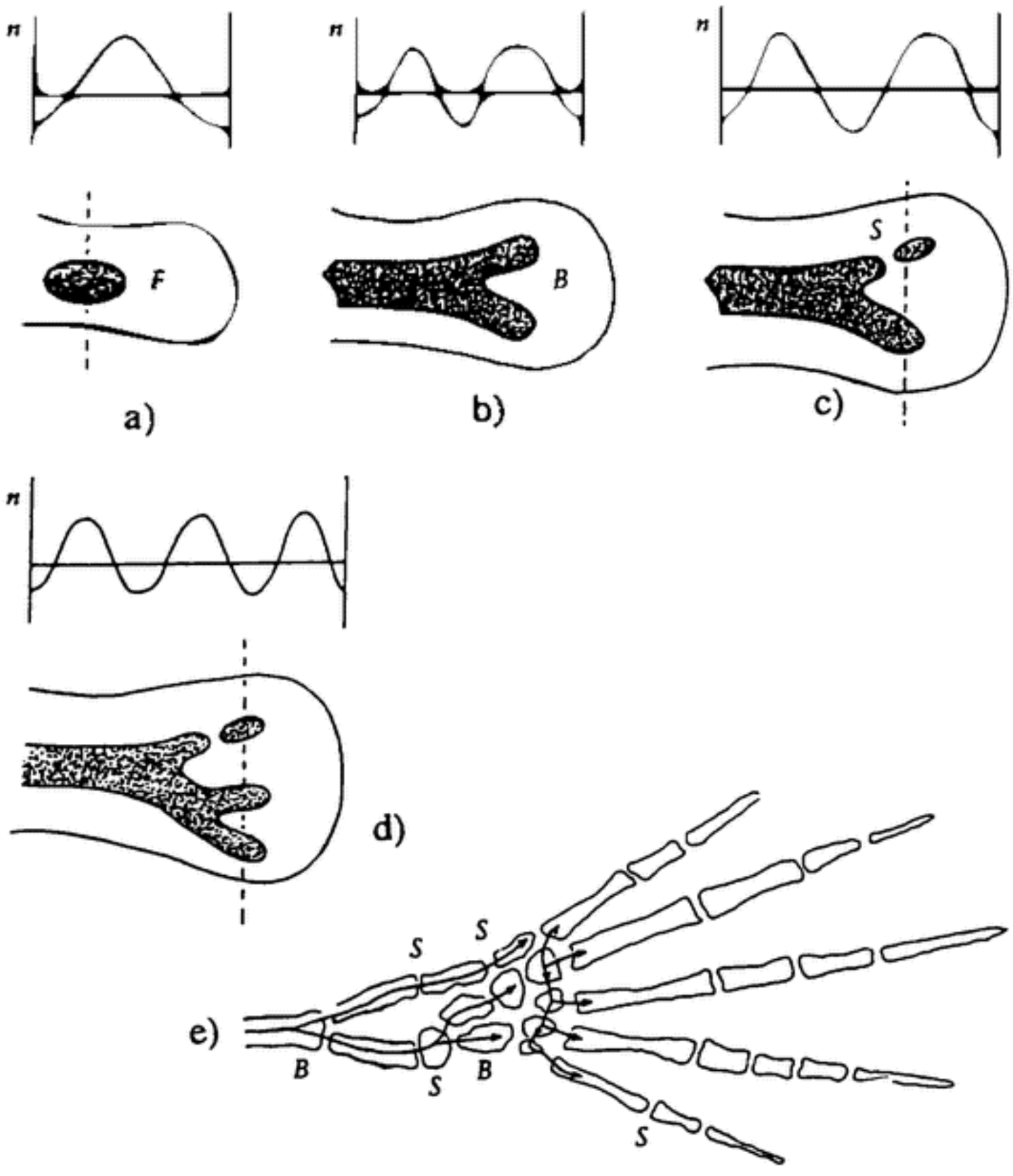


Wimsatt
-> generative entrenchment

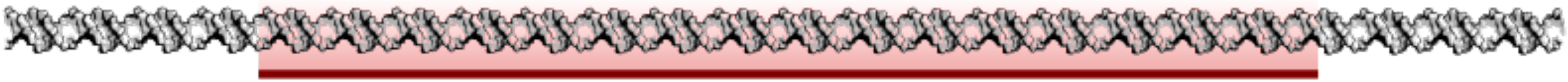


Structuralism and the concept of the Bauplan

