

# Seleção natural e adaptações

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# Adaptações



# Adaptação

O fato de que os organismos estão adaptados aos seus ambientes é reconhecido pelos filósofos desde há muito tempo e antecede o trabalho de Darwin em muitos séculos.

## William Paley (1743-1805)



Clérigo e teólogo inglês, escreveu a obra “Natural Theology: or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature” em 1802, que se tornou um paradigma da Teologia natural.



# O Argumento de Paley

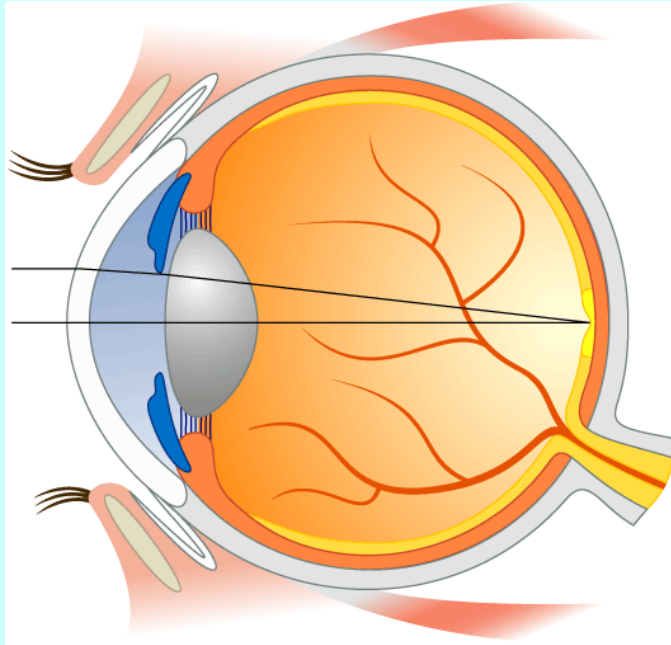


Se você encontra uma pedra, você poderia dizer que ela simplesmente esteve sempre aí, sem que se ache isso um absurdo.

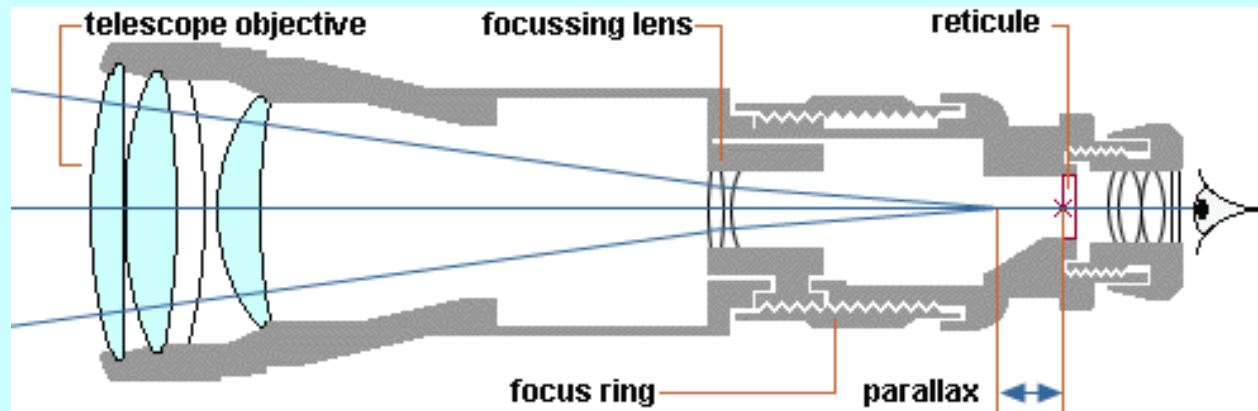
Se, por outro lado, você encontra um relógio, você somente pode concluir que foi feito por um fabricante de relógios.



# O Argumento de Paley



O raciocínio com relação ao relógio poderia ser estendido aos seres vivos dada a sua complexidade. Um dos exemplos de Paley é a estrutura dos olhos, comparada à de um instrumento construído com propósito claro, o telescópio.



# **E o lamarckismo?**

A teoria da evolução por herança de caracteres adquiridos não oferece explicações para a existência de adaptações, uma vez que estas apareceriam espontaneamente.

# E o lamarckismo?



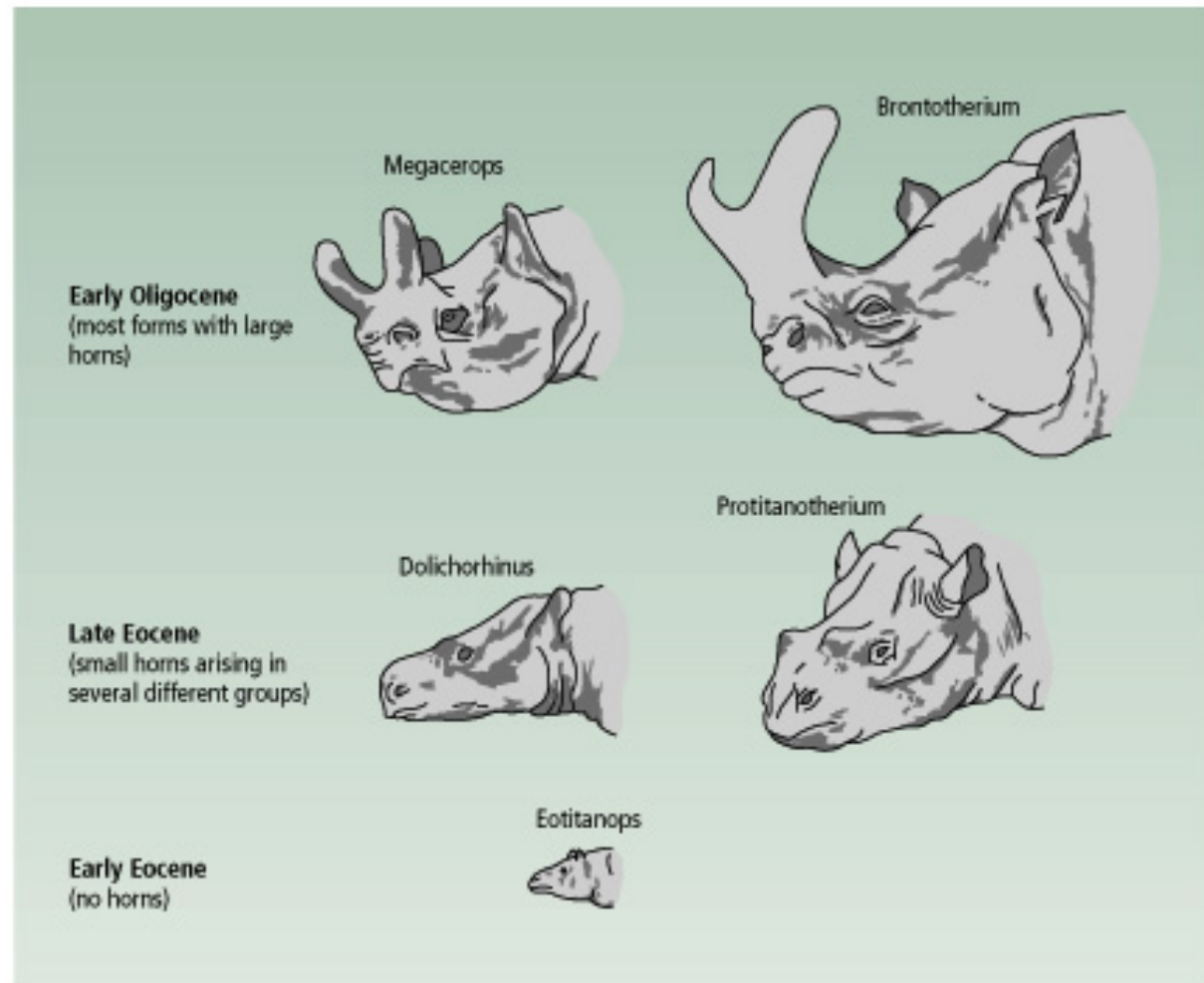
Imagine que haja herança dos caracteres adquiridos. Como então explicar a direção adaptativa do uso ou desuso de órgãos? Qual é o processo que implica essa direção?



