How many species are there?

**Taxonomic Hierarchy**

- Kingdom
- Phylum (in animals) or Division (in plants)
- Class
- Order
- Family
- Genus
- ***Species***
- Subspecies
- Population

Why the focus on species?

- The *species* is the lowest level of classification at which there are good chances that organisms with different descriptive names will also possess substantial genetic differences.
- The *species* is increasingly biodiversity’s currency.

The process of species description

Original methods have not changed dramatically

- Based on the *Systema Naturae* (1758) of the founder of modern systematics, Carolus Linnaeus.
- Believed that species could be classified because each was an individual “creation of God” and thus fixed in its characters.

Fundamentals remain the same:

- A Latin binomial.
- A formal published description.
- A type specimen deposited in a museum.
A New Species of Frog from the Meseta de Cabo Cruz, Eastern Cuba (Leptodactylidae, Eleutherodactylus)

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ABSTRACT.—A new species of Eleutherodactylus is described from several caves on a limestone plateau, the Meseta de Cabo Cruz, in eastern Cuba. It is a member of the subgenus Euhyas and is most similar to E. planirostris. However, it is larger in size, has strongly arched vomerine odontophores, a different call, and a different habitat preference. The two Cuban subspecies of E. planirostris are elevated to full species, E. casparii and E. goini.

Holotypes and paratypes:
- The author of a new species chooses a single specimen considered to best represent the species being described = the holotype.
- May choose other specimens from the type series that will reinforce the understanding of the species = paratypes.
- Holotypes and paratypes are deposited in public institutions so that they are accessible to any worker who needs to inspect them.

D. didona Magrini & Vanni (Holotype)
Latest advance in holotype access

- http://ip30.eti.uva.nl/zma3d/home.html

Bar Coding of Life Project

- Works with fragments.
- Works for all stages of life.
- Unmasks look-alikes.
- Reduces ambiguity.
- Makes expertise go further.
- Democratizes access.
- Opens the way for an electronic handheld field guide, the Life Barcoder.

Some terms to clarify:

- **Taxonomy** is the name given to the study of classification of organisms, often, but not always, based on their phylogenetic relationships.
- Morphological similarity alone is the primary criterion applied.

How are these related?

Some terms to clarify:

- **Systematics** is the field that embraces the classification of organisms, usually based on phylogenetic inferences.
- **Phylogeny** refers to the evolutionary relationships among species.
- Relies on the methods of **cladistics**

Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly *Astraptes fulgerator*. Some terms to clarify:

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Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly *Astraptes fulgerator*.
Groups that share unique features which were not present in distant ancestors, that is, synapomorphies

Lumpers and splitters:

- Those who think that the differences between two or more species are minor and that they all should be treated as one are called lumpers.
- Those who think the differences, and thus the species, are valid are called splitters.
- Particularly a problem with “popular” groups, e.g., birds.
- Old World (described by Europeans) lumpers versus New World (described by North Americans) floras (splitters).
Current status?
- 1.7 million species have so far been named and described and reside in museum/herbarium collections

Richard Evans Schultes – gentleman explorer, field botanist extraordinary, elucidator of hallucinogenic plants and father of modern ethnobotany.

Progress is slow –
The crisis in taxonomy
- Right when the field is most relevant, taxonomy as a science is moribund.
- Numbers of taxonomists are declining, not increasing.
- With its methods largely unchanged since the Victorian age
- Considered quaint and antiquated
- Field remains so low-tech -- still depends on an expert eye and extraordinary recall.

Taxonomic Backlogs
- With traditional methods, and a total of some 10 million species, it would take some 600 years to describe the world’s biota!
- To improve the situation, it has been estimated to take at least a 5x increase in the number of taxonomists
- Cost ~ $3 billion
- Would complete an inventory of global diversity in a timely fashion (30-50 years).
- Is this much money?

B-2 Stealth Bomber: $1.3-2 Billion each
Where are new discoveries being made?

Rate of description is 15,000 new species/year

Many recent discoveries...

- Consider primates, the very best known of organisms.
- Since 1990, 10 new species of monkeys have been discovered
- Two examples are: Callithrix manicorensis and Callithrix acariensis from the Brazilian Amazon

Press Release 05-081 New Primate Discovered in Mountain Forests of Tanzania: "Highland mangabey" is first African monkey to be described in more than two decades

'Woof,' er... 'Chirp' - New Species of 'Barking' Bird Is Discovered

- PHILADELPHIA - Robert Ridgely was hiking down an Ecuadorian mountain path to record bird songs last November when he heard a strange sound - a call akin to a dog's bark. (AP) 1998
- At 10 inches, the bird is the second-largest known Antpitta
- Its most striking feature is a broad white facial stripe that arches below the eye, contrasting with a black crown.

