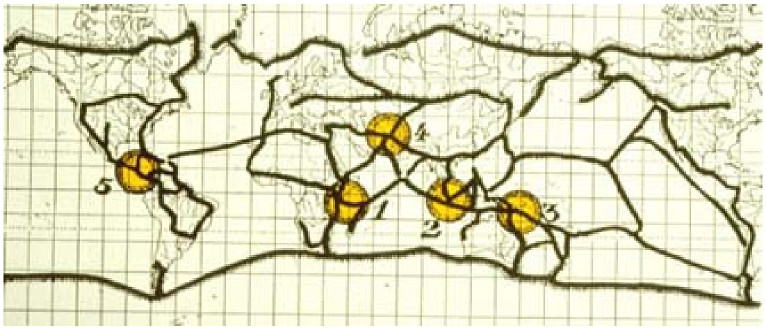
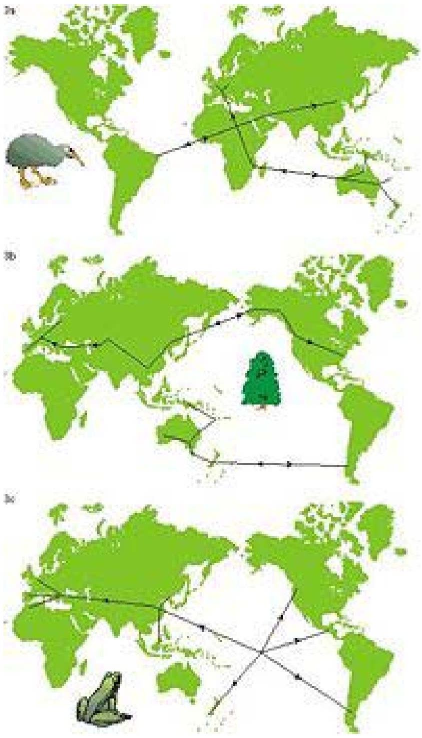
II. Vicariance Biogeography

The breakthrough in the application of cladistic reasoning to biogeography was led by the ichthyologists Gary Nelson and Donn Rosen at the American Museum of Natural History in NY and their interfacing of Leon Croizat's Panbiogeography with Hennig's phylogenetic systematics.



Leon Croizat (1894-1982) was an Italian botantist who once worked at Harvard and ultimately gained a position in Venezuela. Croizat argued that life and earth evolve together -which meant that geographic barriers and biotas coevolved. Croizat developed a new biogeographic methodology, which he named 'panbiogeography '. This method was basically to plot distributions of organisms on maps and connect the disjunct distribution areas or collection localities together with lines called tracks.



Croizat found that individual tracks for unrelated groups of organisms were repetitive, and considered the resulting summary lines as generalized tracks which indicated the preexistence of ancestral biotas, subsequently fragmented by tectonic and/or climatic changes. Some authors, mainly those belonging to the dispersalist establishment, have dismissed Croizat's contributions, considering him as idiosyncratic, or a member of a lunatic fringe. Others have considered Croizat as one of the most original thinkers of modern comparative biology, whose contributions advanced the foundations of a new synthesis between earth and life sciences.

Following its synthesis with phylogenetic systematics, Croizat's panbiogeography has emerged as being central to vicariance or cladistic biogeography. In spite of this synthesis, some authors currently agree in the distinction between Croizat's panbiogeography and cladistic biogeography (Morrone 2000). After initially welcoming the cladists co-opting of his approach, Croizat ultimately came to rejecting both phylogenetics and the Nelson and Rosen's attempts for a synthesis.

Panbiogeography: distantly-related taxa will have similar disjunction patterns in their distributions due to contraction of the former ranges because of tectonic and/or climatic changes. Croizat emphasized the study of multiple taxa rather than a single group, which was more common at the time and associated with the center of origin approaches to biogeography.

Dispersalists were the counter point to vicariance biogeography as well as the counter point to the idea of centers of origin or "cradles of evolution."

Arguments included such as statements as restricted by temperature 20 ^{o}C , distributions overlap with nearest relatives, intermediate forms trace speciation, highest diversity, etc.

But in reality were "unproven just-so stories" without verification

"…Gary Nelson joined Donn Rosen in New York in 1967, and began the campaign of argument and persuasion that eventually turned the American Museum of Natural History into the world's leading institute of systematics, or a hotbed of crazy cladists, depending on your point of view."

(Patterson, 1995).