# A ortogênese

**Figure 10.1**

Two lineages of titanotheres showing parallel body size increase and the evolution of horns. Only two of many lineages are illustrated. Reprinted, by permission of the publisher, from Simpson (1949).



# A ortogênese... e a inércia!



Foto de esqueleto (esquerda) e reconstrução artística (abaixo) do alce irlandês gigante *Megaceros giganteus*, extinto há cerca de 7700 anos. Segundo alguns pesquisadores do começo do século XX, teria sido extinto por causa da ortogênese inercial.



# A adaptação e a seleção natural

A seleção natural pode explicar todas as **adaptações**. Entretanto ela não pode explicar toda a **evolução**, uma vez que há mudanças evolutivas que não implicam seleção natural, tal como aquelas produzidas por **deriva genética**.

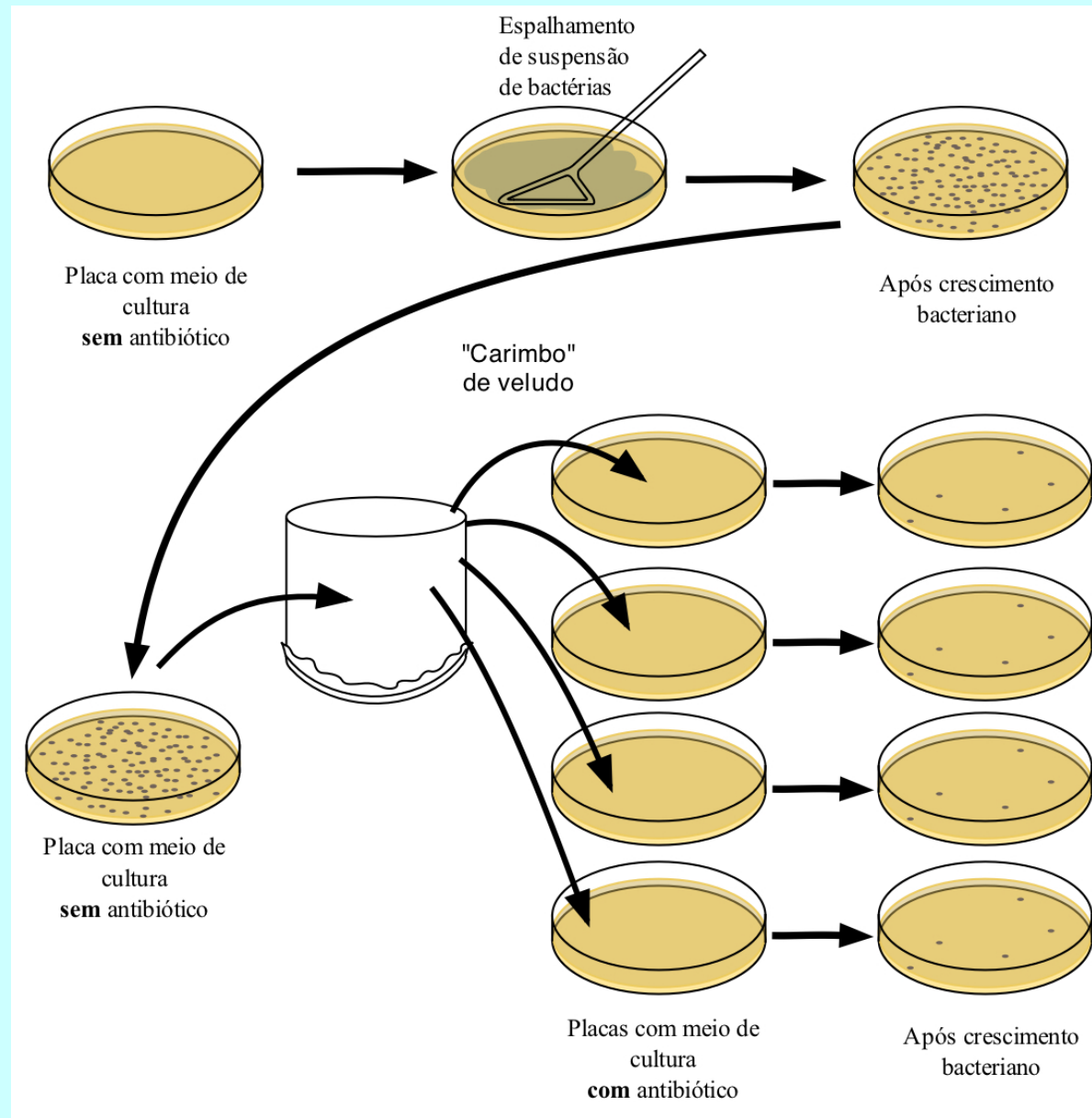
# As mutações dependem do ambiente?

Uma questão que durante muito tempo ficou no ar é a seguinte:

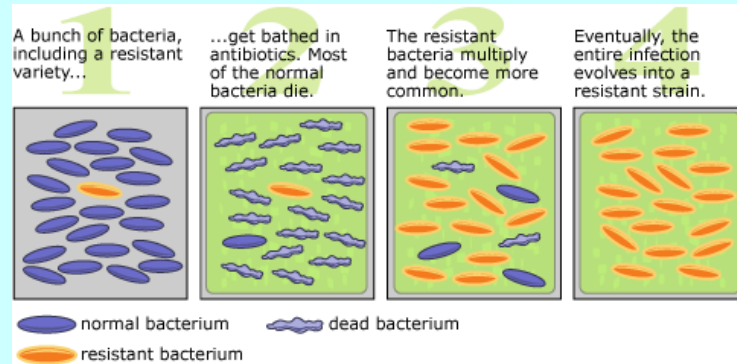
As mutações dependem das mudanças ambientais ou são independentes delas?



# O Experimento “do veludo”

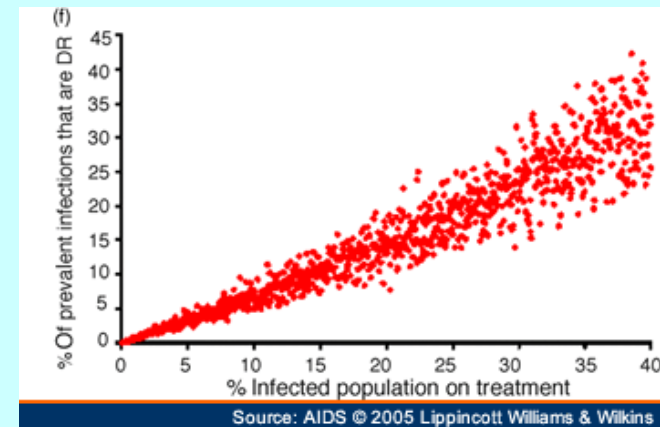
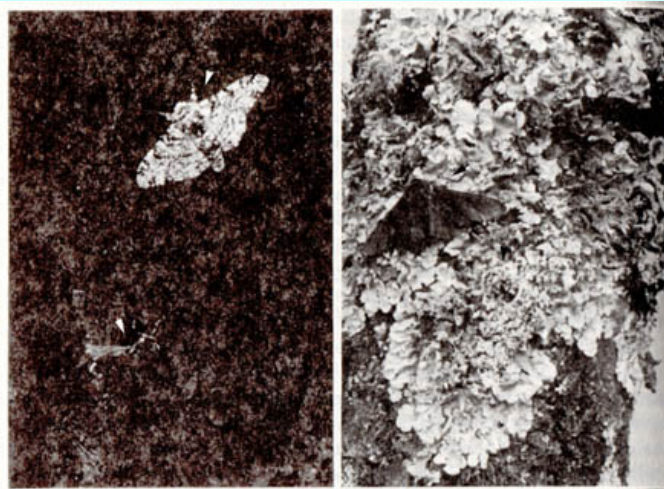


