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Taking Stock of the World's Species

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TAKING STOCK OF THE WORLD'S SPECIES

Wouldn't it be great if every animal and plant had an easy-to-read label, telling you to which species it belongs?

0 1 6 96 2 12 4 5 6 83

Introduction

by Samantha Russell

Scientists are to establish a giant catalogue of life - to, in effect, "barcode" every species on Earth. This poster aims to provide an overview of DNA barcoding: what is it? and why is it controversial?

A barcode for biodiversity

A barcode is a machine-readable digital tag that can identify items to a useful level of uniqueness [1].
The intent of DNA barcoding is to use a short DNA sequence from a uniform locality on the genome to:

- Assign unknown individuals to species [2]
- Reveal those that are undescribed

Image of an apple with a barcode.

Example:
An apple may, (in addition to a tag indicating what sort of apple it is), have a major classification 'fresh produce', a 'best before' *date and a* supplier code [1].

Short code

The segment of DNA that is rapidly gaining currency for "barcoding" animal species is the first 648 DNA units of a gene called *cytochrome c oxidase 1* (*COI*). The gene is one of the few that escape the shuffling of genetic material between generations because it belongs to the mitochondria, energy-producing subunits of the cell that are inherited solely from the mother.

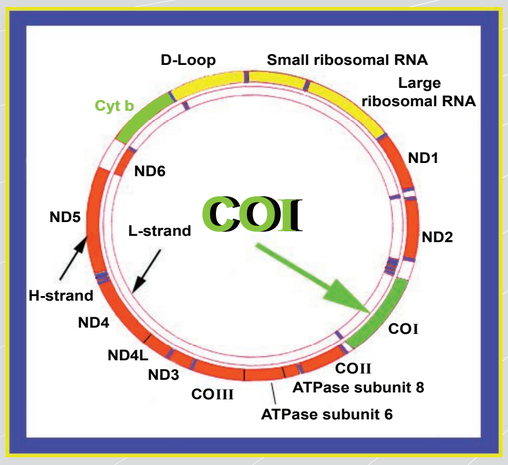


Diagram of the mitochondrial genome.

COI is particularly suitable because of these properties:

- Rapid rate of change
- Easy to amplify
- Low intraspecies variability

One gene fits all?

The central idea to "barcoding" is standardization, the vast majority of DNA barcoding papers follow this structure, in that *COI*, and only *COI*, is used and analyzed through the Neighbour-Joining (N-J) method – whereby simple pairwise distances are interpreted through phenetic clustering to produce tree-like representations of species clusters [3].

But the *COI* gene alone may not have sufficient powers of discrimination for all animal groups; the effectiveness of DNA barcoding for identifying specimens in species-rich tropical biotas is unknown [4].

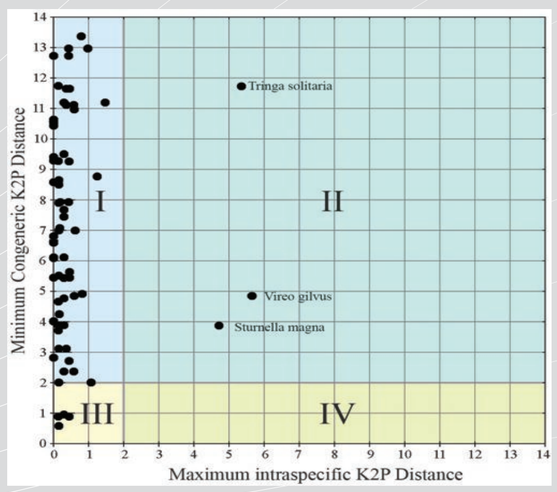
Promises and pitfalls

Promise: A single gene is sequenced for use as the barcode. To be used universally allowing standardization of protocols [3].

Pitfall: No single gene will work for all taxa. In flowering plants another approach has been put forward, e.g. the *trnH-psbA* intergenic spacer but in a study, Kress [5] suggests that multiple genetic loci might be necessary to account for the common hybridization and polyploidy events in angiosperms [6].

Promise: *COI* barcode sequences differ much more among than within species. E.g. A study on North American birds [7], revealed that all 260 species had unique *COI* barcodes, with differences between species much more frequent - on average, 18 times more common - than those within species.

Pitfall: Exceptions occur among some species that diverged very recently or hybridize regularly [8].
Assumes intraspecific variation in negligible, or at least lower than interspecific values.



Results for 73 species of N.A birds
I. consistent with current taxonomy
II. possible lumped species
III. recent divergence or hybridization
IV. possible taxonomic misidentification

Promise: Helping to discover cryptic species [9].

Pitfall: Cryptic species identifications are contingent upon a pre-existing understanding of species are therefore not representative of the 90% unknown biodiversity [3].

Promise: A hand-held barcoder, such as the one envisioned here would make barcoding cheaper, faster and more portable, providing many benefits for science and society.

Pitfall: This attractive aspect relies on future technology.

Image of a '*Star Trek*' style hand-held sequencer.

Biodiversity isn't black and white

- Despite its promise and quick start, DNA barcoding has not yet won unanimous support. The very term *'DNA barcoding'* is unfortunate, as it implies that each species has a fixed and invariant characteristic [2].
- But do barcodes work in practice? The answer is yes, but some work remains before a barcode system is likely to become universal.
- So why aren't taxonomists rushing to embrace DNA barcoding?

The resistance stems from doubt that DNA bar codes can distinguish between closely related species [10] and morphologically highly similar species [4].

- Earth is home to an estimated 10 million species of plants and animals.

Many doubt that a single gene can serve to define all species, or substitute for the painstaking study of morphology and the years of training required for good taxonomy.

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