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Cladistics - Constructing Cladograms

This is the construct that allows us to describe the relatedness of every living organism in an evolutionary context.

What is implied by a branch?

What is the relationship between organisms on the same branch, or adjacent branches?

Before we revisit phylogeny in a much grander way, we will want to dig into cladistics,

so that we are equipped with some important terminology.

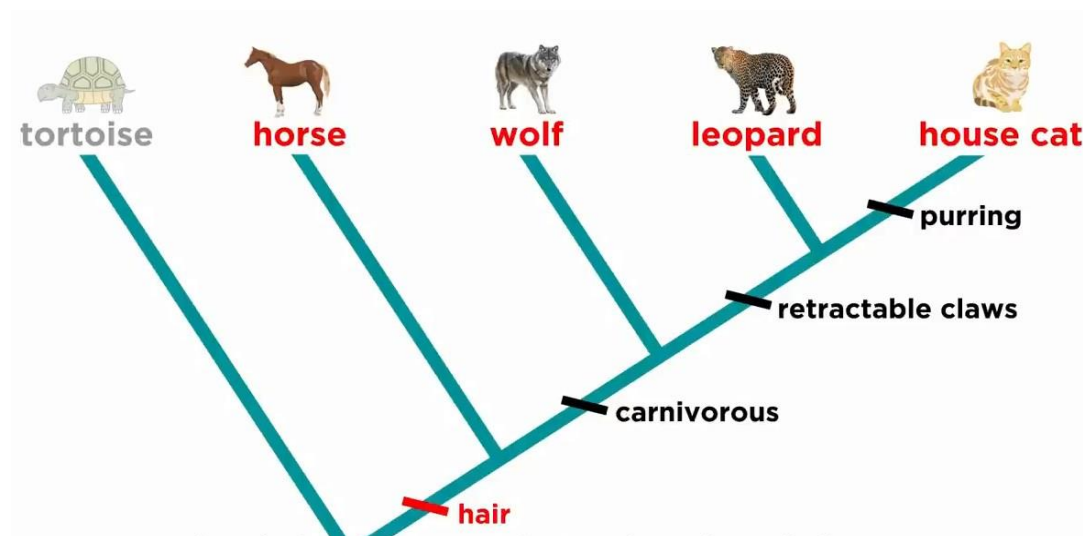
Cladistics is a method of classifying organisms according to their common characteristics.

Cladograms are branching diagrams that show the relationships between clades.

Clades are the fundamental unit of phylogeny.

These are groups of organisms believed to have evolved from a common ancestor.

Let's start by looking at a simple cladogram.



For example, you could probably realize that leopards and domestic cats are the only animals on the cladogram with retractable claws.

However, there's a lot more to this, so, let's take a closer look.

At the very bottom of the cladogram, you'll see the word "hair".

Given its position below this second branch, we can conclude that all the organisms on the cladogram except for tortoises, have hair.

This means that the tortoises are an outgroup.

They serve as a useful comparison for the animals in our study.

Like all animals, tortoises do share common ancestry with the other animals in the cladogram, the most recent of which is represented by this fork here, after which there is divergence.

In fact, tortoises share many characteristics with mammals.

They have an internal skeleton, they are amniotes that give birth to offspring on dry land, they are four-limbed tetrapods, and the list continues.

However, we are not concerned with those shared characteristics in this particular cladogram.

We are only interested in animals with hair, which are referred to as mammals.

Again, since the word "hair" shows up right between the branches leading to tortoises and horses, it means that this characteristic arose after the most recent common ancestry of these groups.

There are no tortoises in existence, either extant or in the fossil record, with hair.

Since the "hair" characteristic is shared by all the animals in the study group, we call it an ancestral characteristic.

All animals in the "in group" share this characteristic.

It is, in fact, an ancestral characteristic of all mammals.

One quick note about ancestral characteristics and outgroups.

In some cladograms, the ancestral characteristic is placed at the very base.

For example, we could have chosen “backbone” as the ancestral characteristic if we had preferred.

As we will come to see, cladograms are simply concept maps.

After the word “hair” you’ll then see the word “carnivorous.”

The horse lineage branches off here.

This is because horses do not share that characteristic.

That is, horses are not part of the mammalian order “carnivora”, as wolves are.

However, horses do have hair, being members of mammalia, so horses are more closely related to wolves than tortoises.

As we are beginning to understand, an animal’s placement on a cladogram can help determine its relatedness to other animals.

If we continue up the cladogram, we see that the wolf, for example, is more closely related to the leopard than to the horse, and that the leopard is more closely related to the domestic cat than to the wolf.