In contrast to dispersal models that explained disjunctions by dispersal across pre-existing barriers, Nelson and Rosen proposed that disjunct distributions would come about because vicariance events would divide ancestral populations and the taxa would then subsequently evolved in place. Thus, rather than overcoming barriers, vicariance models used the appearance of barriers to fragment ancestral species ranges.

Their approach incorporated Hennig's emphasis on cladistics and used parsimony to construct area cladograms.

Construct an area cladogram

1. Cladograms are produced for each group of organisms.
2. The names of the taxa at the terminal tips of the cladograms are *replaced by* the names of the areas in which each taxon occurs = area cladograms.

Examine for possible barriers that correspond to nodes of cladogram

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BEGIN TAXA;
	DIMENSIONS NTAX=11;
	TAXLABELS
		EP
		NP
		JAP
		NZ
		AUST
		SA
		MED
		WP
		IND
		CAR
		TEP
;
ENDBLOCK;

BEGIN DISTRIBUTION;
	TITLE='Haliotis';
	NTAX=31;
	RANGE
		rufescens	: 1,
		kamschatkana		: 2,
		sorensii	: 1,
		walallensis	: 1,
		cracherodii	: 1,
		corrugata	: 1,
		gigantea		: 3,
		discus	: 3,
		sieboldii		: 3,
		fulgens	: 1,
		roei	: 5,
		scalaris	: 5,
		laevigata	: 5,
		cyclobates	: 5,
		rubra	: 5,
		australis		: 4,
		varia	: 8,
		midae	: 6,
		tuberculata	: 7,
		lamellosa	: 7,
		ovina	: 8,
		divesicolor	: 8,
		pustulata	: 9,
		iris	: 4,
		pourtalesi	: 10,
		roberti	: 11,
		planata		: 8,
		glabra	: 8,
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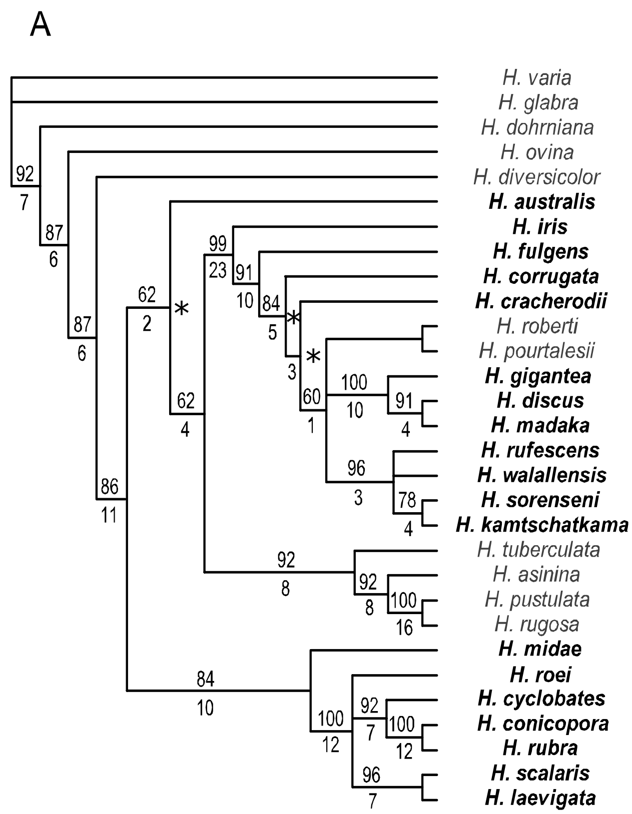

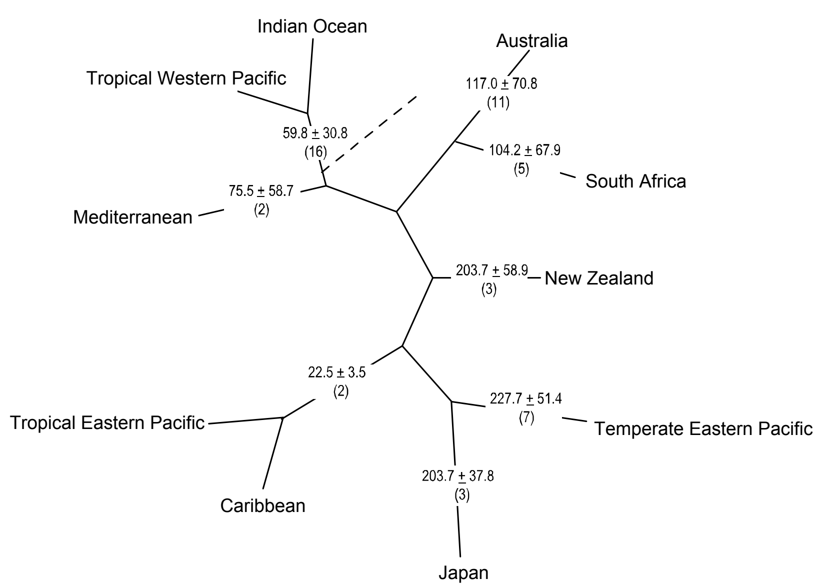

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            dorniana      : 8,
            asinia        : 8 9,
            rugosa        : 9;