# A adaptação e a seleção natural



## Resistência de bactérias a antibióticos

## Resistência de HIV a drogas



## Mudança nas proporções de formas camufladas

# A seleção natural pode explicar mesmo **todas** as adaptações?

- Adaptações complexas
- Desvantagens de condições intermediárias

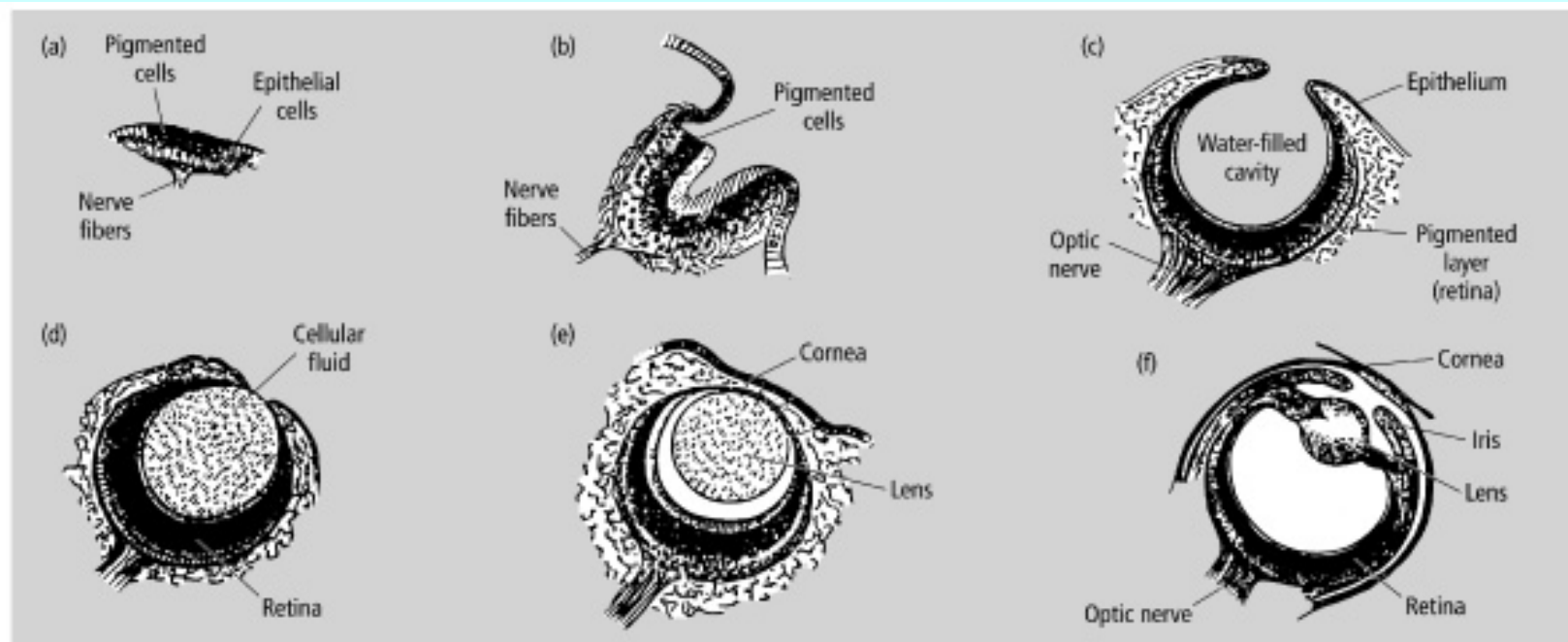
# Adaptações complexas

“Se fosse possível demonstrar a existência de qualquer órgão complexo que não pudesse ser formado por meio de numerosas pequenas modificações sucessivas, minha teoria desmoronaria completamente.”

(Darwin, 1859).



# Adaptações complexas

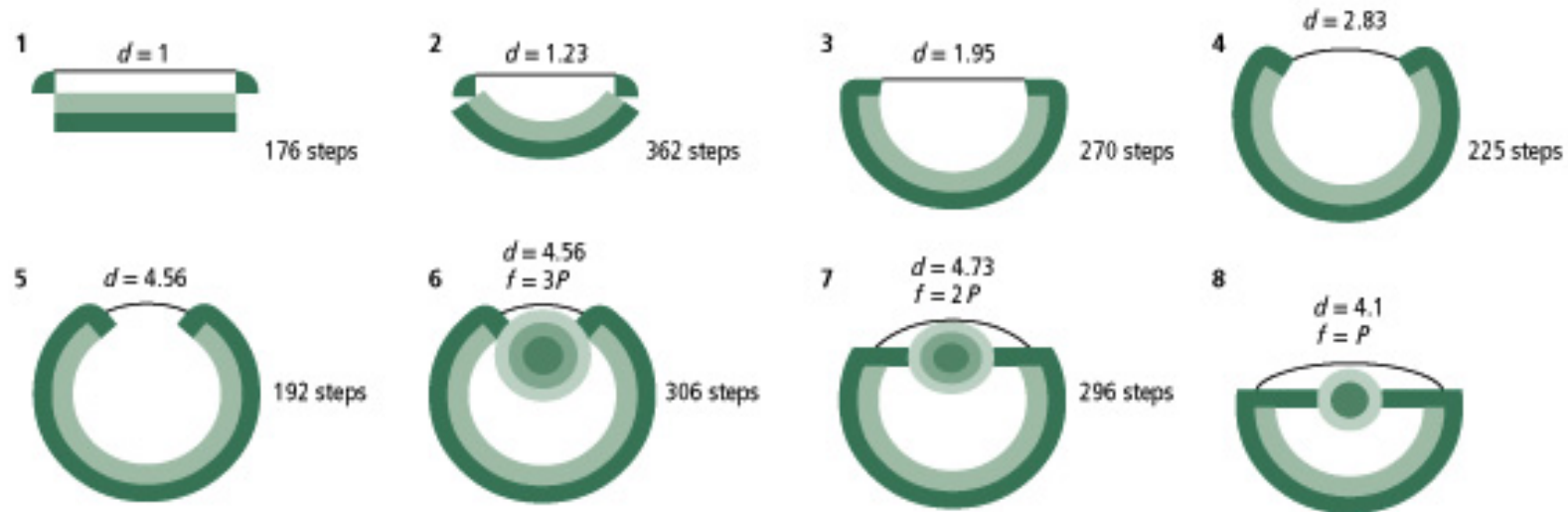


**Figure 10.2**

Stages in the evolution of the eye, illustrated by species of mollusks. (a) A simple spot of pigmented cells. (b) A folded region of pigmented cells, which increases the number of sensitive cells per unit area. (c) A pin-hole camera eye, as is found in *Nautilus*. (d) An eye cavity filled with cellular fluid

rather than water. (e) An eye is protected by adding a transparent cover of skin and part of the cellular fluid has differentiated into a lens. (f) A full, complex eye, as found in the octopus and squid. Redrawn, by permission of the publisher, from Strickberger (1990).