This is fairly straightforward, each animal listed is more closely related to the animal on its right than on its left due to their more chronologically recent common ancestry.

What is somewhat less intuitive is that it doesn’t always work in reverse.

So, domestic cats, clearly, are more closely related to leopards than any other animal on the cladogram and leopards are more closely related to domestic cats than any other animal on the cladogram.

However, a horse is equally as related to a wolf as it is to a leopard, and a tortoise is equally as related to a horse as it is a wolf.

Tortoises are not more closely related to horses than to leopards even though the cladogram might make it look like they are.

The reason for this is that we can rewrite the cladogram any way we please as long as each species still has the correct characteristics.

For example, even though most cladograms are written with a single line and numerous branches, we could instead write the cladogram like this, using the same characteristics.

Notice that the domestic cat has the same characteristics, while the horses still only share the characteristic of hair.

This is because the domestic cat is the focus point of the cladogram.

So, tortoises are equally distantly related to all mammals, they're not closer to horses or cats or any other mammal in the cladogram.

Rewrite the cladogram with new animals!!!

To cement this let's rewrite the cladogram with new animals, so it looks like this.

Now the horse is at the "top" and the domestic cat is closer to the "bottom."

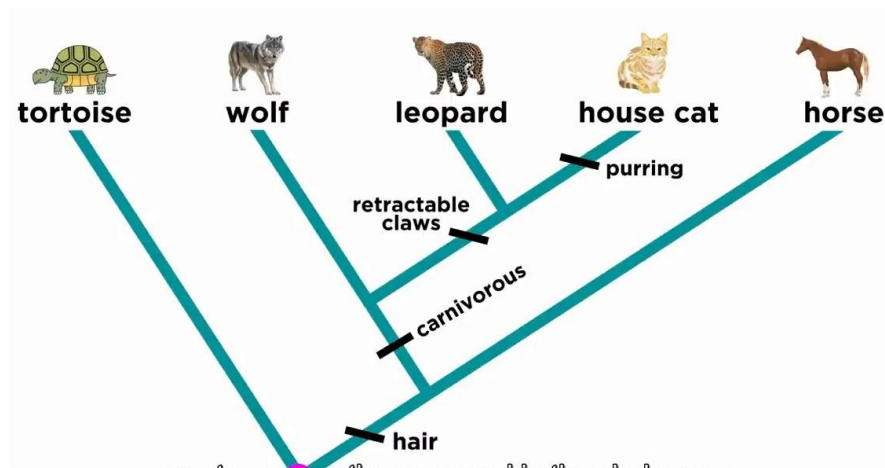
Again, this doesn't mean anything about their evolution.

Horses aren't "more evolved" than turtles or cats, they're just the animal that possesses the greatest number of the characteristics listed on this particular cladogram.

Each time an animal branches off there is generally a characteristic listed that separates it from the others.

These are known as derived characteristics.

Derived characteristics shared by all members of a clade are known as **synapomorphies.**



Going back to our original cladogram, the ability to purr is a derived characteristic, or synapomorphy, that is possessed only by the domestic cat and no other animal on the cladogram.


Likewise, the animals in order carnivora, the wolf, leopard, and domestic cat, are the only animals in the cladogram with carnivorous, meat-eating teeth.

Now let's try building our own cladogram

To build a cladogram, you first start with the species you're interested in studying¹, and then determine a list of evolutionary characteristics that separate them². This table depicts the five organisms we will investigate, those being butterflies, frogs, humans, crocodiles, and birds, as well as four characteristics, those being the presence of a spine, amniotic eggs, diapsid skulls, and feathers. We can also see which of these characteristics are present or absent for each organism³.

To make the cladogram, we observe which characteristics are more or less commonly held⁴.

	Butterfly	Frog	Human	Crocodile	Bird
spine	absent	present	present	present	present
amniotic eggs	absent	absent	present	present	present
diapsid skulls	absent	absent	absent	present	present
feathers	absent	absent	absent	absent	present