-process structuralism



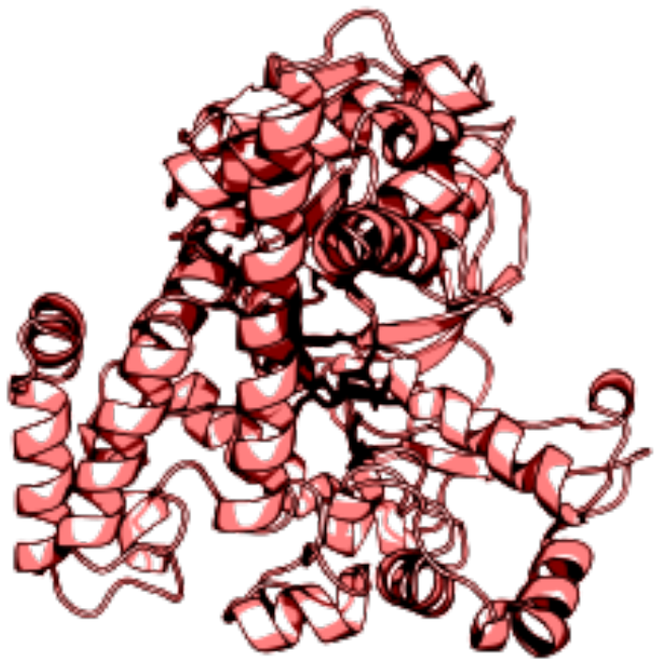
DNA



Gene

mRNA

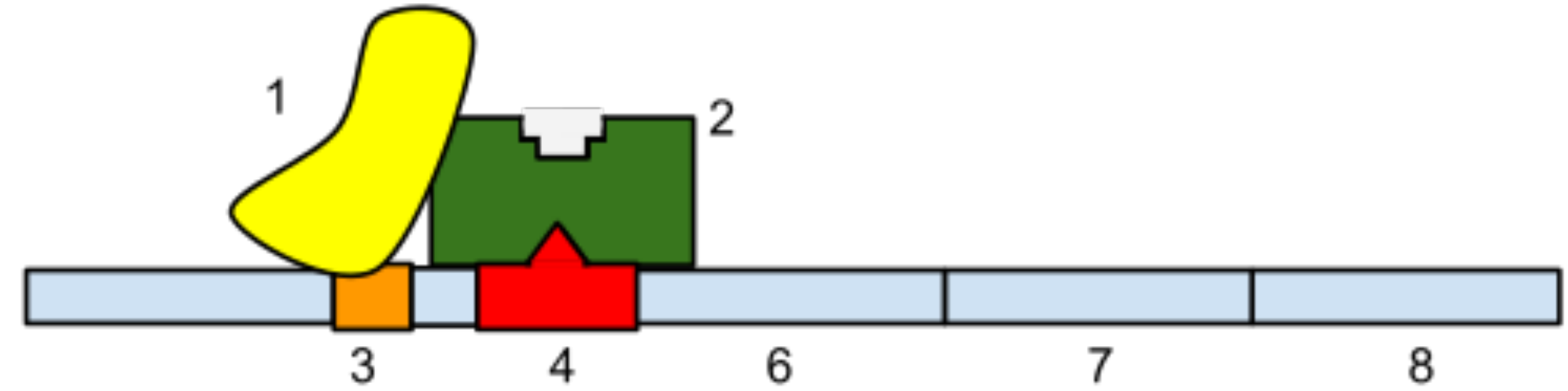
Protein



Function

ncRNA

Function