# Adaptações complexas



**Figure 10.3**

Eight stages in the evolution of the eye in a computer model. The initial stage has a transparent cell layer, a light-sensitive cell layer, and a dark pigmented bottom cell layer. It first improves its optical properties by buckling in (up to stages 4–5); by stage 5 it approximately corresponds to the pin-hole camera eye (see Figure 10.2c). It then improves by the evolution of a lens

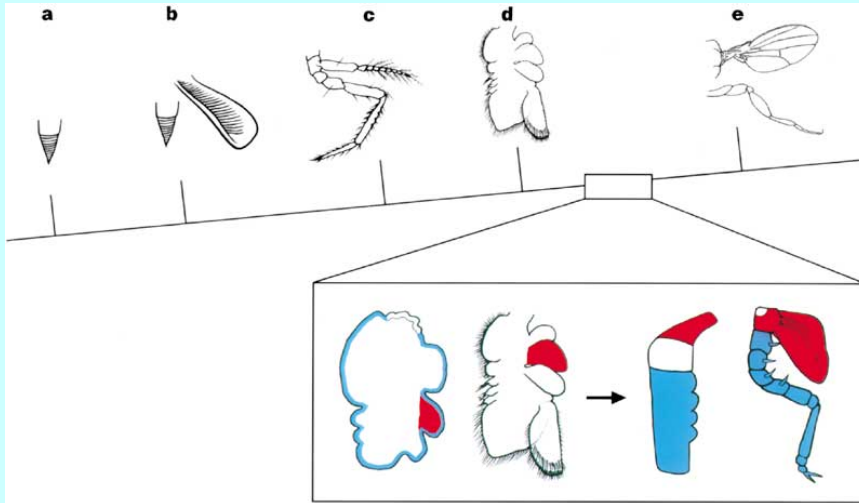
(stage 6). The lens shape then changes, and the iris flattens, to improve the focusing properties.  $f$  is the focal length of the lens; it has the best optical properties when  $f$  equals the distance from the lens to the retina ( $P$ ): this feature gradually improves in the final three phases (stages 6–8).  $d$  indicates the change in shape and is the normalized diameter of the eye. Redrawn, by permission of the publisher, from Nilsson & Pelger (1994).

# Formas intermediárias de estruturas

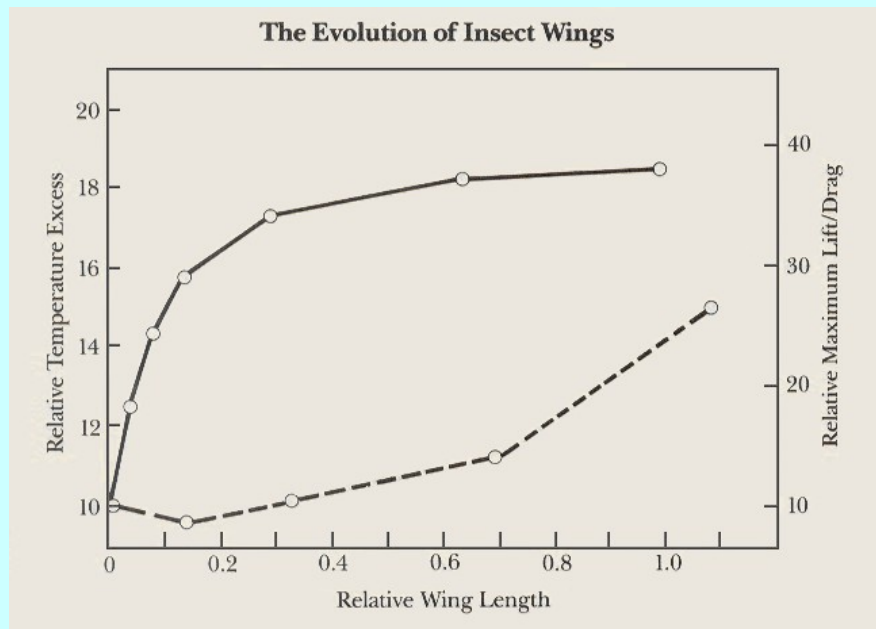
Para quê serviriam “meias asas”?

Lembrete: Um organismo intermediário **tem** que sobreviver!

# Pré-adaptações ou exaptações



Homologia de apêndices de insetos



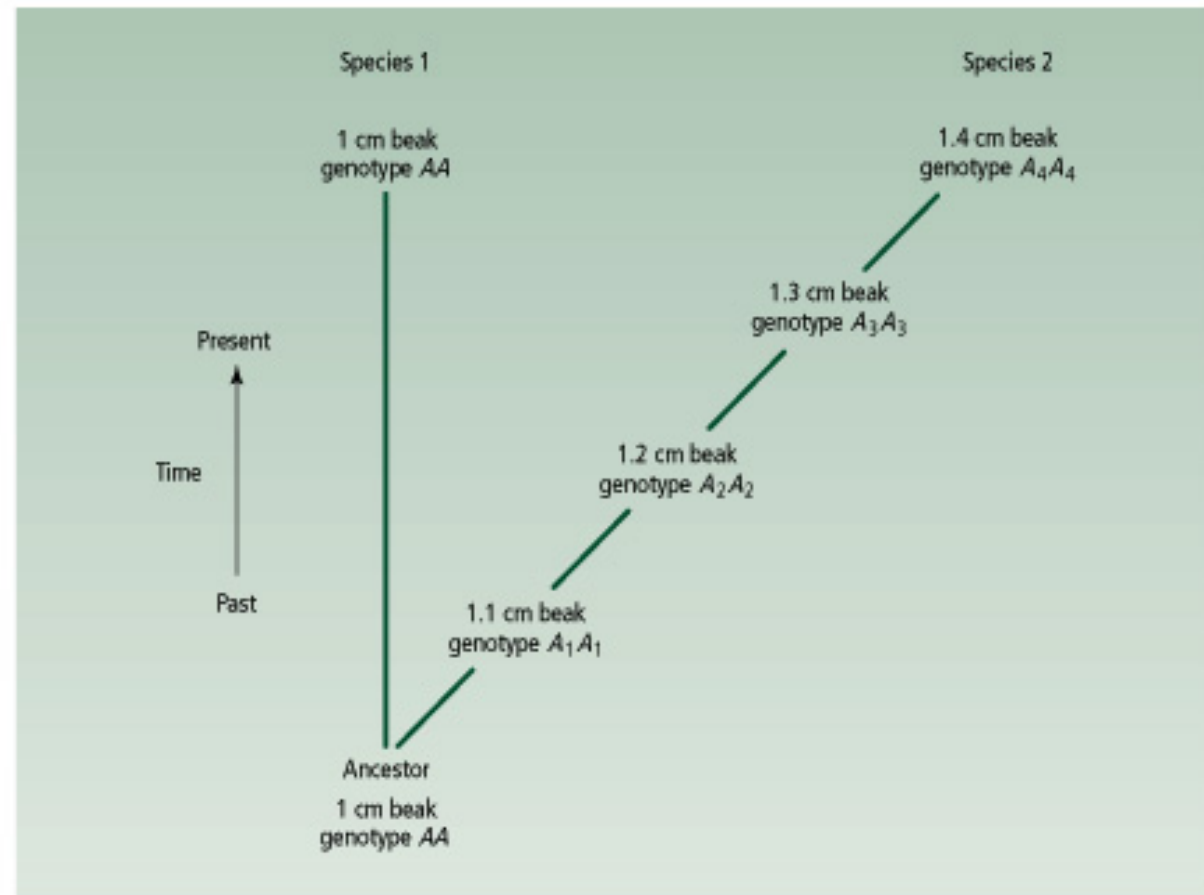
Propriedades termoregulatórias e de capacidade de planagem em apêndices achatados



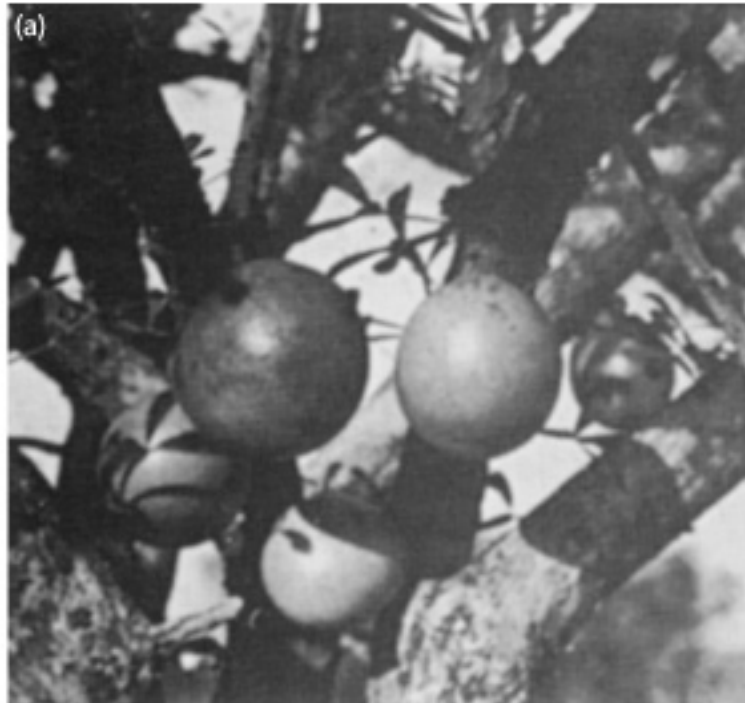
# O acúmulo de pequenas modificações

**Figure 10.5**

A cross between the two modern species would show that the large beak size difference is controlled by a single gene of large effect ( $A$  vs  $A_4$ ). However, the modern difference has evolved by a number of small stages in the past. The Fisherian evolution is invisible in a modern cross. (0.5 in  $\approx$  1.25 cm.)