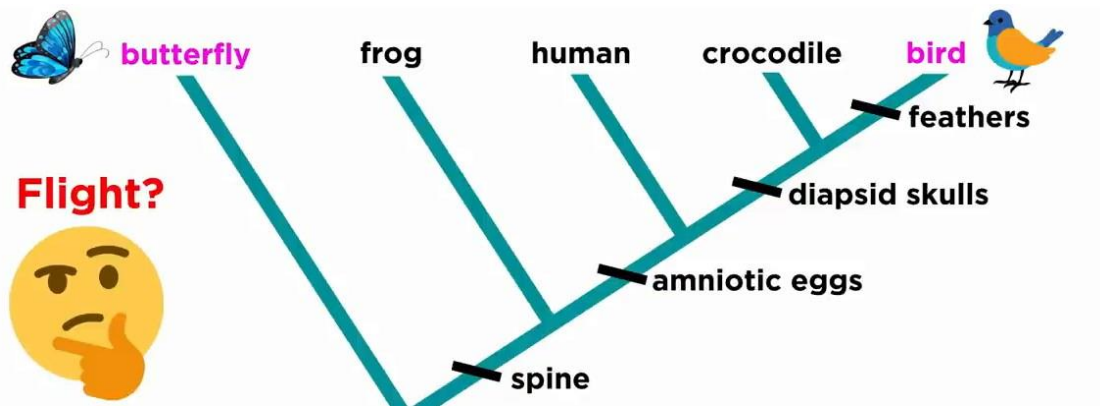
For example, butterflies are the only animals out of these that do not have a spine.

So let's put butterfly on the first branch, and spine as the first characteristic.

Of those remaining, the only one that does not utilize amniotic eggs is the frog, so let's put the frog next, and write amniotic eggs here.

The rest is just the same, humans don't have diapsid skulls so that's next, and then crocodiles do not have feathers while birds do, which puts them at the focus point.

So clearly, the birds and crocodiles are the most closely related, while the butterflies are an outgroup.



Looking at the cladogram you may have some questions.

Why, for example, didn't we use the characteristic of "flight" to separate the birds from the crocodiles?

Well, it is true that this is a derived characteristic of birds, but butterflies are also capable of flight, since insects convergently evolved the same characteristic, so it wouldn't be a good fit for the cladogram since you could accidentally group the birds and butterflies together.

Likewise, we didn't use the characteristic "warm-blooded".

This is because both humans and birds are endotherms, but crocodiles are not endotherms even though crocodiles are more closely related to birds than to humans.

Crocodiles and birds are both part of the clade of animals known as archosaurs, which also includes the dinosaurs.

This is because they share more recent common ancestry with each other than any other animals in the cladogram.

So, both "flight" and "warm blood" are examples of convergent evolution, the process by which different organisms independently evolve similar traits.

Essentially, what we're doing when we build a cladogram is trying to put closely-related animals into distinct clades.

You could potentially build a cladogram for any set of organisms as long as you know a bit about their evolutionary histories, as well as their shared and derived characteristics.

With this concept understood, let's move forward and learn more about cladistics.

Wishing you the best of luck
Dr. Maissoun Ziadeh

Cladistics	التصنيف التفريقي	Backbone	العمود الفقري
Constructing	بناء	Concept Maps	خرائط مفاهيم
Cladograms	المخطط التفريقي	Carnivorous	لاحم
Relatedness	العلاقة	Lineage	النسب
Evolutionary	تطوري	Members	أعضاء
Context	سياق	Wolves	الذئاب
Implied	يعني - يتضمن	Determine	تحديد
Branch	الفرع	Straightforward	واضح
Relationship	العلاقة	Chronologically	التسلسل الزمني
Adjacent	المجاورة	Reverse	الاتجاه المعاكس
Phylogeny	علم تطور السلالات	Species	نوع
Grander	أكبر	Derived Characteristics	الخصائص المشتقة
Dig into	نتعمق	Synapomorphies	تمائل شكلي
Equipped	مجهزين	Purr	صوت القط - الخرخرة
Terminology	المصطلحات	Possessed	يملك
Classifying	تصنيف	Depicts	يصور
Clades	الفروع الحيوية	Spine	العمود الفقري
Fundamental Unit	الوحدة الأساسية	Amniotic eggs	بيض يحيط بالجنين
Believed to	يعتقد	Diapsid Skulls	جماجم منقوصة
Evolved	تطورت	Feathers	الريش
Common Ancestor	سلف مشترك	Commonly Held	شيوع
Conclusions	الاستنتاجات	Utilize	يستخدم
Realize	تدرك	Focus point	نقطة التركيز
Leopards	الفهود	Convergently	بشكل متقارب
Domestic Cats	القط المنزلية	Warm-blooded	ذوات الدم الحار
Retractable	قابلة للسحب / الاختفاء	Convergent Evolution	التطور المتقارب
Claws	مخالب	Independently	بشكل مستقل
Outgroup	مجموعة خارجية	Traits	سمات
Existence	الوجود	Potentially	افتراضياً
Fossil Record	السجل الأحفوري	Evolutionary Histories	تاريخ تطوري
Mammals	الثدييات	Shared and Derived	المشتركة والمشتقة



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