      TREE
T1=(24,(10,(26,(((1,2,3,4,25),(9,(7,8))),(5,6)))),((16,((18,(11,(12,13),(14,15))),(22,(21,(29,(17,27,28)))))),
((19,20),(30,(23,31)))));
ENDBLOCK;
```

Contrasts:
Panbiogeography: emphasis of endemism and disjunction of multiple taxa
Dispersal Biogeography: migration across barriers
Vicariance Biogeography: barriers arise to disrupt distributions

In reality distributional data are insufficient to resolve decisively either dispersal or vicariance as the cause of a disjunct distribution pattern.

Platnick and Nelson (1978) argued one should not worry about its cause but whether or not it conforms to a general pattern of relationships shown by other groups of taxa endemic to the areas occupied (multiple taxa approach?).

They argued against the dispersal hypothesis because it was "impossible" to falsify, moreover it was unlikely for several different organisms to disperse together. Besides, multiple dispersals (by same organism) and extinctions destroy would have destroyed phylogenetic patterns.

Area cladograms examined by comparison with other unrelated taxonomic groups endemic to the relevant areas and corroboration of a particular pattern is equivalent to a general statement for the relative recent ancestry of the biotas under examination.

Why are taxa distributed where they are today?

1. They evolved *in situ*
2. They evolved elsewhere and dispersed into new areas.
3. Difference between vicariance and dispersal lies in the relationship between the age of a taxon and the age of the barriers limiting the area.
4. Vicariance predicts that taxa in two (or more) areas and the barriers between them are the *same age;* whereas dispersal always predicts that the barrier predates the taxa.

Age of the barrier therefore becomes important.

Success of finding a congruent vicariant pattern in nature depends on the frequency with which common factors have affected the phylogeny and distribution of two or more groups of organisms.

Cladistic biogeography is very useful for analyzing and comparing biotic patterns at the highest resolution so as to compare them to independent sources of data such as geological patterns.

Historical Biogeography

1. rigorous logic and hypothesis testing
2. rigorous phylogenetic systematics
3. use of area cladograms
4. emphasis on fossil data

A cladistic view of world history combined with the cladistic method in systematics makes it possible to express area interrelationships as hierarchical relations from biotic information.

However, with the advent of molecular techniques and phylogeography the disperalists have new life.

"Madagascar is another interesting example. For many years, phylogenetic studies of native groups have been interpreted as evidence of a vicariant origin associated with the separation of Indo/Madagascar from Africa about 165 Ma. But several recent research results [18] suggest the presence of a land bridge about 80 Ma that connected Madagascar/India to South America/Antarctica. Their data on reptiles indicated that the ancient families Boidae, Iguanidae, and Podocnemidae arrived on Madagascar at about the postulated time of the bridge connection. But more recent reptilian families indicate overseas migrations. In regard to the endemic terrestrial mammals, molecular age determinations indicate that lemurs colonized Madagascar between 50 and 60 Ma, tenrecs between 42 and 25 Ma, carnivores at 26 to19 Ma, and rodents at 24 to 20 Ma. An analysis of fossil and DNA evidence from ratite birds suggested that they were originally flying birds of Paleocene origin that could have easily dispersed to Madagascar from Africa.

Cladistic biogeography remained a relatively popular movement until the late 1990s when an outpouring of work on molecular genetics began to have its effect. In more recent years, it has become obvious that most of the distributions of contemporary clades, which vicarianists attributed to the fractionation of Gondwana, took place in the Tertiary or more recent times. The kind of allopatric speciation that takes place when a barrier is formed to divide a formerly continuous population does not present a problem. In nature, this kind of speciation is evidently the most common. However, vicarianism does not permit the recognition of the type of allopatric speciation that takes place when members of a population migrate across a barrier to colonize a new area, nor does it consider sympatric or parasympatric speciation to be important. It is these various handicaps that have resulted in the decline of cladistic biogeography."

Briggs (2005)