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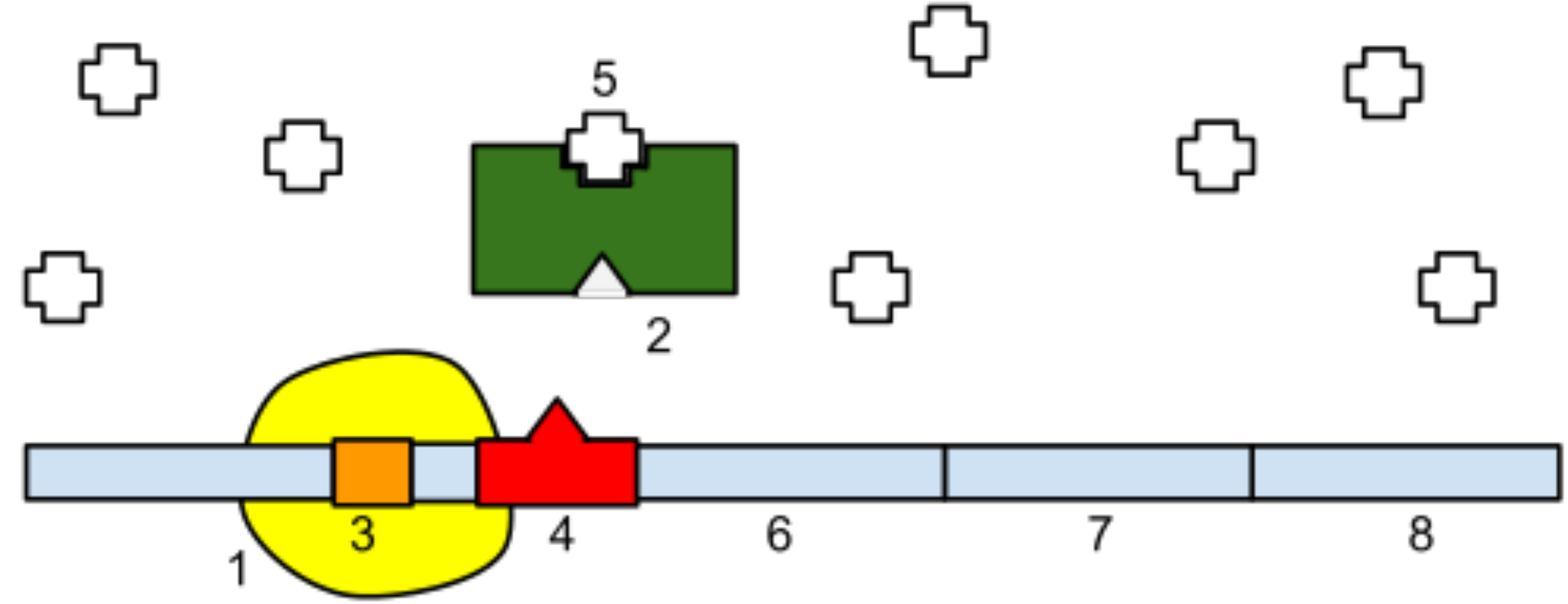
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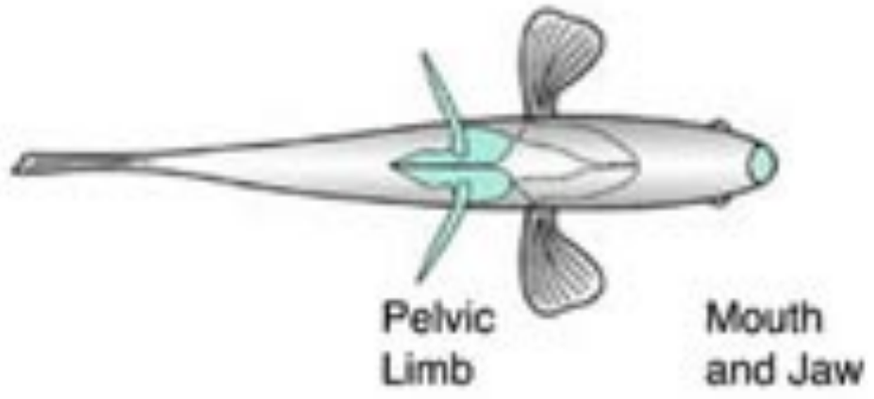
Marine

