endless forms
most beautiful and most wonderful
have been, and are being, evolved.

Although Darwin titled his book On the Origin of Species, he never clearly defined ‘species,’ nor satisfactorily explained the process of speciation — “that mystery of mysteries — the first appearance of new beings on this Earth.”
He focused on natural selection & adaptation within & between species.

Species of blackberry in our area?!!

what is a ‘species’?

Genetic & phenotypic divergence & local adaptation require:

Prezygotic & postzygotic barriers isolate the gene pools of biological species.

Gene flow can disrupt local adaptation, resulting in a kind of ‘average’ adaptation that is not ‘perfectly’ specialized to any of the local environments.


Fig. 1: Schematic representation of the matching between breeding time (closed dots = laying date 1 SD) and caterpillar peak-date (black dots = SD) in the commoner habitats (deciduous on the mainland, evergreen on Corsica), and the mismatching in the less common habitats. The black arrows indicate the mean date of maternal food demand, when the young are approximately 10 days old. Close ties between arrow and black bar indicates good match. See text for details.

{adaptive divergence requires interrupted gene flow: reproductive isolation}
For the past 50 years or so, many influential evolutionary biologists, have held that
physical separation among members of a species,
such as that caused by the emergence of a mountain chain,
typically drives the splitting of one species into two.
Populations separated by geographic barriers can't interbreed
and eventually evolve into distinct species.
Examples of this speciation process, called(speciation)
abound.

Charles Darwin recognized allopatry as a driving force of speciation.
But he also thought populations could diverge into separate species
in the absence of physical barriers, an idea now called(sympatric speciation).
However, his successors were at a loss to explain how this could happen,
and they could find few examples.
By 1907, textbooks dismissed(speciation),
and few researchers have taken sympatry seriously.
Now the situation is changing fast....

Ring species, which consist of two reproductively isolated forms
connected by a chain of intergrading populations,
have often been described as
examples of speciation despite gene flow...
Two forms of greenish warbler,
one in west Siberia (TL = P. t. viridanus) and
one in east Siberia (ST = P. t. plumbeitarsus),
coeexist in central Siberia
and can therefore be considered separate species.
... amplified fragment length polymorphism (AFLP) markers
show distinct differences between
two reproductively isolated forms
but gradual change through the ring connecting these forms.
(PTv=TL & Ptp=ST do not recognize each other’s songs & won't mate)

Fig. 1. (A) Map of Asia showing
the range of greenish warblers in the breeding season.
Different colors represent different subspecies...
The hatched area in central Siberia indicates the overlap zone
between viridanus and plumbeitarsus. The gap in the ring
in northern China is likely due to recent habitat destruction.

Fig. 2. Genetic distance based on AFLP markers
increases with geographic distance around the southern ring.

Genetic and ecological divergence of a monophyletic cichlid species pair
under fully sympatric conditions in Lake Ejagham, Cameroon

We have focused our study on a particular pair of forms within the lake
that currently appears to be in the process of speciation.
This pair is characterized by an unique breeding colouration
and specific morphological aspects ... (including size)
It has differentiated into a large inshore and a small pelagic form,
apparently as a response to differential utilization of food resources.
(body size differences adapted to habitat-food-ecological niche:
 large inshore eats big insects, snails etc. & small open water eats small plankton)

Sympatric speciation is not often observed.
Still, breeding and brood care occurs in overlapping areas, both in time and space.
(sympatric breeding (same place = shallow bottom) gives opportunity to hybridize)
Analysis of nuclear gene flow on the basis of microsatellite polymorphisms
shows a highly restricted gene flow between the forms,
suggesting
This reproductive isolation is apparently achieved by
although occasional mixed pairs can be observed.
Our findings are congruent with recent theoretical models for sympatric speciation,
which show that differential ecological adaptations in combination with
... could easily lead to...
Debates over the meaning of 'species' were already common before Darwin. For example, Darwin wrote about the difficulties associated with species definitions: ‘Nor shall I here discuss the various definitions … of the term species. No one definition has as yet satisfied all naturalists; yet every naturalist knows vaguely what he means when he speaks of a species.’

The discovery that species evolve and give rise to new species radicalized the ages-old conundrum. Biologists of Darwin's time were familiar with taxonomic puzzles over whether one was dealing with varieties or species. But with the realization that varieties gradually become species, it seemed for many that the game was up — that species designations did not simply appear to be arbitrary, but were in fact truly arbitrary.

The modern version of this debate lies between various versions of the phylogenetic species concept and Mayr's biological species concept. The biological species concept (‘Could they interbreed?’) has a number of problems that have led scientists to propose alternative species concepts. Some scientists have turned to examining the evolutionary history of populations. {not ‘Do they have the potential to interbreed in the future?’, but ‘Have they been interbreeding recently?’; or are the lineages ‘distinct population segments’ DPSs or, equivalently ‘evolutionarily significant units’ ESUs?}

These phylogenetic species concepts are currently a topic of great debate.

The endangered species act of 1973 includes any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature. {a DPS is considered to be an evolutionarily significant unit (ESU)}

Not ‘potentially’ but actually; actual recent interbreeding is revealed by genetic markers.

Pacific salmon have been extirpated from nearly 40% of their historical habitat and of the remaining salmon populations, almost one half are thought to be at risk of extinction. … the potential remedies for the salmon problem have huge implications for the ways people extract water, develop industrial, commercial and private properties, generate electricity, transport goods, harvest fish, …

Given their propensity to home to natal streams, salmon are naturally subdivided into a hierarchy of genetically distinct groups that tend to show local adaptation … Advances in molecular genetic and statistical tools have led to impressive algorithms for discriminating among groups within species. … resolution of distinct genetic lineages within a species does not help to identify which hierarchical level of organization is the appropriate one to save.