Jocotoco Antpitta Grallaria ridgelyi

- Restricted to bamboo thickets in wet, upper subtropical forest in the upper Rio Chinchipe drainage, province Zamora-Chinchipe, Ecuador

New centipede species found in NY's Central Park

USA: July 26, 2002

NEW YORK - A new species of poisonous predator - a tiny centipede that may well be the world's smallest - has been discovered in Central Park, the heart of the nation's largest city, scientists said this week.
California home to 27 new species
Wednesday, January 18, 2006; Posted: 6:39 p.m. EST (23:39 GMT)

SEQUOIA NATIONAL PARK, California (AP) -- Twenty-seven previously unknown species of spiders, centipedes, scorpion-like creatures and other animals have been discovered in the dark, damp caves beneath two national parks in the Sierra Nevada, biologists say.

"You get the feeling you're Lewis and Clark, charting undiscovered territory," she said. "Caves are one of the last frontiers."

Taxonomic Frontiers?
- Plant species everywhere, particularly in the tropics
- Many new species of lizards and amphibians being discovered throughout the tropics
- Fishes -- less than half of freshwater fishes of the Neotropics are described!

Marine systems
- Deep sea floor may contain as many as a million undescribed species.
- Entirely new communities of organisms--hydrothermal vent communities--were found less than two decades ago.
- More than 20 new families or subfamilies, 50 new genera, and 100 new species from these vents have been identified.

One example: The Cyclophora
- An entirely new phylum, the Cyclophora, was first described in 1995
- Added to the existing 35 phyla in existence
- Ciliate creatures that live on the mouthparts of lobsters in Norway.

Taxonomic Hierarchy

Kingdom
- Phylum (in animals) or Division (in plants)
Class
Order
Family
Genus
***Species***
Subspecies
Population
Microorganisms...
- Insects, mites, worms, fungi, bacteria, and other tiny creatures
- Over 1000 species of invertebrates may be found in a single m² of a European beech forest (Schaefer and Schauermann, 1990)
- A single gram of soil may contain millions of individuals and several thousand species of bacteria (Torsvik et al., 1994)
- "The black hole of taxonomy." E.O. Wilson

Unimaginably abundant and largely unknown. - - numbers could change species totals by a factor of 10 or more!

TAXONOMIC DISTRIBUTION OF SPECIES

So, how many species?
A simple question that has generated much controversy

Terry Erwin: How many insects are on earth?
Erwin sampled from 19 trees
- A single tree species *Luehea seemanii*.
- Sampling was carried out over the space of three seasons (early rainy, late rainy, early dry, late dry) in order to estimate seasonal changes in species diversity.

**Erwin’s Results**
- 160 of these species were "host specific" - Live nowhere but in the tops of *Leuhea seemanii*.
- Beetles account for two fifths of known insects - tree's canopy houses 400 host-specific insects of all kinds (160*5/2)
- Two thirds of tropical forest insects live in the canopy - 600 insect species inhabited all parts of the tree.

**Final estimate**
- 50,000 tropical tree species worldwide - 600*50,000 = 30,000,000 species of insects!
- More recent work in Manaus, Brazil and Tambopata, Peru, has estimate to 50,000,000 species of insects!

**Did Erwin underestimate?**
- [Graph showing the relationship between number of samples and number of species, indicating the onset of diminishing returns]
Erwin’s species accumulation curve

OTHER ESTIMATES OF GLOBAL SPECIES DIVERSITY

Nigel Stork and Tony Gaston

- Used the ratio of butterflies to other insects to arrive at an estimate.
- Assumed that the very well studied British insect fauna would be representative of all insect faunas.

Stork and Gaston (cont’d)

- In Britain there are 67 species of butterfly for 22,000 insect species.
- There are between 15,000 and 22,000 species of butterfly worldwide
  - $67:22,000 = 15-22,000:?$
- Which would result in between 4.9 and 6.6 million insect species a worldwide

Robert May

- Conjectured that all animal species worldwide could be estimated using a simple relationship between body size and number of species
- Roughly speaking, for each 10-fold decrease in body length, the number of species increases by a factor of 100
- Consider the number of species of butterflies compared to that of cats (or some other large vertebrate).

May’s results... between 10 and 50 million species worldwide.
Is this all “academic”?

- It does illustrate how little we know about life on earth
- Influences people’s perceptions of the magnitude of the crisis

End:
“How many species?”