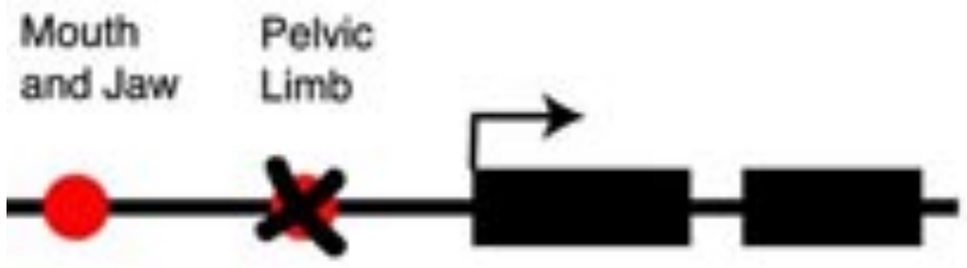
Freshwater

Marine Stickleback Pitx1 Gene

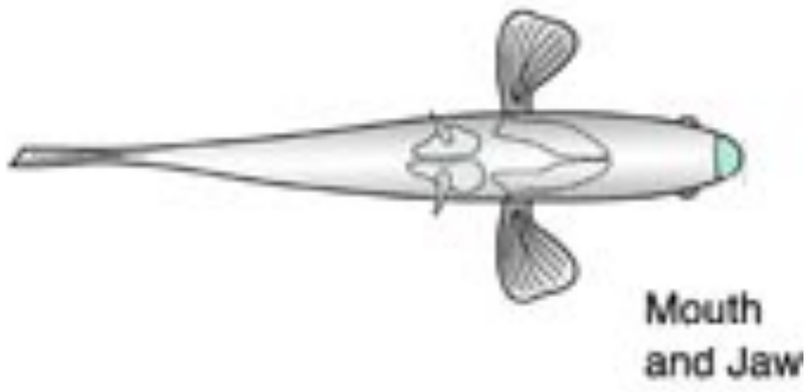
In Marine Sticklebacks Pitx1 Gene is turned on