# Adaptações “anacrônicas”



**Figure 10.6**

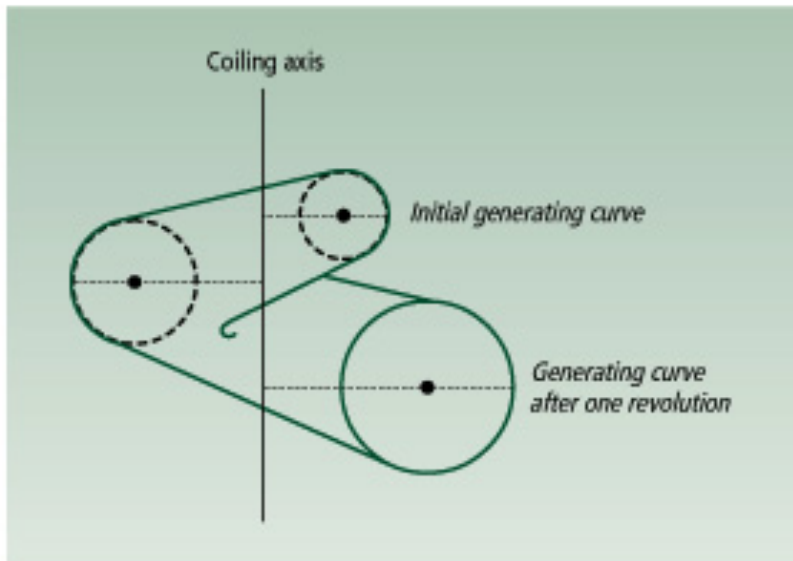
The fruits of (a) *Crescentia alata* (Bignoniaceae) and (b) *Annona purpurea* (Annonaceae) are two examples of fruits that were probably eaten by large herbivores that recently went

extinct. The larger fruits in (a) are about 8 in (20 cm) long; the fruit in (b) is nearer 12 in (30 cm) long. Both trees were photographed in Santa Rosa National Park, Costa Rica. (Photos courtesy of Dan Janzen.)

# O Morfoespaço



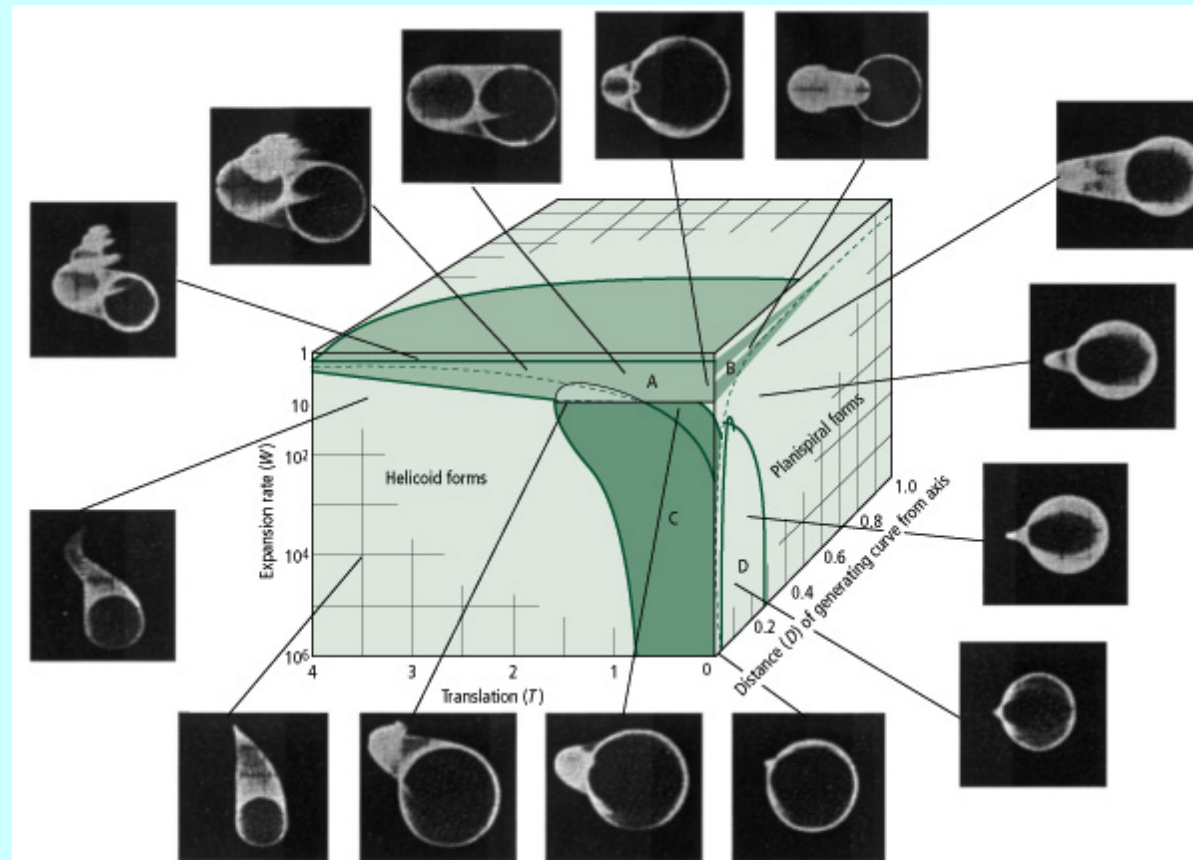
# Modelagem matemática da forma de uma concha



**Figure 10.8**

The shape of a shell can be described by three numbers. The translation rate ( $T$ ) describes the rate at which the coil moves down the coiling axis:  $T = 0$  for a flat planispiral shell, and is an increasingly positive number for increasingly elongated shells. The expansion rate ( $W$ ) describes the rate at which the shell size increases; it can be measured by the ratio of the diameter of the shell at equivalent points in successive revolutions;  $W = 2$  in the figure. The distance from the coiling axis ( $D$ ) describes the tightness of the coil; it is the distance between the shell and the coiling axis, and in the figure it is half the diameter of the shell. See Figure 10.9 for many theoretically possible shell shapes with different values of  $T$ ,  $W$ , and  $D$ . Redrawn, by permission of the publisher, from Raup (1966).