The NMFS defines reproductively isolated groups of salmon with unique evolutionary legacies as Evolutionarily Significant Units (ESUs). The NMFS has identified 51 ESUs within the 6 species of Pacific salmonids; for legal purposes they are treated as separate species that must be recovered; 26 of these currently are listed under the ESA.

The barred owl, a close relative of the spotted owl, has invaded the Pacific Northwest. (from Northeast) This owl can out hunt the spotted owl and is generally more resilient. Worse than that, the barred owls can breed with the spotted owls. Together they create a hybrid owl that can reproduce. {an endangered species destroyed by gene flow!!!}
The archaeological record cannot resolve whether domestic dogs originated from a single wolf population or arose from multiple populations at different times. Mitochondrial DNA sequences were analyzed from 162 wolves at 27 localities worldwide (W#) and from 140 domestic dogs representing 67 breeds (D#). Several methods of phylogenetic analysis, including maximum likelihood supported a grouping of dog haplotypes into four distinct clades.

**Wolves (W) were the ancestors of dogs (D).**

- **Clade IV:** three haplotypes that were identical or very similar to a wolf haplotype found western Russia, which suggests recent hybridization.
- **Clade III:** a variety of breeds such as the German shepherd, Siberian husky, and Mexican hairless.
- **Clade II** included 2 Scandinavian breeds & 2 wolf haplotypes.
- **Clade I:** many common and ancient breeds such as the dingo, New Guinea singing dog, African basenji, and greyhound.

The coyote (out group) and wolf ... diverged about one million ybp, as estimated from the fossil record.

**Dogs are a folk species — ‘the same kind.’**

**Are they a biological species?**

**Are they an Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) or Phylogenetic Species?**

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Emma Marris asks whether Linnaeus’s legacy is cut out for conservation. Take a less iconic mammal ... 

**Preble’s meadow jumping mouse** (Zapus hudsonius preblei).

It’s a threatened tea-cup-sized rodent with comically large feet and a counterbalancing tail, and spends its life hopping about the foothills of the Front Range in Colorado and Wyoming.

Or that’s how some would have it. Others say that the subspecies, is a spurious one, and that the creatures called by that name are just plain old meadow jumping mice (Zapus hudsonius), a species with which the United States is crawling. The streamside habitat preferred by the foothill mice is also prime real-estate land for development.

The degree of protection accorded to the mice thus has implications for developers.

... in 2005, the US Fish and Wildlife Service announced plans to drop Preble’s mouse from its list of threatened species and subspecies because of new genetics work by Rob Ramey. [another group] was commissioned to do further genetic tests. It disagreed with Ramey. The agency called in an outside group; its verdict: the subspecies exists.
Emma Marris asks whether Linnaeus's legacy is cut out for conservation.

Although it might be tempting just to see a story of evil developers and good conservationists, the mice highlight a more fundamental problem.

The phylogenetic approach can... call older taxonomy into doubt, by at least one reckoning, the phylogenetic approach comes up with 48% more species than the biological species concept does for the same group of organisms.

"We are able to slice the genetic pie thinner and thinner," says Craig Manson...

The act includes in its definition of species 'subspecies' and 'distinct population segments' but offers no definitions for either of these categories.

The reason why the relation between this mouse and that mouse can't be nailed down with jurisprudential exactitude is the same reason that there are any mice in the first place: evolution.

The problem is that the idea of a distinct species predates Darwin's insights into their origins.

Carl Linnaeus thought that species were made separate from one another by God, and that they stayed that way. But Darwin showed us otherwise.

As one species splits into two over the millennia, there is no magic generation in which they are clearly separate.

"It is kind of like asking when you are a child and when you are an adult - where is the boundary? "...

The National Marine Fisheries Service...

shares the job of enforcing the Endangered Species Act...

and deals with the anadromous creatures - those that divide their lifecycle between salt and fresh water... (salmon)...

... of the ten listed populations... on which most money is spent, eight are anadromous salmon or steelhead (rainbow trout).

Anadromous fish nearly always return to their natal stream to reproduce, and so fish from different streams...

are almost completely isolated when it comes to breeding.

So in the case of the chinook salmon (Oncorhynchus tshawytscha, which, as it happens, is considered by many to be the tastiest), those that spawn in the Columbia River basin are divided up into at least eight distinct population segments on the basis of their specific location and the timing of their runs.

{which result in "phylogenetically distinct segments" w/ genetic differences}

Although there are many more than eight populations in the basin, their listing groups them together into units of a manageable size.

... the distinct population segment combines a biological description of the relationships with a value judgement as to whether a population is important.

"You really need something besides science to decide where on that level you are going to focus," ...

Endangered Species Recovery Act of 2004 (Introduced in House) HR 4475 IH...

... the Endangered Species Act of 1973 (16 U.S.C. 1533(a)) is amended by adding the following:

'(4) ...The Secretary shall determine ... the 109 species that are in the greatest danger of extinction throughout all or a significant portion of their range. ...'.

'The Secretary may not include a species in the list unless inclusion of the species is approved by the majority vote of a panel comprised of the Secretary of the Interior, the Secretary of Transportation, and the Secretary of Defense.'

Managing and maintaining "species" diversity is going to be challenging!