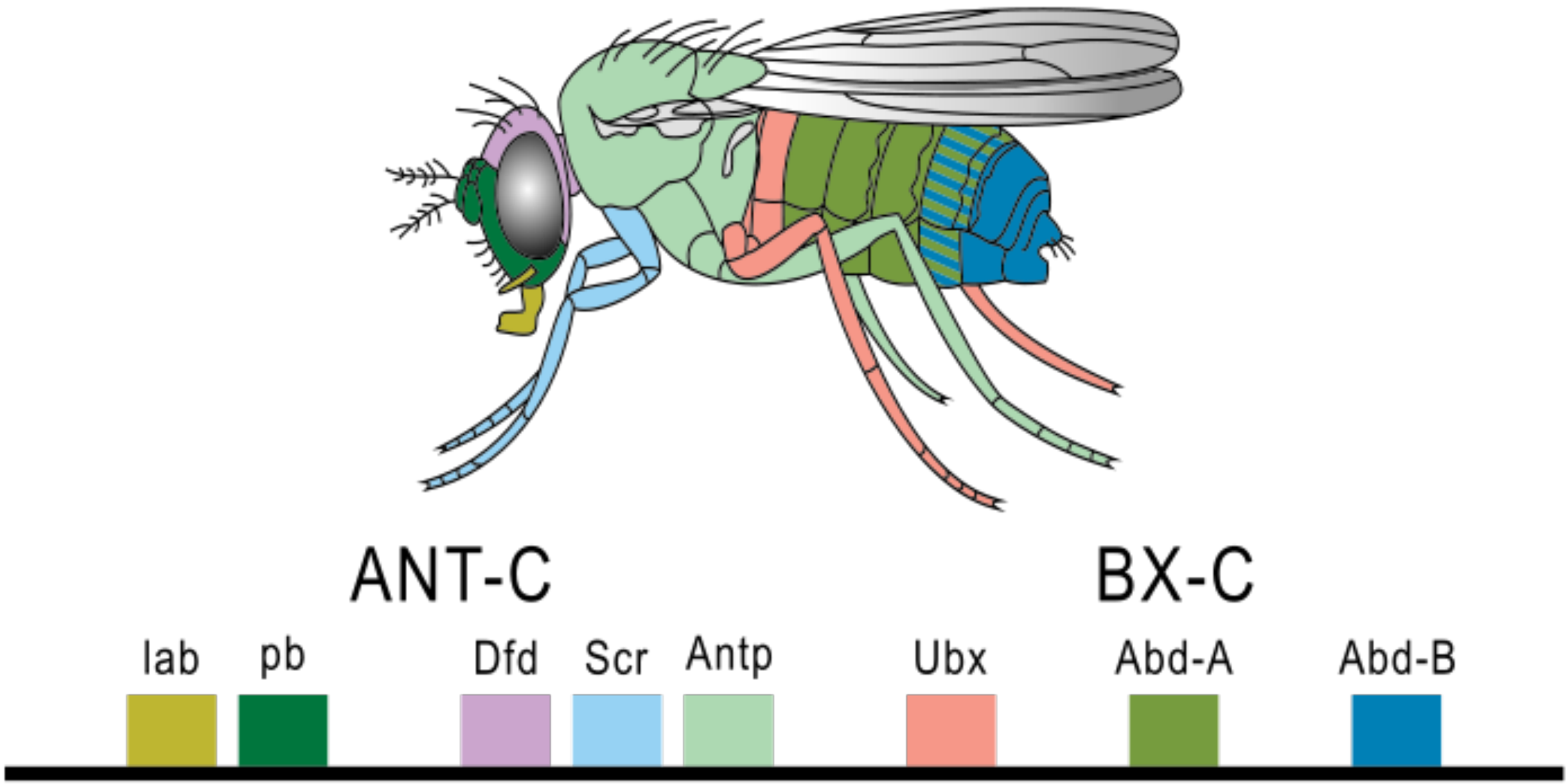


Freshwater Stickleback Pitx1 Gene



In Freshwater Sticklebacks Pitx1 Gene is turned on




ANT-C
BX-C
lab
pb
Dfd
Scr
Antp
Ubx
Abd-A
Abd-B

lab pb Hox3 Dfd Scr ftz Antp Ubx abd-A Abd-B

Euperipatoides

Archegozetes

Phalangium

Cupiennius

Centruroides

Glomeris

Lithobius

Strigamia

Porcellio

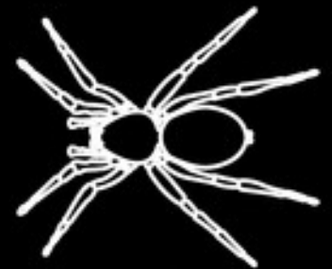
Artemia

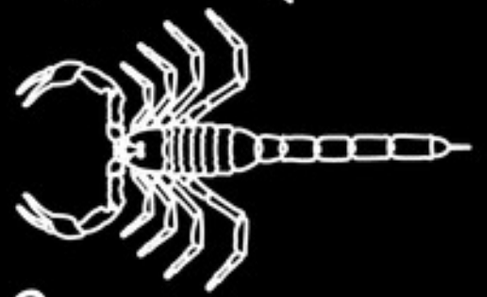
Thermobia

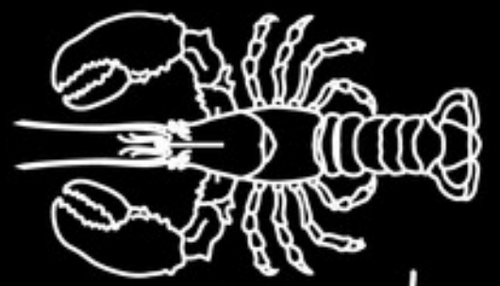
Oncopeltus

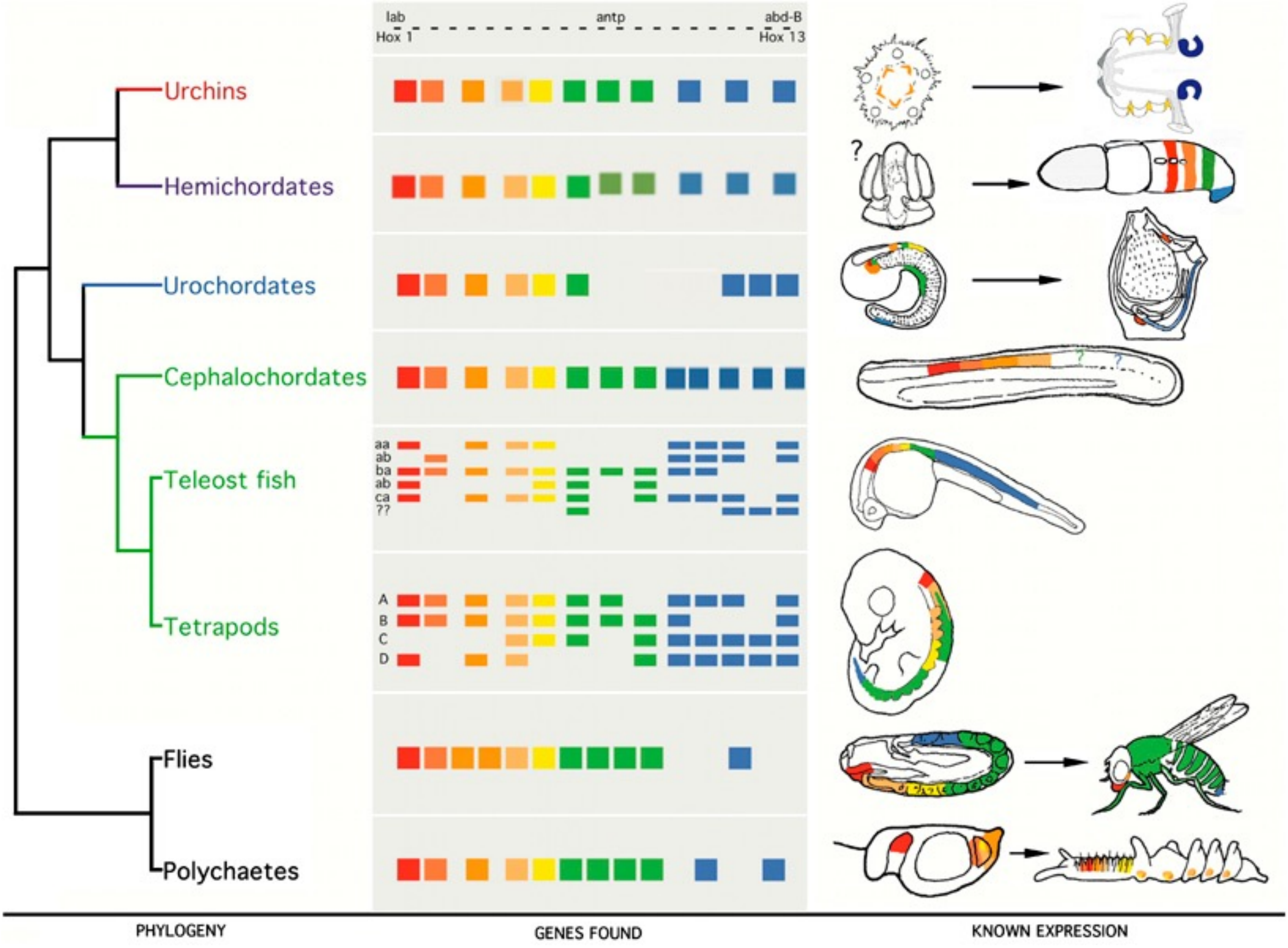
Tribolium

Drosophila








lab
Hox 1
antp
abd-B
Hox 13
Urchins
Hemichordates
Urochordates
Cephalochordates
Teleost fish
Tetrapods
Flies
Polychaetes
aa
ab
ba
ab
ca
??
A
B
C
D
?
PHYLOGENY
GENES FOUND
KNOWN EXPRESSION

Niche construction

Niche construction

-organisms as passive and as active

-> organismic adaptations as **solutions** of organisms to the **problems** posed by the environment

-> ‘organisms construct every aspect of their environment themselves’ (Lewontin 1983, 104)

-> organisms as **active agents** in their own evolution

Niche construction

$$O_{t+1} = f(O_t, E_t)$$

$$E_{t+1} = g(E_t)$$

traditional view

vs

niche construction

$$O_{t+1} = f(O_t, E_t)$$

$$E_{t+1} = g(O_t, E_t)$$

Niche construction

Three types of phenomena:

-> organisms choose their ecological niche

-> importance of environmental factors depending on the type of organism

-> transformation of the environment (e.g. oxygen in the atmosphere)

Niche construction

-> niche construction as an important but underappreciated factor in evolutionary biology

-Niche construction and evolutionary explanation:

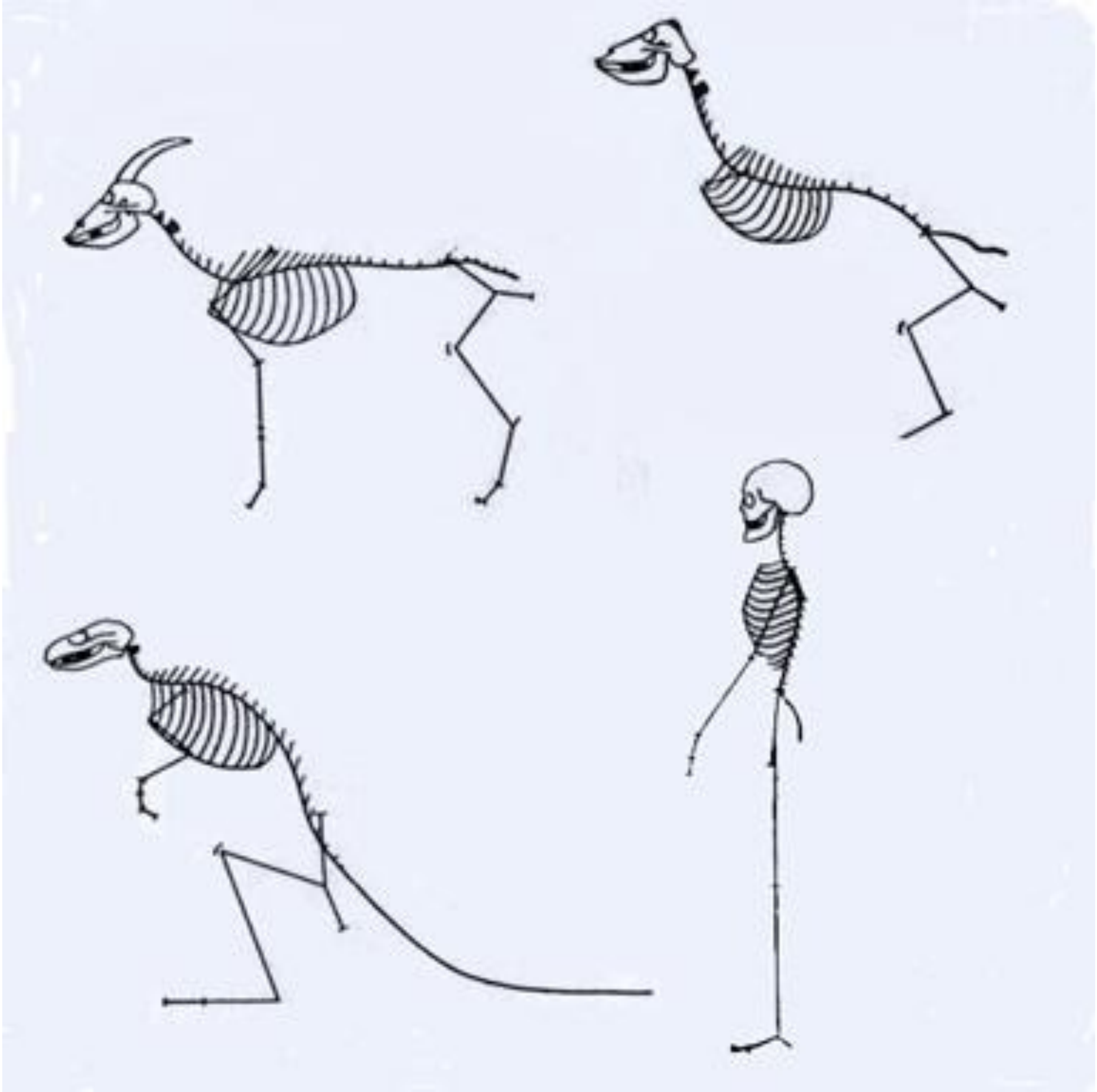
-> influence of organisms on the environment as an <u>inheritance system</u>

-> GS: ‘the actions of organisms on their environment at one time affect what mutation can give rise to later’ (GS, 58).

-> West-Eberhard & evolutionary innovation

‘For these reasons I consider genes followers, not leaders, in adaptive evolution’ (West-Eberhard 2005, 6547).

-> separate argument from NC -> key points: **priority** in evolutionary causation - **active** vs **passive** factors in evolutionary processes



Slijper’s goat

From West-Eberhard, *Developmental plasticity and evolution*

Phenotypic plasticity enables organisms to develop functional phenotypes **despite** variation and environmental change via **phenotypic accommodation** -- adaptive mutual adjustment among variable parts during development **without genetic change**. (51)

Responsive phenotype structure is the **primary source** of **novel** phenotypes. (503)

For further study:

-Godfrey-Smith, *Philosophy of Biology*, ch. 4

-Sterelny & Griffiths, *Sex & Death*, ch. 10

-Rosenberg & McShea, ch. 1 & 3

- natural theology
- Design argument
- William Paley , adaptations
- Herschel
- apparent design / adaptations
- each trait is an adaption - adaptationism
- Gould , Lewontin , Spandrels of San Marco -in Sober