# Distribuição das conchas reais no morfoespaço



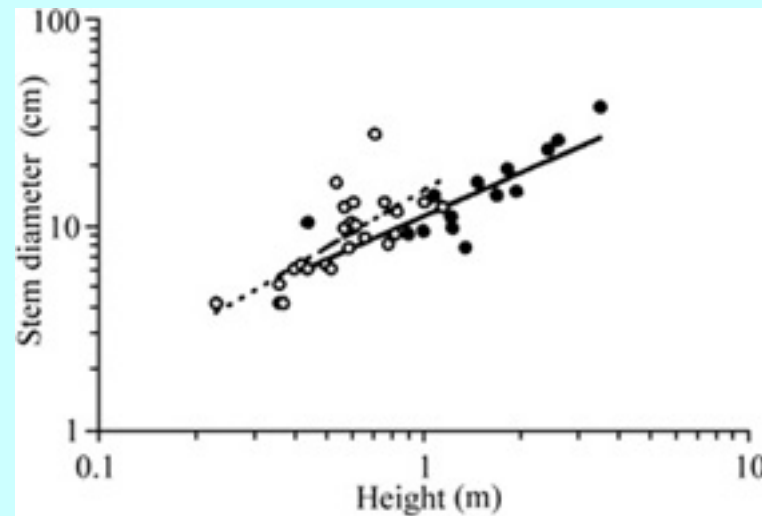
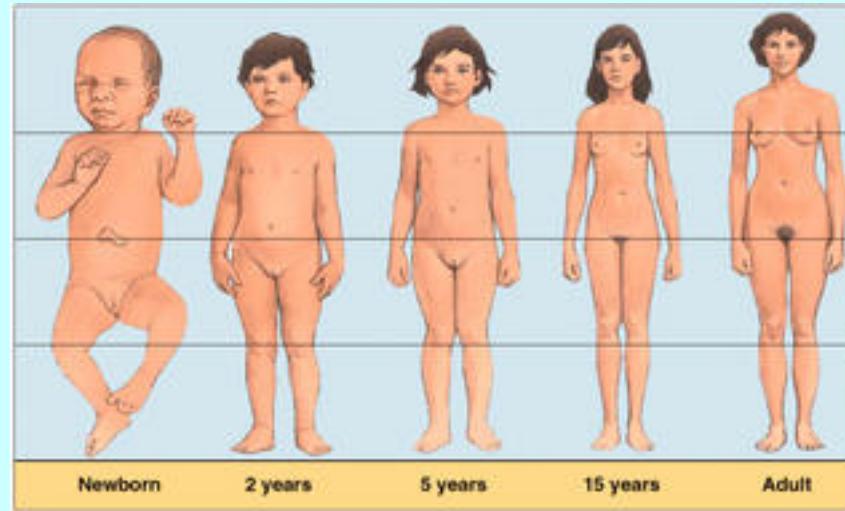
**Figure 10.9**

The three-dimensional cube describes a set of possible shell shapes. Around the outside of the figure, 14 possible shell shapes are illustrated as drawn by a computer. Only four regions in the cube are actually occupied by natural species: A, B, C, and D. All

other regions in the cube represent theoretically possible but naturally unrealized shell shapes. The space is called a morphospace. reprinted, by permission of the publisher, from Raup (1966).

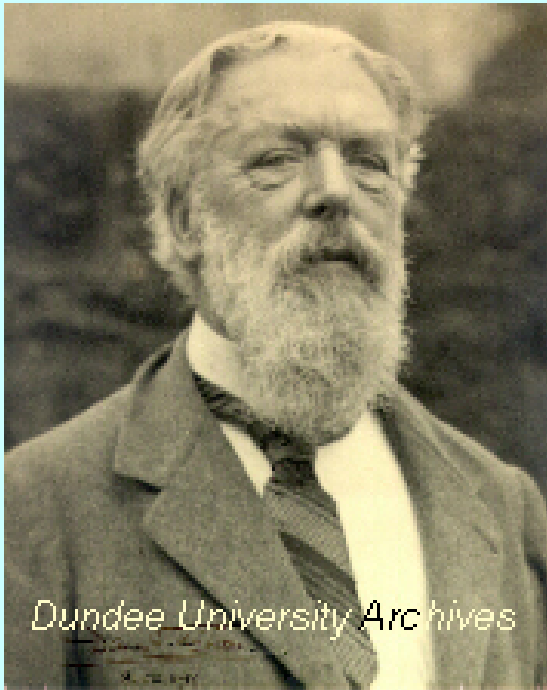


# Relações alométricas

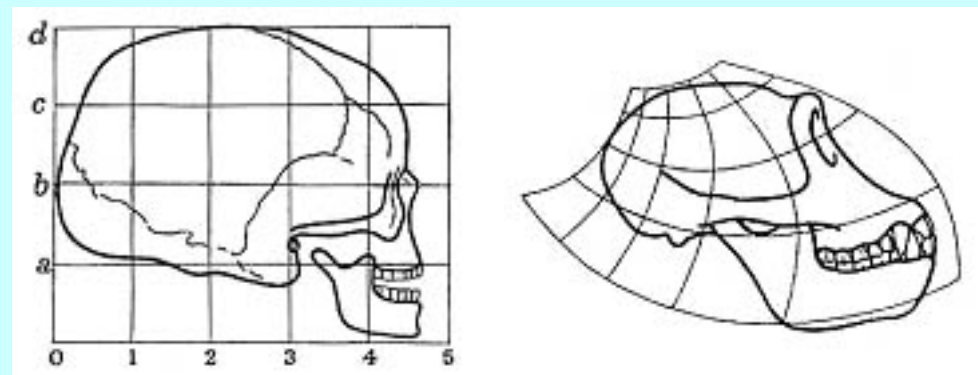
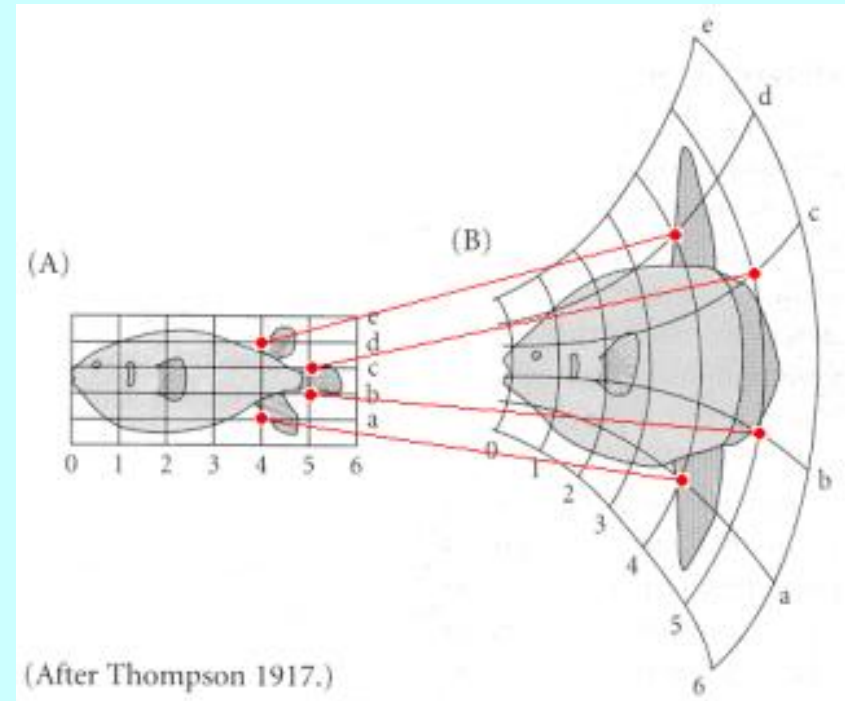




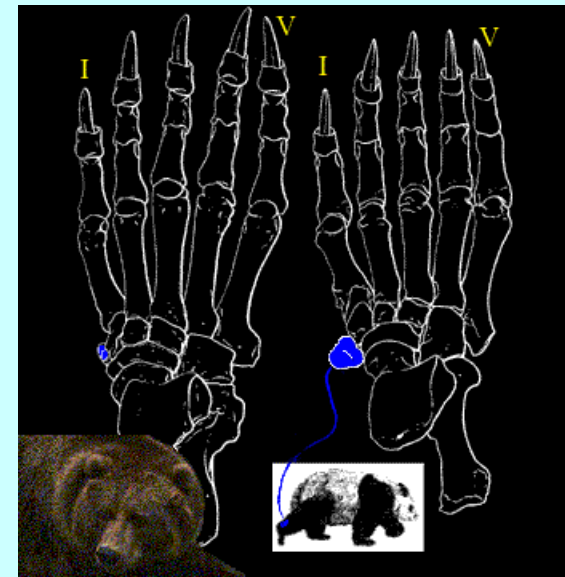
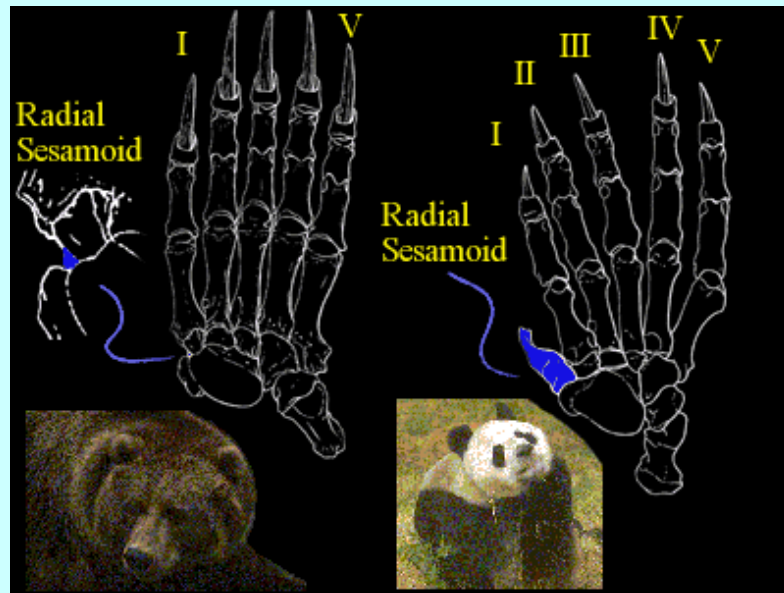
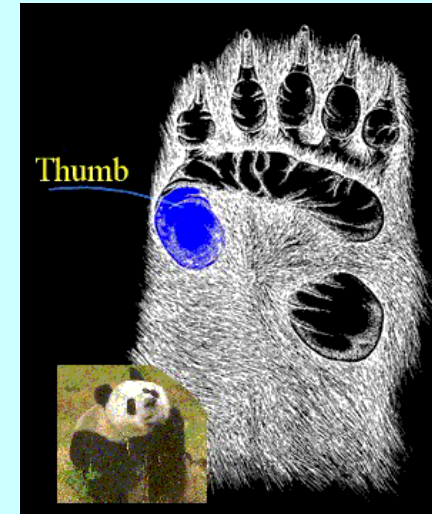
# Restrições alométricas



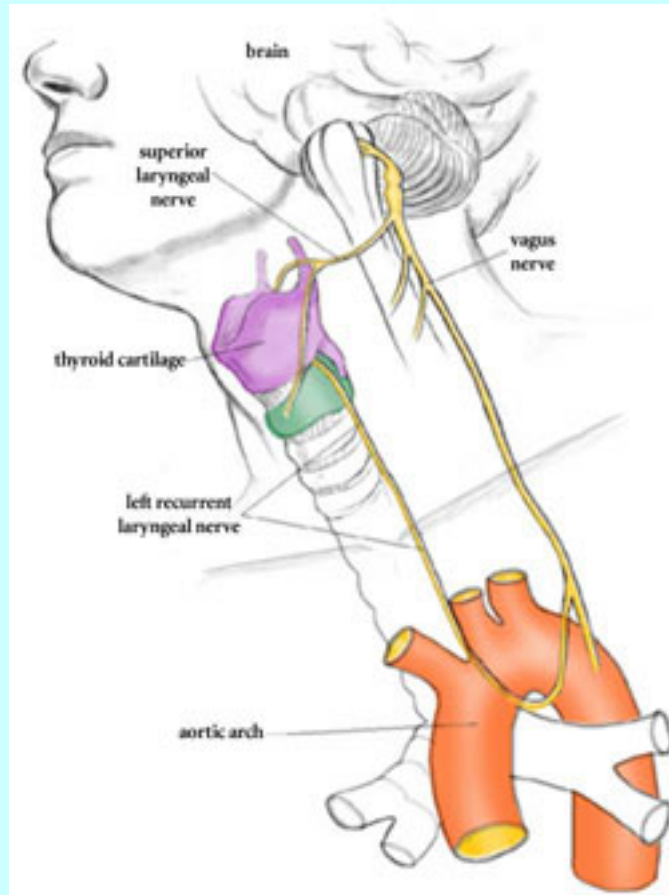
D'Arcy W. Thompson e as relações alométricas.



# O “polegar” do panda



# Restrições históricas

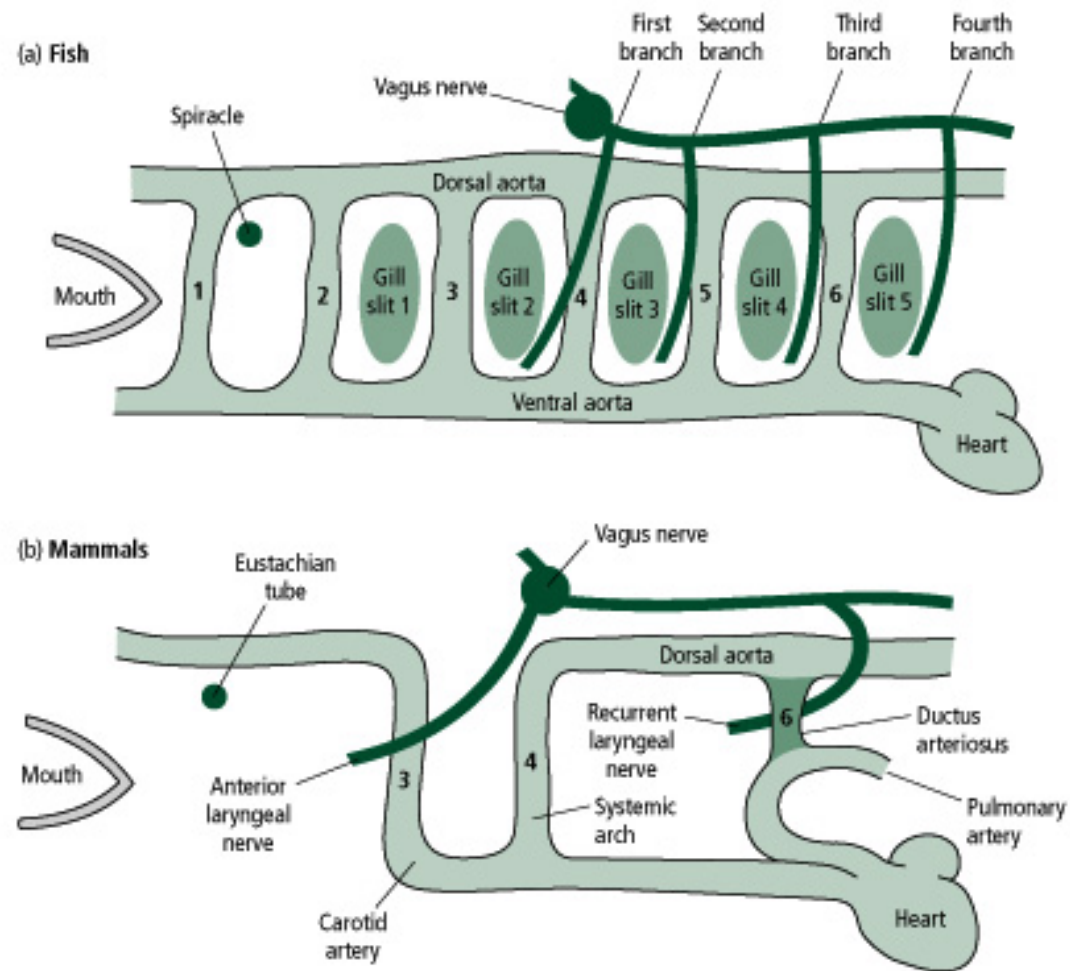


Trajetória do nervo laríngeo (ramo do nervo vago, X nervo craniano).

# Restrições históricas

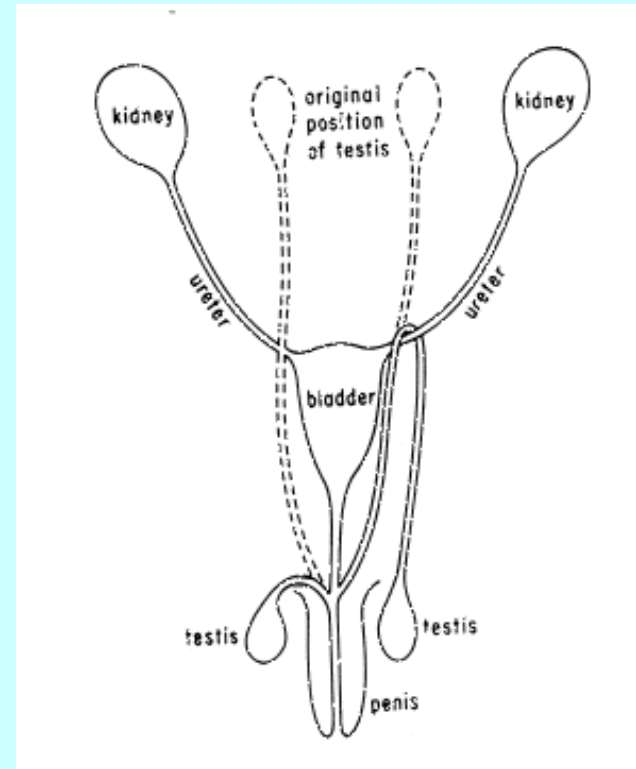
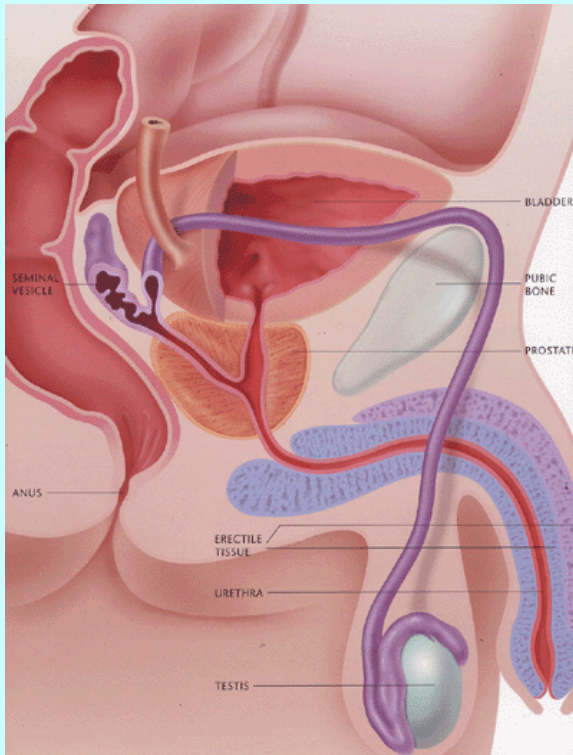
**Figure 10.12**

Evolution of the recurrent laryngeal nerve. (a) In fish, the vagus nerve sends direct branches between successive gill arches. (b) In mammals, the gill arches have evolved into a very different circulatory system. The descendant nerve of the fish's fourth vagus now passes from the brain, down to the heart (in the thorax) and back up to the larynx. Redrawn, by permission of the publisher, from Strickberger (1990), modified from de Beer (1971).



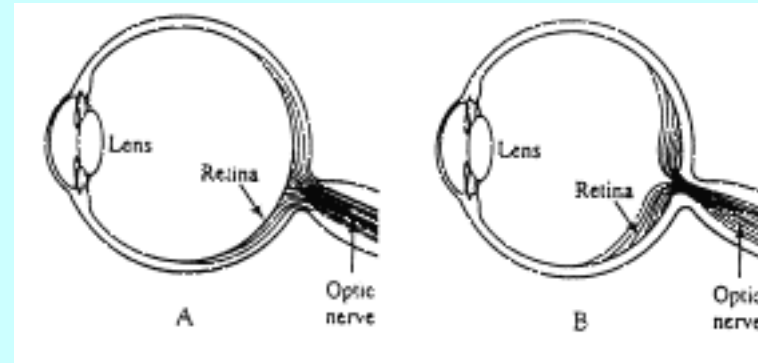


# Restrições históricas

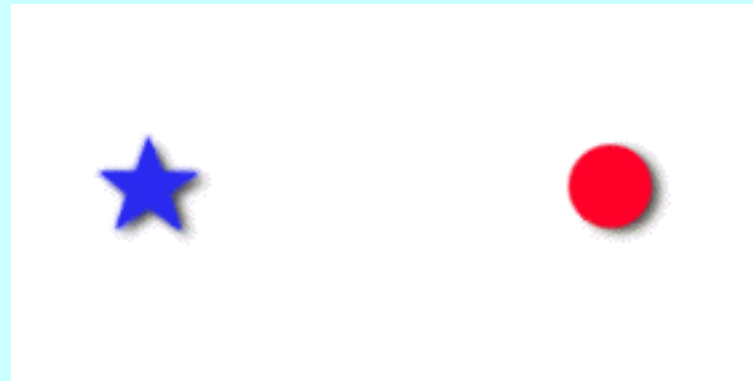


Posição do vaso deferente

# Restrições históricas



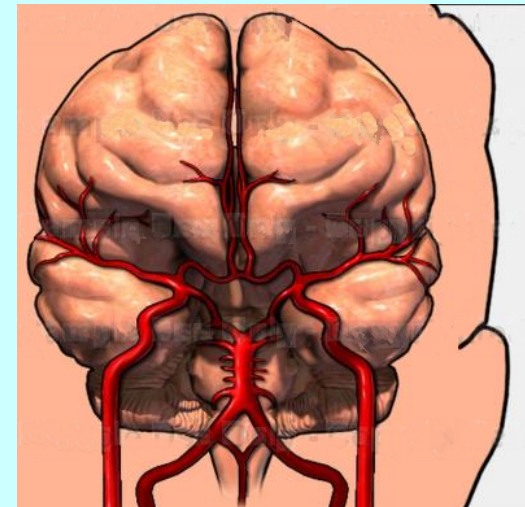
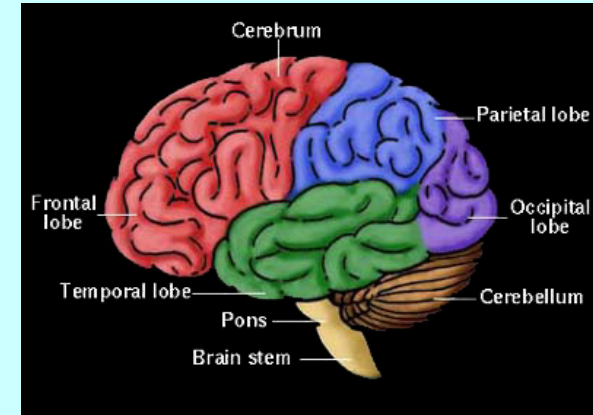
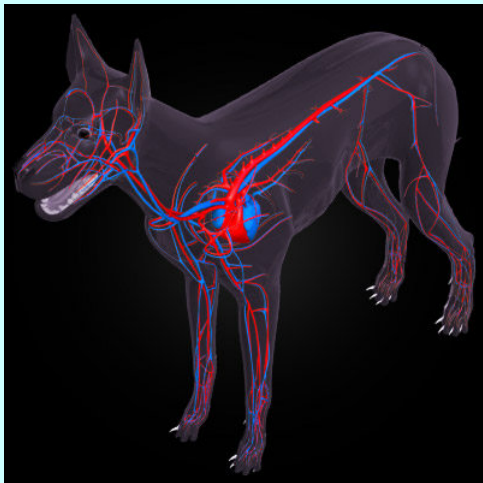
Olho de lula (Mollusca, Cephalopoda, esquerda) e humano (direita)



Ponto cego. Feche o olho direito e fixe o esquerdo no ponto vermelho e aproxime-se até a estrela azul desaparecer.



# Restrições históricas



# Restrições históricas





# Restrições morfo-funcionais

